FPL

March 31, 2015

Marc Harris, P.E.
Florida Department of Environmental Protection
Industrial Wastewater Section
2600 Blair Stone Road, MS 3545
Tallahassee, Florida 32399-2400

CERTIFIED MAIL
RETURN RECEIPT REQUESTED
7011 3500 0000 7495 6983

RE: Florida Power & Light Company-St. Lucie Plant
IWW Permit No. FL0002208
Heated Water Report - Heated Water Plan of Study

Enclosed please find two signed and sealed copies of the Florida Power & Light Company (FPL) ~~St. Lucie Plant Heated Water Report (HWPOS) submitted~~ in accordance with Section VI.1 of the St. Lucie Plant Industrial Wastewater Permit, FL0002208.

FPL believes that the results of HWPOS demonstrate that the heated cooling water being discharged by the Plant:

1) does not raise the surface temperature near the Plant's open ocean outfalls to more than 97°F;
2) does not heat adjacent coastal waters above the limitations specified in Rule 62-302.520(4)(b), F.A.C.; and,
3) results, as predicted by previous models, in minimal recirculation from the Plant's discharge to its intake and thus meets that the requirement for the Ambient Monitoring report.

These conclusions should result in a determination that No Further Action is required for the issues.

If you have any questions or need additional information, please contact Vince Munné at (772) 263-2847.

Sincerely,

Christopher R. Costanzo

Christopher R. Costanzo
Site Vice President
St. Lucie Plant

VPPSL051

Enclosure: Bound copy of Heated Water Report – February 2015

cc: Siting Office, local FDEP Office

HEATED WATER REPORT

Florida Power and Light, St. Lucie Nuclear Power Plant

Submitted To: Florida Power and Light
St. Lucie Plant
6451 South Ocean Drive
Jensen Beach, FL 34957

Submitted By: Golder Associates Inc.
6026 NW 1st Place
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and

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8502 SW Kansas Avenue
Stuart, FL 34997

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Golder Associates Inc.

February 2015 113-87743

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EXECUTIVE SUMMARY

The FPL St. Lucie Nuclear Plant (Plant) on Hutchinson Island, Florida completed an Extended Power Uprate (EPU) in 2012 that increased the thermal output from 2,700 megawatts (MWt) to 3,034 MWt. In association with the EPU, a request for modification to the Industrial Wastewater Facility (IWWF) permit was submitted by FPL to the Florida Department of Environmental Protection (FDEP) to change the St. Lucie Plant's heated water discharge limitations. This permit modification was approved by the FDEP on December 23, 2010 contingent upon FPL performing additional temperature monitoring in the Atlantic Ocean near the St. Lucie Plant cooling water system intake and discharge structures. FPL contracted the team of Golder Associates Inc (Golder) and CSA International (CSA) to implement the Heated Water Plan of Study in fulfillment of the additional temperature monitoring requirements. Nine temperature monitoring stations and two current monitoring stations were installed in the vicinity of the Plant from February 8, 2013 to December 18, 2014, a period of 22 months. Though initially intended to be a two year study, FDEP approved ending the study early based on a review of preliminary data and findings. The study was conducted to evaluate three thermal criteria:

1. Demonstrate that the heated water discharge from the Plant does not raise the surface temperature near the Plant's open ocean outfalls to more than 97 °F.

2. Demonstrate that the heated water discharge from the Plant does not heat adjacent coastal waters more than the limitations specified in Rule 62-302.520(4)(b), F.A.C.

3. Evaluate the potential re-circulation of heated water through the cooling water intakes and monitoring of the Atlantic Ocean ambient temperature in the vicinity of the Plant.

The results of the study confirm that the discharge from the Plant does not raise surface temperature near the Plant's open ocean outfalls above the regulatory limit of 97 °F.

The regulatory threshold for discharge into coastal waters, defined as waters shoreward of the 18 foot depth contour, varies seasonally from 2 °F above ambient temperature and not greater than 92 °F during the summer months of June, July, August, and September to 4 °F above ambient and not greater than 90 °F for the remainder of the year. The crux of the coastal analysis lies in determining the 'ambient' temperature. Two analyses were conducted wherein the ambient temperature was defined based on different assumptions. These analyses provide a 'lower bound' and 'upper bound' estimate of the potential influence of the plume on coastal stations. The 'upper bound' analysis, considered a worst-case scenario, shows potential incursions of the plume into coastal waters less than one-percent of the time with an average temperature during the incursions of 0.5 °F above the threshold temperature. The 'lower bound' analysis, considered a best-case scenario, resulted in a potential coastal incursion rate of 0.24-percent with an average temperature 0.3 °F above the threshold temperature. Nearly all of these

potential incursions were detected at the surface at the middle coastal station (where the discharge pipes cross the 18 foot depth contour), during the summer months when the threshold was 2 °F above ambient, and when surface currents were southbound. The maximum temperature observed in coastal waters was 89.0 °F on September 6, 2013. During non-summer months, the maximum recorded temperature was 86.9 °F on October 4, 2014. Both of these maximums are three degrees below the absolute regulatory thresholds for discharges into coastal waters.

The evaluation of potential recirculation of the discharge plume through the intakes demonstrated a statistical likelihood of recirculation 1.7 percent of the time. On average, when recirculation was indicated, the intake temperature was 1.3 °F above the ambient temperature.

Considering the limitations of mathematical modeling, these results are interpreted to largely confirm the model results. Given the low frequency of occurrence and low magnitude of the observed coastal incursions and potential recirculation of the plume into the Plant's intakes, FPL considers the influence of the plume to be *de minimus* and concludes that it will not cause any adverse environmental impacts.

Another condition of FDEP approval of the IWWF permit modification was preparation of the Ambient Monitoring Report (AMR). The AMR was a feasibility study report to identify and evaluate potential locations in the Atlantic Ocean near the Plant for permanent siting of remote thermometers. Following submission of the AMR, FDEP allowed it to be implemented as a part of the HWPOS and this study fulfills that requirement. Based on the conclusions presented in this report regarding potential recirculation of the plume, FPL concludes that additional monitoring of ambient ocean temperatures in the vicinity of the Plant is not warranted.

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1.0 INTRODUCTION

The FPL St. Lucie Nuclear Plant (Plant) on Hutchinson Island, Florida completed an Extended Power Uprate (EPU) in 2012 that increased the thermal output from 2,700 megawatts (MWt) to 3,034 MWt. In association with the EPU, a request for modification to the Industrial Wastewater Facility (IWWF) permit was submitted by FPL to the Florida Department of Environmental Protection (FDEP) to change the St. Lucie Plant's heated water discharge limitations. This permit modification was approved by the FDEP December 23, 2010 contingent upon FPL performing additional temperature monitoring in the Atlantic Ocean near the Plant cooling water system intake and discharge structures. The additional monitoring requirements are defined in Administrative Order AO022TL, Conditions 14, 15 and 17:

> Condition 14: No later than 90 days after the effective date of this Order, the Permittee shall prepare and submit for the Department's review and approval a feasibility study report (Ambient Monitoring Report) for 1) the identification and evaluation of potential locations in the Atlantic Ocean that are near the Facility's ocean intake structure and meet the requirements of Rule 62- 302.520(3)(a), F.A.C., for permanently siting remote thermometers; and 2) the evaluation of commercially available remote thermometers. Each option, which shall consist of a location and a thermometer, shall be ranked based on equal weighting of technical and economic feasibility. The results of the ranking shall be presented in the Ambient Monitoring Report. In addition, the Ambient Monitoring Report shall include a plan and schedule for implementing the highest ranked option. The schedule shall include milestones and the completion date. The implementation shall take no longer than 18 months from the effective date of this Order.
>
> Condition 15: No later than 30 days after installing the new thermometer(s), the Permittee shall provide a certification to the Department, signed and sealed by a licensed Professional Engineer, that the thermometer(s) have been properly installed and calibrated
>
> Condition 17: No later than 180 days after the effective date of this Order, the Permittee shall prepare and submit for the Department's review and approval a plan of study (Heated Water POS) and schedule to confirm the results of the mathematical model used for simulating the near and far field extent of the Facility's heated water discharge. The Heated Water POS shall be designed and implemented to demonstrate that the heated water discharge from the Facility: 1) does not raise the surface temperature near the Facility's open ocean outfalls to more than 97°F; and 2) does not heat adjacent coastal waters more than the limitations specified in Rule 62-302.520(4)(b), F.A.C. This study also shall evaluate whether and to what extent the heated water discharge raises the temperature of the cooling water entering the Facility above ambient temperature. The study shall commence within 90 days after completion of both uprate projects for Unit 1 and 2. The study shall last no less than 24 months from commencement. The results of the study shall be submitted in a report (Heated Water Report) to the Department for review and approval no later than 60 days after the approved Heated Water POS completion date. The schedule shall include milestones and the completion date."

The Ambient Monitoring Report (AMR) was submitted to FDEP on March 13, 2011. The Heated Water Plan of Study (HWPOS) was submitted to FDEP on June 16, 2011 and approved by FDEP on August 18, 2011. It was agreed by FPL and FDEP that monitoring of the ambient ocean temperature as a component of the Heated Water Plan of Study (HWPOS) would fulfill the requirements of the AMR over

the duration of the HWPOS. An extension was approved by the FDEP to submit results within 120 days after completion of the study. Both nuclear generating units at the Plant were operational for the duration of the study with the exception of refueling outages. The outage for Unit 1 ran from September 29 to November 12, 2013 and the outage for Unit 2 ran from March 1 to April 23, 2014.

1.1 Objectives

The objectives of the study are to develop data to confirm the predictions of the mathematical thermal model used to simulate the near-field and far-field extent of the Plant's heated water plume in the Atlantic Ocean. This validation includes three specific thermal criteria:

1. Demonstrate that the heated water discharge from the Plant does not raise the surface temperature near the Plant's open ocean outfalls to more than 97 °F.
2. Demonstrate that the heated water discharge from the Plant does not heat adjacent coastal waters more than the limitations specified in Rule 62-302.520(4)(b), F.A.C.
3. Evaluate the potential re-circulation of heated water through the cooling water intakes and monitoring of the Atlantic Ocean ambient temperature in the vicinity of the Plant.

Coastal waters are defined in Rule 62-302.520(3), F.A.C. as all non-fresh water shoreward of the most seaward 18 foot depth contour. Rule 62-302.520(4)(b), F.A.C. specifies the thermal limitations as "Heated water with a temperature at the point of discharge (POD) more than 2° F higher than the ambient (natural) temperature of the RBW shall not be discharged into coastal waters in any zone during the months of June, July, August, and September. During the remainder of the year, heated water with a temperature at the POD more than 4° F higher than the ambient (natural) temperature of the RBW shall not be discharged into coastal waters in any zone. In addition, during June, July, August, and September, no heated water with a temperature above 92° F shall be discharged into coastal waters. Further, no heated water with a temperature above 90° F shall be discharged into coastal waters during the period October thru May."

1.2 Discharge Plume Model

The modeling referenced in the Administrative Order and the associated responses to Requests for Additional Information was completed by Golder in 2010. This effort included near-field and far-field plume modeling and was based on three environmental conditions:

- Maximum observed northbound current of 0.7 fps
- Maximum observed southbound current of 1.3 fps
- Slack current (i.e., no current)

Under these conditions, the modeling results and other analyses provided indicated the following:

- Thermal criteria for open waters limit water temperatures to 17°F above ambient. Consequently, the mixing zone needed for the St. Lucie Plant will be small (less than 9,949 cubic feet for both diffusers). Heated water exiting the diffusers at 119°F would be cooled down to 97°F before it reaches the surface. Outside the mixing zone, water quality standards for open waters will be met.
- The surface thermal plumes (defined by the 2°F above ambient isotherm), in all three of the current conditions that were modeled, are entirely seaward of the 18-foot contour and do not enter coastal waters.
- Recirculation can only occur during southward currents and only a small portion of the thermal discharge can be recirculated into the intake. The velocity cap intake openings are located approximately 12 to 18 feet below the surface and the plume modeling indicated that the elevated temperatures from the discharge would influence only the top 6 feet of the water column. Under these conditions, the impact of recirculation on intake water temperatures would be no more than approximately 1.2° F.
- Based on a comparison of water temperature frequency distributions for two National Data Buoy Center Stations and the St. Lucie intake, the St. Lucie intake temperature is an excellent surrogate for the ambient water temperature.

2.0 METHODOLOGY

To achieve the objectives of the Heated Water Plan of Study (HWPOS), nine temperature monitoring stations and two Acoustic Doppler Current Profilers (ADCPs) were installed in the vicinity of the Plant. The study ran from February 8, 2013 to December 18, 2014.

2.1 Equipment selection, and installation

2.1.1 Moorings

Components utilized for the assembly of the mooring stations were selected based on the servicing requirements and anticipated and known ocean and bottom conditions and water depths within the study area. Each mooring consisted of a surface buoy, galvanized wire rope, galvanized chain, anchors and temperature logger mounts (see Figure 1 and Photo Log). Due to the expected wave heights and periods for the study area the surface buoy selected for this study was a spar buoy. Spar buoys present less surface area (relative to other buoy designs) to hydrodynamic forces from currents and wave action that occur in the upper, near surface, water column. The spar design also allowed for a smaller anchor system. Moorings were high-visibility yellow in color and were equipped with day markings, a top-mounted strobe light, and reflective tape to maximize mooring visibility both during the day and night.

The components used for the mooring and logger mounts were selected so that the temperature loggers could withstand a reasonable degree of damage due to vessel traffic, anchor or fishing line entanglement, divers/swimmers, and intentional vandalism.

To accommodate the surface HOBO loggers (discussed in Section 2.1.2), polyvinyl chloride (PVC) tubes were inserted into the buoy approximately 2 feet below the waterline. The temperature loggers were placed into the PVC tubes and secured with stainless steel pins. For the water-column temperature loggers, composite mounts were constructed. The custom mounts secured and protected the HOBO loggers and could be bolted onto the wire rope of the mooring at specified depths. For the near-bottom temperature loggers, composite mounts were bolted to aluminum frames. The aluminum frames were constructed so that they rested on the ocean bottom and remained stationary. The bottom mounts were cabled to the anchors of the mooring using wire rope. Aluminum frames were also used for the ADCPs. The inshore ADCP frame was cabled to the mooring anchor using wire rope and installed at a distance away from the mooring to avoid interference with the ADCP measurements. The offshore ADCP was cabled to an independent anchor because there was no mooring at that location.

2.1.1.1 Mooring Retro-Fit

During the survey, on July 10, 2014, all mooring wires were retro-fitted to prevent marine life entanglement. After considerable design and testing of options to stiffen the mooring wires a very stiff

and durable polyethylene covering was selected and used to encase the mooring wires (see Figure 2). Photographs of the buoys and components are presented in the attached Photo Log.

2.1.2 HOBO Temperature Loggers

Onset HOBO Pro V2 (HOBO) temperature loggers were selected and used for the study. The HOBO temperature logger was selected due to its relatively small size, data storage capacity, battery life, ruggedness, temperature accuracy and stability. The operational range for these HOBO loggers is -40°C to 70°C (-40° F to 158° F). Accuracy of the HOBO logger is ±0.2°C. The HOBO Pro V2 has a battery life of over six years, depending on sampling rate. For this study, the HOBO loggers recorded temperatures every 15 minutes. Two loggers were installed at each location and depth to provide back-up in the event of instrument failure.

Two sets of HOBO loggers were used during the study: an initial set and a "swing set". During each maintenance event, HOBO loggers that had been deployed were removed from the moorings and returned to the laboratory. They were replaced in the field with loggers from the swing set. This approach allowed HOBO loggers to undergo cleaning, maintenance if necessary, laboratory calibration and verification prior to each sampling interval.

2.1.3 Acoustic Doppler Current Profilers

Nortek Aquadopp Profilers were selected and used for this study. A 1MHz model with a right angle transducer head was used to achieve the maximum accuracy and resolution for the water depths at the study site. Using a right angle head allowed the ADCP to be mounted parallel to the bottom and maximizing the vertical extent of the water column for which it was able to measure currents (See Photo Log). The ADCPs provided water velocity measurements (current speed and direction) at multiple levels, or 'bins' throughout the water column. Bin size for the study was set at a maximum of 1.0 m and a sampling rate of 15 minutes with a 60 second averaging (One 60 second averaged value was recorded every 15 minutes). Accuracy of the Aquadopp Profiler is ±0.5cm/s.

2.2 Equipment Calibration

2.2.1 HOBO Temperature Loggers

The HOBO loggers used in the study were factory calibrated using a NIST-traceable standard thermometer. A NIST calibration certificate was provided for each logger.

Prior to deployment of the loggers, two calibration soaks were conducted to ensure all loggers were providing consistent readings over a range of temperatures. A sampling rate of 5 minutes was used for all calibration soaks. All loggers were placed in close proximity to one another for a minimum of 24 hours. The first soak, a warm soak, occurred in the discharge canal near the FPL discharge monitoring station (EFF-2) and the second soak, a cold soak, took place in the ocean in the study area. Two factory-

calibrated SeaBird SBE 39 NIST-traceable temperature loggers were included in the soaks as the calibration standard.

After the initial calibration soaks, the loggers being prepared for installation in the field were soaked together with the SBE 39 loggers in a warm and then a cold water bath for a minimum of 24 hours for each soak.

Following the first year of the study, and again at the end of the study an ocean soak was conducted with all loggers. The loggers were removed from their moorings and placed, along with the two SBE 39 loggers, in close proximity to each other at a common location in the ocean in the study area for a minimum of two hours.

From each set of calibration data, a correction factor was generated for each HOBO logger. The correction factor was calculated as the average difference between each logger and the average of the two SBE-39 loggers. Correction factors specific to each HOBO logger and deployment interval were applied to the field temperature data prior to data processing to account for differences between individual HOBO loggers.

2.2.2 Acoustic Doppler Current Profilers

The current sensors on the Nortek Aquadopp ADCPs are factory calibrated and do not require field calibration. Each unit was tested to verify that all heading, temperature, pressure, and pitch and roll sensors were operating correctly. Though each compass system was calibrated at the factory; during the on-site equipment installation, the compass readings were adjusted to correct for any magnetic deviation at the study site. The ADCP mounts used for the study were constructed of aluminum and contained no magnetic materials that could affect the compass readings.

A check of the ADCP sensors, conducted prior to initial equipment installation, resulted in all sensors responding correctly and within their calibrated range. Following approximately 14 months of data collection, an error was identified in the configuration file for the internal compass of the inshore ADCP. The result of the error was that readings from the internal compass were not reliable. While current data was valid relative to the ADCP (speed and direction - left, right, up, down, forward, or backward), the orientation of the ADCP was unknown and therefore the real-world direction of the currents could not be determined. Following correction of the configuration file and subsequent collection of current data from both ADCP locations, a relationship between the flow at each location was determined and used to estimate the orientation of the inshore ADCP and generate usable current data for that location.

At the completion of the project, the ADCPs were sent back to the factory for calibration verification.

2.3 Temperature Monitoring Station Locations

The locations of the moorings, ADCPs, and intake headwall HOBO loggers are presented in Figure 3 and discussed below.

2.3.1 Coastal Waters Monitoring Stations

The 18 foot contour, as determined from Coast & Geodetic Survey charts is the demarcation line between the Open Ocean and Coastal Waters as defined in Chapter 62-302.520, F.A.C. Therefore, three stations were located along the 18 foot contour to monitor for potential incursions into coastal waters: the first station was approximately one mile north of the Y-discharge, the second station was centrally located between the two Plant discharge pipes, and the third station was approximately one mile south of the Y-port discharge.

The monitoring station at the 18 foot contour between the discharge pipes is designed to cover an onshore or slack current condition. This is also the closest point in coastal waters to the source of the heated water. The north and south coastal stations were positioned at locations where the thermal plume model predicted the highest probability of the plume crossing the coastal boundary during periods of north or south current flow. Redundant HOBO loggers were installed at the surface, mid-depth and near the bottom at all coastal monitoring locations.

2.3.2 Surface Discharge Monitoring Stations

Surface discharge monitoring stations for the Y-port diffuser were located along the centerline of the discharge pipes. The final locations were determined on the day of deployment by measuring surface temperatures and selecting the location with the maximum observed temperature. Similarly, for the multi-port diffuser the installation location was selected on the day of deployment by measuring surface temperatures along a transect approximately 400 feet offshore of the beginning of the diffuser and perpendicular to the multi-port diffuser pipe. The location with the maximum observed surface temperature was determined to be to the south of the multiport diffuser. Results of the thermal studies used to determine station locations are presented in Figure 4. Two HOBO loggers were mounted on each of the buoys within 2 feet of the surface to provide redundant measures of surface water temperatures.

2.3.3 Ambient

A mooring station was installed to determine the ambient ocean temperature in the vicinity of the Plant's offshore intakes. It was located approximately 1,400 feet southeast of the Plant's offshore intakes in 30 feet of water. This location was selected based on the following criteria:

- The monitoring station must be in ocean waters (i.e., seaward of the most seaward 18 foot depth contour).

- The monitoring station should be near the intake structures.
- The monitoring station should be outside the hydraulic zone of influence of the intake structure. Based on the quantity of water withdrawn, there should be at least 500 feet between the ambient monitoring station and the nearest intake structure.
- The intake structure is located in 24 feet of water. Therefore, the ambient monitoring station should be located in water at least 30 feet deep, so that the deepest HOBO logger can be mounted above the anchor structure at a depth about equal to the water depth at the intake (24 feet)
- The ambient station should be located to minimize potential influence of the discharge plume, while simultaneously minimizing the distance from the intake structure. In addition, with a vertical array of HOBO loggers, when the thermal plume reaches the ambient station, its vertical extent can be determined and accounted for in the calculation of the 'ambient' temperature.

The vertical array of HOBO loggers for the ambient monitoring station consisted of redundant loggers at the following depths:

- 2 feet below the surface, mounted in the buoy (surface temperature)
- 7 feet below the surface (top of the intake structures)
- 12 feet below the surface (top of the intake opening)
- 15 feet below the surface (middle of the intake opening)
- 18 feet below the surface (bottom of the intake opening)
- 24 feet below the surface (depth at the intake structures)

2.3.4 Cooling Water Intake Monitoring Station

A monitoring station was installed approximately 150 feet northeast of the offshore velocity caps. This station included two HOBO loggers at the surface and two loggers at a depth of 15 feet, equivalent to the middle of the openings of the velocity caps. This station is intended to determine the presence of the plume in the vicinity of the intake structures

2.3.5 Intake Canal Headwall

Intake water temperatures were measured at the intake canal headwall (eastern end of the canal where water first enters the canal from the intake pipes). Two HOBO loggers were suspended in the intake flow on a weighted line at a depth of approximately 10 feet from the surface. The weighted line was secured to a catwalk above the intake canal.

2.4 ADCP Station Locations

Two ADCPs were deployed in the project area to measure ocean currents in the vicinity of the Plant. One ADCP was installed offshore, southeast of the diffuser discharges (Figure 3). The second ADCP was installed at the 18 foot contour between the discharges pipes (co-located with the central coastal monitoring station).

2.5 Mooring Maintenance and Data Collection

Regularly scheduled maintenance events were critical in keeping the moorings and sensors functioning properly and to ensure acceptable data recovery. During each maintenance event, all mooring components were checked for wear and replaced if necessary. The mooring location was verified using GPS navigation equipment and repositioned if necessary, however, over-time the anchors became buried in sand and were essentially fixed. Mooring maintenance and data collection was done using SCUBA divers.

Initially, maintenance events were done on a monthly basis to ensure instrumentation and data were not compromised, by accident or vandalism, to the point where the required data could not be retrieved to meet the study objectives. After three monthly maintenance events were completed, the maintenance interval was increased to quarterly. During the first year of the study an additional maintenance event was conducted after the first quarterly event due to the large amount of bio-fouling that occurred during the summer months. A bimonthly schedule was adopted for year-two of the study.

Initially, for each data collection and maintenance event, the entire mooring was recovered onto the survey vessel. The HOBO loggers were changed out and the mooring was cleaned and inspected. This turned out to be a time consuming and labor intensive process, and also presented certain hazards. During the third maintenance event the mounts for the temperature loggers were modified so that all moorings and bottom mounts were able to be cleaned and inspected by divers, and all loggers were switched out using divers. Hobo loggers were returned to the laboratory where they were downloaded, cleaned, and calibrated prior to re-deployment during the next maintenance event.

2.6 Data Analysis

2.6.1 Coastal Stations

Identification of potential incursions of the thermal discharge plume into the coastal environment was initially based on the following working assumptions:

- There is a natural (i.e., not discharge induced) temperature difference (both spatial and temporal) between the shallow near shore coastal stations and the deeper offshore monitoring stations. Consequently, a simple comparison of the coastal station temperatures to the open ocean ambient monitoring temperature is not a satisfactory method for determining when potential coastal intrusions of heated discharge water occur.
- Given the spacing of the coastal stations (approximately one mile between each station) and their locations (outside the area where the thermal plume is normally expected), the discharge plume will potentially impact only one coastal station at a time.
- Given the buoyant nature of the heated water plume, surface temperatures are most likely to be influenced.

- The 18 thermistors at the three coastal stations can be used to separate "common" variability (i.e., natural spatial and temporal temperature variability) from "special" variability that may be associated with a potential incursion of the heated discharge.

The first step in the data analysis process is to determine the station that might be potentially influenced by the plume and remove it from the determination of "common" variability for each time step. This station was identified as the coastal station with the highest surface temperature.

To account for potential naturally-occurring vertical stratification at the coastal stations, the differences (deltas) between the remaining coastal temperature values and the average value at that time step and depth are individually calculated. This produces 12 delta values that represent the common variability in temperatures in the Project area after accounting for the potential influence of the plume and potential natural stratification. For each time step, these delta values are pooled for a 24-hour period around the time step of interest (from 12-hours before to 12-hours after).

The next step is to establish a coastal ambient upper confidence limit (UCL) temperature for each time-step that includes the common or natural temperature variability. This is accomplished using the standard box-plot methodology introduced by John Tukey in his 1970 book *Exploratory Data Analysis* (Tukey, 1970). This method is a standard statistical technique that uses the interquartile range (75^{th} percentile minus 25^{th} percentile) to identify potential data outliers.

Following the standard box-plot methodology, the inter-quartile range of these delta values is calculated and multiplied by 1.5. This temperature range is then added to the 75^{th} percentile to determine the UCL for the ambient coastal temperature. The UCL is then added to the average temperature at each depth (calculated as above, excluding the potentially influenced station) to generate depth-specific values above which measured values would be considered anomalous. The coastal waters regulatory thermal criteria defined in Rule 62-302.520(4)(b), F.A.C. (2 °F June through September; 4 °F the remainder of the year) is added to the threshold values at each depth to establish a temperature criteria, against which the highest depth-specific temperatures recorded at the potentially-influenced station are compared. When the water temperature at any depth exceeds the threshold temperature for that time step, the first criterion for a coastal incursion of heated water above the regulatory limit is met.

The second criterion is based on the assumption that only one station can be influenced by the plume at a time. After eliminating the coastal station with the warmest temperature, as the station potentially influenced, the other two stations are considered ambient. In order for the potentially-influenced station to exceed the regulatory criteria and be 2 or 4 °F above ambient it must be 2 or 4 °F above the next warmest station. If both of these criteria were met, that time step was considered to be a potential incursion of the plume into coastal waters.

Temperature trends and ocean current data were then examined to evaluate the likelihood that the statistical trigger, suggesting an incursion of the plume, is real. Patterns that would suggest a statistical trigger is an anomaly not due to the discharge plume include:

- Consistent ocean currents moving the plume away from the station with the possible incursion
- A local warming or cooling trend reaching each coastal station at a different time (e.g., a pulse of warm or cool water moving through the area that reaches the coastal stations in sequence, but with a time lag between them).

Following correction of the inshore ADCP data (Section 2.4) and subsequent re-assessment of the thermal data, it became evident that there are periods when the discharge plume is influencing two stations simultaneously. The prevalent example of this is during extended periods of southbound currents. A pattern can be seen in which Station C (southern coastal station) appears to be influenced by the plume at a low consistent level while Station B (between the discharge pipes) is more substantially, but intermittently, influenced. This pattern is not seen when there is a consistent northbound current (Figure 5).

Based on this observation, the initial analysis for coastal incursions is interpreted to provide a lower bound estimate of the potential influence of the thermal discharge on coastal waters. The limitation in the procedure is in calculating the coastal ambient temperature from the two remaining stations, when one of those two stations may be influenced by the plume. This would artificially elevate the calculated threshold temperature. A higher threshold temperature would generate fewer statistical indications of a coastal incursion. Following this realization, a second analysis was conducted without the assumption that only one station could be influenced at a time.

In the revised analysis, the UCL for the ambient coastal temperature and regulatory criteria (2 or 4 °F, depending on season) are added to the lowest recorded depth-specific temperature at each time step, to determine the calculated threshold temperature for a potential incursion. Also, the second criterion discussed above, which was based entirely on the assumption of the plume only influencing one station at a time, was removed from the revised analysis. By using only the lower temperature, instead of the average of the lower two, the resulting calculated threshold temperature may be artificially depressed. An artificially depressed threshold would occur when the difference between the two stations was the result of natural processes and not due to the influence of the plume. A lower threshold temperature would generate more statistical indications of a coastal incursion. Therefore, the revised analysis for coastal incursions is interpreted to provide an upper bound estimate of the potential influence of the thermal discharge on coastal waters.

The crux of the issue for the coastal analysis is to determine a valid coastal ambient temperature. This is difficult considering the fact that low levels of influence from the plume can have the same effect on coastal temperatures as otherwise naturally occurring spatial and temporal processes. We therefore present and discuss the results of both analyses below as the lower bound and upper bound estimates of the potential levels of discharge plume influence on coastal waters, with the 'true' value likely falling between the two estimates. The initial analysis using the assumption that the plume can only influence one station at a time underestimates the potential influence of the discharge plume because there are clear instances when two stations are being influenced at the same time-step. Without that assumption, the analysis likely over-estimates the influence of the plume as it defaults to always assuming two stations are being influenced. Under this scenario, some thermal variation in the coastal data is attributed to the discharge plume that is in reality the result of natural-occurring spatial and temporal variation.

Potential coastal incursions from both analyses were detected on 15-minute time steps. These time-steps were then grouped together into 'occurrences' to further characterize the potential incursions. Occurrences are defined as a series of 15-minute time-steps that are potential coastal incursions interrupted by no more than a 1-hour period without a potential incursion.

The second coastal criterion was assessed by a direct comparison of measured temperatures to the absolute coastal criteria of 90 °F during summer months (June to September) and 92 °F during non-summer months.

2.6.2 Discharge Stations

The compliance criterion for the discharge stations is that the surface temperature not be raised above 97 °F. Surface temperatures are measured at each discharge location and compared directly to the 97 °F temperature threshold.

2.6.3 Ambient, Intake, Headwall Stations

The initial step in assessing the potential re-circulation of heated discharge water is the determination of an ambient temperature against which the intake temperature can be compared. The ambient station had redundant HOBO loggers at the surface and at depths of 7, 12, 15, 18, and 24 feet. The data collected at this station was evaluated to determine how the 'ambient' temperature would be determined for comparison to the Plant intake temperature. It was ultimately determined that 'ambient' would be defined as the average of the 12, 15, and 18 foot temperature readings. This was based on:

- Thermal stratification is readily apparent between the different depths. Warm surface waters, from natural stratification or the heated water discharge from the Plant, can be seen most clearly in readings taken from the surface and 7 foot depth.

- The coastal area adjacent to the Plant is subject to upwelling events that bring cold, dense water up from depth. The influence of these events can be seen most clearly at the 24 foot depth.
- The 12, 15, and 18 foot depths correspond to the depth of the offshore intake openings.

A similar methodology to that used for the coastal stations was used to determine the potential for re-circulation between the discharge and the intake. For each time step, the intake temperature (measured at the intake canal headwall) was compared to the ambient temperature, as defined above, to determine a temperature difference (ΔT_M). To separate common or natural temperature variability from special variability, the interquartile range for the ΔT_M was calculated for a two-week time frame centered on each time-step and multiplied by 1.5. This value was then added to the 75^{th} percentile of the ΔT_M over that timeframe to establish the time-step-specific ΔT_M(UCL). When the actual ΔT_M at any particular time step is greater than the ΔT_M(UCL), the potential exists statistically for recirculation between the discharge and the intake.

Additionally, current speed and direction were incorporated in the determination of re-circulation. If currents at both the inshore and offshore ADCP locations each average more than 0.1 meter/second in a general northerly (along-shore) direction for two hours prior to a time-step, any increase in temperature detected at the intake headwall relative to the ambient station is not likely the result of the plume and is therefore disregarded. The bounds on 'northerly' were defined as within 45 degrees of the shoreline in a northerly direction. The shoreline is oriented approximately 15 degrees west from magnetic north.

3.0 RESULTS

The HWPOS ran from February 8, 2013 to December 18, 2014. Initially planned to be a 2-year study, FDEP authorized the early termination of the study following a review of preliminary results.

3.1 Calibration

3.1.1 Onset HOBO loggers

During the initial ocean and canal calibration soaks, two HOBO loggers were identified that did not meet the calibration standards for the study. These units were removed from service and replacement units were obtained. During all subsequent pre-deployment calibration soaks as well as the mid-study and end-of-study ocean soaks, all HOBO loggers were within 0.2 °C (0.36 °F) of the temperature measured by NIST-traceable thermometers. This is within the FDEP calibration standard (+/- 0.5 °C or 0.9 °F) for field temperature measurements (DEP-SOP-001/01 FT 1000). The correction factors applied to the HOBO loggers ranged from -0.29 to 0.34 °F with an average of 0.10 °F

3.2 Data Gaps and Corrections

There are brief data gaps during each maintenance event when HOBO loggers and ADCPs are being serviced, downloaded, and de-fouled. Additional data gaps resulted from unforeseen events during the field deployment and are discussed below.

3.2.1 Temperature Data

There were several incidents of data loss from the HOBO loggers. Due to the redundant loggers at each location, incidents affecting a single logger were inconsequential following minor adjustments to the calculations to account for the missing data. There were two incidents that impacted both loggers at a particular station. During the maintenance event on February 6, 2014 it was discovered that the entire bottom HOBO logger mount had been lost at Station C, presumably to being snagged by a vessel's anchor as the wire rope connecting the bottom mount to the mooring anchor had broken. It is unlikely that this data loss influenced the conclusions of the study since there were no potential incursions of the plume into coastal waters detected at the bottom depth at any station. The second incident involved a boat strike on Mooring D that resulted in the mooring cable being severed and the buoy being set adrift. This occurred on February 1, 2014. Surface temperatures at the other two discharge stations did not exceed 80 °F during this time therefore it is safe to conclude that there was not an exceedance of the surface discharge criteria (97 °F) at Station D during this period. Table 1 summarizes data gaps in thermal data collected by the HOBO loggers.

3.2.2 Ocean Current Data

Incidents of data loss experienced by the ADCP's are detailed in Table 2. The inshore and offshore ADCPs were in general agreement regarding the direction of ocean currents. During periods of data loss

at one station, ocean currents at that location were assumed to be consistent with measured currents at the other station or omitted from the analysis.

3.3 Coastal Stations

There are two different regulatory thresholds for thermal influence on coastal waters based on the time of the year (Rule 62-302.520(4)(b), F.A.C). During summer months (June – September) coastal waters cannot be raised more than two degrees above ambient or exceed 92 °F. For the remainder of the year, the threshold is four degrees above ambient or 90 °F. Results of the coastal analysis are therefore presented as a year-round summary as well as divided into the summer and non-summer periods. Measured coastal temperatures did not exceed the absolute criteria of 92 °F and 90 °F at any point in the study. Under both statistical approaches (as discussed in Section 2.6.1), and considering both the statistical conclusions and subjective review of the data, all of the potential coastal incursions were detected at the surface. In addition, the majority were detected at the central coastal station (located between the discharge pipes), with no more than five potential occurrences at the north and south coastal stations combined. As discussed, we used two approaches to identifying potential coastal incursions that provided upper bound and lower bound estimates of potential incursions. A comparison of summary statistics from each approach is provided in Table 3. Occurrences of potential coastal incursions under each approach are summarized in Tables 4 and 5. Attachments 1-1 thru 1-23 show surface temperatures recorded at each coastal station, the upper bound calculated incursion threshold, and time-steps at which the upper bound calculated threshold is exceeded. The upper bound analysis is presented as a worst-case scenario for coastal influence of the plume.

3.3.1 Lower Bound Estimate

Under the initial analysis, which provides the lower bound estimate of potential coastal incursions, a total of 157 potential coastal incursions (15 minute time-steps) were detected. This corresponds to 0.24 percent of time-steps, and these can be grouped into 44 individual occurrences with an average duration of one hour and an average temperature 0.3°F above the calculated threshold.

<u>Summer Months</u>

The majority of the potential coastal incursions (154 of 157 time-steps and 43 of 44 occurrences) were detected during the summer months for a rate of 0.66 percent during these four months. The average temperature above the calculated threshold was 0.3°F. The average occurrence duration was one hour.

<u>Non-Summer Months</u>

A single occurrence, composed of three time-steps which averaged 0.2°F above the threshold, was detected during non-summer months (November, 2013). This corresponds to only 0.007 percent of time steps for non-summer months.

3.3.2 *Upper Bound Estimate*

Under the revised analysis, with the understanding that the plume occasionally influences multiple stations at the same time, potential coastal incursions were detected at 597 time-steps or 0.92 percent of the time. The average duration was 1.5 hours and on average the measured temperature was 0.5°F above the calculated threshold.

Summer Months

As with the initial analysis, the majority of these (591 of 597) were detected during summer months for a rate of 2.52 percent of summer time-steps. The 591 potential incursions can be grouped into 90 occurrences with an average duration of 1.75 hours and an average temperature 0.5°F above the calculated threshold.

Non-Summer Months

The remaining non-summer incursions can be grouped into two occurrences, each with three time-steps (45-minutes long) and an average recorded temperature 0.3°F above the calculated threshold. Both of these occurrences happened during November, once in 2013 and once in 2014.

3.4 Discharge Stations

There were no recorded incidents of the surface temperature at any of the discharge locations exceeding the regulatory threshold of 97 °F. The maximum observed temperature was 90.9 °F at Station E on September 8, 2013. Attachments 2-1 thru 2-23 show the surface temperatures recorded at each discharge station.

3.5 Potential Recirculation

The evaluation of potential recirculation is not driven by regulatory thresholds and therefore does not involve seasonal or regulatory criteria. Based on a comparison of measured intake temperatures to the calculated thresholds, potential recirculation was detected at 1.7 percent of time-steps. On average, when the intake temperature exceeded the calculated threshold it was 1.3 °F above the ambient temperature. There was no indication of seasonality in the identification of potential re-circulation episodes.

4.0 DISCUSSION

The objective of the study was to validate the conclusions of the mathematical thermal model used to simulate the extent and magnitude of the heated water plume from the Plant. That model used three basic environmental scenarios (current flow regimes) to generalize the Atlantic Ocean in the vicinity of the Plant. As is the case with any modeling effort, this area is more dynamic and variable than the scenarios included in the models. The results of this study, including the limited deviations from the model results, should be interpreted with this understanding.

In large part, the results of the study confirm the predictions of the mathematical model. The model predicted that discharged cooling water would be sufficiently mixed such that surface temperatures would not be raised above 97°F at the points of discharge. The highest surface temperature detected at the points of discharge was 90.9 °F. The discharge temperature from the Plant at that time was between 111 and 112 °F, nearly 21 degrees higher than the measured surface temperature. These results confirm the model predictions regarding the influence of the plume on surface temperatures at the points of discharge.

The model predicted that the plume would be re-circulated through the offshore intakes and back into the Plant on only a very limited basis. The predicted level of influence of the plume was up to 1.2 °F above ambient. The measured frequency of recirculation events was only 1.7 percent of the time and produced an average intake temperature 1.3 °F above the ambient temperature when these episodes were observed. Within a reasonable tolerance, these results confirm the model predictions regarding re-circulation of the heated water discharge. The AMR identified locations and technologies for installation of a permanent buoy station to monitor ambient ocean temperatures. The results of this study confirm model predictions and demonstrate minimal potential re-circulation of the plume. FPL therefore concludes that implementation of the AMR and additional monitoring of ambient ocean temperatures is not warranted.

The analysis of potential incursions of the thermal plume into coastal waters suggests that the plume did infrequently cross into coastal waters. This is contrary to the conclusion from the model that suggested that the +2 °F isotherm would not reach the 18 foot coastal water boundary. During periods of consistent current flow, it appears that the northern or southern coastal stations (depending on current direction) reflect a low-level influence of the plume, as the downstream station is regularly slightly warmer than the upstream station; although the magnitude of the difference only very rarely exceeds the regulatory threshold even when using the 'upper bound' analysis. Incursions of the thermal plume that do exceed the regulatory threshold are almost entirely seen at the central coastal station located between the discharge pipes. This is intuitive due to the proximity of the central station to the discharges. There is also a pattern of coastal incursions occurring during southbound currents that have an on-shore component (as measured at the inshore ADCP). Ninety percent of coastal incursions occurred when the

surface currents were southbound while only ten percent occurred during northbound currents. During southbound currents, nearly two-thirds of the incursions occurred when there was an onshore component to surface flow. One possible explanation for this asymmetry in the incursion patterns is the northeasterly net direction of the Y-port diffuser. This orientation of the Y-port diffuser facilitates smoother entrainment of the plume into a northbound current, but with a southbound current the Y-port discharge velocity is counter to the current, which may result in the plume becoming more laterally dispersed, or 'ballooning out' before being carried southward. This may be an explanation for the fact that more potential incursions are detected during southbound currents than northbound currents.

The two alternative analyses conducted to assess potential coastal incursions provide an upper and lower bound to the potential levels of influence of the plume on coastal waters. The upper bound analyses, interpreted as a worst-case scenario, suggests that the plume exceeded regulatory criteria at the coastal water boundary less than 1 percent of the time with an average temperature 0.5 ^{o}F above the threshold temperature. The lower bound estimate was 0.24 percent of the time with an average temperature 0.3 ^{o}F above the threshold. These results do not confirm the model prediction that the plume would not enter coastal waters. Nevertheless, considering the limitations of any model and the low frequency and low magnitude of the potential incursions, Golder considers the influence of the plume on coastal waters to be *de minimus* and concludes that it will not cause any adverse environmental impacts.

5.0 CONCLUSION

Conclusions from the HWPOS are:

- Surface temperatures at the point of discharge do not exceed the regulatory criteria of 97 , confirming model predictions
- The plume does occur within coastal waters in exceedance of regulatory criteria though instances are rare (< 1 percent) and minor (< 0.5 °F).
- The plume is likely re-circulated through the Plant though instances are rare (~1.7 percent) and minor (1.3 °F)
- Implementation of the AMR and continued ambient ocean temperature monitoring is not warranted

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Attachments

SJL/GMP/edk

6.0 REFERENCES

Tukey, John W. (1970). Exploratory Data Analysis, Volume 1. Addison Wesley Publishing Company, Reading, MA.

TABLES

Table 1: Data Gaps from HOBO Logger Deployments

Location	Beginning	Ending	Duration (days)	Cause/Result
C-Surface-1	6/12/13 3:00 PM	8/7/13 8:15 AM	55.7	Programming error (logging data every second, logger ran out of memory), no overall loss due to redundant logger
H-12ft-2	11/12/13 9:30 AM	11/12/13 7:45 PM	0.4	Programming error (logger began recording late), no overall loss due to redundant logger
G-Surf-1	11/12/13 1:00 PM	2/6/14 10:00 AM	85.9	Programming error (logging hourly instead of every 15 minutes), no overall loss due to redundant logger
C-Mid-2	11/12/13 2:00 PM	2/6/14 9:30 AM	85.8	Logger malfunction, no overall loss due to redundant logger
C-Bottom	11/12/13 2:00 PM	2/6/14 9:30 AM	85.8	Lost bottom mount, both loggers lost, 86 day data gap
Intake-1	11/13/13 10:15 AM	2/6/14 10:00 AM	85.0	Programming error (logging hourly instead of every 15 minutes), no overall loss due to redundant logger
D-surface	2/1/14 10:00 AM	2/6/14 10:15 AM	5.0	Boat Strike, mooring severed, 5 day data gap

Table 2: Data Gaps from ADCP Deployments

Location	Beginning	Ending	Duration (days)	Cause/Result
ADCP-B	3/12/13 6:00PM	4/2/13 12:00PM	20.8	ADCP became buried in shifting sands; mounts were retro-fitted to raise ADCPs and prevent recurrence
ADCP-B	5/13/14 2:45AM	6/17/14 10:15AM	35.3	ADCP was found upside down; mounts were additionally anchored to prevent recurrence

Table 3: Summary Statistics from the Lower Bound and Upper Bound Estimates of Plume Influence on Coastal Waters

	Lower Bound			Upper Bound		
	Overall	Summer	Non-Summer	Overall	Summer	Non-Summer
Number of potential coastal exceedances (15-minute timesteps)	157	154	3	597	591	6
Rate of potential coastal exceedances (as percentage)	0.24	0.66	0.007	0.92	2.52	0.014
Number of 'occurrences'	44	43	1	92	90	2
Average duration of 'occurrences' (in 15-minute intervals)	1 hr	1 hr	45 minutes	1.5 hrs	1.75 hrs	45 minutes
Maximum 'occurrence' duration	4 hrs	4 hrs	45 minutes	7.25 hrs	7.25 hrs	45 minutes
Average exceedance of threshold (^{o}F)	0.3	0.3	0.2	0.5	0.5	0.3

Table 4: Potential Coastal "Occurrences" Under the Lower Bound Analysis (All Detected at the Surface)

Coastal Station	Start	End	Number of 15-minute time-steps with exceedances	Average temperature over the threshold (°F)
Mid	6/20/13 10:15 PM	6/20/13 10:15 PM	1	0.24
North	6/30/13 1:30 PM	6/30/13 1:30 PM	1	0.46
Mid	8/26/13 2:30 AM	8/26/13 3:00 AM	2	0.13
Mid	8/31/13 9:30 PM	8/31/13 10:15 PM	3	0.12
Mid	9/4/13 10:30 PM	9/4/13 11:15 PM	3	0.24
Mid	9/8/13 12:15 AM	9/8/13 12:15 AM	1	0.47
Mid	9/8/13 2:15 AM	9/8/13 5:15 AM	12	0.25
Mid	9/8/13 7:45 AM	9/8/13 8:00 AM	2	0.09
Mid	9/8/13 6:00 PM	9/8/13 7:00 PM	2	0.16
North	9/16/13 1:00 PM	9/16/13 1:15 PM	2	0.05
Mid	9/19/13 3:15 AM	9/19/13 4:30 AM	4	0.18
Mid	9/20/13 1:00 AM	9/20/13 1:45 AM	4	0.26
Mid	9/25/13 12:15 PM	9/25/13 12:15 PM	1	0.02
Mid	9/26/13 2:15 PM	9/26/13 3:00 PM	4	0.35
Mid	9/27/13 9:15 AM	9/27/13 9:45 AM	3	0.30
Mid	9/29/13 3:30 AM	9/29/13 3:30 AM	1	0.17
Mid	9/29/13 6:30 AM	9/29/13 11:45 PM	8	0.16
Mid	11/27/13 9:45 PM	11/27/13 10:15 PM	3	0.21
Mid	6/16/14 5:30 AM	6/16/14 5:30 AM	1	0.02
Mid	6/29/14 3:45 AM	6/29/14 7:15 AM	13	0.17
South	6/29/14 10:15 AM	6/29/14 12:15 PM	8	0.14
Mid	6/30/14 4:45 AM	6/30/14 5:30 AM	4	0.51
Mid	6/30/14 12:45 PM	6/30/14 12:45 PM	1	0.28
Mid	7/1/14 5:00 AM	7/1/14 5:00 AM	1	0.48
Mid	7/2/14 2:00 AM	7/2/14 2:30 AM	2	0.45
South	7/7/14 5:30 PM	7/7/14 5:30 PM	1	0.02
Mid	7/7/14 11:00 PM	7/8/14 12:00 AM	5	0.80
Mid	7/18/14 3:30 AM	7/18/14 7:30 AM	15	0.20
Mid	7/23/14 12:00 PM	7/23/14 12:00 PM	1	0.08
Mid	8/6/14 10:30 AM	8/6/14 10:45 AM	2	0.21
Mid	8/25/14 3:15 AM	8/25/14 4:00 AM	4	0.28
Mid	9/11/14 4:15 PM	9/11/14 5:30 PM	3	0.42
Mid	9/14/14 8:45 PM	9/14/14 9:00 PM	2	0.10
Mid	9/15/14 1:15 AM	9/15/14 1:15 AM	1	0.30
Mid	9/15/14 7:30 AM	9/15/14 9:15 AM	8	0.64
South	9/15/14 1:15 PM	9/15/14 2:00 PM	3	0.11
Mid	9/15/14 8:15 PM	9/15/14 8:15 PM	1	0.01
Mid	9/17/14 5:00 AM	9/17/14 6:00 AM	5	0.19
Mid	9/17/14 10:30 PM	9/17/14 10:30 PM	1	0.27
Mid	9/20/14 6:45 AM	9/20/14 8:45 AM	9	0.37
Mid	9/20/14 8:45 PM	9/20/14 8:45 PM	1	0.31
Mid	9/20/14 10:45 PM	9/20/14 11:30 PM	3	0.36
Mid	9/25/14 3:15 AM	9/25/14 3:15 AM	1	0.21
Mid	9/30/14 3:45 PM	9/30/14 4:30 PM	4	0.68

Table 5: Potential Coastal "Occurrences" Under the Upper Bound Analysis (All Detected at the surface)

Coastal Station	Start	End	Number of 15-minute time-steps with exceedances	Average temperature over the threshold (°F)
Mid	7/18/13 6:30 AM	7/18/13 7:15 AM	4	0.14
Mid	8/5/13 10:45 PM	8/6/13 1:15 AM	11	0.74
Mid	8/26/13 1:45 AM	8/26/13 3:15 AM	7	0.37
Mid	8/26/13 4:45 AM	8/26/13 6:45 AM	9	0.32
Mid	8/26/13 8:15 AM	8/26/13 8:15 AM	1	0.59
Mid	8/31/13 9:30 PM	8/31/13 10:15 PM	4	0.36
Mid	9/1/13 12:00 AM	9/1/13 1:30 AM	7	0.10
Mid	9/4/13 9:45 PM	9/5/13 1:30 AM	12	0.16
Mid	9/5/13 11:00 PM	9/6/13 12:00 AM	3	0.07
Mid	9/7/13 11:00 AM	9/7/13 12:00 PM	3	0.20
Mid	9/7/13 2:30 PM	9/7/13 4:45 PM	7	0.21
Mid	9/8/13 12:15 AM	9/8/13 12:15 AM	1	0.58
Mid	9/8/13 2:15 AM	9/8/13 6:30 AM	18	0.90
Mid	9/8/13 7:45 AM	9/8/13 8:45 AM	5	0.67
Mid	9/8/13 5:00 PM	9/9/13 12:15 AM	29	0.35
Mid	9/9/13 1:45 AM	9/9/13 2:30 AM	4	0.07
Mid	9/18/13 9:15 AM	9/18/13 10:30 AM	6	0.12
Mid	9/18/13 12:00 PM	9/18/13 12:00 PM	1	0.04
Mid	9/19/13 3:15 AM	9/19/13 5:45 AM	7	0.51
Mid	9/20/13 12:45 AM	9/20/13 2:00 AM	6	0.51
Mid	9/21/13 10:30 AM	9/21/13 11:00 AM	3	0.29
Mid	9/25/13 12:00 PM	9/25/13 12:30 PM	3	0.29
Mid	9/26/13 2:15 PM	9/26/13 3:45 PM	7	0.32
Mid	9/27/13 9:15 AM	9/27/13 9:45 AM	3	1.05
Mid	9/27/13 12:45 PM	9/27/13 2:00 PM	3	0.35
Mid	9/27/13 8:45 PM	9/27/13 10:45 PM	8	0.27
Mid	9/29/13 2:30 AM	9/29/13 4:30 AM	5	0.34
Mid	9/29/13 5:45 AM	9/29/13 10:45 AM	17	0.57
Mid	9/29/13 10:30 PM	9/30/13 12:15 AM	8	0.37
Mid	11/27/13 9:45 PM	11/27/13 10:15 PM	3	0.28
Mid	6/9/14 5:15 AM	6/9/14 5:30 AM	2	0.04
Mid	6/9/14 8:15 AM	6/9/14 8:15 AM	1	0.12
Mid	6/15/14 3:00 AM	6/15/14 4:15 AM	5	0.07
Mid	6/16/14 4:45 AM	6/16/14 7:00 AM	10	0.37
Mid	6/23/14 11:30 AM	6/23/14 11:30 AM	1	0.02
Mid	6/23/14 3:15 PM	6/23/14 3:15 PM	1	0.01
Mid	6/24/14 1:45 AM	6/24/14 3:00 AM	3	0.07
Mid	6/26/14 12:30 AM	6/26/14 12:30 AM	1	0.06
Mid	6/29/14 3:00 AM	6/29/14 9:30 AM	26	0.65
South	6/29/14 10:15 AM	6/29/14 12:15 PM	8	0.23
Mid	6/30/14 4:00 AM	6/30/14 9:30 AM	21	0.80
Mid	6/30/14 12:15 PM	6/30/14 12:45 PM	3	0.88
Mid	7/1/14 4:45 AM	7/1/14 7:00 AM	10	0.57
Mid	7/2/14 12:45 AM	7/2/14 3:15 AM	8	0.58
Mid	7/6/14 5:45 PM	7/6/14 6:15 PM	3	0.07
Mid	7/7/14 10:00 AM	7/7/14 11:00 AM	4	0.62

Table 5: Potential Coastal "Occurrences" Under the Upper Bound Analysis (All Detected at the surface) (Continued, Page 2 of 2)

Coastal Station	Start	End	Number of 15-minute time-steps with exceedances	Average temperature over the threshold (°F)
South	7/7/14 4:15 PM	7/7/14 4:15 PM	1	0.03
South	7/7/14 5:30 PM	7/7/14 5:30 PM	1	0.02
Mid	7/7/14 10:00 PM	7/8/14 2:30 AM	17	0.87
Mid	7/8/14 7:00 AM	7/8/14 7:45 AM	4	0.14
Mid	7/11/14 12:45 AM	7/11/14 12:45 AM	1	0.08
Mid	7/18/14 3:30 AM	7/18/14 8:45 AM	21	0.65
Mid	7/18/14 8:30 PM	7/18/14 9:15 PM	3	0.10
Mid	7/19/14 6:30 AM	7/19/14 6:30 AM	1	0.08
Mid	7/19/14 7:45 AM	7/19/14 8:45 AM	2	0.37
Mid	7/22/14 10:30 PM	7/23/14 3:00 AM	13	0.22
Mid	7/23/14 10:30 AM	7/23/14 1:30 PM	12	0.46
Mid	8/6/14 6:15 AM	8/6/14 8:30 AM	7	0.09
Mid	8/6/14 10:15 AM	8/6/14 11:15 AM	5	0.66
Mid	8/11/14 11:15 PM	8/11/14 11:15 PM	1	0.05
Mid	8/15/14 5:30 PM	8/15/14 7:00 PM	6	0.25
Mid	8/15/14 9:30 PM	8/15/14 9:45 PM	2	0.23
Mid	8/16/14 5:15 AM	8/16/14 5:30 AM	2	0.09
Mid	8/23/14 10:15 PM	8/23/14 10:15 PM	1	0.12
Mid	8/25/14 3:15 AM	8/25/14 4:00 AM	4	0.32
Mid	8/27/14 2:45 AM	8/27/14 4:00 AM	6	0.18
Mid	9/6/14 12:15 AM	9/6/14 12:30 AM	2	0.04
Mid	9/6/14 8:30 AM	9/6/14 11:15 AM	10	0.30
Mid	9/10/14 2:00 PM	9/10/14 4:15 PM	7	0.13
Mid	9/11/14 10:00 AM	9/11/14 10:00 AM	1	0.30
Mid	9/11/14 4:00 PM	9/11/14 6:15 PM	7	0.62
Mid	9/12/14 3:00 AM	9/12/14 5:30 AM	10	0.41
Mid	9/14/14 3:45 PM	9/14/14 3:45 PM	1	0.09
Mid	9/14/14 8:45 PM	9/14/14 9:15 PM	3	0.13
Mid	9/15/14 1:00 AM	9/15/14 1:15 AM	2	0.63
Mid	9/15/14 6:45 AM	9/15/14 12:30 PM	23	1.06
South	9/15/14 1:15 PM	9/15/14 2:00 PM	3	0.18
Mid	9/15/14 7:45 PM	9/15/14 9:45 PM	8	0.18
Mid	9/16/14 7:45 PM	9/16/14 7:45 PM	1	0.11
Mid	9/16/14 10:15 PM	9/16/14 11:45 PM	7	0.34
Mid	9/17/14 4:45 AM	9/17/14 7:45 AM	13	0.40
Mid	9/17/14 10:30 PM	9/17/14 10:30 PM	1	0.77
Mid	9/20/14 6:45 AM	9/20/14 9:00 AM	10	0.53
Mid	9/20/14 8:45 PM	9/20/14 8:45 PM	1	0.39
Mid	9/20/14 10:45 PM	9/21/14 2:45 AM	17	0.59
Mid	9/21/14 12:00 PM	9/21/14 1:15 PM	5	0.24
Mid	9/21/14 7:30 PM	9/21/14 11:00 PM	14	0.36
Mid	9/24/14 2:00 PM	9/24/14 4:00 PM	8	0.54
Mid	9/25/14 3:00 AM	9/25/14 6:15 AM	10	0.43
Mid	9/26/14 12:45 AM	9/26/14 1:15 AM	3	0.18
Mid	9/30/14 3:45 PM	9/30/14 4:45 PM	5	0.61
Mid	11/28/14 3:30 AM	11/28/14 4:00 AM	3	0.27