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28 July 2009

Mark D. Driscoll, M.S.
Senior Water Resources Scientist
ESS Group, Inc.
888 Worcester Street, Suite 240
Wellesley, MA 02482

SUBJECT: FINAL REPORT
POST CABLE INSTALLATION
THERMAL MONITORING PROGRAM
LONG ISLAND REPLACEMENT CABLE PROJECT
NORWALK, CT
OSI JOB# 08ES069

Dear Mr. Driscoll:

During the period 17 September 2008 through 27 January 2009 Ocean Surveys, Inc. (OSI) conducted a sediment temperature monitoring program for ESS Group, Inc. (ESS) as part of the ongoing environmental investigation for the Long Island Replacement Cable (LIRC) Project in Norwalk, CT. Temperature probes were installed in the sediment at two distinct testing areas (Figure 1) to record in situ temperature fluctuations caused by the current load of the newly installed cables. All work was conducted from the *R/V Ready II* by a three-person OSI field team consisting of a Project Manager (Diver), Project Scientist (Diver), and a Field Engineer (Dive Tender). The following report outlines the operational aspects of the instrument installation including the equipment and methods used during the survey, a summarized schedule of operations, and a detailed data discussion accompanied by time series plots of all the data.

FIELD OPERATIONS SCHEDULE

The probes remotely recorded temperature on site over a 133-day period requiring only two trips to the project site for installation and recovery of the probes. The first trip was made on 17 September 2008 and included all equipment installations. OSI returned on 27 January 2009 for the recovery of the *in situ* instrumentation.

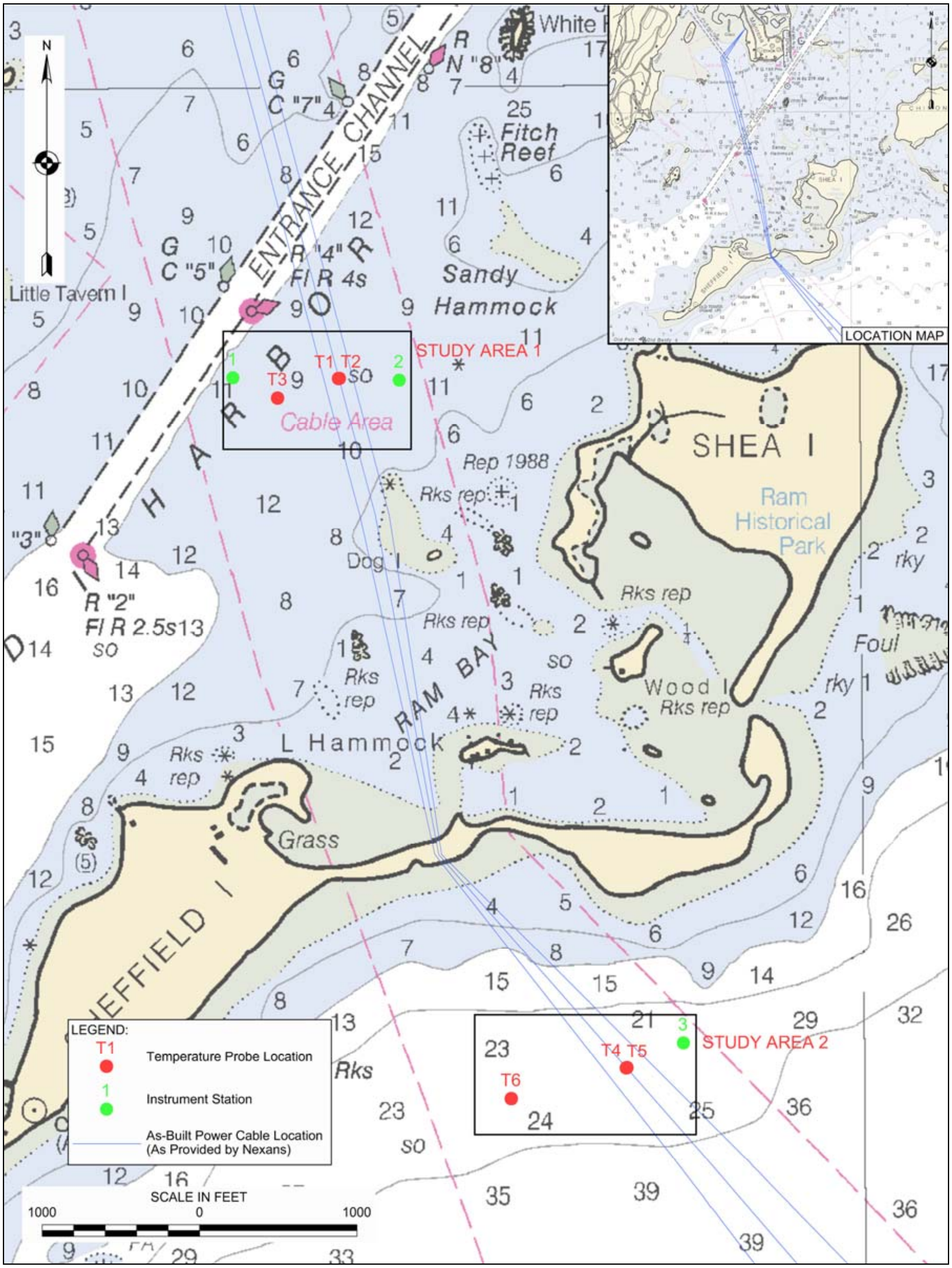


Figure 1. Location map showing the positions of the sampling stations.

[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

VESSEL AND EQUIPMENT

The fieldwork was completed on the *R/V Ready II*, a 25-foot fiberglass survey vessel with a fully enclosed cabin and twin 150 HP outboard engines. The boat was equipped with a suite of instrumentation including radar and VHF radio to ensure safe vessel navigation in a wide range of weather conditions. An onboard hoisting davit with winch and ample deck space enable the *R/V Ready II* to handle instruments and equipment for a wide variety of data collection operations (Figure 2).

Figure 2. Survey Vessel *R/V Ready II.*

Vessel Navigation and Equipment Positioning

A Trimble DSM 4000 series Global Positioning System (GPS) interfaced with a HYPACK hydrographic software package was used for vessel navigation and instrument positioning. The navigation system receives GPS satellite transmissions every second and converts these data into x-y grid coordinates in the specified coordinate system. Differential position correctors received from a local U.S. Coast Guard DGPS radio transmitter are applied to the stand-alone satellite transmissions by the GPS receiver. This is done to correct for transmission errors caused by atmospheric variability and multi-path error. The corrected position data are recorded by the navigation computer and displayed as a text string in real-time. The navigation computer simultaneously projects a facsimile of the survey vessel onto a geo-referenced digital image of the survey area, and displays this image on a video monitor visible to the vessel operator. The complete navigation system provides a highly accurate visual representation of the survey vessel location in real time as well as simultaneous target acquisition and data logging capabilities.

[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

All project coordinates were referenced to the New York State Plane Coordinate System, Long Island Zone, North American Datum 1983 (NAD 83), in units of feet. All times are expressed in UTC, Universal Coordinated Time (or Greenwich Mean Time - GMT).

Sediment Temperature Monitoring

The purpose of the thermal monitoring program was to document any changes in sediment temperatures at 4-foot, 2-foot, and 1-foot intervals below the sediment/water interface. Data were collected from within two specific areas: the first in soft sediment within an oyster lease in Norwalk Harbor, (T1-T3) and the second on the south side of Sheffield Island in a sandy clam habitat area, (T4-T6). Three thermal probes were installed within each of the 2 study areas. Specifically, probes were placed:

A. Directly over the top of Cable #2, (T1 and T4)
B. 3-feet east of Cable #2, (T2 and T5)
C. At a background station 50-ft west of the position of the removed Cable #1, (T3 and T6)

Temperature was measured using specialized thermal probes and data loggers (Figures 3 and 4). Each thermal probe contained seven (7) Onset HOBO Water Temp Pro v2 data loggers. These data loggers have an accuracy of ±0.3°F and were set up to record every 15 minutes. The loggers were positioned within each probe so that temperatures were recorded at:

A. 0.1 foot above the sediment/water interface (1 primary unit)
B. 1-foot below the sediment/water interface (1 primary and 1 backup unit)
C. 2-feet below the sediment/water interface (1 primary and 1 backup unit)
D. 4-feet below the sediment/water interface (1 primary and 1 backup unit)

The thermal probes were installed using a two-man dive team. The divers jetted the probes into the sediment to the desired depth using a high-pressure water jetting system. The probes were recovered in the same manner after the four-month deployment period. One probe, (T4), was lost during the survey period. Diver observations during the recovery indicated the probe might have been hit during fishing activities in the area. The recorded temperature data of the remaining probes are presented as time series plots and provided as ASCII data listings on CD-ROM.

Figure 3. Onset HOBO Water Temp Pro V Data Logger.

[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

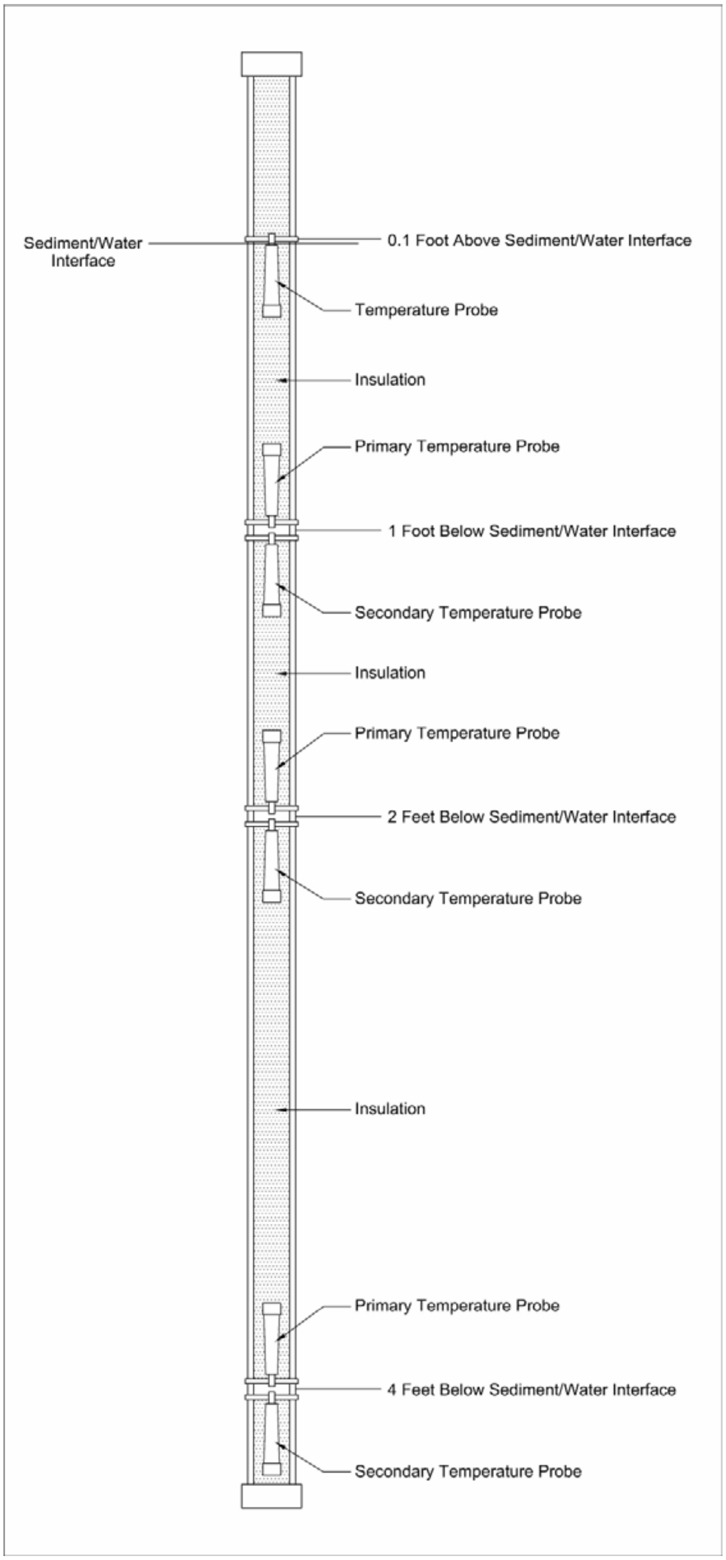


Figure 4. Thermal Probe

[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

DATA DISCUSSION

Overview

The temperature data collected by the probes showed a gradual seasonal change throughout the deployment. The mean starting temperature in September for the inner harbor was 67.3 °F while the mean starting temperature for the offshore location was 68.7 °F. The mean ending temperature in January was 39.9 °F for the inner harbor and 38.7 °F for the offshore location, see Table 1.

Table 1. Mean Temperature Values

Probe Depth	Inner Harbor		Offshore	
	Starting Temperature	Ending Temperature	Starting Temperature	Ending Temperature
- 0.1 ft	71.2 °F	32.5 °F	70.9 °F	32.9 °F
1.0 ft	69.2 °F	37.7 °F	69.9 °F	36.8 °F
2.0 ft	66.8 °F	41.7 °F	68.6 °F	39.8 °F
4.0 ft	61.9 °F	47.9 °F	65.4 °F	45.3 °F
Mean	67.3 °F	39.9 °F	68.7 °F	38.7 °F
UCONN	71.2 °F	32.5 °F	71.2 °F	32.7 °F

When the probes were installed in September 2008, the near bottom water temperatures (-0.1 ft probes) were higher than the sediment temperatures, which decreased with depth down to the lowest probe at 4.0 ft into the sediment. As water temperatures began to cool during the fall months, the sediment temperatures decreased at a much slower rate as the sediment naturally retained heat. A transitional period took place in mid to late October when water and sediment temperatures were roughly the same. As the water temperatures continued to cool into the winter months, the difference between sediment temperatures at various depths and water temperature became more evident (see graphs in Attachment 1). Throughout the deployment, water temperatures decreased an average of 38.4 °F while the deepest sediment temperatures only decreased an average of 15.3 °F.

Water Temperatures

The near bottom water temperature probes installed 0.1 ft off the bottom were cross-checked with the UCONN water quality moorings installed at instrumentation stations in the vicinity of the thermal probes (Figure 1). Each UCONN moorings consisted of a current meter, sediment trap and YSI Model 6000 UPG (or equivalent) water quality sonde recording water temperature, salinity and turbidity. The YSI temperature data was utilized for comparisons with this data set. The OSI and UCONN data sets were relatively similar throughout the deployment period (Figures 5 & 6). Temperature fluctuations of 2 to 4 °F occurred twice a day consistent with tidal variations. Larger regional temperature fluctuations that occurred on the order of 4 to 10 days were most likely caused by local weather/rain events.

[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

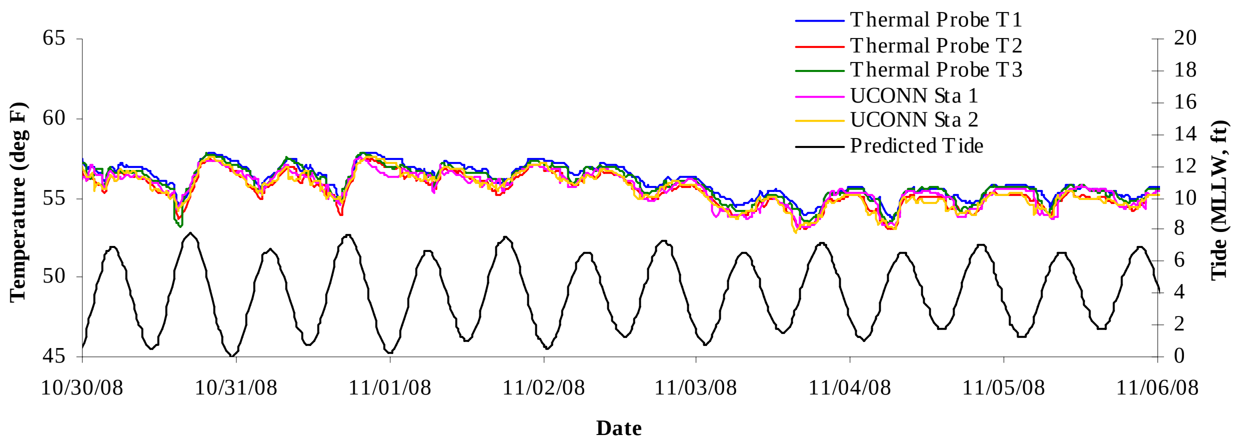


Figure 5. Near-bottom water temperature within Sheffield Harbor.

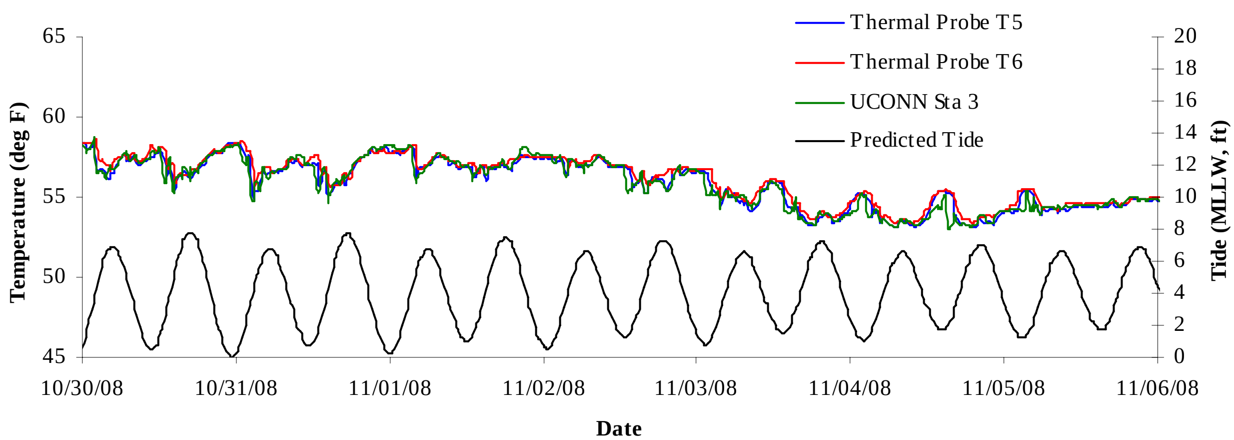


Figure 6. Near-bottom water temperature offshore Sheffield Island.

Temperature at Depth Comparison

The following graphs (Figure 7-9) show temperature comparisons between Thermal Probes T1-T3 for various sediment depths. In Figures 7 & 8 the temperature data for T1 appears to be slightly cooler at the beginning of the deployment and slightly warmer near the end. This is most likely due to the fact that the thermal probe was installed inside the cable installation trench. This produced the effect discussed earlier where deeper probes experience more insulation from the surrounding sediment. In Figure 9 there is evidence that the T1 thermal probe was being heated by an outside source that is not seen by the other two probes. On several occasions throughout the deployment, this sensor experiences small fluctuations in temperature, irregular in nature, upwards of 1 to 3 °F and a general warming of the probe over longer durations.

[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

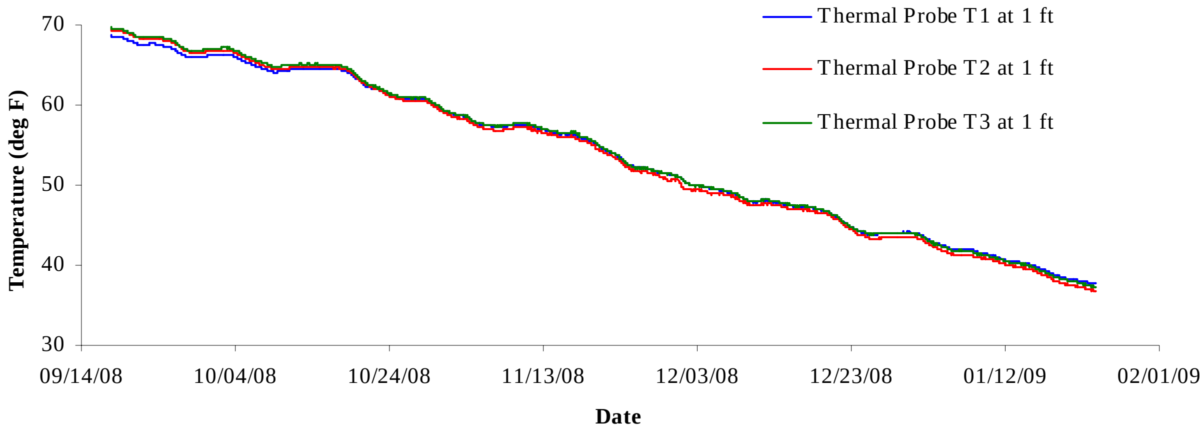


Figure 7. Sheffield Harbor temperature data 1 ft into sediment.

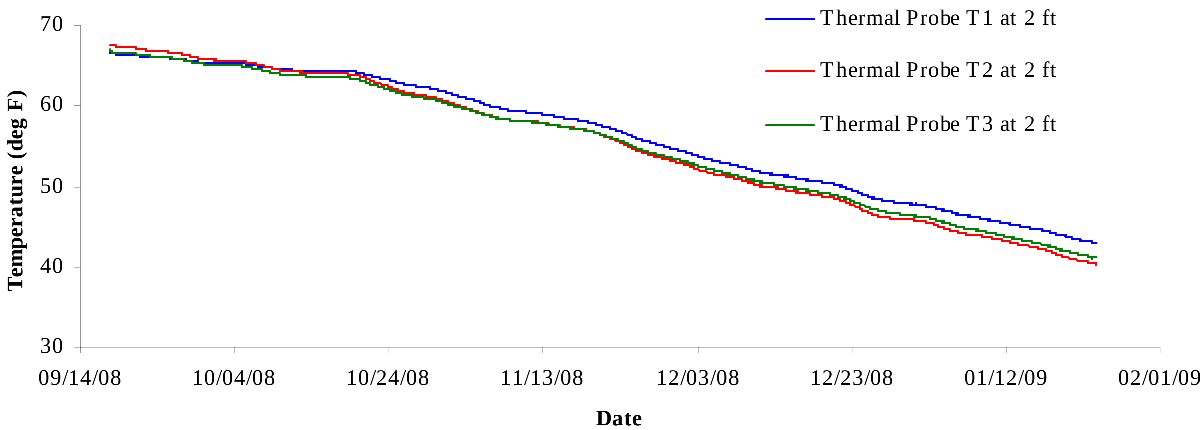


Figure 8. Sheffield Harbor temperature data 2 ft into sediment.

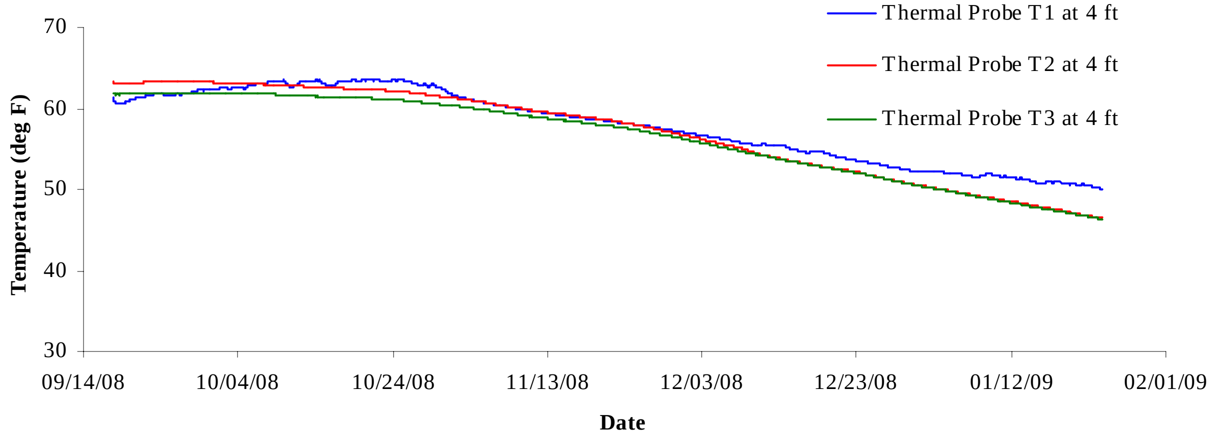


Figure 9. Sheffield Harbor temperature data 4 ft into sediment.

[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

Cable Load Influences

Figure 10 displays the 4 ft deep temperature data for all three Sheffield Harbor thermal probes as it compares to cable load data provided by Northeast Utilities. Fluctuations in temperatures at the T1 thermal probe 9 (directly over Cable #2) appear to correlate with periods of cable load. As mentioned earlier these fluctuations were on the order of 1 to 3 °F and a general warming of the probe over longer durations. The sediment temperatures appear to subside back to normal conditions during the period of 30 October through 10 December when there was no load on the cable. However, later in the deployment the cable was turned off from 12-30 December and the sediment appears to have retained the heat remaining consistently 2 °F warmer than the other two probes.

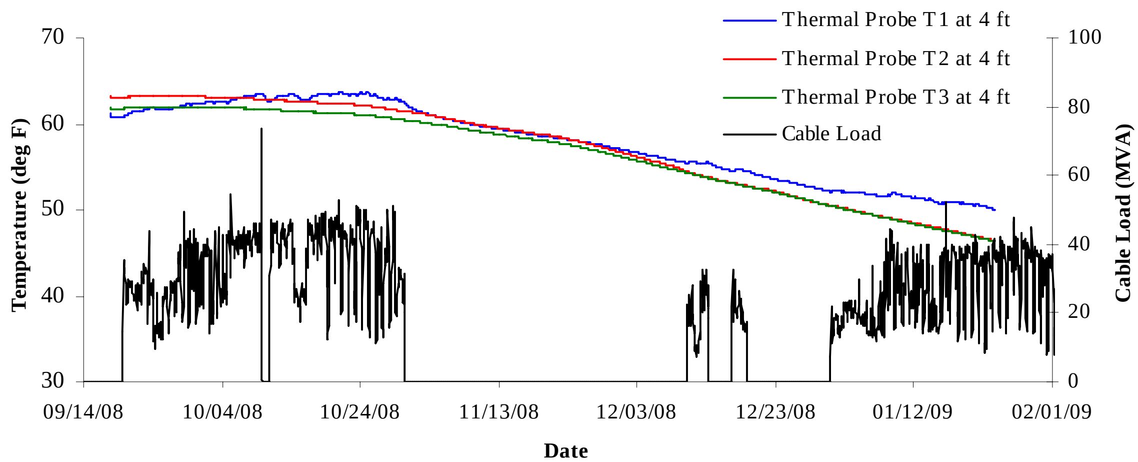


Figure 10. Cable load influence on sediment temperature.

The thermal probe deployments revealed that the heat generated by the submarine cables while they are under an electrical load, likely influences the sediment temperature at the immediate cable/sediment interface, which is well below the area of greatest biological activity (top 30 cm) (Hines and Comtois, 1985[1]). Heat generated by the cable was not seen to influence temperatures within two feet of the seabed. It was also shown that water temperature fluctuations near the seabed, both seasonally and weekly from weather/rain events, play a strong role in the sediment temperatures within the first foot of the seabed, the most biologically active zone.

A digital copy of this report, including all attachments and project data files, is included on the enclosed CD-ROM.

If you have any further questions regarding the operational aspects of this project, please do not hesitate to contact me. It has been a pleasure to contribute to this project, and we look forward to working with you in the future.

Sincerely,

Ken Cadmus
Manager – Coastal Sciences

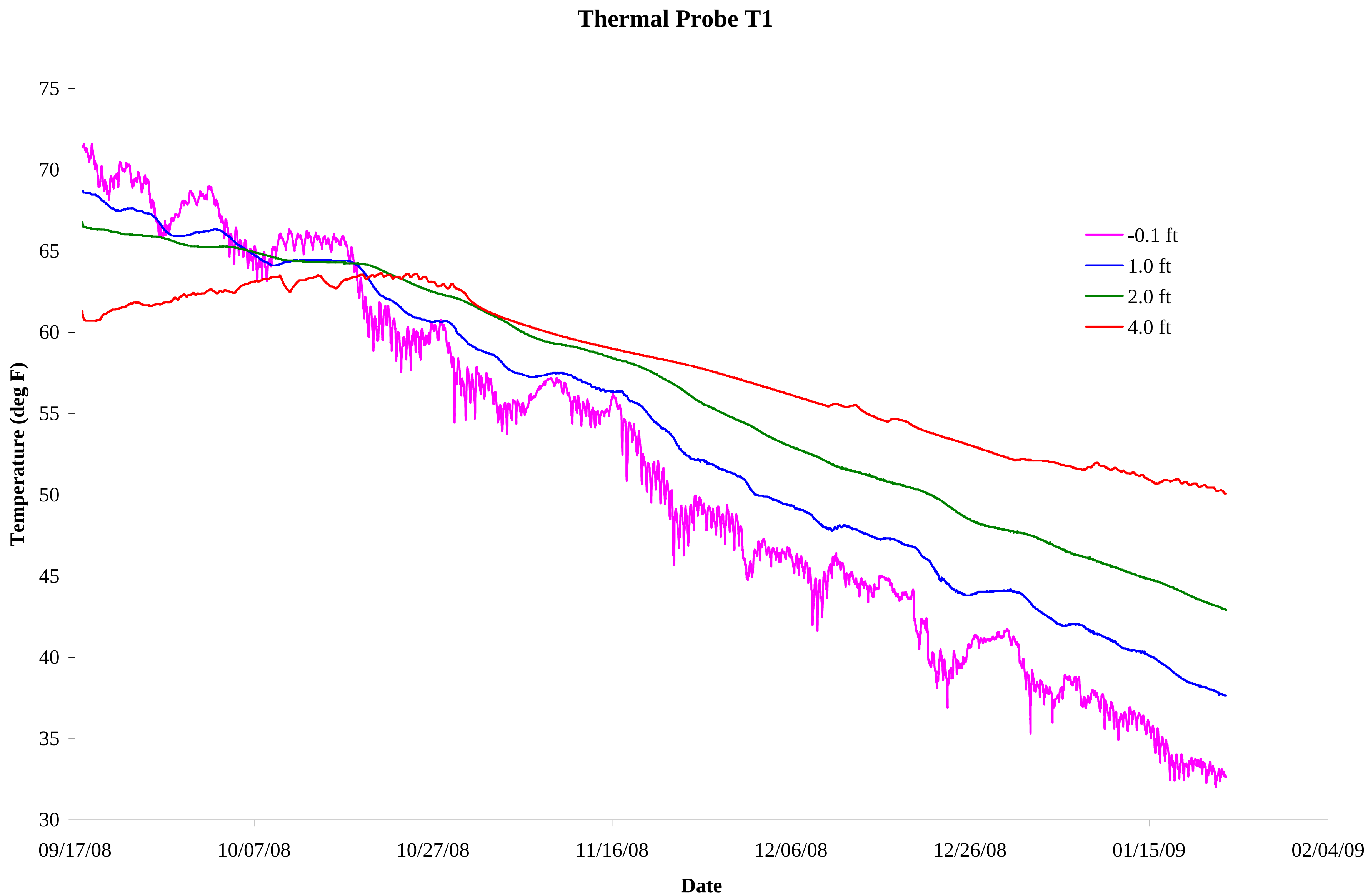
[1] Hines, A.H. & K.L. Comtois. 1985. Vertical distribution of infauna in a subestuary of central Chesapeake Bay. Etuaries, vol. 8. no 3. p. 296-304.

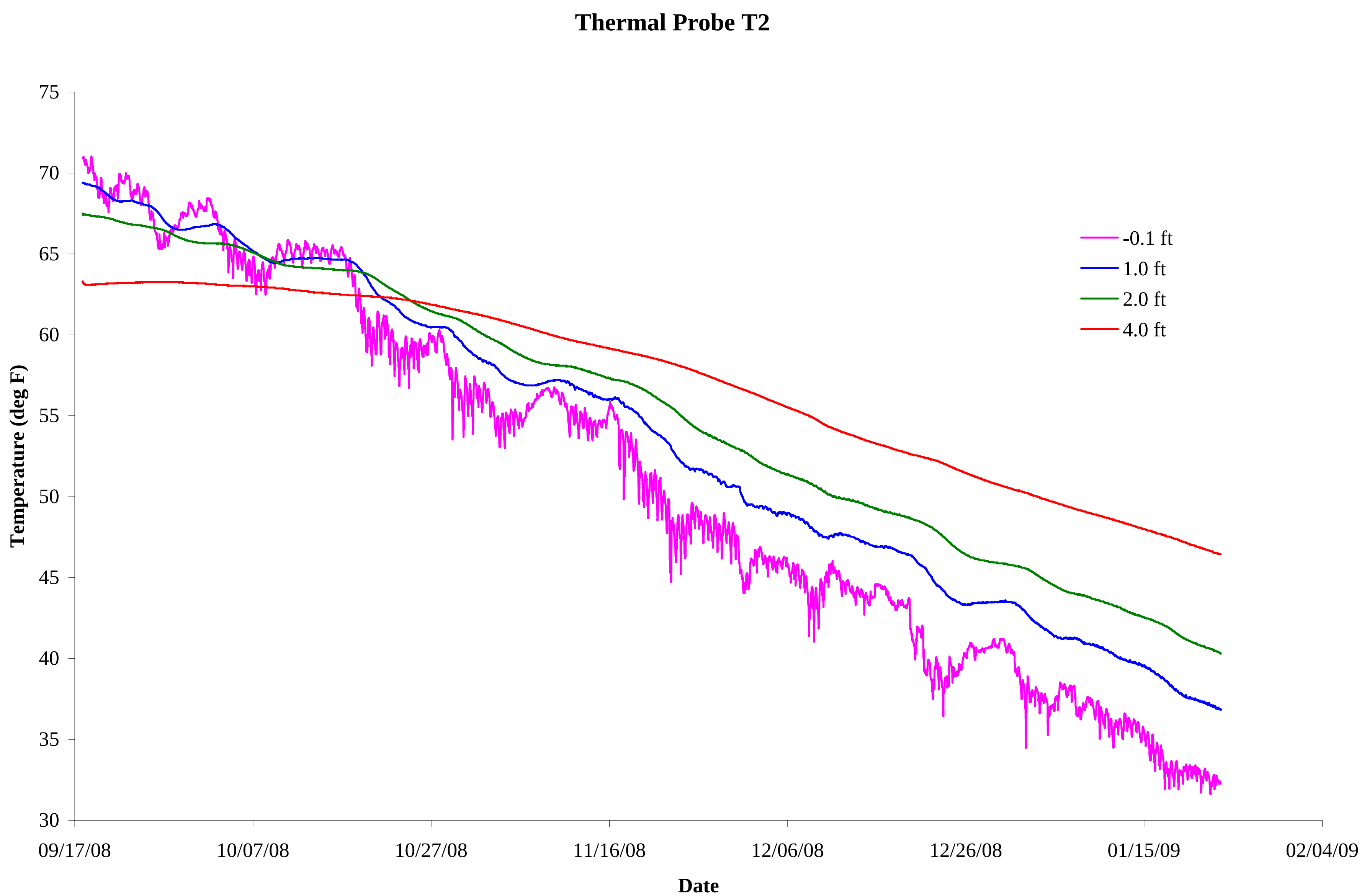
ATTACHMENT 1

TEMPERATURE PROBE DATA

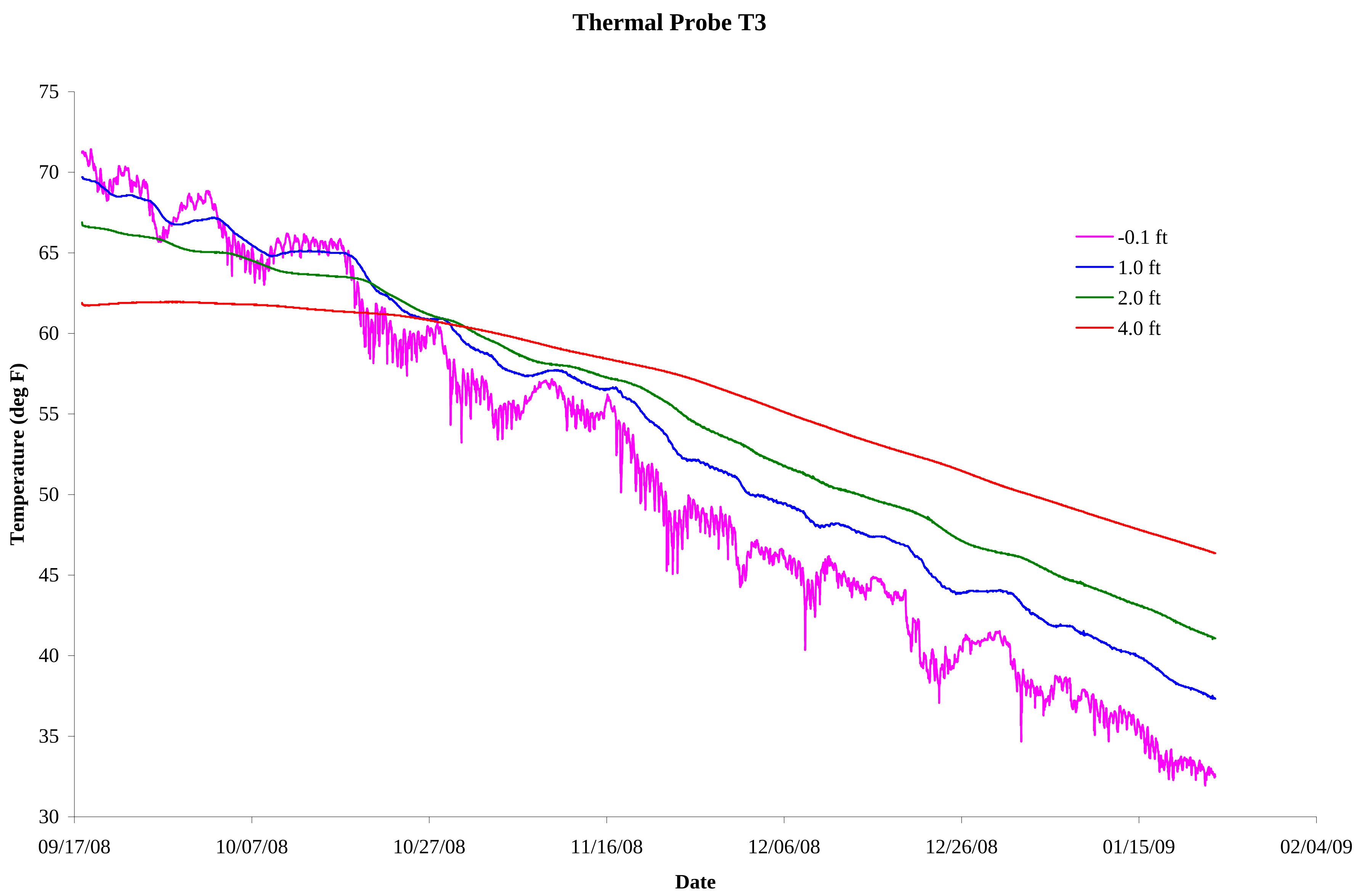
Long Island Replacement Cable Project
Norwalk, CT

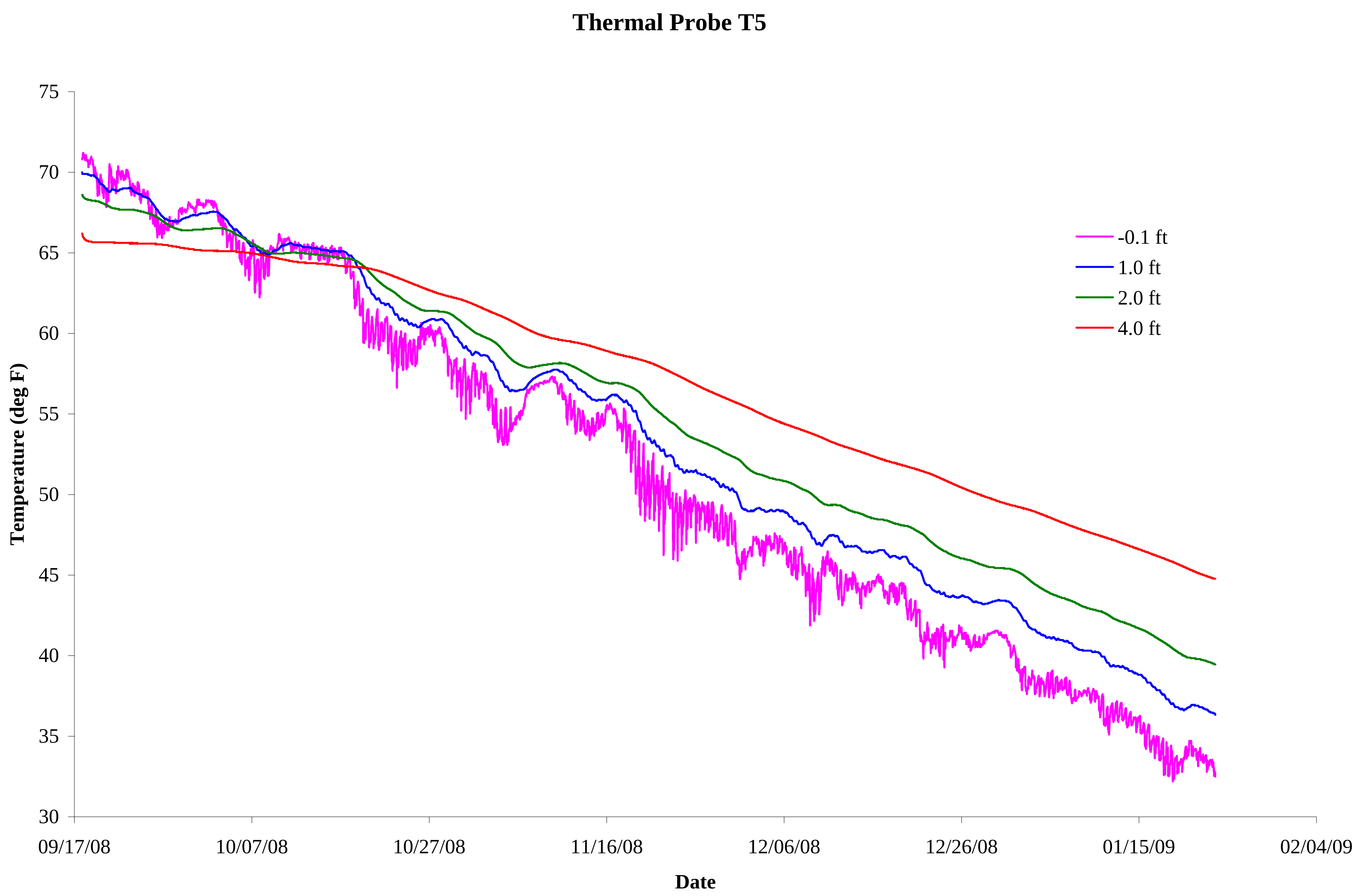
September 2008 – January 2009


Thermal Probe T1
Temperature (deg F)
75
70
65
60
55
50
45
40
35
30
09/17/08
10/07/08
10/27/08
11/16/08
12/06/08
12/26/08
01/15/09
02/04/09
Date
-0.1 ft
1.0 ft
2.0 ft
4.0 ft

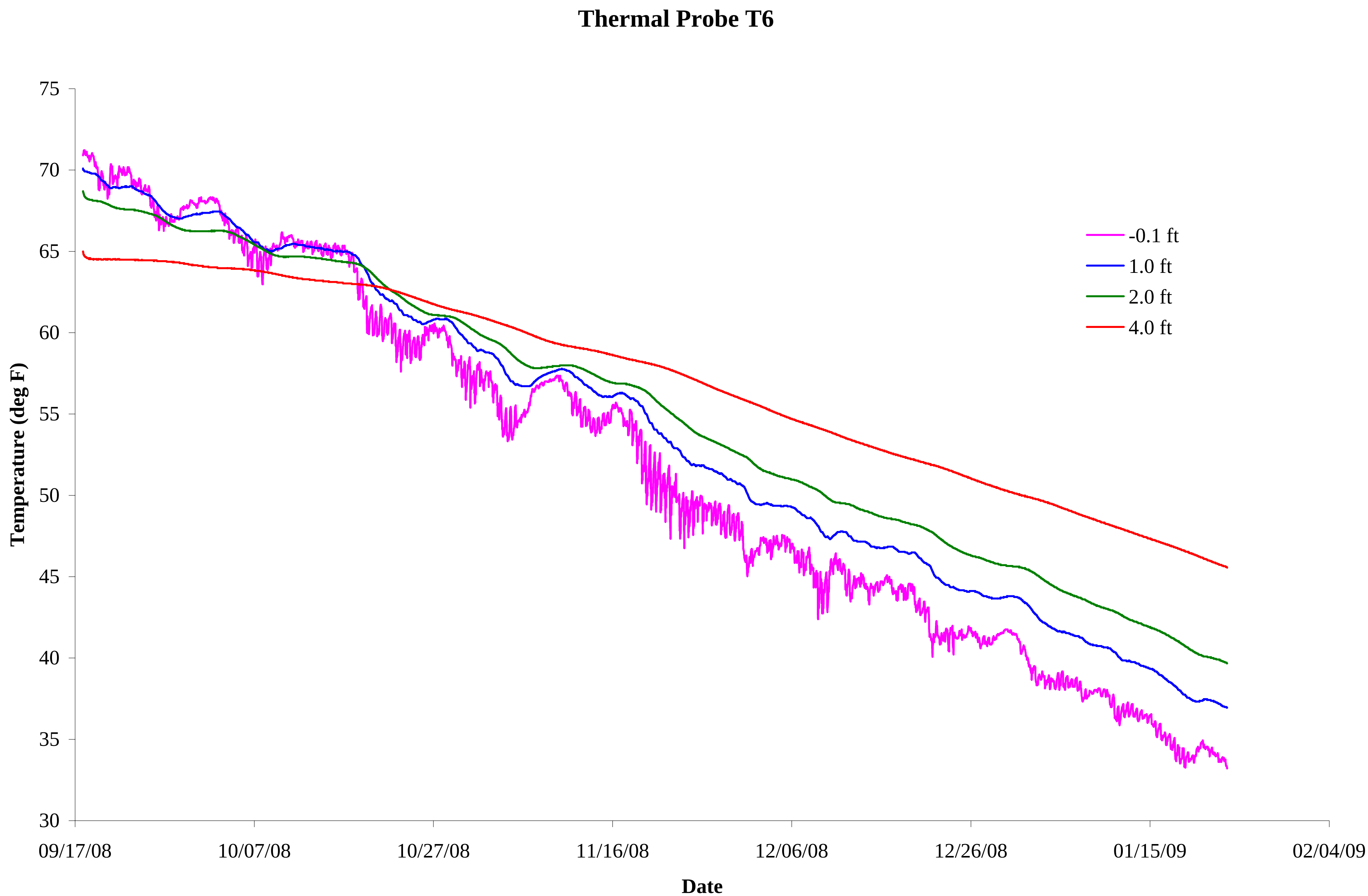


Thermal Probe T2
Temperature (deg F)
75
70
65
60
55
50
45
40
35
30
09/17/08
10/07/08
10/27/08
11/16/08
12/06/08
12/26/08
01/15/09
02/04/09
Date
-0.1 ft
1.0 ft
2.0 ft
4.0 ft

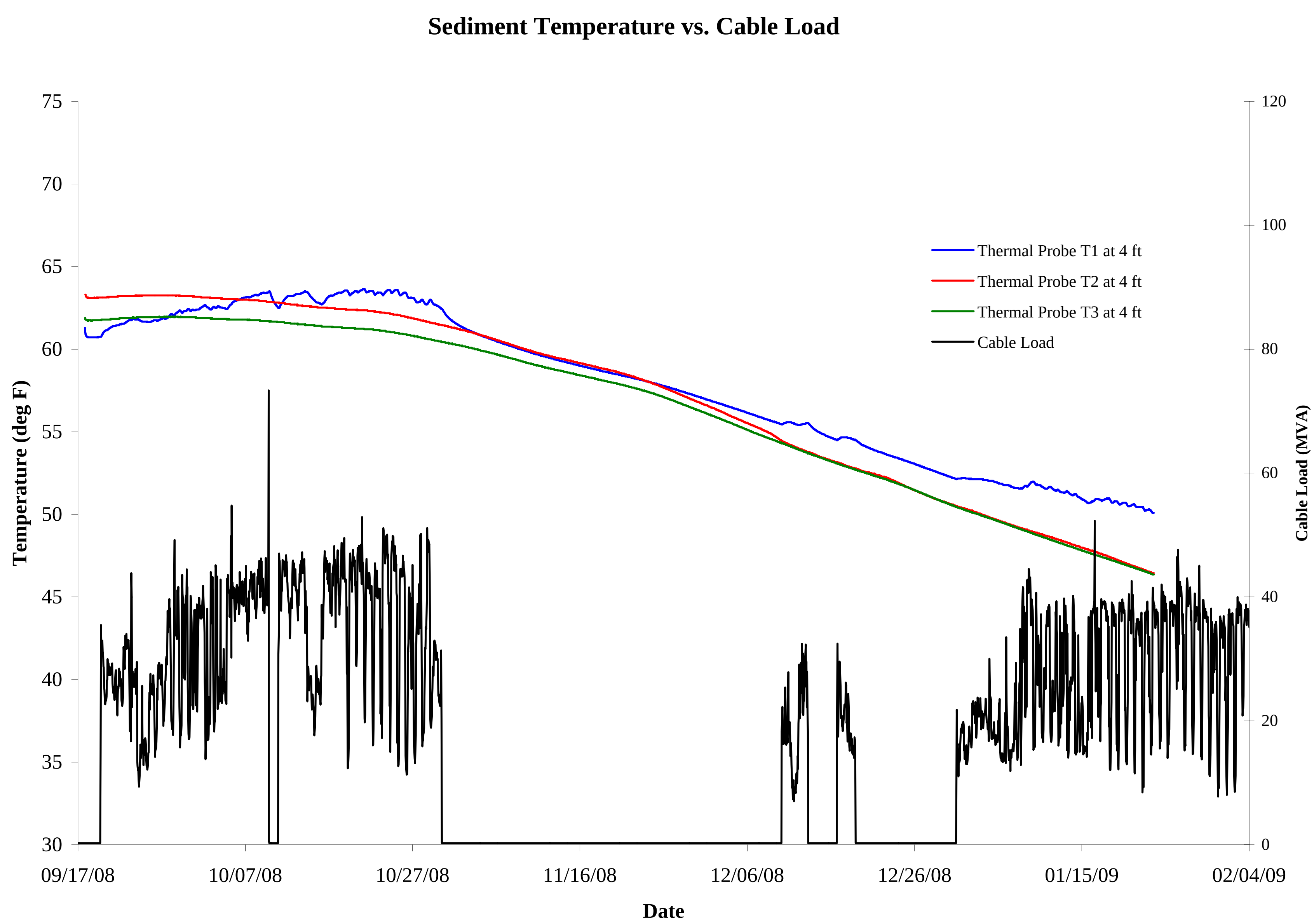

Thermal Probe T3
Temperature (deg F)
75
70
65
60
55
50
45
40
35
30
09/17/08
10/07/08
10/27/08
11/16/08
12/06/08
12/26/08
01/15/09
02/04/09
Date
-0.1 ft
1.0 ft
2.0 ft
4.0 ft



Thermal Probe T5
Temperature (deg F)
75
70
65
60
55
50
45
40
35
30
09/17/08
10/07/08
10/27/08
11/16/08
12/06/08
12/26/08
01/15/09
02/04/09
Date
-0.1 ft
1.0 ft
2.0 ft
4.0 ft



Thermal Probe T6
Temperature (deg F)
75
70
65
60
55
50
45
40
35
30
09/17/08
10/07/08
10/27/08
11/16/08
12/06/08
12/26/08
01/15/09
02/04/09
Date
-0.1 ft
1.0 ft
2.0 ft
4.0 ft


Sediment Temperature vs. Cable Load
Temperature (deg F)
75
70
65
60
55
50
45
40
35
30
Cable Load (MVA)
120
100
80
60
40
20
0
Thermal Probe T1 at 4 ft
Thermal Probe T2 at 4 ft
Thermal Probe T3 at 4 ft
Cable Load
09/17/08
10/07/08
10/27/08
11/16/08
12/06/08
12/26/08
01/15/09
02/04/09
Date