Effects of Docks on Submerged Aquatic Vegetation in Lakes Butler and Jessamine, Orange County, Florida

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Final Report

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EXECUTIVE SUMMARY

With each new request for a dock permit, concerns about the cumulative impacts of dock proliferation along the coasts and shorelines seem to have increased (NOAA 2001, Sanger and Holland 2002, Kelty and Bliven 2003, Alexander and Robinson 2004, 2006). Regulatory agencies responsible for managing docks, including the Orange County Environmental Protection Division, are increasingly being required to defend their dock permitting guidelines and policies. An improved understanding of the individual and cumulative effects of residential docks should result in better aquatic management to help ensure that additional docks do not harm the environment, but still provide waterfront property owners reasonable access to the water (Kelty and Bliven 2003). Therefore, Biological Research Associates (BRA) was contracted by the Orange County Environmental Protection Division to conduct this study.

There is considerable evidence that docks intercept sunlight, alter patterns of water flow, introduce chemicals into the environment, and impact public access and navigation (Kelty and Bliven 2003). The vessels using docks also affect resources to varying degrees. However, scientific investigations and resulting literature quantifying the biological effects associated with the individual and cumulative impacts of docks are limited (Kelty and Bliven 2003). The majority of the studies that have been conducted to assess the impacts of docks on submerged or emergent vegetation have been conducted in estuarine ecosystems (Kearney et al. 1983, Molnar et al. 1989, Fresh et al. 1995, Loflin 1995, Burdick and Short 1999, Shafer 1999, Beal and Schmit 2000, MacFarlane et al. 2000, Fresh et al. 2001, Sanger and Holland 2002, Steinmetz et al. 2003, 2004, Alexander and Robinson 2004, 2006, Sanger et al. 2004a, 2004b). Only one available study has evaluated the effects of docks on littoral zone habitat and communities in freshwater lakes (Garrison et al. 2005). Submerged aquatic vegetation (SAV) provides shore protection from breaking waves; stabilizes soft sediments and reduces turbidity; provides refuge from fish predation; serves as critical shelter, spawning, and nursery habitat; provides food and substrate for algae, bacteria, invertebrates, fish, amphibians, reptiles, and birds; and produces dissolved oxygen required by aerobic organisms (Engel and Pederson 1998, Kelty and Bliven 2003, Garrison et al. 2005).

The purpose of this study was to determine the effects of typical permitted, constructed docks on the density and diversity of SAV within freshwater lakes in Orange County, Florida. The major issues that were considered included whether the amount of light penetrating beneath a dock affected the density and diversity of SAV growing beneath it, and if there were other variables, aside from light penetration, that affected the density and diversity of SAV beneath docks. Recommendations to mitigate the effects of docks on the density and diversity of SAV based on the results of this investigation, as well as previous studies, were also developed.

Two lakes in Orange County with different trophic status classifications were selected for this study: oligotrophic Lake Butler and mesotrophic/eutrophic Lake Jessamine. Ten docks and ten reference sites were surveyed in each lake from 25 June through 6 July 2007. Field water quality measurements were collected at the waterward end of each terminal dock platform, and levels of irradiance or photosynthetically active radiation (PAR) were measured on the terminal platform dock surface, just above the water surface under the center of each terminal platform, and underwater under the center of each terminal platform just above the lake bottom or at the top of the SAV sequentially under similar weather/cloud cover conditions. The terminal platform is the part of the dock that is connected to the access walkway, is located at the end of the dock, and is designed to secure and load or unload a vessel or conduct other water dependent activities. Two line transects were set up by snorkelers under the terminal platform from the landward to the waterward end of each dock or at each reference site to survey the SAV. Information on the numbers and species of SAV present was collected using a 0.5-m^2 PVC rectangular quadrat, and enough quadrat samples were collected along each transect so that at least 50% of each transect was sampled. The following information was collected during each survey: height of terminal dock platform above water, length and width of terminal platform, dock plank spacing and materials, presence and measurements of boathouses and scoured areas, presence of jet skis and boats, presence of cleared access corridors, descriptions of associated shoreline and other lakeshore activities, species of emergent and floating vegetation present around the dock or reference site and associated shoreline, and miscellaneous other pertinent information. Similar information was collected at each reference site; reference sites were located near surveyed docks or in locations of undisturbed shoreline.

Six species of SAV were found in both lakes: coontail (*Ceratophyllum demersum*), eelgrass (*Vallisneria americana*), hydrilla (*Hydrilla verticillata*), Illinois pondweed (*Potamogeton illinoensis*), leafy bladderwort (*Utricularia foliosa*), and stonewort (*Nitella* spp.). Lemon bacopa (*Bacopa caroliniana*), muskgrass (*Chara* spp.), and southern naiad (*Naja guadalupensis*) were found only in Lake Butler, while spikerush (*Eleocharis* spp.) was observed only in Lake Jessamine. The SAV in Lake Butler was thin and small compared to the SAV that occurred in Lake Jessamine, which was often very large, very dense, and grew to the lake surface.

For this investigation overall, including beneath docks, SAV density (the number of stems SAV/m^2) was most affected by the percent of surface light above the SAV/bottom, while SAV diversity (calculated using Simpson's and Shannon-Wiener Diversity Indices) was most affected by the clarity of the water. Overall, turbidity had the most influence on SAV diversity, while Secchi disk depth had the most influence on SAV diversity under docks. Turbidity and Secchi disk depth are both related to the clarity of the water and are affected by water quality; these parameters served as indicators of water quality associated with a surveyed dock or reference site since laboratory water quality samples were not collected as part of this investigation. Higher SAV diversity observed in oligotrophic Lake Butler can be attributed to its superior water quality and lower nutrient levels as compared to mesotrophic/eutrophic Lake Jessamine. Because of the higher nutrient concentrations in Lake Jessamine, the water is less clear due to phytoplankton and associated microbes present in the water column and the lake's higher biological productivity. The high productivity of Lake Jessamine is the cause of the much larger and more robust SAV in Lake Jessamine compared to Lake Butler and is presumably why many areas of Lake Jessamine have undesirable levels of SAV. SAV diversity was also affected by the pH of the water, and the significantly higher pH in Lake Jessamine compared to Lake Butler was most likely a result of higher photosynthesis associated with the more productive plant community. Because of the clarity of the water in Lake Butler, the percent of surface light at the SAV/bottom was higher compared to values calculated for Lake Jessamine.

Similar to previous studies conducted in estuarine ecosystems in Alabama, Georgia, South Carolina, Virginia, Connecticut, and Massachusetts (Kearney et al. 1983, Burdick and Short 1999, Shafer 1999, Sanger and Holland 2002, Alexander and Robinson 2004, 2006, Sanger et al. 2004a, 2006a) and the one available lake study conducted in Wisconsin (Garrison et al. 2005), the results of this study documented a significant reduction in available light under docks with a corresponding significant decrease in plant density or abundance. Since the widths of the docks surveyed in both lakes were similar, the effect of dock width on light penetration or plant density could not be evaluated in this investigation. Similar to what was found by Burdick and Short (1999), SAV density was significantly higher under docks oriented north/south compared to those oriented east/west in both Lakes Butler and Jessamine. While dock plank spacing was determined not to be a significant factor in this study, observations during mid-day surveys indicated that surface light penetrated beneath the dock through the spaces in the planks.

In summary, there is a lot of evidence indicating that docks affect the aquatic environment; however, scientific studies documenting these effects are limited. We conducted a study in June and July 2007 to determine the effects of docks on the density (the number of stems of vegetation per m^2) and diversity (the number of different species) of SAV in Lakes Butler and Jessamine in Orange County, Florida. The results of our study indicated that SAV density was most influenced by the amount of sunlight that reached the vegetation underwater. The diversity of SAV was most affected by the clearness of the lake water, which is influenced by water quality. The higher SAV diversity observed in Lake Butler was because of its superior water quality and lower nutrient levels as compared to Lake Jessamine. Similar to previous studies, this study documented a decrease in sunlight under docks, with a related decrease in plant density. In addition, the density of SAV was higher under docks that faced east/west as compared to those facing north/south in both lakes.

1.0 INTRODUCTION

With each new request for a dock permit, concerns about the cumulative impacts of dock proliferation along the coasts and shorelines seem to have increased (NOAA 2001, Sanger and Holland 2002, Kelty and Bliven 2003, Alexander and Robinson 2004, 2006). Regulatory agencies responsible for managing docks, including the Orange County Environmental Protection Division, are increasingly being required to defend their dock permitting guidelines and policies. An improved understanding of the individual and cumulative effects of residential docks should result in better aquatic management to help ensure that additional docks do not harm the environment, but still provide waterfront property owners reasonable access to the water (Kelty and Bliven 2003). Therefore, Biological Research Associates (BRA) was contracted by the Orange County Environmental Protection Division to conduct this study.

The numbers of requests for permits to construct docks along the coasts and shores in marine, estuarine, and freshwater ecosystems have increased in recent years (Sanger and Holland 2002, Kelty and Bliven 2003, Alexander and Robinson 2004, 2006, Sanger et al. 2004a, Garrison et al. 2005). Population growth, a strong economy, increased discretionary spending, increased boat sales, and limited mooring and public docking facilities have all contributed to this trend.

There is considerable evidence that docks intercept sunlight, alter patterns of water flow, introduce chemicals into the environment, and impact public access and navigation (Kelty and Bliven 2003). The vessels using docks also affect resources to varying degrees. However, scientific investigations and resulting literature quantifying the biological effects associated with the individual and cumulative impacts of docks are limited (Kelty and Bliven 2003). The majority of the studies that have been conducted to assess the impacts of docks on submerged or emergent vegetation have been conducted in estuarine ecosystems (Kearney et al. 1983, Molnar et al. 1989, Fresh et al. 1995, Loflin 1995, Burdick and Short 1999, Shafer 1999, Beal and Schmit 2000, MacFarlane et al. 2000, Fresh et al. 2001, Sanger and Holland 2002, Steinmetz et al. 2003, 2004, Alexander and Robinson 2004, 2006, Sanger et al. 2004a, 2004b). Only one available study has evaluated the effects of docks on littoral zone habitat and communities in freshwater lakes (Garrison et al. 2005). Submerged aquatic vegetation (SAV) provides shore protection from breaking waves; stabilizes soft sediments and reduces turbidity; provides refuge from fish predation; serves as critical shelter, spawning, and nursery habitat; provides food and substrate for algae, bacteria, invertebrates, fish, amphibians, reptiles, and birds; and produces dissolved oxygen required by aerobic organisms (Engel and Pederson 1998, Kelty and Bliven 2003, Garrison et al. 2005).

The purpose of this study was to determine the effects of typical permitted, constructed docks on the density and diversity of SAV within freshwater lakes in Orange County, Florida. The major issues that were considered included whether the amount of light penetrating beneath a dock affected the density and diversity of SAV growing beneath it, and if there were other variables, aside from light penetration, that affected the density and diversity of SAV beneath docks. Recommendations to mitigate the effects of docks on the density and diversity of SAV based on the results of this investigation, as well as previous studies, were also developed.

2.0 METHODS AND MATERIALS

Two lakes in Orange County, Florida with different trophic status classifications were selected for this study: Lake Butler and Lake Jessamine. Lake Butler is one of the Butler Chain of Lakes; this chain of freshwater lakes is classified as Outstanding Florida Waters by the Florida Department of Environmental Protection (FDEP) due to its excellent water quality and wildlife habitat. Lake Butler is an oligotrophic lake, which means it has very clear water, has a sand bottom, maintains high dissolved oxygen concentrations throughout the water column, is nutrient poor, and has low biological productivity (Wetzel 1983). Lake Butler, which is 1,700 acres in size, is located in the Town of Windermere about five miles north of Walt Disney World at Latitude 28.49 North and Longitude 81.55 West in Section 19, Township 23 South, Range 28 East (Map 1 in Appendix A). Lake Jessamine is located approximately five miles south of Downtown Orlando at Latitude 28.48 North and Longitude 81.39 West in Section 14, Township 23 South, Range 29 East (Map 1). This 292-acre lake is classified as mesotrophic/eutrophic. Mesotrophic lakes are in the range between oligotrophic and eutrophic lakes. Mesotrophic lakes have intermediate nutrient availability, with corresponding moderate algal and plant growth and biological activity and intermediate water clarity, while eutrophic lakes have high nutrient levels, high biological productivity, and poor water clarity (Wetzel 1983).

Ten docks and ten reference sites were surveyed in each lake. Docks were selected based on the following criteria: (1) the docks were at least five years old, (2) the docks were permitted by the Orange County Environmental Protection Commission or were of a size and configuration that would be permitted by the Orange County Environmental Protection Commission (Figure 1), (3) docks were selected to be representative of the entire lake, and (4) docks were selected to be representative of all possible orientations. Reference sites were typically selected near surveyed docks. If there was no undisturbed shoreline near a surveyed dock, a reference site was selected in a location of undisturbed shoreline (Figure 2). Reference sites were selected to be representative of the entire lake and to be representative of all possible shoreline orientations.

Surveys were conducted in Lake Butler from 25 June through 27 June 2007, and they were performed in Lake Jessamine on 28 June, 29 June, and 6 July 2007. All docks and reference sites were accessed by boat. Surveys were conducted by a team of two BRA ecologists/water resource analysts and included Ms. Kym Rouse Campbell and Mr. Dan Hammond from 25 through 29 June 2007 and Ms. Campbell and Mr. Mike Reyes on 6 July 2007.

Field water quality measurements were collected at the waterward end of the terminal dock platform at a water depth of 0.5 m. The terminal platform is the part of the dock that is connected to the access walkway, located at the end of the dock, and is designed to secure and load or unload a vessel or conduct other water dependent activities. Water temperature, pH, dissolved oxygen concentration, and specific conductivity were determined using a YSI 6920 multi-parameter water quality sonde. Turbidity was measured with a Hach Turbidimeter Model 2100P. The YSI 6920 was maintained and calibrated for pH and specific conductivity prior to the start of the surveys according to FDEP and YSI protocols

A. B.

Figure 1. Examples of the docks that were surveyed in Lake Butler (A) and Lake Jessamine (B).

A. B.

Figure 2. Examples of reference sites that were surveyed in Lake Butler (A) and Lake Jessamine (B).

and specifications; verification of pH and specific conductivity occurred after the completion of the surveys. The YSI 6920 was calibrated for dissolved oxygen at the start of each survey day, and verification of dissolved oxygen levels occurred at the end of each survey day according to FDEP and YSI protocols and specifications. The Hach Turbidimeter Model 2100P was verified for turbidity at the start and end of each survey day. Similar field water quality information was collected at the waterward end of each reference site.

The water depth and a Secchi disk reading were measured at the waterward end of each dock or reference site. The sediment substrate was characterized under each dock and at each reference site either visually or by collecting a sample by snorkeling. Sub-meter global positioning system (GPS) data were collected at the waterward edge of each dock and reference site using a Trimble Pro XR TDC1. Many 4.0 megapixel digital photographs of each dock and reference site were taken using a Fijifilm FinePix S5100 digital camera.

Levels of irradiance or photosynthetically active radiation (PAR) (µmol/m^2/second) were collected using a LI-192SA underwater quantum sensor attached to a lowering frame connected to a LI-1400 data logger (LI-Cor, Inc., Lincoln, Nebraska). The data logger was set to record the mean PAR level collected over a 30-second period. Levels of PAR were measured on the terminal platform dock surface, just above the water surface under the center of the terminal platform, and underwater under the center of the terminal platform just above the lake bottom or at the top of the SAV sequentially under similar weather/cloud cover conditions. At the center or waterward end of each reference site, PAR levels were measured just above the water surface and underwater just above the lake bottom or at the top of the SAV sequentially under similar weather/cloud cover conditions. The lowering frame with the attached quantum sensor was held from the boat to determine PAR levels on each terminal dock platform surface, and a snorkeler held the lowering frame with the attached quantum sensor for all PAR measurements collected just above the water surface and underwater. Light data under the docks and underwater are presented as a percentage of surface light using a comparison to the almost simultaneous light measurements obtained at the dock or water surface.

Two line transects were set up by snorkelers under the terminal platform of each dock to survey the SAV. The transects ran from the landward to the waterward end of the terminal platform and were equidistant from the dock edge and each other; their length depended on the length of the terminal platform. Each end of the measuring tapes was secured with pink plain wire staff flags. Information on the numbers and species of SAV present was collected using a 0.5-m x 1.0-m (0.5 m^2) PVC rectangular quadrat, with the 1.0-m side placed parallel to the transect and the transect measuring tape in the center of the quadrat. Enough quadrat samples were collected along each transect so that at least 50% of each transect was sampled. The number, percent coverage, and species of SAV found in each quadrat were recorded by snorkelers in Dive Rite underwater notebooks. The same procedure was used to survey the SAV at each reference site. The transect lengths and distances between transects for each reference site were similar to those used to survey the SAV under the terminal platforms of docks and represented the range of different transect lengths and distances.

For each dock, the following measurements were collected: height of terminal dock platform above water, length and width of terminal platform, and dock plank spacing and materials. Additional comments recorded for each dock included: information regarding boathouses and scoured areas, including dimensions; the presence of jet skis and boats; information regarding cleared access corridors; information regarding the associated shoreline and other lakeshore activities; the species of emergent and floating vegetation present around the dock and the associated shoreline; and any other useful or pertinent information. For each reference site, the species of emergent and floating vegetation present were recorded. Fish and wildlife that were seen or heard during surveys were also recorded.

Data were analyzed using JMP® software (SAS Institute 2002). To determine the effects of lake and site type on dock data, reference site data, field water quality data, PAR data, and SAV survey data, data were first cast into a two-way multiple analysis of variance (MANOVA) using lake, site type, and their interaction as factors ($p = 0.05$). Significant effects and interactions were further explored with one-way and two-way analysis of variance (ANOVA) and Tukey multiple comparison procedures ($p = 0.05$). Multiple regression procedures yielding multivariate and Pearson product-moment correlations were used to determine significant correlations ($p = 0.05$) between SAV density and diversity and various light, water quality, and dock parameters.

Diversity indices (Simpson's and Shannon-Wiener) were calculated for SAV data obtained from each surveyed dock and reference site in Lakes Butler and Jessamine using EcoMeth Software (Exeter Software 2003) that is companion to Krebs (1999). Diversity measurements and confidences limits (95%) were calculated by bootstrapping (5,000 iterations). The Simpson's Diversity Index is a nonparametric measure of heterogeneity that makes no assumptions about the shape of the species-abundance curves and places the most weight on the more common species (Krebs 1999). The Shannon-Wiener Diversity Index is a nonparametric measure of heterogeneity based on information theory; it increases with the number of species in the community and usually does not exceed 5.0 for biological communities and places the most weight on the rare species in the community sample (Krebs 1999).

3.0 RESULTS

Available records indicate that 216 docks have been permitted in Lake Butler and 64 docks have been permitted in Lake Jessamine by the Orange County Environmental Protection Division from 1989 through July 2007 (Table 1 in Appendix B). These permits are for new dock construction, as well as for the expansion and reconstruction of existing docks, including docks that were built before permits were required. For Lake Butler, more dock permits were issued in 2004 compared to other years, followed by 1999 and 1998. The highest number of docks permits issued for Lake Jessamine occurred in 1991 and 2005 (Table 1). More homes have been constructed around Lake Butler in recent years (and many homes were observed to be under construction/renovation during the surveys) as compared to Lake Jessamine, which is surrounded by mostly older neighborhoods (although fairly new homes were observed along the northern shoreline during the surveys).

The location of each dock and reference site surveyed in Lake Butler is shown on Maps 2 and 3 in Appendix A, while Map 4 contains the location of each surveyed dock and reference site in Lake Jessamine. With the exception of a cove in the northwest corner of Lake Butler that was avoided deliberately because of previous clearing, filling, and restoration activities, docks and reference sites were surveyed in all areas of the lake (Maps 2 and 3). Docks and reference sites were surveyed in all areas of Lake Jessamine with the exception of areas that were sprayed for the control of hydrilla (*Hydrilla verticillata*) immediately before the surveys, which included the southern coves and portions of the northeastern areas of the lake (Map 4).

Tables 2 through 6 in Appendix B contain information collected for the docks and reference sites surveyed in Lakes Butler and Jessamine. The number used for each surveyed dock is the dock permit number(s) issued by the Orange County Environmental Protection Division, and reference sites for each lake were numbered R-1 through R-10. Two surveyed docks did not have Orange County Environmental Protection Division permit numbers (D-1219 in Lake Butler and D-5143 in Lake Jessamine) (Table 2); this occurred either because the dock was constructed before dock permits were required, or the dock was permitted under a different address, owner, or contractor. Copies of field data sheets for all surveyed docks and reference sites are included in Appendix C, and photographs of each surveyed dock and reference site are included on the CD in Appendix D (this CD also includes electronic files of the report and field data sheets).

Because this study was conducted during Florida's rainy season, afternoon thunderstorms were a daily threat. On the first day of the surveys (25 June 2007), only two surveys could be completed in Lake Butler because of thunderstorms that began at mid-day and continued throughout the afternoon (Tables 2 and 6). Surveys in Lake Jessamine were ended early in the afternoon on 29 June 2007 because of an approaching thunderstorm, and the final two surveys were completed the morning of 6 July 2007 (Tables 2 and 6). Surveys conducted during the mornings were conducted under sunny conditions, and clouds started to build by mid-morning (Tables 2 and 6). Surveys conducted from mid-day on were conducted under partly to mostly cloudy conditions.

Half of the docks surveyed in Lake Butler were oriented either east/west or west/east, while three docks were oriented either southwest/northeast or northeast/southwest (Maps 2 and 3 and Table 2). Two docks surveyed in Lake Butler were oriented south/north or north/south. Two of the reference sites surveyed in Lake Butler were oriented east/west, three were oriented either southwest/northeast or northeast/southwest, one was oriented south/north, and four reference sites were oriented either southeast/northwest or northwest/southeast (Maps 2 and 3 and Table 6). Six of the ten docks surveyed in Lake Jessamine were oriented either east/west or west/east, and four were oriented either north/south or south/north (Map 4 and Table 2). Six of the ten reference sites surveyed in Lake Jessamine were oriented either east/west or west/east, two were oriented either north/south or south/north, one was oriented northwest/southeast, and one reference site was oriented northeast/southwest (Map 4 and Table 6).

The MANOVA of dock data indicated that lake was a significant effect ($F = 4.986$, $p = 0.0002$). The average age of docks surveyed in both lakes was just over nine years (Table 3) and was not significantly different ($F = 0.018$, $p = 0.8940$). The terminal platforms of docks surveyed in Lake Butler were significantly larger than those surveyed in Lake Jessamine ($F = 7.416$, $p = 0.0139$) (Table 3); however, the terminal platforms lengths and widths were not significantly different between lakes ($F = 4.169$, $p = 0.0561$; $F = 1.440$, $p = 0.2457$). Four docks surveyed in Lake Butler had no spacing between planks, while only one dock surveyed in Lake Jessamine had no plank spacing (Table 2). The plank spacing of docks surveyed in Lakes Butler and Jessamine was not significantly different ($F = 3.269$, $p = 0.0873$) (Table 3). The surface of nine docks surveyed in each lake was made of pressure treated wood, while the surface of one dock in each lake was constructed of plastic composite planks (Table 2). The height of the terminal platform above water for docks surveyed in Lake Butler was significantly higher than docks surveyed in Lake Jessamine (F = 103.565, $p < 0.0001$) (Figure 3 and Table 3). The water depth at the waterward end of the terminal platforms of the docks surveyed in Lakes Butler and Jessamine was not significantly different (F = 2.356, p = 0.1422) (Table 3). The average water depth at the waterward end of reference sites in Lakes Butler and Jessamine was not significantly different (1.08 m, 0.91 m, F = 2.217, p = 0.1538); water depths at the waterward end of surveyed reference sites ranged from 0.60 to 1.72 m in Lake Butler and 0.56 to 1.20 m in Lake Jessamine (Table 6). The substrate under all docks surveyed in Lake Butler was sand, while half of the docks surveyed in Lake Jessamine had muck underneath (Table 2). For reference sites in Lake Butler, the substrate type was sand with the exception of one site, and half of the reference sites in Lake Jessamine had muck substrate (Table 6).

All docks surveyed in this study had associated boathouses (Table 4). Of the 20 docks surveyed, only three had empty boathouses. The MANOVA of boathouse dimensions indicated boathouse size was similar in both lakes (F = 0.173, p = 0.2578) (Table 5). The boat in the boathouse was covered with some type of cover at only one dock surveyed in both lakes (Table 4). Scouring was observed under the boathouses in 40 percent of the docks surveyed in Lake Butler, while 70 percent of the docks surveys in Lake Jessamine had scouring under the boathouses (Table 4). Jet skis were present at half of the docks surveyed in Lake Butler and at 30 percent of the docks surveyed in Lake Jessamine. Eighty percent of the docks surveyed in Lake Butler had associated access corridors, and thirty percent of the docks surveyed in Lakes Jessamine had access corridors associated with them (Table 4). All of the docks surveyed in Lake Butler had beaches or sandy areas associated with them, while only half of the docks surveyed in Lake Jessamine had associated beaches.

A.

B.

Figure 3. Docks surveyed in Lake Butler (A) were significantly higher ($p < 0.05$) above the water than docks surveyed in Lake Jessamine (B).

With the exception of one dock in Lake Butler, all docks surveyed had associated emergent vegetation either adjacent to the shoreline or adjacent to the dock (Table 4). Seven species of emergent or floating-leaved vegetation were associated with the docks surveyed in Lake Butler, while eight species were associated with Lake Jessamine docks (Tables 4 and 7). Softrush (*Juncus* spp.) and water pennywort (*Hydrocotyle* spp.) were found only around Lake Butler docks, while soft-stem bulrush (*Scirpus validus*), cattail (*Typha* spp.), and duck potato (*Sagittaria lancifolia*) were associated only with Lake Jessamine docks. Eleven species of emergent or floating-leaved vegetation were associated with Lake Butler reference sites, while nine species were associated with reference sites surveyed in Lake Jessamine (Tables 6 and 7). Saw-grass (*Cladium jamaicense*), water pennywort, softrush, maidencane (*Panicum hemitomon*), and sand cordgrass (*Spartina bakeri*) were found only at Lake Butler reference sites, and soft-stem bulrush, primrose willow (*Ludwigia peruviana*), and willow (*Salix* spp.) were found only at reference sites surveyed in Lake Jessamine (Table 7). All species of emergent vegetation that were associated with docks in each lake were also found at references sites in that particular lake. Saw-grass, sand cordgrass, primrose willow, and willow were associated with reference sites, but were not found at docks (Table 7). The coverage of emergent vegetation was higher at reference sites as compared to docks; however, the higher coverage of emergent vegetation at reference sites did not appear to affect SAV densities.

Field water quality data collected during surveys of docks and references sites in Lakes Butler and Jessamine are presented in Table 8 and summarized in Table 9; both tables are located in Appendix B. The MANOVA of field water quality data indicated that lake was a significant effect ($F = 14.974$, $p < 0.0001$), site type (dock vs. reference site) was not a significant effect ($F = 0.098$, $p = 0.6718$), and the lake-site type interaction was not a significant effect ($F = 0.052$, $p = 0.8909$). Water temperatures obtained during surveys in Lakes Butler and Jessamine were not significantly different ($F = 2.632$, $p = 0.1130$) (Table 9). The pH values recorded during surveys in Lake Jessamine were significantly higher than in Lake Butler ($F = 51.272$, $p < 0.0001$). The dissolved oxygen concentrations measured during surveys in both lakes were not significantly different ($F = 0.686$, $p = 0.4128$). The lowest dissolved oxygen levels obtained during the study were measured at a reference site in Lake Jessamine (R-6) and at a dock in Lake Jessamine (00-207) (Table 8). Specific conductivity values obtained during surveys in Lake Butler were significantly higher than levels measured in Lake Jessamine ($F = 155.726$, $p < 0.0001$). Turbidity levels measured in Lake Jessamine were significantly higher than values obtained in Lake Butler ($F = 23.027$, $p < 0.0001$). The highest turbidity level obtained during this study was recorded at a reference site in Lake Jessamine (R-6), the same site where the lowest dissolved oxygen level was recorded (Table 8). Secchi disk readings for Lake Butler were significantly higher than those obtained for Lake Jessamine ($F = 23.680$, $p < 0.0001$) (Table 9).

The irradiance or PAR data obtained for each surveyed dock and reference site is presented in Table 10 and summarized in Table 11 in Appendix B. The percent of surface PAR below surveyed docks in Lake Butler was significantly higher than values calculated for docks surveyed in Lake Jessamine ($F = 5.555$, $p = 0.0300$) (Table 11). The ANOVA of PAR data indicated that lake was a significant effect ($F = 5.961$, $p < 0.0197$), site type was a significant effect ($F = 131.727$, $p < 0.0001$), and the lake-site type interaction was not a significant effect ($F = 1.095$, $p = 0.3024$). Therefore, the percent of surface PAR just above the SAV/bottom obtained for docks and reference sites was significantly higher in Lake Butler as compared to Lake Jessamine ($p < 0.05$) (Table 11 and Figure 4). In addition, the percent of surface PAR just above the SAV/bottom was significantly higher at reference sites as compared to docks in both lakes ($p < 0.05$). Compared to the other surveyed docks, the percent of surface PAR just above the SAV/bottom was highest at Lake Butler Dock D-1219 (Table 10); this was because the survey was conducted early in the morning when the angle of the sun was low, allowing a large amount of light to penetrate under the dock from the east.

Information regarding the transects used to conduct the SAV surveys at each dock and reference site in Lakes Butler and Jessamine is presented in Table 12 and summarized in Table 13; both tables are located in Appendix B. The MANOVA of SAV transect information indicated that lake was a significant effect ($F = 0.597$, $p = 0.0032$), site type was not a significant effect ($F = 0.146$, $p = 0.3270$), and the lake-site type interaction was not a significant effect ($F = 0.088$, $p = 0.5827$). The length of transects for Lake Butler surveys was significantly longer than transect length for surveys conducted in Lake Jessamine ($F = 13.063$, $p = 0.0009$) (Table 13). The distance between transects and the dock or reference site edge was not significantly different for SAV surveys conducted in Lakes Butler and Jessamine ($F = 1.243$, $p = 0.2718$). The number of quadrats sampled along each transect was significantly higher for Lake Butler surveys compared to Lake Jessamine surveys ($F = 8.647$, $p = 0.0055$), and the percent of each transect sampled was significantly higher for surveys conducted in Lake Jessamine as compared to Lake Butler surveys ($F = 8.667$, $p = 0.0055$) (Table 13). The total area sampled for the SAV surveys was significantly higher in Lake Butler as compared to Lake Jessamine ($F = 10.329$, $p = 0.0027$). For both lakes, transect sites were similar for docks and reference sites.

Six species of SAV were found in both lakes: coontail (*Ceratophyllum demersum*), eelgrass (*Vallisneria americana*), hydrilla, Illinois pondweed (*Potamogeton illinoensis*), leafy bladderwort (*Utricularia foliosa*), and stonewort (*Nitella* spp.) (Tables 14 and 15 in Appendix B). Lemon bacopa (*Bacopa caroliniana*), muskgrass (*Chara* spp.), and southern naiad (*Naja guadalupensis*) were found only in Lake Butler, while spikerush (*Eleocharis* spp.) was observed only in Lake Jessamine. The SAV in Lake Butler was thin and small compared to the SAV that occurred in Lake Jessamine, which was often very large, very dense, and grew to the lake surface (Figure 4).

The diversity indices calculated from SAV data obtained from surveyed docks and references sites in Lakes Butler and Jessamine are presented in Table 16, located in Appendix B. Diversity indices could not be calculated for one dock in Lake Butler, two docks in Lake Jessamine, and three reference sites in Lake Jessamine either because no SAV was found during a survey, only one species of SAV was present during a survey, or not enough SAV was found during a survey.

Table 17, located in Appendix B, includes summary data resulting from the SAV surveys conducted at docks and reference sites in both lakes. The MANOVA of SAV data indicated that lake was a significant effect ($F = 1.897$, $p < 0.0001$), site type was a significant effect ($F = 0.663$, $p = 0.0045$), and the lake-site type interaction was a significant effect ($F = 0.728$, $p = 0.0026$). The total number of SAV

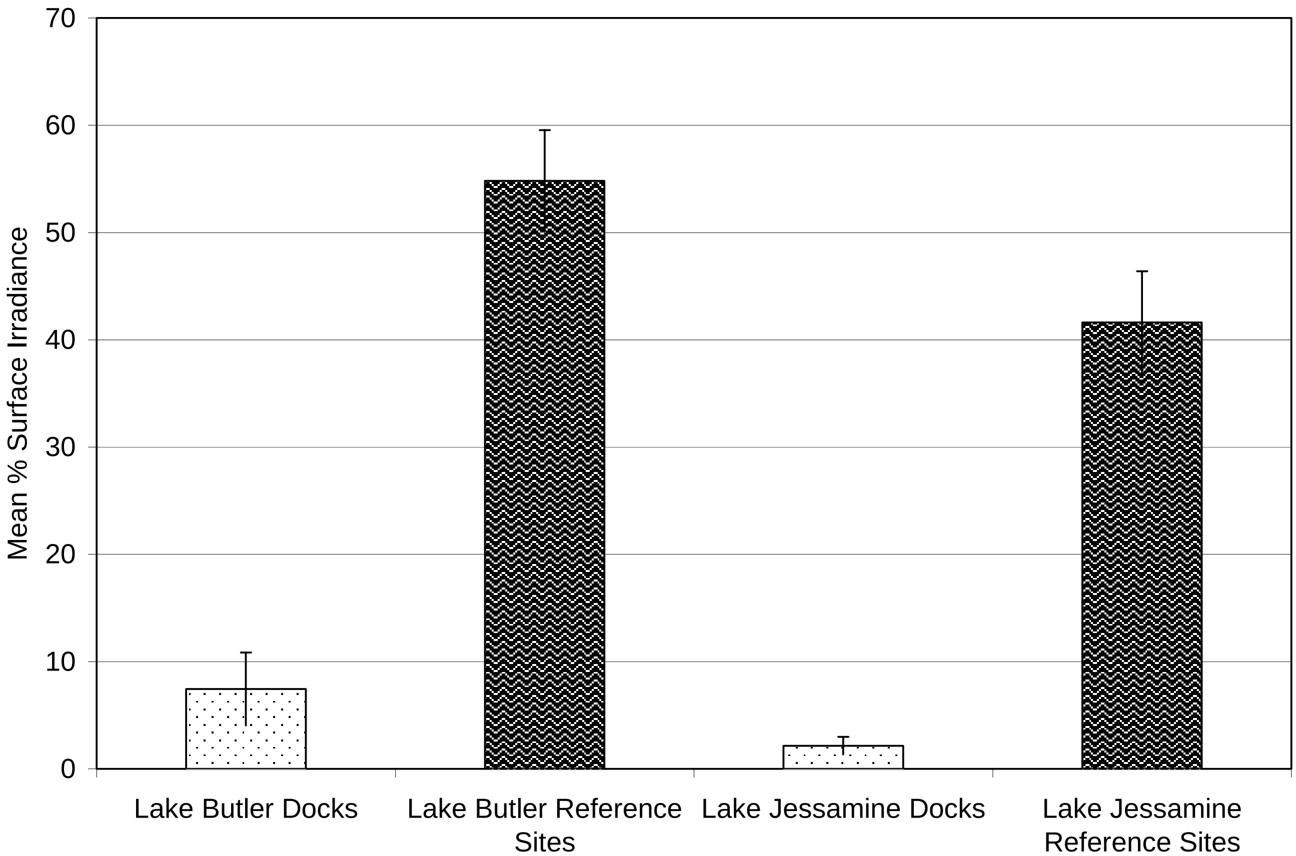

Figure 4. The mean percent surface irradiance just above the SAV/bottom for Lake Butler docks (n = 10), Lake Butler reference sites (n = 10), Lake Jessamine docks (n = 10), and Lake Jessamine reference sites (n = 10), Orange County, Florida, 25 June Through 6 July 2007. Error bars represent the standard error.

A.

B.

Figure 5. Differences in the size of SAV in Lake Butler (A) and Lake Jessamine (B).

species found during surveys was not significantly different between docks and reference sites ($F = 0.306$, $p = 0.5833$); however, the total number of SAV species observed in Lake Butler was significantly higher than the total number found in Lake Jessamine ($F = 9.298$, $p = 0.0043$) (Table 17). There was a significant difference between the total number of SAV individuals found at Lake Butler docks, Lake Butler reference sites, Lake Jessamine docks, and Lake Jessamine reference sites (Lake: $F = 24.709$, $p < 0.0001$; Site Type: $F = 16.372$, $p = 0.0003$; Lake-Site Type: $F = 9.929$, $p = 0.0033$) (Table 17). There was a significant difference between the density or the total number of stems of SAV/m^2 observed at Lake Butler docks, Lake Butler reference sites, Lake Jessamine docks, and Lake Jessamine reference sites (Lake: $F = 21.844$, $p < 0.0001$; Site Type: $F = 16.051$, $p = 0.0003$; Lake-Site Type: $F = 7.599$, $p = 0.0091$) (Table 17). The density of SAV was highest at Lake Butler reference sites, followed by Lake Butler docks, Lake Jessamine reference sites, then Lake Jessamine docks. The total percent coverage of SAV observed during surveys was not significantly different between lakes ($F = 1.207$, $p = 0.2792$), but the total percent coverage of SAV found during surveys was significantly higher in reference sites as compared to docks ($F = 17.946$, $p = 0.0002$) (Table 17).

Simpson’s and Shannon-Wiener Diversity Index values were significantly higher in Lake Butler compared to values calculated for Lake Jessamine (Simpson’s: $F = 8.668$, $p = 0.0056$; Shannon-Wiener: $F = 10.068$, $p = 0.0031$); however, there was no significant difference in Simpson’s and Shannon-Wiener Diversity Index values calculated for docks and reference sites (Simpson’s: $F = 0.828$, $p = 0.3691$; Shannon-Wiener: $F = 0.194$, $p = 0.6624$). There was a significant difference in the Simpson’s and Shannon-Wiener Diversity Index values calculated for Lake Butler docks, Lake Butler reference sites, Lake Jessamine docks, and Lake Jessamine reference sites (Simpson’s: $F = 16.791$, $p = 0.0002$; Shannon-Wiener: $F = 14.196$, $p = 0.0006$) (Table 17). Calculated diversity index values were highest for Lake Butler reference sites, followed by Lake Jessamine docks and Lake Butler docks, and lowest for Lake Jessamine reference sites.

The results of the analyses described above are summarized in Table 18. Those parameters determined to have ecological significance included the height of the dock terminal platform above water, the pH, specific conductivity, turbidity, Secchi disk readings, and the percent of surface light or PAR just above the SAV/bottom. The differences in parameters related to transect size and the area sampled for SAV between lakes were due to the fact that the terminal platforms of the docks surveyed in Lake Butler were significantly larger ($p < 0.05$) than those surveyed in Lake Jessamine. The ecologically significant parameters were subjected to the additional analyses described below to determine their effects on SAV density and diversity.

For surveyed docks and reference sites in Lakes Butler and Jessamine, the variable that had the most influence on SAV density (the number of stems SAV/m^2) was the percent surface light or PAR just above the SAV/bottom (Figure 6). SAV density was significantly correlated with the percent of surface light just above the SAV/bottom, as well as with pH and specific conductivity (Table 19). SAV diversity (Simpson’s and Shannon-Wiener Diversity Indices) for surveyed docks and reference sites was most influenced by turbidity (Figure 7). There was a significant correlation ($p < 0.05$) between both SAV diversity indices and turbidity and Secchi disk depth (Table 19).

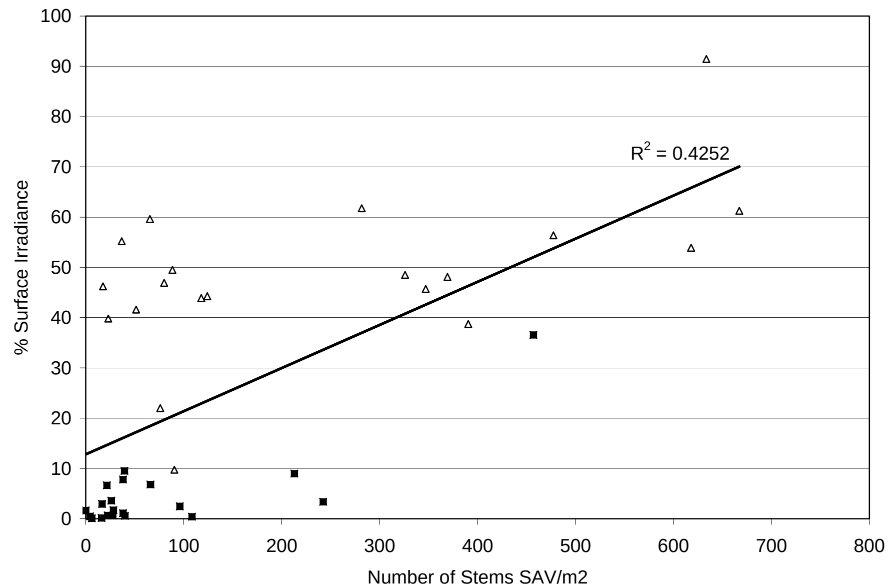

Figure 6. The Relationship Between SAV Density and the Percent Surface Irradiance Just Above the SAV/Bottom for Surveyed Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007. Solid Squares Represent Docks, While Clear Triangles Represent Reference Sites.

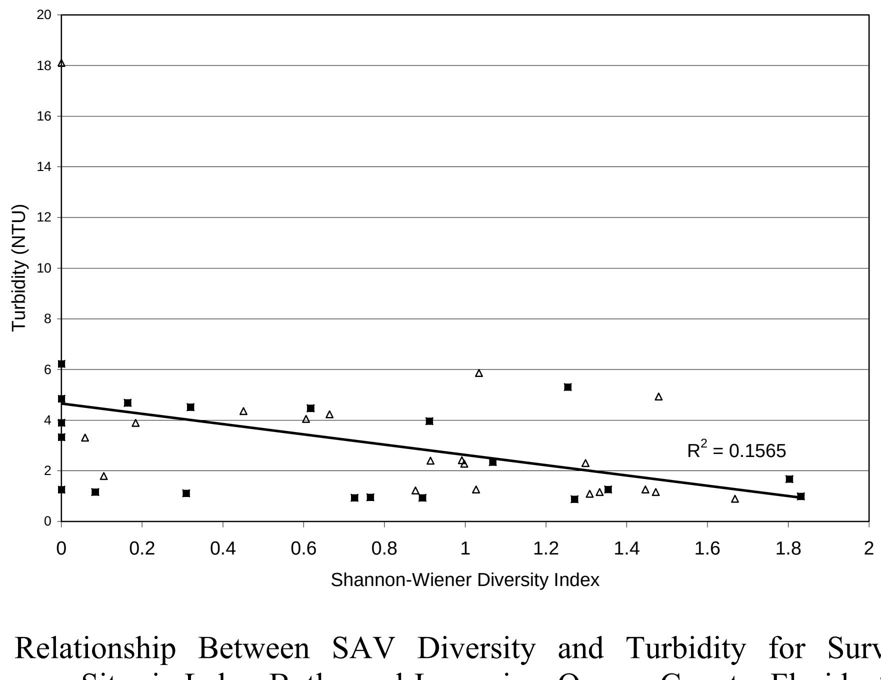

Figure 7. The Relationship Between SAV Diversity and Turbidity for Surveyed Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007. Solid Squares Represent Docks, While Clear Triangles Represent Reference Sites.

For surveyed docks in both lakes, the percent surface light or PAR just above the SAV/bottom most influenced SAV density (Figure 8). SAV density below docks was significantly correlated ($p < 0.05$) with the percent surface light just above the SAV/bottom (Table 20). The correlation between SAV density and the orientation of the dock (docks were re-categorized to be either north/south or east/west, depending on which orientation was most closely represented the orientation of the dock, for further analysis) was close to being statistically significant (Table 20). The SAV density under docks that were oriented north/south (Mean = 156.97 stems SAV/m^2, Range = 0-457 stems SAV/m^2) was significantly higher than the density under docks that were oriented east/west (Mean = 41.37 stems SAV/m^2, Range = 4.5-213 stems SAV/m^2) ($F = 5.261$, $p = 0.0348$). There was a strong positive relationship between SAV density and the height of the dock terminal platform above water (Figure 9 and Table 20). Although not significantly different ($p > 0.05$), shading increased the closer the dock terminal platform was to the water surface (Figure 10). SAV diversity under docks was most influenced by the Secchi disk depth (Figure 11). There was a significant correlation between SAV diversity (as represented by the Shannon-Wiener Diversity Index) and Secchi disk depth (Table 20). The correlation between Simpson's Index Diversity values and Secchi disk depth was almost significant statistically (Table 20).

The wildlife and fish observed or heard during the surveys in Lakes Butler and Jessamine are listed in Table 21. Large numbers of osprey (*Pandion haliaetus*) were observed and heard while conducting surveys in Lake Butler, and many osprey nests were located around the lake. Osprey were also observed while conducting surveys in Lake Jessamine, but not in the large numbers as in Lake Butler. Various wading birds and fish common to Central Florida were seen in both lakes. A raccoon was observed at the Town of Windermere boat ramp in Lake Butler, and pig frogs (*Rana grylio*) were heard calling in Lake Jessamine.

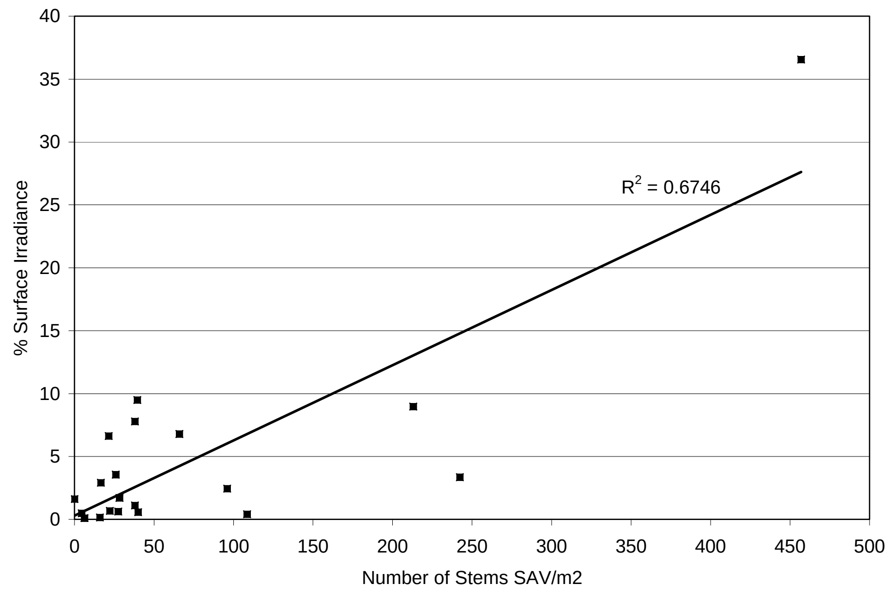

Figure 8. The Relationship Between SAV Density and the Percent Surface Irradiance Just Above the SAV/Bottom for Surveyed Docks in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

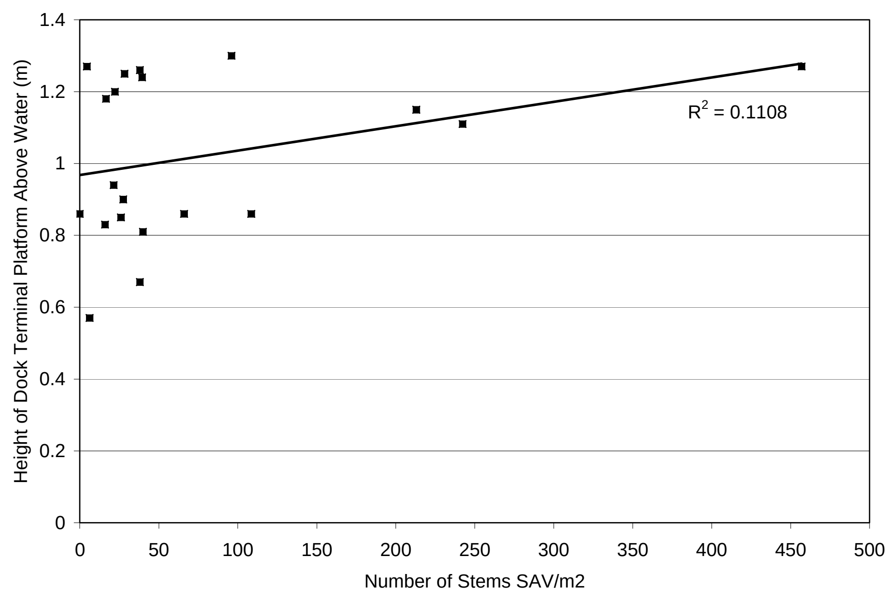

Figure 9. The Relationship Between SAV Density and the Height of the Dock Terminal Platform Above Water for Surveyed Docks in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

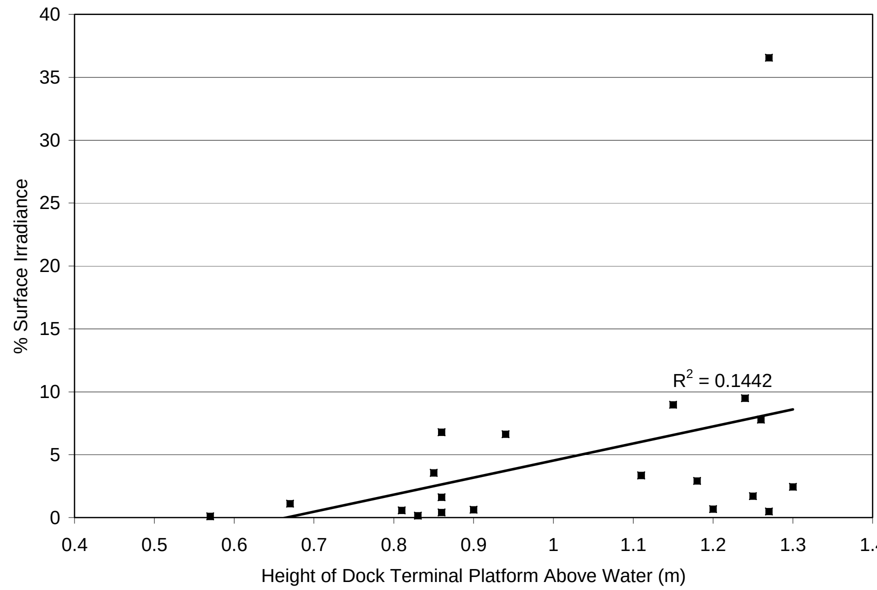

Figure 10. The Relationship the Height of the Dock Terminal Platform Above Water and the Percent Surface Irradiance Just Above the SAV/Bottom for Surveyed Docks in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

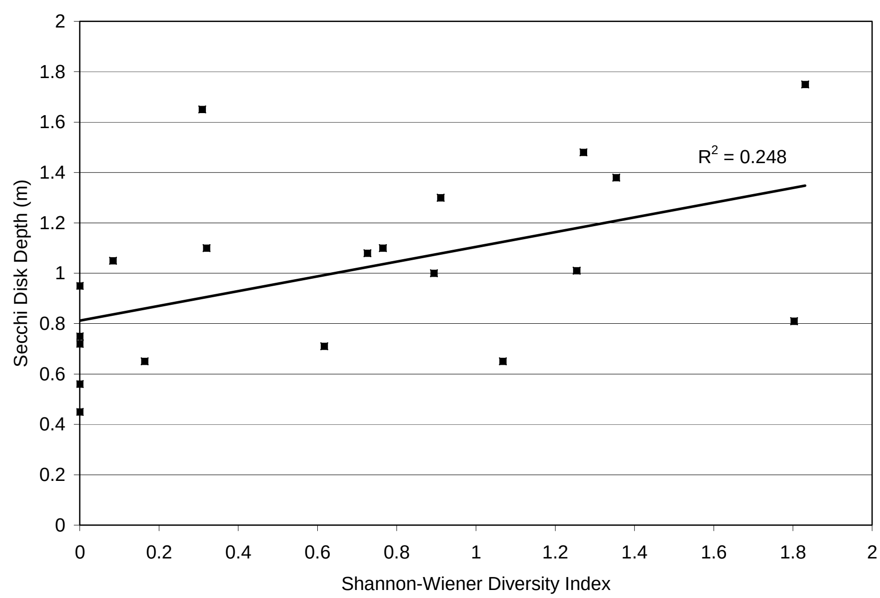

Figure 11. The Relationship Between SAV Diversity and Secchi Disk Depth for Surveyed Docks in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

4.0 DISCUSSION

For this investigation overall, as well as beneath docks, SAV density was most affected by the percent of surface light above the SAV/bottom, while SAV diversity was most affected by the clarity of the water. Overall, turbidity had the most influence on SAV diversity, while Secchi disk depth had the most influence on SAV diversity under docks. Turbidity and Secchi disk depth are both related to the clarity of the water and are affected by water quality; these parameters served as indicators of water quality associated with a surveyed dock or reference site since water quality samples were not collected as part of this investigation. Higher SAV diversity was observed in oligotrophic Lake Butler because of its superior water quality and lower nutrient levels as compared to mesotrophic/eutrophic Lake Jessamine. Recent nutrients levels for Lake Butler are as follows: total nitrogen = 490 µg/l, total phosphorus = 12 µg/l, and chlorophyll = 1 µg/l, and recent levels for Lake Jessamine are: total nitrogen = 784 µg/l, total phosphorus = 8 µg/l, and chlorophyll = 7.9 µg/l (www.orange.wateratlas.usf.edu). Because of the higher nutrient concentrations in Lake Jessamine as compared to Lake Butler, the water is less clear because of the phytoplankton and other suspended particles present in the water column and the lake's higher biological productivity. The high productivity of Lake Jessamine is the cause of the much larger and more robust SAV in Lake Jessamine compared to Lake Butler and is why many areas of Lake Jessamine contain undesirable levels of SAV.

In Lake Jessamine, eelgrass was more commonly observed growing under docks, as compared to Illinois pondweed, the most dominant native SAV species observed in the lake. In two lakes in Southeast Wisconsin, Garrison et al. (2005) found that eelgrass was more common under docks as compared to control areas. Eelgrass is particularly well adapted to growing in low light conditions (Titus and Stephens 1979).

SAV diversity was also affected by the pH of the water, and the significantly higher pH in Lake Jessamine compared to Lake Butler was most likely a result of higher photosynthesis associated with the more productive plant community. Because of the clarity of the water in Lake Butler, the percent of surface light at the SAV/bottom was higher compared to values found for Lake Jessamine.

Similar to previous studies conducted in estuarine ecosystems in Alabama, Georgia, South Carolina, Virginia, Connecticut, and Massachusetts (Kearney et al. 1983, Burdick and Short 1999, Shafer 1999, Sanger and Holland 2002, Alexander and Robinson 2004, 2006, Sanger et al. 2004a, 2006a) and the one available lake study conducted in Wisconsin (Garrison et al. 2005), the results of this study documented a significant reduction in available light under docks with a corresponding significant decrease in plant density or abundance. We found that shading increased the closer the dock terminal platform was to the water surface; therefore, the height of the dock terminal platform above water was a major factor influencing the percent of surface light reaching the SAV/bottom. Garrison et al. (2005) found significant shading under piers with a corresponding reduction in aquatic plant abundance in a study conducted in two lakes in Southeast Wisconsin. In a study conducted in Connecticut, Kearney et al. (1983) found that dock height was the major physical parameter influencing saltmarsh cordgrass (*Spartina alterniflora*) beneath docks. Burdick and Short (1999) found that eelgrass (*Zostera marina*) populations in two estuaries in Massachusetts were impacted under and directly adjacent to docks, as shown by depressed shoot density and canopy structure; they identified dock height as the most important factor affecting light intensities and plant densities, and dock orientation and width were also important factors. Since the widths of the docks surveyed in both lakes were similar, the effect of dock width on light penetration or plant density could not be evaluated in this investigation. Similar to what was found by Burdick and Short (1999), SAV density was significantly higher under docks oriented north/south compared to those oriented east/west in Lakes Butler and Jessamine. In a study conducted in Perdido Bay, Alabama, Shafer (1999) attributed the continued survival of seagrasses under docks to their north/south orientation. While dock plank spacing was determined not to be a significant factor in this study, observations during mid-day surveys indicated that surface light penetrated beneath the dock through the spaces in the planks (Figure 12).

In general, the neighborhoods surrounding Lake Butler are more affluent than those surrounding Lake Jessamine; this could account for the larger docks in Lake Butler compared to those in Lake Jessamine. Because of the larger docks, longer transects and more quadrats were needed to survey the SAV in Lake Butler as compared to the surveys conducted in Lake Jessamine. A higher percentage of the transect area was surveyed for SAV in Lake Jessamine because of the shorter docks compared to Lake Butler.

Observations during the surveys of docks in both lakes indicated that boat traffic around the docks had an effect on the surrounding SAV. Many studies have shown that boat activity associated with docks adversely affects the plant community (Loflin 1995, Burdick and Short 1999, Sanger and Holland 2002). More access corridors were observed around the docks in Lake Butler as compared to Lake Jessamine, and aquatic plants were usually not present in these access corridors. However, the areas around many of the docks in Lake Jessamine were so choked with submerged and floating-leaved vegetation that access into and out of the dock and maintaining an access corridor could be extremely difficult (Figure 13). Compared to Lake Butler, more scouring was observed under the boathouses in Lake Jessamine, and the scoured-out areas were filled with extremely soft sediments. Differences in the amount of scouring observed under boathouses could be due to differences in boat use.

There were fewer beaches associated with docks in Lake Jessamine as compared to Lake Butler. Lake Jessamine is less desirable for swimming than Lake Butler because the water is not as clear and many areas are choked with submerged and floating-leaved vegetation because of the higher nutrient levels. Beaches also have an effect on SAV since swimming activities and beaching boats and jet skis can uproot and damage SAV.

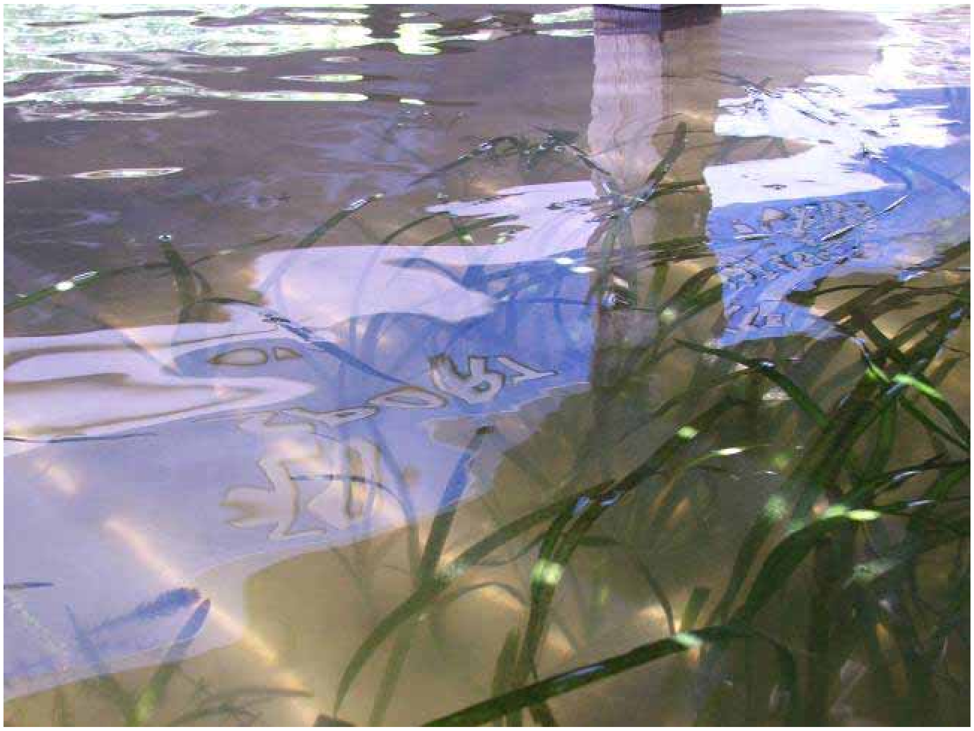

Figure 12. Light Penetrating Beneath a Dock Through the Plank Spaces in Lake Jessamine.

Figure 13. Example of a Dock in Lake Jessamine That is Completely Surrounded by High Densities of Submerged and Floating-Leaved Vegetation.

5.0 RECOMMENDATIONS

Listed below are recommendations to mitigate the effects of docks on SAV density that are based on the results of this investigation, as well as previous studies conducted by others.

1. **Dock Height:** The bottom of the dock should be constructed to be at least 1.3 m (4.3 feet) above the normal high water elevation of the lake for docks oriented north/south (see Item 3 below). Shafer and Lundin (1999) recommend a dock height of 1.52 m (5.0 feet) above mean high water as measured from the top surface of the deck.

2. **Dock Width:** Since all docks surveyed in this investigation were of similar widths, this variable was not evaluated. However, Burdick and Short (1999) identified dock width as an important factor affecting seagrass survival under docks and recommended narrow docks [2-m (6.6-feet) wide or less] over wide docks. Shafer and Lundin (1999) recommended a dock width of no more than 1.2 m (3.9 feet) and a terminal platform width of no more than 1.83 m (6.0 feet) to minimize impacts to seagrasses. Additional investigations of docks of different widths in lakes in Orange County would be necessary to provide additional recommendations on dock width.

3. **Dock Orientation:** To the maximum extent that it is practicable (many property owners have little choice concerning the orientation of the dock since most docks are constructed perpendicular to shore), the dock terminal platform should be oriented north/south. Since the detrimental effects of east/west dock orientation could be at least partially offset by increased dock height, higher minimum height requirements for docks oriented in an east/west direction could enhance SAV survival. Burdick and Short (1999) suggested that poor orientation (east/west) can double the dock height required to support eelgrass in Massachusetts estuaries.

4. **Plank Spacing:** Plank spacing was not a significant variable in this study, but observations during surveys indicated that light penetrated beneath docks through the spacing in the planks. Therefore, spacing in the planks is recommended over planks with no spacing. Shafer and Lundin (1999) recommend the gaps between boards be a minimum of 12.7 mm (0.5 inches) in order to minimize impacts to seagrasses. The results of a study conducted on eelgrass under docks in the Lower St. Johns River indicated that innovative alternatives that increase light beneath docks should be investigated to provide homeowners with additional options for dock construction (Steinmetz et al. 2003, 2004). Terminal platforms constructed of fiberglass grids have been shown to reduce the amount of seagrass loss due to shading by docks and terminal platforms (Shafer and Robinson 2001).

5. **Floating Docks:** Floating docks were not evaluated in the study. However, Burdick and Short (1999) determined that floating docks generally resulted in the complete elimination of seagrass cover. Both Burdick and Short (1999) and Shafer and Lundin (1999) recommended that floating docks should be avoided if possible. However, floating docks with areas of perforated decking to allow sunlight penetration could mitigate this problem. Additional investigations of floating docks in lakes in Orange County would be necessary to provide additional recommendations on floating docks.

6. Boating Impacts: The Orange County Environmental Protection Division regulations on dock construction should be reviewed to determine if revisions could be implemented to minimize the impacts of boat mooring (e.g., additional regulations regarding boathouses and access corridors). In addition, incentives to property owners could be developed to promote the construction of shared docks, which would contribute to reducing the potential cumulative impacts from multiple docks.

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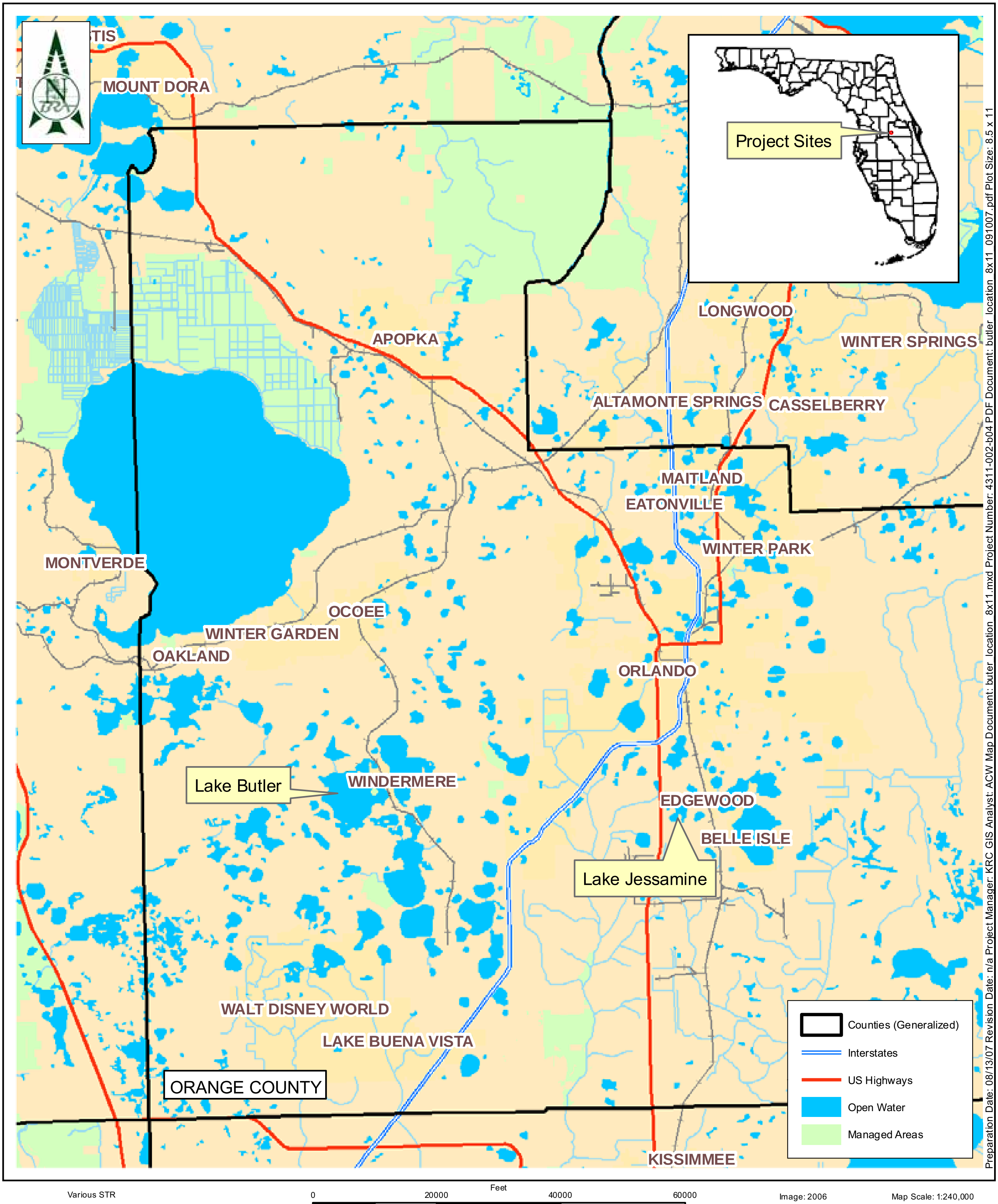
APPENDIX A

Maps



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Map 1.
Locations of Lakes Butler and Jessamine
Orange County, Florida

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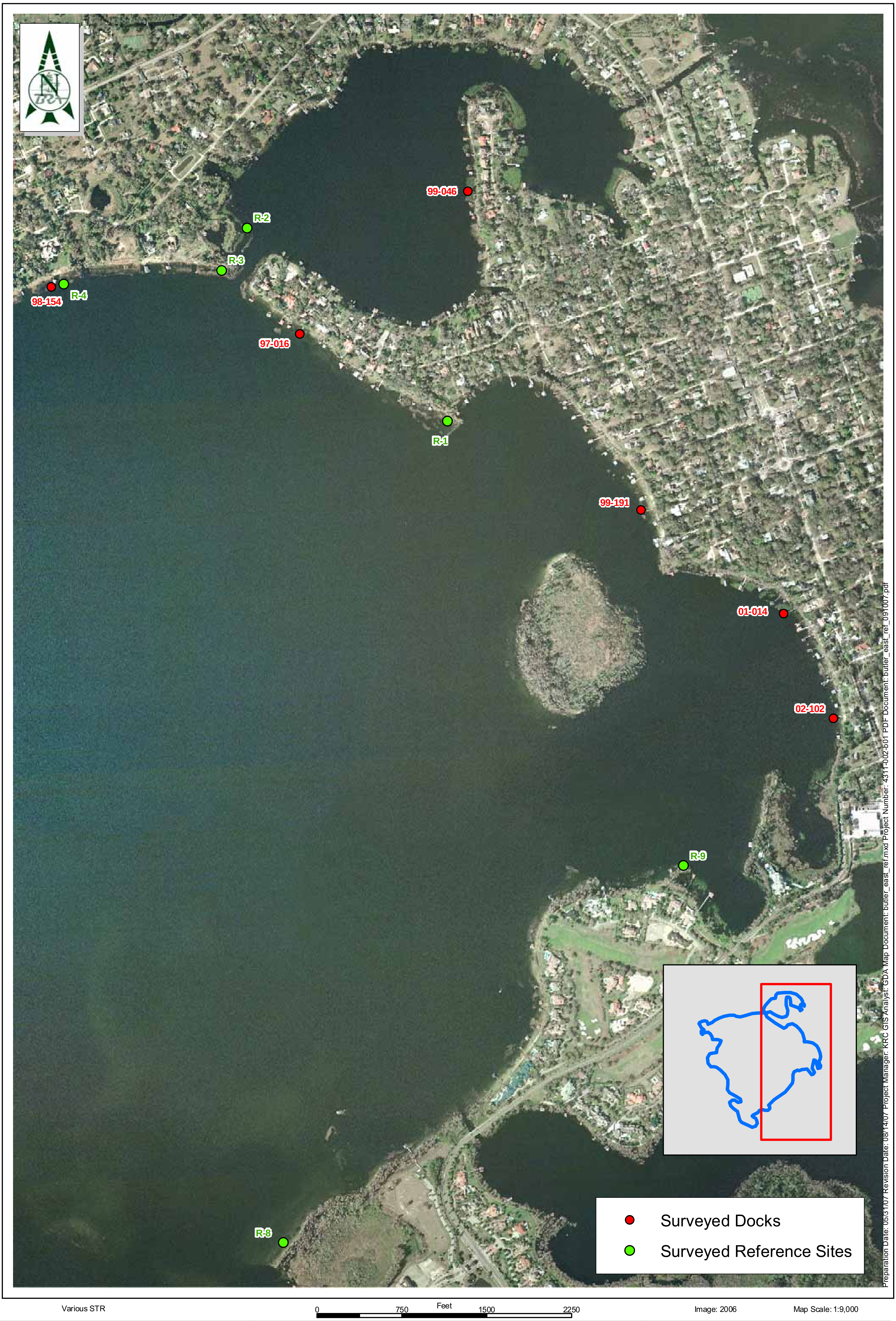

Map 2. Location of Docks and Reference Sites Surveyed in East Lake Butler Orange County, FL 25 June Through 27 June 2007.

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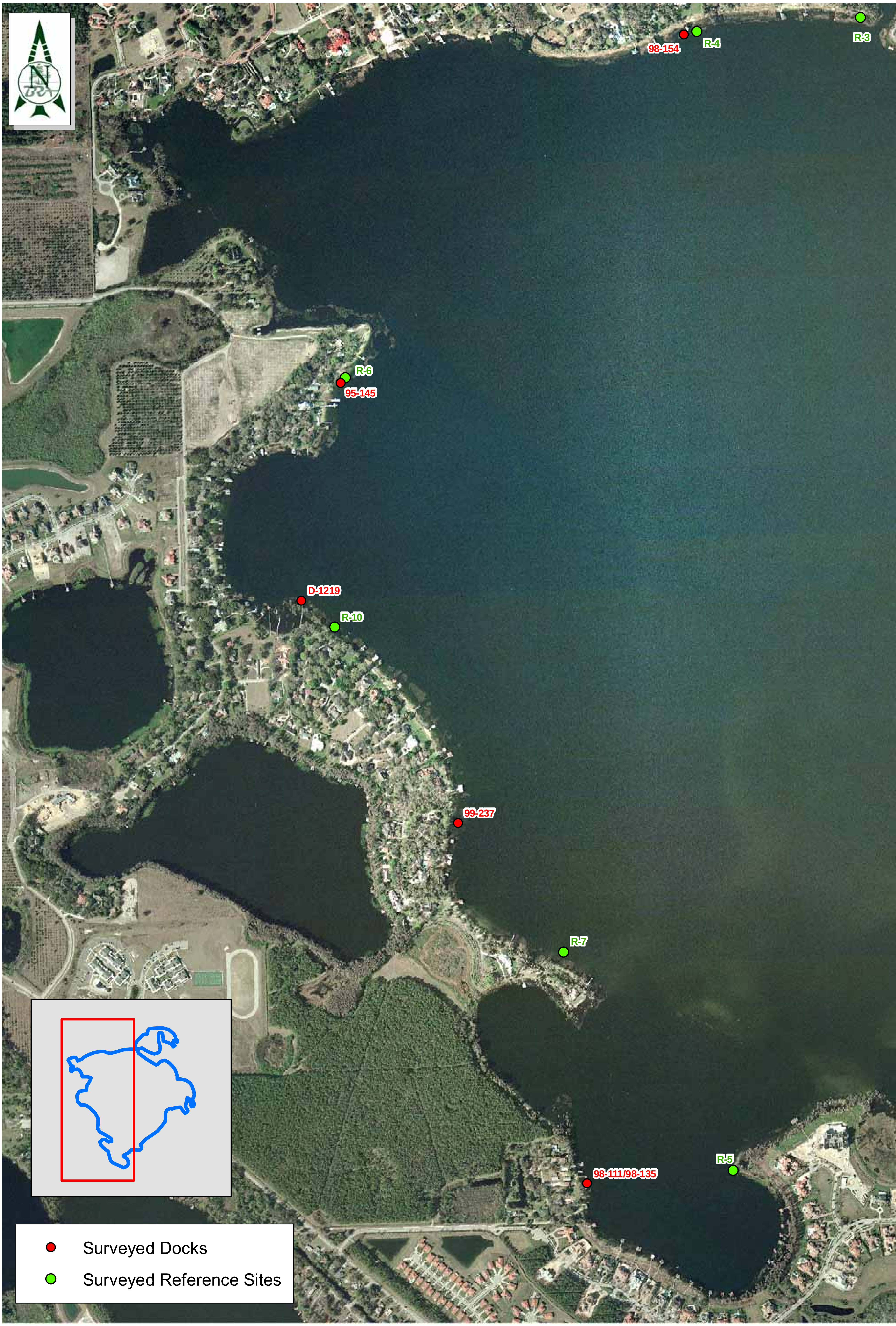

Preparation Date: 05/31/07 Revision Date: 08/14/07 Project Manager: KRC GIS Analyst: GDA Map Document: butler_west_ref.mxd Project Number: 4311-002-001 PDF Document: butler_west_ref_091007.pdf

Various STR

Feet: 0 750 1500 2250

Image: 2006

Map Scale: 1:9,000

Map 3. Location of Docks and Reference Sites Surveyed in West Lake Butler Orange County, FL 25 June Through 27 June 2007

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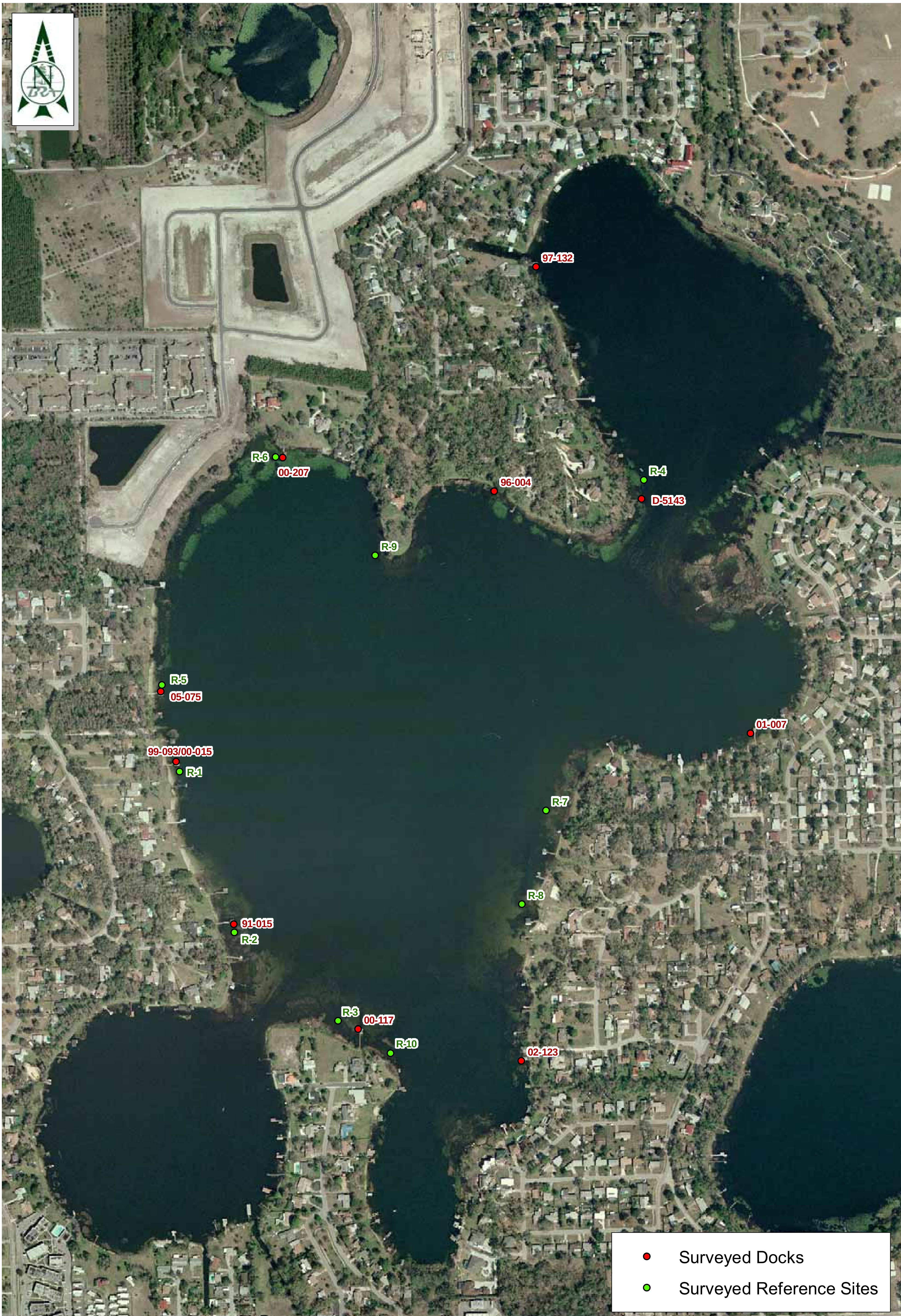

Preparation Date: 05/31/07 Revision Date: 08/14/07 Project Manager: KRC GIS Analyst: GDA Map Document: jessamine_docks_ref.mxd Project Number: 4311-002-b01 PDF Document: jessamine_docks_ref_091007.pdf

Various STR

Feet 0 500 1000 1500

Image: 2006

Map Scale: 1:6,000

Map 4. Location of Docks and Reference Sites Surveyed in Lake Jessamine Orange County, FL 28 June Through 6 July 2007

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APPENDIX B

Tables

Table 1. Dock Permits Issued by Orange County Environmental Protection Division for Lakes Butler and Jessamine, Orange County, Florida.

Year	Lake Butler	Lake Jessamine
1989	6	2
1990	0	0
1991	0	8
1992	0	5
1993	0	2
1994	0	1
1995	6	2
1996	10	3
1997	13	4
1998	24	1
1999	25	2
2000	19	6
2001	10	3
2002	17	5
2003	13	2
2004	30	5
2005	20	8
2006	14	3
2007 (Through July)	9	2
Total	**216**	**64**

Table 2. Information for Each Dock Surveyed in Lakes Butler and Jessamine, Orange County Florida, 25 June Through 6 July 2007.

Dock Number	Dock Address	Survey Date	Survey Start/End Time	Weather	Age of Dock	Latitude	Longitude	Dock Orientation	Dock Terminal Platform Length (m)	Dock Terminal Platform Width (m)	Dock Terminal Platform Size (m^2)	Dock Plank Spacing (mm)	Plank Materials	Height of Dock Terminal Platform Above Water (m)	Water Depth at Waterward End (m)	Substrate Type
Lake Butler																
99-191	536 Butler Street, Windermere, FL 34786	25 June 2007	9:45/10:45	Partly Cloudy	8	28.49340982	-81.53851078	Southwest/Northeast	9.24	3.70	34.19	0	Pressure Treated Wood	1.18	1.05	Sand
97-016	930 W. 2nd Avenue, Windermere, FL 34786	25 and 26 June 2007	14:00/14:30 and 8:10/8:45	Overcast, Just After Storms, More Storms Building/Sunny	10	28.49784778	-81.54782149	Southwest/Northeast	6.00	4.90	29.40	0	Pressure Treated Wood	1.11	0.95	Sand
99-046	20 Pine Street, Windermere, FL 34786	26 June 2007	9:00/9:50	Sunny/Partly Cloudy	9	28.50122240	-81.54310546	West/East	7.15	4.39	31.39	0	Pressure Treated Wood	1.27	1.38	Sand
98-154	11800 Lake Butler Boulevard, Windermere, FL 34786	26 June 2007	11:35/12:05	Partly Sunny	9	28.49924824	-81.55440183	South/North	7.40	4.20	31.08	0	Pressure Treated Wood	1.3	1.10	Sand
02-102	1036 Main Street, Windermere, FL 34786	26 June 2007	13:10/13:50	Partly Sunny, Storms Building	5	28.48827755	-81.53332190	West/East	3.90	4.30	16.77	6	Plastic Composite	1.24	1.08	Sand
98-111/98-135	12048 Sandy Shores Drive, Windermere, FL 34786	26 June 2007	14:20/15:00	Mostly Cloudy/Partly Sunny	9	28.47227655	-81.55781719	East/West	2.90	4.10	11.89	8	Pressure Treated Wood	1.15	1.00	Sand
01-014	836 Main Street, Windermere, FL 34786	26 June 2007	15:50/16:30	Sunny/Partly Cloudy	6	28.49083313	-81.53463409	Southwest/Northeast	7.40	4.10	30.34	2	Pressure Treated Wood	1.2	1.75	Sand
D-1219	1219 Kelso Boulevard, Windermere, FL 34786	27 June 2007	8:15/9:00	Sunny	17	28.48604623	-81.56509769	North/South	6.00	4.20	25.20	10	Pressure Treated Wood	1.27	1.65	Sand
99-237	1437 Kelso Boulevard, Windermere, FL 34786	27 June 2007	9:10/10:00	Sunny	8	28.48077030	-81.56105943	East/West	7.30	4.12	30.08	6	Pressure Treated Wood	1.25	1.48	Sand
95-145	12404 Summerport Lane, Windermere, FL 34786	27 June 2007	10:10/10:40	Partly Cloudy	12	28.49111050	-81.56394266	East/West	3.34	4.24	14.16	6	Pressure Treated Wood	1.26	0.81	Sand
Lake Jessamine																
99-093/00-015	5409 Lake Jessamine Drive, Orlando, FL 32839	28 June 2007	8:15/8:50	Sunny	8	28.48166995	-81.38980367	East/West	4.10	4.10	16.81	6	Pressure Treated Wood	0.85	1.20	Muck
91-015	5483 Alandale Court, Orlando, FL 32839	28 June 2007	9:45/10:15	Partly Cloudy	16	28.47912362	-81.38884557	East/West	7.33	4.60	33.72	8	Pressure Treated Wood	0.57	0.65	Muck
00-117	705 Padgett Court, Orlando, FL 32839	28 June 2007	11:00/11:30	Partly Cloudy	7	28.47745310	-81.38669886	North/South	3.75	4.80	18.00	6	Pressure Treated Wood	0.67	0.72	Sand
97-132	5401 Jessamine Lane, Orlando, FL 32839	28 June 2007	12:35/13:05	Partly Cloudy, Storms Building, Showers During Survey	10	28.48922808	-81.38326720	East/West	6.00	3.00	18.00	5	Pressure Treated Wood	0.81	1.22	Sand
96-004	5558 Jessamine Lane, Orlando, FL 32839	28 June 2007	13:20/13:55	Mostly Cloudy, Showers Ending	11	28.48575667	-81.38408894	South/North	2.90	4.25	12.33	4	Pressure Treated Wood	0.86	1.72	Muck
D-5143	5143 Cranes Point Court, Orlando, FL 32839	28 June 2007	14:10/14:35	Partly Sunny	9	28.48559549	-81.38149412	East/West	2.89	4.38	12.66	6	Pressure Treated Wood	0.83	0.92	Muck
05-075	5347 Lake Jessamine Drive, Orlando, FL 32839	29 June 2007	8:15/8:55	Sunny	12	28.48276198	-81.39004903	East/West	2.54	3.70	9.40	0	Plastic Composite	0.94	1.00	Muck/Sand
00-207	5526 Jessamine Lane, Orlando, FL 32839	29 June 2007	9:30/10:00	Sunny	7	28.48635020	-81.38781318	South/North	2.90	4.12	11.95	10	Pressure Treated Wood	0.86	0.65	Sand
01-007	501 Rockwood Lane, Orlando, FL 32839	29 June 2007	10:45/11:25	Partly Cloudy	6	28.48191748	-81.37966275	North/South	7.47	2.60	19.42	10	Pressure Treated Wood	0.9	1.30	Sand
02-123	430 Bywater Drive, Orlando, FL 32839	29 June 2007	12:35/13:10	Mostly Cloudy, Storms Building	5	28.47690275	-81.38382553	West/East	2.20	3.85	8.47	14	Pressure Treated Wood	0.86	0.45	Sand

Table 3. Summary Descriptive Information Regarding Docks Surveyed in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

	Mean (Range) Dock Age (Years)	Mean (Range) Dock Terminal Platform Length (m)	Mean (Range) Dock Terminal Platform Width (m)	Mean (Range) Dock Terminal Platform Size (m^2)	Mean (Range) Plank Spacing (mm)	Mean (Range) Height of Dock Terminal Platform Above Water (m)	Mean (Range) Water Depth at Waterward End (m)
Lake Butler Docks (n=10)	9.3 (5-17)	6.06 (2.90-9.24)	4.23 (3.70-4.90)	25.45 (11.89-34.19)	3.8 (0-10)	1.22 (1.11-1.30)	1.23 (0.81-1.75)
Lake Jessamine Docks (n=10)	9.1 (5-16)	4.21 (2.20-7.47)	3.94 (2.60-4.80)	16.07 (8.47-33.72)	6.9 (0-14)	0.82 (0.57-0.94)	0.98 (0.45-1.72)

Table 4. Additional Information for Each Dock Surveyed in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

Dock Number	Boathouse Length (m)	Boathouse Width (m)	Boathouse Size (m^2)	Orientation of Boathouse to Dock	Boat in Boathouse	Boat Covered	Scouring in Boathouse	Jet Skis Present	Access Corridor	Shoreline Type	Emergent Vegetation Present
Lake Butler											
99-191	9.24	2.30	21.25	Southeast	Yes	Yes	Yes	Yes	Yes	Beach	Maidencane
97-016	8.80	6.60	58.08	Northwest	No	No	No	No	No	Beach/Seawall	
99-046	7.10	3.70	26.27	South	Yes	No	Yes	Yes	Yes	Beach/Seawall	Maidencane, White Water-Lily
98-154	7.40	4.30	31.82	West	No	No	No	Yes	Yes	Beach	Maidencane, Torpedograss
02-102	7.20	4.20	30.24	South	Yes	No	Yes	Yes	No	Beach/Seawall	Softrush
98-111/98-135	7.20	3.20	23.04	South	Yes	No	No	No	Yes	Beach	Torpedograss
01-014	7.40	3.90	28.86	Northwest	Yes	No	No	No	Yes	Beach/Seawall	Torpedograss, White Water-Lily, Spatterdock, Softrush
D-1219	7.88	3.56	28.05	Northwest	Yes	No	No	No	Yes	Sand/Vegetated	Maidencane, Torpedograss, Pickerelweed
99-237	7.30	4.15	30.30	South	Yes	No	Yes	Yes	Yes	Sand/Vegetated	Maidencane, Torpedograss, Softrush
95-145	7.48	3.35	25.06	North	Yes	No	No	No	Yes	Sand/Vegetated	Maidencane, Torpedograss, Water Pennywort
Lake Jessamine											
99-093/00-015	7.50	3.30	24.75	South	Yes	No	Yes	Yes	No	Sand/Vegetated	Torpedograss, White Water-Lily
91-015	7.30	3.00	21.90	North	Yes	No	Yes	No	No	Muck/Vegetated	Torpedograss, Maidencane, White Water-Lily
00-117	7.65	3.75	28.69	East	Yes	Yes	Yes	Yes	No	Beach	Torpedograss, White Water-Lily, Spatterdock, Soft-Stem Bulrush, Pickerelweed
97-132	8.90	3.10	27.59	North	Yes	No	Yes	No	Yes	Beach	Maidencane, White Water-Lily, Cattail, Soft-Stem Bulrush
96-004	7.50	3.16	23.70	West	No	No	No	No	No	Vegetated	Maidencane, Torpedograss, Cattail
D-5143	7.65	3.44	26.32	South	Yes	No	Yes	No	No	Vegetated	Spatterdock, White Water-Lily, Pickerelweed, Duck Potato
05-075	7.30	3.30	24.09	North	Yes	No	No	No	No	Beach	Torpedograss, White Water-Lily, Spatterdock, Cattail
00-207	7.40	3.19	23.61	East	Yes	No	No	No	No	Vegetated	White Water-Lily, Pickerelweed
01-007	8.98	3.30	29.63	Northeast	Yes	No	Yes	Yes	Yes	Beach	Torpedograss, White Water-Lily, Soft-Stem Bulrush
02-123	7.10	3.00	21.30	North	Yes	No	Yes	No	Yes	Beach	Torpedograss, Pickerelweed, White Water-Lily

Table 5. Summary Information for Boathouses Associated with Docks Surveyed in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

	Mean (Range) Boathouse Length (m)	Mean (Range) Boathouse Width (m)	Mean (Range) Boathouse Size (m^2)
Lake Butler Docks (n=10)	7.70 (7.10-9.24)	3.93 (2.30-6.60)	30.29 (21.25-58.08)
Lake Jessamine Docks (n=10)	7.73 (7.10-8.98)	3.25 (3.00-3.75)	25.16 (21.30-29.63)

Table 6. Information for Each Reference Site Surveyed in Lakes Butler and Jessamine, Orange County Florida, 25 June Through 6 July 2007.

Reference Site Number	Survey Date	Survey Start/End Time	Weather	Latitude	Longitude	Reference Site Orientation	Water Depth at Waterward End (m)	Substrate Type	Shoreline Type	Emergent Vegetation Present
Lake Butler										
R-1	25 June 2007	11:30/12:30	Overcast, Storms Building	28.49566996	-81.54379060	Southwest/Northeast	0.85	Sand	Vegetated	Saw-Grass, Cattail, Pickerelweed, Duck Potato, Water Pennywort, Torpedograss
R-2	26 June 2007	10:05/10:45	Mostly Cloudy	28.50044314	-81.54920902	East/ West	0.85	Muck	Vegetated	Spatterdock, Cattail, Pickerelweed, Softrush
R-3	26 June 2007	10:55/11:25	Mostly Cloudy	28.49942769	-81.54993804	South/North	0.92	Sand	Vegetated	Torpedograss, White Water-Lily, Cattail, Water Pennywort, Softrush
R-4	26 June 2007	12:20/12:50	Mostly Cloudy	28.49916728	-81.55429375	Southeast/Northwest	1.20	Sand	Vegetated	Maidencane, Torpedograss, Water Pennywort
R-5	26 June 2007	15:05/15:35	Partly Cloudy	28.47250894	-81.55392502	Northwest/Southeast	1.10	Sand	Vegetated	Maidencane, Torpedograss, White Water-Lily, Spatterdock, Softrush
R-6	27 June2007	10:50/11:15	Partly Cloudy	28.49123555	-81.56381485	East/ West	0.60	Sand	Vegetated	Torpedograss, Water Pennywort
R-7	27 June2007	11:20/12:05	Partly Cloudy	28.47770440	-81.55832241	Northeast/Southwest	1.27	Sand	Sand/Vegetated	Maidencane, Torpedograss, Water Pennywort, Softrush
R-8	27 June2007	12:20/12:45	Mostly Cloudy	28.47582950	-81.54877103	Northwest/Southeast	1.06	Sand	Sand/Vegetated	Torpedograss, Water Pennywort, Softrush, Sand Cordgrass
R-9	27 June2007	13:10/13:40	Mostly Cloudy	28.48477098	-81.53754004	Northwest/Southeast	1.72	Sand	Sand/Vegetated	Maidencane, White Water-Lily, Softrush
R-10	27 June2007	13:50/14:30	Mostly Cloudy	28.48540168	-81.56423301	Southwest/Northeast	1.27	Sand	Sand/Vegetated	Maidencane, Torpedograss
Lake Jessamine										
R-1	28 June 2007	9:05/9:35	Partly Cloudy	28.48150856	-81.38974919	East/West	1.05	Muck	Sand/Vegetated	Torpedograss, White Water-Lily, Spatterdock, Soft-Stem Bulrush
R-2	28 June 2007	10:25/10:50	Partly Cloudy	28.47899739	-81.38884791	East/West	0.65	Muck/Sand	Muck/Vegetated	Torpedograss, White Water-Lily, Pickerelweed, Cattail
R-3	28 June 2007	11:35/12:15	Partly Cloudy	28.47758668	-81.38704461	North/South	0.56	Sand	Vegetated	Torpedograss, White Water-Lily, Spatterdock, Pickerelweed, Duck Potato, Cattail
R-4	28 June 2007	14:45/15:10	Mostly Cloudy	28.48588075	-81.38144728	East/West	1.20	Muck	Vegetated	Spatterdock, White Water-Lily, Pickerelweed, Duck Potato
R-5	29 June 2007	9:05/9:25	Sunny	28.48285933	-81.39003345	East/West	1.00	Sand	Beach	Torpedograss, White Water-Lily
R-6	29 June 2007	10:10/10:35	Partly Cloudy	28.48636023	-81.38793502	South/North	0.77	Muck	Vegetated	White Water-Lily
R-7	29 June 2007	11:35/12:20	Mostly Cloudy	28.48078655	-81.38329389	Northwest/Southeast	1.01	Sand	Vegetated	Torpedograss, Pickerelweed, Duck Potato
R-8	29 June 2007	13:20/14:00	Mostly Cloudy, Storms Building, Showers During Survey	28.47934069	-81.38375470	West/East	0.70	Sand	Vegetated	Torpedograss, Pickerelweed
R-9	6 July 2007	9:30/10:30	Sunny	28.48479859	-81.38621912	West/East	1.12	Sand/Riprap	Vegetated	Torpedograss, Pickerelweed, Duck Potato
R-10	6 July 2007	10:45/11:45	Sunny	28.47707149	-81.38613502	Northeast/Southwest	1.00	Muck	Vegetated	Torpedograss, Pickerelweed, Duck Potato, Cattail, Water Pennywort, Primrose Willow, Willow

Table 7. Species of Emergent Vegetation Present for Each Surveyed Dock and Reference Site, 25 June Through 6 July 2007, Orange County, Florida.

Emergent Vegetation Observed		Lake Butler		Lake Jessamine	
Common Name	**Scientific Name**	**Dock**	**Reference Site**	**Dock**	**Reference Site**
Cattail	*Typha* spp.		x	x	x
Duck Potato	*Sagittaria lancifolia*		x	x	x
Maidencane	*Panicum hemitomon*	x	x	x	
Pickerelweed	*Pontedaria cordata*	x	x	x	x
Primrose Willow	*Ludwigia peruviana*				x
Sand Cordgrass	*Spartina bakeri*		x		
Saw-grass	*Cladium jamaicense*		x		
Softrush	*Juncus* spp.	x	x		
Soft-Stem Bulrush	*Scirpus validus*			x	x
Spatterdock	*Nuphar lutea*	x	x	x	x
Torpedograss	*Panicum repens*	x	x	x	x
Water Pennywort	*Hydrocotyle* spp.	x	x		
White Water-Lily	*Nymphaea odorata*	x	x	x	x
Willow	*Salix* spp.				x

Table 8. Field Water Quality Data for Each Surveyed Dock and Reference Site, Orange County, Florida, 25 June Through 6 July 2007.

Dock/Reference Site Number	Water Temperature (C)	pH (SU)	Dissolved Oxygen Concentration (mg/l)	Specific Conductivity (mS/cm)	Turbidity (NTU)	Secchi Disk Depth (m)
Lake Butler Docks						
99-191	30.04	7.87	7.36	0.256	1.16	1.05
97-016	30.56	7.76	7.96	0.254	1.25	0.95
99-046	29.77	7.86	7.46	0.256	1.26	1.38
98-154	29.84	7.60	7.46	0.253	0.95	1.10
02-102	30.13	7.65	7.87	0.255	0.93	1.08
98-111/98-135	30.64	7.92	7.77	0.255	0.93	1.00
01-014	29.98	7.49	7.63	0.255	0.99	1.75
D-1219	29.18	7.85	7.21	0.252	1.11	1.65
99-237	29.15	7.77	7.21	0.252	0.87	1.48
95-145	29.29	7.64	7.62	0.253	1.67	0.81
Lake Butler Reference Sites						
R-1	31.07	8.04	8.06	0.256	1.09	0.85
R-2	29.81	7.73	7.80	0.256	1.26	0.85
R-3	29.79	7.58	7.55	0.254	1.26	0.92
R-4	30.34	7.58	7.67	0.254	1.79	1.20
R-5	30.42	7.59	7.70	0.252	2.42	1.10
R-6	29.72	7.84	8.18	0.253	1.22	0.60
R-7	29.40	7.72	7.94	0.253	0.89	1.27
R-8	30.40	8.13	8.57	0.255	2.28	1.06
R-9	30.14	7.67	7.53	0.255	1.16	1.72
R-10	30.87	7.86	8.10	0.256	1.16	1.27
Lake Jessamine Docks						
99-093/00-015	29.43	8.56	6.81	0.230	4.47	0.71
91-015	28.97	8.05	5.08	0.232	2.34	0.65
00-117	30.11	8.61	8.28	0.231	3.33	0.72
97-132	30.67	8.68	8.50	0.232	5.30	1.01
96-004	30.33	8.83	8.67	0.231	3.96	1.30
D-5143	30.90	8.87	9.13	0.232	4.84	0.56
05-075	28.86	8.84	8.00	0.229	3.90	0.75
00-207	28.31	7.72	4.11	0.233	4.68	0.65
01-007	29.16	8.65	8.47	0.230	4.51	1.10
02-123	30.10	8.78	8.98	0.231	6.22	0.45
Lake Jessamine Reference Sites						
R-1	29.53	8.74	8.05	0.228	5.86	0.72
R-2	28.74	8.06	4.01	0.234	2.30	0.65
R-3	30.31	8.77	8.92	0.231	2.40	0.56
R-4	31.26	8.65	9.03	0.233	4.93	0.79
R-5	28.88	8.82	8.23	0.229	3.89	0.75
R-6	27.86	7.17	1.49	0.237	18.10	0.77
R-7	30.15	8.81	8.60	0.230	4.36	0.85
R-8	30.28	8.89	9.09	0.231	4.05	0.70
R-9	29.53	8.62	7.89	0.253	4.23	0.78
R-10	29.61	8.33	5.20	0.255	3.31	0.55

Table 9. Summary Field Water Quality Data for Surveyed Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

	Mean (Range) Water Temperature (C)	Mean (Range) pH (SU)	Mean (Range) Dissolved Oxygen Concentration (mg/l)	Mean (Range) Specific Conductivity (mS/cm)	Mean (Range) Turbidity (NTU)	Mean (Range) Secchi Disk Depth (m)
Lake Butler Docks and Reference Sites (n = 20)	30.03 (29.15-31.07)	7.76 (7.49-8.13)	7.73 (7.21-8.57)	0.254 (0.252-0.256)	1.28 (0.87-2.42)	1.15 (0.60-1.75)
Lake Jessamine Docks and Reference Sites (n = 20)	29.65 (27.86-31.26)	8.52 (7.17-8.89)	7.33 (1.49-9.13)	0.234 (0.228-0.255)	4.85 (2.30-18.10)	0.75 (0.45-1.30)

Table 10. Irradiance or Photosynthetically Active Radiation (PAR) Data for Each Surveyed Dock and Reference Site, 25 June Through 6 July 2007.

Dock/Reference Site Number	PAR at Dock/Reference Surface (µmol/m2/second)	PAR Below Dock Above Water Surface (µmol/m^2/second)	Percent Surface PAR Below Dock	PAR Just Above Submerged Vegetation/Bottom (µmol/m^2/second)	Percent Surface PAR Just Above Submerged Vegetation/Bottom
Lake Butler Docks					
99-191	1,380	32.4	2.35	40.35	2.92
97-016	498.1	16.8	3.37	16.7	3.35
99-046	1,084	18.82	1.74	5.2	0.48
98-154	2,105	40.4	1.92	51.6	2.45
02-102	521.2	41.73	8.01	49.5	9.50
98-111/98-135	514	41.7	8.11	46.1	8.97
01-014	1,894	21.4	1.13	12.7	0.67
D-1219	757.3	52.23	6.90	276.8	36.55
99-237	1,260	19.88	1.58	21.47	1.70
95-145	1,586	53.2	3.35	123.4	7.78
Lake Butler Reference Sites					
R-1	784.5	na	na	347.1	44.24
R-2	695.4	na	na	305.2	43.89
R-3	549.5	na	na	212.9	38.74
R-4	2,318	na	na	1,420	61.26
R-5	2,126	na	na	1,031	48.49
R-6	432.2	na	na	395.2	91.44
R-7	2,017	na	na	1,087	53.89
R-8	2,185	na	na	1,350	61.78
R-9	2,244	na	na	1,265	56.37
R-10	2,252	na	na	1,083	48.09
Lake Jessamine Docks					
99-093/00-015	835.6	15.2	1.82	29.8	3.57
91-015	1,499	2.3	0.15	1.5	0.10
00-117	1,999	12.3	0.62	22.1	1.11
97-132	1,741	8.9	0.51	10.03	0.58
96-004	1,173	13.3	1.13	19.03	1.62
D-5143	2,024	11.8	0.58	3.1	0.15
05-075	756.4	11.3	1.49	50.2	6.64
00-207	1,327	8.5	0.64	5.5	0.41
01-007	1,865	25.9	1.39	11.7	0.63
02-123	518	31.2	6.02	35.2	6.80
Lake Jessamine Reference Sites					
R-1	1,436	na	na	316	22.01
R-2	449	na	na	222.2	49.49
R-3	2,084	na	na	962.8	46.20
R-4	838	na	na	393	46.90
R-5	1,063	na	na	103.6	9.75
R-6	611.8	na	na	279.5	45.68
R-7	2,285	na	na	1261	55.19
R-8	839.9	na	na	334.4	39.81
R-9	1,230	na	na	511.6	41.59
R-10	1,531	na	na	913	59.63

Table 11. Summary of Percent Surface Photosynthetically Active Radiation (PAR) Below Docks and Underwater for Surveyed Docks and Reference Sites, 25 June Through 6 July 2007.

	Mean (Range) Percent Surface PAR Below Dock	**Mean (Range) Percent Surface PAR Just Above Submerged Vegetation/Bottom**
Lake Butler Docks (n=10)	3.84 (1.13-8.11)	7.44 (0.48-36.6)
Lake Butler Reference Sites (n=10)	na	54.82 (38.74-91.44)
Lake Jessamine Docks (n=10)	1.44 (0.15-6.02)	2.16 (0.10-6.79)
Lake Jessamine Reference Sites (n=10)	na	41.62 (9.75-59.63)

Table 12. Submerged Aquatic Vegetation Survey Transect Information for Surveyed Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

Dock/Reference Site Number	Length of Each Transect (m)	Distance Between Transects and Edge of Dock/Reference Site (m)	No. of Quadrats Sampled Along Each Transect	Percent of Each Transect Sampled	Total Area Sampled (m^2)
Lake Butler Docks					
99-191	9.20	1.2	5	54.35	5.0
97-016	6.00	1.6	3	50.00	3.0
99-046	7.10	1.4	4	56.34	4.0
98-154	7.40	1.4	4	54.05	4.0
02-102	4.00	1.4	2	50.00	2.0
98-111/98-135	2.90	1.3	2	68.97	2.0
01-014	7.40	1.3	4	54.05	4.0
D-1219	6.00	1.3	3	50.00	3.0
99-237	7.30	1.3	4	54.79	4.0
95-145	3.34	1.3	2	59.88	2.0
Lake Butler Reference Sites					
R-1	9.00	1.2	5	55.56	5.0
R-2	8.00	1.4	4	50.00	4.0
R-3	7.00	1.4	4	57.14	4.0
R-4	7.00	1.4	4	57.14	4.0
R-5	4.00	1.3	2	50.00	2.0
R-6	4.00	1.3	2	50.00	2.0
R-7	7.00	1.4	4	57.14	4.0
R-8	7.00	1.4	4	57.14	4.0
R-9	6.00	1.4	3	50.00	3.0
R-10	6.00	1.4	3	50.00	3.0
Lake Jessamine Docks					
99-093/00-015	4.10	1.3	3	73.17	3.0
91-015	7.30	1.5	4	54.79	4.0
00-117	3.75	1.6	2	53.33	2.0
97-132	6.00	1	3	50.00	3.0
96-004	2.90	1.4	2	68.97	2.0
D-5143	2.90	1.4	2	68.97	2.0
05-075	2.50	1.3	2	80.00	2.0
00-207	2.90	1.3	2	68.97	2.0
01-007	7.50	0.85	4	53.33	3.0
02-123	2.20	1.3	2	90.91	2.0
Lake Jessamine Reference Sites					
R-1	4.10	1.3	3	73.17	3.0
R-2	7.30	1.5	4	54.79	4.0
R-3	4.00	1.6	2	50.00	2.0
R-4	4.00	1.3	2	50.00	2.0
R-5	3.00	1.3	2	66.67	2.0
R-6	3.00	1.3	2	66.67	2.0
R-7	7.00	0.85	4	57.14	4.0
R-8	2.50	1.3	2	80.00	2.0
R-9	4.00	1.3	2	50.00	2.0
R-10	4.00	1.3	2	50.00	2.0

Table 13. Summary Submerged Aquatic Vegetation Survey Transect Information for Surveyed Docks and Reference Sites in Lake Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

	Mean (Range) Length of Each Transect (m)	**Mean (Range) Distance Between Transects and Edge of Dock/Reference Site (m)**	**Mean (Range) No. of Quadrats Sampled Along Each Transect**	**Mean (Range) Percent of Each Transect Sampled**	**Mean (Range) Total Area Sampled (m^2)**
Lake Butler Docks and Reference Sites (n = 20)	6.28 (2.90-9.20)	1.36 (1.20-1.60)	3.4 (2.0-5.0)	54.33 (50.00-68.97)	3.4 (2.0-5.0)
Lake Jessamine Docks and Reference Sites (n = 20)	4.25 (2.20-7.50)	1.30 (0.85-1.60)	2.6 (2.0-4.0)	63.04 (50.00-90.91)	2.5 (2.0-4.0)

Table 14. Data Obtained During Submerged Aquatic Vegetation (SAV) Surveys for Surveyed Docks and Reference Sites in Lake Butler, Orange County, Florida, 25 Through 27 June 2007.

Dock/ Reference Site Number	No. Coontail	No. Stems Coontail/m^2	Percent Coverage Coontail	No. Eelgrass	No. Stems Eelgrass/m^2	Percent Coverage Eelgrass	No. Hydrilla	No. Stems Hydrilla/m^2	Percent Coverage Hydrilla	No. Illinois Pondweed	No. Stems Illinois Pondweed/m^2	Percent Coverage Illinois Pondweed	No. Leafy Bladderwort	No. Stems Leafy Bladderwort/m^2	Percent Coverage Leafy Bladderwort	No. Lemon Bacopa	No. Stems Lemon Bacopa/m^2	Percent Coverage Lemon Bacopa	No. Muskgrass	No. Stems Muskgrass/m^2	Percent Coverage Muskgrass	No. Southern Naiad	No. Stems Southern Naiad/m^2	Percent Coverage Southern Naiad	No. Stonewort	No. Stems Stonewort/m^2	Percent Coverage Stonewort	Total No. SAV Species	Total No. SAV Individuals	Total No. Stems SAV/m^2	Total Percent Coverage SAV
Docks																															
99-191	0	0.00	0.00	2	0.40	0.10	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	81	16.20	0.49	2	83	16.60	0.59
97-016	0	0.00	0.00	517	172.33	43.08	70	23.33	0.23	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	50	16.67	1.50	90	30.00	0.90	4	727	242.33	45.72
99-046	0	0.00	0.00	18	4.50	1.13	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	1	18	4.50	1.13
98-154	0	0.00	0.00	30	7.50	1.88	20	5.00	0.05	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	258	64.50	5.81	76	19.00	0.57	4	384	96.00	8.30
02-102	0	0.00	0.00	17	8.50	2.13	15	7.50	0.08	1	0.50	0.25	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	1	0.50	0.05	45	22.50	0.68	5	79	39.50	3.17
98-111/ 98-135	0	0.00	0.00	236	118.00	29.50	1	0.50	0.01	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	2	1.00	0.09	187	93.50	2.81	4	426	213.00	32.40
01-014	0	0.00	0.00	20	5.00	1.25	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	69	17.25	1.55	0	0.00	0.00	2	89	22.25	2.80
D-1219	0	0.00	0.00	20	6.67	1.67	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	1351	450.33	13.51	2	1371	457.00	15.18
99-237	0	0.00	0.00	90	22.50	12.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	23	5.75	0.17	2	113	28.25	12.17
95-145	0	0.00	0.00	52	26.00	6.50	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	24	12.00	0.36	2	76	38.00	6.86
Reference Sites																															
R-1	0	0.00	0.00	340	68.00	17.00	280	56.00	0.56	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	2	620	124.00	17.56
R-2	31	7.75	1.94	230	57.50	14.38	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	40	10.00	0.90	0	0.00	0.00	41	10.25	0.92	70	17.50	0.53	5	472	118.00	18.66
R-3	0	0.00	0.00	1490	372.50	93.13	0	0.00	0.00	10	2.50	1.23	6	1.50	0.06	0	0.00	0.00	0	0.00	0.00	56	14.00	1.26	0	0.00	0.00	4	1562	390.50	95.67
R-4	0	0.00	0.00	545	136.25	34.06	1734	433.50	39.02	0	0.00	0.00	380	95.00	3.80	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	3	2669	667.25	76.88
R-5	0	0.00	0.00	270	135.00	33.75	5	2.50	0.03	182	91.00	44.59	20	10.00	0.40	0	0.00	0.00	0	0.00	0.00	5	2.50	0.23	170	85.00	2.55	6	652	326.00	81.54
R-6	0	0.00	0.00	377	188.50	47.13	892	446.00	40.14	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	2	1269	634.50	87.27
R-7	0	0.00	0.00	1150	287.50	71.88	397	99.25	8.93	0	0.00	0.00	0	0.00	0.00	114	28.50	2.57	0	0.00	0.00	0	0.00	0.00	811	202.75	6.08	4	2472	618.00	89.46
R-8	0	0.00	0.00	585	146.25	36.56	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	542	135.50	4.07	2	1127	281.75	40.63
R-9	0	0.00	0.00	930	310.00	77.50	5	1.67	0.15	186	62.00	30.38	0	0.00	0.00	0	0.00	0.00	10	3.33	0.10	0	0.00	0.00	301	100.33	3.01	5	1432	477.33	100.00
R-10	0	0.00	0.00	220	73.33	18.33	420	140.00	12.60	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	168	56.00	1.68	3	1108	369.33	32.61

Table 15. Data Obtained During Submerged Aquatic Vegetation (SAV) Surveys for Surveyed Docks and Reference Sites in Lake Jessamine, Orange County, Florida, 28 June Through 6 July 2007.

Dock/Reference Site Number	No. Coontail	No. Stems Coontail/m^2	Percent Coverage Coontail	No. Eelgrass	No. Stems Eelgrass/m^2	Percent Coverage Eelgrass	No. Hydrilla	No. Stems Hydrilla /m^2	Percent Coverage Hydrilla	No. Illinois Pondweed	No. Stems Illinois Pondweed/m^2	Percent Coverage Illinois Pondweed	No. Leafy Bladderwort	No. Stems Leafy Bladderwort/m^2	Percent Coverage Leafy Bladderwort	No. Spikerush	No. Stems Spikerush/m^2	Percent Coverage Spikerush	No. Stonewort	No. Stems Stonewort/m^2	Percent Coverage Stonewort	Total No. SAV Species	Total No. SAV Individuals	Total No. Stems SAV/m^2	Total Percent Coverage SAV
Docks																									
99-093/ 00-015	0	0	0	65	21.67	48.75	0	0.00	0.00	13	4.33	4.33	0	0.00	0.00	0	0	0	0	0.00	0.00	2	78	26.00	53.08
91-015	0	0	0	1	0.25	0.56	7	1.75	1.75	17	4.25	4.25	0	0.00	0.00	0	0	0	0	0.00	0.00	3	25	6.25	6.56
00-117	0	0	0	0	0.00	0.00	38	19.00	19.00	2	1.00	1.00	0	0.00	0.00	0	0	0	36	18.00	0.72	3	76	38.00	20.72
97-132	0	0	0	54	18.00	40.50	56	18.67	18.67	0	0.00	0.00	10	3.33	0.83	0	0	0	0	0.00	0.00	3	120	40.00	60.00
96-004	0	0	0	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0	0	0	0.00	0.00	0	0	0.00	0.00
D-5143	0	0	0	0	0.00	0.00	0	0.00	0.00	12	6.00	6.00	20	10.00	2.50	0	0	0	0	0.00	0.00	2	32	16.00	8.50
05-075	0	0	0	17	8.50	19.13	3	1.50	1.50	23	11.50	11.50	0	0.00	0.00	0	0	0	0	0.00	0.00	3	43	21.50	32.13
00-207	0	0	0	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	145	72.50	18.13	72	36	9	0	0.00	0.00	2	217	108.50	27.13
01-007	0	0	0	109	27.25	61.31	1	0.25	0.25	0	0.00	0.00	0	0.00	0.00	0	0	0	0	0.00	0.00	2	110	27.50	61.56
02-123	0	0	0	49	24.50	55.13	23	11.50	11.50	60	30.00	30.00	0	0.00	0.00	0	0	0	0	0.00	0.00	3	132	66.00	96.63
Reference Sites																									
R-1	0	0	0	0	0.00	0.00	0	0.00	0.00	228	76.00	76.00	0	0.00	0.00	0	0	0	0	0.00	0.00	1	228	76.00	76.00
R-2	0	0	0	10	2.50	5.63	0	0.00	0.00	344	86.00	86.00	0	0.00	0.00	0	0	0	0	0.00	0.00	2	354	88.50	91.63
R-3	0	0	0	0	0.00	0.00	1	0.50	0.50	34	17.00	17.00	0	0.00	0.00	0	0	0	0	0.00	0.00	2	35	17.50	17.50
R-4	0	0	0	0	0.00	0.00	0	0.00	0.00	80	40.00	40.00	0	0.00	0.00	0	0	0	0	0.00	0.00	1	160	80.00	40.00
R-5	0	0	0	6	3.00	6.75	3	1.50	1.50	172	86.00	86.00	0	0.00	0.00	0	0	0	0	0.00	0.00	3	181	90.50	94.25
R-6	14	7	1.75	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	640	320.00	80.00	40	20	5	0	0.00	0.00	3	694	347.00	86.75
R-7	0	0	0	0	0.00	0.00	0	0.00	0.00	147	36.75	36.75	0	0.00	0.00	0	0	0	0	0.00	0.00	1	147	36.75	36.75
R-8	0	0	0	0	0.00	0.00	7	3.50	3.50	39	19.50	19.50	0	0.00	0.00	0	0	0	0	0.00	0.00	2	46	23.00	23.00
R-9	0	0	0	18	9.00	20.25	0	0.00	0.00	85	42.50	42.50	0	0.00	0.00	0	0	0	0	0.00	0.00	2	103	51.50	62.75
R-10	0	0	0	0	0.00	0.00	1	0.50	0.50	130	65.00	65.00	0	0.00	0.00	0	0	0	0	0.00	0.00	2	131	65.50	65.50

Table 16. Species Diversity Indices Calculated for Submerged Aquatic Vegetation (SAV) Surveys for Surveyed Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

Dock/Reference Site Number	Simpson's Diversity Index	Shannon-Wiener Diversity Index
Lake Butler Docks		
99-191	0.024	0.084
97-016	0.464	1.308
99-046	0	0
98-154	0.501	1.354
02-102	0.582	1.446
98-111/98-135	0.498	1.027
01-014	0.351	0.765
D-1219	0.027	0.105
99-237	0.326	0.726
95-145	0.435	0.894
Lake Butler Reference Sites		
R-1	0.495	0.992
R-2	0.633	1.831
R-3	0.088	0.309
R-4	0.512	1.271
R-5	0.681	1.803
R-6	0.418	0.877
R-7	0.648	1.668
R-8	0.499	0.998
R-9	0.517	1.333
R-10	0.613	1.472
Lake Jessamine Docks		
99-093/00-015	0.264	0.617
91-015	0.468	1.034
00-117	0.513	1.068
97-132	0.567	1.298
96-004	0	0
D-5143	0.457	0.914
05-075	0.557	1.254
00-207	0.441	0.911
01-007	0	0
02-123	0.627	1.479
Lake Jessamine Reference Sites		
R-1	0	0
R-2	0.055	0.184
R-3	0.056	0.164
R-4	0	0
R-5	0.095	0.320
R-6	0.143	0.451
R-7	0	0
R-8	0.262	0.606
R-9	0.29	0.664
R-10	0.015	0.059

Table 17. Summary Data Obtained During Submerged Aquatic Vegetation (SAV) Surveys for Surveyed Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007. Values Not Having the Same Letter are Significantly Different ($p < 0.05$).

Site Type	Mean (Range) Total No. of SAV Species)	Significance	Mean (Range) Total No. of SAV Individuals	Significance	Mean (Range) Total No. of Stems SAV/m2	Significance	Mean (Range) Total Percent Coverage SAV	Significance	Mean (Range) Simpson's Diversity Index	Significance	Mean (Range) Shannon-Wiener Diversity Index	Significance
Lake Butler Docks (n = 20)	2.8 (1-5)	A	336.6 (18-1,371)	A	115.74 (4.5-457)	A	12.83 (0.59-45.72)	A	0.3208 (0-0.582)	A	0.7709 (0-1.446)	A
Lake Butler Reference Sites (n =20)	3.6 (2-6)	A	1,338.3 (472-2,669)	B	400.67 (118-667.25)	B	64.03 (17.56-100)	A	0.5104 (0.088-0.681)	B	1.2554 (0.309-1.831)	B
Lake Jessamine Docks (n =20)	2.3 (0-3)	A	83.3 (0-217)	C	34.98 (0-108.5)	C	36.63 (0-96.63)	A	0.3894 (0-0.627)	C	0.8575 (0-1.479)	C
Lake Jessamine Reference Sites (n=20)	1.9 (1-3)	A	207.9 (35-694)	D	87.63 (17.5-347)	D	59.41 (17.50-94.25)	A	0.0916 (0-0.290)	D	0.2448 (0-0.664)	D
Lake Butler (n = 40)	3.2 (1-6)	A	837.5 (18-2,669)	A	258.21 (4.5-667.25)	A	38.43 (0.59-100)	A	0.4156 (0-0.681)	A	1.0132 (0-1.831)	A
Lake Jessamine (n = 40)	2.1 (0-3)	B	145.6 (0-694)	B	61.30 (0-347)	B	48.02 (0-96.63)	A	0.2405 (0-0.627)	B	0.5512 (0-1.479)	B
Docks (n = 40)	2.6 (0-5)	A	209.9 (0-1,371)	A	75.36 (0-457)	A	24.73 (0-96.63)	A	0.3551 (0-0.627)	A	0.8142 (0-1.479)	A
Reference Sites (n = 40)	2.8 (1-6)	A	773.1 (35-2,669)	B	244.15 (17.5-667.25)	B	61.72 (17.5-100)	B	0.3010 (0-0.681)	A	0.7501 (0-1.831)	A

Table 18. Summary of Parameters Analyzed Associated With Surveyed Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

Parameter	Significantly Different Between Lakes ($p < 0.05$)?	Significantly Different Between Docks and Reference Sites ($p < 0.05$)?
Age of Docks	No	na
Dock Terminal Platform Size	Yes	na
Dock Plank Spacing	No	na
Height of Dock Terminal Platform Above Water	Yes	na
Water Depth at Waterward End of Terminal Platform	No	na
Water Depth at Waterward End of Reference Site	na	No
Boathouse Size	No	na
Water Temperature	No	na
pH	Yes	na
Dissolved Oxygen Levels	No	na
Specific Conductivity	Yes	na
Turbidity	Yes	na
Secchi Disk Reading	Yes	na
Percent Surface Light Below Docks	Yes	na
Percent Surface Light Above SAV/Bottom	Yes	Yes
Length of SAV Survey Transect	Yes	No
Distance Between Transects	No	No
Number of Quadrats Sampled	Yes	No
Percent of Transect Sampled	Yes	No
Total Area Sampled for SAV	Yes	No
Total Number of SAV Species	Yes	No
Total Number of SAV Individuals	Yes	Yes
SAV Density	Yes	Yes
Total Percent Coverage SAV	Yes	No
SAV Diversity	Yes	No

Table 19. Correlations (Pearson Product-Moment Correlation Coefficients) Between Submerged Aquatic Vegetation (SAV) Density and Diversity Calculated for Surveyed Docks and Reference Sites in Lakes Butler and Jessamine and Various Light and Water Quality Parameters.

	SAV Density (No. Stems SAV/m^2)	p	SAV Diversity (Simpson's Diversity Index)	p	SAV Diversity (Shannon-Wiener Diversity Index)	p
Percent of Surface Light Just Above SAV/Bottom	0.6522	0.0000	0.1982	0.2202	0.1689	0.2976
pH (SU)	-0.5271	0.0005	-0.2570	0.1094	-0.2899	0.0696
Specific Conductivity (mS/cm)	0.4615	0.0027	0.3046	0.0560	0.3421	0.0307
Turbidity (NTU)	-0.1147	0.4810	-0.3814	0.0152	-0.3955	0.0115
Secchi Disk Depth (m)	0.3072	0.0539	0.3205	0.0437	0.3931	0.0121

Table 20. Correlations (Pearson Product-Moment Correlation Coefficients) Between Submerged Aquatic Vegetation (SAV) Density and Diversity Calculated for Surveyed Docks in Lakes Butler and Jessamine and Various Dock, Light, and Water Quality Parameters.

	SAV Density (No. Stems SAV/m^2)	p	SAV Diversity (Simpson's Diversity Index)	p	SAV Diversity (Shannon-Wiener Diversity Index)	p
Orientation of Dock (N/S or E/W)	0.4277	0.0600	-0.3866	0.0923	-0.3868	0.0920
Height of Dock Above Water (m)	0.3328	0.1516	0.2774	0.2363	0.3504	0.1298
Percent of Surface Light Just Above SAV/Bottom	0.8214	0.0000	-0.1634	0.4913	-0.1375	0.5633
pH (SU)	-0.3015	0.1965	-0.3899	0.0893	-0.4407	0.0518
Specific Conductivity (mS/cm)	0.3404	0.1419	0.3448	0.1365	0.3970	0.0831
Turbidity (NTU)	-0.3051	0.1909	-0.3736	0.1047	-0.3995	0.0810
Secchi Disk Depth (m)	0.2727	0.2448	0.4322	0.0570	0.4980	0.0255

Table 21. Mammals, Birds, Fish, and Amphibians Observed/Heard During Surveys of Docks and Reference Sites in Lakes Butler and Jessamine, Orange County, Florida, 25 June Through 6 July 2007.

Lake Butler	Lake Jessamine
Raccoon (*Procyon lotor*)	Common moorhen (*Gallinula chloropus*)
Great blue heron (*Ardea herodias*)	Great blue heron (*Ardea herodias*)
Great egret (*Ardea alba*)	Great egret (*Ardea alba*)
Osprey (*Pandion haliaetus*)	Osprey (*Pandion haliaetus*)
Largemouth bass (*Micropterus salmoides*)	Largemouth bass (*Micropterus salmoides*)
Mosquitofish (*Gambusia holbrooki*)	Mosquitofish (*Gambusia holbrooki*)
Sailfin molly (*Poecilia latipinna*)	Sailfin molly (*Poecilia latipinna*)
Sunfish (*Lepomis* sp.)	Sunfish (*Lepomis* sp.)
	Pig frog (*Rana grylio*)

APPENDIX C

Field Datasheets

APPENDIX D

CD of Electronic Files of Project Photographs, Field Data Sheets, and Report