APPENDIX A: Climate and Meteorology

A-1. Meteorology Data Analysis Update

MEMORANDUM

To:	Mr. Bob Jacko	Date:	May 27, 2015
		File No.:	VA101-460/3-A.01
From:	Brendan Worrall	Cont. No.:	VA15-02445
Re:	Black Butte Copper Project Meteorology Data Analysis Update		

1 – INTRODUCTION

Knight Piésold Ltd. (KP) has been retained by Tintina Resources to complete a site wide water balance for the Black Butte Copper Project site, for the purpose of providing estimates of water that may be required during the Mill start-up phase. This memorandum details the methods and data used to generate long-term estimates of precipitation and evaporation for the Project location. These parameters are used as inputs to the Site Water Balance. The data presented in this memo supersede data presented in VA15-02387.

2 – PROJECT SITE DATA: TINTINA STATION

KP was provided site specific meteorological data from the Tintina weather station. This station is located at the Black Butte Project site at an elevation of approximately 1737 meters above sea level (masl), as shown on Figure 1. Site data were provided to KP by Bison Engineering and are available from April 2012 to December 2014. Months that had fewer than 20 days of recorded data were excluded from the summaries shown in Table 1 and the subsequent data analyses. The precipitation and temperature records have 27 and 30 monthly values respectively. The precipitation record for March 2013 contains a one-day event in which 102 mm (4 in) of precipitation was recorded.

Table 1 Tintina Station Precipitation and Temperature

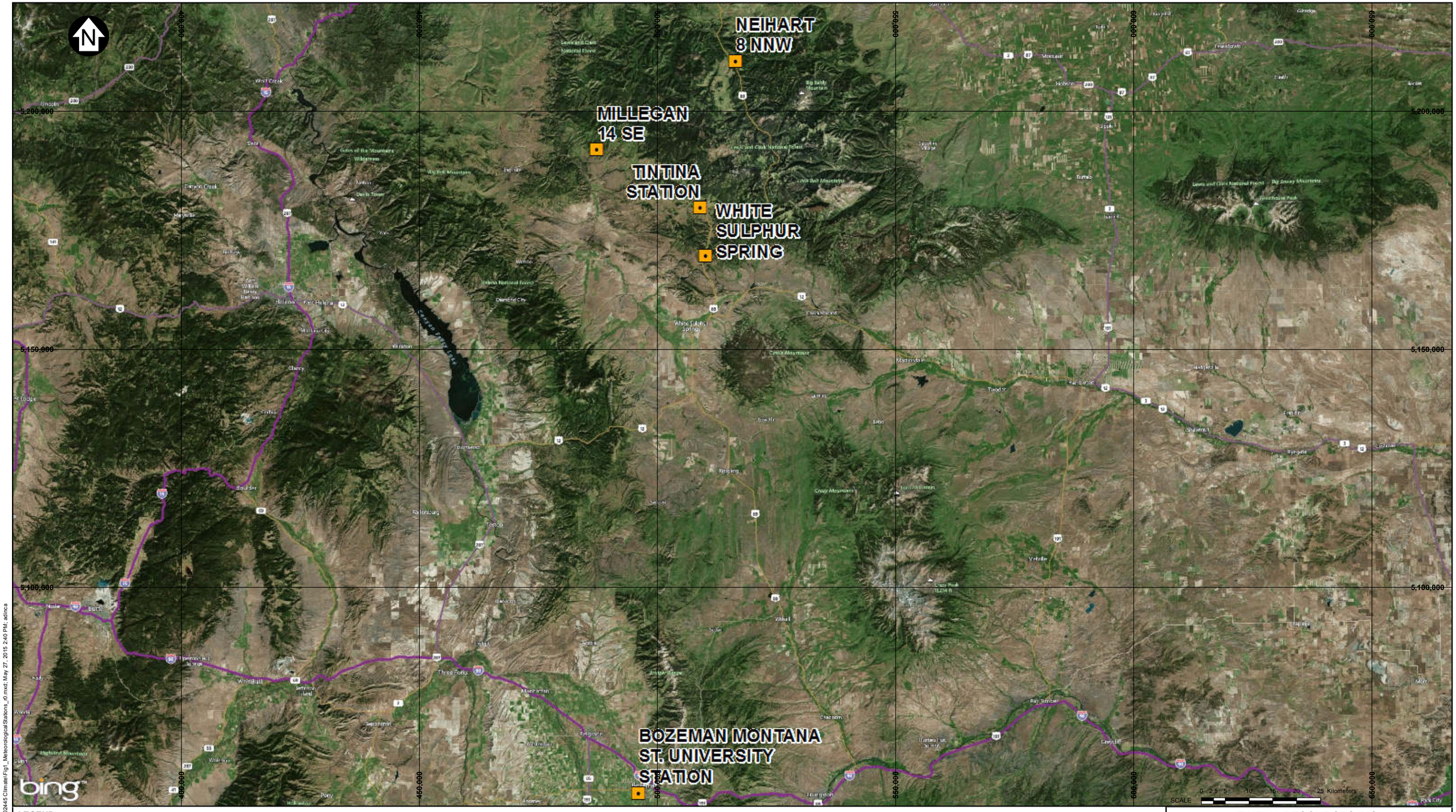
Precipitation (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012					63	88	45	12	4	46	28	7	-
2013	17	34	184	23	68					10	19	34	-
2014	41	4	79	47	21	144	31	82	37	19	13		-
Average	29	19	132	35	51	116	38	47	20	25	20	21	552

Temperature (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012					5.6		16.9	15.1	9.8	1.5	-2.0	-8.0	-
2013	-8.0	-7.2	-4.0	-0.3	7.5	11.6	16.7		11.2	-0.4	-3.3	-10.2	-
2014	-7.8	-13.2	-3.9	0.8	7.0	9.0	15.8	13.8	8.7	5.1	-6.0	-6.5	-
Average	-7.9	-10.2	-3.9	0.2	6.7	10.3	16.5	14.4	9.9	2.1	-3.8	-8.2	2.2

The measured records at Tintina station indicate a mean annual precipitation of 552 mm and a mean annual temperature of 2.2 ^{o}C. The monthly temperature data were used with the Thornthwaite equation to estimate a mean annual potential evapotranspiration (PET) of 441 mm, as shown in Table 2. PET is considered to be generally equivalent to pond evaporation.



LEGEND:

- METEOROLOGICAL STATION

NOTES:

1. BASE MAP: BING ONLINE.

2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 12N.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	27MAY'15	ISSUED WITH MEMO	BTW	KK	KDE

TINTINA RESOURCES INC.

BLACK BUTTE COPPER PROJECT

METEOROLOGICAL STATIONS

Knight Piésold CONSULTING

P/A NO. VA101-460/3

REF NO. VA15-02445

FIGURE 1

REV 0

SAVED: M:\1\101\00460\03\A\GIS\Figs\VA15-02445 Climate\Fig1_MeteorologicalStations_r0.mxd; May 27, 2015 2:40 PM; adinca

Table 2 Tintina Station PET (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012					50		123	104	63	12	0	0	-
2013	0	0	0	0	62	89	121		70	0	0	0	-
2014	0	0	0	9	59	73	116	96	57	34	0	0	-
Average	0	0	0	4	57	81	120	100	63	15	0	0	**441**

3 – REGIONAL DATA: BOZEMAN STATION AND MILLEGAN STATION

Four regional meteorological stations were investigated for comparison with the Tintina station. The locations of these stations are shown on Figure 1 and the mean annual meteorology values are summarized in Table 3.

Table 3 Regional Station Summary

Station	Elevation (masl)	Period of Record	Mean Annual Precipitation (mm)	Mean Annual Temperature (^{o}C)	Mean Annual Pan Evaporation (mm)
Bozeman	1,482	1892 - 2015	470	6.2	936
Millegan 14 SE	1,515	1984 - 2015	473	5.0	-
White Sulphur Spring	1,658	1949 - 1981	402	-	-
Neihart 8 NNW	1,594	1967 - 2013	542	5.4	-

Two of the regional stations above have periods of record concurrent with the entire Tintina record: Bozeman and Millegan 14 SE (Millegan). Data from both stations show strong correlation with the Tintina data, and both have long-term records available (longer than 30 years). The Bozeman station is located approximately 125 km south of the Tintina station at an elevation of approximately 1480 masl; the Millegan station is located approximately 25 km northwest of the Tintina station at an elevation of approximately 1515 masl. The Bozeman station has a mean annual precipitation of 470 mm, a mean annual temperature of 6.2 °C, and a mean annual pan evaporation of 936 mm. The Millegan station has a mean annual precipitation of 473 mm and a mean annual temperature of 5.0 °C; no pan evaporation data are available. The precipitation and temperature values for Bozeman and Millegan are based on a period of record from 1892 to 2015 and from 1984 to 2015, respectively. The pan evaporation at Bozeman is based on a period of record from 1948 to 1969.

3.1 BOZEMAN POND EVAPORATION ESTIMATES

Two estimates of pond evaporation were generated for the Bozeman station. First, pond evaporation was calculated by applying a standard pan coefficient of 0.70 to the measured pan evaporation values (1948-1969), yielding a mean annual value of 655 mm. Second, monthly PET was calculated using the monthly mean temperature data (1892-2015) and the Thornthwaite equation, yielding a mean annual value of 556 mm. Both estimates of pond evaporation exceed the mean annual precipitation for the Bozeman station, as shown in Table 4.

Table 4 Bozeman Station Precipitation and Estimated Pond Evaporation (mm)

Parameter	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation	1892 - 2015	22	19	34	48	74	74	34	32	43	39	28	23	470
Pond Evaporation (70% Pan Evaporation)	1948 - 1969	0	0	0	59	96	107	144	126	77	46	0	0	655
Pond Evaporation (Thornthwaite)	1892 - 2015	0	1	6	33	69	97	126	113	69	36	5	0	556

3.2 MILLEGAN POND EVAPORATION ESTIMATE

As with Bozeman, monthly PET was calculated using the monthly mean temperature data (1984-2015) and the Thornthwaite equation, yielding a mean annual value of 516 mm. This estimate of pond evaporation at Millegan exceeds the mean annual precipitation for the Millegan station as shown in Table 5.

Table 5 Millegan 14 SE Station Precipitation and Estimated Pond Evaporation (mm)

Parameter	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation	1984 - 2015	22	19	31	45	66	82	52	42	35	31	25	24	473
Pond Evaporation (Thornthwaite)	1984 - 2015	0	0	6	29	64	92	120	106	66	30	2	0	516

4 – LONG-TERM ESTIMATES FOR PROJECT SITE: TINTINA-BOZEMAN COMPARISON

The short-term monthly precipitation and temperature records collected at the Tintina station were compared to the concurrent records for the Bozeman station to develop scaling relationships. These relationships were applied to the respective long-term Bozeman records to generate synthetic temperature and precipitation series for the Project site. The resulting temperature series was used to develop estimates of long-term evaporation for the site.

4.1 PRECIPITATION

The precipitation data were correlated using a double mass curve analysis, as shown on Figure 2. March 2013 was excluded from the analysis because the extreme event recorded at the Tintina station did not occur in the Bozeman record. The exclusion of March 2013 from the analysis is a conservative approach with respect to water availability at the Project site and does not suggest that the Tintina data for March 2013 are erroneous. The resulting curve is reasonably stable and has a slope of 1.08 when the best-fit line is taken through the origin, indicating that the site receives slightly more precipitation than Bozeman. Applying the calculated factor of 1.08 to the Bozeman precipitation record results in a long-term mean annual precipitation estimate for the Project site of 507 mm. This value is similar to, but slightly lower than, the mean annual precipitation recorded at the Tintina site from 2012 to 2014 (552 mm).

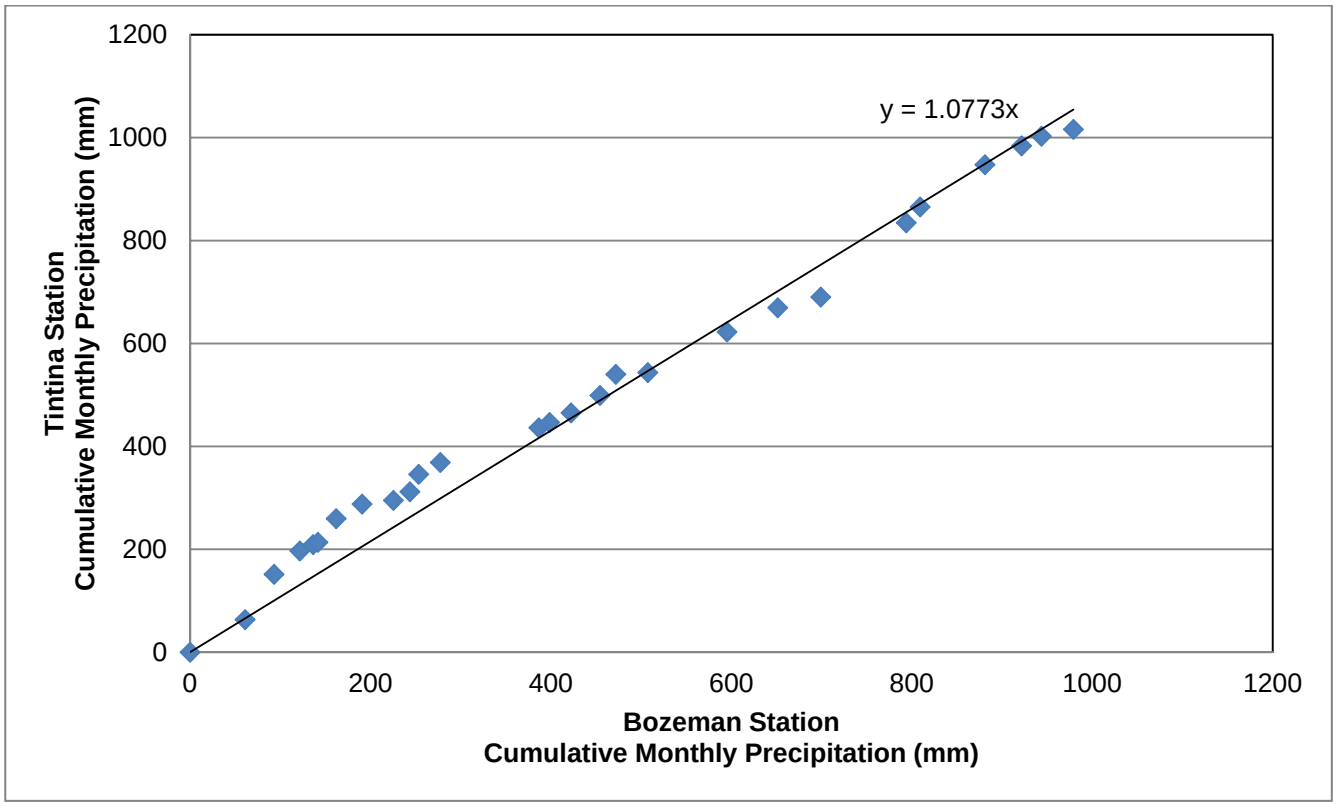


Figure 2 Tintina-Bozeman Precipitation Double Mass Curve

4.2 TEMPERATURE

The temperature data were correlated using a simple linear regression analysis, as shown on Figure 3. The resulting curve indicates that the datasets are strongly correlated and that the Project site is consistently approximately 4.7 ^{o}C colder than Bozeman. The regression equation was applied to the long-term Bozeman temperature record to develop a synthetic temperature series for the Project site. The mean annual value for this series is 1.5 °C, which is similar to the mean annual temperature recorded at the site from 2012 to 2014 (2.2 ^{o}C).

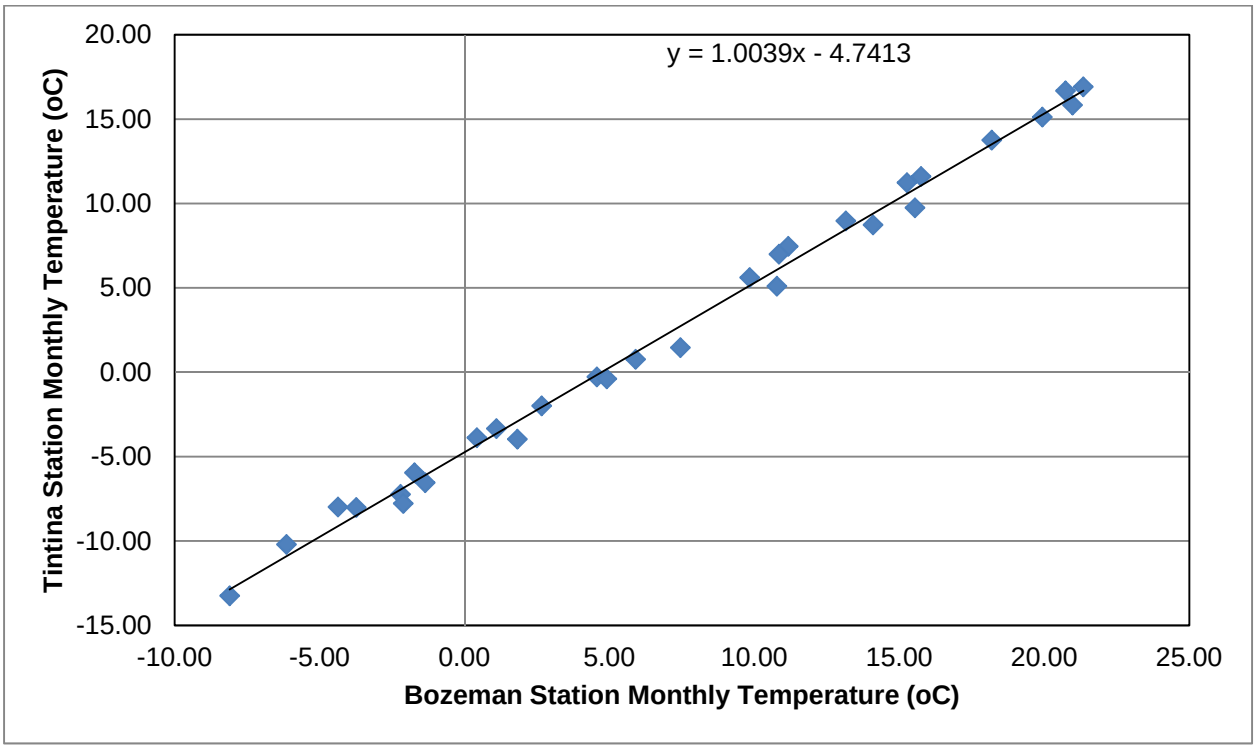


Figure 3 Tintina-Bozeman Temperature Regression

4.3 EVAPORATION

The long-term monthly Tintina-Bozeman temperature series for the Project site and the Thornthwaite equation were used to estimate a long-term mean annual PET for the site of 436 mm. This value is approximately 120 mm lower than the long-term mean annual PET for the Bozeman station (556 mm). This result, which corresponds to a ratio of Project site to Bozeman PET of 0.78, is due to the lower temperatures at the Project site.

An alternative estimate of long-term pond evaporation for the Project site was made by scaling the Bozeman station pond evaporation estimate that was based on the long-term pan evaporation record. The pan-based pond evaporation estimate for Bozeman was scaled to the Project site by the derived PET ratio between the two sites of 0.78. The estimated pond evaporation for the Bozeman station derived on the basis of the pan evaporation records was 669 mm, so applying a factor of 0.78 results in an alternative pond evaporation estimate of 525 mm for the Project site.

5 – LONG-TERM ESTIMATES FOR THE PROJECT SITE: TINTINA – MILLEGAN COMPARISON

The short-term monthly precipitation and temperature records collected at the Tintina station were also compared to the concurrent records for the Millegan station to develop scaling relationships. These relationships were applied the respective long-term records to generate long-term temperature and precipitation series for the Project site. The resulting temperature series was used to develop an estimate of long-term evaporation for the site.

5.1 PRECIPITATION

The precipitation data were correlated using a double mass curve analysis, as shown on Figure 4. Again, March 2013 was excluded from the analysis because the extreme event recorded at the Tintina station did not occur in the Millegan record. The resulting curve is reasonably stable and has a slope of 0.88 when the best-fit line is taken through the origin, indicating that the Project site generally receives slightly less precipitation than Millegan (March 2013 being the exception). Applying the calculated factor of 0.88 to the Millegan precipitation record results in a long-term mean annual precipitation estimate for the Project site of 416 mm. This value is substantially lower than the mean annual precipitation recorded at the Tintina site from 2012 to 2014 (552 mm), even after taking March 2013 into account. This is because the Millegan station recorded wetter conditions during the period of comparison (2012-2014) than during its long-term period of record. By generating a synthetic precipitation series for the Tintina station based on the 2012 to 2014 period of comparison, the same relationship between the period of comparison and the long-term period is implicitly assumed to apply at both the Millegan and Tintina stations.

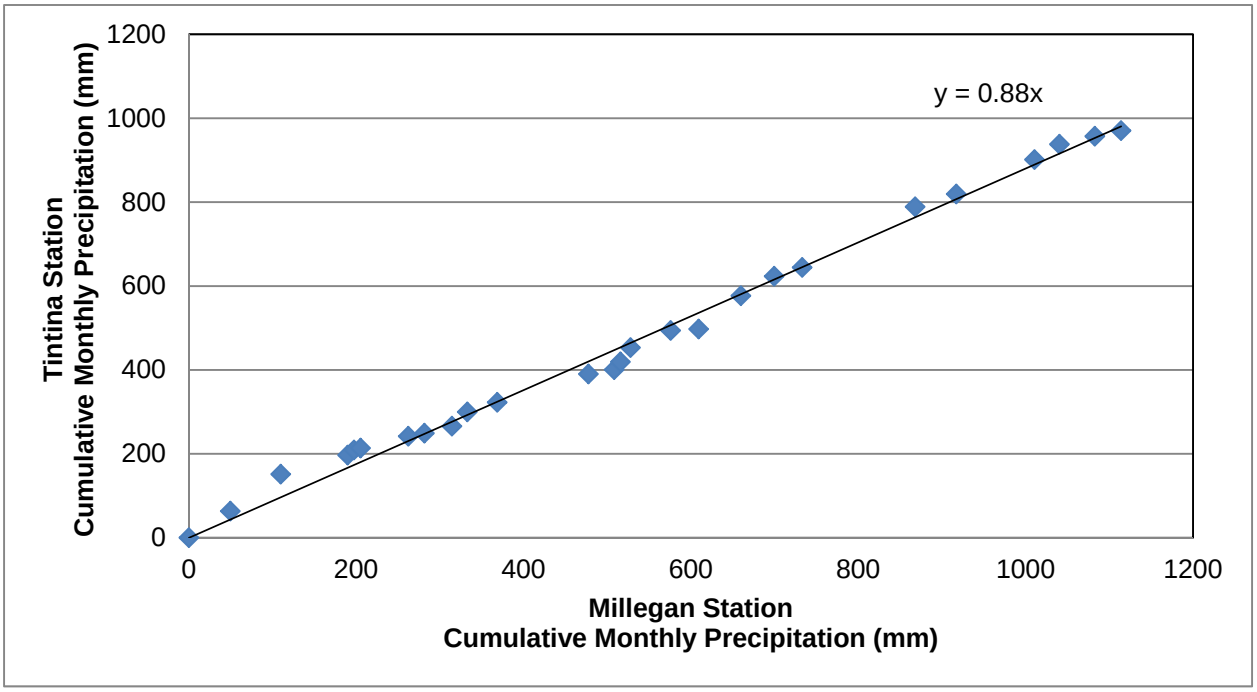


Figure 4 Tintina-Millegan Double Mass Curve

5.2 TEMPERATURE

The temperature data were correlated using a simple linear regression analysis, as shown on Figure 5. The resulting curve indicates that the datasets are strongly correlated and that the site is consistently approximately 3.1 ^{o}C colder than Millegan. The regression equation was applied to the long-term Millegan temperature record to develop a long-term synthetic temperature series for the Project site. The mean annual temperature for this series is 1.9 °C, which is similar to the mean annual temperature recorded at the site from 2012 to 2014 (2.2 ^{o}C).

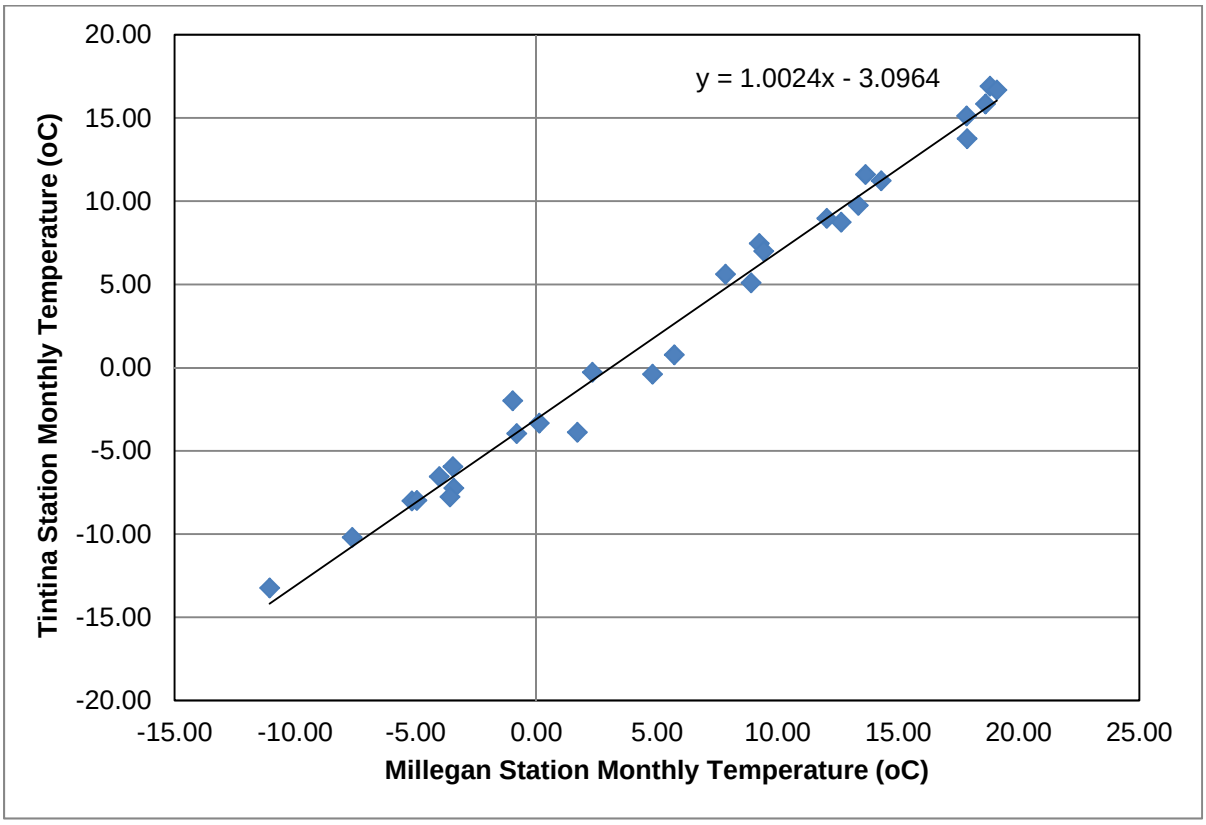


Figure 5 Tintina-Millegan Temperature Regression

5.3 EVAPORATION

The long-term monthly Tintina-Millegan temperature series for the Project site and the Thornthwaite equation were used to estimate a long-term mean annual PET for the site of 424 mm. This value is approximately 92 mm lower than the long-term mean annual PET for the Millegan station (516 mm). This result is due to the lower temperatures at the Project site.

6 – SUMMARY AND RECOMMENDATIONS

Two analyses were completed for the Project site in order to obtain the best possible estimate of precipitation, temperature and evaporation.

Synthetic series of monthly precipitation and temperature were generated for the Black Butte Project site (Tintina meteorological station, elevation 1737 masl) for the period 1892 to 2015 using the Bozeman station, and for the period 1984 to 2015 using the Millegan station. The mean annual precipitation values calculated for the Project site are 507 mm and 416 mm, respectively. These are lower than the mean annual precipitation recorded at the Tintina station in 2012 to 2014. The Millegan station, located close to the Project site, indicates that the 2012 – 2014 period was wetter than the long-term average, whereas the Bozeman station indicates that the 2012 – 2014 period deviated less from the long-term average conditions. It is recommended to adopt the long-term precipitation estimate for the Project site based on the Tintina-Millegan comparison because the Millegan station is located closer to the Project site, and can be considered more representative of Project site climate patterns, and because the Tintina-Millegan estimate yields a more conservative result with respect to water supply availability.

Three estimates of long-term mean annual pond evaporation were generated for the Project site. Two estimates are based on temperature values and the Thornthwaite equation. Analysis using the Tintina-Bozeman temperature series yields a mean annual PET of 436 mm; and analysis using the Tintina-Millegan temperature series yields a mean annual PET of 424mm. The third estimate, which is based on pan evaporation at the Bozeman station scaled to the Project site, yields a mean annual pond evaporation value of 514 mm. Given the level of uncertainty in the evaporation estimates, it is recommended that the most conservative approach be applied for water balance analyses, and as such the highest evaporation estimate (514 mm) for the Project site should be used for modelling purposes.

The values presented below in Table 6 represent those considered to be most representative of the Project site when the most conservative approach, with respect to water availability, is taken. The values below represent an average annual water deficit of 98 mm.

Table 6 Long-Term Project Precipitation and Pond Evaporation

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (mm)	20	17	27	39	58	72	45	37	31	27	22	21	416
Pond Evaporation (mm)	0	0	0	47	76	84	113	99	60	36	0	0	514

Table 7 presents the wet and dry annual precipitation values up to the 1:100 return period. These values are calculated based on the mean annual precipitation, and the standard deviation of complete annual precipitation values, calculated using the annual precipitation values from the Tintina-Millegan precipitation series. The analysis assumes a normal distribution.

Table 7 Wet and Dry Return Period Project Precipitation

Return Period	Annual Precipitation (mm)
1:100 year **wet** (mean + 2.326 s.d.)	624
1:50 year **wet** (mean + 2.054 s.d.)	600
1:20 year **wet** (mean + 1.645 s.d.)	563
1:10 year **wet** (mean + 1.282 s.d.)	531
Mean Annual Precipitation	**416**
1:10 year **dry** (mean - 1.282 s.d.)	302
1:20 year **dry** (mean - 1.645 s.d.)	270
1:50 year **dry** (mean - 2.054 s.d.)	233
1:100 year **dry** (mean - 2.326 s.d.)	209

NOTES:
1. The standard deviation was calculated to be 89 mm.

It is recommended that meteorological data collection should be continued at the Tintina weather station to provide a longer period of record for comparison to the regional stations. The analyses presented in this memo can be updated at a later date when additional data are available.

We trust that the information presented is suitable for your needs. If you have any questions or concerns, please do not hesitate to contact the undersigned.

Prepared: _____
Brendan Worrall, EIT – Staff Engineer

Reviewed: _____
For Craig Nistor, M.Sc., P.Geo. – Senior Geoscientist

Approval that this document adheres to Knight Piésold Quality Systems: _____

/bw