Memorandum for the Record
From: Gerald M. Szal, Environmental Analyst, MassDEP/DWM, Worcester MA
Date: November 6, 2007
Subject: Review of water temperature data from the Lower Basin of the Charles River, 2003-2005.

BACKGROUND

The Lower Basin of the Charles River, from the Watertown Dam to the new Charles River Dam and Locks, is classified as Class B Warm Water. Massachusetts Surface Water Quality Standards for this classification list a maximum temperature criterion of 28.3ºC (83ºF). In addition, the Standards state that the thermal rise due to a discharge into such a waterbody shall not exceed 2.8ºC (5ºF) based on the minimum expected flow for the month.

In developing this memorandum my goal was to document whether or not exceedances of the two temperature criteria described above have occurred in the Lower Charles and to characterize their magnitude, frequency, temporal duration and areal extent when information to conduct such an analysis was available. In those instances where a thermal rise between water quality stations exceeded 2.8ºC (5ºF), I also evaluated the potential that a thermal discharge caused the observed rise.

Surface water temperature data from three separate field-sampling programs were reviewed for this assessment. All data evaluated in this memorandum were collected from years 2003-2005. Most of the information available for the Lower Charles was collected downstream of the Boston University (B.U.) Bridge where the river greatly widens and deepens.

U.S. EPA REGION 1 DATA

U.S. EPA staff, from the Region 1 laboratory in Chelmsford, MA, sampled the Lower Charles River from 1998-2005 (see Faber, 2006). Only the last three years of those studies (i.e., 2003-2005) were reviewed for this memorandum. In addition, only EPA data from stations located downstream of the Watertown Dam were evaluated.

EPA conducted three different types of sampling events. First, routine water quality sampling was conducted at six to ten stations (depending on year of study) at least once per month in July, August and September during the 2003-2005 period in dry-weather. Second, the agency also conducted a series of wet-weather sampling events in each of these years. Third, sampling at additional stations was conducted one day in 2004 and one day in 2005. Approximate locations of the EPA sampling stations (and locations of some major landmarks) are listed in Table 1 and are based on MassGIS river miles.

Wet weather, 2003-2005: During the wet-weather sampling in 2003-2005 no exceedances of the maximum temperature criterion (28.3ºC; 83ºF) or the delta temperature criterion (2.8ºC; 5ºF) were confirmed.

Dry weather, 2003: EPA sampling took place at eleven stations in 2003. Exceedances of the maximum water quality criterion value (28.3ºC; 83ºF) were found at a number of stations during the July 8, 2003 sampling event in 2003. Water temperatures measured by EPA downstream of the Watertown Dam ranged from 82.6ºF to 84.7ºF that day. The most upstream exceedance occurred at CRBL04. No exceedances of the delta temperature criterion were seen in the EPA dataset for July 8, 2003.

No exceedances of the criteria for maximum temperature or delta temperature (due to a known thermal discharge) were seen in the EPA sampling events in August or September of 2003 (see all the 2003 EPA data at: http://epa.gov/ne/lab/reportsdocuments/charles/report2003.pdf).

Dry Weather, 2004: EPA reduced the number of sampling locations to seven in 2004. Dry-weather sampling events took place in 2004 on July 13; August 10; August 30; September 14; and October 7. No exceedances of either the maximum temperature or delta temperature criteria were detected on these dates (see all the 2004 EPA data at: http://epa.gov/ne/lab/reportsdocuments/charles/report2004.pdf).

Table 1. Approximate MassGIS River Mile Points for **EPA Water Quality Stations and** Reference Points in the Charles River, Lower Basin. [Note: The information below was developed from Table A-1 and Figure 1 from the EPA report at: http://epa.gov/ne/lab/reportsdocuments/charles/report2004.pdf and transcribed to MassGIS to obtain mid-line river miles.]

Station	Location	Approximate MassGIS River Mile
	Watertown Dam	**9.2**
CRBL04	Herter East Park, 10 m off south bank	5.9
CRBL05	Magazine Beach, 10 m off north bank	3.6
	Boston University (B.U.) Bridge	**3.35**
CRBL06	Downstream of B.U. Bridge, center channel	3.1
	Harvard Bridge (a.k.a. Mass. Ave. Bridge)	**2.37**
CRBL07	Downstream of Mass. Ave. and Stony Brook, 10 m off south shore	2.2
CRBLA8	Off the Esplanade (new station in 2002)	1.9
CRBL09	Upstream of the Longfellow Bridge, Cambridge side	1.8
CRBL10	Upstream of the Longfellow Bridge, near community boating area, Boston side	1.5
	Longfellow Bridge	**1.44**
	Mirant Kendall Thermal Discharge	1.36
CRBL11	Between Longfellow Bridge and Old Dam (& boat locks), center channel	1.1
	Old Boat Locks near Museum of Science (midpoint	**0.93**
CRBL12	Upstream of RR bridge, center channel	0.78
	Terminus of the New Charles River Boat Locks*	**0.44**

*** Note that the terminus of the Boat Locks (where the locks meet Boston Harbor) is found at MassGIS river mile 0.44 rather than at river mile 0.0 as one might expect.**

Dry weather, 2005: EPA conducted routine sampling at seven stations in 2005 (additional stations were added for a special study described below). Routine sampling stations stretched from upstream of the Watertown Dam to a point near the new Charles River Dam. Dry weather sampling in 2005 was conducted on June 8; July 13; August 9; September 7; and October 5 (all the 2005 EPA data for the Lower Charles can be viewed at: (http://epa.gov/ne/lab/reportsdocuments/charles/report2005.pdf).

Exceedances of the 28.3ºC (83ºF) thermal criterion were detected on August 9, 2005. These occurred at the two most downstream stations, CRBL11 and CRBL12. Both stations are located downstream of the Longfellow Bridge. In comparison to water temperatures at these stations, temperatures reported for Station CRBL06, near the B.U. Bridge, did not violate the maximum criterion. Temperature exceedances seen at CRBL11 and CRBL12 on August 9, 2005 are notable partly because the monitoring for that segment of the river took place between 8:30 and 9:00 in the morning when water temperatures typically have not reached their peak daily values.

EPA staff conducted a more detailed study of the temperature regime downstream of the B.U. Bridge on August 11, 2005 at stations with locations that differ from those listed in Table 1 (a site map for the August 11, 2005 study is provided in Figure 6 at the following EPA website: http://epa.gov/ne/lab/reportsdocuments/charles/report2005.pdf). During the August 11, 2005 survey, EPA staff found that the surface water temperature measured at 2:42 pm at a "reference" station near the B.U. bridge was 27.3ºC (81.1ºF). By comparison, the surface water temperatures measured at a series of other stations, the locations of which ranged from about 225 m upstream of the Longfellow Bridge (which is upstream of Mirant Kendall's discharge) to a point just upstream of the new Charles River Dam and Locks, all violated the maximum temperature criterion of 28.3ºC (83ºF). Surface water temperatures (measured between 3:14 and 4:29 pm) at these downstream stations ranged from 30ºC (86ºF) to 30.5ºC (86.9ºF). Water temperatures (at 3:51 pm) near the Mirant Kendall thermal discharge were extremely high: 37ºC (98.6ºF) at the surface, and 37.8ºF (100.4ºF) at 0.6 meters below the surface.

During the August 11, 2005 sampling date, the total river miles over which exceedances of the thermal maximum temperature criterion were observed was approximately 0.9 miles. The area where exceedances were observed stretched both upstream and downstream of the Kendall thermal discharge. The lack of sampling stations between the station near the B.U. Bridge and those more downstream prohibited a characterization of the full upstream extent of the exceedances.

Delta temperature exceedances (i.e., delta temperatures >2.8ºF [5ºF] thought to be due to a discharge) were observed on August 11, 2005 between the most upstream station (just downstream of the B.U. bridge) and all other stations located downstream of this "reference" station. Some of the delta temperature exceedances were detected only below the surface.

Exceedances of the warm water maximum allowable temperature criterion of 28.3ºC (83ºF) and the delta temperature criterion of 2.8ºC (5ºF) seen by EPA on August 11, 2005, were considered by EPA to be "influenced" by the Mirant Kendall discharge (source: Faber, 2006). Because the

Lower Charles greatly widens and deepens downstream of the B.U. Bridge, river velocities in this segment of the river are negligible during periods of low river flow, which typically occur in the summer. At these times the Lower Basin, downstream of the B.U. Bridge, acts more like a lake than a river and Mirant's thermal effects have been shown to move both upstream and downstream. The potential for the Mirant Kendall Station, which was operating near full-capacity over the summer of 2005, and at about half that level in 2004, to heat the Lower Basin is described in Section 5.3 of the Determination Document for the Mirant Kendall NPDES permit (see the following website: http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/draftpermit/Kendall_Determin-Doc_06_08_04.pdf):

> "*Information submitted by the permittee indicates that, under proposed baseload operation, the discharge plume from Kendall Station has the capability to extend completely across the Charles River in the widest part of the lower basin. In addition, when river flows are very low, the projected summertime thermal influence of Mirant Kendall's discharges will likely extend from the BU bridge, downstream past the facility, to the New Charles River Dam, a distance of about 3 linear miles (Mirant Kendall, May 2001). The surface acreage of this segment of the river is about 450 acres, a little over 2/3 of the total surface area of the lower Charles River Basin (670 acres).*"

Reasonable Cause for Temperature Criteria Exceedances

The reader may question whether or not the maximum and delta temperature exceedances described in the section above were due to the Mirant Kendall discharge or whether they were due to some other source. Other than the Kendall discharge, there are at least three potential sources of the exceedances of the maximum temperature criterion (28.3ºC) observed by EPA on August 9 and 11, 2005 and the delta temperature exceedances seen by EPA on August 11, 2005. These are a) CSO discharges; b) solar radiation; and c) thermal discharges other than Mirant Kendall's. Due to reasons outlined below, none of these potential alternate sources, nor any combination of these alternate sources, can logically be considered to be the primary cause(s) of the maximum or delta temperature exceedances observed by EPA in August of 2005.

a) **Major CSO discharges should not have occurred in days preceding the EPA survey.** According to preliminary data released by the National Weather Service, Boston MA Station, precipitation from August 6-August 10, 2005 totaled 0.02 inches. On the 11th, the date of the EPA intensive survey, the total rainfall accumulation was 0.2 inches. None of these rainfall events is expected to have resulted in CSO discharges to the Lower Basin of the size needed to cause the maximum temperature exceedances seen on August 9 or to elevate temperatures in the middle of the Basin by over 5ºF on August 11.

b) **Other data from the Lower Basin rule out solar heating as the primary source of delta temperature changes beyond background.** Table 2 provides mean values for surface water temperature readings collected by Marine Research, Inc. (MRI), consultants to Mirant Kendall, over the July-September period of 2004 and 2005 from the nighttime Push-Net sampling (a fish collection technique) program (these and other data collected by Mirant are discussed further in the section of this report entitled "MIRANT KENDALL DATA"). Note

that in both years the mean surface water temperature over the July-September period steadily *increased* from a station just downstream of the B.U. Bridge (at 1.4 miles upstream from the Kendall discharge) to stations near the Mirant Kendall discharge and then steadily *decreased* at points farther downstream from the discharge on the Boston side of the Lower Basin:

Table 2: Summary water temperature (ºF) data from sampling stations downstream of the B.U. Bridge, Lower Basin of the Charles are provided below. Station location relative to the Mirant Kendall thermal discharge is also provided. Temperature data listed are the mean of surface water temperature measurements taken at the beginning of nighttime Push Net sampling runs conducted by MRI in the Lower Basin over the July-September period in 2004 and 2005 (24-26 sampling events/station in 2004 and 22-26 sampling events/station in 2005). Also listed are station distances from the Mirant Kendall thermal discharge, and station locations relative to the Kendall discharge (upstream, downstream or across river). Data source: Mirant Kendall, CD, April, 2006.

Stations Upstream from the Kendall discharge; station distance from the Kendall discharge in miles	Mean Temperature 2004 (ºF)	Mean Temperature 2005 (ºF)
1.4	73	75.9
0.8	74.6	77.9
0.6	74.1	N.A.
0.4	74.7	N.A.
Station directly across river from Kendall discharge; station distance from the Kendall discharge in miles		
0.2	76.2	81.4
Stations Downstream and increasingly across river from the Kendall discharge; station distance from the Kendall discharge in miles		
0.025 (near the Cambridge side)	77.1	82.8
0.1 (half-way across the Basin)	76.1	82
0.5 (near the Boston side)	75.7	79.8

If the primary cause of water temperature increases beyond upstream ambient in the Lower Basin was solar radiation, one would expect to see a continued increase in temperature from the B.U. Bridge down to the stations farthest (and across river) from the discharge listed in the chart above. That is not the case, however. One can see that in both 2004 and 2005 the mean surface water temperature *decreased* at the two stations farthest downstream from the Kendall discharge. At the station located 0.5 miles across river and downstream from the company's discharge, the mean surface water temperature decreased by about 1.4ºF in 2004 compared to the temperature at the station nearest the discharge; in 2005 the decrease in mean water temperature between the two stations was even greater – about 3ºF. These data indicate that cooling, rather than warming, was occurring at the two stations sampled by MRI that were downstream of the company's

discharge. This information rules out solar radiation as the major cause of the delta temperature changes seen in the vicinity of the Mirant Kendall discharge in both 2004 and 2005.

c) **Mirant Kendall's thermal discharge has a great ability to heat the Lower Basin.** 7Q10 flow of the Charles River in the vicinity of the Mirant Kendall thermal discharge is approximately 14.2 MGD (22 cfs) (taken from the EPA Fact Sheet for the Mirant Kendall discharge permit at the following web-link: http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/draftpermit/kendall_factsheet_june2_2004.pdf). The permitted flow for the Mirant Kendall discharge is approximately 70 MGD with a maximum delta temperature limit of 11.1ºC (20ºF) and an upper maximum discharge temperature of 40.6ºC (105ºF). Thus, the ratio of Kendall discharge flow to Charles River 7Q10 flow is about 4.9. This, combined with the permitted delta temperature, enables the facility to heat much of the surface of the Lower Basin [see item **f)** below for a discussion on Mirant's effects to the surface of the water column vs. effects to bottom waters].

   Mirant's effect of the surfacewater temperature in the Lower Basin was evident in 1999, when Btu output was only about 127 MMBtu/hr over the July-September period that year (based on data from Mirant presented in the EPA response to comments on the draft permit). During the summer of 1999, the plant was still operating as a "peaking" facility and there were large surges in electrogeneration each day during hours of peak energy demand. The facility had installed thermistors at a number of stations in the Lower Basin to track the effects of the facility's thermal plume. Surfacewater temperatures at these stations and plant heat load data were submitted as graphics in the facility's Final Environmental Impact Report (Figures 3-35 and 3-33 in: EOEA No. 11754. Final Environmental Impact Report, Kendall Square Station Equipment Upgrade Project, Cambridge, MA. Vol. 1 of 2. Southern Energy Kendall L.L.C. Prepared by TRC, May, 2000). Water temperature rose and fell on a daily basis at each station. However, the delta temperature between stations located downstream of the Longfellow Bridge compared to those at the "ambient" upstream station, located near the B.U. Bridge were correlated with plant heat load. When Btu input from the facility was highest, the delta temperature in surfacewater between the most upstream station and stations downstream of the Longfellow Bridge rose as high as about 6.5°F. By contrast, delta temperatures between these stations when plant load was much lower were in the range of 2.5 to 4°F.

   It is reasonable to believe that delta temperatures beyond ambient would increase with plant load given similar dilution from upstream. Heat load over the July-September period in 2005 averaged about 469 MMBtu/hr. This is approximately 3.7 times the average heat load over the same period in 1999. Therefore, it is reasonable to expect that this facility's ability to heat the surfacewaters of the Lower Basin, already demonstrated in 1999, had increased dramatically by 2005.

d) **Mirant's discharge is by far the largest permitted thermal discharge downstream of the B.U. Bridge.** In addition to the Mirant Kendall NPDES permit, two other NPDES permits exist which allow the permittee to discharge thermal effluent to the Lower Charles between the B.U. Bridge and the Museum of Science. The more upstream of the two is the MIT "Magnet Lab" (Permit # MA0004898) which discharges non-contact cooling water near the

Harvard Bridge. MIT has a second outfall for this permit but it was not active over the summer of 2005 (personal communication by phone from Zhanna Davidovitz, MIT, to the author on August 19, 2007). Based on written reports from MIT, 0.08 MGD of heated water was consistently being released over the 2003-2005 period from the Magnet Lab. The second permit is for the Biopure Corporation (Permit # MA0036404). Biopure is permitted to discharge 0.027 MGD of primarily reverse-osmosis reject water on the Cambridge side of the river near the Museum of Science. According to Biopure (personal communication by phone from Jason Cupp, Biopure, to the author on August 15, 2007), there is very little increase in temperature of the discharge water over the water received by Biopure from its source at Fresh Pond in Cambridge. Mirant's discharge over the summer of 2005 was approximately 650 times the discharge rates of MIT and Biopure combined. Thus, it appears that no other permitted dischargers exist in this area of the Charles that could account for major alterations of water temperature throughout the Lower Charles as were seen by EPA in August of 2005.

e) **The rate of temperature change per mile in the Lower Basin is closely linked to Btu input from the Mirant Kendall thermal discharge.** EPA and MassDEP prepared linear regressions of the data from Table 2 (see the regression for the 2004 dataset at: http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898c3-6.pdf ; and the regression for the 2005 dataset at: http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898c3-7.pdf , discussed in more detail in this memo within the section entitled "Warming in the Lower Basin due to Kendall's thermal discharge"). The slopes of these regression lines denote the change in surface water temperature (ºF) per change in distance from the Mirant Kendall discharge.[1]

Note that the slopes in the regression lines are substantially different between the two years: for 2004 the slope is –2.67; for 2005 the slope is –4.99. That is, over the July-September period in 2004 the temperature change per mile distance from the Kendall discharge was about 2.67ºF while in 2005, that figure was 4.99ºF. Also note that the 2005/2004 ratio of change in temperature with change in distance, i.e., the ratio of the slopes of the regression lines over those two years, is 4.99/2.67. This ratio is equal to about 1.87.

The value of 1.87 is very close to the ratio of Btu input from the facility over the July-September period in 2005 compared to that in 2004. In 2004 Mirant Kendall's Btu input to the Lower Basin was about 510,120 million Btu over the July-September period, while in 2005 the company's heat load to the Lower Basin was about 1,031,136 million Btu over that same period (data taken from Mirant Kendall submittal to EPA:

[1] The reader should note that, although the total distance between the most upstream station (1.4 miles upstream of the discharge) and the most downstream station (0.5 miles downstream from the discharge) is 1.9 miles, station location in the regressions was plotted as the absolute distance from the station to the discharge rather than as "river mile". This was done in order to allow an evaluation of the relationship between distance from the discharge (upstream, across or downstream) vs. water temperature. Thus, the reader may note that distance in the regression graphics only extends to 1.4 miles which is the greatest distance of any of the stations from the Kendall discharge.

http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898b1-3.pdf). The ratio of Btu input over these two years is approximately 2.0.

The fact that the ratio of Btu input over the July-September, 2005 vs. that over the same period in 2004 is closely related to the increase in temperature per mile relative to the Kendall discharge in 2005 suggests that the facility's Btu input greatly influenced temperature increases beyond background ambient in 2005. River flows entering the Lower Basin over the July-September period in 2005 were low - only about 56% of that entering the basin over that same period in 2004. As a result, there was less of a potential for dilution of Mirant's discharge in 2005 than in 2004.

f) Mirant's discharge primarily heats the upper water column. Heated water, in the temperature range typically discharged by Mirant, is much more buoyant than cooler water. Thus Mirant's discharge is expected to float. Based on this physical property of water, the facility's energy input to the Lower Basin will be primarily expended in altering the temperature of the upper water column. Therefore, it makes sense that a large increase in Btu input to the system in 2005, relative to 2004, was accompanied by a large increase in *surface* delta temperatures of the Lower Basin in 2005 relative to 2004.

Thus, there are two compelling reasons to conclude that the maximum temperature excursions and the delta temperature excursions noted by EPA in August of 2005 were due to the Kendall discharge.

1) If solar radiation was the primary cause of the delta temperature rises over upstream ambient that were seen in the Lower Basin over the July-September period in 2004 and 2005, there should be no diminution of water temperatures in the Lower Basin at points downstream of the Kendall discharge. However, as mentioned above, mean water temperatures in the Mirant Kendall dataset decrease at stations located across and downstream from the facility's discharge.

2) The ratio of Kendall's Btu input in 2005 vs. that in 2004, and the ratio of the change in surface water temperatures per unit distance in the Lower Basin downstream of the B.U. Bridge in 2005 vs. that in 2004 are approximately equal (2.0 vs. 1.87). This is evidence that Mirant's heat input to the Lower Basin in 2005 was closely tied to the delta temperature changes above ambient that occurred at the surface of the water column over a very long stretch of the Lower Basin (approximately 1.9 miles) over the summer of 2005.

Based on the above information the logical conclusion from these data is that the temperature excursions seen by EPA were primarily due to Mirant Kendall's heated discharge.

MASSACHUSETTS WATER RESOURCES AUTHORITY DATA:

The Massachusetts Water Resources Authority (MWRA) also collected surface water temperature data in 2004 and 2005 at a number of stations in the Lower Charles beginning from a point near Magazine Beach (upstream of the B.U. Bridge) extending to a point between the Old Locks (adjacent to the Museum of Science) and the new Charles River Dam. MWRA station

locations and reference points in the Lower Charles are listed in Table 3 below in terms of approximate MassGIS river miles in the theoretical mid-line of river flow.

Table 3: Approximate MassGIS River Mile Points for MWRA Water Quality Stations and Reference Points in the Charles River Lower Basin.

Station	Location	Approximate MassGIS River Mile
005	Upstream of B.U. Bridge, near Magazine Beach	3.67
	Boston University (B.U.) Bridge	**3.35**
006	Downstream of B.U. Bridge near B.U. Boathouse	3.24
007	Near MIT Boathouse, Cambridge side	2.62
	Harvard Bridge (a.k.a. Mass. Ave. Bridge)	**2.37**
008	Downstream side of Mass. Ave Bridge	2.3
009	Between Harvard and Longfellow Bridges	1.68
	Longfellow Bridge	**1.44**
	Mirant Kendall Thermal Discharge	1.36
010	Downstream of Longfellow bridge and Kendall Discharge, approximately mid-way between Cambridge and Boston shorelines	1.28
	Old Boat Locks near Museum of Science (midpoint)	**0.93**
011	Between Boat Locks at Mus. of Science and new C.R. Dam	0.77
	Terminus of the New Charles River Boat Locks*	**0.44**

* Note that the terminus of the Boat Locks, i.e., where the locks meet Boston Harbor, is found at MassGIS river mile 0.44 rather than at river mile 0.0 as one might expect.

Maximum Temperature Criterion Exceedances

Note: See **Appendix 1** for 2005 data for Stations 006, 008, 009 010 and 011.

Station 005: Over the months of July-September, MWRA surface water temperature measurements were taken at Station 005 on 15 occasions in 2004 and 13 occasions in 2005. The highest temperature recorded at Station 005 over all MWRA sampling dates in 2004 and 2005 was 26.35ºC (79.4ºF) in 2004 and 27.97ºC (82.3ºF) in 2005. No exceedances of the maximum temperature criterion were seen at this station either year.

Station 006: Over the months of July-September, surface water temperature measurements were collected at Station 006 on eight occasions in 2004 and 9 occasions in 2005. The highest temperatures recorded at Station 006 in 2004 and 2005 were 26ºC (78.8ºF) and 27.54ºC (81.6ºF), respectively. No exceedances of the maximum temperature criterion were seen at this station either year.

Station 007. This station was monitored on 8 occasions in 2004 and the same number of times in 2005. The highest temperatures recorded by MWRA at this station over these two years were 26.15ºC (79.1ºF) in 2004 and 28.15ºC (82.67ºF) in 2005. No exceedances of the maximum warm water temperature criterion were seen either year.

Station 008. This is the first station in the downstream progression of MWRA stations that exceeded the maximum temperature criterion for Class B warm waters over the 2004-2005 sampling period. Over the July-September period, surface water temperature was measured by MWRA staff at this station eight times in 2004, and the same number of times in 2005. No exceedances of the 28.3ºC (83ºF) criterion were seen in 2004. The maximum surface water temperature documented in 2004 at this station by MWRA was 28.97º [78.6ºF]. One exceedance of the maximum temperature criterion was observed at this station in 2005 when a temperature of 28.97ºC (84.1ºF) was measured.

Station 009: Surface water temperature was monitored at Station 009 eight times in 2004 and the same number of times in 2005. No exceedances of the maximum temperature criterion were documented in 2004 (maximum temperature recorded was 26.1ºC).

In 2005 exceedances of the maximum allowable temperature criterion were seen on half the sampling events (i.e., on four of the eight monitoring dates) over the July-September period. MWRA monitoring at this station, on all four days when exceedances were noted, was conducted between 7:50 and 8:15 a.m. when ambient river temperatures are near their low point for the diurnal cycle. Thus, ambient river temperatures, and temperatures at Station 009 probably rose to even higher levels in the latter part of the day than those recorded by MWRA at time of sampling.

Station 010: Exceedances of the maximum allowable temperature criterion were also seen at this station. No exceedances were seen in 2004, but exceedances were documented on four occasions (i.e., on 50% of the sampling dates) in 2005 over the July-September monitoring period. The highest water temperature measured by MWRA at this station in 2004 was 25.85ºC (78.5) and in 2005 was 29.25ºC (84.7ºF).

Station 011: Exceedances of the maximum allowable temperature criterion were observed in 2005, but not in 2004. In 2005 exceedances of this criterion were observed on 50% of the eight sampling events. The highest water temperature measured by MWRA at this station in 2004 was 26.62ºC (79.9ºF), and in 2005 was 29.59ºC (85.3ºF).

Delta Temperature Criterion Exceedances:

Water temperatures at MWRA Station 006 were compared with those from more downstream stations using the 2004 and 2005 datasets to determine if exceedances of the delta temperature criterion of 2.8ºC (5ºF) due to a discharge had taken place in areas downstream of the B.U. Bridge on any particular day.

2004: In 2004 there was only one instance where differences between temperatures at Station 006 and other, more downstream stations, exceeded the 2.8ºC (5ºF) value. This occurred on August 18 when there was a 2.9ºC (5.2ºF) rise between Stations 006 and 011.

2005: Delta temperature differences in 2005 between Station 006 and Stations 008, 009, 010 and 011 are listed in **Appendix 1**.

Delta temperatures exceeded a value of 2.8ºC (5ºF) between Station 006 and Stations 010 and 011, but not at other MWRA stations. Delta temperatures between Station 006 and Station 010 only exceeded the 2.8ºC (5ºF) value on one occasion in 2005. Exceedances of this value between Stations 006 and 011 were seen on four of the eight monitoring dates over the July-September period.

There is an anomalous aspect of the MWRA dataset. Note that the average temperature at station 011 was warmer than that at 010 in 2005:

Table 4: Average temperatures over the July-September, 2005 period at each of the MWRA stations. [Note: table is based on draft temperature information from Kelly Coughlin, MWRA (in preparation).]

MWRA Station	Approx. MassGIS River mile	Average Temperature (ºC)	Average Temperature (ºF)
006	3.24	25.0	77
008	2.29	25.8	78.4
009	2.19	27.2	81
010	1.41	27.5	81.5
011	0.6	27.7	81.9

This does not appear to be consistent with the information from the Mirant Kendall data discussed in the previous section (EPA data) where we saw consistent cooling at stations downstream of the Mirant Kendall discharge between the discharge and the Old Boat Locks adjacent to the Museum of Science. One might expect that, because the MWRA Station 010 is fairly close to Mirant's discharge, surface temperatures at that station would be warmer than those at MWRA Station 011, which is located farther downstream. There are at least two factors that could explain the apparent incongruity.

First, the relative locations of the MWRA vs. the MRI stations were different. The extent of warming from the Kendall discharge at each station would depend on the nature of the thermal plume and its travel within the basin at the time of MWRA sampling. Water flowing downstream along the Cambridge side of the river and under the Museum of Science may be consistently warmer than that reaching the middle of the river where MWRA Station 010 was located because Mirant's discharge is located on the Cambridge wall of the river.

In fact, the above scenario was predicted by Mirant (Mirant Kendall, 2001). The facility conducted modeling runs, based on input data from 1999, to project effects of the company's increased discharge of heat on water temperatures in the Lower Basin. In several of these runs, projected surface water temperatures in the middle of the basin, near the point where the MWRA station 010 is located, were lower than those at the approximate location for MWRA station 011 (i.e., similar to what MWRA found). Although the plume effects predicted from this modeling spread throughout the Lower Basin during times of low summertime river flows, the highest surface water temperatures were often projected to lie downstream of the facility, along the Cambridge shoreline and past the Museum of Science, similar to what was seen by MWRA. It should be noted that the output from modeling runs showed that temperatures in the middle and high-80s (Fahrenheit) would have predominated at the surface of the water column throughout

the Lower Basin downstream of the Harvard Bridge for many of the days for which modeling was conducted. These high temperatures are similar to those found by EPA (see the segment of this memo entitled U.S. EPA REGION 1 DATA above).

In a previous section of this memorandum [see: Reasonable Cause for Criteria Exceedances, paragraph e) and associated graphics] I highlighted the fact that, based on MRI sampling station data, temperature and station distance from the Kendall discharge were highly correlated. Note that the MRI stations used in that analysis did not extend into the segment of the river downstream from the Museum of Science, as did the MWRA stations.

By comparison to the MWRA stations, the three MRI stations were positioned somewhat along a transect downstream *and across* the river from the Kendall discharge. The most downstream of these three stations was located adjacent to the Museum of Science in the Old Boat Locks, 0.5 miles downstream and across river from the Kendall discharge (i.e., near the Boston shoreline). In about half of the modeling runs cited above (Mirant, 2001) the company projected water temperatures at the Old Boat Locks to be lower than those along the Cambridge shoreline and downstream of the discharge. Wind effects and plume movement may have partially accounted for the differences in model output.

A second possibility for the observed differences between EPA and MWRA data is the potential that un-permitted thermal discharges downstream of the Mirant Kendall discharge may be responsible for the temperature differences seen between MWRA Station 011 compared to 010. However, this office currently has no knowledge of any substantial thermal discharges to the Lower Basin downstream of Mirant Kendall's.

Summary of MWRA information

Maximum temperature exceedances:

2004 MWRA data: No exceedances of the 28.3ºC (83ºF) maximum warm water criterion were seen in any of the 2004 MWRA data.

2005 MWRA data: Exceedances of the maximum temperature criterion occurred at Station 008 and all other stations downstream, but no exceedances of this criterion were seen in any of the data reported from stations upstream of Station 008. Based on these data exceedances of the maximum criterion appear to have stretched over a distance of about 1.5 river miles in 2005. Due to the location of the Mirant Kendall thermal discharge and the rate of its Btu input to the Lower Charles, and due to other issues outlined above in this memorandum (see the section entitled "Reasonable Cause for Criteria Exceedances") it appears logical that the exceedances of the maximum temperature criterion noted by the MWRA in 2005 were primarily due to the thermal influence of the discharge. It is notable that on three of the four monitoring dates over the July 20-August 11 period, exceedances of the maximum temperature criterion occurred at Station 010, and all four sampling events at Station 011 had exceedances over this same period. MWRA reports that water temperatures on these dates were measured between 7:15 and 7:57 am. In natural systems, water temperatures are typically coolest in early morning due to the lack of solar radiation at night and the loss of heat from the waterbody to the atmosphere at night. One would

expect, therefore, that water temperatures even higher than those recorded by MWRA would have occurred in the afternoon over the July 20-August 11 period due to additional Btu input from solar radiation.

Delta temperature exceedances: Delta temperature exceedances between MWRA Station 006 (slightly downstream of the B.U. Bridge) and stations downstream of the Longfellow Bridge were seen over the July-September time period in 2004 and 2005. Delta temperature exceedances between Stations 006 and 011 occurred on one occasion in 2004. In 2005, exceedances of this criterion (between 006 and other more downstream stations) were seen at Station 010 on one occasion and at Station 011 on four of the eight occasions over which same-day measurements were made at both stations (i.e., Stations 006 and 011). Delta temperature exceedances at Station 010 were considered to be due to the influence of the Mirant Kendall discharge (rather than due to solar radiation or to other discharges). It appears logical that the delta temperatures seen at Station 011 were *primarily* from the Kendall discharge, but there may have been increased warming of the Lower Basin, in addition to that from the Mirant Kendall discharge, between MWRA Stations 010 and 011 from unknown sources.

MIRANT KENDALL DATA

The most extensive dataset available for the Lower Basin, with regard to water temperature downstream of the B.U. Bridge, was gathered by Marine Research, Inc. (MRI), consultants to Mirant Kendall. The MRI data were collected as part of a water quality and biomonitoring sampling program developed by the facility to characterize the Lower Charles and potential effects of their thermal discharge. Part of the study plan included the measurement of water temperature at a number of stations both upstream and downstream of the Mirant Kendall discharge.

In a previous section of this memorandum [Reasonable Cause for Criteria Exceedances, paragraph e)] I referenced graphics included in the Response to Comments section of the NPDES permit for the Mirant Kendall station. These graphics contain linear regressions on mean surface water temperatures collected at a number of stations located both upstream and downstream of the Mirant Kendall heated discharge vs. distance of each station from that discharge. The regressions help establish that the Kendall discharge was responsible for statistically-significant elevations of background temperatures in the upper portion of the water column during the July-September period of 2004 and 2005.

In the presentation below, surface water temperature data collected at three of the stations included in the regression analysis are compared to data from an upstream station here termed the “Hyatt Reference Station”. The Hyatt Reference Station was located slightly downstream of the B.U. Bridge and about 1.4 miles upstream of the Mirant Kendall discharge. It is used here as an index of ambient water temperatures from the terminus of the preceding river segment (Watertown Dam to B.U. Bridge). The other three stations evaluated below are referred to here as “test” stations because they are fairly close to the Kendall discharge and may have been affected by the discharge. Data from the test stations are compared to those from the reference station to evaluate potential warming effects of the Mirant Kendall discharge.

MRI station locations (Table 5) are listed in order from upstream to downstream.

Table 5: Locations of selected stations from the MRI water quality and biological sampling program relative to the Mirant Kendall thermal discharge.

Station name	Station location Upstream/Downstream/Across from the Kendall Discharge	Distance in miles from each station to the Kendall discharge
Hyatt Reference Station	Upstream, Cambridge side of Basin	1.4 miles
Arthur Fiedler Test Station	Upstream and across river, on Boston side of the basin	0.4 miles
Boston Test Station	Across river, on Boston side of the basin	0.2 miles
Mid-Channel Test Station	Downstream, approximately mid-channel	0.1 miles

Note that although the Arthur Fiedler and Boston Test stations are not downstream of the Kendall discharge, they are still considered "test" stations. This is because, based on modeling submitted by Mirant Kendall (Mirant Kendall, 2001), surface water temperatures at these stations were predicted to be influenced by Mirant Kendall's thermal plume.

The sampling stations listed above were not always evaluated by MRI on the same day over the 2004-2005 period. Data assessed here include only those from sampling days when both reference and test stations were concurrently sampled. Most of these "paired" sampling events (i.e., events that took place at both the reference station and any one particular test station) took place within 1.5 hours; the greatest period of elapsed time between paired sampling events was slightly less than 2.3 hrs.

2005 Maximum temperatures: Temperature information from the Hyatt Reference Station and the Boston Test Station demonstrates that the 28.3ºC (83ºF) maximum warm water criterion was exceeded at the surface of the water column in 2005 at several stations in the Lower Basin, downstream of the Longfellow Bridge. On five of the six paired-station sampling events that took place over the July 20 – August 23 period in 2005 excursions beyond the 28.3ºC (83ºF) criterion occurred at the Boston Test Station, but none occurred at the Hyatt Reference Station (see **Fig. 1**). Maximum inter-station lag time between these two stations on any of the sampling days used in this analysis was <1.4 hrs. Thus, any excursions beyond the maximum temperature criterion at the Boston Station were not due to high upstream water temperatures. Due to the location of the Mirant Kendall discharge, the location of the Boston Test Station and the buoyancy of the thermal discharge from Mirant Kendall, high surface water temperatures probably stretched completely across the Lower Basin of the Charles on these occasions.

Similarly, on the seven sampling dates over the July 20 – September 1 period in 2005 when temperatures were measured at both the Hyatt Reference Station and the Mid-Channel Test Station, six exceedances of the 28.3ºC (83ºF) criterion were documented at the Mid-Channel Test Station, but none were documented at the Hyatt Reference Station (see **Fig. 2**).

Delta temperatures, Hyatt Reference vs. Arthur Fielder Test Station: Surface water temperature differences between the Hyatt Reference Station and the Arthur Fiedler Test Station

exceeded the maximum delta temperature criterion on four of the 14 occasions when both stations were evaluated over the July 11 through October 11, 2005 time period (see **Fig. 3**).

Delta temperatures, Hyatt Reference vs. Boston Test Station: Surface water temperatures measurements were made at both the Hyatt Reference Station and the Boston Test Station on 17 separate days over the July 20 through October 11, 2005 period (see **Fig. 4)**. On eleven of these sampling dates the allowable delta temperature criterion of 2.8ºC (5ºF) was exceeded between the two stations.

Delta temperatures, Hyatt Reference vs. Mid-Channel Test Station: The delta temperature criterion was exceeded in surface waters between the Hyatt and Mid-Channel stations on 12 of the 14 different sampling days when concurrent sampling took place at these two stations over the July 11 through October 13, 2005 period (see **Fig. 5**).

Warming in the Lower Basin due to Kendall's thermal discharge: EPA and MassDEP conducted analyses of MRI's surface water temperature measurements for both 2004 and 2005 (see EPA Region 1's response to Mirant Kendall's Comment C3 in the Responses to Public Comments to the Mirant Kendall NPDES permit at: http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898rtcc1.pdf). This was done in part to determine if Mirant Kendall's discharge was responsible for an apparent trend in which water temperature rose with nearness to the Kendall discharge, even at fairly great distances from the discharge.

To test the null hypothesis that monitoring station distance from the Kendall discharge had no relation to water temperature, the EPA and MassDEP computed the average surface water temperature over the July-September period in 2004 and 2005 at each of a number of stations used by MRI in sampling for juvenile blueback herring and alewives. A significant rise in average water temperatures with increasing proximity to the facility would be cause to reject the null hypothesis and accept the alternate hypothesis that monitoring station distance from the Kendall discharge and mean water temperature at each station *were* related.

These agencies found that in both 2004 and 2005, average surface water temperature was significantly correlated (R-square = 0.83, $p<0.02$ for 2004 data; and R-square = 0.98, $p< 0.0002$ for 2005 data) with station distance from the Kendall discharge, and that these average temperatures rose with the proximity of each station to the discharge (see: http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898c3-6.pdf for the 2004 regression; and http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898c3-7.pdf for the 2005 regression. Both are taken from EPA, 2007). Because there was a significant rise in temperature with increasing proximity to the discharge, and because the thermal input from the facility during these periods was massive (see http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898b1-2.pdf) with no other known large thermal discharges in the area, these results caused the EPA and MassDEP to determine that the temperature rise was primarily attributable to the Kendall thermal discharge (see EPA, 2007, response to Comments on the Draft Permit, Section C3A.3: Temperature vs. distance from Mirant Kendall's discharge, at:

http://www.epa.gov/region1/npdes/mirantkendall/assets/pdfs/finalpermit/finalma0004898rtcc1.pdf).

Due to the relative buoyancy of warm water, Mirant's discharges over the summer of 2005 would be expected to primarily affect surface water temperatures. In addition, during the summer a thick layer of saline water lies along the bottom of the Lower Basin that inhibits mixing with the upper water column. Salt water enters the Lower Basin through the New Charles River Dam and Locks. Because saline water is more dense than freshwater, it sinks to the bottom of the Lower Charles Basin as it enters. As the weather warms in the spring, boat traffic through the dam and locks increases, and this is accompanied by an increase of the rate of salt water input to the Lower Charles. As the saline layer builds in the area just upstream of the dam it moves upstream. In some years the salt layer has been known to reach beyond the B.U. Bridge. When river flows increase in the fall, winter and spring much of the saline layer is driven out of the Lower Basin. The salt layer begins to build again as river flows decrease and boat traffic increases in the late spring. Due to a density differential between fresh water in the upper water column and saline water in the lower water column thermal mixing between the two layers is inhibited.

Based on to the issues outlined in the preceding paragraph, it appears logical to believe that Mirant's Btu input to the Lower Charles would primarily be expended in the upper water column.

Additional analysis regarding the MRI datasets can be found in the segment of this memorandum entitled "Reasonable Cause for Criteria Exceedances" (beginning on pg. 4).

SUMMARY

Based on the field data collected from EPA, MWRA, and MRI, multiple exceedances of both the delta temperature criterion and the maximum temperature criterion for Class B Warm Water occurred at the surface of the water column over the summer and early fall, 2005 in the Lower Basin of the Charles. Exceedances occurred throughout the Lower Basin, downstream of the Watertown Dam, on at least on one occasion in 2003. One exceedance of the delta temperature criterion was seen in 2004.

In 2005 a large number of exceedances of the maximum temperature criterion occurred in the Lower Basin. In that year, the maximum temperature criterion was exceeded throughout the portion of the Lower Basin that extends from a point slightly downstream of the Harvard Bridge, and at a number of monitoring locations farther downstream, to a point about half-way between the Museum of Science and the new Charles River Dam (no monitoring was conducted at points farther downstream). This is a distance of approximately 1.5 miles. At some stations, especially those downstream of the Longfellow Bridge, exceedances of the maximum criterion occurred on most of the sampling events that occurred over about a six-week period from mid-July through August, 2005.

Exceedances of the maximum temperature criterion were not seen at locations upstream of the Harvard Bridge over this period. Due to the large volume of heated water discharged by the

Mirant Kendall facility during the summer of 2005, the lack of any other known large thermal discharges in this area of the Lower Basin over the summer of 2005, the lack of criteria exceedances at points upstream of the Harvard Bridge, and the close association between Btu input from the facility in 2004 and 2005 and delta temperature rise in surface waters of the Lower Basin per change in distance from the Kendall discharge, it appears reasonable to assume that the exceedances of the maximum warm-water temperature criterion seen in 2005 were primarily due to the influence of the heated discharge from Mirant Kendall.

A large number of exceedances of the delta temperature criterion were also noted in the summer and early fall in 2005. These were determined by a comparison of surface water temperature measurements taken at stations near the B.U. Bridge compared to those taken at sites downstream. The delta temperature exceedances were primarily limited to stations that were located within 0.4 miles from the Mirant Kendall thermal discharge although temperature differences between an upstream "reference" station and one "test" station located about 0.75 miles downstream of the Kendall discharge exceeded the delta temperature criterion on four occasions in 2005. It is unclear whether or not the Mirant Kendall thermal discharge was completely responsible for the delta temperature exceedances seen at this particular station, or whether another unknown discharge or other conditions exacerbated the already-high water temperatures attributable to the Mirant Kendall discharge.

Zone of Passage Issues: The Arthur Fiedler and the Boston test stations are near the Boston shoreline and across the river from the Kendall thermal discharge. Delta temperature exceedances as well as maximum temperature exceedances were seen at both these stations and are of concern with regard to zone of passage for fish and other organisms. This concern stems from the fact that exceedances seen at the Arthur Fiedler and Boston test stations indicated that high temperatures and/or high delta temperatures probably stretched from the Cambridge shoreline (where Kendall's thermal discharge is located) completely across the surface of the Lower Basin to the Boston shoreline.

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APPENDIX 1
2005 Surface Water Temperatures at MWRA Stations

Data listed below include all surface water temperature measurements for the five MWRA stations listed below over the July-September, 2005 period, from days when all five stations were sampled. Surface water temperatures reported below were measured at either 0.1 m or 0.3 m below the surface as the MWRA dataset includes information from two different study types. Maximum and delta temperature exceedances are highlighted**.** Exceedances of the MA Water Quality Standard's delta temperature criterion of 2.8ºC (5ºF) considered to be due to a discharge were calculated by comparing temperatures at Stations 008-011 with those at the "reference" station, 006. The single exceedance seen at Station 010 is considered to be due to the Kendall discharge. Those at Station 011, although thought to be primarily influenced by Mirant Kendall's discharge, may have been enhanced by other, unknown discharges (see text). Note that no exceedances of the maximum temperature criterion occurred at the "reference" station (Station 006).

Station	Date	Time of day	Temp. (ºC)	Temp. (ºF)	Delta Temp. (ºC)	Delta Temp.(ºF)
006	20-Jul-05	8:58 AM	27.1	80.7		
008	20-Jul-05	8:22 AM	27.6	81.7	0.5	0.9
009	20-Jul-05	7:52 AM	**29.4**	**85.0**	2.4	4.2
010	20-Jul-05	7:33 AM	**29.3**	**84.7**	2.2	3.9
011	20-Jul-05	7:13 AM	**29.5**	**85.1**	2.4	4.3
006	21-Jul-05	8:50 AM	27.5	81.6		
008	21-Jul-05	8:21 AM	**29.0**	**84.1**	1.4	2.6
009	21-Jul-05	8:00 AM	**29.4**	**84.9**	1.9	3.3
010	21-Jul-05	7:42 AM	**29.2**	**84.6**	1.7	3.0
011	21-Jul-05	7:24 AM	**29.6**	**85.3**	2.1	3.7
006	10-Aug-05	8:35 AM	25.7	78.3		
008	10-Aug-05	8:06 AM	26.3	79.3	0.6	1.1
009	10-Aug-05	7:51 AM	**28.4**	**83.1**	2.7	4.9
010	10-Aug-05	7:35 AM	28.2	82.8	2.5	4.6
011	10-Aug-05	7:22 AM	**28.5**	**83.3**	**2.8**	**5.1**
006	11-Aug-05	9:03 AM	26.4	79.5		
008	11-Aug-05	8:30 AM	26.9	80.5	0.5	0.9
009	11-Aug-05	8:14 AM	**29.1**	**84.4**	2.7	4.8
010	11-Aug-05	7:57 AM	**28.6**	**83.4**	2.2	3.9
011	11-Aug-05	7:38 AM	**29.0**	**84.3**	2.6	4.7
006	30-Aug-05	11:22 AM	24.9	76.9		
008	30-Aug-05	10:52 AM	25.8	78.5	0.9	1.6
009	30-Aug-05	10:43 AM	27.0	80.6	2.1	3.8
010	30-Aug-05	10:35 AM	27.4	81.4	2.5	4.5
011	30-Aug-05	10:23 AM	27.8	82.0	**2.8**	**5.1**
006	31-Aug-05	8:46 AM	24.8	76.6		
008	31-Aug-05	8:20 AM	25.5	77.9	0.7	1.3
009	31-Aug-05	8:09 AM	26.1	79.0	1.3	2.3

Station	Date	Time of day	Temp. (ºC)	Temp. (ºF)	Delta Temp. (ºC)	Delta Temp.(ºF)
010	31-Aug-05	7:53 AM	27.2	81.0	2.4	4.3
011	31-Aug-05	7:37 AM	27.4	81.3	2.6	4.6
006	20-Sep-05	9:21 AM	22.3	72.1		
008	20-Sep-05	8:47 AM	22.8	73.0	0.5	0.9
009	20-Sep-05	8:32 AM	24.4	75.8	2.1	3.8
010	20-Sep-05	8:15 AM	25.6	78.0	**3.3**	**6.0**
011	20-Sep-05	7:57 AM	25.5	77.8	**3.2**	**5.8**
006	21-Sep-05	9:03 AM	21.6	70.8		
008	21-Sep-05	8:26 AM	22.2	72.0	0.7	1.2
009	21-Sep-05	8:11 AM	24.2	75.5	2.6	4.7
010	21-Sep-05	7:53 AM	24.2	75.5	2.6	4.7
011	21-Sep-05	7:38 AM	24.7	76.4	**3.1**	**5.6**

Figures

Fig. 1. 2005 Surface water temperatures at Hyatt and Boston stations for all days when both stations were sampled over the July 20- August 23 period are depicted below. Data source: Mirant Kendall

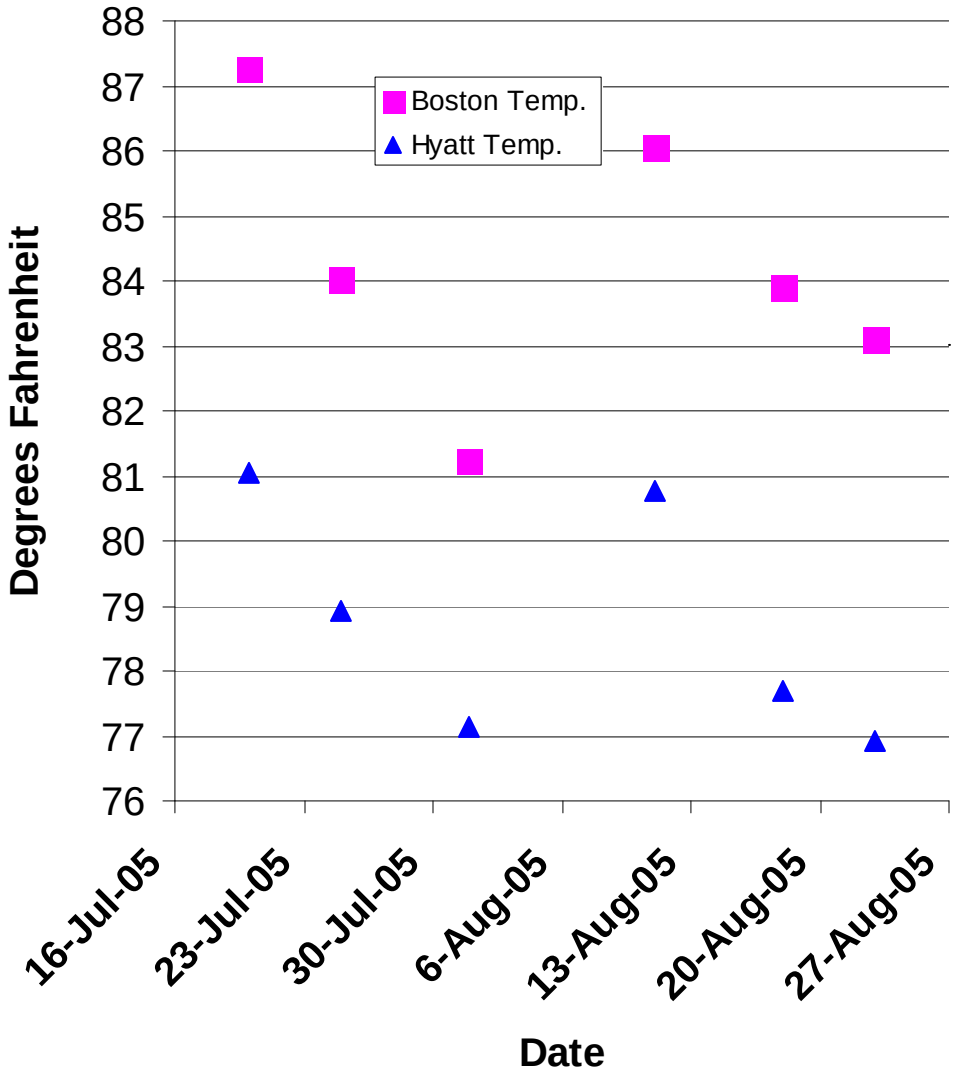

Fig. 2. 2005 Surface water temperatures at the Hyatt and Mid-Channel stations from all dates when sampling was conducted at both stations over the July 11 - Sep. 1 period are depicted below. Data source: Mirant Kendall

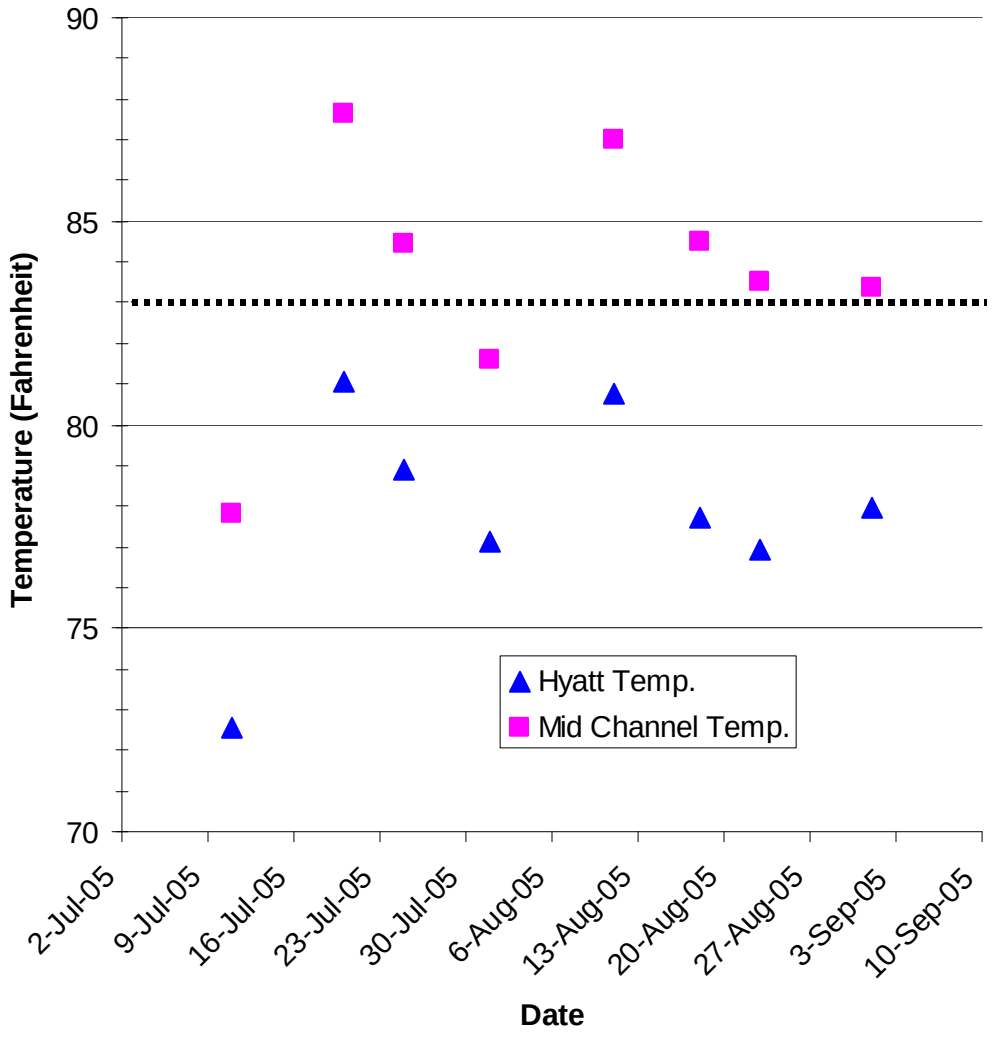

Fig. 3. 2005 Delta Temperatures between Hyatt and A.Fiedler stations (2 ft. depth) from all dates when sampling was conducted at both stations over July 11-Oct. 11; max. inter-station temporal differences between stations on any day was 1 hr. 22 min.

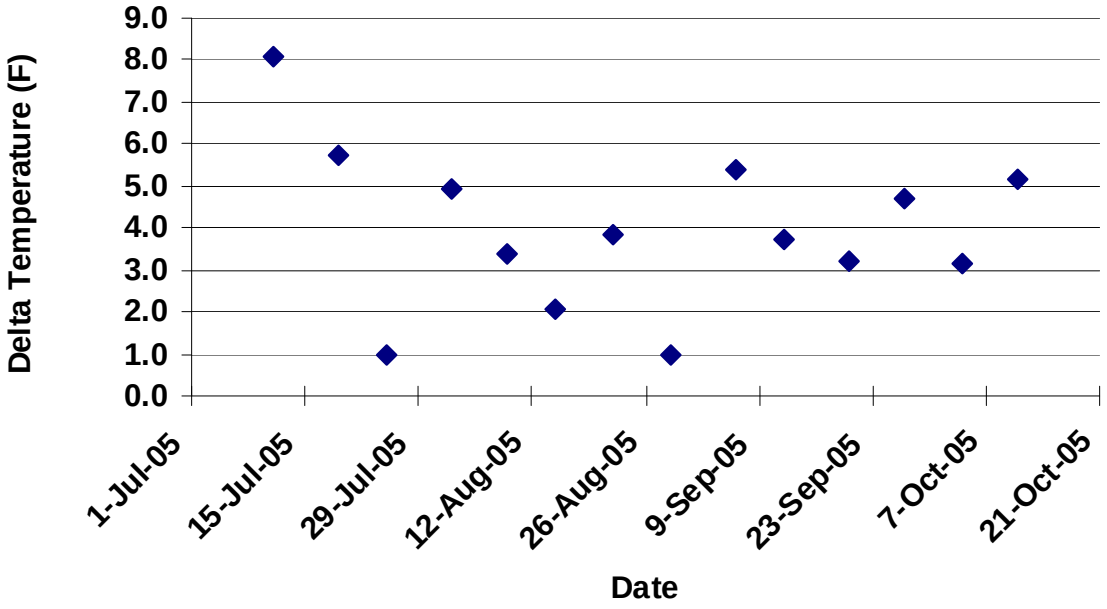

Fig. 4. 2005 Delta Temperature (F) between Hyatt and Boston stations (surface water) from days when sampling was conducted at both stations over July 20-Oct. 11; maximum interstation time lag for any day was 1.75 hrs; data from Mirant Kendall

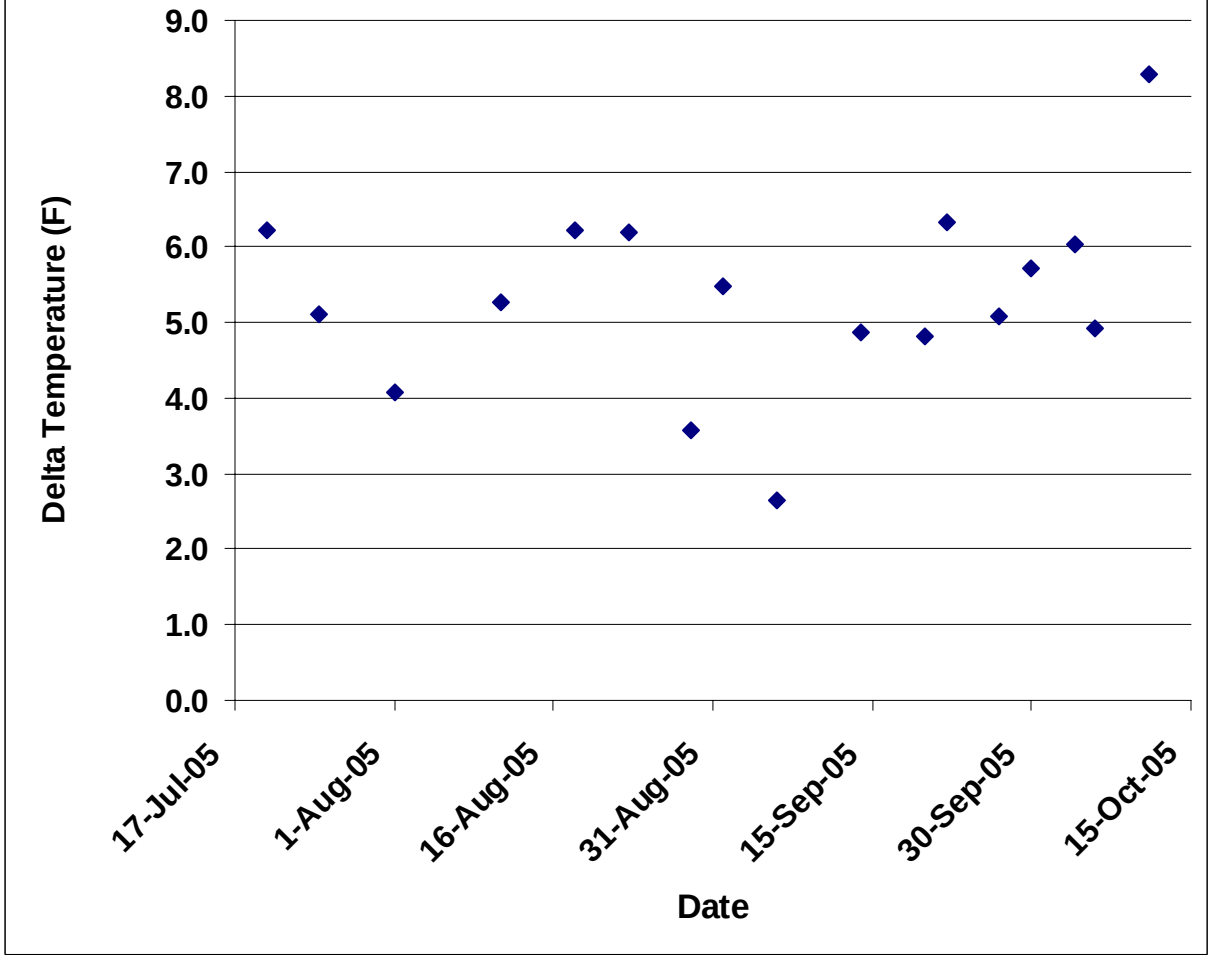

Fig. 5. 2005, Delta Temperatures between Hyatt and Mid-Channel Stations (surface water) from days when sampling was conducted at both stations over July 11 - Oct. 13; maximum interstation time lag for any day was <2.3 hrs; data from Mirant Kendall