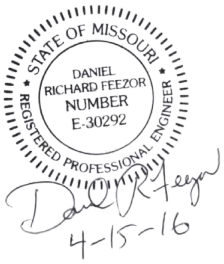
EXPANDED HEAT REMOVAL PILOT STUDY QUARTERLY REPORT

BRIDGETON LANDFILL

BRIDGETON, ST. LOUIS COUNTY, MISSOURI

April 2016



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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 first quarter of 2016.

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

2 SYSTEM OPERATION

The heat extraction system has operated consistently during the first quarter of 2016. The system has operated with minimal operational or physical changes since the expansion completed on June 26, 2015 (GIWs-8, -9, -11, -12 and -13). A review of **Appendix B** shows consistent heat removal rates from each point during the reporting period.

3 DATA SUMMARY

The collection of in-waste temperature measurements have been obtained weekly during the first quarter of 2016 as part of the on-going pilot study. The measurements of in-waste temperatures are presented graphically in **Appendix A**. The inflow temperature, outflow temperature and flow rate are recorded at each heat removal unit on a near weekly basis. These parameters are utilized to calculate the heat extraction rate (kilowatts) at each individual removal point. The heat extraction rate, for each point, is presented graphically with the respective flow rate (gallons per minute) in **Appendix B**.

4 SUMMARY AND DISCUSSION OF RESULTS

The BL has continued the successful operation of twelve (12) heat removal points this reporting period. The heat removal system has operated with only minor maintenance since the expansion of the system in June of 2015. The system continues to operate with minimal interruption.

The data collected during the reporting period is relatively consistent with data recorded in previous quarters. A review of the in-waste temperature measurements show consistent temperatures during the reporting period. The TMPs at approximately five (5) and nine (9) feet to the north of heat removal points have continued to exhibit significant temperature reductions compared to measurements obtained prior to the system initiation. The in-waste temperature measurements adjacent to heat removal points on the south side have shown a consistent reduction from the original temperatures, however these reductions are significantly less in magnitude compared to the north.

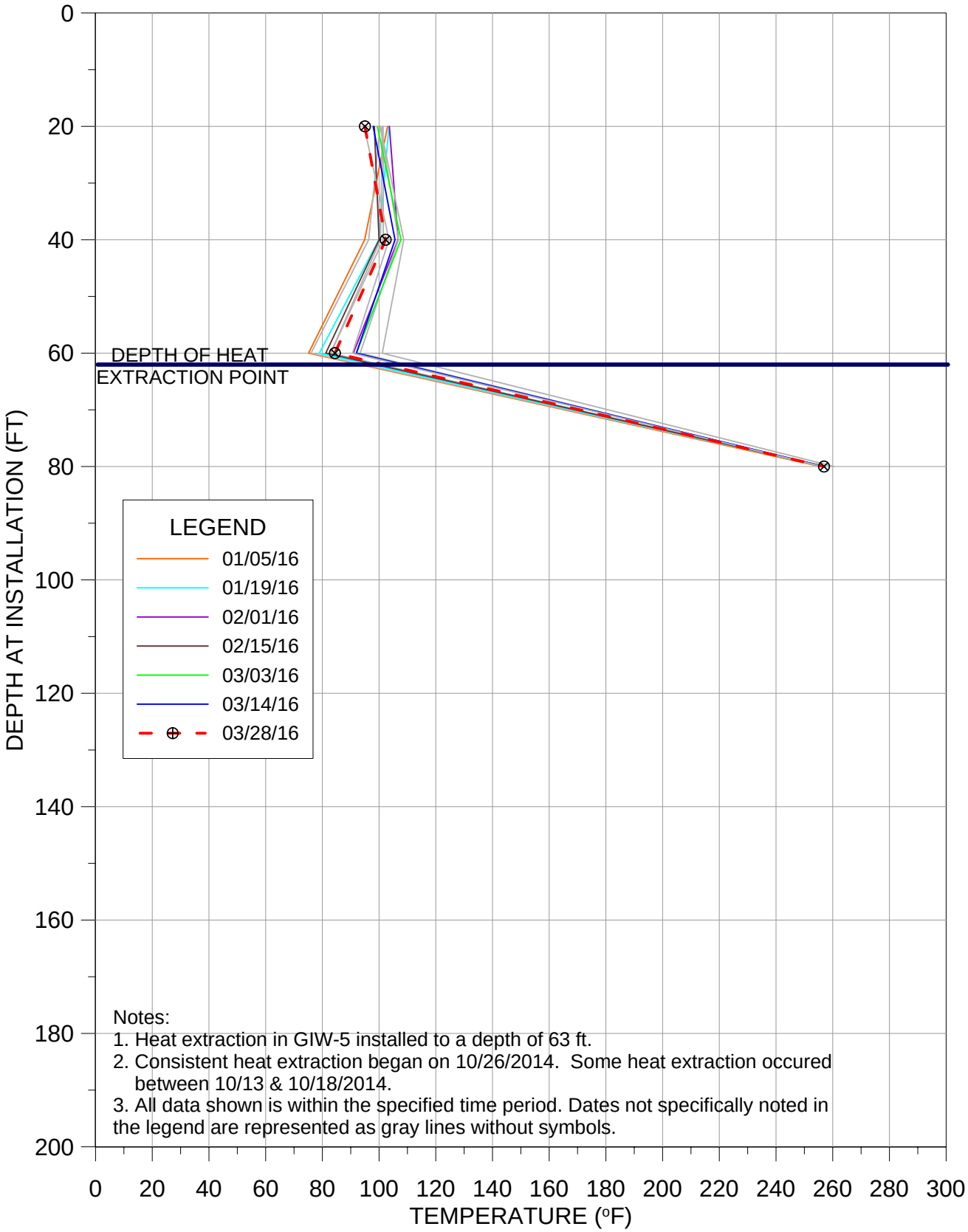
The temperatures on the north side of the heat removal points have remained significantly lower compared to the south side. This indicates normal landfill heat generation in the waste on the north side of the heat removal points.

A review of the heat removal point data for this reporting period has been conducted. The initial or south line of heat removal points have shown relatively steady rates of energy removal. The steady-state removal rate of the northern line of points are higher than the points installed on the south row of points. This is expected and likely attributed to the deeper depth of the heat removal points on the north row.

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

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

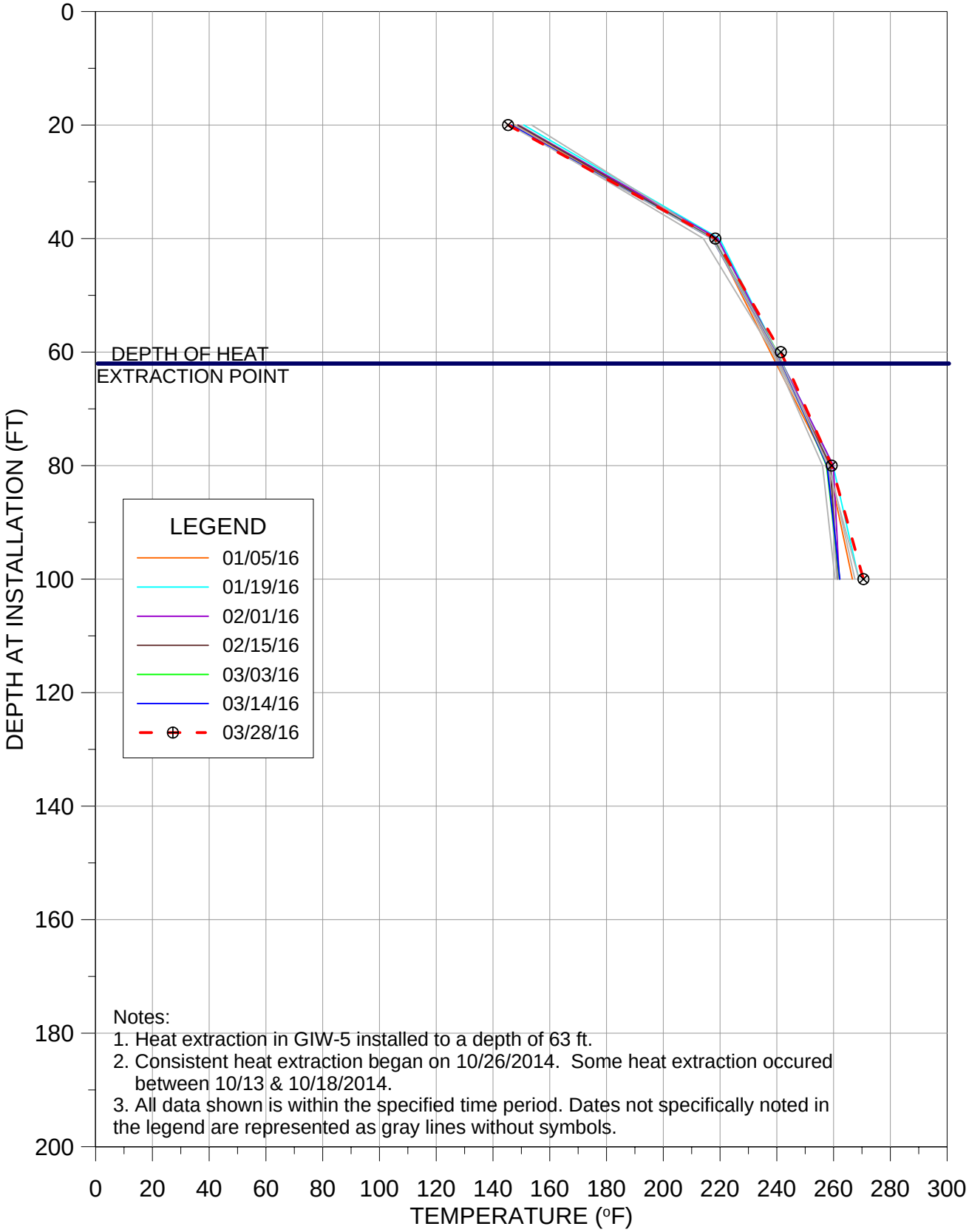
TMP-5-5N



Notes:
1. Heat extraction in GIW-5 installed to a depth of 63 ft.
2. Consistent heat extraction began on 10/26/2014. Some heat extraction occured between 10/13 & 10/18/2014.
3. 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
(1/1/16 - 3/31/16)

TMP-5-5S



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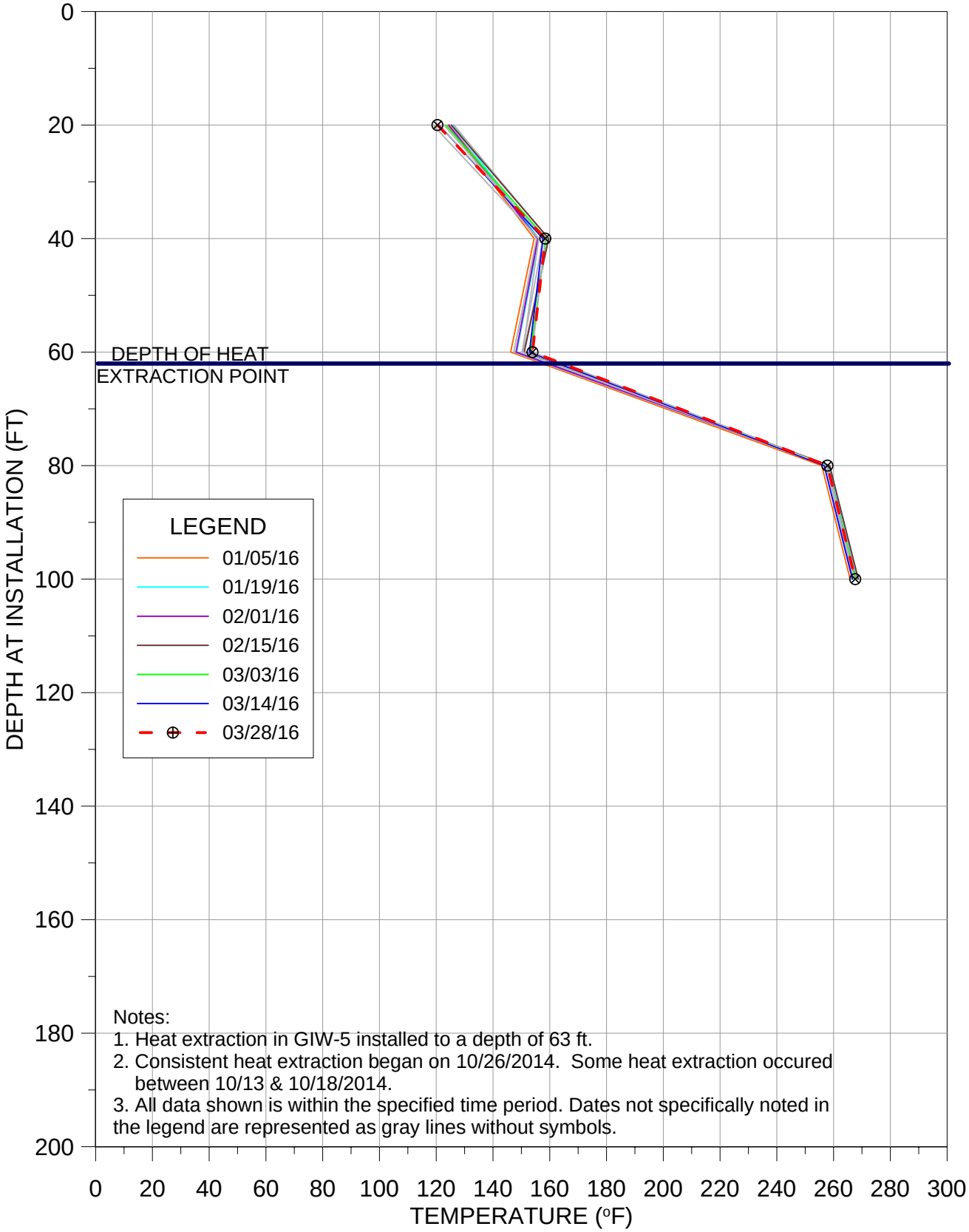
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

TMP-5-9N



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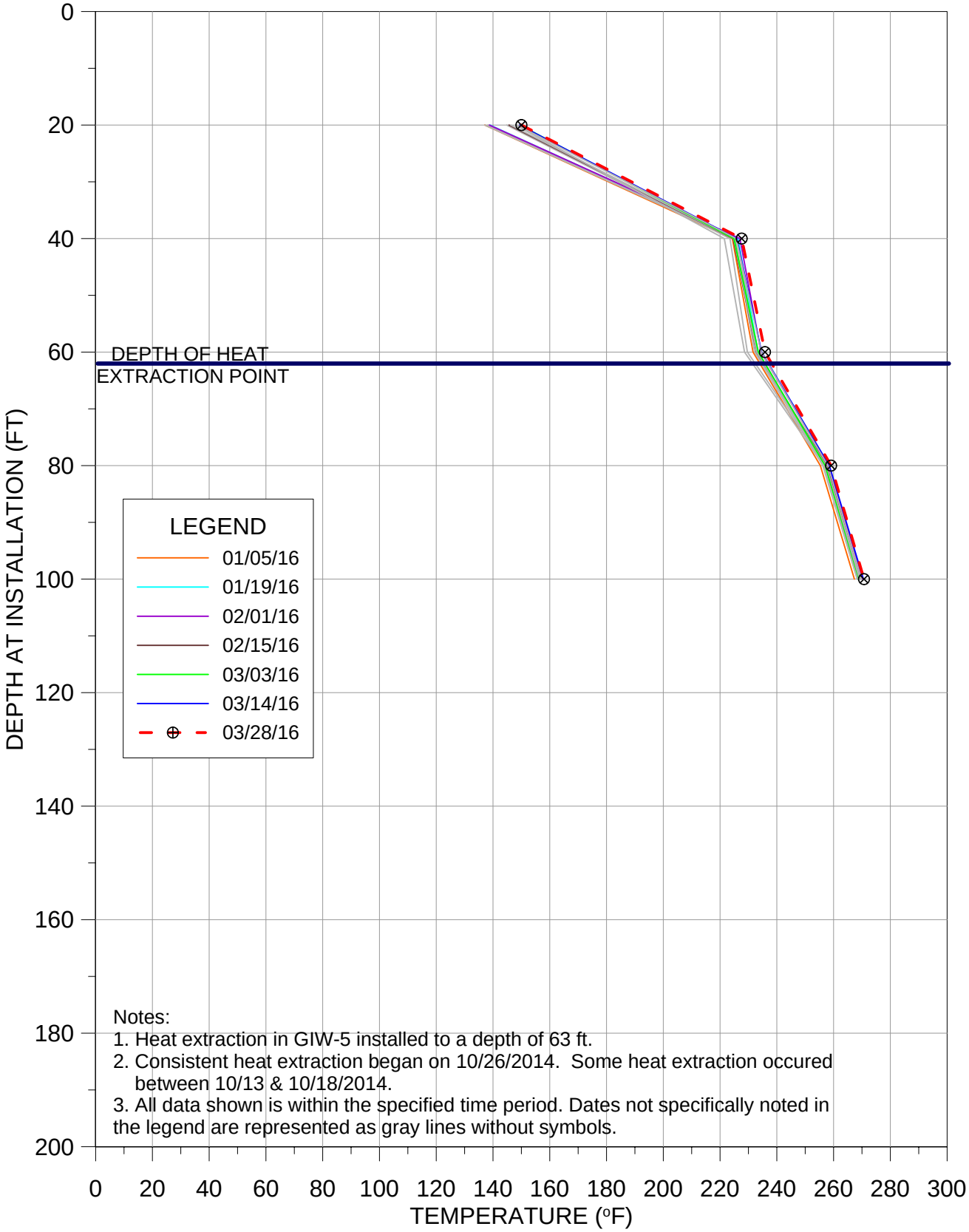

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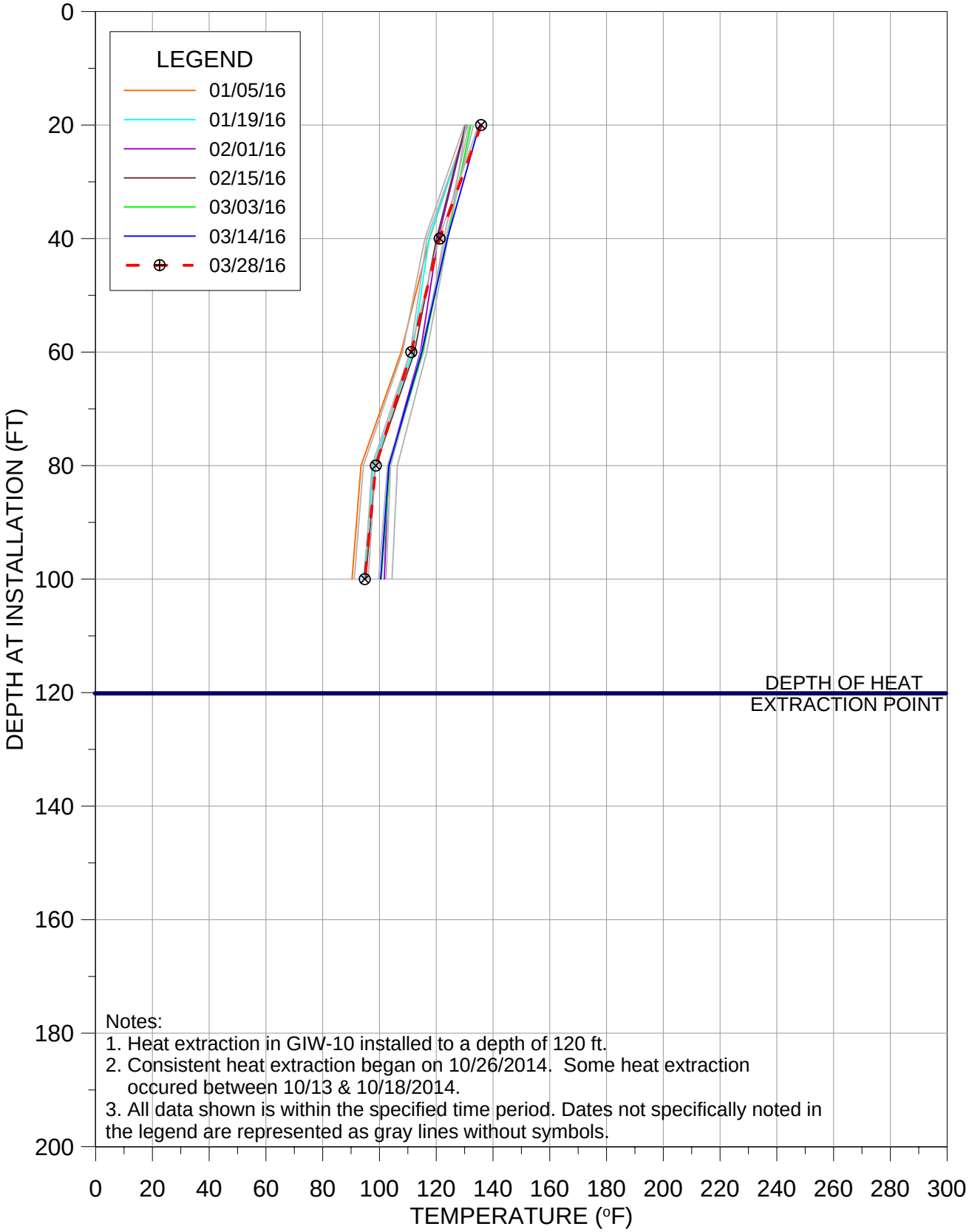
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

TMP-10-5N



Notes:
1. Heat extraction in GIW-10 installed to a depth of 120 ft.
2. Consistent heat extraction began on 10/26/2014. Some heat extraction occured between 10/13 & 10/18/2014.
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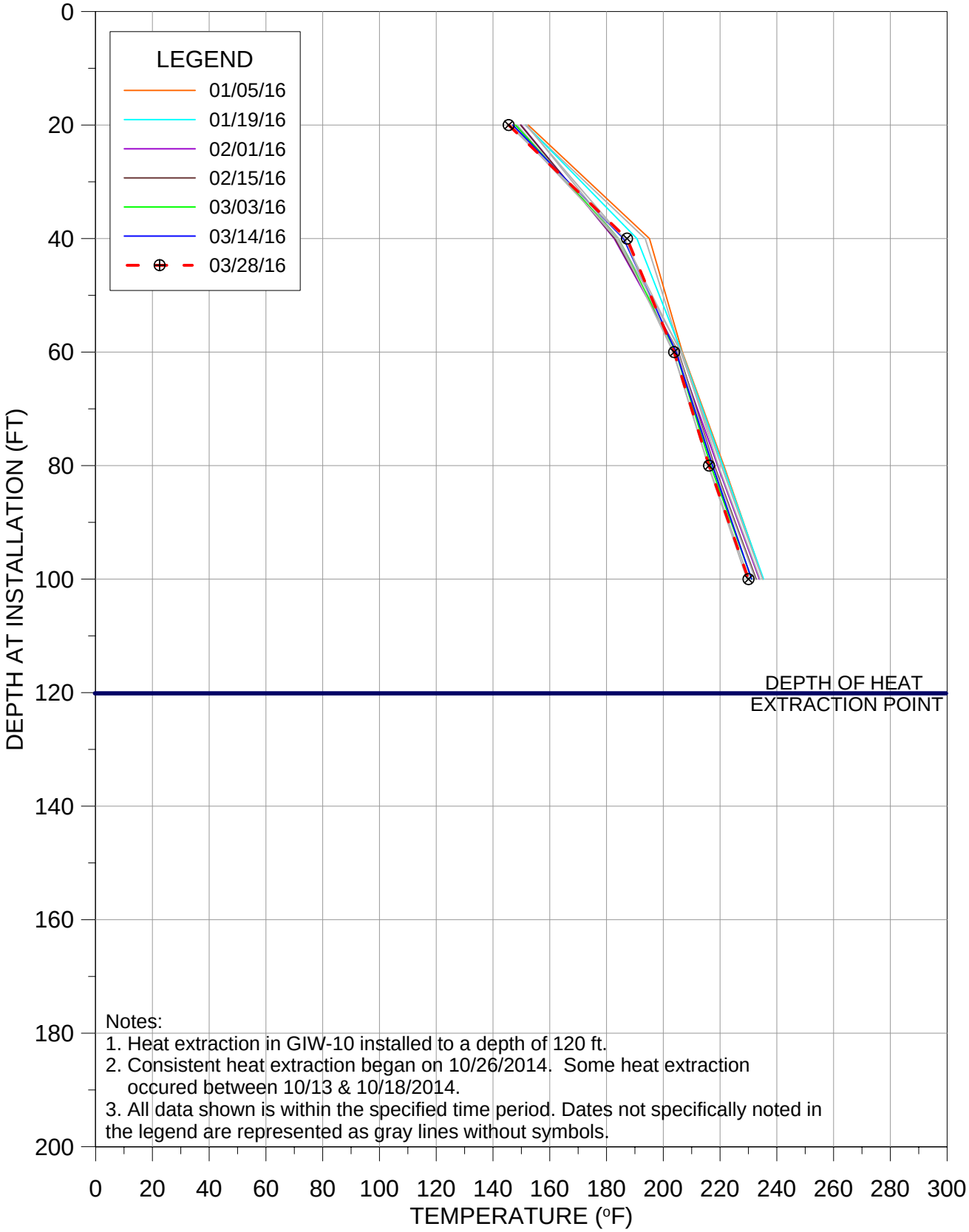
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

TMP-10-5S



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BRIDGETON LANDFILL
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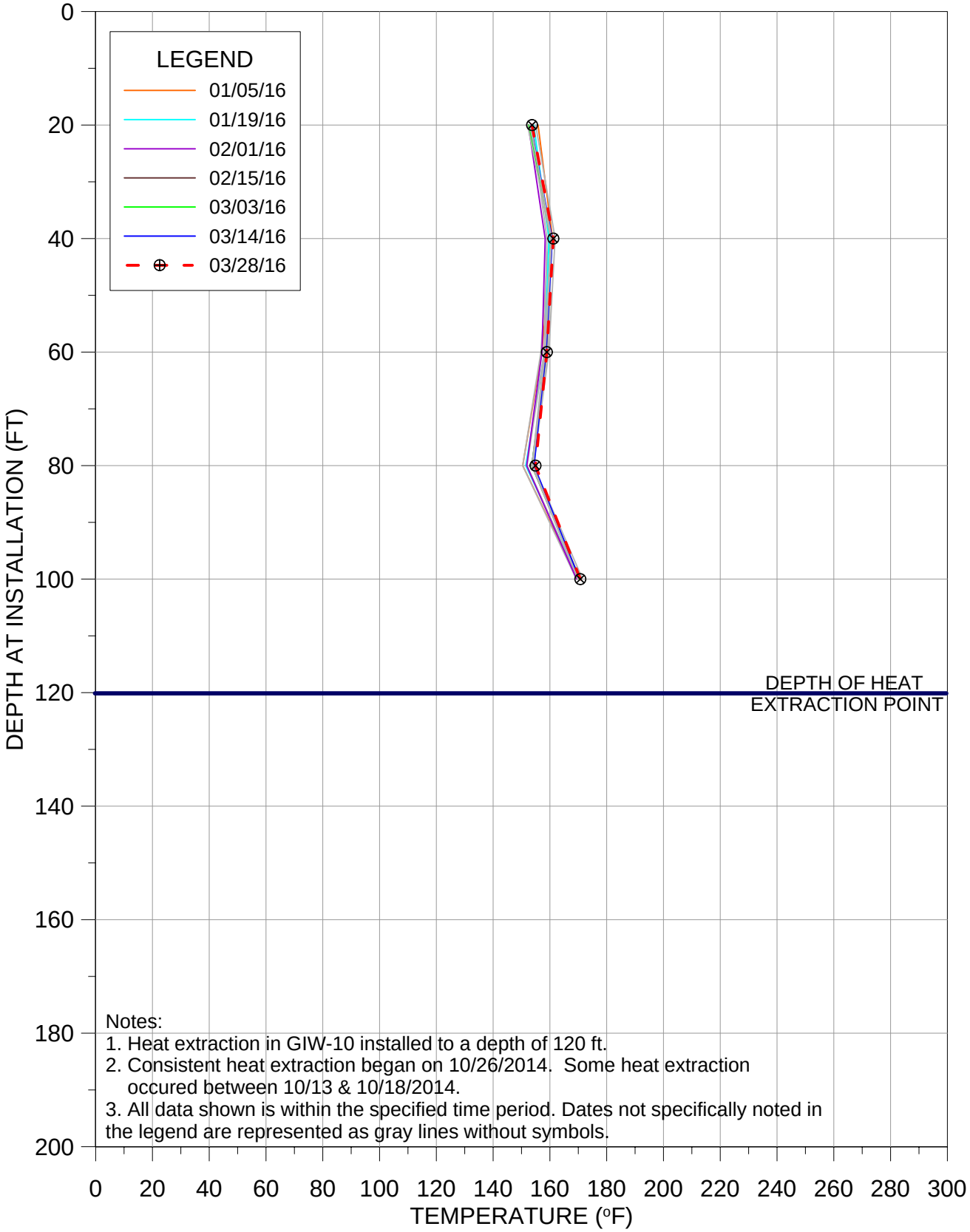
TMP-10-9N



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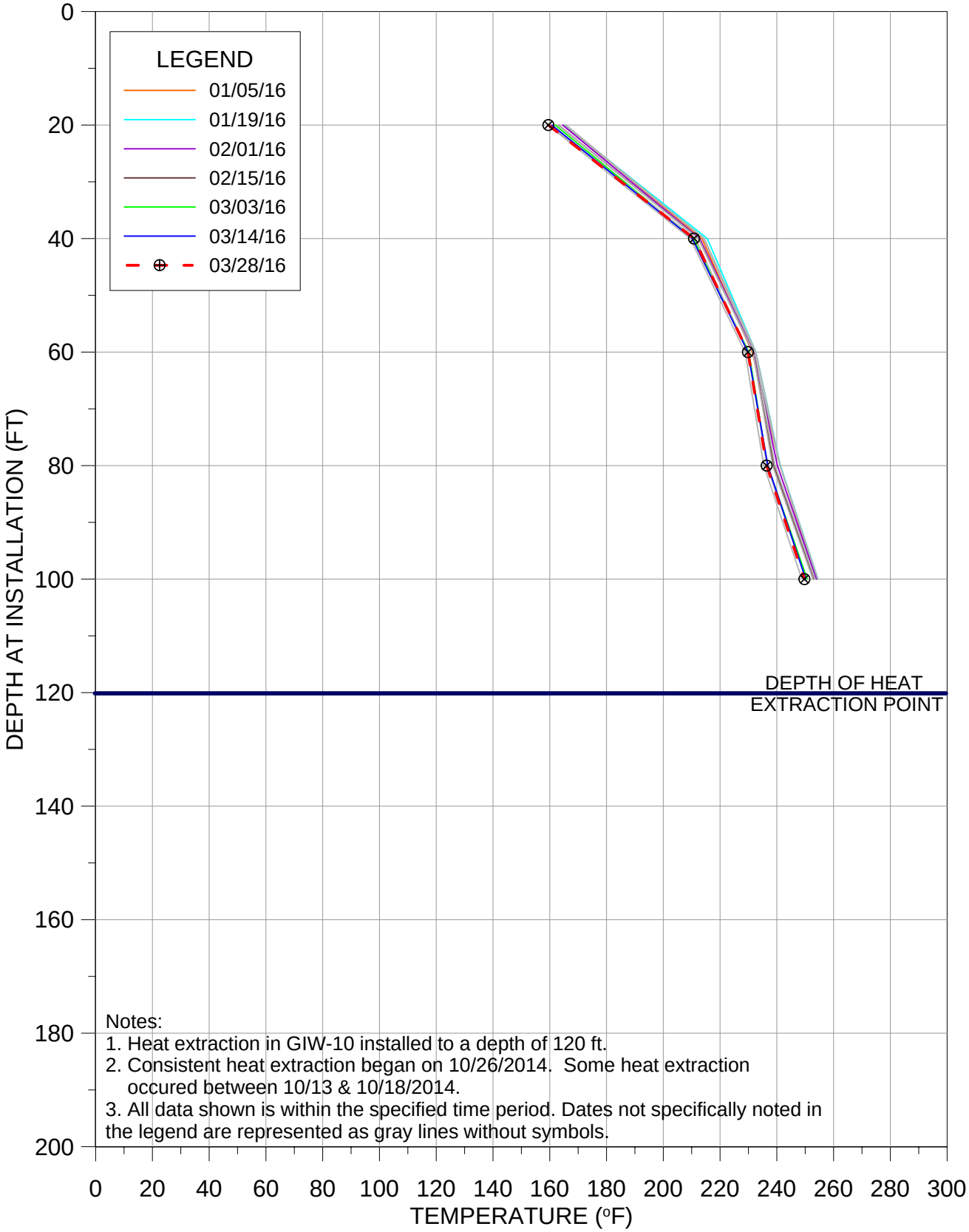

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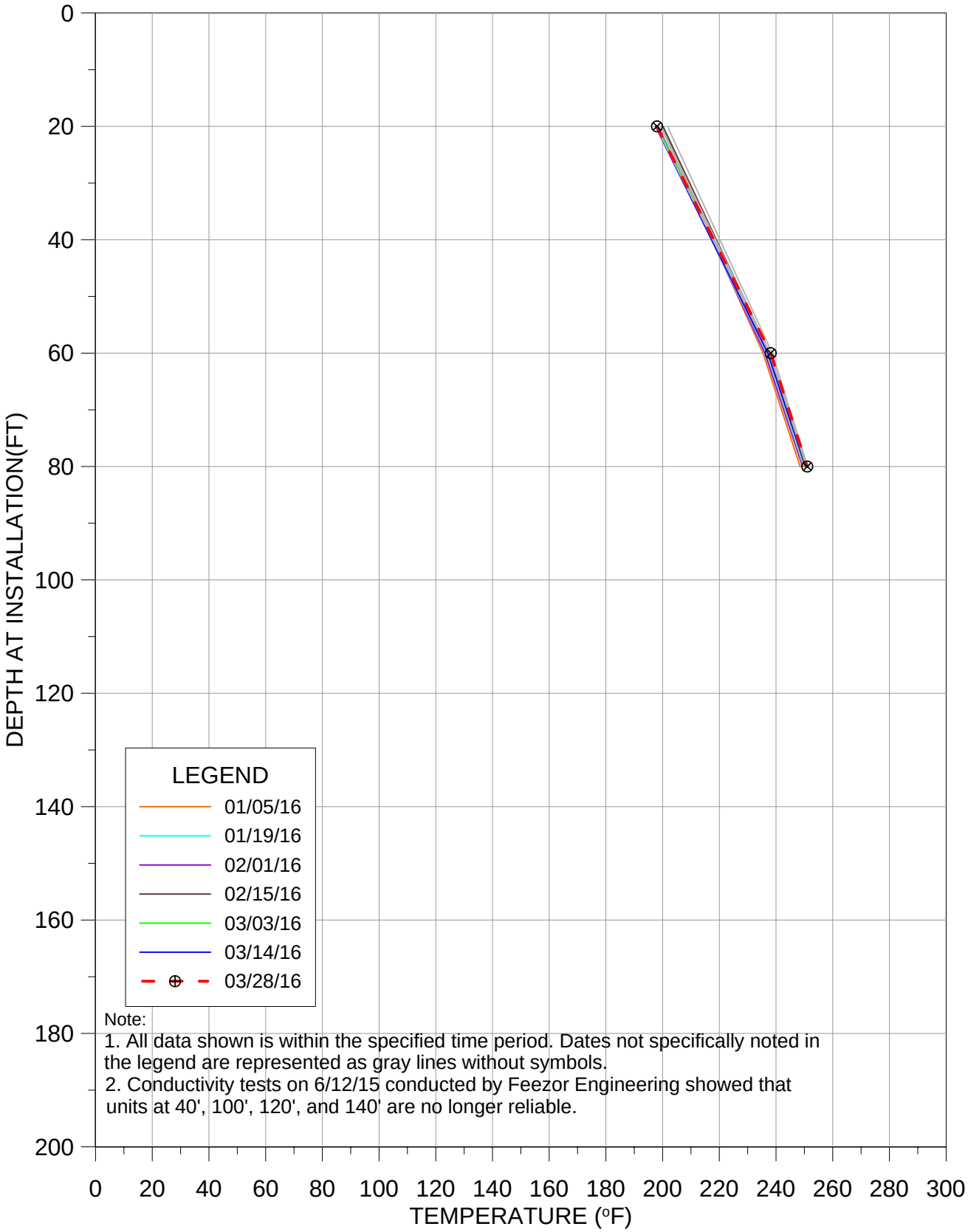
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

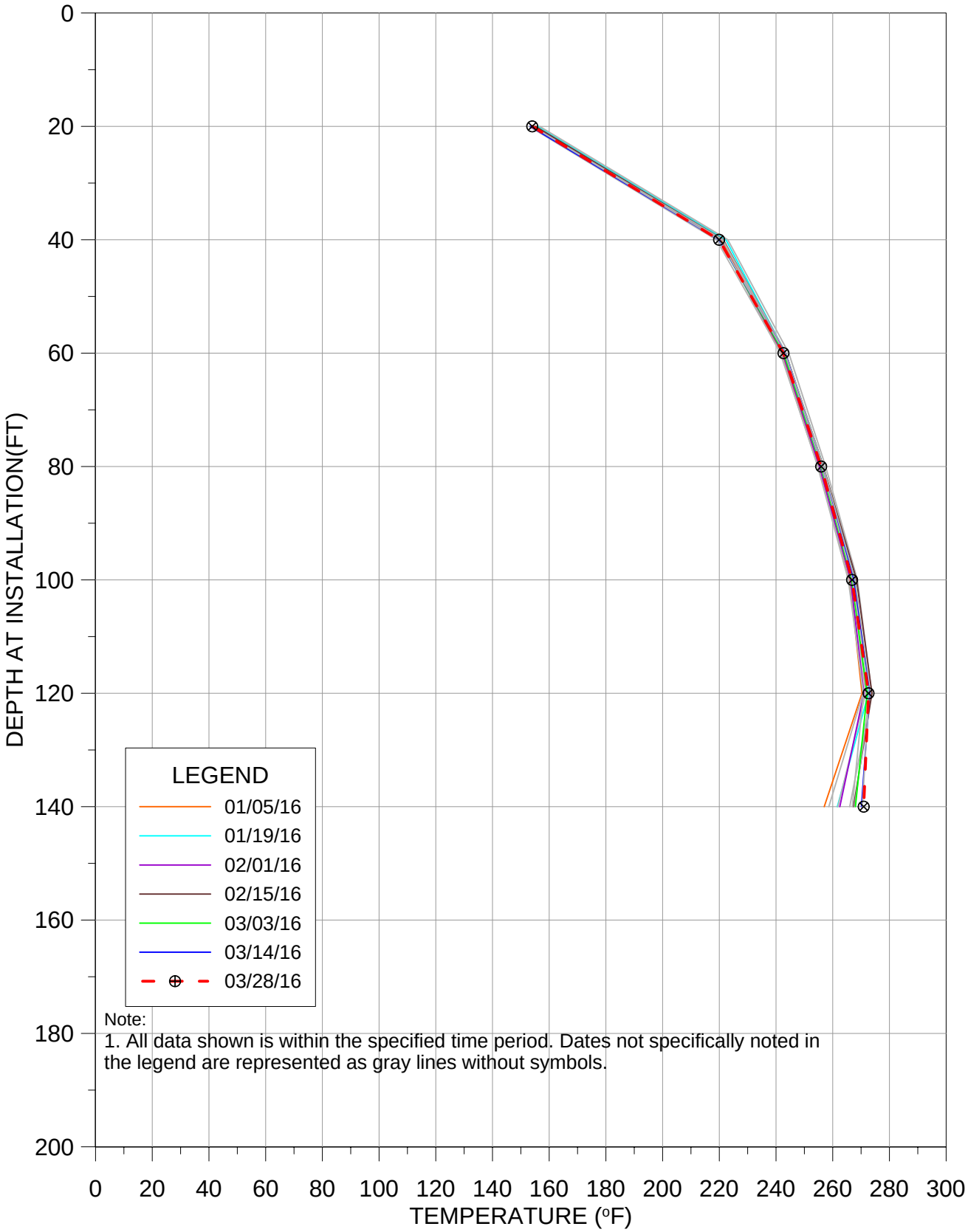
TMP-19



Note:
1. All data shown is within the specified time period. Dates not specifically noted in the legend are represented as gray lines without symbols.
2. Conductivity tests on 6/12/15 conducted by Feezor Engineering showed that units at 40', 100', 120', and 140' are no longer reliable.

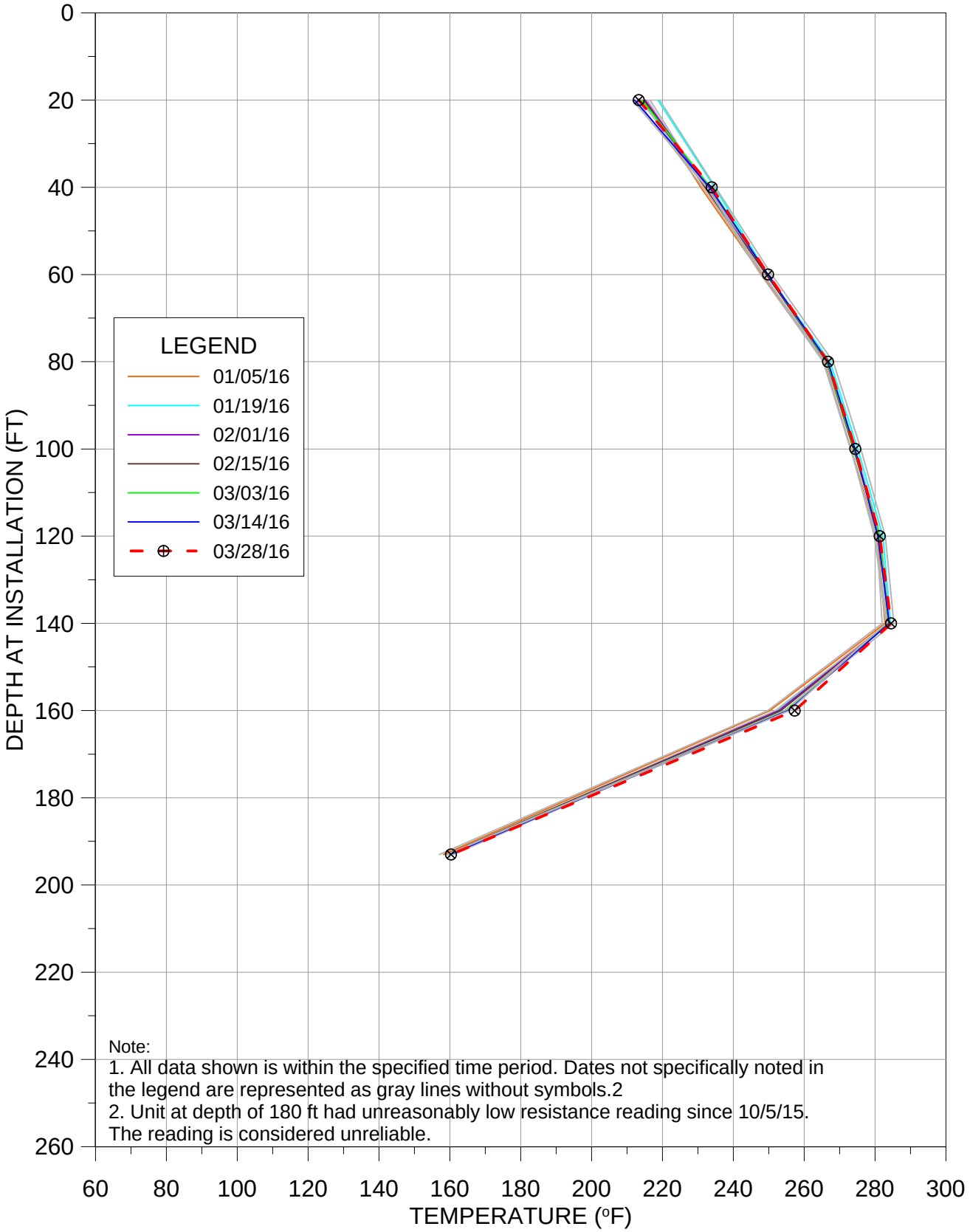
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

TMP-20



TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

TMP-31



Note:
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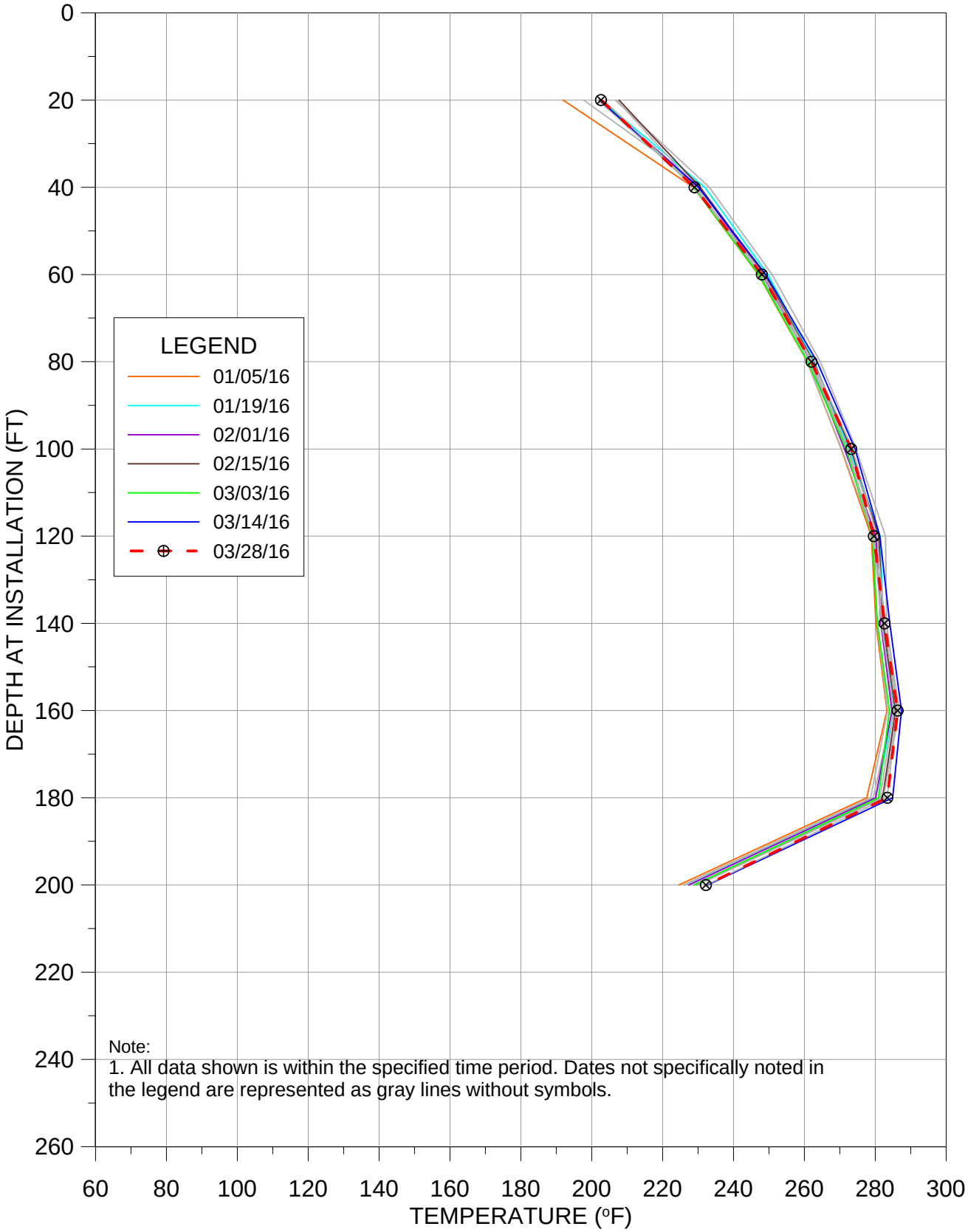
2. Unit at depth of 180 ft had unreasonably low resistance reading since 10/5/15. The reading is considered unreliable.

TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

TMP-32



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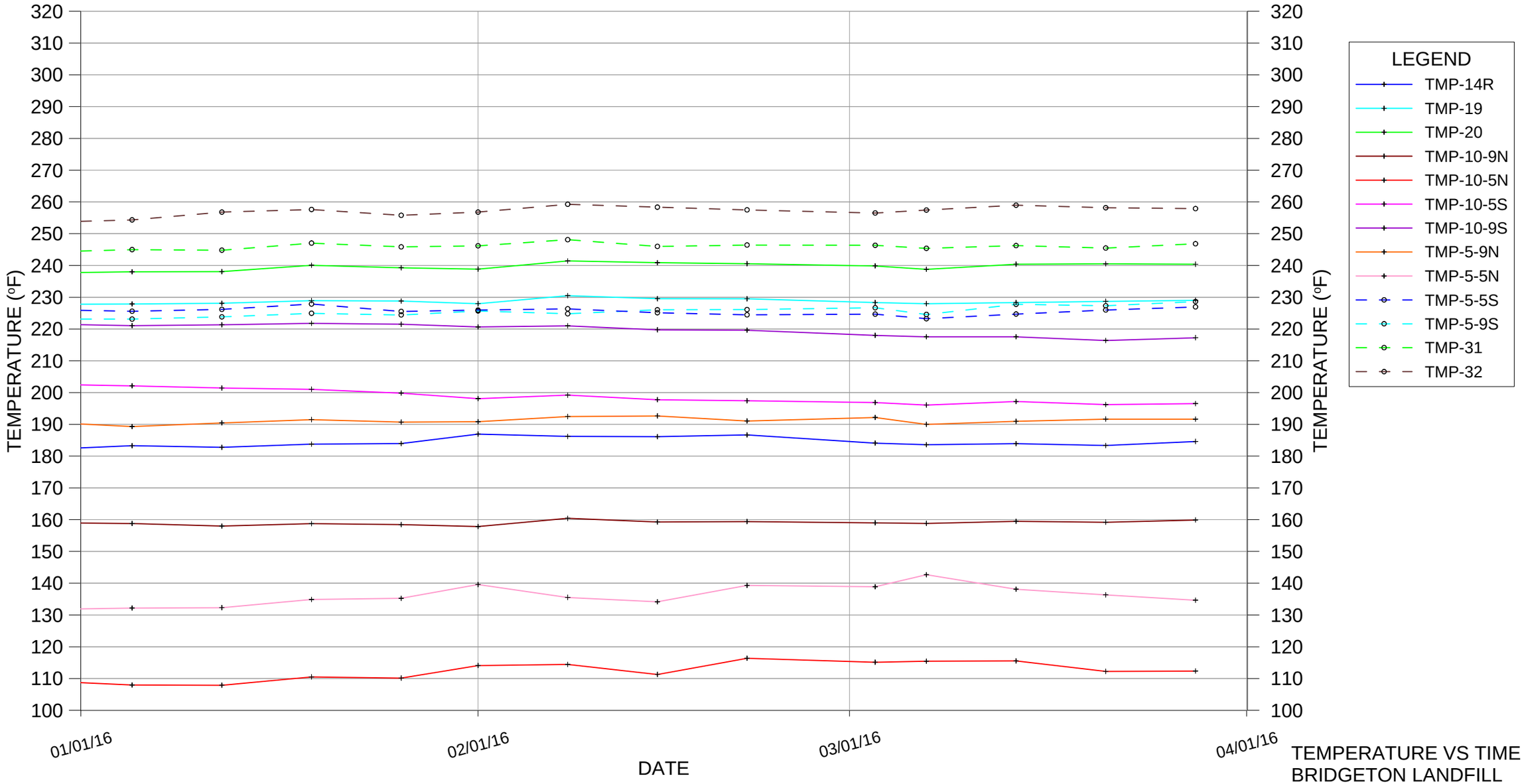
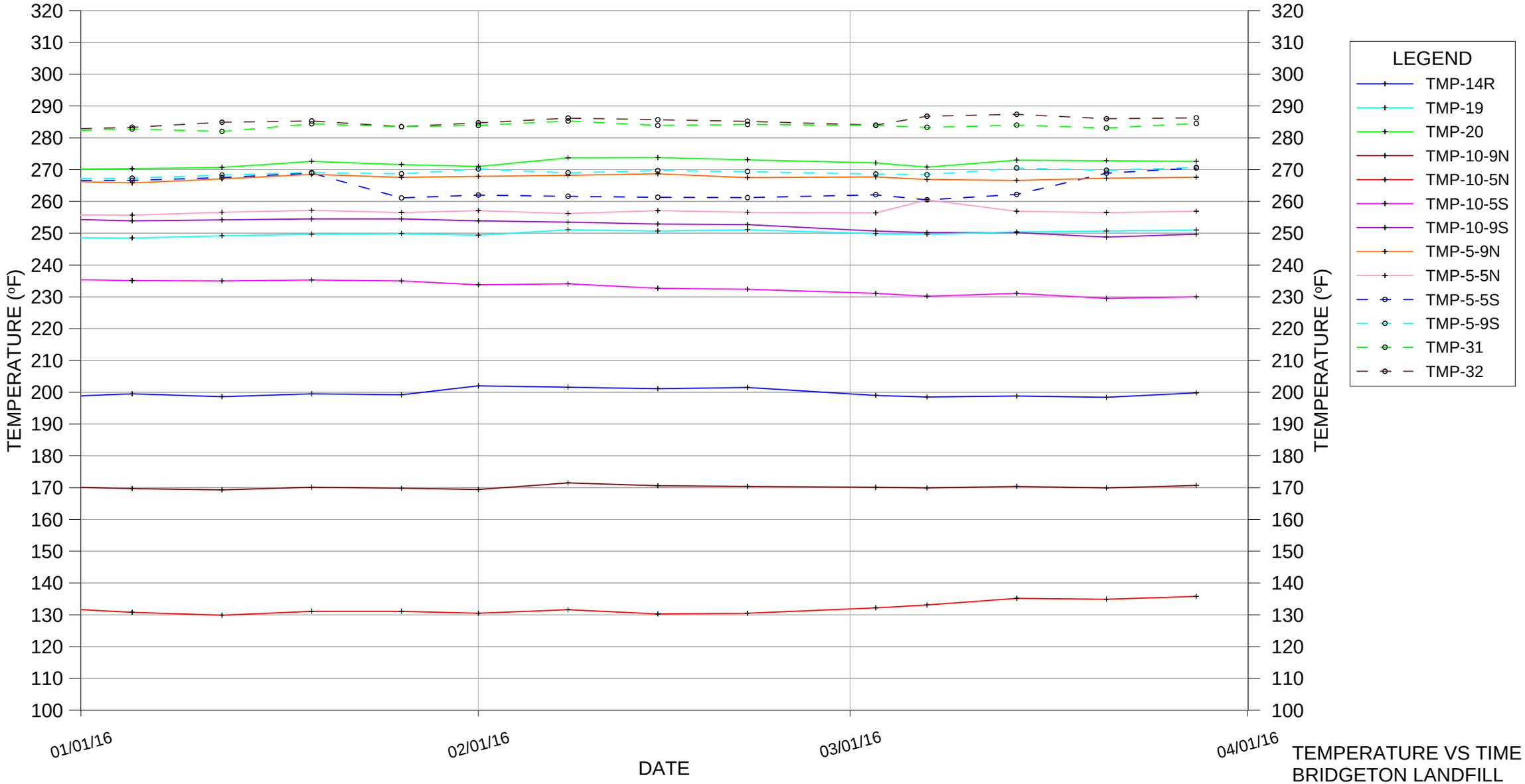
TEMPERATURE VS DEPTH
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

AVERAGE TEMPERATURES



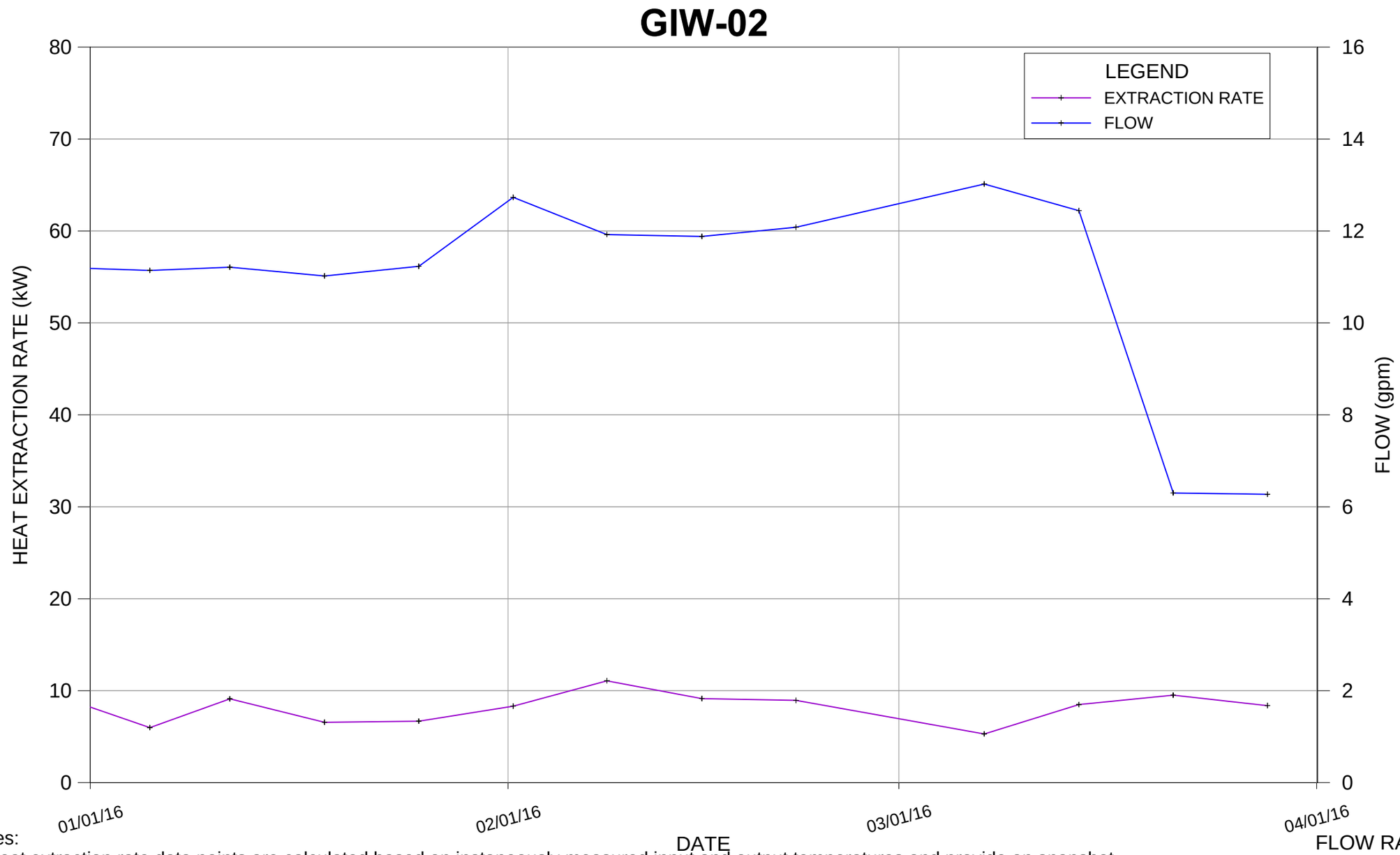
TEMPERATURE VS TIME
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

MAXIMUM TEMPERATURES



TEMPERATURE VS TIME
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

Appendix B – Heat Removal Point Data Graphs (First Quarter)



Notes:
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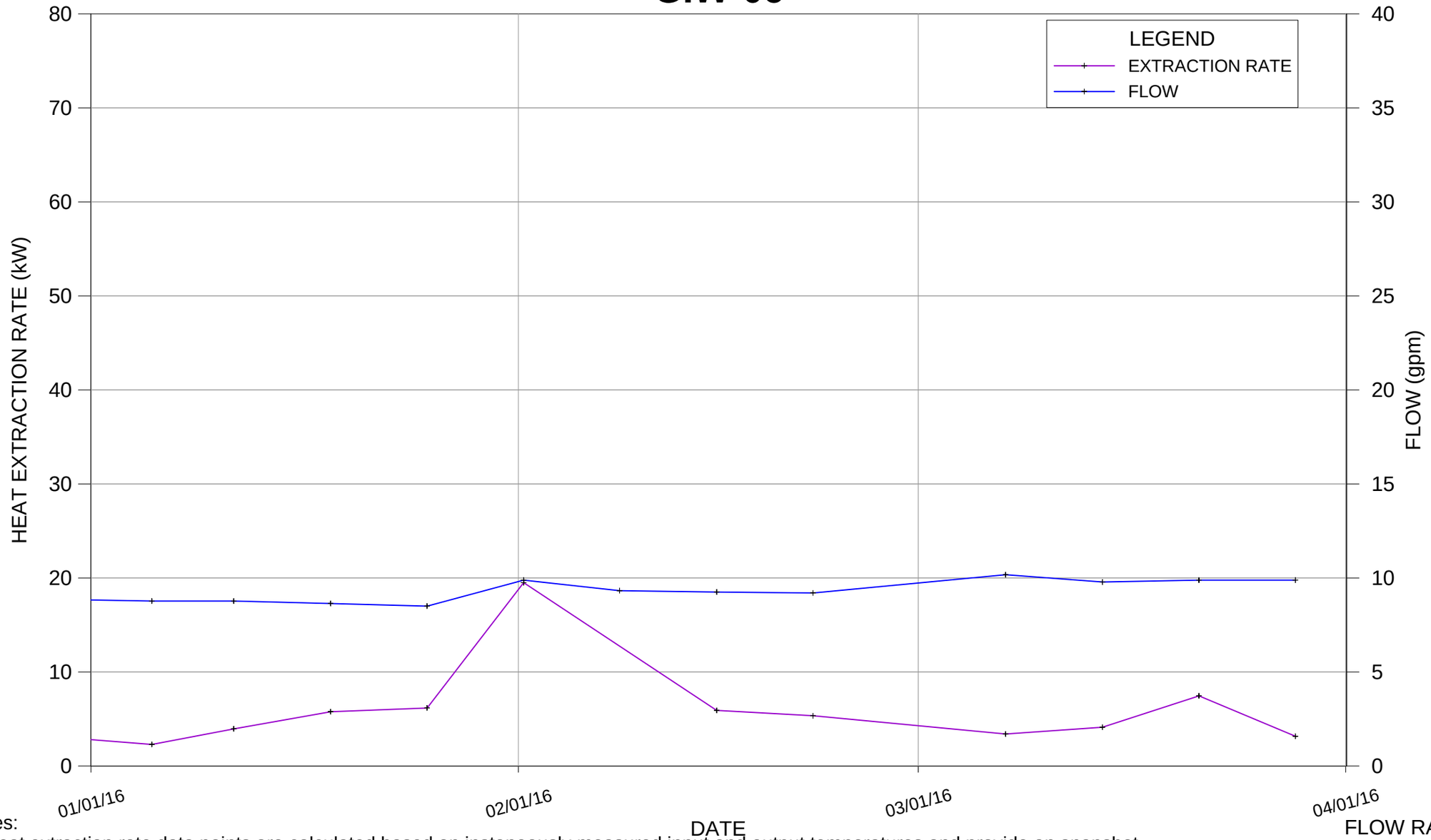
2. The temperature reading for GIW-2 on 11/17/2015 was deemed unreliable based Feezor Engineering's review and comparison of prior and subsequent readings. Therefore, the heat extration rate for 11/17/15 was removed.

FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

GIW-03



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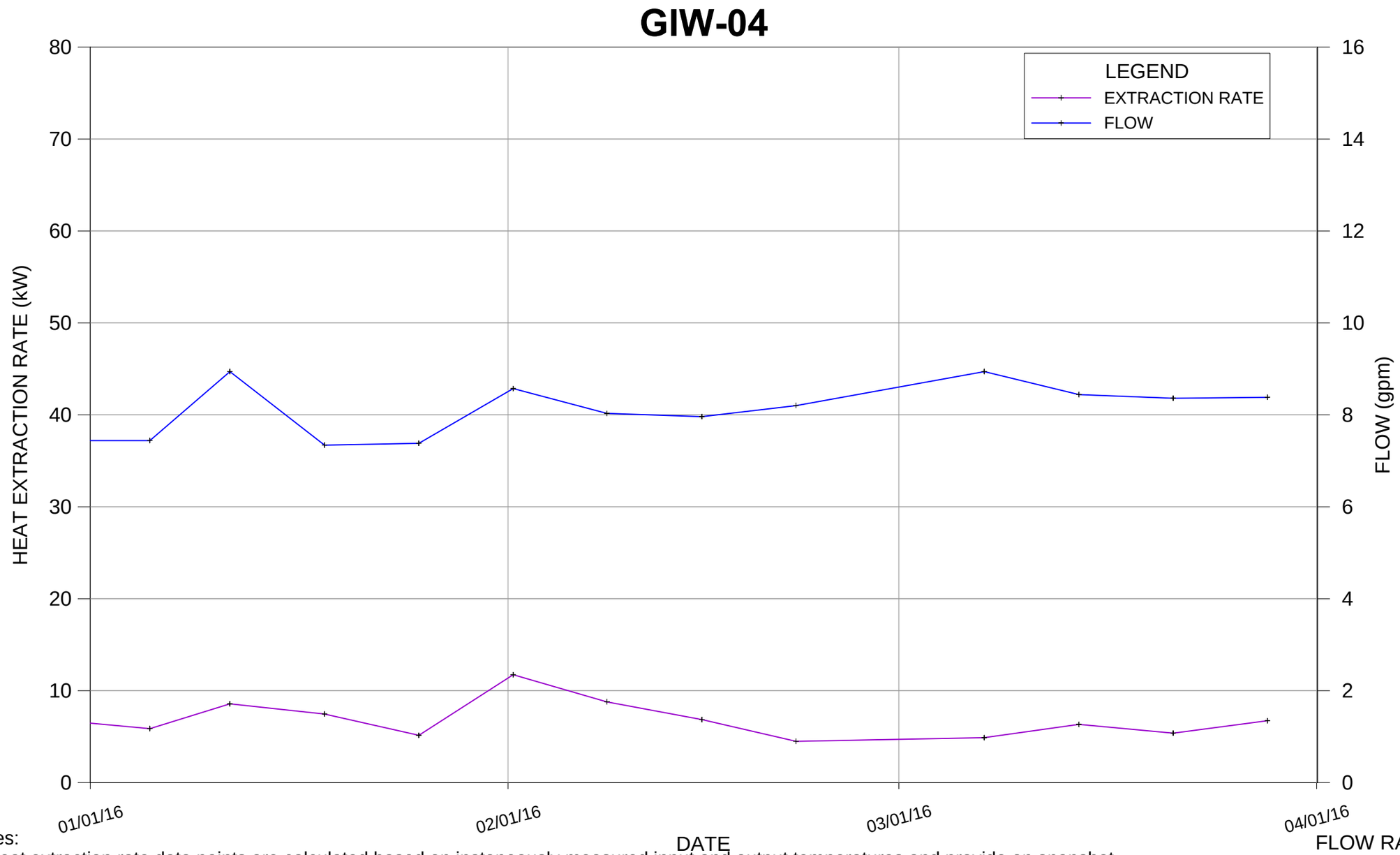

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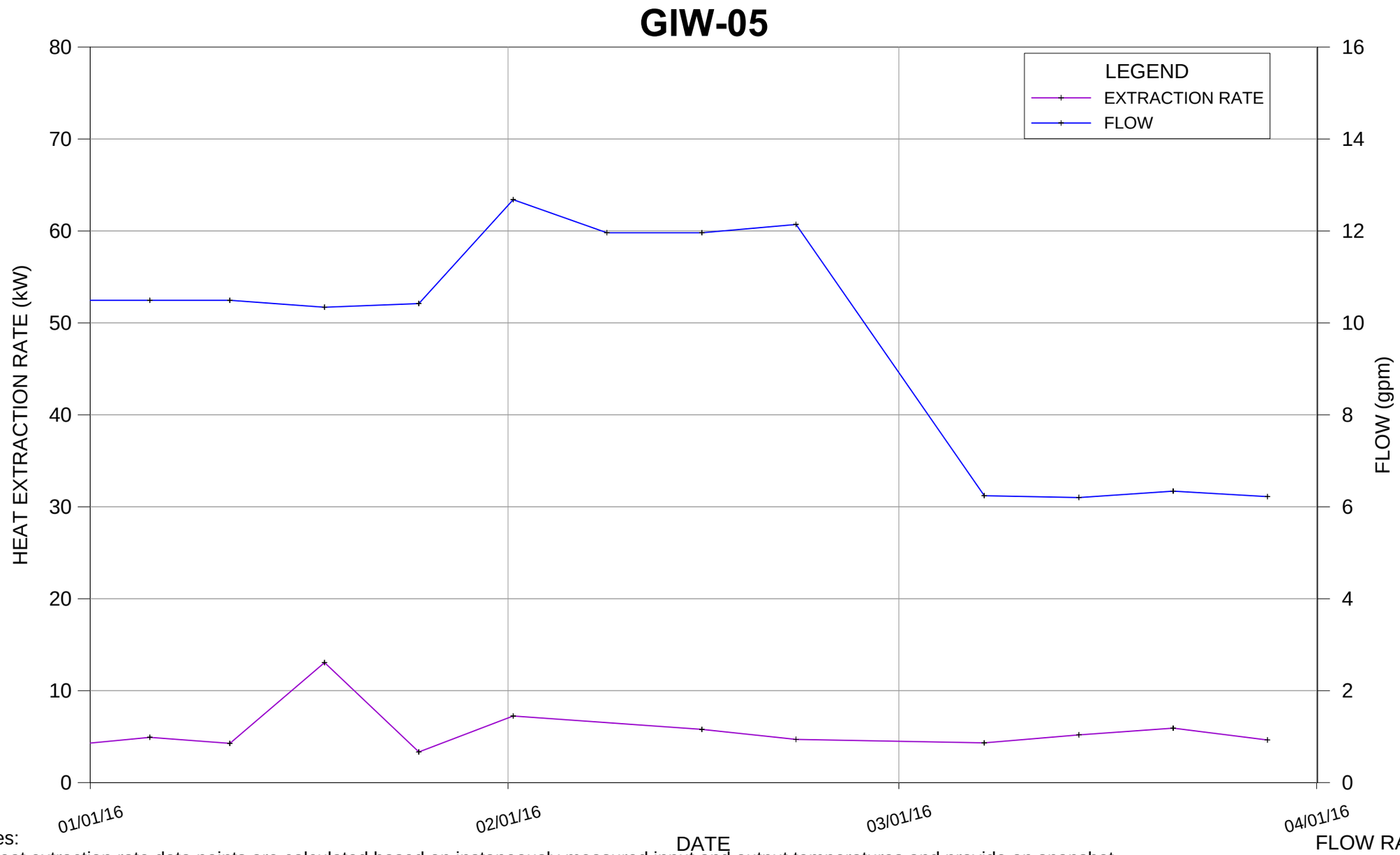

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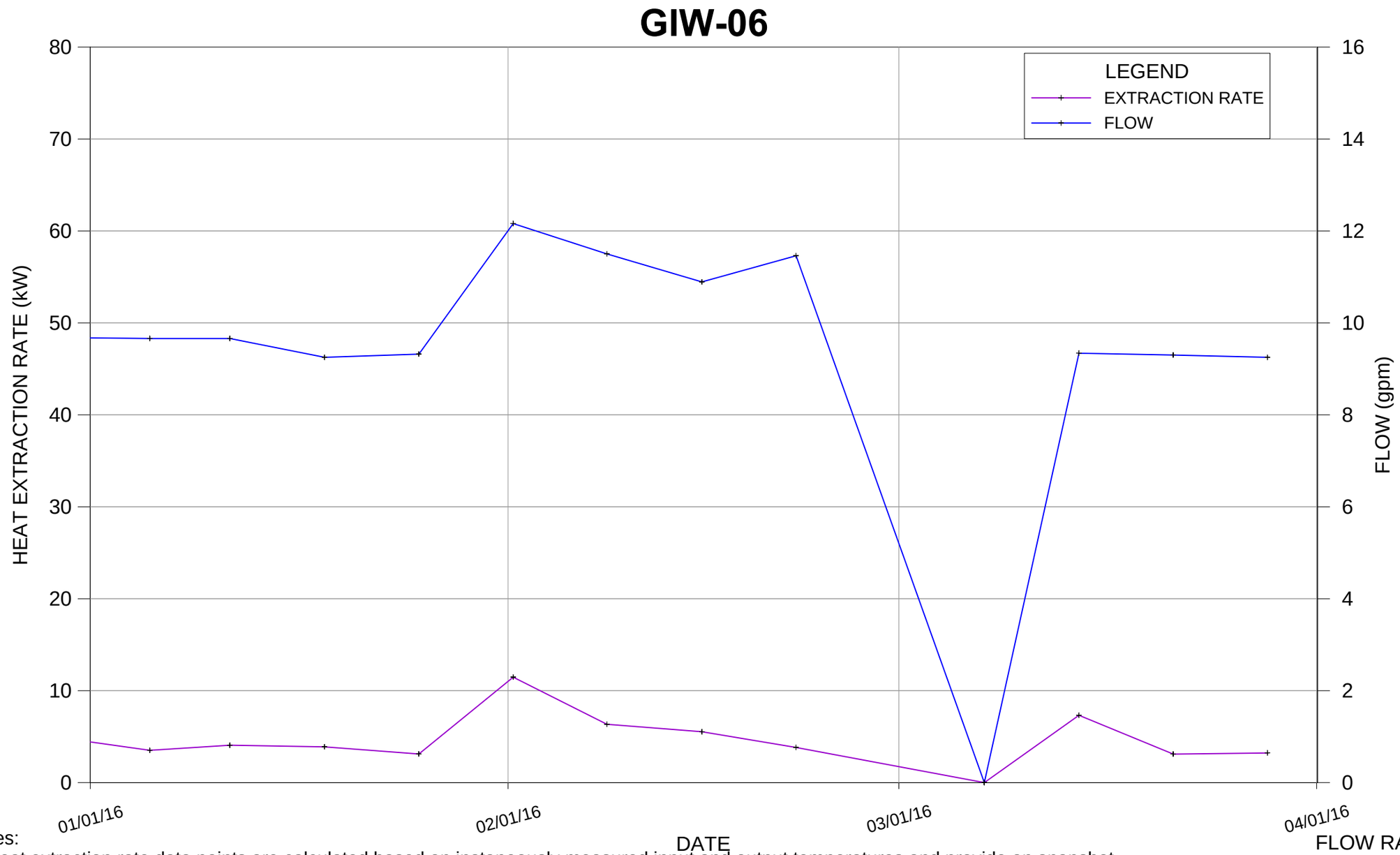

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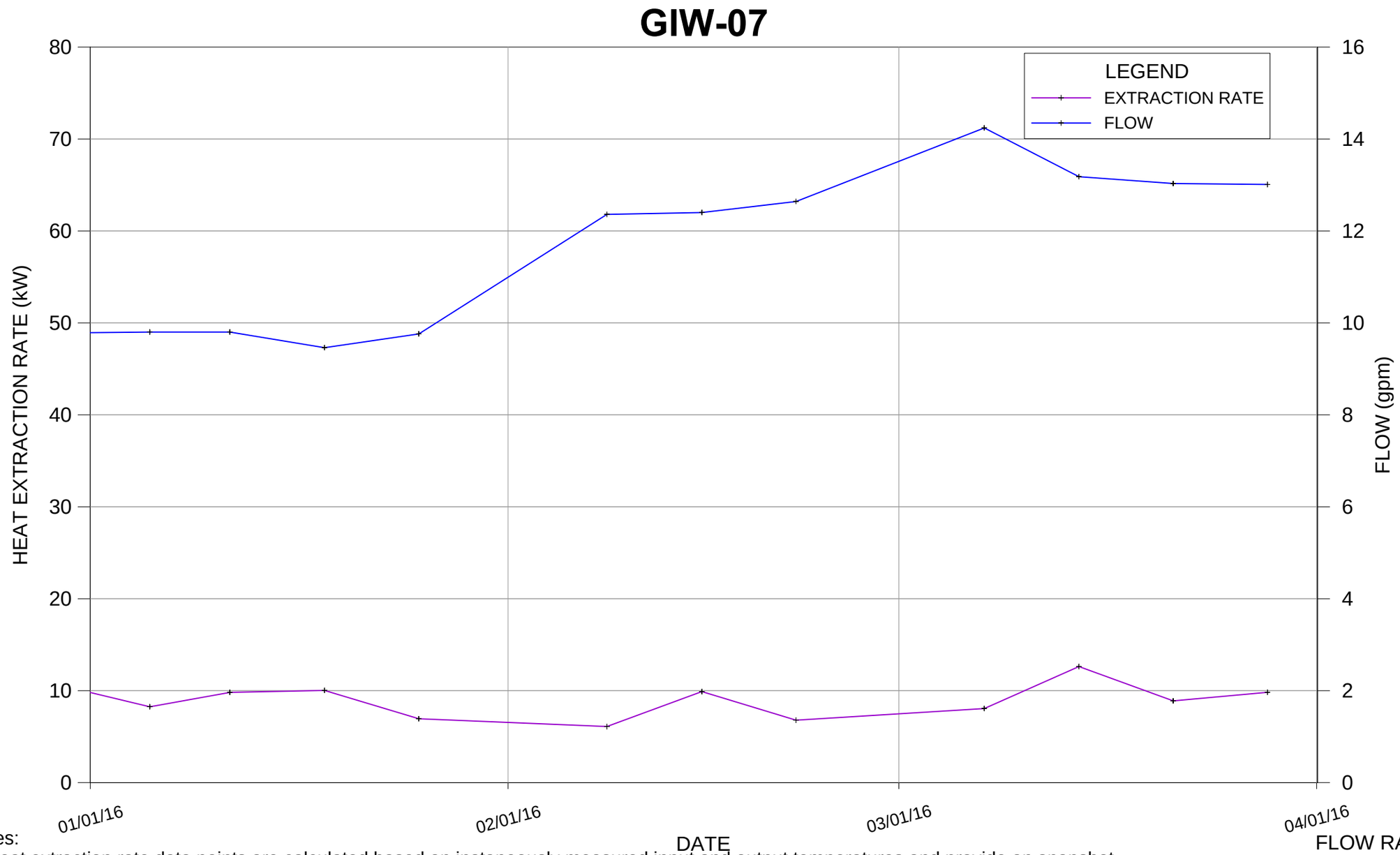

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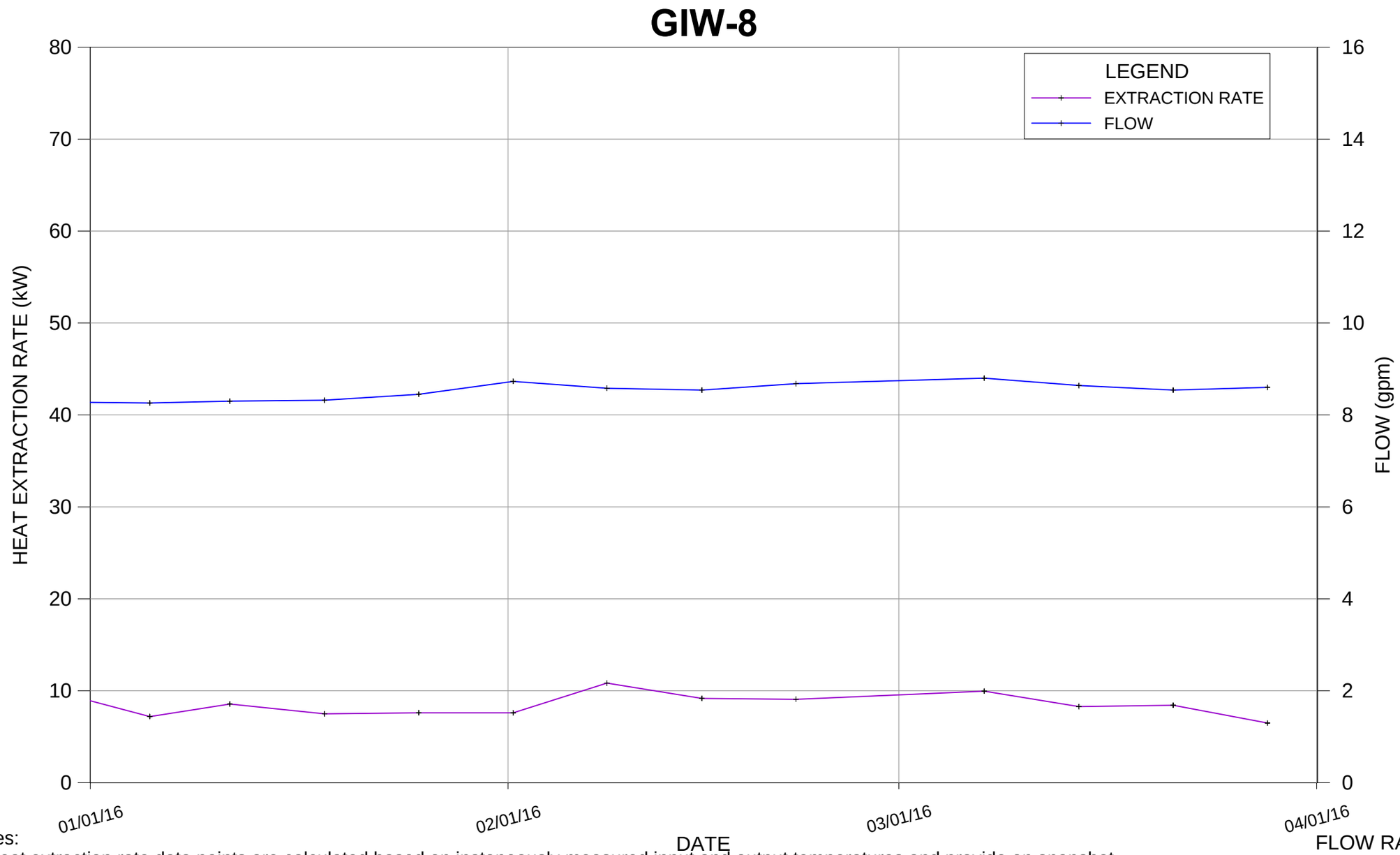

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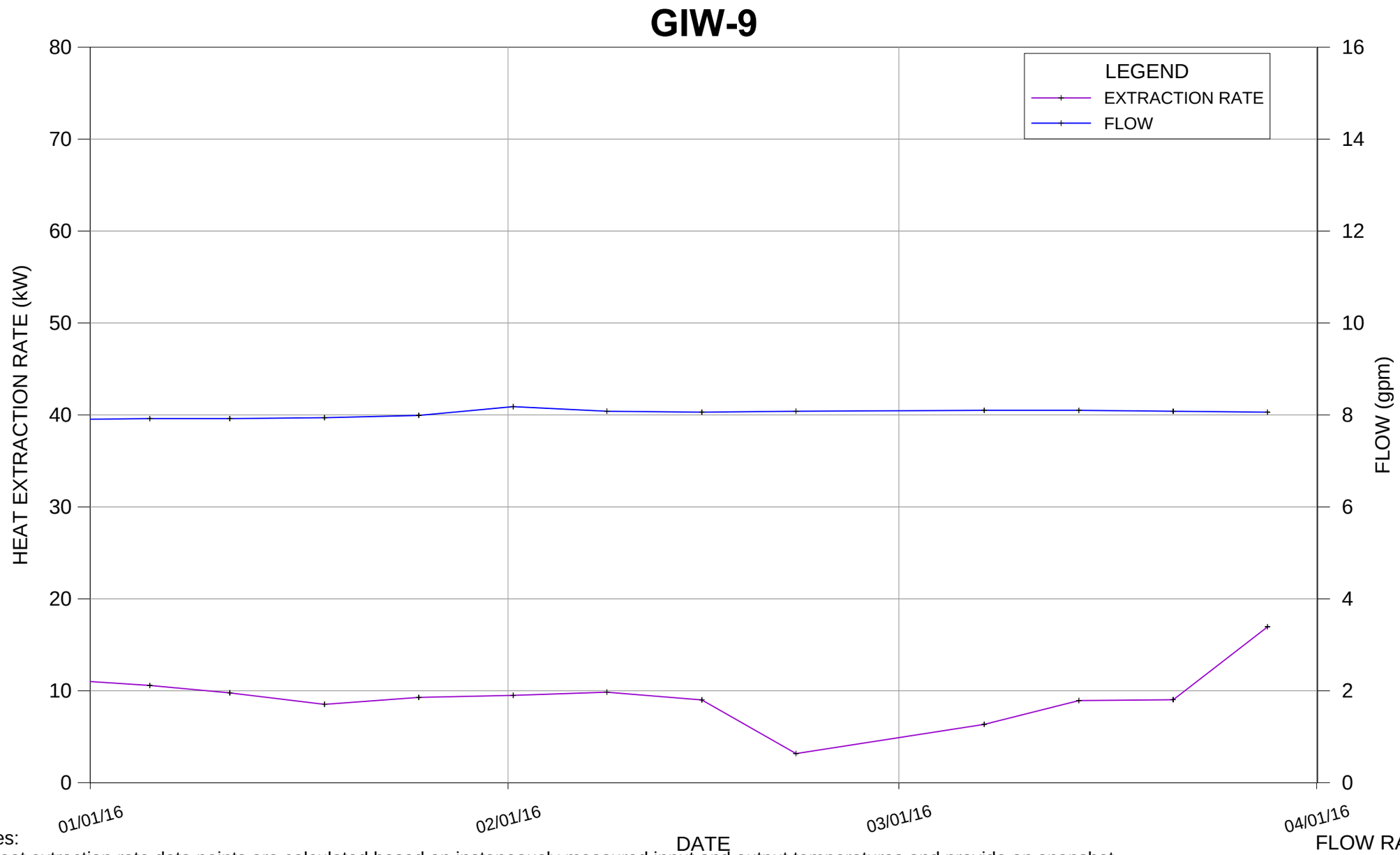

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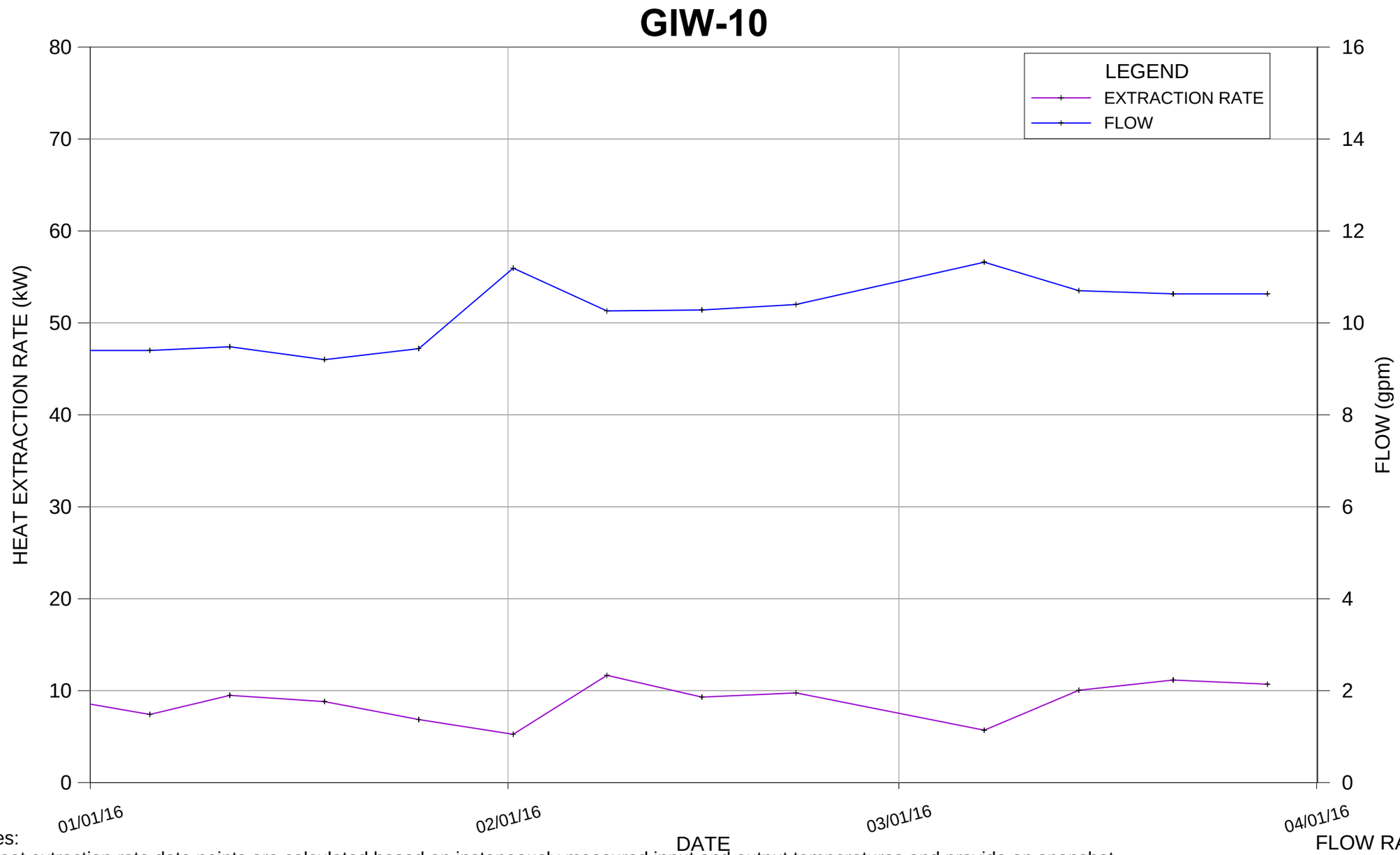

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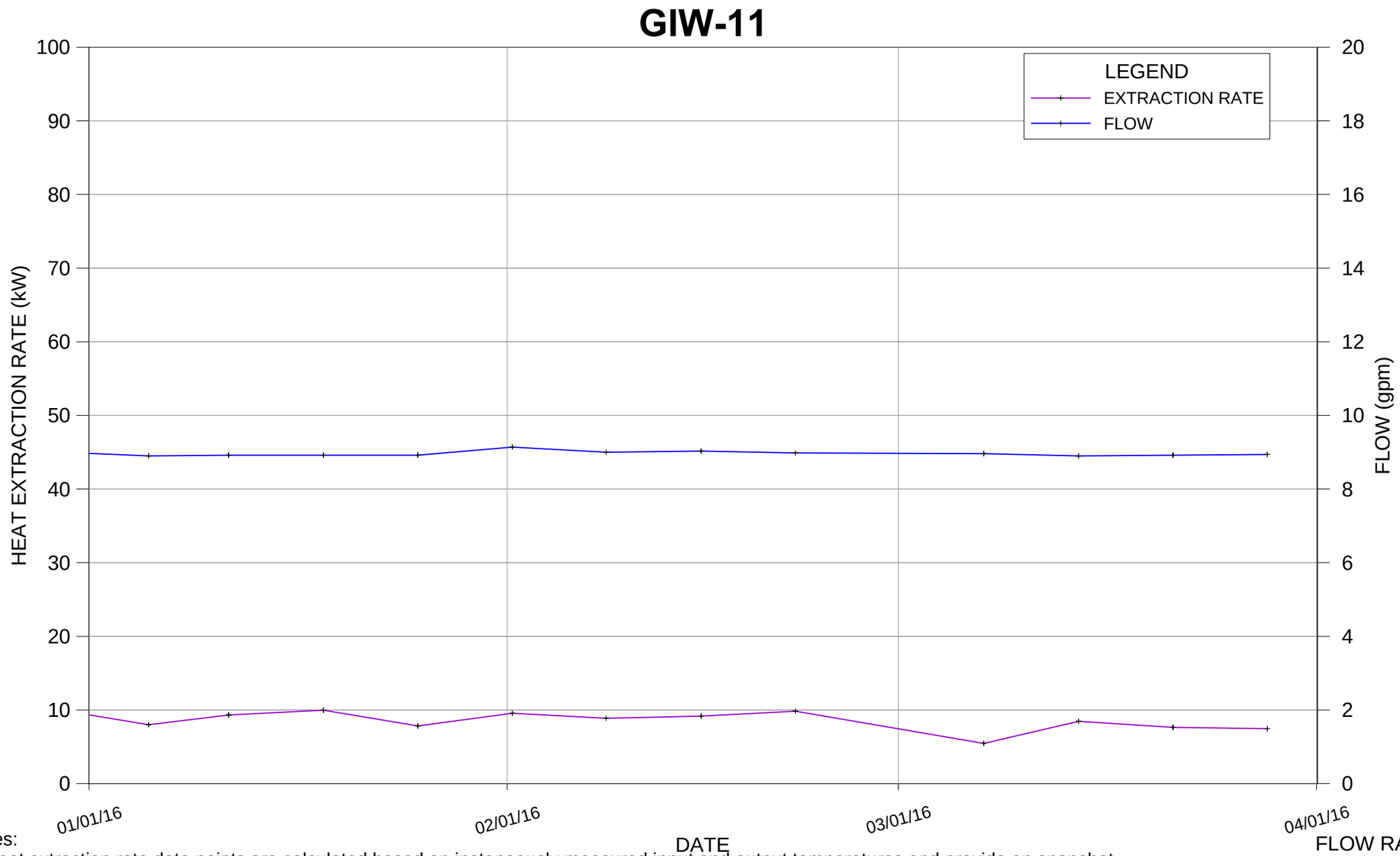
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)



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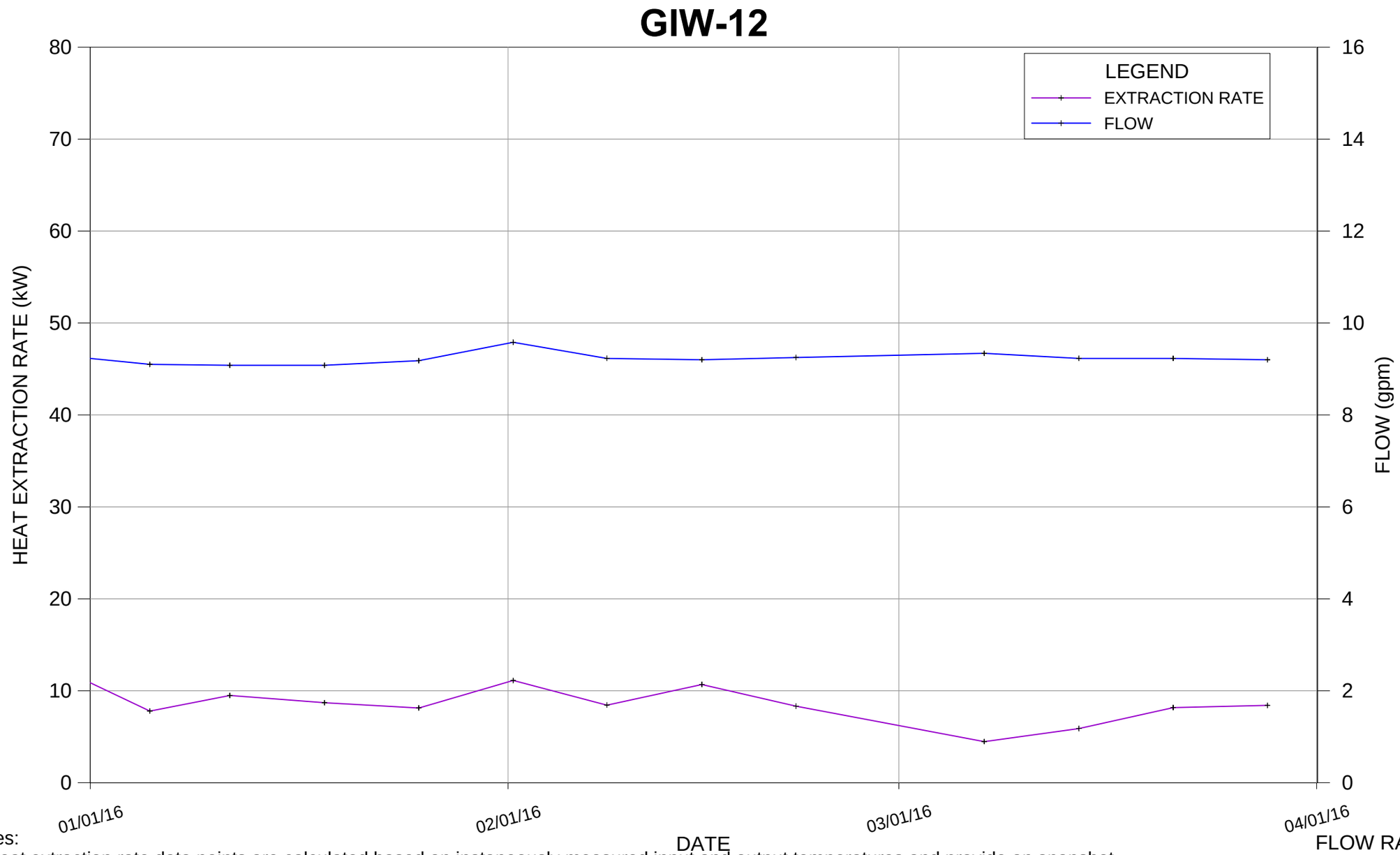

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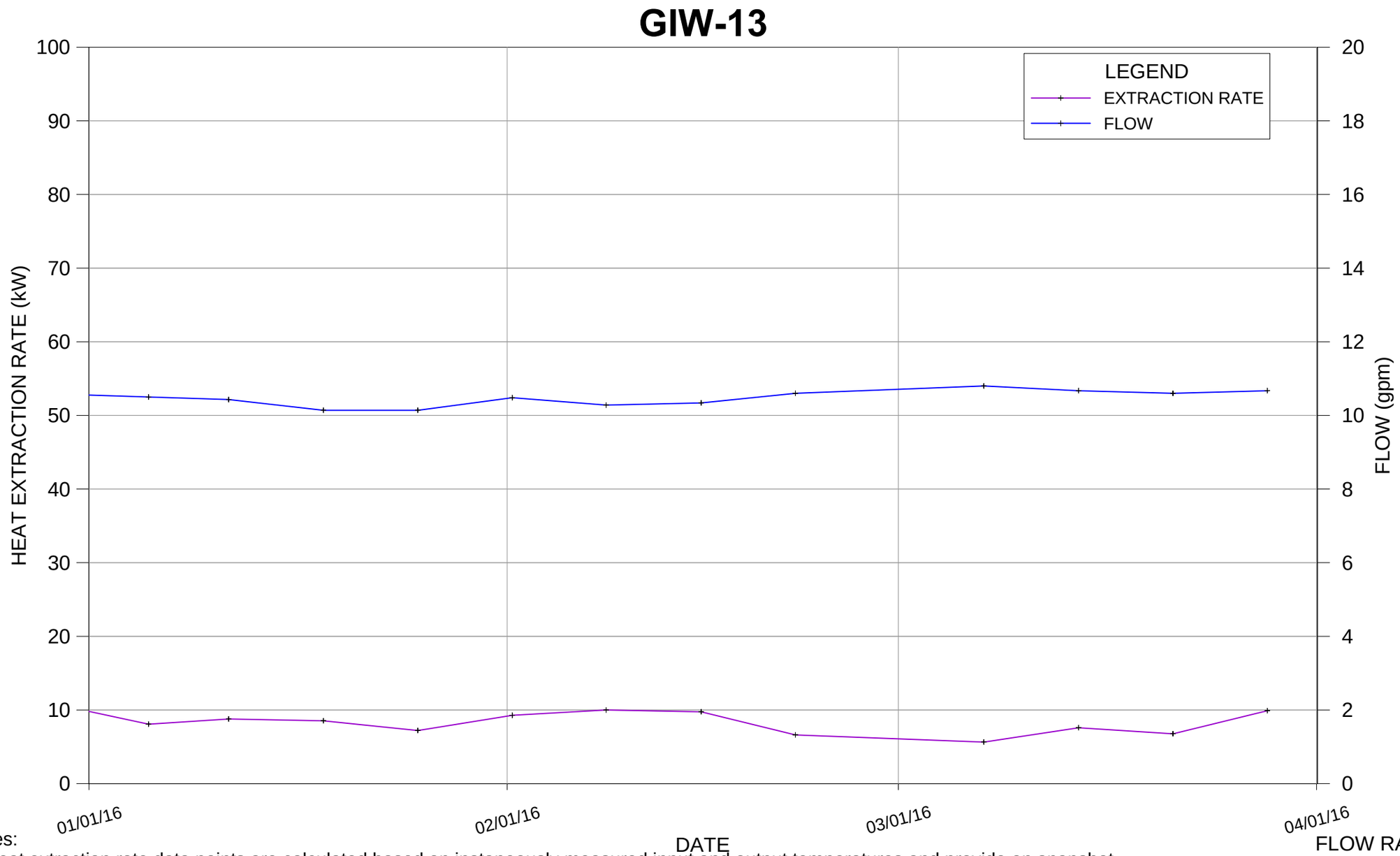

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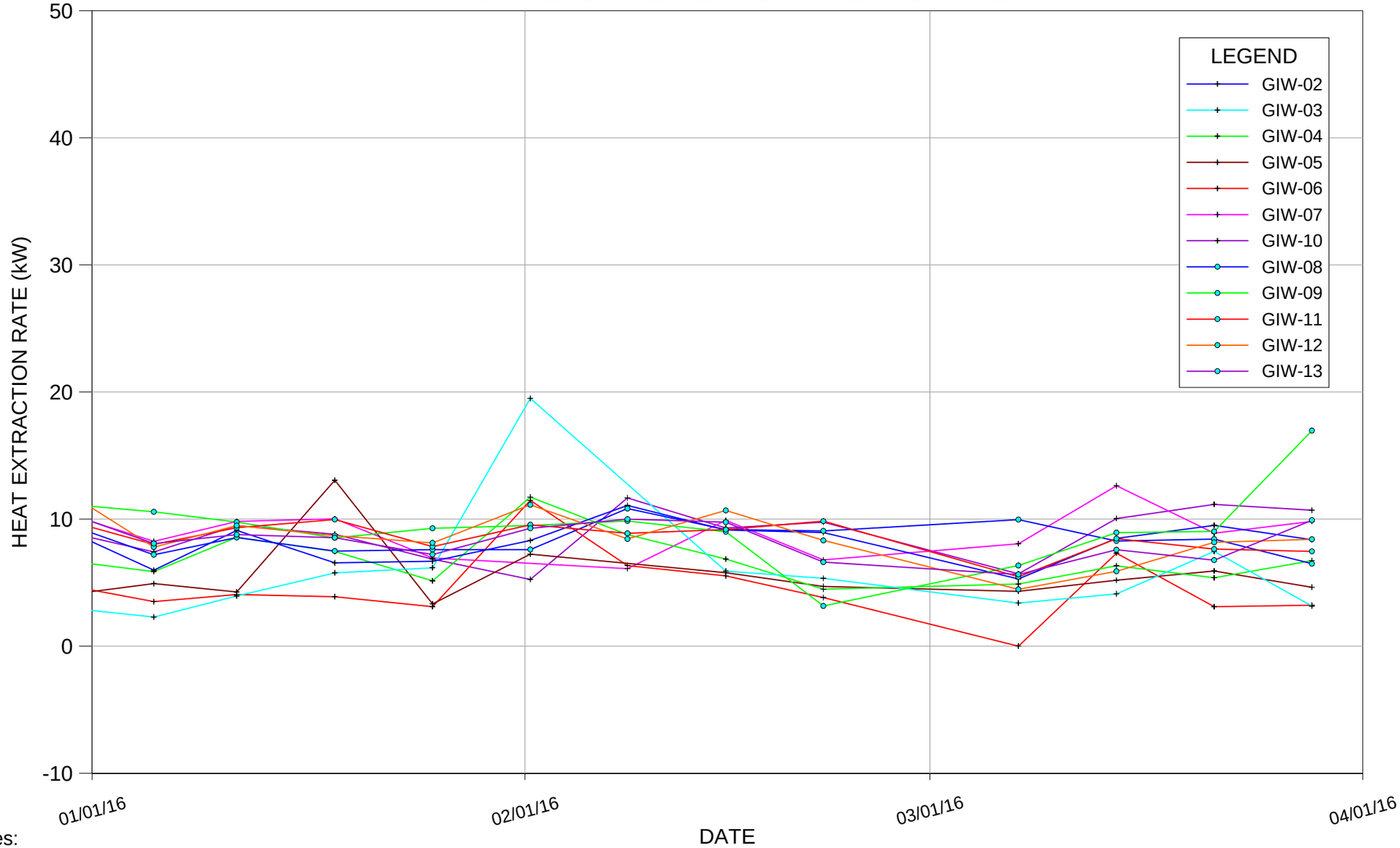
FLOW RATE AND HEAT EXTRACTION VS TIME
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

RATE OF ENERGY REMOVAL



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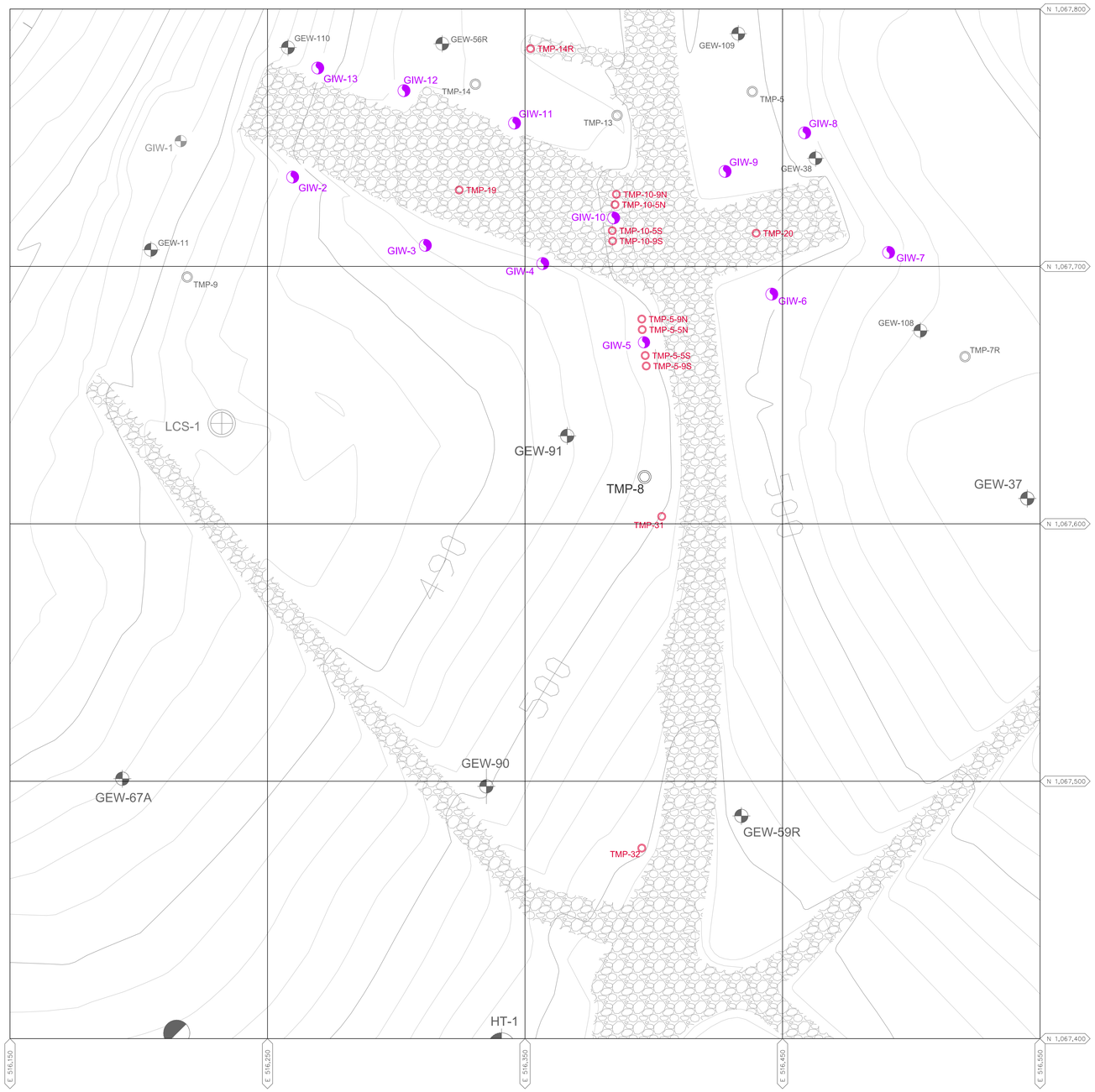
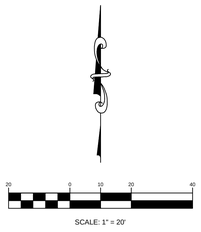
ENERGY REMOVAL RATE
BRIDGETON LANDFILL
(1/1/16 - 3/31/16)

Appendix C – Temperature Monitoring Probe Layout





LEGEND

- EXISTING GRADE (2' CONTOUR)
- 500 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

FEEZOR ENGINEERING, INC.
Engineering for a Better World

OCTOBER 2015
DESIGNED BY: AMR
APPROVED BY: ALK

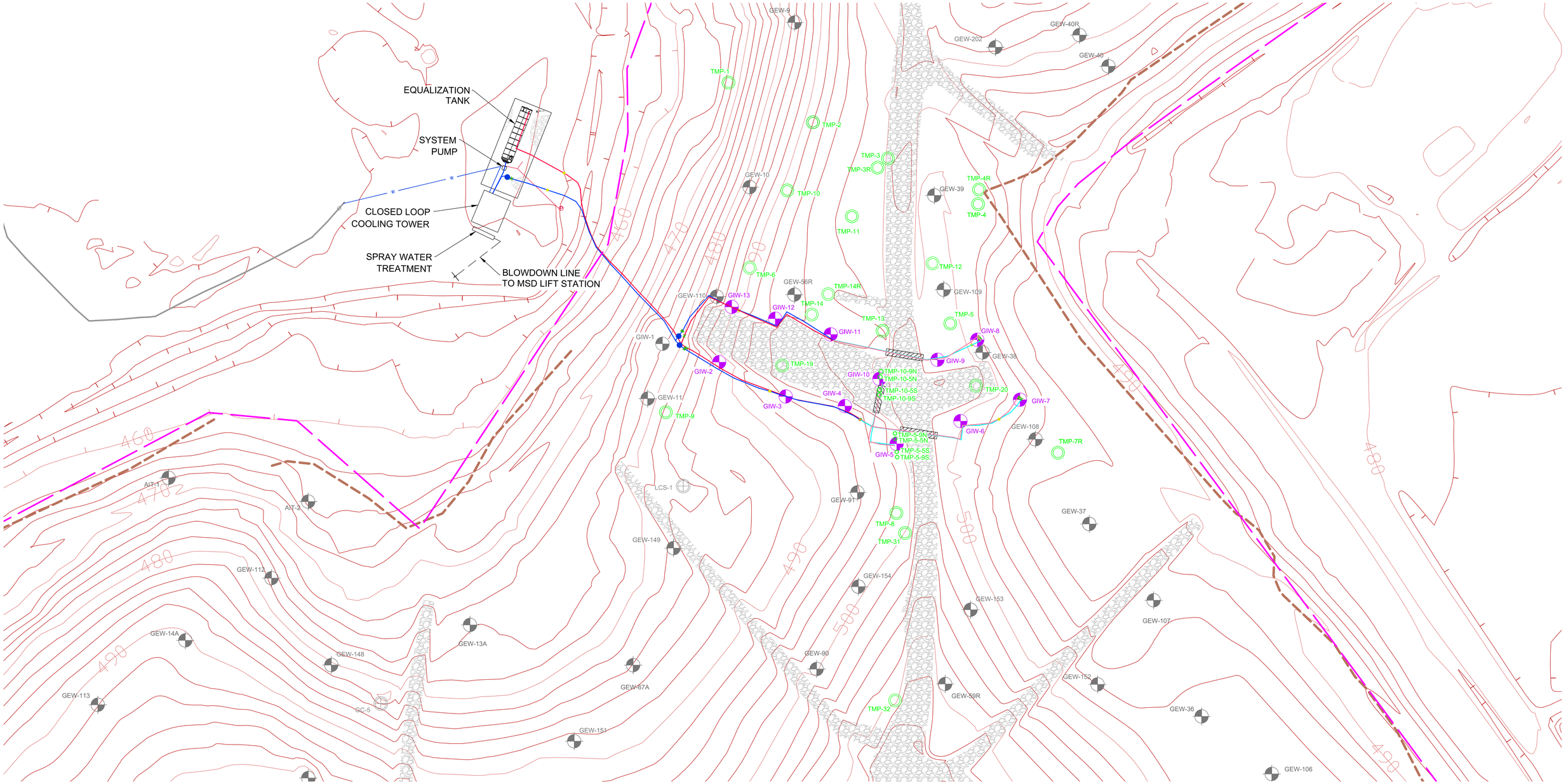
TEMPERATURE MONITORING PROBE LAYOUT

PROJECT NUMBER: BT-045 | FILE PATH:

REVISION | DATE

DRAWING NO.: 001

Appendix D – Heat Removal System Plan View



LEGEND

- EXISTING GRADE (2' CONTOUR)
- 500 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

30 0 15 30 60

SCALE: 1" = 30'

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	Engineering for a Better World FEEZOR ENGINEERING, INC.	OCTOBER 2015 DESIGNED BY: DMK APPROVED BY: ALK
HEAT REMOVAL SYSTEM PLAN VIEW			
PROJECT NUMBER: BT-062	FILE PATH: C:\Users\aaron\Desktop\HE Quarterly Report\BT-055-Proposed Cooling Points- As Built-Corporate Pres 10-7-15.dwg		REVISION / DATE

DRAWING NO.: **001**

Appendix E – Heat Extraction System Operating Log (First Quarter)

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Arron Weber

Date: 1-21-2016

Time: 11:45

Actions Taken or Observations:

Both OMEGA HH806AW thermocouple data loggers Calibrated to output from OMEGA CL3512A Thermometer Calibrator

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Michael Spurgeon

Date: 2-1-2016

Time: 1000

Actions Taken or Observations:

GIW 7 off due to construction around the well

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Heat Extraction System Operating Log

Name: Michael Spurgeon

Date: 2-2-2016

Time: 1015

Actions Taken or Observations:

Replaced pressure release value on GIW 7

BRIDGETON LANDFILL

Heat Extraction System Operating Log

Name: Michael Spurgeon

Date: 3-07-16

Time: 0830

Actions Taken or Observations:

GIW6 was truned off due to construction.

- 0845 - I truned GIW6 on.