



EXPANDED HEAT REMOVAL PILOT STUDY QUARTERLY REPORT

BRIDGETON LANDFILL

BRIDGETON, ST. LOUIS COUNTY, MISSOURI

July 2016

Prepared For:

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Expanded Heat Removal Pilot Study

Quarterly Report

Bridgeton Landfill, LLC

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1 INTRODUCTION

This document is being submitted as a quarterly update regarding the Expanded Heat Removal Pilot Study underway in the South Quarry of the Bridgeton Landfill in Bridgeton, Missouri. This update was requested by the Missouri Department of Natural Resources (MDNR) in a letter dated September 4, 2014, and includes a summary of work and data collected during the Second Quarter 2016 operational period.

The following discussion includes a summary of activities and field data compiled during the Second Quarter 2016 operational period regarding the Heat Extraction System Pilot Study underway at the Bridgeton Landfill (BL). This quarterly update provides a presentation of in-waste temperature measurements, heat removal results for each removal location, status of the current heat removal system, operating log for the reporting period, and a discussion of measurement results. Data collected from in-place waste temperatures are presented in **Appendix A**. Graphical presentations of heat removal point data are provided in **Appendix B**. Plan views of the Temperature Monitoring Probes (TMP) and current heat removal system are provided as **Appendix C** and **Appendix D**, respectively. **Appendix E** provides entries made to the Heat Extraction System Operating Log during the Second Quarter 2016 operational period.

2 SYSTEM OPERATION

The heat extraction system has operated consistently during the Second Quarter 2016 operational period, with the following exceptions described below and presented in **Appendix E**:

- Heat removal location GIW-02 was observed to be off on April 18, 2016. Upon discovery of the deactivated status of GIW-02, the heat removal location was immediately turned on; and
- The entire heat removal system was discovered to be deactivated on June 1, 2016, presumably due to an electrical failure. Upon discovery of the deactivated status, the heat removal system was immediately reactivated on the same date.

Except as described above, the system has operated with minimal operational or physical changes since the expansion completed on June 26, 2015 (GIWs-08, -09, -11, -12 and -13). A review of **Appendix B** shows heat removal rates were generally consistent at each location during the Second Quarter 2016 operational period.

3 DATA SUMMARY

In-waste temperature measurements were collected on a weekly basis during the Second Quarter 2016 operational period as part of the on-going pilot study. Graphical presentations of

in-waste temperature measurements are presented in **Appendix A**. The inflow temperature, outflow temperature, and flow rate are measured and recorded at each heat removal unit on a weekly basis. These measurements are utilized to calculate the heat extraction rate (in kilowatts) at each individual removal point. The heat extraction rates for each point are graphically presented with the respective flow rate (in gallons per minute) in **Appendix B**.

4 SUMMARY AND DISCUSSION OF RESULTS

The BL continued the successful operation of twelve (12) heat removal locations during the Second Quarter 2016 reporting period. The heat removal system has operated with only minor maintenance since the expansion of the system during June 2015. The system generally continues to operate with minimal interruption.

Measurements collected during the reporting period are relatively consistent with data recorded during previous quarters. A review of in-waste temperature measurements shows consistent temperatures during the reporting period, with the exception of locations affected by the system shutdown (presumably the result of an electrical failure) observed on June 1, 2016. The TMPs at approximately five (5) and nine (9) feet to the north of heat removal points continue to exhibit significant temperature reductions compared to measurements obtained prior to heat removal system initiation. Additionally, in-waste temperatures adjacent to northern line of heat removal locations continue to show generally lower temperatures relative to temperatures measured south of the southern line of heat removal locations.

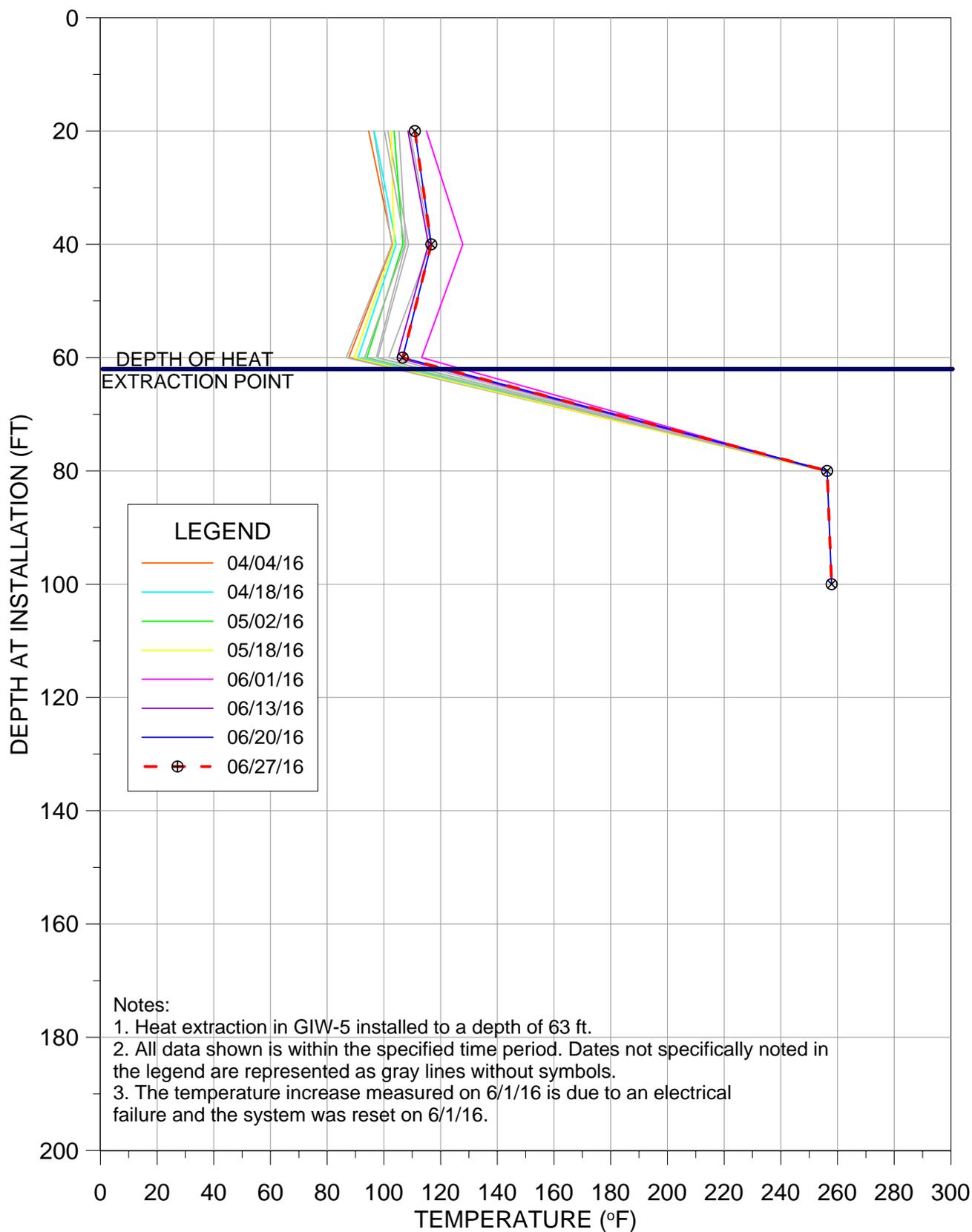
Subsurface temperatures on the north side of the heat removal locations continue to remain significantly lower compared to the south side. This suggests normal landfill heat generation in the waste to the north of the heat removal points.

A review of the heat removal point data for this reporting period has also been conducted. The initial (south line) heat removal locations (GIW-02, -03, -04, -05, -06, -07, and -10) have shown relatively steady rates of energy removal. The steady-state heat removal rates of the northern line of heat removal locations (GIW-08, -09, -11, -12, and -13) are generally greater than the steady-state heat removal rates of the southern line. This is expected and likely attributed to the greater depth of the heat removal locations on the northern line.

BL is continuing the operation of the expanded heat removal pilot study system at the facility.

Appendix A – Temperature Monitoring Probe Graphs (Second Quarter 2016)

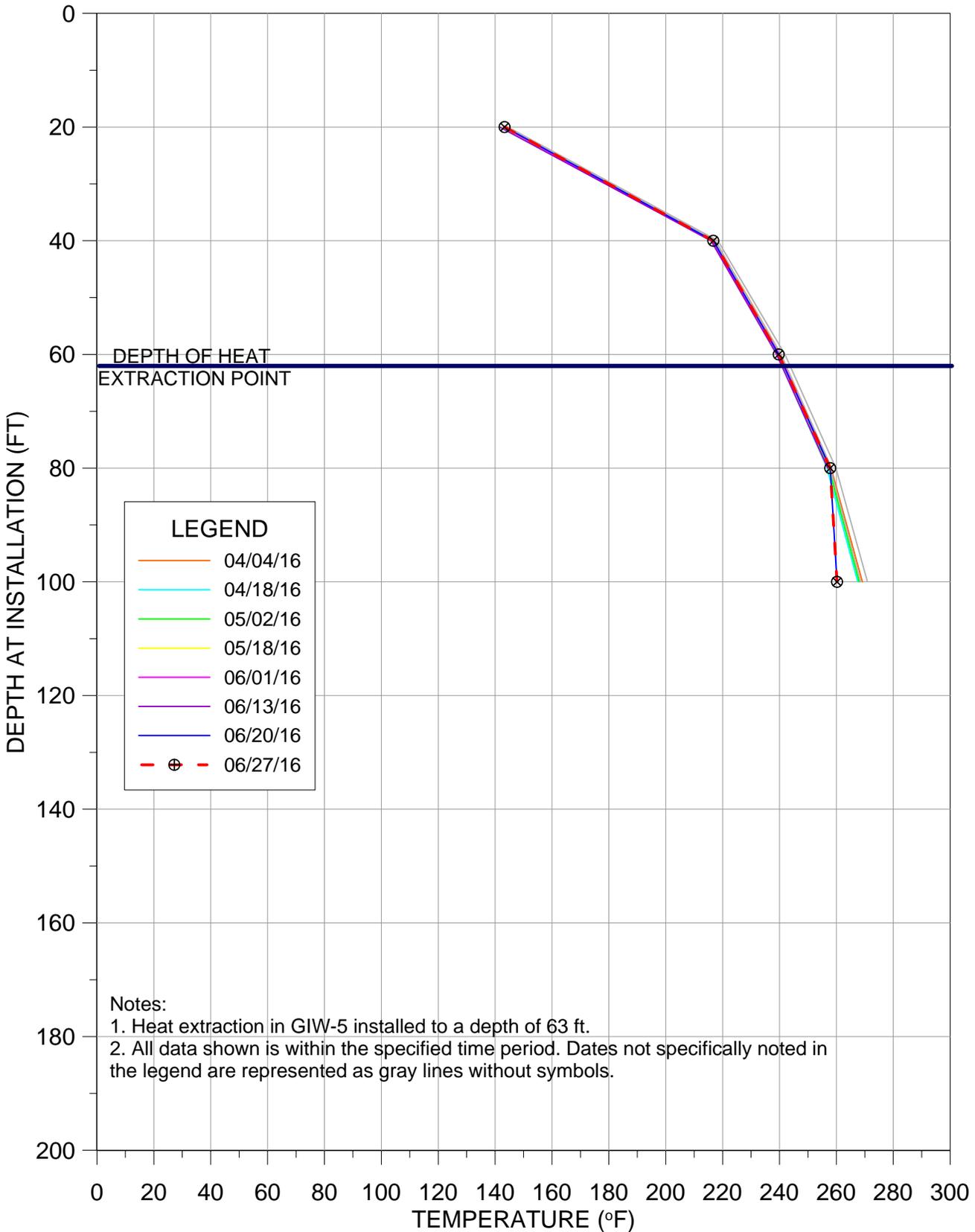
TMP-5-5N



Notes:

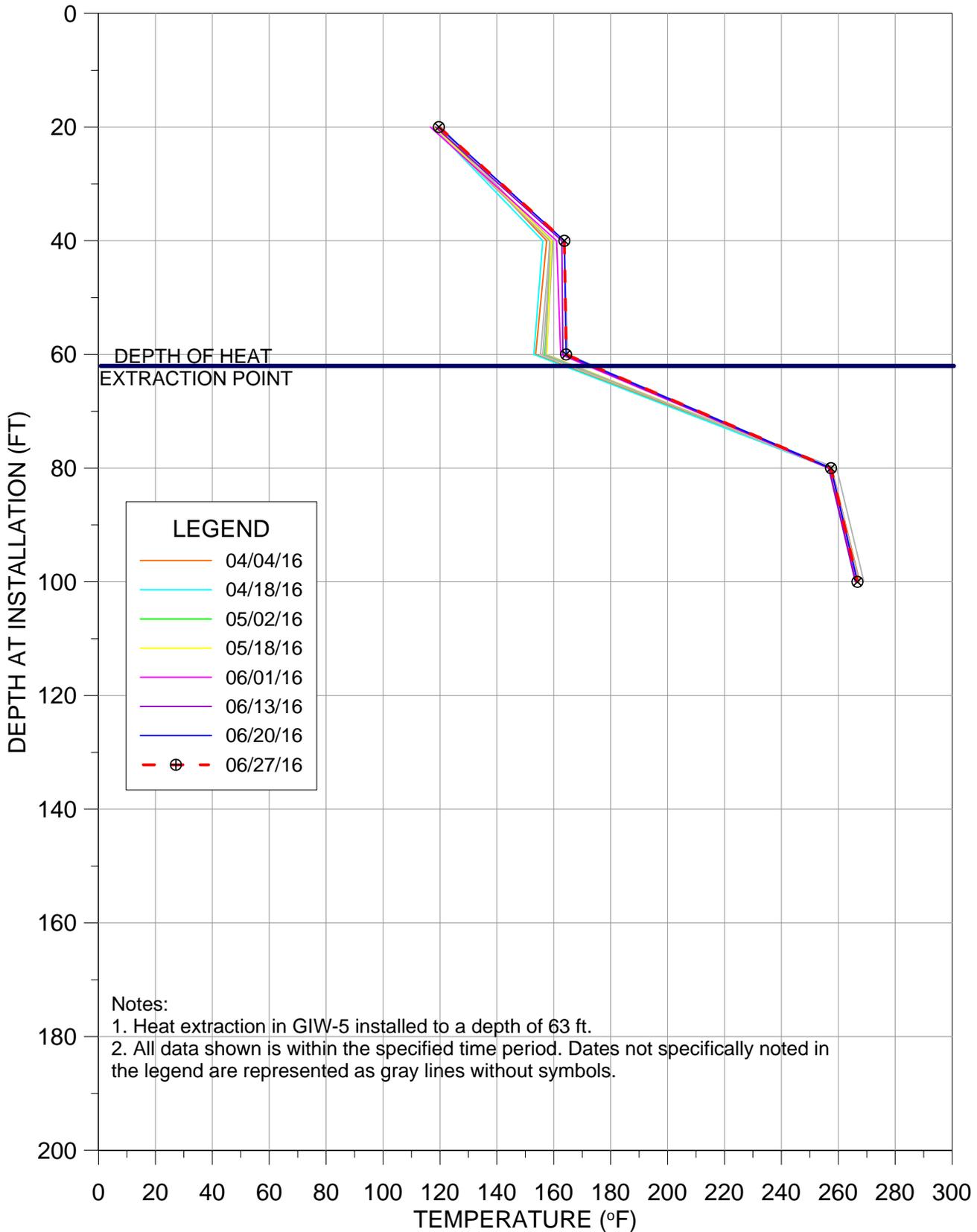
1. Heat extraction in GIW-5 installed to a depth of 63 ft.
2. All data shown is within the specified time period. Dates not specifically noted in the legend are represented as gray lines without symbols.
3. The temperature increase measured on 6/1/16 is due to an electrical failure and the system was reset on 6/1/16.

TMP-5-5S



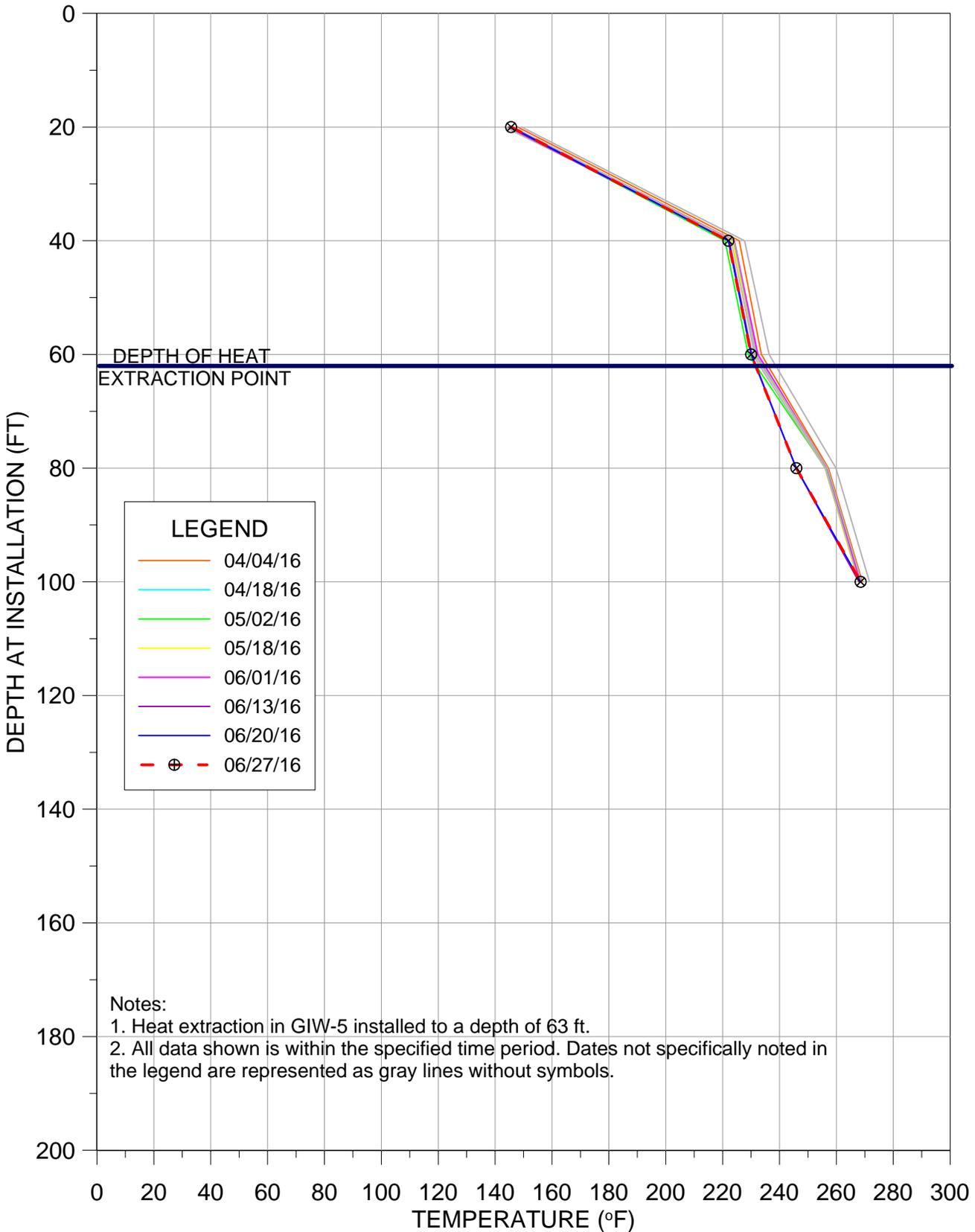
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-5-9N



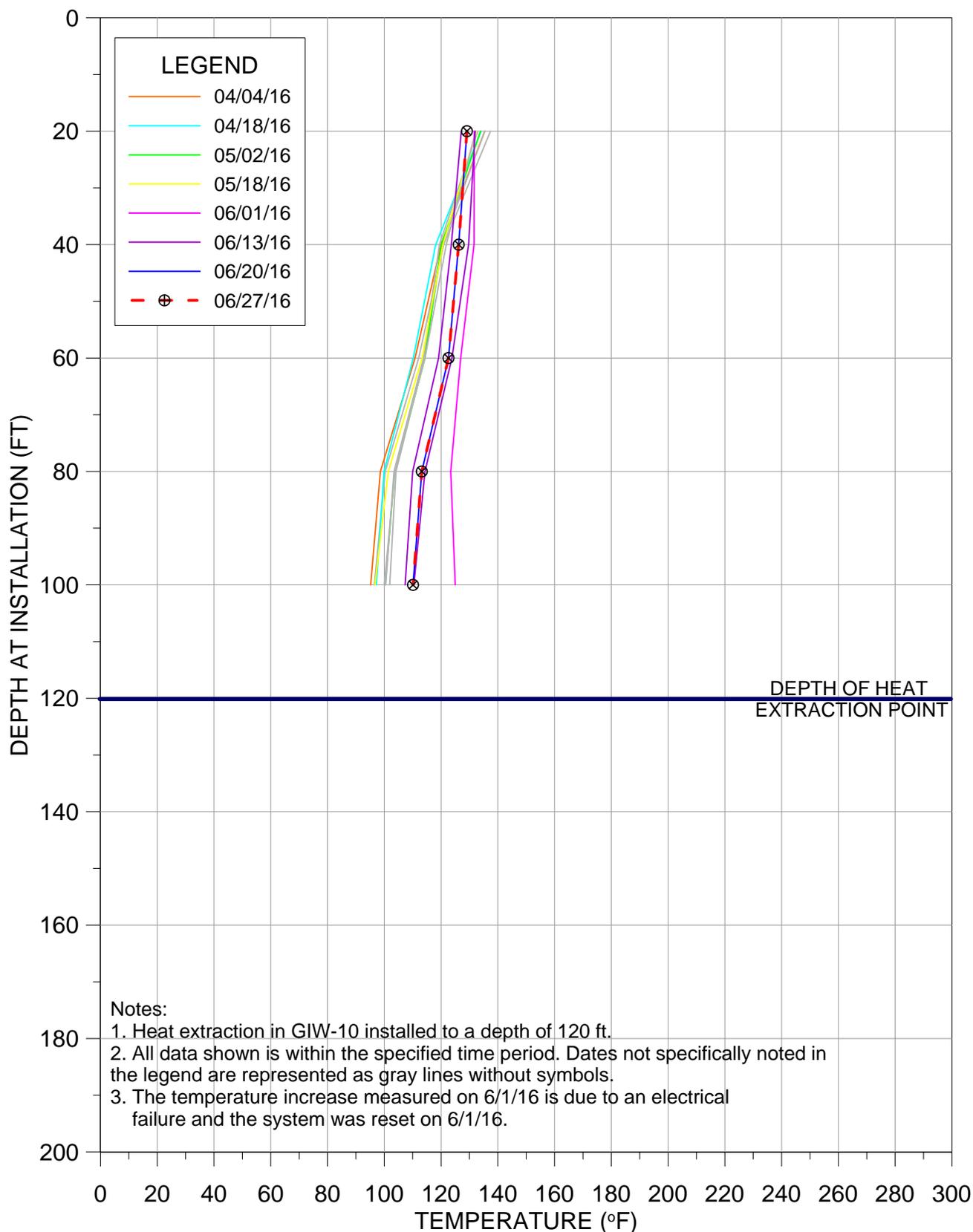
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-5-9S



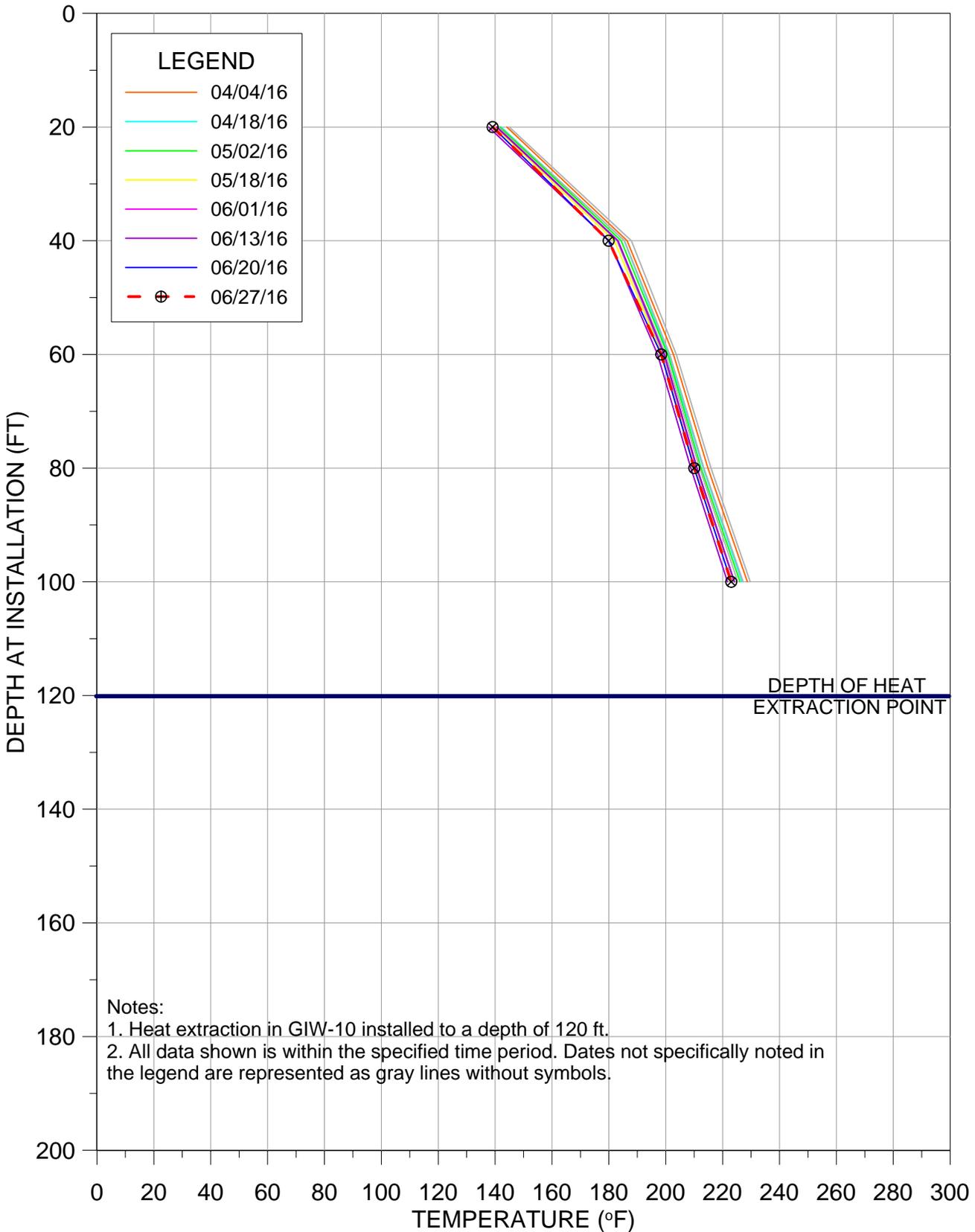
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-10-5N



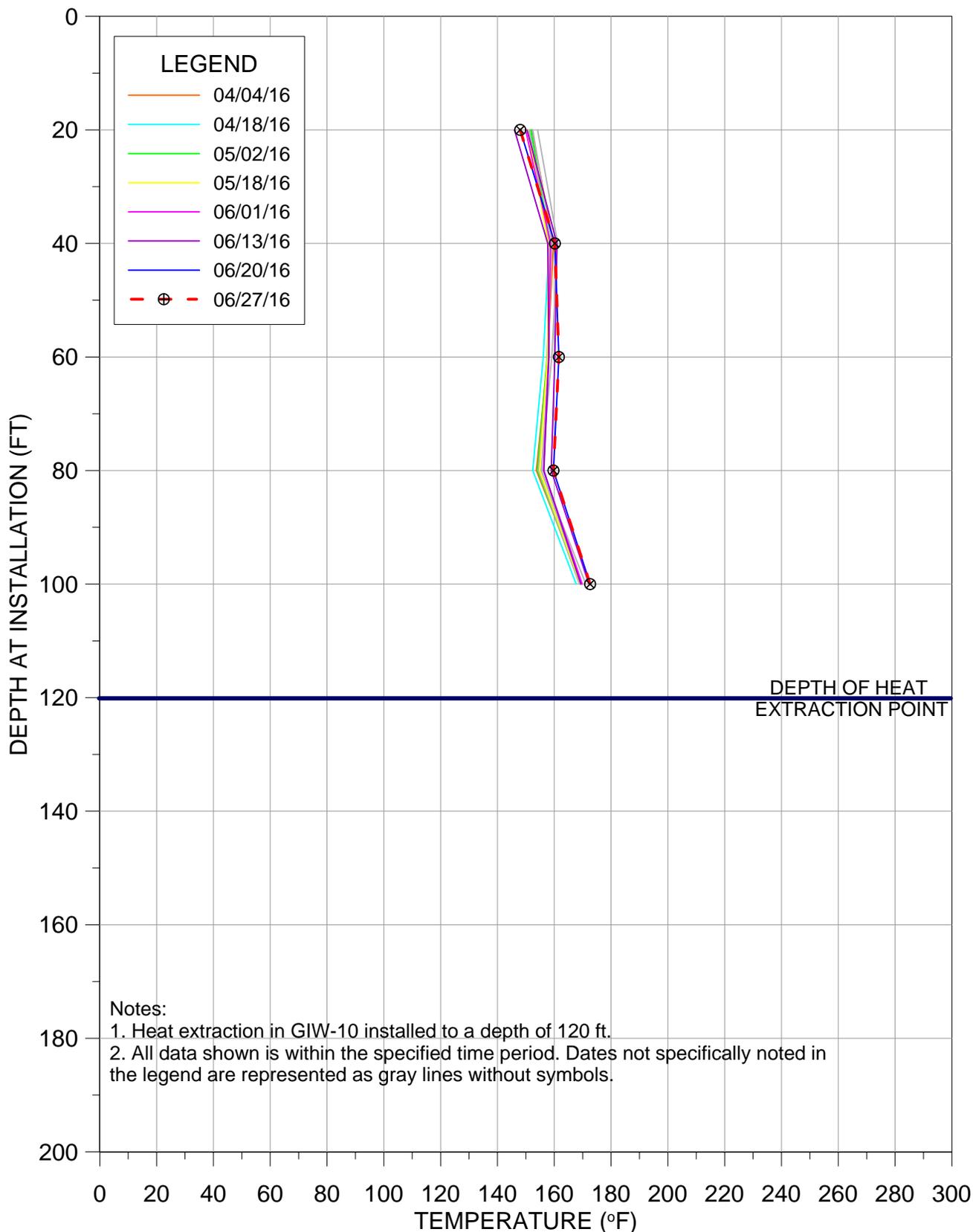
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-10-5S



TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

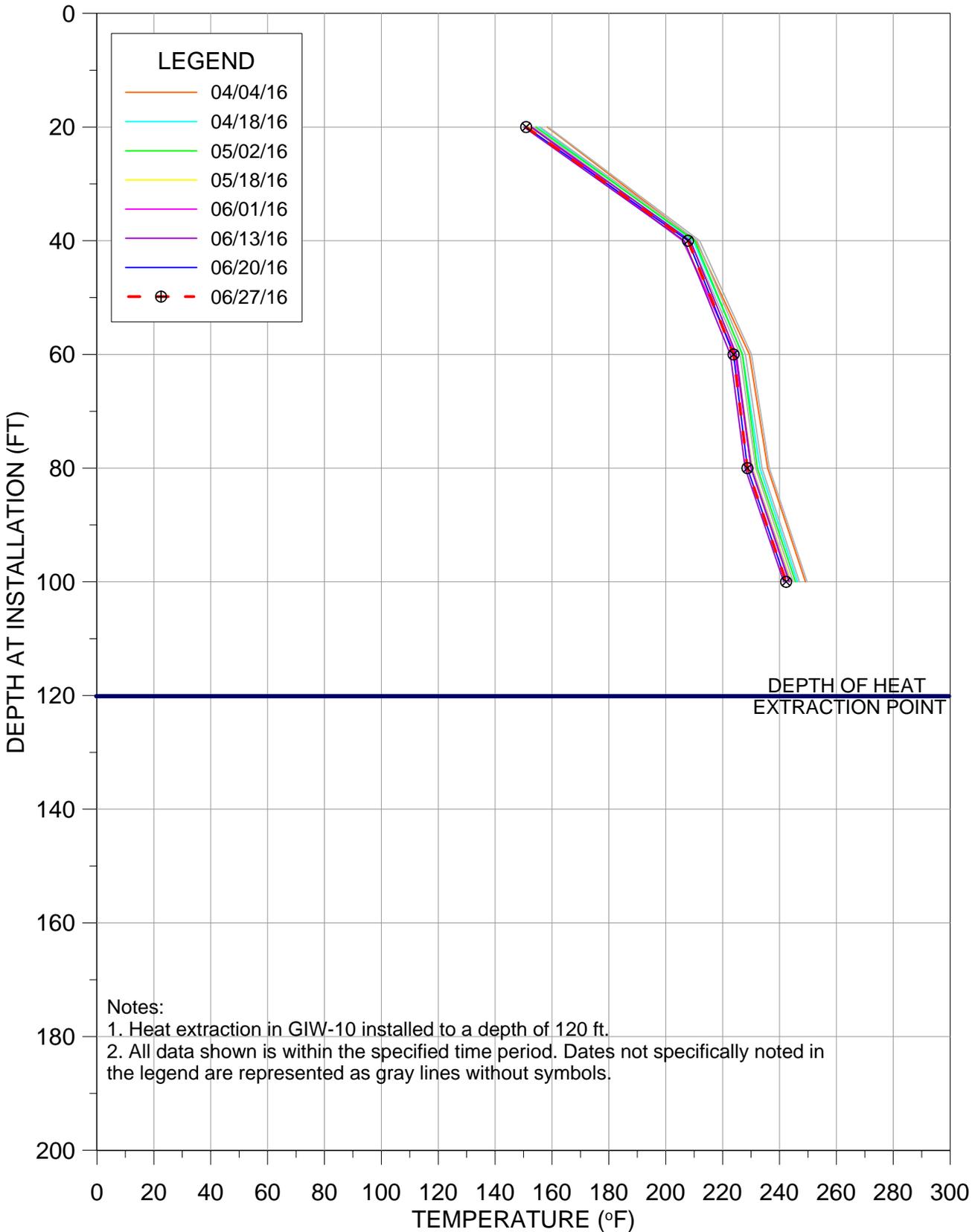
TMP-10-9N



DEPTH OF HEAT
EXTRACTION POINT

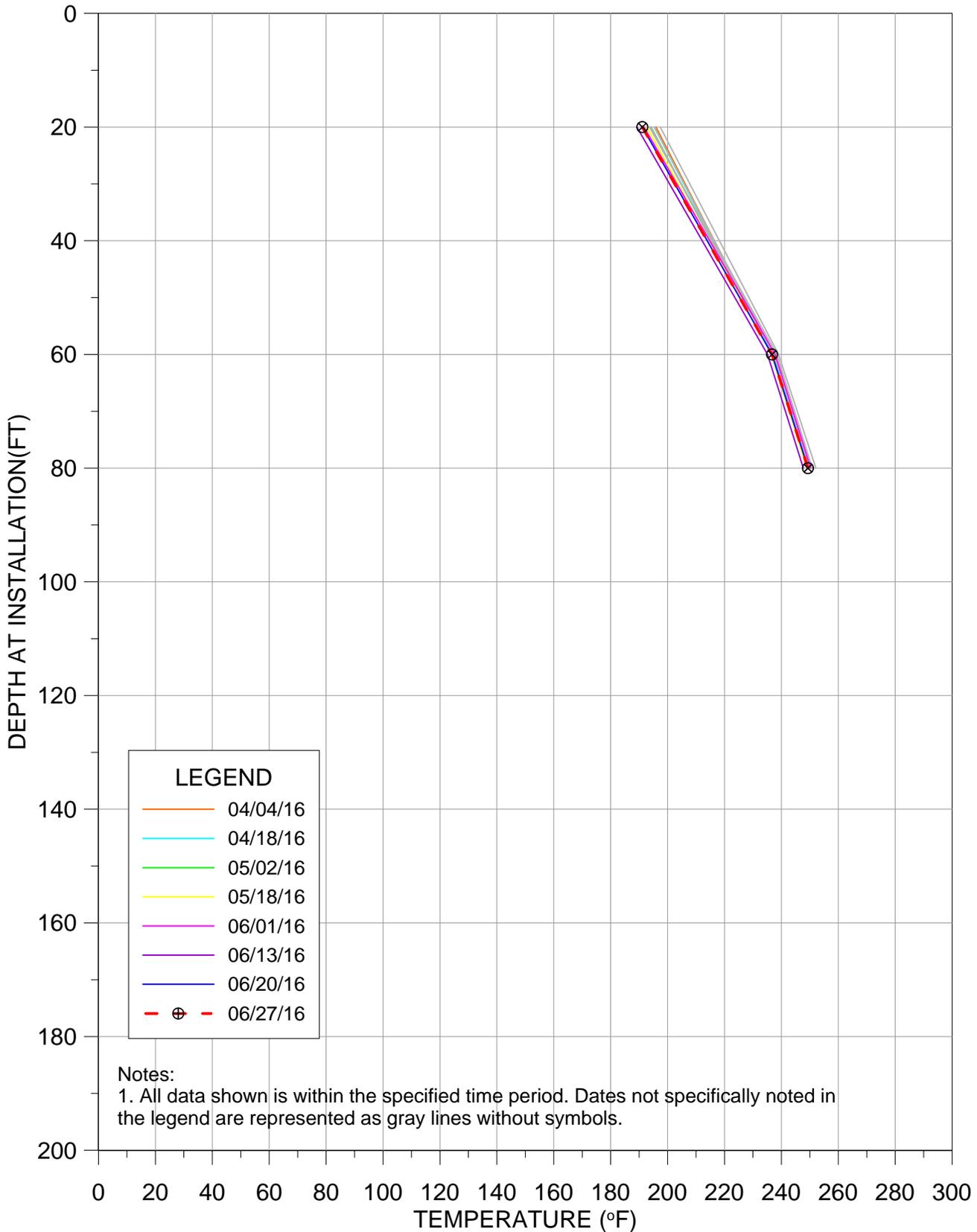
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-10-9S



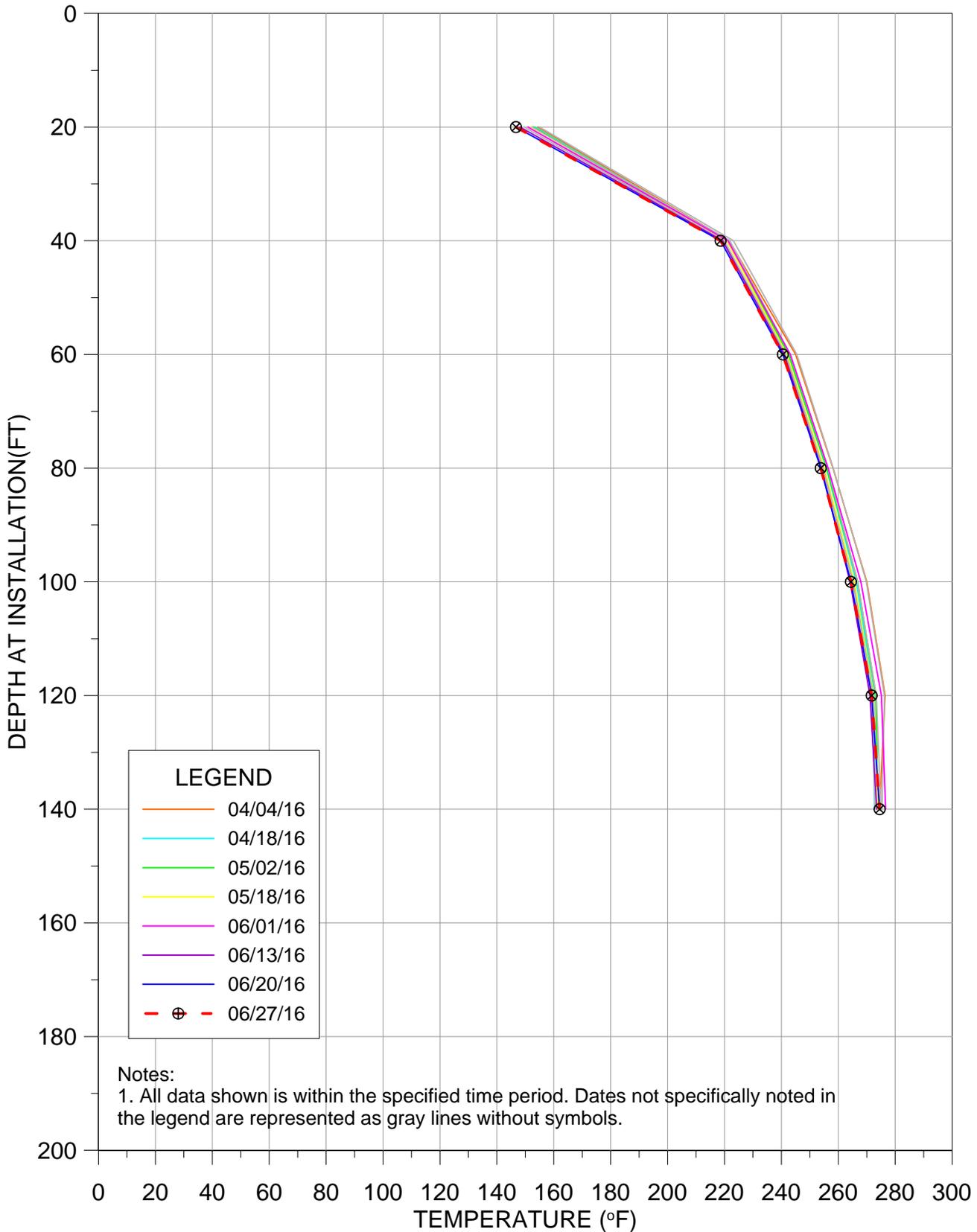
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-19



TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-20



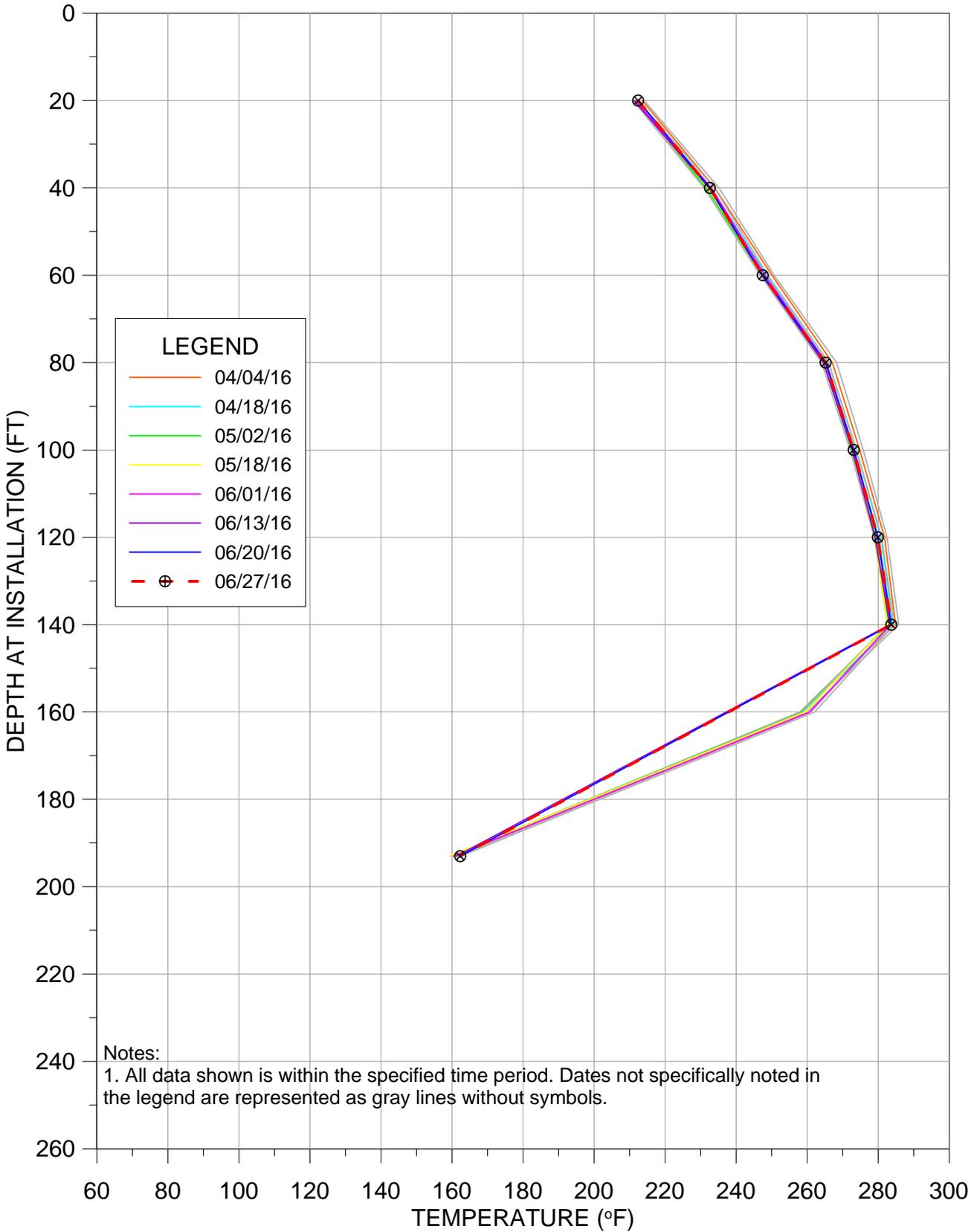
LEGEND

- 04/04/16
- 04/18/16
- 05/02/16
- 05/18/16
- 06/01/16
- 06/13/16
- 06/20/16
- 06/27/16

Notes:
1. All data shown is within the specified time period. Dates not specifically noted in the legend are represented as gray lines without symbols.

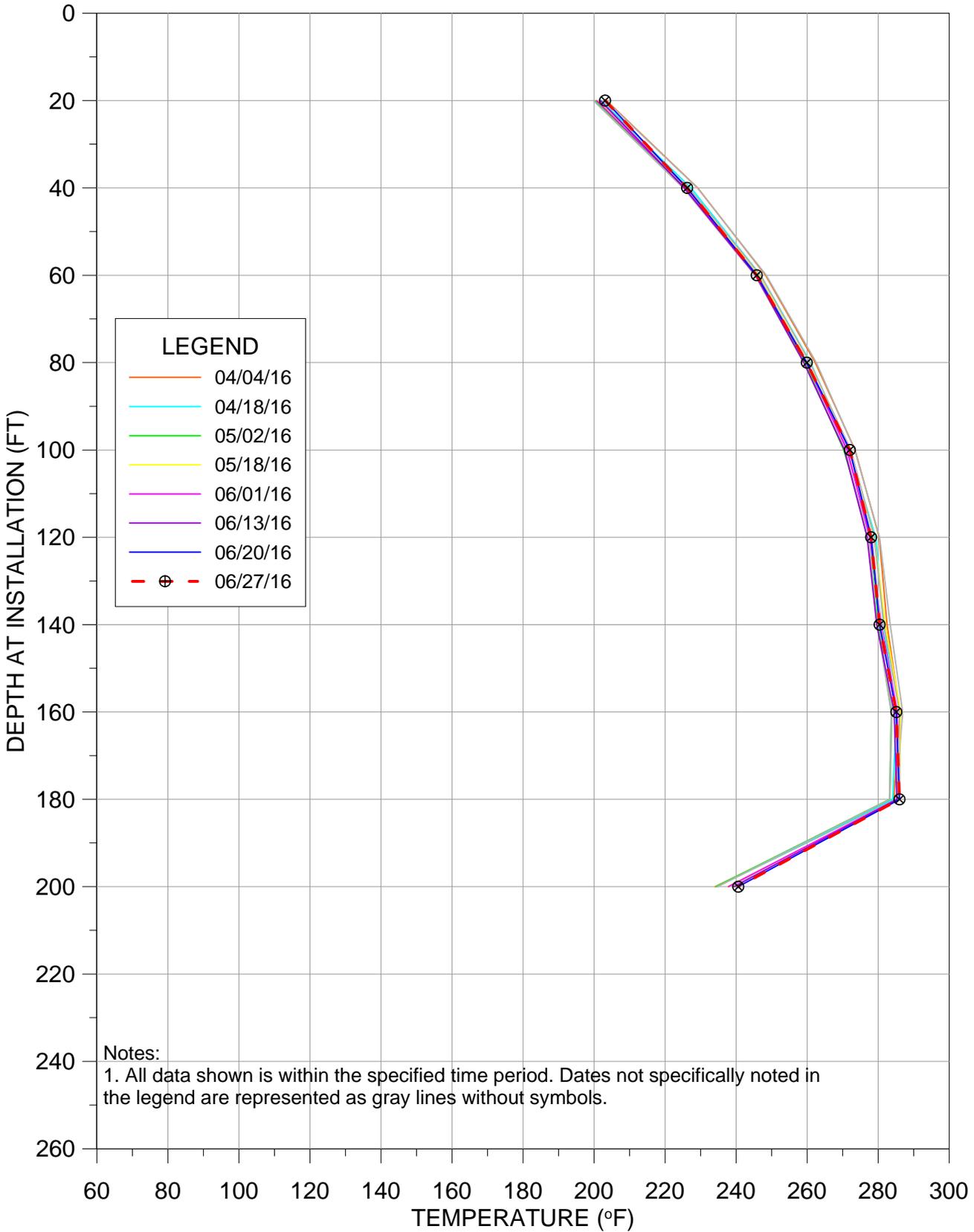
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-31



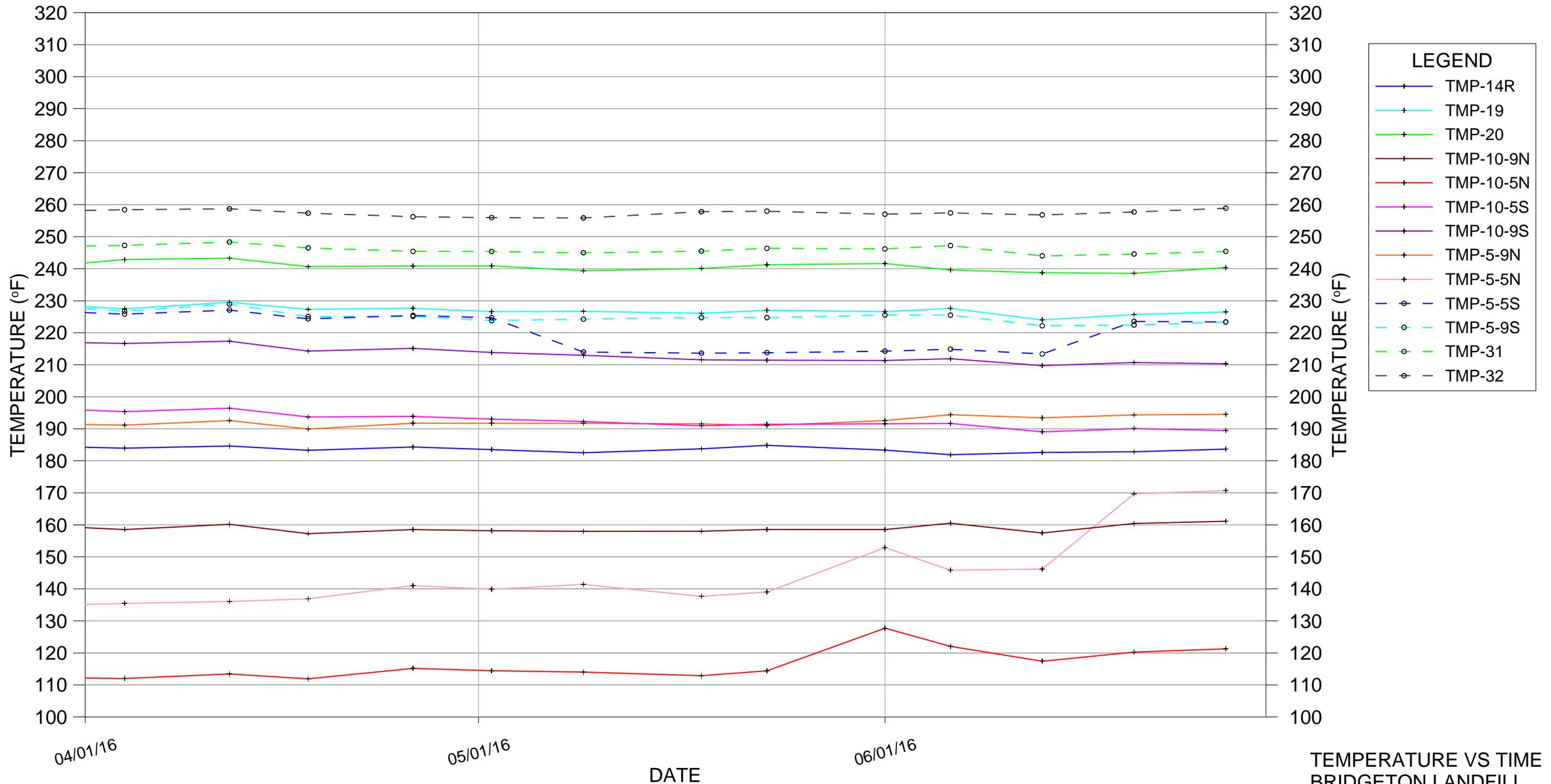
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

TMP-32



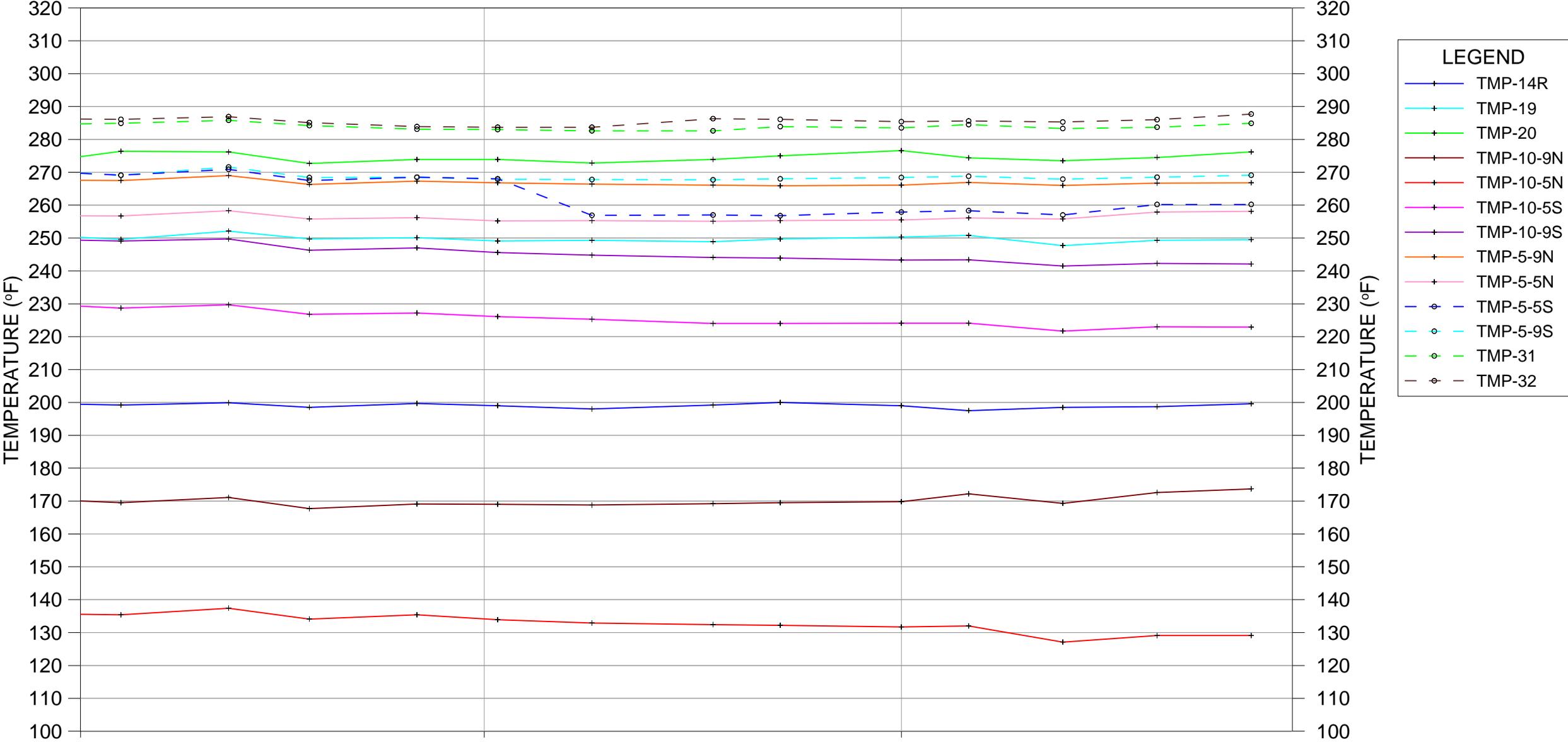
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

AVERAGE TEMPERATURES



TEMPERATURE VS TIME
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

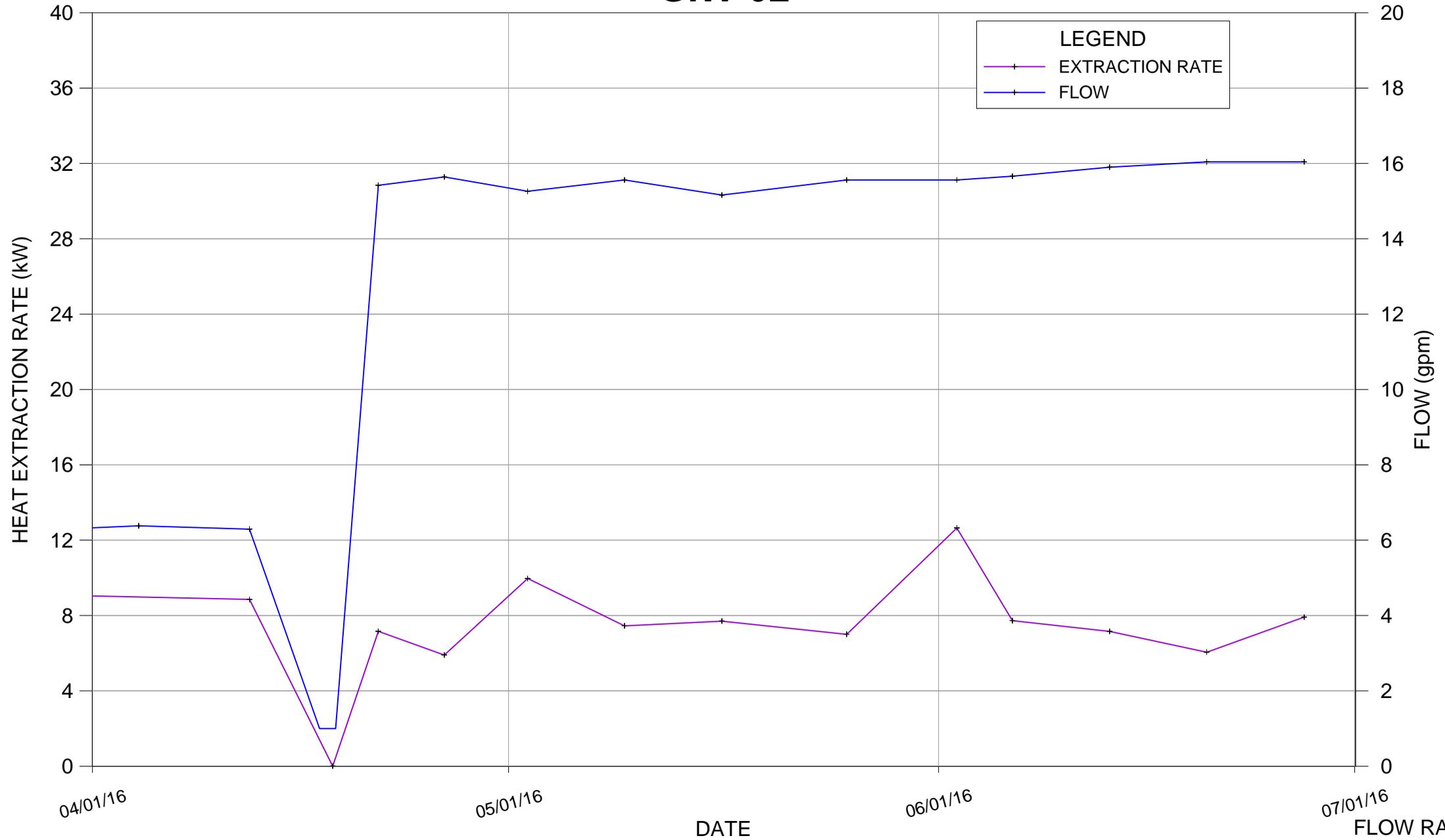
MAXIMUM TEMPERATURES



TEMPERATURE VS TIME
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

Appendix B – Heat Removal Point Data Graphs (Second Quarter 2016)

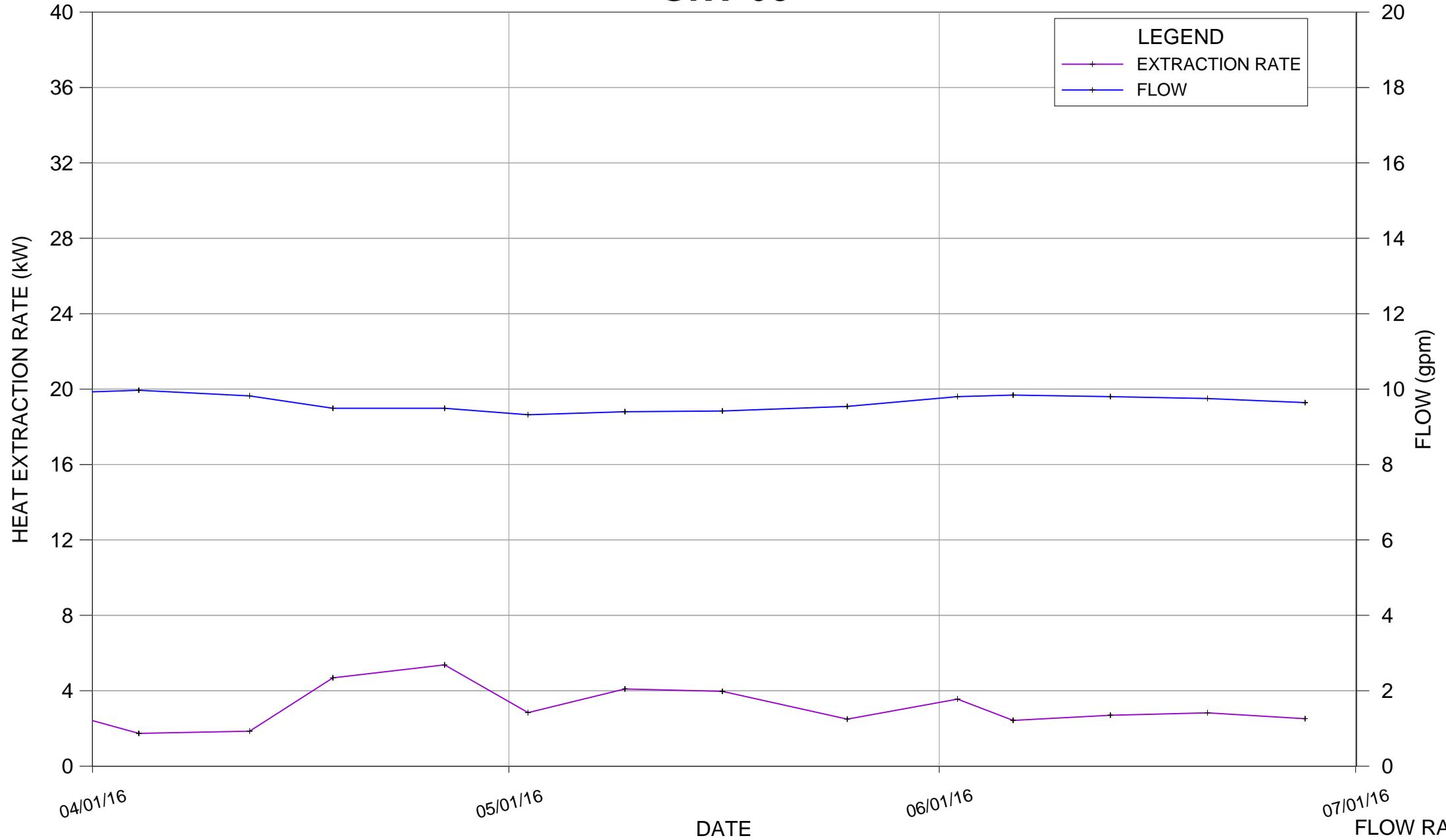
GIW-02



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

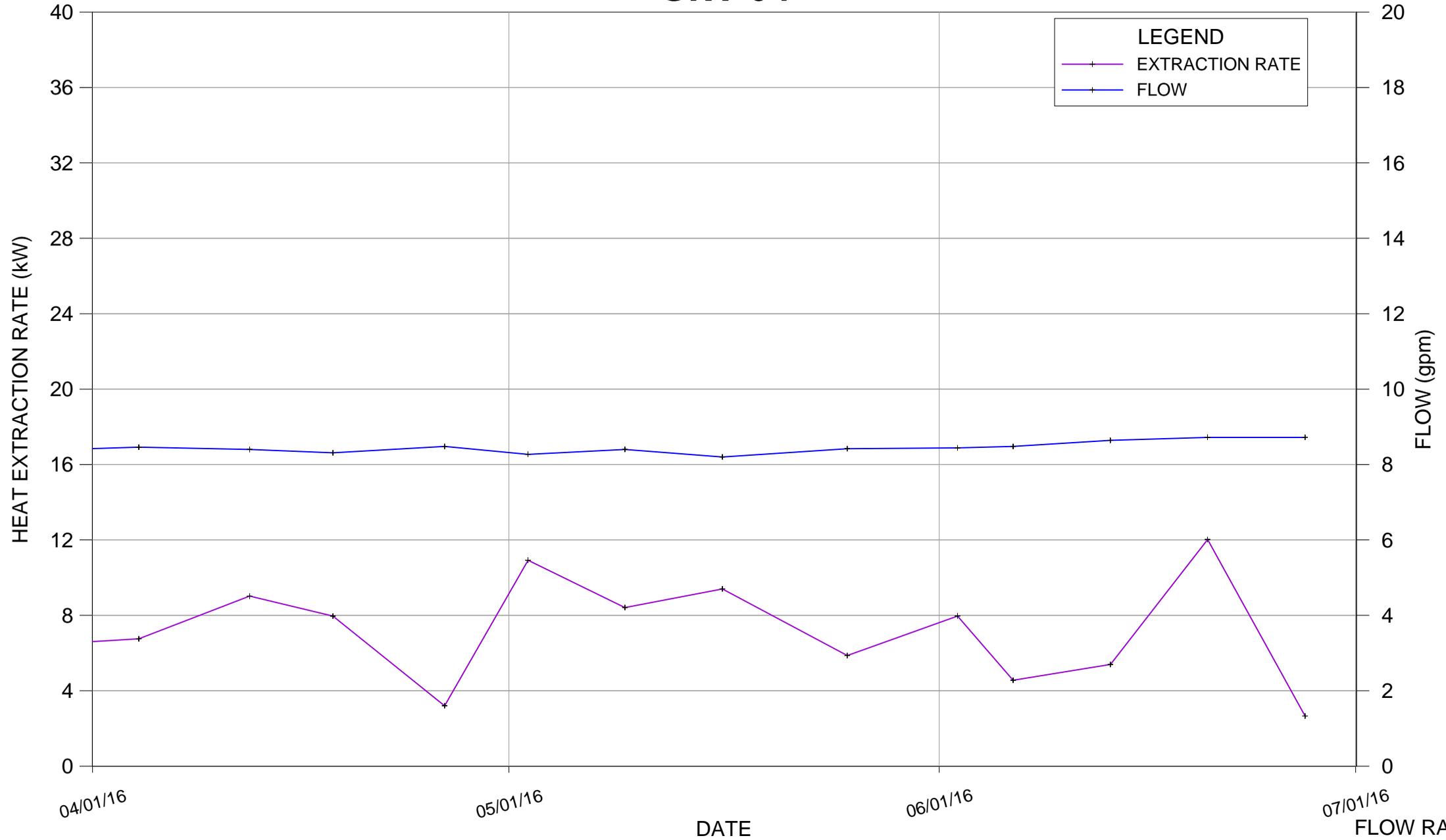
GIW-03



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

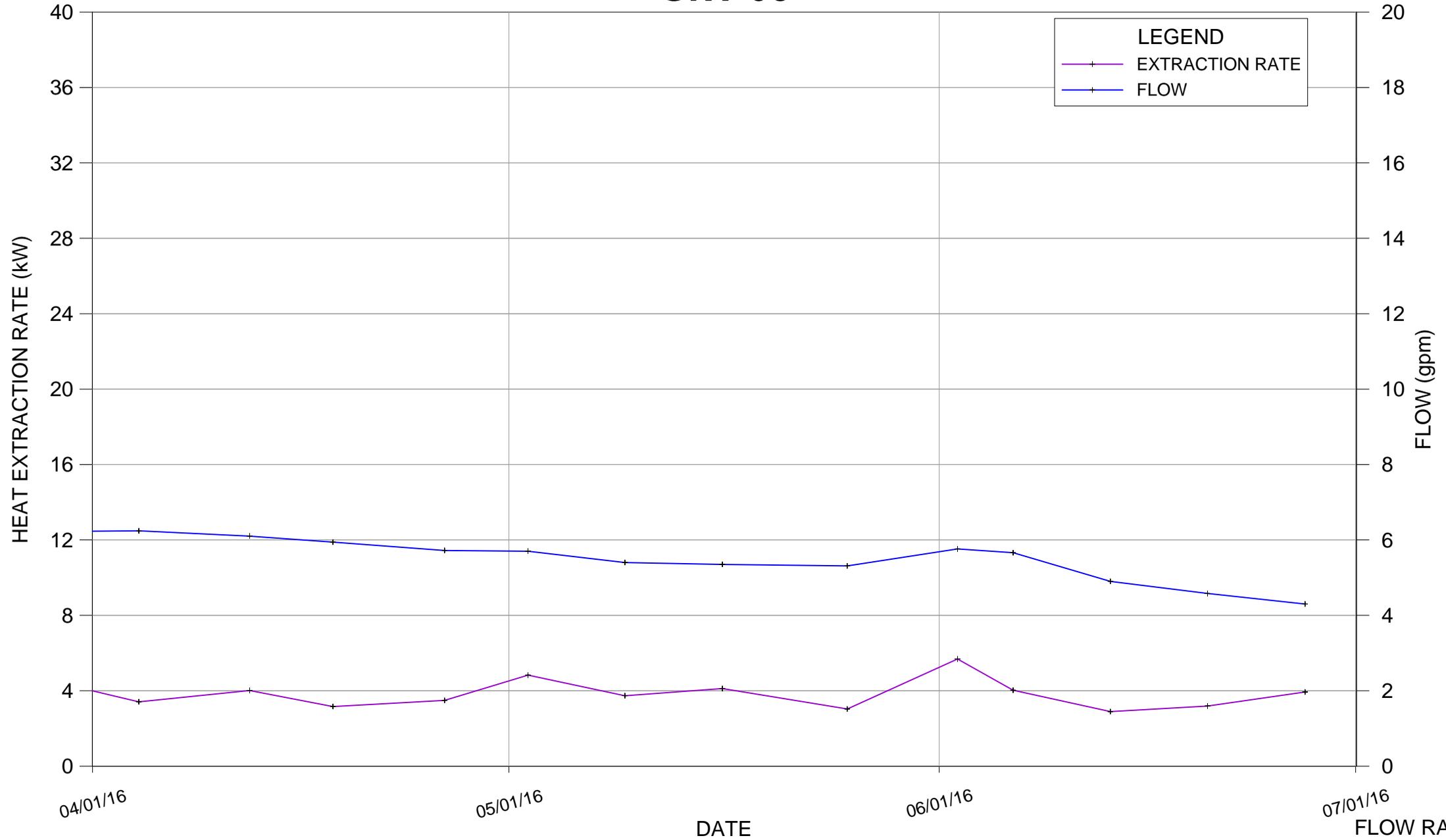
GIW-04



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

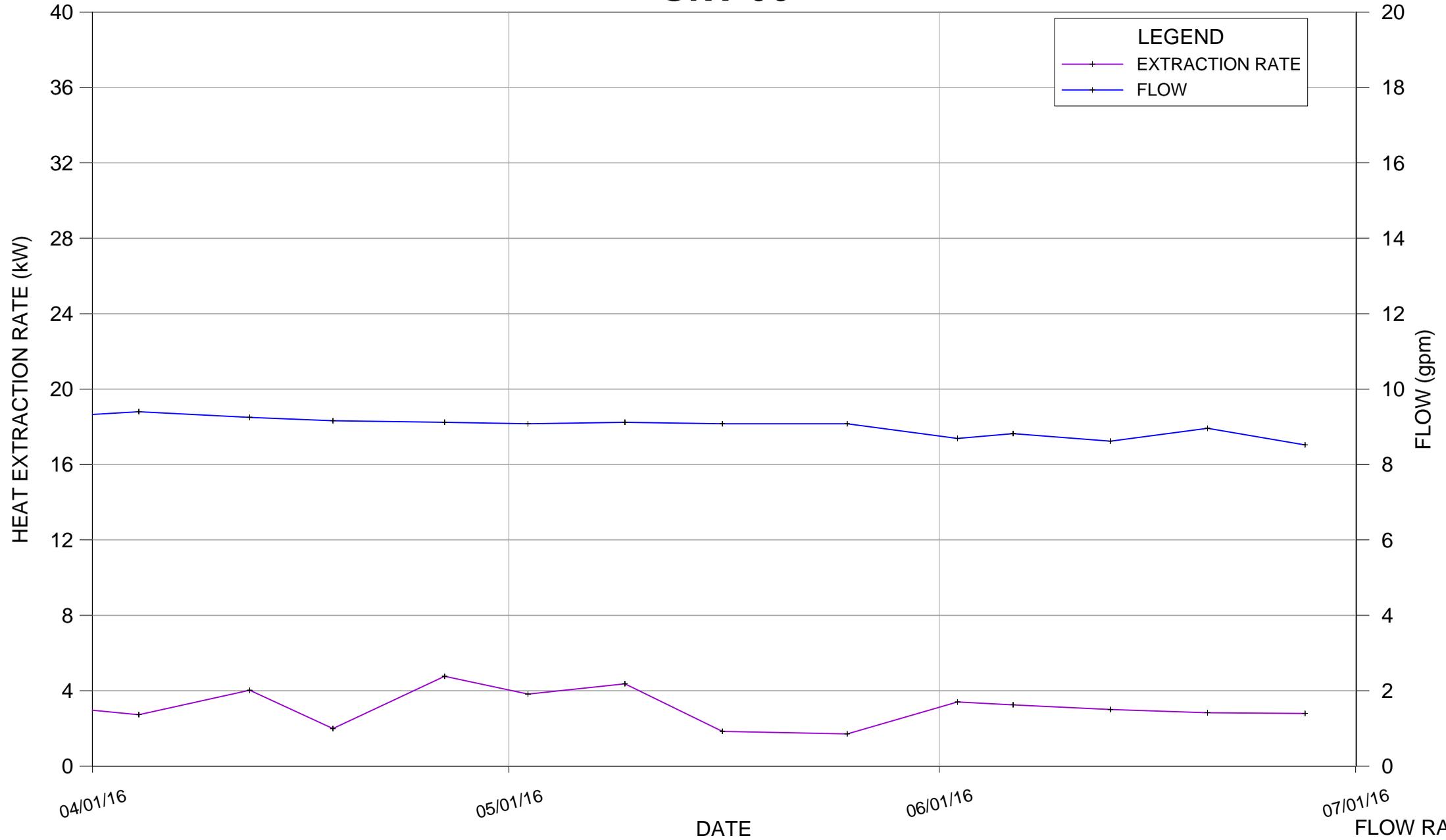
GIW-05



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

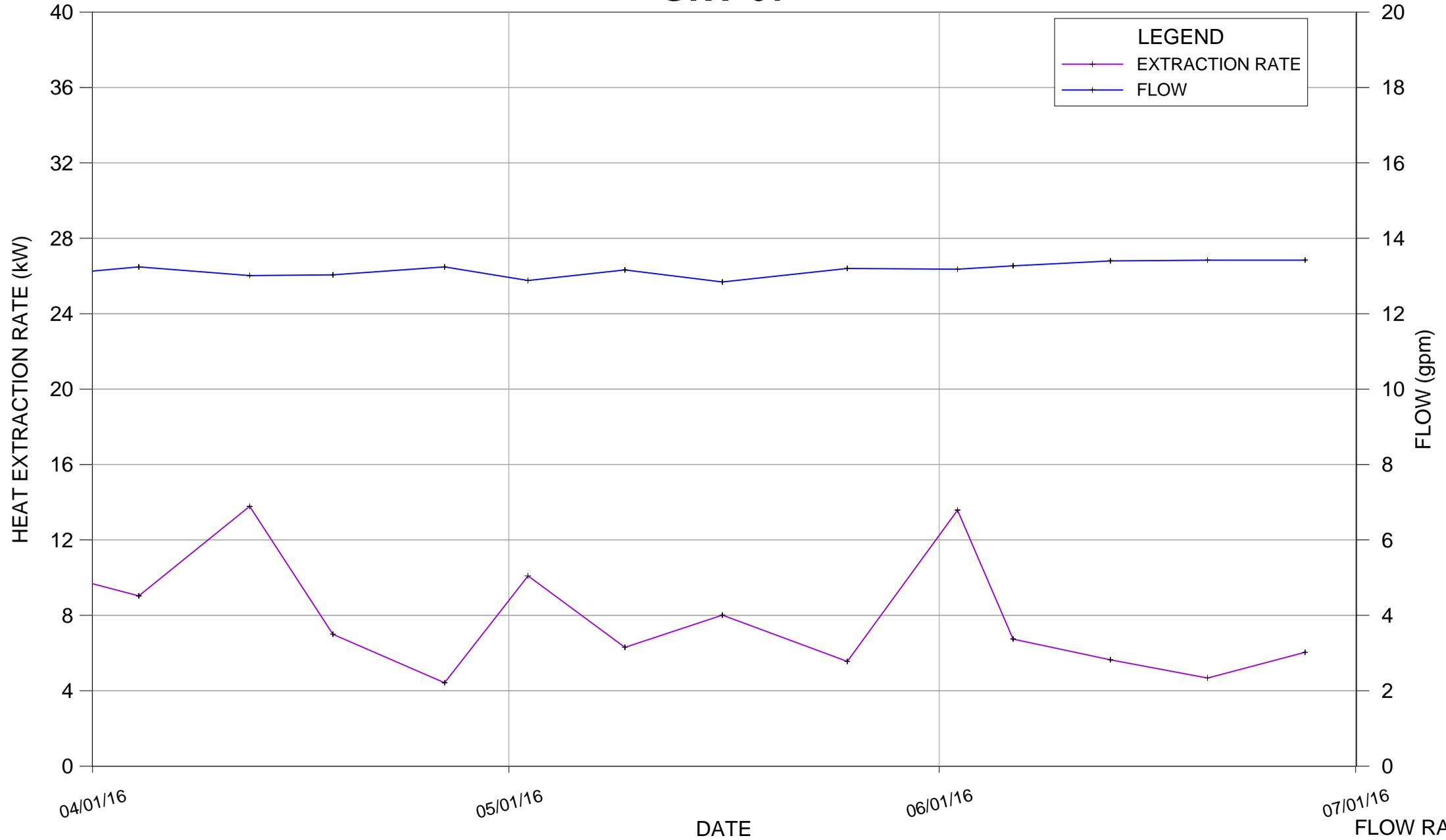
GIW-06



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

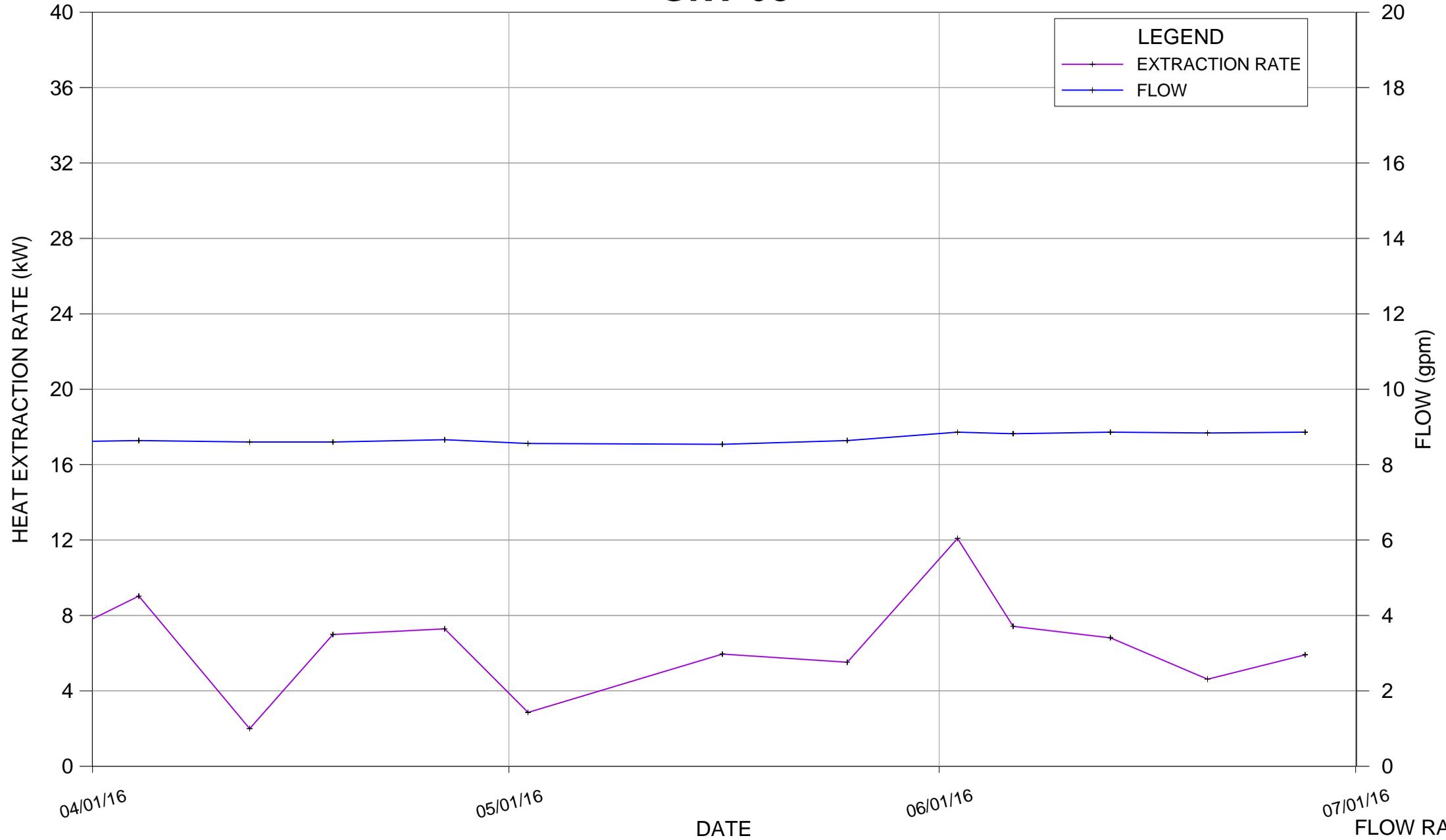
GIW-07



Note: Heat extraction rate data points are calculated based on instantaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

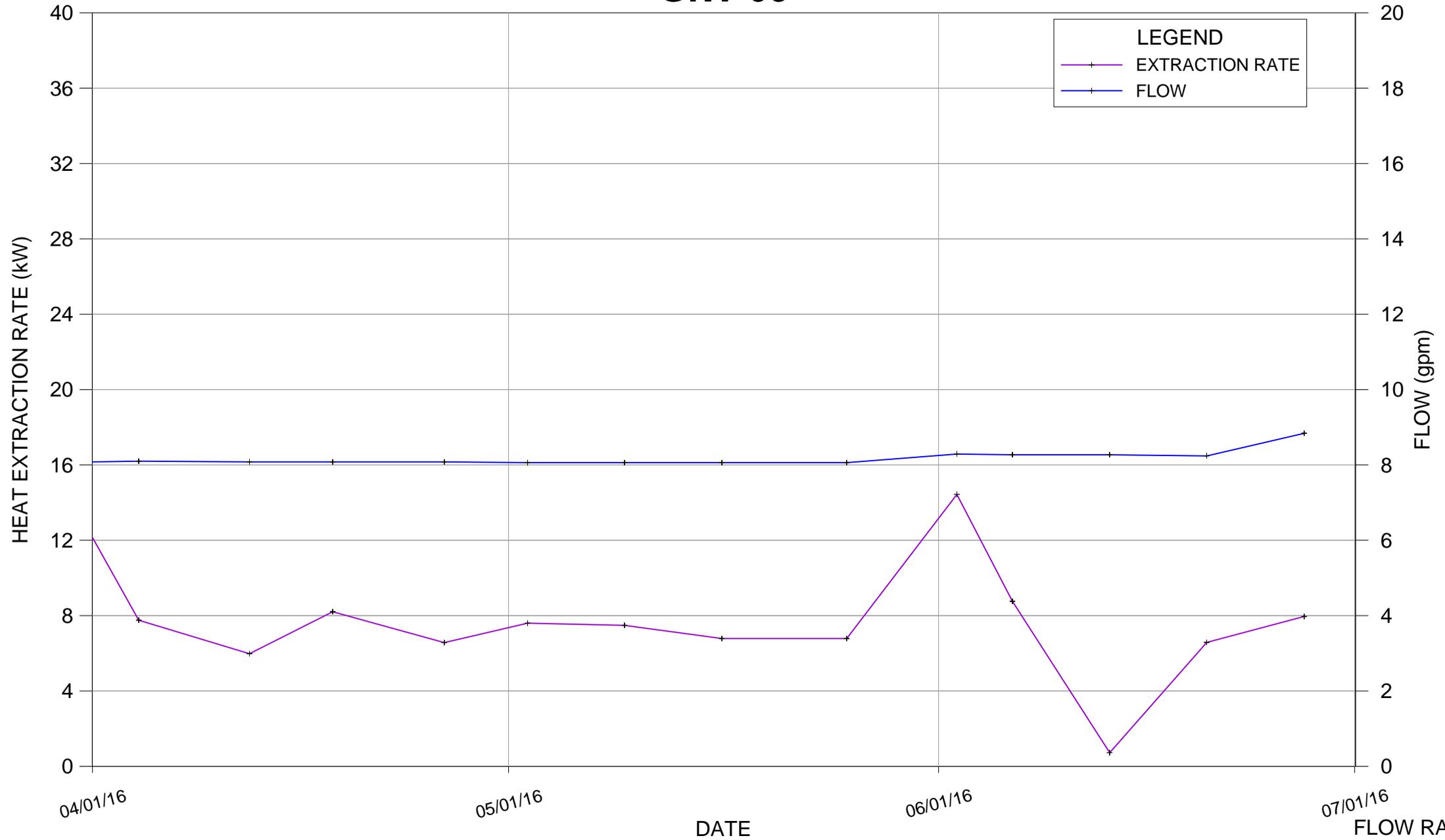
GIW-08



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

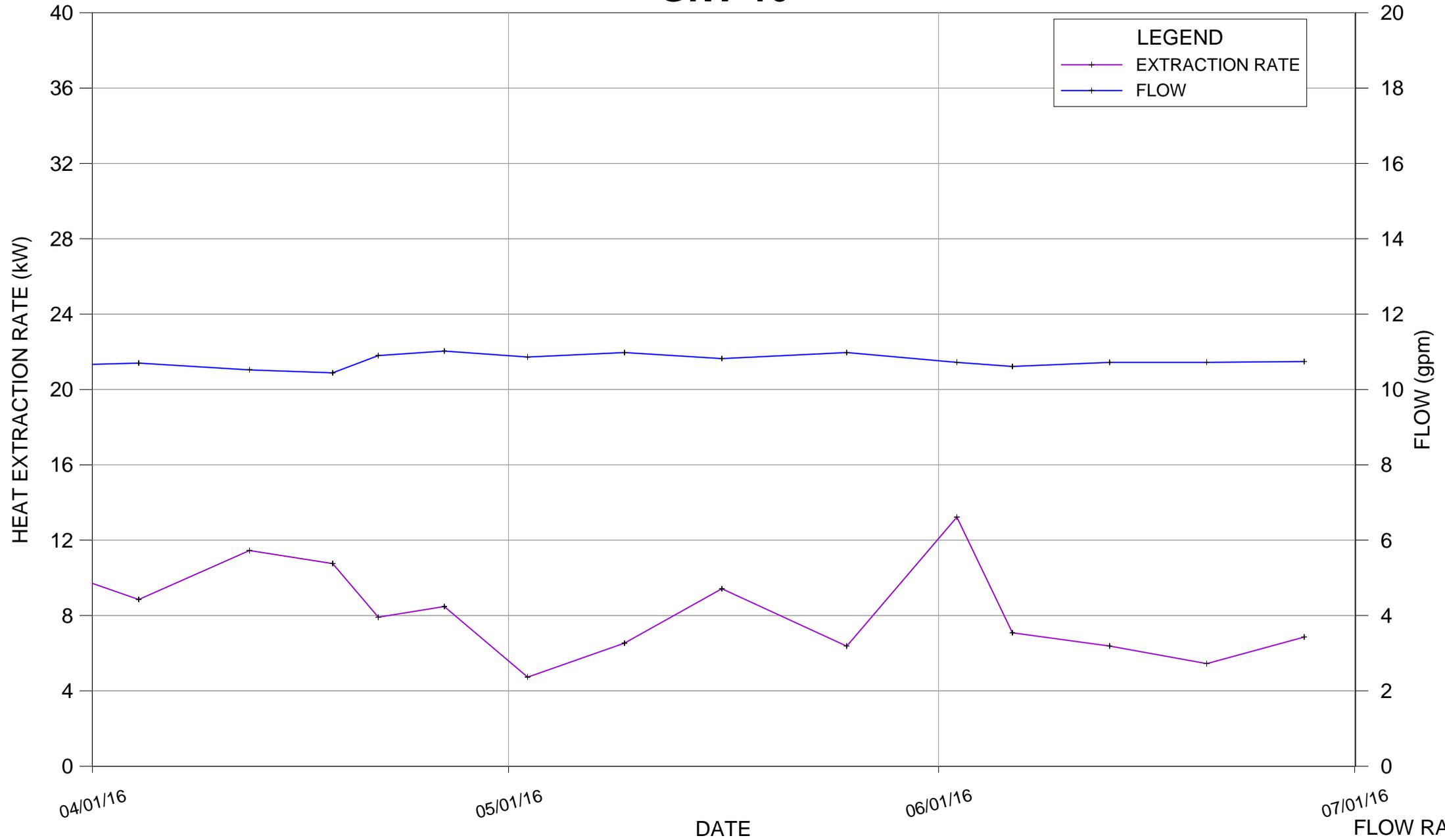
GIW-09



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

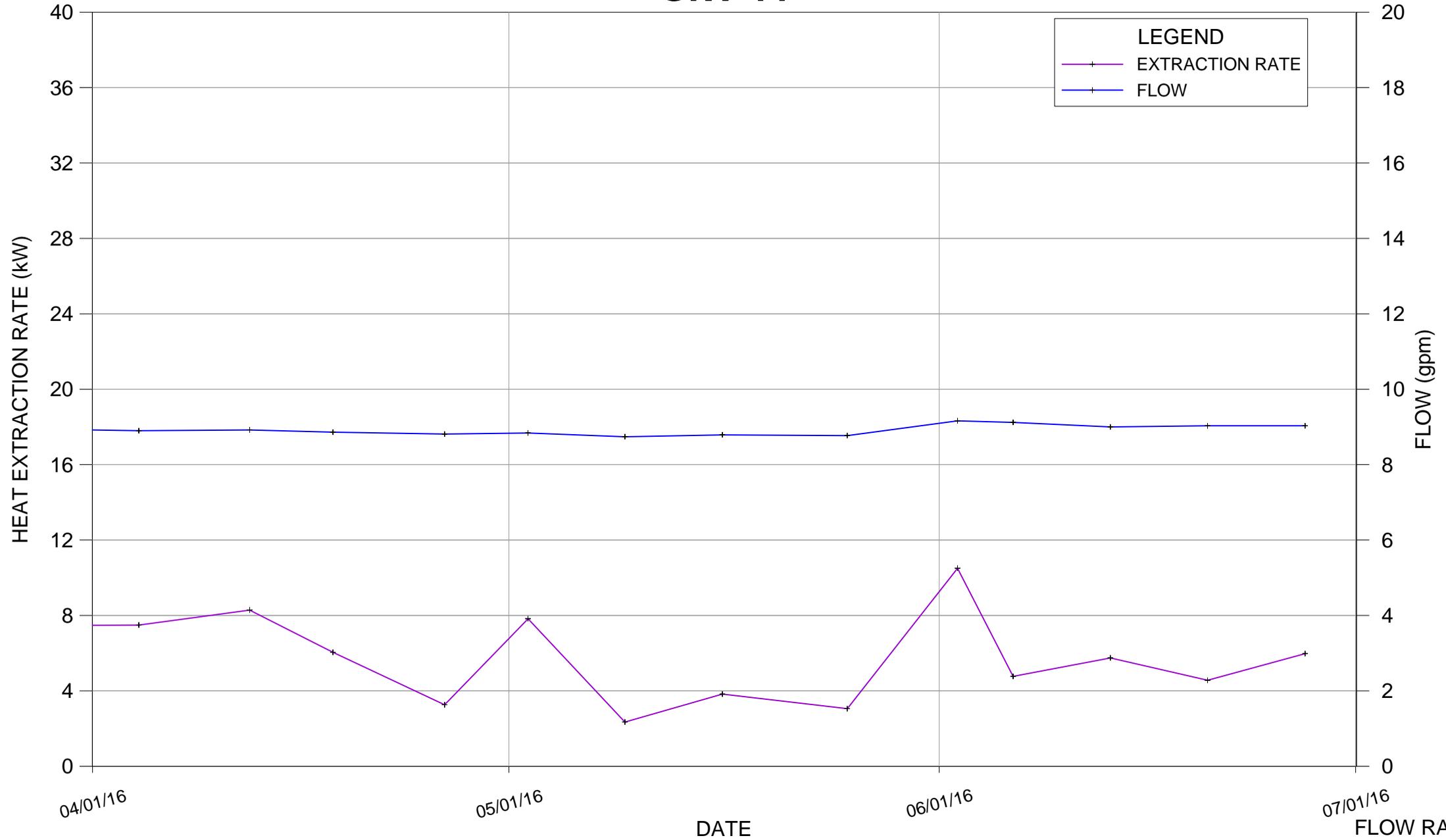
GIW-10



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

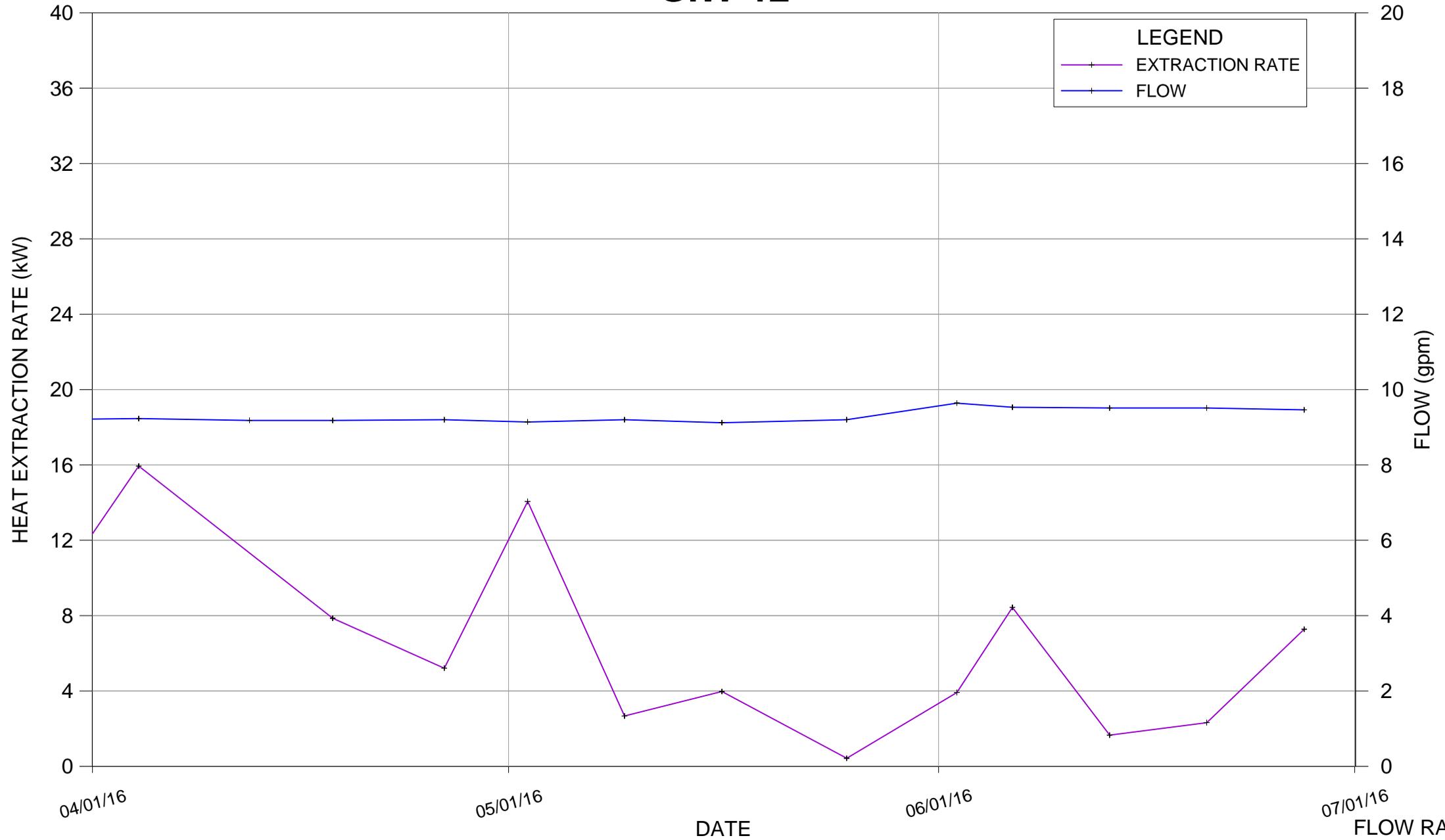
GIW-11



Note: Heat extraction rate data points are calculated based on instantaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

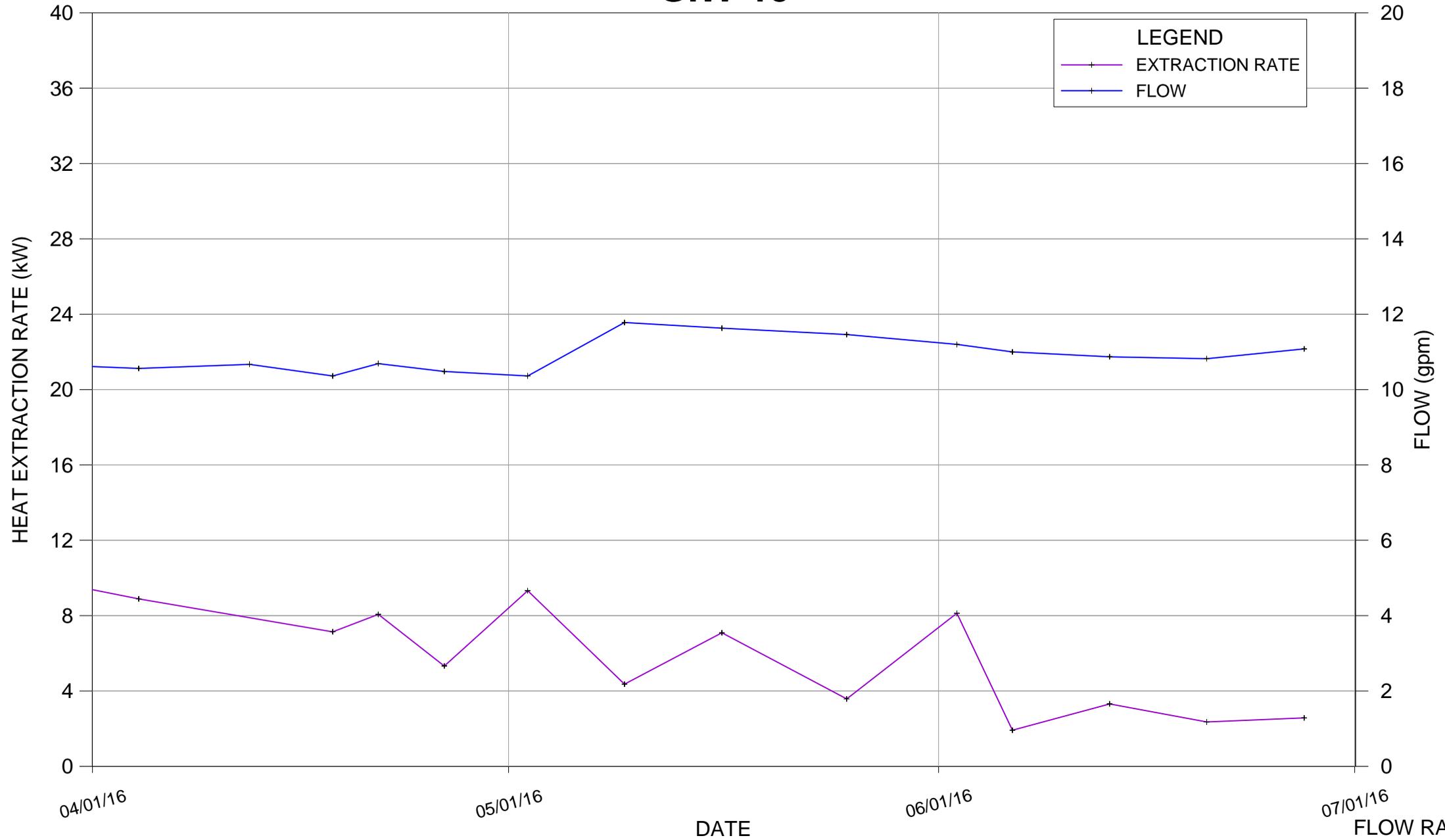
GIW-12



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

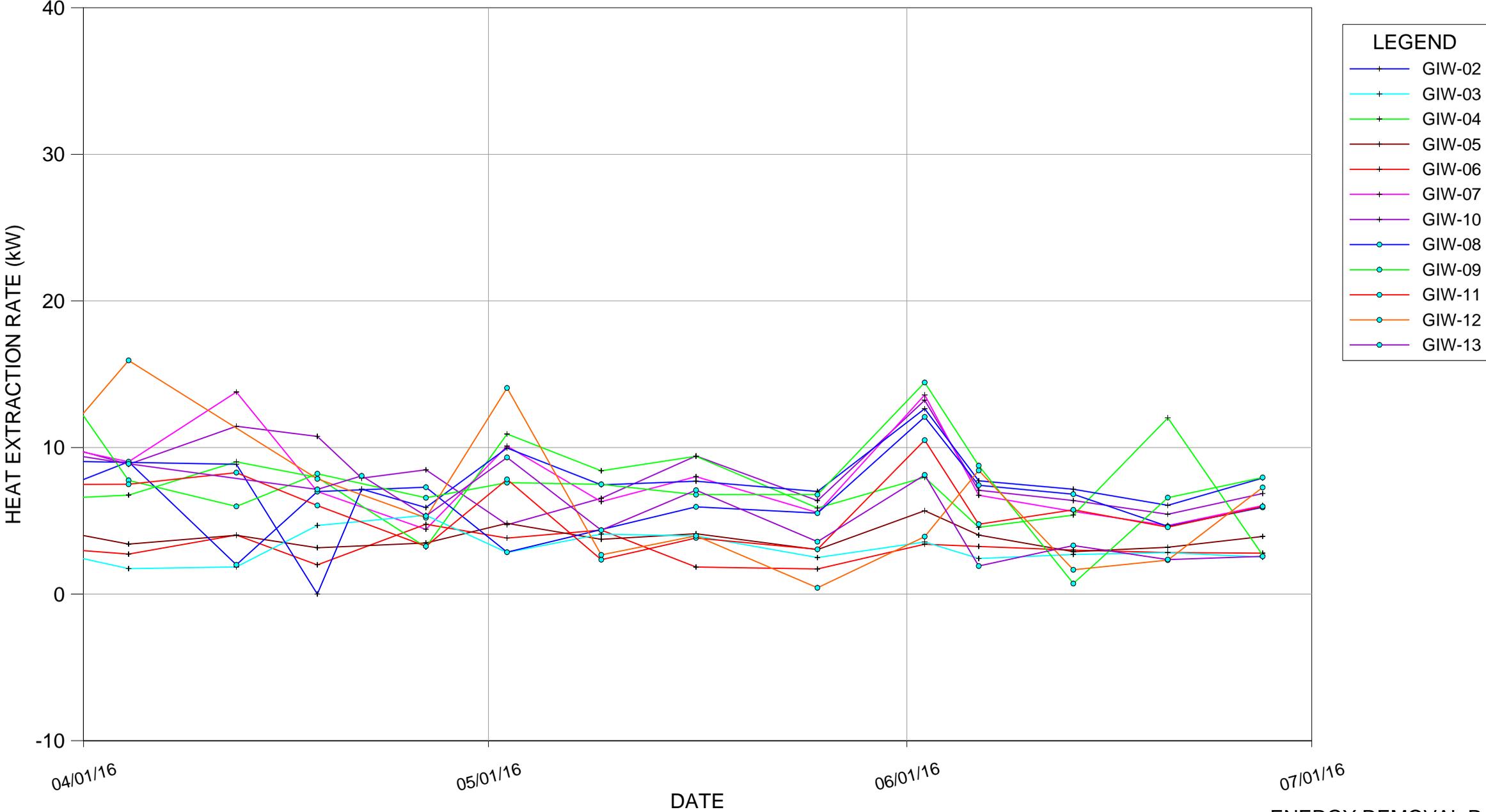
GIW-13



Note: Heat extraction rate data points are calculated based on instaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

FLOW RATE AND HEAT EXTRACTION VS TIME BRIDGETON LANDFILL (04/01/16 - 06/30/16)

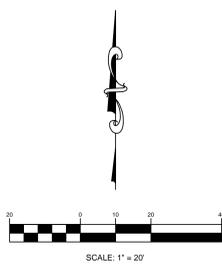
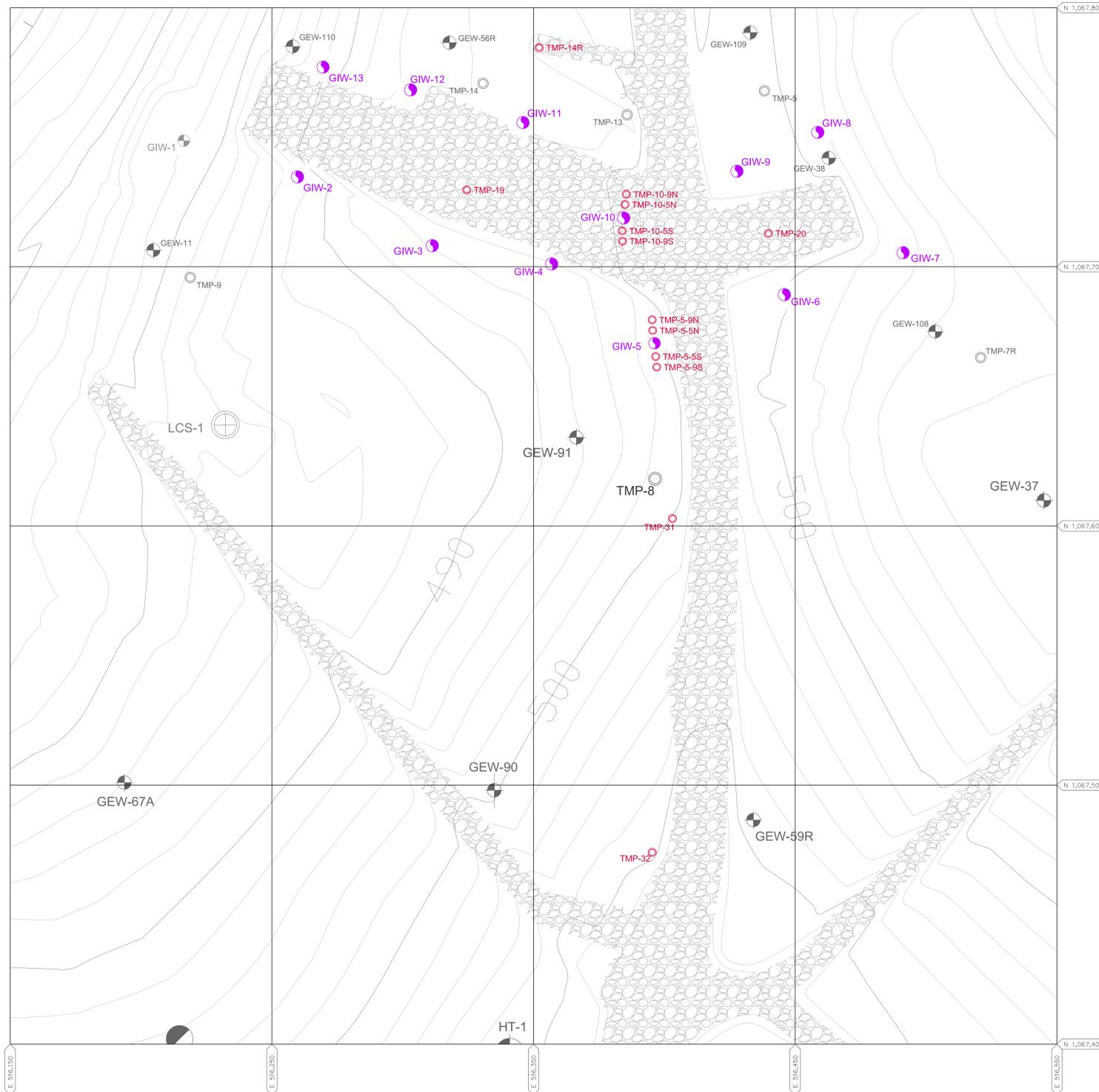
RATE OF ENERGY REMOVAL



Note: Heat extraction rate data points are calculated based on instantaneously measured input and output temperatures and provide an snapshot. Input and output temperatures fluctuate and the heat extraction rate varies inbetween data points from the connecting lines shown.

ENERGY REMOVAL RATE
BRIDGETON LANDFILL
(04/01/16 - 06/30/16)

Appendix C – Temperature Monitoring Probe Layout



LEGEND

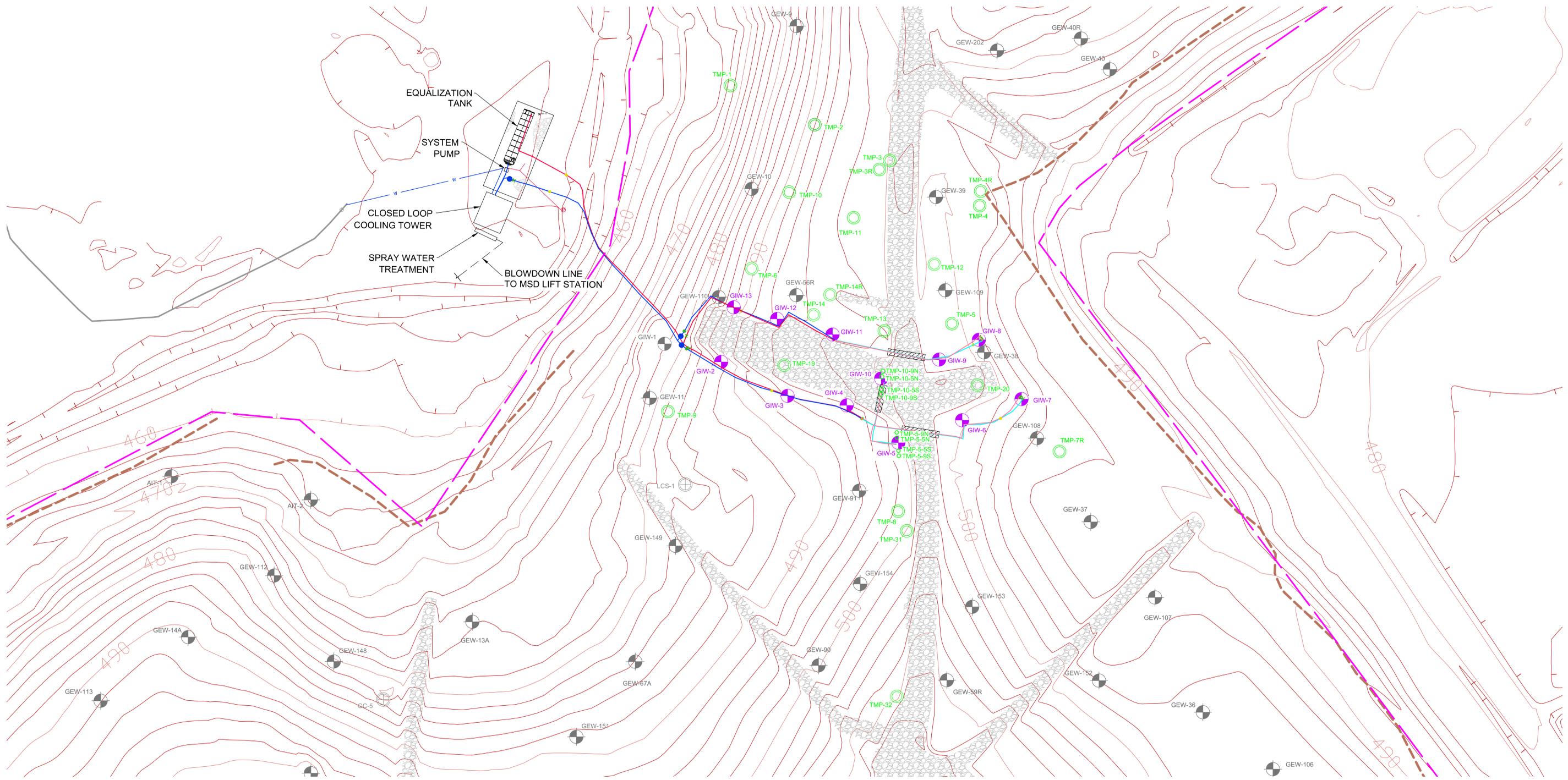
- EXISTING GRADE (2' CONTOUR)
- EXISTING GRADE (10' CONTOUR)
- EXISTING GAS EXTRACTION WELL
- EXISTING GAS INTERCEPTOR WELL
- EXISTING TEMPERATURE MONITORING PROBE
- HEAT REMOVAL POINT WITHIN GAS INTERCEPTOR WELL
- PILOT STUDY TEMPERATURE MONITORING PROBE

TMP INSTALLATION			
ID	Northing	Easting	Depth (ft)
TMP-19	1067729.43	516324.34	140
TMP-14R	1067784.62	516352.17	140
TMP-20	1067712.59	516439.87	140
TMP-5-9S	1067661.16	516397.18	100
TMP-5-5S	1067665.2	516396.79	100
TMP-5-5N	1067675.28	516395.69	100
TMP-5-9N	1067679.41	516395.37	100
TMP-10-9S	1067709.77	516384.13	100
TMP-10-5S	1067713.85	516384	100
TMP-10-5N	1067723.9	516384.95	100
TMP-10-9N	1067727.77	516385.53	100
TMP-31	1067602.84	516403.11	192.96
TMP-32	1067474.00	516395.36	205.2

NOTES:
 1.) AERIAL TOPOGRAPHY WAS PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014.

BRIDGETON LANDFILL, LLC 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	TEMPERATURE MONITORING PROBE LAYOUT		OCTOBER 2015	DRAWING NO.:
			DESIGNED BY: AMR	001
TEMPERATURE MONITORING PROBE LAYOUT			APPROVED BY: ALK	
PROJECT NUMBER: BT-045 FILE PATH:			REVISION	DATE

Appendix D – Heat Removal System Plan View



LEGEND

	EXISTING GRADE (2' CONTOUR)
	EXISTING GRADE (10' CONTOUR)
	EXISTING GAS EXTRACTION WELL
	EXISTING TEMPERATURE MONITOR PROBE
	EXISTING HEAT EXTRACTION POINT
	4" COOLING LOOP INFLUENT PIPING (EXISTING)
	2" COOLING LOOP INFLUENT PIPING (EXISTING)
	4" COOLING LOOP EFFLUENT PIPING (EXISTING)
	2" COOLING LOOP EFFLUENT PIPING (EXISTING)
	TEMPERATURE MONITORING LOCATION
	CHECK VALVE
	FLOW CONTROL VALVE
	FLOWMETERS
	EXISTING SOLID WASTE PERMIT BOUNDARY
	EXISTING QUARRY HIGHWALL

NOTES:
 1) AERIAL TOPOGRAPHY WAS PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014.

BRIDGETON LANDFILL, LLC 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	BRIDGETON LANDFILL EXPANDED HEAT EXTRACTION PILOT STUDY ADDITIONAL HEAT EXTRACTION PTS		OCTOBER 2015	DRAWING NO.:
			DESIGNED BY: DMK	001
HEAT REMOVAL SYSTEM PLAN VIEW			APPROVED BY: ALK	
<small>PROJECT NUMBER: BT-062 FILE PATH: C:\Users\dmk\OneDrive\OneDrive\Projects\BT-062\Project\Drawings\HEAT Removal System Plan View.dwg</small>			REVISION	DATE

Appendix E – Heat Extraction System Operating Log (Second Quarter 2016)

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Michael Spurgeon

Date: 4-15-16

Time: 0930

Actions Taken or Observations:

- Replaced GIW-2 and 8 input RTD wires.
- Rechecked Readings.
- Readings are stable.

