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APPENDIX B

MARY RIVER REGIONAL HYDROLOGIC ANALYSIS

(16 Pages)

NB102-181/11-8
Rev 0
January 30, 2009

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Our Reference: NB102-181/11-A.01
Continuity Nbr.: VA08-01442

August 21, 2008

Mr. Richard Cook
Senior Scientist
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1650 Main Street West
North Bay, Ontario , P1B 8G5

Dear Richard,

Re: Mary River Regional Hydrologic Analysis

Since July 2006, Knight Piésold Ltd. (KPL) has been collecting hydrologic data in the vicinity of the proposed Mary River mine site for the purposes of characterizing the hydrologic regime of the mine site area and providing input to hydrologic analyses for the mine. A map showing the location of these gauges is provided on Figure 1 and preliminary analyses of these data are presented in the Hydrology Baseline Report (Knight Piésold Ltd, 2008). Approximately two and a half years of measured flow data are available for each of the project hydrology stations, but because of the high interannual variation of both the volume and timing of streamflow in the Arctic, this record length is insufficient to allow for complete hydrologic characterization. Ideally, long-term records of more than 20 years of streamflow data would be available for the analyses, but as this is not the case, an effort was made to correlate the site flow data with concurrent regional streamflow data, with the intent of using the resulting regression equations with long-term streamflow data to produce long-term synthetic flow datasets for the site stations. However, viable correlations could not be produced, and this result is attributed to the large distances between the limited regional stations available and the mine area, and the high spatial variability of both streamflow and precipitation on Baffin Island. Consequently, the final analysis was limited to estimating the mean annual discharge (MAD) for each hydrology station using ratios of concurrent and long-term regional precipitation data. The logical assumption was made that relative differences in regional annual precipitation, from year to year, would reflect relative differences in site annual runoff. The analysis and results of the above procedures are presented in the following sections.

Correlation of site and regional streamflow data

Water Survey of Canada (WSC) historical streamflow records were reviewed and data from stations on the Sylvia Grinnell River and the Apex River on Baffin Island, and on Freshwater Creek 1000 km east-south-east of Mary River on the mainland, were selected as most suitable for the analysis based on their proximity to the Project site, their catchment size, and their period of record. The sparse availability of hydrologic stations in the area surrounding Mary River is evidenced by the large distances (950 to 1000 km) between them and the site, and by the huge differences in their catchment areas, which range from 58.5 km^2 (Apex River) to 2980 km^2 (Sylvia Grinnell River). Other WSC gauges were located a similar distance from the Project site but their drainage areas were much too large to be appropriate for this analysis. Data from the selected stations were then correlated with concurrent periods of record from hydrology station H2, on the Tom River. Station H2 was selected because of the completeness of its streamflow record, and because of its relatively large drainage area (217.5 km^2), which is most similar in size to that of the regional stations.

The data correlation was done using simple linear regression, an example of which is shown on Figure 2. All of the regression results were very poor, with R^2 values equal to or less than 0.30. Ideally, R^2 values for this type of analysis should lie above 0.80. The records were then adjusted for differences in freshet timing due to the large range in latitude between the sites, but the regression results only improved to a best R^2 of 0.72, which is shown on Figure 3. The main reason for the poor results in this analysis is believed to be the large distances between Mary River and the regional sites, coupled with highly localized precipitation patterns. Long-term annual precipitation data at Iqaluit, which is in the vicinity of the regional streamflow stations, were compared to records at Hall Beach, Pond Inlet and Clyde River, and no correlations were found. Precipitation driven flow events were not common to all or even some of the sites, and heat driven melt events were not synchronous either, resulting in non-synchronous streamflow records. Shifting the flow records to match peaks during the freshet period did seem to improve the regression results; however, with only two years of data and significant spatial and temporal differences in summer precipitation, the results are marginal at best. It was therefore concluded that the streamflow regression models were not able to produce reasonable results, and an effort was then made to relate the short-term site streamflow records to concurrent regional climate records, with the intent of using long-term climate records to predict long-term flow values.

Investigating Precipitation-Runoff Modelling

Ideally, one would develop relations between monthly precipitation and site streamflow, such that long-term regional climate records could be used to model long-term site streamflow values. In this instance, however, it is not possible to simply correlate precipitation and streamflow on a monthly basis because of the effects of snow accumulation and melt on the flow pattern, and it is not possible to do this on an annual basis because of the limited period of site flow record. It may be possible to develop a sophisticated non-linear rainfall-runoff model, using precipitation and temperature values as input and the limited flow record for calibration purposes, but in order for this to be successful the climate record must be representative of climate conditions in the basins of interest. Climate records for Pond Inlet, Hall Beach, Nanisivik and Clyde River were chosen as potentially representative of the climate at Mary River based on and their relative positions surrounding the Mary River project site and their proximities to the site, which range in distance from 160 km for Pond Inlet to 400 km for Clyde River. An effort was made to correlate the data amongst three of these four sites. Nanisivik was excluded as its high elevation and the greater number of regional stations would only further complicate the analysis. The analysis was conducted according to the idea that if the surrounding regional sites have similar climate patterns then it follows that Mary River should as well. The shortest climate record is that of Pond Inlet, beginning in 1975, and therefore all three records were truncated at 1975, and then both the temperature and precipitation values for the concurrent period were regressed on a monthly and annual basis. Examples of the annual temperature and precipitation regression plots are shown on Figures 4 and 5, respectively, while the entire analysis is summarized in Table 1. Both Hall Beach and Clyde River temperatures are reasonably correlated with Pond Inlet temperatures, though not well with each other. However, there are no meaningful correlations between any of the regional precipitation records, which suggests that precipitation in the Mary River basin, and the corresponding streamflow patterns, are independent of the precipitation patterns of the regional stations.

To test this idea, the short-term precipitation data collected at the Mary River camp were regressed on a monthly basis against the concurrent precipitation records for Hall Beach and Nanisivik. The records were not analyzed annually as there are not enough data to permit it. Clyde River and Pond Inlet were excluded from this analysis as their records are not concurrent with Mary River's. Precipitation data at the camp were collected only during the summer months using a "TE525 Tipping Bucket Rain Gauge", and consequently no snowfall values were recorded. The results suggest that rainfall at both Hall Beach and

Nanisivik may be somewhat correlated with rainfall at Mary River on a monthly basis, as shown on Figure 6. However, because of the limited data used for these correlations and the lack of a Project snowfall record, these findings are not considered conclusive, and subsequently the likelihood of developing a meaningful rainfall-runoff model is not good. Given the substantial effort required to develop such a model, the decision was made to not proceed with such an exercise at this time. As a result, we are not able to produce long-term synthetic streamflow values for the Mary River hydrology stations.

Relating changes in precipitation to changes in streamflow

Faced with this situation, but still requiring preliminary estimates of mean annual discharge at each hydrology station, it was postulated that since annual precipitation must be correlated to annual runoff when assessed on an hydrologic year basis (October through September), a reasonable approach would be to use regional climate records to place the short-term site streamflow records in the context of long-term patterns. The logical assumption was made that relative differences in regional annual precipitation, from year to year, would reflect relative differences in site annual runoff. To test this assumption, annual precipitation at Iqaluit and concurrent annual runoff for the Apex River were compared, and the regression results, which are shown on Figure 7, support this idea. Therefore, it was concluded that the mean values of the short-term site streamflow records could reasonably be translated to equivalent long-term mean annual discharge values according to changes in the regional precipitation records.

Prior to doing this, the Project streamflow records were reviewed for completeness. Only 2007 had an entire season of streamflow recorded at any of the sites. For sites where a portion of the 2007 record was missing, the missing data were synthesized by either linear regression with data from a site with a complete record, or similarly by drainage area proration, resulting in a complete 2007 streamflow series at all the Project hydrology stations. To translate the mean values of this one year of record into equivalent long-term annual means, the potentially representative regional precipitation records at Hall Beach and Nanisivik were again analyzed. The total precipitation values for the 2007 hydrologic year (October 2006 through September 2007) were computed as percentages of the respective long-term mean precipitation. At Nanisivik, 2007 was 20% wetter than average, while at Hall Beach, 2007 was 10% wetter than average. On this basis, precipitation for the 2007 hydrologic year, and the corresponding 2007 streamflow at Mary River, were estimated to be 15% greater than normal.

In order to estimate annual variability in streamflow, coefficients of variation (cv - the standard deviation divided by the mean) were also calculated for both the Nanisivik and Hall Beach annual precipitation records, and were found to be 0.33 and 0.22, respectively. The value of 0.33 was chosen to represent the annual streamflow variation at the Mary River hydrology sites, since the high value is more conservative from water and environmental management perspectives. The 15% correction factor was applied to the 2007 mean annual discharge at each of the nine Mary River hydrology stations to calculate long-term mean annual discharges, and corresponding 10-year wet and dry annual return period flows were computed using the cv of 0.33 and assuming a Normal distribution. The results are summarized in Table 2. Table 3 presents estimated monthly distributions of streamflow as a percentage of MAD. These monthly values are based solely on the 2007 flow distribution, and while it is recognized that flow patterns vary from year to year, and that one year alone is not likely to represent the long-term average patterns, it does provide an indication of the variability of monthly flows between sites and the distribution of flows throughout the year.

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Effects of climate change

Future climate change will likely impact the timing and magnitude of streamflow at Mary River. A recent memo by Rowan Williams Davies and Irwin Inc. (RWDI), which outlines the effects of climate change at the Project site, suggests that precipitation will increase throughout the next century. Increased precipitation would logically result in increased streamflow; however, increasing temperatures, which are also predicted in the RWDI memo, may result in increased evaporation and/or sublimation that could counteract the increased precipitation effects. The mean annual discharge for each Mary River hydrology station was recalculated using the precipitation increases presented by RWDI, without adjustment for any streamflow reducing effects of increased temperature, as they cannot be quantified at this time. These results likely represent upper bound estimates of potential streamflow increases. The results are presented in Table 3. Climate change is also expected to change the shape of the annual hydrograph, with increasing temperatures resulting in an earlier freshet, less precipitation falling as snow, changes in permafrost conditions and increased intensity of storm events; however, we have not completed any analysis to assess these potential affects.

The results of the above analysis are based on limited data. There is also a high degree of uncertainty with respect to the applicability of the regional data to the Mary River Project site and it is recommended that the analysis should be updated as more data become available.

If you have any questions or comments please contact the undersigned.

Yours sincerely

KNIGHT PIESOLD LTD.

Kyle Terry, B.Sc.
Staff Scientist

Jaime Cathcart for Jeremy Haile, P.Eng.
President

References:

Knight Piésold Ltd. (2008). *Baffinland Iron Mines Mine Corporation Mary River Project Baseline Hydrology Report Rev B.* (Reference No. NB102-00181/7-6)

RWDI AIR Inc. (2008). *Addendum to Climate Change Memo: Climate Change Model Predictions for Input into the Mary River Definitive Feasibility Study.* (Reference No. W07-5226I)

Attachments:	Table 1 Rev 0	Regional Temperature and Precipitation Correlations
	Table 2 Rev 0	Summary of Synthetic Mean Annual Discharge (MAD)
	Table 3 Rev 0	Distribution of Streamflow as a Percentage of Mean Annual Discharge
	Table 4 Rev 0	Future Mean Annual Discharge as a Result of Climate Change
	Figure 1 Rev 0	Streamflow Gauging Stations – Mary River Project Site and

	Surrounding Area
Figure 2 Rev 0	Regional Hydrologic Analysis – Regression of H2 and Sylvia Grinnell River Daily Discharge Records (2007)
Figure 3 Rev 0	Regional Hydrologic Analysis – Regression of H2 and Sylvia Grinnell River Shifted Daily Discharge Records (2007)
Figure 4 Rev 0	Linear Regression of Annual Average Regional Temperature Records (1976-2006)
Figure 5 Rev 0	Linear Regression of Total Annual Regional Precipitation Records (1976-2004)
Figure 6 Rev 0	Linear Regression of Mary River and Hall Beach/Nanisivik Daily Rainfall Records (2006-2007)
Figure 7 Rev 0	Regional Hydrologic Analysis – Correlation of Apex River Annual streamflow and Iqaluit Annual Precipitation Records

cc: Steve Aiken

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TABLE 1

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

REGIONAL HYDROLOGIC ANALYSIS
REGIONAL TEMPERATURE AND PRECIPITATION CORRELATIONS

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Rev'd July 16, 2008

Sites	Temperature R^2 Correlation													
	January	February	March	April	May	June	July	August	September	October	November	December	Average Monthly	Annual
Pond Inlet and Hall Beach	0.76	0.76	0.78	0.71	0.69	0.66	0.27	0.49	0.64	0.83	0.61	0.66	0.66	0.83
Pond Inlet and Clyde River	0.76	0.8	0.73	0.62	0.86	0.69	0.59	0.32	0.79	0.75	0.7	0.72	0.69	0.71
Hall Beach and Clyde River	0.54	0.51	0.55	0.53	0.72	0.59	0.45	0.33	0.75	0.76	0.59	0.53	0.57	0.53

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Rev'd July 16, 2008

Sites	Precipitation R^2 Correlation													
	January	February	March	April	May	June	July	August	September	October	November	December	Average Monthly	Annual
Pond Inlet and Hall Beach	0.09	0.00	0.26	0.05	0.25	0.12	0.00	0.10	0.01	0.21	0.04	0.06	0.10	0.04
Pond Inlet and Clyde River	0.05	0.01	0.00	0.03	0.02	0.04	0.04	0.00	0.00	0.08	0.03	0.00	0.03	0.01
Hall Beach and Clyde River	0.20	0.14	0.21	0.04	0.00	0.08	0.01	0.01	0.04	0.01	0.14	0.10	0.08	0.04

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TABLE 2

BAFFINLAND IRON MINES CORPORATION
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REGIONAL HYDROLOGICAL ANALYSIS
SUMMARY OF SYNTHETIC MEAN ANNUAL DISCHARGE (MAD)

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Site	2007	Long Term Synthetic		Coefficient of Variation	10-Yr Return Period	
	MAD	MAD	MAUR		Dry MAD	Wet MAD
	m^3/s	m^3/s	$l/s/km^2$		m^3/s	m^3/s
H1	1.28	1.11	4.5	0.33	0.63	1.57
H2	1.46	1.27	5.8	0.33	0.75	1.85
H3	0.19	0.17	5.6	0.33	0.10	0.24
H4	0.05	0.04	4.3	0.33	0.02	0.06
H5	0.03	0.02	3.7	0.33	0.03	0.01
H6	1.89	1.64	6.8	0.33	0.95	2.33
H7	0.11	0.10	6.8	0.33	0.06	0.14
H8	1.51	1.31	6.3	0.33	0.76	1.86
H9	1.06	0.92	5.8	0.33	0.53	1.31

Notes:
1) A complete year of 2007 streamflow data was not collected at all sites. Data gaps were filled by creating synthetic streamflow records through regression analysis or area proration
2) Regional precipitation data from Hall Beach and Nanisivik were used to calculate the long term synthetic MADs
3) The 10-yr return periods assume a normal distribution

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TABLE 3

BAFFINLAND IRON MINES CORPORATION
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REGIONAL HYDROLOGICAL ANALYSIS
DISTRIBUTION OF STREAMFLOW AS A PERCENTAGE OF MEAN ANNUAL DISCHARGE

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Rev'd August 20, 2008

Site	Percentage of Mean Annual Discharge (%)											
	January	February	March	April	May	June	July	August	September	October	November	December
H1	0	0	0	0	0	346	508	299	98	0	0	0
H2	0	0	0	0	0	303	533	277	78	0	0	0
H3	0	0	0	0	0	325	579	236	85	0	0	0
H4	0	0	0	0	0	323	445	282	95	0	0	0
H5	0	0	0	0	0	373	340	328	80	0	0	0
H6	0	0	0	0	0	322	590	242	33	0	0	0
H7	0	0	0	0	0	356	574	227	60	0	0	0
H8	0	0	0	0	0	305	599	229	54	0	0	0
H9	0	0	0	0	0	325	579	236	85	0	0	0

Notes:
1) Monthly percentages based soley on 2007 streamflow data
2) No data were collected between the months of October through May. Flow was assumed to be zero based on casual observations by staff on site and temperature record.
3) The measured streamflow records do not begin at zero flow. Data were synthesized for missing portions by decay curve application and/or linear regression, depending upon the amount of data missing
4) Almost no streamflow data were recorded at H9 during June and July 2007. Percentages were assumed to be equal to those at H3 based upon catchment characteristics.

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TABLE 4

BAFFINLAND IRON MINES CORPORATION
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REGIONAL HYDROLOGICAL ANALYSIS
FUTURE MEAN ANNUAL DISCHARGE AS A RESULT OF CLIMATE CHANGE

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Rev'd August 12, 2008

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Site	Period			
	Current MAD	2020s MAD	2050s MAD	2080s MAD
	m^3/s	m^3/s	m^3/s	m^3/s
H1	1.11	1.11 - 1.25	1.11 - 1.39	1.29 - 1.67
H2	1.27	1.27 - 1.43	1.27 - 1.59	1.48 - 1.91
H3	0.17	0.17 - 0.19	0.17 - 0.21	0.20 - 0.26
H4	0.04	0.04 - 0.05	0.04 - 0.05	0.05 - 0.06
H5	0.02	0.02 - 0.02	0.02 - 0.03	0.02 - 0.03
H6	1.64	1.64 - 1.85	1.64 - 2.05	1.91 - 2.46
H7	0.10	0.10 - 0.11	0.10 - 0.13	0.12 - 0.15
H8	1.31	1.31 - 1.47	1.31 - 1.64	1.53 - 1.97
H9	0.92	0.92 - 1.04	0.92 - 1.15	1.07 - 1.38

Notes:

1) Climate change MADs were calculated using precipitation values provided by RWDI Inc. (2008) for the periods presented in the above table.

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