Exhibit 6

Final Hydrodynamic and Temperature Modeling Report

for

Robinson Creek, Illinois

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Final

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Revision History

The following table presents the revision history for the Robinson Creek Modeling Report.

Table i-1 Revision history of Robinson Creek Modeling Report

Revision Number	Release Date	Comments
0	October 7, 2016	Initial release of Report. Grid was developed to start from 0.3 miles upstream of Robinson POTW until the confluence to Sugar Creek. Point source time series were developed. Simulation period is from 2011 through 2015. Hydrology calibration and validation are through 2015. Several scenarios were setup using the calibrated model.
1	March 17, 2017	Final release of Report. Report was updated per comments from Marathon.
2	May 9, 2017	Revised release of Final Report (REV2). Simulated period extended from 2011 through 2016. Revised the air Temperature for the downstream portion of the creek and updated the meteorological parameters in the creek. Updated the temperature assumption for Robinson POTW. Used the bi-weekly temperature data from Marathon Refinery. Hydrology calibration and validation are through 2016.

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1.0 INTRODUCTION

Robinson Creek is an approximately 8.3-mile long creek beginning from 1.2 miles upstream of Washington Park Deer Run Golf Course and flowing easterly towards Sugar Creek away from the City of Robinson (Figure 1-1). Sugar Creek drains into Wabash River in Indiana 5 miles downstream of the Robinson Creek-Sugar Creek confluence. The Robinson Creek watershed has a drainage area of approximately 22 square miles and is located within the City of Robinson, which has a population of approximately 7,700. There are two tributaries draining into Robinson Creek: a 2.8-mile long tributary flowing through Quail Creek Country Club and discharging into the upper portion of Robinson Creek, and a 2.2-mile long unnamed tributary discharging in the downstream portion of Robinson Creek. Quail Creek and the headwaters of Robinson Creek are located within the City of Robinson, while the unnamed tributary and the downstream areas of Robinson Creek are located in agricultural-dominated areas. Robinson Creek also receives water from ephemeral stream channels and ditches from the agricultural lands.

There are two prime dischargers into Robinson Creek: Robinson Publicly Owned Treatment Works (POTW) outfall (National Pollutant Discharge Elimination System [NPDES] Permit # IL0030732) and Marathon Refinery (NPDES Permit # IL0004073). Robinson POTW has a maximum permitted discharge of 6.25 million gallons per day (MGD). It discharges into Robinson Creek approximately 0.3 miles upstream of the Quail Creek-Robinson Creek confluence, and approximately 1.5 miles upstream of the Marathon Refinery outfall. The Marathon Refinery discharges to Robinson Creek approximately 0.75 miles below the Quail Creek-Robinson Creek confluence.

In the draft 2015 NPDES permit for Marathon Refinery, the Illinois Environmental Protection Agency (IEPA) required that the maximum temperature in Robinson Creek after mixing with the Marathon Refinery effluent not exceed the background (upstream) in-stream temperature by 5°F (2.8°C) on a continuous basis. The permit also stated that water discharged from the Marathon Refinery should not cause the in-stream temperature to be greater than 60°F in the winter (December – March) more than 1% of the time, with a maximum not-to-exceed temperature of 63°F. During the summer (April – November), the water discharged from the Marathon Refinery should not cause the in-stream temperature be greater than 90°F more than 1% of the time, with a maximum not-to-exceed temperature of 93°F.

In order to determine if the Marathon Refinery could comply with the not-to-exceed delta (Δ) of 5°F under the increased monitoring frequency imposed by the draft permit, a model was developed to assess temperature in Robinson Creek upstream and downstream of the Marathon Refinery during the past 6 years. The hydrodynamic and temperature model, Environmental Fluid Dynamics Code (EFDC), was used to develop a hydrodynamic model to quantify the sources (Robinson POTW, Marathon Refinery, tributary inputs, and meteorological inputs) of the increase in temperature between the upstream and downstream Robinson Creek sampling stations. The hydrodynamic model was used to determine the frequency and magnitude of 5°F Δ exceedances and the in-stream temperatures in various conditions.

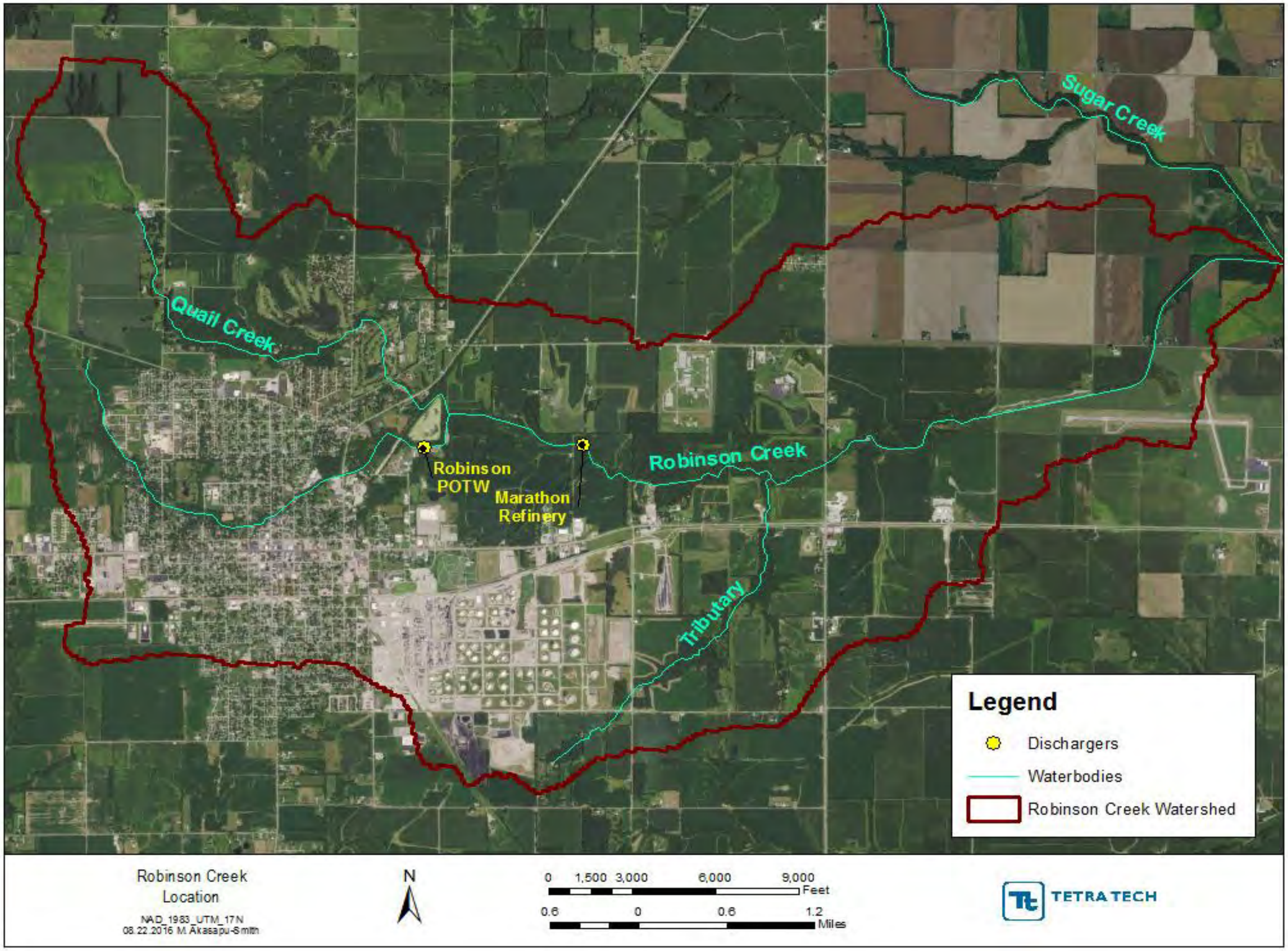

Figure 1-1 Location of Robinson Creek, its tributaries, and direct dischargers

2.0 MODEL BACKGROUND

EFDC is a hydrodynamic and water quality modeling package for simulating 1-D, 2-D, and 3-D flow and transport in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and nearshore to shelf scale coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications and is considered public domain software (Hamrick 1992).

The physics of the EFDC model, and many aspects of the computational scheme, are equivalent to the widely used Blumberg-Mellor model (Blumberg & Mellor 1987) and the U.S. Army Corps of Engineers' CH3D or Chesapeake Bay model (Johnson et al. 1993). The EFDC model solves the 3-D, vertically hydrostatic, free surface, turbulent averaged equations of motion for a variable density fluid. Dynamically coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity, and temperature are also solved. The two turbulence parameter transport equations implement the Mellor-Yamada level 2.5 turbulence closure scheme (Mellor & Yamada 1982; Galperin et al. 1988).

The EFDC model uses Cartesian or curvilinear, orthogonal horizontal coordinates. The numerical scheme employed in the EFDC model to solve the equations of motion uses second order accurate spatial finite differencing on a staggered grid. The model's time integration employs a second order accurate three-time level, finite difference scheme with an internal-external mode splitting procedure to separate the internal shear, or baroclinic mode, from the external free surface gravity wave, or barotropic mode.

3.0 HYDRODYNAMIC MODEL DEVELOPMENT

3.1 Data Requirements

The EFDC hydrodynamic and temperature model required extensive data inputs, which were obtained from several sources including the Marathon Petroleum Company (MPC), United States Geological Survey (USGS), National Climatic Data Center (NCDC), and Weather Bureau Army Navy (WBAN). These data were needed to develop the computational grid, meteorological inputs, and point source time series. Data were also used for temperature calibration and validation. Data collected for the Robinson Creek modeling are provided in the table below (Table 3-1).

Table 3-1 Data sources for the Robinson Creek modeling effort

Data Source	Data Type
Marathon Petroleum Company (MPC), LP	Meteorological Inputs (Air Temperature, Precipitation) Point Source Discharges Flow and Temperature
United States Geological Survey (USGS)	Tributary and Watershed Inflows
National Climatic Data Center (NCDC)	Meteorological Inputs (Air Temperature, Precipitation)
Weather Bureau Army Navy (WBAN)	Meteorological Inputs (Air Temperature, Pressure, Humidity, Cloud Cover, Wind)

3.2 Computational Grid

The Robinson Creek model domain extended from 0.3 miles upstream of Robinson POTW downstream to the confluence with Sugar Creek. To represent the channel longitudinal shape and channel width, the average grid cell size was set to approximately 50 meters long by 5 meters wide. The tributaries and Robinson Creek headwater were not represented in the grid, but estimated flows and temperatures were input into the model (see Section 3.5). Figure 3-1 shows the horizontal model grid system.

The vertical structure was represented by specifying the number of vertical layers for each horizontal grid cell. For the Robinson Creek model, one layer at each cell was selected to model the vertical structure of the system due to the typical depth of the creek, which was reported to be 1 foot to 2 feet deep by MPC. The vertical thickness of each layer changes among horizontal cells depending on the volume of water. During high flows and storm events, the cell thickness would increase accordingly to accommodate the increase in water volume.

No bathymetric data were available at Robinson Creek. Using the National Elevation Dataset (NED) in 1/3 arc-second resolution (10 meters), elevations at the upstream and downstream point of the model grid were estimated. Using the elevations and length of the creek, an initial estimate of the slope of the creek was established. The water depth of the creek was estimated based on the knowledge of local MPC staff and aerial imagery. With the initial slope and initial water depth, bottom elevations were calculated. The estimated slope was adjusted based on the model results.

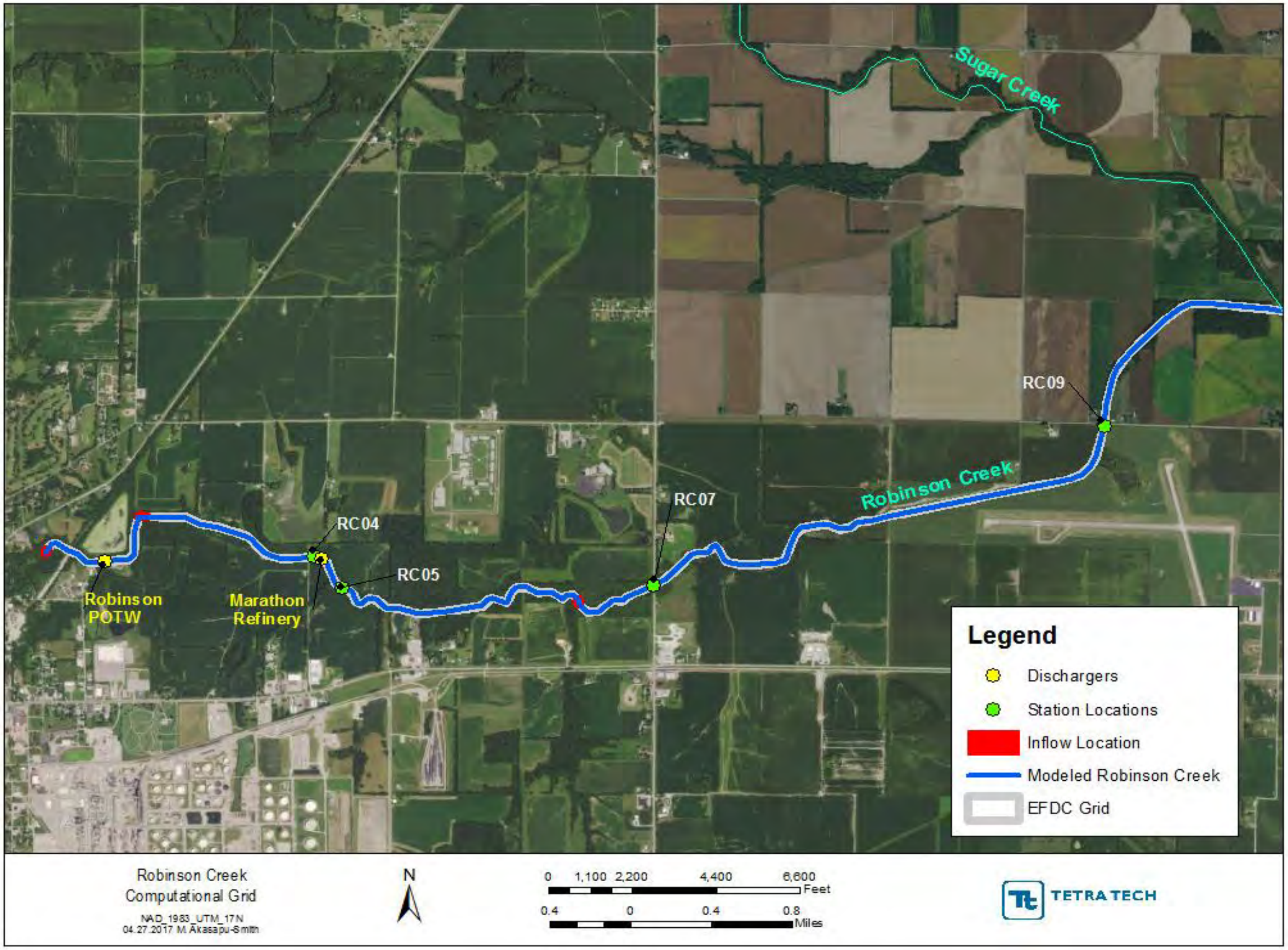

Figure 3-1 Robinson Creek EFDC model grid

3.3 Meteorological Data

Meteorological data from weather stations in close proximity to Robinson Creek were used to develop atmospheric conditions and wind time series files for the EFDC model (Figure 3-2). The data included precipitation, pressure, air temperature, relative humidity, wind speed and direction, and cloud cover. The time series used the reported data or were calculated from the reported data. The Meteorological Data Analysis and Preparation Tool (MetADAPT), a weather processing tool developed by Tetra Tech, was used to develop the meteorological input files to the Robinson Creek EFDC model.

Data from the National Climatic Data Center Summary of the Day (NCDC-SOD), National Climatic Data Center Surface Airway (NCDC-SA), and MPC were used to create the Robinson Creek EFDC model weather files. The NCDC-SOD data were obtained from Global Historical Climatology Network – Daily (GHCN-D) dataset. The NCDC-SA data were obtained from two sources: a web subscription from NCDC and Integrated Surface Database (ISD) maintained by the National Oceanic and Atmospheric Administration (NOAA). MPC also provided weather data to Tetra Tech.

Table 3-2 summarizes the weather data sources for the Robinson Creek EFDC model. Precipitation and air temperature data came from the NCDC-SOD station 116558 located at Palestine, Illinois. Air temperature, pressure, relative humidity, cloud cover, and wind speed and direction data came from the NCDC-SA station Weather Bureau Army Navy (WBAN) 93819 located at Indianapolis International Airport. MPC collected air temperature, precipitation, and wind speed and direction at Robinson Refinery. However, the wind data collected by MPC were not in a format that could be used to create meteorological input files for the EFDC model; therefore, the NCDC-SOD wind data were used instead. The temporal data availability varied at each station; therefore, data collected at multiple stations were sometimes combined to create the time series. The MPC data, which were collected in the Robinson Creek watershed, were always used whenever available, and data collected at the NCDC-SA and NCDC-SOD stations were used to fill in any missing data time periods. Figure 3-2 shows the location of NCDC-SOD station and the MPC weather station. WBAN 93819 was not included in the figure because it is located 100 miles northeast of the watershed.

Table 3-2 Data availability for the weather parameters used in the Robinson Creek EFDC model

Parameter	Data Availability		
	MPC: Robinson Refinery	NCDC-SA: 93819	NCDC-SOD: 116558
Precipitation, in/hr (.pre)	11/05/2015-01/04/2016	-	01/09/1901-12/31/2016
Altimeter pressure, mbar (.alt)	-	07/01/1996-12/31/2016	-
Dry-bulb temperature, ^{0}F (.tmp)	07/01/2010-01/04/2016	07/01/1996-12/31/2016	01/01/1901-12/31/2016-
Relative humidity, % (.hum)	-	07/01/1996-12/31/2016	-
Wind speed and direction, mi/hr and degrees (.win)	07/01/2010-01/04/2016	07/01/1996-12/31/2016	-
Cloud cover, tenths (.tsk)	-	07/01/1996-12/31/2016	-
Cloud adjusted solar radiation, ly/hr (.sr2)	-	Processed from .tsk	-

The reported precipitation, air temperature, pressure, and wind speed and direction were used to develop the EFDC model time series, and no additional processing was conducted.

The cloud cover data used in the Robinson Creek model setup were defined based on records from station WBAN 93819. Data for cloud cover from ISD were provided in terms of sky cover, which is a verbal description of the cloud cover. Based on the information provided in the User's Manual of MetADAPT, the following MetADAPT numerical assignments for cloud cover estimates from the sky conditions parameters was applied:

- CLR (clear) : 0
- SCT & OBS (scattered and obscured): 4.38
- BKN (broken): 7.5
- OVC (overcast): 10

Solar radiation, which is critical to the EFDC model temperature simulation, was computed using cloud cover and the latitude of station WBAN 93819, which was the closest station to the Robinson Creek watershed with cloud cover data. The CE QUAL-W2 method in MetADAPT was used to compute the solar radiation using sun angle relationships and shading from the cloud cover (Cole 2003).

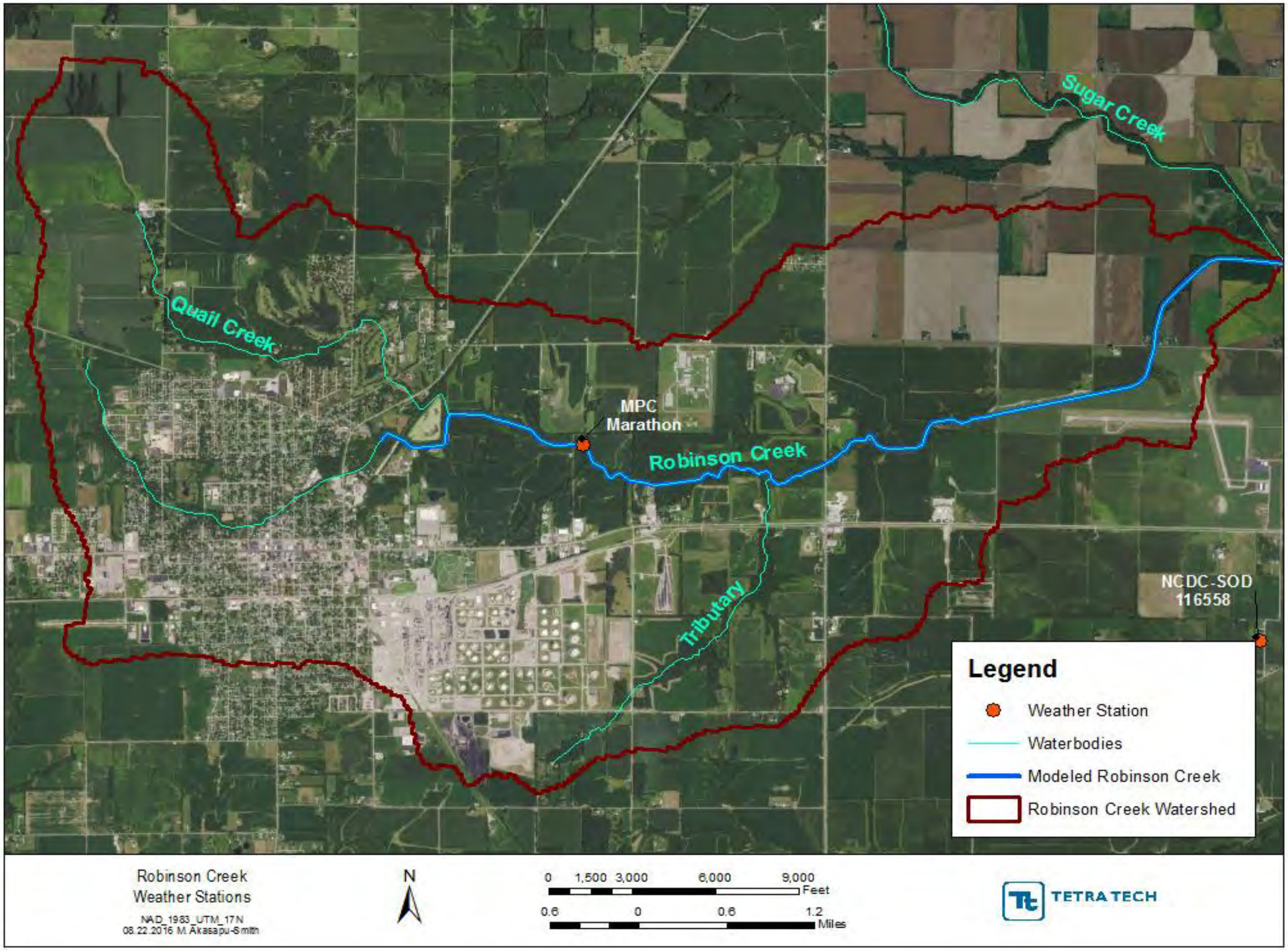

Figure 3-2 Location of weather stations near the Robinson Creek model

3.4 Point Source Discharges

Flows and temperatures from the two permitted NPDES facilities discharging into Robinson Creek, the Robinson POTW and Marathon Refinery, were included in the EFDC model (Figure 3-3). Table 3-3 presents the point source facilities included in the model and gives the NPDES number, facility name, facility type, receiving waterbody name, permitted flow, and the EFDC model cell where the facility was input into the model.

Table 3-3 Summary of point source discharges in the Robinson Creek model

NPDES Number	Facility Name	Facility Type	Receiving Water	County	State	Permitted Flow (MGD)	Model Input Cell (i,j)
IL0030732	City of Robinson WWTP†	MUN	Robinson Creek	Crawford	IL	6.25	(12,5)
IL0004073	Marathon Petroleum Company, LLC	IND	Robinson Creek	Crawford	IL	-	(56,5)

†Robinson POTW reported as City of Robinson WWTP in EPA-PCS

Flows and temperature data for the two NPDES point source dischargers were obtained from MPC in the form of Discharge Monitoring Reports (DMRs). Additional flow data for Robinson POTW were downloaded from the U.S. Environmental Protection Agency – Permit Compliance System (EPA-PCS). Table 3-4 summarizes the time period of data received from the agencies.

Table 3-4 Summary of data received from MPC for the Robinson Creek model

NPDES Facility	Parameter	Agency	Time period	Frequency of DMR
Robinson POTW (IL0030732)	Flow	EPA-PCS	10/2010 – 7/2015 and 11/2015 – 12/2015	Monthly
		MPC	8/7/2015 – 8/10/2015	20-min
			9/3/2015 – 9/14/2015	Hourly
	Temperature	MPC	8/2015 – 1/2016	Weekly
			11/11/2015 – 12/31/2015	5-min
Marathon Refinery (IL0004073)	Flow	MPC	1/1/2011 – 8/31/2015	Bi-weekly
			8/7/2015 – 8/10/2015	20-min
			9/2015 – 12/2015	Hourly
	Maximum Flow		1/1/2016 – 12/31/2016	Hourly
	Temperature	MPC	1/1/2011 – 12/31/2016	Bi-weekly
			8/7/2015 – 8/10/2015	20-min
			11/3/2015 – 12/31/2015	5-min

*Flows for October through December 2010 were downloaded from EPA-PCS

The point source discharge flow and temperatures were input into the model at their highest provided sampling temporal frequency. For Robinson POTW, monthly average flows downloaded from EPA-PCS were used from October 2010 through July 2015 and November 2015 through December 2016. MPC provided 20–minute flows from August 7, 2015 through August 10, 2015 and hourly flows from September 3, 2015 through September 14, 2015, and the higher frequency flow data were used for these months. For temperature, weekly data provided by MPC for Robinson POTW from August 2015 through January 2016 were used to calculate monthly temperatures which were applied for the missing periods (Table 3-5). Five–minute data were supplied from November 2015 through December 2015.

Table 3-5 Default water temperatures for Robinson POTW for periods without data used in the Robinson Creek model

Constituent	Assumption
Water Temperature	70.0 ^{o}F January - April
	80.0 ^{o}F May - October
	60.0 ^{o}F November - December

MPC provided flows for the Marathon Refinery. Bi-weekly flows were provided and used for the simulation from January 2011 through August 2015; 20–minute flow data were provided and used from August 7, 2015 through August 10, 2015; and hourly flow data were provided and used from September 2015 through December 2016. MPC also provided effluent temperatures for the Marathon Refinery. Bi–weekly temperature data were provided and used from January 2011 through December 2016.

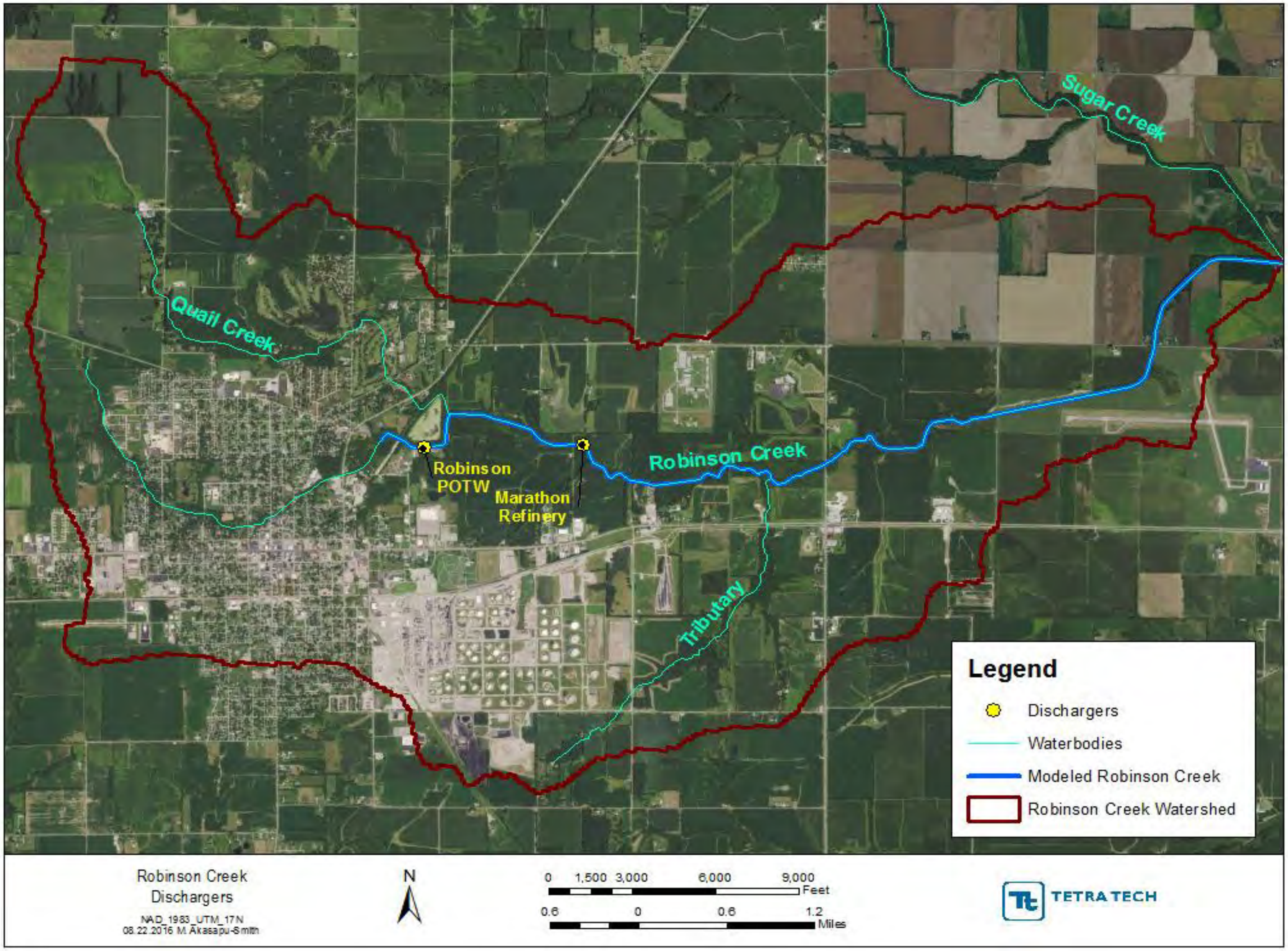

Figure 3-3 Location of point source dischargers in the Robinson Creek model

3.5 Tributary and Watershed Flows and Temperatures

There were no USGS monitoring gages located in the Robinson Creek watershed. The USGS gage closest to Robinson Creek, USGS 03343820 located in Kickapoo Creek at 1320E Road near Charleston, IL, was selected to represent the watershed and tributary flows. Located 40 miles northwest from Robinson Creek, the watershed had a similar area (17,728 acres) and land use as compared to the Robinson Creek watershed (Figure 3-6) (USGS 2016).

Measured discharge from USGS 03343820 was area–weighted to develop a flow time series to represent the Robinson Creek watershed flows, as well as flows from Quail Creek and from the tributary downstream of Marathon Refinery. The location of the tributary flow input locations in the EFDC model are shown in Figure 3-5.

Water temperature data were available at USGS 03343820 from July 2014 through October 2015. Because of the lack of water temperature data at the creek, an initial temperature data time series was created using the following equation:

$$Watershed\ Temperature = Air\ Temperature\ \times Potency\ Factor + Base\ Temperature$$

A potency factor of 0.5 was assumed to calculate watershed temperature. A general contour map of mean earth temperature for the state of Illinois was used to establish the base temperature for the Robinson Creek watershed (LSPC 2009). The base temperature was used for the summer months. Based on the winter in-stream temperatures observed at the USGS 03343805, a lower base temperature for the winter months was used. The resulting watershed and tributary temperatures are shown in Figure 3-4. The higher estimated water temperatures during the winter of 2015 through 2016 was due to the relatively higher air temperatures.

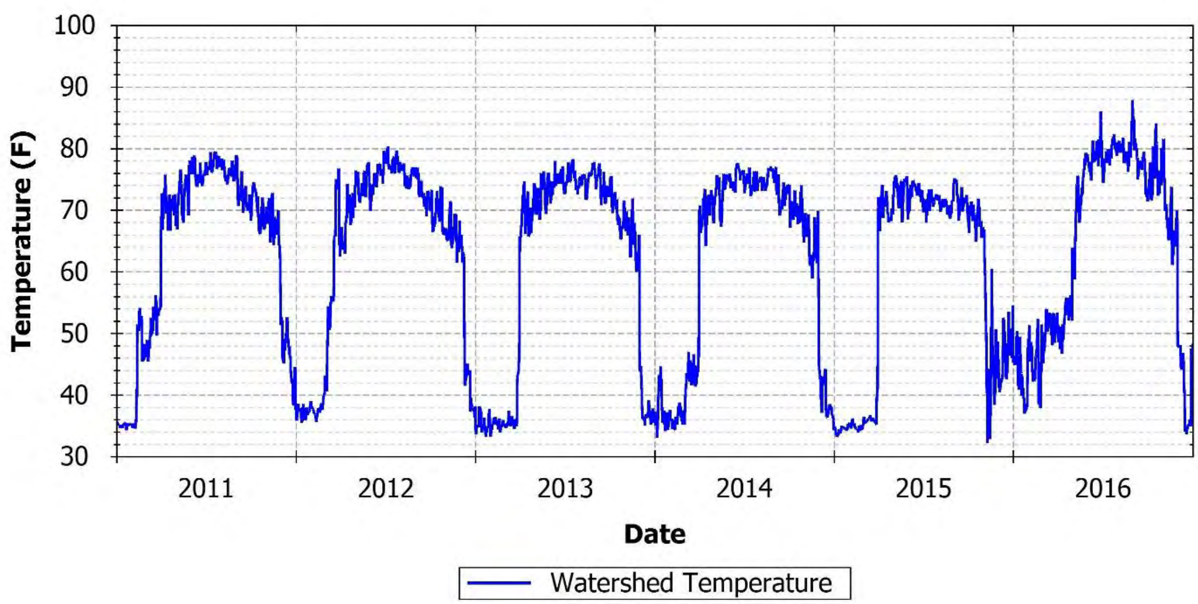

Figure 3-4 Watershed temperature input in the Robinson Creek model

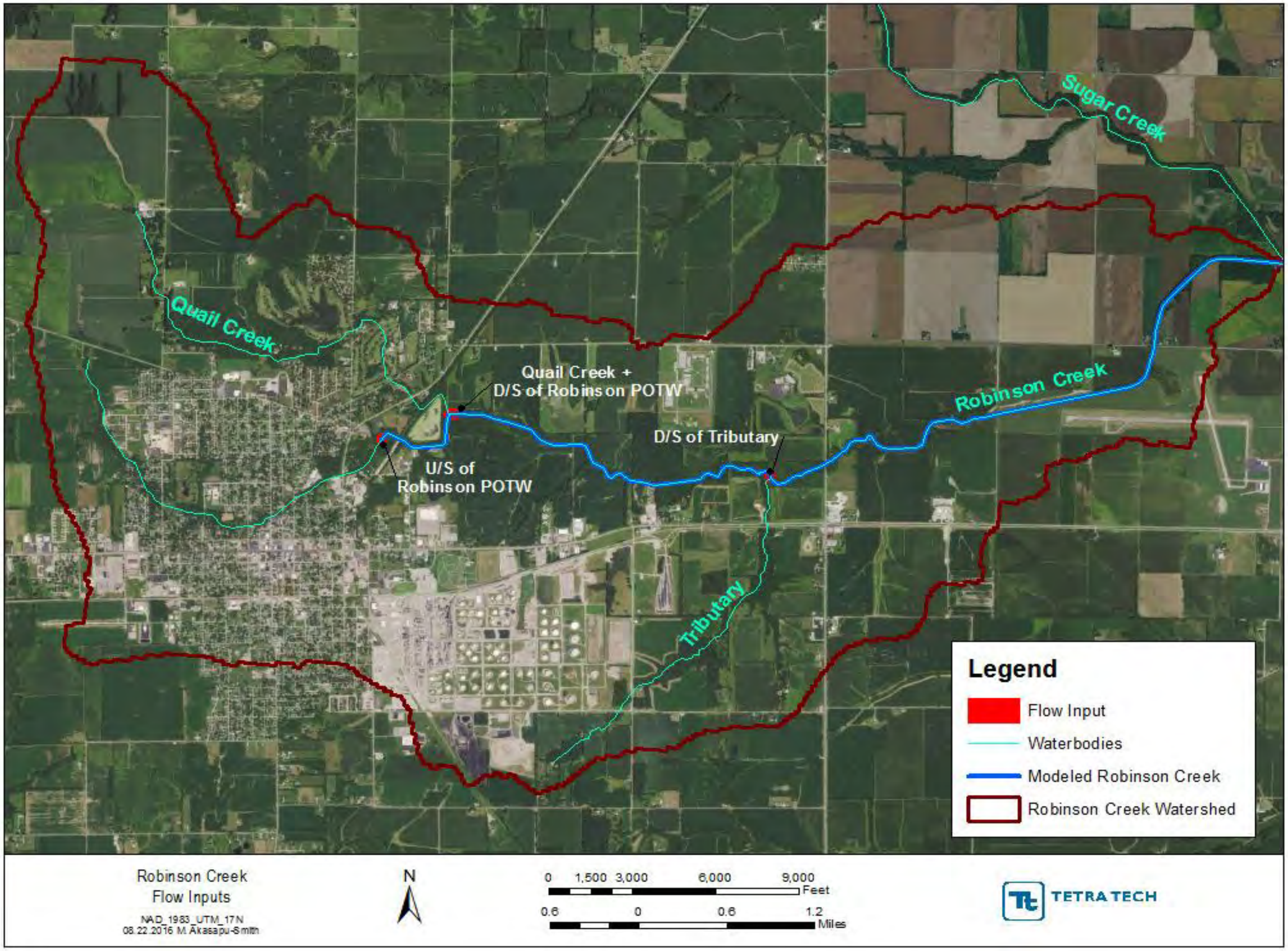

Figure 3-5 Location of stream flow inputs in the Robinson Creek model

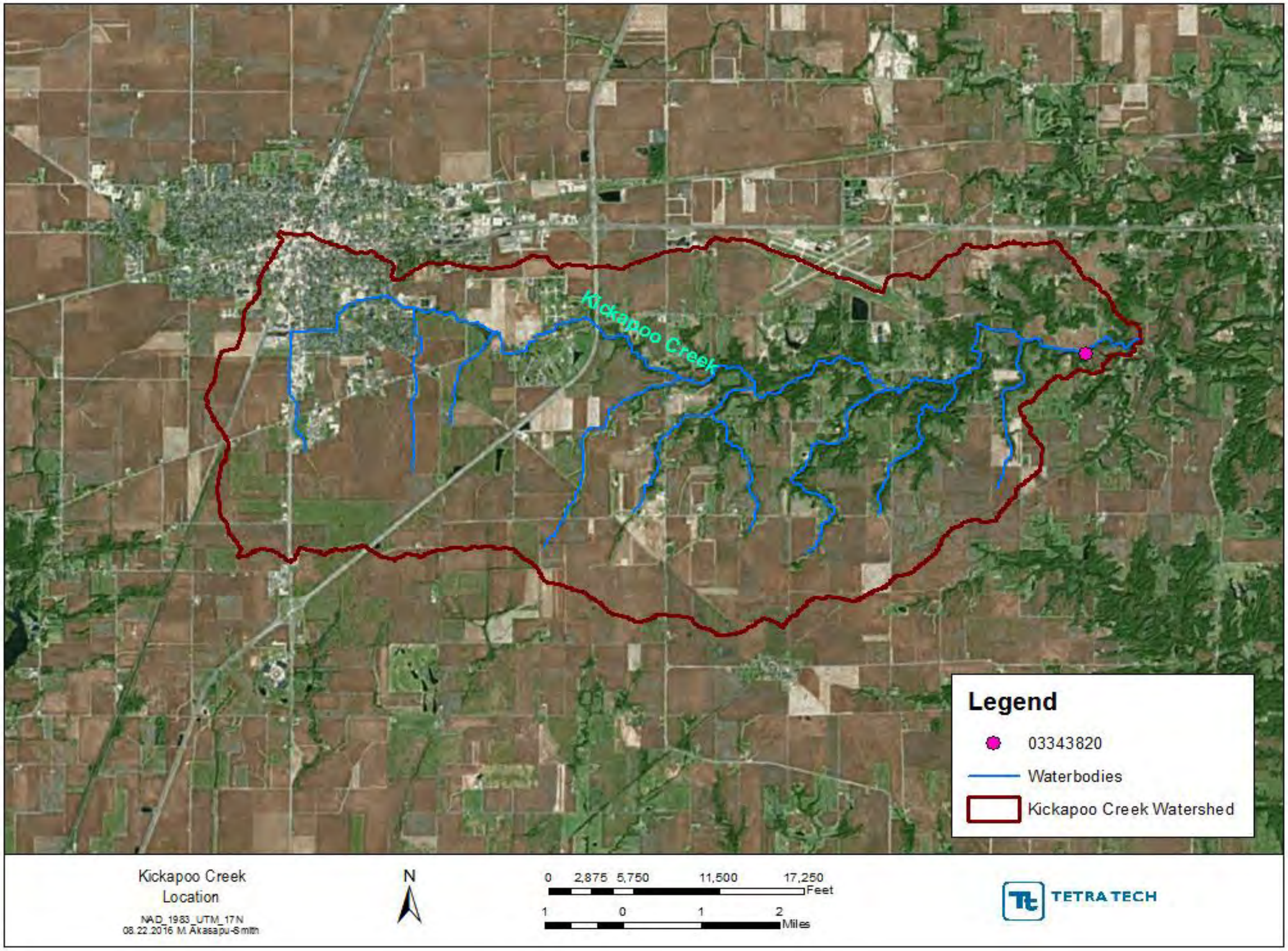

Figure 3-6 Location of Kickapoo Creek watershed

4.0 TEMPERATURE CALIBRATION, VALIDATION, AND VERIFICATION

The EFDC hydrodynamic and temperature model was simulated for a 6-year period from October 1, 2010 through December 31, 2016. The period from October 1, 2010 through December 31, 2010 was used as a spin up period for the model to equilibrate the initial conditions.

The hydrodynamic model was calibrated to the 2016 Datasonde data collected by MPC in collaboration with Midwest Biodiversity Institute (MBI), validated to in-stream MPC grab samples collected between 2011 and 2015, and verified to 2015 - 2016 continuous HOBO data collected as part of MPC's intense data collection in collaboration with MBI. The 2016 Datasonde data were collected at a frequency of 10-minutes. The grab samples were collected at a maximum frequency of twice per week. The HOBO data in 2015 were collected at either a frequency of 5-minutes and 20-minutes, while the data collected in 2016 were at a frequency of 10 minutes.

4.1 In-Stream Water Temperature Calibration, Validation, and Verification Data

MPC recorded in-stream water temperatures at four station locations: (1) the current downstream monitoring station, RC09 (BFC-10), located 3.9 miles downstream of the Marathon Refinery outfall; (2) a historical downstream monitoring station, RC07 (BFC-11), located 1.7 miles downstream of the MPC outfall, (3) immediately downstream of the Marathon Refinery outfall, RC05 (EMZ), and (4) an upstream monitoring station, RC04 (BFC-25) located between Robinson POTW and Marathon Refinery outfall (Figure 4-1).

In 2016, MPC and MBI deployed continuous recorders from January 2016 through February 2017 to collect in-stream temperature data at RC04, RC05, RC07, and RC09. Grab sample data were collected when effluent temperature was above the seasonal thresholds of 60°F in the winter and 90°F in summer at a maximum frequency of twice per week. During the past 5 years, MPC collected data at RC09 and RC04 as required in their permit from 2011 - 2015. In 2015, MPC conducted two intensive data sampling collections. MPC collected 20-minute temperature data from August 7, 2015 through August 10, 2015, and 5-minute temperature data from November 4, 2015 through January 5, 2016 at RC04 and RC09. MPC also collected 10-minute temperature data at RC04, RC05, and RC09 from June through December of 2016.

Table 4-1 summarizes the in-stream water temperature data used in the Robinson Creek model. The Datasonde data collected by MPC and MBI were used to calibrate the EFDC temperature model, the grab sample data collected by MPC as part of the permit requirement were used to validate the EFDC temperature model, and the HOBO data collected by MPC and MBI during the intensive sampling collections were used to verify the EFDC temperature model.

Table 4-1 Summary of in-stream water temperature stations in the Robinson Creek model

Station ID	Station Name	Agency	Frequency of Data	Time Period	Type
RC09	Downstream Monitoring Station	MBI	10-min	1/25/2016 – 12/15/2016	Calibration
		MPC	Twice per Week	1/2/2012 – 12/31/2015	Validation
			20-min	8/7/2015 – 8/10/2015	Verification
			10-min	9/14/2016 – 12/31/2016	
			5-min	11/4/2015 – 1/5/2016	

Station ID	Station Name	Agency	Frequency of Data	Time Period	Type
RC07	Historical Downstream Monitoring Station	MBI	10-min	1/25/2016 – 12/15/2016	Calibration
RC05	Edge of Mixing Zone	MBI	10-min	1/25/2016 – 12/15/2016	Calibration
		MPC	10-min	7/13/2016 – 9/14/2016	Verification
RC04	Upstream Monitoring Station	MBI	10-min	1/25/2016 – 12/15/2016	Calibration
		MPC	Twice per Week	1/2/2012 – 12/31/2015	Validation
			20-min	8/7/2015 – 8/10/2015	Verification
			10-min	7/13/2016 – 12/31/2016	
			5-min	11/4/2015 – 1/5/2016	

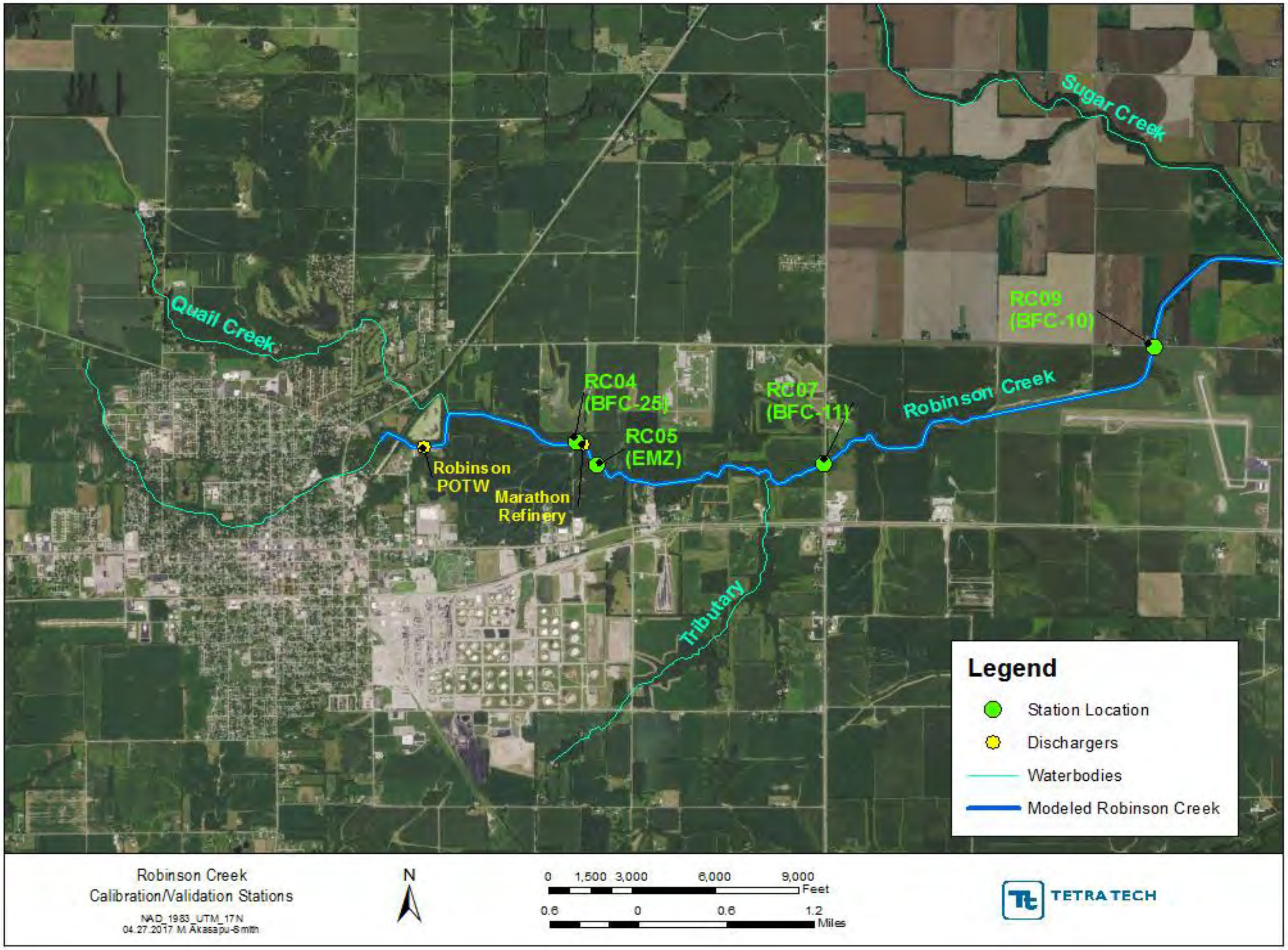

Figure 4-1 Location of water temperature stations in the Robinson Creek model

4.2 In-Stream Water Temperature Calibration, Validation, and Verification

An appropriate representation of the vertical and horizontal distribution of heat in creeks is important to correctly represent the density-driven circulation in the system. The Robinson Creek EFDC model was calibrated to represent heat distribution using temperature measurements collected at the four locations as described in Section 4.1. The parameters adjusted during the model calibration were the solar radiation attenuation coefficient and the heat transfer coefficient between the water column and the solid bed. These parameters control most of the vertical structure of heat in the model (Hamrick 1992; Ji 2008). Based on the aerial imagery, it was observed that the upstream portion of the creek, from Robinson POTW to downstream of Marathon Refinery, the creek was more canopied and turbulent compared to the downstream portion of the creek. To emulate this observation, solar radiation penetrating the water surface was increased in the downstream section of the watershed.

A summary of the calibration, validation, and verification results at the four monitoring stations is presented in Table 4-2, Table 4-3 and Figure 4-2 through Figure 4-18. The station locations are presented in Figure 4-1.

The calibration results indicated that the model was capable of reproducing, with high precision, the temperature variations observed in the evaluated stations in 2016, and calibration can be classified as Good or Very Good based on modeling statistical standards (Donigian 2002 and McCutcheon et al. 1990). The calibration statistics were overall Very Good at all four stations, with the difference in temperatures in the range of 0.5 – 3 °F, average percent errors less than 3.5%, and high indices of agreement and R^2 values (Table 4-3). Statistically, model performance was best at RC04, RC07, and RC09 during the summer calibration and winter calibration periods (Table 4-). During the critical summery calibration period, defined as from June 15, 2016 through September 16, 2016, the indices of agreement ranged from 0.61 to 0.69 and the R^2 ranged from 0.79 to 0.88. A review of the statistical data indicated that the model does not capture the lowest temperatures well during this period. The calibration plots at RC04, RC05, RC07, and RC09 suggest that the calibration during the summer as well as winter period captured the trends and magnitude well, including capturing the overall diurnal trends and timing observed in the measured temperature. Based on the visual comparison of temperatures at the four stations during the summer and winter periods, there is a lag in the modeled in-stream temperatures especially in the peaks. This may be due to the different time steps of the model inputs during these periods.

The validation results (Figure 4-5 and Figure 4-17) at RC04 and RC09 indicate that the model performed very well compared with the in-stream grab sample data, both statistically and visually. The model successfully captured the seasonal variations in the temperatures. The modeled in-stream temperatures during the summer periods appeared to simulate higher temperatures than the measured temperatures. However, the higher modeled in-stream temperatures cannot be indicative of over simulation of the stream temperatures because the grab samples were taken in the mornings, usually between 8:00 am – 10:00 am, while the highest daily summer temperatures occurred in afternoons between 3:00 pm – 7:00 pm. Because the fluctuations in in-stream temperatures are dominantly influenced by the hour of the day due to air temperature and solar radiation, the grab samples do not necessarily reflect in-stream temperatures that could have occurred in the afternoon.

The verification results (Figure 4-6, Figure 4-10, and Figure 4-18) at RC04, RC05, and RC09 demonstrate that the model performed well compared to the continuous HOBO data except at RC05, where statistically the percent errors were higher and the R^2 was poor. This may be because of dilution characteristics of the stream modeled in the model and the differences in time steps. However, during this same period, the model performed very well compared to the Datasonde data, which indicated that there are differences between in-stream temperature measurements using the different data collection tools. The differences between the two datasets was frequently less than 1°F, but this can impact statistical comparison results. The differences may be because of the instrument error recorded in HOBO probes when compared to the Datasondes or due to the locations of the probes in the stream.

Table 4-2 Robinson Creek EFDC model water temperature calibration statistics by season

Station ID	Measured (°F)				Simulated (°F)				Percent Errors (%)				R^2	Index of Agrmt
	5 %tile	Mean	Median	95 %tile	5 %tile	Mean	Median	95 %tile	5 %tile	Mean	Median	95 %tile		
Summer Calibration Period 4/1/2016 – 11/30/2016														
RC04	53.74	66.41	66.62	78.98	52.93	65.13	63.79	80.05	1.5	1.9	4.2	-1.3	0.85	0.95
RC05	65.89	77.34	78.66	90.05	63.74	76.68	77.39	89.97	3.3	0.9	1.6	0.1	0.87	0.96
RC07	58.02	71.90	71.09	87.08	58.96	70.73	68.68	86.46	-1.6	1.6	3.4	0.7	0.90	0.97
RC09	52.41	68.80	68.68	84.09	51.15	66.20	64.17	82.64	2.4	3.8	6.6	1.7	0.88	0.95
Critical Summer Calibration Period 6/15/2016 – 9/16/2016														
RC04	68.56	75.48	76.33	79.75	62.04	73.43	74.94	82.43	9.5	2.7	1.8	-3.4	0.69	0.79
RC05	79.78	85.81	86.34	90.67	78.09	85.03	86.35	91.07	2.1	0.9	0.0	-0.4	0.64	0.88
RC07	74.92	82.90	83.60	89.49	73.18	81.28	82.15	89.64	2.3	2.0	1.7	-0.2	0.61	0.85
RC09	71.74	79.24	79.90	85.15	65.46	76.66	77.97	84.41	8.8	3.3	2.4	0.9	0.64	0.81
Winter Calibration Period 1/1/2016 – 3/31/2016; 12/1/2016 – 12/31/2016														
RC04	37.50	45.96	43.32	59.21	38.63	46.86	44.90	57.20	-3.0	-2.0	-3.7	3.4	0.94	0.96
RC05	53.23	59.17	59.04	66.10	51.94	57.20	57.15	63.63	2.4	3.3	3.2	3.7	0.74	0.77
RC07	42.40	51.32	50.71	63.11	41.98	51.15	49.85	62.95	1.0	0.3	1.7	0.2	0.91	0.95
RC09	38.43	48.92	46.56	60.73	37.35	47.83	46.23	59.92	2.8	2.2	0.7	1.3	0.93	0.96

Table 4-3 Robinson Creek EFDC model water temperature calibration, validation, and verification statistics

Station ID	Measured (°F)				Simulated (°F)				Percent Errors (%)				R^2	Index of Agrmt
	5 %tile	Mean	Median	95 %tile	5 %tile	Mean	Median	95 %tile	5 %tile	Mean	Median	95 %tile		
Calibration Period 1/2016 – 12/2016														
RC04	39.07	58.38	60.05	78.32	40.09	57.96	59.32	78.78	-2.6	0.7	1.2	-0.6	0.94	0.98
RC05	56.27	71.52	72.08	89.77	53.66	70.44	73.58	88.95	4.6	1.5	-2.1	0.9	0.94	0.98
RC07	44.38	66.24	66.93	86.31	45.92	65.35	65.95	85.35	-3.5	1.4	1.5	1.1	0.94	0.98
RC09	40.55	60.99	62.06	82.81	38.77	58.98	59.56	81.43	4.4	3.3	4.0	1.7	0.94	0.98
Validation Period 2011 - 2015														
RC04	35.00	53.88	49.00	78.85	36.72	54.74	49.98	77.99	-4.9	-1.6	-2.0	1.1	0.94	0.98
RC09	36.00	55.02	50.00	79.00	33.47	54.78	50.50	80.68	7.0	0.4	-1.0	-2.1	0.93	0.98
Verification Period 8/2015 – 12/2016														
RC04	41.09	58.41	57.33	78.25	42.17	57.98	56.67	78.43	-2.6	0.7	1.2	-0.2	0.94	0.98
RC05	77.99	84.76	85.35	90.29	79.68	84.29	84.42	89.57	-2.2	0.6	1.1	0.8	0.33	0.75
RC09	41.93	55.78	55.65	74.25	37.18	52.75	53.34	72.93	11.3	5.4	4.1	1.8	0.9	0.95

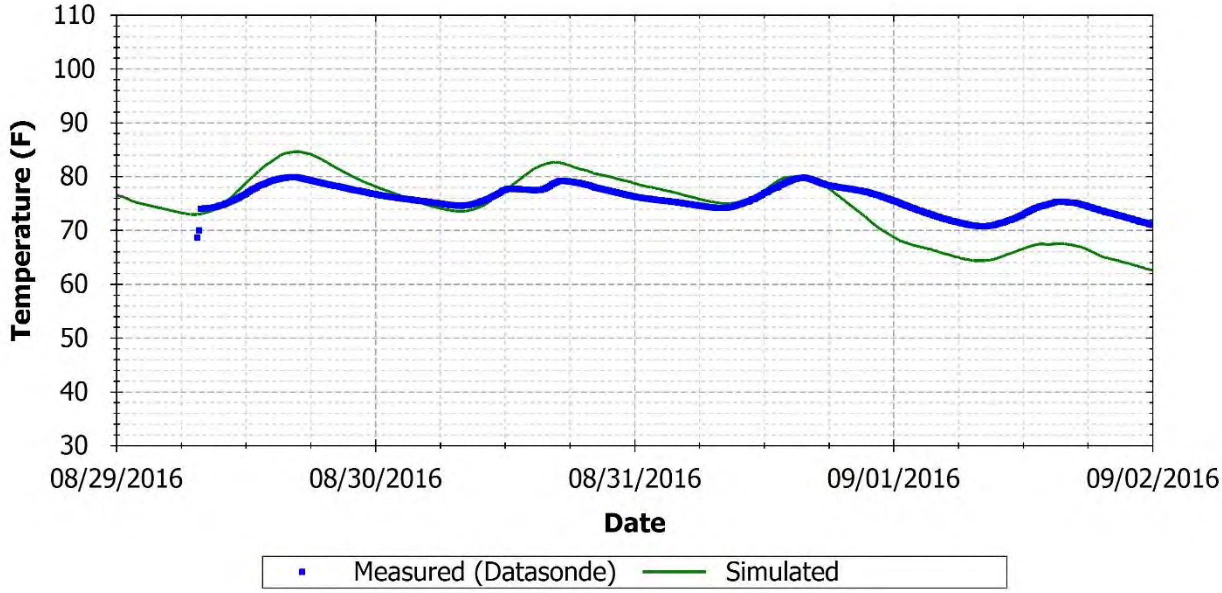

Figure 4-2 Water temperature calibration comparison at station RC04, upstream monitoring station, for summer 2016 Datasonde data

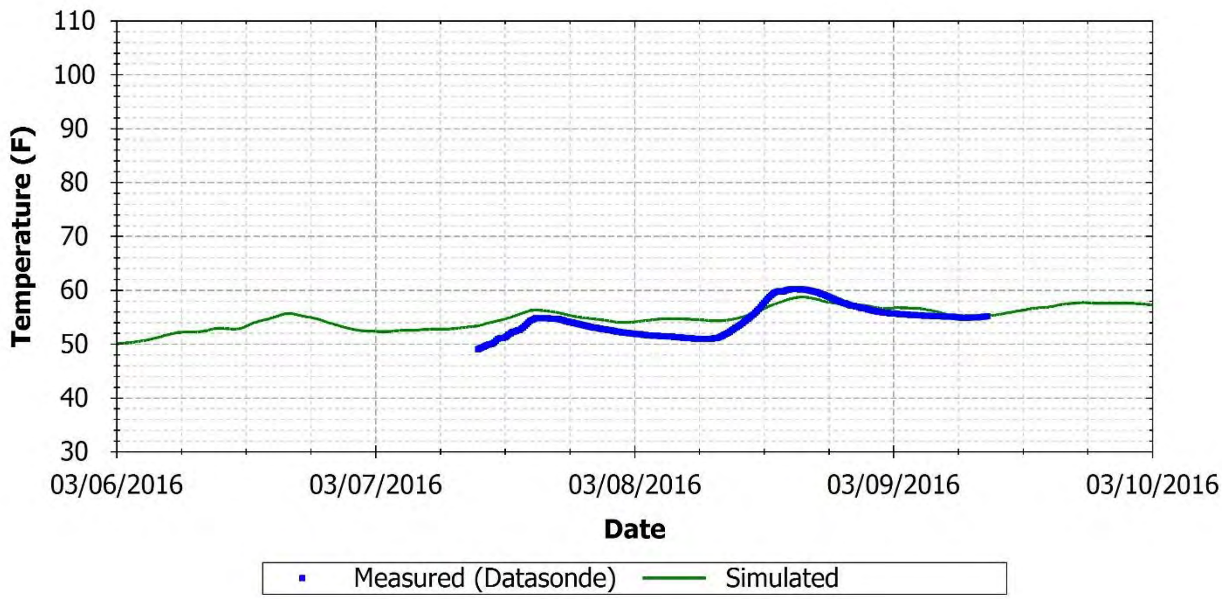

Figure 4-3 Water temperature calibration comparison at station RC04, upstream monitoring station, for winter 2016 Datasonde data

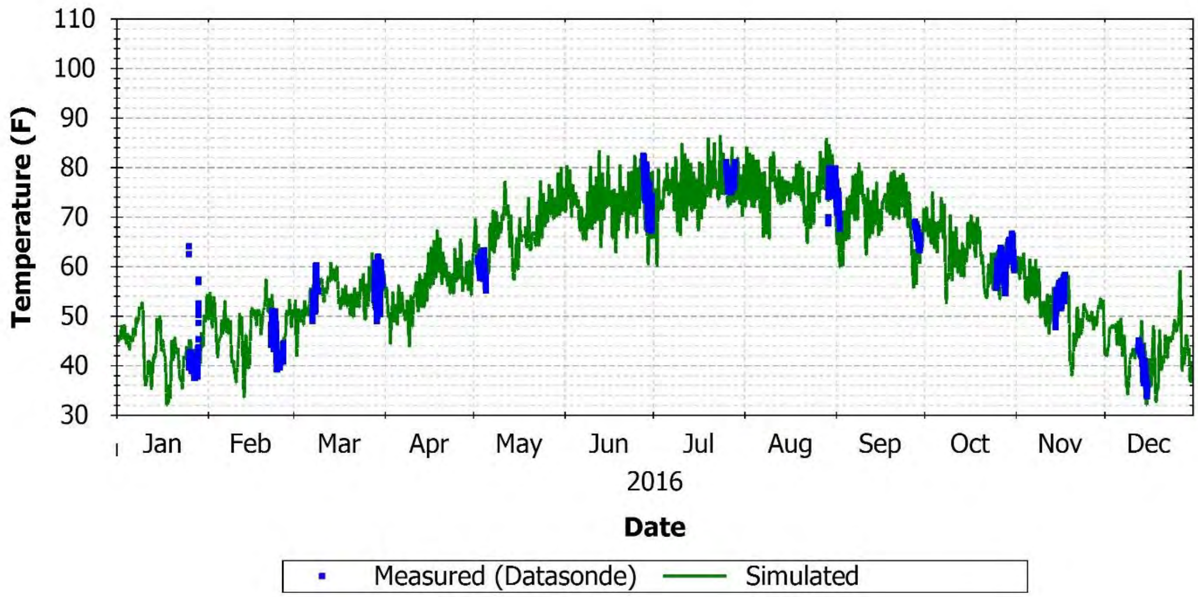

Figure 4-4 Water temperature calibration comparison at station RC04, upstream monitoring station, for the year 2016 Datasonde data

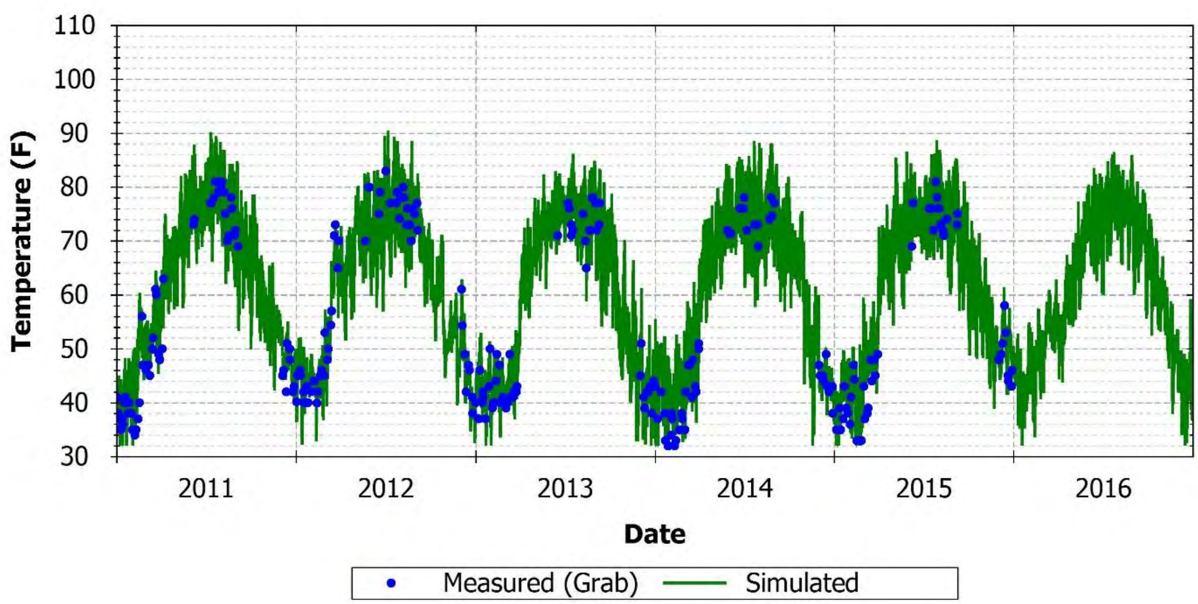

Figure 4-5 Water temperature validation comparison at station RC04, upstream monitoring station, from 2011 – 2015 in-stream grab samples

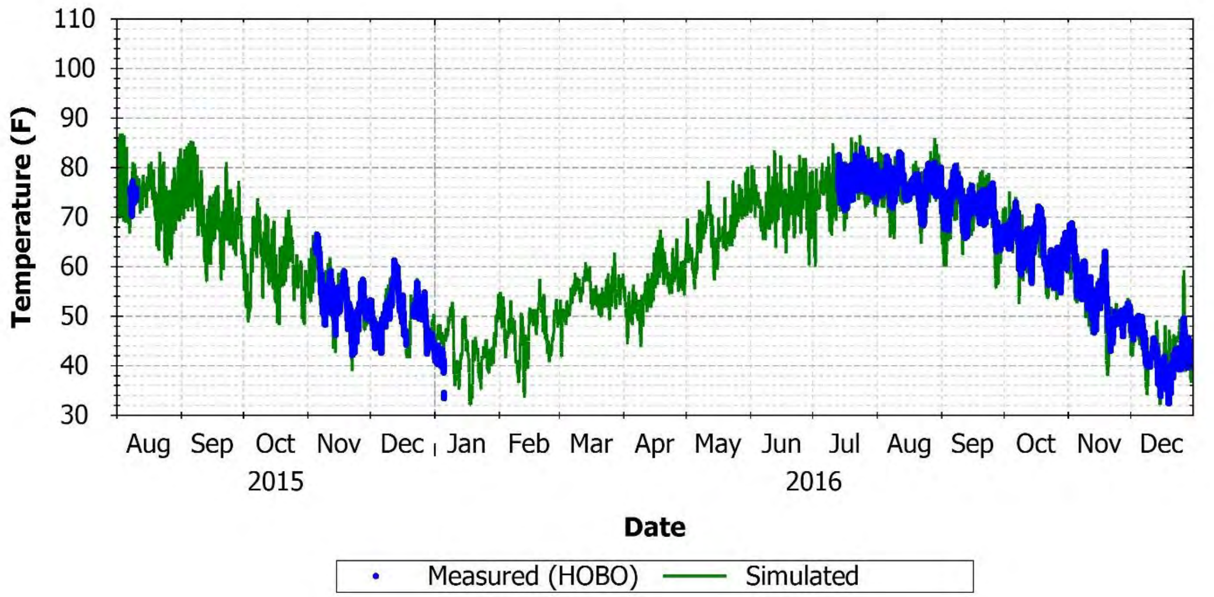

Figure 4-6 Water temperature verification comparison at station RC04, upstream monitoring station, from 2015 – 2016 HOBO data

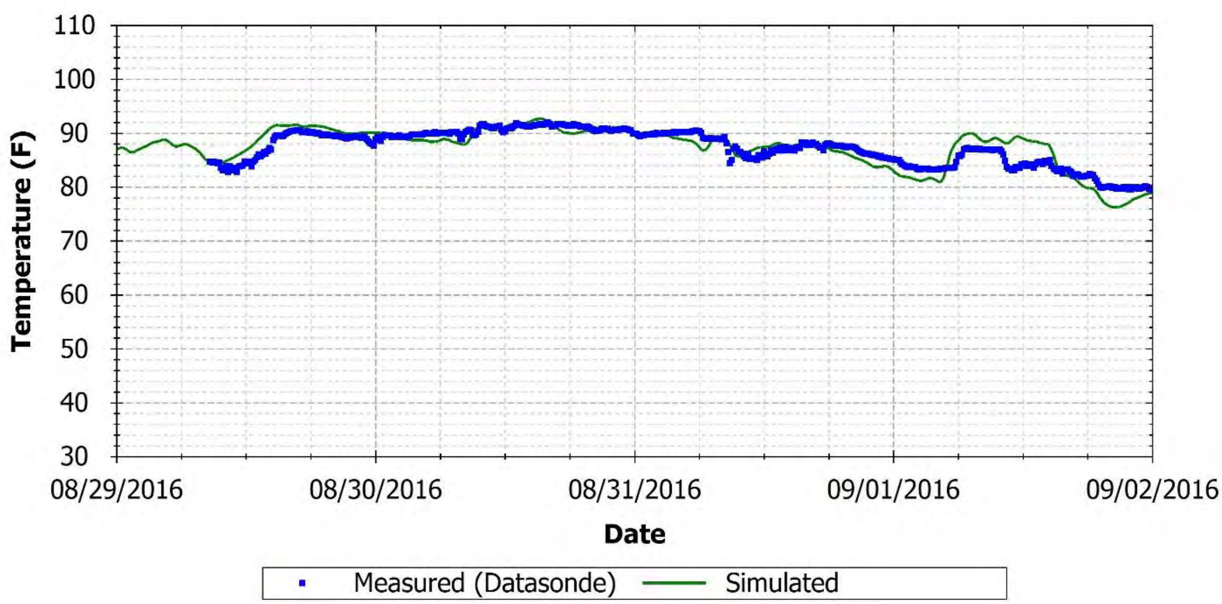

Figure 4-7 Water temperature calibration comparison at station RC05, edge of mixing zone, for summer 2016 Datasonde data

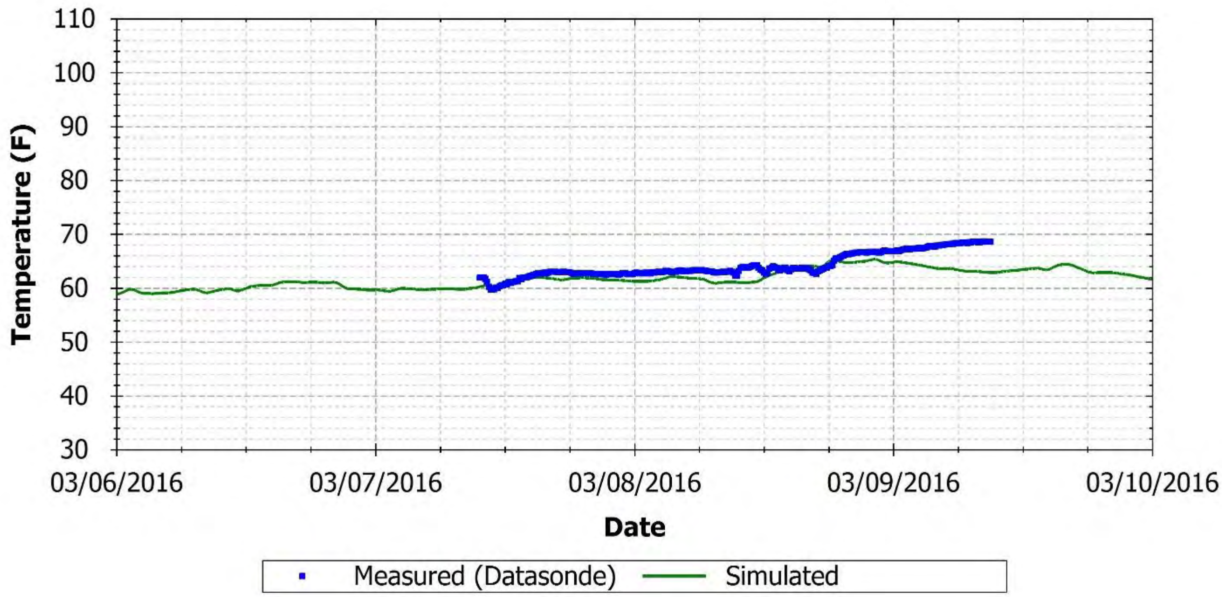

Figure 4-8 Water temperature calibration comparison at station RC05, edge of mixing zone, for winter 2016 Datasonde data

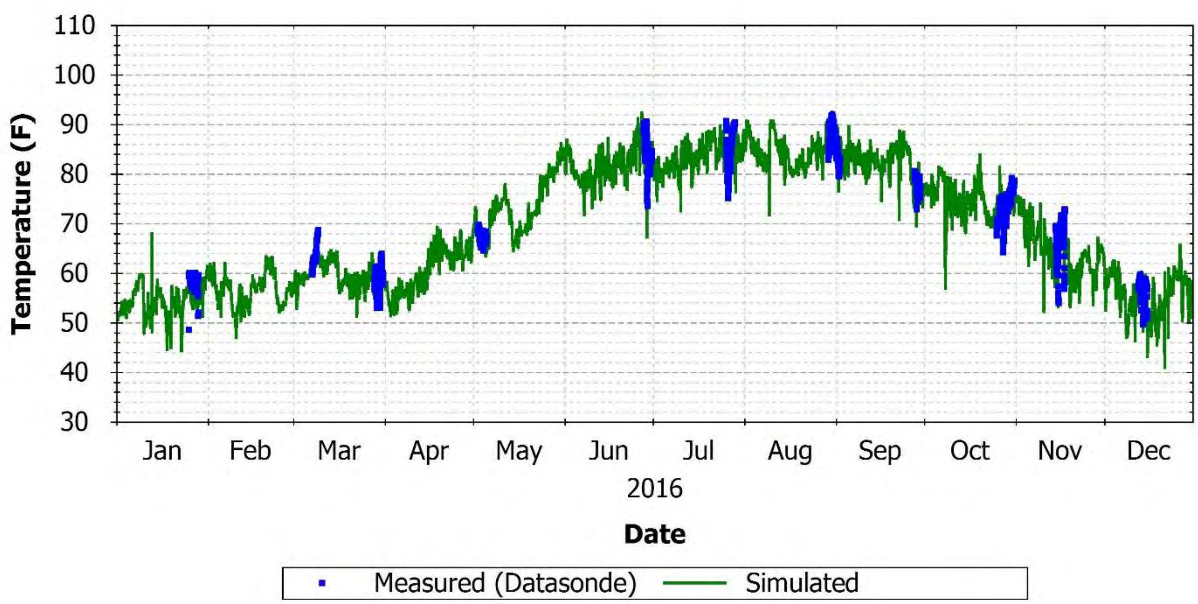

Figure 4-9 Water temperature calibration comparison at station RC05, edge of mixing zone, for the year 2016 uDatasonde data

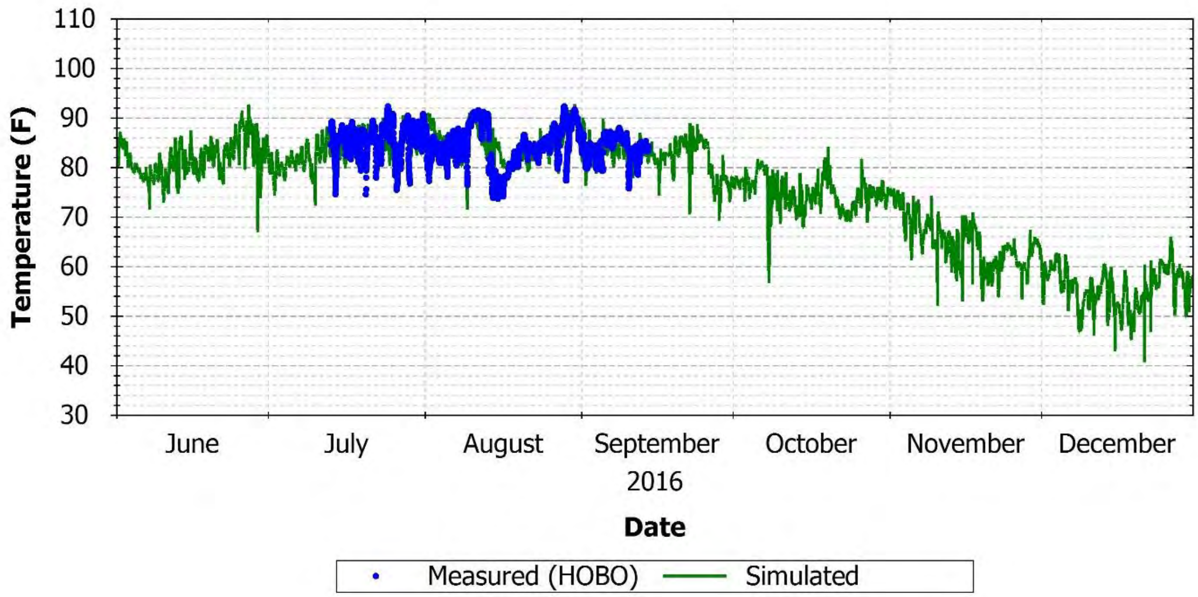

Figure 4-10 Water temperature verification comparison at station RC05, edge of mixing zone, for summer 2016 HOBO data

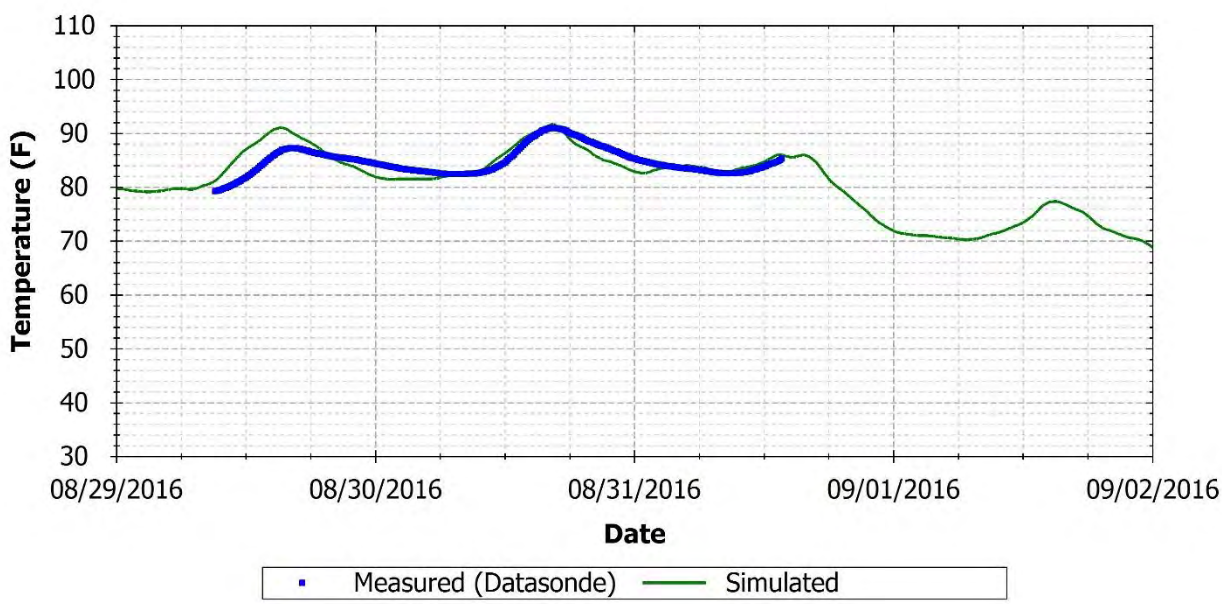

Figure 4-11 Water temperature calibration comparison at station RC07, historical downstream monitoring station, for summer 2016 Datasonde data

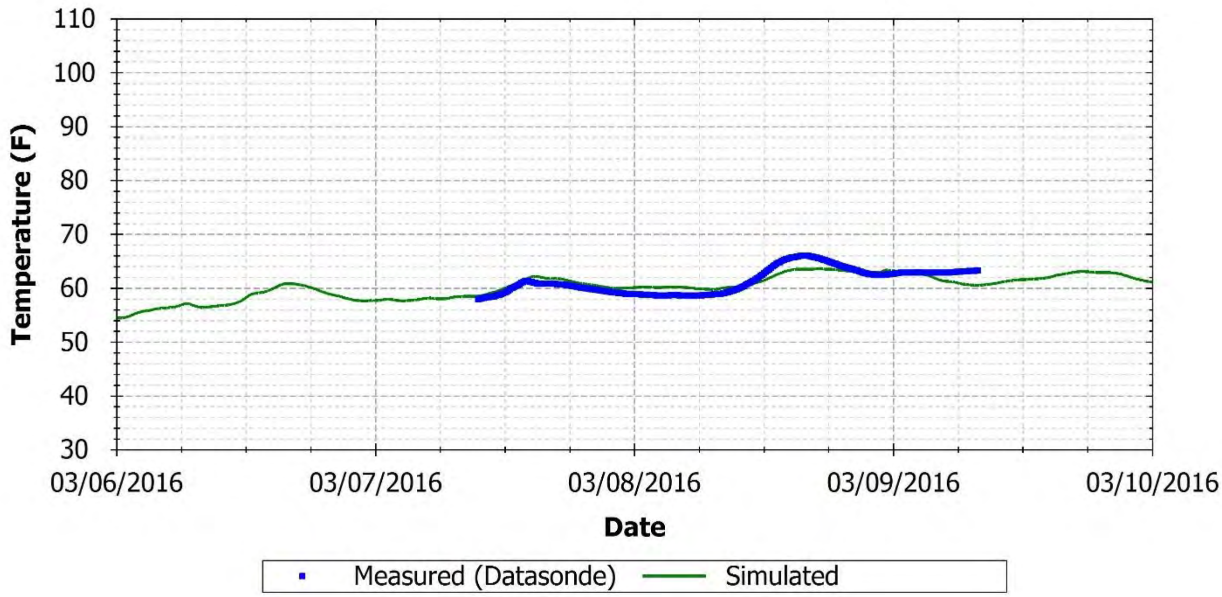

Figure 4-12 Water temperature calibration comparison at station RC07, historical downstream monitoring station, for winter 2016 Datasonde data

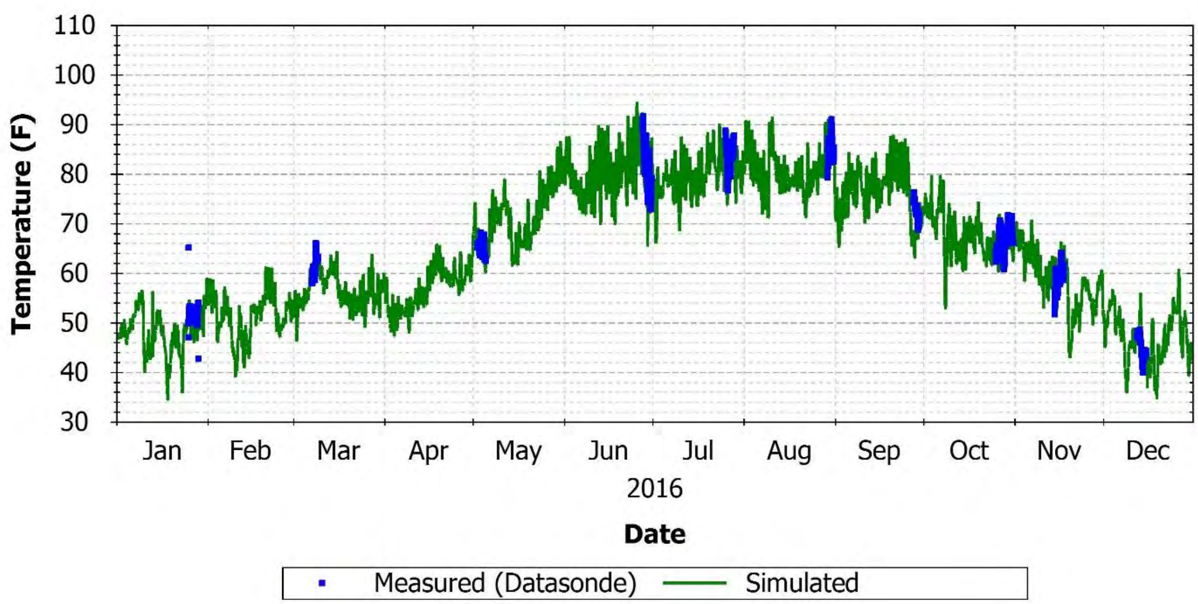

Figure 4-13 Water temperature calibration comparison at station RC07, historical downstream monitoring station, for the year 2016 Datasonde data

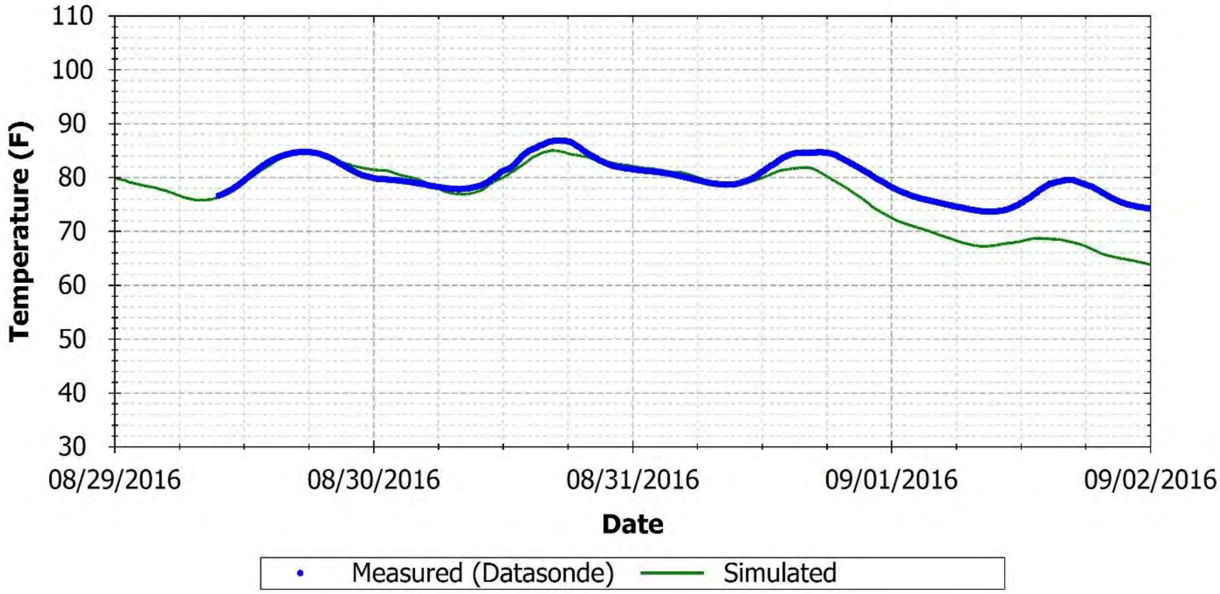

Figure 4-14 Water temperature calibration comparison at station RC09, downstream monitoring station, for summer 2016 Datasonde data

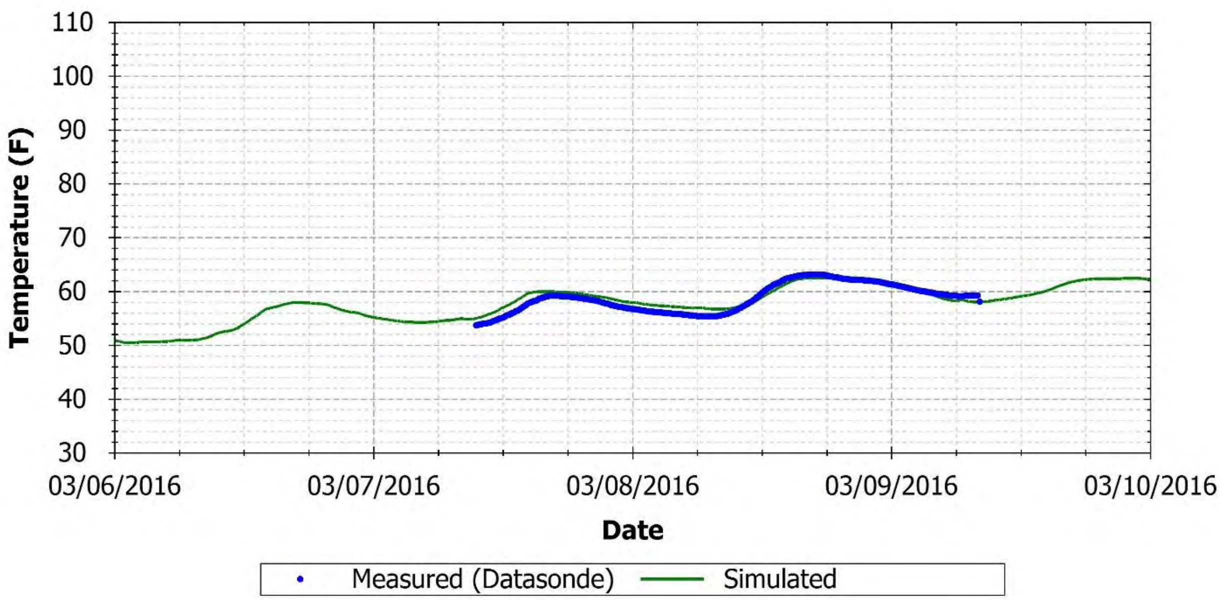

Figure 4-15 Water temperature calibration comparison at station RC09, downstream monitoring station, for winter 2016 Datasonde data

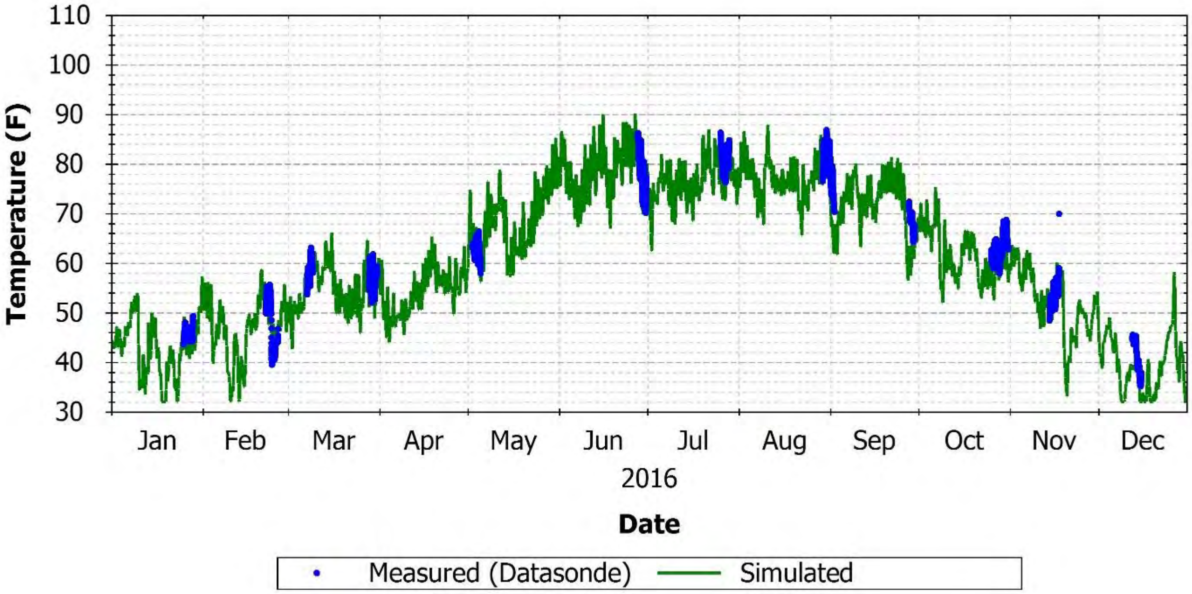

Figure 4-16 Water temperature calibration comparison at station RC09, downstream monitoring station, for the year 2016 Datasonde data

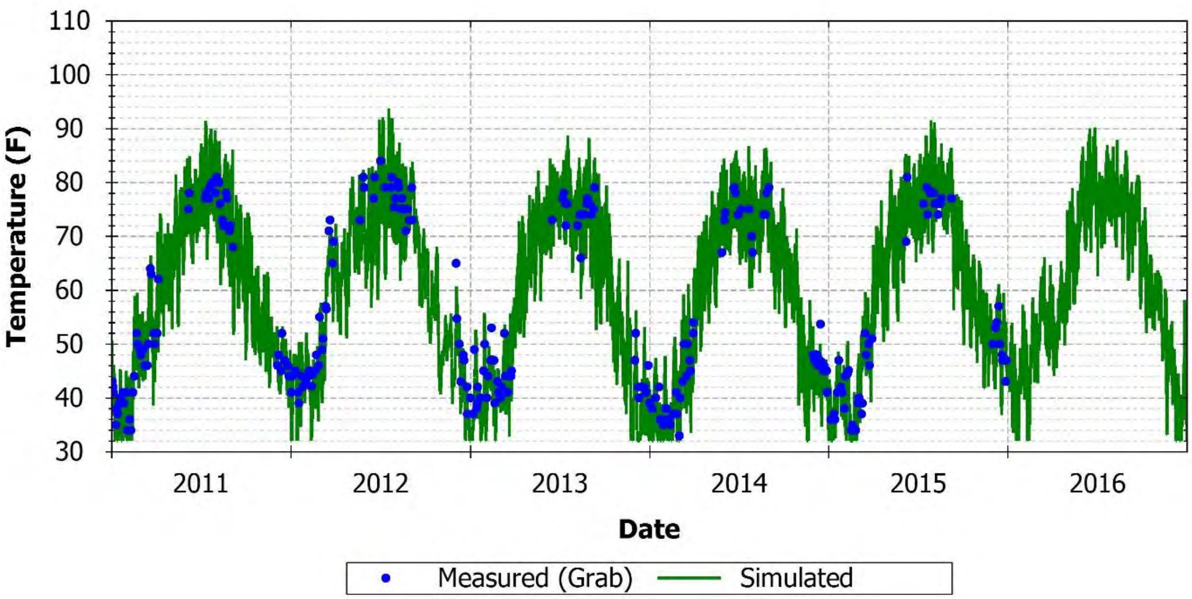

Figure 4-17 Water temperature validation comparison at station RC09, downstream monitoring station, from 2011 – 2015 in-stream grab samples

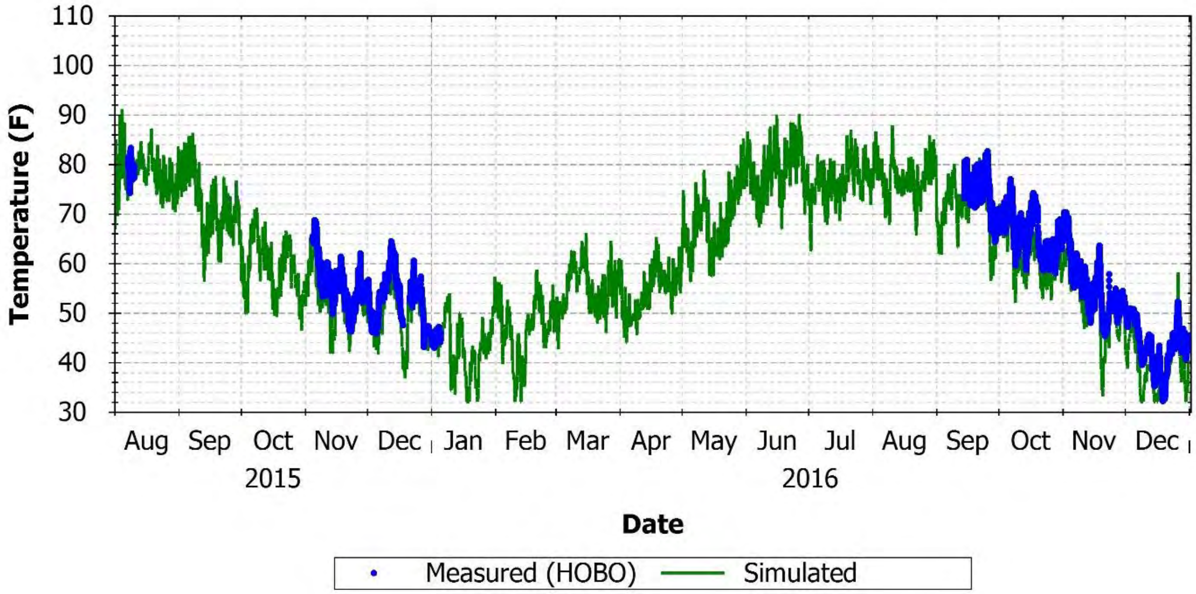

Figure 4-18 Water temperature verification comparison at station RC09, downstream monitoring station, from 2015 – 2016 HOBO data

4.3 Water Temperature Deltas

In the draft permit for NPDES IL0004073, IEPA required that the maximum temperature in Robinson Creek downstream of the Marathon Refinery was not to exceed the upstream in-stream temperature by more than 5°F. In order to evaluate the ability of the model to represent measured temperature deltas at RC04 and RC09, and at RC04 and RC07, the modeled deltas were compared to the measured deltas. As shown in Figure 4-20 and Figure 4-23 the simulated water temperature delta at RC09 and RC07 during the winter period was captured well compared to the measured delta except for few periods. The simulated delta peaks were shifted by several hours compared to the measured deltas, which was likely due to the model simulating in-stream temperature peaks by one to three hours later than measured peaks. This occurrence can be observed during summer periods as well (Figure 4-19 and Figure 4-22). However, the simulated deltas were within range of the measured deltas for the majority of the times.

Figure 4-21 compares the modeled deltas to the measured deltas from in-stream grab samples at RC04 and RC09. The grab samples were collected in the morning, typically between 8:00 am and 9:00 am. In-stream deltas were lower in the morning than the afternoon, as shown in both the modeled data and intensive data sets. Overall, the model matched the trends in the measured deltas throughout the five-year period, but does show deltas greater than 5°F Δ throughout the modeling period during times when grab samples were not collected.

The calibrated modeling results indicated that temperatures in the Robinson Creek may have had deltas greater than 5°F approximately 3.7% of the time from 2011 – 2016 at the current downstream sampling location, RC09 (Figure 4-24), and 15.2% of the time from 2011 – 2016 at the historical downstream sampling location, RC07 (Figure 4-25).

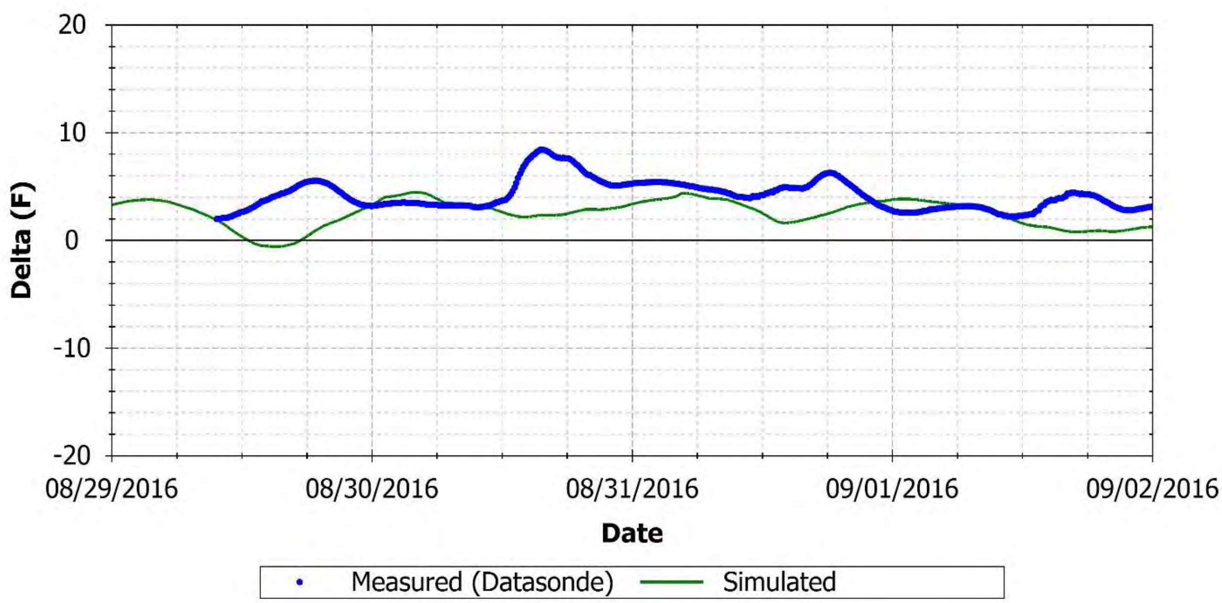

Figure 4-19 Comparison of water temperature delta between RC04 and RC09 for summer 2016 Datasonde data

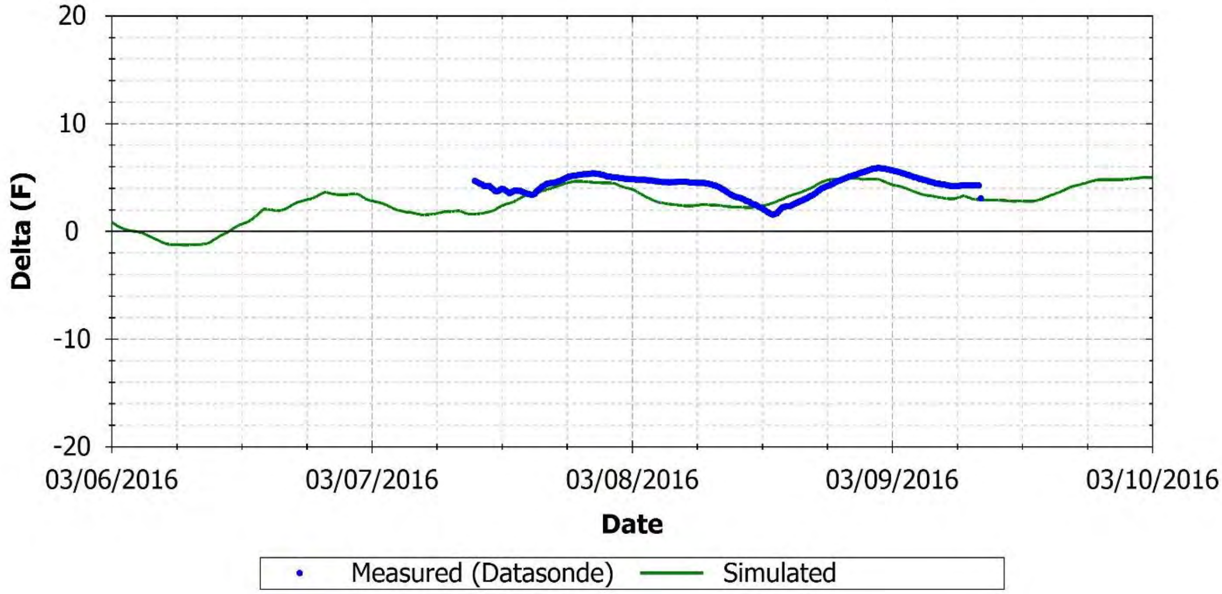

Figure 4-20 Comparison of water temperature delta between RC04 and RC09 for winter 2016 Datasonde data

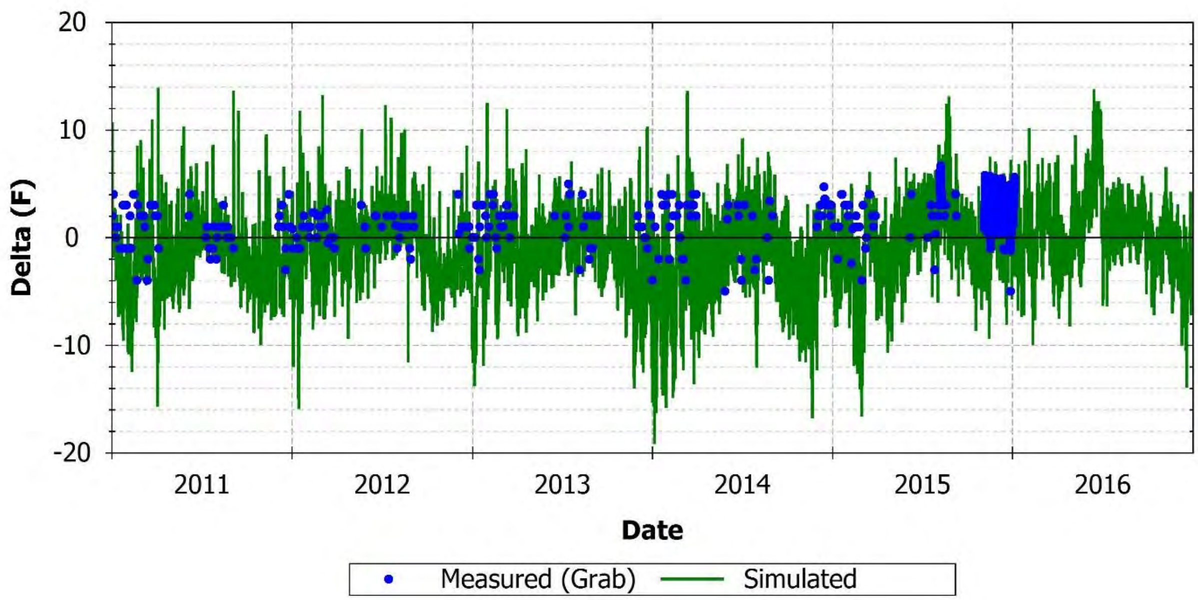

Figure 4-21 Comparison of water temperature delta between RC04 and RC09 from 2011 – 2015 in-stream grab samples

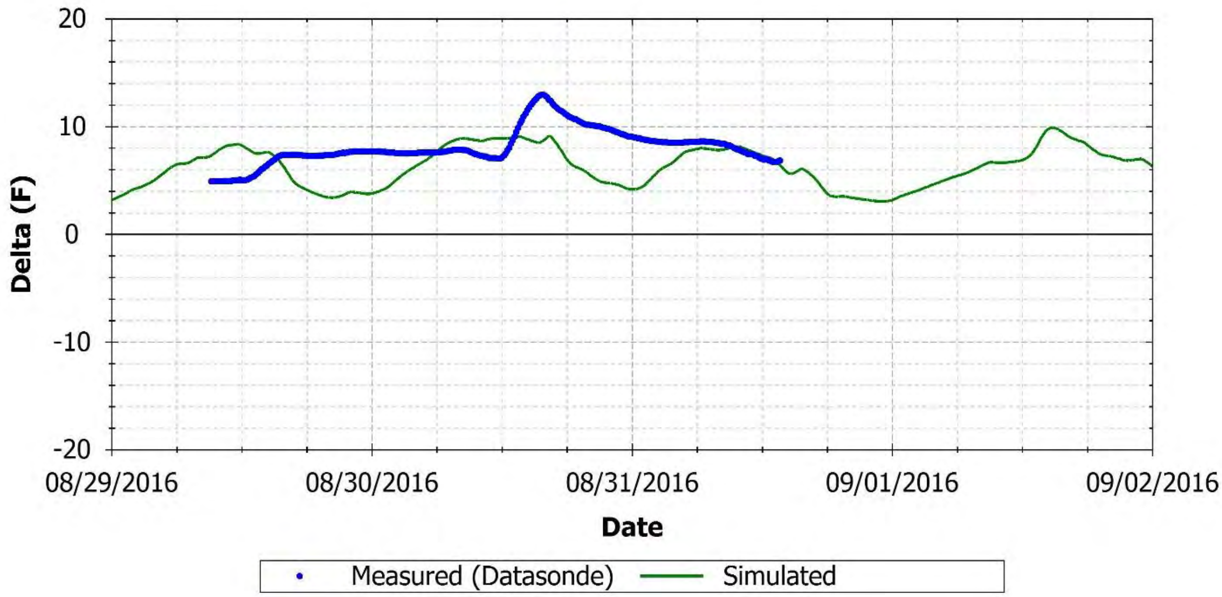

Figure 4-22 Comparison of water temperature delta between RC04 and RC07 for summer 2016 Datasonde data

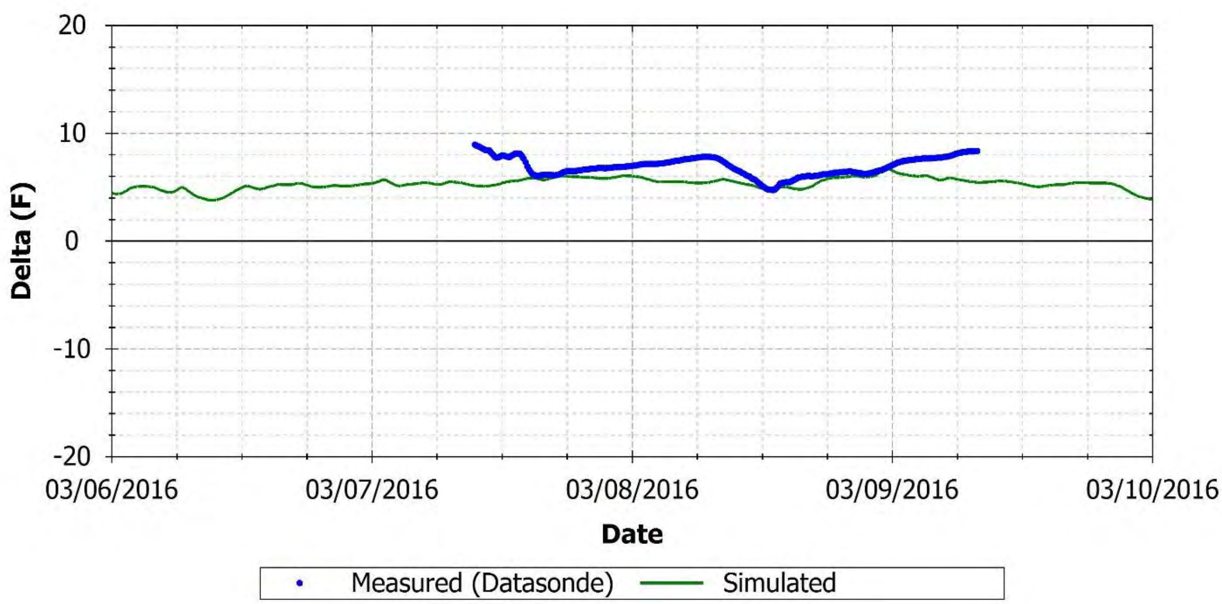

Figure 4-23 Comparison of water temperature delta between RC04 and RC07 for winter 2016 Datasonde data

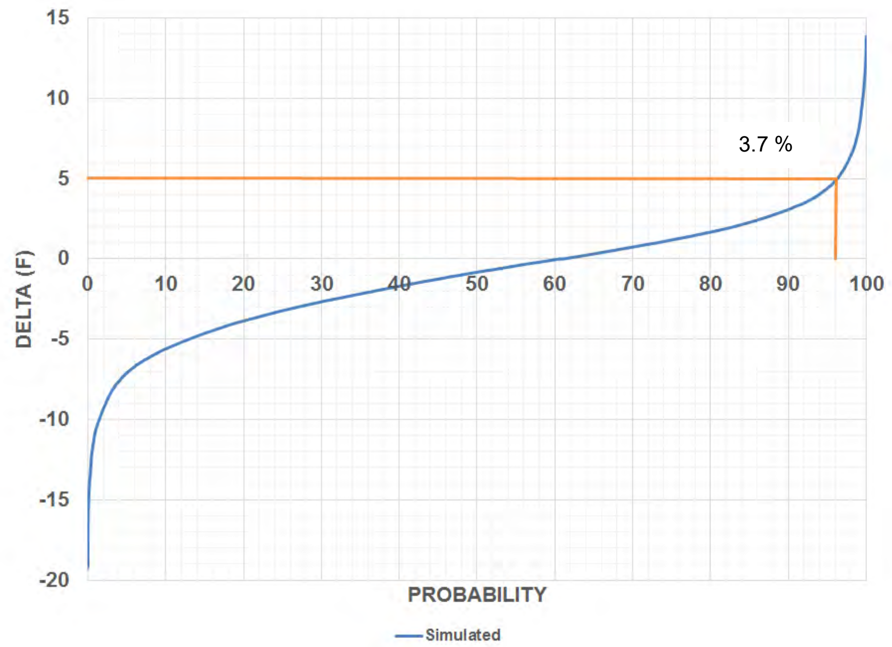

Figure 4-24 Percent exceedance of water temperature delta between RC04 and RC09 from 2011 – 2016

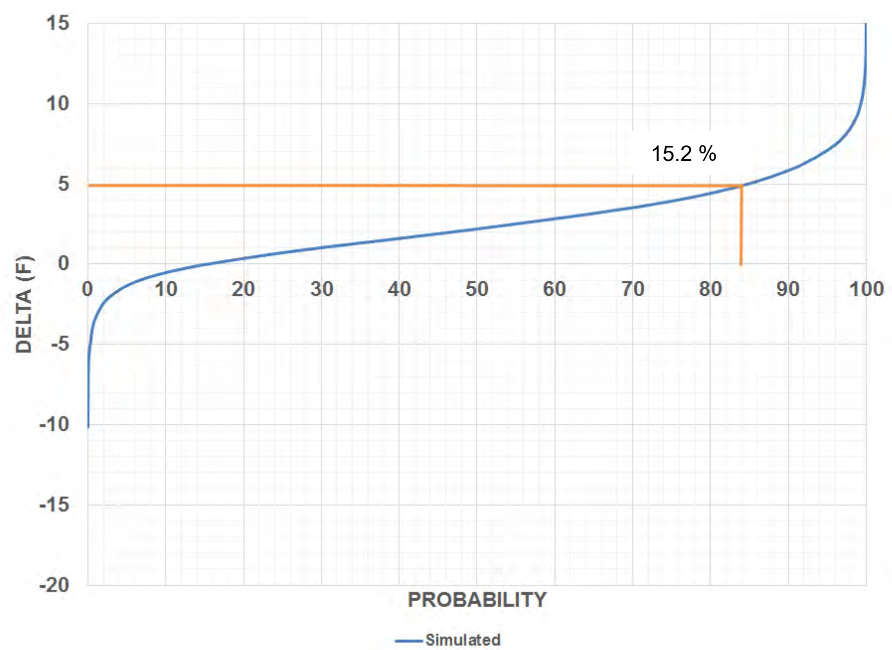

Figure 4-25 Percent exceedance of water temperature delta between RC04 and RC07 from 2011 – 2016

4.3.1 Multivariate Regression Analysis

A multivariate regression analysis was performed to determine the cause(s) of the downstream temperatures at RC07, and RC09, and the associated deltas (Table 4-4). Model input variables analyzed included the Robinson POTW effluent temperatures, Marathon Refinery effluent temperatures, ambient air temperatures, solar radiation, and the percentage of Marathon Refinery effluent flow. All variables had p-values less than 0.05 for both multivariate regression analyses, indicating that all variables were statistically significant in determining the temperatures at RC07 and RC09 and the deltas at these locations (Table 4-5 and Table 4-6).

The strongest predictors of temperature at RC07 were the percentage of Marathon Refinery effluent flow, ambient air temperature, followed by Marathon refinery effluent temperature due to the low p-values (Table 4-5). The temperature deltas were most strongly correlated to the percent Marathon flows and Marathon Refinery temperature. This indicates that while in-stream temperatures at RC07 were influenced by a combination of meteorological conditions along with Marathon inputs, and the in-stream deltas at RC07 were highly influenced by Marathon Refinery.

Based on Table 4-6, the ambient air temperature, followed by the Marathon Refinery temperature, had the lowest p-values and were the strongest predictors of in-stream temperature and in-stream deltas at RC09. The Robinson POTW effluent temperature, ambient solar radiation, and percentage of Marathon flow in Robinson Creek had the highest p-value compared to the other input variables for in-stream deltas at RC09. This indicates that the POTW temperature, solar radiation, and the proportion of flow that Marathon contributes, while important, were not the dominant variables in predicting the associated deltas at RC09.

Table 4-4 Multivariate Regression Statistics for predicting in-stream temperatures and deltas at RC07 and RC09

Regression Variable	Regression Statistics			
	RC07		RC09	
	In-stream Temperature	Delta	In-stream Temperature	Delta
Multiple R	0.97	0.60	0.97	0.55
R Square	0.94	0.36	0.94	0.30
Observations	2192	2192	2192	2192

Table 4-5 Statistical significance of multiple variables to predict in-stream temperature and deltas at RC07

Variables	In-stream Temperature at RC07		In-stream Deltas at RC07	
	Coefficients	P-value	Coefficients	P-value
Intercept	-1.35	1.24E-04	-0.04	8.15E-01
POTW Temp, °C	0.10	1.07E-11	-0.07	4.34E-16
Marathon Refinery Temp, °C	0.32	3.05E-104	0.08	8.98E-27
Ambient Air Temperature, °C	0.45	0.00E+00	0.004	4.37E-06
Ambient Solar Radiation, Watt/m^2	0.01	2.45E-46	-0.002	2.95E-01
Percent Marathon Flows, %	2.78	2.14E-21	3.91	9.35E-123

Table 4-6 Statistical significance of multiple variables to predict in-stream temperature and deltas at RC09

Variables	In-stream Temperature at RC09		In-stream Deltas at RC09	
	Coefficients	P-value	Coefficients	P-value
Intercept	-3.32	1.20E-19	-2.02	2.11E-13
POTW Temp, °C	0.14	2.27E-19	-0.03	2.05E-02
Marathon Refinery Temp, °C	0.29	1.50E-77	0.04	9.14E-05
Ambient Air Temperature, °C	0.52	0.00E+00	0.08	1.59E-46
Ambient Solar Radiation, Watt/m^2	0.01	7.30E-52	0.00	2.16E-01
Percent Marathon Flows, %	-1.02	7.05E-04	0.12	6.07E-01

5.0 TEMPERATURE SCENARIOS

5.1 Robinson Creek EFDC Model Scenarios

In addition to the Calibrated Model, scenarios were setup to further investigate the change in temperature delta between locations downstream of the Marathon Refinery and RC04, located immediately upstream of the Marathon Refinery. The scenarios were developed in order to further explain the causes of changes in temperature in Robinson Creek, specifically under what conditions the temperature delta was greater than 5°F.

The scenario results were used to investigate in-stream temperatures and deltas at three locations downstream of the Marathon Refinery (referred to as downstream locations): (1) RC05, (2) RC07, and (3) RC09 (Figure 5-1).

The following scenarios were run and evaluated:

- ***Calibrated Model:*** The calibrated model included the watershed flows, Robinson POTW, and Marathon Refinery contributions. The setup and development of the model is described in Section 3.0 and 4.0.
- ***7Q10 Model***: The 7Q10 flow (the lowest 7-day average flow that occurs on average once every 10 years) is 0 cfs in Robinson Creek upstream of the Robinson POTW. For the 7Q10 Model, all the tributary flows were removed from the calibrated model. The watershed flow contribution was set to 0 cfs, and the only sources of flow into Robinson Creek were the Robinson POTW and Marathon Refinery.
- ***Without Marathon Model***: The Marathon Refinery flows and temperature loads were removed from the calibrated model. The only source of flow into Robinson Creek was from the watershed flows and the Robinson POTW.
- ***Marathon Winter/Summer Temperature Scenarios (end of pipe temperatures held constant)***: Five scenarios were setup with constant end of pipe effluent temperatures for the Marathon Refinery for winter and summer periods.
  - 60°F/90°F
  - 55°F/85°F
  - 50°F/80°F
  - 45°F/75°F
  - 35°F/60°F

The scenarios were selected to allow for an evaluation of in-stream temperature dynamics across a variety of watershed and Marathon effluent temperature conditions. The results from Without Marathon Model provide information on the impacts of the refinery on in-stream temperature, and the results from the 7Q10 Model provide information on the impact of watershed flows on in-stream temperature. The results from the Marathon Winter/Summer Temperature Scenarios demonstrate what end of pipe temperatures are needed to have a Δ of 5°F or less at each downstream station, and what the associated in-stream temperatures would be at each downstream station.

Key scenario figures are provided in Appendix A. Section A.1 contains the Δ plots and percent exceedance time plots for the Calibrated Model, 7Q10 Model, Without Marathon Model, and Marathon Winter/Summer Temperature Scenarios for the year 2015, and for summer and winter of 2015. Section A.2 contains information on in-stream temperature Δ percent exceedances at RC09, RC07, and RC05 from 2011 through 2016.

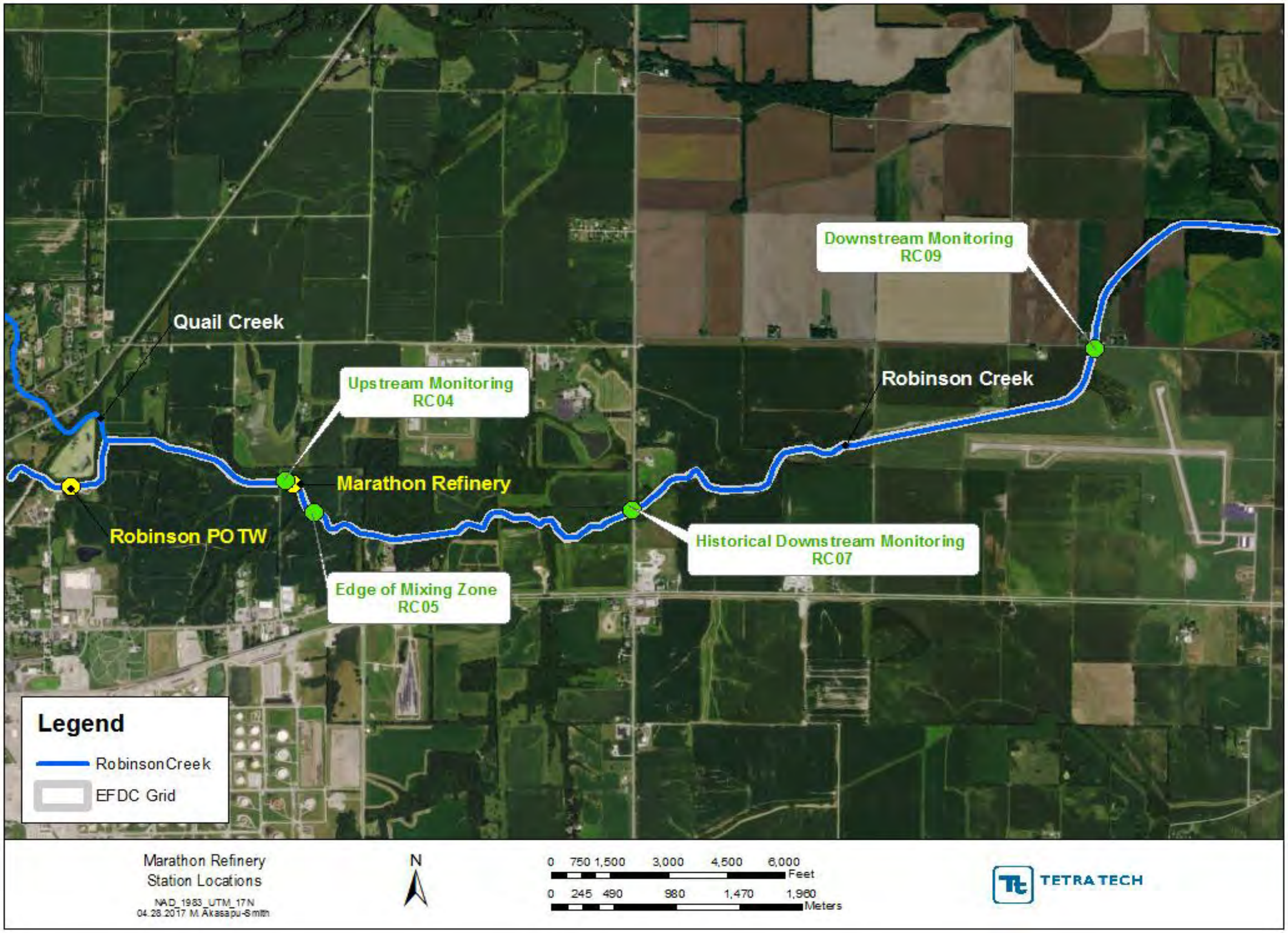

Figure 5-1 Location of monitoring stations in Robinson Creek

5.2 Robinson Creek EFDC Scenarios Summary

Following model setup and development, the calibrated model was further analyzed to determine temperature behavior in Robinson Creek. Figure 5-2 provides the in-stream temperature deltas at the three downstream locations in 2016. In 2016, the deltas were greatest at RC05. During the month of June and fall period in 2016, the deltas at this location were occasionally greater than 20°F. At RC07, the deltas frequently ranged between 3°F and 10°F during the late summer, fall, and winter months. During late spring and early summer the deltas were frequently below 5°F. The deltas were typically lowest at the current downstream monitoring location, RC09. However, at times, such as when the ambient air temperature was similar or greater than the Marathon Refinery temperature and there was a large amount of solar radiation, the deltas were lower at RC07. During these periods, the solar radiation and air temperatures provided additional heat transfer to the stream, causing increased temperatures further downstream at RC09, and as a result, higher deltas.

It was observed that the modeled in-stream temperatures at RC07 were greater than at RC05 at times. All of these periods occurred during the critical summer period and between 12:00pm and 8:00pm. During most of these periods, the ambient air temperatures were approximately 10°F greater than the in-stream temperature at RC05, and the ambient air temperature was the driver of the increase in the in-stream temperature in the model. An EFDC model simulation was run with the MPC001 input removed (background simulation), and the same phenomenon occurred, indicating again that the cause of the in-stream temperature rise was the ambient air temperature and not the MPC001 discharge.

However, this phenomenon of in-stream temperatures at RC07 greater than RC05 was not observed in any the measured datasets, and only on one occasion were measured temperatures at RC07 greater than they were at RC05 in the Datasonde data. This artifact in the model may be due to a variety of factors, including in-stream temperature and discharger assumptions made as part of the model input setup, or an overestimation of solar radiation on hot days.

An analysis of in-stream temperature compared to air temperatures showed that stream temperatures followed similar trends as air temperatures, and that stream temperatures were often similar to air temperatures, especially during spring and summer (Figure 5-3 through Figure 5-4). This corresponds to the multivariate regressions, which indicated that air temperature was the most strongly correlated variable to in-stream temperature at RC09. Patterns in the air temperature appear to impact the amount of heat transfer from the stream to the air and vice versa. For example, relatively cool air temperatures for several days followed by a warm day prevent in-stream temperatures from rising on the warm day, likely due to cooler soil temperatures. In addition, large diurnal fluxes reduce in-stream temperatures at night and can prevent large increases in stream temperatures during the day.

The results from the 7Q10 Model provided an analysis of temperature behavior in Robinson Creek when inflow from the watershed is 0 cfs, and the only source of flow is from the Robinson POTW and Marathon Refinery. Figure 5-6 provides the in-stream temperature deltas at the three downstream locations during 2016 for the 7Q10 Model. The deltas were greater in the 7Q10 Model compared to the Calibrated Model, indicating that the additional flow in the stream provides greater dilution of the Marathon Refinery effluent temperature loads. The largest deltas occurred at the RC05, similar to the calibrated model. Under 7Q10 conditions, the model predicted deltas at RC07 typically range between 5°F and 10°F, and between 2°F and 5°F at RC09.

In-stream temperatures and deltas were lowest in the Without Marathon Model, indicating that Marathon Refinery is a large source of heat in Robinson Creek downstream of its discharge location. At the RC05 and RC07 stations, the model predicted that the delta was less than 5°F at all times except for the months of May and June, the deltas were as high as 10°F at RC07. However, even with the removal of the Marathon Refinery from the model, the delta was greater than 5°F 2.5% of the time at RC09. This is due to heat transfer from the ambient air to the stream and from solar radiation, which naturally warms the stream as it moves from the RC04 sampling point to the RC09 sampling point.

Longitudinal plots of the average in-stream temperature during a summer period (7/15/2016 – 7/31/2016) and a winter period (12/7/2016 – 12/14/2016) in 2016 provide a visual summary of changes in stream temperature from the RC04 sampling point to the RC09 sampling point for the Calibrated Model, 7Q10 Model, and Without Marathon Model (Figure 5-8 and Figure 5-9). These plots averaged the hourly model outputs for both periods. During the summer, the Marathon Refinery discharge increased the stream temperature by approximately 8°F on average. In the 7Q10 Model, temperatures increased 10°F at the Marathon Refinery discharge location. Temperatures in the stream decreased along the reach between RC04 and RC09 as heat transfer occurred from the stream to the air because ambient air temperatures were typically cooler than the stream, specifically at night. The tributary inflow downstream of the Marathon Refinery discharge location provided an additional 1°F of temperature decrease immediately upstream of RC07. At this location, the average increase in stream temperature was approximately 5°F in the summer for the Calibrated Model and 6°F for the 7Q10 Model. During the summer, in-stream temperatures in the Without Marathon Model on average increased 1°F due to heat transfer from the warmer air temperatures and from solar radiation. During the winter, the Marathon Refinery effluent increased temperatures in the stream by 10°F under normal flow conditions, and by 11 °F under 7Q10 conditions. Temperatures in the stream also decreased along the reach between RC04 and RC09 due to low air temperatures.

Temperatures in the stream, as well as deltas, were evaluated for the Marathon Winter/Summer Temperature Scenarios, where the end of pipe temperatures were held constant. When the end of pipe temperatures were held to a constant 90°F during summer, the delta at RC07 was expected to be greater than 5°F 19.5% of the time and at RC09 was expected to be greater than 5°F 4.1% of the time. The summer end of pipe temperature is significantly greater than the in-stream temperatures in the fall and spring, causing larger deltas during these periods. When the Marathon Refinery temperatures were held to a constant of 60°F during summer period and a constant 35°F during winter, the in-stream delta was less than 5°F 0.6% of the times at RC07 and 1.4% at RC09.

In the Calibrated Model and all other scenario models, in-stream temperatures were always less than 90°F at RC04 but the percent of hours where the in-stream temperatures were greater than 90°F was always less than 1%. However, for all scenarios, including when the Marathon end of pipe temperature was held at 35°F, in-stream temperatures were greater than 60°F at all sampling stations during portion of the 2012 winter period.

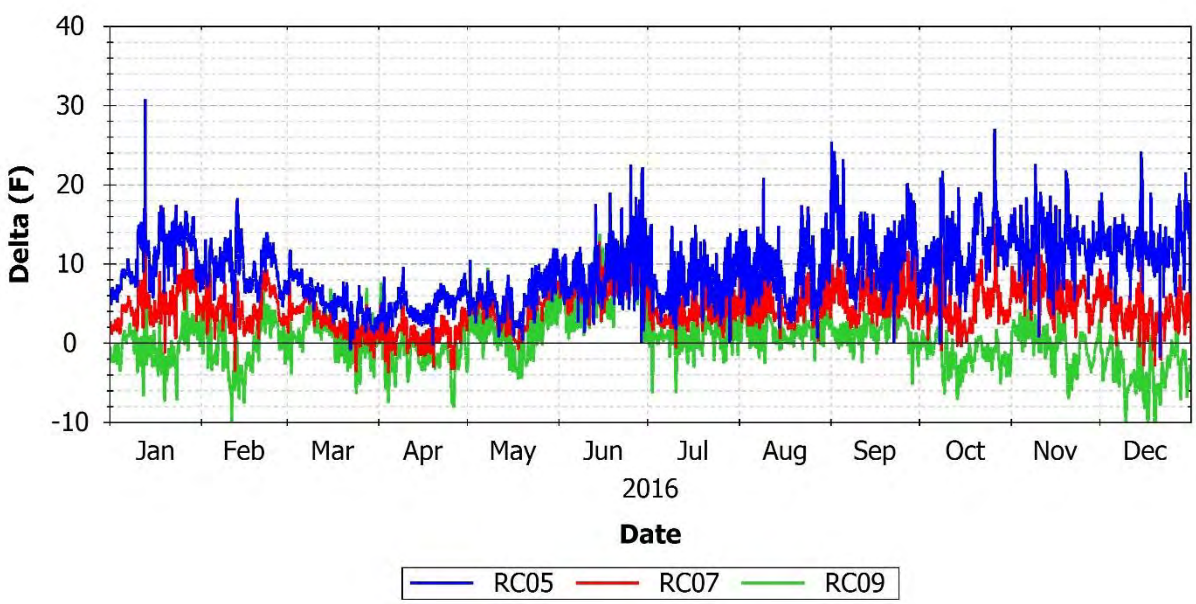

Figure 5-2 Deltas for Calibrated Model using RC04 as the upstream monitoring station during 2015

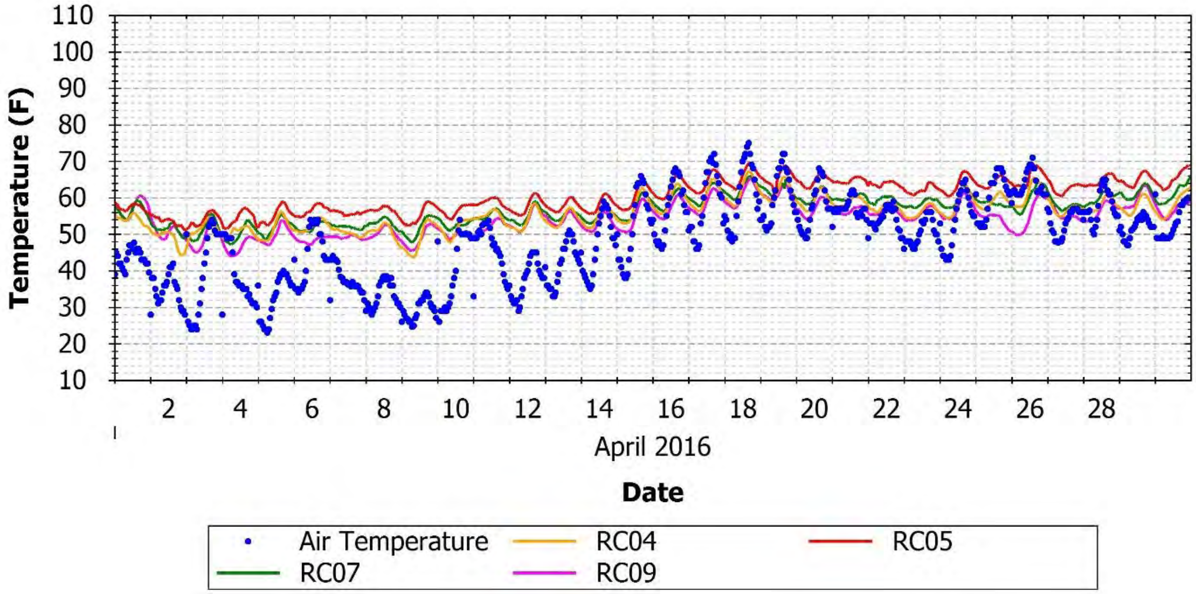

Figure 5-3 Stream temperatures at the monitoring stations for the Calibrated Model and air temperatures during April 2016

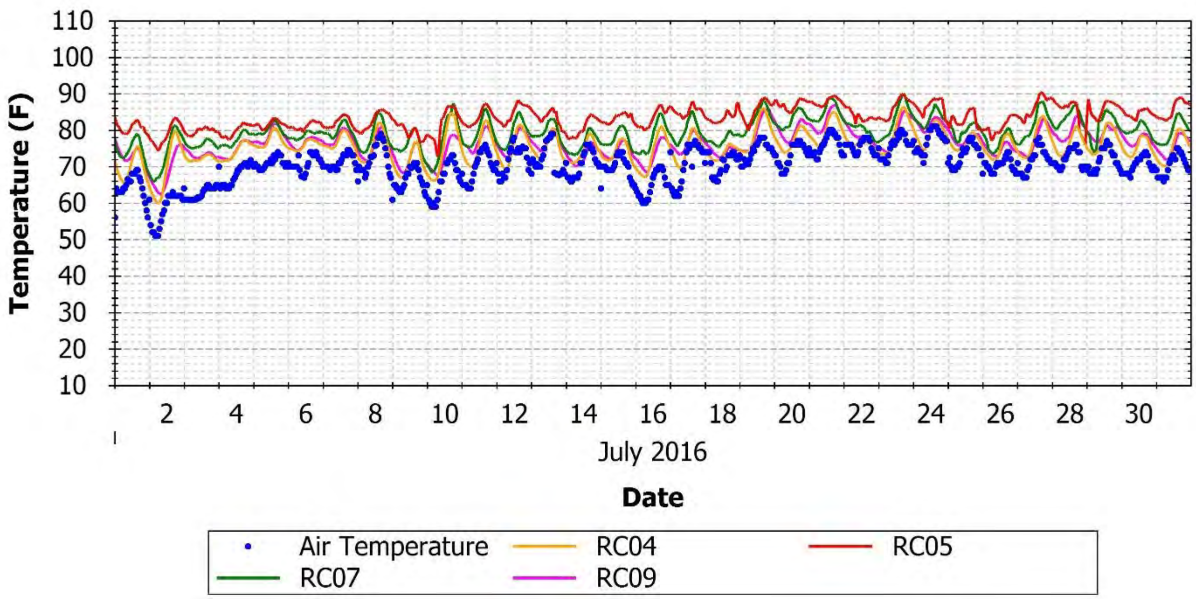

Figure 5-4 Stream temperatures at the monitoring stations for the Calibrated Model and air temperatures during July 2016

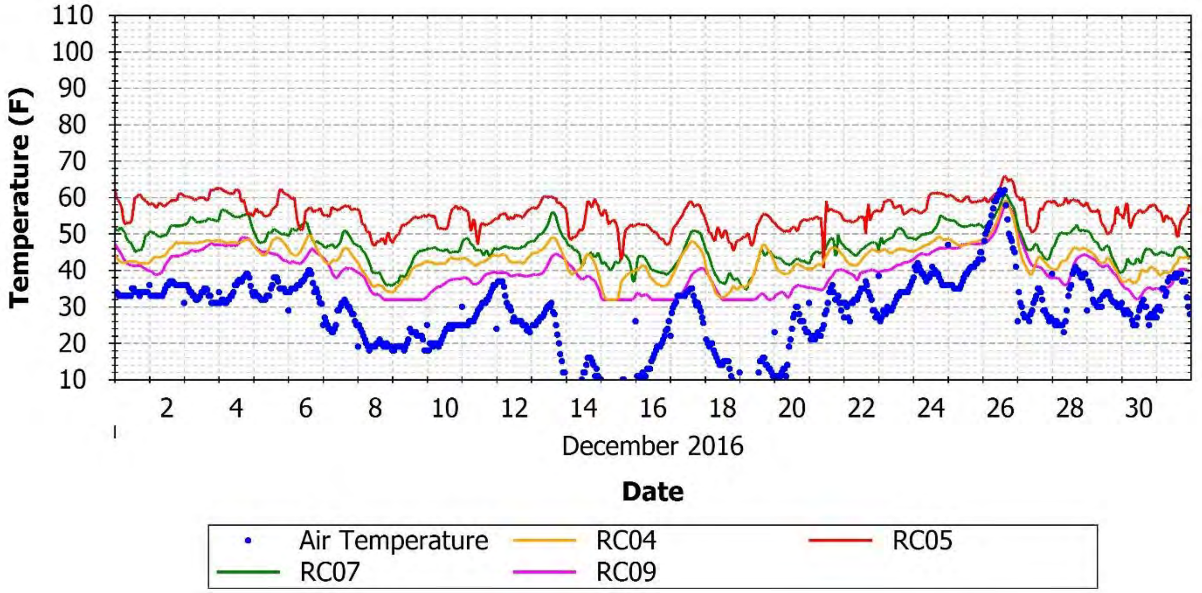

Figure 5-5 Stream temperatures at the monitoring stations for the Calibrated Model and air temperatures during December 2016

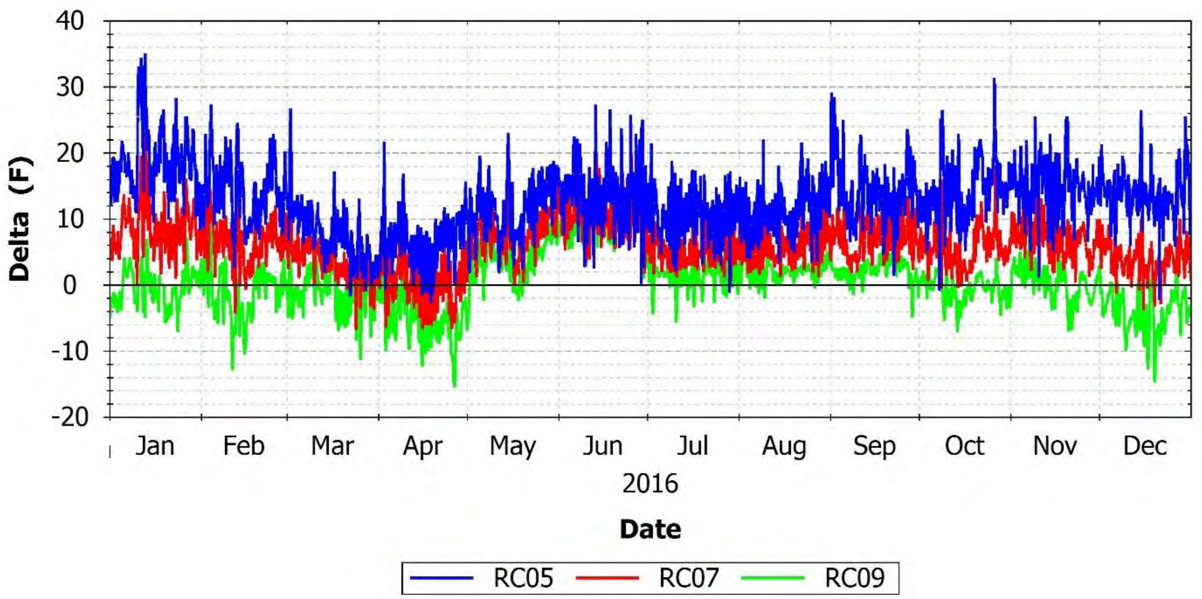

Figure 5-6 Deltas for the 7Q10 Model using RC04 as the upstream monitoring station during 2016

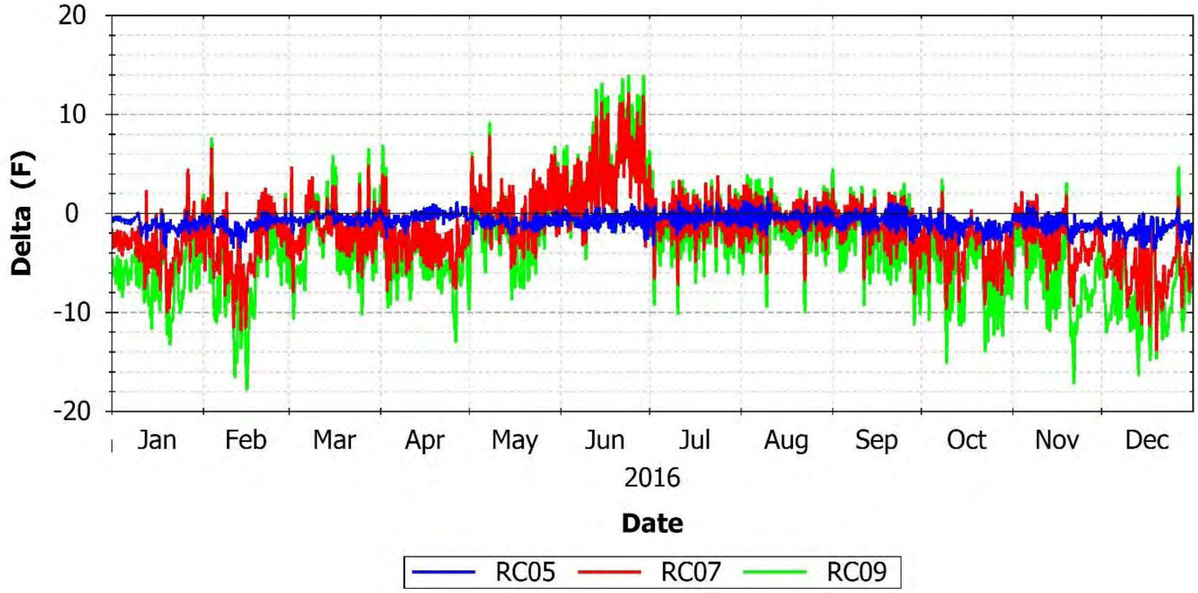

Figure 5-7 Deltas for the Without Marathon Model using RC04 as the upstream monitoring station during 2016

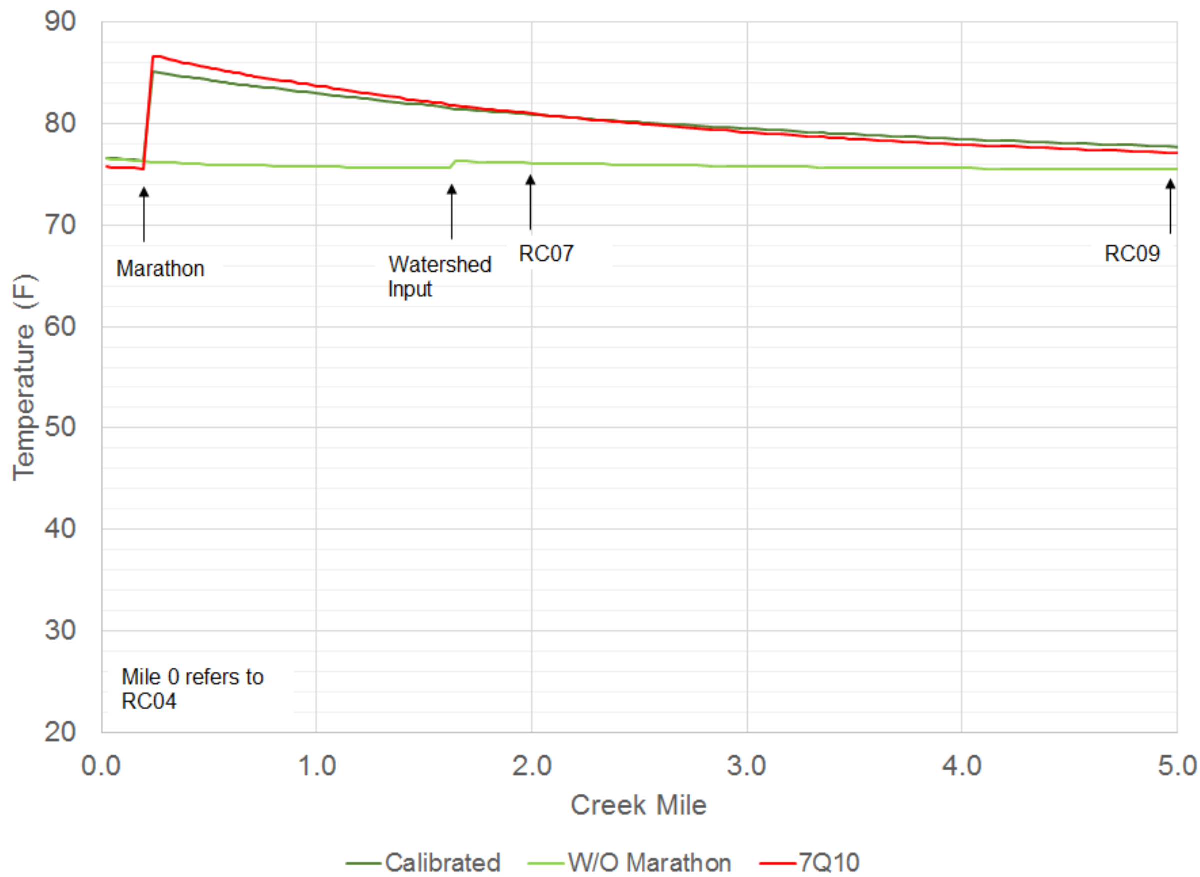

Figure 5-8 Mean longitudinal profile for the period 7/15/2016 – 7/31/2016 for three scenarios

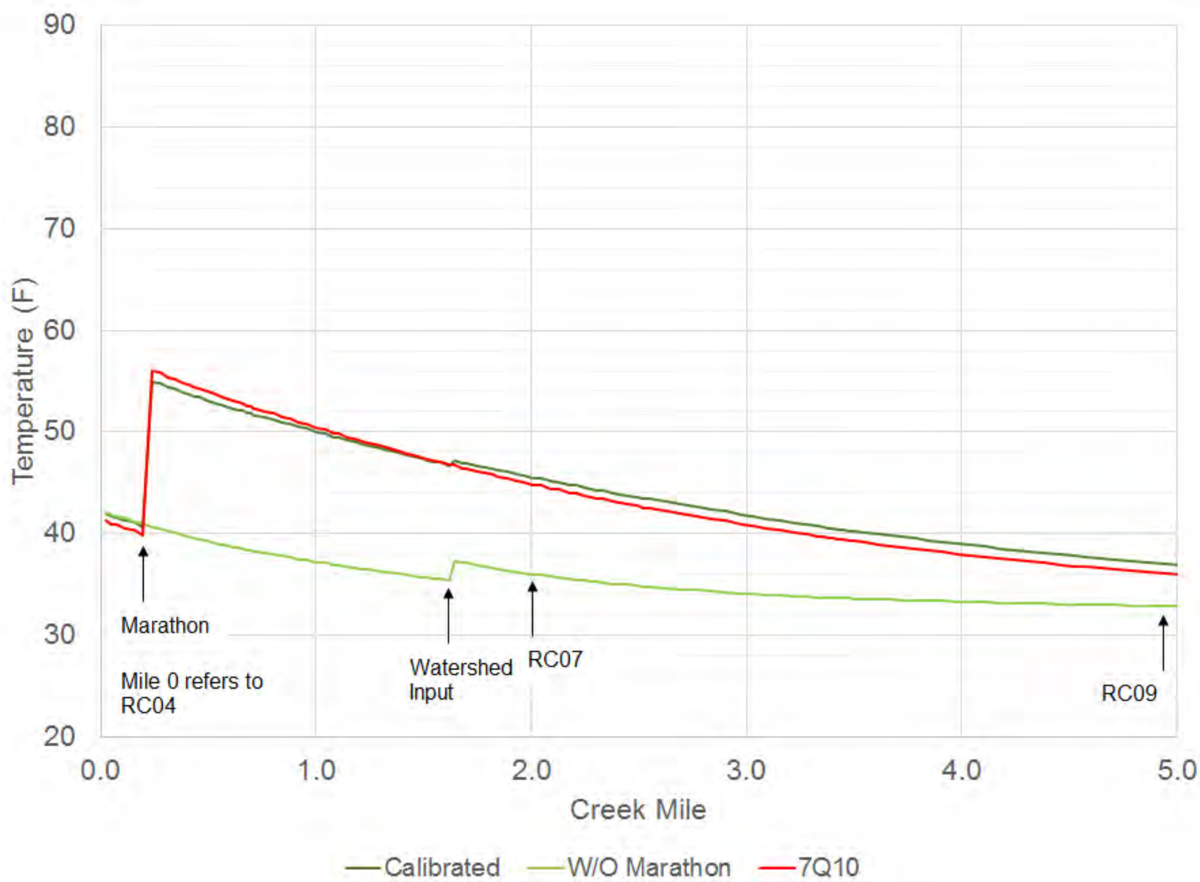

Figure 5-9 Mean longitudinal profile for the period 12/7/2016 – 12/14/2016 for three scenarios

Table 5-1 In-stream temperature delta percentage exceedances at RC09, RC07, and at RC05 using RC04 as the upstream monitoring station from 2011 – 2016

Scenario	% time Δ greater than 5°F at RC09			% time Δ greater than 5°F at RC07			% time Δ greater than 5°F At RC05		
	Winter	Summer	Total	Winter	Summer	Total	Winter	Summer	Total
Calibrated	2.4%	4.4%	3.7%	10.4%	17.7%	15.2%	77.8%	60.2%	66.1%
7Q10	1.8%	6.5%	4.9%	19.4%	31.9%	27.7%	90.2%	87.1%	88.1%
60°F/90°F	1.6%	5.4%	4.1%	2.2%	28.0%	19.5%	34.4%	76.0%	62.2%
55°F/85°F	1.2%	4.0%	3.1%	1.2%	18.9%	13.0%	14.7%	55.4%	41.9%
50°F/80°F	1.0%	3.3%	2.5%	0.7%	11.6%	8.0%	4.1%	37.0%	26.0%
45°F/75°F	0.9%	2.7%	2.1%	0.4%	6.5%	4.4%	0.8%	23.6%	16.0%
35°F/60°F	0.7%	1.7%	1.4%	0.2%	0.8%	0.6%	0.0%	3.4%	2.3%
W/O Marathon	1.1%	3.2%	2.5%	0.6%	2.3%	1.7%	0.0%	0.0%	0.0%

Table 5-2 Percentage of hours between 2011 and 2016 in-stream temperatures are greater than 90F in the summer, and 60F and 63F in the winter for the Calibrated Model

Location	Calibrated	60°F/90°F	35°F/60°F
% of Hours In-stream Temperature >90°F			
RC04	0.0%	0.0%	0.0%
RC05	0.3%	0.0%	0.0%
RC07	0.5%	0.3%	0.0%
RC09	0.1%	0.1%	0.1%
% of Hours In-stream Temperature >60°F			
RC04	3.2%	3.2%	3.2%
RC05	11.8%	3.4%	0.7%
RC07	4.9%	2.9%	1.4%
RC09	3.5%	2.7%	1.9%
% of Hours In-stream Temperature >63°F			
RC04	1.9%	1.9%	1.9%
RC05	5.8%	1.8%	0.1%
RC07	2.7%	1.7%	0.7%
RC09	2.1%	1.5%	0.9%

6.0 SUMMARY AND CONCLUSIONS

Based on the results from the calibrated model and the scenario runs, the following conclusions can be made:

- Under current operating conditions, from 2011 through 2016, deltas greater than 5°F likely occurred more than 15.2% of the time in Robinson Creek at the historic monitoring location, RC07. Under current operating conditions, from 2011 through 2016, deltas greater than 5°F likely occurred more than 3.7% of the time in Robinson Creek at the current monitoring location, RC09.
- RC09 had the lowest occurrence of deltas greater than 5°F compared to the two other downstream monitoring locations, RC07 and the RC05, because the in-stream temperatures typically decrease as you move further away from the Marathon Refinery discharge location.
- A combination of factors contribute to the in-stream deltas at RC07 and RC09:
    - Robinson POTW effluent temperatures relative to Marathon Refinery effluent temperatures. For example, higher Robinson POTW effluent temperatures increase the in-stream temperatures at RC04 and cause lower deltas at RC07 and RC09.
    - Marathon Refinery effluent temperature relative to in-stream temperature. For example, Marathon Refinery effluent temperatures close to in-stream temperatures at RC04 cause lower deltas at RC07 and RC09.
    - Ambient air temperature relative to Marathon Refinery effluent temperatures. For example, low ambient air temperature relative to Marathon Refinery effluent temperatures reduce in-stream temperature due to heat loss from the stream to the air and cause lower deltas at RC07 and RC09.
    - Solar radiation. For example, less heating of Robinson Creek occurs on days with cloud cover and lower solar radiation, causing lower deltas at RC07 and RC09.
    - In-stream flow distribution between Marathon Refinery, Robinson POTW, and tributary flows. For example, when the Robinson POTW and tributary flows make up a greater proportion of flow in Robinson Creek, more water is available to cool the effluent from Marathon Refinery, causing lower deltas at RC07 and RC09.
- The Marathon Refinery effluent would need to be cooled to less than 35°F in the winter for deltas to be less than 5°F at all downstream monitoring stations at all times.
- The Marathon Refinery effluent would need to be cooled to 60°F in the summer for deltas to be less than 5°F more than 99% of the time at monitoring stations RC07 and RC09.
- Under current operating conditions, in-stream temperatures of 90°F or greater occurred 0.5% at RC07 and 0.1% at RC09 during the summer.
- Under current operating conditions, in-stream temperatures were at times greater than 60°F at RC04 and all downstream monitoring stations during the winter.
- Due to in-stream temperatures greater than 60°F at RC04 and high ambient air temperatures, if the Marathon Refinery effluent was cooled to 35°F the in-stream temperatures would still be greater than 60°F more than 1% of the time at RC07 and RC09.

In addition, as discussed in the previous sections, data were limited for many of the sources required to develop the EFDC model, therefore several assumptions had to be made during the modeling process regarding flows and temperatures. Despite the data assumptions, the model performed very well statistically and visually compared to the measured data. This indicates that the model is a useful tool for predicting in-stream temperatures when measured data are not available. In addition, the model can be used to evaluate changes in in-stream temperatures as a result of changes in Marathon operating procedures and MPC001 discharges. However, the data assumptions may limit the model's ability to always accurately represent conditions at the monitoring stations on an hourly basis because many of the inputs represent weekly or monthly averages. When tributary and point source measured data were available, there was a large amount of variability in flows and temperatures in a single day. For example, MPC 001 effluent discharge flows varied by as much as 1.5 MGD daily and temperatures varied by as much as 1.5° F daily.

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Appendix A: Temperature Scenario Results

A.1 Scenario Results to Evaluate Δ5°F Exceedances

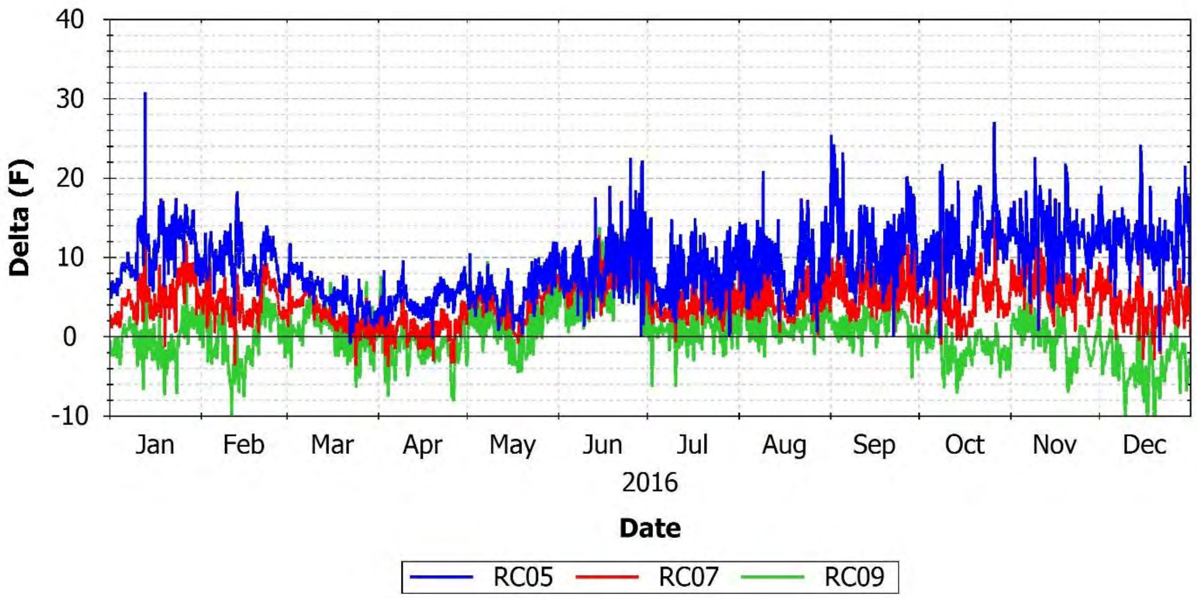

Figure A-1: Deltas for Calibrated Model using RC04 as the upstream monitoring station during 2016

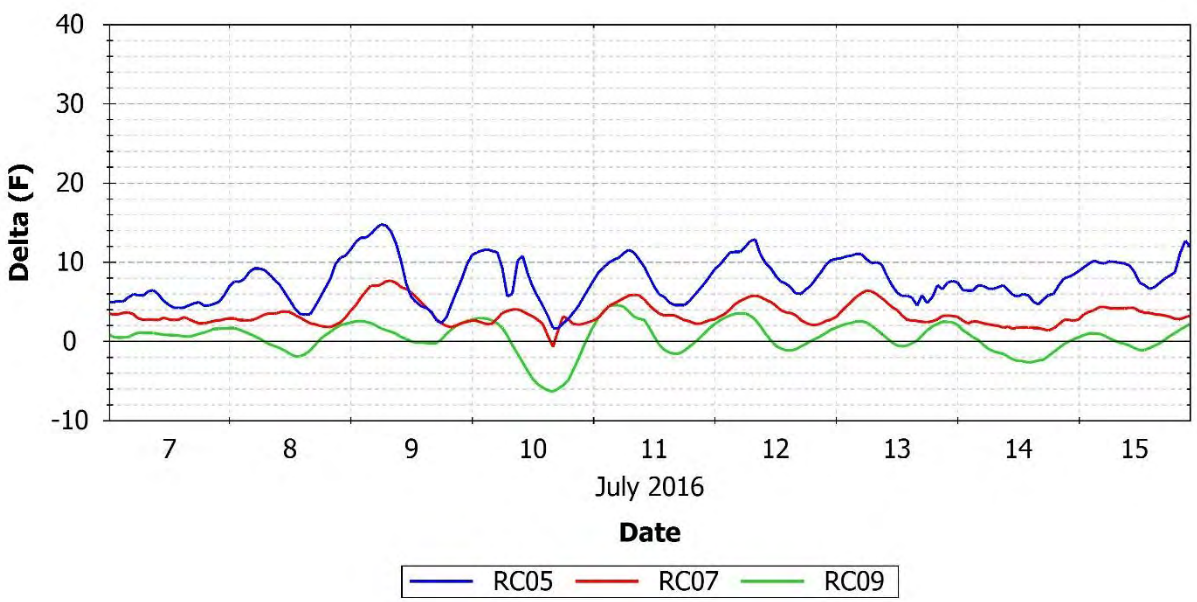

Figure A-2: Deltas for Calibrated Model using RC04 as the upstream monitoring station during July 2016

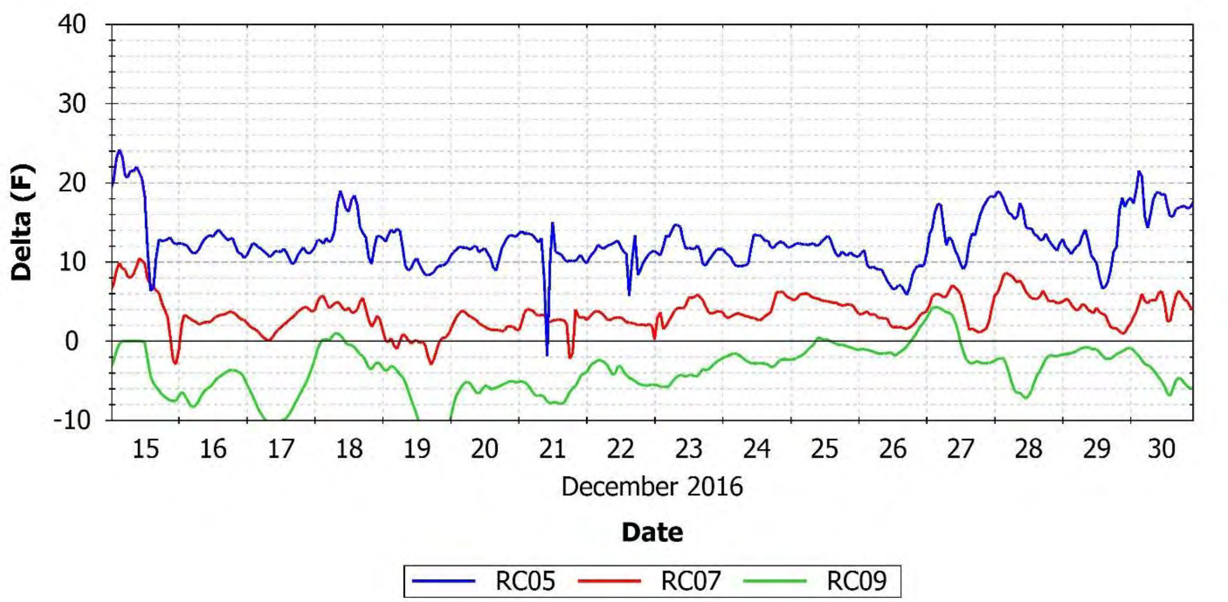

Figure A-3: Deltas for Calibrated Model using RC04 as the upstream monitoring station during December 2016

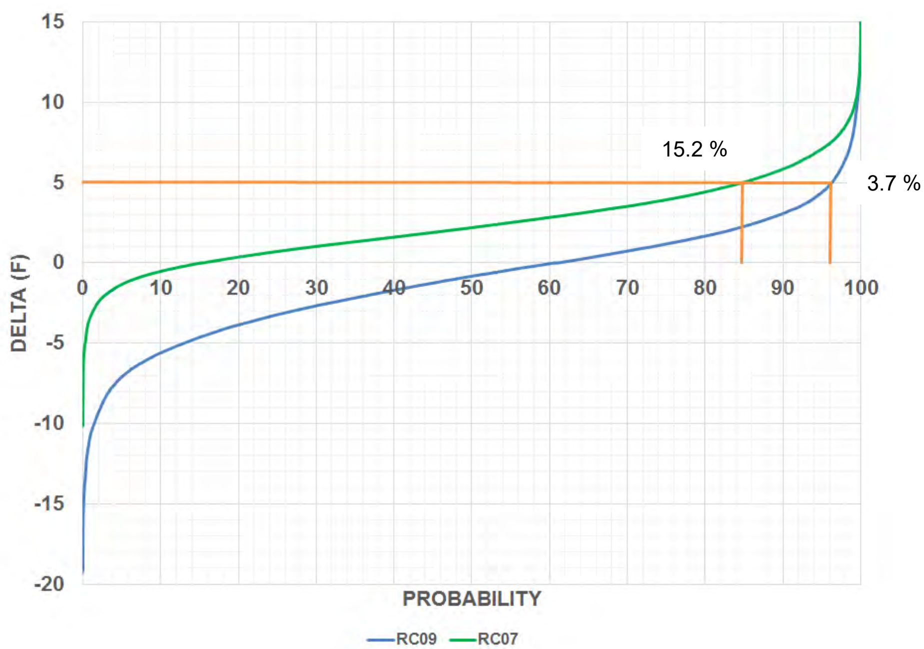

Figure A-4: Percent exceedance of water temperature delta between RC04 and RC07 and between RC04 and RC09 from 2011 – 2016 for Calibrated Model

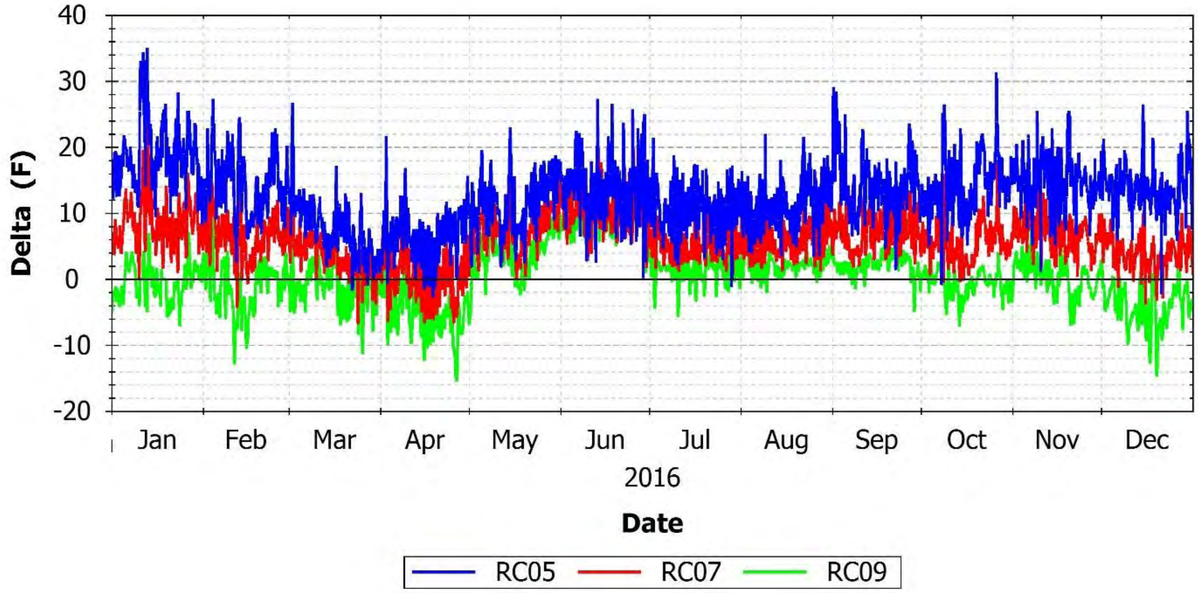

Figure A-1: Deltas for 7Q10 Model using RC04 as the upstream monitoring station during 2016

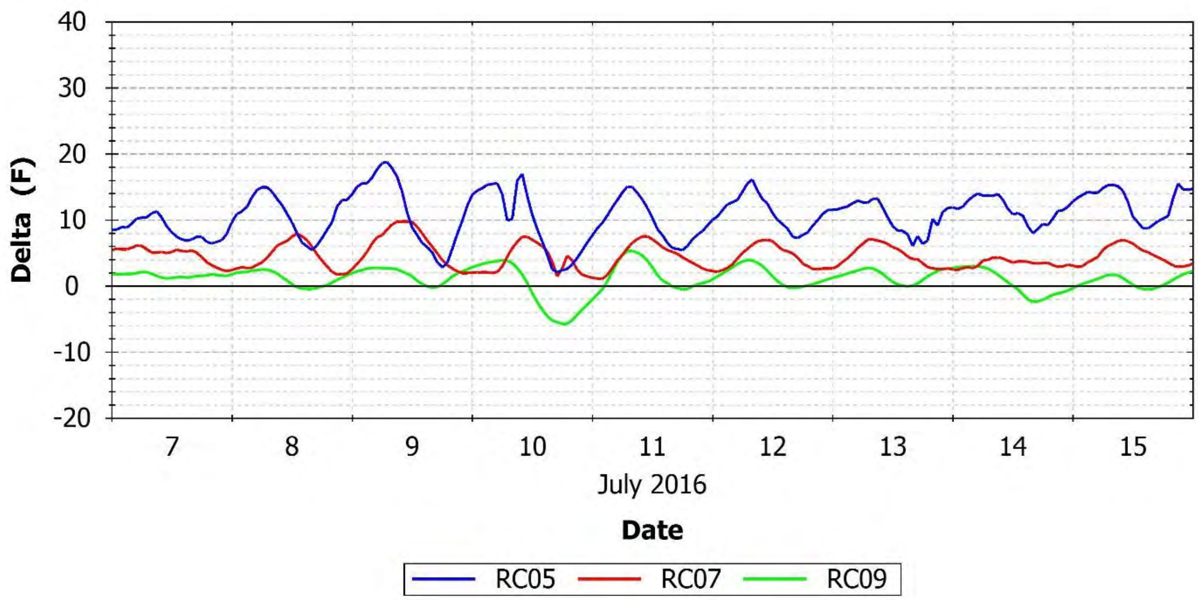

Figure A-2: Deltas for 7Q10 Model using RC04 as the upstream monitoring station during July 2016

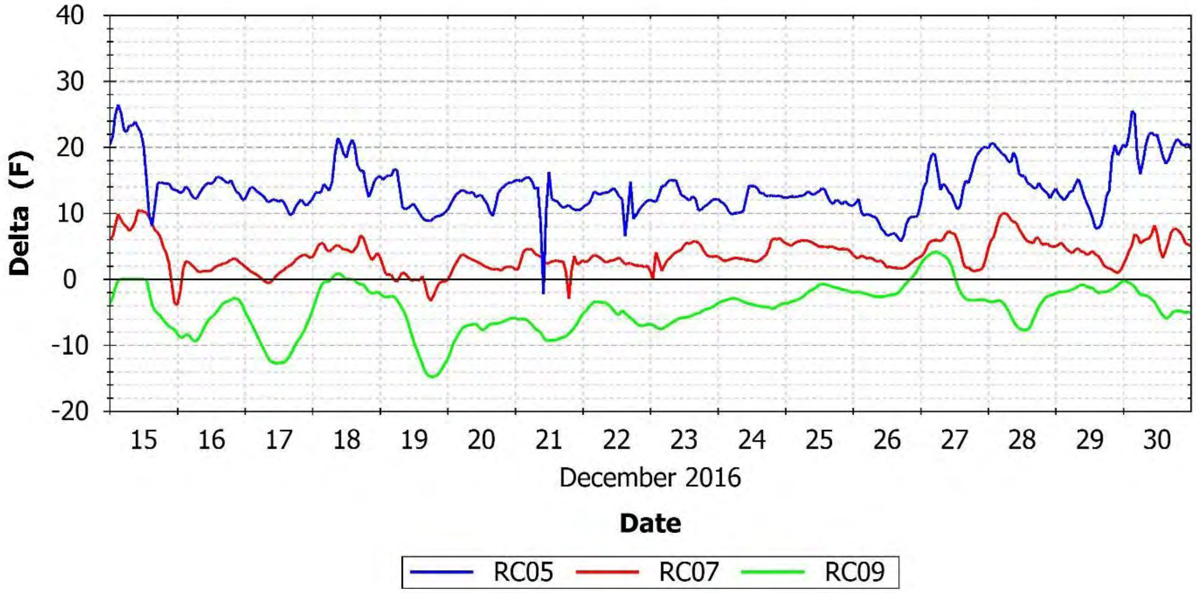

Figure A-3: Deltas for 7Q10 Model using RC04 as the upstream monitoring station during December 2016

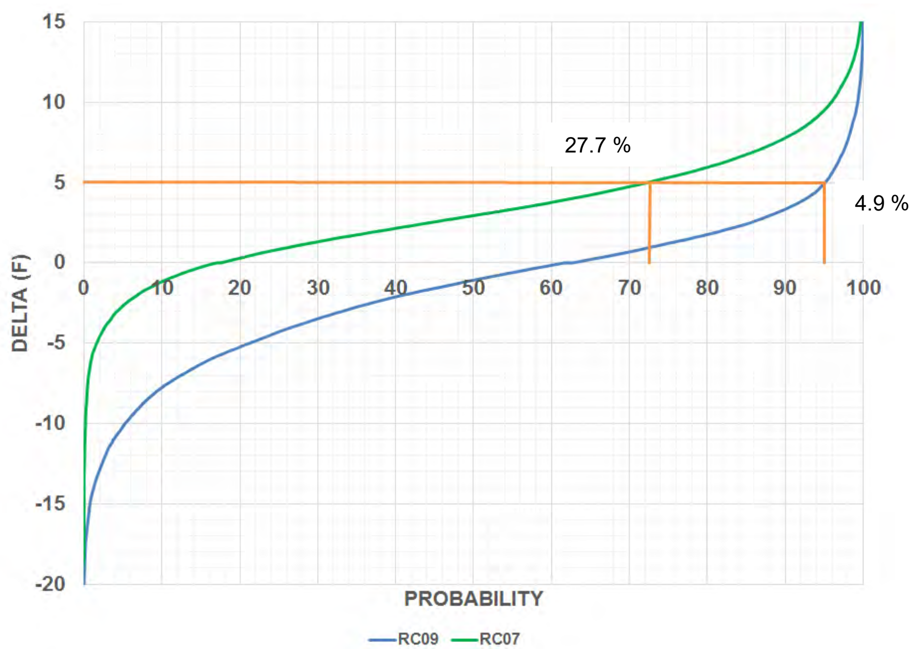

Figure A-4: Percent exceedance of water temperature delta between RC04 and RC07 and between RC04 and RC09 from 2011 – 2016 for 7Q10 Model

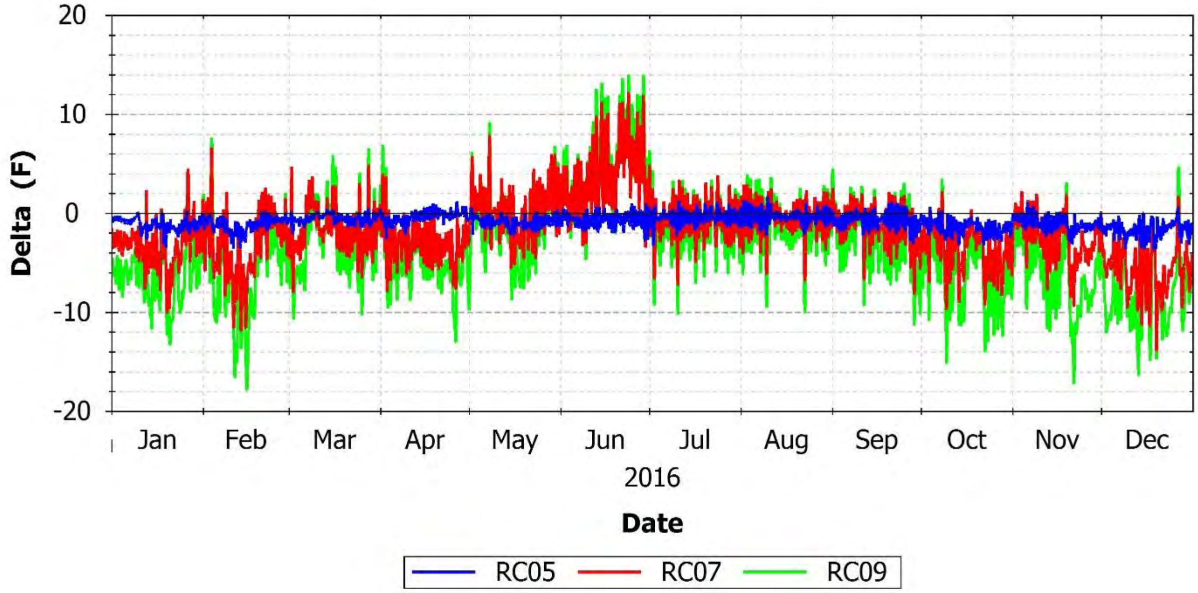

Figure A-5: Deltas for Without Marathon Model using RC04 as the upstream monitoring station during 2016

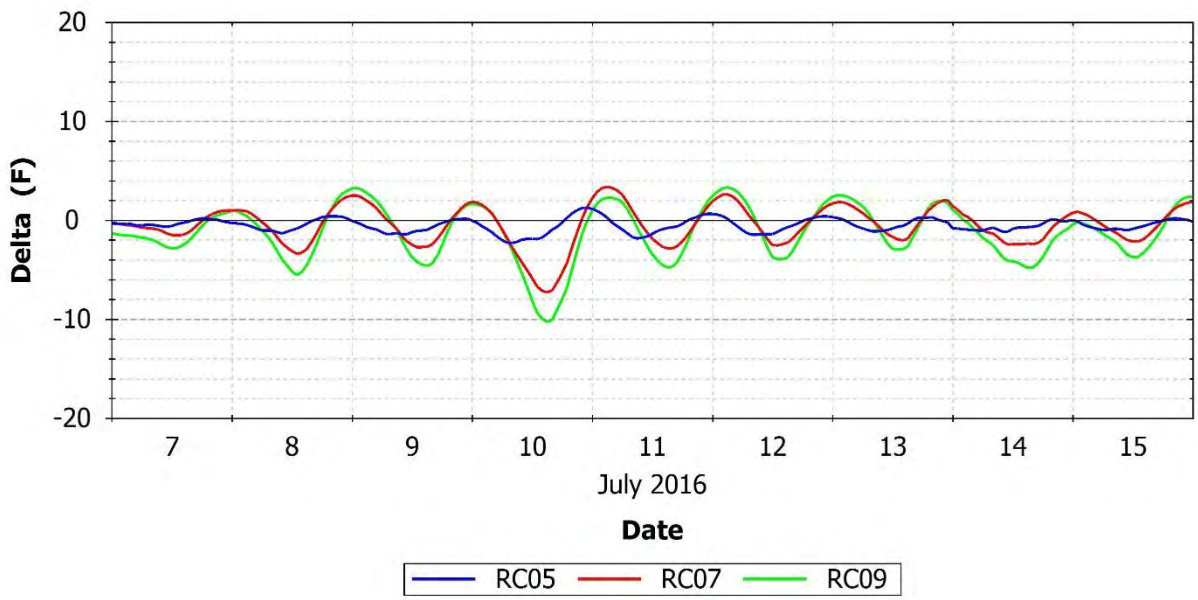

Figure A-6: Deltas for Without Marathon Model using RC04 as the upstream monitoring station during July 2016

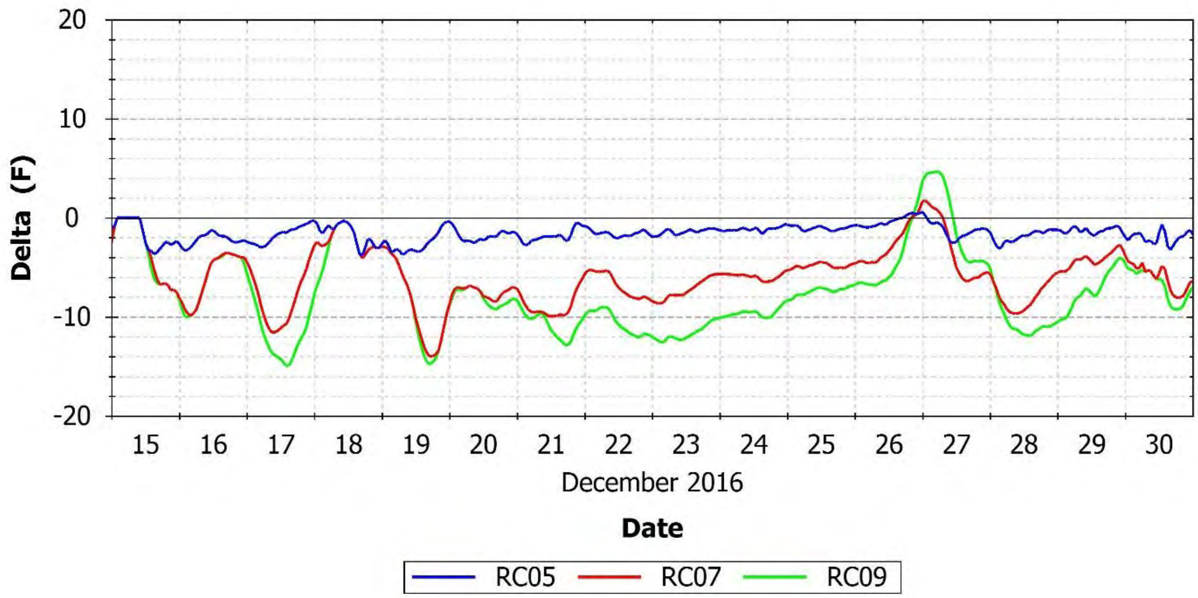

Figure A-7: Deltas for Without Marathon Model using RC04 as the upstream monitoring station during December 2016

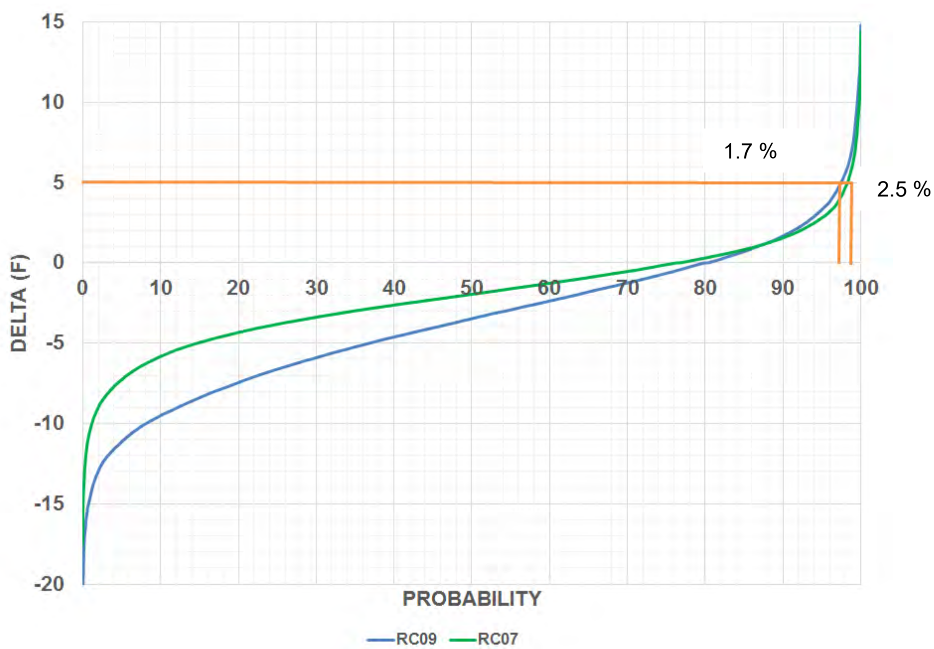

Figure A-8: Percent exceedance of water temperature delta between RC04 and RC07 and between RC04 and RC09 from 2011 – 2016 for Without Marathon Model

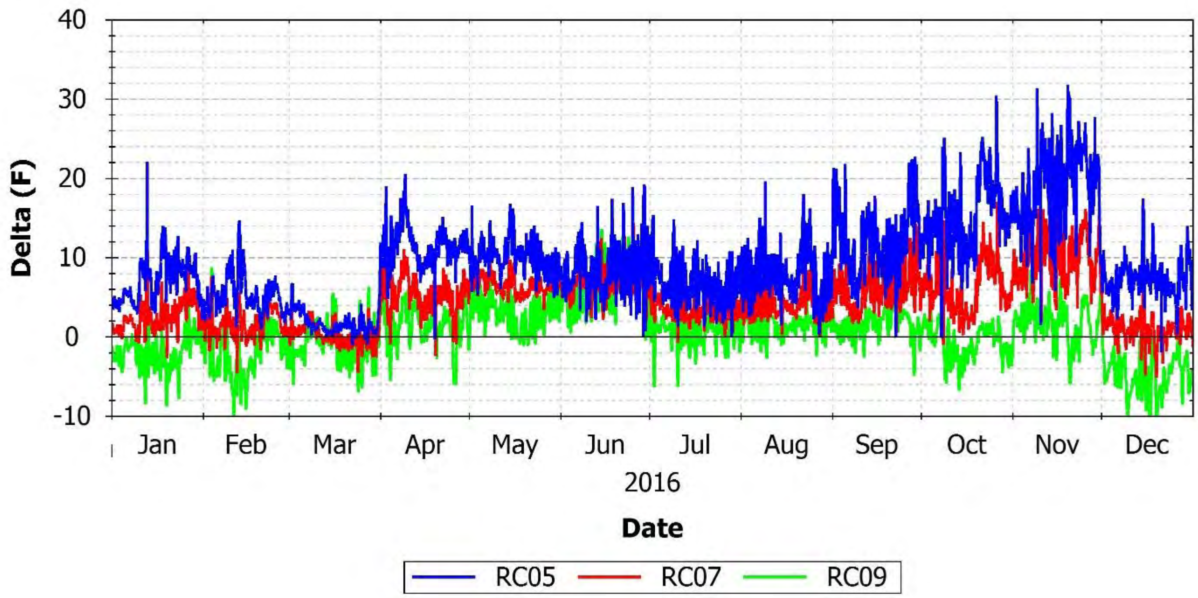

Figure A-9: Deltas for Marathon Winter/Summer 60/90 Scenario using RC04 as the upstream monitoring station during 2016

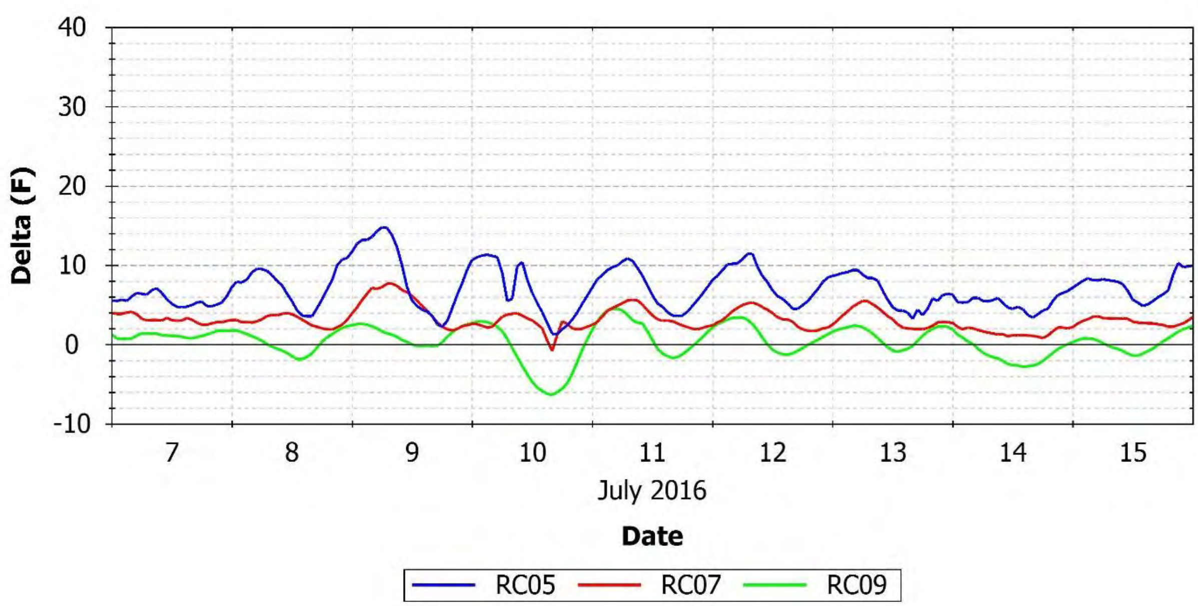

Figure A-10: Deltas for Marathon Winter/Summer 60/90 Scenario using RC04 as the upstream monitoring station during July 2016

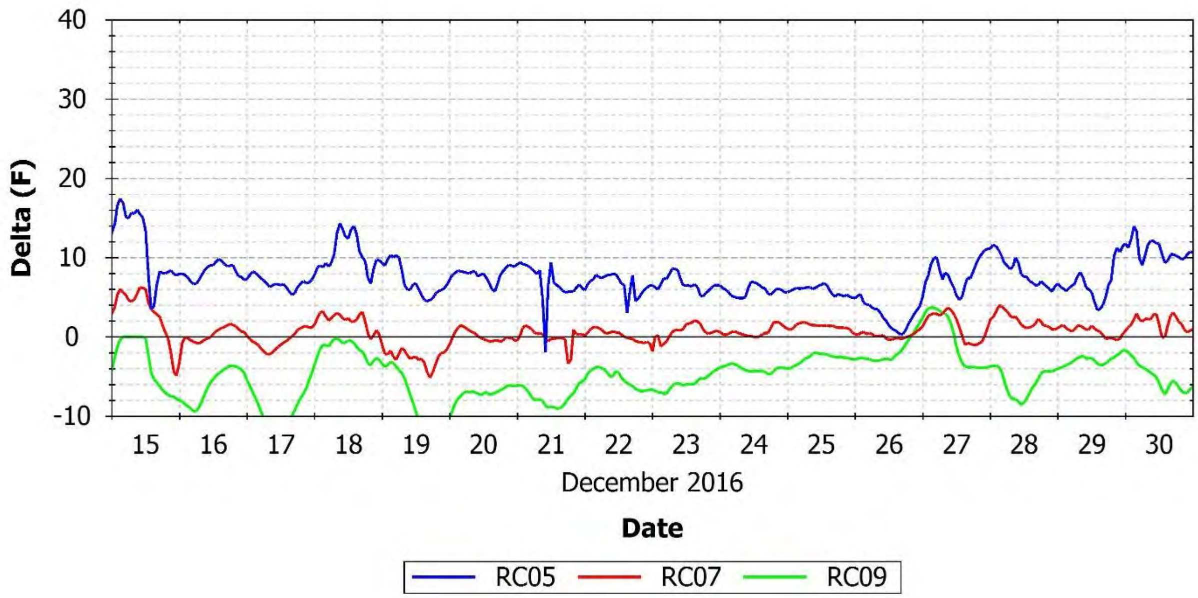

Figure A-11: Deltas for Marathon Winter/Summer 60/90 Scenario using RC04 as the upstream monitoring station during December 2016

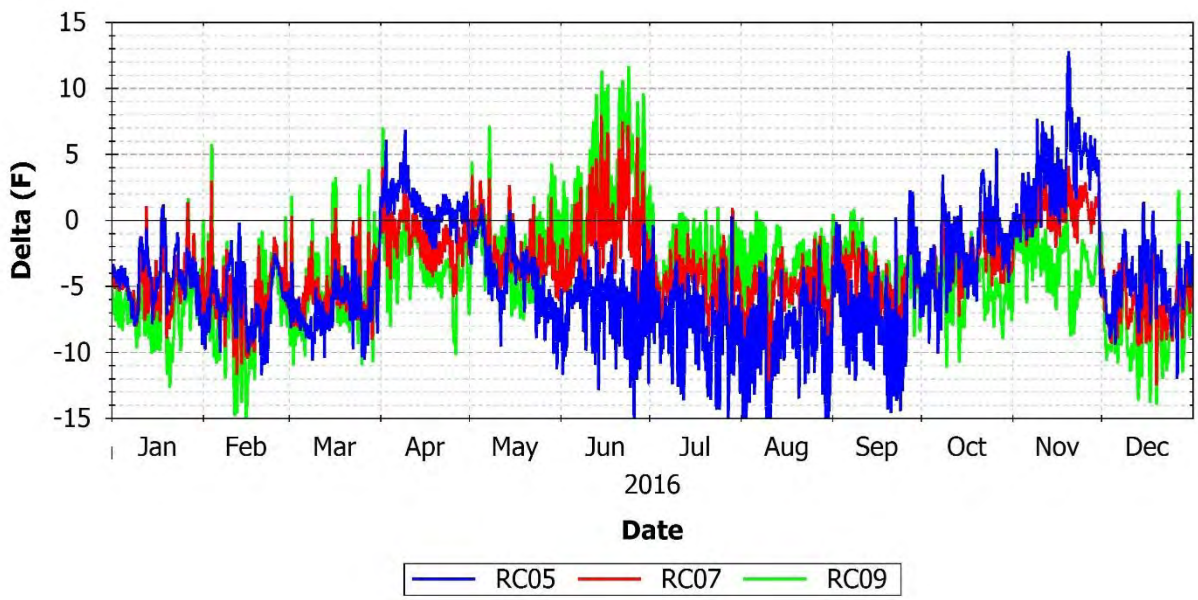

Figure A-12: Deltas for Marathon Winter/Summer 35/60 Scenario using RC04 as the upstream monitoring station during 2016

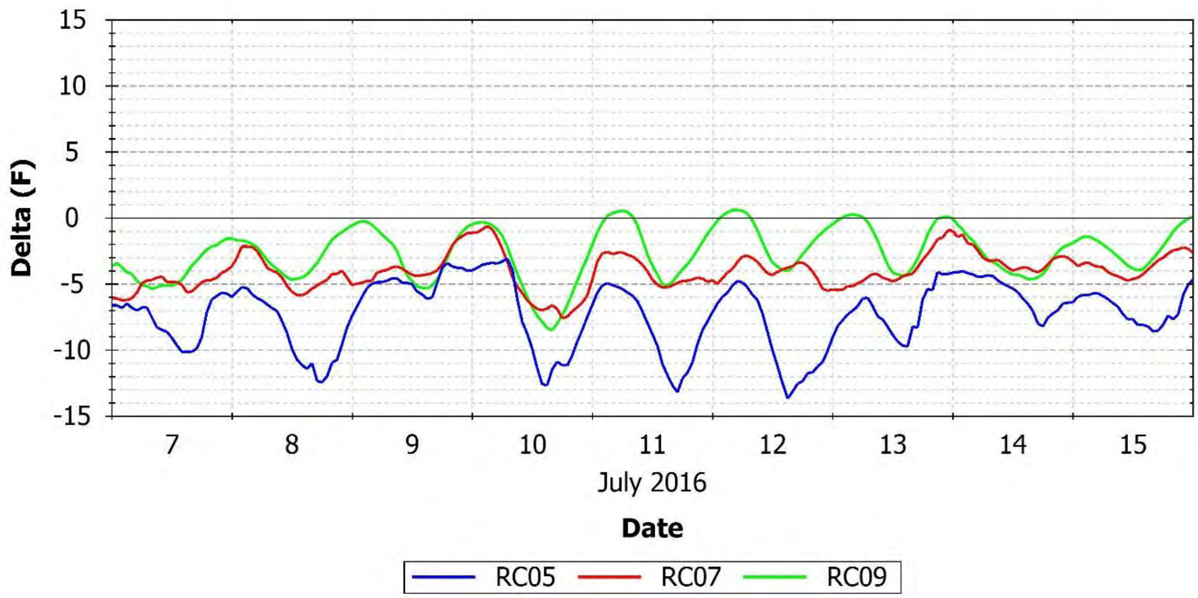

Figure A-13: Deltas for Marathon Winter/Summer 35/60 Scenario using RC04 as the upstream monitoring station during July 2016

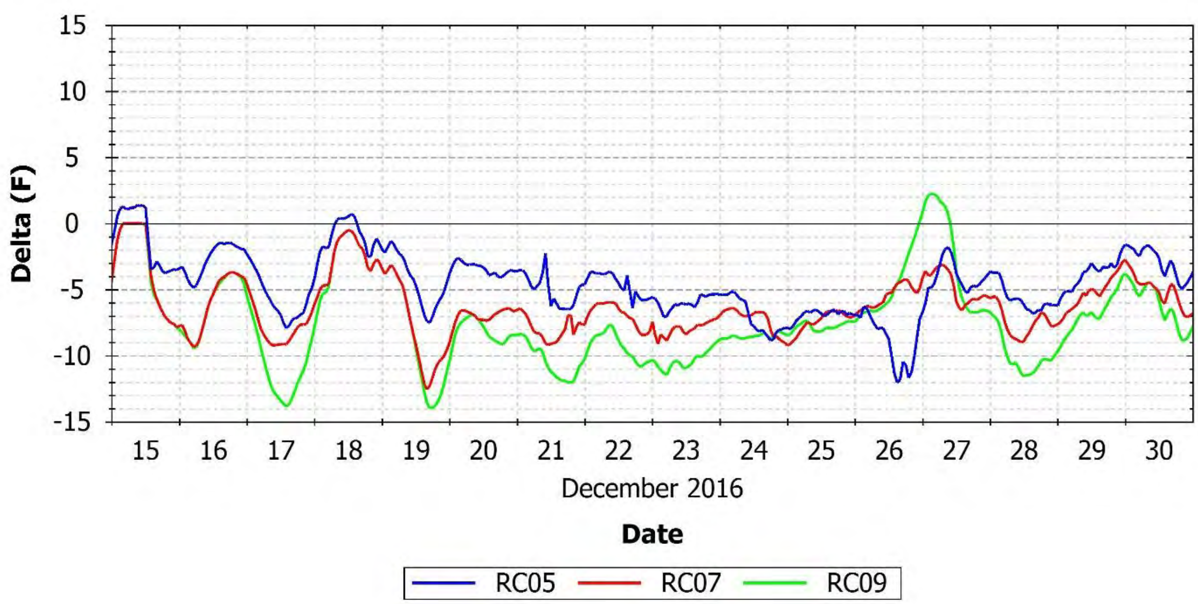

Figure A-14: Deltas for Marathon Winter/Summer 35/60 Scenario using RC04 as the upstream monitoring station during December 2016

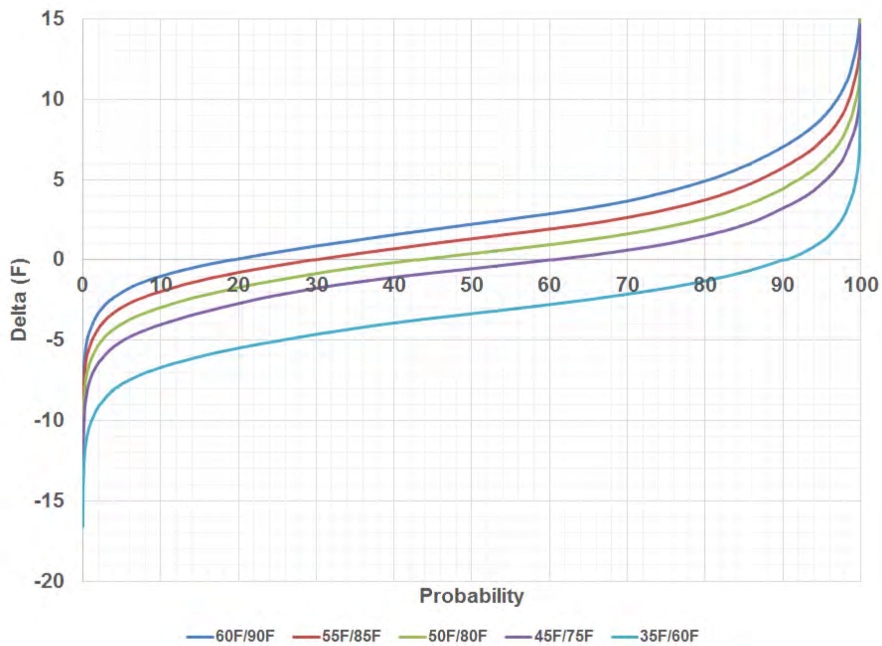

Figure A-15: Percent exceedance of water temperature delta between RC04 and RC07 from 2011 – 2016 for Marathon Winter/Summer Temperature Scenarios

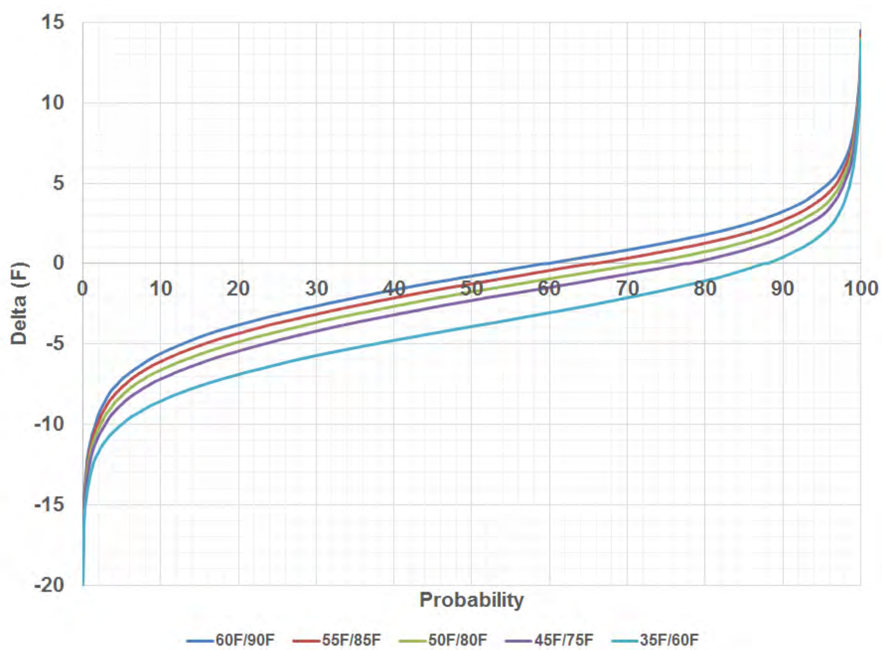

Figure A-16: Percent exceedance of water temperature delta between RC04 and RC09 from 2011 – 2016 for Marathon Winter/Summer Temperature Scenarios

Table A-1 In-stream temperature total hourly delta exceedances with RC04 as the upstream monitoring station from 2011 – 2016 for the calibrated model results

	April – November (>Δ5°F)			December – March (>Δ5°F)		
Year	Total Hours	Number of Hours Δ >5°F	% of Hours Δ >5°F	Total Hours	Number of Hours Δ >5°F	% of Hours Δ >5°F
Location: RC05						
2011	5856	2733	47%	2904	1813	62%
2012	5856	4493	77%	2928	1476	50%
2013	5856	2979	51%	2904	2412	83%
2014	5856	2782	48%	2904	2586	89%
2015	5856	3343	57%	2904	2745	95%
2016	5856	4832	83%	2928	2557	87%
Location: RC07						
2011	5856	239	4%	2904	305	11%
2012	5856	984	17%	2928	182	6%
2013	5856	624	11%	2904	257	9%
2014	5856	255	4%	2904	117	4%
2015	5856	1576	27%	2904	94	3%
2016	5856	2529	43%	2928	859	29%
Location: RC09						
2011	5856	130	2%	2904	67	2%
2012	5856	160	3%	2928	91	3%
2013	5856	76	1%	2904	114	4%
2014	5856	118	2%	2904	61	2%
2015	5856	463	8%	2904	24	1%
2016	5856	591	10%	2928	63	2%

Table A-2 In-stream temperature total hourly delta exceedances with RC04 as the upstream monitoring station from 2011 – 2016 for the 7Q10 model results

	April – November (>Δ5°F)			December – March (>Δ5°F)		
Year	Total Hours	Number of Hours Δ >5°F	% of Hours Δ >5°F	Total Hours	Number of Hours Δ >5°F	% of Hours Δ >5°F
Location: RC05						
2011	5856	4718	81%	2904	2771	95%
2012	5856	5598	96%	2928	2426	83%
2013	5856	5050	86%	2904	2587	89%
2014	5856	4897	84%	2904	2659	92%
2015	5856	4822	82%	2904	2587	89%
2016	5856	5508	94%	2928	2722	93%
Location: RC07						
2011	5856	803	14%	2904	565	19%
2012	5856	2170	37%	2928	384	13%
2013	5856	1411	24%	2904	259	9%
2014	5856	1314	22%	2904	230	8%
2015	5856	1927	33%	2904	434	15%
2016	5856	3581	61%	2928	1518	52%
Location: RC09						
2011	5856	199	3%	2904	72	2%
2012	5856	286	5%	2928	47	2%
2013	5856	166	3%	2904	61	2%
2014	5856	163	3%	2904	46	2%
2015	5856	410	7%	2904	15	1%
2016	5856	1045	18%	2928	74	3%

Table A-3 In-stream temperature total hourly delta exceedances with RC04 as the upstream monitoring station from 2011 – 2016 for the Without Marathon model results

	April – November (>Δ5°F)			December – March (>Δ5°F)		
Year	**Total Hours**	**Number of Hours Δ >5°F**	**% of Hours Δ >5°F**	**Total Hours**	**Number of Hours Δ >5°F**	**% of Hours Δ >5°F**
Location: RC05						
2011	5856	0	0%	2904	0	0%
2012	5856	0	0%	2928	0	0%
2013	5856	0	0%	2904	0	0%
2014	5856	0	0%	2904	0	0%
2015	5856	0	0%	2904	0	0%
2016	5856	0	0%	2928	0	0%
Location: RC07						
2011	5856	97	2%	2904	6	0%
2012	5856	127	2%	2928	39	1%
2013	5856	42	1%	2904	46	2%
2014	5856	36	1%	2904	14	0%
2015	5856	211	4%	2904	0	0%
2016	5856	282	5%	2928	6	0%
Location: RC09						
2011	5856	105	2%	2904	38	1%
2012	5856	102	2%	2928	54	2%
2013	5856	52	1%	2904	53	2%
2014	5856	99	2%	2904	24	1%
2015	5856	380	6%	2904	0	0%
2016	5856	398	7%	2928	20	1%

Table A-4 In-stream temperature total hourly delta exceedances with RC04 as the upstream monitoring station from 2011 – 2016 for the Marathon: 60/90 Scenario

	April – November (>Δ5°F)			December – March (>Δ5°F)		
Year	Total Hours	Number of Hours Δ >5°F	% of Hours Δ >5°F	Total Hours	Number of Hours Δ >5°F	% of Hours Δ >5°F
Location: RC05						
2011	5856	4176	71%	2904	944	33%
2012	5856	4924	84%	2928	307	10%
2013	5856	3815	65%	2904	1090	38%
2014	5856	3987	68%	2904	906	31%
2015	5856	4359	74%	2904	1193	41%
2016	5856	5429	93%	2928	1567	54%
Location: RC07						
2011	5856	851	15%	2904	51	2%
2012	5856	1322	23%	2928	65	2%
2013	5856	1296	22%	2904	101	3%
2014	5856	526	9%	2904	61	2%
2015	5856	2191	37%	2904	3	0%
2016	5856	3661	63%	2928	109	4%
Location: RC09						
2011	5856	158	3%	2904	49	2%
2012	5856	157	3%	2928	74	3%
2013	5856	99	2%	2904	89	3%
2014	5856	111	2%	2904	33	1%
2015	5856	640	11%	2904	2	0%
2016	5856	729	12%	2928	28	1%

Table A-5 In-stream temperature total hourly delta exceedances with RC04 as the upstream monitoring station from 2011 – 2016 for the Marathon: 35/60 Scenario

	April – November (>Δ5°F)			**December – March (>Δ5°F)**		
Year	**Total Hours**	**Number of Hours Δ >5°F**	**% of Hours Δ >5°F**	**Total Hours**	**Number of Hours Δ >5°F**	**% of Hours Δ >5°F**
Location: RC05						
2011	5856	74	1%	2904	0	0%
2012	5856	192	3%	2928	0	0%
2013	5856	426	7%	2904	0	0%
2014	5856	103	2%	2904	0	0%
2015	5856	187	3%	2904	0	0%
2016	5856	228	4%	2928	0	0%
Location: RC07						
2011	5856	54	1%	2904	0	0%
2012	5856	78	1%	2928	21	1%
2013	5856	28	0%	2904	10	0%
2014	5856	4	0%	2904	9	0%
2015	5856	72	1%	2904	0	0%
2016	5856	49	1%	2928	0	0%
Location: RC09						
2011	5856	80	1%	2904	18	1%
2012	5856	95	2%	2928	40	1%
2013	5856	17	0%	2904	38	1%
2014	5856	14	0%	2904	14	0%
2015	5856	170	3%	2904	0	0%
2016	5856	236	4%	2928	5	0%

A.2 Scenario Results to Evaluate 60/90°F End–of–Pipe Compliance

Table A-6 In-stream maximum temperature exceedances from 2011 – 2016 for the calibrated model results

	April – November (>90°F)				December – March (>60°F)			
Year	**Total Hours**	**Max Temp (°F)**	**Number of Hours >90°F**	**% Hours >90°F**	**Total Hours**	**Max Temp (°F)**	**Number of Hours >60°F**	**% Hours >60°F**
Location: RC04								
2011	5856	90.16	2	**0.0%**	2904	64.43	57	2.0%
2012	5856	90.45	2	**0.0%**	2928	72.45	452	15.4%
2013	5856	86.13	0	**0.0%**	2904	61.18	8	**0.3%**
2014	5856	88.53	0	**0.0%**	2904	65.25	21	**0.7%**
2015	5856	88.68	0	**0.0%**	2904	63.22	16	**0.6%**
2016	5856	86.46	0	**0.0%**	2928	62.74	13	**0.4%**
Location: RC05								
2011	5856	91.57	31	**0.5%**	2904	69.95	297	10.2%
2012	5856	93.38	20	**0.3%**	2928	77.17	682	23.3%
2013	5856	89.44	0	**0.0%**	2904	67.58	100	3.4%
2014	5856	89.99	0	**0.0%**	2904	65.80	104	3.6%
2015	5856	90.94	4	**0.1%**	2904	69.29	423	14.6%
2016	5856	92.58	56	**1.0%**	2928	67.54	461	15.7%
Location: RC07								
2011	5856	91.55	17	**0.3%**	2904	66.54	104	3.6%
2012	5856	94.96	59	**1.0%**	2928	73.54	500	17.1%
2013	5856	90.40	2	**0.0%**	2904	61.31	14	**0.5%**
2014	5856	91.81	22	**0.4%**	2904	63.72	15	**0.5%**
2015	5856	93.16	27	**0.5%**	2904	63.77	67	2.3%
2016	5856	94.51	41	**0.7%**	2928	64.34	158	5.4%
Location: RC09								
2011	5856	91.40	6	**0.1%**	2904	66.39	70	2.4%
2012	5856	93.69	29	**0.5%**	2928	71.10	416	14.2%
2013	5856	88.67	0	**0.0%**	2904	58.51	0	**0.0%**
2014	5856	86.70	0	**0.0%**	2904	61.06	4	**0.1%**
2015	5856	91.43	5	**0.1%**	2904	61.09	13	**0.4%**
2016	5856	90.06	1	**0.0%**	2928	66.10	100	3.4%

Table A-7 In-stream maximum temperature exceedances from 2011 – 2016 for the 7Q10 model results

	April – November (>90°F)				December – March (>60°F)			
Year	**Total Hours**	**Max Temp (°F)**	**Number of Hours >90°F**	**% Hours >90°F**	**Total Hours**	**Max Temp (°F)**	**Number of Hours >60°F**	**% Hours >60°F**
Location: RC04								
2011	5856	91.21	6	0.1%	2904	67.59	118	4.1%
2012	5856	91.29	3	0.1%	2928	72.69	438	15.0%
2013	5856	88.50	0	0.0%	2904	67.27	80	2.8%
2014	5856	87.96	0	0.0%	2904	66.83	65	2.2%
2015	5856	90.34	2	0.0%	2904	71.49	267	9.2%
2016	5856	86.41	0	0.0%	2928	68.33	166	5.7%
Location: RC05								
2011	5856	92.09	61	1.0%	2904	74.20	1262	43.5%
2012	5856	94.60	52	0.9%	2928	80.79	1185	40.5%
2013	5856	90.19	5	0.1%	2904	72.73	832	28.7%
2014	5856	90.40	8	0.1%	2904	69.09	910	31.3%
2015	5856	91.62	17	0.3%	2904	77.32	1559	53.7%
2016	5856	95.80	154	2.6%	2928	71.07	1605	54.8%
Location: RC07								
2011	5856	94.23	52	0.9%	2904	71.05	168	5.8%
2012	5856	95.72	79	1.3%	2928	72.39	463	15.8%
2013	5856	92.49	16	0.3%	2904	66.91	77	2.7%
2014	5856	93.81	56	1.0%	2904	68.38	87	3.0%
2015	5856	95.00	69	1.2%	2904	69.89	379	13.1%
2016	5856	96.66	107	1.8%	2928	71.78	372	12.7%
Location: RC09								
2011	5856	92.23	9	0.2%	2904	66.36	61	2.1%
2012	5856	93.90	30	0.5%	2928	70.06	368	12.6%
2013	5856	88.59	0	0.0%	2904	59.49	0	0.0%
2014	5856	87.02	0	0.0%	2904	59.59	0	0.0%
2015	5856	92.21	9	0.2%	2904	64.12	34	1.2%
2016	5856	90.56	3	0.1%	2928	68.88	158	5.4%

Table A-8 In-stream maximum temperature exceedances from 2011 – 2016 for the Without Marathon Model

	April – November (>90°F)				**December – March (>60°F)**			
Year	**Total Hours**	**Max Temp (°F)**	**Number of Hours >90°F**	**% Hours >90°F**	**Total Hours**	**Max Temp (°F)**	**Number of Hours >60°F**	**% Hours >60°F**
Location: RC04								
2011	5856	92.00	6	**0.1%**	2904	64.71	59	2.0%
2012	5856	94.84	14	**0.2%**	2928	72.53	450	15.4%
2013	5856	87.41	0	**0.0%**	2904	61.49	8	**0.3%**
2014	5856	91.92	14	**0.2%**	2904	66.26	25	**0.9%**
2015	5856	89.98	0	**0.0%**	2904	63.65	17	**0.6%**
2016	5856	87.97	0	**0.0%**	2928	63.10	16	**0.5%**
Location: RC05								
2011	5856	92.39	7	**0.1%**	2904	65.15	55	1.9%
2012	5856	94.38	14	**0.2%**	2928	72.09	444	15.2%
2013	5856	87.16	0	**0.0%**	2904	61.41	8	**0.3%**
2014	5856	90.31	1	**0.0%**	2904	65.49	21	**0.7%**
2015	5856	90.41	2	**0.0%**	2904	63.36	13	**0.4%**
2016	5856	87.63	0	**0.0%**	2928	63.17	17	**0.6%**
Location: RC07								
2011	5856	90.40	3	**0.1%**	2904	63.21	29	**1.0%**
2012	5856	95.33	42	**0.7%**	2928	71.89	414	14.1%
2013	5856	88.40	0	**0.0%**	2904	58.05	0	**0.0%**
2014	5856	87.11	0	**0.0%**	2904	61.08	4	**0.1%**
2015	5856	90.66	3	**0.1%**	2904	62.47	8	**0.3%**
2016	5856	88.89	0	**0.0%**	2928	62.65	26	**0.9%**
Location: RC09								
2011	5856	92.11	11	**0.2%**	2904	64.56	34	1.2%
2012	5856	96.30	48	**0.8%**	2928	70.04	377	12.9%
2013	5856	89.60	0	**0.0%**	2904	56.06	0	**0.0%**
2014	5856	85.66	0	**0.0%**	2904	57.88	0	**0.0%**
2015	5856	93.20	13	**0.2%**	2904	59.44	0	**0.0%**
2016	5856	89.42	0	**0.0%**	2928	64.32	33	1.1%

Table A-9 In-stream maximum temperature exceedances from 2011 – 2016 for the Marathon: 60/90 Scenario

	April – November (>90°F)				December – March (>60°F)			
Year	**Total Hours**	**Max Temp (°F)**	**Number of Hours >90°F**	**% Hours >90°F**	**Total Hours**	**Max Temp (°F)**	**Number of Hours >60°F**	**% Hours >60°F**
Location: RC04								
2011	5856	90.16	2	**0.0%**	2904	64.43	57	2.0%
2012	5856	90.45	2	**0.0%**	2928	72.45	452	15.4%
2013	5856	86.13	0	**0.0%**	2904	61.18	8	**0.3%**
2014	5856	88.54	0	**0.0%**	2904	65.26	21	**0.7%**
2015	5856	88.68	0	**0.0%**	2904	63.22	16	**0.6%**
2016	5856	86.46	0	**0.0%**	2928	62.74	13	**0.4%**
Location: RC05								
2011	5856	90.11	2	**0.0%**	2904	67.69	63	2.2%
2012	5856	91.84	5	**0.1%**	2928	72.66	450	15.4%
2013	5856	87.98	0	**0.0%**	2904	65.59	19	**0.7%**
2014	5856	88.65	0	**0.0%**	2904	71.49	22	**0.8%**
2015	5856	89.16	0	**0.0%**	2904	68.47	17	**0.6%**
2016	5856	88.73	0	**0.0%**	2928	67.76	27	**0.9%**
Location: RC07								
2011	5856	91.27	8	**0.1%**	2904	63.27	36	1.2%
2012	5856	95.09	53	**0.9%**	2928	71.43	411	14.0%
2013	5856	89.60	0	**0.0%**	2904	60.25	4	**0.1%**
2014	5856	91.98	17	**0.3%**	2904	65.43	13	**0.4%**
2015	5856	93.09	26	**0.4%**	2904	64.65	13	**0.4%**
2016	5856	92.72	15	**0.3%**	2928	62.67	37	1.3%
Location: RC09								
2011	5856	91.29	6	**0.1%**	2904	64.41	39	1.3%
2012	5856	93.72	29	**0.5%**	2928	70.07	383	13.1%
2013	5856	88.36	0	**0.0%**	2904	57.26	0	**0.0%**
2014	5856	86.75	0	**0.0%**	2904	59.57	0	**0.0%**
2015	5856	91.11	5	**0.1%**	2904	60.87	4	**0.1%**
2016	5856	89.80	0	**0.0%**	2928	64.48	46	1.6%

Table A-10 In-stream maximum temperature exceedances from 2011 – 2016 for the Marathon: 35/60 Scenario

	April – November (>90°F)				December – March (>60°F)			
Year	Total Hours	Max Temp (°F)	Number of Hours >90°F	% Hours >90°F	Total Hours	Max Temp (°F)	Number of Hours >60°F	% Hours >60°F
Location: RC04								
2011	5856	90.14	2	**0.0%**	2904	64.42	57	2.0%
2012	5856	90.42	2	**0.0%**	2928	72.45	452	15.4%
2013	5856	86.13	0	**0.0%**	2904	61.18	8	**0.3%**
2014	5856	88.52	0	**0.0%**	2904	65.25	21	**0.7%**
2015	5856	88.67	0	**0.0%**	2904	63.21	16	**0.6%**
2016	5856	86.45	0	**0.0%**	2928	62.74	13	**0.4%**
Location: RC05								
2011	5856	82.88	0	**0.0%**	2904	59.59	0	**0.0%**
2012	5856	75.95	0	**0.0%**	2928	63.94	110	3.8%
2013	5856	77.31	0	**0.0%**	2904	58.17	0	**0.0%**
2014	5856	82.83	0	**0.0%**	2904	60.06	4	**0.1%**
2015	5856	77.33	0	**0.0%**	2904	60.02	2	**0.1%**
2016	5856	79.36	0	**0.0%**	2928	57.18	0	**0.0%**
Location: RC07								
2011	5856	86.43	0	**0.0%**	2904	58.25	0	**0.0%**
2012	5856	90.17	2	**0.0%**	2928	69.07	248	8.5%
2013	5856	82.36	0	**0.0%**	2904	56.80	0	**0.0%**
2014	5856	83.63	0	**0.0%**	2904	60.01	1	**0.0%**
2015	5856	84.97	0	**0.0%**	2904	60.60	3	**0.1%**
2016	5856	86.07	0	**0.0%**	2928	58.67	0	**0.0%**
Location: RC09								
2011	5856	88.66	0	**0.0%**	2904	61.35	10	**0.3%**
2012	5856	92.68	19	**0.3%**	2928	68.91	319	10.9%
2013	5856	84.99	0	**0.0%**	2904	54.81	0	**0.0%**
2014	5856	83.93	0	**0.0%**	2904	56.29	0	**0.0%**
2015	5856	89.92	0	**0.0%**	2904	58.33	0	**0.0%**
2016	5856	87.58	0	**0.0%**	2928	61.50	6	**0.2%**