FINAL REPORT

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Evaluation of the Safety and User Response to Embedded Roadway Lighting Systems on an FDOT Demonstration Project

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Introduction

The current Florida Department of Transportation (FDOT) Roadway Lighting Standards provide for motorist and pedestrian safety but do not take into account biological conditions on adjacent property. Roadway lighting can adversely affect sea turtle hatchlings. The roadway lighting can cause the disorientation of the hatchlings during their journey across the beach from the nest to the ocean.

The FDOT has undertaken a demonstration project in which the existing roadway lighting system was replaced with embedded roadway lighting during the sea turtle nesting season (May-October). The purpose of this demonstration project was to determine if innovative lighting techniques could illuminate pavement markings but not impact sea turtles on adjacent beaches. A FDOT consultant contractor preformed the design and installation of the embedded lighting systems. The project site consists of approximately 0.65 miles of SR A1A in Boca Raton, Florida. The limits of SR A1A lighting demonstration project are from the north side of the City of Boca Raton's Spanish River Park south entrance driveway to the south side of the entrance to the Sea Ranch condominiums.

The existing roadway which runs adjacent to the beach, has a typical section consisting of two undivided 12 foot travel lanes, a 5 foot paved shoulder and an asphalt paved pedestrian path offset from the roadway. This scenic stretch of roadway is popular and receives significant vehicle, bike and pedestrian traffic. Existing area lighting at the site was modified to eliminate a lighting hazard for the marine turtles. This involved deactivating the existing overhead street lighting, placing amber lenses on existing pedestrian pathway lights and installing low bollard mounted luminaires along the pedestrian and bike ways. As a safety counter measure, an embedded pavement lighting system was installed in the roadway.

The primary objectives of this research project were to assess the existing and new lighting systems in terms of lighting sufficiency and determine public acceptance of this type of project. It is hoped that the alternative lighting system will result in reduced mortality rates for marine turtles on the adjacent beaches, while at the same time not adversely impacting motorist, bicyclist, or pedestrian safety. Additionally, it was important to the FDOT to determine whether this type of project would be accepted/supported by the traveling public. The primary tasks performed in support of these objectives included the following:

- Measuring illumination levels and lighting distribution on the roadway and adjacent beach areas for the existing and alternative lighting systems,
- Obtaining and analyzing motorist, bicyclist, and pedestrian responses to a survey about the alternative lighting system, and
- Analyzing past and present crash statistics for the affected roadway segments.

Concurrent with this research a separate study was conducted to evaluate the affect of the lighting changes on sea turtles utilizing the adjacent beach area (11).

Part I: Evaluation of the Roadway Lighting Reconfigurations

Introduction

This part of the report focuses on an evaluation of the effects of the lighting reconfigurations implemented as a part of the demonstration program for reducing lighting impacts to sea turtle nesting beaches. A description of the existing lighting systems prior to reconfiguration is provided. Details of the reconfigured lighting systems are discussed. Measured illumination levels for the existing system and for the new reconfigured systems are provided. An evaluation and comparison of the lighting quality is also included.

Existing Lighting System

Test Roadway Section

The test area for the project was a section of SR A1A in Boca Raton, Florida, approximately 0.65 miles in length. In 1998, the City of Boca Raton sent a request to FDOT to turn off existing street lights that were known to cause sea turtle hatchlings to disorient toward land. After a review of the lighting system, FDOT determined that the streetlights were installed by Florida Power and Light (FPL) and the City was paying a monthly utility for lighting. Additionally, the City had a coastal lighting ordinance. FDOT had no objection to turning off the streetlights along SR A1A. The City was hesitant to do this without providing alternative lighting. When funding for a demonstration lighting project was approved, the area was selected because of the following reasons:

- FDOT District 4 Design Section had no Lighting Justification Report this segment of roadway.
- It was determined that FPL installed the cobra head fixtures on already existing poles at the request of the City of Boca Raton.

The existing roadway which runs adjacent to the beach, has a typical section consisting of two undivided 12 foot travel lanes, 5 foot paved shoulder and an asphalt paved pedestrian path. This scenic stretch of roadway is popular and receives moderate vehicle, bike and pedestrian traffic. Eastern side (Northbound) borders a beach area. The area immediately adjacent to the roadway shoulder is a beach dune covered with heavy foliage consisting primarily of Sea Grape trees. The western side of the roadway contains a paved pedestrian pathway. The west side of the roadway is largely undeveloped but does include the vehicular entrances to the Spanish River Park and a government office complex. The test area begins at the intersection of SR 800 (Spanish River Blvd) and SR A1A (Ocean Blvd) and proceeds south along A1A, ending at the south entrance to Spanish River Park. A map providing the test site layout is provided in Figure 1.

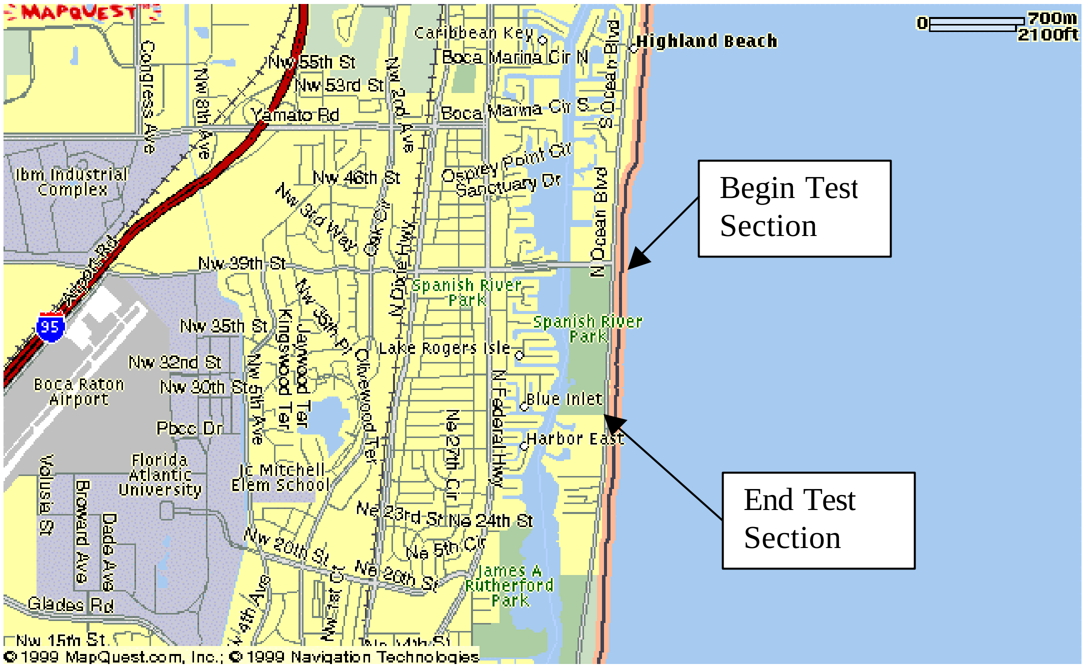


Figure 1. Test Site Location

Original Lighting Configuration

The existing roadway test section was configured with area lighting provided by 150 w cobra head type HPS luminaires mounted on pre-cast concrete utility distribution poles at a mounting height of approximately 25 feet. The area lighting was located only on the western (southbound) side of the roadway. Luminaires were spaced at approximately 200 ft. intervals. Additionally, lighting of the pedestrian pathway was supplemented by pole mounted HPS luminaires area lighting, located adjacent to the pathway at approximately 200 ft. intervals at a mounting height of approximately 10 feet. Ambient lighting from adjacent light sources was minimal because of the absence of development on either side of the roadway. Figure 2 provides an illustration of the lighting of the typical roadway section. Figure 3 is a photo that provides a view of the original roadway. Figure 4 and Figure 5 are photographs of the cobra head and pedestrian path lights, respectively.

Original Illumination Levels

Existing illumination levels were measured using an EXTECH Model 401036 digital photometer. Figure 6 is a photo of the EXTECH photometer. In general, illumination levels were recorded along the roadway at location coinciding with the locations of the cobra headlights and at the midpoint between the cobra headlights. The objective was to obtain an understanding of the maximum and minimum illumination levels. This resulted in an approximate interval of 100 ft. between measurement locations. Illumination values were taken at the center of the pedestrian path, center of the bike lane and at the center of the southbound travel lane. Illumination levels were measured at the pavement surface.

A record of the recorded illumination levels is included as Appendix A: Illumination Levels of Original Lighting Configuration to the report. Table 1 presents a summary of the recorded illumination data. . It should be noted that the existing lighting system was not a roadway lighting system. The FDOT had no Lighting Justification Report for this segment of the roadway. It was determined that FPL installed the cobra head fixtures on already existing poles at the request of the city of Boca Raton. The lighting system generally provided area lighting for the pedestrian path and roadside area on the western side of the roadway. Illumination levels for the pedestrian path varied from 0.58 to 5.27 fc. Illumination values for the bike lane were approximately one-half of the values for the pedestrian path. The southbound travel lane received minimal illumination ranging from 0.06 to 0.44 fc. The illumination levels on the northbound far side of the roadway were negligible. Figure 7 provides a graphic representation of the illumination distribution developed with AGI software (1).

Illumination levels were also measured on the beach area. With the exception of the beach access corridor at the intersection of Spanish River Blvd. and SR A1A, no illumination from the existing lighting systems could be measured at the beach. Additionally, none of the existing luminaires were visible at the beach.

Table 1. Summary of Illumination Levels (fc) of Site With Original Lighting Configuration

	Crosswalk	Pedestrian Path	Bike Lane	Travel Lane
Average	1.17	2.89	1.19	0.24
High	2.09	5.27	2.20	0.44
Low	0.22	0.58	0.29	0.06

Revised Lighting Configuration

The revisions to the original lighting system were intended to reduce the lighting hazard presented by the existing lighting to nesting turtles and their hatchlings that utilize the adjacent beach area bordering the eastern side of the roadway. The following modifications to the existing lighting were implemented:

1. **Deactivation of the Cobra Head Area Lights**

The elevated HPS cobra head luminaires were turned off. These were believed to present the greatest hazard because of their mounting height.

2. **Replacement of Lenses on Pedestrian Pole Mounted Luminaires**

The clear lenses on the pedestrian luminaires were replaced with amber lenses. This reduced the lumen output of the luminaires and of course, changed the color spectrum of the light. Light sources that emitting low levels of short-wave length light (sources that appear deep red or yellow) effect both hatchling and nesting turtles less than do light sources emitting higher levels of short wave length light (sources that appear whitish). Low pressure sodium luminaries are good lighting substitutes. Yellow tinted incandescent luminaries and amber lenses can be acceptable substitutes (2). FPL has participated in previous research investigating the feasibility of shielding and filtering existing roadway lighting luminaries (3).

3. **Installation of Embedded Pavement Lighting**

A system of embedded pavement lighting was installed to provide delineation of the traffic lanes and other roadway features. The embedded pavement lighting was to improve the driver's ability to navigate the roadway in the absence of roadway lighting. The embedded light system provides high visibility guidance for the motorist under low light conditions.

The product used was the Smartstud system by Harding Traffic Systems (4). The device is an embedded pavement type marker with an array of LED lamps that are inductively powered. Figure 8 is a photo a Smartstud road marker. Figure 9 is a photo providing view of the roadway after revisions to the lighting systems. The embedded lighting system is clearly shown in the photo (5).

4. **Installation of Bollard Mounted Luminaires Along the Bike Lanes**

A series of bollard-mounted luminaires were installed in the grassed area immediately outside of the bike lanes on both sides of the roadway. This was technically a variance from the FDOT's standard design requirements. However, this variance was justified because of the objective of the demonstration project, which was to provide design engineers with valid lighting options when developing roadway and bridge lighting systems adjacent to sea turtle nesting beaches. Low-level lighting was selected to provide illumination of the bike lane and the adjacent vehicle travel lane. The luminaires used were the Model RFB luminaires by Bronzlite, Genlyte-Thomas Group, LLC (5). These 100w bollard mounted luminaires are approximately 11 inches in height. These outdoor pathway type luminaires were installed at approximately 40-foot intervals. Figure 10 is a photo of the Bronzlite RFB/RFC luminaires. The photometrics of the Bronzlite RFB/RFC luminaires are provided in Figure 11. Note that because of the low height of the fixture, the lighted area is limited to approximately 5 feet from the luminaire.

5. **Installation of Bollard Mounted Luminaires Along the Sidewalk on Spanish River Blvd**

Bronzlite RFHD bollard mounted luminaires were installed along the inside of the existing sidewalk approaching the intersection of Spanish River Blvd and SR A1A. This sidewalk is an area of moderate pedestrian traffic. Visitors to the beach typically park along Spanish River Blvd. and walk down to the beach crossing SR A1A at the intersection of Spanish River Blvd. and SR A1A. The selected 100w luminaires are approximately 41 inches in height and were placed at approximately 40-foot intervals. Figure 12 is a photo of the Bronzlite RFHD luminaires. The photometrics of the Bronzlite RFHD luminaires are provided in Figure 13.

Illumination Levels with the Revised Lighting System

Measurement of illumination levels was conducted using the same procedure used in measuring the illumination under the original lighting configuration. A record of the recorded illumination levels is enclosed as Appendix B: Illumination Levels with Modified Lighting Configuration to this report. Table 2 provides a summary of the measured illumination levels. Illumination levels for the pedestrian path varied from 0.33 to 3.50 fc. Illumination values for the bike lane ranged from 0.21 to 1.53 fc. The southbound travel lane received illumination ranging from 0.04 to 1.24 fc. The illumination levels on the northbound far side of the roadway were negligible.

Table 2. Summary of Illumination Levels (fc) of Site With Revised Lighting Configuration

	Crosswalk	Pedestrian Path	Bike Lane	Travel Lane
Average	0.28	1.33	1.53	0.39
High	0.88	3.50	3.95	1.24
Low	0.05	0.33	0.21	0.04

Comparison of the Lighting Quality of the Original and Revised Configurations

Embedded Pavement Lighting

The embedded roadway lights had no effect on either the roadway or area lighting. They are a delineation and marking device and do not produce sufficient lumen output for area lighting purposes. User evaluations of the embedded lighting system and accident statistics for the project are discussed in section two of this report.

Pedestrian Pathway Lighting

Reduced low and high illumination levels occurred along the pedestrian path as a result of eliminating the cobra head overhead lighting and from using amber lenses on the pedestrian path lights. The range of illumination levels 0.33 to 3.50 fc remains within the acceptable levels for low volume pedestrian traffic ways (6). The existing spacing of the pedestrian pole luminaires and the absence of the overhead lighting contributed to a relatively high uniformity ratio along the pathway. Pedestrian user evaluation of the pathway lighting is discussed in section two of this report.

Bike Lane Lighting

The addition of the 11-inch high bollard luminaires along the bike lane provided illumination of the bike lane in the immediate area of the luminaire. The effective lighted area was essential limited by the low height of the luminaires. Therefore the measured illumination values were significantly affected by the proximity of the measurement to a bollard luminaire. Illumination values ranged from 0.21 fc to 3.50 fc. Again because of their low height, they provided little improved visibility of bicyclists to the motorist. Therefore, the lighting contribution of the bollard luminaires was principally to delineate the bike lane. Bicyclist user evaluation of the bike lane lighting is discussed in section two of this report.

Roadway Lighting

Neither the existing lighting system nor the revised lighting systems made significant contributions to roadway lighting. The existing lighting system was configured to provide area lighting of the pedestrian area on the western side of the roadway. The location of the overhead cobra head luminaires permitted limited illumination of the bike lane but contributed little illumination to the travel lanes. The illumination levels in the south bound travel lane with the existing lighting average 0.24 fc. With the revised system they averaged 0.39 fc. Motorist user evaluation of the roadway lighting is discussed in section two of this report.

Crosswalk Lighting

The elimination of the overhead cobra lighting significantly reduced the illumination levels in the crosswalks. The areas on the eastern side of SR A 1A received only minimal spillage from the bollard lighting. The average illumination level was 0.28 fc.

Conclusions and Recommendations

Pedestrian Pathway

The pre-existing overhead cobra luminaries at the project site contributed significantly to the pedestrian pathway lighting. When these luminaries were deactivated, the spacing of the remaining pathway lighting was such that there were some areas of the pathway without sufficient illumination. New designs and permanent modifications to existing installations should include adjustments to provide acceptable levels of lighting for pedestrian traffic and acceptable uniformity ratios. Consideration should also be given to security for the pedestrians. In some situations, illumination of the areas adjacent to the pedestrian pathway may also be appropriate. The use of amber filters on the pathway luminaries did not significantly affect the illumination levels.

Bike Lane and Adjacent Vehicle Travel Lane

The low mount bollard luminaries illuminated the bike path and the pavement lane only in the area immediately adjacent to the luminaire. Given the spacing of approximately 40 feet and the 11-inch height, the installation for the most part only provided a delineation of the bike path. Visibility of the cyclist to the drivers and uniformity ratios would have been improved with pole-mounted luminaries. However, the need for breakaway mounting and inclusion of amber filtering need to be addressed.

Embedded Pavement Lighting

Embedded pavement lighting was installed to provide enhanced delineation of the pavement marking for the motorist. The lighting system functioned properly and apparently added to the delineation. No adverse traffic related events were noted that could be attributed to the embedded lighting system.

Applicability to Other Locations

This demonstration project clearly involved a balance of budget and time related considerations while focusing on project objects, which were to demonstrate the feasibility of utilizing lighting designs more consistent with nesting and hatchling turtle welfare. Clearly, the project objectives were achieved. Designers do have the tools to make new developments and permanent improvements to existing installations compliant with establishing lighting standards and at the same time avoid adverse impacts to nesting and hatchling turtles.

Table 3. Recommended Illuminance Values for Road and Pedestrian Conflict Areas (4)

Road and Pedestrian Conflict Area		Pavement Classification (Minimum Maintained Average Values)			Uniformity Ratio	Veiling Luminance Ratio
Road	Pedestrian Conflict Area	R1 lux/fc	R2 & R3 lux/fc	R4 lux/fc	E_{avg}/E_{min}	L_{vmax}/L_{avg}
Freeway Class A		6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Freeway Class B		4.0/0.4	6.0/0.6	5.0/0.5	3.0	0.3
Expressway	High	10.0/1.0	14.0/1.4	13.0/1.3	3.0	0.3
	Medium	8.0/0.8	12.0/1.2	10.0/1.0	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Major	High	12.0/1.2	17.0/1.7	15.0/1.5	3.0	0.3
	Medium	9.0/0.9	13.0/1.3	11.0/1.1	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Collector	High	8.0/0.8	12.0/1.2	10.0/1.0	4.0	0.4
	Medium	6.0/0.6	9.0/0.9	8.0/0.8	4.0	0.4
	Low	4.0/0.4	6.0/0.6	5.0/0.5	4.0	0.4
Local	High	6.0/0.6	9.0/0.9	8.0/0.8	6.0	0.4
	Medium	5.0/0.5	7.0/0.7	6.0/0.6	6.0	0.4
	Low	3.0/0.3	4.0/0.4	4.0/0.4	6.0	0.4

Table 4. Recommended Minimum Illumination Values for Walkways/Bikeways (4)

Maintained Illuminance Values for Walkways/Bikeways			
	E_H lux/fc	E_{Vmin} lux/fc	E_{avg}/E_{min} *
Pedestrian Areas	5.0/0.5	2.0/0.2	4.0

* Horizontal only

E_H = average horizontal illuminance at walkway/bikeway
E_{vmin} = minimum vertical illuminance at 1.5 m (4.9 ft.) above walkway/bikeway measured in both directions parallel to the main pedestrian flow

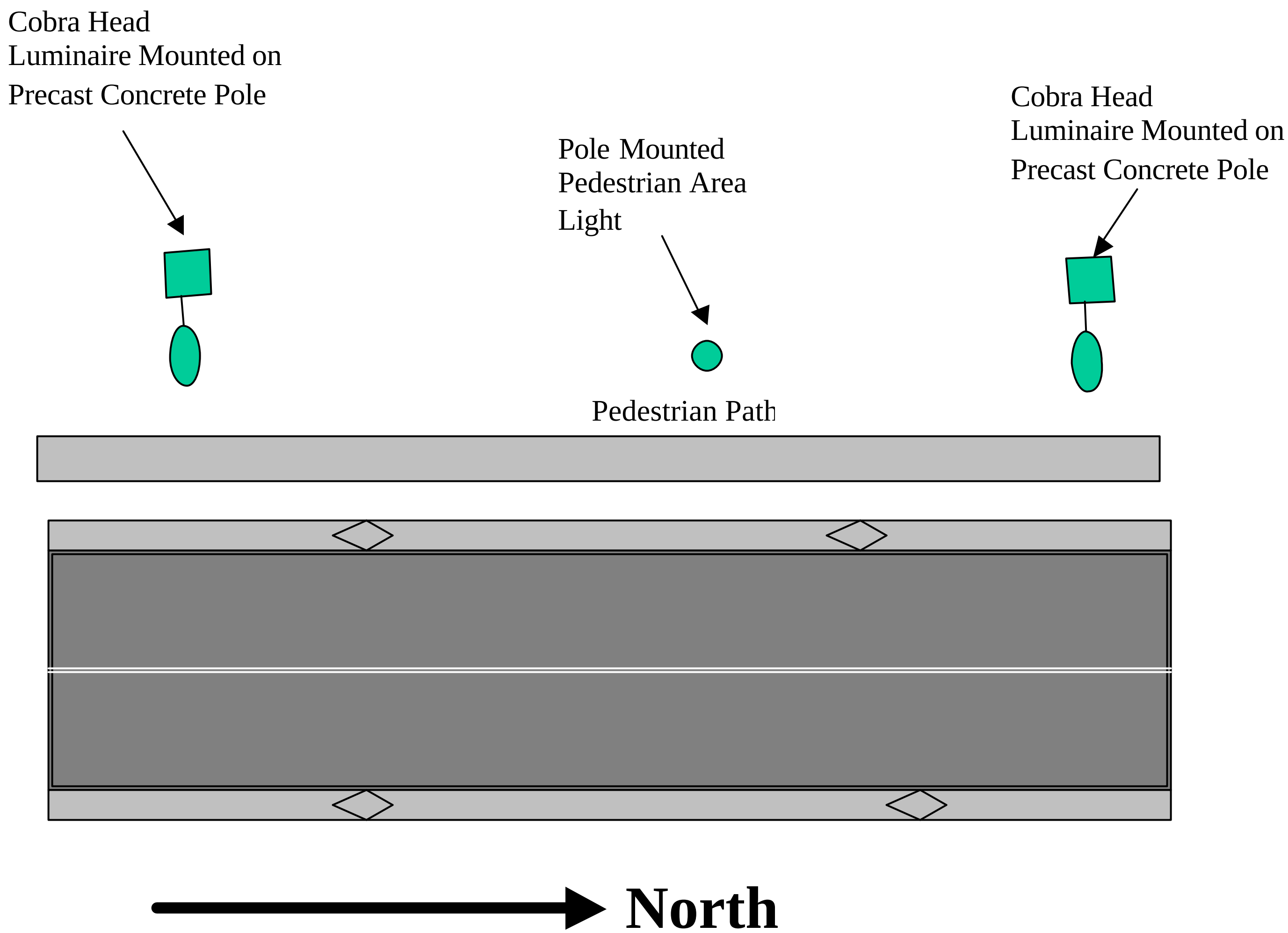


Figure 2. Typical Roadway Section

Figure 3. Photo of Original Roadway Configuration

Figure 4. Photo of Typical Cobra Head Area Luminaire

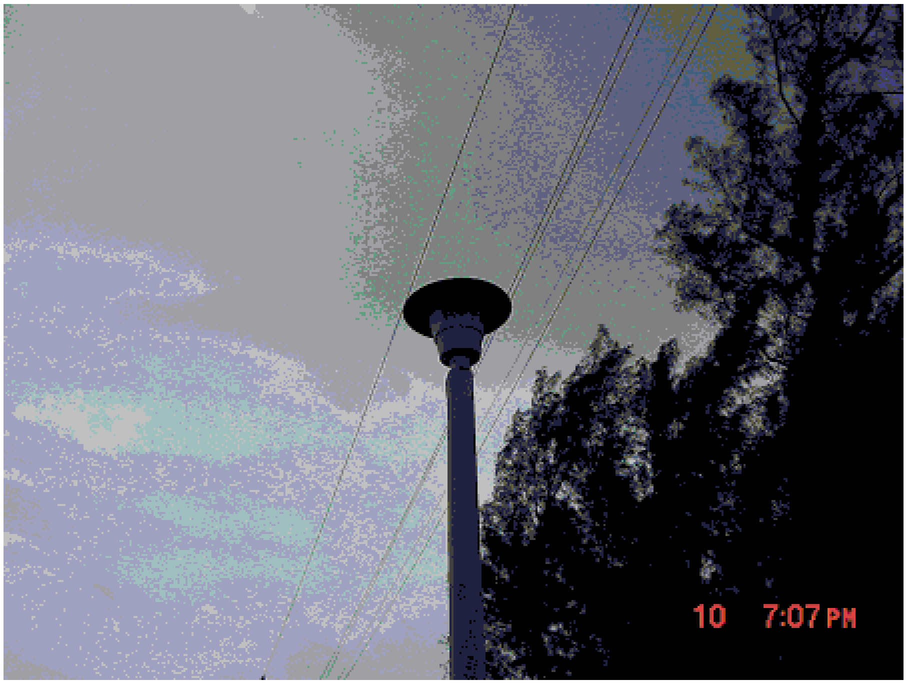


Figure 5. Photo of Typical Pole Mounted Pedestrian Area Luminaire

Figure 6. Photo of EXTECH Photometer

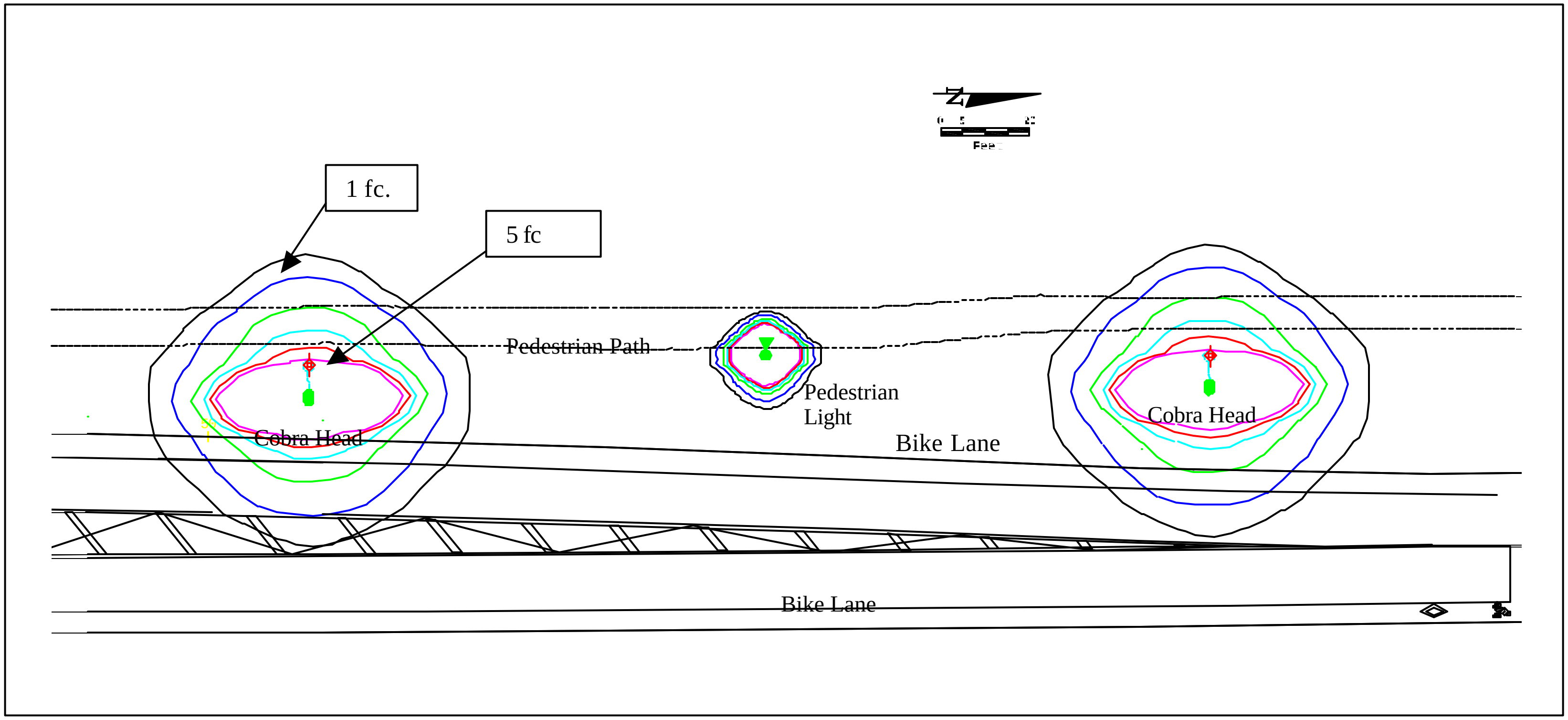


Figure 7. Isocandle Model of Typical Original Roadway Section

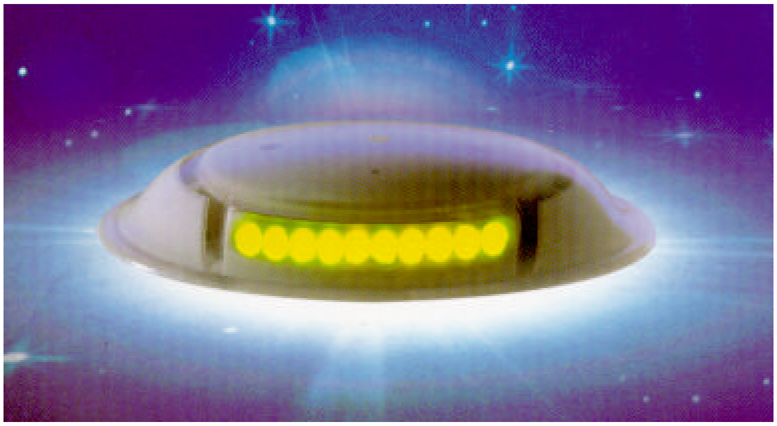


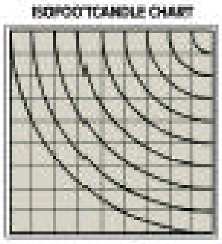
Figure 8. Illustration of a Smartstud Pavement Marker (4)

Figure 9. Photo of the Roadway After Lighting System Revisions

Figure 10. Photo of the Bronzlite RFB/RFC Bollard Luminaires (5)

PHOTOMETRICS

ISOFOOTCANDLE CHART



Louver Optics

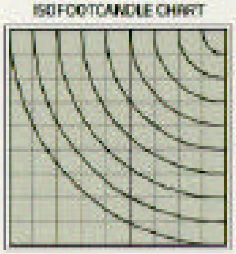
	100W INC 1750L	28W FLUOR 1600L	42W FLUOR 3200L	50W MH 3400L	70W MH 5600L	100W MH 9000L	70W HPS 6400L	100W HPS 9500L
1	1.2	1.1	2.2	2.3	3.4	6.1	4	6
2	1	0.9	1.8	1.9	2.8	5.34	3.3	5
3	0.6	0.5	1	1.1	1.3	2.34	1.6	2.4
4	0.5	0.4	0.8	0.9	1.1	2	1.3	2.1
5	0.2	0.1	0.2	0.3	0.5	0.9	0.6	1
6	0.1	0.05	0.1	0.2	0.3	0.5	0.3	0.6
7	0.05	0.02	0.1	0.1	0.1	0.2	0.1	0.2
8	0	0	0.02	0.02	0.03	0.1	0.03	0.1

Figure 11. Bronzlite RFB/RFC Photometrics (5)

Figure 12. Photo of Bronzlite RFHB Bollard Mounted Luminaire (5)

PHOTOMETRICS

ISOFOOTCANDLE CHART



Louver Optics

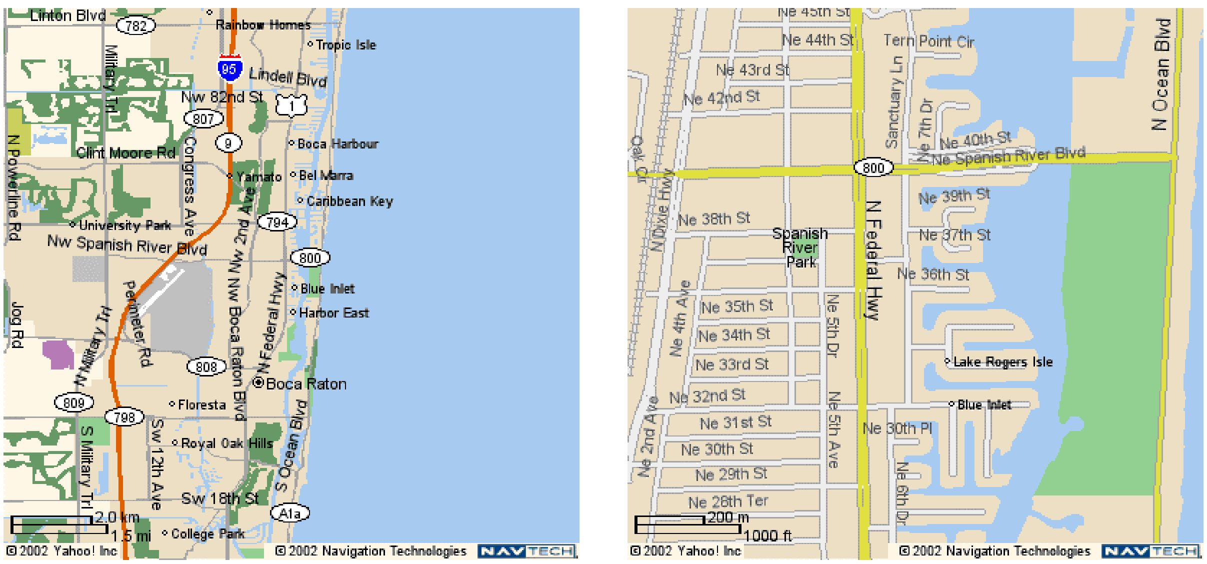
	100W INC 1750L	28W FLUOR 1600L	42W FLUOR 3200L	50W MH 3400L	70W MH 5500L	100W MH 9000L	70W HPS 6400L	100W HPS 9500L
4	0.9	0.8	1.6	2	2.7	4.4	3.1	4.7
6	0.8	0.7	1.5	1.9	2.6	4.2	3	4.5
8	0.8	0.7	1.4	1.8	2.4	4	2.8	4.2
10	0.5	0.5	0.9	1.3	1.5	2.7	2	3
12	0.4	0.4	0.5	0.7	1.3	2.2	1.6	2.4
14	0.2	0.1	0.3	0.4	0.5	0.08	0.6	0.9
16	0.2	0.1	0.1	0.2	0.2	0.3	0.2	0.3
18	0.1	0	0.1	0.1	0.1	0.2	0.1	0.2

Figure 13. Photometrics for the Bronzlite RFHD Luminaires (5)

Part II: Roadway User Opinion Survey Results and Accident Experience Summary

Introduction

A Florida Department of Transportation (FDOT) experimental roadway lighting project was conducted to study its impact on sea turtle nesting beaches adjacent to the roadway. New lighting hardware was installed along SR A1A in the vicinity of Spanish River Park (see Figure 14). This new lighting was all of a low-level design, consisting of bollard-style fixtures on the side of the road, and self-illuminating raised pavement makers within the roadway. The details about this design are contained in Part I of this report.



(a) Boca Raton area **(b) SR A1A / SR 800 intersection area**

Figure 14. Study Location

The main focus of this part of the research project was to obtain public opinion about the roadway lighting system change. A secondary task was to summarize and assess accident information for SR A1A and SR 800 in the immediate vicinity of the lighting system.

A survey instrument facilitated obtaining public opinion about the project. This aspect of the project will be discussed first, followed by a discussion about the accident data.

Survey Design

A survey instrument was developed to solicit opinions on the new lighting scheme from users of this particular stretch of SR A1A roadway.

In addition to opinion-oriented questions about the new lighting infrastructure, other included questions sought information about travel behavior on this roadway. Socio-economic questions were also included so that user opinion responses could be correlated with personal respondent characteristics.

The physical format of the survey was an 8.5” x 11” double-sided form that was tri-folded. It was designed such that it could be distributed on-site, and then returned via US mail.

The survey was sent to the FDOT for preliminary review, and then reviewed by graduate students for readability and understandability. The survey was then submitted to the University of Florida Institutional Review Board (IRB) for final approval (this is standard procedure for any studies involving human subjects).

The survey is shown in Appendix C: Survey Form.

Survey Distribution

As mentioned, the intended audience for this survey was users (motorists, bicyclists, and pedestrians) of the SR A1A facility where the new lights were installed. It was decided that the best way to target this audience was to hand out the surveys on-site to passing motorists, bicyclists, and pedestrians, and to supplement this effort with a mailing of surveys to local residents and leaving surveys at the City of Boca Raton Park Ranger Station for pick-up by visitors.

Surveys were distributed at the intersection of SR A1A and SR 800/Spanish River Boulevard (a signalized intersection) on August 16, 2001. In order to maximize the number of surveys distributed, surveys were handed out during the afternoon peak traffic period from 3:45 – 8:00 pm. A crew of four survey distributors was utilized to hand out surveys at each of the three approaches to the signalized intersection as well as users of the pedestrian path and bicycle lane. Surveys were distributed to motorists while they were queued at a red signal indication on their respective approach. Pedestrians and bicyclists were solicited for a survey as they passed individual survey distributors. A summary of general observations during the survey distribution process is included in Appendix D: Survey Distribution Notes.

The FDOT District 4 also supplied UF researchers with the names and addresses of 480 residents that lived within the immediate locality of this section of roadway. Surveys were mailed to 430 of these addresses (21 were undeliverable and returned), a few days after the on-site survey distribution effort. It is possible that some of these residents also received surveys during the on-site roadway distribution; but since the surveys were anonymous, it is not possible to know whether there were multiple submissions by any individuals.

Finally, about 500 surveys were left at the park ranger station. About 100 surveys were picked-up by visitors from this location.

The survey distribution and return numbers are summarized in Table 5.

Table 5. Survey Distribution and Return

Survey Distribution Method	Amount
Handed out to motorists, peds, and bicyclists on-site	≈ 800
Mailed to local residents	409
Pick-up from park ranger station by visitors	≈ 100
Total surveys distributed	1309
Total surveys returned[a]	259
Survey return rate	19.8%

[a] Four surveys were returned after due date and were not entered into the database; thus, the survey analysis was based on a total of 255 returned surveys.

The survey return rate of about 20 percent is a very respectable return rate, indicating that the potential survey respondents were generally interested in expressing their opinions on this issue.

The range of postal zip codes for respondents' places of residence is indicated in Table 6.

Table 6. Zip Codes of Returned Surveys (respondent indicated)

Zip Code
33062, 33064, 33069, 33304, 33308, 33334, 33408, 33426, 33428, 33430, 33431, 33432, 33433, 33434, 33435, 33437, 33441, 33442, 33444, 33445, 33460, 33483, 33486, 33487, 33496, 33498 30 survey respondents did not indicate their zip code

Survey Results

Table 7 summarizes the demographic characteristics of the survey respondents. In general, the number of male and female respondents was balanced, while the majority of the respondents was married and had at least a college degree. The average household income was very high and the average age was relatively high (both of these results were expected due to retirees comprising the majority of residents of this particular area).

Note: The average household income value is only a rough estimate as 38.4% of the respondents checked the '$100,000 or more' category (which was quantified as $150,000 for average estimation purposes). Also, 9.4% of the survey respondents did not respond to this question—a significant non-response rate on income-related questions is typical for any general population survey.

Table 7. Survey Respondent Demographics Summary

Gender	
Male	51.4%
Female	47.8%
Marital Status	
Single	22.4%
Married	59.6%
Separated or Divorced	10.6%
Widowed	5.5%
Education	
Some or no high school	1.2%
High school diploma or equivalent	12.2%
Technical college degree (A.A.)	8.2%
College degree	48.6%
Post-graduate degree	27.8%
Other	
Average household income	$96,000
Average age	50

Table 8 provides a summary of the responses to survey question #1, "What is your primary mode when traveling on SR A1A". Eighty percent of the survey respondents indicated that their primary mode was driving a personal vehicle. This result was expected since the majority of the survey recipients were vehicle drivers, and motorized vehicle traffic dominates the usage of this roadway.

Table 8. Survey Responses to Question #1 (Primary Mode)

Primary mode of travel on SR A1A	Frequency Count	Percentage
Personal vehicle driver	206	80.8
Personal vehicle passenger	37	14.5
Bus	0	0.0
Bicycle	7	2.7
Pedestrian	3	1.2
Other	1	0.4
No response	1	0.4
Total	**255**	**100.0**

Although only a small percentage of survey respondents indicated that their primary mode of travel on this road is either a bicycle or walking, there was still a significant percentage of survey respondents that indicated they use SR A1A as a pedestrian and/or bicyclist even though their primary mode was the personal automobile. Sixty-nine respondents (27.1%) indicated that they make one or more trips per week as a pedestrian on this roadway and 37 respondents (14.5%) indicated that they make one or more trips on this roadway as a bicyclist.

It was attempted to distribute surveys to as many passing pedestrians and bicyclists as possible, but for some reason, many of these people expressed ambivalence toward responding to a survey. This was despite the effort of survey distributors to even emphasize to potential survey recipients that the opinions of pedestrians and bicyclists were especially desired. Some surveys were distributed to pedestrians headed to/from the beach. However, many of these people were only pedestrians for the purpose of walking from their parking spot to the beach and back. Many of these people revealed that they were not from the area, and thus were unlikely to be pedestrian path users, particularly after dark.

Table 9 gives a summary of the trip making characteristics of the 255 survey respondents. As expected, most travel activity in the evening hours and very early morning occurs between 6 PM and midnight. A significant percentage of trips do occur between 4 and 6 AM, particularly for pedestrians and bicyclists. Most pedestrian and bicycle trips are made for recreational purposes, but some trips are made for the other purposes as well.

Table 9. Summary of Trip Making Characteristics

	Trips as a Motorist	**Trips as a Pedestrian**	**Trips as a Bicyclist**
Avg. # of round trips/week[a]	9.3	3.8	4.0
Primary times of travel (%)			
6 to 8 PM	41.9	48.4	49.1
8 to 10 PM	28.1	25.3	22.8
10 PM to 12 AM	18.2	8.8	14.0
12 AM to 2 AM	4.7	3.3	3.5
2 to 4 AM	1.7	3.3	0.0
4 to 6 AM	5.5	11.0	10.5
Total	100.0	100.0	100.0
Trip purpose (%)			
Work/Business	35.5	4.9	7.0
Educational/School	4.5	1.2	3.5
Recreational	33.2	84.0	73.7
Errands/Shopping	23.7	3.7	8.8
Other	3.2	6.2	7.0
Total	100.0	100.0	100.0

[a] This average is based only on respondents that indicated a number of trips greater than zero for that mode.

Of those respondents that indicated they make trips along SR A1A with their bicycle, 39% indicated that they use the on-street bicycle lane and 61% indicated they use the sidewalk/path. Forty-six percent of those making bicycle trips indicated that their bicycle was equipped with lights.

The main emphasis of the survey was the opinion questions (#13 – 18). These questions were developed so as to be able to assess how the roadway users felt about the relative importance of protecting sea turtle nesting beaches along this road and what impact lighting level changes might have on their desire to continue to use this road and whether the new lighting levels were considered safe for the different modes of travel.

Table 10 summarizes the response percentages to these opinion questions.

Table 10. Response Percentages to Survey Questions #13-18

	Agree Strongly	Agree	Neutral	Disagree	Disagree Strongly	No Response
The location of the lighting fixtures on this roadway is a safety concern for me.	12.2	13.7	17.3	23.5	23.9	9.4
A reduction in lighting levels at night will deter me from using the roadway.	3.9	6.7	6.3	29.0	47.8	6.3
Sea turtle safety should be a primary concern on this roadway.	40.0	30.2	10.6	8.6	5.1	5.5
The nighttime lighting levels along SR-A1A are adequate for *motor vehicles*.	42.4	40.4	4.7	4.3	2.4	5.9
The nighttime lighting levels along SR-A1A are adequate for *pedestrians*.	27.5	29.4	16.9	9.4	4.7	12.2
The nighttime lighting levels along SR-A1A are adequate for *bicyclists*.	24.3	30.2	18.8	8.2	3.1	15.3

Note: Due to rounding, percentages for each question may not sum exactly to 100.0

The higher non-response rates for the last two questions is likely due to respondents that do not walk or ride this section of roadway feeling that they could not adequately make this judgment. The fact that the question about sea turtle safety had the lowest non-response rate is a good indication that most everyone had an opinion on this matter, one way or another.

Ordered Probit Model Results

An ordered probit model is well suited to the analysis of discrete qualitative choice data, particularly data that have an ordinal (or ranking) nature to the response range [6]. The intent of the ordered probit analysis is to determine which characteristics (e.g., socioeconomic and/or trip-making) make a person more or less likely to agree or disagree with a certain statement. Three of the six opinion questions were chosen for an ordered probit analysis, #13 – 15. The results for the analysis of each of these questions are presented below.

Question #13 was intended to gauge whether respondents were concerned about the location of the low-level lighting fixtures. The ordered probit results for this question are shown in Table 11.

Table 11. Ordered Probit Estimation for Survey Question #13

Variable[a]	Estimated Coefficient	T-statistic
Constant	1.6961	6.3157
Age (years)	-0.0136	-2.8188
Gender (1 – female; 0 – male)	0.2080	1.4582
Initial log likelihood		-457.57
Log likelihood at convergence		-351.23
$\bar{r}^2$ (corrected rho-squared)		0.229
Number of observations		227

Note: A negative coefficient indicates increased likelihood of indicating that the location of lighting fixtures is a safety concern.
[a] Dependent variable: response to "The location of the lighting fixtures on this roadway is a safety concern for me"; agree strongly → 1; agree → 2; neutral → 3; disagree → 4; disagree strongly → 5

Given the proximity of the lighting fixtures to the bicycle lane and sidewalk/path in some locations, it was suspected that bicyclists in particular might be more concerned than the other modes due to the possibility of colliding with one of these light fixtures. This, however, did not turn out to be case. In fact, none of the mode-specific indicator variables was found to be significant, as well as none of the logical trip making characteristics. The only variables found to be statistically significant were those for age and gender. For this question, older persons were more likely to indicate that the location of the lighting fixtures was a safety concern for them. Women were more likely to indicate that the location of the lighting fixtures was *not* a safety concern for them.

The age and gender variables are significant at over the 90 percent confidence level ($t_{0.10,\infty}$ = 1.282) using a one-tailed t-test.

The goodness-of-fit measure, corrected rho-squared, for this model is calculated with the following equation:

$$\bar{r}^2 = 1 - \frac{L^*(\hat{b}) - k/2}{L^*(0)} \qquad (1)$$

where: $L^*(\hat{b})$ = log-likelihood at model convergence
$L^*(0)$ = log-likelihood at zero
k = number of coefficients in the model

Question #14 was intended to measure whether reduced lighting levels along the roadway would discourage respondents from using the roadway at night. The ordered probit results for this question are shown in Table 12.

Table 12. Ordered Probit Estimation for Survey Question #14

Variable[a]	Estimated Coefficient	T-statistic
Constant	1.6843	4.7939
Age (years)	-0.0065	-1.1303
Single marital status (1 if yes; 0 otherwise)	0.4047	1.8375
# of motor vehicle round trips/week	0.0267	2.8275
Annual household income > $65,000 (1 if yes; 0 otherwise)	0.2291	1.4452
Primary mode is bicycle or pedestrian (1 if yes; 0 otherwise)	0.9716	1.6248
Initial log likelihood		-430.62
Log likelihood at convergence		-264.44
$\bar{r}^2$ (corrected rho-squared)		0.379
Number of observations		228

Note: A negative coefficient indicates increased likelihood of being deterred from using roadway due to reduced lighting levels.

[a] Dependent variable: response to "A reduction in lighting levels at night will deter me from using this roadway"; agree strongly → 1; agree → 2; neutral → 3; disagree → 4; disagree strongly → 5

It was suspected that pedestrians and bicyclists might be more concerned about reduced lighting levels than motor vehicle drivers/passengers. It turned out that those that indicated their primary mode was either 'Bicycle' or 'Pedestrian' (question #1) actually were *more* likely to disagree that a reduction in nighttime lighting levels would deter them from using the roadway[1]. Other variables that were found to be statistically significant included 'age', 'single marital status', '# of motor vehicle round trips/week', and 'annual household income > $65,000'. Consistent with the previous question, older persons were again found to be more likely to indicate that reduced lighting levels would deter them from using the roadway.

All model variables but age are significant at over the 90 percent confidence level ($t_{0.10, \infty}$ = 1.282) using a one-tailed t-test. The age variable is significant at just under the 90 percent confidence level.

Question #15 was intended to measure the general level of support for measures intended to increase sea turtle safety along this section of SR A1A. The ordered probit results for this question are shown in Table 13.

[1] Although it should have been apparent to all survey respondents that most of the questions on this survey pertained to the consideration of nighttime conditions, it was later realized that the question #14 wording probably would have been better as follows: "A reduction in lighting levels at night will deter me from the using the roadway *at night*."

Table 13. Ordered Probit Estimation for Survey Question #15

Variable[a]	Estimated Coefficient	T-statistic
Constant	-0.7591	-2.0588
Age (years)	0.0212	3.8357
Single marital status (1 if yes; 0 otherwise)	-0.6946	-3.1461
Holds a post-graduate degree (1 if yes; 0 otherwise)	-0.4170	-2.4243
# of motor vehicle round trips/week	0.0258	3.3284
Gender (1 – female; 0 – male)	-0.3651	-2.3732
Annual household income > $65,000 (1 if yes; 0 otherwise)	0.1823	1.1617
Initial log likelihood		-315.68
Log likelihood at convergence		-281.51
$\bar{r}^2$ (corrected rho-squared)		0.097
Number of observations		228

Note: A negative coefficient indicates increased support for sea turtle safety on SR A1A (i.e., more likely to respond toward the ‘agree’ side of the response range.

[a] Dependent variable: response to “Sea turtle safety should be a primary concern on this roadway”; agree strongly → 1; agree → 2; neutral → 3; disagree → 4; disagree strongly → 5

Older persons were less likely to support sea turtle safety on this roadway. This is generally consistent with the findings from the ordered probit results for both questions #13 and #14. It seems as though these people may be more set in their ways and are less receptive to change. Also consistent with earlier findings, women are again more likely to be supportive of sea turtle safety on this roadway. Women generally may be more sensitive to environmental concerns than men. For question #14, respondents from high-income households are less likely to be deterred from using the roadway due to reduced lighting levels. For question #15, these individuals were less likely to be supportive of sea turtle safety on this roadway. This possibly indicates that these people do not perceive this project to provide adequate benefits for the costs.

Somewhat surprisingly, no mode specific characteristics were found to be significant. It was thought that those who use this road mostly as a pedestrian or bicyclist, or even in combination with a motorized mode, would feel more strongly one way or the other than those that only use a motorized vehicle on this roadway; but that was not the case with these data.

All variables but income are significant at over the 99 percent confidence level ($t_{0.01,\infty} = 2.326$) using a one-tailed t-test. The income variable is significant at just under the 90 percent confidence level ($t_{0.10,\infty} = 1.282$).

Accident Data Summary

Copies of accident reports were obtained from the City of Boca Raton for the years 1999, 2000, and 2001 within the project limits. These reports were reviewed and are summarized in this section.

Table 14 below gives a very condensed summary of the reported accident statistics for the years 1999 – 2001 for the approaches to, and including the intersection of, SR A1A and SR 800 (Spanish River Park Blvd.). A more detailed summary can be seen in Appendix E: Accident Report Summary. For the purposes of this summary, accidents[2] that occurred within 100 feet of the intersection were classified as occurring *at* the intersection, while any accidents that occurred between 100 ft and 1/10 mile were classified as occurring on the approach to the intersection. Accidents that occurred more than 1/10 mile from the intersection were not included in this summary.

Table 14. Accident Summary

	Total Reported Crashes	Fatality Crashes	Injury Crashes	Property Damage Only Crashes	Crashes at SR A1A / SR 800 Intersection	Crashes after Dark	Crashes with Peds and/or Bicycles
SR A1A							
1999	7	0	1	6	6	3	0
2000	6	0	4	2	5	2	1
2001	9	0	0	9	5	0	0
SR 800							
1999	14	0	7	7	5	4	0
2000	9	0	8	1	1	1	0
2001	8	0	3	5	4	1	0
Total	**53**	**0**	**23**	**30**	**26**	**11**	**1**

Table 15 below provides a summary of the distribution of crash types within the project limits. These data show that rear-end type crashes are predominant. This is not uncommon for signal-controlled intersections, as inattentive motorists do not realize vehicles ahead of them are stopped for the signal, especially in scenically "distracting" areas such as this. However, many of these rear-end accidents are actually due to a parking situation on one of the intersection approaches, which will be discussed later.

[2] The term 'accident' and 'crash' are used synonymously in this report.

Table 15. Crash Type Distribution

Year	Accident Type*								Total
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
1999	13	1	3	2	0	2	0	0	21
2000	9	1	1	2	1	0	1	0	15
2001	10	0	4	0	1	1	0	1	17
Total	**32**	**2**	**8**	**4**	**2**	**3**	**1**	**1**	**53**
%	**60**	**4**	**15**	**7**	**4**	**6**	**2**	**2**	**100%**

* 1 = REAR END
2 = REAR END WITH PARKED VEHICLE
3 = SIDE-SWIPE
4 = COLLISION WITH FIXED OBJECT
5 = COLLISION WITH STREET SIGN/LIGHT POLE
6 = COLLISION WITH TREE/SHRUBBERY
7 = COLLISION WITH BICYCLE
8 = BACKED INTO VEHICLE

Quantitatively speaking, crash frequency, crash rate, and crash severity are three commonly used measures of the relative safety[3] of a roadway facility.

Crash frequency is simply the number of crashes that have occurred at the location of interest over a specified period of time. Crash rate is typically a more meaningful measure than just crash frequency, as it accounts for the volume of traffic that has been exposed to a potential crash at the location of interest. Crash rate is usually measured in terms of million entering vehicles (MEV) for spot locations such as an intersection, or million vehicle miles (MVM) traveled for roadway sections. The following equations were used to calculate these measures for this study.

$$CR(\text{spot}) = \frac{1{,}000{,}000 * C}{365 * T * V} \tag{2}$$

where:

CR = crash rate
C = number of reported crashes
T = time frame of the analysis, years
V = Annual Average Daily Traffic (AADT)

[3] Note that accident statistics are generally only considered a surrogate measure for the safety of a facility. Also keep in mind that these statistics reflect only *reported* accidents. It is not known what level of accident under-reporting may be present at this particular site. However, a study by Hauer and Hakkert (1988) estimated that generally the number of injuries requiring hospitalization is underreported by about 20%, only about half of all injuries occurring in accidents are reported, and motorists report fewer than half of all property damage only (PDO) accidents.

$$CR(\text{section}) = \frac{1{,}000{,}000 * C}{365 * T * V * L} \qquad (3)$$

where:

L = length of analysis section, miles
Other variables are as defined previously

The calculated crash rate for the intersection of SR A1A/SR 800 over the three-year period is:

$$CR(\text{spot}) = \frac{1{,}000{,}000 * 26}{365 * 3 * 20{,}600} = 1.153 \text{ crashes per million entering vehicles}^{4} \qquad (4)$$

The calculated crash rate for the roadway section to the east of the SR A1A/SR 800 intersection over the three-year period is:

$$CR(\text{section}) = \frac{1{,}000{,}000 * 21}{365 * 3 * 16{,}100 * 0.081} = 14.706 \text{ crashes per million vehicle miles}^{5} \qquad (5)$$

The calculated crash rate for the north-south roadway sections leading to the SR A1A/SR 800 intersection over the three-year period is:

$$CR(\text{section}) = \frac{1{,}000{,}000 * 6}{365 * 3 * 12{,}350 * 0.162} = 2.739 \text{ crashes per million vehicle miles}^{6} \qquad (6)$$

[4] Typically, an average AADT value over the three-year period would be used, but 2001 AADT information was unavailable at the time of preparation of this document. Thus, just the year 2000 AADT value was used as this is probably fairly close to what a three-year average would be (1999 value was 19,900, and the 2001 value is probably slightly more than the 2000 value).

[5] This roadway section length covers the distance between 100 ft to 528 ft (1/10 mile) from the SR A1A/SR 800 intersection, for a total length of 428 ft (0.081 miles).

[6] This roadway section length covers the distance between 100 ft to 528 ft (1/10 mile) from the SR A1A/SR 800 intersection on both the north and south sides of the intersection, for a total length of 856 ft (0.162 miles). The AADT of 12,350 vehicles is the average of the AADT on the north and south sides of the intersection (i.e., 13,400 and 11,300)

In general, a crash rate of 1.153 for the SR A1A/SR 800 intersection is relatively low. This rate, combined with a qualitative review of the accident reports (described below) does not reveal any major concerns with the safety of this intersection.

The crash rate of 14.706 for the SR 800 roadway section approaching the SR A1A/SR 800 intersection is very high. The main contributing factor to this crash rate appears to be the side-street parking allowed to the east of the intracoastal waterway bridge. Many of the reported accidents along this roadway section were related to parking maneuvers, most notably, vehicles stopping in the outside through lane to let a parked car enter traffic, and then the stopped vehicle being rear-ended. Some various other parking maneuver-related accidents were also reported. To a much lesser extent, but also reported several times, were accidents related to loss of vehicle control or reduced braking ability on the intracoastal waterway bridge steel grating when wet.

The crash rate of 2.739 for the SR A1A roadway sections approaching the SR A1A/SR 800 intersection is reasonably low. This rate, combined with a qualitative review of the accident reports (described below) does not reveal any major concerns with the safety of these roadway sections.

As for crash severity, as seen in Table 14, most of the accidents involve property damage only (PDO). No fatalities occurred in this vicinity over the three-year period. Of the injuries that occurred, these appeared to be mostly minor in nature (as inferred from the accident report narratives). Thus, the overall severity of crashes occurring in this area should not be cause for any major concern, especially considering the high proportion of elderly drivers in this area.

The rest of the discussion that follows centers on a more qualitative review of the accident reports. Since the focus of this study was on the implementation of a new low-level lighting system in this vicinity along SR A1A, the logical area to focus on is whether lighting issues have appeared to be a contributing factor to accidents in the past (with the previous lighting system). The second-to-last column in Table 14 indicates the number of crashes that occurred during dusk or dark (with street lighting) conditions. It is important to realize, however, that this only indicates the lighting conditions present when the crash took place. It makes no implication about whether lighting conditions were a contributing factor to the crash. Twenty-one percent of the total accidents occurred under these lighting conditions. It is not known what percentage of the daily traffic occurred under these conditions, as hourly volume counts were not available from the count stations on these approaches. Given that nighttime conditions offer less visibility than the daytime (weather permitting), with or without streetlights, it is not unusual for nighttime accidents to be disproportionate (in terms of traffic volume) to daytime accidents.

Roadway lighting is not currently included as an option for contributing causes on the Florida Traffic Crash Report Form since roadway lights are not required, as roadway design for nighttime conditions is based on vehicle headlight illumination. Nonetheless, a review of the crash report form narratives (for the nighttime accidents) completed by the investigating officers did not contain any references to street lighting (or lack thereof) as being a possible contributing cause for any of these accidents.

The new low-level lighting system was first activated in May 2001. Nine accidents occurred within the project limits between January and April of 2001, while eight accidents occurred between June and December. No accidents were reported for the month of May. Of these 17 accidents, only one occurred during nighttime conditions, and this was due to careless driving (as indicated in the crash report). Incidentally, there was one accident involving one of the new low-level lights. This was an early-morning accident (6:19 AM) in June, in which the light was struck as a result of a vehicle having to swerve onto the shoulder to avoid an oncoming vehicle that had crossed the centerline. No injuries were reported other than the light. The crash report form indicated daylight conditions for this accident. Although only a limited of accident data are currently available for the post low-level lighting system installation, no discernable trends are revealed with these six months of data for the latter half of 2001.

In an area such as this on SR A1A, with a potentially significant percentage of pedestrians and bicyclists in the area due to its scenic and recreational nature, roadway lighting can certainly offer potential safety benefits. Thus, one of the metrics that should be considered is collisions with pedestrians and bicyclists during nighttime conditions, in addition to accident rates and severity. For these accident data (1999 – 2001), only one of the total 53 accidents involved a collision with a pedestrian or bicycle, bicyclist in this case, and that occurred during daylight conditions (in the crosswalk at the intersection). This certainly does not indicate any previous or current problem with motor vehicle versus pedestrian/bicycle interaction problems, particularly as it relates to street lighting conditions. This is likely a function of relatively low vehicle speeds (posted speed of 35 mph, and consistent with observed speeds) and increased driver awareness in this area.

Part III: Conclusions and Recommendations

Evaluation of Lighting System Modifications - Conclusions

In general area lighting levels and uniformity were reduced by the elimination of the overhead lighting. The remaining pedestrian area lights did provide adequate illumination levels along the pedestrian pathway. However, with regard to security, the existence of non-illuminated areas adjacent to the pathway is problematic. The experience at the site did not indicate a security problem during the demonstration and users generally felt comfortable with the lighting. A better long-term approach would include augmenting the existing pedestrian lighting with additional pathway lighting.

Visibility in the travel lanes and the bike lanes appears to have been adequate for the traffic conditions of the roadway. The embedded roadway lighting and the low bollard luminaires served principally as delineation aids. It seem likely that both contributed to the safety of the roadway, however, the short demonstration duration and limited accident data do not permit a statistical conclusion.

Evaluation of the Roadway User Survey and Accident Statistics - Conclusions

Opinion Survey

The ordered probit models developed for this study indicated the demographic and socioeconomic factors that were significant in explaining varying levels of support from certain types of individuals. Generally, it was found that older persons were less supportive of the new lighting system than younger persons, and women were more supportive of the new system than men. Somewhat surprisingly, no mode specific factors (i.e., bicycle, pedestrian, motor vehicle) were found to be any more significant than the others in explaining opinion responses.

Overall, roadway users were very supporting of this alternative lighting system for the benefit of sea turtle nesting safety. The percentages in Table 10 generally draw out this conclusion. For the first two opinion questions, the responses were heavily weighted towards the 'disagree' side (the supporting side for these questions) and for the latter four questions; the responses were heavily weighted towards the 'agree' side (the supporting side for these questions).

Accident History

Although the post-low level lighting installation data time period is limited, there does not appear to be any particular roadway safety concerns with nighttime conditions along SR A1A in the project area to this point. There is a possibility that the in-roadway illuminated pavement markers might actually improve safety for motor vehicle traffic at night as the lane delineation is probably more clearly defined for all vehicles overall than with reflective pavement markers. However, from the limited data to this point, and the general lack of nighttime accidents along SR A1A in both the pre- and post-low level lighting system installation, no conclusion can be drawn on this issue. Overall, one could conclude that the change in lighting system in this area is a non-issue as far as safety is concerned. However, there does appear to be a safety issue with the parallel parking allowed along SR 800 in the vicinity of SR A1A. While this is not related directly to any lighting issues, the elimination of overhead lighting in these parking areas could potentially exacerbate this problem even more. It should be noted, however, that the parallel parking along SR 800 is prohibited after 10 PM (and regularly enforced). Thus, parking activity during nighttime hours is already limited.

Recommendations

General Observations Supporting Recommendations

- For the most part, the roadway users in this area were receptive and interested in expressing their opinions about this project. The user survey results indicated that a majority of respondents were supportive of the efforts to minimize the impact of lighting on nesting turtles and their hatchlings.

- The accident data for the three-year period analyzed as part of this study do not highlight any lighting-related safety problems for this section of SR A1A. However, the amount of data corresponding to the time period of the new lighting system is still limited.

- The project did demonstrate the feasibility of utilizing alternative lighting systems that when properly designed can satisfy current lighting design criteria and at the same time, minimize potential lighting hazards to turtles.

Recommended Action Items

- Continue to operate the modified lighting configuration at the project site during appropriate time periods to reduce the lighting hazard for sea turtles. Monitor and evaluate crash statistics to obtain improved safety and performance measures. The crash reports and statistics for this site should continue to be monitored closely for the next year.

- Consider improving the area lighting along the pedestrian pathway at the project site to improve the uniformity of the area lighting in the absence of the overhead lighting.

- Initiate a follow up public opinion survey at the project site again to gauge public support. This likely also enhances the Department’s reputation with the community as they feel their opinions are valued.

- Much value could be achieved by developing a Practice Manual for Designing Roadway Lighting Systems in Environmentally Sensitive Areas. This would not necessarily offer new lighting criteria, but would show the designer how to use alternative lighting products in the design. This would be a valuable resource for Florida and for the nation.

References

1. Lighting Analyst Inc. AGI 32. http://www.agi32.com/index.htm

2. Witherington, B.E. and Martin, R.E. Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. FMRI Technical Report TR-2. Florida Department of Environmental Protection. 1996

3. Cowen, E. and Salmon, M. Influence of Filtered Roadway Lighting on the Orientation of Hatchling Loggerhead Turtles, Caretta caretta L. Project Report for Florida Power and Light, Florida Atlantic University, 1998

4. Harding Traffic Systems. Smartstud. http://www.hardingsystems.com/traffic/

5. Bronzelite, Genlyte-Thomas Group LLC. Bronzlite Bollard Luminaires. http://www.bronzelite.com/

6. Illumination Engineering Society of North America. American National Standard Practice for Roadway Lighting ANSI/IESNA RP-8-00. New York, NY. 1999

7. Bureau of Transportation Statistics. Transportation Safety. BTS-CD-16. USDOT.

8. Greene, William H. Econometric Analysis, Second Edition. Macmillan Publishing Company. 1993.

9. Hauer, E. and Hakkert, A.S. Extent and Some Implications of Incomplete Accident Reporting. Transportation Research Record 1185, Transportation Research Board, Washington, DC. pp. 48-58. 1998.

10. Institute of Transportation Engineers. Manual of Transportation Engineering Studies. Prentice-Hall Publishing. 1994.

11. Salmon, Michael. Coastal Roadway Lighting Impacts on Nesting Endangered and Threatened Marine Turtles and Their Hatchlings. Final Report. Florida Department of Transportation. 2002

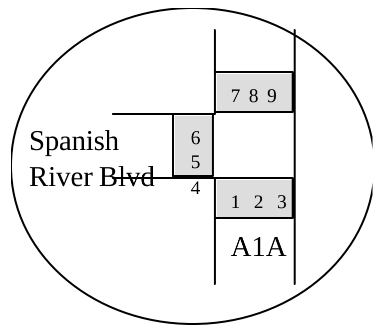
Appendix A: Illumination Levels of Original Lighting Configuration

Recorded Illumination Values
Original Lighting Configuration

Station	Light Condition	PP	BL	TL	
60+25	1	2.74	1.32	0.26	
59+23	4	0.66	0.51	0.10	
58+22	1	3.47	1.37	0.27	
57+27	4	0.70	0.55	0.11	
56+23	1	2.53	0.39	0.08	
55+20	2	3.82	0.92	0.18	
54+11	1	2.70	1.45	0.29	
53+14	2	3.78	0.81	0.16	
52+26	1	2.41	1.36	0.27	
51+24	2	3.80	0.89	0.18	
50+25	1	2.79	1.20	0.24	
49+24	2	3.55	1.04	0.21	
48+26	1	2.80	1.51	0.30	
47+24	4	0.62	0.32	0.06	
46+21	1	2.21	1.98	0.40	
45+20	3	5.21	2.12	0.42	
44+21	4	0.71	0.56	0.11	
43+22	1	3.10	1.05	0.21	
42+19	4	0.58	0.37	0.07	
14+15	3	5.01	1.99	0.40	
39+29	3	4.98	1.80	0.36	
38+39	4	0.61	0.29	0.06	
37+49	3	5.06	2.03	0.41	
36+50	3	5.24	2.19	0.44	
35+53	3	5.27	2.20	0.44	
34+59	4	0.74	0.51	0.10	
33+86	3	4.97	1.80	0.36	
32+65	4	0.72	0.53	0.11	
31+27	3	5.02	2.09	0.42	
30+60	4	0.79	0.55	0.11	
AVERAGE		2.89	1.19	0.24	
HIGH		5.27	2.20	0.44	
LOW		0.58	0.29	0.06	

Roadway Light	**1**
Pedestrian Light	**2**
Roadway and Ped Light	**3**
Midpoint (Low Light)	**4**
Pedestrian Path	**PP**
Bike Lane	**BL**
Travel Lane	**TL**

Illumination in Foot Candles



Crosswalk Measurements

CW1	1.85
CW2	0.54
CW3	0.29
CW4	2.02
CW5	1.11
CW6	1.91
CW7	2.09
CW8	0.48
CW9	0.22

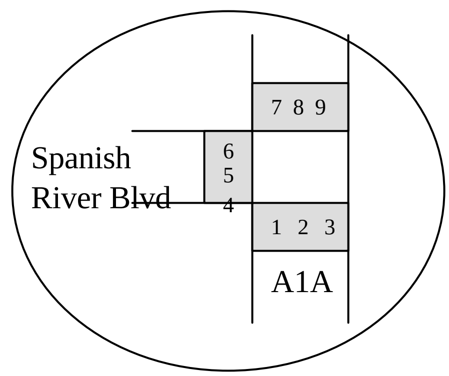
Appendix B: Illumination Levels with Modified Lighting Configuration

Recorded Illumination Values
Revised Lighting Condition

Station	Light Condition	PP	BL	TL	CW
60+25	1	0.70	0.56	0.23	
59+23	4	2.04	2.10	0.45	
58+22	1	3.50	3.04	0.88	
57+27	4	0.52	0.40	0.08	
56+23	1	2.01	1.14	0.14	
55+20	2	1.70	1.20	0.33	
54+11	1	0.61	0.75	0.19	
53+14	2	1.12	0.70	0.14	
52+26	1	0.55	0.82	0.15	
51+24	2	1.85	0.59	0.10	
50+25	1	0.79	0.98	0.15	
49+24	2	1.27	3.95	1.08	
48+26	1	0.55	1.03	0.21	
47+24	4	0.41	0.33	0.06	
46+21	1	0.50	0.21	0.09	
45+20	3	2.41	3.10	0.99	
44+21	4	0.72	2.07	0.75	
43+22	1	0.55	0.92	0.14	
42+19	4	0.57	0.81	0.12	
40+15	3	2.24	3.36	1.02	
39+29	3	2.61	1.74	0.35	
38+39	4	0.43	3.79	1.24	
37+49	3	1.95	2.15	0.55	
36+50	3	2.12	0.81	0.09	
35+53	3	3.02	1.07	0.22	
34+59	4	0.45	0.52	0.04	
33+86	3	2.06	1.61	0.22	
32+65	4	0.54	3.19	0.98	
31+27	3	1.78	2.51	0.74	
30+60	4	0.33	0.41	0.05	
AVERAGE		1.33	1.53	0.39	
HIGH		3.50	3.95	1.24	
LOW		0.33	0.21	0.04	

Roadway Light	**1**
Pedestrian Light	**2**
Roadway and Ped Light	**3**
Midpoint (Low Light)	**4**
Pedestrian Path	**PP**
Bike Lane	**BL**
Travel Lane	**TL**

Illumination in Foot Candles



Crosswalk Measurements

CW1	0.88
CW2	0.54
CW3	0.29
CW4	0.18
CW5	0.07
CW6	0.20
CW7	0.21
CW8	0.08
CW9	0.05

Appendix C: Survey Form

UNIVERSITY OF FLORIDA

TRC
Transportation Research Center

BOCA RATON LIGHTING PROJECT OPINION SURVEY

The University of Florida is conducting an evaluation of a new roadway lighting system that has been installed on SR-A1A, in the vicinity of the Spanish River Park in Boca Raton. This stretch of roadway previously used an overhead lighting system. The new lighting system uses low-level and in-road fixtures. It is hoped that this new lighting system is less disruptive to nearby sea turtle nesting sites, while not negatively impacting motorists, bicyclists, or pedestrians. This new lighting system has been functional since June 2001.

As part of this evaluation, we need the opinions of those people that have used this facility regularly, both before and after this lighting change. Users of the facility include motorized vehicle operators, bicyclists, and pedestrians. The results of this survey will enable transportation engineers to consider the impacts this lighting change has had on the desirability of using this facility and the general user perceptions of the change.

If you are a regular user of this facility, particularly at night when the lights are on, please complete this survey and return by September 14th. No postage is necessary. Please do not include your name or address, as the survey results are intended to be anonymous. We appreciate your assistance.

TRAVEL INFORMATION

1. What is your primary mode when traveling on SR-A1A?
   Personal vehicle driver | Personal vehicle passenger | Bus
   Bicycle | Pedestrian | Other ____________

Answer the following questions if you have used SR-A1A as a *motorist* after dark:

2. How many round trips per week do you make on this roadway? _______

3. At what times do you primarily travel on this roadway? (check all that apply)
   6 to 8 PM | 10 PM to 12 AM | 2 to 4 AM
   8 to 10 PM | 12 AM to 2 AM | 4 to 6 AM

4. For trips made using this roadway, what percentage of them are for each purpose listed below? (%'s should sum to 100)
   _____ Work or business related | _____ Recreational | _____ Other
   _____ Educational or school related | _____ Errands or shopping

Answer the following questions if you have used SR-A1A as a *pedestrian* after dark:

5. How many trips per week do you make on this roadway? _______

6. At what times do you primarily travel on this roadway? (check all that apply)
   6 to 8 PM | 10 PM to 12 AM | 2 to 4 AM
   8 to 10 PM | 12 AM to 2 AM | 4 to 6 AM

7. What is the purpose?
   Work or business related | Recreational | Other
   Educational or school related | Errands or shopping

Answer the following questions if you have used SR-A1A as a *bicyclist* after dark:

8. How many trips per week do you make on this roadway? _______

9. Which of the following do you primarily utilize? On-street bicycle lane | Sidewalk path

10. Is your bicycle equipped with lights? Yes | No

11. At what times do you primarily travel on this roadway? (check all that apply)
    6 to 8 PM | 10 PM to 12 AM | 2 to 4 AM
    8 to 10 PM | 12 AM to 2 AM | 4 to 6 AM

12. What is the purpose?
    Work or business related | Recreational | Other
    Educational or school related | Errands or shopping

YOUR OPINION

	Agree Strongly	Agree	Neutral	Disagree	Disagree Strongly
13. The location of the lighting fixtures on this roadway is a safety concern for me.					
14. A reduction in lighting levels at night will deter me from using the roadway.					
15. Sea turtle safety should be a primary concern on this roadway.					
16. The nighttime lighting levels along SR-A1A are adequate for *motor vehicles*.					
17. The nighttime lighting levels along SR-A1A are adequate for *pedestrians*.					
18. The nighttime lighting levels along SR-A1A are adequate for *bicyclists*.					

YOURSELF

19. What is your gender? Male Female

20. What is your marital status? Single Married Separated or divorced Widowed

21. What is your highest level of education?

Some or no high school	Technical college degree (A.A.)	Post-graduate degree
High school diploma or equivalent	College degree	

22. What is your approximate annual household income?

No income	$20,000 – 29,999	$50,000 – 59,999	$80,000 – 89,999
Under $10,000	$30,000 – 39,999	$60,000 – 69,999	$90,000 – 99,999
$10,000 – 19,999	$40,000 – 49,999	$70,000 – 79,999	$100,000 or more

23. What is your age?

Under 16 years	21 to 25 years	31 to 35 years	46 to 55 years	66 to 75 years
16 to 20 years	26 to 30 years	36 to 45 years	56 to 65 years	Over 75 years

24. What is the zip code at your residence? ____________

Thank you for completing this survey. When completed, please fold the survey so that the return address is displayed. No postage is necessary. If you have any questions about this survey or research project, please contact the Transportation Research Center at the University of Florida (352-392-7575).

Appendix D: Survey Distribution Notes

- Four people distributing
  - Dr. Scott Washburn, Sergio Quevedo, Carlos Ramirez, and Jessica Popik
- 2000 total surveys printed
  - ~ 430 sent via mail to Boca residents, 21 returned as undeliverable
  - ~ 500 left in Ranger station, 400 retrieved by Ann Broadwell
  - ~ 220 left with Jessica (local resident)—ultimately not used
  - ~ 800 passed out to motorists, pedestrians, and bicyclists at intersection of SR-A1A and Spanish River Blvd.

Conditions

- Distributed Thursday, August 16, 2001 form 3:45 to 8:00 PM
  - 15 min. rest break and 15 min. dinner break
- Traffic conditions
  - Light from 3:45 to 4:30 PM
  - Heavy from 4:30 to 6:00 PM
  - Light from 6:00 to 8:00 PM
  - Southbound had lowest level of traffic
  - Southbound and northbound traffic dropped off most
  - Eastbound had fairly consistent traffic levels
- Weather conditions
  - Sunny / Partly cloudy
  - Hot early on (90s) and shady later (80s)

Observations

- Southbound (2 lanes, 1 thru and 1 right)
  - Focused on thru movements
  - Right turns on red or green provided no queuing of right turns
  - ~ 50% took survey when offered
- Northbound (2 lanes, 1 thru and 1 left)
  - Able to distribute to both movements, but focus on thrus
  - ~ 50% (Carlos) and ~ 75% (Sergio) took survey when offered
- Eastbound (2 lanes, 1 left and 1 right)
  - Focused on left turns
  - Right turns on red or green arrow provided no queuing of right turns
  - ~ 75% took survey when offered

- Bicyclist observation
  - Two types: casual and serious cyclists
  - General disinterest from serious cyclists
  - ~ 10% overall took survey when offered
  - Nowhere for cyclist to put survey to take home (no backpack or pocket)
  - Comments from cyclists
    - "No one should ride at night"
    - "I like the lights but don't want a survey"
- Pedestrian observation
  - Two types: beach-bound and trail (exercise) peds
  - ~ 20% overall took survey when offered
  - Peds living near intersection were more responsive
  - Two rollerbladers took survey
  - Comments from peds
    - "Smartstud lights are too bright" (speaking as a motorist)
    - "Get rid of all the lights"
- Motorist observation
  - ~ 20% negative response (against having the lights), 80% positive
  - Cell phone users: ~ 25% (Scott) and ~10% (Sergio) took survey when offered
  - "Monkey see, monkey do"
    - Motorists generally did whatever the first motorist in queue did
    - If the first person took the survey then everyone else did too and vice versa
  - Speaking Spanish (Sergio & Carlos) encouraged response from Hispanics
  - People with really expensive cars seemed less likely to take surveys
  - Older ladies driving alone were less likely to take surveys
  - Younger people responded better to taking survey
  - Comments from motorists
    - "Looks like an airport runway" (several times, but not clear whether they thought that was good or bad)
    - "Is it working for the turtles?" (several times)
    - "How much did this cost?" (several times)

Appendix E: Accident Report Summary

SR A1A AND SR 800 ACCIDENT SURVEY

YEAR	ACCIDENT DATE	LOCATION	WITHIN PROJECT LIMITS	ROAD NAME	TIME OF DAY	LIGHTING CONDITION	PROPERTY DAMAGE ONLY (PDO)	INJURIES (HOW MANY)	FATALITIES (HOW MANY)
1999	01/17/99	0.10 mi N of SR 800	Yes	SR A1A	1:42 AM	4	Yes (street sign)	0	0
	01/23/99	0.02 mi W of SR A1A	Yes	SR 800	6:28 PM	4	Yes	0	0
	01/30/99	0.50 mi W of SR A1A	No	SR 800	4:55 PM	1	Yes	1	0
	02/25/99	Intersection of SR A1A & SR 800	Yes	SR A1A	3:58 PM	1	Yes	1	0
	03/04/99	0.06 mi W of SR A1A	Yes	SR 800	1:17 PM	1	Yes	0	0
	03/26/99	0.03 mi W of SR A1A	Yes	SR 800	2:59 PM	1	Yes	0	0
	03/30/99	0.04 mi W of SR A1A	Yes	SR 800	5:45 PM	1	Yes	0	0
	03/30/99	0.01 mi S of SR 800	Yes	SR A1A	10:18 AM	1	Yes (street sign)	0	0
	04/02/99	0.01 mi N of Spanish R Bl (SR 800)	Yes	SR A1A	12:23 PM	1	Yes	0	0
	04/14/99	0.02 mi W of SR A1A	Yes	SR 800	6:02 PM	1	Yes	1	0
	04/17/99	0.06 mi W of SR A1A	Yes	SR 800	12:19 PM	1	Yes	1	0
	05/07/99	0.04 mi W of SR A1A	Yes	SR 800	4:57 PM	1	Yes	0	0
	05/11/99	0.03 mi W of SR A1A	Yes	SR 800	6:27 AM	3	Yes	1	0
	05/31/99	Intersection of SR A1A & SR 800	Yes	SR 800	11:15 AM	1	Yes	1	0
	07/08/99	Intersection of SR A1A & SR 800	Yes	SR A1A	5:26 AM	4	Yes	0	0
	07/11/99	0.01 mi W of SR A1A	Yes	SR 800	8:50 AM	1	Yes	0	0
	07/13/99	0.25 mi S of SR 800	No	SR A1A	10:43 PM	4	Yes	4	0
	07/26/99	0.01 mi W of SR A1A	Yes	SR 800	10:17 PM	4	Yes	0	0
	09/16/99	0.06 mi W of SR A1A	Yes	SR 800	7:04 PM	1	Yes	1	0
	09/30/99	At Intersection (2 Ft N of SR 800)	Yes	SR A1A	3:37 PM	1	Yes	0	0
	10/11/99	0.10 mi W of SR A1A	Yes	SR 800	2:30 PM	1	Yes	2	0
	11/17/99	0.10 mi W of SR A1A	Yes	SR 800	11:21 PM	4	Yes	1	0
	11/23/99	At Intersection (10 Ft S of SR 800)	Yes	SR A1A	3:47 PM	1	Yes	0	0
	11/25/99	On ICW bridge W of SR A1A	No	SR 800	2:49 AM	4	Yes (guardrail)	0	0
2000	01/08/00	Intersection of SR A1A & SR 800	Yes	SR A1A	6:58 PM	4	Yes	1	0
	01/24/00	0.19 mi W of SR A1A	No	SR 800	2:19 PM	1	Yes	1	0
	01/26/00	0.04 mi W of SR A1A	Yes	SR 800	1:19 PM	1	Yes	0	0
	01/30/00	0.08 mi W of SR A1A	Yes	SR 800	12:03 PM	1	Yes	0	0
	03/06/00	0.01 mi S of SR 800	Yes	SR A1A	1:17 PM	1	Yes	0	0
	03/11/00	0.06 mi W of SR A1A	Yes	SR 800	2:03 PM	1	Yes	0	0
	03/17/00	On ICW bridge W of SR A1A	No	SR 800	11:57 AM	1	Yes	0	0
	04/04/00	Intersection of SR A1A & SR 800	Yes	SR A1A	10:28 AM	1	Yes	1	0
	05/20/00	0.02 mi S of SR 800	Yes	SR A1A	4:19 PM	1	Yes	2	0
	08/06/00	0.04 mi W of SR A1A	Yes	SR 800	12:47 PM	1	Yes	0	0
	09/28/00	0.05 mi W of SR A1A	Yes	SR 800	8:39 AM	1	Yes	0	0
	10/30/00	Intersection of SR A1A & SR 800	Yes	SR 800	3:28 PM	1	Yes	0	0
	11/02/00	0.10 mi W of SR A1A	Yes	SR 800	12:37 PM	1	Yes	1	0
	11/03/00	0.06 mi W of SR A1A	Yes	SR 800	9:14 AM	1	Yes (landscape, signs)	0	0
	11/07/00	0.10 mi N of SR 800	Yes	SR A1A	10:56 PM	4	Yes	0	0
	11/11/00	0.014 mi N of SR 800	Yes	SR A1A	4:10 PM	1	Yes	3	0
	11/25/00	0.06 mi W of SR A1A	Yes	SR 800	4:51 PM	2	Yes	0	0
2001	01/03/01	At Intersection (25 Ft W of SR A1A)	Yes	SR 800	12:30 PM	1	Yes	0	0
	01/25/01	0.25 mi S of SR 800	No	SR A1A	1:01 PM	1	Yes	1	0
	01/27/01	0.04 mi W of SR A1A	Yes	SR 800	2:22 PM	1	Yes	2	0
	01/28/01	0.10 mi N of SR 800	Yes	SR A1A	12:21 PM	1	Yes	0	0
	02/10/01	0.01 mi W of SR A1A	Yes	SR 800	1:47 PM	1	Yes	0	0
	02/20/01	Intersection of SR A1A & SR 800	Yes	SR A1A	1:02 PM	1	Yes	0	0
	03/13/01	0.10 mi W of SR A1A	Yes	SR 800	1:43 PM	1	Yes	0	0
	03/14/01	0.08 mi S of SR 800	Yes	SR A1A	4:28 PM	1	Yes	0	0
	03/20/01	0.10 mi W of SR A1A	Yes	SR 800	12:42 PM	1	Yes	2	0
	04/05/01	At Intersection (30 Ft W of SR A1A)	Yes	SR 800	12:35 PM	1	Yes	0	0
	06/10/01	3900 Blk of SR A1A (S of SR 800)	Yes	SR A1A	6:19 AM	1	Yes (turtle lights)	0	0
	07/05/01	Intersection of SR A1A & SR 800	Yes	SR 800	1:51 AM	4	Yes (bushes, sign)	0	0
	07/20/01	0.10 mi W of SR A1A	Yes	SR 800	11:23 AM	1	Yes	2	0
	08/21/01	At Intersection (10 Ft S of SR 800)	Yes	SR A1A	7:09 PM	1	Yes	0	0
	08/29/01	0.06 mi N of SR 800	Yes	SR A1A	11:45 AM	1	Yes	0	0
	10/01/01	At Intersection (10 Ft S of SR 800)	Yes	SR A1A	1:43 PM	1	Yes	0	0
	10/23/01	0.25 mi W of SR A1A	No	SR 800	7:35 AM	1	Yes	1	0
	11/01/01	0.10 mi S of SR 800	Yes	SR A1A	2:15 PM	1	Yes	0	0
	12/04/01	Intersection of SR A1A & SR 800	Yes	SR A1A	1:51 PM	1	Yes	0	0

LIGHTING CONDITION CODE		LEGEND	
1	DAYLIGHT	Bl =	Boulevard
2	DUSK	Blk =	Block
3	DAWN	ICW =	Intracoastal Waterway
4	DARK (STREET LIGHT)	R =	River
5	DARK (NO STREET LIGHT)		
88	UNKNOWN		

BOUNDARY LIMITS ARE RADIUS OF 0.10 MILE AROUND INTERSECTION OF SR A1A AND SR 800

ROWS HIGHLIGHTED IN YELLOW INDICATE ACCIDENTS THAT OCCURRED DURING NIGHTIME HOURS