RESTORING THE ROOKERY BAY ESTUARY
A PROJECT CONNECTING PEOPLE AND SCIENCE FOR LONG-TERM COMMUNITY BENEFIT
Rookery Bay National Estuarine Research Reserve

Rookery Bay Watershed Engineering Research Project

Task 3.6.3 – Final Report and Map

Photo-Interpretation and Mapping for the Rookery Bay Reserve

Prepared for Rookery Bay National Estuarine Research Reserve
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Table of Contents

List of Tables

List of Figures

List of Appendices

Executive Summary

Rookery Bay National Estuarine Research Reserve (RBNERR) received a grant for a three-year project to help local communities manage freshwater flows in the Rookery Bay Estuary. The intent of this project was to create benthic habitat maps of the aquatic areas of the RBNERR through the following steps: 1) acquire high definition, geo-referenced aerial photography, 2) utilize the expertise of senior level photo interpreters to map the visible natural resources via remote sensing techniques, 3) conduct a sufficient number of number of field verification site inspections to verify each of the applicable ecological signatures, and 4) create a geodatabase, associated example maps, and a final report.

The visible ecological features were identified, field signature confirmed, and mapped; resulting in the identification of the following natural resources: Submerged-Aquatic Vegetation (SAV), oysters, seagrass (continuous and discontinuous beds), tunicates, and hard bottom. The corresponding acreages for each of these categories are noted below:

- **SAV** **3,347 acres;**
- **Oysters** **149 acres;**
- Seagrass Discontinuous 1,372 acres;
- Seagrass Continuous 127 acres;
- **Seagrass (Total)** **1,499 acres;**
- **Hard bottom** **213 acres, and;**
- **Tunicates** **4 acres.**

Example hard copy maps were produced for the entire study area. Also, an interactive map was created which had hyperlinks to each associated field data sheet as well as hyperlinks to the underwater videos for the sites which were video documented. Eighty-six (86) different videos clips were recorded which covered all of the different bottom community types encountered and were primarily acquired for future research purposes A corresponding technical memorandum summarizing the data was drafted.

Recommendations for future investigations include the remapping of these resources on regular intervals of approximately 4-5 years at minimum, and that the historic limits of SAV be mapped for the entire area, as was performed for the CARL boundary. Finally, that permanent transects be installed within the study area to further monitor the species and relative health of the representative habitats. This will provide a more complete picture of estuarine health and improve the ability of RBNERR to monitor potential habitat changes or responses to restoration efforts.

This baseline data will now be available to RBNERR and other watershed managers to help identify natural resource trends and could be used as a predictive tool to support the recently created hydrodynamic model.

Project Objectives

The National Estuarine Research Reserve System (NERRS) Science Collaborative puts Reserve-based science to work for coastal communities coping with the impacts of land use change, stormwater, non-point source pollution, and habitat degradation in the context of a changing climate. Estuarine health is dependent upon the quality, quantity and timing of freshwater inputs. The Rookery Bay watershed is one of four distinct watersheds that drain overland freshwater into the RBNERR. This watershed has been historically impacted by widespread dredge and fill operations used to drain large tracts of land for development and an increasing demand for freshwater to sustain the densely populated coastal communities. As a result, the timing and volume of freshwater entering the estuary has been altered. The health of the estuary and its wildlife depend on seasonally appropriate flows of freshwater.

The RBNERR received a NOAA grant to increase knowledge of the water flow parameters necessary to maintain estuarine health in the Rookery Bay Estuary, provide an understanding of the knowledge, attitudes, and beliefs of water users, formulate future educational efforts, and develop a community-based decision making tool for water use and allocation.

In an effort to understand anthropogenic changes to the Rookery Bay estuary (Figure 1), Scheda Ecological Associates, Inc. (Scheda) scientists performed a literature review and an analysis of available historic aerial imagery to assess the potential of documenting changes in estuarine habitats over time. Photo interpretation of a series of aerials can be an effective means to assess changes in habitat types. This process includes visual review of habitats; SAV, oyster beds, and hard bottom communities, based on visual "signatures" in the photographs. During this process, it was noted that there had never been aerial photography specifically flown to identify submerged aquatic resources within the Rookery Bay Estuary. Collaboration with South Florida Water Management District (SFWMD) and Southwest Florida Water Management District (SWFWMD) confirmed this lack of data. In addition, both SFWMD and SWFWMD conduct aerial surveys of other areas in Florida with the specific goal of monitoring seagrass beds as indicator species of estuarine health. The project team decided to acquire high definition, geo-referenced aerial photography that would provide baseline data and could then be utilized to detect changes within the natural community. By comparing the results of the baseline mapping data to future mapping efforts, a trend analysis of the benthic habitats could be produced. This trend analysis map could then be used to gauge changes in response to future fresh water inflow alterations over time. The objectives of the current photo interpretation and mapping effort included:

- Initial review of aerial photographs for quality assurance/quality control;
- Ascertain pertinent signatures that required field verification;
- Development of biologic signature protocols to select field verification points;
- Conduct field verification of the ecological signatures;
- Compilation of the data to provide interactive GIS maps identifying various natural resources and the corresponding acreages; and
- Prepare a report that summarized the information gleaned from the photo interpretation combined with the field verification.

The intent of this report and corresponding maps is to provide a concise summary of the existing benthic conditions. This information could be used for future trend analyses within the Rookery Bay Estuary. In addition, this tool can be utilized by RBNERR and other watershed managers to document changes in the estuary that could provide valuable insight into the biological response of the estuary to future water management decisions and resultant flow dynamics.

Mapping Methodology

Image Acquisition

Seagrass aerial mapping is a multi-step process consisting of imagery acquisition, imagery processing, performance of the associated ground-truthing for signature verification, and photo-interpretation of the benthic features. The imagery acquisition adheres to strict data-capture criteria that must be satisfied in order to collect aerial photography including: atmospheric conditions, sun angle, water depth, and water transparency conditions (Finkbeiner, M., 2001). Table 1 (below) lists the image capture criteria.

Table 1: Imagery Acquisition Criteria

Environmental Consideration	Specification Required for Data Capture
Atmospheric Conditions: Cloud Cover	<2%
Atmospheric Conditions: Wind	< 10 m.p.h.
Sea Surface: Wave Height	< 61 cm (2 ft)
Sun Angle	30^o - 45^o
Tidal Stage	Low tide level
Water Transparency	2 m

Digital imagery acquisition was conducted using a Microsoft Ultra-Cam Eagle with a 100mm lens airborne imaging sensor. The area was flown at an altitude of 17,500 feet under the specific climatological and tidal conditions noted in Table 1.

Aerial data must be accurate and the RBNERR data adhered to the following standards:

- Positional Accuracy: Orthophotogrammetric Mapping meets or exceeds the USGS National Map Accuracy Standards at a scale of 1:12,000.
- Horizontal Datum: Horizontal Datum must be referenced to the Florida State Plane Coordinate System, East Zone (0901), Units US Survey Feet, North American Datum of 1983 (2007) including the most recent NSRS adjustment.
- Vertical Datum: Vertical Datum must be referenced to the North American Vertical Datum of 1988 (NAVD 88), Units US Survey Feet, using the most recent geoid model to compute orthometric heights based on GPS derived ellipsoid heights.
- Photogrammetric Mapping Survey Control: The photogrammetric ground control must be adequate to support the accuracy specifications identified for this project.

Aerial Cartographics of America Inc. (ACA) was contracted to acquire the aerial photography. They also submitted a survey report that documented and certified the procedures and accuracies of the horizontal and vertical control, aircraft positioning systems and aerial triangulation utilized in the photogrammetric mapping project.

Since all of these conditions must be met simultaneously, it makes it difficult to select over-flight dates. In general, the flight window which is used by the SWFWMD, SFWMD and the St. John's River Water Management District (SJRWMD) seagrass mapping efforts is performed in December through February to capitalize on the best possible water clarity potentials. The winter months in Florida are typically drier and cooler which results in superior water clarity (less phytoplankton); however, this is also coincides with lower seagrass biomass (Ries, T. F., 1993 & Tomasko, D., et al, 2005). Although seagrass biomass reaches its maximum during the summer growing months, the water clarity is not typically sufficient to view the bottom characteristics and so these mapping efforts are performed in the winter months to maximize the viewing potential of the shallow bottom areas. Performing these mapping projects in the winter also likely underestimates the seagrass coverage; however, since subsequent mapping efforts are also flown during the same winter season, the comparisons are compatible for trend analyses purposes (Ries, T. F., Kurz, R. C., 1998)

For this effort the tidal conditions were forecasted to be optimal during the first and third weeks of December 2014; coincidentally a weak cold front passed over the area on December 2nd which greatly improved the atmospheric conditions. On December 10, 2014 all of the conditions were conducive to proceed with the image acquisition and so the contractor (ACA) was given authorization by RBNERR to fly.

After acquisition, raw imagery undergoes post-processing and editing to reduce radiometric resolution (amount of information captured per pixel) from 12 to 8 bit, to remove distortion, and to geo-reference images to ground locations. The processing of raw imagery generates 0.3 m resolution digital ortho-photographs.

ACA was able to capture the imagery for the entire study area over 10 flight lines (Appendix 1) and a total of 204 tiles (photos). These photos have a 60% overlap and a 30% side lap to ensure that there is ample coverage to address reflectance and glare issues. The photos are then analyzed and composited into a mosaic image for review purposes.

Image Inspection Process

The imagery was inspected at ACA's Orlando office to determine whether the imagery capture was sufficient or whether it would need to be re-flown. All ten flight lines were thoroughly inspected by Scheda's project manager (PM) along with Ms. Kris Kaufman, Senior Scientist with SWFWMD who manages their seagrass mapping effort. In-person photo inspection is necessary since images are not fully processed until approved and must be viewed on unique software not readily available. In addition, the images can appear differently on different computer monitors and ACA utilizes high definition monitors and implements strict protocols for image viewing. The images were found to be of very high quality and the underwater features were discernible, with the exception of a very few locations around Marco Island. Since Marco Island was not part of the RBNERR study area, only limited mapping was performed there, except for the updating of the shoreline feature which was performed with the augmentation of available ESRI imagery. Thus the imagery acquisition was approved as acceptable and no additional flights were deemed necessary.

With the acceptance of the imagery, ACA was asked to perform a color balance exercise, specifically for the water features within the imagery capture. Color balance of imagery is a technique that involves adjustments of the associated color histograms to enhance the underwater features to facilitate the photo-interpretation process (Luan, X., et. al., 2014). Color correction included multiple balancing efforts of water and land features in order to enhance benthic features in the water while maintaining natural coloring of land features to the extent possible. Multiple variations of color balancing were reviewed and one was ultimately approved by the PM and Ms. Kaufman. The final product was then color balanced by ACA and sent to Scheda, via an external drive, to begin the photo-interpretation process.

Shoreline Updates

The mapping of water-based natural resources initially requires a boundary condition, such as the project limits inclusive of the shoreline component. For this project both were provided so that the mapping boundaries were known. After the initial review of the shoreline boundary, it was evident that although the shoreline boundaries did exactly match the 2014 image. To address this situation it was agreed upon to re-delineate the shoreline so it matched the 2014 imagery. This involved extending some small creeks, adding missed islands, and also delineating open water features within the mangrove community, which were not mapped previously, again the 0.5-acre threshold was applied when deciding on what shoreline updates were delineated.

Photo-Interpretation Procedures

Photo-interpretation is the process of identifying and describing features in a photograph based on tone, color, contrast, and texture (Finkbeiner et al. 2001). Photo-interpretation is currently conducted using heads up (interpreting imagery on a computer screen) photogrammetric techniques and digital photogrammetric workstations are utilized for direct capture of digital data in an ArcGIS geo-database (Kaufman 2006). Detailed descriptions for program methods can be found in Kurz et al. (2000) and Tomasko (2005).

Photo Science Inc. was hired to perform the photo-interpretation work for this project as their senor image analyst has over 35 years of experience mapping natural resources in Florida. In addition their photo-interpreter was instrumental in the mapping of SAV, seagrass, oyster beds, and other bottom features throughout Florida for the SWFWMD, SFWMD, and Suwannee River Water Management District (SRWMD). The external hard drive, with the color balanced imagery was delivered to them for review.

Once identified in the photographs, benthic features are classified using modified codes from the Florida Land Use Land Cover Classification System (FLUCCS) (Table 2). Modified FLUCCS is the standard mapping classification utilized by the state water management districts [(SFWMD, SWFWMD, and the St. Johns River Water Management District (SJRWMD)] for their benthic resources. Seagrass mapping at this scale cannot differentiate between the four major seagrass species found in peninsular Florida. This is due to the various morphological expressions of each seagrass type (Ries, T. F., Kurz, R. C., 1998). Therefore, the seagrass category covers any of the seagrass species as long as they were mono specific in nature, i. e. not mixed with macro algae. A classification of either 9113 (patchy seagrass) or 9116 (continuous seagrass) is applied to mono-specific seagrass beds. In order to ensure consistency in delineation, the following classification conventions are used for patchy and continuous seagrass. Patchy seagrass is defined as greater than 25 percent un-vegetated bottom visible within the seagrass polygon (Kurz et al. 2000). This category appears as singular, isolated patches of seagrass or extensive areas of patch strands mixed with open bottom. Continuous seagrass is defined as polygons with less than 25 percent un-vegetated bottom visible (Kurz et al. 2000). The standard statewide mapping threshold for delineation of underwater features, at this scale, is 0.5 acre (Kaufman, K. A., 2006), which was used for the SAV, seagrass, hard bottom, and Tunicates. The SRWMD mapped oyster beds in 2001, which Scheda performed the signature identification component of this effort. During the PI process the photo-interpreter noted that they could delineate these features down to a quarter acre and did so, even though their scope only mandated a half acre threshold. For this reason the oysters were delineated down to a quarter acre to capture as many of these smaller features as possible. Table 2 provides the mapping threshold of each category.

Table 2: Modified Florida Land Use Land Cover Classes

FLUCCS Code	Definition/Description	Mapping Unit
0	Not Classified (Land)	0.5 acre
6510	Un-vegetated Bottom/Tidal Flats (waters less than 2 m depth)	0.5 acre
6540	Oysters	0.25 acres
6560	Hard Bottom Communities (corals, sponges, live rock, etc.)	0.5 acres
9100	Submerged Aquatic Vegetation	0.5 acre
9113	Seagrass, Patchy	0.5 acre
9116	Seagrass, Continuous	0.5 acre
9200	Tunicates (field verified)	0.5 acre

Visiting locations in the field allows photo-interpreters to correlate the photographic signatures seen in the imagery with field conditions. Photographic signatures are evaluated and verified to successfully differentiate seagrass, algae, oyster beds, and hard bottom from features that may have similar appearances to macro algae. For areas that are mapped on a regular basis, a minimum of one site for every five square miles are field visited (Kaufman, personal communication). For this project, applying this formula over the 248 mi^2 area would equate to approximately 50 sites; however, since this is the first time that this area was mapped, coupled with the fact that there were multiple visible signatures; Scheda was contracted to visit a minimum of 160 signature identification sites. Each site was specifically selected to correspond with an identifiable signature, or in areas with uniquely different signatures, as well as areas which appeared to be devoid of natural resources. These sites were strategically selected to cover the entire study area while still being accessible by boat. Once these locations were selected, their corresponding coordinates were obtained and loaded onto a handheld Humminbird® 735 Series GPS unit so that these sites could be located in the field. RBNERR staff and volunteers provided their time and boats to take Scheda's senior biologist to each site for signature identification (Table 3). Five field days were originally envisioned to field verify the 160 sites. The first site reconnaissance was performed in February (9th, 10th, 11th, & 12th) and covered 88 sites. The next field visit was performed in March (16th & 17th) and covered an additional 51 sites. During the PI process, it is typical for the photo-interpreter to come across signatures or areas that are slightly different or unclear and so these additional sites are identified to be field verified to ensure that the resources are being mapped correctly. An additional 76 field check sites were selected and their corresponding coordinates were obtained. On May 7th and 8th these additional 76 sites were also field verified (Figure 2). A grand total of 215 field check sites were field visited.

Table 3: Signature Field Verification Sites

Date	Departure Location	Investigator	Boat Operator	Boat	Site Locations	Sites Verified
9-Feb-15	Shell Island Road	Capt. Brad Young	Kevin Cunniff	Ranger	Henderson Creek, Hall Bay, Rookery Bay, east of Keewaydin Island, north to Dollar Bay	122, 109, 110, 159, 121, 158, 157, 135,132, 142, 140, 154, 156, 155, 153, 151, 152, 139, 78, 124, 149, 9
10-Feb-15	Shell Island Road	Capt. Brad Young	Jill Schmid	Ranger	Dollar Bay, south through Intracoastal, Shell Bay, south to Halloway Island to east of Keewadin Island to south of Munlin Island	12, 150, 144, 146, 145, 147,148,141, 127, 1, 143, 98, 136, 133, 137, 130, 134, 131A, 136, 129, 128, 123, 125, 104, 118
11-Feb-15	Goodland Station	Capt. Brad Young	Beverly Anderson Capt. Pete	Gambusia	Barfield Bay, Caxambas Bay, Caxambas Pass, Robert's Bay, south of Horrs Island	95, 82, 77, 93, 81, 91, 94, 88, 90, 106, 92, 99, 92, 99, 101, 107, 53,
12-Feb-15	Goodland Station	Capt. Brad Young	Pat O'Donnell	Gambusia	TTI from Round Key to Fakahatchee Bay to Tripod Key	15, 4, 10, 14, 3, 18, 168A (301), 6, 5, 6A (300), 22, 19, 25, 23, 28, 24, 16, 2, 31, 17, 32, 40
16-Mar-15	Goodland Station	Capt. Brad Young	Pat O'Donnell	Gambusia	TTI from Round Key to Gullivan Bay to Sugar Bay	11, 171, 172, 169, 170, 176, 166, 167, 163, 164, 165, 162, 161, 13, 21, 37, 37A, (304), 191, 35, 33, 201, 177, 174, 173, 57, 41
17-Mar-15	Shell Island Road	Capt. Brad Young	Kevin Cunniff	Ranger	Henderson Creek south to Isle of Capri to Sea Oat Island to Tarpon Bay	122, 122A (304), 180, 119, 181, 182, 20, 198, 117, 184, 183, 116, 205, 112, 185, 186, 187, 113, 105, 115, 103, 108, 197
7-May-15	Goodland Station	Capt. Brad Young	Pat O'Donnell	Gambusia	TTI from Goodland to Fakahatchee Bay to Faka Union Bay to Pumpkin Bay to Blackwater Bay	235, 236, 237, 241, 242, 209, 211, 208, 210, 240, 218, 222, 223, 215, 216, 217, 221, 276, 213, 291, 207, 214, 238, 239, 220, 219, 224, 285, 286, 206, 196, 190, 234, 233, 229, 270, 275, 271, 272
8-May-15	Goodland Station	Capt. Brad Young	Pat O'Donnell	Gambusia	Goodland to South of Marco Island to Stingaree Island (Jolly Bridge)	246, 278, 179, 280, 243, 250, 251, 248, 247, 255, 252, 249, 244, 245, 254, 283, 253, 256, 258, 261, 262, 257, 228, 284, 227, 273, 274, 281, 282, 232, 231, 100, 195, 76, 30, 67, 85, 188, 62, 265, 70

Ten Thousand Islands (TTI)

At each site, Scheda's biologist physically verified the subsurface conditions using a mask and snorkel in order to provide species identification. Any other observed marine fauna and/or flora was also noted.

All data collected, such as bottom conditions, species presence (algae, seagrass, oysters, hard bottom communities, or otherwise), depth, and any other general observations was entered onto data sheets in the field (Appendix 2). These standard data sheets were supplied by the SWFWMD and were then modified (added SAV, oysters, and hard bottom categories) for use in the Rookery Bay study area. The modified data form was approved by RBNEER staff. The completed data sheets were then provided to Photo Science to utilize during their photo-interpretation process.

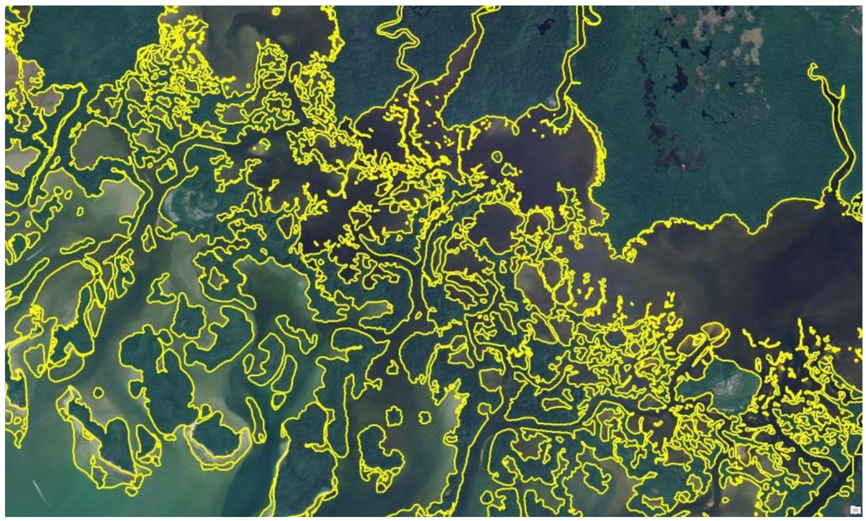
For this project underwater video clips of the various bottom conditions were also captured to document the actual bottom environment observed in the field. These videos provide a visual log of each particular location which can be used for future change analysis assessments.

During the field site inspections there were a number of general and specific findings that were observed in the field which are germane and important to producing an accurate map. These findings were all relayed to the mapping firm to facilitate their PI process. Examples include the following:

- The sediments in many portions of the study area; Ten Thousand Islands, especially within the shallow sections, exhibited a thick layer of fine sediments which were easily re-suspended. These same areas have limited to no seagrass communities; however, in some sections they did exhibit green filamentous algae mixed in with the sediments. Although these areas did exhibit a unique signature, they were mapped as un-vegetated bottom/tidal flats (6510).
- Overall many areas, which were primarily un-vegetated substrate, but did have small populations of scattered drift algae, however they were so scattered that they didn't produce a distinct signature, thus these areas were mapped as un-vegetated bottom/tidal flats (6510).
- Oyster beds (6540) exhibited a very unique photo signature and if an area was greater than 0.25-acre, these were mapped accordingly. However, the oyster communities which are attached to the propagules of the red mangrove trees were not delineated as part of this mapping effort.
- Calcareous algae was also noted in areas south of Marco Island near Caxambas Pass (Check Site #88); although these areas were distinctive and thus were mapped as SAV; unfortunately these species did not produce a unique signature that can be distinguished from the other algal species, so these could not be mapped as a separate categories.
- Mono-specific populations of seagrass did produce a unique signature, so areas which were primarily composed of seagrass species were mapped as seagrass, either discontinuous beds (9113) or continuous beds (9116).
- Shoal grass (*Halodule wrightii*) was the most prevalent seagrass species within the study area, with only scattered patches of turtle grass (*Thalassia testudinum*) or manatee grass (*Syringodium filiforme*), all of these were mapped as seagrass if they were not mixed with algae species.
- The most prominent attached algae species noted in the field were paddle grass (*Halophila decipiens*), star grass (*Halophila engelmannii)*, feather grass (*Caulerpa prolifera)* and common Caulerpa (*Caulerpa mexicana*); all of these species were included in the SAV (9100) category.
- The drift algae noted in the field was primarily brown algae and this was evident throughout the study area and was included in the SAV (9100) category.
- Mono-specific areas of hard bottom community was primarily noted in portions of the Ten Thousand Island region of the study area and consisted of soft corals, sponges, live rock and worm rock, these were mapped as hard bottom (6560).

Quality Control of Maps

To internally assess the PI map accuracy, Scheda's senior photo-interpreter visited the Photo Science office to directly oversee the mapping process and to try and address any specific questions related to the field verified sites. During the overall PI process, additional points were selected for field verification, as part of an adapted management approach to acquiring signature verification locations. This resulted in a total of 215 points which were field inspected to further refine the signature identification process. With these additional field verification points, the proto-interpreter can fine tune the various signature variations (tone, texture, color, etc.) to match the field documented resource being mapped; e. g. the subtleties of each signature is better defined so that there is good correlation and consistency in the PI process. Finally, after delivery of the initial map, all field data points were cross checked against the map to verify that these were correctly identified; this resulted in some minor changes that were made before the final mapping product was approved.



Example of the Line Work

Hyperlinked Data

As an additional feature of the map, Scheda staff enhanced the map to make it interactive so that it could be updated regularly and kept current over time. To accomplish this, all of the field data points with the corresponding detailed field data entries were hyperlinked; this allowed map users to quickly access the full data sheet for each of the sites. In addition, the obtained video clips were also added via a hyperlink; this again allows the map user to actually view what the bottom conditions were during the signature identification field visits. As future data is collected for these points, it can be added these linked sites to keep the map updated over time.

Results and Discussion

Figure 3 is a compilation of the maps produced for this summary report and these help illustrates the results of this mapping effort These were scaled to cover the entire Rookery Bay area, however, the GIS product can be viewed at any scale for resource management purposes.

SAV

This category, Submerged Aquatic Vegetation (SAV), consists of algae (drift or attached) or areas with a mixture of primarily algae and limited visible seagrass beds signature. This category (9100) totaled over 3,347 acres or approximately 4% of the entire mapped area. This category was the most prevalent natural resource mapped within the study area. Since this is the first comprehensive mapping effort for this region, no statements can be made in relation to whether this coverage is typical or not.

Example: Photo-interpretation Delineations (Oysters beds and SAV)

Oysters

Typically oyster beds (6540) are mapped to the same (0.5 acre) threshold as the other natural features (SAV, seagrass, hard bottom, etc.) however as noted in the PI Procedures section, the oyster beds were delineated to a 0.25 acre size. This change in mapping threshold is possible due the distinct "edge" that oyster beds produce. By doing so, approximately 71% more oyster polygons are included in this mapping effort (779 total oyster polygons; 550 of which were below the 0.5 acre size). Please note, that oysters which are attached to the propagules of red mangrove were not delineated or mapped. This category totaled over 149 acres or 0.2% of the entire mapped area.

Mono-Specific Seagrass

Seagrass beds which were mono-specific in nature, e.g. were not mixed with algae species, were delineated as either (9113) discontinuous or continuous (9116). The resultant acreages were as follows: 127 acres of continuous seagrass coverage or 0.2% and 1,372 acres or 1.6% of discontinuous seagrass, which equates to a total of 1,499 acres of mono-specific seagrass beds or 1.8% of the entire mapped area. Please note that there is more seagrass within the study area, however it was mixed with the SAV so was mapped as SAV because to the mix class situation.

Hard bottom

Hard bottom (6560) communities (coral species, sponges, live rock, etc.) had a distinctive signature and thus were also mapped separately to identify the presence of this important natural feature within the study area. This category yielded 213 acres or 0.25% of the entire mapped area. Again, this resource was only mapped if it was above the minimum mapping unit threshold and if it was the dominant feature; mixed classes, that also had some limited hard bottom communities embedded within were not mapped as hard bottom, rather they were mapped to correspond with the visibly dominate resource. This determination is made by the photo-interpreter; basically if visible signature resembles the known hard bottom signature, it was mapped accordingly, even if there were some (less than ~50%) of other habitats (most commonly algae) mixing within that particular polygon. This is standard practice for this sort of remote sensing work; otherwise it becomes very difficult to consistently map mixed class polygons.

Un-Vegetated Bottom/Tidal Flats

The remaining bottom classification was comprised of un-vegetated bottom/tidal flats (6510) communities and totaled 79,771 acres or 94% of the entire mapped area. Many of these areas may also have small amounts, less than the mapping threshold, of natural resources embedded, (SAV, seagrass, hard bottom, etc.); however, these were mapped as tidal flats. This sort of percentage is not unusual, for example Tampa Bay's mapping resulted in approximately 95% of that study area be mapped as un-vegetated bottom; there is no norm for this percent cover as each study area is driven by the physical makeup (depths, slopes, sediment types, etc.) of the bay in question (Kaufman, personal communication).

Tunicates

A very unique feature within the study area was noted; in two separate locations a mono-specific bed of tunicates (sea squirts) was discovered. These locations had thousands of individual organisms completely carpeting the bottom of the bay and resulted in an identifiable signature. Thus these were also identified and mapped as Tunicates (9200); the total acreage of this community was 4 acres. A video clip of this community is included as part of the hyperlinked map (Check Site #195).

Conclusions/Recommendations

Per the results of our internal mapping quality control review, the resultant map achieved the industry standard of 90% accuracy and accurately represents the submerged aquatic natural resources within the RBNERR study area. To formally assess the map accuracy, a thematic accuracy assessment is recommended to be completed on the final product. This typically involves a random selection of points within the study area which are then field checked to verify that the map has correctly identified the presence or absence of the noted bottom types (Kaufman. 2006). The industry standard is approximately 1 site for every five square miles thus for this project size, that equates to 50 accuracy assessment sites. This ideally is done as soon as possible after the maps are delivered to avoid the potential for changes to occur in the field between the image capture and the field conditions at the time of the assessment. If this is not possible, then performing an accuracy assessment at the same time of the year of the image acquisition (winter months) will lessen the seasonality differences and facilitate these comparisons.

This data resource can be used as the baseline condition so that the coverage of these natural resources can be documented over time, especially in relation to potential changes to estuarine inflow timing and volumes that may be affected by weir/gate operations changes or watershed capital improvement projects. This will help document the ecological responses within the estuary. For example, if the discharges to Henderson Creek are improved to mimic the natural flow rates and annual timings, then natural resources such as oysters bed and seagrass populations, should exhibit a positive response which can be documented over time.

It is recommended that RBNERR establish a plan to conduct an aerial survey and remap this same area at regular intervals (minimum of 4 to 5 years). This recommendation is based upon our direct involvement with the various ongoing aquatic mapping programs in the State; the SWFWMD maps every two years, while the SFWMD does this intermittently, but typically they are done at 5-year intervals which is similar to the SJRWMD program. Other mapping efforts are performed more frequently (Lake Panasoffkee was done annually for ten years, as was the first three years of the SFWMD's Stormwater Treatment Areas (STA) mapping program, both of these were then curtailed to a three year plan, because in both of those cases the change detected was not significant enough to justify the costs. The frequency of these remapping efforts seems to be based upon the costs and available funding as the determining factor for many entities. The remap of the area will be less costly to perform as each mapping event can build upon the prior, thus only the change in the resources location and extent, would need to be documented. These updates should also verify that the shoreline feature is still accurate, depending upon the frequency of the remap effort, the shoreline may or may not need to updated; if there are notable changes over time, then this should be included as part of the PI deliverable.

It is also recommended that another historic SAV limits mapping effort be explored for the entire Rookery Bay study area, like was done for the CARL property boundary. Although these efforts can be difficult to perform and are very dependent on the availability of good imagery, if there are historic aerials obtainable which cover the entire Rookery Bay area and have sufficient water penetration to discern the bottom features then these could be utilized to provide an approximate baseline for the entire study area. Again, these map updates would serve as a powerful tool to document the natural and beneficial results of improving the discharges to the receiving water bodies or to identify other effects or changes from catastrophic events such as hurricanes.

Mapping using aerial interpretation is a powerful tool to document change over time and is used by many natural resource managers in Florida; however, it is imperative to understand that it is a gross mapping process that is not capturing all of the natural resources within the entire area due to the mapping thresholds and limitations of this research approach. Also, it can only identify the presence and absence of a particular natural feature, not the species, nor the relative health of that resource. For this reason, it is further recommended that a complimentary concurrent field monitoring aspect be added to this overall RBNERR assessment. In many parts of Florida, permanent transects are established throughout the mapped area which are visited annually to identify the species, health (epiphyte loads, blade length, depth, etc.) and extent of the mapped resource. With this information, the health, as well as the relative abundance, of the mapped resources can be accurately documented and tracked over time (Avery, W. M., and J. O. R. Johansson, 2001). Based upon the SWFWMD's seagrass monitoring program, for this size study area, it is recommended that a minimum of 15 transects be deployed and surveyed annually. The actual number of transects are completely dependent upon the amount of resources available to initially install the monumentation and then to monitor these sites annually, Scheda was instrumental in establishing the 115 permanent transects for the west central coastal areas, which have been monitored continuously since 1997. The currently used data sheets and monitoring parameters which are now being used in many parts of the State can be modified for RBNERR's purpose. This effort is being performed with trained volunteers, mostly from the many interested agencies, which could help defray the cost of monitoring these transects over time.

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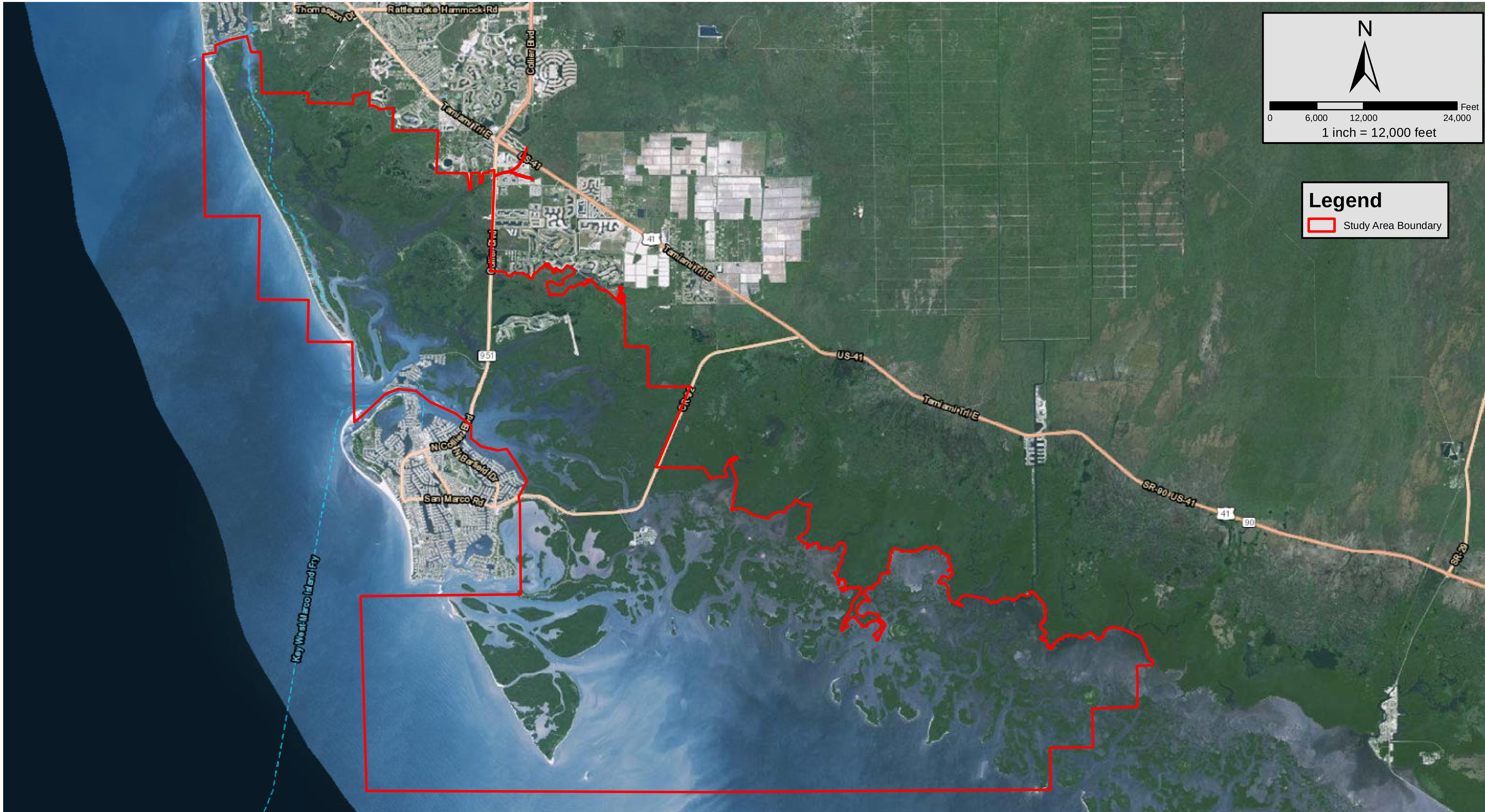

Figure 1
Study Area Boundary

Rookery Bay
Collier County, Florida

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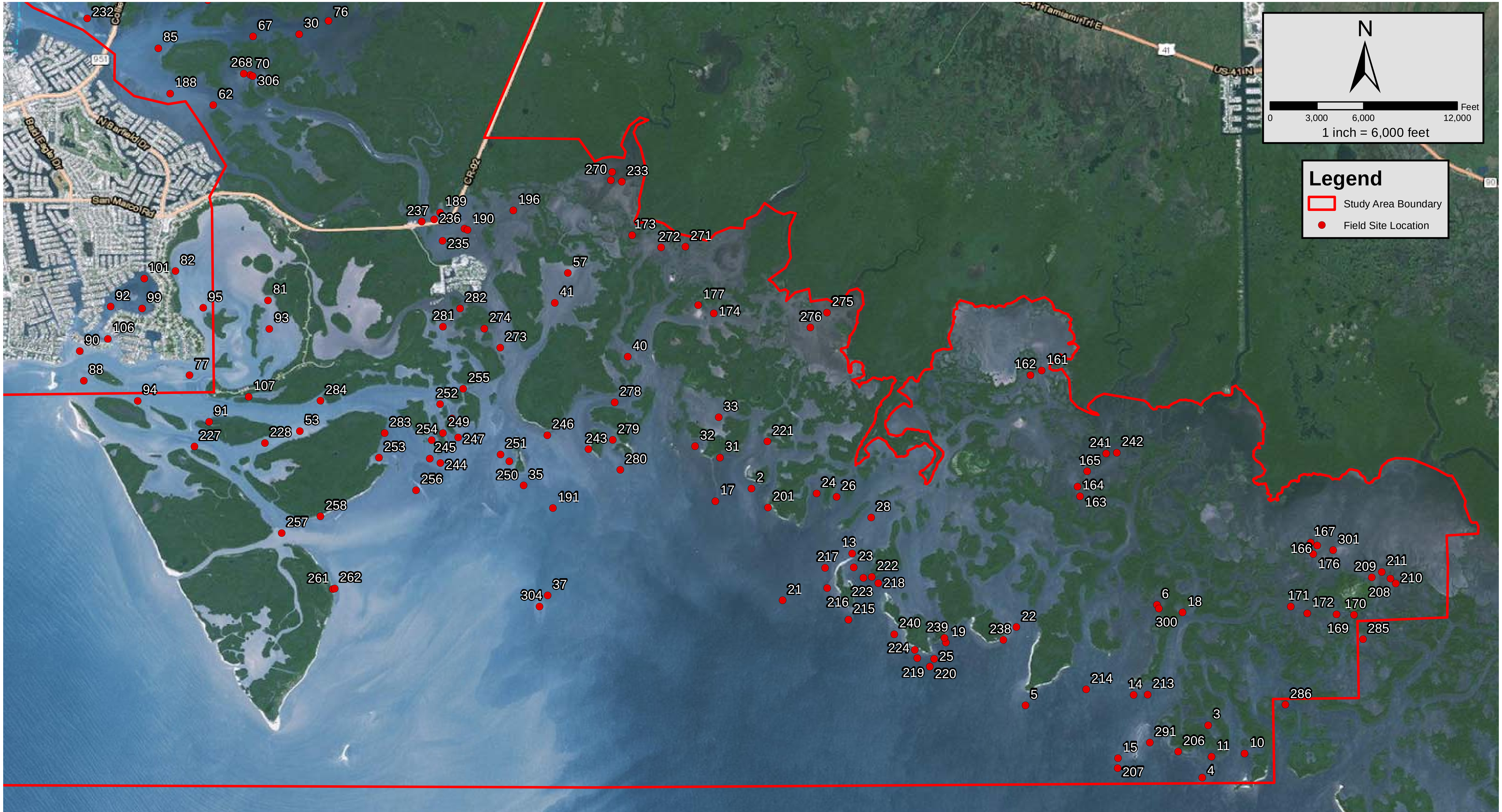

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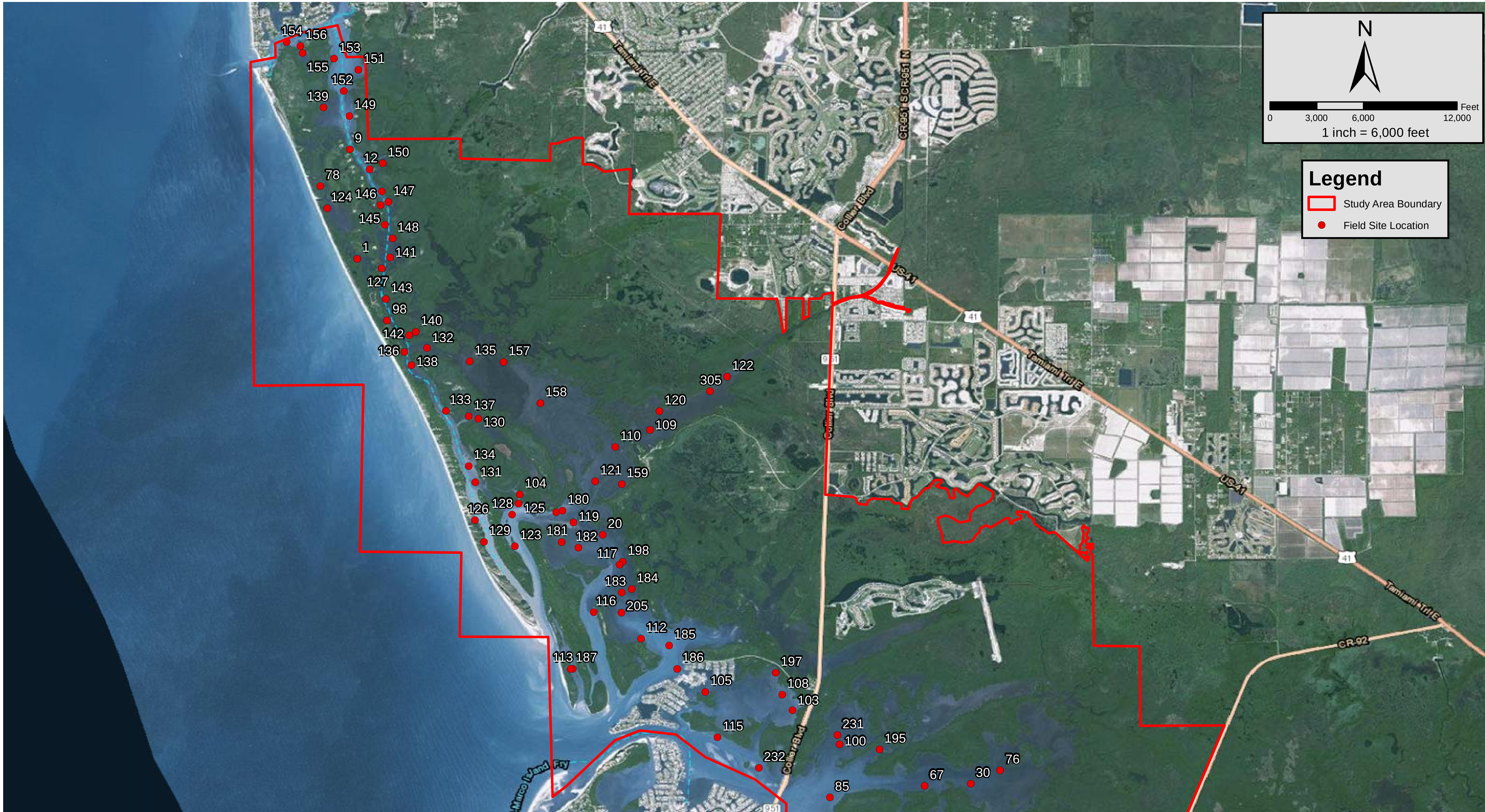
Figure 2
Field Site Point Location Map

Sheet 1 of 2
Rookery Bay
Collier County, Florida



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Field Site Point Location Map

Sheet 2 of 2
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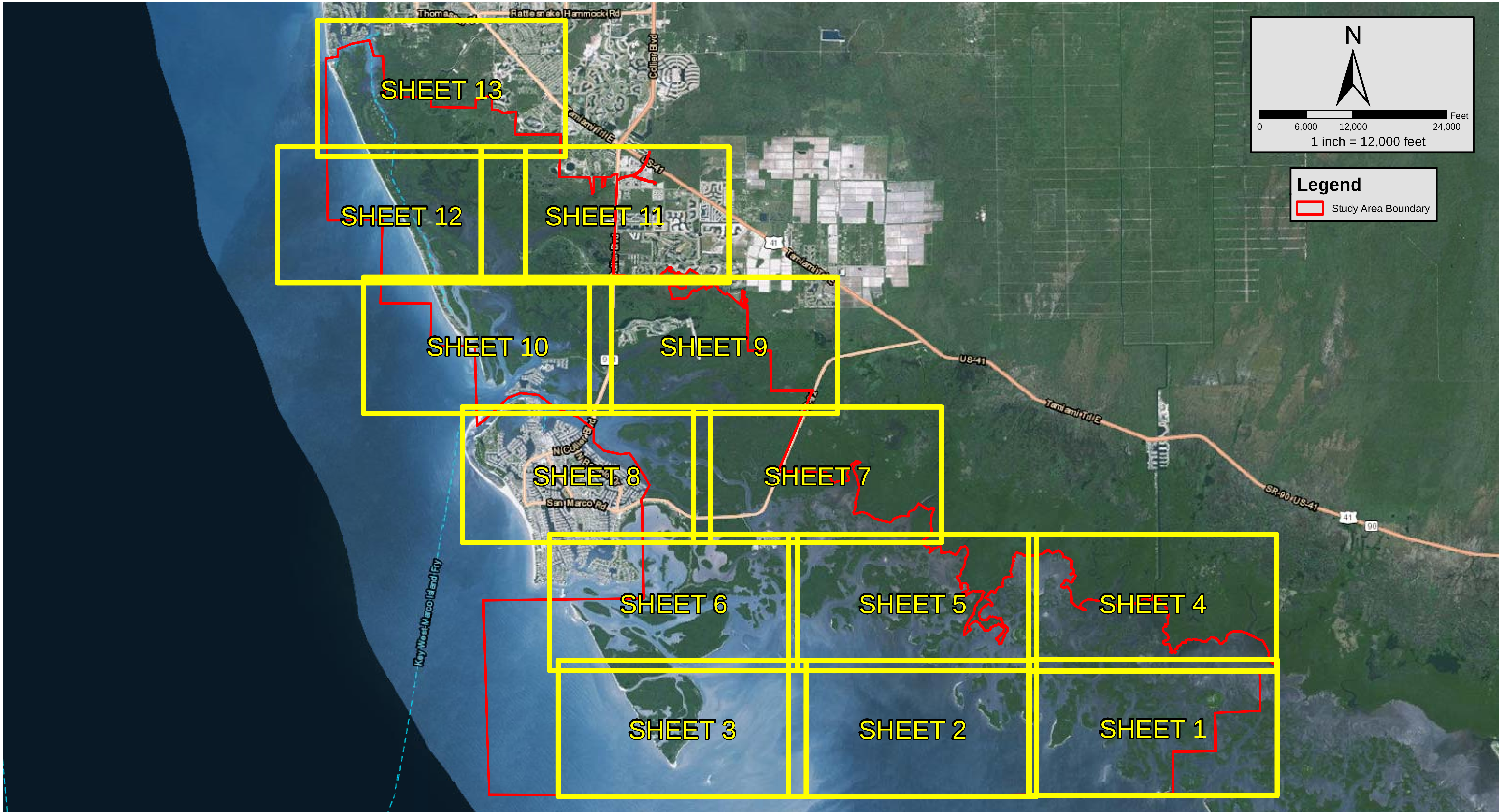

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Figure 3
SAV Resource Detail Key Map

Rookery Bay
Collier County, Florida

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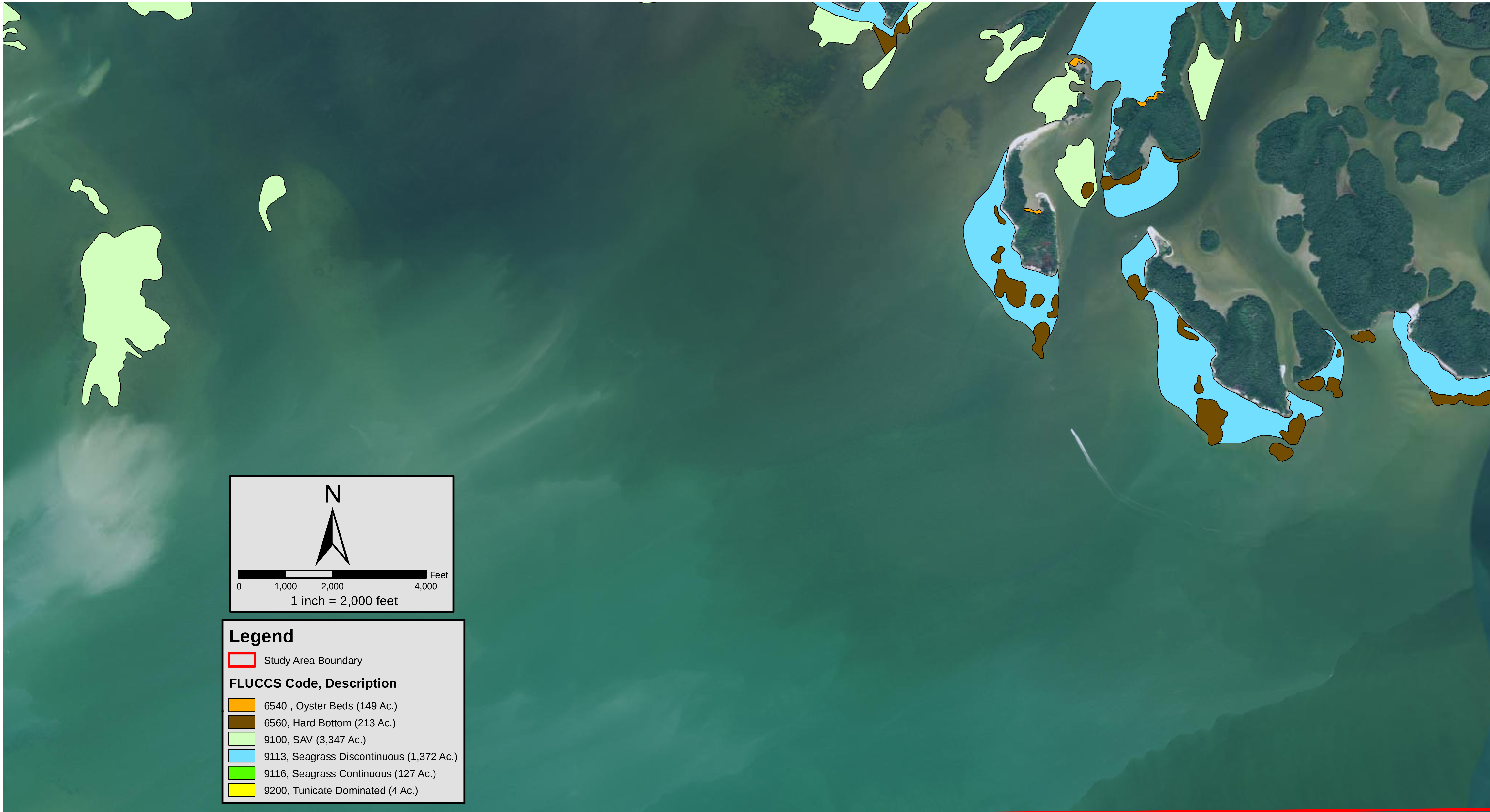
Figure 3
SAV Resource Detail Map

Page 1 of 13
Rookery Bay
Collier County, Florida



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NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM SCIENCE COLLABORATIVE

Figure 3
SAV Resource Detail Map

Rookery Bay
Collier County, Florida

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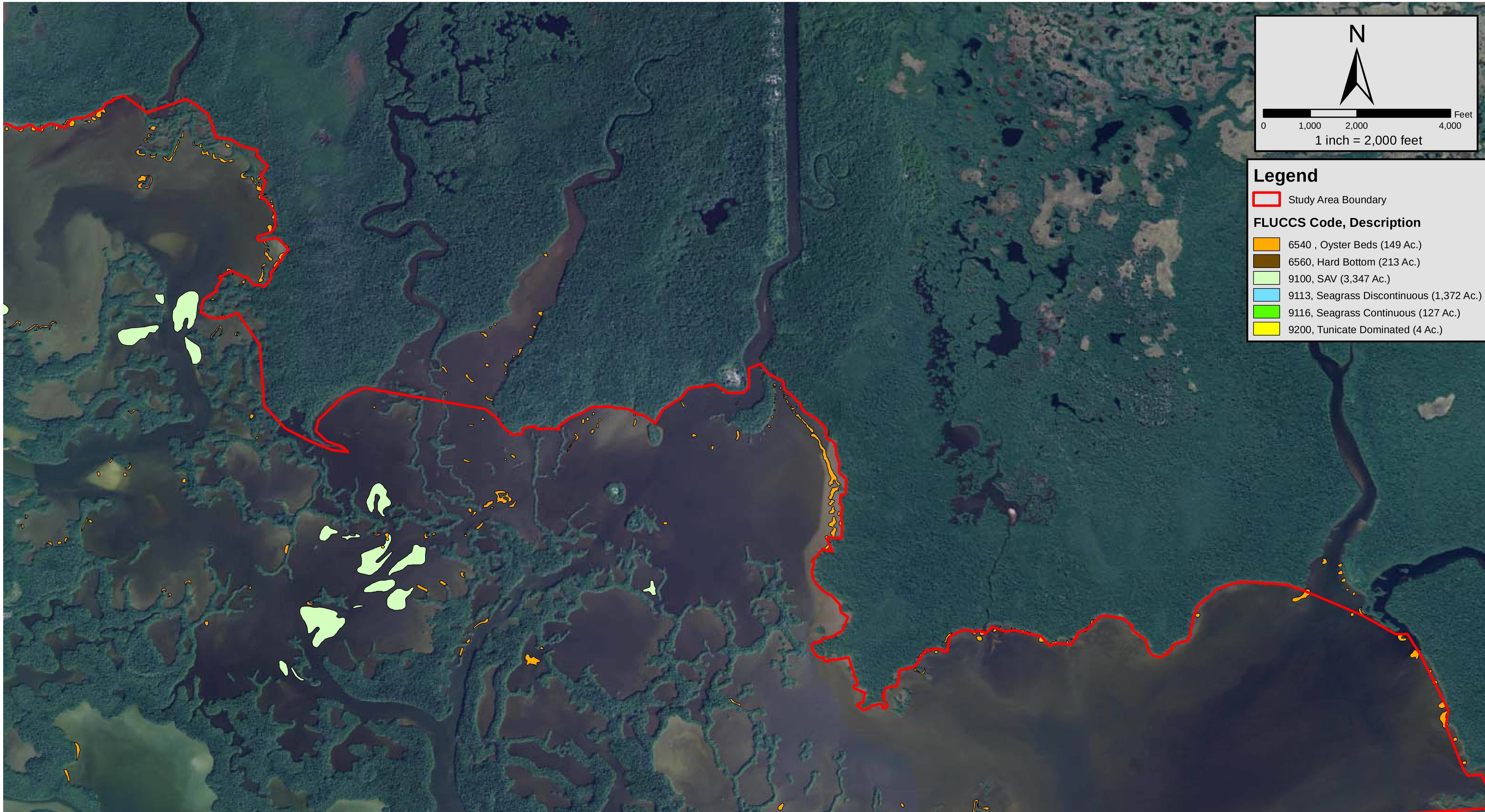

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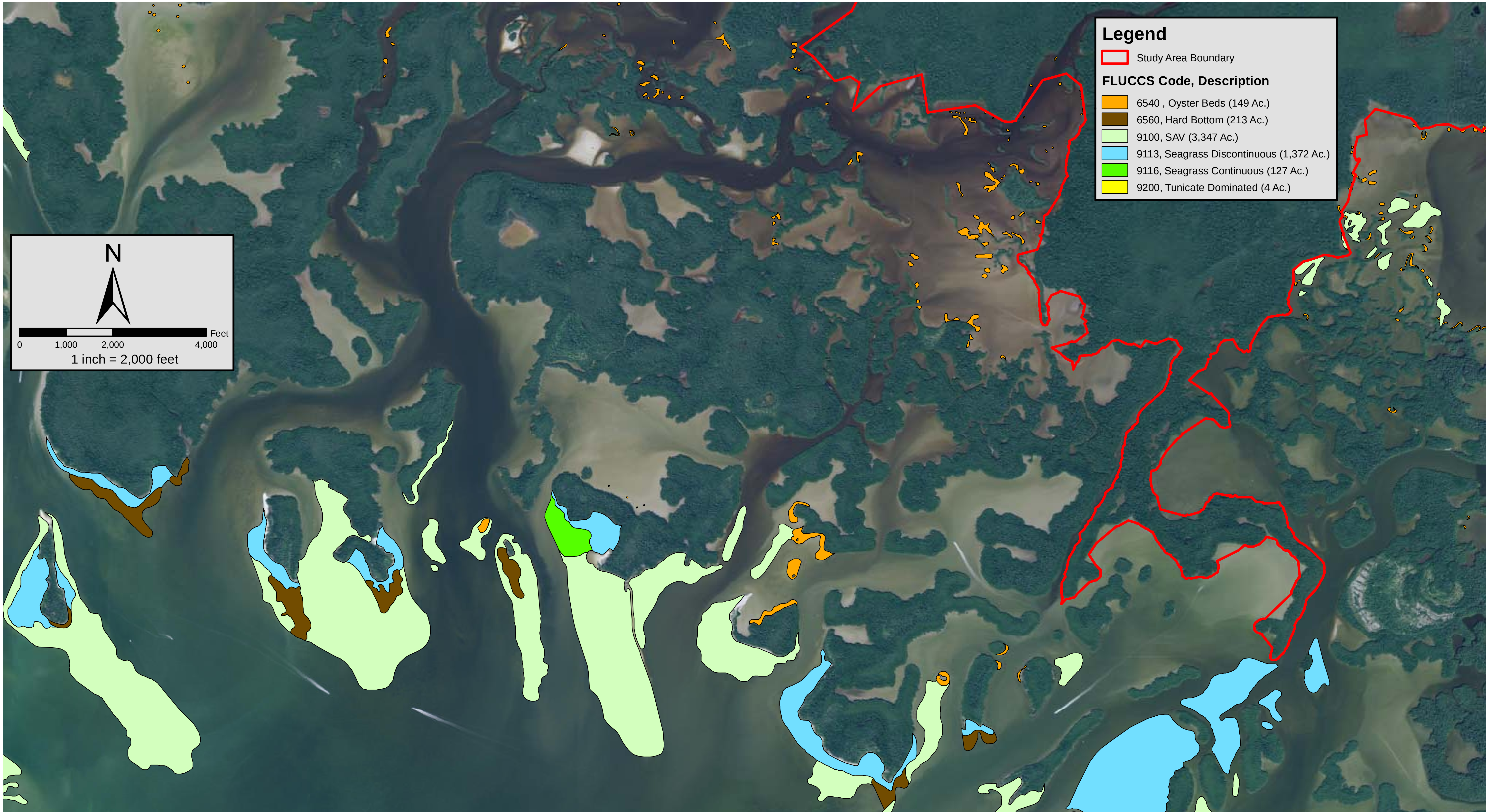

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Page 5 of 13
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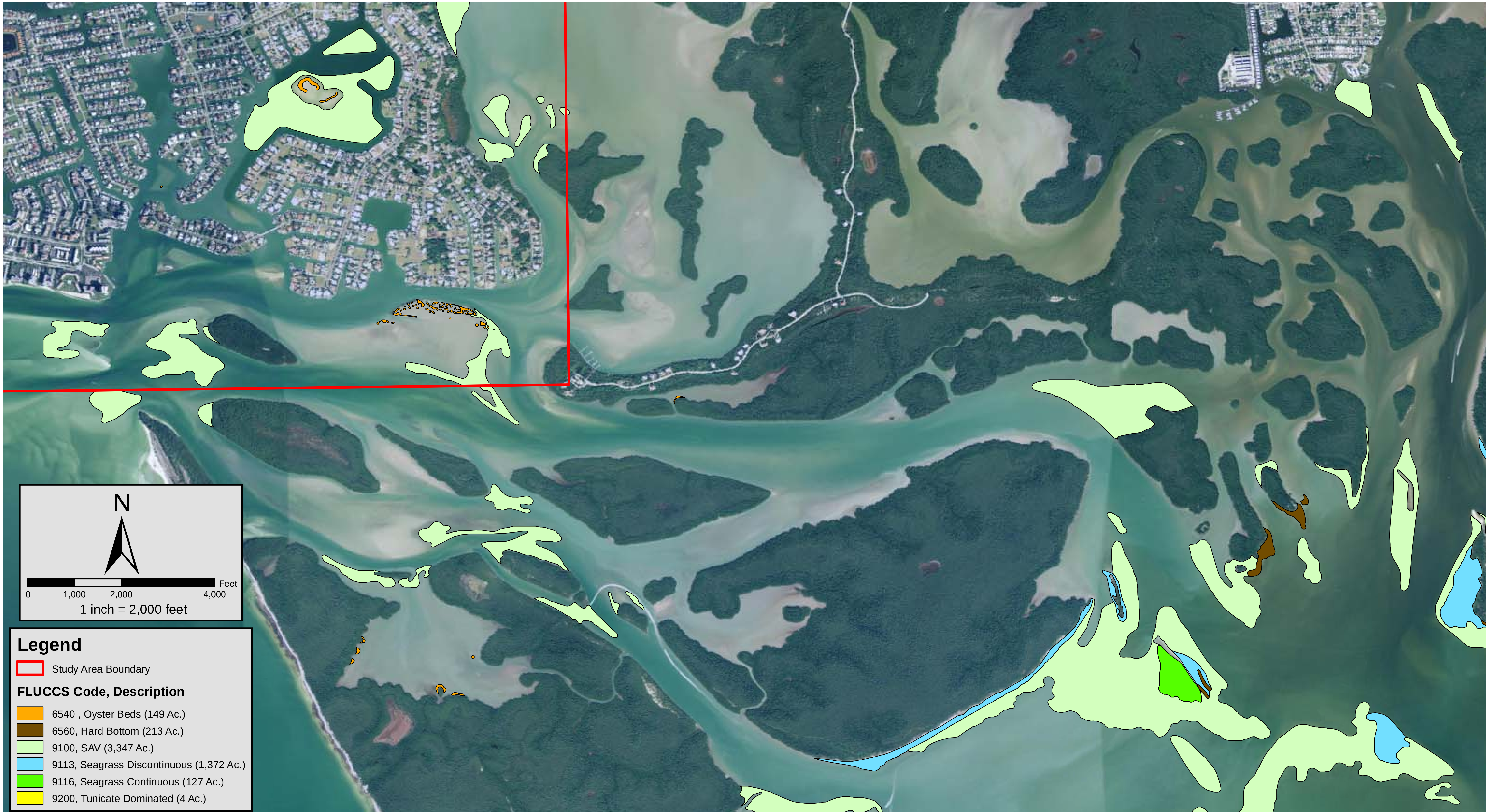

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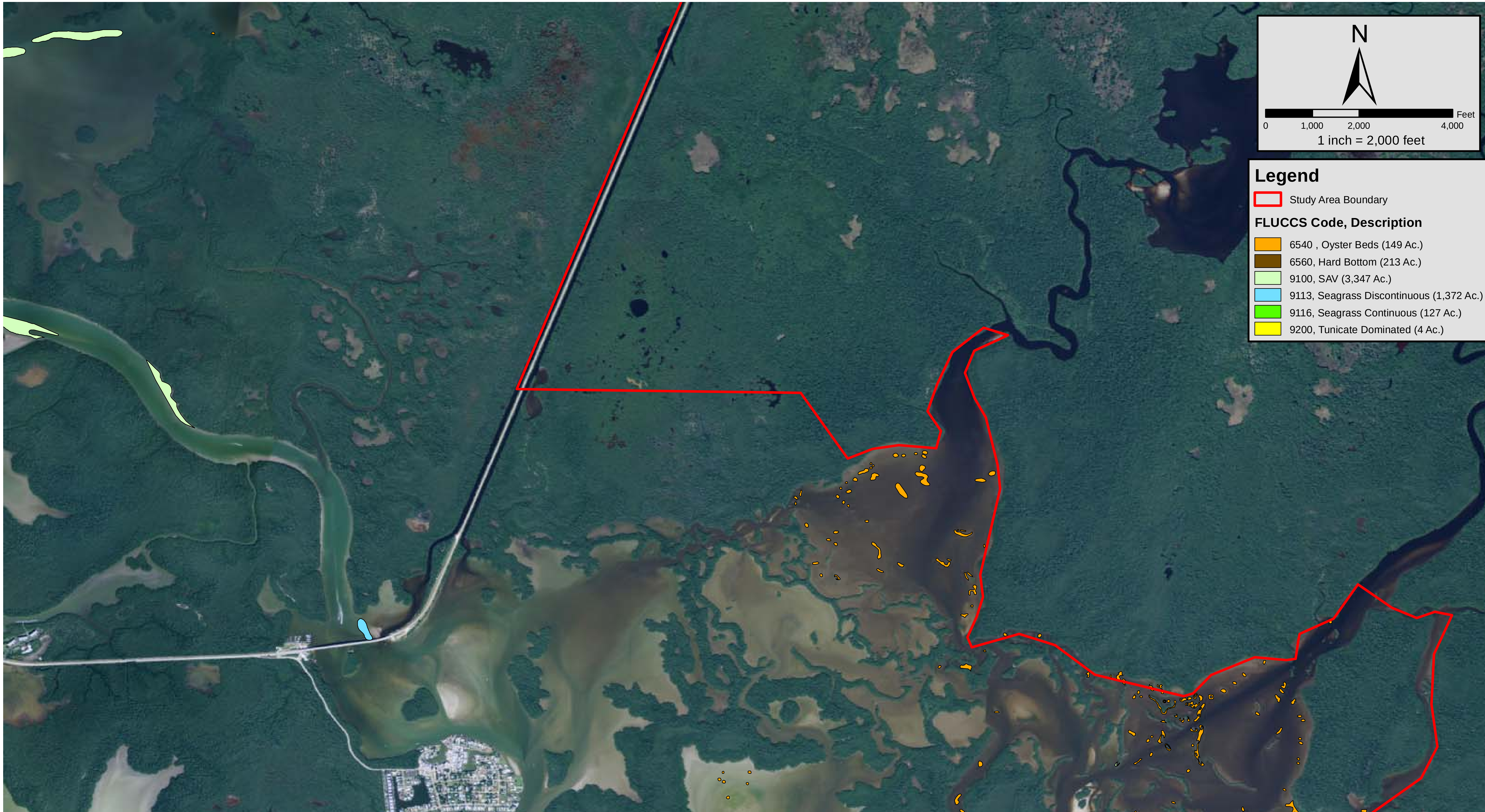

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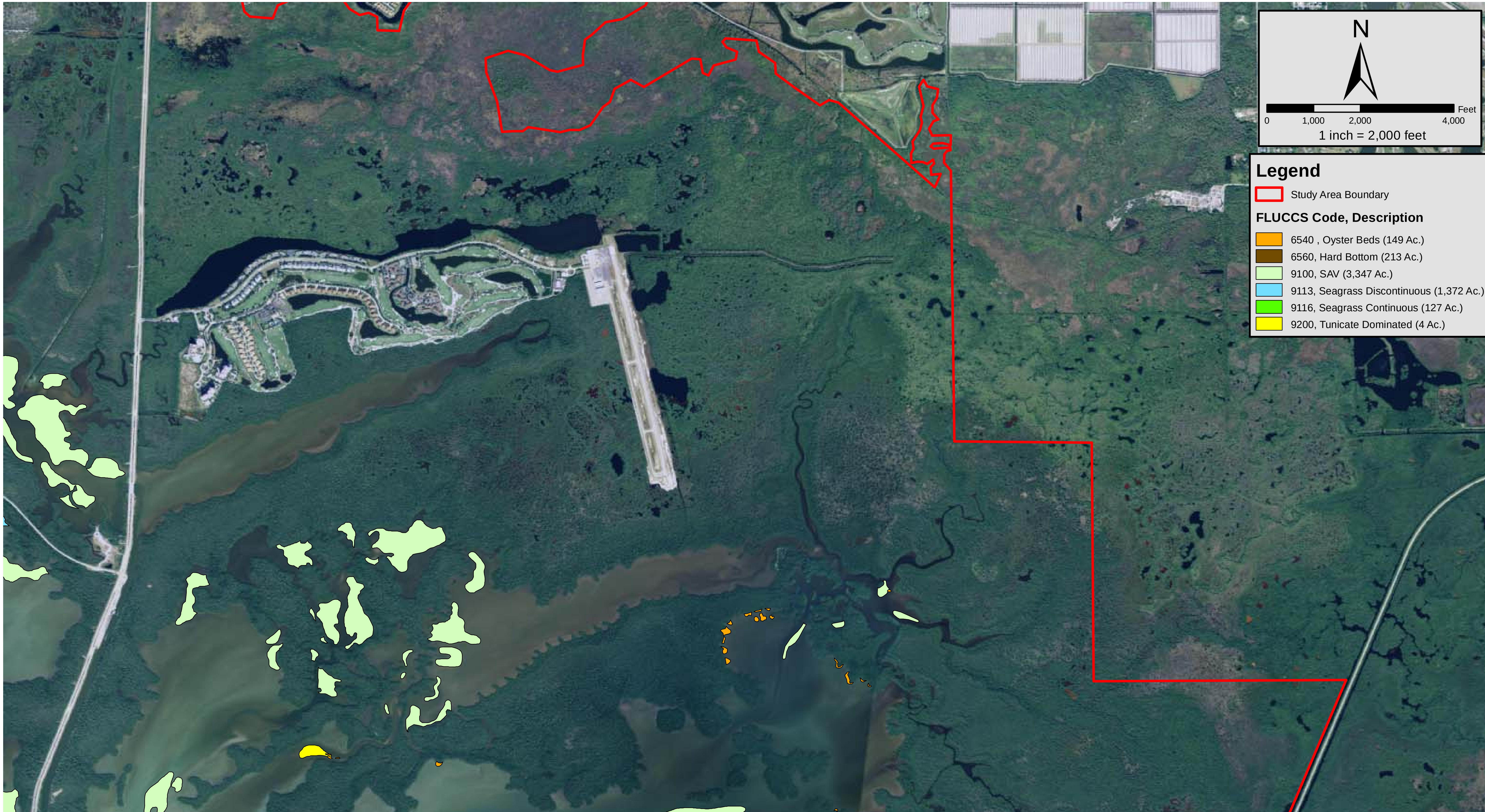

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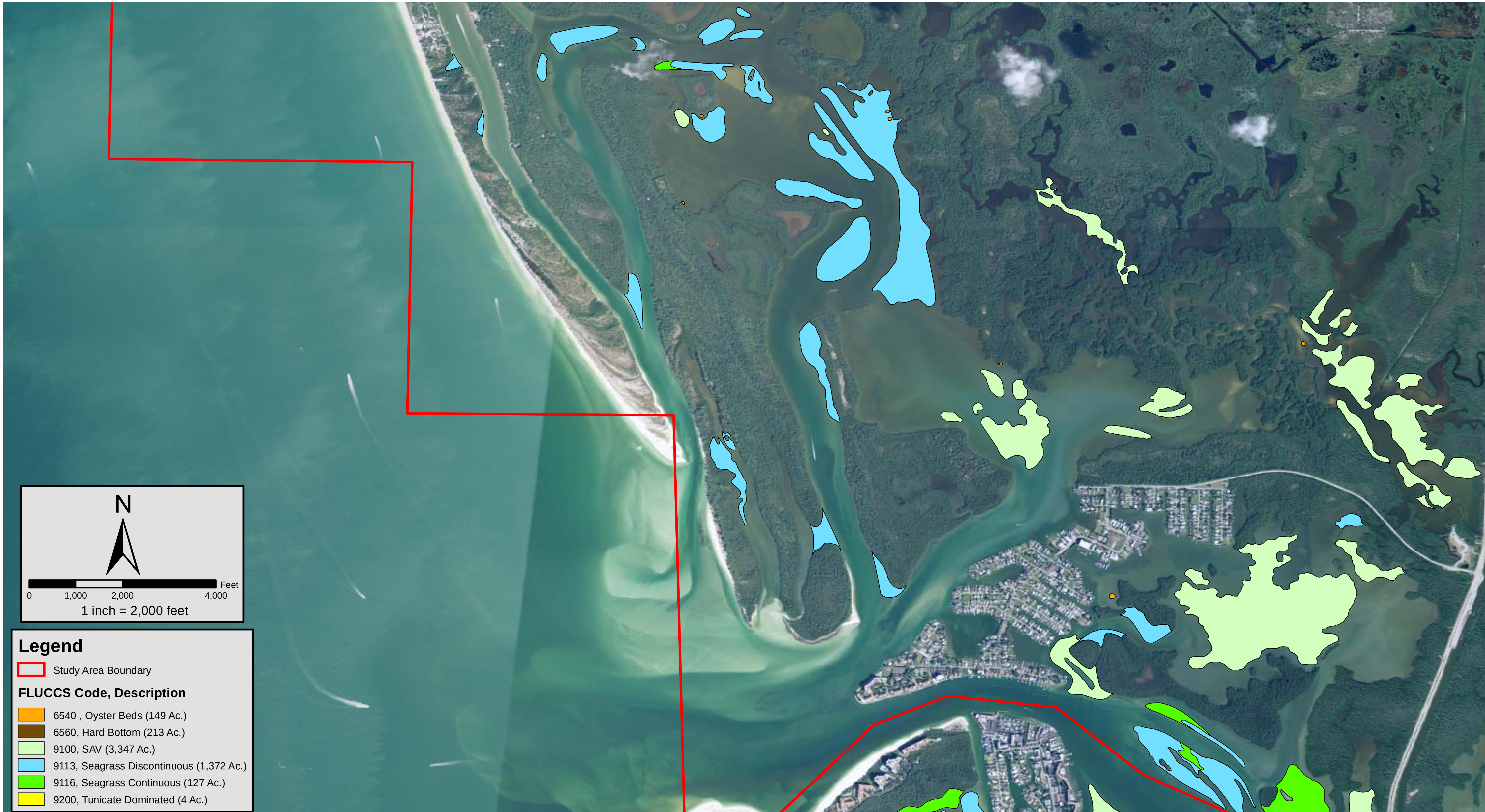

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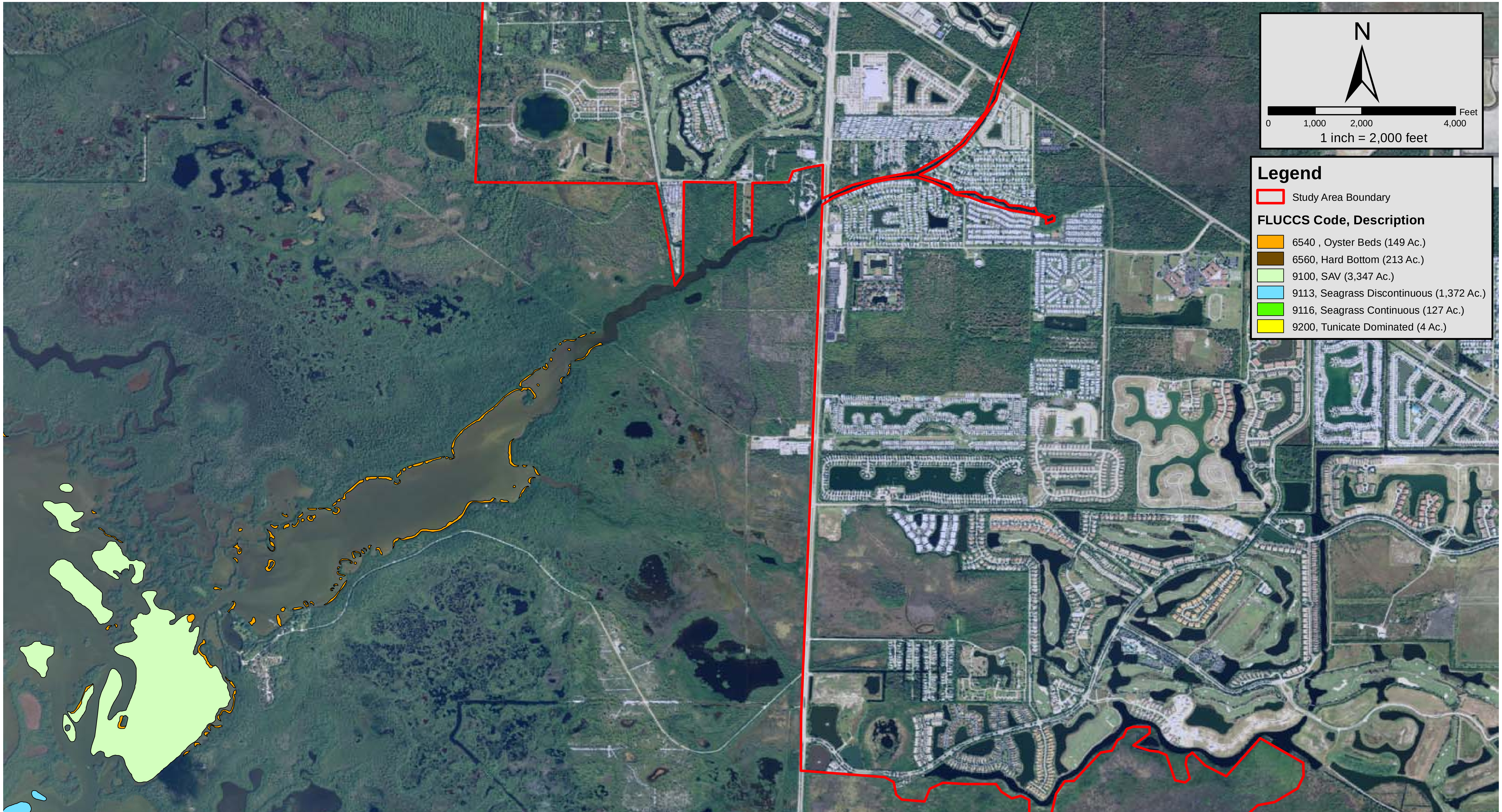

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Figure 3
SAV Resource Detail Map

Page 12 of 13
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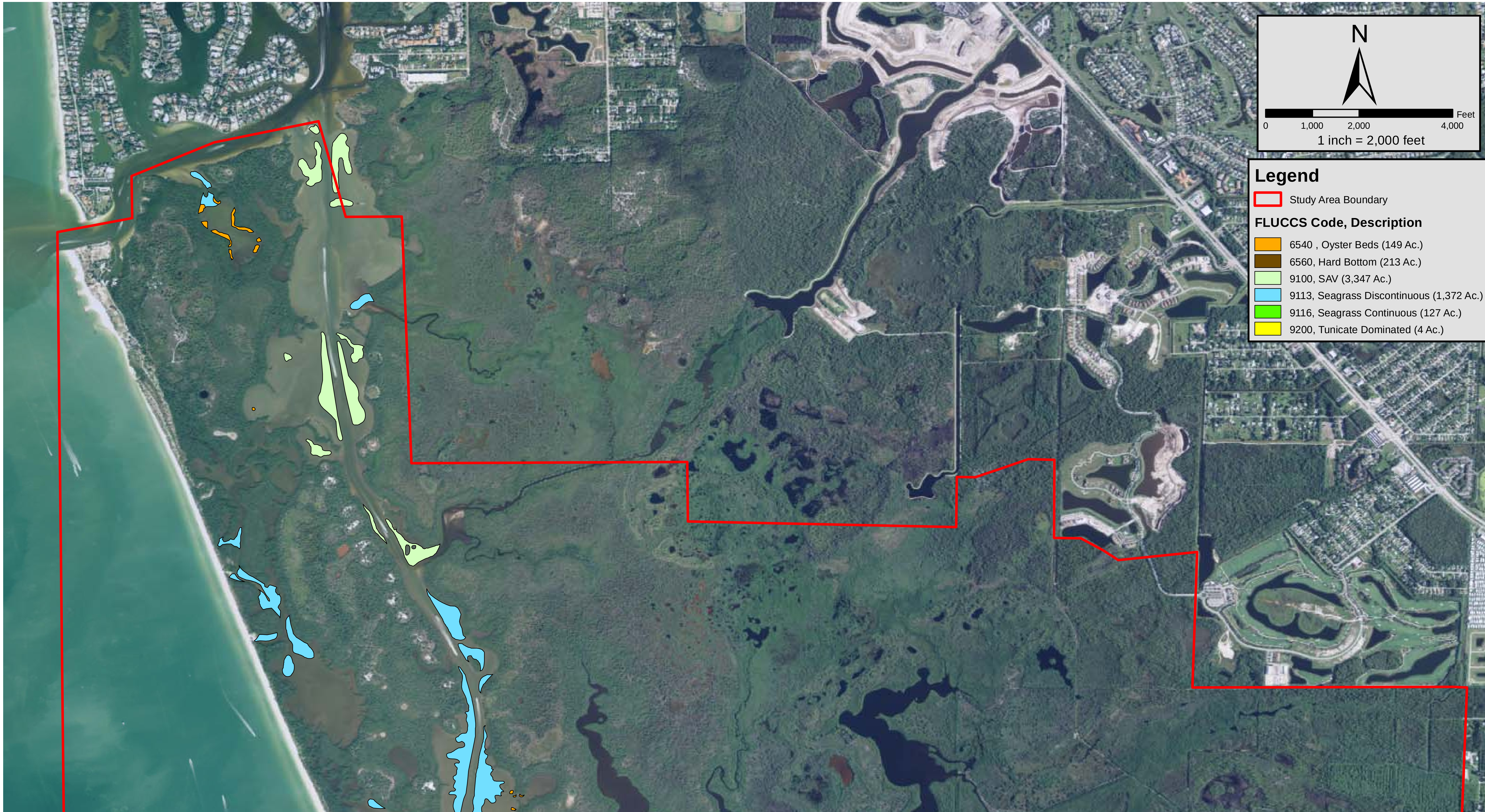

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A PROJECT CONNECTING PEOPLE AND SCIENCE FOR LONG-TERM COMMUNITY BENEFIT

DEPARTMENT OF ENVIRONMENTAL PROTECTION FLORIDA

Rookery Bay National Estuarine Research Reserve

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE NOAA

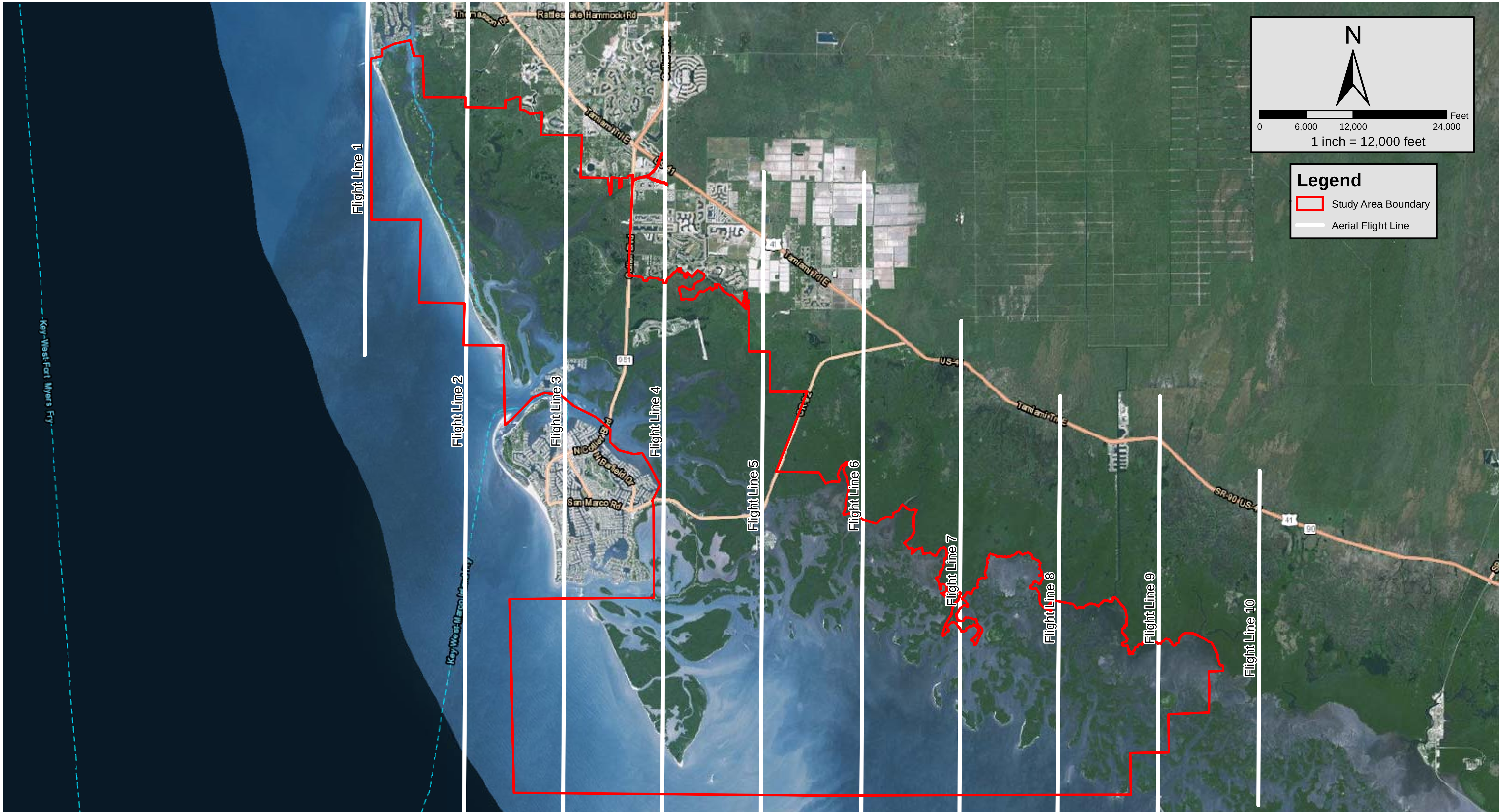
UNIVERSITY of NEW HAMPSHIRE

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM SCIENCE COLLABORATIVE

Figure 3
SAV Resource Detail Map

Rookery Bay
Collier County, Florida

Appendices



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Appendix 1
Image Acquisition Flight Lines

Rookery Bay
Collier County, Florida

Rookery Bay Field Data Sheet

DATE: ____________________ GPS Model: ____________________

Principle Investigator: ____________

DOM_SG_SPC	dominant seagrass species at site
LES_DOM_SG_SPC	any other species at the site
EPIPHYTES (0-3)	0 is clean, 1 is light, 2 is moderate, 3 is heavy

SG = Seagrass

STATION NAME	DEPTH	SEAGRASS (P/A)	ALGAE (P/A)	IF NO SG, DOM_COVER	NOTES
			Drift Algae		
		P A	P A	Oyster	
		DOM_SG_SPC	SPC:	Hard Bottom	
		H.w Thal Syr Rup H.d H.e	Rooted MacroAlgae	Dark Seds	
ALTERNATE COORDINATES VISITED? Y N		**LES_DOM_SG_SPC**	P A	SAND	
		H.w Thal Syr Rup H.d H.e	SPC:	Other: (Fill In)	
		EPIPHYTES (0-3)			

STATION NAME	DEPTH	SEAGRASS (P/A)	ALGAE (P/A)	IF NO SG, DOM_COVER	NOTES
			Drift Algae		
		P A	P A	Oyster	
		DOM_SG_SPC	SPC:	Hard Bottom	
		H.w Thal Syr Rup H.d H.e	Rooted MacroAlgae	Dark Seds	
ALTERNATE COORDINATES VISITED? Y N		**LES_DOM_SG_SPC**	P A	SAND	
		H.w Thal Syr Rup H.d H.e	SPC:	Other: (Fill In)	
		EPIPHYTES (0-3)			

STATION NAME	DEPTH	SEAGRASS (P/A)	ALGAE (P/A)	IF NO SG, DOM_COVER	NOTES
			Drift Algae		
		P A	P A	Oyster	
		DOM_SG_SPC	SPC:	Hard Bottom	
		H.w Thal Syr Rup H.d H.e	Rooted MacroAlgae	Dark Seds	
ALTERNATE COORDINATES VISITED? Y N		**LES_DOM_SG_SPC**	P A	SAND	
		H.w Thal Syr Rup H.d H.e	SPC:	Other: (Fill In)	
		EPIPHYTES (0-3)			