Post Construction Assessment of Fill Material

for the

South St. Lucie County Emergency Dune Restoration and Revegetation Project

Prepared for:

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EXECUTIVE SUMMARY

The Florida Department of Environmental Protection (Department) became concerned about the material placed as part of the St. Lucie County Emergency Dune Restoration and Revgetation project in April 2005 following reports of poor sediment quality and compaction. According to 62B-33.0155(1)(h), Florida Administrative Code (F.A.C.),

> *"All fill material placed seaward of the control line shall be sand which is similar to that already existing on the site in both coloration and grain size. All such fill material shall be free of construction debris, rocks, clay, or other foreign matter; shall be obtained from a source landward of the coastal construction control line; and shall be free of coarse gravel or cobbles."*

The Department's Bureau of Beaches and Coastal Systems (BBCS) conducted site inspections of the project area in late April and early May. Laboratory analyses of sediment samples taken from the project area were conducted. BBCS staff reviewed the results of the sediment testing and provided a memorandum on the characteristics of the material. An additional site inspection was conducted by PBS&J on June 8, 2005 for the purpose of providing a report to the Department characterizing the potential impacts due to the conditions at the site.

Findings: Visual inspection of the fill material and analyses provided by the Department suggests the fill material does not satisfy the permit conditions. The fill material does not match the existing beach sediments in color. According to a standard Munsell Soil Color Chart, the fill material exhibits a gray coloration, while existing beach sediments are light brown in color. Results of the sediment analysis indicated the fill material consists of higher percent fines (approximately an order of magnitude) as compared to existing beach sediments. In addition, the fill material has a high shell and coarse gravel/rock component as compared to the existing beach sediments.

Escarpments were observed during the site inspections. Though escarpments are often problematic in beach and dune restoration projects, the compacted nature of the fill material due to increased level of fines leads to an expectation of more persistent escarpments.

A five-year comparison of sea turtle nesting density and nesting success within the project area shoreline for the months of March 2005 through June 2005 shows a significant reduction in nesting success within the project fill area as compared to the native beach between 2001 and 2004. Adverse impacts to nesting success are expected for the 2005 season based upon the preliminary nesting data for May and June. The low nesting success and high number of false crawls within the project fill area may be attributed to the compaction of the fill material and presence of escarpments within the project area.

The immediate loss of foraging resources (food) may result in short-term impacts to foraging activities by shorebirds. Expected delay in recolonization may be significant if fines eroding from the fill material cause impacts in the intertidal region.

The determination of physical performance and biological impact of the fill material is dependent on morphologic changes and results of biological monitoring, which are still pending.

Based on the results of this assessment, the fill material does not appear to be similar to the existing beach sediment and may be considered non-compatible.

The report outlines remedial actions for consideration by the Department including immediate action to remove material, deferred action in responses to sea turtle nesting season and the no action alternative.

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1.0 PURPOSE

On May 25, 2005, the Florida Department of Environmental Protection (Department), Bureau of Beaches and Coastal Systems (BBCS), requested PBS&J assist with a post construction assessment of potential impacts due to the placement of fill during the South St. Lucie County Emergency Dune Restoration and Revegetation Project. The report includes a discussion of physical and biological effects on the coastal system. Issues addressed include:

- the similarity of placed sediments relative to existing beach sediments in both coloration and grain size;
- the potential for escarpment formation resulting from the placed sediments;
- the coastal protection performance and protective value of the placed sediments;
- the potential for excessive aeolian (wind-blown) transport;
- the suitability of substrate for establishment of salt tolerant dune vegetation;
- the facilitation of continued natural recovery;
- whether the placed sediments constitute suitable sea turtle nesting substrate;
- the composition of placed sediments as viable shorebird nesting substrate; and,
- whether the constructed project will result in elevated levels of turbidity in the nearshore zone adjacent to the project.

The report also presents several recommendations for remediation techniques that are offered to the Department for their consideration.

2.0 BACKGROUND

St. Lucie County is located on the eastern coastline of Florida and has approximately 22 miles of shoreline fronting the Atlantic Ocean. As reported by the Department, 17.3 miles of shoreline along St. Lucie County is designated as critically eroded (BBCS, 2005). Of these areas designated as critically eroded, the southern end of the County between Department reference monuments R-80 and R-115 has narrow beaches that offer little protection to upland development from storm events. St. Lucie County completed a study in December 2001 that documented the historic and current erosion conditions for the southern 13 miles of the County. This study reported the most vulnerable area of the beach is located along three miles of developed shoreline between R-98 and R-115 (Coastal Planning and Engineering, Inc., 2001).

Hurricanes Frances and Jeanne made landfall just south of St. Lucie County during the 2004 hurricane season. Hurricane force winds, waves and surge affected St. Lucie County by severely eroding the beaches and dunes. Following these hurricanes, the

Department reported that severe erosion conditions exist for the entire length of shoreline along St. Lucie County (BBCS, 2005).

To mitigate damage in vulnerable areas, St. Lucie County planned an emergency dune restoration and revegetation project for the southern end of the County. The South St. Lucie County Emergency Dune Restoration and Revegetation Project was proposed along 3.66 miles of shoreline from R-88 to R-90 and from R-98 to R-115. Design documents were prepared by Coastal Planning and Engineering, Inc. (CP&E) for the permit application to state and federal regulatory agencies (Appendix A). A Coastal Construction Control Line (CCCL) permit (SL-213) was issued by the Department on February 17, 2005 and subsequently amended on April 1, 2005 to allow construction to continue during the early portion of the sea turtle nesting season until May 1, 2005 (Appendix B).

3.0 INTRODUCTION

The South St. Lucie County Emergency Dune Restoration and Revegetation Project was constructed along a length of beach located from approximately 300 feet south of R-Monument 98 to approximately 990 feet south of R-Monument 115. The areas from R-88 to R-90 and approximately 400 feet south of R-101 to 350 feet south of R-103 were not constructed. Apparently, St. Lucie County designated these areas as lower priority because of timing and the lack of development. The fill material for the project was reportedly obtained from an upland source located at the Dickerson mine located north of the City of Ft. Pierce on Indrio Road just west of I-95. The material was truck hauled to the project site and placed along the project length. Project construction was initiated March 1, 2005 and ended April 29, 2005. CP&E provided construction progress and fill volume summary tables, located in Appendix C. Construction generally progressed from north to south with the placement of approximately 160,000 cubic yards of material.

The Department became concerned about the material placed on the beach on April 20, 2005 following reports of poor sediment quality and compaction by the U.S. Fish and Wildlife Service (FWS) South Florida Ecological Services Office. BBCS conducted a site inspection of the project area on April 21, 2005, and again on May 2, 3, and 4, 2005, after which a report was provided to the Department on May 5 2005 (Appendix D). BBCS tasked Coastal Technology Corporation. (Coastal Tech) to conduct a laboratory analysis of sediment samples taken from the project area. In addition, independent sediment samples and analysis were performed by CP&E. BBCS staff reviewed the results of the sediment testing and provided a memorandum on the characteristics of the material (Appendix E). The Department tasked PBS&J to perform an additional site inspection, which was completed on June 8, 2005. The purpose of the inspection was to provide the Department with an assessment of the conditions at the site based on visual examination, grab samples of the existing sediments and fill material, and photographic documentation of the project area.

This report compiles information from the site inspection as well as other documentation provided by the Department, the Florida Fish and Wildlife Conservation Commission

(FWC), Coastal Tech, CP&E and the United States Fish and Wildlife Service (USFWS). The report presents a general assessment of the physical and biological effects on the coastal system by the placement of this fill material. In addition, this report provides recommendations for remediation techniques, which may be considered by the Department for mitigation of impacts posed by the placement of fill material.

4.0 COASTAL ENGINEERING ASSESSMENT

The following section presents the results of an evaluation of the existing beach sediments and compatibility of fill material used to complete the South St. Lucie County Emergency Dune Restoration and Revegetation Project. Results are presented in three categories as follows:

- Physical Assessment
- Coastal Protection Performance Assessment
- Biological Assessment

4.1 Physical Assessment

According to 62B-33.0155(1)(h), Florida Administrative Code (F.A.C.), fill material shall be sand which is similar to that already existing on the site in both coloration and grain size; all such fill material shall be free of rocks, clay, coarse gravel and cobbles. Two areas of concern exist relative to the compatibility of the fill material used for placement along the South St. Lucie County Emergency Dune Restoration and Revegetation Project site. First, the fill material is not similar in color to existing beach sediments. Second, the grain size of the fill material is not similar to that of the existing sediment. The fill material has a higher percentage of fines, contains minerals, contains rocks, and exhibits the tendency to compact and lithify (cement).

During the site inspection conducted on June 8, 2005, surface samples were obtained from R-98 and R-111 of the existing sediments and fill material. These samples were used to conduct a visual inspection and characterization.

The existing sediments on the beach prior to this project were medium to fine grained and light brown in color with significant shell material and instances of well-rounded conglomerates (Appendix G). Conglomerates are well-rounded rock made up of cemented coarse-grained sediments combined with shell, sand and mud.

The fill material is darker in color with a gray hue that does not match the existing sediments. According to a standard Munsell Chart, a standard measure for describing color, the fill material *in situ* exhibits a gray color, while the existing sediments are light brown in color. Appendix G provides additional photographs of the material examined.

Figure 1 Color comparison of fill material (left) and existing beach sediments (right).
Date of photos: June 8, 2005

Results of the sediment analysis presented by Coastal Tech and CP&E as interpreted by BBCS staff indicates the fill material consists of a higher percent fines (approximately an order of magnitude) as compared to the existing beach sediments. In addition, the fill material has a high shell and coarse gravel/rock component as compared to the existing beach sediments.

During the June 8, 2005 site inspection, large-size rocks were frequently observed on the surface and immediate sub-surface (top 6 inches) along the project area. Through visual examination, the rocks from the fill predominately consist of coarse-grained sediments and shell comprised of broken and angular fragments. These rocks exhibit a more angular shape than those of the existing beach (Appendix G). The size of rocks found in the fill material ranged, in short/long axis dimensions, from larger (5 inch by 10 inch) pieces in the northern portion (R-98) to smaller (3 inch by 6 inch) pieces observed in the southern portion (R-111) of the fill project. Smaller pieces of rock observed along the southern end of the project may be a result of tilling.

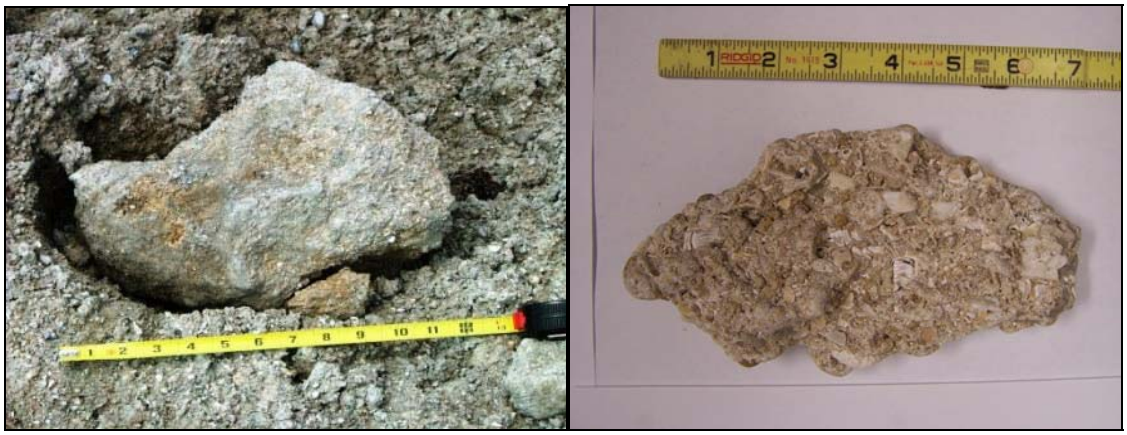

Figure 2 Comparison of sub-surface rock in fill material (left) and existing beach rock (right).
Date of photos: May 2, 2005 (left) and June 8, 2005 (right)

Based on visual and tactile examination, the fill material appeared compacted as compared to the existing beach sediments. A fill material sample taken from R-98 required minimal effort to break apart, while the sample taken from R-111 required significantly more force to break apart. Compaction is caused by physical processes during which sediments are consolidated, resulting in the reduction of pore spaces as grains are packed closer together. Compaction of beach sediments is commonly determined from measurements of beach shear resistance using a cone penetrometer. Increases in shear resistance can be attributed to increases in compaction, but may also be related to the particle shape, surface characteristics, and chemical interaction between particles (Spangler 1982). Cone penetrometer readings are the standard method for assessing and comparing compaction levels of beach material. These tests are difficult to conduct in areas of high shell content. No cone penetrometer data was available for this review.

Tilling operations were observed during the May 2, 2005 site inspection. Tilled versus un-tilled areas of the berm were observed as part of the June 8, 2005 site inspection. Areas of the berm tilled after fill placement qualitatively demonstrated reduced levels of compaction. However, based on observation, the fill material still exhibited a greater tendency to compact as compared to the existing beach sediments. The high percentage of fines present in the fill material, combined with rainfall in late May, appear to have diminished the effects of tilling within the project area. Numerous washouts were also observed along the slope of the berm, suggesting stormwater run-off due to limited percolation through the fill material. Ponding of water on the surface of the filled berm was reported by local residents after rainfall events in May 2005.

Figure 3 Washout in the fill material along the slope of the berm. Date of photo May 2, 2005.

Escarpments were observed during the May and June site inspections. Though escarpments are often problematic in beach and dune restoration projects, the compacted nature of the fill material due to the increased level of fines leads to an expectation of more persistent escarpments. The vertical height of the escarpments may also increase as storm waves begin to erode the slope of the berm. The irregular edge of the escarpment, when viewed in planform, is also an indication of the variation of soil types in the fill sediments.

Figure 4 Escarpment along fill project. Date of photo May 2, 2005

4.2 Coastal Protection Performance Assessment

Dune restoration projects are typically designed to provide protection from low to moderate (2-year to 10-year return interval) storm events. As indicated in Section 2.0, the project area is critically eroded and erosional stresses are high along south St. Lucie County. These stresses were exacerbated by Hurricanes Frances and Jeanne. CP&E provided an estimate of project storm survivability in the project design document (CP&E 2005). The results indicated a protective value of the dune restoration project and performance level to be expected for a 10-year return interval storm event.

The compatibility of fill material can affect the protective value and overall performance of the project. The profile form or the shape of the beach resulting from coastal processes is dependent on several key factors, one of which is sediment grain size (Dean,

1987). Dissimilar sediments may erode differently than existing sediments (Dean, 2002). Finer sediments will erode more rapidly then coarse sediments. The shape of the beach and dune, as well as the rate at which it is eroded, is dependent on sediment compatibility. The lack of sediment consistency will influence how the fill material responds to wave interaction and erosion processes.

The high percentage of fines in the fill material can increase the likelihood for aeolian (wind-blown) transport. This may cause localized impacts to the beach and dune system whereby fine sediments are transported throughout the project area. These sediments, blown into swimming pools, and onto patios, parking lots and landscaped lawns, can cause a nuisance to residents. In addition, aeolian transport can affect dune vegetation; excessive Aeolian transport may cause the roots to become exposed, ultimately damaging the plant. The winnowing of fines from the fill material may also affect turbidity in the nearshore zone and to a lesser degree the longevity of the project. This winnowing effect accelerates the aeolian erosion of the dune, which can expose coarser material, thereby affecting the aesthetics of the dune feature.

The permit required planting of native salt-tolerant vegetation along the dune crest. To date, St. Lucie County has not planted the dune and requested that individual property owners plant the dunes fronting their properties. During the June 8, 2005 site inspection, planting was observed along several properties with vegetation such as sea oats, sea grapes and saw palmetto. One property owner (R-115.4) planted sod on the landside (west) of the restored dune crest.

Native salt-tolerant dune vegetation has a tendency to survive in harsh environments. Dune vegetation must be able to tolerate loose, dry, unstable, nutrient-poor soils, as well as exposure to wind, salt spray, sand abrasion, intense sunlight, and storms. The soils of existing dunes drain rapidly, creating xeric (dry) conditions. Thus, dune species have evolved several morphological adaptations to survive in this harsh environment. Some dune species spread by sub-surface or surface runners that creep across the sand. Many species re-root from higher up their stems when buried by blowing sand, and consequently develop a matted root system. Some species are so dependent on the dune habitat that they lose vigor without shifting sands, which constantly stimulate the plant to send out new shoots (Wagner 1964; Myers and Ewel 1990; Maun 1998).

Establishing dune vegetation within the project limits may be difficult due to the compact sediments; however, once established, this vegetation could aid to reduce the formation of gullies by providing increased percolation and creating surface obstacles to break up sheet flow from rainfall. Aeolian transport of finer sediments may also be reduced due to the presence of vegetation.

4.3 Biological Assessment

Visual inspection of the fill material and review of the sediment analyses provided by the Department suggests that the fill material does not satisfy Rule requirements, as specified in Rule 62B-33 F.A.C. The fill material is not similar in color and grain size to the sand that exists within the project area shoreline. The fill material consists of higher percent fines content as compared to the existing beach samples collected along Department control monument R-90. The color of the fill material is not similar to the existing beach sand and fines were observed throughout the project area during the June 8, 2005 site inspection.

4.3.1 Potential effects of the fill material on sea turtles

The majority of the research on sea turtle nesting and hatching success has been performed on beaches nourished with an offshore sand source. Since the project area berm was created using an upland sand source, there are obvious differences in water content, salinity, and the shape of the beach profile in comparison to nourished beaches created with dredged sediment. However, the same physical parameters can potentially affect nesting/nesting success, incubation success, and hatchling emergence.

Hatching success may be reduced when sediment grain size, density, shear resistance, color, gas diffusion rates, organic composition, and moisture content of the fill material are different from the natural beach sand (Nelson and Dickerson 1988; D.A. Nelson 1991; Ackerman 1991, Ackerman et al. 1991, 1992; Ehrhart 1995; Rice 2001). Sand temperature changes can alter the incubation time, which can lead to increased predation and alter the sex ratio of hatchlings (Schulman et al. 1994). Temperature-dependent sex determination in sea turtles results in the production of female hatchlings at warm temperatures and male hatchlings at cooler temperatures relative to the threshold temperature range between 28 and 30 degrees Celsius (Mrosovky 1995). Altered beach conditions may also hamper embryonic development (Ackerman et al. 1992) and reduce behavioral competence of hatchlings, including changes in locomotion (Miller et al. 1987). Beaches nourished with sand dredged from an offshore sand source have been demonstrated to be warmer due to increased water retention and the darker sediment color as compared to natural beaches (Ernest 2001). The warmer sands of nourished beaches may significantly reduce incubation periods and contribute to a higher incidence of late-stage embryonic mortality (Ernest 2001). However, no significant differences in overall reproductive success were recorded during a three-year study of nourished Martin County beaches immediately to the south of the fill material project area despite changes in the temperature and moisture content of the nest cavity (Ernest 2001).

Research has shown that the principal effect of beach nourishment on sea turtle reproduction is a reduction in nesting success (i.e., the percentage of emergences resulting in nests) due to beach compaction and the unnatural beach profile created during project construction (USFWS 2002). Data from the 1998 Ocean Ridge Shore Protection Project in Palm Beach County suggested substantial negative effects in nesting success during the nesting season immediately following beach nourishment (Palm Beach County Department of Environmental Resource Management, 2001). Ernest and Martin

(1999) also found that the principal effect on sea turtle reproduction was a reduction in nesting success during the first year after project construction in Martin County. Data from both projects suggest that the negative effects of beach nourishment on nesting success persist for approximately two years after construction. In the Martin County study, there was no change in frequency of emergence, only a reduction in nesting success on the nourished beach. The reduction in nesting success was similar in both tilled and untilled areas, indicating that factors other than compaction, such as changes in the width of the beach profile, were responsible for the decrease in attractiveness of the beach as nesting habitat (Ernest 2001). Other studies conducted along the beaches of southeast Florida have documented longer times for nourished beaches to return to pre-construction nesting success levels. A study by Steinitz et al. (1998) on the nourished beaches of Jupiter Island (Palm Beach County) found that a period of two to three years was necessary for the nourished beach to become more penetrable at depths of approximately 20 cm. Moulding and Nelson (1988) reported a seven-year recovery period for the nourished beach sand to return to its pre-construction density.

The South St. Lucie County project area has historically supported a high density of loggerhead sea turtle nests. During the 2003 nesting season (between March 1 and September 30), a total of 1,432 sea turtle nests were deposited on South St. Lucie County beaches from 225 feet north of Department control monument R-98 to the St. Lucie County/Martin County line (approximately 860 feet south of R-115). Of the 1,432 nests in 2003, 1,359 were loggerhead nests, 42 were green sea turtle nests, and 31 were leatherback nests. A total of 1,887 nests were laid during the 2002 season (1,627 loggerhead, 229 green, and 31 leatherback).

Table 1 provides a five-year comparison of nesting density and nesting success within the project area shoreline for the months of March through June. This comparison shows a significant reduction in nesting success for all three sea turtle species within the project fill area as compared to the native beach between 2001 and 2004. The only exception is the low nesting success of green sea turtles in 2004; however, the number of green sea turtle nests is historically low on the project area beach. With the exception of 2002, the number of false crawls (i.e., non-nesting emergences) by loggerhead turtles from March to June 2005 is more than two times to four times greater than previous years, resulting in an extremely low nesting success of 14.37% in 2005.

Table 1 - Sea turtle nesting summary for the South St. Lucie County Dune Restoration Project Area for the months of March through June, 2001-2005

Loggerhead			
Year	**# of Nests**	**# of False Crawls**	**Nesting Success**
2005*	335	1997	14.37
2004	575	413	58.20
2003	918	549	62.58
2002	1107	1276	46.45
2001	973	914	51.56
Green Turtle			
Year	**# of Nests**	**# of False Crawls**	**Nesting Success**
2005*	11	56	16.42
2004	4	23	14.81
2003	8	2	80.00
2002	69	46	60.00
2001	4	0	100.00
Leatherback			
Year	**# of Nests**	**# of False Crawls**	**Nesting Success**
2005*	7	19	26.92
2004	20	9	68.97
2003	31	9	77.50
2002	31	10	75.61
2001	34	11	75.56

*Notes: Data was provided by Ecological Associates, Incorporated, under contract to St. Lucie County. All nesting data for 2005 is preliminary, computer entries have not been verified by comparison to field data sheets. No designation of nesting within fill material versus *in-situ* (non-fill) sediment seaward of the dune was provided for the 2005 data. Data for 2005 includes only that portion of the project area that received fill material (~300 ft. south of R-98 to ~990 ft. south of R-115). Data for 2001 to 2004 includes the entire length of shoreline, both filled areas and areas that did not receive fill (between R-88 and R-90 and ~400 feet south of R-101 to 350 feet south of R-103).

Table 2 - 2005 Sea turtle nesting results for the areas of the South St. Lucie County Dune Restoration Project that did not receive fill material, March through June

	Loggerhead	Green Turtle	Leatherback
# of Nests	78	5	4
# of False Crawls	168	12	6
Nesting Success	31.71	29.41	40

*Notes: Data was provided by Ecological Associates, Incorporated, under contract to St. Lucie County. All nesting data for 2005 is preliminary, computer entries have not been verified by comparison to field data sheets. The areas from R-88 and R-90 and approximately 400 feet south of R-101 to 350 feet south of R-103 did not receive fill material.

Table 2 provides the 2005 nesting results from March through June for the areas of the South St. Lucie County Dune Restoration Project shoreline that did not receive fill. Although nesting success within the non-filled areas is relatively low as compared to the data from 2001 through 2004 within the project fill area, nesting success within the non-filled areas is more than twice as high as compared to the project fill area (Table 2). Nesting success within the non-filled South St. Lucie County project shoreline is also similar to nesting success on the recently nourished beaches of Martin County, located immediately south of the project area (Table 3). The 4.1-mile long Martin County Nourishment Project was completed on April 23, 2005. As of June 30, 2005, loggerhead nesting success on the newly nourished Martin County beach was 33.91%, as compared to 31.71% within the non-filled areas of the South St. Lucie County project, and 14.37% within the South St. Lucie County project fill area. This comparison suggests that the nesting habitat within the South St. Lucie County project area is less attractive to nesting females than the recently nourished Martin County project area, which more resembles the natural (i.e., non-filled) beach, and implies differences in the quality of the nesting substrate/habitat.

Table 3 - 2005 Sea turtle nesting results for the Martin County Nourishment Project, March through June

	Loggerhead	Green Turtle	Leatherback
# of Nests	567	5	72
# of False Crawls	1105	10	53
Nesting Success	33.91	33.33	57.6

*Notes: Data was provided by Ecological Associates, Incorporated, under contract to St. Lucie County. All nesting data for 2005 is preliminary, computer entries have not been verified by comparison to field data sheets.

As mentioned previously in Section 4.1, the fill material exhibits a tendency to compact. High compaction levels result in an increased expenditure of energy by nesting females due to the increased length of time required to excavate the nest, as well as repeated attempts to successfully excavate a nest. Tilling can significantly reduce compaction levels, thereby reducing the time involved in nest excavation (Ernest 2001). As discussed previously, the high percentage of fines present in the fill material, combined with

rainfall in late May, appear to have negated the effects of tilling within the project area. Numerous washouts exist along the slope of the berm, suggesting limited percolation through the fill material, and ponding of water on the surface of the filled berm has been reported by local residents after rainfall events. These observations raise concerns for the moisture content of the incubation environment within the project fill area.

In addition, it was presented in Section 2.0 that the compaction of the fill material appears to be contributing to the formation of escarpments. Escarpments interfere with sea turtle access to the nesting beach and may contribute to behavior modification of nesting females, resulting in false crawls or situations where nesting females choose marginal or unsuitable areas to deposit eggs. Within the project fill area, nesting females only have a choice between the filled berm/dune and the existing sediment seaward of the dune. As of June 8, 2005, several nests had been deposited seaward of the toe of the fill in the existing sediment near the mean high water line (MHWL). There is an expectation that the majority of nests laid seaward of the berm will be overwashed, potentially inundating the nests. Prolonged tidal inundation of nests deposited seaward of escarpments often results in nest failure (USFWS 2002). If the escarpments persist and increase in vertical height during the 2005 nesting season, access to the nesting beach may be further impeded, and an increase in nests deposited seaward of the dune may occur.

On June 9, 2005, PBS&J contacted USFWS and FWC to discuss their observations of the fill material and agency concerns for adverse impacts to sea turtle nesting habitat. Both agencies conducted independent site inspections of the project area beach prior to the teleconference. During the teleconference, the relatively low nesting success observed during May 2005 was discussed. Both agencies voiced concern that nesting success would likely be low for the season within the project fill area as compared to the density of nests that the project area has historically supported. All participants voiced concern for hatching success due to the high content of fines in the fill material, compaction of the berm, and increased potential for interference with hatchling emergence due to the compaction of the incubation environment and structure of the nest cavity. Additionally, there was consensus that clutch depths within the fill berm could be shallow due to the compaction of the material, potentially affecting incubation time and embryonic development.

A full assessment of the effects of the fill material upon overall reproductive success will not be available until the end of the 2005 nesting season. Adverse impacts to nesting success are expected for the 2005 season based upon the preliminary nesting data for May and June. The low nesting success and high number of false crawls within the project fill area (Table 1) may be attributed to the compaction of the fill material and presence of escarpments within the project area.

Ecological Associates, Inc. (EAI) biologists, under contract to St. Lucie County, conduct daily surveys of the number of nests, non-nesting emergences, and emergence locations. Additionally, the depth and structure of the nest cavity (depth to the top and bottom of the egg chamber) will be measured during nest excavation to assess the potential effect of

compaction upon clutch depth. Nest inventories should also be conducted in accordance with FWC guidelines: the number of hatchlings that escape the nest, number of live and dead hatchlings in the nest, number of pipped live and dead hatchlings, and the number of unhatched eggs.

Given the concerns for hatching success and the potential for interference with hatchling emergence, collection of sediment samples from the excavated egg chambers during the 2005 nesting season is recommended to characterize the incubation environment. Sediment characteristics should be determined from grab samples from a representative number of excavated egg chambers along the project area beach (i.e., sufficient number of samples from high hatching success nests, low hatching success nests, and any nests with complete failure of hatching). Laboratory analysis of grain size distribution, carbonate content and moisture content should be conducted. In addition, the degree of saturation should be calculated, and the porosity of the sediment at each sample depth should be determined. If cementation is encountered, the observer should visually estimate the degree of cementation and obtain digital photographs of the nest cavity. A record of rainfall in the project area should also be maintained during the sea turtle nesting season for possible correlation with compaction levels within previously tilled or untilled areas.

Dependent upon the 2005 hatching results, additional collection and analysis of sediment samples at varying depths (12-inch, 18-inch, and 24-inch depths) may be necessary at the end of the 2005 nesting season for the purpose of characterizing the nesting environment and potential differences in nesting choices based upon variations in the sediment characteristics along the project area beach. This information would assist in the development of appropriate remediation measures to ameliorate the apparently poor nesting habitat.

4.3.2 Potential effects of the fill material on beach infauna recolonization

Sandy beaches are generally populated by small, short-lived organisms with high reproductive potential. Several studies have investigated the recolonization of beach infauna following nourishment projects and found that nourished beaches exhibit short-term declines in infaunal abundance, biomass, and taxa richness following beach nourishment, recovering to pre-nourishment levels within one year after sand placement (Reilly and Bellis 1983; Gorzelany and Nelson 1987; Hume and Pullen 1988; and Dodge et al., 1991 and 1995). Placement of sediment that closely matches the existing beach sediment is considered extremely important in the minimization of adverse effects to beach fauna (Hayden and Dolan 1974; Gorzelany and Nelson 1987; Baca and Lankford 1988). Increased amounts of fine sediments can alter infaunal community structure. Recovery time for organisms is usually longer if the percentage of silts and clays is high, as the fine sediment may affect interstitial organisms (Rakocinski et al., 1996).

A study by Van Dolah et al., (1992) attributed rapid recovery to the similarity of fill material to existing sediments, as well as placement of the fill high on the beach, well above mean sea level. The extreme decrease in the population of beach infauna following nourishment of the beaches on Bogue Banks, NC, was attributed to the poor

match in grain size between the placed sand and natural beach. The sand source utilized in the Bogue Banks project contained a very high shell content that was not comparable to the natural beach (Peterson et al., 2000).

Several factors appear to influence the effects of recruitment/recolonization of beach infauna and macrofauna. These factors include the size and type of the fill sediment and the compatibility of the fill to the existing beach. Coarser grains allow for more efficient burrowing and low content of fines minimizes the effects on feeding efficiency. Some studies have suggested that changes in the geomorphology and sediment characteristics may have a greater influence on the recovery rate of invertebrates than direct burial or mortality (USDOI/FWS 2000).

The sediment analyses of the South St. Lucie County Emergency Dune Restoration and Revegetation Project suggest that infaunal/macrofaunal population recovery times will be delayed by the high fines content in the fill material, and infauna recolonization may be further impeded by the lack of adjacent and underlying infaunal populations. Horizontal migration of existing beach infauna will take longer due to the relatively long project length. Underlying infaunal populations may also not have recovered to pre-hurricane densities prior to fill placement, decreasing the supply of recruiting adults. Recruitment of pelagic larvae may be delayed by the preferential colonization of the existing beach sediment seaward of the filled berm, and this preferential colonization could alter the infaunal community structure of the berm.

The presence of fines within the fill material may be a persistent source of turbidity to nearshore waters as storm waves begin to erode the berm. This turbidity may impair the feeding efficiency of invertebrates and visual-feeding of surf zone fishes.

4.3.3 Potential effects of the fill material on shorebirds

No shorebird monitoring information was available for the project area beach. The immediate loss of foraging resources, and expected delay in infaunal/macrofauna recolonization, may result in short-term impacts to foraging activities by shorebirds. This may be significant if fines eroding from the fill material cause infaunal/macrofauna impacts in the intertidal region.

5.0 CONCLUSIONS

PBS&J conducted a field visit on June 8, 2005, examined the geotechnical information provided by BBCS, and discussed potential impacts of the dune fill project with resource agencies. Review of the contract documents was not conducted. Based on this information, the fill material placed on the dune appears not to meet the compatibility criteria cited in the CCCL permit (SL-213). Characteristics that appear out of compliance include color, the presence of a high percentage of fines and the presence of a high percentage of coarse material.

PBS&J recommends that BBCS coordinate additional geotechnical testing of the entire length of the berm to quantify the extent of the project that may be out of compliance. It is also suggested that the geotechnical analysis consider modifying the ASTM testing

standards to use a significantly large sampling size in order to adequately account for coarse material (greater than that held on the ¼-inch sieve). ASTM standards are sufficient for quantifying fines.

The determination of physical performance and biological impact of the fill material is dependent on morphologic changes and results of biological monitoring, which are still pending.

PBS&J also recommends that the sea turtle monitoring outlined in section 4.3.1 be implemented to establish actual sea turtle emergence, nesting and nesting success within the fill area. As part of this monitoring, a control area as close to the project as possible should be considered.

6.0 REMEDIATION OPTIONS

The following remediation recommendations are presented for consideration by the Department:

1. Remove all existing fill material and perform complete replacement with beach compatible material during the current (2005) sea turtle nesting season.

2. The following options would be completed after the 2005 sea turtle nesting season.

    a. Remove all existing fill material and replace with beach compatible material.
    b. Determine the amount of fill material remaining and replace the eroded portion of the dune with beach compatible material. Mechanically mix or till the beach compatible material with the surface of the existing fill material.
    c. Place a three (3) foot layer of beach compatible material over the remaining existing fill material and mix or till the surface.

3. Allow the existing fill material to be completely eroded and rebuild the dunes with beach compatible material.

4. No action.

Removal of fill material during sea turtle season is generally considered difficult due to the potential for impacts to sea turtle emergence, nesting or hatching success. State and federal regulatory resource agencies will evaluate this option closely.

Action taken to remove, mix or otherwise alter the fill material after sea turtle season mitigates this issue. However, such actions potentially serve to exacerbate the problems associated with the poor quality material in the system. Alternative remedial actions undertaken after November 2005 may result in chronic turbidity problems in the nearshore zone caused by erosion of the fine-grained sediments and subsequent suspension in the water column, cause irregular erosion patterns in the dunes which may

influence the protective quality of the dunes and may impede natural recovery. Remedial actions undertaken after October 31, 2005 as well as the no action alternative, may also generate a public response to the conditions on the beach.

Mixing the existing fill material with clean beach compatible material will have the affect of reducing the overall percentage of fines in the dune system. Planting of dune vegetation will also assist in the trapping of fines in the dunes.

A remediation plan should be developed to examine remediation techniques that mitigate the issues associated with the introduction of non-compatible fill. Protocols should be developed to construct and then monitor the results and effectiveness of the remediation actions.

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