APPENDIX A

2014 HYDROMETRIC MONITORING PROGRAM REPORT

MEMORANDUM

To:	Mr. James (Jim) Millard	Date:	December 16, 2014
Copy To:		File No.:	NB102-181/34-A.01
From:	Andrew Rees	Cont. No.:	NB14-00636
Re:	2014 Hydrometric Monitoring Program		

1 – INTRODUCTION

The 2014 Mary River hydrometric monitoring program was initiated in late June around the onset of the spring melt period. Site visits were conducted to re-install pressure transducers and conduct flow measurements at six previously established monitoring stations (Table 1). The hydrometric stations are a part of the streamflow monitoring program supporting the Aquatic Effects Monitoring Plan (AEMP) and are shown on Figure 1.

Table 1 2014 Hydrometric Monitoring Stations

Station ID	Station Name	Period of Record	Drainage Area (km^2)	Coordinates (UTM)	
				Easting	Northing
H01	Phillips Creek, East Tributary	2006-2008, 2011-2014	250	532831	7946247
H02	Tom River near outlet to Mary Lake	2006-2008, 2010, 2014	210	555712	7915514
H04	Camp Lake Tributary (CLT-2)	2006-2008, 2010, 2014	8.3	557639	7915579
H05	Camp Lake Tributary (CLT-1 L1)	2006-2008, 2010-2014	5.3	558906	7915079
H06	Mary River	2006-2008, 2010-2014	240	563922	7912984
H11	Sheardown Tributary (SDLT-1)	2011-2014	3.6	560503	7913545

Final site visits were made by BIM staff between September 6 and 9 to remove the stations prior to winter freeze-up. During each site visit by KP staff, benchmark and water level surveys were conducted and pressure transducers were installed or downloaded. During the June site visits, discharge was measured using dilution gauging where flows were too high to allow for safe access to the channel, and the velocity-area technique using a wading current meter was used where lower flows permitted safe access to the channel. No discharge measurements were made at H06 during the June site visit due to an unseasonably large amount of ice in the channel. After each site visit, all field notes, photos, and data were reviewed and archived using Knight Piésold's FULCRUM data management system.

2 – STAGE-DISCHARGE MEASUREMENTS

The stage-discharge measurements obtained in 2014 were compared to the existing rating curves updated in the 2013 Hydrologic Data Collection Program Summary (KP, 2014). The rating curves for each station, inclusive of the 2014 measurements, are shown on Figures 2 to 7. Stage-discharge measurements recorded when ice was present in the channel were not used in the definition of stage-discharge rating curves. A discussion and interpretation of the fit of the current data to the existing rating curves is provided in the following sections:

- **H01 (Phillip's Creek, East Tributary)** - A stage-discharge measurement was recorded at H01 during the June site visit and is consistent with the existing rating curve (Figure 2). As such, the existing rating curve was used for the development of the 2014 streamflow record.
- **H02 (Tom River)** - A stage-discharge measurement was recorded at H02 during the June site visit and is generally consistent with the existing rating curve (Figure 3). The channel at H02 appears to be stable and the existing rating curve was used for the development of the 2014 flow record. Additional high flow measurements are recommended at H02 to verify the upper half of the rating curve.
- **H04 (CLT-2)** - Three stage-discharge measurements were recorded at H04 in 2014. The gauging data do not agree well with previous low flow measurements (Figure 4). It was noted in KP, 2014 that the calculated 2013 streamflow record did not agree well with previous years. It was suggested that there may have been a shift in the stream channel control. The measurements obtained in 2014 also suggest that there has been a shift in the channel control. A preliminary change to the rating curve was made to accommodate the low flow measurements made in 2013 and 2014. The shift accounts for infilling of the channel with sand, which is the most likely change in the stream channel at H04. No recent higher flow measurements are available to validate the upper half of the rating curve and without higher flow data there is little confidence in the accuracy of flows recorded above 0.4 m^3/s. Additional measurements are required across a range of flows to further update the rating curve at H04.
- **H05 (CLT-1 L1)** - Stage-discharge measurements were recorded at H05 during the June and July site visits and are consistent with the existing rating curve (Figure 5). The rating curve was used for the development of the 2014 flow record.
- **H06 (Mary River)** - No stage-discharge measurements were recorded at H06 in 2014. Discharge was measured during the June site visit; however, ice in the channel prevented an accurate measurement of stage. The rating curve at H06 has been consistent over the past several years and the channel appears to be stable. As such, the existing rating curve (Figure 6) was used for the development of the 2014 flow record.
- **H11 (SDLT-1)** - Four stage-discharge measurements were recorded at H11 during 2014. The measurements all plot below the existing rating curve (Figure 7). It appears that there has been a shift in the downstream control since the 2013 measurements were made. The four measurements obtained in 2014 were across a range of stage/discharge conditions and it was possible to establish a new rating curve. A transition point in the channel geometry was evident around 4.01 m of stage height and separate curves were developed for lower and higher flows. As with the previous rating curve, there is considerable uncertainty around higher stage/discharge conditions at H11 due to the lack of field measurements for validation. In future years, multiple measurements should be obtained at H11 to strengthen the new rating curve, especially under high flow conditions.

3 – STREAMFLOW HYDROGRAPHS

Streamflow records were developed for each station by applying the water level records to the corresponding rating curves. The discharge hydrographs for H01, H02, H04, H05, H06, and H11 are presented on Figures 8 to 13. Each water level record underwent a quality review and periods identified to be affected by channel ice or other anomalies were removed from the record. The discharge hydrograph for H04 is considered to be provisional as there are insufficient data to validate the full rating curve. A gap exists in the H06 hydrograph where the water level fell below the initial installation elevation, which had to be higher than normal due to ice in the channel. The sensor at H06 was lowered during the July site visit and data collection resumed.

The discharge records were converted to equivalent unit runoff (discharge per unit area) and are compared to the daily precipitation record on Figure 14. Most of the records agree well with each other, exhibiting similar timing and magnitude of runoff events and similar patterns to previous years. The station at H11, with a generally lower elevation catchment, exhibited a much smaller freshet and muted response to some late season precipitation events. In previous years, the unit runoff from H04 and H05 exhibited similar patterns and magnitude of flow. The shifted rating curve at H04 brings the unit runoff into better alignment with

H05 (Figure 15). Additional flow measurements are required for the validation of the rating curve at H04 if the station is to remain in operation.

4 – SUMMARY

The total annual runoff during 2014 season at the mine site was greater than most previous years. The freshet flows at H11 occurred in mid to late June and in July at the other stations. A strong diurnal melt patter is evident through the first half of July and the peak of freshet flows occurred between July 17 to 22. The peak flows were not as high as in some pervious years but freshet flows started later than normal and were of longer duration. A summary of flows at H05 from 2006 to 2014 is shown on Figure 16. The mean monthly discharge and unit runoff for each station in 2014 are summarized in Table 2.

The 2014 hydrometric monitoring program allowed for the confirmation of rating curves at several stations and the identification of possible control changes at other stations. It is recommended that future hydrometric monitoring include frequent site visits to ensure the proper operation of data loggers and to confirm or improve rating curves.

5 – REFERENCES

Knight Piésold Ltd. (KP), 2014. Letter to: Jim Millard, Baffinland Iron Mines Corporation. Re: *2013 Hydrologic Data Collection Program Summary.* February 24. North Bay, Ontario. Ref. No. NB13-00532.

Signed:

Andrew Rees, Ph.D. - Project Environmental Scientist

Reviewed and Approved:

Richard Cook, P.Geo. (Ltd.) - Senior Environmental Scientist

Attachments:

Table 2 Rev 0	Summary of 2014 Mean Monthly Runoff
Figure 1 Rev 0	2014 Hydrology Monitoring Station Locations
Figure 2 Rev 0	H01 - Phillip's Creek East Tributary - Rating Curve
Figure 3 Rev 0	H02 - Tom River - Rating Curve
Figure 4 Rev 0	H04 - Camp Lake Tributary (CLT-2) - Rating Curve
Figure 5 Rev 0	H05 - Camp Lake Tributary (CLT-1 L1) - Rating Curve
Figure 6 Rev 0	H06 - Mary River - Rating Curve
Figure 7 Rev 0	H11 - Sheardown Lake Tributary (SLDT-1) - Rating Curve
Figure 8 Rev 0	H01 – Phillip's Creek East Tributary - 2014 Measured Streamflow Hydrograph
Figure 9 Rev 0	H02 - Tom River - 2014 Measured Streamflow Hydrograph
Figure 10 Rev 0	H04 - Camp Lake Tributary (CLT-2) - 2014 Measured Streamflow Hydrograph
Figure 11 Rev 0	H05 - Camp Lake Tributary (CLT-1 L1) - 2014 Measured Streamflow Hydrograph
Figure 12 Rev 0	H06 - Mary River - 2014 Measured Streamflow Hydrograph
Figure 13 Rev 0	H11 - Sheardown Lake Tributary (SLDT-1) - 2014 Measured Streamflow Hydrograph
Figure 14 Rev 0	2014 Unit Runoff Hydrograph Compilation
Figure 15 Rev 0	2014 Unit Runoff Hydrograph Comparison - H04 and H05
Figure 16 Rev 0	Measured Streamflow Hydrographs - Record H05 (2006-2014)

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TABLE 2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

SUMMARY OF 2014 MEAN MONTHLY RUNOFF

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Station	Mean Monthly Measured Discharge (m^3/s)				Period of Record
	June	July	August	September	
H01	7.0*	13.4	7.2	2.1*	June 24 to September 8
H02	6.3*	21.3	9.1	1.9*	June 24 to September 8
H04	0.3*	0.5	0.3	0.1*	June 23 to September 9
H05	0.3*	0.4	0.2	0.1*	June 22 to September 8
H06	-	31.1*	9.8*	1.9*	July 1 to September 6
H11	0.122*	0.094	0.094	0.036*	June 19 to September 6

Station	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Period of Record
	June	July	August	September	
H01	28.1*	53.7	28.7	8.6*	June 24 to September 8
H02	30.2*	101.4	43.2	9.1*	June 24 to September 8
H04	34.3*	61.5	30.1	6.9*	June 23 to September 9
H05	53.6*	78.3	38.5	10.3*	June 22 to September 8
H06	-	129.6*	41.0	7.8*	July 1 to September 6
H11	34.0*	26.0	26.0	10.0*	June 19 to September 6

I:\1\02\00181\34\A\Correspondence\NB14-00636 - UPDATED 2014 Hydrology Summary\Tables and Figures\[Table 2.xlsx]Table 2

NOTES:

1. INCOMPLETE MONTHLY DATA RECORDS INDICATED BY AN ASTERIX.

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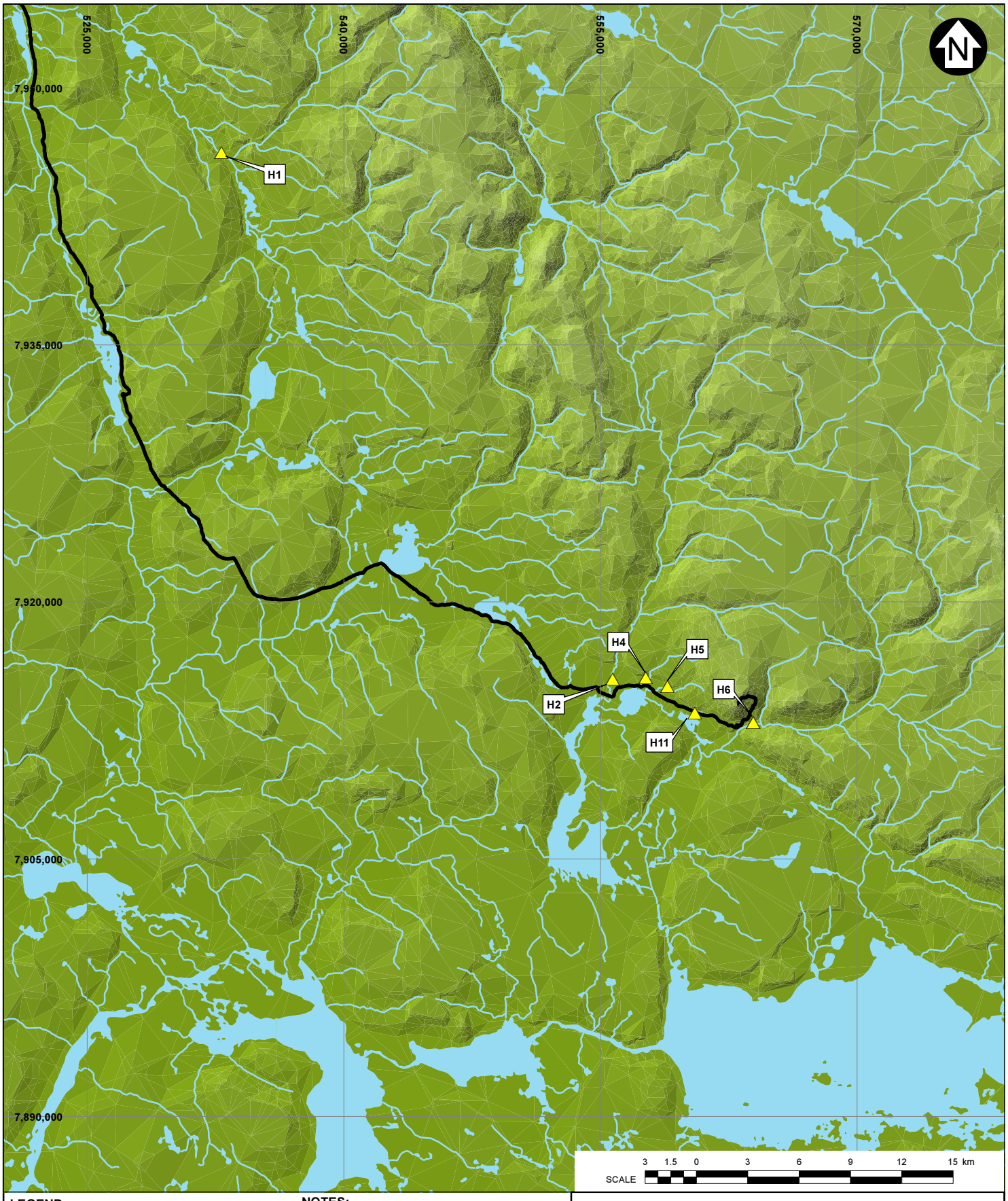

LEGEND:

- STREAM FLOW GAUGING STATION
- MILNE INLET TOTE ROAD
- RIVER/STREAM/DRAINAGE
- WATER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

2014 HYDROLOGY MONITORING STATION LOCATIONS

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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REF NO. NB14-00636

FIGURE 1

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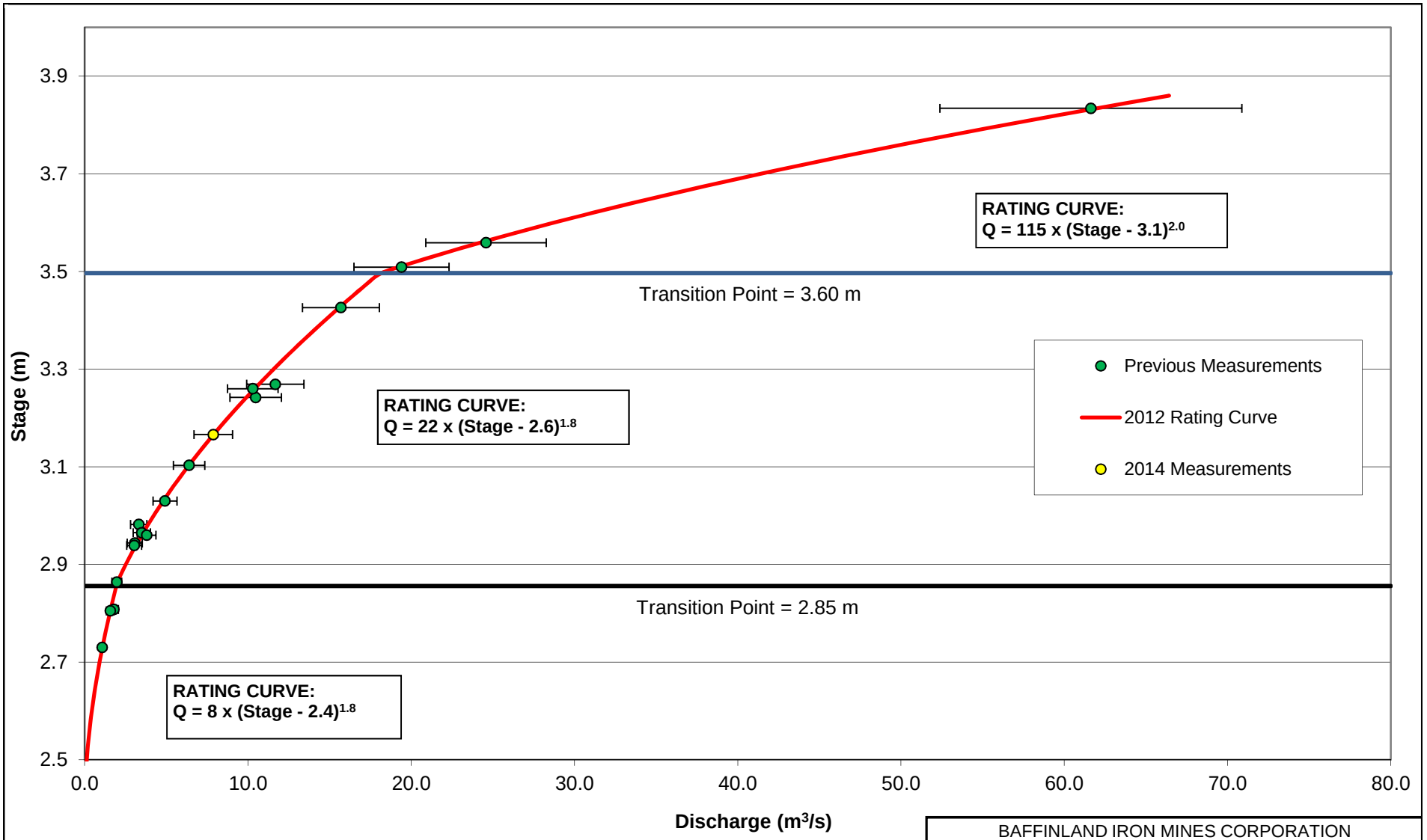

NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

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MARY RIVER PROJECT

H01 - PHILLIP'S CREEK EAST TRIBUTARY RATING CURVE

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REF NO. NB14-00636

FIGURE 2

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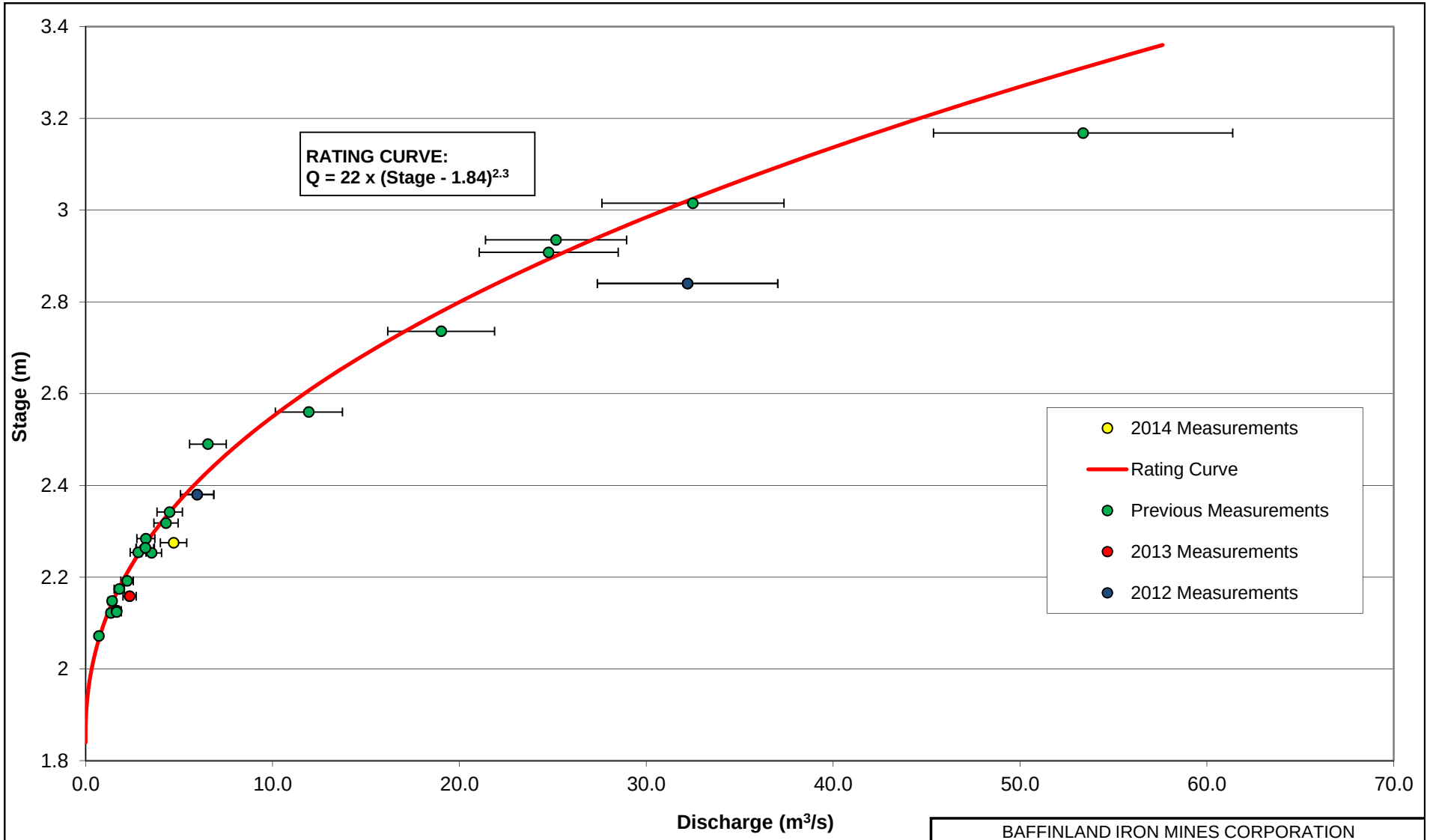

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NOTES:

1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

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MARY RIVER PROJECT

H02 - TOM RIVER
RATING CURVE

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FIGURE 3

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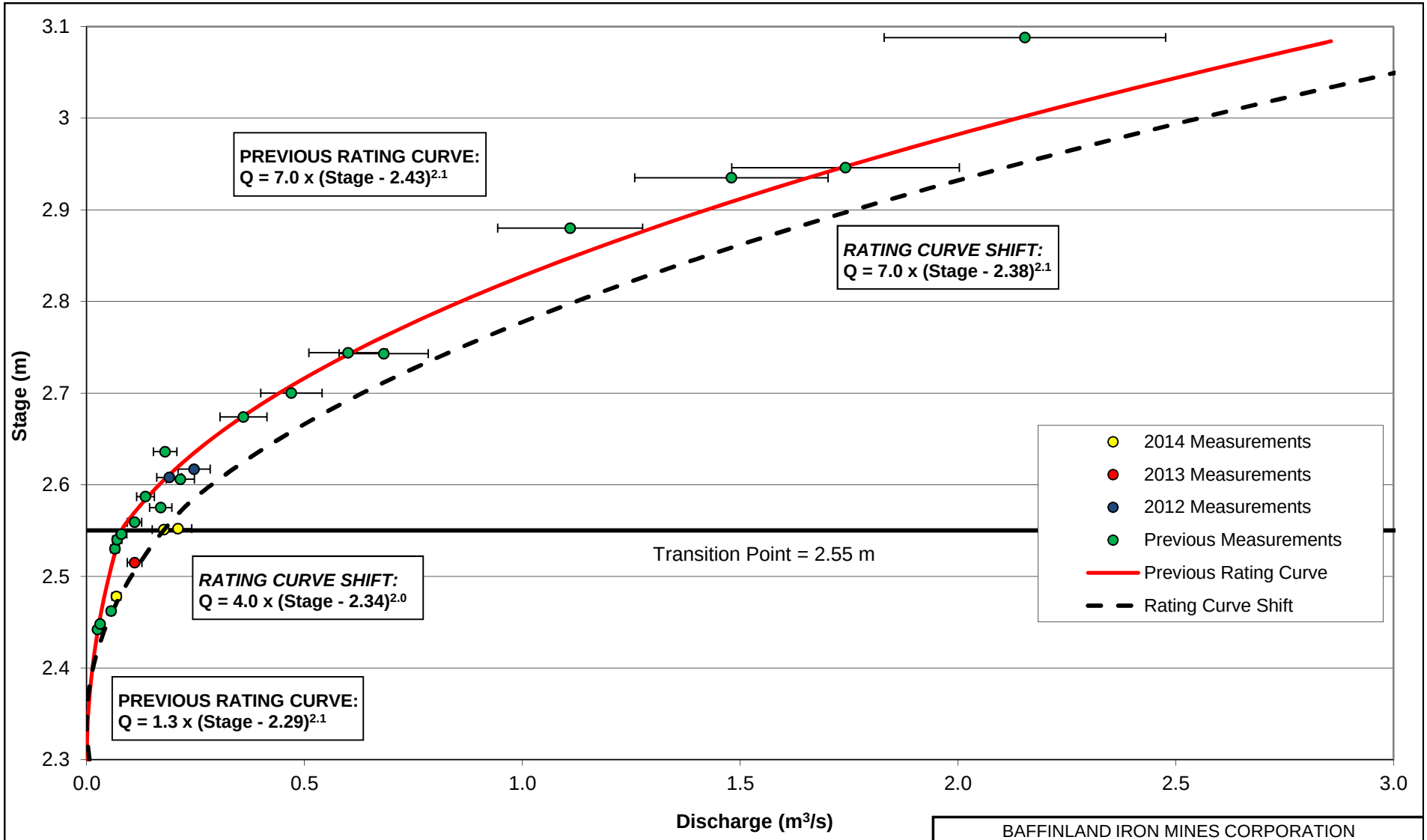

NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

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MARY RIVER PROJECT

H04 - CAMP LAKE TRIBUTARY (CLT-2)
RATING CURVE

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FIGURE 4

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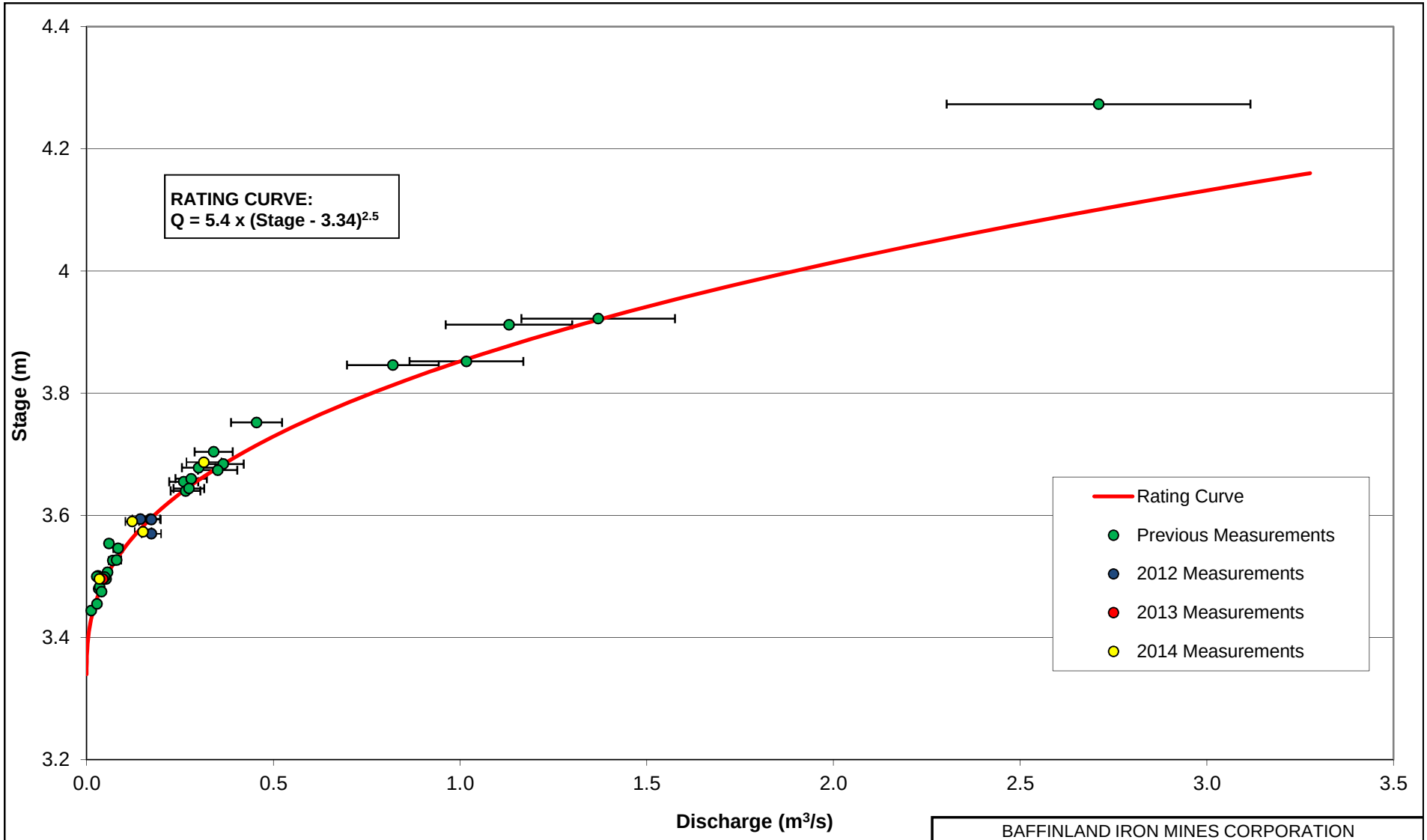

NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

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0	16DEC'14	ISSUED WITH MEMO	ALR	DKK	RAC

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MARY RIVER PROJECT

H05 - CAMP LAKE TRIBUTARY (CLT-1 L1)
RATING CURVE

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FIGURE 5

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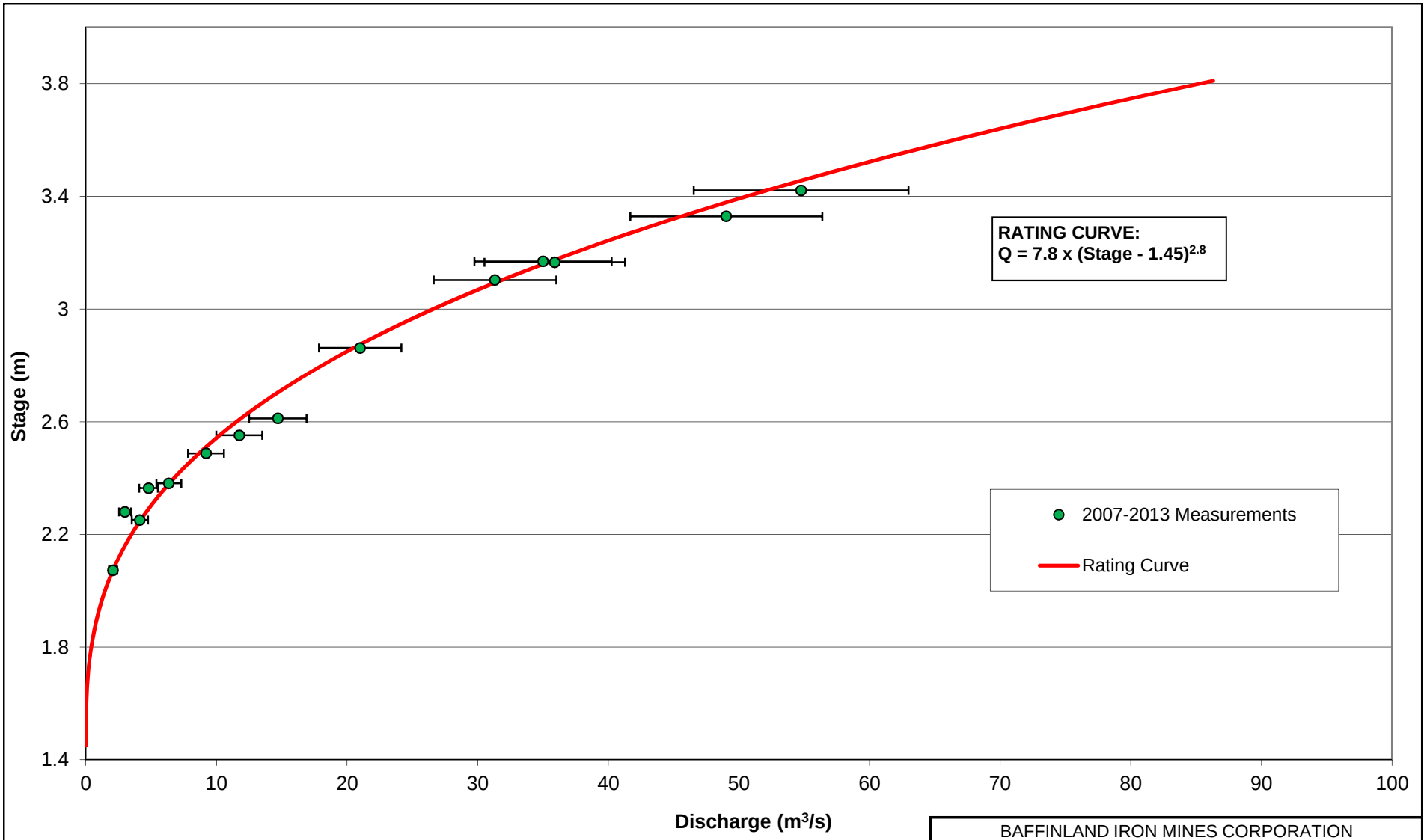

NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.
2. NO DISCHARGE MEASUREMENTS COLLECTED IN 2014.

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MARY RIVER PROJECT

H06 - MARY RIVER
RATING CURVE

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FIGURE 6

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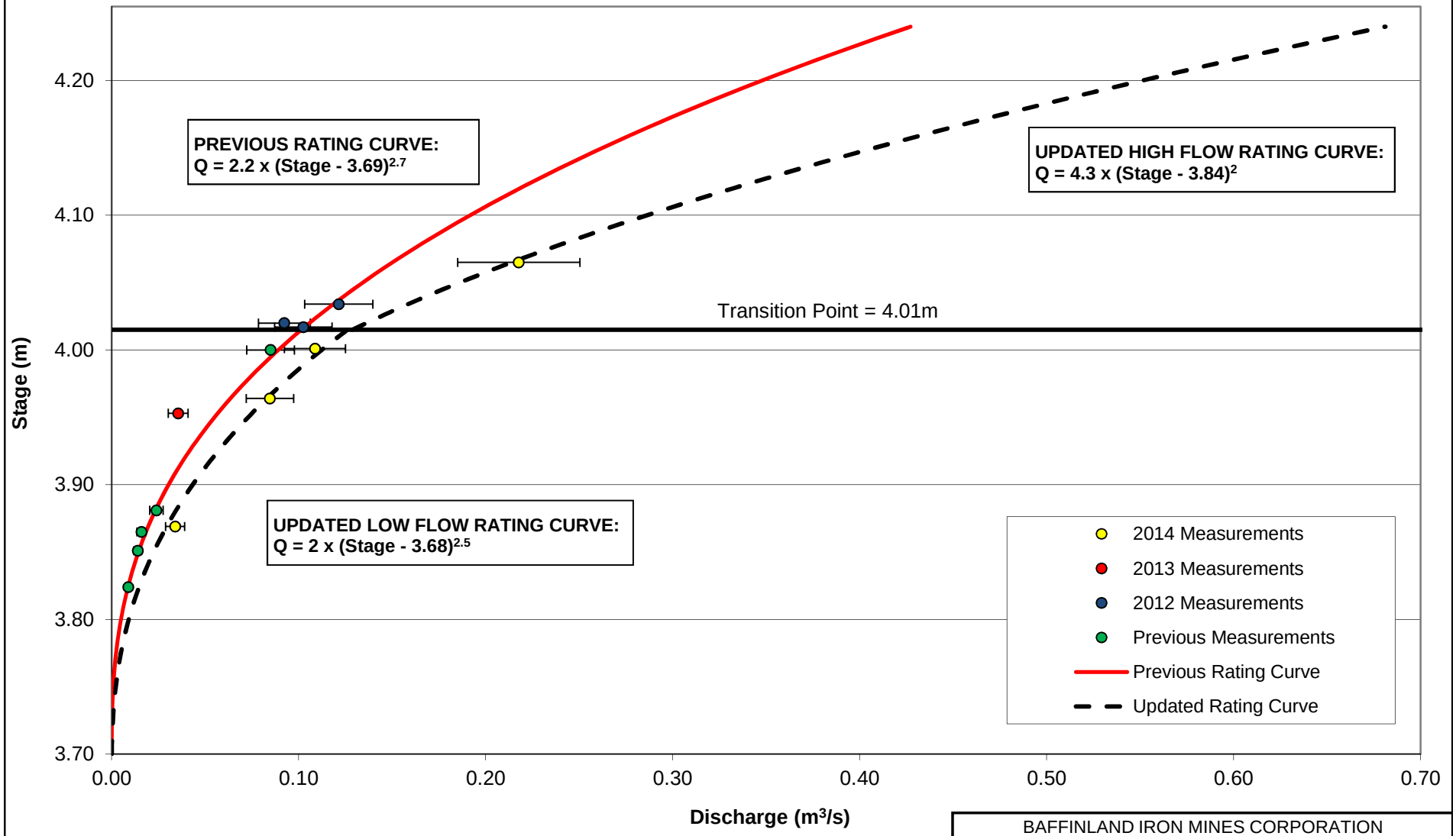

NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

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MARY RIVER PROJECT

H11 - SHEARDOWN LAKE TRIBUTARY (SLDT-1) RATING CURVE

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FIGURE 7

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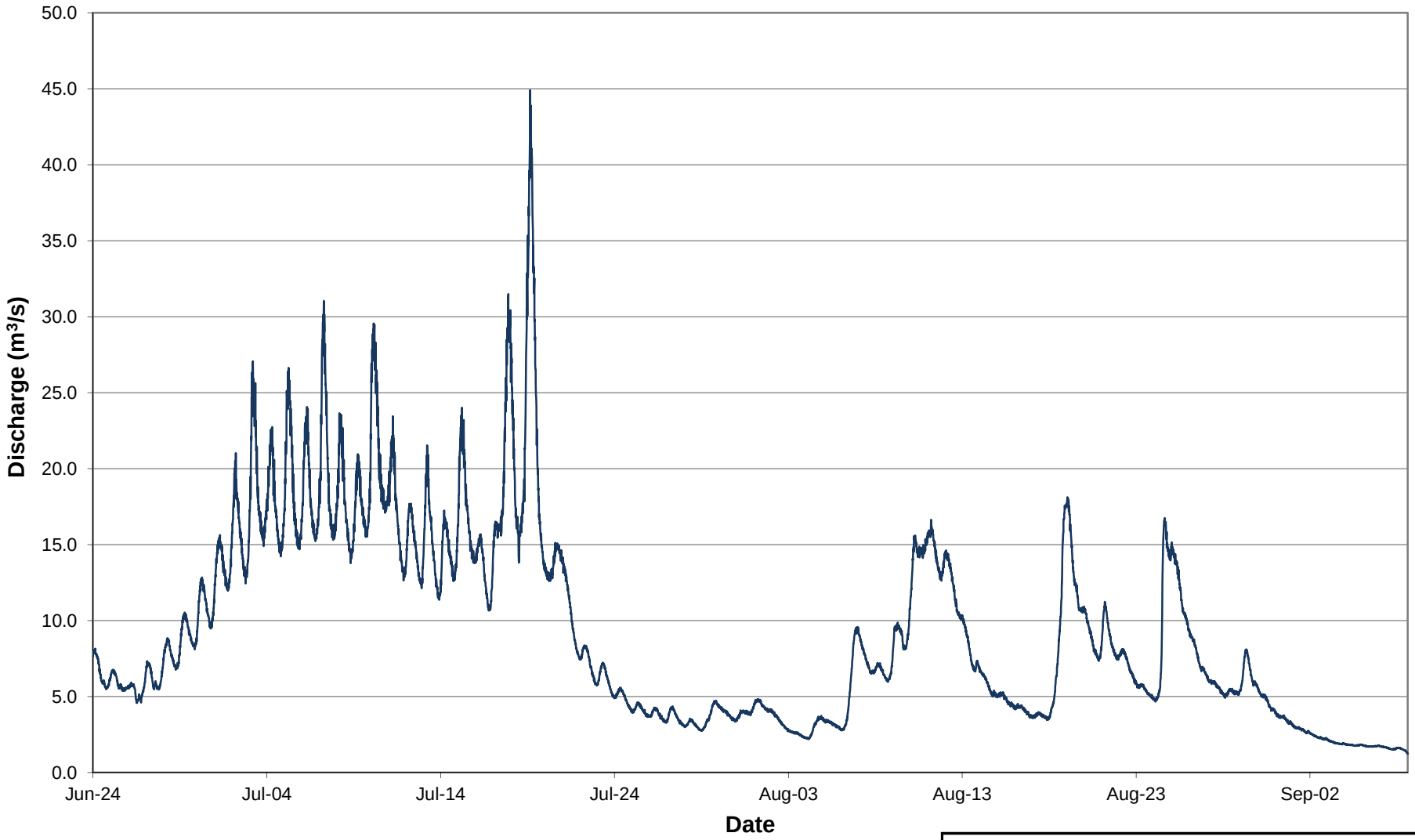

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MARY RIVER PROJECT

H01 - PHILLIP'S CREEK EAST TRIBUTARY
2014 MEASURED STREAMFLOW HYDROGRAPH

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FIGURE 8

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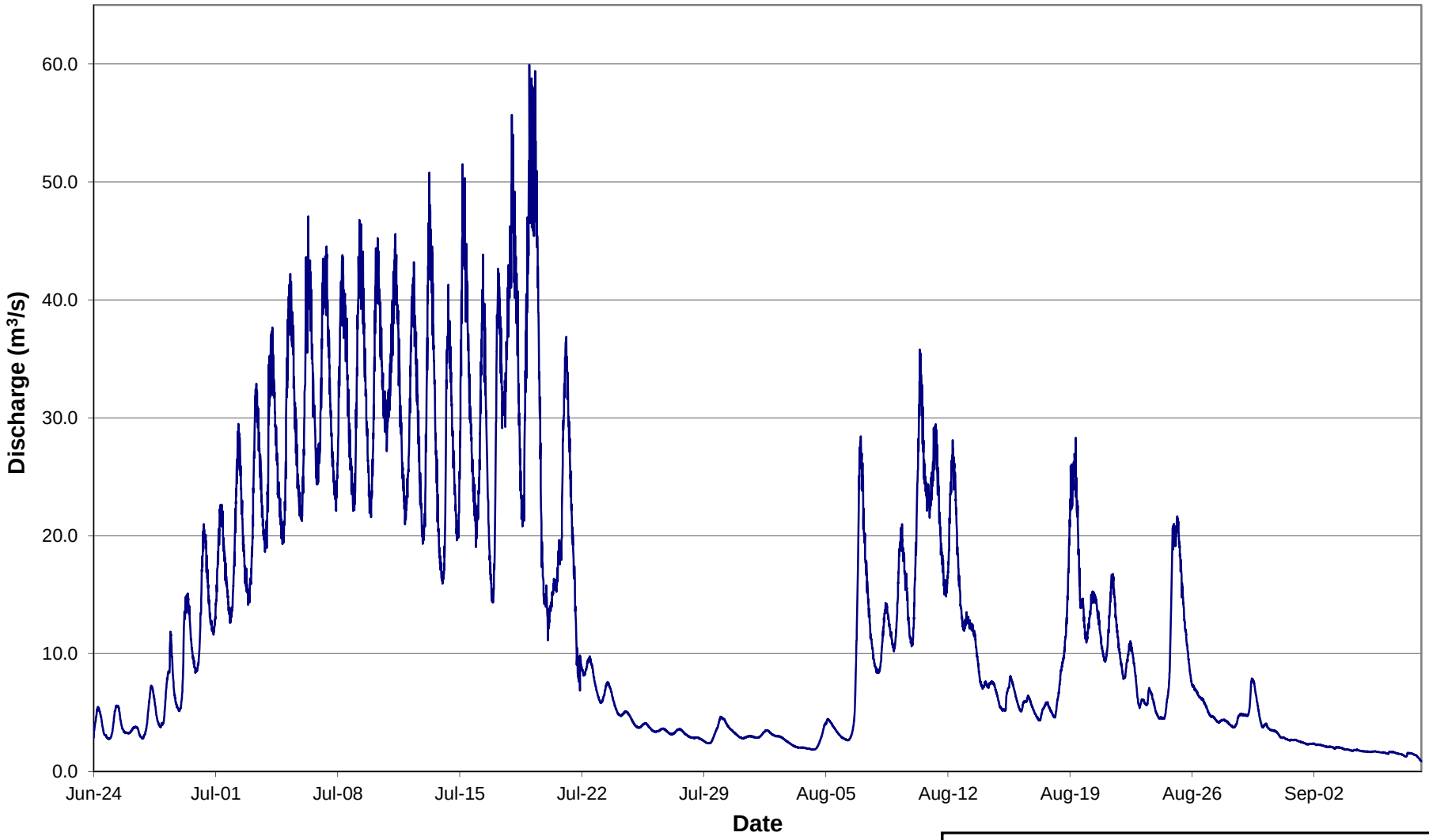

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MARY RIVER PROJECT

H02 - TOM RIVER
2014 MEASURED STREAMFLOW HYDROGRAPH

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FIGURE 9

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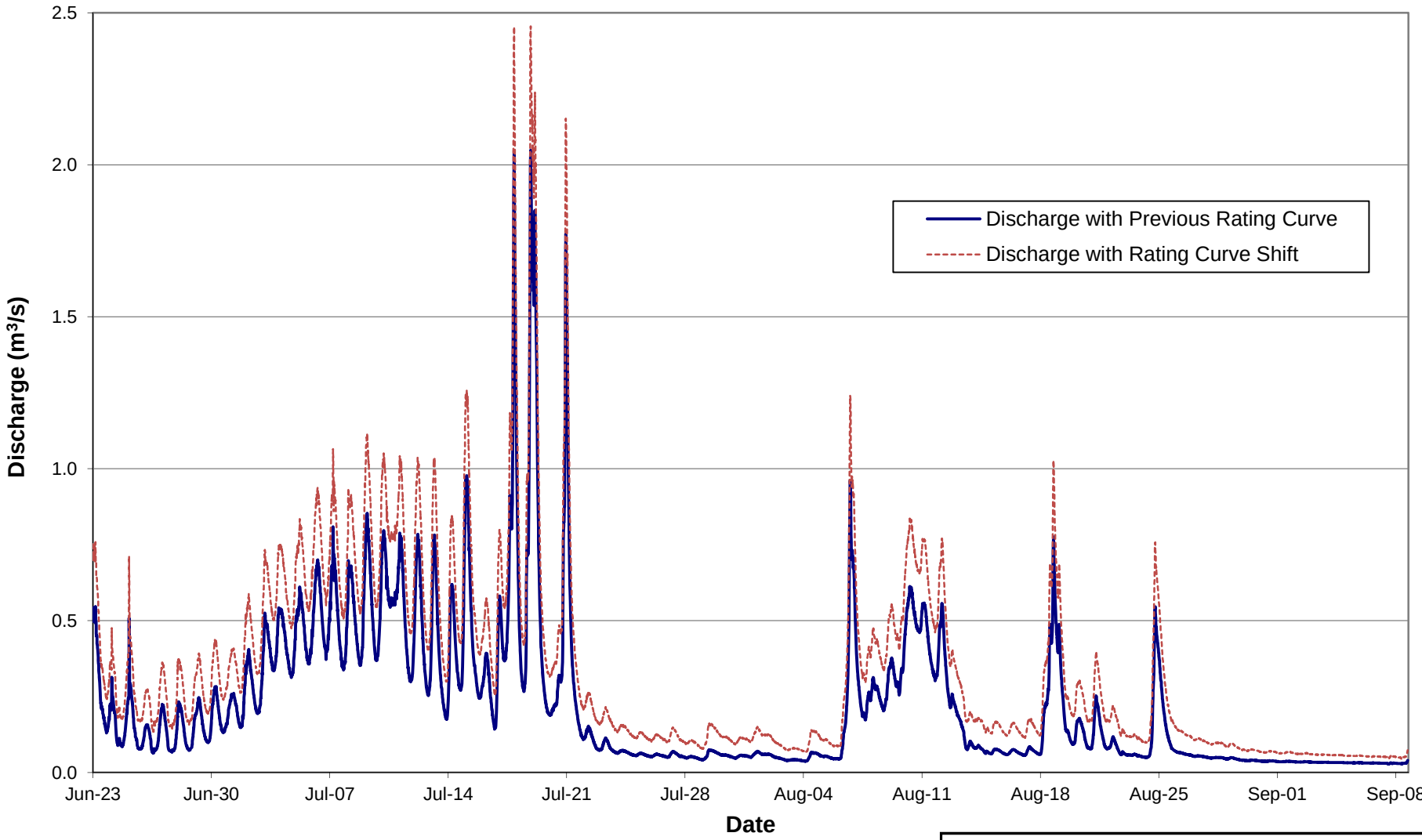

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MARY RIVER PROJECT

H04 - CAMP LAKE TRIBUTARY (CLT-2)
2014 MEASURED STREAMFLOW HYDROGRAPH

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FIGURE 10

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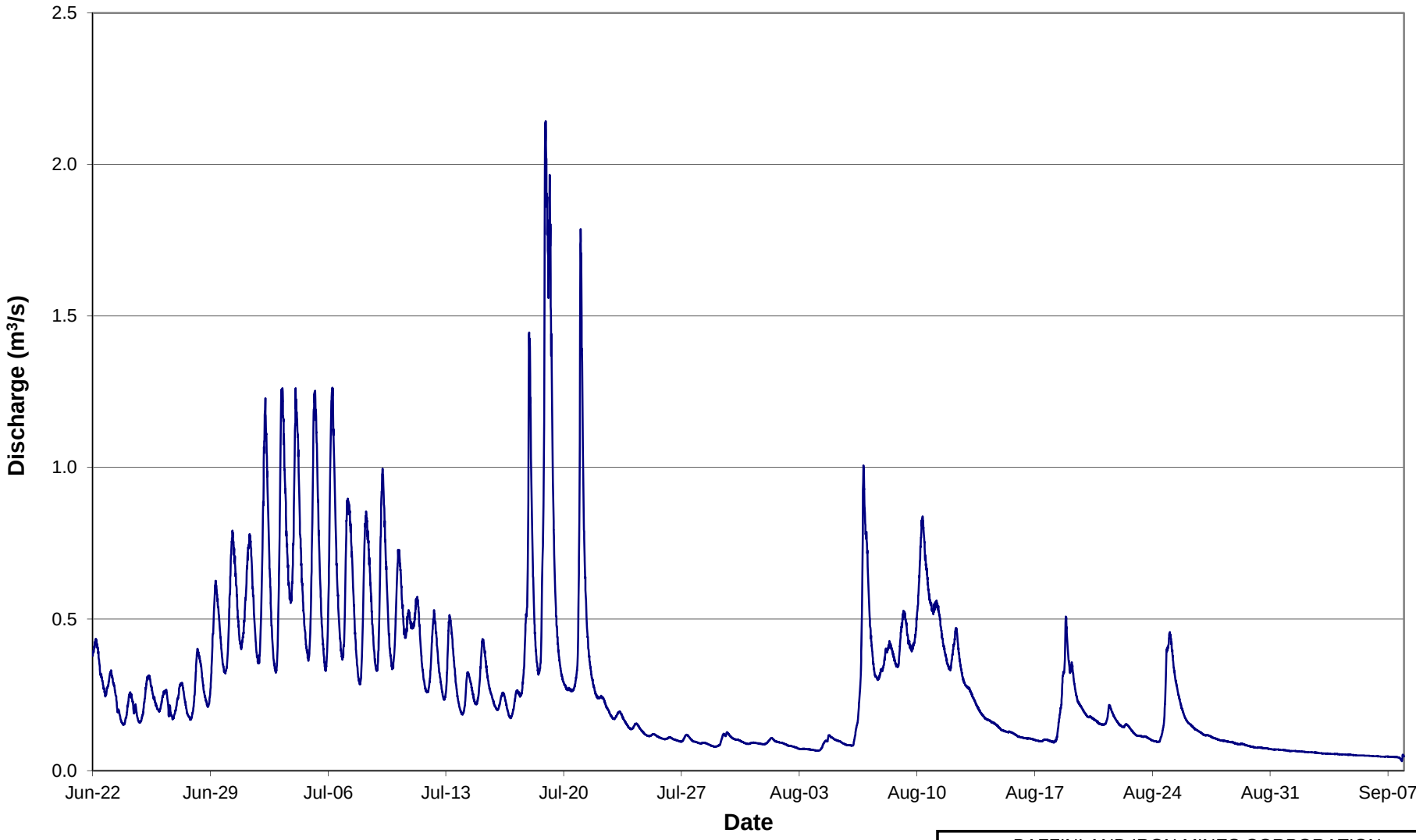

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H05 - CAMP LAKE TRIBUTARY (CLT-1 L1)
2014 MEASURED STREAMFLOW HYDROGRAPH

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FIGURE 11

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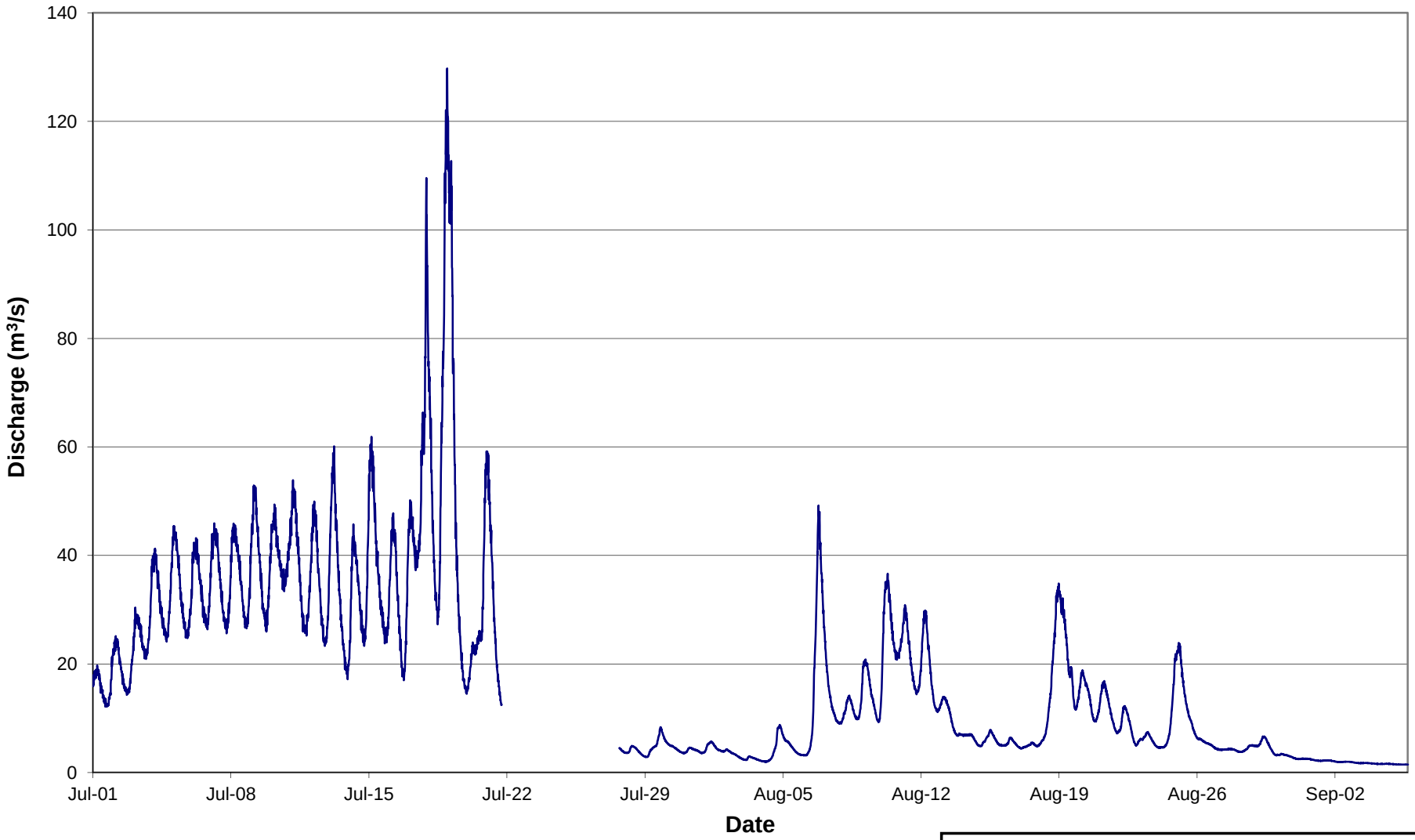

NOTES:

1. INITIAL INSTALLATION HIGHER THAN NORMAL DUE TO ICE IN CHANNEL. WATER LEVEL DROPPED BELOW SENSOR ON JULY 22 AND WAS LOWERED DURING SITE VISIT ON JULY 28.

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H06 - MARY RIVER
2014 MEASURED STREAMFLOW HYDROGRAPH

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FIGURE 12

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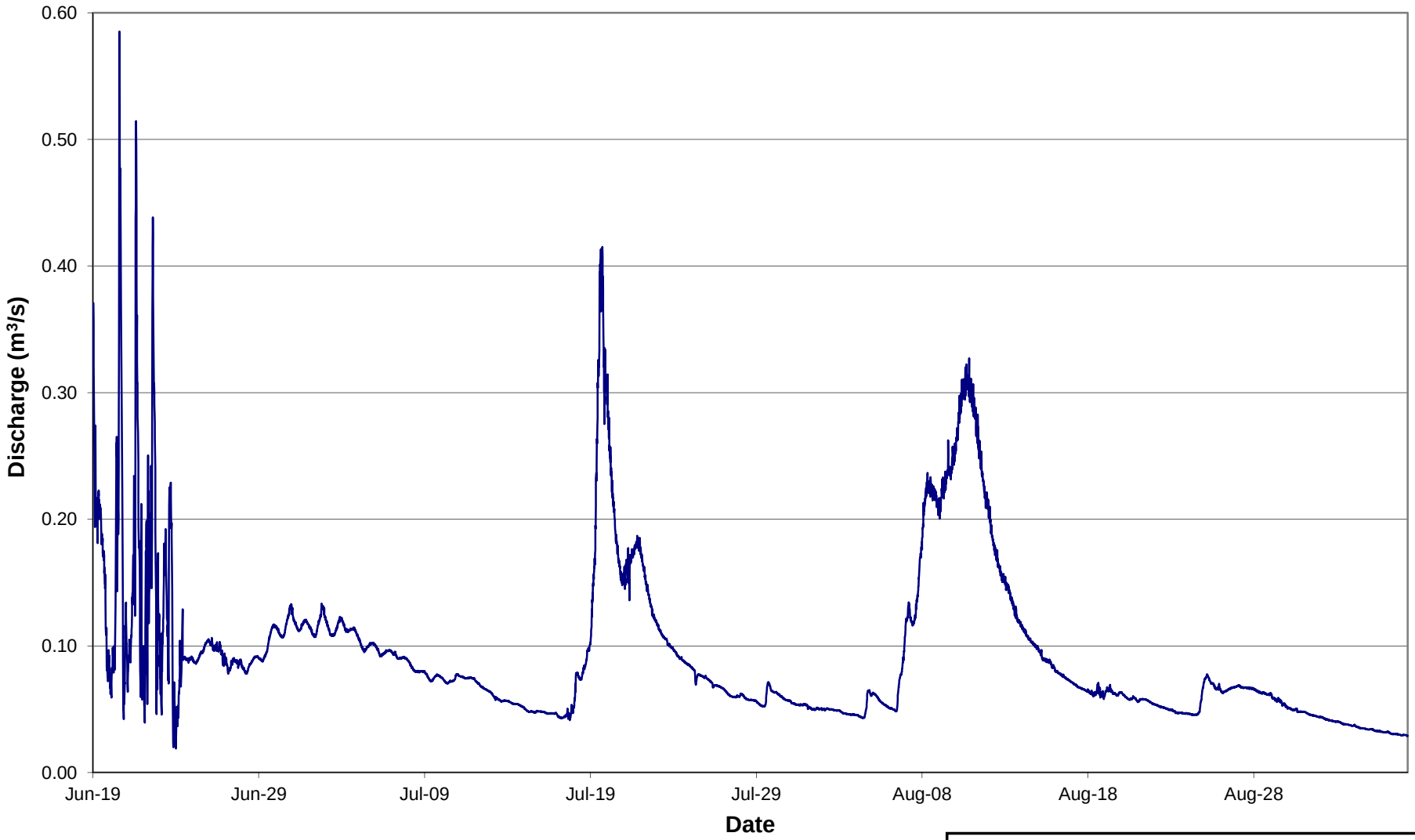

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MARY RIVER PROJECT

H11 - SHEARDOWN LAKE TRIBUTARY (SLDT-1)
2014 MEASURED STREAMFLOW HYDROGRAPH

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FIGURE 13

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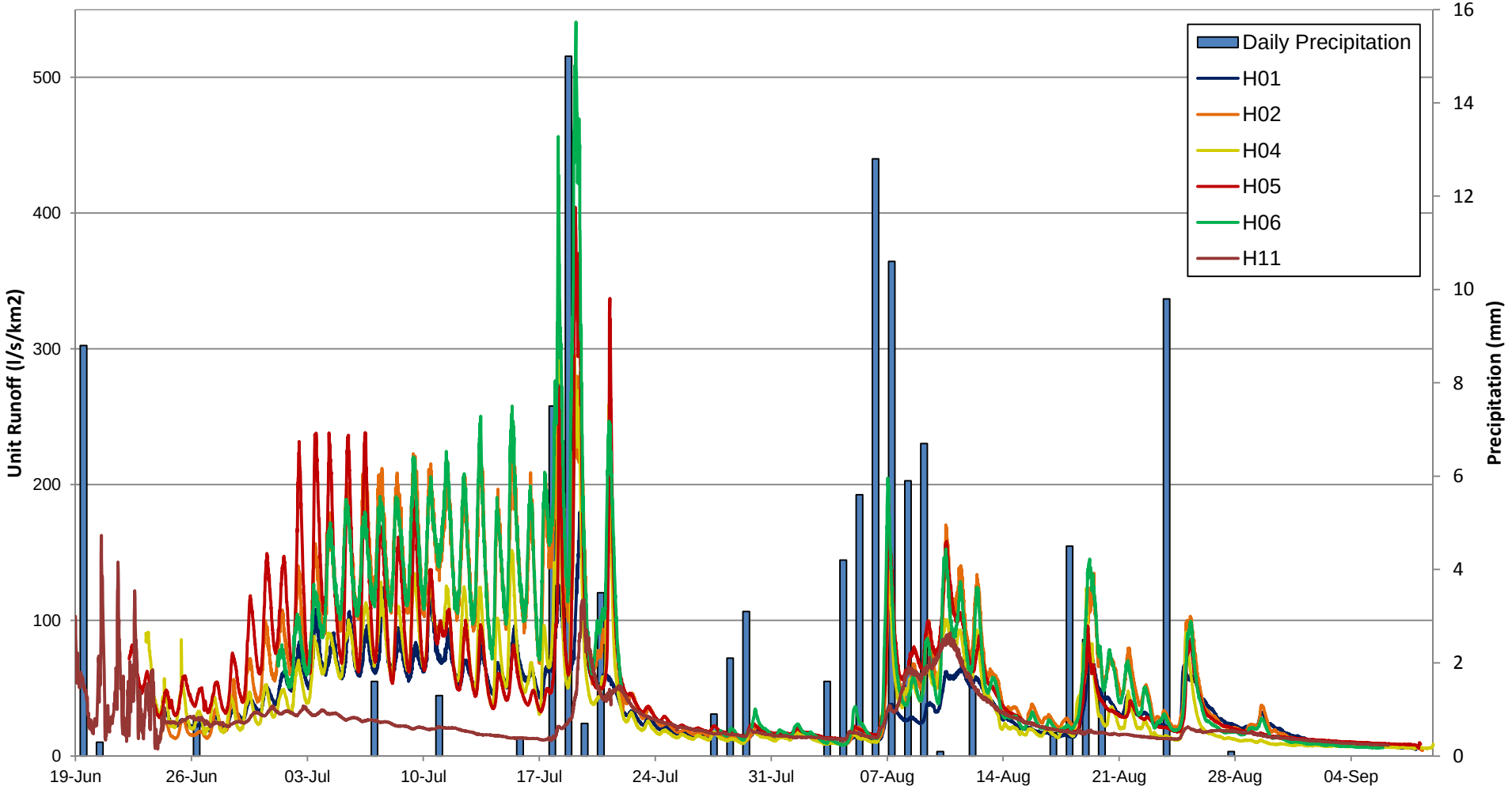

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MARY RIVER PROJECT

2014 UNIT RUNOFF HYDROGRAPH COMPILATION

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FIGURE 14

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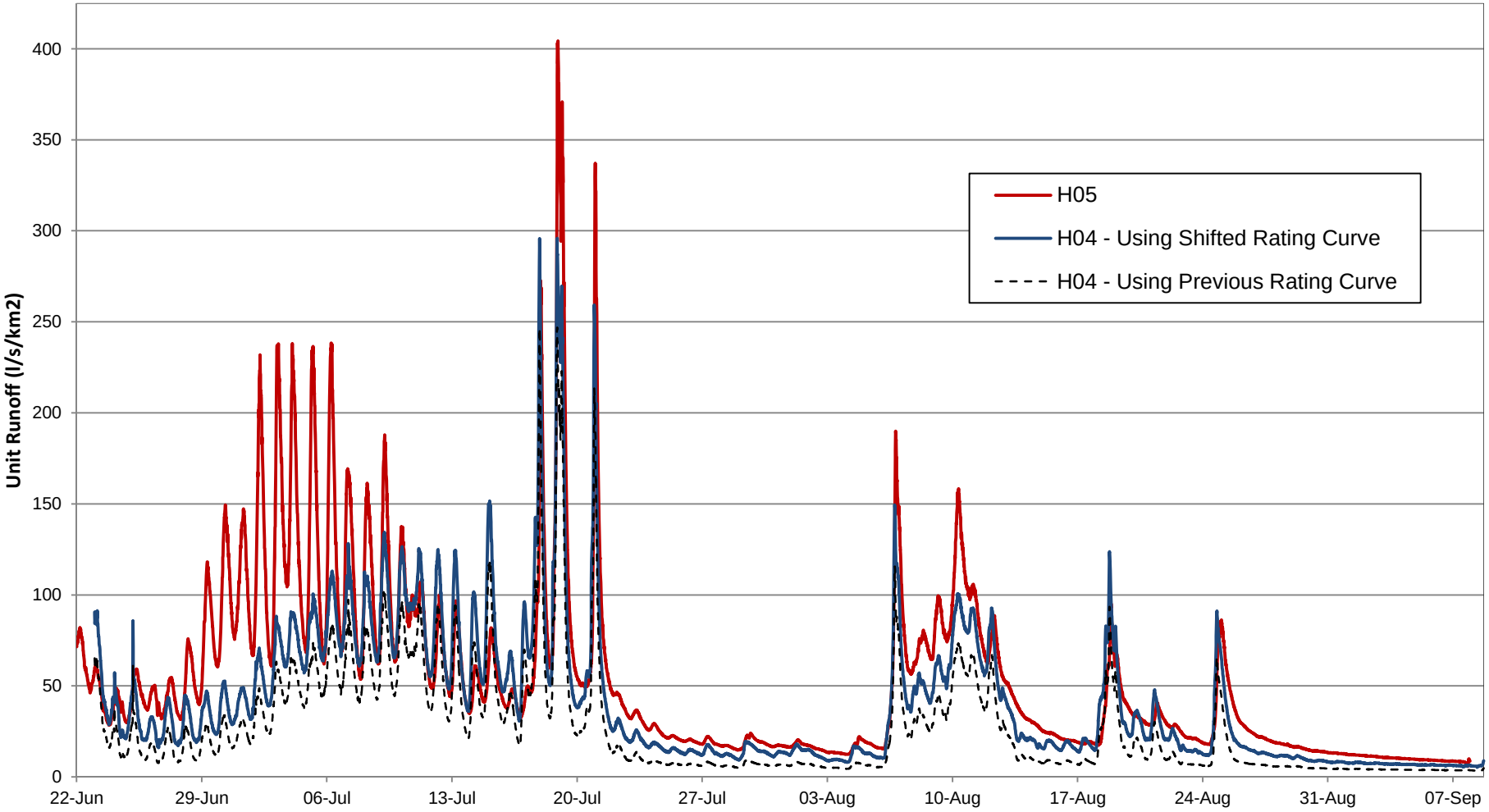

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MARY RIVER PROJECT

2014 UNIT RUNOFF HYDROGRAPH COMPARISON H04 AND H05

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REF NO. NB14-00636

FIGURE 15

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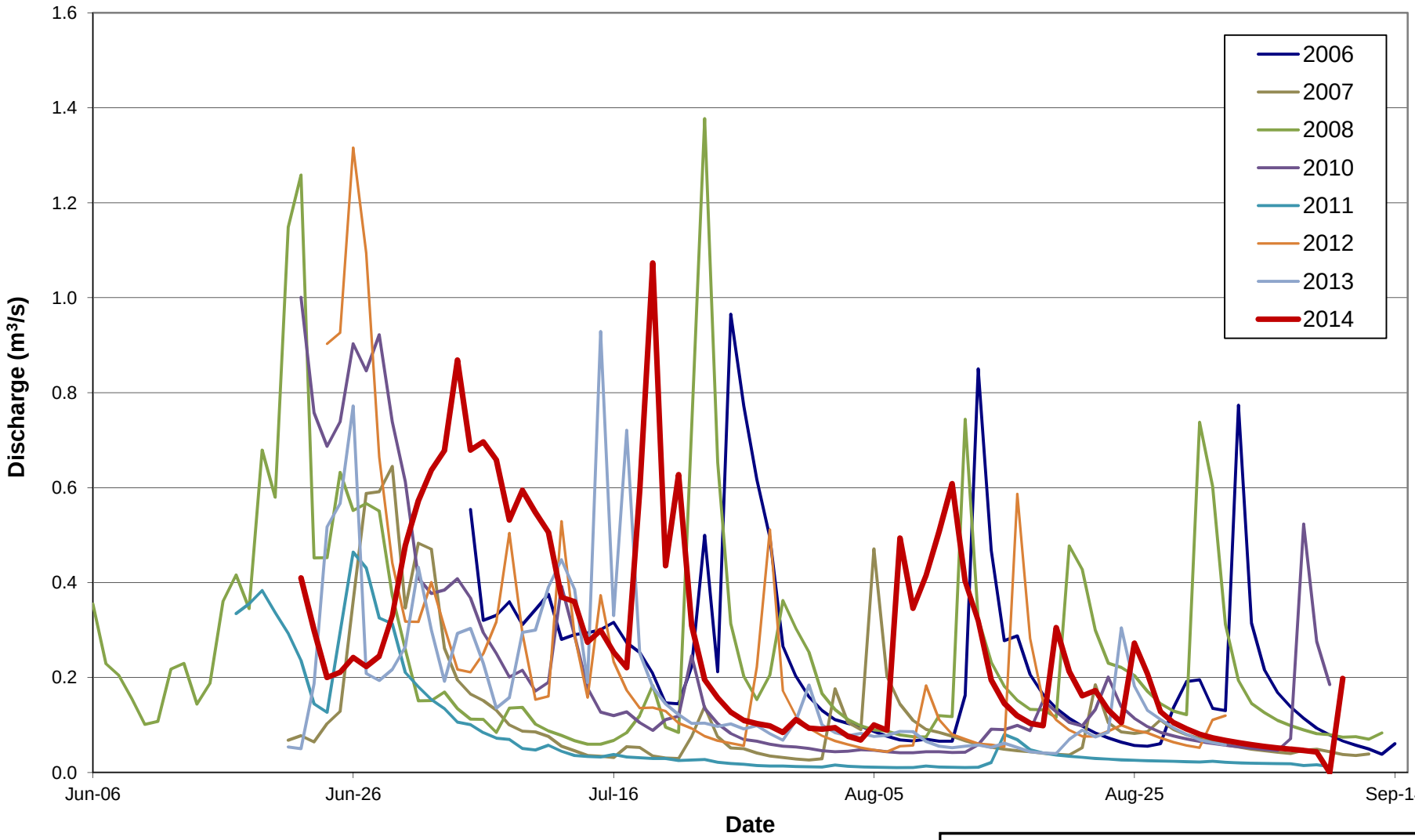

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0	16DEC'14	ISSUED WITH MEMO	ALR	DKK	RAM

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MARY RIVER PROJECT

MEASURED STREAMFLOW HYDROGRAPHS
RECORD H05 (2006-2014)

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P/A NO. NB102-181/34

REF NO. NB14-00636

FIGURE 16

REV 0