APPENDIX 7A

HYDROLOGY BASELINE REPORT

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

  

BASELINE HYDROLOGY REPORT

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BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

BASELINE HYDROLOGY REPORT
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BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

BASELINE HYDROLOGY REPORT
(REF. NO. NB102-181/30-7)

EXECUTIVE SUMMARY

This report presents a summary of the hydrologic data collected at 18 streamflow monitoring stations and two water level monitoring stations as a part of baseline studies for Baffinland Iron Mines Corporation's Mary River Project. These data, in addition to regional data, provide the basis for hydrologic assessment for engineering design and environmental assessment of the Project. During the summer of 2006, 13 streamflow monitoring stations were installed, four by Water Survey of Canada (WSC) and nine by Knight Piésold Ltd. (KPL). Seven of the KPL stations were installed within drainages immediately surrounding the proposed mine site. The other two KPL streamflow stations installed in 2006 were located to the north and south of the proposed mine site and provide information on spatial variability. The WSC streamflow monitoring stations were all installed within lakes on large river systems to the south of the Mine Site. During June 2008, a further four streamflow monitoring stations and one water level monitoring station were installed by KPL. These streamflow stations were all installed at various points along the proposed southern railway alignment, which would connect the Mary River Mine Site to the planned Steensby Port Site to the south, while the water level monitoring station was installed in Sheardown Lake. A monitoring program was not conducted during 2009, and only select stations were re-installed during the 2010 and 2011 monitoring programs. The nineteenth and twentieth monitoring stations were installed in June 2011 on a potentially impacted tributary of Sheardown Lake and in 3 km Lake. The purpose of all 20 hydrometric stations is to collect baseline information within the Mary River Project area, which can then be utilized in the design, construction, reclamation, environmental assessment and on-going monitoring of the Project.

The key findings within this report pertain to four main hydrometric parameters: timing of runoff, magnitude of runoff, spatial variability of timing and magnitude of runoff, and long-term runoff estimates. Runoff in the vicinity of the Mary River Project are characterised as follows:

- Streamflow typically commences in early to mid-June as temperatures climb above 0 ^{o}C, and ends in late September to late October, depending upon watershed characteristics.
- The annual hydrograph is dominated by a nival (snowmelt) freshet, which occurs between late June and the end of July, followed by a period of low baseflows driven by permafrost melt and shallow subsurface flow. Baseflows are punctuated by precipitation events through July to early September.
- Precipitation runoff events are usually quite large and flows increase rapidly as interception, infiltration, and evapotranspiration are minimal due to shallow permafrost, cool temperatures and lack of vegetative cover.

The timing and magnitude of runoff was first estimated from regional analyses and then reassessed with the addition of onsite measurements. Regional data indicated that mean annual unit runoff (MAUR) in the vicinity of Mary River should be slightly less than 10 l/s/km^2. They also suggested that mean annual peak daily unit runoff values likely range from less than 100 l/s/km^2 for watersheds with significant lake volumes, to over 400 l/s/km^2 for smaller watersheds without lakes. The actual measured results generally validate these estimates and are as follows:

- Watersheds H1-H7 operated by KPL had an average MAUR of 9.5 l/s/km^2 for the years of 2007-2008 and 2010-2011. The lowest measured annual mean unit runoff was recorded at H9 in 2007 at 3 l/s/km^2. The highest annual mean unit runoff was 19 l/s/km^2 recorded in 2008 within the Isortoq River watershed, which contains significant glacial cover. The highest mean annual unit runoff measured in a non-glaciated catchment was 18 l/s/km^2 in the BR11 watershed during 2008.
- The annual maximum peak daily unit runoff varied greatly among the sites, and resulted from snowmelt events, precipitation events, as well as combinations of both. The lowest peak daily unit runoff for watersheds with at least one complete year of data was 99 l/s/km^2, measured within the extensively lake covered BR137 catchment during 2008. The highest annual peak daily unit runoff was recorded in during a July 2006 rain event in the H4 watershed, which registered a unit runoff of 446 l/s/km^2.

As noted above, significant variation was recorded within both the annual hydrograph shape and the volume and intensity of unit runoff. Numerous factors can be attributed to this variation, but the primary factors are listed below:

- The proportion of lakes within a watershed has a significant effect on both the hydrograph shape and unit runoff. Because the lakes are still free of ice and contain attenuated runoff when precipitation begins to fall as snow and permafrost melt ends, rivers fed by lakes typically freeze up approximately a month later than systems that do not include lakes. Furthermore, lakes attenuate rapid runoff events as well as diurnal fluctuations in runoff, resulting in much lower intensity and longer duration storm event runoff and an overall smoother hydrograph. Lakes also allow larger volumes of water to evaporate than does the surrounding land, therefore lowering the mean annual unit runoff in catchments with large lake components.
- In smaller watersheds, windblown snow deposition may act to increase and/or decrease the mean annual unit runoff depending on whether a net gain or net loss of snow is occurring within the watershed. In larger watersheds, windblown snow is typically less significant as gains tend to balance the losses.
- Runoff from higher elevation areas tends to be greater than from lower elevation areas due to orographic enhancement of precipitation.

Finally, long-term mean discharge values were developed for seven hydrologic stations, as was a methodology for estimating peak return period discharge. Results are summarized as follows:

- The long-term mean annual unit runoff values ranged from 7.5 l/s/km^2 at H1 to 11.5 l/s/km^2 at H3. The average long-term mean annual unit runoff for all stations was 9.5 l/s/km^2.
- The 10-year mean monthly wet and dry return period discharge ranged between 14% and 229% of mean monthly discharge.
- 200-yr return period peak instantaneous discharge estimates range from a low of 340 l/s/km^2 in the largest monitored watershed (Ravn River) to almost 2500 l/s/km^2 in the smallest monitored watershed (H5).

Climate change was also discussed within this report as it pertains to the Mary River Mine Site. It was concluded that a conservative approach should be applied to hydrologic estimates to account for potential changes in annual, seasonal and extreme flow events due to climate change.

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SECTION 1.0 - INTRODUCTION

This report presents a summary of the hydrologic data collected from 2006 through 2008 and from 2010 through 2011 at 18 streamflow monitoring stations and two water level monitoring stations established for the Mary River Project. These data, in addition to regional data, are used to provide estimates of long-term flow conditions and statistical streamflow analysis at the Project site. The Mary River Project is located on northern Baffin Island in the Canadian Arctic, approximately 1000 km north-northeast of Iqaluit. The main deposit is located on the southern edge of an upland plateau, while the camp and much of the Project area south of the main deposit is at lower elevation. The landscape is dotted with numerous lakes and small water bodies.

Since the monitoring program began in 2006, Knight Piésold Ltd. (KPL) has operated eight streamflow monitoring stations and one water level monitoring station for varying periods of time on watercourses near the exploration site that could potentially be impacted by the Project. Five streamflow monitoring stations and one water level monitoring station have also been operated to the south of the Mine Site along the proposed railway alignment and near Steensby Port. The final station operated by KPL is located to the north of the Mine Site on a tributary of Phillips Creek, which flows into Milne Inlet at the Milne Port Site. The hydrometric monitoring program is completed by the installation and operation of four regional monitoring stations operated by Water Survey of Canada (WSC). These stations were installed on large river systems to help characterize the regional hydrology in the vicinity of the Project. The locations of the hydrometric monitoring stations along with their corresponding drainage areas are shown on Figures 1.1, 1.2 and 1.3, and listed on Table 1.1. All of the KPL stations were operated during open water conditions only, resulting in a data collection season from early to mid-June to mid-September. While streamflow has been witnessed and measured outside of this period, it has largely been of a negligible volume, especially within the smaller catchments where the KPL stations are located. Flows were extrapolated to zero outside the measured record to account for these unrecorded flows. The WSC streamflow stations, however, are operated year-round as the pressure sensors of their gauges are located deep within lakes, allowing them to remain typically unfrozen throughout the winter. WSC also have to estimate flow conditions once ice forms on the lakes and outflow channels.

The following sections discuss regional hydrology before summarizing the collected data. An analysis to estimate long-term flow conditions is then presented, followed by statistical peak flow, and wet and dry monthly flow analyses. Finally, discussions of groundwater hydrology and climate change at Mary River are presented before the final section provides the conclusions and recommendations of the report.

SECTION 2.0 - REGIONAL STREAMFLOW AND CLIMATE CHARACTERIZATION

Baffin Island is one of the northernmost and coldest parts of Canada and the Mary River Project is situated towards the northern end of the Island. Regional data indicate a mean annual temperature of approximately -15 °C. Mean daily temperatures are below -20 °C from November through April, and are only above freezing (0 °C) during June through August, with July mean daily maximum temperatures reaching only 6-10 °C. The long length of the sub-zero degree temperatures in this region results in a very short runoff period that typically occurs from June through September, but may extend to late October or even early November in systems where large lakes are present. The frigid temperatures also result in very low precipitation values for northern Baffin Island, from the combined effect of the low moisture carrying capacity of cold air and the scarcity of liquid water for much of the year. According to Natural Resources Canada, the mean annual total precipitation ranges from 200 to 400 mm in the Project area, classifying it as semi-arid. Mean annual precipitation data at the closest regional climate stations agree with this range. Figure 2.1 presents the locations of these regional climate stations, while Figures 2.2 and 2.3 present graphs of average monthly precipitation and temperature for each regional station, respectively. Processes that act to further limit water available for runoff are evaporation, transpiration and sublimation. The frigid climate and subsequent lack of significant vegetative cover combine to minimize the volume of water evaporated and transpired to very low levels. Sublimation, which is the process by which solid water changes phase directly to water vapour, occurs during the winter months and is increased by blowing snow transport which is very common in the Mary River region. Therefore, sublimation may result in a greater loss of potential runoff than either evaporation or transpiration, and has been found to result in losses of up to 50% of winter precipitation in Arctic environments (Liston and Sturm, 2004).

Streamflow regimes in the high Arctic are influenced by numerous factors, most important of which is temperature. Throughout the winter months the temperatures are bitterly cold, as described above, resulting in streams either drying up or freezing solid and ceasing to flow. As temperatures rise above 0 °C, snow and ice melt and streamflow resumes until freeze-up occurs during the following winter. Considerable differences in the timing and volume of runoff occur between systems depending on elevation, aspect, glacial cover and lake cover. A watershed's elevation affects the timing of the onset of the summer melt, and can also affect the volume of precipitation it receives as a result of orographic influences. The aspect of a watershed can also play a role in the timing of the summer melt, and possibly in the depth, and therefore volume, of permafrost melt later in the summer. Glacial cover tends to greatly increase the volume of runoff in a watershed, especially in the late summer, relative to other catchments that receive runoff only from permafrost melt and precipitation. Finally, lake content within a watershed acts to attenuate the effects of storm and melt events, resulting in a smoothed hydrograph without the rapid changes in runoff observed in catchments without significant lake area. Lakes also provide a source of water to river systems later in the year, due to attenuation of inflows, when precipitation is falling as snow, permafrost melt has ceased, and other systems are no longer receiving input of water and are therefore drying up and/or freezing over. As a result, systems that include significant lake components tend to continue to flow later into the winter than watersheds with little or no lake volume.

The presence of permafrost within the watersheds of the region, coupled with the lack of vegetative cover, also has an effect on hydrologic systems. Permafrost typically does not allow water to infiltrate the ground to any great depth, while the lack of surface vegetation results in little to no impedance or loss of runoff as it flows to the river channels. Therefore, storm driven runoff events tend to produce flashy streamflow conditions.

Five regional hydrologic stations operated by WSC were reviewed in an attempt to characterize the hydrology in the region around the Mary River Project Area. Due to the sparse hydrologic network in the Canadian Arctic, these systems are a significant distance from the Project, have records with few complete years, and are not all currently active. These five stations, listed in Table 2.1 and presented on Figure 2.1, range in location from 640 km northwest of the Mary River camp, to 1000 km southeast of the camp, and have drainage areas ranging from 60 km^2 to 2980 km^2. These systems begin to flow in late May to mid-June, with the southern watersheds melting earlier than the northern watersheds. The majority of annual runoff then typically occurs during the nival freshet in late June through July, with runoff decreasing through the late summer before freezing up again at the onset of winter. The freeze-up date is significantly different between the northern and southern sites, ranging from late September in the northern watersheds more similar in latitude to Mary River, to November and December for the sites located far to the south near Iqaluit. Mean annual unit runoff (MAUR) also differs between the northern and southern watersheds. The southern watersheds have an average MAUR of 10 $l/s/km^2$, while the northern watersheds average 6 $l/s/km^2$. The mean annual peak daily unit runoff varies more randomly amongst the sites, with a low of 105 $l/s/km^2$ at Marcil Creek and a high of 251 $l/s/km^2$ on the Mecham River. The hydrographs of average daily unit runoff at each station are presented on Figure 2.4. Through analysis of the regional WSC streamflow stations, it is assumed that the smaller, non-lake containing watersheds in the immediate vicinity of the Mary River Mine Site should begin to flow in early to mid-June and cease to flow in late September to early October, have MAUR values of approximately 8 to 10 $l/s/km^2$, and have mean annual peak daily unit runoff values ranging from approximately 100 to 400 $l/s/km^2$. In watersheds containing significant lake coverage, flows are expected to end later and have a lower mean annual unit runoff.

SECTION 3.0 - MARY RIVER HYDROLOGY PROGRAM

3.1 MARY RIVER HYDROMETRIC PROGRAM AND DATA SUMMARY

A streamflow monitoring program was initiated at the Mary River Project site in July 2006. To date, there have been 14 streamflow monitoring stations and two water level monitoring stations in seasonal operation within the Project area. There were also four regional WSC hydrology stations installed in 2006 that are funded by Baffinland Iron Mines Corp (BIM) and are located near the Project area. The following sections provide a summary of the datasets collected at all stations, with presentation of the datasets in the form of site specific rating curves, hydrographs, and summary tables. These data, coupled with onsite observations, suggest that streamflow at the Project site typically begins in early June and ends in late September. The annual hydrographs are dominated by a nival (snowmelt) freshet in late June to mid-July, and low flows punctuated by large, rapid, rainfall runoff events in late July through early September. The hydrographs also exhibit significant diurnal variability during the freshet and just prior to freeze-up, likely due to temperature driven snowmelt and/or permafrost melt/freeze. Annual maximum instantaneous discharges either occur as a result of snowmelt during the freshet, rainfall during summer precipitation events, or a combination of both. Streamflow can also rise extremely rapidly during rainfall driven runoff events, as a result of limited interception by vegetation and low infiltration due to shallow permafrost.

Revision 0 of the Mary River Baseline Hydrology Report (KPL, 2009) was prepared for BIM by KPL after the 2008 data collection period. During this Rev 0 analysis, streamflow was assumed to begin June 1 and end September 30 for most sites, with streamflow extending until October 31 at those stations with significant lake area within their watershed. For those stations with missing periods of data, which may be a result of late installation dates, logger damage or malfunction, or the lowering of the water surface below the level of the pressure transducer, data was synthesized using linear regression with nearby stations in order to calculate monthly values. Linear interpolation was used to extend the flow records from June 1 to the low flows at the beginning of the measure record and from the end of the measured record to the September 30 or October 31 dates of zero flow. This interpolation was deemed reasonable through the assessment of regional data, as well as the knowledge that the total volume of interpolated flow comprises a very small fraction of the measured streamflow volume. In 2006, no data were recorded at any of the sites during the month of June as the stations were not yet established, and considering that no nearby data were available to synthesize data for this month, no annual statistics were calculated for that year.

Since the 2008 report was issued, hydrometric monitoring programs were continued through the 2010 and 2011 open water seasons at select hydrometric stations. The results of the 2010 monitoring program were presented in a 2010 Hydrologic Data Collection Summary letter (KPL, 2010) while the 2011 results are presented within this report. For those stations where additional years of streamflow data (post 2008) were recorded, the analysis and results from the previous reports were updated, while for those stations without additional streamflow data the previous analyses have not been updated. The most notable differences between the 2008 analysis and the current analysis are that recession curves based on, or similar to, those presented by WSC were used to extend the start and end of the measured records to the date of zero flow; the flow records do not have pre-set start and end dates.

A brief description of each gauging station is provided in the following section, along with a discussion of the streamflow record and rating curve quality, a description of the data collection techniques used, and a summary of the regression and/or interpolation analysis used to synthesize missing periods of streamflow. Rating curves, daily steamflow hydrographs and streamflow summary tables are also presented for each site.

3.2 HYDROMETRIC MONITORING AND ANALYSIS PROCEDURES

Common hydrometric monitoring procedures were applied to all stations operated by KPL, and are summarized in the following sub-sections.

3.2.1 Station Installation and Removal

The hydrometric monitoring stations are comprised of an Instrumentation Northwest Inc. (INW) PT2X pressure transducer with internal data logger, which is housed within a 2 m or 3 m length of aluminum pipe. The pipes are attached to a bedrock outcrop or large boulders, which provide a stable location to measure stage. The pressure transducer is surveyed to two benchmarks during each site visit (prior to 2010 stations were only surveyed during installation, relocation and removal) to ensure that the transducer remains stationary and functioning correctly during the monitoring season, and so that the stage record from successive years can be corrected to a common datum. The monitoring station locations were selected to provide good hydraulic conditions for streamflow gauging. These criteria include:

1) A stable hydraulic control,
2) Suitable installation conditions,
3) A site with minimal turbulence and water surface fluctuations,
4) A site where the pressure transducer will remain submerged at low flows, and
5) Suitable conditions for accurate discharge measurement at a wide range of flow conditions.

The stream gauges are installed annually once melt of frozen channel ice allowed access to the station locations. The pressure transducers are programmed to record water level measurements at 15 minute intervals throughout the season.

3.2.2 Discharge Measurements

Three different techniques were used to collect discharge measurements at the monitoring stations: velocity meter, rhodamine dye and fluorometer, and an Acoustic Doppler Current Profiler (ADCP). When flow in the channels allowed for safe wading, the discharge measurements were recorded using a velocity meter and the velocity-area technique. When the discharge was too high to allow for safe wading of the river, the dilution technique was employed at most sites by use of rhodamine dye slug injection. At sites whose channel characteristics do not allow for thorough mixing of rhodamine dye, an ADCP was used to measure discharge during unwadeable flow conditions. This method also makes use of the velocity-area technique but the ADCP, which is engineered to float on the water surface and is pulled across the channel on a tethered rope, uses Doppler technology to measure high resolution depth and velocity data.

Measurement uncertainty for the velocity-area measurements was quantified by assessing the precision between concurrent discharge measurements, the distribution of cross-sectional discharge within depth-velocity measurement cells (ideally each cell contains less than 5% of the total discharge) and a qualitative assessment of the measurement transect quality. Measurement uncertainty for the dilution measurements was quantified primarily by visual assessment of the mixing quality during the measurement, the quality of the dye injection and the sonde location and calibration, and by assessing the precision between concurrent discharge measurements. Measurement uncertainty for the ADCP was quantified by assessing the difference between successive measurements and the difference between the measured discharge and the total discharge, which includes estimates of the flow along the edges and bottom of the channel. Typical measurement uncertainty ranged from +/- 5% to 15% of measured discharge. For ease of presentation, as well as to add some conservatism to the figures, the error bars on each rating curve figure associated with the calibration discharge measurements have been set at +/- 15%.

3.2.3 Rating Curve Development

Water level data collected at each monitoring station were corrected to the station datum, based on the benchmark surveys, to become stage data. Water level to stage corrections were undertaken in Aquarius time series software, which allows advanced data correction and correction tracking.

The rating curves were derived by visual fit to the stage-discharge calibration points collected at each station, with direct consideration of the estimated uncertainty associated with each point. The form of the rating curve equation is also based on general hydraulic theory pertaining to open channel flow, which predicts that stage and discharge will be related by a power function with values of the coefficient and exponent being dependent on the hydraulic characteristics of the control section at the gauge (Maidment, 1993). The empirical rating curve equation can be compared against the expected theoretical values of the exponent and coefficient, which serves as a useful check on its reliability and accuracy when extrapolated to predict high flows.

3.3 H1 - NORTHERN CONTROL SITE

The H1 hydrology station was first installed on July 5, 2006 on a tributary of Phillips Creek approximately 40 km northwest of the Mary River camp. It is the most northerly of all the Project hydrology stations and was originally installed on a potential transportation route between Mary River and Milne Inlet. The catchment area above the gauge is approximately 250 km^2 and includes several small lakes. The location of the gauge site is presented on Figure 1.1, while photos of the gauge site and surrounding terrain are provided in Appendix A.

Sixteen high quality stage-discharge measurements have been successfully collected at the H1 gauging station during the period of record, July 5, 2006 to September 6, 2011. The measurements were collected using a current meter at low flows and rhodamine dye at high flows. The measurements were used to develop the H1 stage-discharge rating curve, which is presented on Figure 3.1. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. However, there is greater uncertainty at high flows beyond the range of measured discharge used to define the rating curve.

The rating curve was applied to the recorded stage record to develop the H1 mean daily streamflow record, which is presented on Figure 3.2. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.1. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Furthermore, data were not recorded during the 2010 monitoring period at H1, but rather the data were synthetized by correlating the measured daily discharge data with concurrent data collect at monitoring station H5. Characteristics of the H1 streamflow record include the following:

- The maximum mean daily discharge was 40 m^3/s recorded on July 4, 2006, which equates to a unit runoff of 160 l/s/km^2.
- Mean monthly runoff at H1 ranged from a low of 2 l/s/km^2 during September 2011, to a high of 63 l/s/km^2 during July 2006.
- Mean annual runoff ranged from a low of 4 l/s/km^2 in 2011 to a high of 11 l/s/km^2 in 2008.

It is recommended that the streamflow monitoring program at H1 be continued in order to gain a greater understanding of long-term streamflow conditions in the northern portions of the Project area closer to Milne Port, but the collection of discharge measurements to further refine the rating curve is no longer considered a priority. Occasional discharge measurements should continue to be collected to confirm rating curve and channel stability.

3.4 H2 - TOM RIVER

The H2 hydrology station was first installed on July 7, 2006 on the Tom River approximately 2.5 km northwest of the Mary River camp. The catchment area above the gauge is approximately 210 km^2 and is comprised primarily of upland areas to the immediate north and northwest of the main Mary River deposit. The location of the gauge site is presented on Figure 1.1 while a more detailed presentation of the H2 watershed is presented on Figure 1.2. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Twenty-one stage-discharge measurements have been successfully collected at the H2 gauging station during the period of record, July 7, 2006 to September 12, 2010. The measurements were collected using a current meter at low flows and rhodamine dye at high flows. The measurements were used to develop the H2 stage-discharge rating curve, which is presented on Figure 3.3. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. However, there is greater uncertainty at high flows beyond the range of measured discharge used to define the rating curve.

The rating curve was applied to the recorded stage record to develop the H2 mean daily streamflow record, which is presented on Figure 3.4. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.2. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Furthermore, data were not recorded during the 2011 monitoring period at H2, but rather the data were synthetized by correlating the measured daily discharge data with concurrent data collect at monitoring station H6. Characteristics of the H2 streamflow record include the following:

- The maximum mean daily discharge was 40 m^3/s recorded on June 28, 2008, which equates to a unit runoff of 190 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 2 $l/s/km^2$ during September 2011, to a high of 92 $l/s/km^2$ during July 2006.
- Mean annual runoff ranged from a low of 6 $l/s/km^2$ in 2011 to a high of 13 $l/s/km^2$ in 2008.

The streamflow monitoring program at H2 has been discontinued, as it is very unlikely that the Tom River will experience significant Project related impacts to water quantity.

3.5 H3 - TOM TRIBUTARY

The H3 hydrology station was first installed on July 7, 2006 on a tributary of the Tom River approximately 5 km north of the Mary River camp. The catchment area above the gauge is approximately 30.5 km^2 and is comprised primarily of upland areas to the immediate north of the main Mary River deposit, including the north slopes of the deposit. The H3 catchment is a sub-catchment of the H2 watershed. The location of the gauge site is presented on Figure 1.1 while a more detailed presentation of the H3 catchment is presented on Figure 1.2. Photos of the monitoring station and surrounding terrain are provided in Appendix A.

Seventeen stage-discharge calibration measurements have been successfully collected at the H3 monitoring station between, July 7, 2006 to September 11, 2010. The measurements were collected using a current meter at all flows. These measurements were used to develop the H3 rating curve, which is presented on Figure 3.5. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. However, there is greater uncertainty at high flows beyond the range of measured discharge used to define the rating curve.

The rating curve was applied to the recorded stage record to develop the H3 mean daily streamflow record, which is presented on Figure 3.6. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.3. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Furthermore, data were not recorded during the 2011 monitoring period at H3, but rather the data were synthetized by correlating the measured daily discharge data with concurrent data collect at monitoring station H6. Characteristics of the H3 streamflow record include the following:

- The maximum mean daily discharge was 9.0 m^3/s recorded on June 28, 2008, which equates to a unit runoff of 295 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 1 $l/s/km^2$ during September 2011, to a high of 145 $l/s/km^2$ during July 2006.

- Mean annual runoff ranged from a low of 8 l/s/km^2 during 2007 and 2011 to a high of 16 l/s/km^2 in 2008.

The streamflow monitoring program at H3 has been discontinued, as it is unlikely that this tributary of the Tom River will experience significant project related impacts to water quantity.

3.6 H4 - CAMP LAKE TRIBUTARY 2

The H4 hydrology station was first installed on July 3, 2006 on a small creek known as Camp Lake Tributary 2, approximately 1 km northwest of the Mary River camp. The catchment area above the gauge is approximately 8.3 km^2 and the catchment includes a portion of the western slope of the main deposit. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the H4 watershed is shown on Figure 1.2. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Nineteen high quality stage-discharge calibration measurements have been successfully collected at the H4 monitoring station between July 7, 2006 to September 11, 2011. Discharge measurements at H4 were recorded using a current meter at all flows. The H4 rating curve is presented on Figure 3.7. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. However, there is greater uncertainty at high flows beyond the range of measured discharge used to define the rating curve.

The rating curve was applied to the recorded water level record to develop the H4 mean daily streamflow record, which is presented on Figure 3.8. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.4. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Furthermore, data were not recorded during the 2010 monitoring period at H4, but rather the data were synthetized by correlating the measured daily discharge data with concurrent data collect at monitoring station H5. Characteristics of the H4 streamflow record include the following:

- The maximum mean daily discharge was 3.7 m^3/s recorded on July 4, 2006, which equates to a unit runoff of 446 l/s/km^2.
- Mean monthly runoff ranged from a low of 1 l/s/km^2 during September 2011, to a high of 101 l/s/km^2 during July 2006.
- Mean annual runoff ranged from a low of 4 l/s/km^2 during 2011 to a high of 14 l/s/km^2 in 2008.

It is recommended that the streamflow monitoring program at H4 be continued in order to gain a greater understanding of baseline streamflow conditions within the watershed, as it is expect that the stream will experience measurable impacts to water quantity during construction and operation of the Mary River project. However, the collection of discharge measurements to further refine the rating curve is no longer considered a priority, rather discharge measurements should continue to be collected periodically to confirm rating curve and channel stability.

3.7 H5 - CAMP LAKE TRIBUTARY 1

The H5 hydrology station was first installed on July 4, 2006 on a small creek known as Camp Lake Tributary 1 approximately 1 km northeast of the Mary River camp. The catchment area above the gauge is approximately 5.3 km^2 and includes of a portion of the western slope of the main deposit. The location of the gauge site is presented on Figure 1.1 while a more detailed presentation of the H5 watershed is presented on Figure 1.2. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Thirty good quality stage-discharge calibration measurements have been successfully collected at the H5 monitoring station between July 4, 2006 to September 9, 2011. Discharge measurements at H5 were recorded using a current meter at all flows. During the data quality review, it was determined that a change had occurred to the control section between the 2008 and 2010 monitoring periods. The change appears to primarily affect flows above a stage of 3.6 m, or approximately 0.2 m^3/s. As a result, two rating curves were developed for the H5 monitoring station as presented on Figure 3.9. The first curve applies to the data collected during 2006 to 2008, while the second curve applies to data collected in 2010-2011. Both rating curves are considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. However, there is greater uncertainty at high flows beyond the range of measured discharge used to define the rating curve.

The rating curves were applied to the recorded stage record to develop the H5 mean daily streamflow record, which is presented on Figure 3.10. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.5. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Characteristics of the H5 streamflow record include the following:

- The maximum mean daily discharge was 1.9 m^3/s recorded on July 4, 2006, which equates to a unit runoff of 358 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 1 $l/s/km^2$ during September 2011, to a high of 77 $l/s/km^2$ during July 2006.
- Mean annual runoff ranged from a low of 4 $l/s/km^2$ during 2011 to a high of 13 $l/s/km^2$ in 2008.

It is recommended that the streamflow monitoring program at H5 be continued in order to gain a greater understanding of baseline streamflow conditions within the watershed, as it is expect that the stream will experience measurable impacts to water quantity during construction and operation of the Mary River project. However, the collection of discharge measurements to further refine the rating curve is no longer considered a priority, rather discharge measurements should continue to be collected periodically to confirm rating curve and channel stability.

3.8 H6 - MARY RIVER CANYON

The H6 hydrology station was first installed on July 7, 2006 on the Mary River within the canyon adjacent to the main deposit, approximately 6 km east of the Mary River camp. The catchment area above the monitoring station is approximately 240 km^2, and is comprised primarily of upland regions along with most of the eastern slope of the main deposit. The catchment also includes a small glacier approximately

5 km^2 in size in its upper headwaters. The location of the gauge site is presented on Figure 1.1 while a more detailed presentation of the H6 watershed is presented on Figure 1.2. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Thirteen good quality stage-discharge calibration measurements have been successfully collected at the H6 gauging station between July 7, 2006 and September 6, 2011. The measurements were collected using a rhodamine dye slug injection at most flows, however a current meter was used to measure very low flows. The H6 rating curve is presented on Figure 3.11. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. .

The rating curve was applied to the recorded stage record to develop the H6 mean daily streamflow record, which is presented on Figure 3.12. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.6. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Characteristics of the H6 streamflow record include the following:

- The maximum mean daily discharge was 53 m^3/s recorded on June 28, 2008, which equates to a unit runoff of 221 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 4 $l/s/km^2$ during September 2011, to a high of 105 $l/s/km^2$ during July 2006.
- Mean annual runoff ranged from a low of 8 $l/s/km^2$ during 2011 to a high of 15 $l/s/km^2$ in 2008.

It is recommended that the streamflow monitoring program at H6 be continued in order to gain a greater understanding of baseline streamflow conditions within the watershed, as it is expect that the stream will experience measurable impacts to water quantity during construction and operation of the Mary River project. However, the collection of discharge measurements to further refine the rating curve is no longer considered a priority, rather discharge measurements should continue to be collected periodically to confirm rating curve and channel stability.

3.9 H7 - MARY RIVER TRIBUTARY

The H7 hydrology station was first installed on July 6, 2006 on a tributary of the Mary River approximately 6.5 km east of the Mary River camp. The catchment area above the station is approximately 14.7 km^2, and drains most of the eastern slope of the main deposit. A unique feature of this watershed compared to what has been observed in other monitored watersheds near Mary River, is the annual development of an extremely large snow drift across from the monitoring station. Wind blowing down the Mary River valley deposits the snow into the deeply incised H7 valley. The result of this deposition is the possible extension of the freshet within the H7 watershed as this snow deposit melts, a potential increase in mean annual discharge, and the delayed installation of the monitoring station. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.2. Photos of the station and surrounding terrain are provided in Appendix A.

Nineteen good quality stage-discharge calibration measurements have been successfully collected at the H7 monitoring station between July 6, 2006 and September 6, 2011. The measurements were collected using a current meter at low flows and rhodamine dye slug injection at high flows. The H7 rating curve is presented on Figure 3.13. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve.

The rating curve was applied to the recorded water level record to develop the H7 mean daily streamflow record, which is presented on Figure 3.14. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.7. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Furthermore, water level data were not recorded during the 2010 monitoring period or during June 2011 at H7, but rather the data were synthetized by correlating the measured daily discharge data with concurrent data collect at monitoring station H6. Characteristics of the H7 streamflow record include the following:

- The maximum mean daily discharge was 3.5 m^3/s recorded on July 23, 2008, which equates to a unit runoff of 238 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 2 $l/s/km^2$ during September 2011, to a high of 118 $l/s/km^2$ during July 2006.
- Mean annual runoff ranged from a low of 7 $l/s/km^2$ during 2007 and 2011 to a high of 13 $l/s/km^2$ in 2008.

It is recommended that the streamflow monitoring program at H7 be continued in order to gain a greater understanding of baseline streamflow conditions within the watershed, as it is expect that the stream will experience measurable impacts to water quantity during construction and operation of the Mary River project. However, the collection of discharge measurements to further refine the rating curve is no longer considered a priority, rather discharge measurements should continue to be collected periodically to confirm rating curve and channel stability.

3.10 H8 - UPPER MARY RIVER

The H8 hydrology station was first installed on July 6, 2006 on the Mary River upstream of H6 and approximately 11 km east of the Mary River camp. The catchment area above the gauge is approximately 208 km^2, and is comprised of the upland regions of the Mary River, which includes a glacier approximately 5 km^2 in size in the upper headwaters. The location of the gauge site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.2. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Thirteen good quality stage-discharge calibration measurements have been successfully collected at the H8 monitoring station between July 6, 2006 and September 14, 2008. The measurements were recorded using a current meter at low flows and an ADCP at high flows. The H8 rating curve is presented on Figure 3.15. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve.

The rating curve was applied to the recorded stage record to develop the H8 mean daily streamflow record, which is presented on Figure 3.16. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.8. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Characteristics of the H8 streamflow record include the following:

- The maximum mean daily discharge was 45 m^3/s recorded on June 28, 2008, which equates to a unit runoff of 216 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 3 $l/s/km^2$ during September 2007, to a high of 87 $l/s/km^2$ during July 2006.
- Mean annual runoff ranged from a low of 7 $l/s/km^2$ during 2007 to a high of 13 $l/s/km^2$ in 2008.

The streamflow monitoring program at H8 has been discontinued, as it is very unlikely that upper watershed of the Mary River will experience measureable project related impacts to water quantity.

3.11 H9 - SOUTHERN ACCESS ROUTE

The H9 hydrology station was first installed on July 5, 2006 at the outlet of a small lake approximately 70 km south of the Mary River camp. The catchment area above the station is approximately 158 km^2, and includes numerous small lakes. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.3. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Fifteen good quality stage-discharge calibration measurements have been successfully recorded at the H9 monitoring station between July 5, 2006 and September 15, 2008. The measurements were recorded using a current meter at low flows and both rhodamine dye slug injection and ADCP at high flows. The H9 rating curve is presented on Figure 3.17. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. However, there is greater uncertainty at high flows beyond the range of measured discharge used to define the rating curve.

The rating curve was applied to the recorded stage record to develop the H9 mean daily streamflow record, which is presented on Figure 3.18. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.9. The streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Streamflow data were extrapolated out through the end of October at H9 after consideration of the magnitude of flows still occurring upon removal of the stations in September, as well as the effects of attenuation of streamflow by waterbodies such as those within the H9 watershed. Characteristics of the H9 streamflow record include the following:

- The maximum mean daily discharge was 16.4 m^3/s recorded on June 23, 2008, which equates to a unit runoff of 104 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 1 $l/s/km^2$ during October, to a high of 29 $l/s/km^2$ during August 2008.
- Mean annual runoff ranged from a low of 3 $l/s/km^2$ during 2007 to a high of 7 $l/s/km^2$ in 2008.

The streamflow monitoring program at H9 has been discontinued, as this watershed will not experience measureable project related impacts to water quantity during the construction, operation and closure of the Mary River project.

3.12 H10 - SHEARDOWN LAKE

The H10 water level monitoring station was first installed on May 30, 2008 at the outlet of Sheardown Lake, approximately 4 km southeast of the Mary River camp. The catchment area above the station is approximately 8.2 km^2, and is comprised primarily of Sheardown Lake and the southern slope of the main deposit. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.2. Photos of the monitoring station and surrounding terrain are provided in Appendix A.

Initially, it was intended that a streamflow monitoring station would be developed at this site, which would include a rating curve, annual hydrographs, etc. However, during a site visit in late June, 2008, it was recorded that water was no longer flowing out of Sheardown Lake, but was flowing into the lake from Mary River. Further investigation revealed that the lake is frequently backwatered by the Mary River, and therefore a rating curve could not be developed for the site. However, a stage record was collected and is presented on Figure 3.19, which records the fluctuations of the lake surface elevation.

3.13 H11 - SHEARDOWN LAKE TRIBUTARY 1

The H11 hydrology station was establish on June 18, 2011 at the outlet of the primary tributary to Sheardown Lake, which is located along the northeastern most shore of the lake. The catchment area above the station is approximately 3.6 km^2, and includes part of the western slopes of the deposit. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.3. Photos of the gauge site and surrounding terrain are provided in Appendix A). The station was established after identification of the channel as being both fish habitat, and potentially subject to measureable impacts related to development of the project.

Five good quality stage-discharge calibration measurements have been successfully recorded at the H11 monitoring station between June 18, 2011 and September 9, 2011. The measurements were recorded using a current meter at all flows. The H11 rating curve is presented on Figure 3.20. The rating curve is considered to be of moderate quality as a result of the fairly low number yet decent distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve.

The rating curve was applied to the recorded stage record to develop the H11 mean daily streamflow record, which is presented on Figure 3.21. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.10. The streamflow record is of short duration and includes relatively high uncertainty, and therefore the record does not include synthetic data at the start and end of the monitoring period.

- The maximum mean daily discharge was 0.096 m^3/s recorded on June 27, 2011, which equates to a unit runoff of 27 $l/s/km^2$.

The streamflow monitoring program at H11 should be continued, with emphasis on collecting further stage-discharge measurements to better define the rating curve as well as the collection of a longer period of record with a broader range of flows to better characterize the watershed.

3.14 H12 - 3KM LAKE

The H12 hydrology station was established on June 21, 2011 in 3km Lake near the proposed Steensby Port. The station was established to monitor water level fluctuation with the lake, as it is currently proposed as the pre-development and early construction water source for Steensby Port. Discharge measurements were not recorded at the station as the outlet of the lake is too shallow and complex to measure flow. The location of the monitoring site is presented on Figure 1.1. Photos of the monitoring station and surrounding terrain are provided in Appendix A. The water level record for the 2011 monitoring period in 3km Lake is presented in Figure 3.22, along with an estimation of the elevation of the lake outlet invert.

3.15 BR11

The BR11 hydrology station was first installed on June 4, 2008 on a tributary of Angajurjualuk Lake approximately 15 km southeast of the Mary River camp. The station is located near the proposed railway crossing and it is the northernmost gauge on the proposed railway alignment between Mary River and Steensby Inlet. The catchment area above the station is approximately 53 km^2. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.2. Photos of the station and surrounding terrain are provided in Appendix A).

Six good quality stage-discharge calibration measurements were successfully collected at the BR11 monitoring station between June 4, 2008 to September 14, 2008. The measurements were collected using a velocity meter at low flows and rhodamine dye slug injection at high flows. The BR11 rating curve is presented on Figure 3.23. The rating curve is considered to be of moderate quality as a result of the fairly low number, yet decent distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve.

The rating curve was applied to the recorded water level record to develop the BR11 mean daily streamflow record, which is presented on Figure 3.24. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.11. The streamflow record includes synthetic data at the start and end of the monitoring period to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data and extrapolation of the rising or falling hydrograph limbs. Characteristics of the BR11 streamflow record include the following:

- The maximum mean daily discharge was 16.2 m^3/s recorded on June 28, 2008, which equates to a unit runoff of 306 $l/s/km^2$.
- Mean monthly runoff ranged from 84 $l/s/km^2$ in June to 14 $l/s/km^2$ in September.
- Mean annual runoff in 2008 was 18 $l/s/km^2$.

The streamflow monitoring program at BR11 has been discontinued, as it is very unlikely that this watershed will experience measureable Project related impacts to water quantity during the construction, operation and closure of the Mary River project.

3.16 BR25

The BR25 hydrology station was first installed on June 6, 2008 on a tributary of Angajurjualuk Lake approximately 30 km southeast of the Mary River camp. It is installed on the northern portion of a proposed railway alignment between Mary River and Steensby Inlet. The catchment area above the station is approximately 113 km^2. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.2. Photos of the station and surrounding terrain are provided in Appendix A (Photos 50-53).

Ten moderate to good quality stage-discharge calibration measurements have been successfully collected at the BR25 monitoring station between June 6, 2008 and September 11, 2010. The measurements were collected using a current meter at low flows and rhodamine dye at high flows. Eight of the calibration measurements were recorded during 2008, and used to develop the BR25 rating curve presented on Figure 3.25. The rating curve is considered to be of moderate quality as a result of the decent number and distribution of discharge measurements used to define the curve, coupled with the relatively poor agreement between the measured points and the rating curve at higher flows. The two measurements recorded during 2010 were found to disagree with the original rating curve, suggesting that a change had occurred to the channel control at the station during 2009. Unfortunately, these measurements were insufficient to develop a rating curve and as a result, a streamflow record could not be developed for 2010.

The 2008 rating curve was applied to the 2008 recorded stage record to develop the BR25 mean daily streamflow record, which is presented on Figure 3.26. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.12. The streamflow record includes synthetic data at the start and end of the monitoring period to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data and extrapolation of the rising or falling hydrograph limbs. Characteristics of the BR25 streamflow record include the following:

- The maximum mean daily discharge was 16.2 m^3/s recorded on June 28, 2008, which equates to a unit runoff of 274 $l/s/km^2$.
- Mean monthly runoff ranged from 74 $l/s/km^2$ in June to 12 $l/s/km^2$ in September.
- Mean annual runoff in 2008 was 18 $l/s/km^2$.

The streamflow monitoring program at BR25 has been discontinued, as it is very unlikely that this watershed will experience measureable project related impacts to water quantity during the construction, operation and closure of the Mary River Project.

3.17 BR96-2

The BR96-2 hydrology station was first installed on June 7, 2008 on a tributary of Cockburn Lake, approximately 90 km southeast of the Mary River camp. It is installed on the southern portion of a proposed railway alignment between Mary River and Steensby Inlet. The catchment area above the station is approximately 31 km^2. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.3. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Ten good quality stage-discharge measurements have been successfully collected at the BR96-2 monitoring station between June 7, 2008 and September 14, 2008. The measurements were collected using a current meter at low flows and rhodamine dye at high flows. Eight of the calibration measurements were recorded during 2008, and used to develop the BR96-2 rating curve presented on Figure 3.27. The rating curve is considered to be of good quality as a result of the number and distribution of discharge measurements used to define the curve, and the relatively close proximity of the points to the curve. However, there is greater uncertainty at high flows beyond the range of measured discharge used to define the rating curve. The two measurements recorded during 2010 were found to disagree with the original rating curve, suggesting that a change had occurred to the channel control at the station during 2009. Unfortunately, these measurements were insufficient to develop a rating curve and as a result, a streamflow record could not be developed for 2010.

The 2008 rating curve was applied to the 2008 recorded stage record to develop the BR96-2 mean daily streamflow record, which is presented on Figure 3.28. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.13. The streamflow record includes synthetic data at the start and end of the monitoring period to extrapolate between the installation/uninstallation of the station and the start and end of flow in the creek. These data were estimated using regional WSC data and extrapolation of the rising or falling hydrograph limbs. Characteristics of the BR96-2 streamflow record include the following:

- The maximum mean daily discharge was 5.1 m^3/s recorded on June 20, 2008, which equates to a unit runoff of 165 $l/s/km^2$.
- Mean monthly runoff ranged from 50 $l/s/km^2$ in June to 13 $l/s/km^2$ in September.
- Mean annual runoff in 2008 was 12 $l/s/km^2$.

The streamflow monitoring program at BR96-2 has been discontinued, as it is very unlikely that this watershed will experience measureable project related impacts to water quantity during the construction, operation and closure of the Mary River Project.

3.18 BR 137

The BR137 hydrology station was first installed on June 14, 2008 in a lake known as 10km Lake on the Ikpikitturjuaq River, which flows into Steensby Inlet approximately 110 km southeast of the Mary River camp. It is the southernmost monitoring station on a proposed railway alignment between Mary River and Steensby Inlet. The catchment area above the station is approximately 314 km^2 and has extensive lake coverage. The location of the monitoring site is presented on Figure 1.1 while a more detailed presentation of the watershed is presented on Figure 1.3. Photos of the gauge site and surrounding terrain are provided in Appendix A.

Twelve moderate to good quality stage-discharge calibration measurements have been successfully collected at the BR137 monitoring station between June 14, 2008 and September 16, 2011. All of the discharge measurements were recorded using a current meter and application of the velocity-area technique. Discharge measurement at this station is uniquely difficult due to deep flow conditions and very large boulder substrate. The rating curve, presented on Figure 3.29, is considered to be of moderate quality as a result of the decent number and distribution of discharge measurements used to define the curve, coupled with the relatively poor agreement between the measured points and the rating curve.

The rating curve was applied to the recorded stage record to develop the BR137 mean daily streamflow record, which is presented on Figure 3.30. The streamflow record is also summarized as mean monthly, seasonal and annual discharge in Table 3.14. The 2008 and 2010 streamflow record includes synthetic data at the start and end of each year to extrapolate between the installation/uninstallation of the station and the start and end of flow in the river. These data were estimated using regional WSC data or extrapolation of the rising or falling hydrograph limbs. Too much of the freshet was unmonitored to allow for extrapolation to zero flow during June 2011. Characteristics of the BR137 streamflow record include the following:

- The maximum mean daily discharge was 31 m^3/s recorded on June 30, 2010, which equates to a unit runoff of 99 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 1 $l/s/km^2$ during October 2008, to a high of 46 $l/s/km^2$ during July 2010.
- Mean annual runoff ranged from 9 $l/s/km^2$ during 2011 to 11 $l/s/km^2$ in 2010.

It is recommended that the streamflow monitoring program at BR137 be continued in order to gain a greater understanding of baseline streamflow conditions within the watershed, as it is expect that the stream will experience measurable impacts to water quantity during construction and operation of the Mary River project. Furthermore, it is the only monitoring station collecting data near Steensby Port. The collection of discharge measurements to further refine the rating curve should remain a focus of the monitoring program, as should confirmation of the current rating curve and channel stability.

3.19 MARY RIVER AT THE OUTLET OF MARY LAKE (WSC 06SA001)

In August 2006, a streamflow monitoring station was established on the Mary River at the outlet of Mary Lake by WSC at the request of and with funding from BIM. The location of the monitoring station is shown on Figure 1.1, and has an upstream watershed area of 690 km^2. Daily flow data for August 2006 through September 2009 were provided by WSC through their online web portal and are presented on Figure 3.31. Average monthly discharge and unit runoff values are summarized in Table 3.15. Hydrometric data were collected by WSC during 2010 and 2011, however they are currently not of high enough quality to be made publicly available, and therefore it was considered prudent to not include the data in this report. Characteristics of the Mary River streamflow record include the following:

- The maximum mean daily discharge was 109 m^3/s recorded on June 29, 2008, which equates to a unit runoff of 158 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 7 $l/s/km^2$ during September 2007, to a high of 60 $l/s/km^2$ during July 2008.
- Mean annual runoff ranged from 6 $l/s/km^2$ during 2007 to 12 $l/s/km^2$ in 2008.

3.20 RAVN RIVER AT THE OUTLET OF ANGAJURJUALUK LAKE (WSC 06SA002)

In August 2006, a streamflow monitoring station was established on the Ravn River at the outlet of Angajurjualuk Lake by WSC at the request of and with funding from BIM. The location of the monitoring station is shown on Figure 1.1, and has an upstream watershed area of 8220 km^2. Daily flow data for August 2006 through September 2009 were provided by WSC through their online web portal and are presented on Figure 3.32. Average monthly discharge and unit runoff values are summarized in Table 3.16. Hydrometric data were collected by WSC during 2010 and 2011, however they are currently not of high enough quality to be made publicly available, and therefore it was considered prudent to not include the data in this report. Characteristics of the Ravn River streamflow record include the following:

- The maximum mean daily discharge was 848 m^3/s recorded on July 1, 2008, which equates to a unit runoff of 103 l/s/km^2.
- Mean monthly runoff ranged from a low of 2 l/s/km^2 during October 2007, to a high of 61 l/s/km^2 during July 2008.
- Mean annual runoff ranged from 7 l/s/km^2 during 2007 to 12 l/s/km^2 in 2008.

3.21 ROWLEY RIVER ABOVE SEPARATION LAKE (WSC 06SB002)

In August 2006, a streamflow monitoring station was established on the Rowley River at the outlet of Seperation Lake by WSC at the request of and with funding from BIM. The location of the monitoring station is shown on Figure 1.1, and has an upstream watershed area of 3500 km^2. Daily flow data for August 2006 through September 2009 were provided by WSC through their online web portal and are presented on Figure 3.33. Average monthly discharge and unit runoff values are summarized in Table 3.17. Hydrometric data were collected by WSC during 2010 and 2011, however they are currently not of high enough quality to be made publicly available, and therefore it was considered prudent to not include the data in this report. Characteristics of the Rowley River streamflow record include the following:

- The maximum mean daily discharge was 626 m^3/s recorded on July 1, 2008, which equates to a unit runoff of 179 l/s/km^2.
- Mean monthly runoff ranged from a low of 1 l/s/km^2 during October, to a high of 62 l/s/km^2 during July 2009.
- Mean annual runoff ranged from 7 l/s/km^2 during 2007 to 11 l/s/km^2 in 2008.

3.22 ISORTOQ RIVER AT THE OUTLET OF ISORTOQ LAKE (WSC 06SB001)

In August 2006, a streamflow monitoring station was established on the Isortoq River at the outlet of Isortoq Lake by WSC at the request of and with funding from BIM. The location of the monitoring station is shown on Figure 1.1, and has an upstream watershed area of 7170 km^2, which includes a portion of the Barnes Ice Cap. Daily flow data for August 2006 through September 2009 were provided by WSC through their online web portal and are presented on Figure 3.34. Average monthly discharge and unit runoff values are summarized in Table 3.18. Hydrometric data were collected by WSC during 2010 and 2011, however they are currently not of high enough quality to be made publicly available, and therefore it was considered prudent to not include the data in this report. Characteristics of the Isortoq River streamflow record include the following:

- The maximum mean daily discharge was 1510 m^3/s recorded on June 28, 2008, which equates to a unit runoff of 211 $l/s/km^2$.
- Mean monthly runoff ranged from a low of 1 $l/s/km^2$ during October, to a high of 102 $l/s/km^2$ during July 2008.
- Mean annual runoff ranged from 15 $l/s/km^2$ during 2007 to 19 $l/s/km^2$ in 2008.

SECTION 4.0 - REGIONAL HYDROLOGIC ANALYSIS

The regional hydrologic assessment described in the Rev 0 version of this report has been updated with streamflow data collected in 2010 and 2011. The previous analysis assumed that the mean discharge recorded during the 2007-2008 monitoring period provided a reasonable estimation of long-term discharge, based upon a review of regional WSC streamflow data, which was used to determine the likely mean annual unit runoff in the Mary River region. Similarly, the current analysis uses the four complete years of measured data (2007-2008 and 2010-2011) as a reasonable estimate of long-term discharge; however the updated analysis provides improved rational to justify this assumption.

Four years of hydrometric data are now available for many of the stations within the Project area; however regional long-term hydrometeorological data that the Project data can be correlated to in order to develop synthetic long-term flow series and associated long-term runoff statistics are still not available. Therefore, efforts were made to determine if the Project data could provide estimates of long-term mean annual runoff on their own. The methodology that was applied was to review long-term streamflow records collected in Nunavut by WSC and assess how the mean discharge in consecutive four-year periods compared to their respective long-term means. The data used in the analysis were collected on the Sylvia Grinnell River (WSC 10UH001), Apex River (WSC 10UH002), Freshwater River (WSC 10TF001) and Brown River (WSC 06OA006). These stations were selected based on their record length and relatively similar watershed and hydrologic characteristics to the Project stations. The percent difference between each four year period and the long-term mean for each station was calculated, and then all of the percent difference values were fit to a normal distribution. The result of the analysis is that 90% of the four year means were within approximately +/- 10% of the long-term mean. In other words, we can be 90% confident that, regionally, the mean of four consecutive years of streamflow data will be within approximately +/- 10% of the long-term mean. Because the analysis was conducted using data collected on regionally similar hydrologic systems, the results were considered applicable to the Project data. Therefore, the mean discharge measured at stations with four years of data was considered representative of the long-term mean discharge. For stations with only three years of data, a fourth year of data was synthesized through correlation with a similar Project station with four years of data, as discussed in Section 3. Using this methodology, long-term mean annual discharge values were generated for seven locations as presented in Table 4.1. Mean annual unit runoff in the project area ranged from a low of 7.5 l/s/km^2 at H1 to a high of 11.5 l/s/km^2 at H3, with a mean of 9.5 l/s/km^2. It was also considered reasonable to assume that the mean monthly discharge distribution measured at stations H1-H7 is comparable to the long-term mean monthly distribution. Long-term discharge estimates were not estimated for stations with two or less complete years of data, as it would typically require developing at least two years of synthetic data at the sites, which would represent at least half of the complete years at the station and increase the uncertainty in the analysis. However, if estimation of long-term runoff is required at a station not presented in Table 4.1, it is recommended that the shorter record be correlated with one or more of the stations in Table 4.1 to derive the estimate.

SECTION 5.0 - PEAK FLOW ESTIMATES

For the purpose of designing river and creek crossings and other mine infrastructure, it was necessary to develop a design flow model. The hydrologic data currently being collected in the Project area are of a short period of record and are not generally appropriate for this application. Rather, long-term historical peak flow and extreme rainfall data collected by Environment Canada were used. These data were combined with an understanding of the hydrologic characteristics of the area to develop a series of peak flow scaling equations. Each equation corresponds to a different return period (flood severity) and requires an input of drainage area to generate a design flow estimate. The equations for return periods of 2 years, 5 years, 10 years, 25 years, 100 years and 200 years are presented, as follows:

$$\mathbf{Q_{2} = 1.1 \times A^{0.79}}$$

$$\mathbf{Q_{5} = 1.7 \times A^{0.77}}$$

$$\mathbf{Q_{10} = 2.0 \times A^{0.76}}$$

$$\mathbf{Q_{25} = 2.6 \times A^{0.75}}$$

$$\mathbf{Q_{100} = 3.5 \times A^{0.73}}$$

$$\mathbf{Q_{200} = 3.9 \times A^{0.73}}$$

Where, Q = peak instantaneous flow in m^3/s
A = drainage area in km^2

These equations were developed according to a regional scaling model using linear moment (L-moment) statistics computed from the historical peak daily flow records for five WSC stations, which are summarized in Table 2.1. Given the regional data available, the model was considered appropriate for catchments ranging in size from 0.5 km^2 to 1000 km^2. A complete discussion of the methodology, assumptions and statistics used to develop the return period discharge equations above is provided in KPL (2006) and attached in Appendix B.

To assess the validity of the results of this peak flow analysis the equations above were applied to the Project hydrology stations. These results are presented in Table 5.1, while Figure 5.1 shows a comparison of the maximum recorded instantaneous flow at each project station and the estimated return period peak flows. All stations were plotted, even those with catchment areas greater than 1000 km^2. The maximum recorded instantaneous peak flow at most stations lie near the predicted 2-year return period flow and less than the 5-year return period flow. Given the period of record at the stations, this result suggests the peak flow model produces reasonable, if not slightly conservative, results. Four low outliers are the H1, H9, BR96-2 and BR137 stations; however they are also hydrologically different to the stations used to produce the peak flow models as they include moderate to considerable proportions of lake area within their watersheds. There are also two high outliers, which for the Isortoq River is likely a result of unique watershed characteristics, as it includes 950 km^2 of the Barnes Ice Cap, while for BR25 it is likely a result of large uncertainty in the upper end and extrapolation of the rating curve.

Given the paucity of regional data available for peak flow prediction, there is undoubtedly a significant level of uncertainty associated with such predictions. However, given the measured results, it is believed that the peak flow model is appropriate. As highlighted by data from H1, H9, BR137 and the Isortoq River, site specific conditions must also be considered when applying the model. Appropriate conservatism should be incorporated into estimates derived from these equations.

SECTION 6.0 - WET AND DRY RETURN PERIOD ANALYSIS

Mean monthly discharges for 10-year wet and dry year return periods were estimated for sites for which long-term mean discharge values were developed (H1-H7). These values illustrate the range of mean monthly discharge likely to occur at each site, and are commonly used in different aspects of the mine design and impact assessment. The analysis made use of the long-term mean annual discharges (MAD) calculated in Section 4 and presented in Table 4.1, and regional 10-yr wet and dry return period mean monthly discharge values. Flow values with a 10-year return period were calculated for regional stations using Palisade Decision Tools @RISK statistical software on the Sylvia Grinnell River and Apex River, as well as the Qinguq River (WSC 06MA002). The stations were selected based upon the similarity of their mean monthly runoff values with those measured at the Project stations. The Qinguq River station was included in this analysis as neither the Sylvia Grinnell nor Apex rivers provided a very good match with site data during low flows in August and September. Ratios were developed between the mean monthly discharge and return period discharge for each station. The most conservative monthly ratio was then applied to the mean monthly discharge at the project stations to derive 10-year wet and dry mean monthly discharge values, as presented in Table 6.1. The results were then compared to the minimum and maximum mean monthly discharge measured at each Project station, and were found to agree with the measured data.

SECTION 7.0 - GROUNDWATER HYDROLOGY

The Mary River Project is located in a zone of continuous permafrost. The active layer in the Project area ranges from approximately 1 m to 2 m in depth, but may be greater in areas where there is loose, sandy soil at the edges of lakes or rivers.

The depth of permafrost in the region is in the order of a half kilometre, based on ground temperature measurements at the former Nanisivik Mine located 270 km northwest of Mary River, where permafrost has been measured at depths greater than 430 m (Gartner Lee, 2003). Boreholes located 450 km west and 450 km south of Pond Inlet indicate permafrost thicknesses of 500 m and 400 m, respectively (Geological Survey of Canada, 2006). A deep thermistor (approx. 400 m) installed near Mary River's No. 1 Deposit during 2007, indicates that the permafrost depth may approach 700 m below the deposit.

Based on this information, it can be assumed that groundwater infiltration and storage is minimal, which is reflected in the observed rapid runoff response of streams to rainfall events. Further, small diurnal fluctuations in the flow patterns are evident in the late July and August base flows, and these may be due to melting of the active permafrost layer as temperatures vary.

SECTION 8.0 - CLIMATE CHANGE

According to the Intergovernmental Panel on Climate Change (IPCC) mission statement, they have been "assess(ing) on a comprehensive, objective, open and transparent basis, the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation" (IPCC, 2004). A significant part of their work has been summarizing the numerous modelling efforts that attempt to predict future climate change under different scenarios. The scenario most often used as a baseline for modelling current and future climate change is the A1B scenario, which represents a future with "Balanced" progress across all resources and technologies from energy supply to end use (Morita *et al*., 1998)", in regards to efforts to minimize climate change and reduce greenhouse gas emissions. It is a 'middle-of-the-road' scenario, neither predicting extreme nor minor climate changes, and is used frequently by the IPCC to estimate mean effects of climate change for different areas. For the Arctic, and the Mary River Mine Site in particular, the ensemble mean of 21 different climate models for the A1B scenario predicts significant increases in both temperature and precipitation by 2080-2099 compared to 1980-1999 mean values, as presented on Figure 8.1 and Figure 8.2. Mean annual temperature is predicted by all 21 models to increase by approximately 4 - 7 ^{o}C by the end of the 21st century in the region of the Mary River Mine Site., with mean December, January and February (DJF) temperatures rising by over 7 ^{o}C and mean June, July and August (JJA) temperatures increasing by approximately 2.5 ^{o}C. An increase in mean annual precipitation was also predicted for northern Baffin Island by 2080-2099, the average of which predicts an increase of 15%-30% over 1980-1999 levels. The mean DJF precipitation is expected to increase approximately 30%, while the mean JJA precipitation is expected to increase by 10%-15%.

The effects of the predicted increases in temperature and precipitation on the hydrology of streams in the Mary River Project area are not easy to determine. For instance, increases in precipitation may not necessarily lead to increases in runoff as they may be offset by higher evaporation rates driven by warmer temperatures. Along similar lines, a shorter winter season resulting from warmer temperatures may not lead to smaller spring freshet flows because higher winter precipitation may be enough to offset the shorter snow-accumulation period. The IPCC predicts that streamflow throughout the Arctic will increase by at least 20% by 2090-2099 over 1980-1999 levels. This is based upon 12 models using the A1B scenario, however they warn that the map in Figure 8.3 is for large scale use only, and should not be applied to more local scales. Also, annual precipitation within the Project area is quite low, so a large percentage increase in precipitation may not result in a large absolute increase in precipitation.

Data collected at the Hall Beach climate station, one of the longest running, most complete regionally representative Environment Canada climate stations in the vicinity of Mary River, lends support to some of the IPCC predictions. As presented on Figure 8.4, the annual average temperature has been rising at a mean rate of 0.4 ^{o}C per decade (statistically significant at the 0.01 significance level) for the last half century. This is similar to the IPCC prediction, as is the increasing summer (JJA) temperature which has been rising at 0.3 ^{o}C per decade (statistically significant at the 0.05 significance level). However the biggest temperature increases have occurred during March through May (MAM) and September through November (SON), with average mean monthly temperature increases of 0.6 and 0.7 ^{o}C per decade respectively (both statistically significant at the 0.01 significance level), whereas the period of

December through February (DJF), predicted by IPCC to record the greatest increase in temperature throughout the next century, did not register a statistically significant trend at any reasonable significance level between 1959 and 2003. The same analysis was conducted using precipitation data, and like winter temperature most trends were not statistically significant at any reasonable level, however a strong increasing trend was identified during the SON period of 2.5 mm/decade, significant at the 0.05 level, as shown on Figure 8.5.

A memo by Rowan Williams Davies and Irwin Inc. (RWDI), which outlines the effects of climate change at the Project site, agrees with the IPCC findings above. They also predict that climate change should alter the shape of the annual hydrograph, as increases in temperature result in an earlier freshet, less precipitation falling as snow which in turn would result in a smaller freshet, and increased intensity of storm events resulting in larger peak runoffs. Other effects of climate change in the Arctic include shrinking glacial and sea-ice cover, changes in permafrost, especially the active layer, and biotic impacts.

Despite the difficulty in predicting what effects climate change will have on the various natural processes operating at the Mary River Mine Site, the current climate models indicate that temperature, precipitation and runoff will increase throughout the rest of the century. However, due to the interdependent nature of the physical processes operating at the Mine Site, it is extremely difficult to predict what net effects such potential changes will have. It is recommended that these predicted changes be considered, and appropriate conservatism be incorporated into hydrologic decisions.

SECTION 9.0 - CONCLUSIONS AND RECOMMENDATIONS

This report presented a summary of the hydrologic data collected at 18 streamflow monitoring stations and two water level monitoring stations for baseline hydrometric studies for Baffinland Iron Mine Corporation's Mary River Project. These data, in addition to regional data, provide the basis for hydrologic analysis for engineering design and environmental assessment of the project. The key findings presented in this report are based on one to four-and-a-half years of data collected between July 2006 and September 2011 and long-term regional datasets.

The key findings within this report pertain to four main hydrometric parameters: hydrograph shape, runoff, variations within both the hydrograph and runoff, and long-term estimates. The characteristics of hydrographs in the vicinity of Mary River are as follows:

- Streamflow typically commences in early to mid-June as temperatures climb above 0 ^{o}C, and ends in late September to late October, depending upon watershed characteristics.
- The annual hydrograph is dominated by a nival freshet which occurs between late June and the end of July, followed by a period of low baseflows driven by permafrost melt and shallow subsurface flow and punctuated by precipitation events through July to early September.
- Precipitation runoff events are usually quite large and flows increase rapidly as interception, infiltration, and evapotranspiration are minimal due to shallow permafrost, cool temperatures and lack of vegetative cover.
- Runoff from higher elevation areas tends to be greater than from lower elevation areas due to orographic enhancement of precipitation.

Similar to hydrograph shape, streamflow values were first estimated from regional analyses and then reassessed using onsite measurements. Initial estimates suggested that mean annual unit runoff (MAUR) in the vicinity of Mary River should be slightly less than 10 l/s/km^2. They also suggested that mean annual peak daily unit runoff values likely range from less than 100 l/s/km^2 for watersheds with significant lake volumes, to over 400 l/s/km^2 for smaller watersheds without lakes. The actual measured results generally validate these estimates and are as follows:

- Watersheds H1-H7 operated by KPL had an average MAUR of 9.5 l/s/km^2 for the years of 2007-2008 and 2010-2011. The lowest measured annual mean unit runoff was recorded at H9 in 2007 at 3 l/s/km^2. The highest annual mean unit runoff was 19 l/s/km^2 recorded in 2008 within the Isortoq River watershed, which contains significant glacial cover. The highest mean annual unit runoff measured in a non-glaciated catchment was 18 l/s/km^2 in the BR11 watershed during 2008.
- The annual maximum peak daily unit runoff varied greatly among the sites, and resulted from snowmelt events, precipitation events, as well as combinations of both. The lowest peak daily unit runoff for watershed with at least one complete year of data was 99 l/s/km^2 within the extensively lake covered BR137 catchment during 2008. The highest annual peak daily unit runoff was recorded in during a July 2006 rain event in the H4 watershed, which registered a unit runoff of 446 l/s/km^2.

As noted above, significant variation was recorded within both the annual hydrograph shape and the volume and intensity of unit runoff. Numerous factors can be attributed to this variation, but the primary factors are listed below:

- The proportion of lakes within a watershed has a significant effect on both the hydrograph shape and unit runoff. Because the lakes are still free of ice and contain attenuated runoff when precipitation begins to fall as snow and permafrost melt ends, rivers fed by lakes freeze up approximately a month later than systems that do not include lakes. Furthermore, lakes attenuate rapid runoff events as well as diurnal fluctuations in runoff, resulting in much lower intensity and longer lasting storm event runoff peaks and an overall smoother hydrograph. Lakes also allow larger volumes of water to evaporate than does the surrounding land, therefore lowering the mean annual unit runoff in catchments with large lake components.
- In smaller watersheds, windblown snow deposition may act to increase and/or decrease the mean annual unit runoff depending on whether a net gain or net loss of snow is occurring within the watershed.

Finally, long-term mean discharge values were developed for seven hydrologic stations, as was a methodology for estimating peak return period discharge. Results are summarized as follows:
- The long-term mean annual unit runoff values ranged from 7.5 l/s/km^2 at H1 to 11.5 l/s/km^2 at H3. The average mean annual unit runoff for all stations was 9.5 l/s/km^2.
- The 10-year mean monthly wet and dry return period discharge ranged between 14% and 229% of mean monthly discharge.
- 200-yr return period peak instantaneous discharge estimates range from a low of 340 l/s/km^2 in the largest monitored watershed (Ravn River) to almost 2500 l/s/km2 in the smallest monitored watershed (H5).

Climate change was also discussed within this report as it pertains to the Mary River Mine Site. It was concluded that temperature and precipitation are expected to increase in the future, but the exact impact on streamflow is difficult to predict. A conservative approach should be applied to hydrologic estimates to account for potential changes in annual, seasonal and extreme flow events due to climate change.

It is recommended that the streamflow monitoring program be continued at the following stations:
- H1
- H4
- H5
- H6
- H7
- H11
- BR137
- Mary River

Continued data collection will allow a greater understanding of baseline streamflow conditions within the Project Area, and provide impact monitoring as it is expect that these streams will experience measurable impacts to water quantity during construction and operation of the Mary River Project. However, the collection of discharge measurements to further refine the rating curves is no longer considered a priority, rather discharge measurements should continue to be collected periodically to confirm rating curve and channel stability.

SECTION 10.0 - REFERENCES

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SECTION 11.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

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TABLE 1.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

SUMMARY OF HYDROLOGY MONITORING STATION CHARACTERISTICS AND LOCATION

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Stations	Station Type	Period of Record	Drainage Area (km^2)	Coordinates (UTM)		
				Zone	Easting	Northing
H01	Streamflow	2006-2008, 2011	250	17W	532831	7946247
H02	Streamflow	2006-2008, 2010	210	17W	555712	7915514
H03	Streamflow	2006-2008, 2010	30.5	17W	557485	7919401
H04	Streamflow	2006-2008, 2010	8.3	17W	557639	7915579
H05	Streamflow	2006-2008, 2010-2011	5.3	17W	558906	7915079
H06	Streamflow	2006-2008, 2010-2011	240	17W	563922	7912984
H07	Streamflow	2006-2008, 2011	14.7	17W	564451	7913194
H08	Streamflow	2006-2008	208	17W	568732	7912881
H09	Streamflow	2006-2008	158	17W	576011	7847687
H10	Water Level	2008	8.2	17W	560905	7911838
H11	Streamflow	2011	3.6	17W	560503	7913545
H12	Water Level	2011	-	17W	597867	7800065
BR11	Streamflow	2008	53	17W	573122	7904914
BR25	Streamflow	2008	113	17W	585420	7900082
BR96-2	Streamflow	2008	31	17W	609300	7839474
BR137	Streamflow	2008,2010-2011	314	17W	598663	7807981
Isortoq River	Streamflow	2006-2009	7170	18W	432810	7780920
Mary River	Streamflow	2006-2009	690	17W	556360	7903750
Ravn River	Streamflow	2006-2009	8220	17W	558020	7894160
Rowley River	Streamflow	2006-2009	3500	18W	411230	7818830

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[Watershed Characteristics Table.xls]Table 1.1

NOTES:

1. STATIONS H1 THROUGH BR137 ARE OPERATED BY KNIGHT PIESOLD LTD. (KPL).
2. THE ISORTOQ, MARY, RAVN AND ROWLEY RIVER STATIONS ARE OPERATED BY WATER SURVEY OF CANADA (WSC).

1	22DEC'11	ISSUED WITH REPORT NB102-181/30-7	KT	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

REGIONAL STREAMFLOW MONITORING STATIONS

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Section Name	ID	Period of Record	# of Years with a Complete Summer Record	Latitude	Longitude	Catchment Area (km2)	Mean Annual Discharge (m3/s)	Average Annual Unit Runoff (l/s/km2)	Average Unit Runoff (June - September) (l/s/km2)	Distance from Mary River (km2)
Apex River at Apex	10UH002	1973 - 2007	7	63^{O}44'03"	68^{O}27'15"	58.5	0.534	10.1	28.55	965
Allen River near mouth	10VC001	1970 - 1984	4	74^{O}50'48"	95^{O}03'31"	448	2.46	5.5	15.69	635
Mecham River near Resolute	10UJ001	1971 - 1979	3	74^{O}41'24"	94^{O}47'10"	86.8	0.63	7.3	17.17	620
Marcil Creek near Arctic Bay	10VC002	1978 - 1983	3	72^{O}59'37"	84^{O}59'16"	139	0.55	4.0	11.73	265
Sylvia Grinell River Near Iqaluit	10UB001	1971 - 2007	15	63^{O}45'59"	68^{O}34'50"	2980	29.81	10.6	31.45	960

M:\1\02\00181\11\A\Data\Hydrology\Hydrology analysis\Regional Analysis\[Table 2.1.xls]Table 2.1

NOTE:

1. SEE FIGURE 2.1 FOR STATION LOCATIONS.

0	22DEC'11	ISSUED WITH REPORT NB102-181/13-7	JM	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H1 - NORTHERN ACCESS ROUTE
STREAMFLOW RECORD SUMMARY

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YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	15.8	5.5	4.3	-	-
2007	3.9	6.9	3.8	1.1	3.9	1.3
2008	11.1	10.3	7.4	2.8	7.9	2.6
2010	12.7	9.5	3.4	3.1	7.1	2.4
2011	8.4	3.1	1.2	0.5	3.3	1.1

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	63	22	17	-	-
2007	16	28	15	4	16	5
2008	44	41	30	11	32	11
2010	51	38	14	12	29	10
2011	33	12	5	2	13	4

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NOTES:

1. DRAINAGE AREA OF H1 IS 250 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
4. NO STREAMFLOW WAS MEASURED IN 2010. DATA ARE ESTIMATED FROM CORRELATION WITH H5.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H2 - TOM RIVER
STREAMFLOW RECORD SUMMARY

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YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	19.4	5.3	3.4	-	-
2007	4.4	7.7	4.0	1.0	4.3	1.4
2008	12.1	12.2	6.7	2.5	8.4	2.8
2010	8.3	14.3	2.3	2.6	6.9	2.3
2011	11.1	3.0	1.3	0.4	4.0	1.3

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	92	25	16	-	-
2007	21	37	19	5	20	7
2008	58	58	32	12	40	13
2010	40	68	11	12	33	11
2011	53	14	6	2	19	6

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NOTES:

1. DRAINAGE AREA OF H2 IS 210 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.

1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.3

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H3 - TOM RIVER TRIBUTARY
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:29:43

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	4.43	0.83	0.55	-	-
2007	0.82	1.47	0.47	0.10	0.72	0.24
2008	2.17	2.20	1.05	0.48	1.47	0.49
2010	1.37	2.81	0.35	0.46	1.25	0.42
2011	2.24	0.53	0.16	0.04	0.74	0.25

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	145	27	18	-	-
2007	27	48	15	3	23	8
2008	71	72	34	16	48	16
2010	45	92	12	15	41	14
2011	73	17	5	1	24	8

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H3.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H1 IS 30.5 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.
5. NO STREAMFLOW DATA WERE RECORDED IN 2011. DATA WERE ESTIMATED FROM CORRELATION WITH H6.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.4

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H4 - CAMP LAKE TRIBUTARY 2
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:16:43

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	0.84	0.29	0.16	-	-
2007	0.11	0.21	0.13	0.04	0.12	0.04
2008	0.72	0.38	0.25	0.09	0.36	0.12
2010	0.70	0.35	0.11	0.11	0.32	0.11
2011	0.29	0.07	0.03	0.01	0.10	0.03

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	101	35	19	-	-
2007	13	25	16	4	15	5
2008	86	46	30	10	43	14
2010	84	43	14	13	38	13
2011	35	8	4	1	12	4

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H4.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H47 IS 8.3 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.
5. NO STREAMFLOW DATA WERE MEASURED IN 2010. DATA WERE ESTIMATED FROM CORRELATION WITH H5.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.5

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H5 - NORTH OF CAMP
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:17:53

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	0.41	0.15	0.09	-	-
2007	0.10	0.10	0.10	0.03	0.08	0.03
2008	0.33	0.22	0.22	0.07	0.21	0.07
2010	0.38	0.19	0.08	0.08	0.18	0.06
2011	0.17	0.05	0.02	0.01	0.06	0.02

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	77	29	18	-	-
2007	19	19	18	5	15	5
2008	62	42	42	13	40	13
2010	72	36	15	15	34	12
2011	32	10	5	1	12	4

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H5.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H5 IS 5.3 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.6

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H6 - MARY RIVER CANYON
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:18:37

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	25.2	9.2	6.1	-	-
2007	5.3	12.2	5.7	1.8	6.3	2.1
2008	14.8	17.0	8.2	3.8	10.9	3.7
2010	9.3	18.8	3.7	3.5	8.8	3.0
2011	14.7	5.3	2.3	1.0	5.8	1.9

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	105	38	26	-	-
2007	22	51	24	7	26	9
2008	62	71	34	16	46	15
2010	39	78	15	15	37	12
2011	61	22	10	4	24	8

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H6.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H6 IS 240 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.7

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H7 - MARY RIVER TRIBUTARY
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:19:05

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	1.73	0.37	0.22	-	-
2007	0.35	0.63	0.24	0.06	0.32	0.11
2008	0.92	0.92	0.27	0.14	0.56	0.19
2010	0.62	1.19	0.10	0.14	0.51	0.17
2011	0.94	0.22	0.08	0.03	0.32	0.10

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	118	25	15	-	-
2007	24	43	17	4	22	7
2008	62	62	19	9	38	13
2010	42	81	7	10	35	12
2011	64	15	5	2	21	7

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H7.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H1 IS 14.7 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.
5. NO DATA WERE MEASURED IN 2010 OR JUNE 2011. DATA WERE ESTIMATED FROM CORRELATION WITH H6.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.8

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H8 - UPPER MARY RIVER
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:19:44

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	18.1	4.2	2.7	-	-
2007	4.2	9.5	3.8	0.7	4.6	1.5
2008	11.9	12.6	5.0	2.0	7.9	2.6

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	87	20	13	-	-
2007	20	46	18	3	22	7
2008	57	60	24	9	38	13

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H8.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H8 IS 208 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. THE FLOWS PRESENTED ABOVE ASSUME THAT ON AVERAGE, MEASUREABLE FLOW BEGINS JUNE 1 AND ENDS SEPT 30.
4. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
5. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.9

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H9 - SOUTHERN ACCESS ROUTE
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:20:47

YEAR	Mean Monthly Measured Discharge (m^3/s)					Mean Discharge (June - Sept)	MAD
	June	July	August	September	October	(m^3/s)	(m^3/s)
2006		3.9	1.7	2.1	0.1	-	-
2007	1.9	2.5	1.0	0.8	0.1	1.5	0.5
2008	4.3	2.3	4.6	1.8	0.2	3.3	1.1

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)					Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	October	($L/s/km^2$)	($L/s/km^2$)
2006	-	24	11	13	1	-	-
2007	12	16	6	5	1	10	3
2008	27	15	29	11	1	21	7

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H9.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H1 IS 158 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. THE FLOWS PRESENTED ABOVE ASSUME THAT ON AVERAGE, MEASUREABLE FLOW BEGINS JUNE 1 AND ENDS SEPT 30.
4. NO STREAMFLOW WAS MEASURED DURING JUNE 2006, AND THEREFORE ANNUAL VALUES COULD NOT BE CALCULATED.
5. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.

1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.10

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

H11 - TRIBUTARY TO SHEARDOWN LAKE
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 13:39:48

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2011	-	0.019	0.015	-	-	-

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2011	-	5	4	-	-	-

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[H11.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF H11 IS 3.6 km^2.

0	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.11

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

BR11
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:21:38

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2008	4.5	4.4	1.8	0.7	2.8	0.9

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2008	84	83	33	14	54	18

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[BR11.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF BR11 IS 53 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. THE FLOWS PRESENTED ABOVE ASSUME THAT ON AVERAGE, MEASUREABLE FLOW BEGINS JUNE 1 AND ENDS SEPT 30.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.12

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

BR25
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:22:59

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2008	8.4	8.0	3.7	1.3	5.4	1.8

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2008	74	71	33	12	47	16

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[BR25.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF BR25 IS 113 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. THE FLOWS PRESENTED ABOVE ASSUME THAT ON AVERAGE, MEASUREABLE FLOW BEGINS JUNE 1 AND ENDS SEPT 30.
4. WATER WAS OBSERVED IN THE CHANNEL IN MID TO LATE MAY 2008, PRIOR TO THE PRESSURE TRANSDUCER'S INSTALLATION, HOWEVER THROUGH VISUAL OBSERVATIONS AND POINT DISCHARGE MEASUREMENTS THE VOLUME OF FLOW WAS DEEMED NEGLIGIBLE.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.13

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

BR96-2
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:23:30

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2008	1.5	1.1	1.3	0.4	1.1	0.4

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2008	50	34	42	13	35	12

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[BR96-2.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF BR96-2 IS 31 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.
3. THE FLOWS PRESENTED ABOVE ASSUME THAT ON AVERAGE, MEASUREABLE FLOW BEGINS JUNE 1 AND ENDS SEPT 30.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.14

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

BR137
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:24:10

YEAR	Mean Monthly Measured Discharge (m^3/s)					Mean Discharge (June - Sept)	MAD
	June	July	August	September	October	(m^3/s)	(m^3/s)
2008	9.65	10.42	13.91	8.67	0.35	10.66	3.59
2010	9.97	14.38	4.91	3.79	0.77	8.26	2.83
2011	-	9.93	4.44	2.16	0.48	-	-

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)					Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	October	($L/s/km^2$)	($L/s/km^2$)
2008	31	33	44	28	1	34	11
2010	32	46	16	12	2	26	9
2011	-	32	14	7	2	-	-

M:\1\02\00181\30\A\Data\Hydrology\Tables and Figures\[BR137.xlsx]Table 3.2

NOTES:

1. DRAINAGE AREA OF BR137 IS 314 km^2.
2. THE FLOWS PRESENTED ABOVE INCLUDE SYNTHETIC FLOWS FOR THE LOW FLOW PERIODS BETWEEN THE INFERRED ZERO FLOW IN THE CHANNEL AND THE INSTALL AND UNINSTALL OF THE PRESSURE TRANSDUCER.

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.15

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

MARY RIVER (WSC 06SA001)
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 15:24:55

YEAR	Mean Monthly Measured Discharge (m^3/s)				Mean Discharge (June - Sept)	MAD
	June	July	August	September	(m^3/s)	(m^3/s)
2006	-	-	19.3	14.2	-	-
2007	6.4	30.0	11.0	4.7	13.0	4.4
2008	24.5	41.2	22.2	11.7	24.9	8.4
2009	24.3	40.5	20.1	5.6	22.6	7.6

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)				Mean Unit Runoff (June - Sept)	MAUR
	June	July	August	September	($L/s/km^2$)	($L/s/km^2$)
2006	-	-	28	21	-	-
2007	9	44	16	7	19	6
2008	35	60	32	17	36	12
2009	35	59	29	8	33	11

M:\1\02\00181\30\A\Data\Hydrology\[WSC.xlsx]Mary Table

NOTES:

1. DRAINAGE AREA OF THE MARY RIVER WSC STATION IS 690 km^2.
2. DATA PROVIDED BY WATER SURVEY OF CANADA (WSC).

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.16

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

RAVN RIVER (WSC 06SA002)
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:25:55

YEAR	Mean Monthly Measured Discharge (m^3/s)					Mean Discharge (June - October)	MAD
	June	July	August	September	October	(m^3/s)	(m^3/s)
2006	-	-	272	260	47.1	-	-
2007	20.2	369	179	92	13.9	134.9	57.0
2008	164	501	295	148	24.2	226.4	95.1
2009	-	-	306	113	-	-	-

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)					Mean Unit Runoff (June - October)	MAUR
	June	July	August	September	October	($L/s/km^2$)	($L/s/km^2$)
2006	-	-	33	32	6	-	-
2007	2	45	22	11	2	16	7
2008	20	61	36	18	3	28	12
2009	-	-	37	14	-	-	-

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NOTES:

1. DRAINAGE AREA OF 06SA002 IS 8220 km^2.
2. DATA PROVIDED BY WATER SURVEY OF CANADA (WSC).

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.17

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

ROWLEY RIVER (WSC 06SB002)
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:31:33

YEAR	Mean Monthly Measured Discharge (m^3/s)					Mean Discharge (June - October)	MAD
	June	July	August	September	October	(m^3/s)	(m^3/s)
2006	-	-	-	-	4	-	-
2007	3	183	54	27	2	54	23
2008	120	209	100	45	3	96	40
2009	-	215	108	26	-	-	-

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)					Mean Unit Runoff (June - November)	MAUR
	June	July	August	September	October	($L/s/km^2$)	($L/s/km^2$)
2006	-	-	-	-	1	-	-
2007	1	52	15	8	1	15	7
2008	34	60	29	13	1	27	11
2009	-	62	31	7	-	-	-

M:\1\02\00181\30\A\Data\Hydrology\[WSC.xlsx]Rowley Table

NOTES:

1. DRAINAGE AREA OF 06SB002 IS 3500 km^2.
2. DATA PROVIDED BY WATER SURVEY OF CANADA (WSC).

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.18

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

ISORTOQ RIVER (WSC 06SB001)
STREAMFLOW RECORD SUMMARY

Print Dec/23/11 14:25:55

YEAR	Mean Monthly Measured Discharge (m^3/s)					Mean Discharge (June - October)	MAD
	June	July	August	September	October	(m^3/s)	(m^3/s)
2006	-	-	-	-	8	-	-
2007	39	712	466	70	4	258	109
2008	372	729	434	76	4	323	136
2009	186	693	563	64	0	301	127

YEAR	Mean Monthly Measured Unit Runoff ($l/s/km^2$)					Mean Unit Runoff (June - November)	MAUR
	June	July	August	September	October	($L/s/km^2$)	($L/s/km^2$)
2006	-	-	-	-	1	-	-
2007	5	99	65	10	1	36	15
2008	52	102	60	11	1	45	19
2009	26	97	79	9	-	42	18

M:\1\02\00181\30\A\Data\Hydrology\[WSC.xlsx]Isortoq Table

NOTES:

1. DRAINAGE AREA OF 06SB001 IS 7170 km^2.
2. DATA PROVIDED BY WATER SURVEY OF CANADA (WSC).

1	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 4.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

REGIONAL HYDROLOGICAL ANALYSIS
SUMMARY OF SYNTHETIC MEAN ANNUAL DISCHARGE (MAD)

Print Jan/04/12 13:43:10

Station	Drainage Area (km^2)	Mean Monthly Measured Unit Runoff ($l/s/km^2$)												
		January	February	March	April	May	June	July	August	September	October	November	December	Annual
H1	250	0	0	0	0	0	36	30	16	7.5	0.4	0	0	7.5
H2	210	0	0	0	0	0	43	44	17	7.8	0.0	0	0	9.4
H3	30.5	0	0	0	0	0	54	57	17	8.9	0.0	0	0	11.5
H4	8.3	0	0	0	0	0	55	30	16	7.2	0.0	0	0	9.0
H5	5.3	0	0	0	0	0	46	26	20	8.5	0.0	0	0	8.5
H6	240	0	0	0	0	0	46	55	21	11	0.2	0	0	11.1
H7	14.7	0	0	0	0	0	48	50	12	6.3	0.0	0	0	9.7

M:\1\02\00181\30\A\Data\Hydrology\[Mary River Streamflow Records_20111207_KT(DEC22).xlsx]Table 4.1

1	22DEC'11	ISSUED WITH REPORT NB102-181/30-7	TR	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 5.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

ESTIMATED AND MEASURED PEAK FLOW SUMMARY

Print Dec/23/11 14:02:22

Site	Drainage Area (km^2)	Estimated Peak Instantaneous Flows (m^3/s)						Measured Peak Instantaneous Flows (m^3/s)	
		2 Year	5 Year	10 Year	25 Year	100 Year	200 Year	# Years	Flow
BR11	53	25	36	41	51	64	71	1	30
BR25	113	46	65	73	90	110	123	1	92
BR96-2	30.7	16	24	27	34	43	47	1	8.9
BR137	314	103	142	158	194	233	259	2.5	32
H1	250	86	119	133	163	197	220	3.5	42
H2	210	75	104	116	143	173	193	3.5	51
H3	30.5	16	24	27	34	42	47	3.5	14.1
H4	8.3	6	9	10	13	16	18	3.5	5.3
H5	5.3	4	6	7	9	12	13	4.5	3.2
H6	240	84	116	129	159	191	213	4.5	100
H7	14.7	9	13	15	20	25	28	3.5	6.6
H8	208	75	104	116	142	172	192	2.5	62
H9	157	60	83	93	115	140	156	2.5	17.5
Mary River (06SA001)	690	192	261	287	350	413	461	3.5	157
Rowley River (06SB002)	3500	694	911	987	1183	1353	1507	2.5	775
Isortoq River (06SB001)	7170	1223	1582	1703	2026	2283	2544	3	1740
Ravn River (06SA002)	8220	1362	1758	1889	2245	2523	2811	3	964

M:\1\02\00181\30\A\Data\Hydrology\[Peak Flow.xls] Site Summary Table

NOTES:

1. PEAK INSTANTANEOUS FLOW DATA FOR WSC STATIONS IS SCALED FROM PEAK DAILY DATA.
2. DAILY VALUES ARE SCALED USING A RATIO OF I/D = 2.8 x $A^{-0.10}$ WHERE "I/D" IS THE RATIO OF INSTANTANEOUS TO DAILY PEAK FLOWS AND "A" IS THE DRAINAGE AREA IN KM^2.

0	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	JM	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 6.1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

WET AND DRY MONTHLY FLOWS

Print Dec/23/11 14:06:14

Station	Return Period	Discharge (m3/s)				
		June	July	August	September	October
H1	10 yr Dry	2.51	2.82	0.97	0.26	
	Minimum Measured	3.93	3.11	1.25	0.53	
	Mean Measured	9.01	7.45	3.97	1.88	
	Maximum Measured	12.66	10.31	7.44	3.07	
	10 yr Wet	15.50	13.52	8.48	4.32	
H2	10 yr Dry	2.51	3.53	0.87	0.23	
	Minimum Measured	4.42	2.99	1.34	0.39	
	Mean Measured	8.99	9.32	3.57	1.64	
	Maximum Measured	12.09	14.34	6.66	2.62	
	10 yr Wet	15.46	16.92	7.63	3.77	
H3	10 yr Dry	0.46	0.66	0.12	0.04	
	Minimum Measured	0.82	0.53	0.16	0.04	
	Mean Measured	1.65	1.75	0.51	0.27	
	Maximum Measured	2.24	2.81	1.05	0.48	
	10 yr Wet	2.84	3.18	1.08	0.62	
H4	10 yr Dry	0.13	0.10	0.03	0.01	
	Minimum Measured	0.11	0.07	0.03	0.01	
	Mean Measured	0.45	0.25	0.13	0.06	
	Maximum Measured	0.72	0.38	0.25	0.11	
	10 yr Wet	0.78	0.46	0.28	0.14	
H5	10 yr Dry	0.07	0.05	0.03	0.01	
	Minimum Measured	0.10	0.05	0.02	0.01	
	Mean Measured	0.25	0.14	0.11	0.04	
	Maximum Measured	0.38	0.22	0.22	0.08	
	10 yr Wet	0.42	0.25	0.23	0.10	
H6	10 yr Dry	3.08	5.04	2.04	0.94	
	Minimum Measured	5.34	5.29	2.32	1.02	
	Mean Measured	11.04	13.30	4.98	2.53	
	Maximum Measured	14.80	18.76	8.21	3.79	
	10 yr Wet	18.99	24.14	8.21	4.12	
H7	10 yr Dry	0.20	0.28	0.04	0.01	
	Minimum Measured	0.35	0.22	0.08	0.03	
	Mean Measured	0.71	0.74	0.17	0.09	
	Maximum Measured	0.94	1.19	0.27	0.14	
	10 yr Wet	1.21	1.34	0.37	0.21	
H8	10 yr Dry	2.44	3.78	0.69	0.16	
	Minimum Measured	4.19	3.20	0.73	0.10	
	Mean Measured	8.74	9.98	2.81	1.11	
	Maximum Measured	11.86	14.63	5.02	1.95	
	10 yr Wet	15.05	18.12	6.01	2.54	
H11	10 yr Dry	0.04	0.03	0.02	0.00	
	Mean	0.14	0.08	0.06	0.03	
	10 yr Wet	0.24	0.14	0.13	0.06	
BR137	10 yr Dry	2.05	4.55	3.91	2.73	0.02
	Mean	7.33	9.26	7.03	4.65	0.42
	10 yr Wet	12.61	15.53	10.15	6.86	1.04

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	23DEC'11	ISSUED WITH REPORT NB102-181/30-7	CBN	KT	JGC

LEGEND:

- WATER SURVEY OF CANADA STATION
- STREAM FLOW GAUGING STATION
- RIVER/STREAM/DRAINAGE
- MILNE INLET TOTE ROAD
- PROPOSED RAIL ALIGNMENT
- CATCHMENT BOUNDARY
- WATER
- RAVN RIVER CATCHMENT
- GLACIER

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. GLACIER COVERAGE IS TAKEN FROM NTS 1:50,000 SCALE AND IS ONLY SHOWN WITHIN CATCHMENT BOUNDARIES.
3. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
4. PROPOSED RAIL ALIGNMENT PROVIDED BY CANARAIL CONSULTANTS INC. IN OCTOBER 2010.
5. WSC STATIONS PROVIDED BY ENVIRONMENT CANADA.

SCALE 10 5 0 10 20 30 40 50 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAMFLOW GAUGING STATION MARY RIVER PROJECT SITE AND SURROUNDING AREA

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/30	7

FIGURE 1.1 REV 1

1	22DEC'11	ISSUED WITH REPORT	TJP	ASM	TJP	JGC
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

SAVED: I:\102\00181\30\A\GIS\Figs\B115_r1.mxd; Jan 05, 2012 7:49 AM; amoore

LEGEND:

- STREAMFLOW GAUGING STATION
- RIVER/STREAM/DRAINAGE
- PROPOSED RAIL ALIGNMENT
- OCEAN / LAKE
- WATERSHED BOUNDARY

NOTES:

1. BASE MAP DEM CREATED FROM 1:50,000 SCALE DATA: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES, (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. GLACIER COVERAGE IS TAKEN FROM NTS 1:50,000 SCALE AND IS ONLY SHOWN WITHIN CATCHMENT BOUNDARIES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	22DEC'11	ISSUED WITH REPORT	TJP	ASM	TJP	JGC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAMFLOW GAUGING STATION
WATERSHED BOUNDARIES
MINE SITE AREA

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/30	7

FIGURE 1.2 REV 1

SAVED: I:\102\00181\30\A\GIS\Figs\B117_r1.mxd; Jan 03, 2012 1:15 PM; amoore

LEGEND:

- STREAMFLOW GAUGING STATION
- RIVER/STREAM/DRAINAGE
- PROPOSED RAIL ALIGNMENT
- OCEAN / LAKE
- WATERSHED BOUNDARY

NOTES:

1. BASE MAP DEM CREATED FROM 1:50,000 SCALE DATA: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES, (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. GLACIER COVERAGE IS TAKEN FROM NTS 1:50,000 SCALE AND IS ONLY SHOWN WITHIN CATCHMENT BOUNDARIES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	22DEC'11	ISSUED WITH REPORT	TJP	ASM	TJP	JGC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

STREAMFLOW GAUGING STATION WATERSHED BOUNDARIES STEENSBY INLET CATCHMENT

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P/A NO.	REF NO.
NB102-181/30	7

FIGURE 1.3 REV 1

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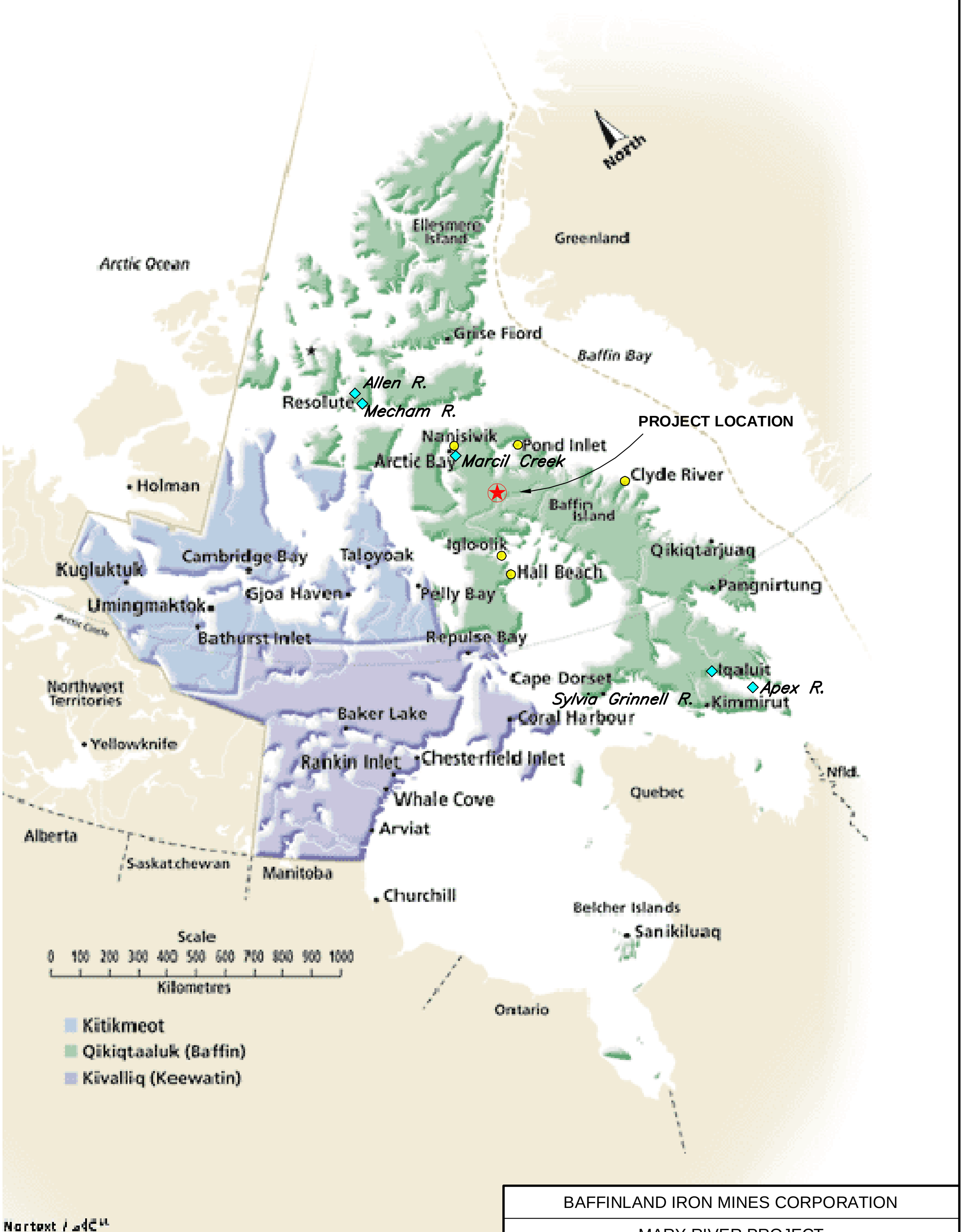

LEGEND:

- REGIONAL CLIMATE STATION
- STREAMFLOW MONITORING STATION

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	22DEC'11	ISSUED WITH REPORT	TJP	NWL	TJP	JGC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

REGIONAL CLIMATE AND STREAMFLOW MONITORING STATIONS

Knight Piésold CONSULTING

P/A NO. NB102-181/30

REF NO. 7

FIGURE 2.1

REV 1

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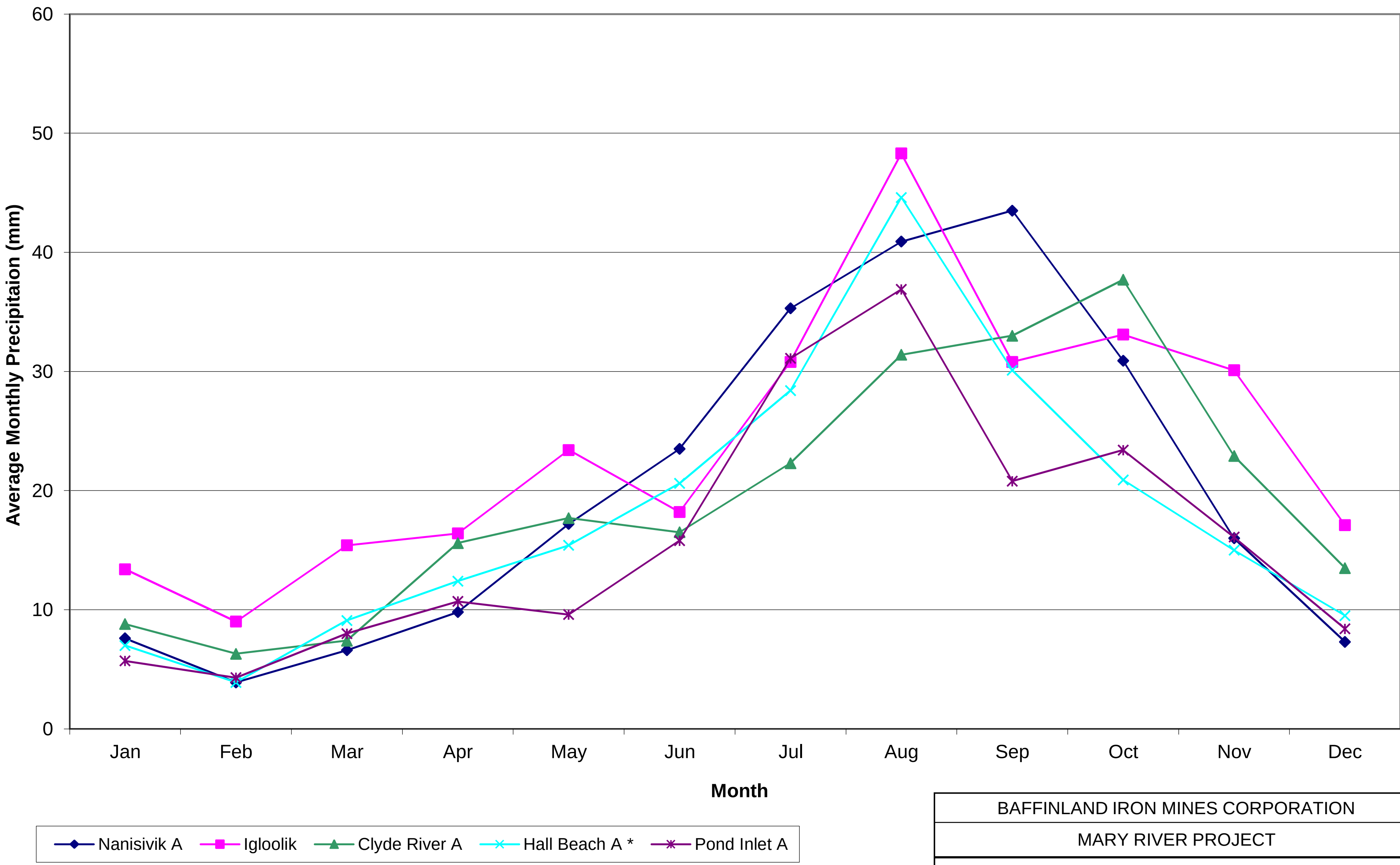

NOTE:
1. PRECIPITATION INCLUDES SNOW AND RAINFALL.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

REGIONAL CLIMATE STATIONS
AVERAGE MONTHLY PRECIPITATION
CLIMATE NORMALS 1971 - 2000

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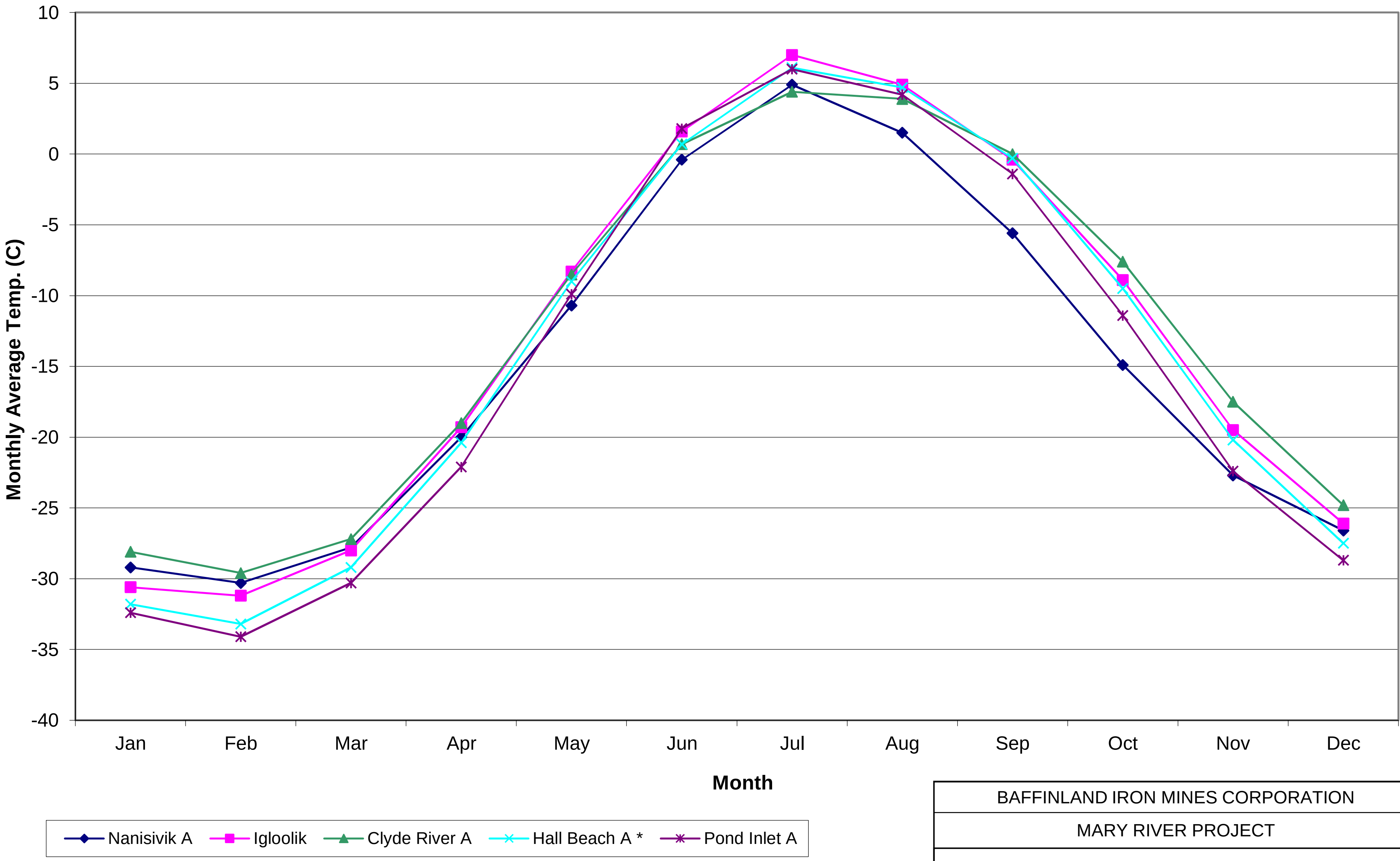
PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 2.2 REV. 0

0	05JAN'08	ISSUED WITH REPORT	JM	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

REGIONAL CLIMATE STATIONS
AVERAGE MONTHLY TEMPERATURE
CLIMATE NORMALS 1971 - 2000

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CONSULTING

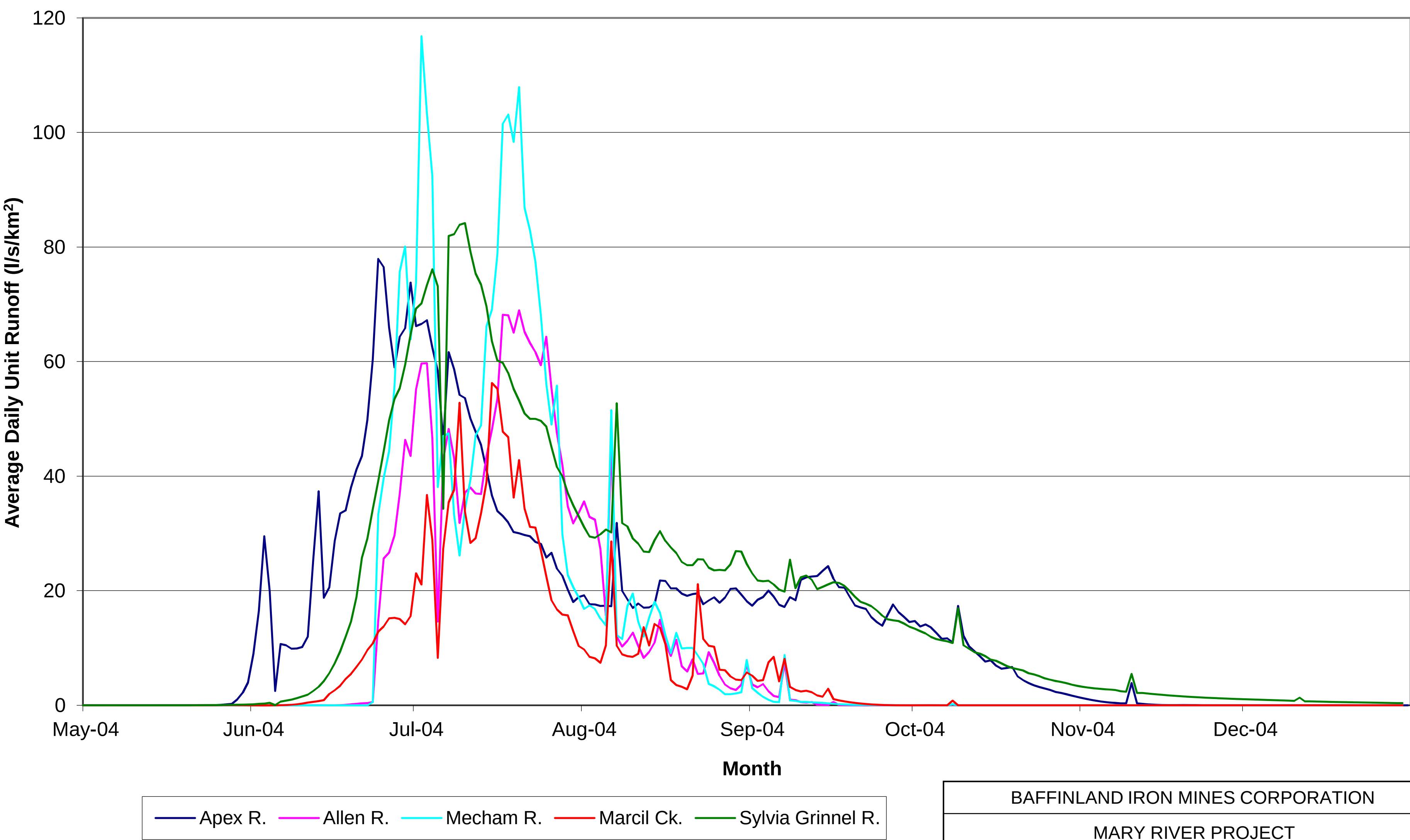
PROJECT / ASSIGNMENT NO. NB102-00181/30

REF NO. 7

FIGURE 2.3

REV. 0

0	05JAN'08	ISSUED WITH REPORT	JM	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NOTES:
1. DRAINAGE AREA IS UNAVAILABLE FOR THE SOPER RIVER (10UJ001) WSC GAUGE.
2. DAILY UNIT RUNOFF AVERAGES INCLUDE DATA FROM 1970 TO 2007.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

REGIONAL STREAMFLOW STATIONS
LONG-TERM AVERAGE DAILY UNIT RUNOFF

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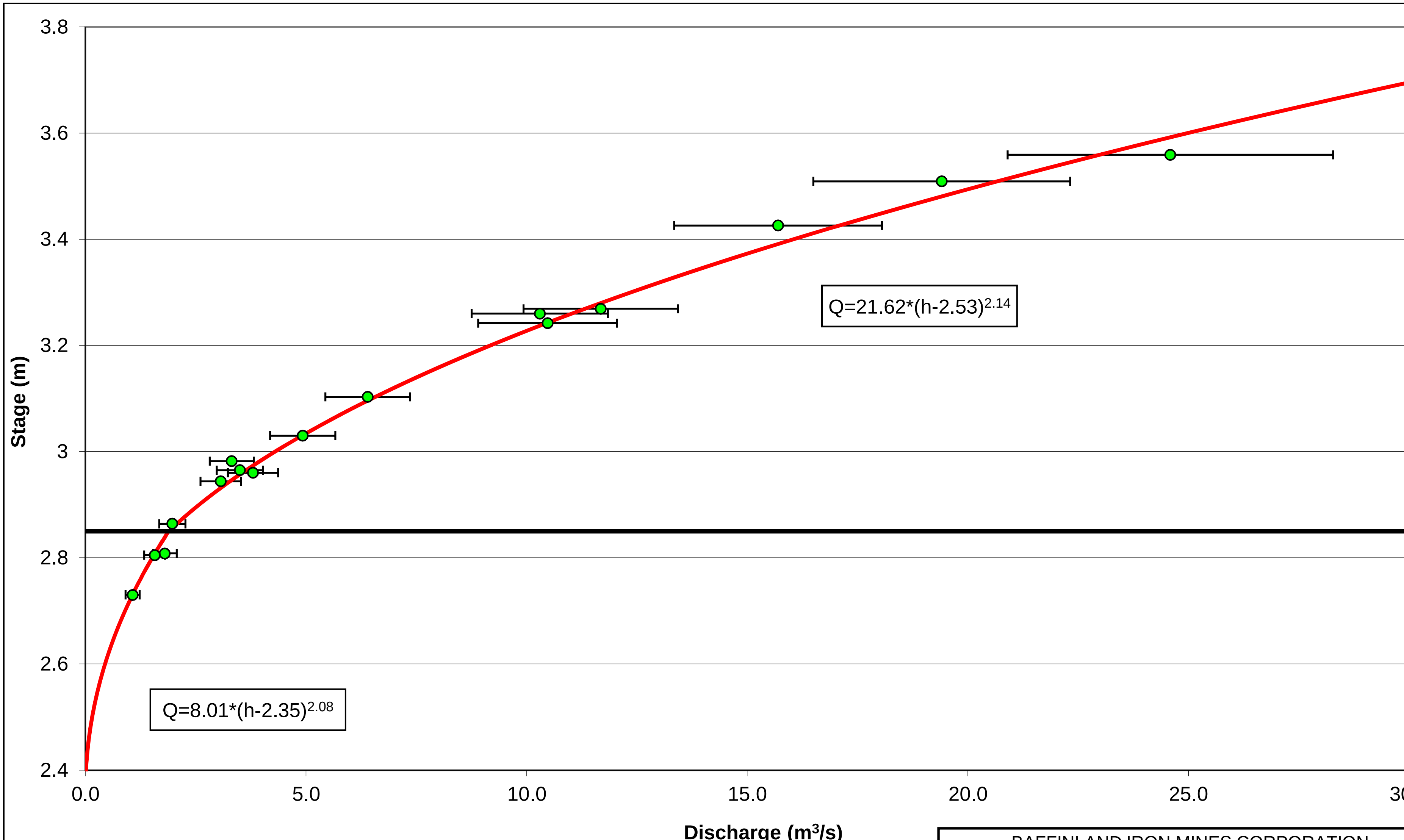
PROJECT / ASSIGNMENT NO.	REF NO.
NB102-00181/30	7

FIGURE 2.4	REV. 0

0	05JAN'08	ISSUED WITH REPORT	JM	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H1 - NORTHERN ACCESS ROUTE
RATING CURVE

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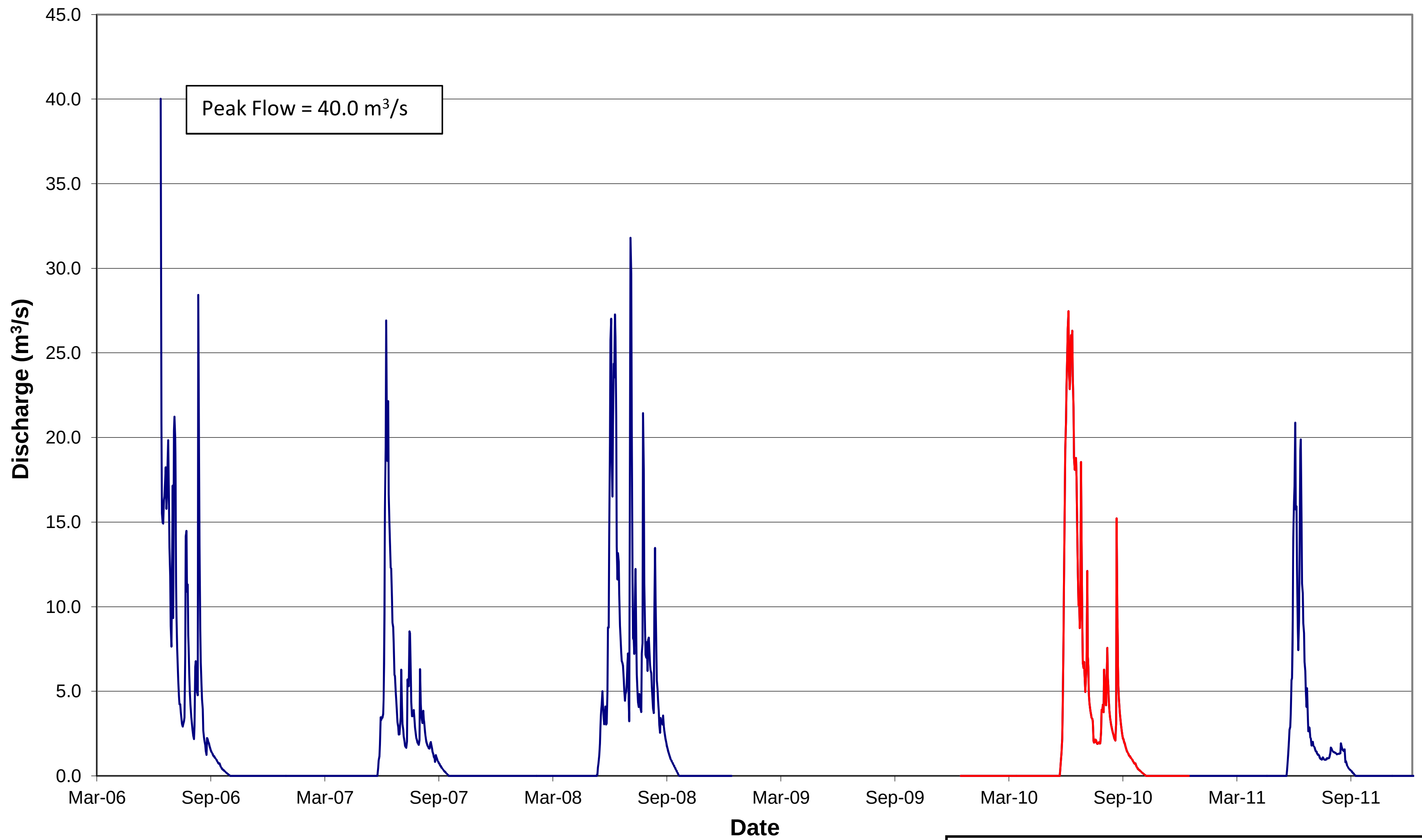
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.1

REV. 1



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H1 - NORTHERN ACCESS ROUTE
MEASURED STREAMFLOW HYDROGRAPH

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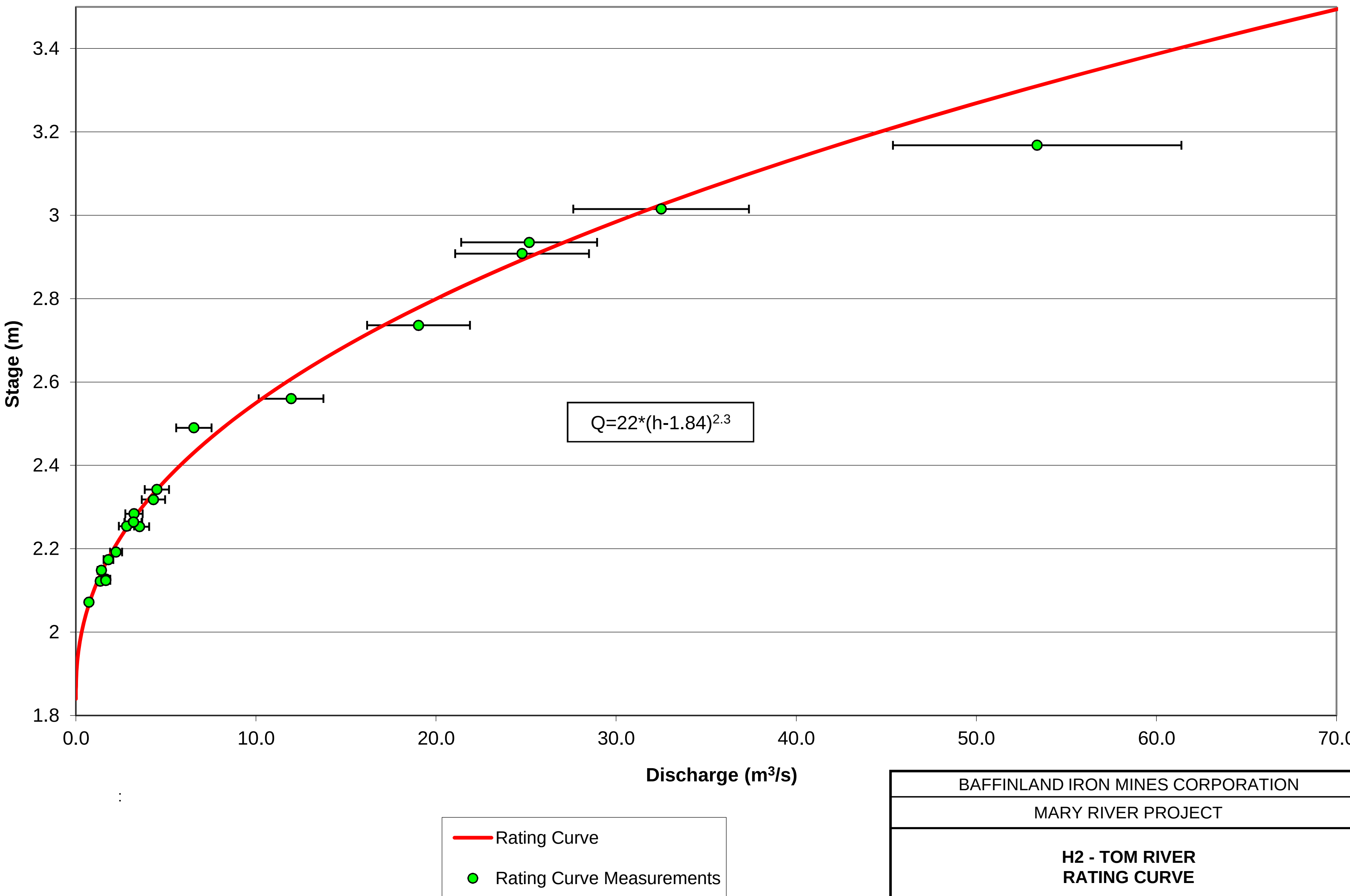
PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 3.2 REV. 1

1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H2 - TOM RIVER
RATING CURVE

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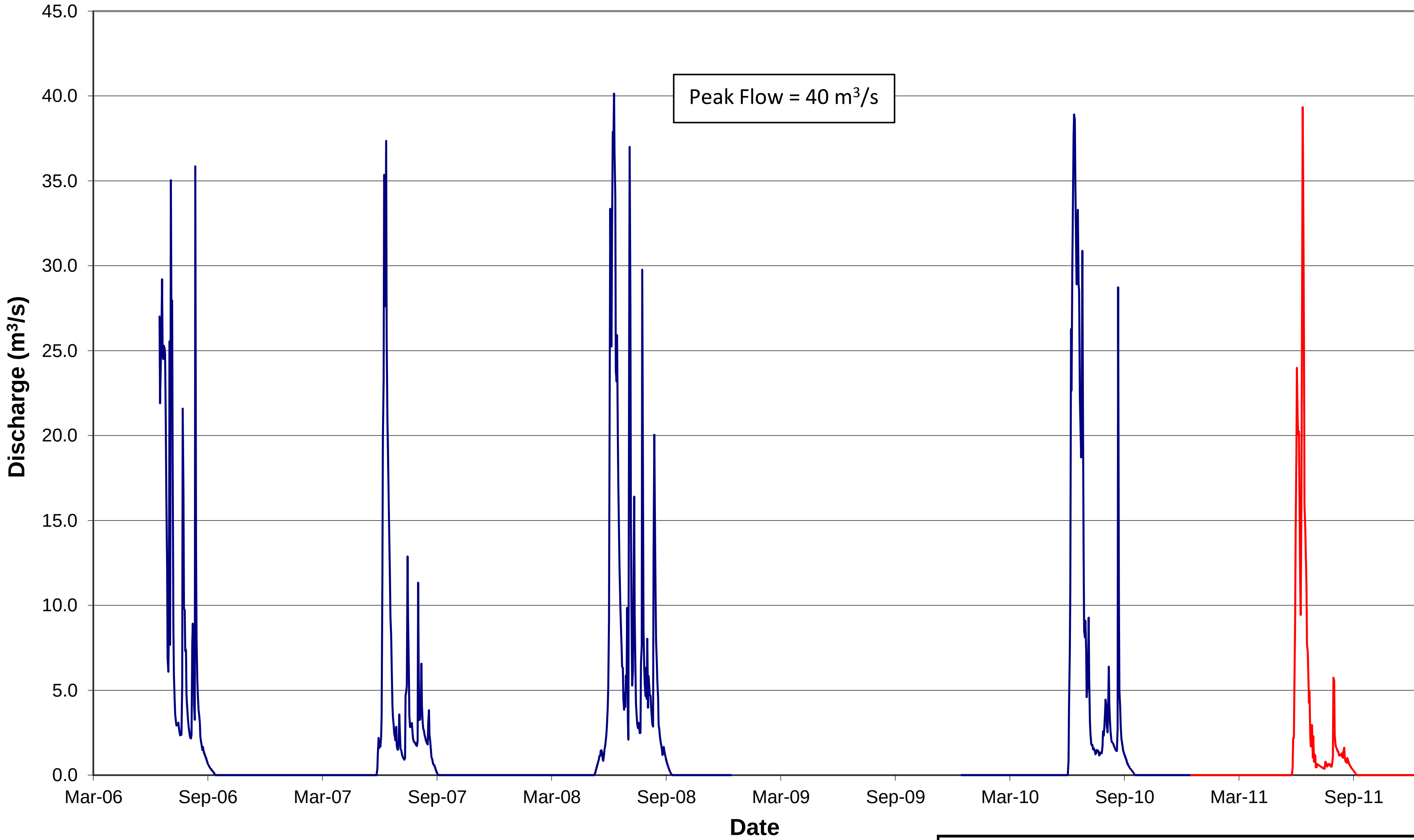
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.3

REV. 1

1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H2 - TOM RIVER
MEASURED STREAMFLOW HYDROGRAPH

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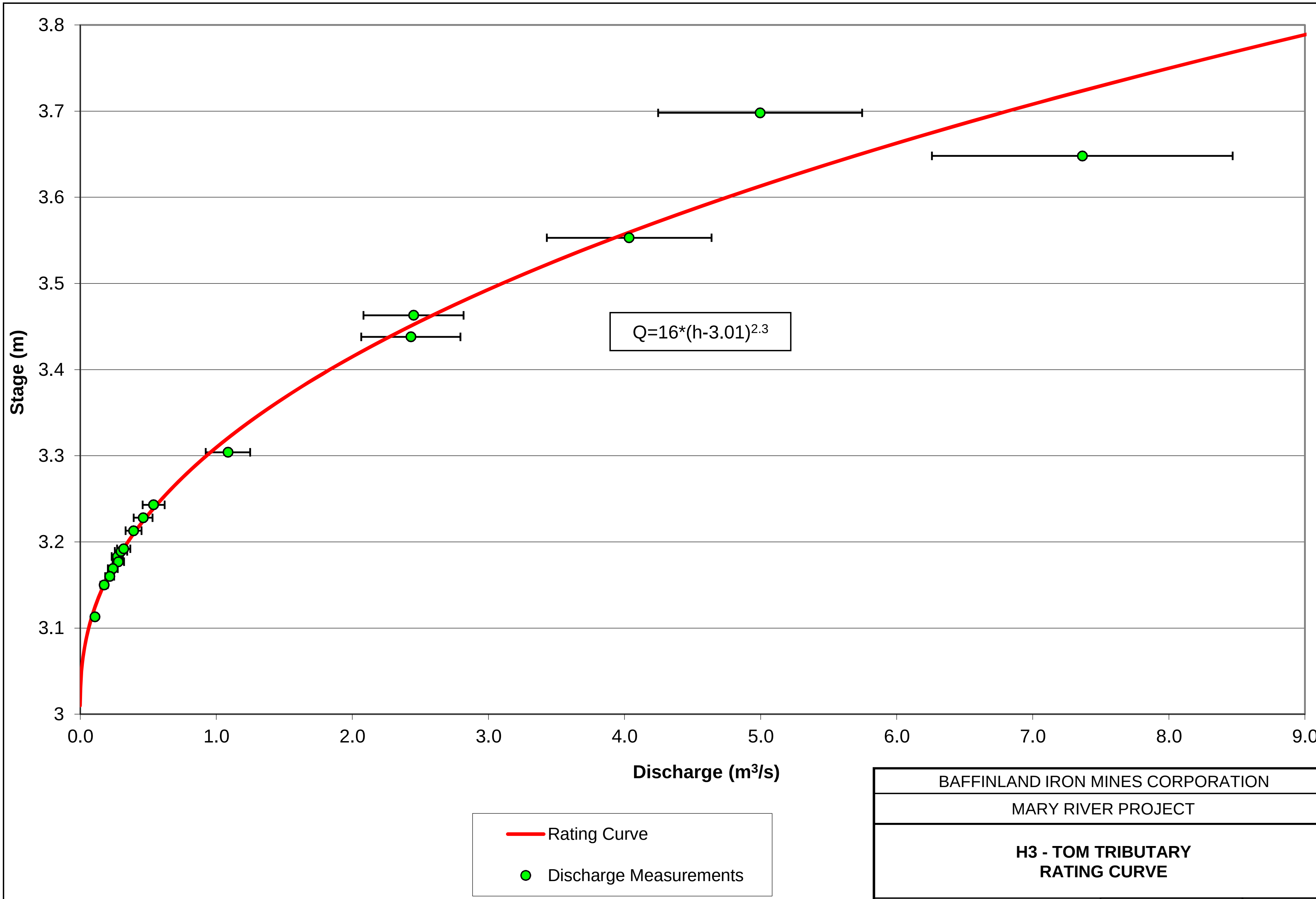
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.4

REV. 1



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H3 - TOM TRIBUTARY
RATING CURVE

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PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 3.5 REV. 1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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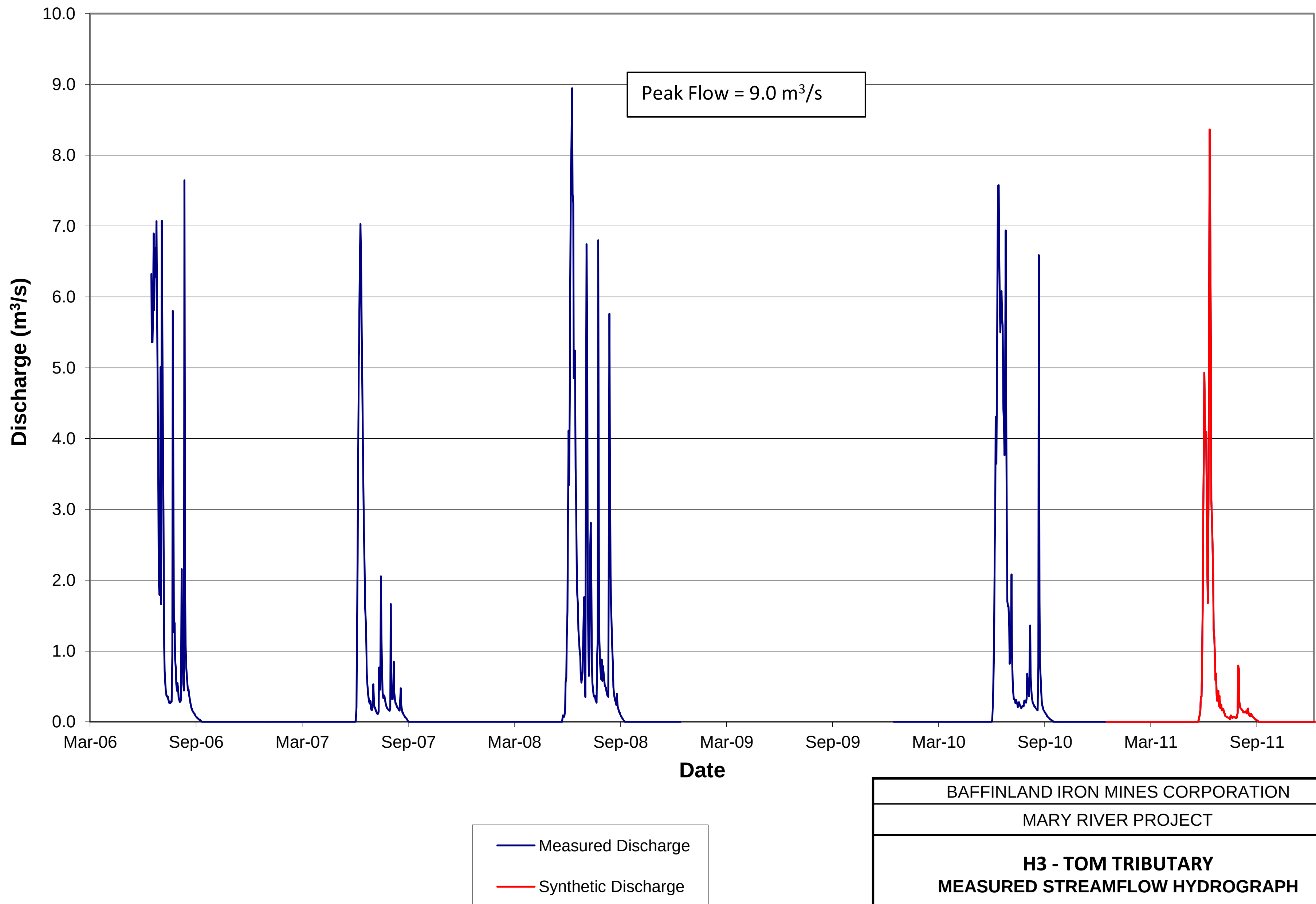

1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H3 - TOM TRIBUTARY
MEASURED STREAMFLOW HYDROGRAPH

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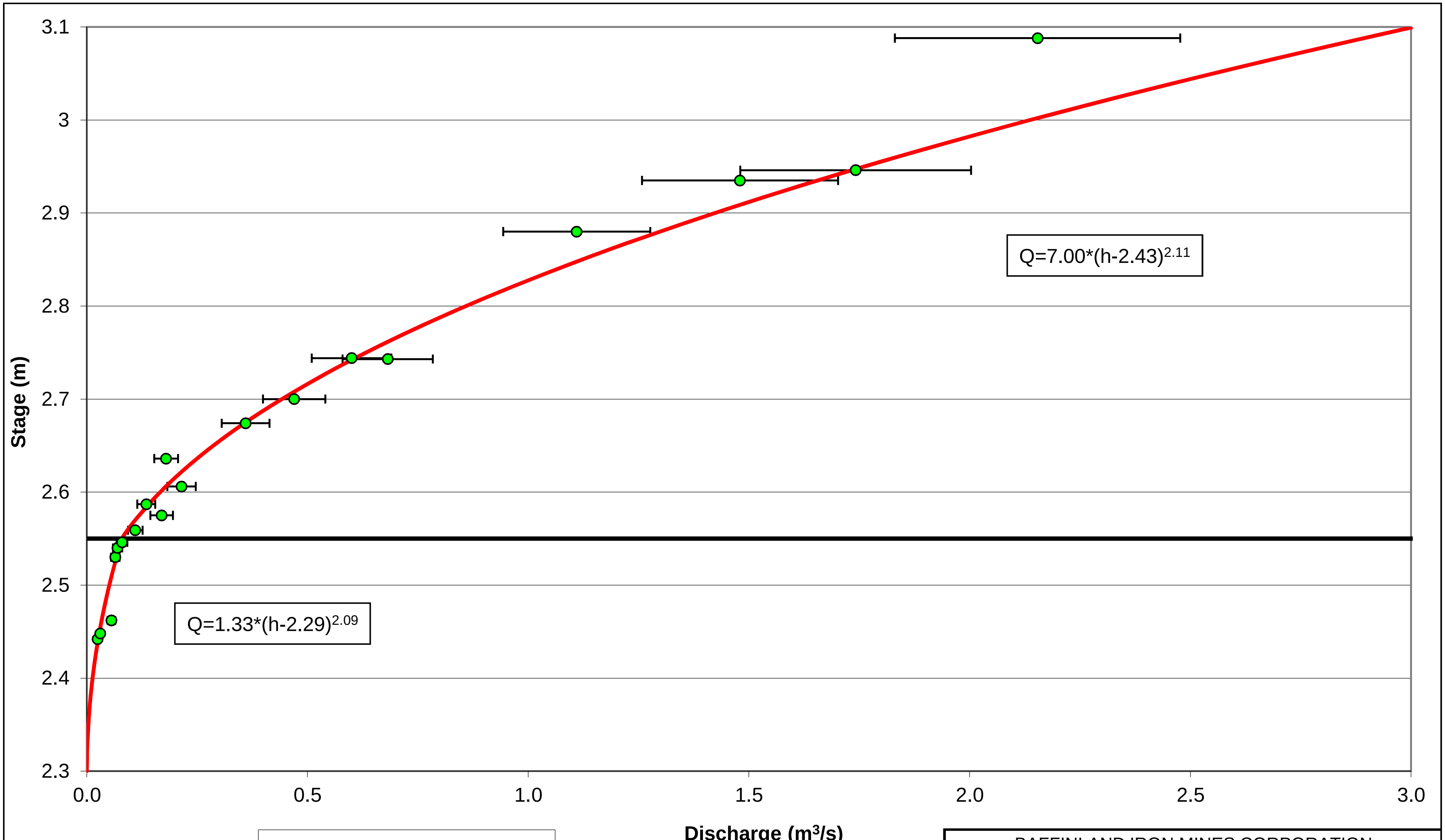
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.6

REV. 1



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H4 - CAMP LAKE TRIBUTARY 2
RATING CURVE

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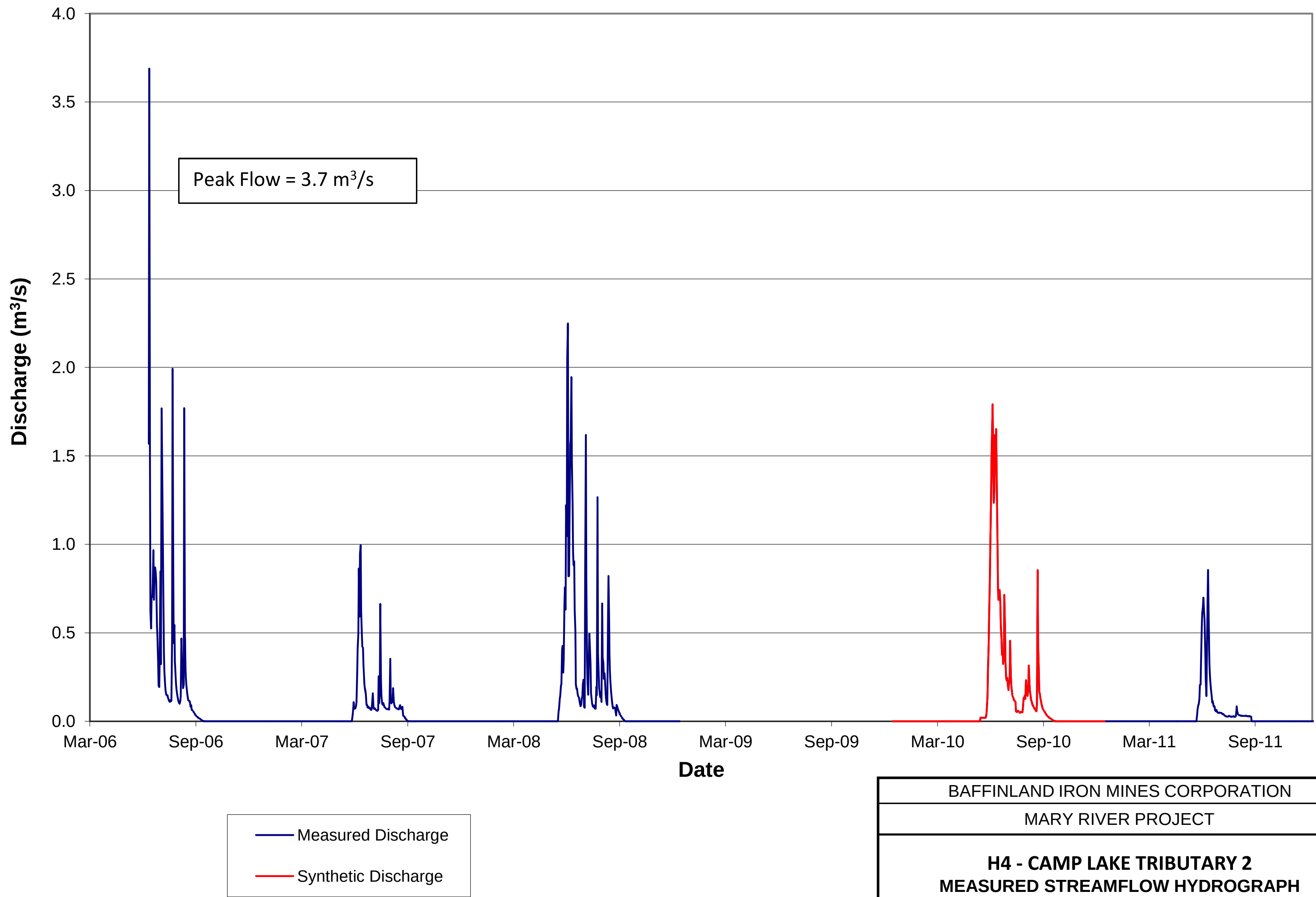
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.7

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H4 - CAMP LAKE TRIBUTARY 2
MEASURED STREAMFLOW HYDROGRAPH

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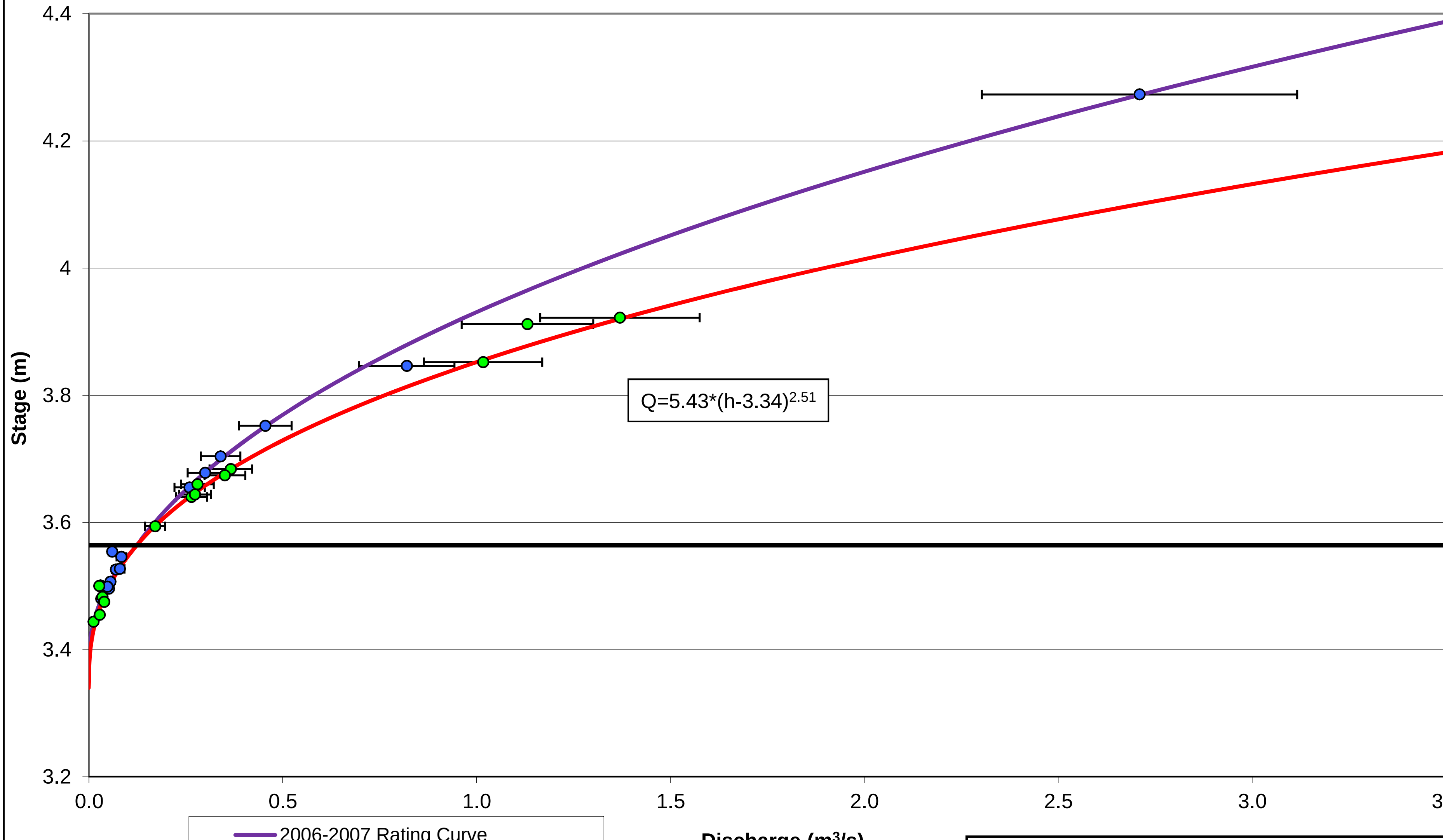
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.8

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H5 - NORTH OF CAMP
RATING CURVE

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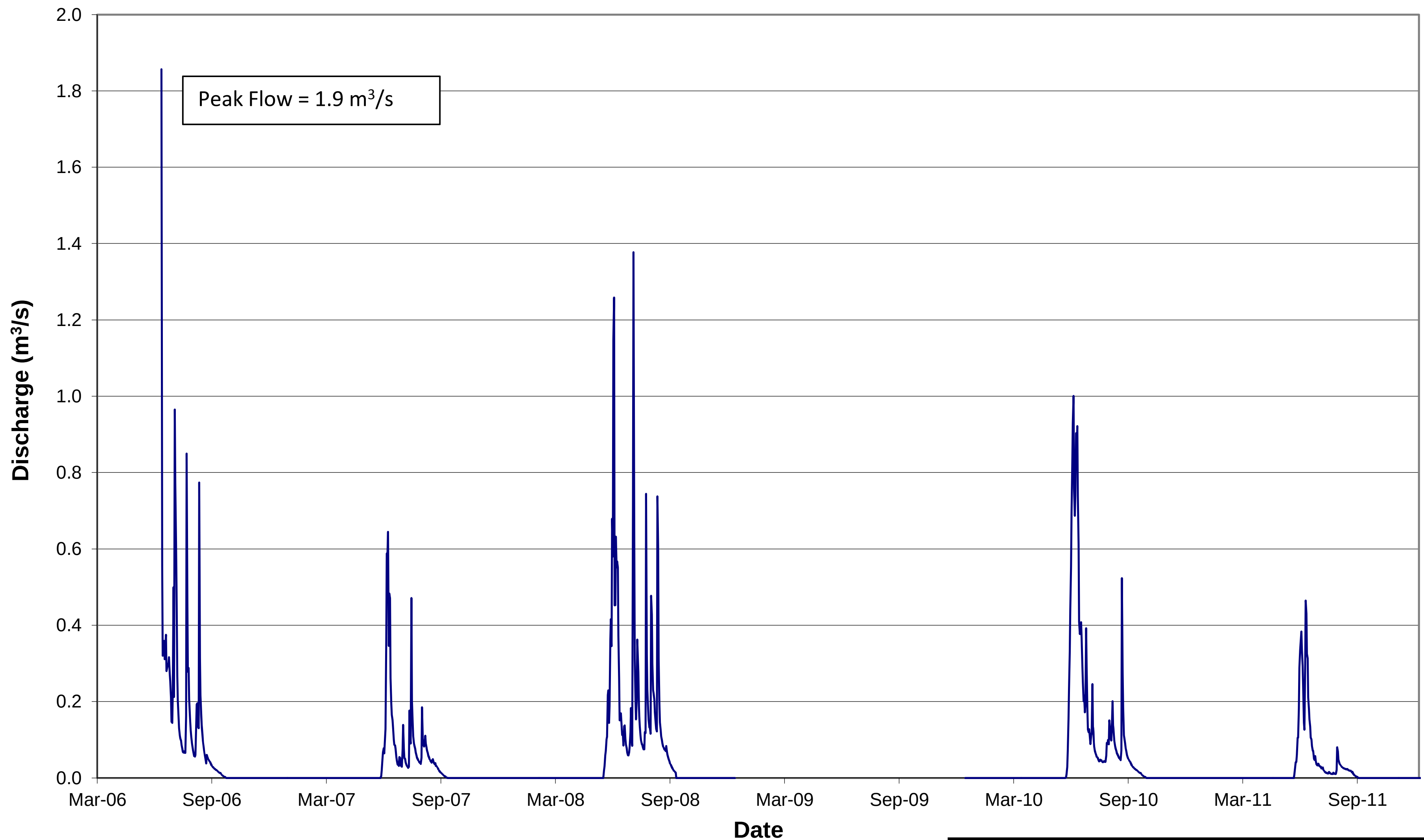
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.9

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H5 - NORTH OF CAMP
MEASURED STREAMFLOW HYDROGRAPH

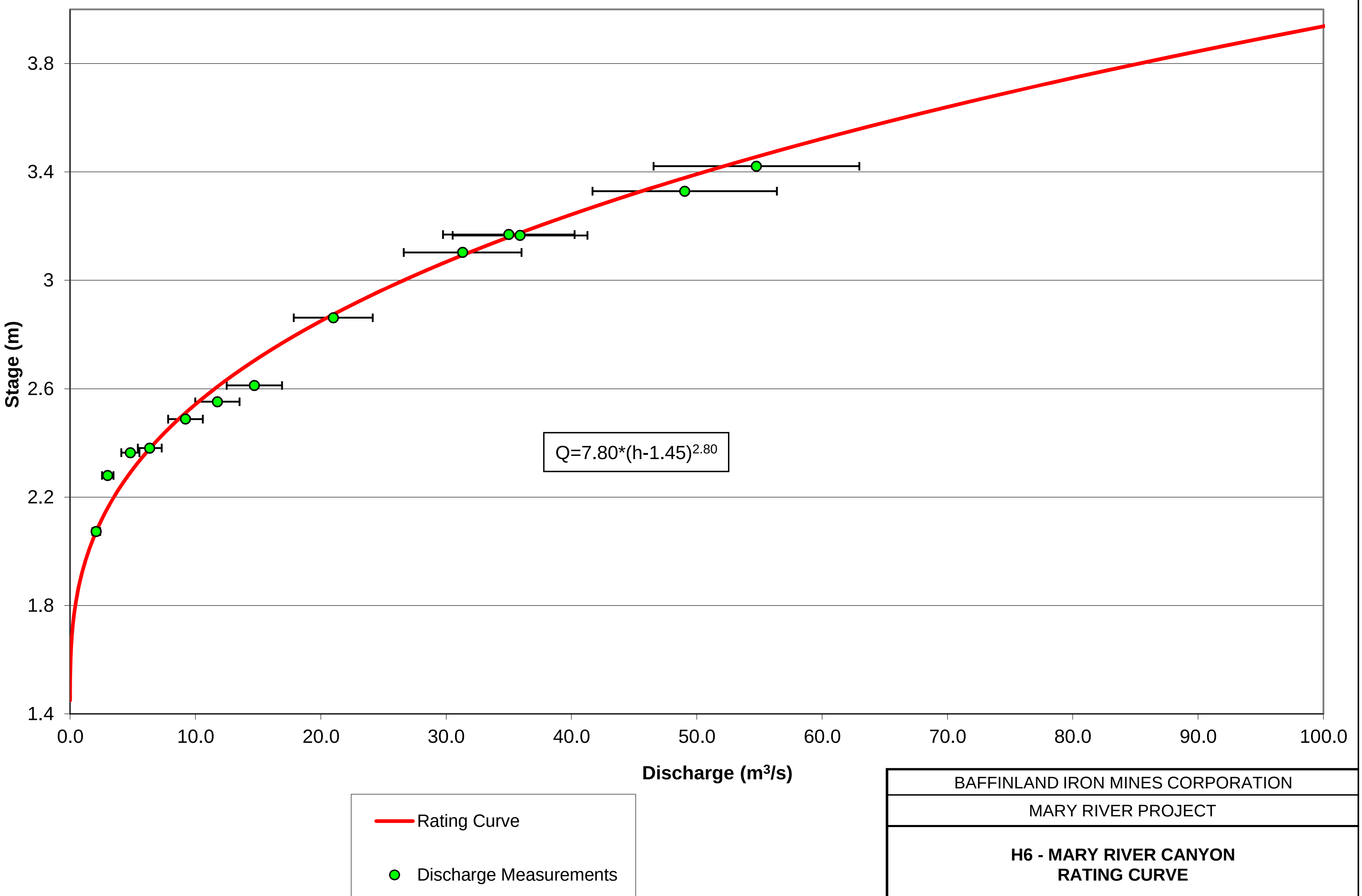
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.10

REV. 1



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

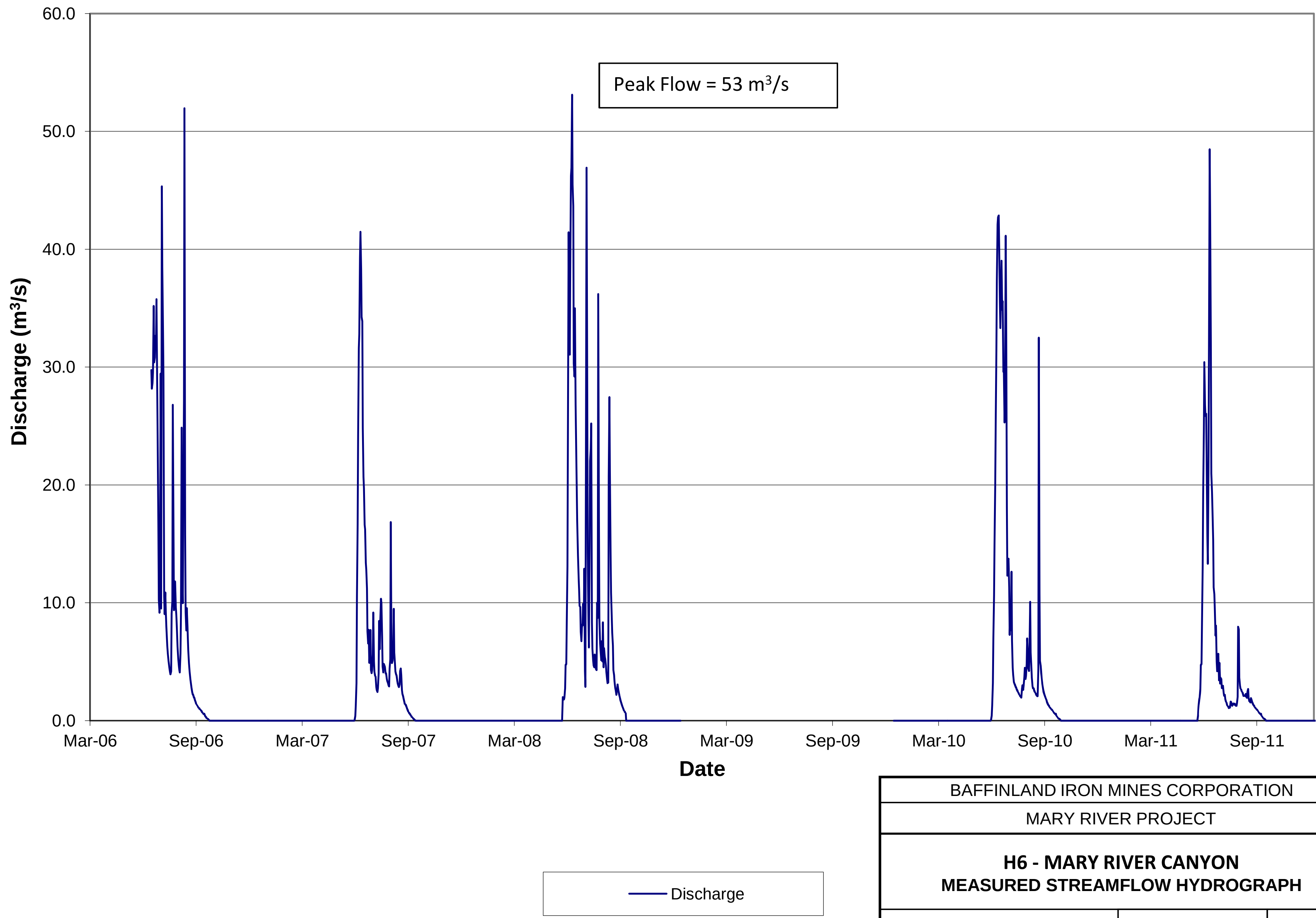
H6 - MARY RIVER CANYON RATING CURVE

Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 3.11 REV. 1

1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H6 - MARY RIVER CANYON
MEASURED STREAMFLOW HYDROGRAPH

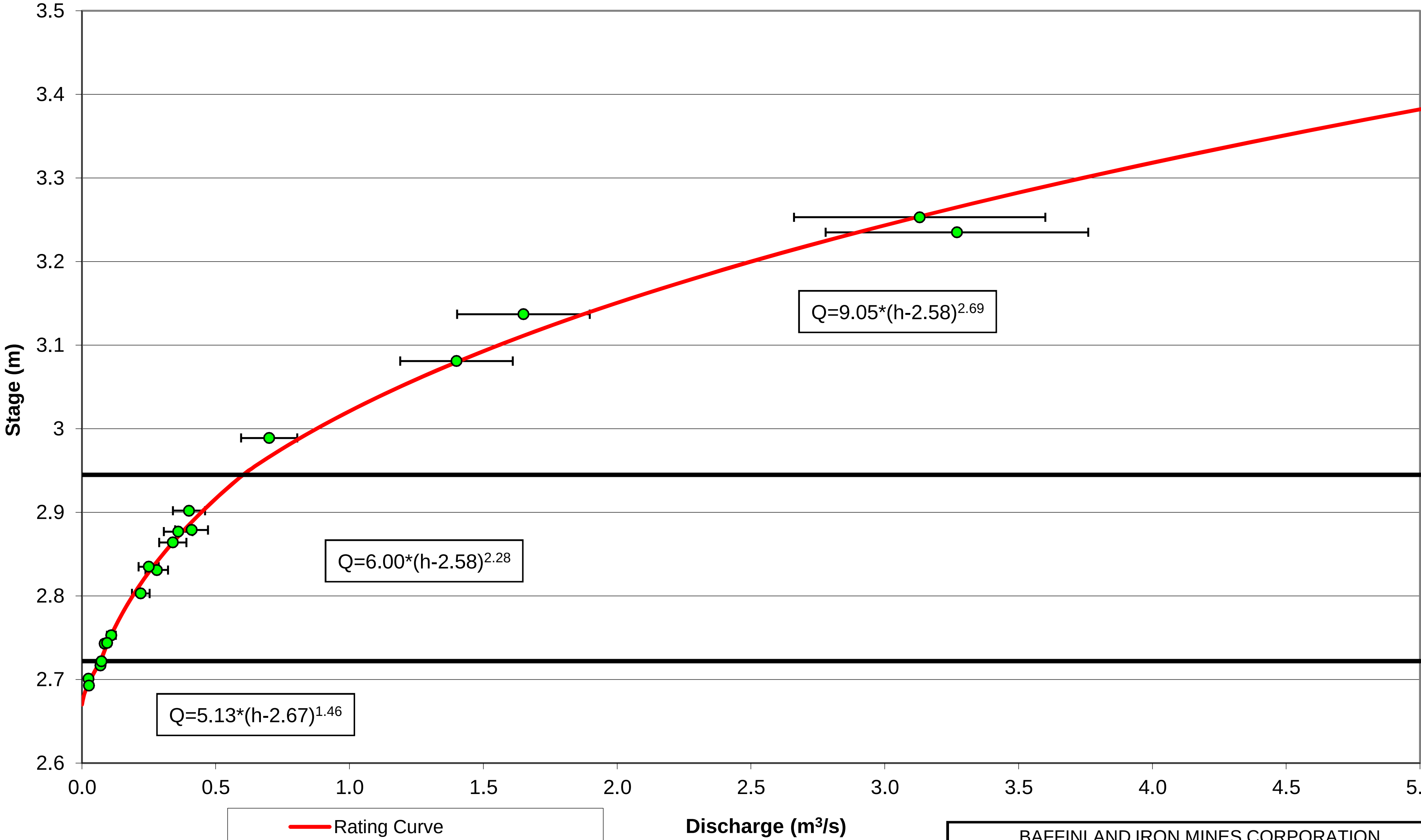
Knight Piésold
CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.12

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H7 - MARY RIVER TRIBUTARY RATING CURVE

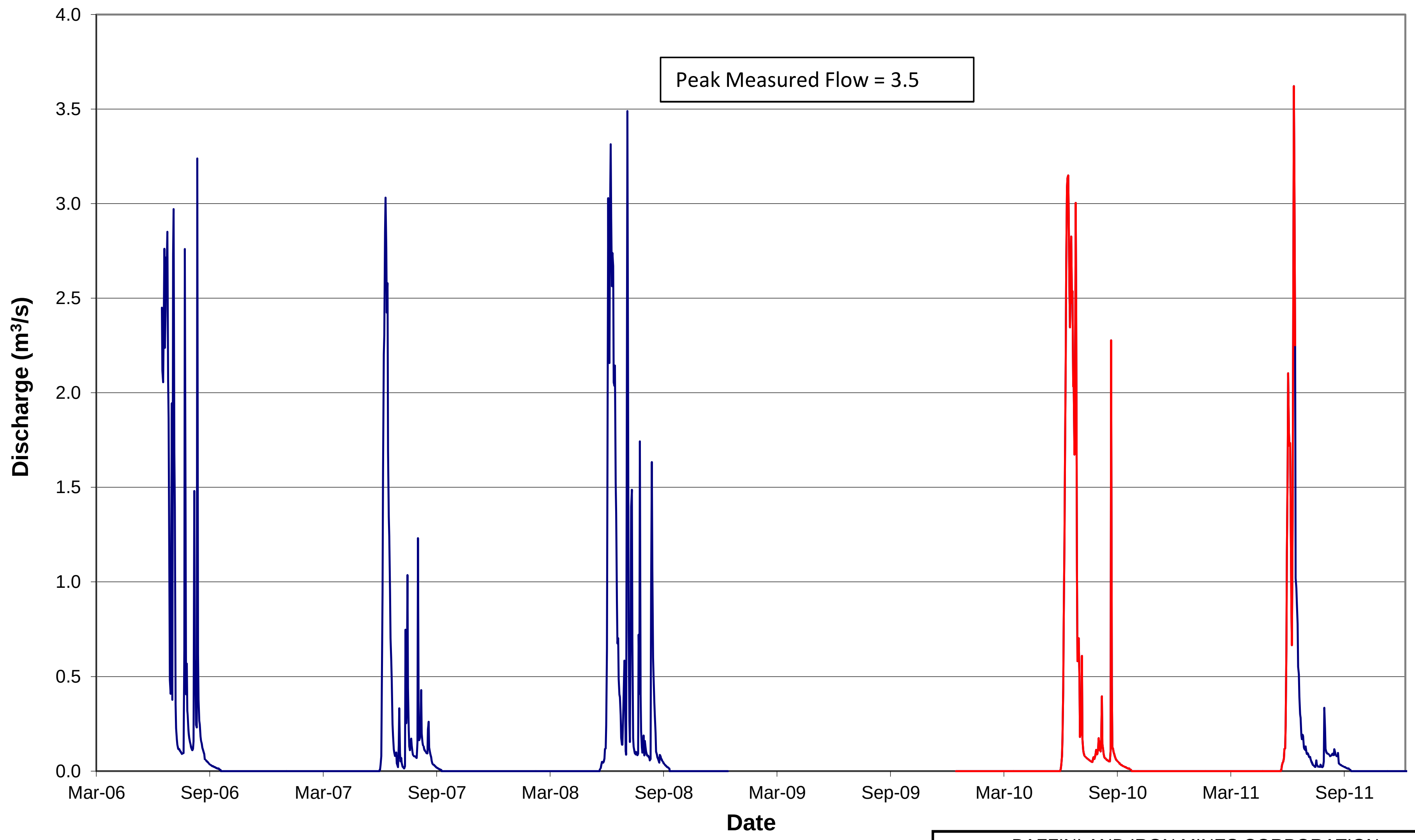
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.13

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H7 - MARY RIVER TRIBUTARY
MEASURED STREAMFLOW HYDROGRAPH

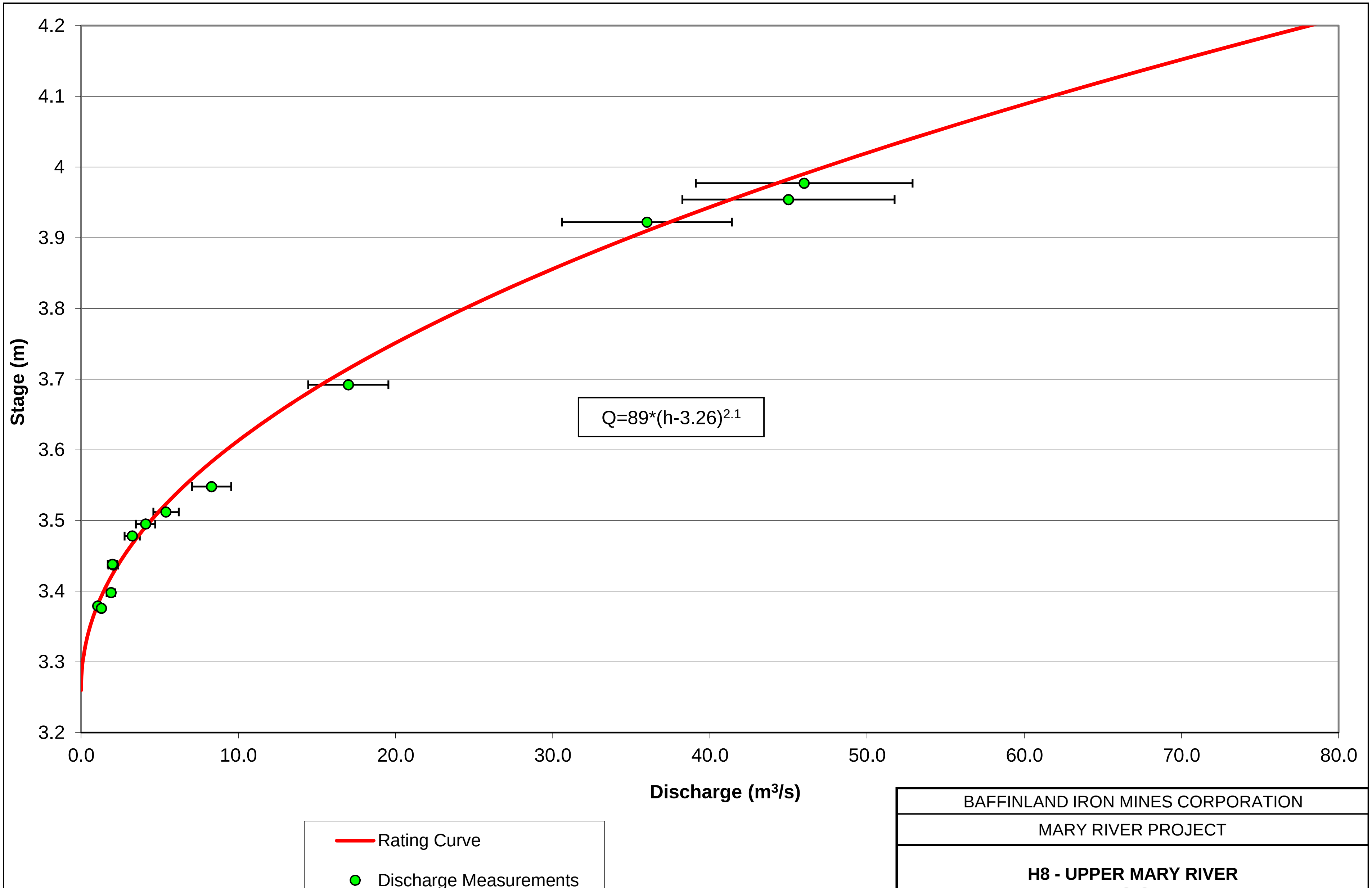
Knight Piésold
CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

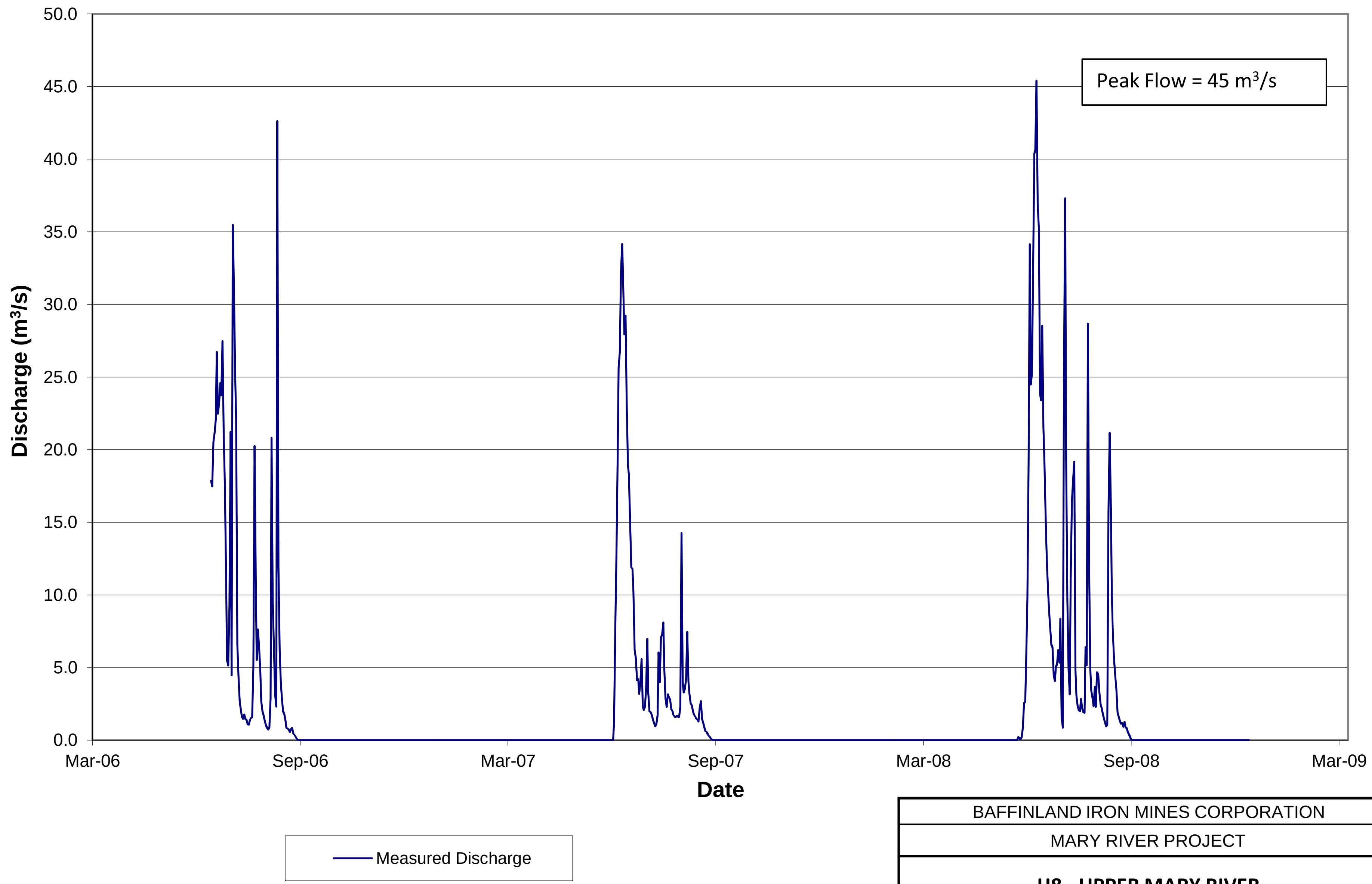
FIGURE 3.14

REV. 1



BAFFINLAND IRON MINES CORPORATION	
MARY RIVER PROJECT	
H8 - UPPER MARY RIVER RATING CURVE	
Knight Piésold CONSULTING	PROJECT / ASSIGNMENT NO. NB102-181/30 ; REF NO. 7
	FIGURE 3.15 ; REV. 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H8 - UPPER MARY RIVER
MEASURED STREAMFLOW HYDROGRAPH

Knight Piésold CONSULTING

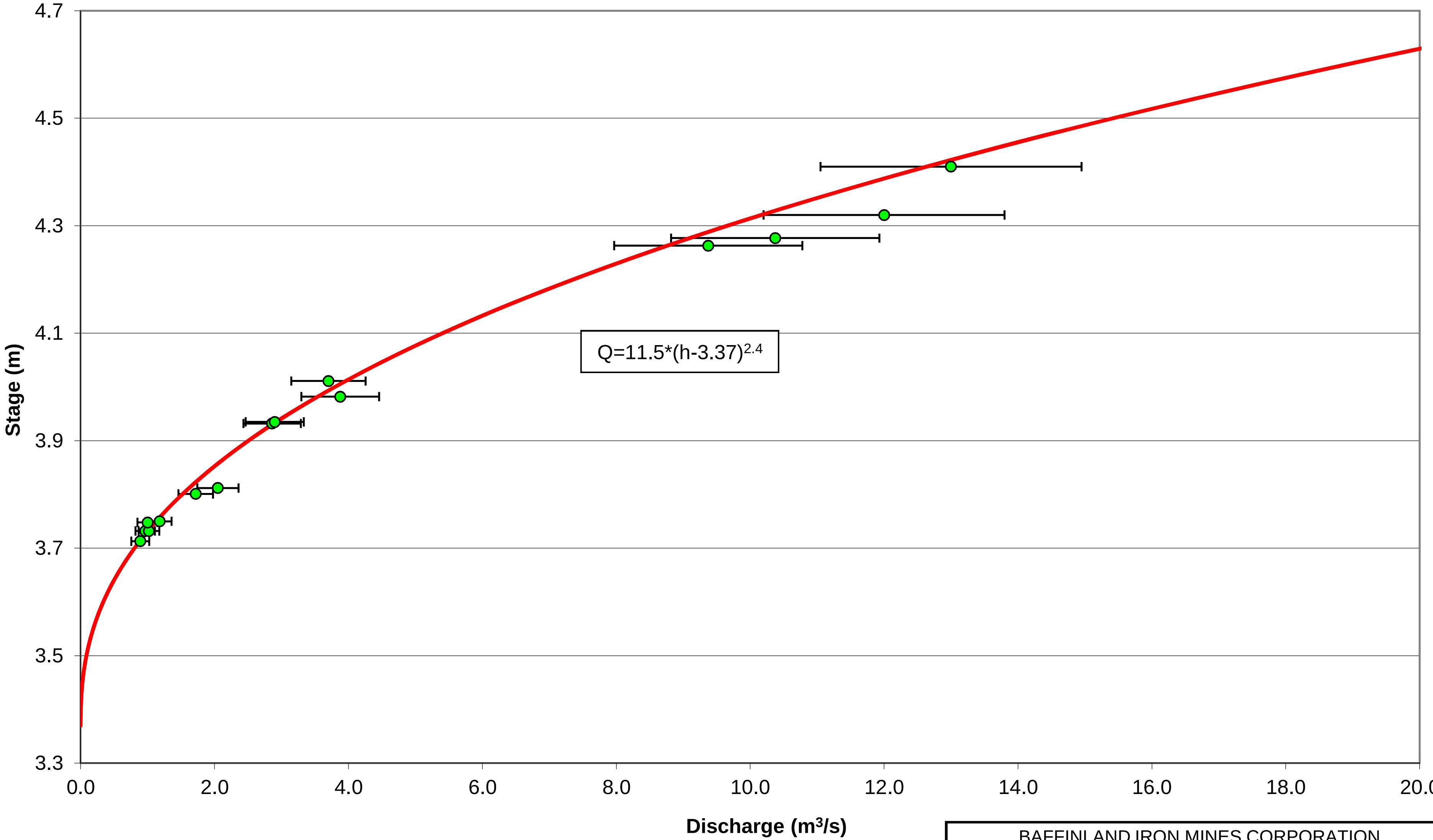
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.16

REV. 0

0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

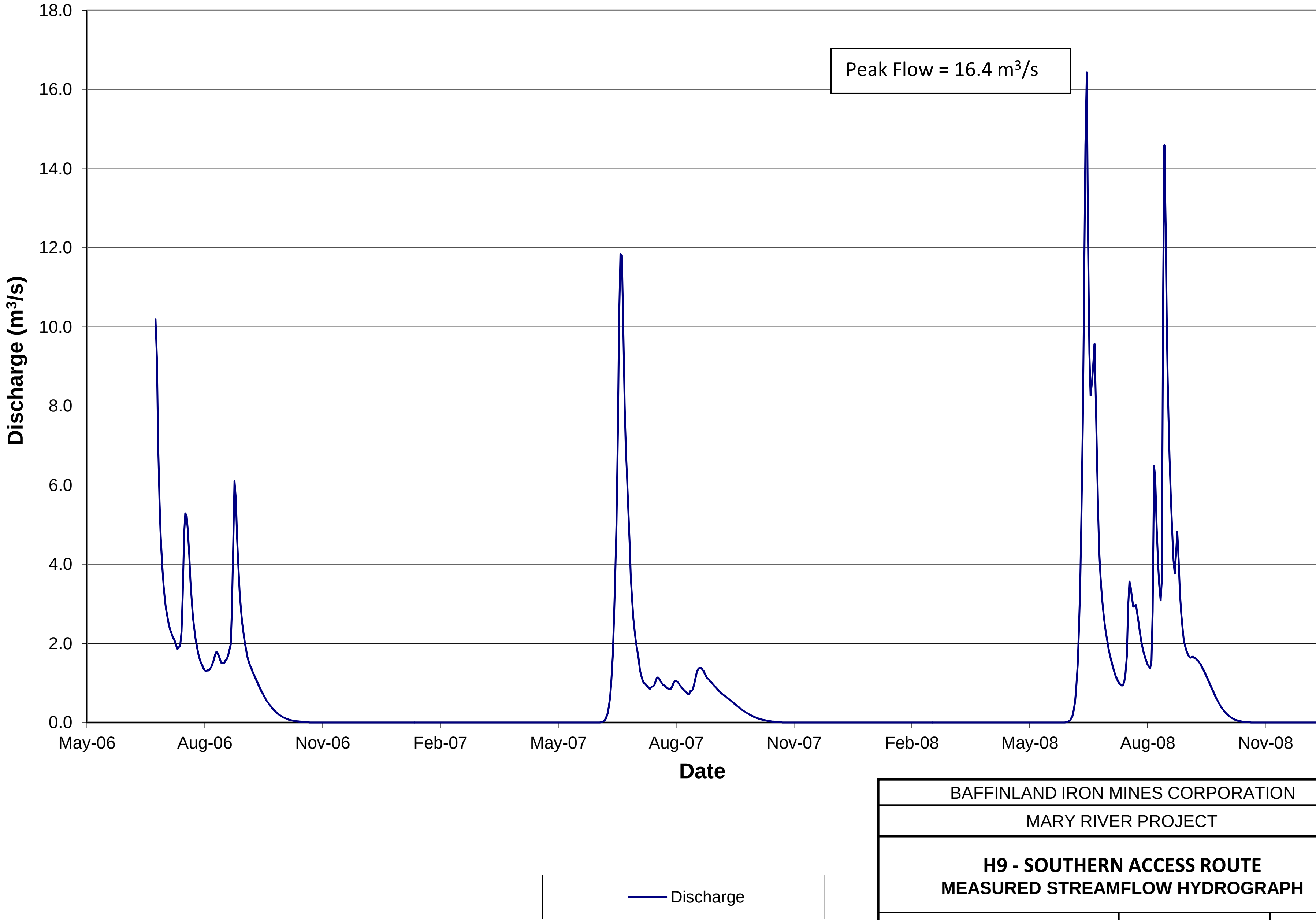
MARY RIVER PROJECT

H9 - SOUTHERN ACCESS ROUTE RATING CURVE

Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 3.17 REV. 0



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H9 - SOUTHERN ACCESS ROUTE
MEASURED STREAMFLOW HYDROGRAPH

Knight Piésold
CONSULTING

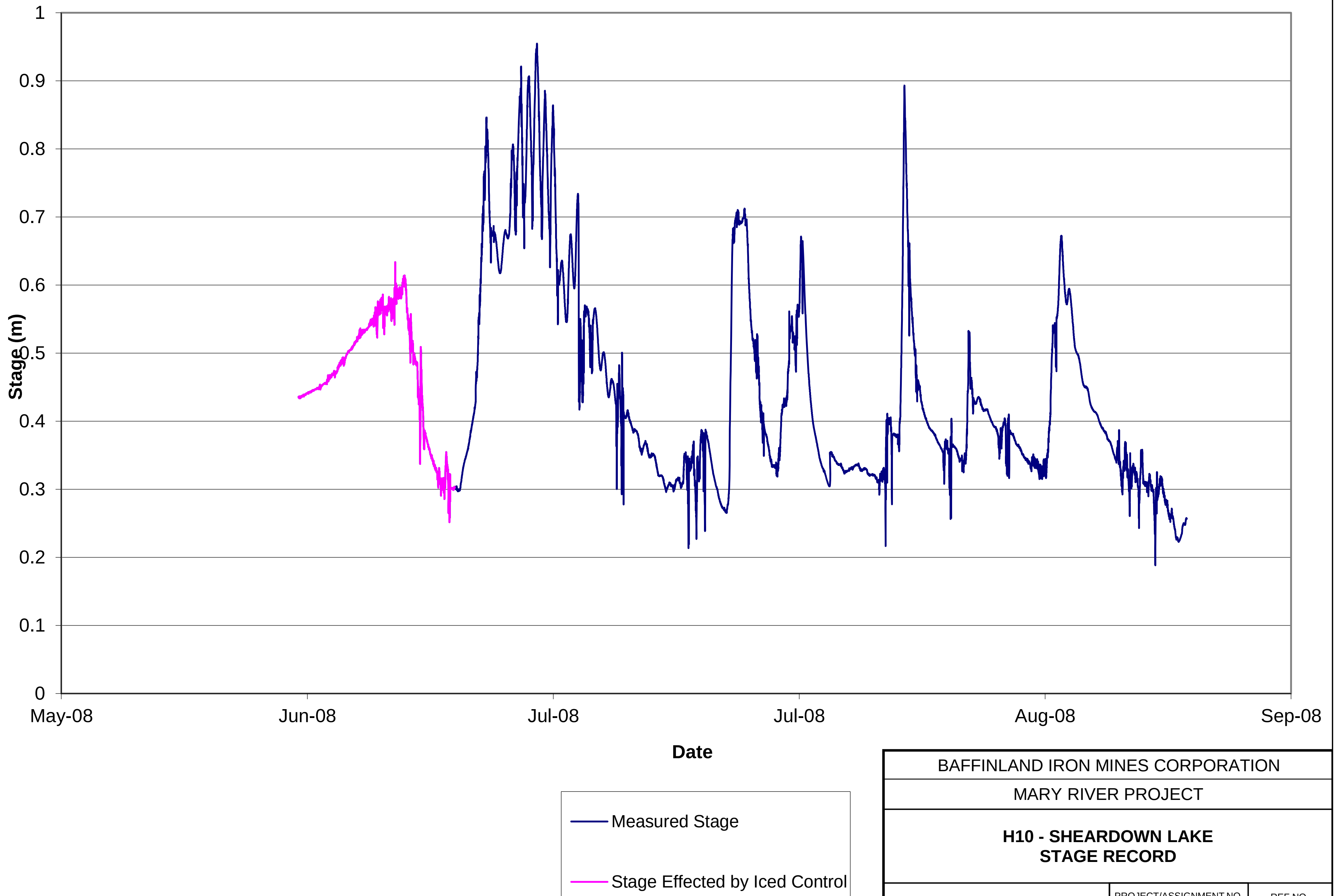
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.18

REV. 0

0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H10 - SHEARDOWN LAKE STAGE RECORD

Knight Piésold CONSULTING

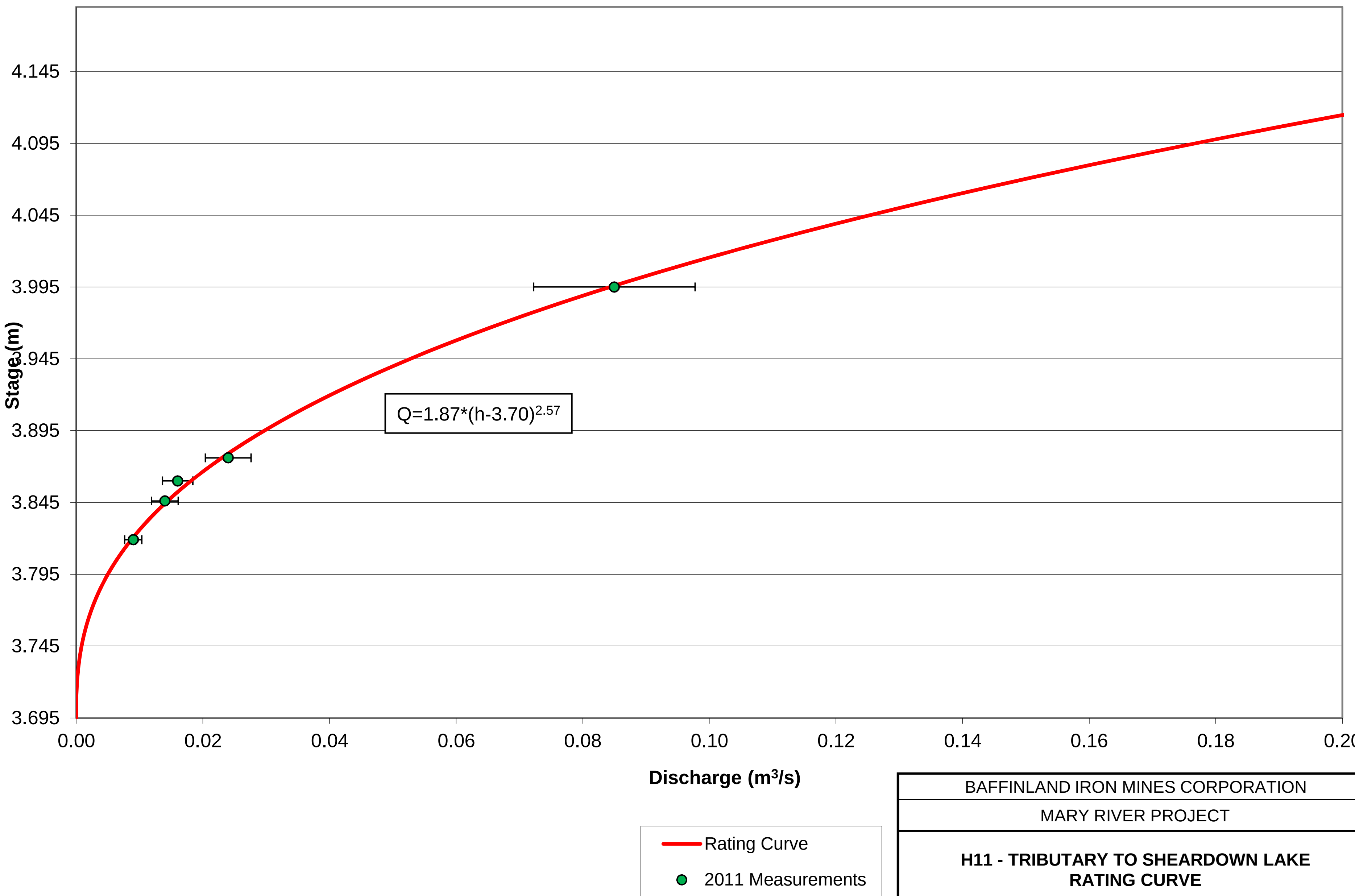
PROJECT/ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.19

REV 0

0	19JAN'09	ISSUED WITH REPORT	KT	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H11 - TRIBUTARY TO SHEARDOWN LAKE
RATING CURVE

Knight Piésold CONSULTING

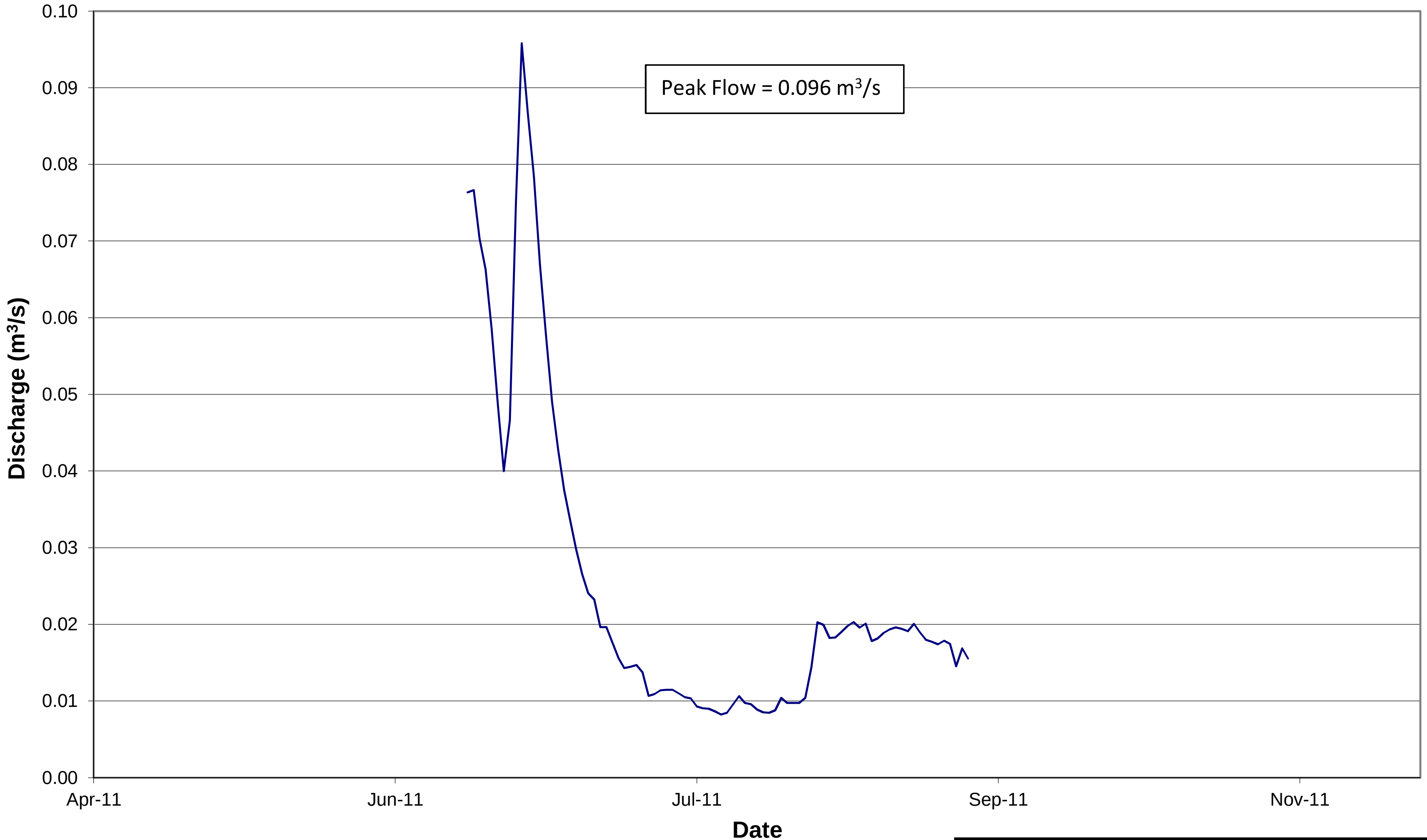
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.20

REV. 0

0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

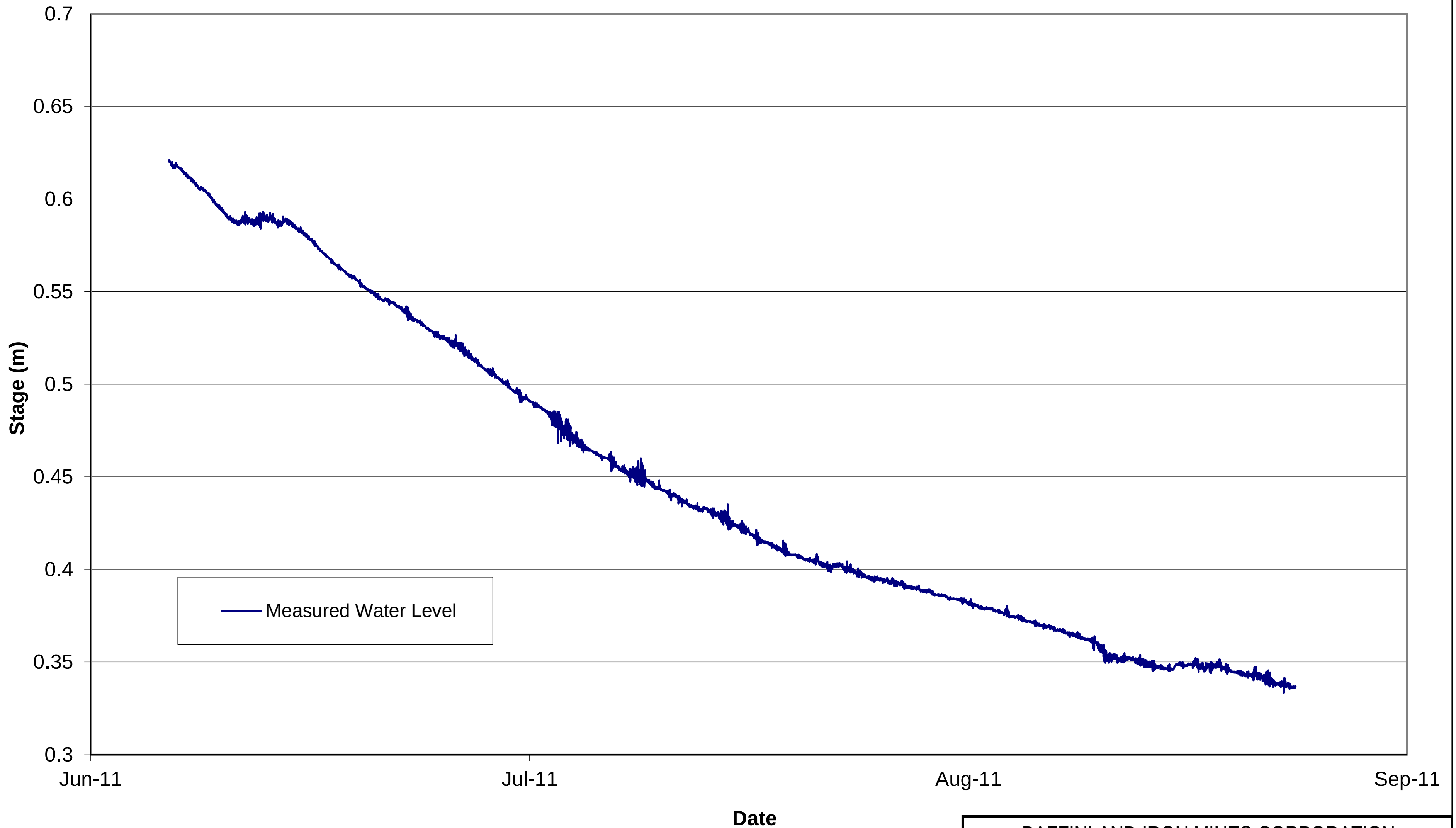
H11 - TRIBUTARY TO SHEARDOWN LAKE
MEASURED STREAMFLOW HYDROGRAPH

Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 3.21 REV. 0

0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

H12 - 3 KM LAKE
STAGE RECORD

Knight Piésold CONSULTING

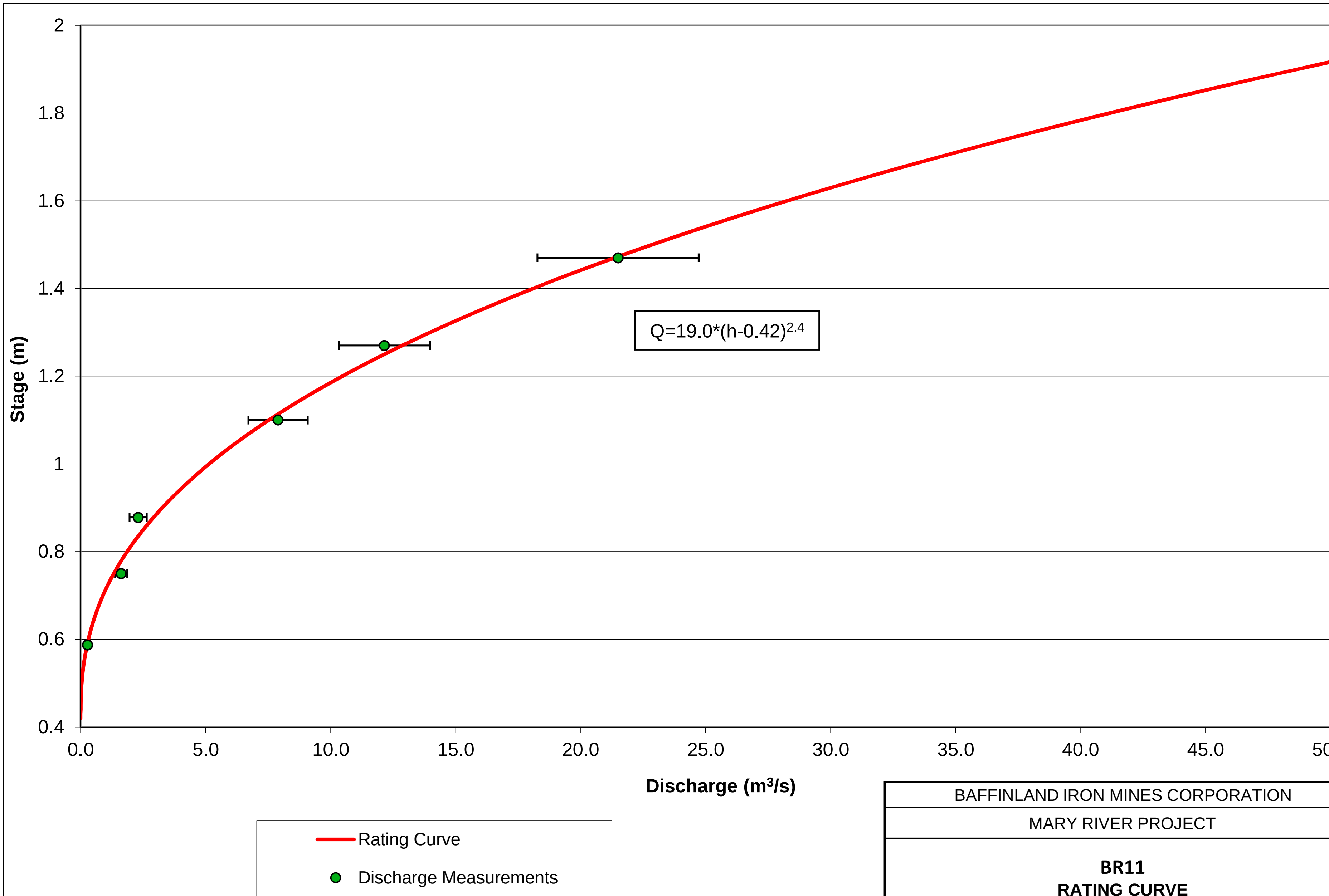
PROJECT/ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.22

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	21DEC'11	ISSUED WITH REPORT	KT	TJP	JGC



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BR11
RATING CURVE

Knight Piésold CONSULTING

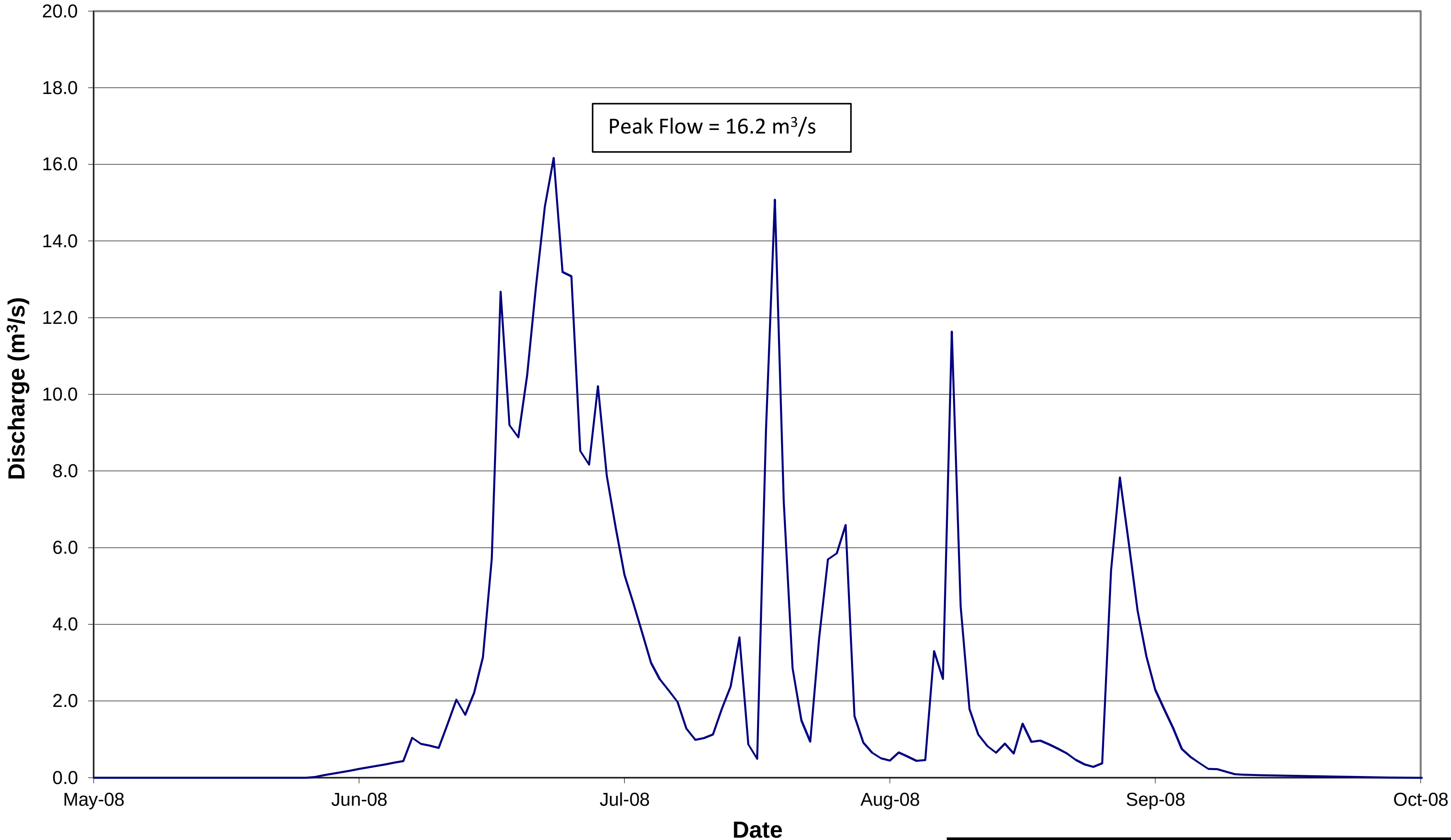
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.23

REV. 0

0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BR11
MEASURED STREAMFLOW HYDROGRAPH

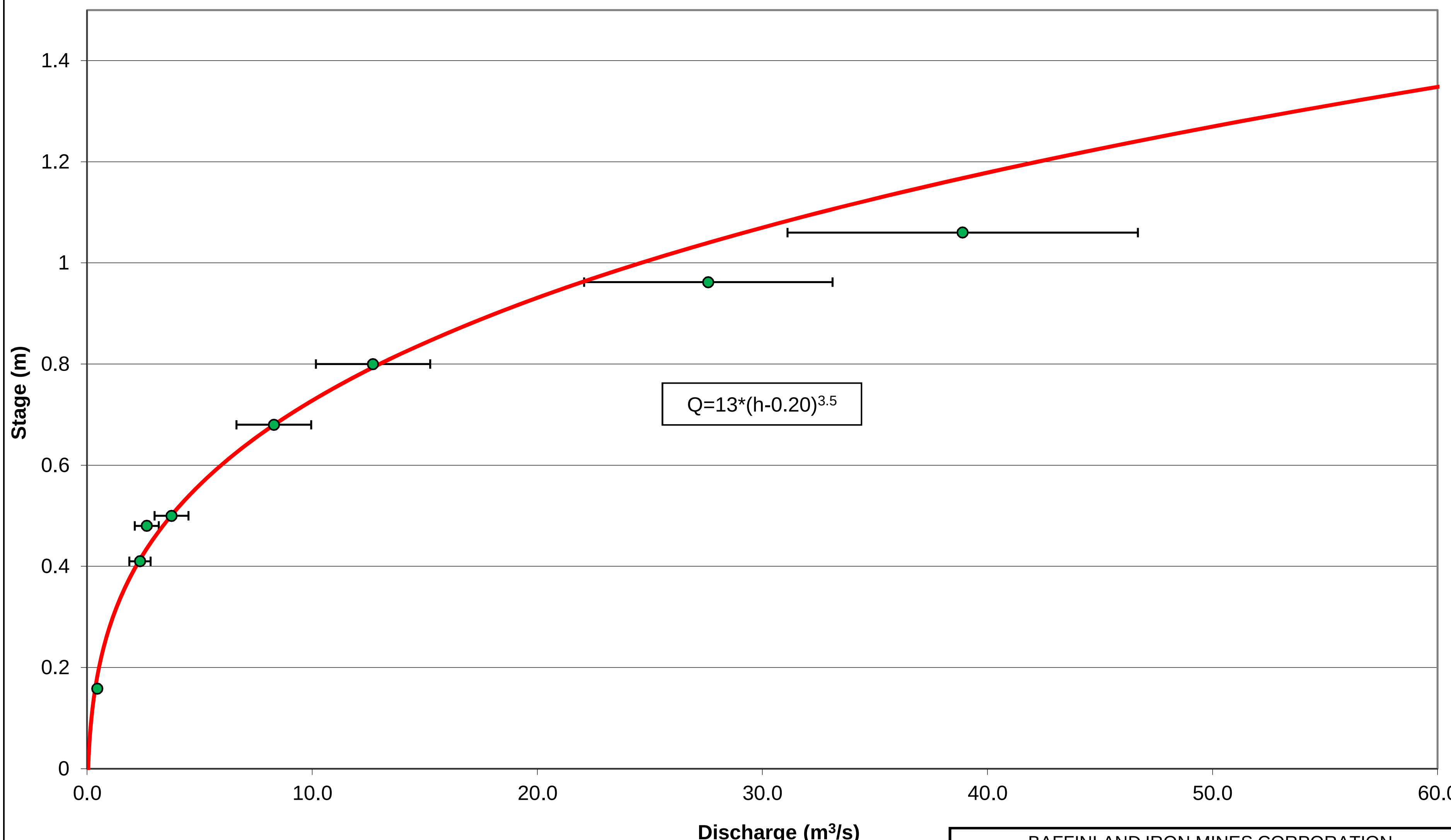
Knight Piésold
CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.24

REV. 0



0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BR25
RATING CURVE

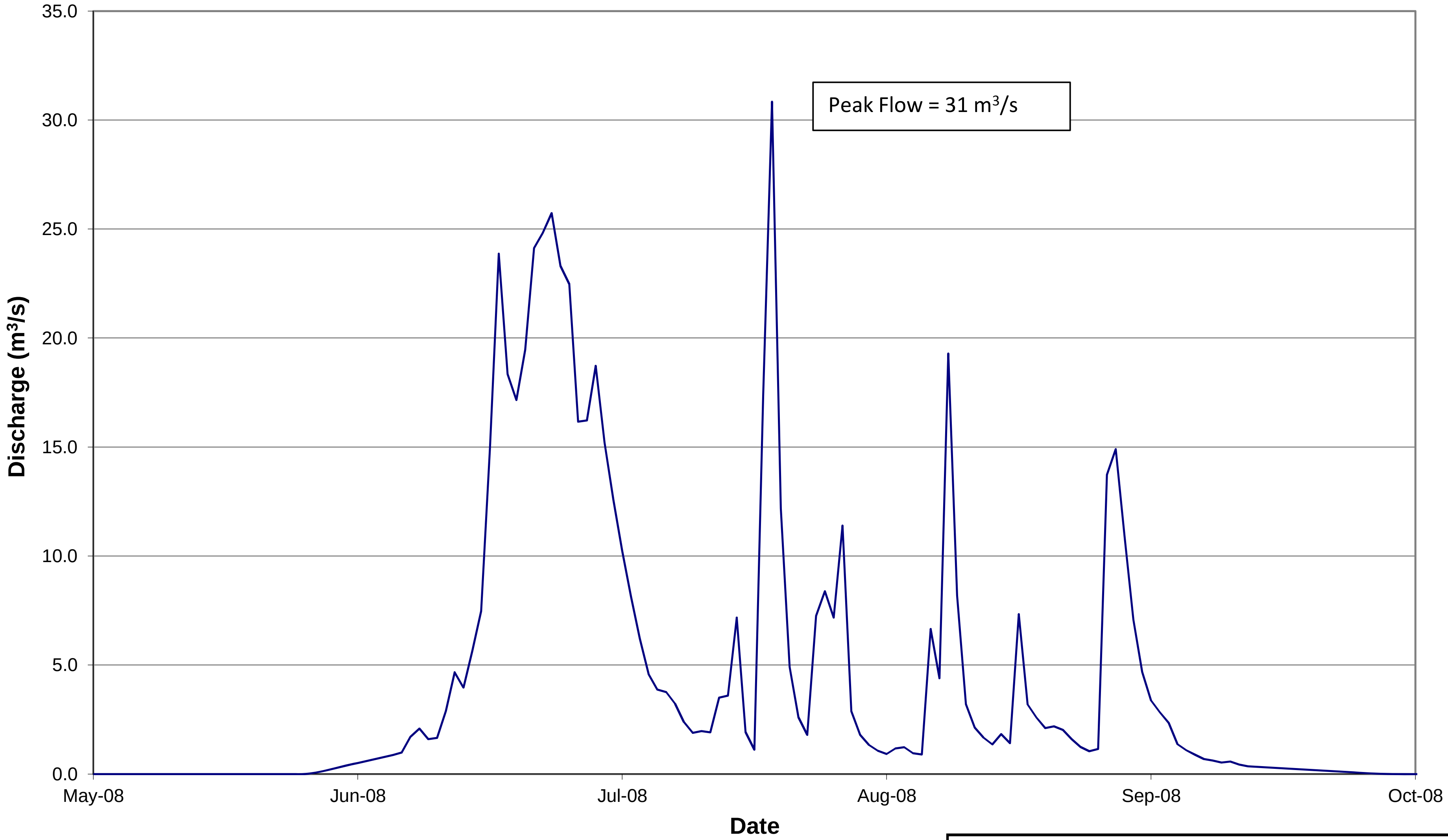
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.25

REV. 0



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

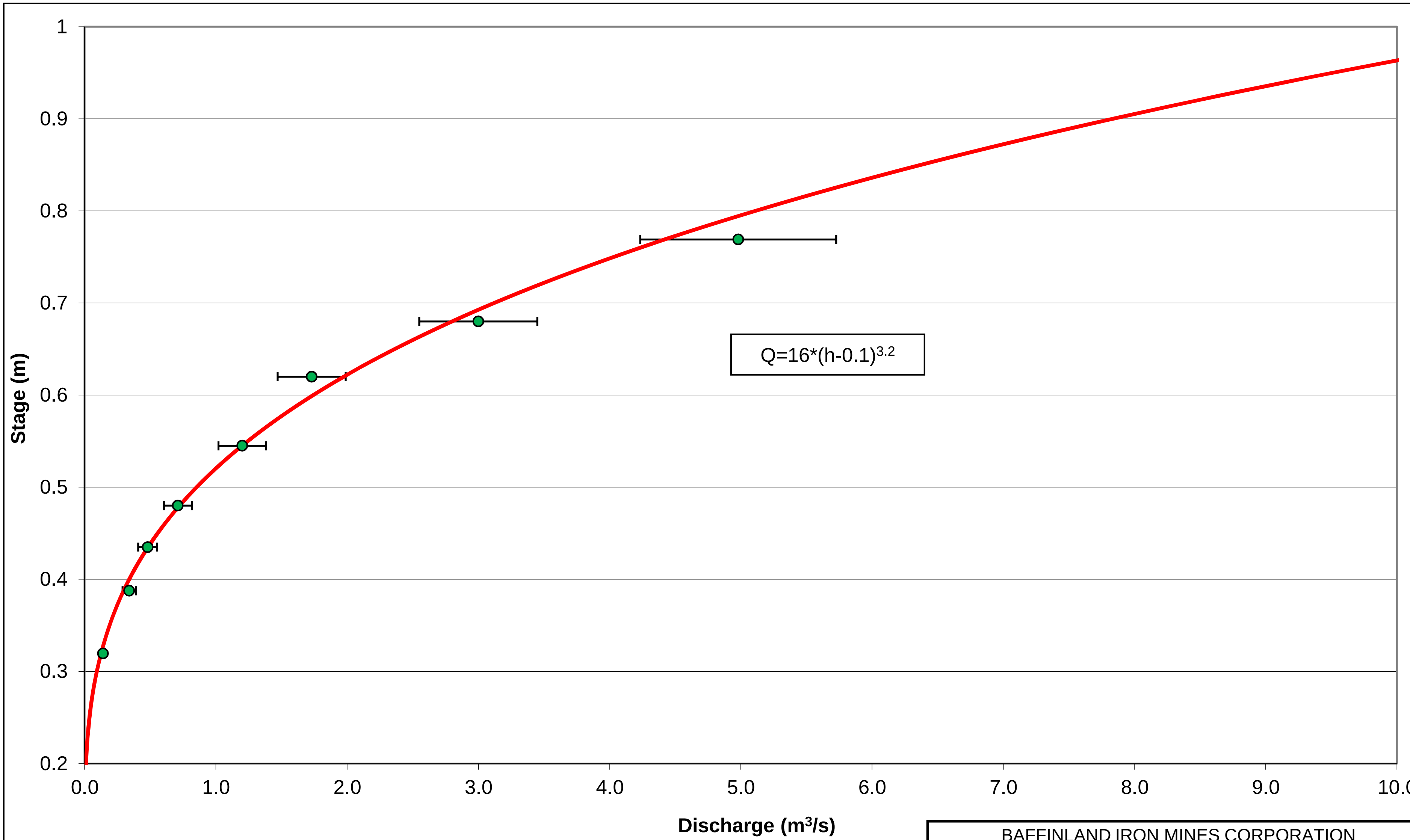
BR25
MEASURED STREAMFLOW HYDROGRAPH

Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 3.26 REV. 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC



REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BR96-2
RATING CURVE

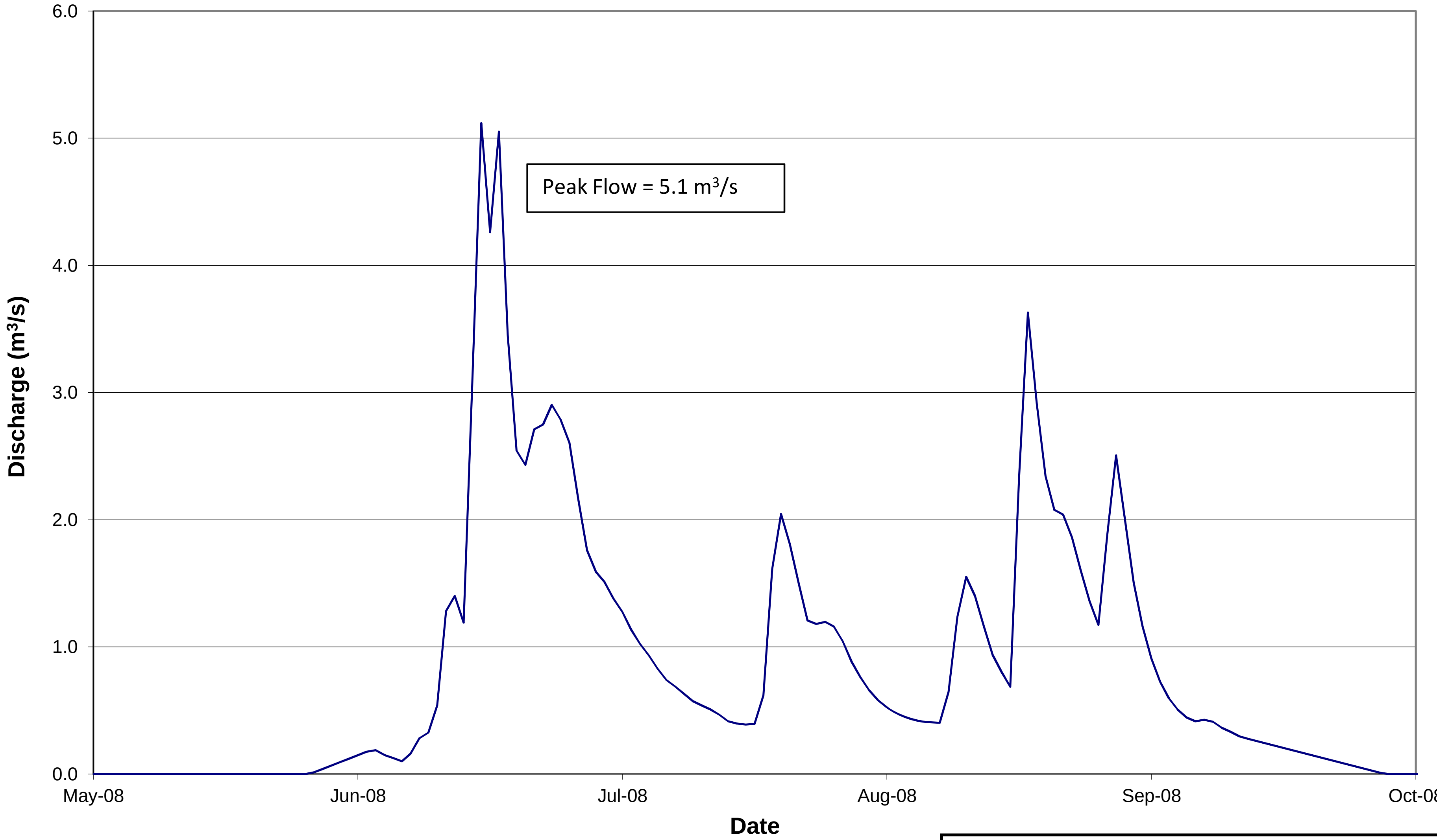
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.27

REV. 0



0	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BR96-2
MEASURED STREAMFLOW HYDROGRAPH

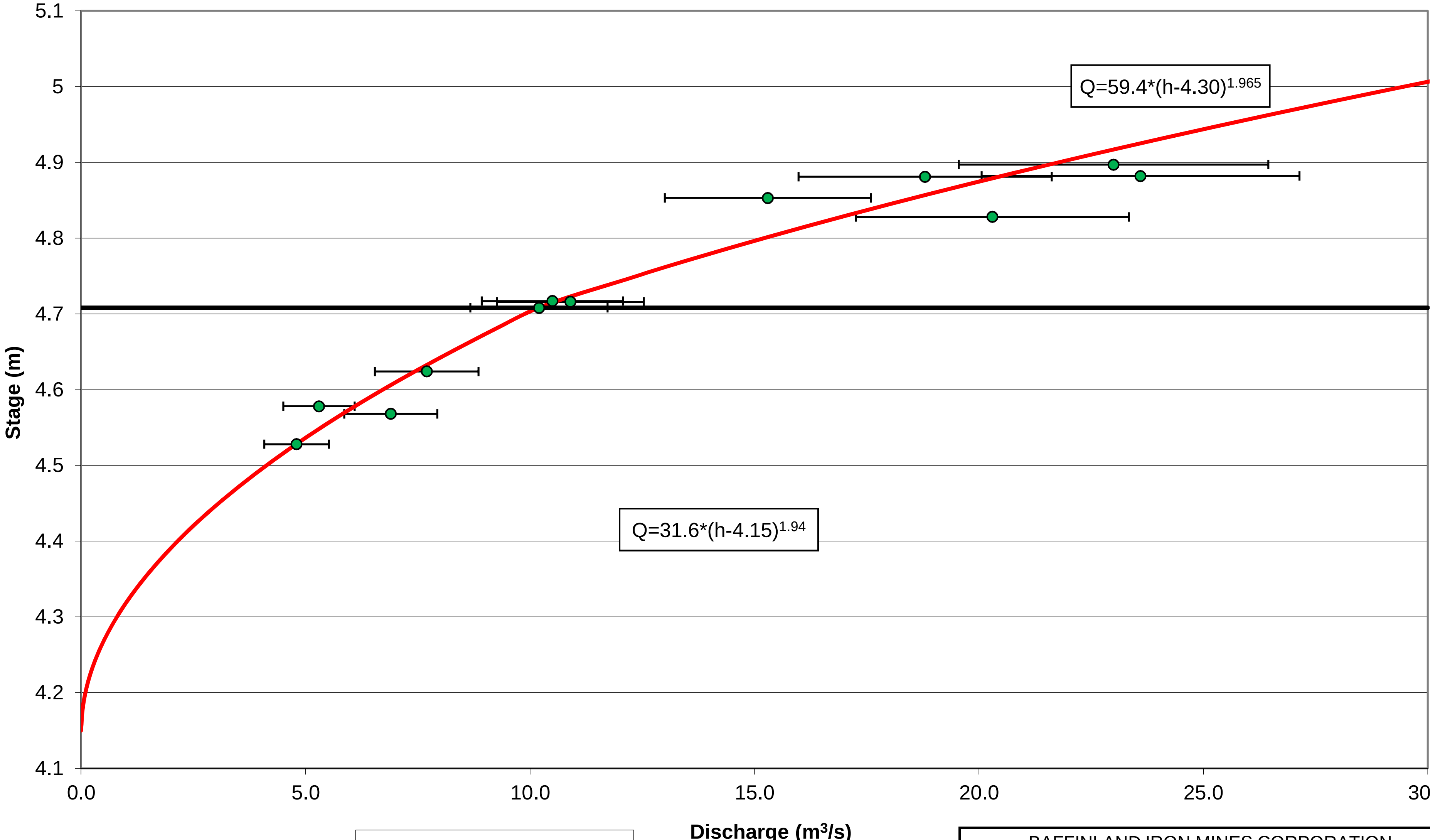
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.28

REV. 0



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BR137
RATING CURVE

Knight Piésold CONSULTING

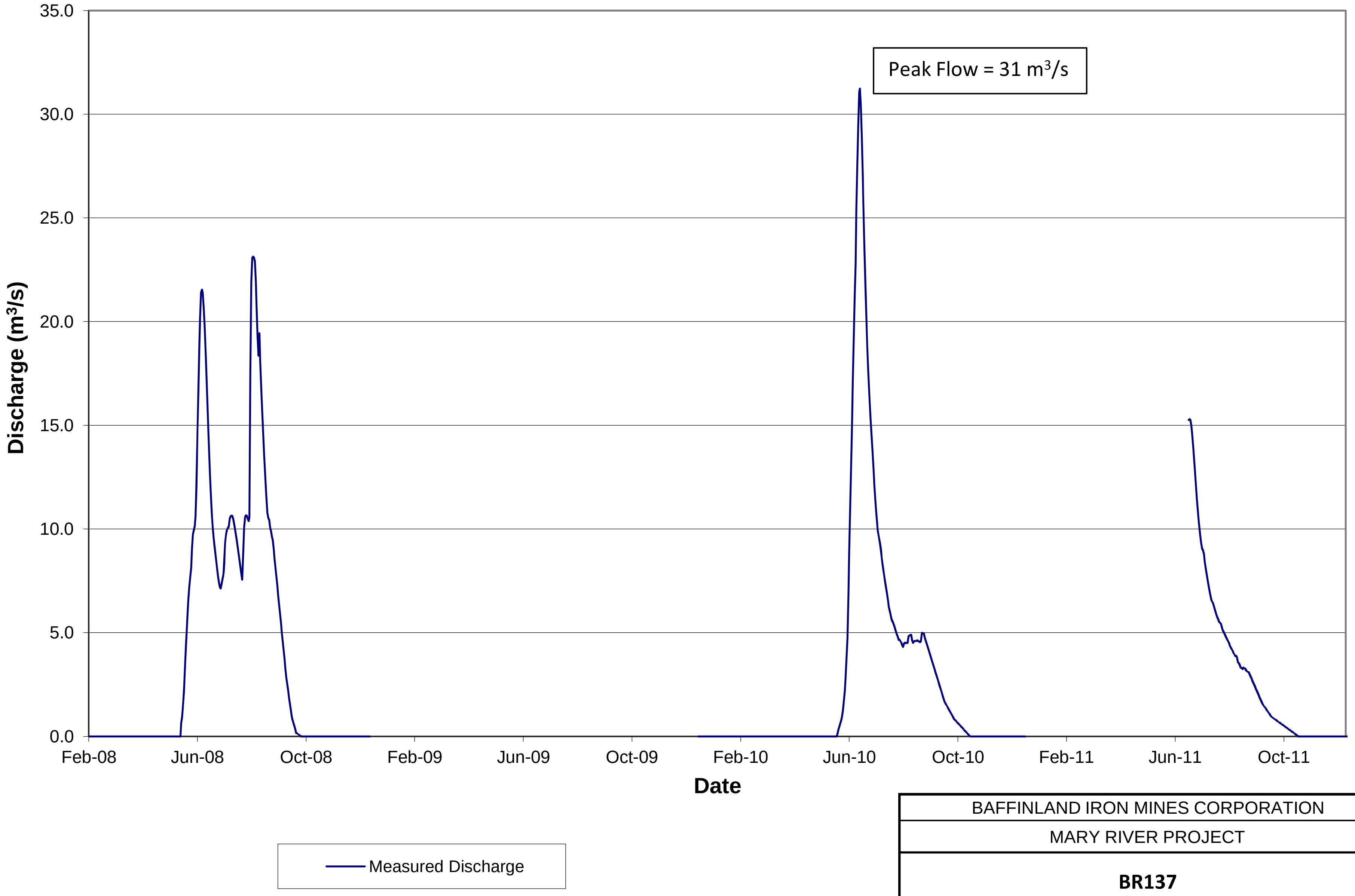
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.29

REV. 1

1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

BR137
MEASURED STREAMFLOW HYDROGRAPH

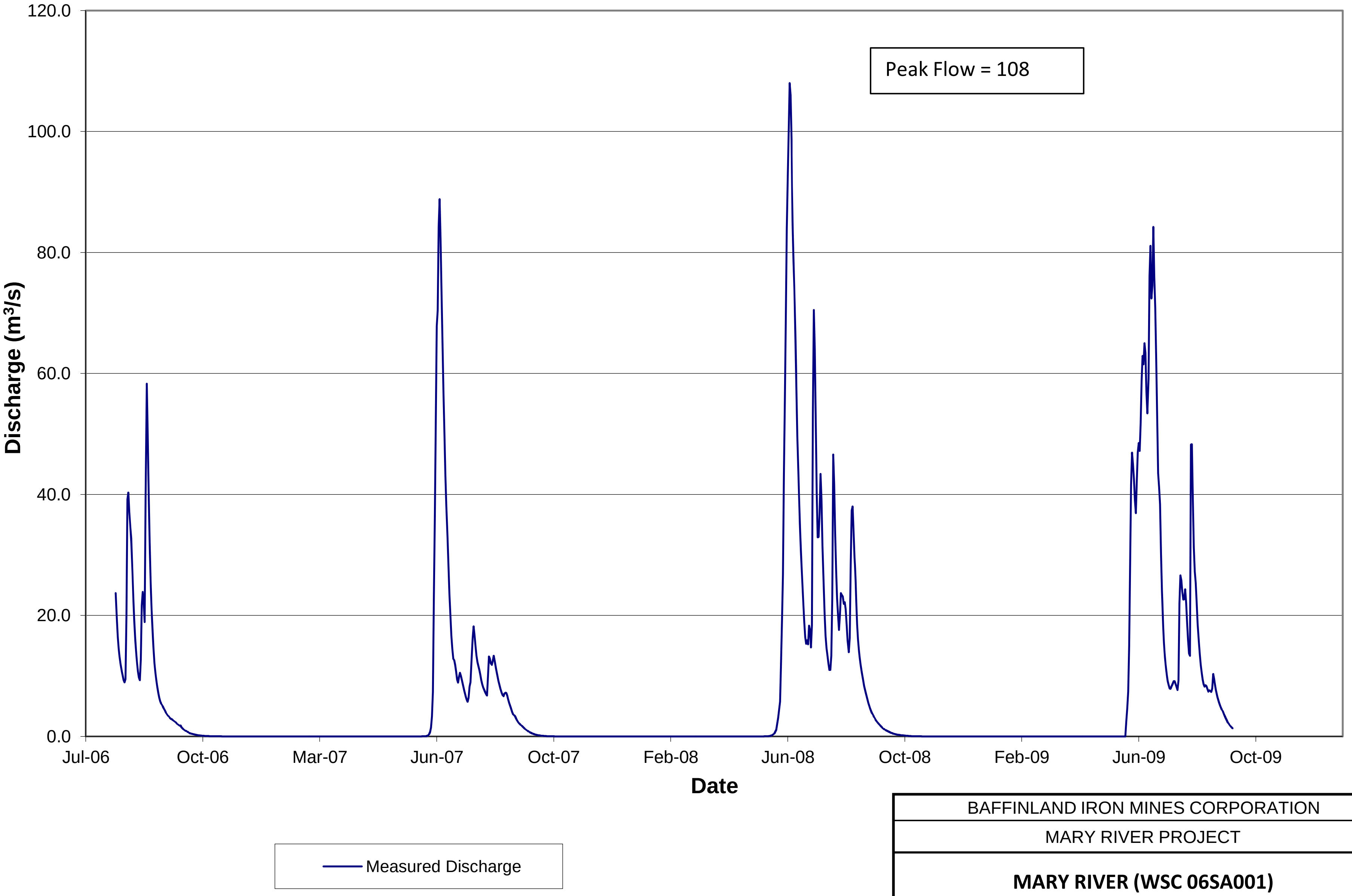
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.30

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MARY RIVER (WSC 06SA001)
MEASURED STREAMFLOW HYDROGRAPH

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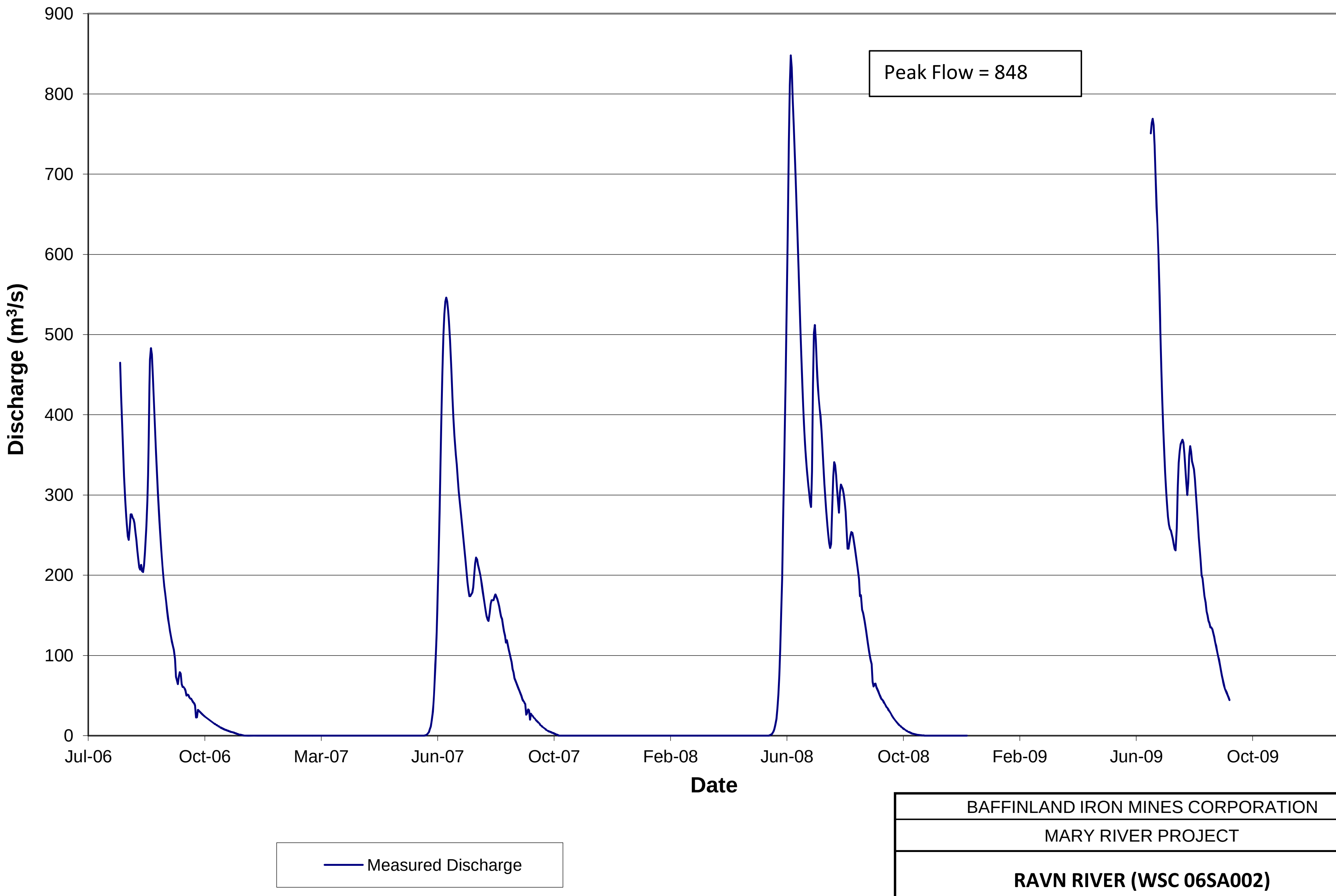
PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 3.31

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

RAVN RIVER (WSC 06SA002)
MEASURED STREAMFLOW HYDROGRAPH

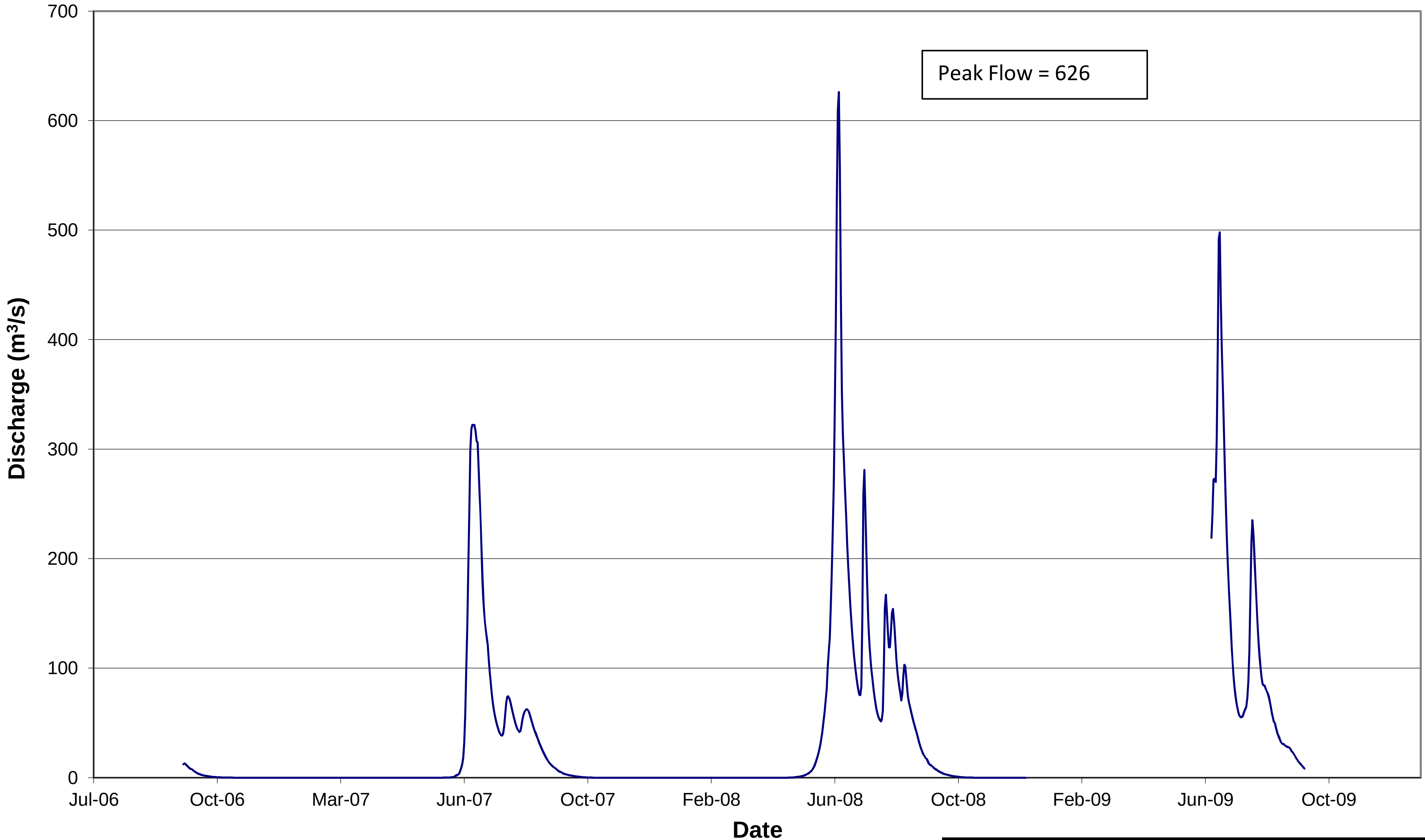
Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO. NB102-181/30

REF NO. 7

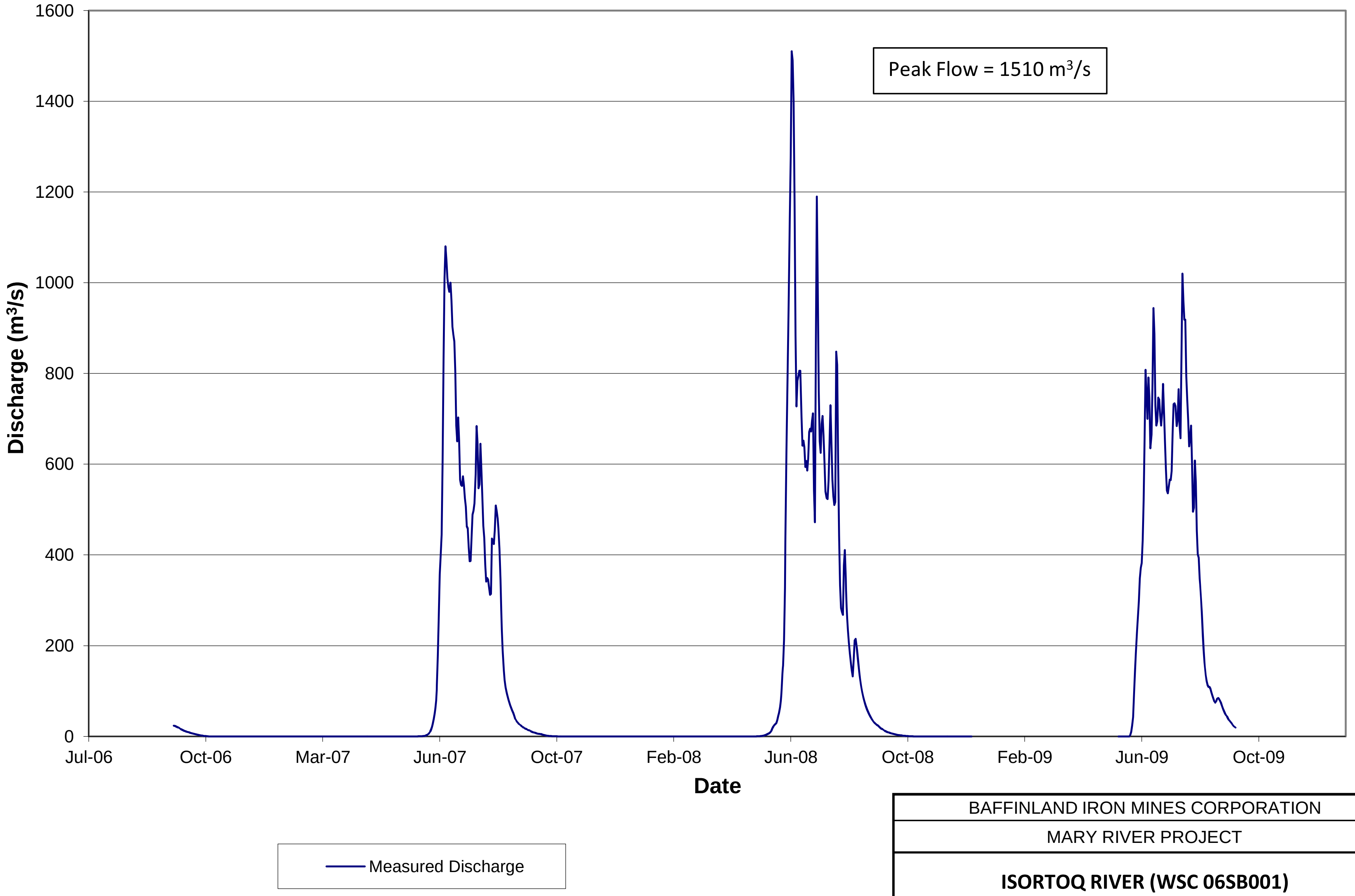
FIGURE 3.32

REV. 1



1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION		
MARY RIVER PROJECT		
ROWLEY RIVER (WSC 06SB002) **MEASURED STREAMFLOW HYDROGRAPH**		
Knight Piésold CONSULTING	PROJECT / ASSIGNMENT NO. NB102-181/30	REF NO. 7
	FIGURE 3.33	REV. 1



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

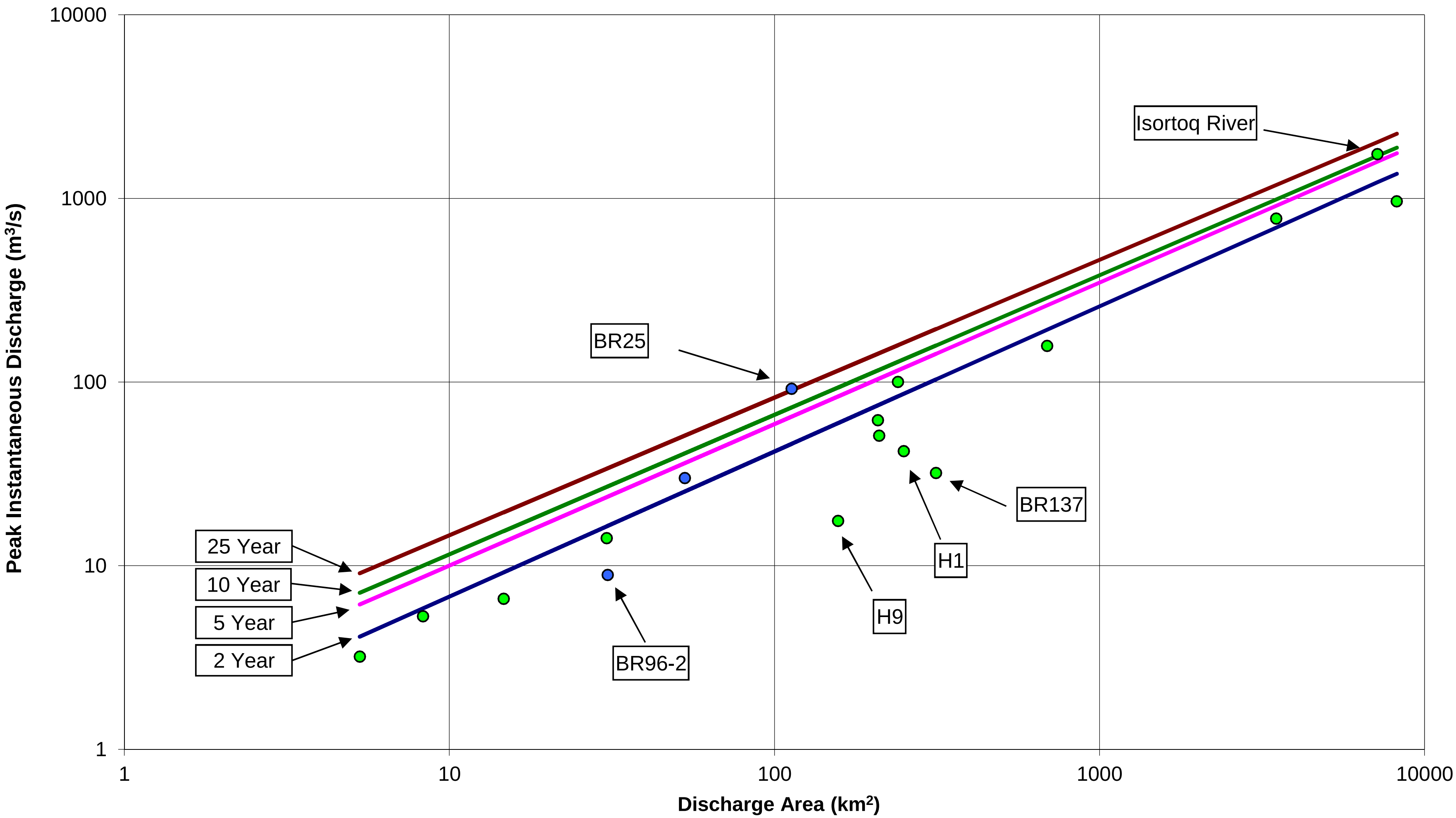
ISORTOQ RIVER (WSC 06SB001)
MEASURED STREAMFLOW HYDROGRAPH

Knight Piésold CONSULTING

PROJECT / ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 3.34 REV. 1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	23DEC'11	ISSUED WITH REPORT	CBN	KT	JGC



NOTES:
1. RETURN PERIOD ENVELOPES ARE ESTIMATED FROM REGIONAL WSC GAUGING STATIONS.
2. BR96-2, BR137, H1 AND H9 STATIONS HAVE MODERATE TO CONSIDERABLE LAKE COVERAGE IN THEIR WATERSHEDS.

LAKES
SERVE TO DAMPEN PEAK FLOWS.

- Stations with 1 year of record
- Stations with more than 1 year of record

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

COMPARISON OF MEASURED AND ESTIMATED PEAK INSTANTANEOUS FLOWS

Knight Piésold CONSULTING

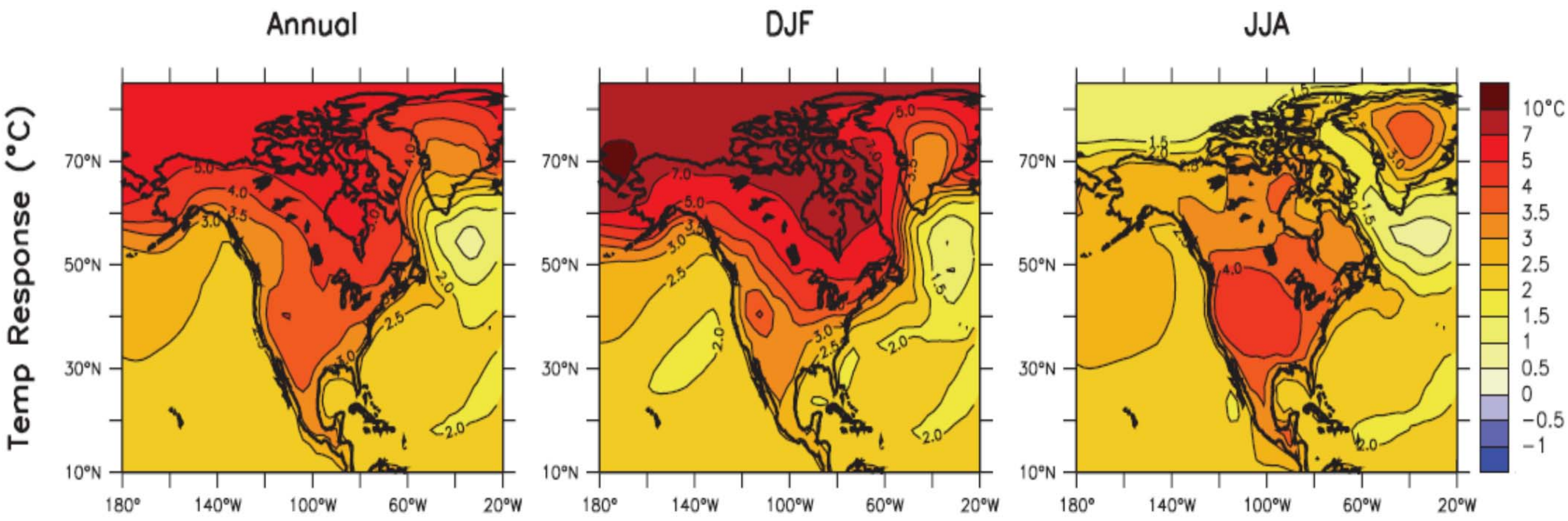
PROJECT/ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 5.1

REV 1

1	21DEC'11	ISSUED WITH REPORT	KT	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NOTES:

1. FIGURES WERE DEVELOPED BY AVERAGING THE RESULTS OF 21 DIFFERENT CLIMATE MODELS OPERATING UNDER THE A1B SCENARIO.
2. SOURCE: CHRISTENSON ET AL. - SEE REPORT REFERENCES SECTION.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

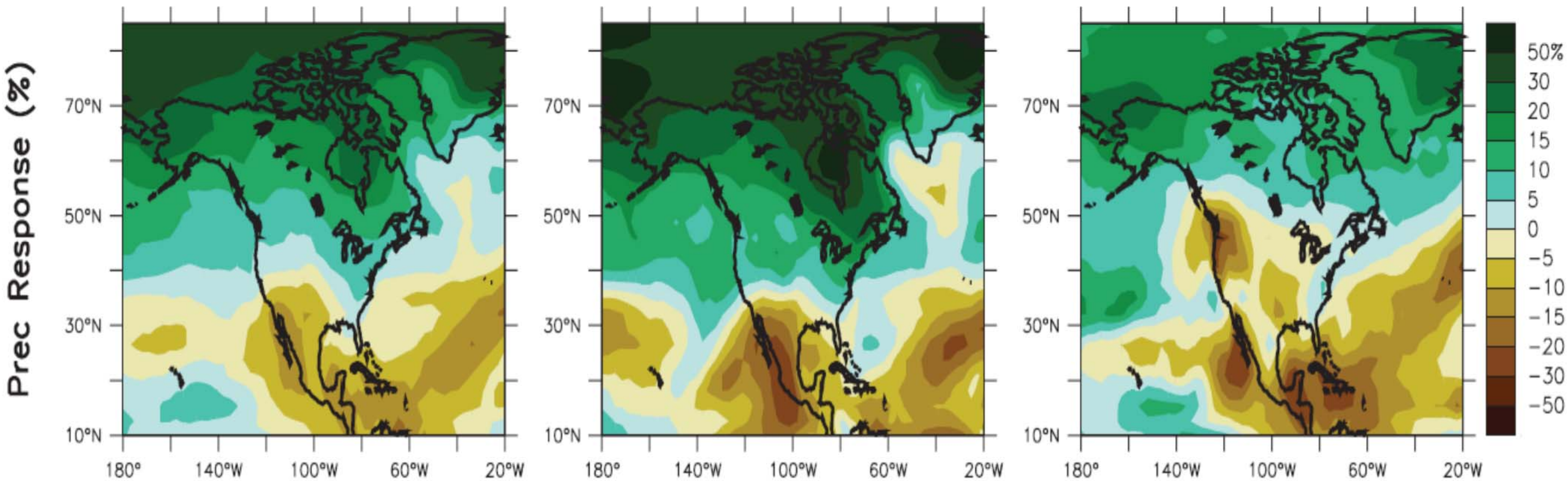
PREDICTED CHANGES IN NORTH AMERICAN TEMPERATURE FROM 1980-1999 TO 2080-2099

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO.	REF NO.
NB102-181/30	7

FIGURE 8.1 REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14JAN'09	ISSUED WITH REPORT	KT	TJP	JGC



NOTES:

1. FIGURES WERE DEVELOPED BY AVERAGING THE RESULTS OF 21 DIFFERENT CLIMATE MODELS OPERATING UNDER THE A1B SCENARIO.
2. SOURCE: CHRISTENSON ET AL. - SEE REPORT REFERENCES SECTION.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14JAN'09	ISSUED WITH REPORT	KT	TJP	JGC

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PREDICTED CHANGES IN NORTH AMERICAN PRECIPITATION FROM 1980-1999 TO 2080-2099

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 8.2

REV 0

Projections and model consistency of relative changes in runoff by the end of the 21st century

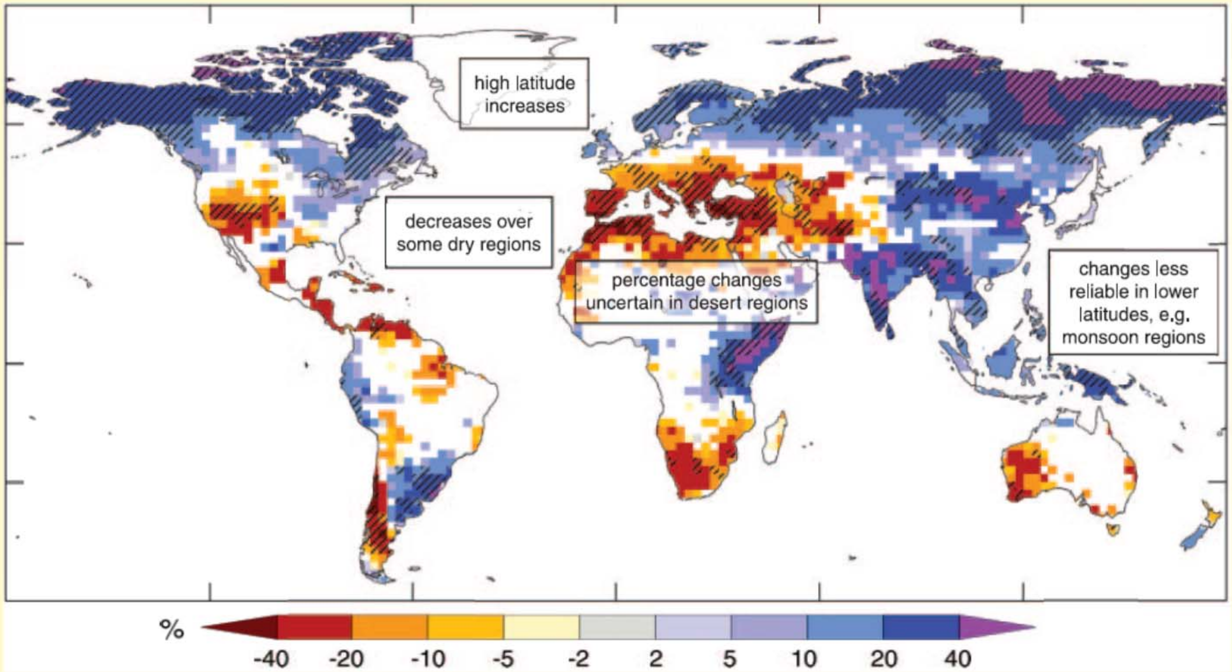


Figure 3.5. Large-scale relative changes in annual runoff (water availability, in percent) for the period 2090-2099, relative to 1980-1999. Values represent the median of 12 climate models using the SRES A1B scenario. White areas are where less than 66% of the 12 models agree on the sign of change and hatched areas are where more than 90% of models agree on the sign of change. The quality of the simulation of the observed large-scale 20th century runoff is used as a basis for selecting the 12 models from the multi-model ensemble. The global map of annual runoff illustrates a large scale and is not intended to refer to smaller temporal and spatial scales. In areas where rainfall and runoff is very low (e.g. desert areas), small changes in runoff can lead to large percentage changes. In some regions, the sign of projected changes in runoff differs from recently observed trends. In some areas with projected increases in runoff, different seasonal effects are expected, such as increased wet season runoff and decreased dry season runoff. Studies using results from few climate models can be considerably different from the results presented here. {WGII Figure 3.4, adjusted to match the assumptions of Figure SYR 3.3; WGII 3.3.1, 3.4.1, 3.5.1}

NOTES:

1. FIGURES WERE DEVELOPED BY AVERAGING THE RESULTS OF 21 DIFFERENT CLIMATE MODELS OPERATING UNDER THE A1B SCENARIO.
2. SOURCE: BERSTEIN ET AL. - SEE REPORT REFERENCES SECTION.

0	14JAN'09	ISSUED WITH REPORT	KT	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

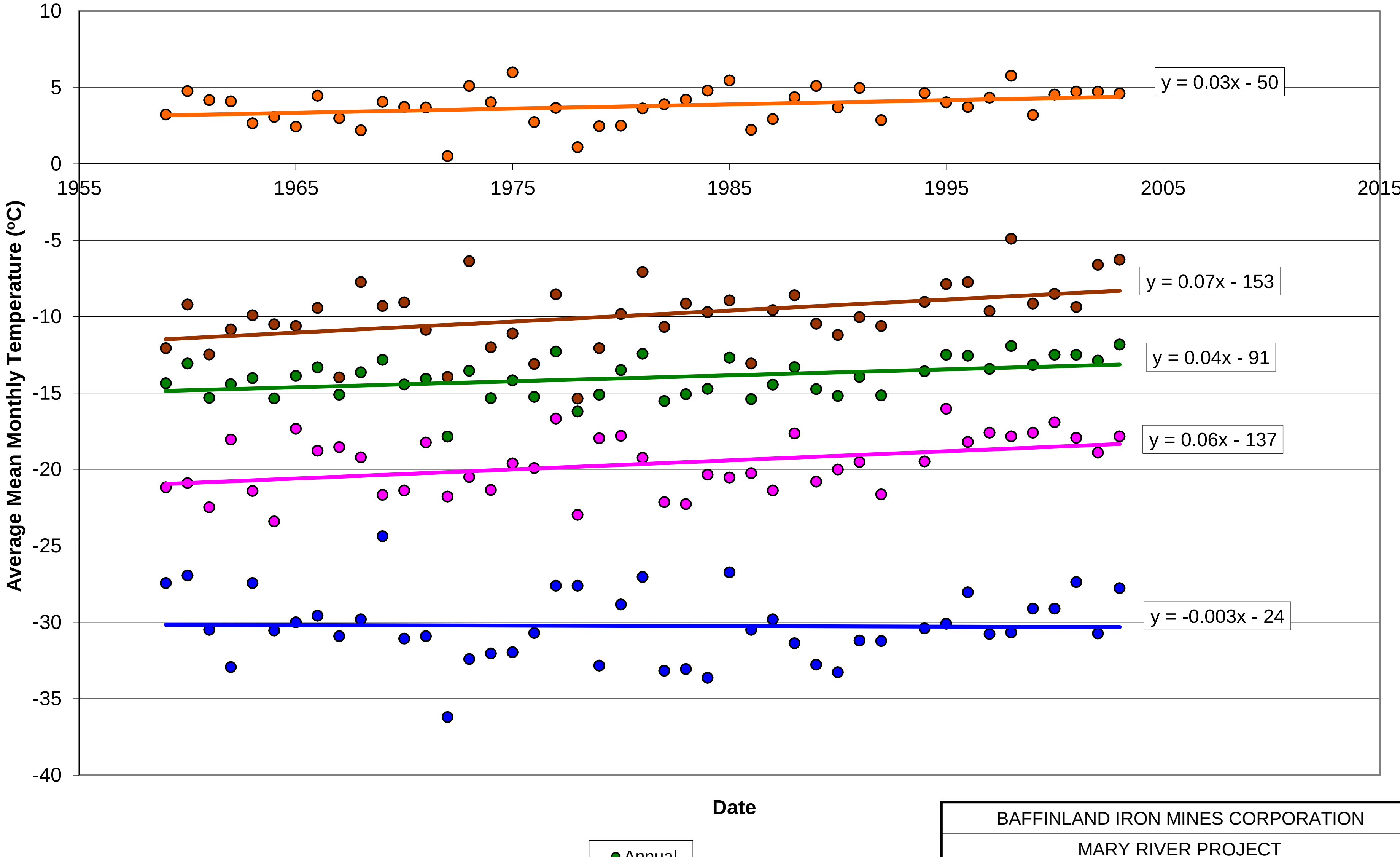
BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

PREDICTED CHANGES IN WORLD RUNOFF FROM 1980-1999 TO 2090-2099

Knight Piésold CONSULTING

PROJECT?ASSIGNMENT NO. NB102-181/30	REF NO. 7	
FIGURE 8.3		REV 0



0	14JAN'09	ISSUED WITH REPORT	KT	TJP	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HALL BEACH TEMPERATURE TRENDS (1959-2003)

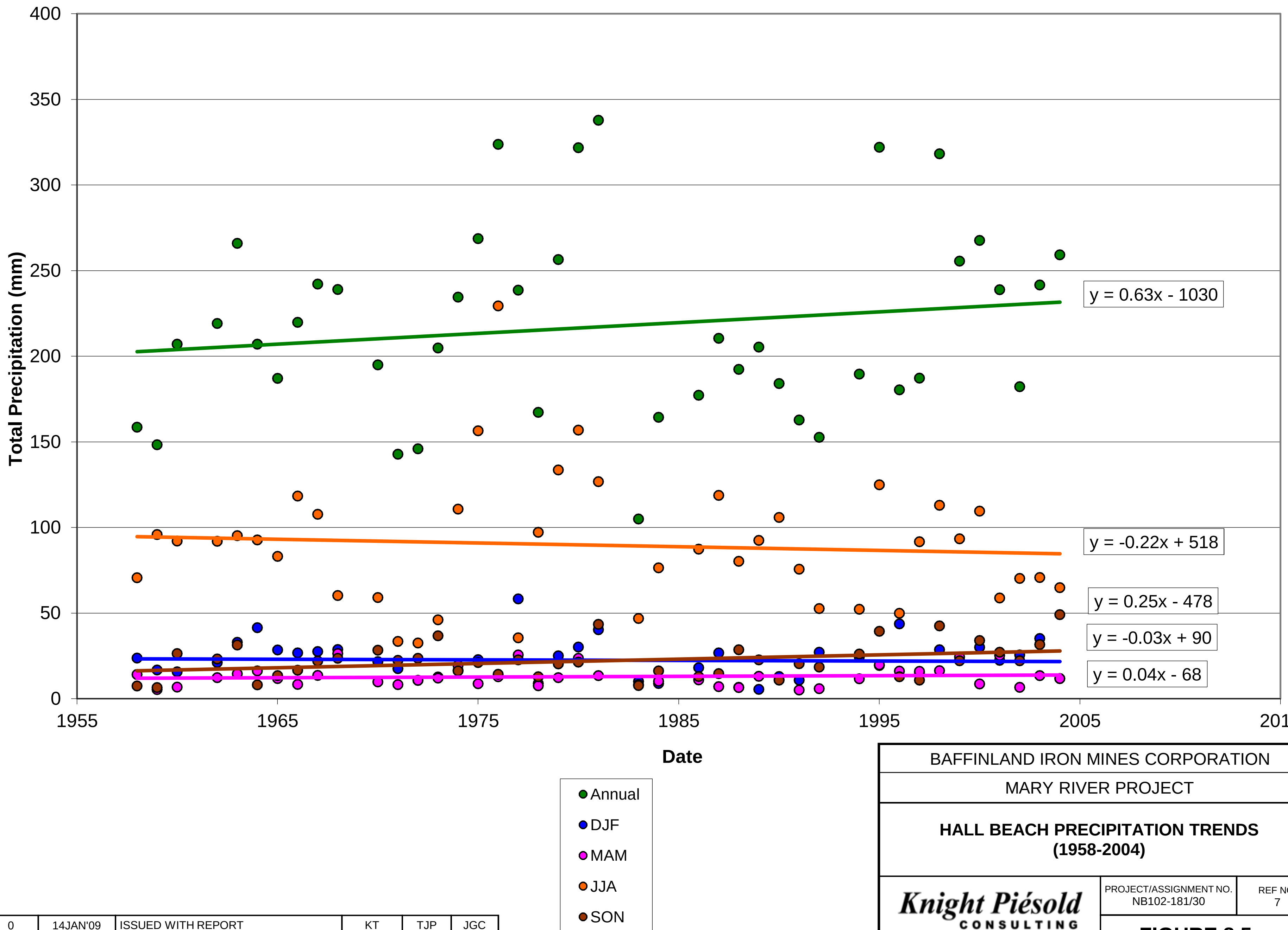
Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 8.4

REV 0



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HALL BEACH PRECIPITATION TRENDS (1958-2004)

Knight Piésold CONSULTING

PROJECT/ASSIGNMENT NO. NB102-181/30

REF NO. 7

FIGURE 8.5

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	14JAN'09	ISSUED WITH REPORT	KT	TJP	JGC

Knight Piésold
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APPENDIX A

PHOTO REPORT

(Pages A-1 to A-31)

PHOTO 1 – Looking upstream from H1 gauging site on June 3, 2008. (Discharge = 2 m^3/s)

PHOTO 2 – Looking upstream from H1 gauging station on June 19, 2008. (Discharge = 9 m^3/s)

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

PHOTO 3 – Looking upstream from H1 gauging station on July 31, 2008. (Discharge = 12 m^3/s)

PHOTO 4 – Looking downstream from H1 gauging site on July 31, 2008. (Discharge = 12 m^3/s)

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

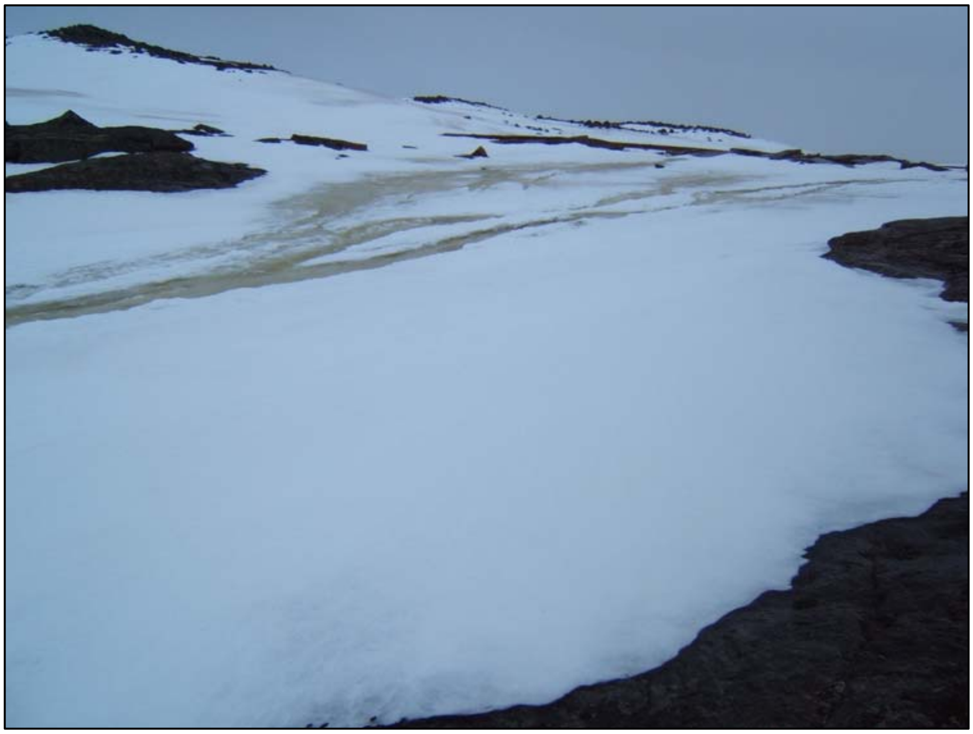

PHOTO 5 – Looking upstream from H1 gauging station on May 20, 2008. (Discharge ≈ 0 m^3/s)

PHOTO 6 –Looking upstream at H2 gauging station on July 31, 2008. (Discharge = 12 m^3/s)

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PHOTO 7 – Looking downstream from H2 gauging station on September 14, 2008. (Discharge = 1 m^3/s)

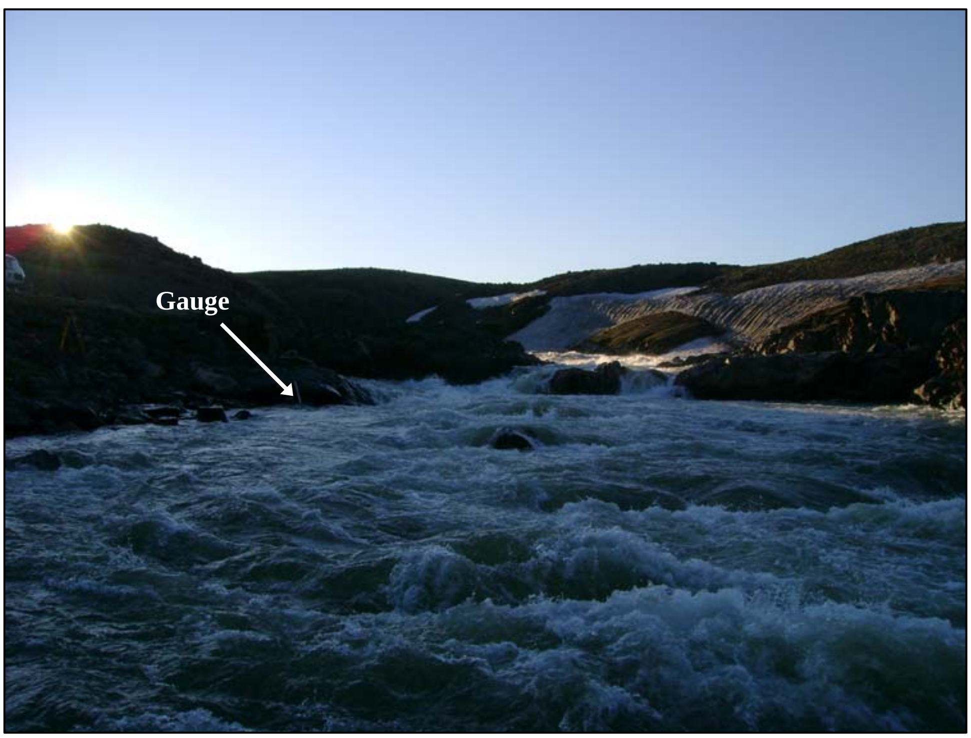

PHOTO 8 – Looking upstream towards H2 gauging station on June 26, 2008. (Discharge = 52 m^3/s)

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PHOTO 9 – Looking downstream from H2 gauging station on June 26, 2008. (Discharge = 52 m^3/s)

PHOTO 10 – Looking downstream towards H2 gauging site on April 21, 2008. (Discharge ≈ 0 m^3/s)

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PHOTO 11 - H3 gauging station on July 31, 2008. (Discharge = 2 m^3/s)

PHOTO 12 - H3 gauging station on Sept 14, 2008. (Discharge = 0.2 m^3/s)

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PHOTO 13 – Looking upstream from H3 gauging site on July 30, 2008. (Discharge = 2 m^3/s)

PHOTO 14 – Looking downstream from H3 gauging site on July 30, 2008. (Discharge = 2 m^3/s)

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PHOTO 15 – Looking upstream from H3 gauging site on May 20, 2008, (Discharge ≈ 0 m^3/s)

PHOTO 16 – H4 gauging site on July 31, 2008, (Discharge = 0.4 m^3/s)

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PHOTO 17 – Looking downstream from H4 discharge measurement site on July 30, 2008, (Discharge = 0.4 m^3/s)

PHOTO 18 – Looking upstream from H4 discharge measurement site on July 30, 2008, (Discharge = 0.4 m^3/s)

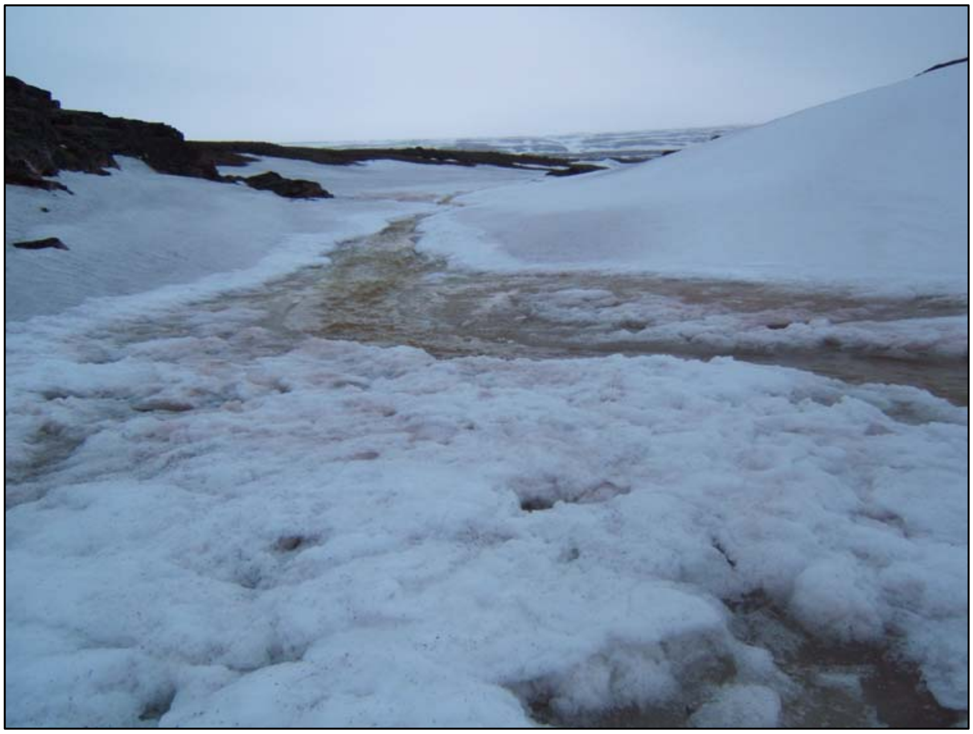

PHOTO 19 – Looking upstream from H4 gauging site on May 20, 2008

PHOTO 20 – Looking downstream from H4 gauging site on May 20, 2008, (Discharge = 0 m^3/s)

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PHOTO 21 – H5 gauging site on July 16, 2008, (Discharge = 0.03 m^3/s)

PHOTO 22 – Looking upstream from H5 gauging site on July 16, 2008, (Discharge = 0.03 m^3/s)

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PHOTO 23 – Looking downstream from H5 gauging station on Sept 13, 2008.

PHOTO 24 – Looking upstream from H5 gauging station on May 20, 2008.

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PHOTO 25 – H6 gauging station on Sept 13, 2008. (Discharge = 1 m^3/s)

PHOTO 26 – Looking upstream from H6 gauging station on July 31, 2008. (Discharge = 14.7 m^3/s)

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PHOTO 27 – Looking downstream from H6 gauging station on July 31, 2008. (Discharge = 14.7 m^3/s)

PHOTO 28 – Looking upstream from H6 gauging station on May 20, 2008. Discharge estimated at approximately 0.3 m^3/s.

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PHOTO 29 – H7 gauging station on July 18, 2008. (Discharge = 0.3 m^3/s)

PHOTO 30 – Looking upstream from H7 gauging station on July 31, 2008. (Discharge = 1.5 m^3/s)

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PHOTO 31 – Looking downstream from H7 gauging station on July 18, 2008. (Discharge = 0.3 m^3/s)

PHOTO 32 – Looking upstream towards H8 gauging station on Sept 14, 2008.

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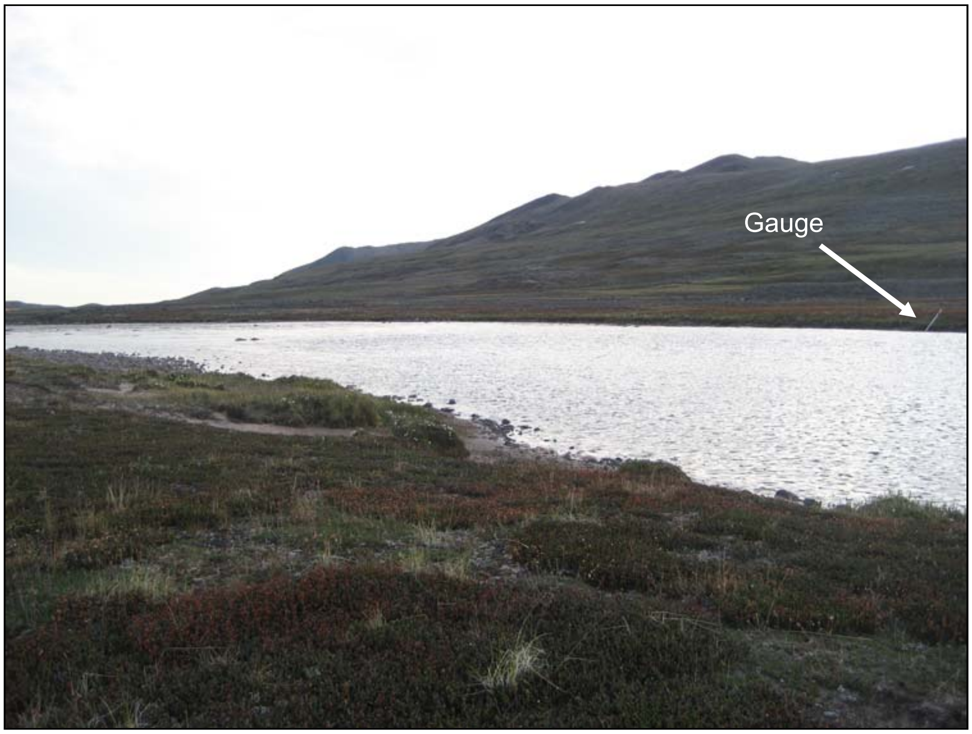

PHOTO 33 – H8 gauging station on July 19, 2008. (Discharge = 19 m^3/s)

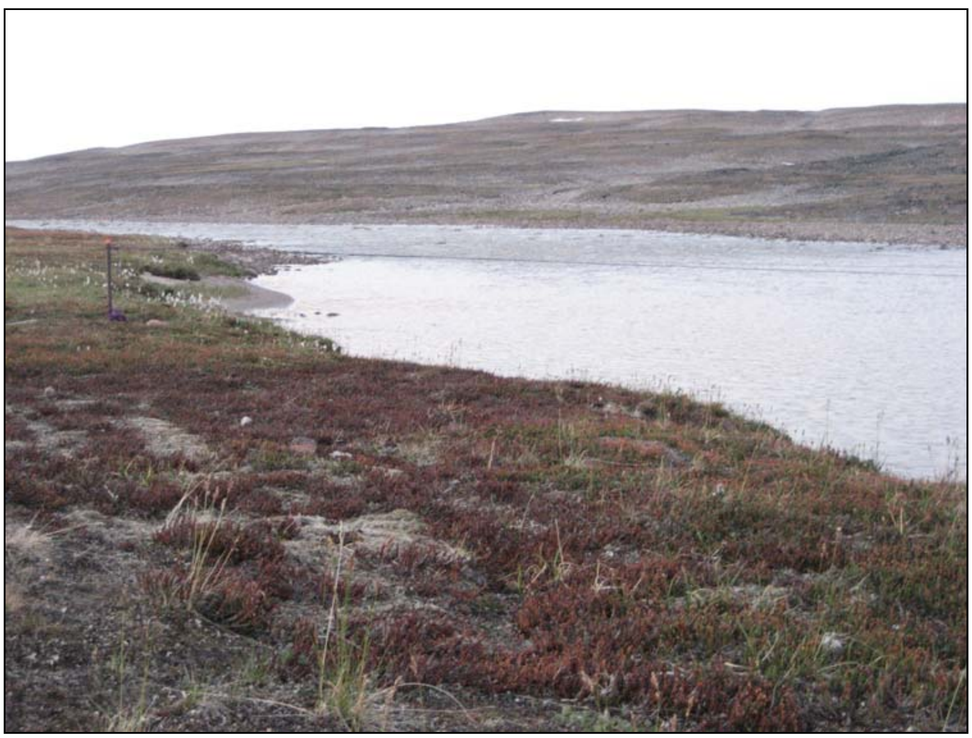

PHOTO 34 – Looking upstream from H8 gauging station on Aug 3, 2008. (Discharge = 3 m^3/s)

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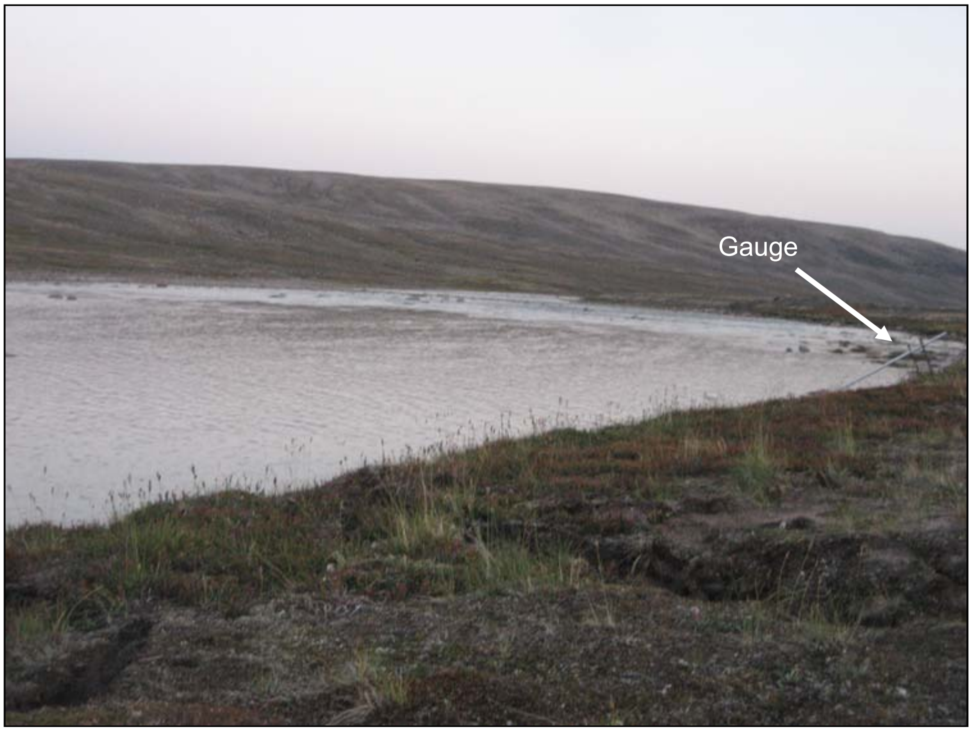

PHOTO 35 – Looking downstream from H8 gauging station on Aug 3, 2008. (Discharge = 3 m^3/s)

PHOTO 36 – H9 gauging station on July 30, 2008. (Discharge = 3 m^3/s)

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PHOTO 37 – Arial view of H9 gauging station on July 30, 2008. (Discharge = 3 m^3/s)

PHOTO 38 – Looking downstream from H9 gauging station on July 17, 2008. (Discharge = 1 m^3/s)

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PHOTO 39 – Looking upstream from H9 gauging station on July 17, 2008. (Discharge = 1 m^3/s)

PHOTO 40 – Looking upstream from H9 gauging station on June 31, 2008. (Discharge = 0 m^3/s)

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PHOTO 41 – H10 gauging station on Aug 3, 2008.

PHOTO 42 – Looking towards Sheardown Lake from H10 gauging station on July 7, 2008.

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PHOTO 43 – Looking towards Sheardown Lake from H10 gauging station on July 7, 2008.

PHOTO 44 – Arial View of H10 gauging station on Aug 3, 2008.

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PHOTO 45 – Arial View looking towards Mary River of H10 gauging station on Sept 16, 2008.

PHOTO 46 – H11 looking upstream on Sept 9, 2011.

PHOTO 47 – H11 looking upstream at the flow measurement location on Sept 9, 2011.

PHOTO 48 – H12 looking upstream on June 21, 2011.

PHOTO 49 – H12 looking downstream on June 21, 2011.

PHOTO 50 – BR11 gauging station on Sept 15, 2008. (Discharge = 0.2 m^3/s)

PHOTO 51 – Looking upstream at BR11 gauging station on June 25, 2008. (Discharge = 12 m^3/s)

PHOTO 52 – Looking downstream from BR11 gauging station on July 15, 2008. (Discharge = 2 m^3/s)

PHOTO 53 – Looking downstream from BR11 gauging station on June 1, 2008.

PHOTO 54 – Gauging station BR25 on September 15, 2008. (Discharge = 0.45 m^3/s)

PHOTO 55 – Looking upstream towards gauging station BR25 on June 25, 2008. (Discharge = 25 m^3/s)

PHOTO 56 – Looking upstream above gauging station BR25 on June 4, 2008.

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PHOTO 57 – Looking downstream below gauging station BR25 on July 29, 2008. (Discharge = 13 m^3/s)

PHOTO 58 – Gauging station BR96-2 on July 29, 2008. (Discharge = 1.2 m^3/s)

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PHOTO 59 – Looking downstream towards gauging station BR96-2 on September 14, 2008. (Discharge = 0.3 m^3/s)

PHOTO 60 – Looking upstream towards gauging station BR96-2 on June 10, 2008. (Discharge = 0.1 m^3/s)

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PHOTO 61 – Looking downstream towards gauging station BR137 on June 15, 2008. (Discharge = 8 m^3/s)

PHOTO 62 – Looking upstream from gauging station BR137 on Aug 2, 2008. (Discharge = 10 m^3/s)

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APPENDIX B

PEAK FLOW ANALYSIS

(Pages B-1 to B-8)

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Memorandum

Date:	October 13, 2006	Our Ref:	NB102-181/6-A.01
To:	Kevin Hawton	Cont.#:	VA06-01475
From:	Jaime Cathcart		
Re:	Hydrology for haul road design		

Kevin,

This memorandum briefly summarizes the hydrologic characteristics of the haul road area and the procedure used to develop design flow estimates for the haul road crossing of streams and rivers.

Hydrology

Baffin Island is one of the northernmost and coldest parts of Canada, and the project area, which is situated towards the northern end of the Island, has a mean annual temperature of approximately -12 °C, and monthly average temperatures that are below -20 °C from December to March and above freezing only from June through August, with a high of 4.4 °C in July. These extremely cold temperatures, combined with permafrost ground conditions, result in a short period of runoff that typically occurs from June to September.

All rivers and creeks, with perhaps the exception of the very largest systems, freeze completely solid during the winter months. Even the Sylvia Grinnell River near Iqaluit, which is the largest system on the Island that is continuously gauged by WSC (basin area of ~4000 km^2), freezes solid by April every year, when the active groundwater reserves are completely depleted or frozen. Streams and rivers usually begin to flow in late May with the melting of snow and ice, then peak in June or July with rising temperatures and corresponding snowmelt, before dropping steadily through to November when flows essentially cease. The peak runoff period is quite short and the volume of the annual hydrograph is low, relative to the rest of Canada, due the region's very low average annual precipitation of approximately 200 mm. The annual runoff coefficient is very high, however, due to the low temperatures (low evaporation) and the ground conditions of permafrost (low infiltration) and minimal vegetative cover (low transpiration). Correspondingly, surface water is abundant, and the region is dotted with thousands of small lakes and streams. The mean annual runoff in the area is typically in the order of 10 l/s/km^2.

The ground conditions are conducive to a very rapid basin runoff response, and peak flows are correspondingly quite large relative to rates of snowmelt and rainfall. Annual peak flows are due to snowmelt, rainfall, or rain and snowmelt, and most commonly occur in July, but may occur at any time during the non-freeze period. Flood water levels in the streams and rivers typically rise and fall very quickly.

Peak Design Flows

For the purpose of designing river and creek crossings for the bulk sample haul road, it was necessary to develop a design flow model. The hydrologic data currently being collected in the project area are of very short duration and the rating curves for the various measurement sites are not yet fully developed, so the

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data are not appropriate for this application. Rather, long-term historical peak flow and extreme rainfall data collected by Environment Canada were used. These data were combined with an understanding of the hydrologic characteristics of the area, as described above, to develop a series of peak flow scaling equations. Each equation corresponds to a different return period (flood severity) and requires an input of drainage area to generate a design flow estimate. The equations for return periods of 2 years, 5 years, 10 years and 25 years are presented, as follows:

$$\mathbf{Q_2 = 1.1 \times A^{0.79}}$$

$$\mathbf{Q_5 = 1.7 \times A^{0.77}}$$

$$\mathbf{Q_{10} = 2.0 \times A^{0.76}}$$

$$\mathbf{Q_{25} = 2.6 \times A^{0.75}}$$

Where, Q = peak instantaneous flow in m^3/s
A = drainage area in km^2

These equations were developed according to a regional scaling model using linear moment (L-moment) statistics computed from the historical peak daily flow records for five WSC stations, as summarized in Table 1. The regional scaling plots for the mean and L-standard deviation are shown on Figure 1. The “least squares fit” equations for these plots are shown in red, and the upper envelope equations are shown in black. The upper envelope equations were selected for design purposes because of the need to incorporate a reasonable margin of error into a model based on such a limited dataset, and because the flood values produced with the envelope equations agree much more closely with those generated by rain-fall runoff modelling using the IDF values summarized in Table 2 and on Figure 2.

In addition to estimates of the mean and L-standard deviation, an estimate of the L-coefficient of skewness (L-Cs) is also required for generating flood quantile values. The values shown in Table 1 indicate a wide range, with two of the five values negative. However, research at the University of BC (Cathcart, 2001) has indicated that the L-Cs may follow a similar scaling pattern to the L-Cv (ratio of the mean to the L-Stdev), given a large enough sample size, and that L-Cs values at any specific scale are often similar to, but slightly less than, that of the L-Cv. Given this information, and the understanding that higher L-Cs values correspond to higher design flows, it was considered prudent, yet reasonable, to use relatively high L-Cs values, so L-Cs values were selected to be slightly less than their associated L-Cv values.

Statistical parameters for basin scales of 10 km^2 and 1000 km^2 were determined to be:

For 10 km^2,
$Q_{mean} = 3.3\ m^3/s$
L-Stdev = 0.84 m^3/s
L-Cv = 0.25
L-Cs = 0.20

For 1000 km^2,
$Q_{mean} = 192\ m^3/s$
L-Stdev = 35 m^3/s
L-Cv = 0.18
L-Cs = 0.16

These parameters where then used to develop synthetic distributions of flood values at the two basin scales, and for this purpose a generalized extreme value (GEV) distribution type was selected. The GEV is commonly used in Canada to model flood distributions and is found to consistently provide a reasonable, yet conservative, fit to measured data (Cathcart, 2001). The derived distributions provided peak daily flood estimates for different return periods at the two scales. These values were used to develop scaling equations for peak daily flows at different return periods.

For design purposes, peak instantaneous values, rather than peak daily values, are required. The preceding discussion dealt with the estimation of peak daily flows, as there is not sufficient peak instantaneous regional data to develop meaningful scaling relationships. However, a limited number of concurrent peak daily and instantaneous flow data sets are available for the region, as summarized in Table 1. These values permitted the development of a regional envelope curve relating drainage areas to ratios of instantaneous to daily peak flow values, according to the equation:

$$I/D = 2.8 \times A^{-0.10}$$

Where, I/D = ratio of instantaneous peak flow to daily flow
A = drainage area in km^2

Application of this equation to the peak daily flow estimates resulted in a series of design flood estimates at different scales, from which the design flow equations for return periods of 2 years, 5 years, 10 years and 25 years were derived. These equations are considered applicable for basin areas ranging from 0.5 km2 to 1000 km2.

For basins smaller than 0.5 km2, it is recommended that the simple Rational Equation be used, as follows:

$$Q = 0.28\ CIA$$

Where, Q = peak instantaneous flow in m^3/s
A = drainage area in km^2
C = runoff coefficient = 0.90
I = rainfall intensity corresponding to the time of concentration.

Time of Concentration should be computed with the modified Kirpich equation: $T_c = 0.13\left(\frac{L}{\sqrt{S}}\right)^{0.77}$

Where, T_c = time of concentration in hours.
L= main channel length in km.
S = main channel slope.

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Signed: ____________________
Jaime Cathcart, Ph.D., P.Eng. - Specialist Engineer

Approved by: ____________________
Jeremy Haile, P.Eng. - President

Reference: Cathcart, J., 2001. The Effects of Scale and Storm Severity on the Linearity of Watershed Response Revealed Through the Regional L-Moment Analysis of Annual Peak Flows. Ph.D. Thesis, Resource Management and Environmental Studies, University of British Columbia, Vancouver, BC, Canada.

Encl:
Table 1 – Regional Flood Statistics for Daily and Instantaneous Peak Flow Records
Table 2 – Estimated Site Rainfall IDF values
Figure 1 – Regional Peak Flow Scaling Plots
Figure 2 – IDF Curves for Mine Site and Transportation Corridor

/jc

TABLE 1

BAFFINLAND IRON MINES CORPERATION
MARY RIVER PROJECT

REGIONAL FLOOD STATISTICS FOR DAILY AND INSTANTANEOUS PEAK FLOW RECORDS

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Rev'd Oct 4, 2006

Region	Station Name	WSC Data	Years of Record			Drainage Area (km^2)	Peak Daily Flows								Peak Instantaneous Flows							Ratio I/D
		Sta. ID	Begin - End	Daily	Instantaneous		mean (m^3/s)	unit mean ($m^3/s/km^2$)	Stdev (m^3/s)	Cv	Cs	L-Stdev (m^3/s)	L-Cv	L-Cs	mean (m^3/s)	Stdev (m^3/s)	Cv	Cs	L-Stdev (m^3/s)	L-Cv	L-Cs	mean
Baffin Island	Duval River near Pangnirtung	10UF001	1977-1983	2	5	95.5									26.24	10.74	0.41	0.08	6.68	0.26	0.07	1.68
	Sylvia Grinnell River near Iqaluit	10UH001	1971-1999	17	9	3980	361.23	0.09	130.48	0.36	-0.26	70.11	0.19	-0.03	422.11	119.75	0.28	0.48	69.86	0.17	0.08	1.10
	Apex River at Apex	10UH002	1973-1992	13	7	58.5	7.85	0.13	3.41	0.43	0.76	1.94	0.25	0.23	10.85	6.02	0.56	0.86	3.55	0.33	0.28	1.37
	Marcil Creek near Arctic Bay	10UB001	1978-1983	3	2	143.9	10.2	0.07	6.80	0.67	0.12	3.74	0.37	0.04								1.56
	Mecham River near Resolute	10VC002	1971-1979	4	2	86.8	22.21	0.26	8.42	0.38	0.79	4.71	0.21	0.21								1.91
	Allen River near Mouth	10VC001	1970-1984	6	5	448.0	60.75	0.14	22.67	0.37	-0.09	12.69	0.21	-0.01	112.34	13.65	0.12	0.44	8.46	0.08	0.16	1.74
Regional Average													0.25	0.09						0.21	0.15	1.56
Northern Quebec	Hamelin River next to Arnaud Rive	03HA009	1963-1978		16	4120	283.13	0.07	79.85	0.28	0.21	46.63	0.17	0.03								
	Hamelin River d/s of Pelletier Lake	03HA012	1980-1993		14	3760	231.64	0.06	58.43	0.25	-0.59	33.45	0.14	-0.10								
	False River	03MB001	1973-1991		24	2140	182.46	0.09	96.53	0.53	-0.73	51.29	0.29	-0.19								
	Tunulic River next to the mouth	03MC001	1973-1993		20	3680	578.15	0.16	131.04	0.23	-0.01	74.66	0.13	-0.002								

Notes:
1) Ratio I/D is the average of the annual ratios of the peak instantaneous to peak daily flows.
2) Statistics were not computed for datasets with 2 or less years of record.
3) Northern Quebec values provided for comparison purposes. Only peak daily statistics were computed.

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TABLE 2

BAFFINLAND IRON MINES CORPORATION
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ESTIMATED SITE RAINFALL IDF VALUES

Duration	Mean	St. Dv.	C.V.
5 min	0.8	0.3	0.35
10 min	1.2	0.4	0.35
15 min	1.5	0.5	0.35
30 min	2.5	0.9	0.35
1 hr	4	1.6	0.40
2 hr	6	2.4	0.40
6 hr	12	6.0	0.50
12 hr	16	8.0	0.50
24 hr	25	12.5	0.50

Year	2	5	10	15	20	25	50	100	200
Freq. Factor	-0.0164	0.719	1.305	1.635	1.866	2.044	2.592	3.137	3.679

Return Period Rainfall Amounts (mm)

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Duration	2 yrs	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	50 yrs	100 yrs	200 yrs
5 min	0.8	1.0	1.2	1.3	1.3	1.4	1.5	1.7	1.8
10 min	1.2	1.5	1.7	1.9	2.0	2.1	2.3	2.5	2.7
15 min	1.5	1.9	2.2	2.4	2.5	2.6	2.9	3.1	3.4
30 min	2.5	3.1	3.6	3.9	4.1	4.3	4.8	5.2	5.7
1 hr	4.0	5.2	6.1	6.6	7.0	7.3	8.1	9.0	9.9
2 hr	6.0	7.7	9.1	9.9	10.5	10.9	12.2	13.5	14.8
6 hr	11.9	16.3	19.8	21.8	23.2	24.3	27.6	30.8	34.1
12 hr	15.9	21.8	26.4	29.1	30.9	32.4	36.7	41.1	45.4
24 hr	24.8	34.0	41.3	45.4	48.3	50.6	57.4	64.2	71.0

Rainfall Intensity (mm/hr)

Duration	2 yrs	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	50 yrs	100 yrs	200 yrs
5 min	9.5	12.0	14.0	15.1	15.9	16.5	18.3	20.1	22.0
10 min	7.2	9.0	10.5	11.3	11.9	12.4	13.7	15.1	16.5
15 min	6.0	7.5	8.7	9.4	9.9	10.3	11.4	12.6	13.7
30 min	5.0	6.3	7.3	7.9	8.3	8.6	9.5	10.5	11.4
1 hr	4.0	5.2	6.1	6.6	7.0	7.3	8.1	9.0	9.9
2 hr	3.0	3.9	4.6	5.0	5.2	5.5	6.1	6.8	7.4
6 hr	2.0	2.7	3.3	3.6	3.9	4.0	4.6	5.1	5.7
12 hr	1.3	1.8	2.2	2.4	2.6	2.7	3.1	3.4	3.8
24 hr	1.0	1.4	1.7	1.9	2.0	2.1	2.4	2.7	3.0

Notes:
1) Data derived from IDF information published for climate stations at Clyde Airport (#2400800) and Pond Inlet Airport (#2403201) by the Atmospheric Environment Branch of Environment Canada.

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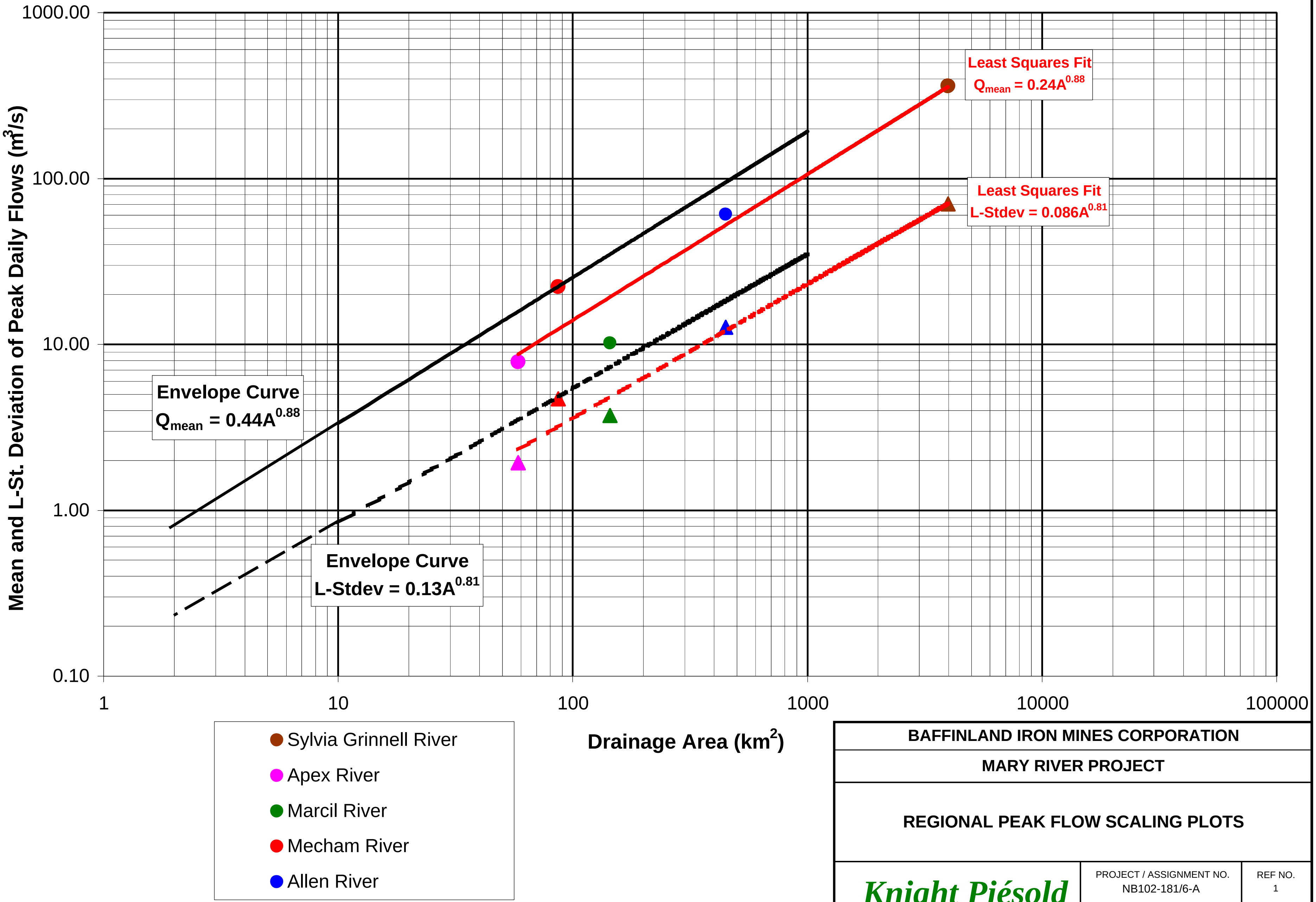

BAFFINLAND IRON MINES CORPORATION		
MARY RIVER PROJECT		
REGIONAL PEAK FLOW SCALING PLOTS		
Knight Piésold CONSULTING	PROJECT / ASSIGNMENT NO. NB102-181/6-A	REF NO. 1
	FIGURE 1	REV. 0

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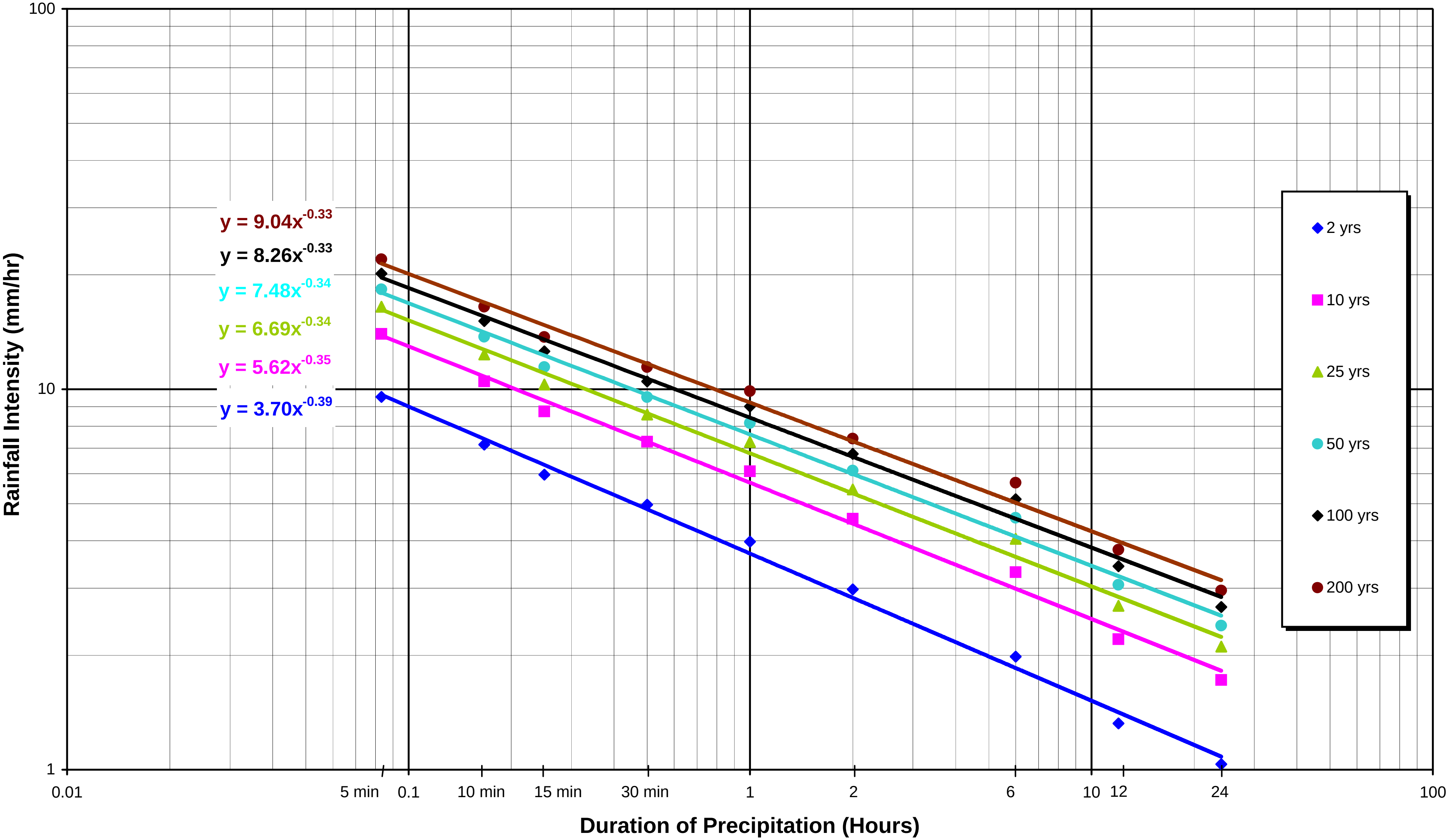

Notes:
1) IDF curves based on extreme precipitation data for Clyde Airport and Pond Inlet Airport, as published by Environment Canada.

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IDF CURVES FOR MINESITE AND TRANSPORATION CORRIDOR

Knight Piésold CONSULTING

PROJECT NO.	REF. NO.	REV.
NB102-181/6	1	0

FIGURE 2