APPENDIX B

NSRSM Topography Sources

CONTENTS

FIGURES

B.1: SOUTH FLORIDA REGIONAL SIMULATION MODEL

TO: Jeffrey Sullivan, South Florida Water Management District (SFWMD), Office of Modeling (OOM)

FROM: Matthew Hinton, United States Army Corps of Engineers (USACE), Interagency Modeling Center (IMC)

DATE: August 27th, 2004

RE: Final South Florida Regional Simulation Model (SFRSM) Topography

The purpose of this memorandum is to present the final SFRSM topography layer that has been developed. This memo will describe the elevation data sources that went into the process, and the methodologies used to combine all available data into a comprehensive and blended layer. Note that all associated data for this project is located on the South Florida Water Management District (SFWMD) network at \\MODSERV1A\hsm_data2\hsmgis\rsm\topo. In that location is a 100-foot DEM in Arc/info Grid format called rsm_topo_g100.

<u>Data Sources</u>

<u>U. S. Geological Survey High-Accuracy Elevation Data Collection (HAEDC)</u>
This dataset consists of point elevations collected throughout the Everglades National Park (ENP) and Water Conservation Area 1 (WCA1). The data was acquired from the USGS website at sofia.usgs.gov on June 3rd, 2004. This website contains metadata and publications about the data. The point elevations are in NAVD88, and have a reported vertical accuracy of 15 centimeters (6 inches). The horizontal datum is UTM17 meters.

<u>Everglades Agricultural Area Digital Elevation Model</u>
This dataset was received as a 500-foot DEM, and was created under an SFWMD contract to Kimley-Horne Associates (KHA). Along with point elevations and transects, much expert knowledge went into the final product. From the metadata provided, KHA states, "Data was gathered from transects and cross sections surveyed by GCY Inc. and Betsy Linsday, P.L.S. EAA farmers were contacted to obtain existing survey info. USSC and King Ranch provided data collected over during the 1990s through the present. GCY Inc. surveyed approximately 15 farm staff gages and muck shots near the staff gages in December 2002 under direction from DHI Inc. DHI used information from interviews of farmers conducted in November and December, 2002 to identify areas of high and/or low elevation on the farms. Extrapolations to adjacent farms was done by DHI based on knowledge of adjacent farm water management practices, crop type, etc. An initial DEM was constructed and distributed to SFWMD, US ACE, and MacVicar Federico and

Lamb, Inc. After comments were received from reviewers, the DEM was revised." No vertical accuracy assessment was provided. The publication date is July 10, 2003.

North Palm Beach Digital Elevation Model

This dataset is a 5-foot DEM in Arc/Info GRID format, and covers portions of Palm Beach County and Martin County east of the natural areas and the EAA. It is based primarily on LIDAR collected by the U.S. Army Corps of Engineers (USACE), but also includes LIDAR data from Palm Beach County, point elevation data from Martin County and points from the USGS 24K quads (described below). In the Constraints section of the draft metadata provided with this DEM, it states, "Limitations of use: CAUTION!! Use this data with caution, it is in draft form. This DEM has not had a complete QAQC. The accuracy of this data is unknown at this time. Preliminary checking of this dataset shows it is within 6 inches to 1 foot in vertical accuracy and 6 inches in relative vertical accuracy. This data should be used on a regional scale for display and modeling purposes. It should not be used for any type of construction purpose or in place of survey data." There are holes in this dataset which require interpolation, and the St. Lucie Canal is represented topographically in the data. There are plans to update this dataset in late 2004 (email from Celia Conrad). This dataset was compiled by Celia Conrad of SFWMD.

Combined Structure and Operational Plan (CSOP) for MWD and C-111 LIDAR Surveys Digital Elevation Model

This dataset is a 25-foot DEM in Arc/Info GRID format, and covers most of Miami-Dade County east of the ENP/LEC levee. Under the Use Constraints section it states, "Survey 03-005 was performed for the purpose of planning studies and hydraulic modeling investigations in South Florida. This data is not intended for, nor is it sufficiently accurate to develop civil works plans and specifications for construction." At this time the vertical accuracy assessment has not been completed. There are many small holes in the data which require interpolation, and there are several bigger holes representing the Lakebelt lakes (~55 feet deep mining pits). This dataset was taken from the SFWMD GIS Enterprise Data Library at \\gisdata1\raster\project\csop\landform\topography\lftopcsp. It is a product of the US Army Corps of Engineers (USACE).

Southwest Florida Feasibility Study Points (SWFFS_PT) and Lines (SWFFS_LIN)

Two datasets were copied from the topography workspace created by Tim Lieberman of SFWMD, at \\ftmserv\swffs\gis\DataLib\Topo\Usgs_Rev. The point data is primarily from the USGS 24K Quad series, with additional points manually added from other topography sources. The lines are primarily from the USGS 24K series 5-foot contours. This data covers the west-northwestern portion of the SFRSM domain. Documentation for this data is available from Tim Lieberman.

Lake Okeechobee Bathymetry

This dataset was received from Mark Brady of SFWMD. It represents depths measured with a sounding pole when the lake stage was measured at 14.5 feet NGVD29. There is no metadata available at this time. Errors could have been introduced by wave action, silt thickness, rock outcroppings and the fact that one flat stage value was assumed for the entire lake.

U. S. Geological Survey 24K Quad Points

This dataset consists of point elevations taken from the USGS 24K Quad Series of maps, and includes various elevations and benchmarks from those products. The coverage \\gisdata1\gislib\vector\other\usgs\q24k\topo\point\district\all_points was copied from the SFWMD's Enterprise GIS Data Library. According to the metadata, "Vertical positional accuracy is based upon the use of USGS source quadrangles which are compiled to meet National Map Accuracy Standards (NMAS). NMAS vertical accuracy requires that at least 90 percent of well defined points tested be within one half contour interval of the correct value. Comparison to the graphic source is used as control to assess digital positional accuracy." Note that the contour interval for this product is 5 feet, suggesting an accuracy of +/- 2.5 feet.

Sources from SFWMD/TRT SUPERTOPO Directory

The following datasets were copied from TRT's SUPERTOPO directory. These datasets have been previously documented:

- 1986 AeroMetric Corporation Survey of the 8.5 Square Mile Area
- 1992 Florida Game and Fish Commission Survey of Holeyland WMA
- 1992 Florida Game and Fish Commission Survey of Rotenberger WMA
- 1992-93 Keith and Schnars Survey of Water Conservation Area 2A
- 1999 EarthData Intn'l Survey of Water Conservation Area 3A
- NOAA Soundings from Everglades National Park staff
- USGS Southern Inland Coastal Systems (SICS) Model Topography
- SFWMD Sub-Regional Groundwater Modeling Topography

All of the above point datasets had their attributes edited to match.

Grid Representing Vertical Datum Conversion between NAVD88 and NGVD29

To convert elevations between the National Geodetic Vertical Datum of 1929 (NGVD29) and the North American Vertical Datum of 1988 (NAVD88), a grid was created by Tim Lieberman using CorspCon. First, he created a grid covering the SFWMD domain at a resolution of 5000 feet. Then, he processed the cell centroids through the Corpscon (rev. 5.11.08) software. According to Tim's documentation, "As part of the topographic analysis for the Southwest Florida Feasibility Study (SWFFS), it was necessary to convert many elevation values from the old vertical datum (NGVD 1929) to the new (NAVD 1988). Currently the two primary methods are either to field-survey each point or to use the Corpscon software. Corpscon was developed by USACE, using code from the USGS Vertcon program, to convert X-Y-Z values from one coordinate system to another. Preliminary analysis suggested that the Corpscon conversion was accurate with 0.10 feet for 95 % of field-surveyed points. This dataset, dz_g5000, is an ArcInfo grid that contains values for the Z-shift between NGVD29 and NAVD88. It covers the entire SFWMD area, with a cellsize of 5000 feet. For a given value in the dataset, NAVD88 = NGVD29 + value. The values generally range between -1.5 and -1.1 feet." This grid is called dz_g5000, and was used to convert the two LIDAR-based DEMs (NPB & CSOP) from NAVD88 to NGVD29.

See the Source Map for the extents used for each listed dataset.

Preprocessing

The following data was preprocessed as described:

NPB LIDAR DEM– resampled from 5-foot to 100-foot DEM in Arc/Info using the CUBIC resampling method.

CSOP LIDAR DEM – resampled from 25-foot to 100-foot DEM in Arc/Info using the CUBIC resampling method.

HAEDC Points – this data was downloaded from the USGS website as Arc/Info export files. 68 files were downloaded and imported into point coverages, their attributes were modified to match, and they were appended. The elevation values were converted from NAVD88 to NGVD29 using VertCon94. The horizontal datum was converted from UTM 17 to NAD 83. Finally, flow barriers (roads and levees) and canals in the vicinity were buffered by 75 feet, and any points falling within this buffer were removed. This process was automated with an AML called proc_haedc.aml, which serves as documentation of the processing steps involved. All of this work was done in a sub-directory of the primary directory called haedc_work_dir.

Sub-Regional Groundwater Points – there were levees "burned into" the elevation data in the vicinity of Broward County. The data was edited by selecting all the values greater than 18 feet, and then reselecting by eye the set of points that represented the levees in Broward County. Those points were eliminated.

Compilation Methodology

A note on Arc Macro Language (AML) programs:
Several amls were used in the processing of this data. A primary aml called build_final_rsm_topo.aml was written to handle all the processing of the data from its initial phase into the final product, after the preprocessing steps were completed. This aml serves as documentation of the processing procedure. Several other amls written by Tim Lieberman were called by the primary aml. These include pts2dem.aml and blendgrids.aml. The pts2dem.aml converts a coverage of point values into a DEM (Arc/Info grid) by creating a TIN data layer, and then converting the TIN into a Lattice. This process introduces erroneous data into the output by extrapolating values around the edges of the input point coverage where there is no underlying data to support it. Because of this the grids are masked to converts cells outside the real data domain to NODATA. The second aml is called blendgrids.aml. This program blends two (only two) grids together along a user-specified swath of data overlap. This code uses the same algorithm as the Arc/Info GRID command 'mosaic'. Because the swath is measured from the NODATA edge of the first, or foreground, grid entered, the order of grid specification is important.

The primary aml build_final_rsm_topo.aml consists of the following steps:

1. Clip point datasets to area of interest - clipped the NOAA Soundings data, the SICS model data, the HAEDC data and the USGS 24K points, using handmade clip coverages.

2. Process Lake Okeechobee bathymetry – converted the DEM of bathymetric values into a point coverage of elevations (NGVD29). The DEM was first divided by 10, then the new values were subtracted from 14.5 (the stage of the lake). That grid was converted to points and projected from NAD27 to NAD83.

3. Process EAA DEM – converted the EAA DEM into points, then clipped them to just include points in the EAA, excluding the Holeyland and Rotenberger WMAs. A clip coverage for this purpose was handmade (eaa_clip).

4. Append point coverages west of the LEC – appended all the points

5. Run TopoGrid for SWFFS data to create DEM – a clip of all the appended points was made, containing all of the SWFFS points and a buffer of points from the other datasets which edged the SWFFS data domain. This was done because when all the appended points were used, the function crashed. TopoGrid was run against this clipped coverage, specifying the clipped point coverage and the contour coverage SWFFS_LIN. This matches the processing done by Tim Lieberman in the construction of the SWFFS topography layer. A mask was then applied to the resultant DEM to eliminate areas where no data exists to support extrapolation.

6. Build DEM of western points – all of the points from the above appended coverage were converted into a 100-foot DEM using pts2dem.aml. A mask was then applied to the resultant DEM to eliminate areas where no data exists to support extrapolation. Note that one small area, south of the 8.5 Square Mile area, had no data points. The extrapolated data that resulted from the TIN creation was kept in this area, because no other data existed. The mask along the eastern edge of the natural areas was built from the SFWMD canals coverage.

7. Blend two 'West' DEMs – the two DEMs created were then blended together using blendgrids.aml, with a swath of 1000 feet specified. The result of this step is a 100-foot DEM called west_g100.

8. Clip Sub-Regional Groundwater points – this dataset was clipped with a handmade clip coverage to reduce the number of points. This dataset is used to fill in the area in Broward County east of the protective levee, between the two LIDAR-based DEMs (NPB and CSOP).

9. Create DEM for Sub-Regional Groundwater points – the subset of points from the Sub-Regional Groundwater topography were run through pts2dem.aml to create a

100-foot DEM. A mask was then applied based on the clip coverage to eliminate cells that had no underlying values to support the TIN interpolation.

10. Process North Palm Beach DEM data – this DEM was divided by 10. Then the vertical datum was converted from NAVD88 to NGVD29 using the conversion grid dz_g5000. An averaging window of 50 X 50 cells was then applied to the cells which had NODATA, to interpolate values. The window was very large due to the size of the “holes” in the original DEM. These holes should be filled in the DEM with better information. Finally, a mask was applied to eliminate the NODATA cells along the boundary of the dataset which picked up values in the interpolation process.

11. Process CSOP DEM – first a grid called csop_lbelt, representing the Lakebelt mining lakes that contained NODATA in the original DEM, was used to apply a value of -56.5 (NAVD88) for those cells. Then the values were converted from NAVD88 to NGVD29 using the grid dz_g5000. Next, an averaging window of 10 X 10 cells was applied to the cells which had NODATA, to interpolate values. Finally, a mask was applied to eliminate the NODATA cells along the boundary of the dataset which picked up values in the interpolation process. Note: there are still a few cells with NODATA values. (MH,8/27/04)

12. Blend DEMs in the LEC – the three DEMs for the LEC were blended together using blendgrids.aml, with a swath of 1200 feet specified. First the NPB DEM (after processing) and the Subreg DEM were blended together into a temporary grid. This grid was then blended with the CSOP DEM (after processing) to create a 100-foot DEM called east_g100.

13. Build final DEM – the two DEMs, west_g100 and east_g100, were combined using the ‘mosaic’ command. This method will average or smooth the input data where it overlaps. Note that the only overlap area is between the NPB DEM and the USGS 24K point data to the north. The rest of the boundary between the east and west DEMs was masked to match exactly. The result is called rsm_topo_g100.

Conclusion

A final GIS data layer representing elevations in the NGVD29 vertical datum resides at /vol/hsm_data2/hsmgis/rsm/topo. It is called RSM_TOPO_G100. The best available topography data for any given area was applied. The weakest datasets are in a portion of Broward County east of the protective levee, and the areas north of Lake Okeechobee. It is anticipated that the USGS elevation data collection effort will acquire data for WCA2 and northern WCA3 in the next year. Also, the North Palm Beach DEM will be updated in late 2004. No agencies of Broward County were contacted in this effort, and perhaps they have useful elevation data. This data should be incorporated in a future update.

It was suggested that the topography layer that has been developed could be tested by applying it to the SFRSM mesh, and then running the SFRSM model using just rainfall and evapotranspiration to assess the flow regime produced. It is recommended that such an analysis be performed. No analyses have been conducted other than visual inspection.

Cc: Jayantha Obeysekera, SFWMD/OOM
Russell Weeks, USACE/H&H
Kenneth Tarboton, SFWMD/OOM
Larry Stout, USACE/IMC
Sharika Senarath, SFWMD/OOM
Jenifer Barnes, SFWMD/OOM
Mark Brady, SFWMD/LO
Tim Lieberman, SFWMD/FTM
Naiming Wang, SFWMD/ELM
Celia Conrad, SFWMD/

ADDENDUM

SFWMD online documentation for Brupdate1

This data set contains a 100 ft resolution, sub-averaged, bare earth, digital elevation model (DEM) derived from airborne LIDAR surveys of Broward County, FL. LIDAR data were collected with an Optech ALTM 1210 LIDAR mapping system in 1999-2002. In total, the surveys covered over 1300 square km and consisted of over 700 million irregularly spaced elevations. Data from individual flight lines were sorted and organized into 5000 by 5000 ft tiles. The points were filtered to remove non-ground surface elevations in order to produce a "bare earth" elevation model, gridded to 5 ft resolution and subaveraged to 100 ft cells. These data were produced as part of the Windstorm Simulation Modeling Project per the contract agreement between Florida International University, International Hurricane Center (IHC) and Broward County.

B.2: NATURAL SYSTEM MODEL V4.6.2

Estimation of Pre-Drainage Topographic Coverage for the NSM

by
Jose Otero, Walter Wilcox, and Cary White
April 21, 2005 Report for RECOVER

Based on
"Contour Development" by Christopher McVoy, Everglades Division, SFWMD
October 8, 2004

Phase 1: Contour Development

Approach:

Contours for the area within the pre-drainage Everglades boundary were hand-drawn by applying the following rules:

(1) Elevations within the [pre-drainage] peat soil portions of the Everglades must be related logically to the directly adjacent upland elevations, specifically: (Everglades) ≤ (Uplands) and (Uplands) – (Everglades) ≤ 2 feet.
(2) Contours should be perpendicular to the pre-drainage directions of flow.
(3) Contours should cross "Big Four" (muck) canals at the 1913 canal survey elevations (FEEC 1914) along the unsubsided majority of canal length.
(4) Contours should <u>not</u> follow 1913 canal survey elevations along subsided portions; near Lake Okeechobee and near the coastal ridge.
(5) Contours should follow subsidence-corrected 1913 canal elevations along the subsided portions.
(6) Southern Lake Okeechobee shoreline, from about Fisheating Creek to Port Myakka (Bacom Point), should be level at 20.5 feet above mean sea level.
(7) Contours should reflect the generally smooth, continuous surface expected from peat accumulation processes.

Few minor and no serious conflicts were found between the above rules; in other words, it was possible to draw contours that satisfied all the above rules with only minor exceptions. It was also found, somewhat surprisingly, that the above set of rules generally constituted a strong set of constraints, that is, they defined the allowable set of contours quite closely. It is important to note that within the Ridge and Slough landscape, the contours represent an average elevation corresponding conceptually to a spatially-weighted average of actual slough, ridge and tree island elevations.

There is an area of uncertainty in the vicinity of the 7 ft and 8 ft contours near the current location of Tamiami Trail (see **Figure B.2-1**). In this case, the central tendency of the various interpretations was used in contour development for NSM.

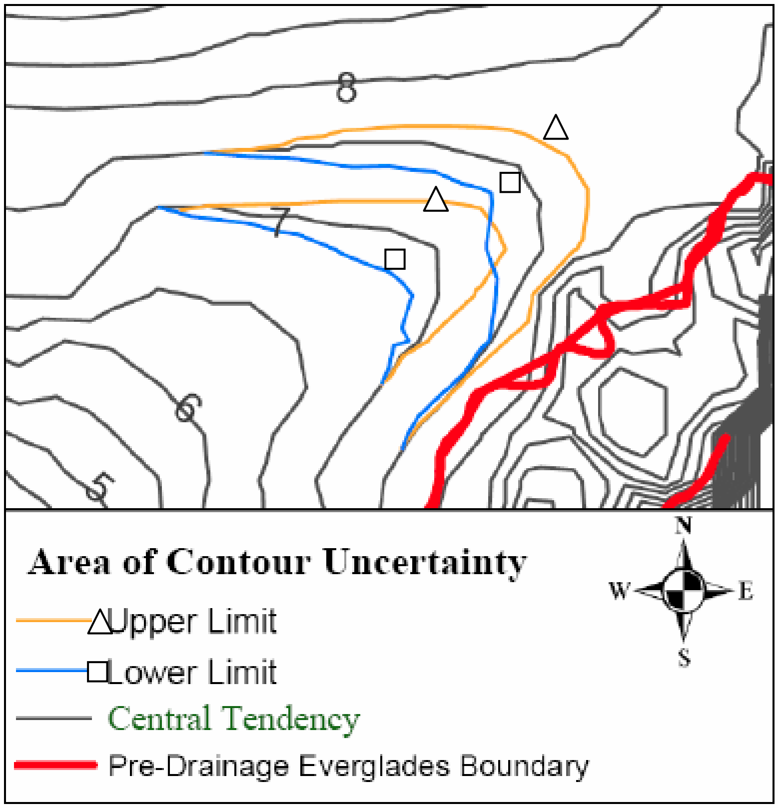

Figure B.2-1. Contour uncertainty near current Tamiami Trail area

<u>Sources referenced in C.McVoy Memo October 8, 2004:</u>

Upland elevations:

(1) High Accuracy Elevation Data Collection (HAEDC) from U.S. Geological Survey as of October 2001 for current elevations below elevation 8 ft.
(2) 1 foot contours generated from NSM 4.6.2 grid cell values
(3) 1 foot contours generated from SFWMM v. 4.5 (? – most recent)
(4) USACE (1960b) map of 1 ft contours

Elevation along eastern edge of Everglades:

(1) Bache (1850)
(2) MacGonigle (1896)
(3) Rose (1898)
(4) Senate Doc 89 (1911)
(5) USACE (1960a)
(6) Gaby (1993)

Landscape directionality (proxy for pre-drainage flow directions):

(1) Board of Commissioners (1935)
(2) USDA-SCS (1940)
(3) McVoy et al. (reviewed)

1913 canal survey elevations:
(1) FEEC (1914); Elevation profiles digitized from same
(2) King (1917)
(3) Wilson (1918)
(4) Crabtree (1921)

1913 canal survey subsidence corrections:
(1) Jennings (1907)
(2) Anonymous (1907)
(3) Wright (1910)
(4) Senate Doc 89 (1911)
(5) McVoy et al. (reviewed)

Pre-drainage elevation of Lake Okeechobee:
(1) Meigs (1879)
(2) Sackett (1888)
(3) Kraemer (1892)
(4) Slattery (1913)

<u>Additional Sources and Use of Information to Supplement C.McVoy Memo Oct. 8.2004, W. Said and R.VanZee , Office of Modeling, SFWMD</u>

Alignment of 8 foot contour south of Miami on west edge of coastal ridge:
(1) Combined Structure and Operational Plan (CSOP) for MWD and C-111 LIDAR Surveys Digital Elevation Model

Sources used to estimate 7 foot contour south of Tamiami Trail include:
(1) Board of Commissioners (1935)
(2) Parker et al. (1955)
(3) FEEC (1914)

Phase 2: Grid development

Approach:

Develop grid data based on the contours developed in Phase 1. Account for known topographic features not exhibited in the contours developed in Phase 1. The processing steps are:

1. Develop preliminary grid data using Arc's TopoGrid.
2. Develop output contours from the preliminary grid data.
3. Compare input contours from Phase 1 with output contours from Phase 2
4. Iterate 1-3 as necessary

Actions:

The actions listed below are an attempt to bring the output contours in line with the intent and criteria used for the input contours, and accounting for known topographic features not exhibited in the input contours. Most of these actions were identified in the workshop of February 22, 2005.

Individual features
Lake Hicpochee and Mullet Slough were reinstated as they existed in NSM 4.6.2, as they were not present in the Phase 1 contours.

Edge matching
Correct contours in areas near the pre-drainage boundary so that the areas outside of the pre-drainage boundary are consistent with current elevations. The areas corrected were:
1. Area near just northeast of historic Everglades (L-8 area)
2. Area near LEC boundary, starting near North New River and to the south
3. Area near Lostman's Slough close to the pre-drainage boundary
4. Area near the headwaters of the Caloosahatchee River.

No-Accretion Criteria
Only subsidence, no accretion, was assumed to have occurred in areas covered by HAED data. Ground elevations from the pre-drainage period compared to current elevations should stay the same or subside. Preliminary grid values were compared to current ground elevations. Where preliminary grid values were lower than NSM 4.6.2 elevations, the NSM 4.6.2 elevations were used.

Product:

The end result of the approaches outlined in Phases 1 and 2 was used in the creation of the NSM 4.6.2 Sens 4 run. Final contours are illustrated in **Figure B.2–2**.

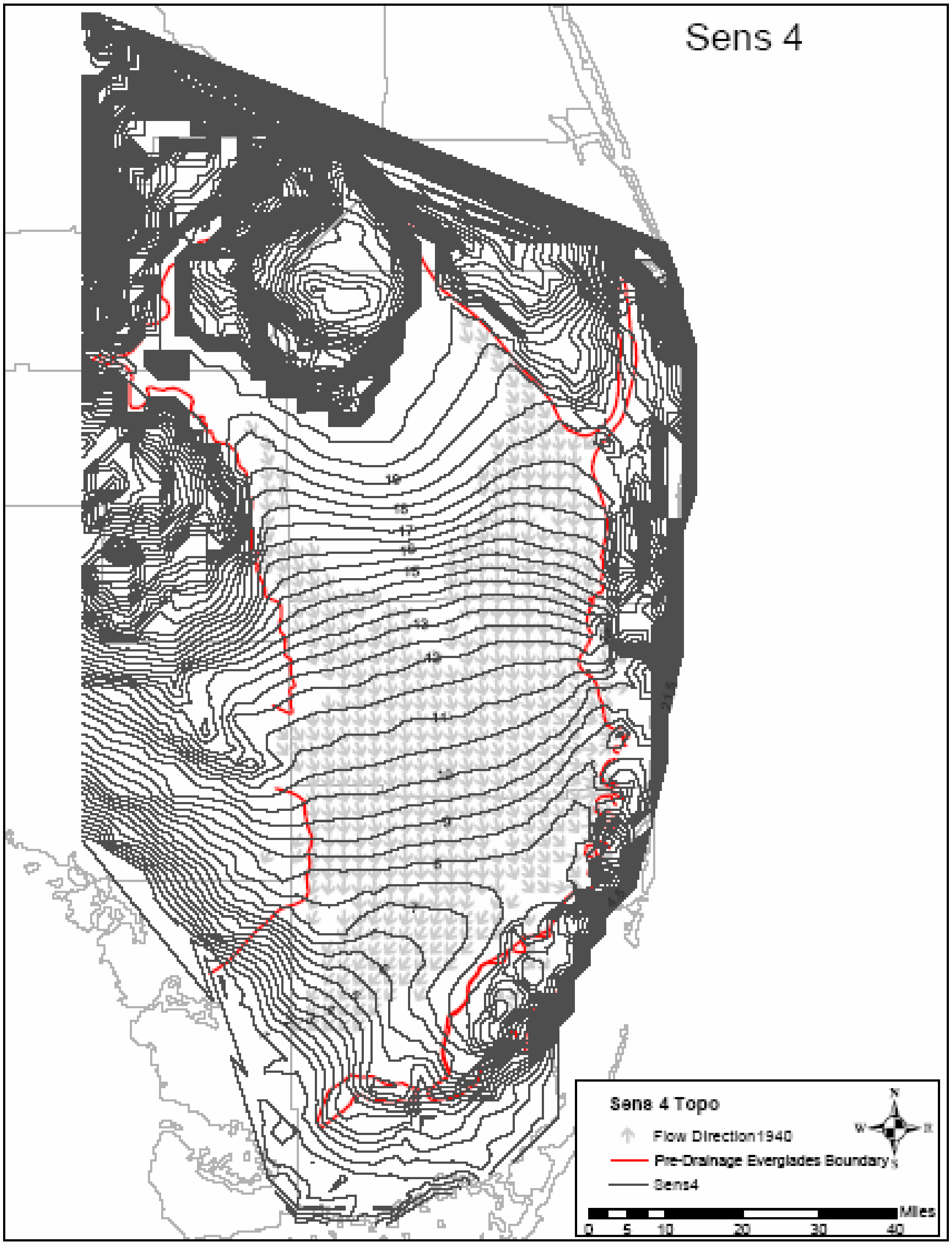

Figure B.2-2. NSM v4.6.2 Sens4 derived as a result of Phases 1 and 2.

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B.3: KISSIMMEE RIVER

Kissimmee River Floodplain Landsurface Elevation Data

Excerpted from Kissimmee Department Spatial Data Documentation
\\Ha1-fs1\fa_bus\krrep\Metadata\Spatial-Data-Doc.doc

All spatial data are stored in the Stateplane Coordinate System, Florida East zone, U.S. survey feet, horizontal datum NAD83, and vertical datum NGVD29. The data are stored in a file system located on an infrastructure server at the South Florida Water Management District's (SFWMD) headquarters in West Palm Beach, Florida.

This data set was developed during 1993 and 1994 by private architectural and engineering contractors for the U.S. Army Corps of Engineers (USACE), Jacksonville District (JAX) in support of the Kissimmee River Restoration (KRR) Project. The data is suitable for applications requiring elevation and high resolution aerial orthoimagery. Some examples of these are inundated area mapping, land use determination, and existence of structures, roads, and drainage features. The data was collected and processed for government use for a specific USACE activity. The Jacksonville District makes no representation as to the suitability or accuracy of these data for any other purpose and disclaims any liability for errors that the data may contain. The data is only valid for their intended use within their content, time, and accuracy specification. Appropriate and professional judgment should be exercised in their use and interpretation.

The data set describes the baseline topographic condition of the Kissimmee River floodplain prior to restoration and serves as the base map the KRREP spatial database. The data set consists of geodetic control, orthoimagery, contours, spot elevations, breaklines, cross sections, bathymetry, and digital terrain models (both GRIDS and TINS). The entire data set was developed relative to the same geodetic control network to ensure good absolute and relative accuracy between thematic data. The control network was designed to support the development of 1:6,000 scale digital orthophotographs and 1 foot contours. It was derived from the Florida High Accuracy Reference Network (HARN). The entire data set meets national map accuracy standards at a scale of 1" = 100'. This means that the horizontal position of features described in these data sets are within +/- 2.5 feet of their absolute location on the ground, contours are within +/- 1 foot and spot elevations are within +/- .5 feet.

The data set is organized by theme and geographic area. Each geographic area is subdivided into blocks which break the files for each pool into manageable units. The digital orthophotographs are further divided into sheets where multiple sheets make up a block.

The themes within the data set are bline, control, grid, index, ortho, spot, tin, and topo:

- **Bline** contains breaklines that were derived through stereocompilation and represent abrupt changes in elevation.
- **Control** contains locations and descriptions for the monuments that comprise the KRR third order geodetic control network.
- **Grid** contains ARC/INFO floating point Grids derived from the breakline and spot elevation data. These use a 60 foot cell size and are stored as a single grids per pool.
- **Index** describes the boundaries of the KRR project area and contains the Pool, Block, and Sheet layout for the project area.
- **Ortho** contains the digital orthophotography for 1994. The orthoimages are 8-bit greyscale TIFF files. The pixel size is 1 x 1 foot. Individual images are 3000 x 2500 pixels. Image quality varies between pools. A project to tonally balance, resample, and compress these images is underway. The new image files will be added to this directory to allow end users to choose images appropriate for their uses.
- **Spot** contains spot elevations derived through stereocompilation at 60 foot intervals throughout the project area; ground survey cross sections run perpendicular to the C-38 canal and spaced at 1000 foot intervals across the floodplain and 250 foot intervals across spoil mounds; and bathymetry for remnant river channel and the C-38 canal. Stereocompiled elevations are good in areas where the ground is not obscured by shadows, tall grasses, and slopes. In areas with dense marsh vegetation, spot elevations do not correspond well with the ground survey cross section elevations. These areas are identifiable in contour, DEM, and lattice data sets which were derived from the spot data. The data in these locations tend to bias towards the cross section data and show a strong linear correlation to the cross section course.
- **Tin** contains lattices derived from the grid data.
- **Topo** contains contours derived from the breakline and spot elevation data. Index contours occur at five foot intervals with supplemental contours at one foot intervals. The contour data for Pool D remain under evaluation. Errors have been found within these files.

Each thematic area is further subdivided into geographic area directories. The geographic areas are Pool A, Pool B, Pool C, and Pool D. These geographic descriptors refer to areas within the Kissimmee River Floodplain.

B.4: SOUTHWEST FLORIDA FEASIBILITY STUDY

Composite Topography for SW Florida, 100-ft.

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Data POC:

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This GIS dataset of topographic elevation data for Southwest Florida was composited from multiple sources, covering the Lower West Coast (or SouthWest) part of the South Florida Water Management District. The dataset is in gridded format, with a cell size of 100 feet. For any given area, the data from the best-available source was used. Sources included LiDAR data, aerial/photogrammetric data, and USGS contour and spot-elevation data (**Figure B.4-1)**. Along the boundaries of the input datasets, values were blended together to eliminate discontinuities. The detail of the data is greater in some areas than in others

Source Data (Fig. 1)

SWFFS LiDAR (source 1 of 9)

USACE, contracting to MD Atlantic Technologies, SWFFS LiDAR.

Type_of_Source_Media: LiDAR XYZ points

Source_Scale_Denominator: 12000

Source_Contribution:

In order to provide better elevation data for areas critical to the Southwest Florida Feasibility Study modeling effort, LiDAR was flown early in 2003. The contract was awarded to MD Atlantic Technologies and was managed by USACE. From the beginning, there were problems with the data. A "final" delivery was received in about Feb. 2005, with the data formatted for 25-ft cells. The raw data are not available. For the final data, most of the striping problems had been resolved, but there were still residual problems. Inadequate filtering of vegetation-canopy returns resulted in spurious peak values, giving a bumpy appearance to the data. Perhaps more significantly, we have concerns about the overall values in sloughs and flowways, where the flowways were not as deep (or well defined) as experts expected. This could be due to insufficient laser returns in heavy canopy. It was difficult to quantify these "errors," due to a lack of known control elevations in these areas. The contract included a QA/QC component, but the survey crew clustered almost all of their QA/QC points along road surfaces or in other bare areas. The stated vertical accuracy from the QA/QC report was about RMSE 0.3 feet. In bare areas, that number may have some validity, but in the vegetated areas that are critical for this study, we have no confidence in the absolute accuracy of the values. The resulting LiDAR topo surface looks reasonable in a relative way, and captures most of the depressional or ridge features that we would expect to find, but we don't know if the numbers are correct or are consistently off by a foot or even more. That's the way it is. Because we didn't have anything better to use, we used it.

West Collier County LiDAR (source 2 of 9)

Collier County Property Apprais, contracting to 3001 Inc., 2001, W.Collier LiDAR.

Type_of_Source_Media: LiDAR XYZ points
Source_Scale_Denominator: 12000
Source_Contribution:
This dataset was contracted to 3001 Inc. by the Collier County Property Appraiser's Office as part of a larger photogrammetric project. The USACE obtained the raw data, covering parts of 20 USGS quadrangles, including spot values and water-body shorelines. The raw data was irregularly spaced, with spots about 10 feet apart, on average. The dataset was processed into an ArcGis grid with a regular spacing of 25 feet, and the shorelines were used to process the water bodies as flat surfaces. According to the contractor's QA/QC report, the vertical RMSE was on the order of 0.3 feet. However, we could not check the locations of the points. The surface, in general, appears more realistic than the SWFFS LiDAR, in that it doesn't suffer from the same vegetation-canopy errors. However, there are some noticeable striping effects, mainly in the form of areas where blocks of data are raised or lowered (by as much as a foot) relative to surrounding blocks. In comparison with the SWFFS LiDAR, for the small area of overlap among them, the W.Collier averages about 1.3 to 1.5 feet lower than the SWFFS LiDAR.

South Webb WMA LiDAR (source 3 of 9)

Obtained from Lee County Govern, contracted to EarthData International, 2002, SWebb LiDAR.

Type_of_Source_Media: LiDAR XYZ points
Source_Scale_Denominator: 12000
Source_Contribution:
This LiDAR data was supplied by the Lee County Government. I'm not sure whether they were the original holders of the data. This dataset covers the southern part of the Cecil M. Webb Wildlife Management Area, located in northern Lee and southern Charlotte counties. The dataset was obtained as irregularly spaced ground points, and was processed into an ArcGis grid with a cell size of 25 feet. Other than the aircraft flight report, I have not seen any QA/QC information. On visual inspection, the elevation surface is impressive. It clearly conveys the "cantaloupe-terrain" nature of the landscape, with numerous shallow depressions, but does not show any vegetation-canopy effects or any obvious striping.

Lee County Photogrammetry (source 4 of 9)

Lee County Government, contracting to EarthData, Lee Photogrammetry.

Type_of_Source_Media: Photogrammetry XYZ Points

Source_Scale_Denominator: 24000

Source_Contribution:

Lee County contracted to EarthData in 1998 to create a digital orthophoto dataset, with associated 2-foot elevation contours and spot-elevation values. Afterward, the USACE contracted with EarthData to provide some QA/QC results and apparently funded updates for some areas. This included areas of known change, such as spoil piles, and also involved the definition of the canal network for Cape Coral. Both the Lee and USACE versions of the data, in XYZ format, were obtained and processed into ArcGis grids with a cell size of 50 feet. Because the USACE version was more recent and apparently was based on better QA work, it was preferred over the original Lee version, except in some coastal areas where blocks of data were missing from the USACE dataset. Care was taken to superimpose a shoreline obtained from Lee County, to differentiate elevation values between low-lying areas and the Gulf of Mexico. I have not seen a QA/QC report on the elevation data, but would guess that the functional RMSE is 1.0 feet. The elevation surface looks good, except that some linear features (such as I-75) appear more as a series of bumps rather than as a continuous ridge.

Immokalee and Camp Keais Photogrammetry (source 5 of 9)

BCB office of SFWMD, contracting to ACA and Kucera, 2004, 2002, Immok. and Camp Keais Photogrammetry.

Type_of_Source_Media: Photogrammetry XYZ Points

Source_Scale_Denominator: 12000

Source_Contribution:

Note: These two datasets were NOT used in making the composite topographic dataset. These two datasets are included in this metadata report because they should be incorporated into the composite topo in the future. They were not included at this time because they overlap with the SWFFS LiDAR dataset and differ significantly enough from it that merging the datasets would result in obvious and significant discontinuities along their borders with that surrounding data.

The Camp Keais photogrammetry was contracted to Kucera in 2002. The deliverable consisted of 1-foot contours, spot elevations, and breakline files. Apparently, the higher areas were of greater importance, and the lower areas, such as the central portion of the strand, were not sampled as rigorously. This results in a blockiness in the resulting topographic surface in the natural areas. I don't have much reason to question the range of elevation values in the blocky areas; it's just that the blocky surface seems much more arbitrary than natural. This source data was processed into an ArcGis grid with a cellsize of 10 feet. In comparison to the SWFFS LiDAR, the SWFFS LiDAR has significantly higher elevations in the natural areas.

The Immokalee photogrammetry was contracted to ACA (Aerial Cartographics of America) in 2004. The specification called for 1-foot contour mapping in the urbanized Immokalee area and 2-foot contours in the outlying natural and agricultural areas. Thus, the natural areas were sampled and processed to lower standards. In addition, the Corkscrew Swamp area and its related flowways were too heavily vegetated to obtain useful ground readings, and since the area was not critical for the project, no effort was made to quantitatively derive elevations in those areas. Instead, some dashed contour lines were drawn in those areas. The deliverable consisted of contour lines, spot elevations, and breakline files. This source data was processed into an ArcGis grid with a cell size of 5 feet. In comparison to the SWFFS LiDAR, this data is much lower in the dashed-contour areas; the true dry-ground elevation is probably somewhere between the two.

USGS Helicopter Survey (source 6 of 9)

U.S. Geological Survey, 2001 (approx.), USGS Helicopter Survey.

Type_of_Source_Media: XYZ Points from Helicopter Survey
Source_Scale_Denominator: 50000
Source_Contribution:
This dataset is sometimes referred to as AHF (Airborne Height Finder) or HAEDC (High Accuracy Elevation Data Collection). It was collected by USGS as part of an effort to obtain complete elevation coverage of the Everglades area. Individual points were collected from a helicopter equipped with GPS, with points sampled every 400 meters (about 1500 feet) along the ground. The stated RMSE of the method is 0.5 feet, but it seems more likely that the RMSE is somewhat higher. The points were obtained from the USGS SOFIA database and were processed to an ArcGis grid with a cell size of 1500 feet. Later, the values were interpolated to a cell size of 500 feet. The dataset was adjusted to ensure compliance with shorelines along the Gulf of Mexico.

USGS Topo Quad Data (source 7 of 9)

Processed from 5-foot contours and spot elevations on published USGS 7.5-minute quadrangle maps, 2005, USGS Topo Quad.

Type_of_Source_Media: Quadrangle map contours and spot elevations
Source_Scale_Denominator: 100000
Source_Contribution:
In areas where newer or better topographic data was not available, it was necessary to use the data from the USGS quadrangle maps to create a backgound elevation surface. Unfortunately, much of the critical area was so low and flat that there were no contour lines on an entire map, so the only source was spot elevations that are rounded to the nearest foot. In general, the USGS quadrangles were processed in two sections: a northern part and a central/southern part.

In the northern part, elevations range as high as 200 feet and the contour lines give a fairly dense representation of the topographic surface. Digital versions of the contour lines were cleaned up and edited for consistency. To the extent practicable, contour lines that result from human activity, such as along road grades, were removed. An elevation surface was created from the contour lines, using the program topogrid, with a cell size of 100 feet. Shorelines were used as controls for the Gulf of Mexico and Lake Okeechobee.

In the southern/central part, wherever better topo datasets were not available, many of the areas were very flat. About 5000 spot elevations were obtained from existing digital data or by digitizing them using digital map images (DRG files) as backgrounds. Again, an elevation surface was created using topogrid, and shoreline rules were enforced. Because the program is especially sensitive to anomalous spot elevations, multiple iterations were required to produce an optimal surface. The resulting elevation surface is by no means perfect, but approaches the best that can be done with the "spotty" data available.

As a guess, one might say that the overall RMSE for this dataset is about 1.5 feet. Hopefully in the lower-lying areas, the accuracy will be better. It should be pointed out that the resulting dataset represents an elevation surface that is much more generalized than the LiDAR or photogrammetric surfaces. One surface may show much more detail and therefore, when compared with this generalized surface, there will be significant "errors" that result more from the smoothness of the data than from actual errors in sampling. Nevertheless, it is recognized that we need better topo data in these low-lying areas, in order to have more confidence in the results of our modeling.

Vertical Datum Conversion (source 8 of 9)

SFWMD, using USACE CorpsCon program, 2003, Vertical Datum Conversion, NAVD88 vs. NGVD29.

Type_of_Source_Media: computer program
Source_Scale_Denominator: 250000
Source_Contribution:
Altough the vertical datum for the output dataset is NAVD 1988, some of the input datasets were still referenced to the vertical datum NGVD 1929. A computer program named CorpsCon, developed by USACE using standard USGS algorithms, was used to create an ArcGis grid. The values of the gridded surface represent the difference, in feet, between the NAVD88 and NGVD29 elevations. Within the study area, the general range of the difference is between -1.50 and -1.10 feet. As an equation, NAVD88-value = NGVD29-value + Difference, where Difference is a negative number. Because the difference values do not change rapidly from one place to another, a cell size of 5000 feet was good enough to ensure that 2-digit accuracy was not sacrificed.

Other sources not used (source 9 of 9)

, Other sources not used.

Type_of_Source_Media: Other sources
Source_Scale_Denominator: 250000
Source_Contribution:
During the process of assembling the best-available topographic data for the study area, several datasets were evaluated that were not used in the final composite.

(1) Bathymetric data -- Offshore and some lake bathymetry were available, but were not required for this effort.

(2) South Lee County Contours -- These were created for SFWMD by Johnson Engineering, in approximately 1998, using a variety of input sources. Because this area was well covered by newer photogrammetry and LiDAR data, this source was not used.

(3) BCB/SGGE Contours -- A set of contours was created for earlier an version of the model for the Big Cypress Basin/Southern Golden Gate Estates area. The primary source was contour maps from the 1970s that were made at the time that SGGE was being laid out for development. Though it gives realistic modeling results in some areas, other areas are obviously incorrect. Because this area was covered by newer LiDAR data, this source was not used.

(4) Hendry/Prewitt -- Elevation contours for a large part of Hendry County were mapped by Prewitt in 1953. Because the source was so old and the contours did not match very well with the USGS contours, this source was not used.

(5) CSF Contours -- The USACE created a contour map in 1960 for the Central and Southern Florida Comprehensive Plan, covering much of the study area. This dataset has been used in the past for other models, such as the 2-by-2-mile Water Management Model (WMM). Again, it was felt that the USGS contours were newer and probably more realistic for the areas of concern.

(6) USGS NED -- The National Elevation Dataset is a USGS effort wherein the digital contours and DEMs were automatically processed to create a seamless dataset for the entire nation. The automated process works very well in mountainous areas, but is very poorly suited for low, flat, coastal areas such as our study area. Also, some steps of the NED processing use data stored in integer meters, which reduces the effective vertical resolution to 3 feet at best. This dataset should not be used for any purpose in southern Florida.

Data Processing:

This product has been through several iterations. The current version was finalized in September 2005, and is not expected to change significantly during the current 5-year cycle of projects and modeling. The following description applies to the current version of the dataset.

(1) The individual source datasets were obtained, processed, and converted to a common projection and vertical datum. All of the datasets were resampled to have exactly the same origin point and the same cell size (100 feet). For source datasets having a cell size smaller than 100 feet, this involved a calculation of the mean value of all source values within each output cell. It was ensured that all source datasets were correctly coded in shoreline areas. In general, Gulf waters were set to sea level (arbitrarily defined as zero in NGVD29 when converted from NAVD88), and low-lying land areas were set to have a minimum value of sea level plus 0.1 feet. Lake Okeechobee was arbitrarily set to a value that corresponds to 14.0 feet NGVD.

(2) The source datasets were combined so that the best-available data for any given area was output. The general rule for "best quality" was: LiDAR >

Photogrammetry > USGS Helicopter > USGS Contours. When two datasets were combined, the better-quality dataset was superimposed on the other. A special "blending" program was used to "feather" the datasets into each other along the border, so that there were no sharp discontinuities that resulted from the merger of the datasets. A quadratic method for blending across the border was used, which gives a more gradual transition than the standard Hermite cubic method. (For more details, see the program blendgrids.aml.) In areas of insufficient overlap or gaps between datasets, extra care was taken to assure a smooth and continuous transition. The output dataset was checked to ensure compliance with shoreline rules.

(3) One area required special attention -- the boundary between the West Collier and SWFFS LiDAR datasets. In general, the two datasets differed by about 1.5 vertical feet, and the area in question was extremely critical for the modeling effort. A special survey was conducted to establish five short E-W transects along the N-S border between the two datasets. Although some trends were noticed from north to south, as a general rule it was noted that the SWFFS LiDAR was about 1 foot high and the W.Collier LiDAR was about 0.5 feet low, when compared to the surveyed transects. It was decided to apply an adjustment within the critical area, such that the two datasets would join seamlessly and also match the surveyed transects. The adjustments were made with a cell size of 100 feet, rather than at the source cell size of 25 feet, and were limited to the Picayune/SGGE/NGGE area, rather than for the entire SWFFS LiDAR area, which extended northward beyond the Caloosahatchee. Thus, this was a tactical adjustment for purposes of allowing modeling to proceed. During subsequent modeling cycles, as better control data becomes available or as new topographic datasets are created, it is expected that this composite topo dataset will continue to be improved.

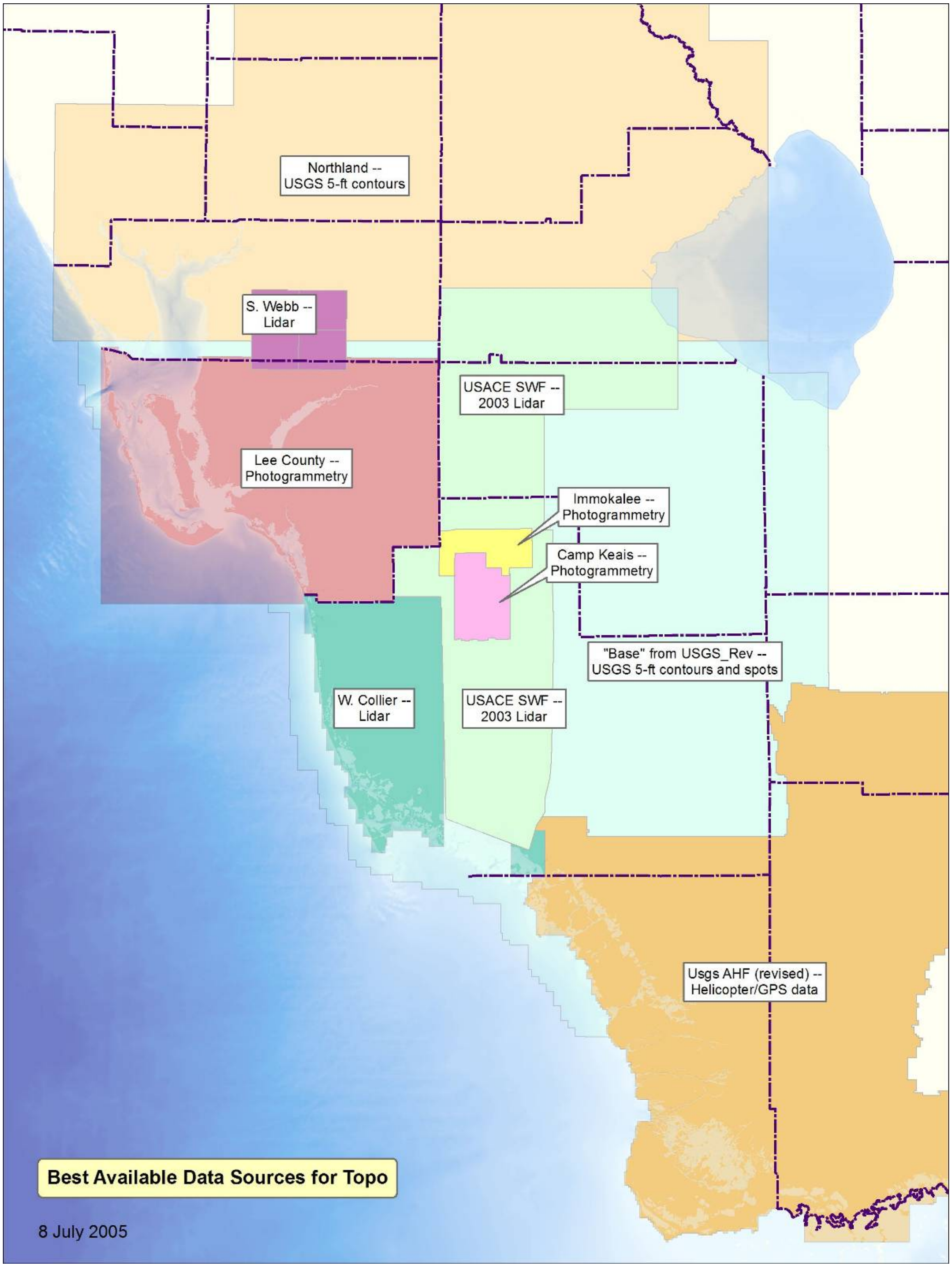

Figure B.4-1. Southwest Florida Feasibility Study Topography Sources