Rookery Bay Watershed Engineering Research Project

Task 3.7 – Addendum to the SAV Trend Summary Technical Memorandum (2/14)

Prepared for Rookery Bay National Estuarine Research Reserve
June 19, 2015

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Introduction

Rookery Bay National Estuarine Research Reserve (RBNERR) received a grant for a three-year project to help manage freshwater flows in the Rookery Bay Estuary (**Figure 1**). One of the initial components of this project was to try and quantify the dynamics of the estuarine habitat conditions. In early 2014 Scheda Ecological Associates (Scheda) was asked to examine historic aerial photos within the Conservation and Recreation Lands (CARL) property boundary, which includes Henderson Creek, to photo interpret for Submerged Aquatic Vegetation (SAV) signatures (**Figure 2**). Remote sensing is an effective tool to analyze large areas for specific habitat types and this same process has been used to perform historic conditions mapping by reviewing historic aerials and delineating the visible resources in question (Finkbeiner, 2001). In February 2014, Scheda examined the various historic aerials to assess the extent and locations of the SAV, oysters, and mangrove communities (**Appendix A**). This report amendment updates the trend analysis to include the recently completed Photo-Interpretation and Mapping of the Rookery Bay Estuary (5/2015) report and compares those to the mapped historic natural resource conditions within the CARL boundary.

Results

The original historic assessment used 1928 aerials, with some supplemental imagery from 1940, to produce a "Historical Conditions" map of SAV within the CARL boundaries of Rookery Bay. That analysis resulted in an estimate of 988 acres of potential SAV signatures within the CARL boundary (**Figure 3**). The report estimated the 1962 SAV coverage within the same footprint at 1,442 acres. The 2014 aerial assessment was specifically flown to detect aquatic resources within the RBNEER which consists of high resolution digital imagery and geo-rectified orthos which were then color balanced to produce the best imagery possible for underwater photo-interpretation purposes. In addition, all of the various observed signatures were field verified at 215 different locations; thus this comprehensive mapping effort was able to detect the difference between SAV, mono-specific seagrass beds, oyster populations and hard bottom communities.

The 2014 SAV and seagrass signatures (**Figure 4**) were combined, for comparison purposes to match the Historic Conditions map, and resulted in a combined total of 671 acres (Table 1).

Table 1

Mapping Timeframes	**SAV Acreages**
1928/1940 (Historic Conditions)	988 acres
1962	1,442 acres
2014	671 acres

Overall, fluctuations in seagrass levels can range from small changes over each mapping interval, to wholesale fluctuations. The former could be stable habitats like Lemon Bay, examples of the latter could be near passes/inlets and other higher energy/dynamic areas in Florida. The acreage changes documented within the CARL boundary, over the time period noted, are not unusual as most of Florida's open water estuaries have shown significant declines in seagrass populations from the 1950s thorough the 2010 (Kurz, 2006 & Tomasko, 2005). Most of these declines can be attributed to anthropogenic impacts such as dredge and fill activities, reduced water quality, and altered drainage. In this region sheet flow and riverine discharges have been severely altered over time (channelization, timing and volume variations); these large salinity variations make it difficult for seagrass or for most estuarine dependent sessile populations to survive.

The 2014 resource map (**Figure 5**) has the SAV, seagrass, oysters and hard bottom communities delineated within the CARL boundary. In particular the area directly downstream and within Henderson Creek had SAV mapped in the Historic Conditions map, but in the 2014 (**Figure 6**) there were no seagrass or SAV mapped in this region. Currently, the primary resources detected within the Henderson Creek area are the noted oyster beds.

Discussion

The noted overall declines in SAV from the Historic Conditions 1928/1940 aerial images to 2014 can be attributed to a variety of factors depending upon which area within the CARL boundary these changes were noted. For example, within the Henderson Creek area (**Figure 6**) the SAV that was present within Henderson Creek, north of Shell Island, in the Historic Conditions map is not present in the 2014 map. These apparent losses may be due to the increased water flows and the alteration of the timing of these freshwater discharge events. The primary seagrass species noted during the 2014 signature identification process was shoal grass (*Halodule wrightii*) and although this species has a relatively high salinity range (5-80 ppt), it will dieback if the waters become completely fresh in nature (McMahan & McMillan; 1968 & 1974, respectively). Thus, when the Henderson Creek flows were increased in the rainy season (summer months), the resultant salinities may fall to 0 ppt thus stressing and ultimately eliminating these species from the area. However in Hall Bay, 2014 SAV and seagrass beds were not as prevalent as in the Historic Conditions map but they were some still there as this area is more influenced by the gulf waters than by the upstream freshwater flows, therefore, is less likely to be detrimentally impacted by changes over time to the freshwater flow patterns.

In the future, as the South Florida Water Management District (SFWMD) improves and reduces the artificial discharge volumes and improves the timing of water deliveries to Henderson Creek and other altered systems, future resource mapping efforts or even in situ monitoring work may note the recovery of seagrass within immediate receiving waters. This current mapping effort provides a baseline condition from which changes to the distribution and abundance of these natural resources can be used as a ‘barometer” to measure changes within the estuary related to anthropogenic alterations. Hopefully, beneficial improvements to the flow rates and timing will have a noticeable increase in the desirable ecological resources for the future.

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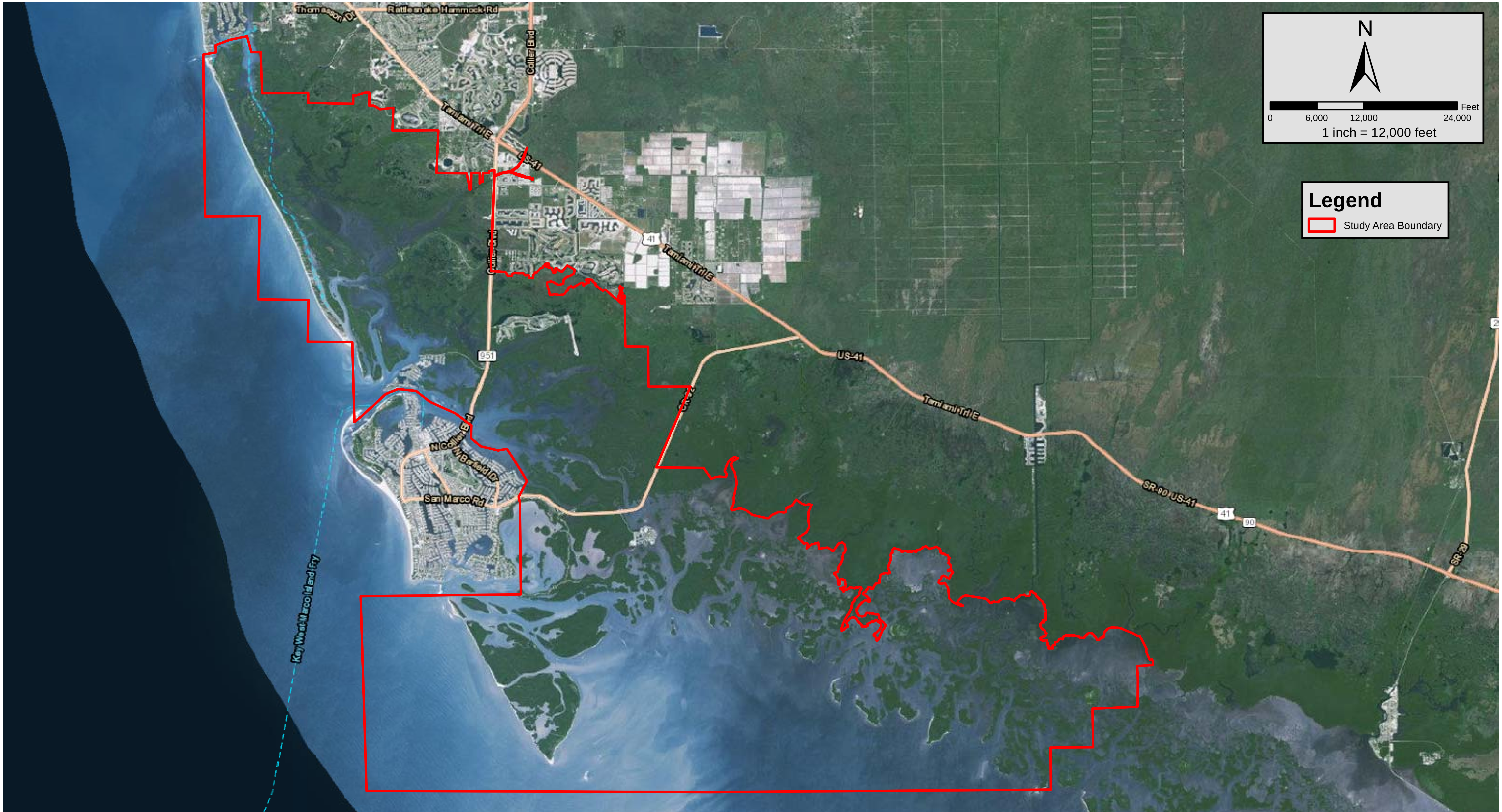

Funding for this project was provided to the Rookery Bay National Estuarine Research Reserve in 2011-2015 by the National Estuarine Research Reserve System's (NERRS) Science Collaborative which is a cooperative agreement between the National Oceanic and Atmospheric Administration (NOAA) and the University of New Hampshire under NOAA grant NA09NOS4190153. The NERRS Science Collaborative puts Reserve-based science to work for coastal communities by engaging the people who need the science in the research process—from problem definition and project design through implementation of the research and use of its results in coastal decisions. For more information about this project please visit www.rookerybay.org/restoreRB or contact Principal Investigator Tabitha Whalen Stadler at the Rookery Bay National Estuarine Research Reserve in Naples, Florida at 239-530-5940.

RESTORING THE ROOKERY BAY ESTUARY

A PROJECT CONNECTING PEOPLE AND SCIENCE FOR LONG-TERM COMMUNITY BENEFIT

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Rookery Bay
National Estuarine Research Reserve

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NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM SCIENCE COLLABORATIVE

Figure 1
Study Area Boundary

Rookery Bay
Collier County, Florida

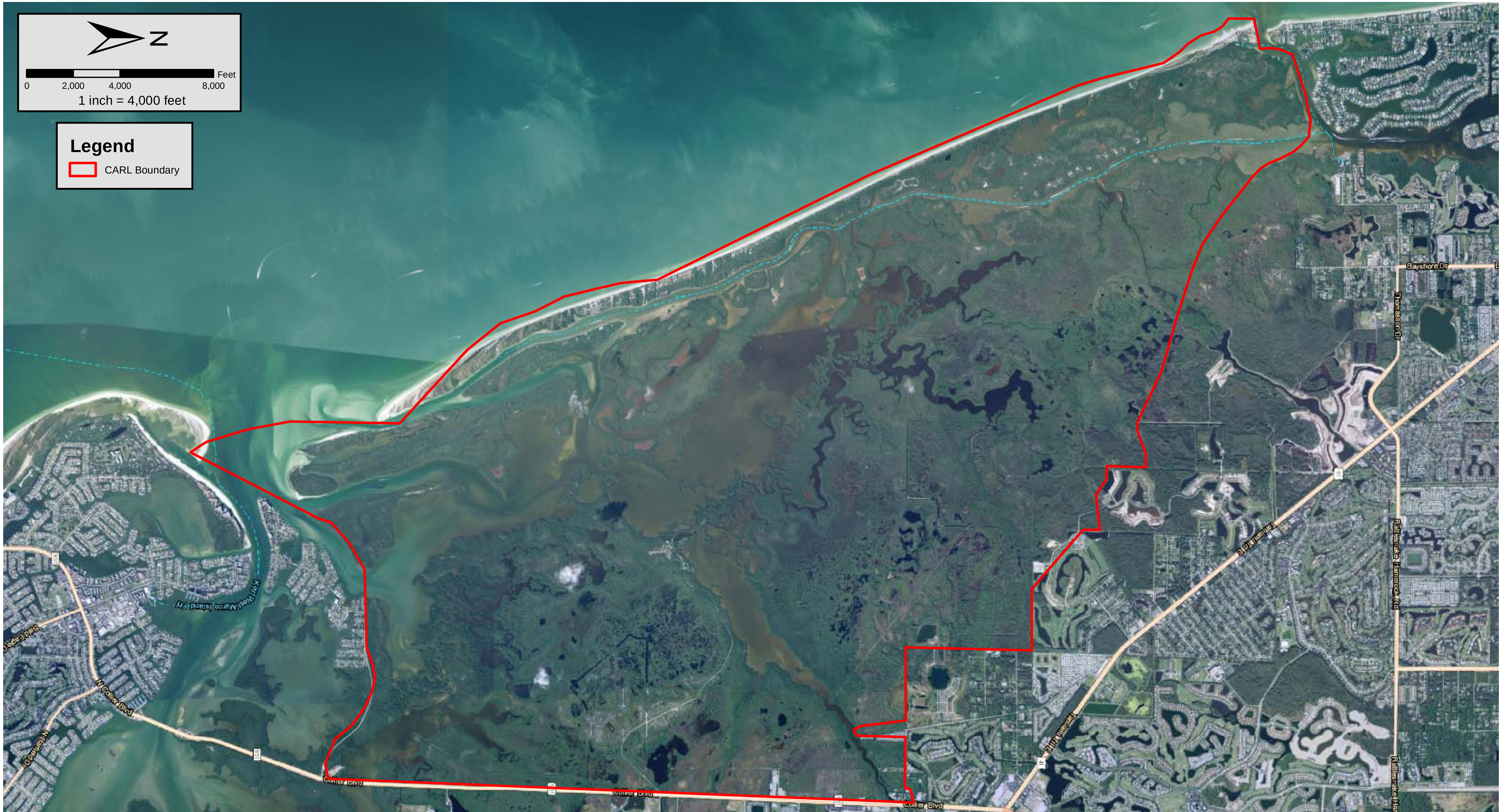

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Figure 2
CARL Boundary Map

Rookery Bay
Collier County, Florida

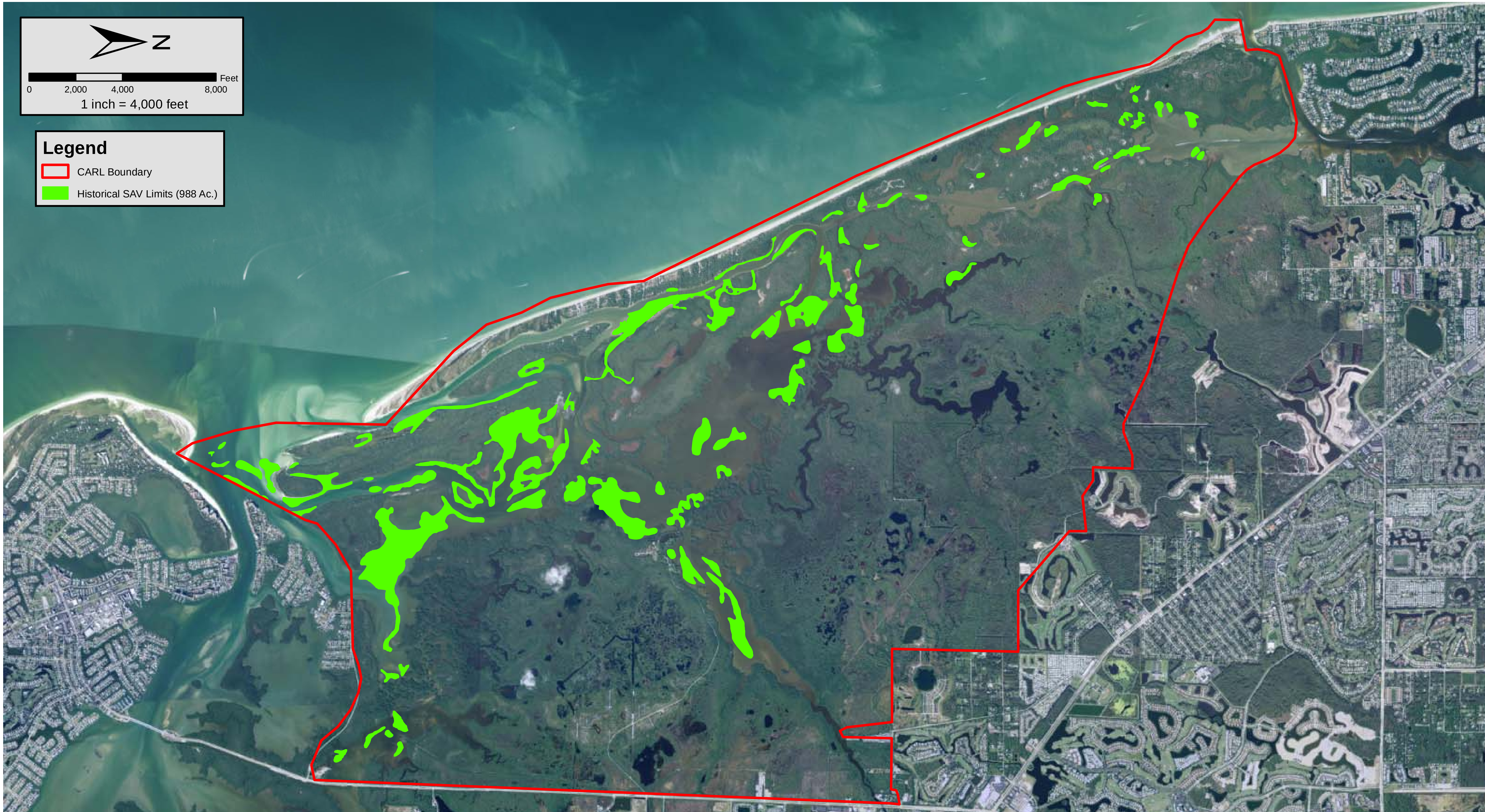

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Figure 3
Historic Conditions 1928/40 SAV Limits Map

Rookery Bay
Collier County, Florida

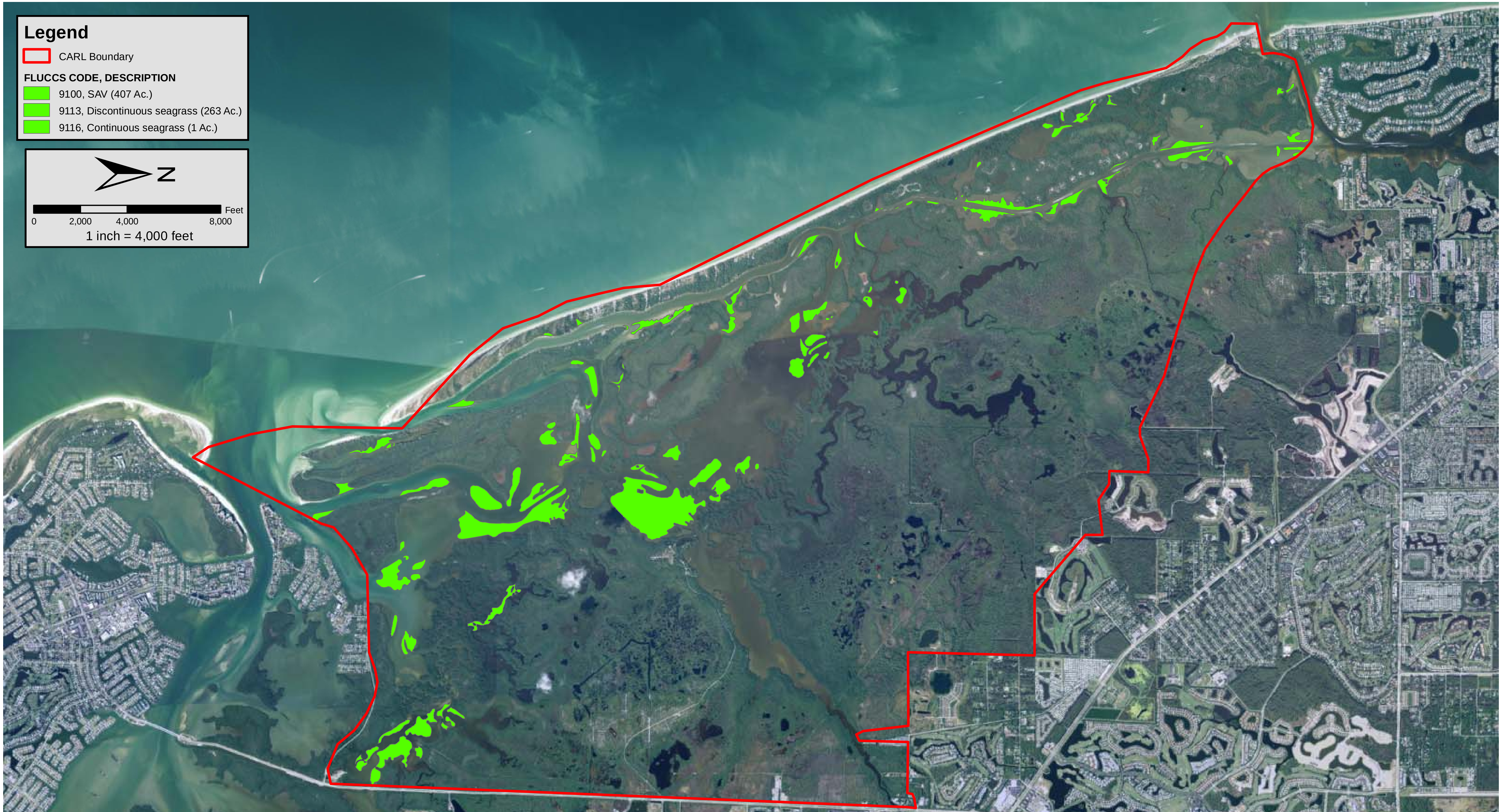

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Figure 4
2014 Conditions SAV Limits Map
Rookery Bay
Collier County, Florida

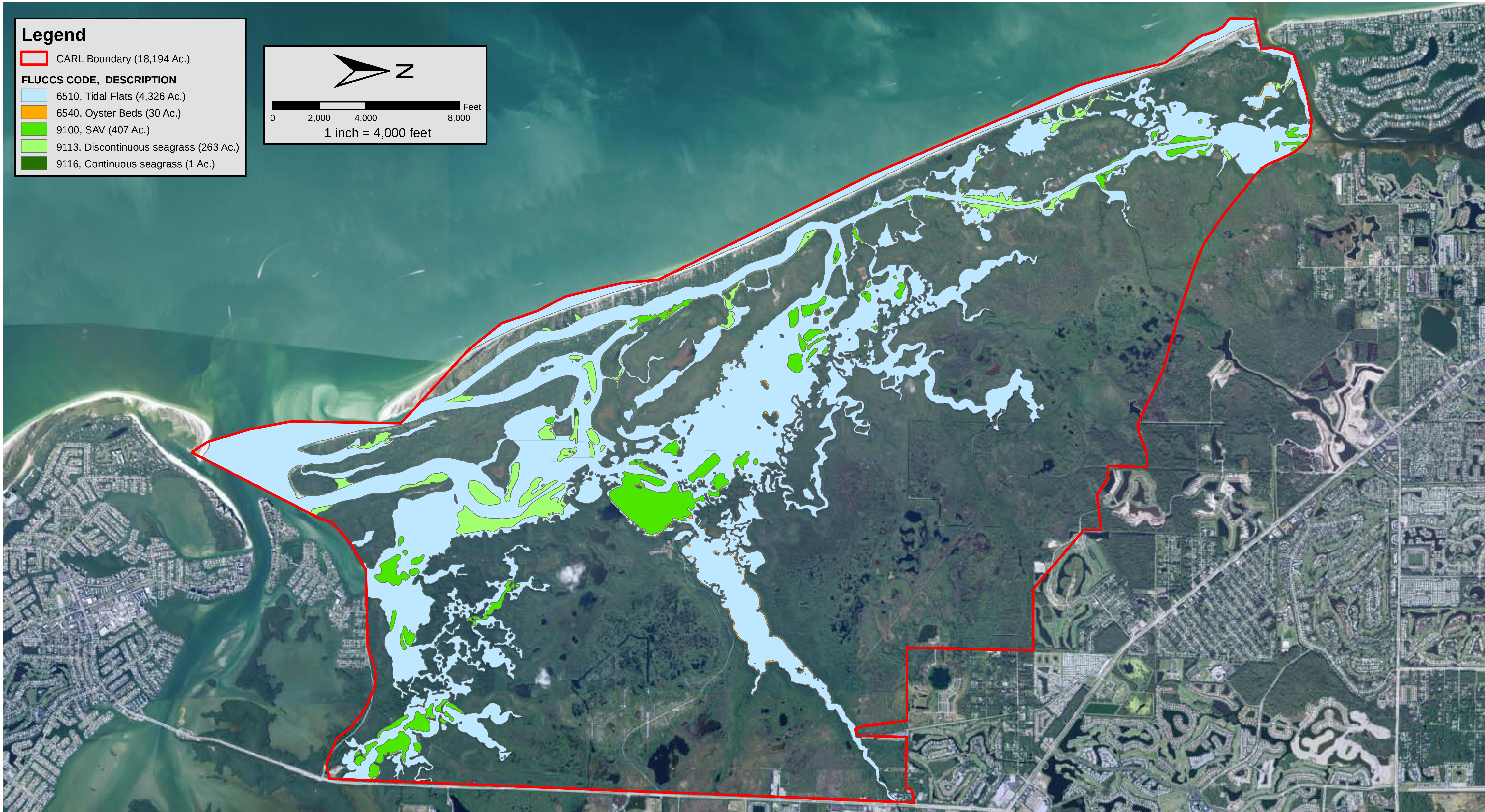

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Figure 5
2014 Conditions Resource Map
Rookery Bay
Collier County, Florida

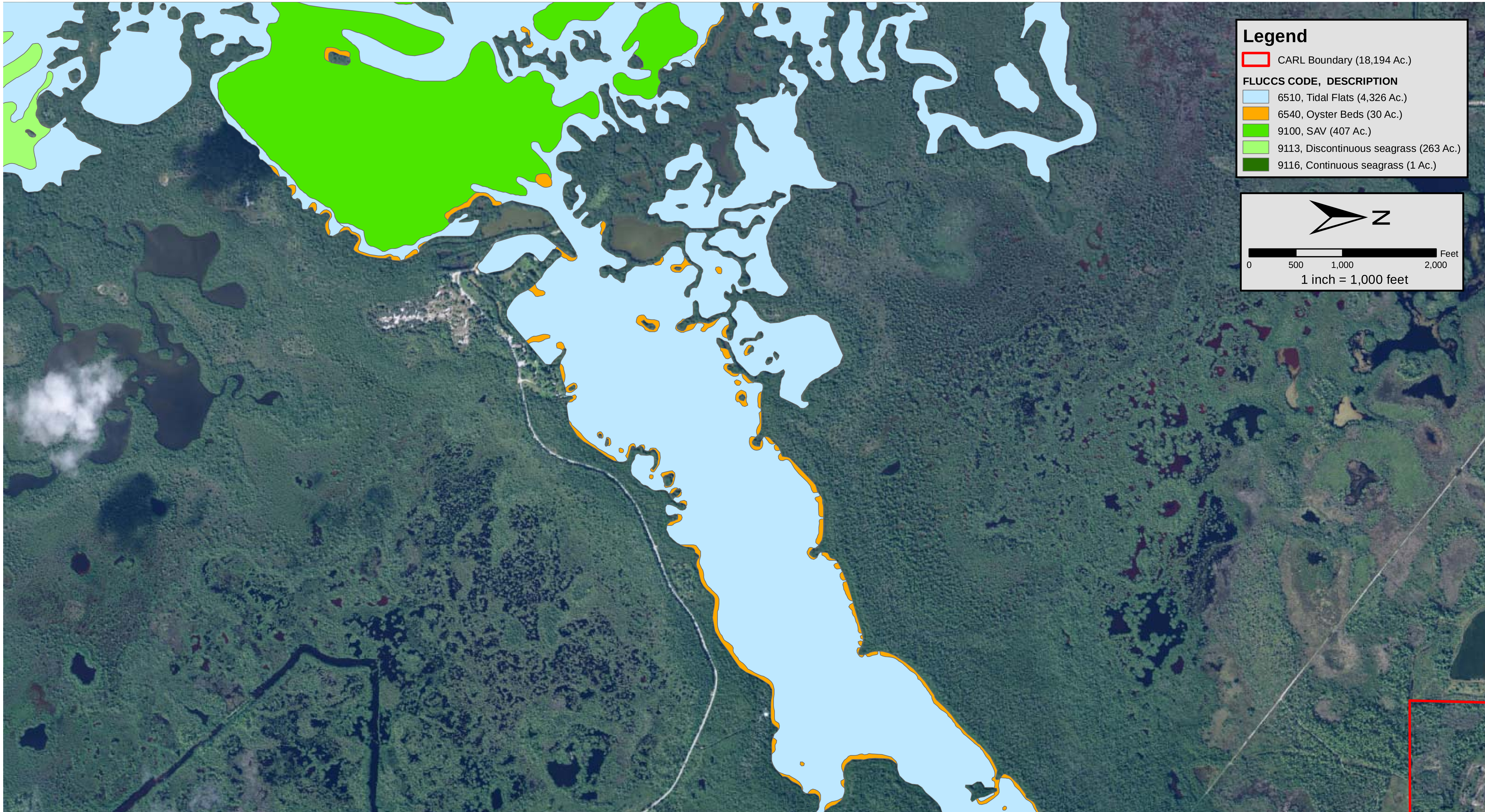

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Figure 6
Henderson Creek Resource Map
Rookery Bay
Collier County, Florida

Appendix A

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Rookery Bay National Estuarine Research Reserve

Task 3.3 Historic Aerial Mapping and Analysis for The Rookery Bay Estuary

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1.0 INTRODUCTION

In an effort to understand anthropogenic changes to the Rookery Bay estuary, Scheda Ecological Associates, Inc. (Scheda) scientists performed an analysis of available historic imagery to assess the potential of documenting changes in estuarine habitats over time. Photo interpretation of a series of aerials (remote sensing) can be an effective means to assess changes in habitat types. This process includes visual review of habitats – submerged aquatic vegetation (SAV), oyster beds, mangrove edge – based on visual “signatures” in the photographs. This practice of analyzing historic images has been performed in other Florida estuaries in the past to establish baseline conditions for targeted habitats, For example, Charlotte Harbor 1950s historic conditions mapping effort, Tampa Bay’s 1950 seagrass mapping endeavor, and the recently completed 1970s historic mapping work for upper Tampa Bay. All remote sensing work should be accompanied with field verification of the visible signatures to ensure that signatures do represent the natural habitats being mapped – and this is not possible with historic aerials. To overcome this lack of field verification, the photo-interpreter must rely on extensive experience mapping similar habitats and a basic estuarine ecological knowledge to map the habitat (or target community).

For this effort, the lead photo-interpreter was Scheda’s principal scientist, Thomas Reis. Mr. Ries has been mapping natural resources since 1987 when he was trained to map wetlands for the US Fish and Wildlife Service (National Wetland Inventory program), since then he has been involved with remote sensing efforts around the State of Florida, which included leading the seagrass mapping effort for the Southwest Florida Water Management District (SWFWMD) and numerous natural resources remote sensing efforts around the State. Finally, he has performed trend analyses of natural resources (SAV and mangrove limits) that involved historic imagery assessments which are relevant to this mapping effort. This experience coupled with a thorough examination of the available imagery was employed to assess whether SAV communities could be accurately mapped for this study area. This report outlines the available data that was used for assessment purposes within the Rookery Bay study area; the methods applied, the limits of historic data, and it presents a limited trend analysis for SAV and mangrove edge data.

2.0 DATA AVAILABLE

The development of trends for the Rookery Bay system is intended to show changes in the ecosystem over time. Of interest to the scientific community are the changes in SAV, oyster beds, and the mangrove edge since these communities are potential indicators of estuarine health. Therefore, Scheda’s scientists examined the historic and current data available for these analyses to determine whether trend maps of these systems could be produced.

2.1 SUBMERGED AQUATIC VEGETATION

Rookery Bay National Estuary Research Reserve (RBNERR) provided imagery from 1928, 1940, 1962, 1963, and 1969. These data sets are composed of un-rectified, black and white, scanned imagery. In addition, RBNERR also provided the 1928 raw images, which exhibited greater image resolution compared to the scanned versions. All the images combined consisted of approximately 50 panels covering the area of interest. Scheda' staff conducted a thorough review of this data and the raw images available at the United States Department of Agriculture (USDA) Archives to assess the quality of the photos. In addition, there are recent aerials available from Collier County Property Appraiser website (2013); however, an assessment of this available imagery revealed that it was not flown under the proper conditions (i.e. low tide, appropriate water quality, and at the proper altitude) to view the natural resources; SAV or oysters. The following list details the historic imagery that was assessed for this analysis:

Photography Date	Number of Tiles Reviewed Within the Study Area	Qualitative Assessment
1928 (No date stamp)	Ten tiles	Good Quality
1940 (February - August)	Eleven tiles	Fair Quality
1962 (December)	Twenty-two tiles	Good Quality
1963	Zero-tiles within study area	N/A
1969 (January)	Seven tiles	Poor Quality

The 1928 photographs covered the entire study area and the photos consisted of good quality imagery; however, there were some limited areas that exhibited sun reflectance which obscures the ability to see into the water column. The areas that were visible were closely assessed and the SAV communities were then delineated.

The 1940 photographs covered the entire study area and the photos consisted of fair quality imagery but also exhibited many areas of sun reflectance, which inhibits the ability to accurately delineate the natural features. This precluded the use of these photographs for assessment in several areas; however, the imagery was useful to augment the assessment of the SAV communities within the areas that were not visible in the 1928 imagery.

The 1962 photographs did cover the entire study area and consisted of good quality imagery and thus were selected for photo-interpretation assessments. The 1963 photographs were also reviewed, however did not cover the study area. The 1969 photographs did cover the entire study area; however, consisted of poor quality imagery for assessing SAV communities; thus was not utilized as part of this analysis.

2.2 OYSTER BEDS

Our literature research as part of Task 3.1, coupled with the information gleaned from interviewing local scientific experts in southwest Florida, confirmed that oysters are another potential indicator of estuarine health as they are sessile in nature and are sensitive to changes to water quality, including salinity regimes. Unfortunately, mapping oyster communities is very difficult primarily because oyster populations can produce a variety of visible “signatures’ depending upon a number of natural factors, e.g. oyster communities can “look” different depending upon whether they are submerged, recently exposed, or dry; which means to map these communities there needs to be extensive field work performed to catalog the many signatures that oysters can display. Therefore, trying to map historic oyster communities, without the accompanying field signature verification, is virtually impossible. Therefore, we did not attempt to map the historic oyster populations as part of this project; however, if new (current) high-quality imagery is secured, along with field verification of the various oyster signatures, then an accurate oyster map can be produced.

2.3 MANGROVE EDGE

Since mangrove communities are an important facet within estuarine ecotones in Florida, these natural resources were also identified as an important resource that should be tracked over time. The three primary mangroves species: white (*Laguncularia racemosa*), black (*Avicennia germinans*), and red (*Rhizophora mangle*) can all tolerate a variety of salinity regimes. They can grow in saltwater, estuarine conditions, as well as in freshwater conditions. Because of this wide range of salt tolerance, they are not a good candidate species to utilize as an indicator of estuarine stress or to track wholesale changes in salinity. However, they are a good general indicator of estuarine health and therefore we have looked at the location of the mangrove edge over time so that resource managers can understand the large-scale changes within their study area. Florida, typically the water management districts, routinely maps the state’s land cover through a hierarchy system called the Florida Land Use, Cover & Forms Classification System (FLUCFCS) which was developed by the Florida Department of Transportation. There are 45 classifications within FLUCFCS, of which 22 are natural features, either terrestrial of wetland types. One of the 22 natural cover features is mangrove communities, these existing map layers are available digitally and can be used to track changes over time within community types. For this analysis, we selected three time periods, which had FLUCFCS mapping available (1988, 1999, and 2009) within the study area.

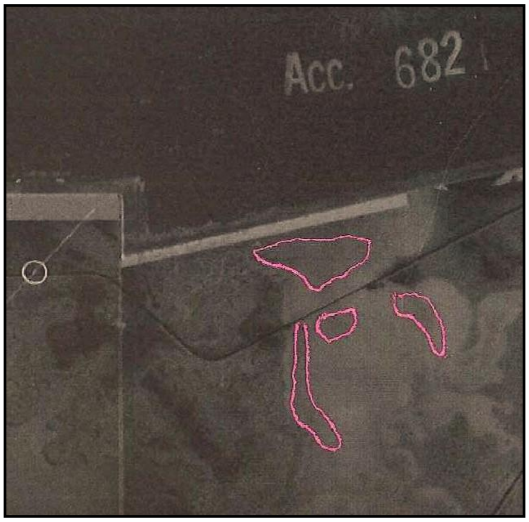
3.0 STUDY APPROACH

3.1 SUBMERGED AQUATIC VEGETATION

The available data are useful for a limited comparison of historic trends. In this case, the only data available to assess "historic" conditions are the 1928 and 1940 photographs. Both of these data sets are generally showing conditions before the population influx of the 1950's and are, therefore, considered "historic." Comparison of these data to the 1960's data would show the trend of changes from historic to some increased level of development. The best case scenario is to also have current conditions data for comparison, but as mentioned previously, this data does not currently exist.

Therefore, Scheda used the following approach to develop a trend analysis. We developed a composite "historic" data set from 1928 and 1940 data (to fill in the gaps left by the 1940s photograph's reflective areas, as discussed below) and compared that condition to 1960s data.

An assessment of the imagery sets revealed that the 1940 coverage was not complete and it exhibited areas of sun reflectance, which inhibits the ability to accurately delineate the natural features. However, it is possible to "fill in the gaps" of the 1928 data sets with SAV signatures from the 1940 coverage and create a composite map that would be useful as an historic data set. Only 3% of the mapped SAV communities were gleaned from the 1940s imagery. During the mapping effort, only areas with clear SAV signatures were delineated; all other signatures (faint signatures, obscured areas, or SAV polygons that were less that 0.5-acre) were not mapped; thus the resultant map is conservative in nature and likely underestimates the actual SAV resources. This is standard protocol for historic mapping efforts since it is not possible to field confirm the mapped polygons. An example subarea of the 1928 imagery with the associated SAV delineated line work is noted below.



To provide an additional quality control aspect of the photo-interpretation process, Scheda solicited an independent review of the SAV mapping process; Ms. Kris Kaufman (SWFWMD's current seagrass mapping manager) reviewed the photo-interpretation process and concurred with the resultant mapping effort. This independent review provided further assurances that this process was consistent with recently completed historic resource mapping efforts.

Figure 1 illustrates the photo-interpretation of SAV communities of both time periods; formulated by using both data sets. Because of the time period between the data sets (1928 to 1940), Scheda conducted a literature review to determine if there were any events that might have affected the ecology of Rookery Bay in between photographs. The literature revealed that there were two significant recorded events that occurred between the time periods. The first event was the initial construction of a portion of the Intra Coastal Waterway (ICW) through the area. The second event was a tropical storm which came through on August 20, 1932. While these events may have had impacts on the location of the natural resources, they do not appear to be significant based on the data available. Therefore, we decided to combine the mapped areas to create a composite SAV layer which represents the Historic Conditions of SAV for the study area (Figure 2).

Unfortunately, there is no other useful historic imagery available to map the submerged aquatic natural resources for this region, other than the 1962 aerial photography. Therefore, the 1962 photography was utilized to delineate the SAV communities within the study area for comparison purposes (Figure 3).

The results of this trend analysis (Figure 4) will help the RBNERR understand changes in the estuary and could identify potential biological targets for further beneficial changes to the watershed. These trends would also help the public understand the anthropogenic impacts to the system.

3.2 MANGROVE EDGE

The South Florida Water Management District (SFWMD) has generated geo-referenced data layers to map their land forms for many years. Their data set serves as documentation of land cover and land use within the SFWMD as it existed in mapped time frames. Land Cover Land Use data was updated by photo-interpretation of aerial photography and classified using the SFWMD modified FLUCFCS classification system. Features were interpreted from the county-based aerial photography (4 in - 2 ft pixel) and updated on screen from the vector data. Horizontal accuracy of the data corresponds to the positional accuracy of the Collier County aerial photography. The minimum mapping unit for classification was 2 acres for wetlands and 5 acres for uplands. The positional accuracy of their data meets USGS NMAS for 1:12000 scale maps.

For this analysis, we selected three time periods, which had FLUCFCS mapping available (1988, 1999, and 2009) within the study area. Utilizing the SFWMD's geo-referenced data layers we were able to perform a trend analysis of the mangrove extents over the various time periods.

4.0 MAPPING METHODOLOGY

Steps performed to conduct this photo-interpretation exercise include:

- Obtained digital raster imagery (Collier County);
- Obtained raw 1928 aerials (RBNERR);
- Geo-referenced all of the historic (1928-1962) imagery into ArcMap GIS ;
- Tiled the images to overlay the project area;
- Plotted hard copies for photo-interpretation (PI) purposes;
- Digitized photo-interpreted the line work into AutoCADD Land Desktop Companion 2010;
- Digitized polygons were imported into ARCGIS to generate the maps and calculate the representative acreages; and
- QA/QC of the mapped SAV line work.

For this study, the project team used ArcGIS for Desktop Basic 10.2 and ArcGIS for Desktop Advanced 10.2 to digitize the vegetation signatures on screen. This software allows the user to increase/decrease the resolution as appropriate to better define areas for delineation, and to accurately delineate individual signatures. Most delineation was performed at a 1:1,200 scale, which provided clear identification of vegetation boundaries while maintaining an accuracy of +/- 10 feet. Photo-interpretation and compilation of seamless vegetation coverage, using raw photography of each time period, was produced. All vegetation units greater than 0.5-acre were delineated, identified and labeled. An accuracy assessment for both spatial and classification accuracies was conducted. The principal photo-interpreter reviewed all mapping efforts for quality control and consistency of delineation; any edits were made accordingly.

5.0 RESULTS AND DISCUSSION

5.1 SUBMERGED AQUATIC VEGETATION

The SAV communities that were delineated to represent Historic Conditions (primarily 1928 with some limited 1940 imagery) yielded 988 acres. The 1962 aerials yielded 1,442 acres of visible SAV communities. This apparent change in SAV coverage is not unusual; other Florida coastal estuarine communities have exhibited similar fluctuations in SAV coverage primarily due to changes in water quality or improved flushing. This mapping effort represents a professional assessment of the obvious SAV signatures within the study area from the available imagery and was performed by a remote sensing professional with decades of experience performing natural resources mapping assessments. The resultant acreages are conservative in nature and should only be used as a general reference of likely SAV coverage for the area. This provides a basis of comparison for other imagery and also to modern imagery, if available.

Currently, there are limited SAV communities within the study area, especially in the vicinity of Henderson Creek, accordingly to reports from the RBNERR staff (Figure 4). These losses are very likely attributed to anthropogenic activities (dredge and fill activities, construction of navigation channels, and reduced water clarity due to water quality degradation). It is our recommendation that the existing conditions are documented by procuring current aerials which are specifically flown to detect SAV habitat. Immediately upon securing this imagery, field investigations should be performed to obtain signature verification of the targeted habitat types; this information is imperative for the photo-interpreter to map the target habitats (existing SAV, oysters and mangrove extent). This information can then be compared to the historic SAV coverage to illustrate the changes to the estuarine communities and also to assess whether future water delivery improvement projects result in the return of some portion of the historic SAV coverage within the region.

5.2 MANGROVE EDGE

The mangrove extent that was mapped in 1988 totaled 9,149 acres (Figure 5). However, this mapping effort appears to have generalized the mangrove limits, i.e. it was not mapped as accurately as subsequent mapping efforts. This conclusion is further confirmed if you look at the 1999 FLUCFCS map of mangroves, which resulted in a very detailed map (Figure 6). The 1999 mapping effort identified a total of 5,894 acres of mangroves within the study area. Finally, the 2009 FLUCFCS mapping data identified 6,726 acres of mangrove communities (Figure 7) within the same study area.

A trend analysis was performed over the noted the time periods (1988, 1999, and 2009), which illustrates the locations of detected change in mangrove coverage from 1988 to 2007 (Figure 8). This apparent 2,423-acre “loss” of mangrove community is likely an artifact of the less detailed mangrove mapping effort of 1988. Therefore, we also compared the detailed mangrove mapping efforts (1999 and 2009) and illustrated that change in mangrove community structure (Figure 9). This trend analysis, gain of 832 acres of mangroves, appears to more accurately depict changes to this community type; as this result is more consistent with documented changes in mangrove communities in southern Florida. Overall, mangrove communities in southern Florida are affected negatively by climatic events, e.g. hard freezes; since there are fewer hard freezes over the past couple of decades, especially this far south in the state, it is anticipated that the mangrove communities would encroach into the adjacent marsh habitats. The

expansion of the mangrove limits also is consistent with sea level rise, which can allow the mangrove seedlings to "float" into the high marsh communities and then propagate, thus expanding the range of the mangrove forest over time.

6.0 SUMMARY

The fact that there is no current aerial photography that has been flown at the appropriate elevations and under the required conditions for examining existing benthic communities i.e. SAV and oysters that could be field verified, represents a tremendous data gap in south Florida. Thus, the RBNERR's commitment to initiate aerial reconnaissance of the Rookery Bay Estuary will provide invaluable scientific data that will significantly enhance the ability of water resource managers to make decisions that are more ecologically sound.