APPENDIX P

APPENDIX P WATER BALANCE CLIMATE AND HYDROLOGICAL ANALYSES

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To provide input for the water balance model for the TCA, climate and hydrological analyses were conducted to assess 10-year wet and 10-year dry conditions. The climate and hydrological analyses are described below.

CLIMATE ANALYSIS

Precipitation

Precipitation was recorded by the meteorological station at the Yellowknife Gold Project (YGP) site from October 2004 to December 2009. Precipitation, occurring as either rain or snow, was recorded as water equivalent.

Mean and Extreme Annual Precipitation

The long-term (1945-2009) and short-term (2004-2009) annual precipitation data was obtained for the Yellowknife Airport meteorological station (ID 2204100). This station, located 83 km southwest of the project site, is the closest climate station operated by the Meteorological Service of Canada.

The short-term mean annual precipitation at Yellowknife Airport was correlated with the precipitation records at the YGP meteorological station. A correlation ratio was developed based on 2005 to 2009 annual precipitation, as shown in Table P1.

TABLE P1: COMPARISON OF ANNUAL MEAN PRECIPITATION

	YGP Site Annual Precipitation (mm)	Yellowknife Airport Annual Precipitatio (mm)
2005	298	389
2006	263	304
2007	172	310
2008	288	398
2009	284	318
Mean	261	343
Correlation ratio	Project Site/Yellowknife Airport = 76%	

The correlation suggests that the project site receives an average of 24% less precipitation than Yellowknife Airport on an annual basis.

A frequency analysis of the Yellowknife Airport data was undertaken using the Hydrological Frequency Analysis Software package (HYFRAN) 1.1. Three different frequency analyses, the Generalized Extreme Value Distribution, the Three Parameter Lognormal Distribution and Log Pearson Type III Distribution, were applied to the long-term annual precipitation. The mean annual and 10-year extreme precipitations at Yellowknife Airport were calculated and are listed in Table P2.

TABLE P2: MEAN AND EXTREME ANNUAL PRECIPITATION		
	Yellowknife Airport Precipitation 1945-2009 (mm)	YGP Site Precipitation (mm)
Mean Annual	273	208
10-Year Wet	354	269
10-Year Dry	200	153

The correlation ratio was applied to the Yellowknife Airport precipitation frequency analysis results to estimate the long-term mean annual and extreme precipitation at the YGP site. As listed in Table P2, the mean annual precipitation at the project site is estimated to be 208 mm. The extreme annual precipitations under 10-year wet and 10-year dry conditions were estimated to be 269 mm and 153 mm, respectively. The monthly precipitation was distributed by taking an average of the 2005-2009 monthly distributions at the Yellowknife Gold meteorological station.

TABLE P3: MONTHLY PRECIPITATION FOR AVERAGE AND EXTREME YEARS (MM)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Percent Distribution	6%	6%	4%	5%	4%	10%	14%	18%	16%	6%	8%	3%	100%
Average	13	12	8	11	8	20	28	38	33	13	17	6	208
10-Yr Wet	17	16	10	14	11	26	36	49	43	17	22	8	269
10-Yr Dry	10	9	6	8	6	15	21	28	24	9	12	4	153

Evaporation

Pan evaporation was recorded at the YGP meteorological station from summer 2005 to 2009. A factor of 0.7 was used to convert pan evaporation rate to lake evaporation rate. The mean annual lake evaporation and monthly distribution were developed by taking the five-year average, see Table P4. It is noted that lake evaporation does not occur during the winter months (October to April) due to the freezing conditions.

TABLE P4: LAKE EVAPORATION AND MONTHLY DISTRIBUTION					
	Lake Evaporation (mm)				
	June	July	August	September	Annual
2005	95	64	67	13	240
2006	97	110	79	30	316
2007	110	113	58	16	296
2008	97	115	63	9	284
2009	68	126	106	31	330
Mean	93	106	75	20	293
Distribution (%)	32	36	25	7	100

HYDROLOGICAL ANALYSIS

Runoff

Runoff was calculated by dividing the total flow volume observed at a hydrometric station by its drainage area. Lake discharges were monitored at four hydrometric stations, namely Round Lake Outlet, Winter Lake Outlet, Narrow Lake Outlet, and Nicholas Lake Outlet, all within the YGP study area. The Narrow Lake station, which measures the combined discharge from Narrow Lake, Winter Lake, and Round Lake drainage basins, was selected to represent the runoff at the project site. It was noted in the 2008 hydrology report that the 2005-2007 spring freshets that peaked in the last two weeks of May were not completely recorded by the hydrometric station. The discharge data from the Water Survey Canada (WSC) hydrometric station, Yellowknife River at Inlet to Prosperous Lake (07SB003), was therefore used to provide an estimate of the annual runoff at the project site. A comparison of the regional stations in terms of the size of drainage area, watershed characteristics and the length of record, led to the selection of this station as the most applicable. It is located 60 km southwest of the YGP site with 68 years (1942-2009) of daily discharge records.

Mean and Extreme Annual Runoff

Monthly runoff June to September was calculated at the Narrow Lake Outlet and Yellowknife River hydrometric stations. A comparison of the short-term (2005-2009) average runoff June to September between the two stations revealed a marginal 5.3 mm difference. It is therefore reasonable to expand the selection to include spring freshet month (May) in the comparison and to assume the same runoff May to September at the project site as at the Yellowknife River station. Based on this assumption, the May runoff at the project site was calculated to be 13.6 mm by subtracting the site runoff Jun-Sep (38.6 mm) from Yellowknife River runoff May-Sep (52.2 mm), as presented in Table P5.

TABLE P5: RUNOFF COMPARISON BETWEEN PROJECT SITE AND YELLOWKNIFE RIVER STATION (MM)

	Yellowknife River Hydrometric Station					Narrow Lake Station				
	May	**Jun**	**Jul**	**Aug**	**Sept**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
2005	5.9	7.9	9.6	11.2	9.7	-	43.6	12.3	6.2	5.7
2006	14	21.3	21.2	17	12.8	-	21.3	10.3	5.7	6.6
2007	6.8	8.4	8.2	8.3	5.8	-	16.3	3.4	1.4	0.2
2008	4.9	5.1	3.9	3.5	5.4	-	6.5	2.7	0.6	4.6
2009	9.6	11.0	17.1	19.2	12.9	-	20.7	15.8	3.1	5.9
5-Year Mean	8.2	10.7	12.0	11.8	9.3	-	21.7	8.9	3.4	4.6
Runoff May and Jun-Sep	8.2	43.9				**13.6**	38.6			
Runoff May-Sep	52.2					Assumed: 52.2				

It was noted that the creeks near the YGP site did not flow during the winter freezing period (October to April). Accordingly, the annual runoff at the project site can be assumed equivalent to the runoff May to September at the Yellowknife River hydrometric Station. Frequency analysis was undertaken using the Hydrological Frequency Analysis Software package (HYFRAN) 1.1. Three different frequency analyses were applied to the long-term (1942-2009) runoff May to September at the Yellowknife River hydrometric station. The mean annual and extreme runoffs at the project site were calculated as averages from the three distributions and are listed in Table P6.

TABLE P6: MEAN AND EXTREME ANNUAL RUNOFF	
Mean Annual Runoff (mm)	42
10-Year Wet Runoff (mm)	68
10-Year Dry Runoff (mm)	20

Monthly Runoff Distribution

The monthly runoff was distributed based on the short-term runoff distribution from June to September using the Narrow Lake hydrometric station and the freshet runoff developed from the Yellowknife River hydrometric station. A summary of the short-term (2005-2009) mean monthly runoff and the percentage monthly distribution at the YGP site are given in Table P7.

TABLE P7: MONTHLY RUNOFF FOR AVERAGE AND EXTREME YEARS (MM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Percent Distribution	0%	0%	0%	0%	26%	42%	17%	7%	9%	0%	0%	0%	100%
Average	0	0	0	0	10.9	17.3	7.1	2.7	3.7	0	0	0	41.7
10-Yr Wet	0	0	0	0	17.8	28.3	11.6	4.5	6.0	0	0	0	68
10-Yr Dry	0	0	0	0	5.1	8.1	3.3	1.3	1.7	0	0	0	19.5

The monthly runoff distribution indicates that the snowmelt freshet typically starts in May and peaks in June. Flows after June are usually due to rainfall and decline to zero by the end of September.