APPENDIX 8A: BASELINE CLIMATE REPORT

CASINO MINING CORPORATION
CASINO PROJECT



BASELINE CLIMATE REPORT

PREPARED FOR:

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VA101-325/14-7
Rev 0
June 14, 2013

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CONSULTING
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ISO 9001 - FS 64925
ISO 14001 EMS 550121
OHSAS 18001 - OHS 550122

CASINO MINING CORPORATION
CASINO PROJECT

BASELINE CLIMATE REPORT
VA101-325/14-7

Rev	Description	Date	Approved
0	Issued in Final	June 14, 2013	KJB

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EXECUTIVE SUMMARY

This report provides baseline climate information for the Casino Project in Yukon Territory, Canada. Specific climate estimates are provided for the Project climate station situated at 1,200 m elevation, along with guidance on scaling these estimates to different elevations within the Project area. The climate estimates presented in this report are based on the available measured site data in conjunction with regional climate data, and corresponding regression analyses that have been used to generate long-term synthetic data series for precipitation and temperature. These synthetic data series have then been used as inputs to a watershed model with which the hydrologic cycle at the Casino Project has been modelled. This model is calibrated to the streamflow data presented in the Casino Baseline Hydrology Report (KPL, 2013), and was used to refine some of the climate values initially developed from more regional information.

This report supersedes the climate estimates provided in the most recent Casino Hydrometeorology Report, dated July 9, 2012 (KPL, 2012), as it includes an additional year of data (2012) and incorporates refinements from the Casino Watershed Model. The updated estimates for key parameters presented here-in are in general agreement with previously estimated values.

The values for key climate parameters, referenced to the Casino Climate Station, are presented below:

CLIMATE PARAMETERS (1,200 m ELEVATION)	VALUE
Mean Annual Temperature	-3 C
Mean January Temperature	-18 C
Mean July Temperature	11 C
Extreme Minimum Temperature	-50 C
Extreme Maximum Temperature	30 C
Mean Annual Precipitation	460 mm
Mean Annual Rainfall	305 mm
Mean Annual Snowfall (Water-Equivalent)	155 mm
Mean Annual Rainfall/Snowfall Distribution	66% / 34%
2-Year 24-Hr Rainfall	32 mm
100-Year 24-Hr Rainfall	71 mm
Mean Annual Sublimation	60 mm
Mean Annual Wind Speed	2.3 m/s
Maximum Wind Gust Speed	14.9 m/s
Prevailing Wind Direction	Northerly
Mean Annual Relative Humidity	68%
Mean Annual Potential Evapotranspiration	300 mm
Mean Annual Maximum Snow Water-Equivalent	100 mm
Mean Monthly Snowmelt for May (Water-Equivalent)	85 mm

Temperature and precipitation can be adjusted to reflect conditions at different elevations according to the following guidelines:

CLIMATIC PARAMETER ELEVATION ADJUSTMENTS	VALUE
Mean Monthly Temperature	- 0.65 °C per 100 m
Mean Annual Precipitation	+7% per 100 m

Potential climate change effects have not been considered explicitly in any of the climate estimates presented above. Appropriate allowances for potential climate change effects should be made where necessary.

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FIGURES

ABBREVIATIONS

AET ..... Actual Evapotranspiration
CMC ..... Casino Mining Corporation
EC ..... Environment Canada
KPL ..... Knight Piésold Ltd.
HKPL ..... Hallam Knight Piésold Ltd.
LOM ..... Life of Mine
MSC ..... Meteorology Service of Canada
NRCan ..... Natural Resources Canada
PET ..... Potential Evapotranspiration
PMP ..... Probable Maximum Precipitation
Project ..... Casino Project
QA/QC ..... Quality Assurance/Quality Control
R^2 ..... coefficient of determination
SWE ..... Snow water equivalent

1 – INTRODUCTION

1.1 PROJECT DESCRIPTION

The Casino Project is located in the Dawson Range Mountains of the Klondike Plateau, approximately 300 km northwest of Whitehorse, Yukon Territory, as shown on Figure 1.1-1. The Casino Project is situated in the Casino Creek and Canadian Creek watersheds. Casino Creek flows in a southerly direction before joining Dip Creek, which drains to the southwest, and which eventually flows into the White River, which is a tributary of the Yukon River. Canadian Creek flows in a northerly direction before joining Britannia Creek, which discharges directly into the Yukon River.

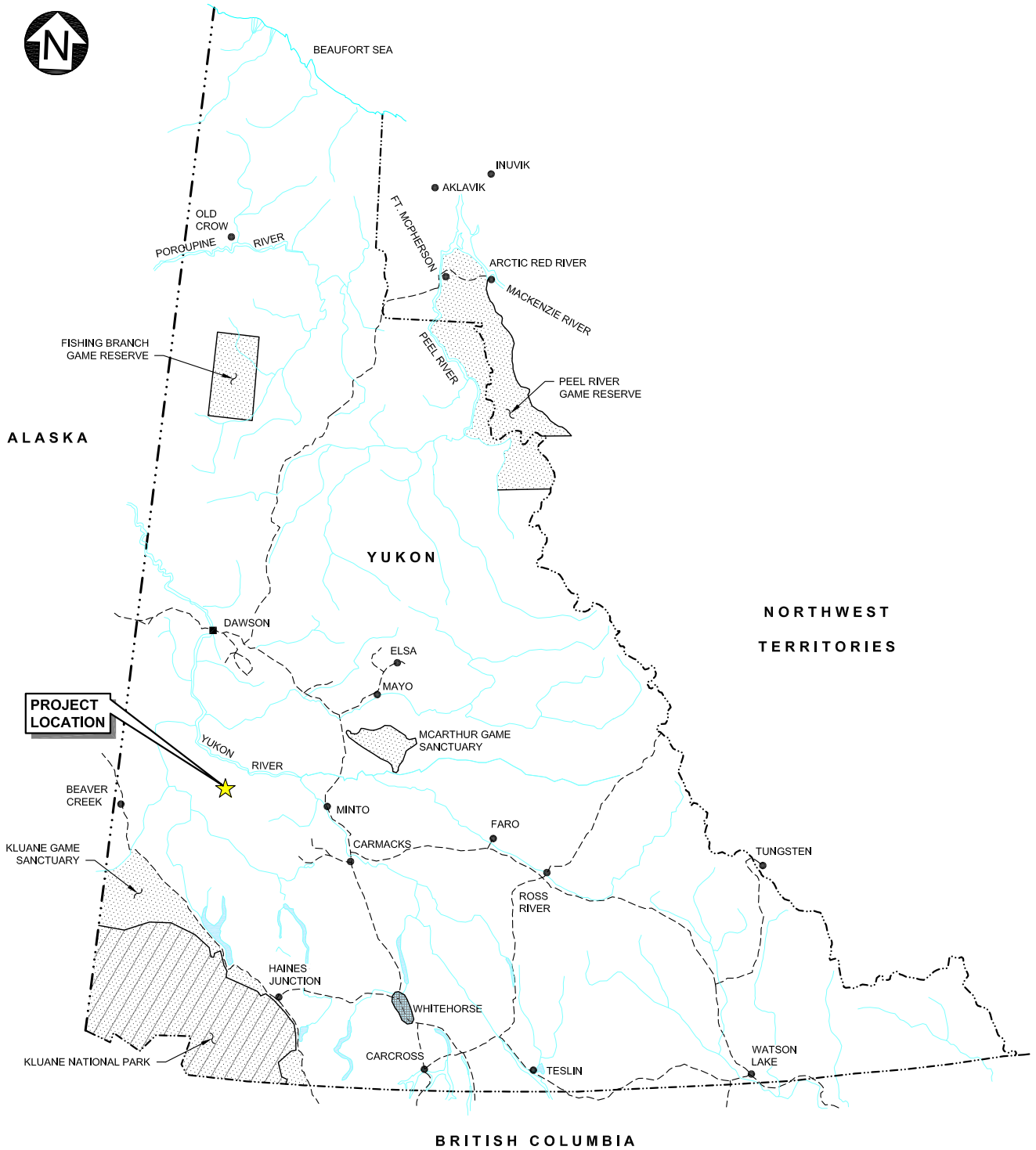
The Project ore body is situated on a ridge between the Casino Creek and Canadian Creek watersheds. The Project includes an airstrip located in the Dip Creek valley and a barge landing on the Yukon River near the Britannia Creek confluence. Access roads to these features will follow the Casino and Dip Creek valleys (to the airstrip) and the Britannia Creek valley (to the barge landing). The main access road to the Project area will connect to Carmacks.

1.2 REGIONAL SETTING

The Project is located within the Boreal Cordillera ecozone, which comprises much of the southern Yukon and a large portion of northern British Columbia, and more specifically within the Klondike Plateau ecoregion (Yukon Government, 2012). The Boreal Cordillera ecozone is broadly characterized by the presence of several mountain ranges, including the Dawson Range, that trend in the north-westerly direction and include extensive plateau regions. The plateaus consist of flat or gently rolling upland terrain separated by broad valleys and lowlands.

The climate is characterized by long, cold, dry winters and short, warm, wet summers, with conditions varying according to altitude and aspect. February through April is typically the driest time, while June through August is typically the wettest, with precipitation driven by convective rainshowers and thunderstorms. Temperatures show strong seasonal variation, with January typically being the coldest month and July the warmest month. Temperature extremes typically occur in the valley bottoms.

The locations of regional climate stations operated by the Meteorological Service of Canada (MSC) are shown on Figure 1.2-1.



CASINO MINING CORPORATION

CASINO PROJECT

PROJECT LOCATION MAP

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REF NO. 7

FIGURE 1.1-1

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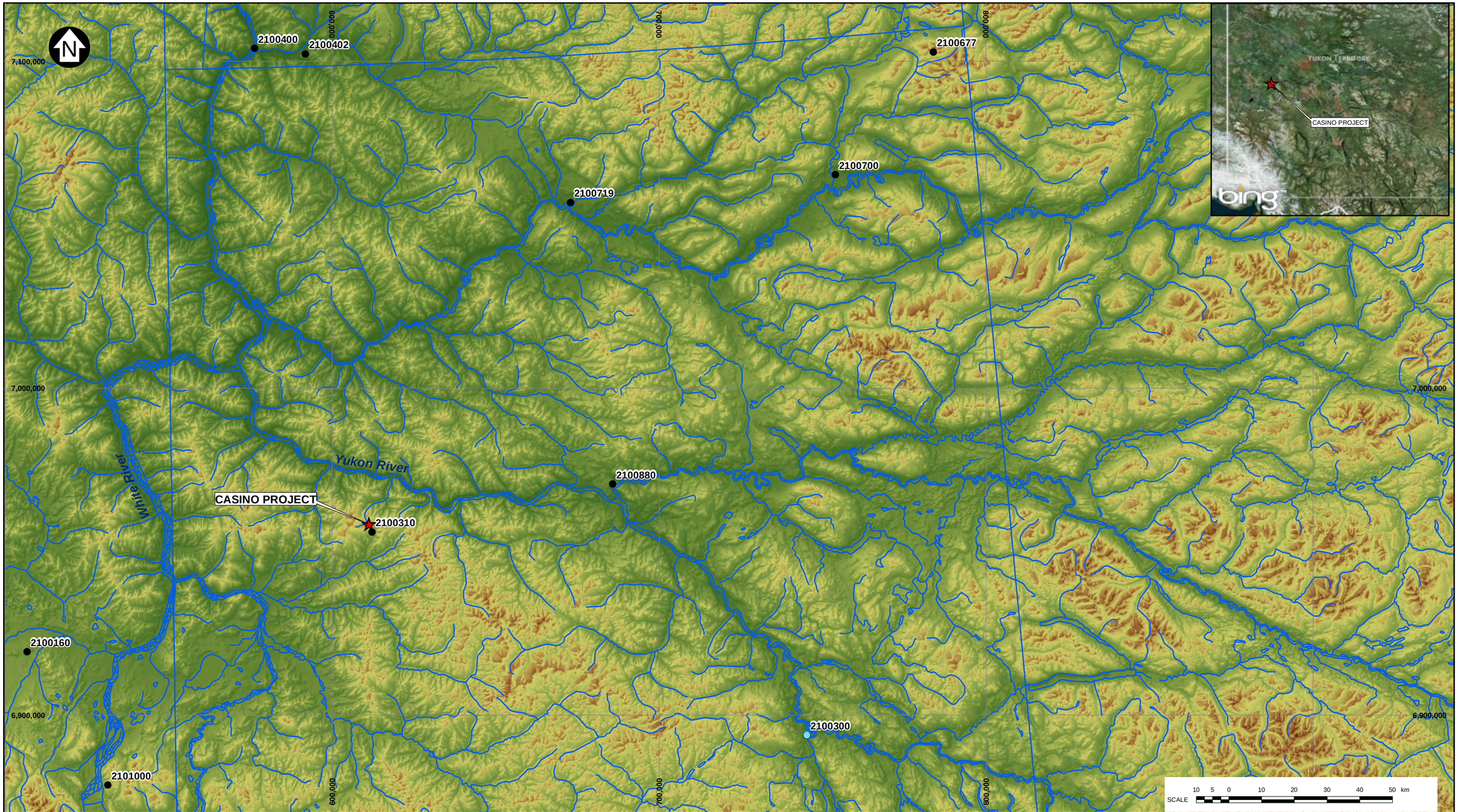

LEGEND:

- PROJECT LOCATION
- REGIONAL CLIMATE STATION
- RIVER/CREEK

ELEVATION RANGE (M)

- < 500
- 500 - 1000
- 1000 - 1500
- 1500 - 2000
- > 2000

NOTES:

1. BASE MAP: NATURAL RESOURCES CANADA DEM
2. COORDINATE GRID IS IN METRES/DEGREES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,100,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

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CASINO MINING CORPORATION

CASINO PROJECT

REGIONAL CLIMATE STATIONS

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REF NO. 7

FIGURE 1.2-1

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1.3 REPORT CONTENT

The climate parameters presented in this report consist of the following:

- Temperature
- Rainfall, snowfall, and total precipitation
- Wind speed and direction
- Relative humidity
- Evapotranspiration, and
- Snowfall, snow accumulation, and snowmelt.

Climate data were collected on-site at the Casino Climate Station located in the upper Casino Creek watershed at an elevation of 1,200 m. The period of site record extends from 1993 to 1994, and from 2008 to present. The site temperature and precipitation data were compared to the long-term record from the MSC climate station at Pelly Ranch, located 80 km to the east at an elevation of 454 m. Correlations between climate data for the Casino and Pelly Ranch climate stations is described in Section 2.0, along with the results of the analysis: 55-year synthetic series of monthly temperature and precipitation at the Casino station. The long-term synthetic precipitation series was then refined using the Casino Watershed Model, and summary statistics were finally computed from the resultant data series.

2 – CLIMATE DATA

2.1 DATA SOURCES

2.1.1 Regional Climate Stations

Regional climate stations are operated by the MSC at several locations within the Klondike Plateau region and within 150 km of the Project location. The locations of the most relevant stations are shown on Figure 1.2-1. The period of record, elevation, and mean annual temperature and precipitation at each station are provided in Table 2.1-1.

Table 2.1-1 Regional MSC Climate Stations

MSC Station Name	Station ID.	Years of Record	Complete Years of Record	Start Year	End Year	Latitude	Longitude	Elevation (m)	Mean Annual Temperature (C)	Mean Annual Precipitation (mm)
Mayo A	2100700	88	81	1925	2012	63° 37'	135° 52'	504	-3.3	305
Pelly Ranch	2100880	61	51	1951	2012	62° 49'	137° 22'	454	-3.8	306
Carmacks	2100300	45	33	1963	2007	62° 06'	136° 18'	525	-3.0	287
Beaver Creek A	2100160	42	29	1968	2012	62° 24'	140° 52'	649	-5.4	417
Dawson	2100400	83	72	1987	1979	64° 03'	139° 26'	320	-4.9	321
Dawson A	2100402	37	27	1976	2012	64° 02'	139° 07'	370	-4.2	363
McQuesten	2100719	27	24	1986	2012	63° 36'	137° 31'	457	-3.3	345
Snag A	2101000	24	22	1943	1966	62° 02'	140° 24'	587	-5.8	372
Casino Creek	2100310	7	0	1969	1995	62° 43'	138° 49'	1100	-4.4	427

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NOTES:
1. DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA.
2. STATIONS WITH LESS THAN FIVE COMPLETE YEARS OF RECORD NOT INCLUDED WITH THE EXCEPTION OF CASINO CREEK.
3. MEAN ANNUAL TEMPERATURE AND PRECIPITATION VALUES BASED ON COMPLETE YEARS OF DATA ONLY, WITH THE EXCEPTION OF CASINO CREEK.

The MSC operated a climate station (Casino Creek, 2100310) within the general Project area, with measured data recorded between 1969 and 1995, but with no years of complete record. The station elevation was 1,100 m. Based on the incomplete data for this station, the mean annual precipitation is approximately 427 mm and the mean annual temperature is -4.4°C. These data were considered in further analyses but were not used directly due to the incomplete nature of the record.

Eight regional stations, listed in Table 2.1-1, have greater than 20 complete years of record. These stations are all situated in low-elevation settings (between 320 m to 649 m). Of these stations, Pelly Ranch is located closest to the Project area (approximately 80 km to the east of the Project area). The mean annual precipitation at the eight long-term stations ranges from 290 mm to 420 mm, and the mean annual temperature ranges from -3°C to -6°C.

2.1.2 Regional Climate Maps

Natural Resources Canada (NRC) maps of mean annual precipitation and lake evaporation in Yukon Territory are presented on Figures 2.1-1 and 2.1-2, respectively. The Project is located in the middle

of a broad zone of relatively low precipitation aligned northwest-southeast between large mountain ranges to the southwest (the St. Elias Mountains near the Pacific Coast) and the northeast (the Mackenzie Mountains along the Northwest Territories border). A zone of less than 400 mm of mean annual precipitation roughly coincides with the Klondike Plateau. More specifically, the Project is located in an area with less than 300 mm of mean annual precipitation, although this map (Figure 2.1-1) is based on relatively few regional climate stations and has a low resolution that does not account for local orographic effects. Mean annual lake evaporation in Yukon Territory is shown on Figure 2.1-2, and indicates variations of evaporation with latitude, but doesn't seem to account for local elevation effects. The Project is located in an area with slightly less than 300 mm in mean annual lake evaporation.

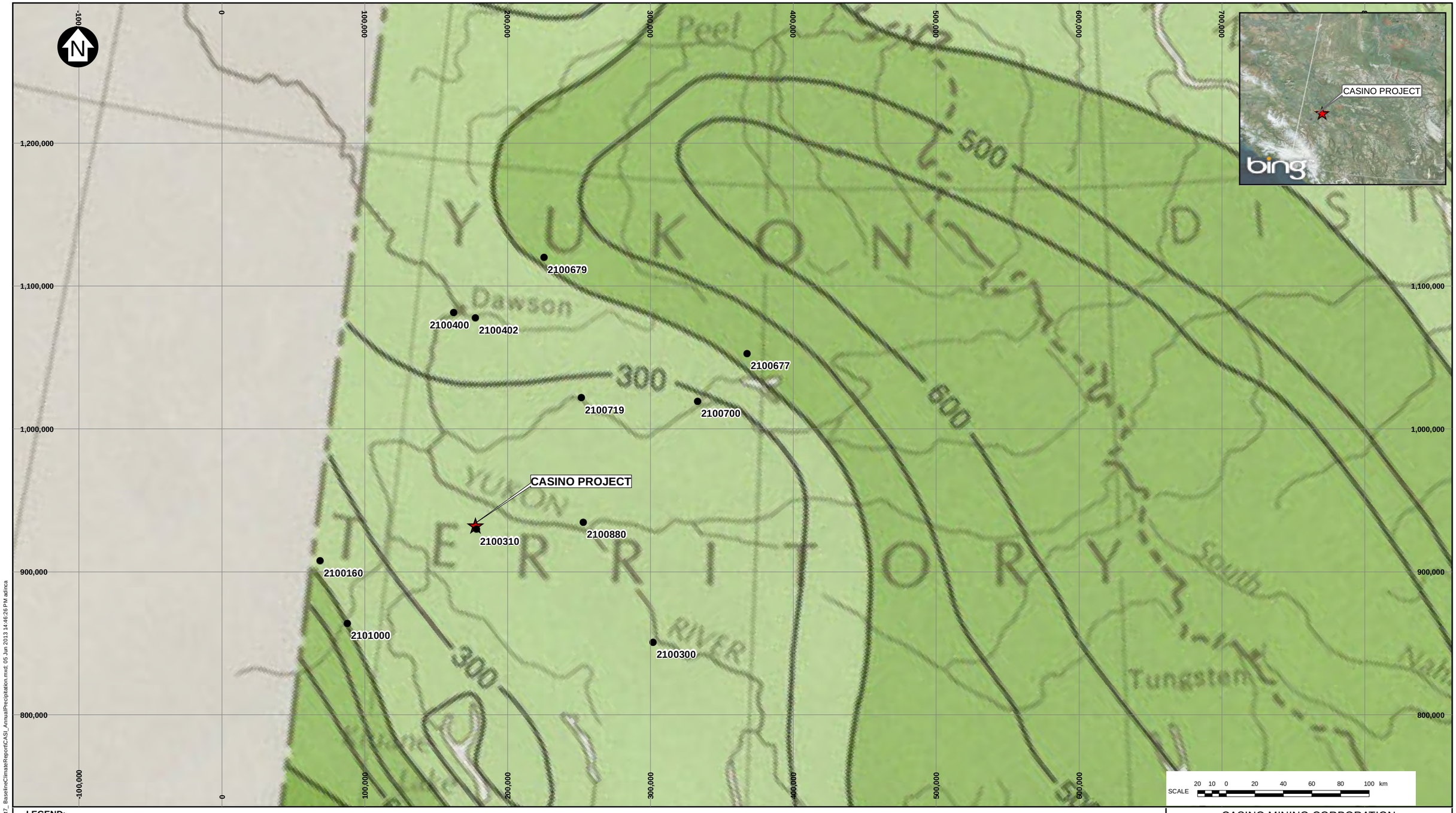
2.1.3 Casino Climate Station

In 1993, Hallam Knight Piésold Ltd. (HKPL) was retained by Pacific Sentinel Gold Corp. to undertake an environmental monitoring program for the Casino Project, which included both meteorology and hydrology monitoring programs. The field techniques followed during the program were presented in the report "Casino Project Baseline Environmental and Socioeconomic Studies" (HKPL, 1993). The data collection program involved the installation of a climate station near the Casino exploration camp, which measured both temperature and precipitation. This station operated from 1993 to 1995. A new Project climate station was established at approximately the same location on October 3, 2008 by RWDI Air Inc., and has been operational since that time. The active climate station is currently maintained by Knight Piésold Ltd (KPL). The Casino climate station is located at an elevation of approximately 1200 m in the upper Casino Creek watershed, as shown on Figure 2.1-3.

The climate station apparatus consists of a 10 m high, free-standing tower equipped with instrumentation, a datalogger, and a logger enclosure (RWDI, 2012). The station records air temperature, rainfall, wind speed and direction, relative humidity, barometric pressure, and snow depth. The datalogger is equipped with a satellite modem and can be accessed remotely.

2.1.4 Casino Snow Course

Yukon Environment has collected 34 years of snowpack data (1977-2012) at a snow course located only a couple hundred meters from the Casino Climate Station (snow course 09CD-SC01). The snow course is situated at an elevation of 1165 m, and its location is shown on Figure 2.1-3. Snow depth and snow water-equivalent (SWE) are measured each year at the beginning of March, April, and May.



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LEGEND:

- PROJECT LOCATION
- REGIONAL CLIMATE STATION

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NOTES:

1. BASE MAP: NATURAL RESOURCES CANADA HYDROLOGICAL ATLAS MEAN ANNUAL LAKE EVAPORATION. VALUES ARE IN MILLIMETRES AND BASED ON 10-YEAR PERIOD 1957-1966.

2. COORDINATE GRID IS IN METRES/DEGREES. COORDINATE SYSTEM: ALBERS CONICAL EQUAL AREA.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:2,500,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

CASINO MINING CORPORATION

CASINO PROJECT

REGIONAL MEAN ANNUAL PRECIPITATION

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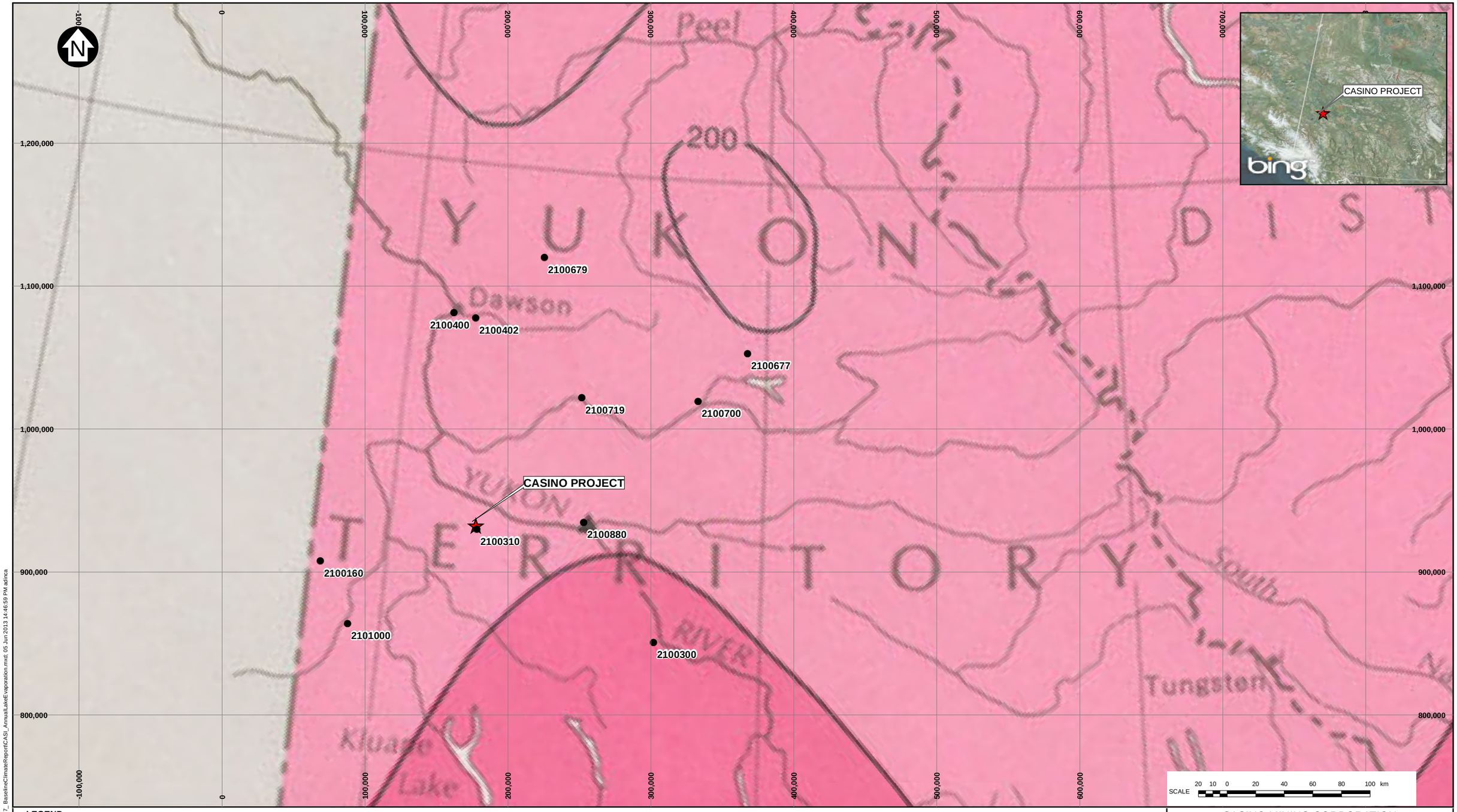
FIGURE 2.1-1 REV 0



LEGEND:

- PROJECT LOCATION
- REGIONAL CLIMATE STATION

NOTES:

1. BASE MAP: NATURAL RESOURCES CANADA HYDROLOGICAL ATLAS MEAN ANNUAL LAKE EVAPORATION. VALUES ARE IN MILLIMETRES AND BASED ON 10-YEAR PERIOD 1957-1966.

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CASINO MINING CORPORATION

CASINO PROJECT

REGIONAL MEAN ANNUAL LAKE EVAPORATION

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REF NO. 7

FIGURE 2.1-2

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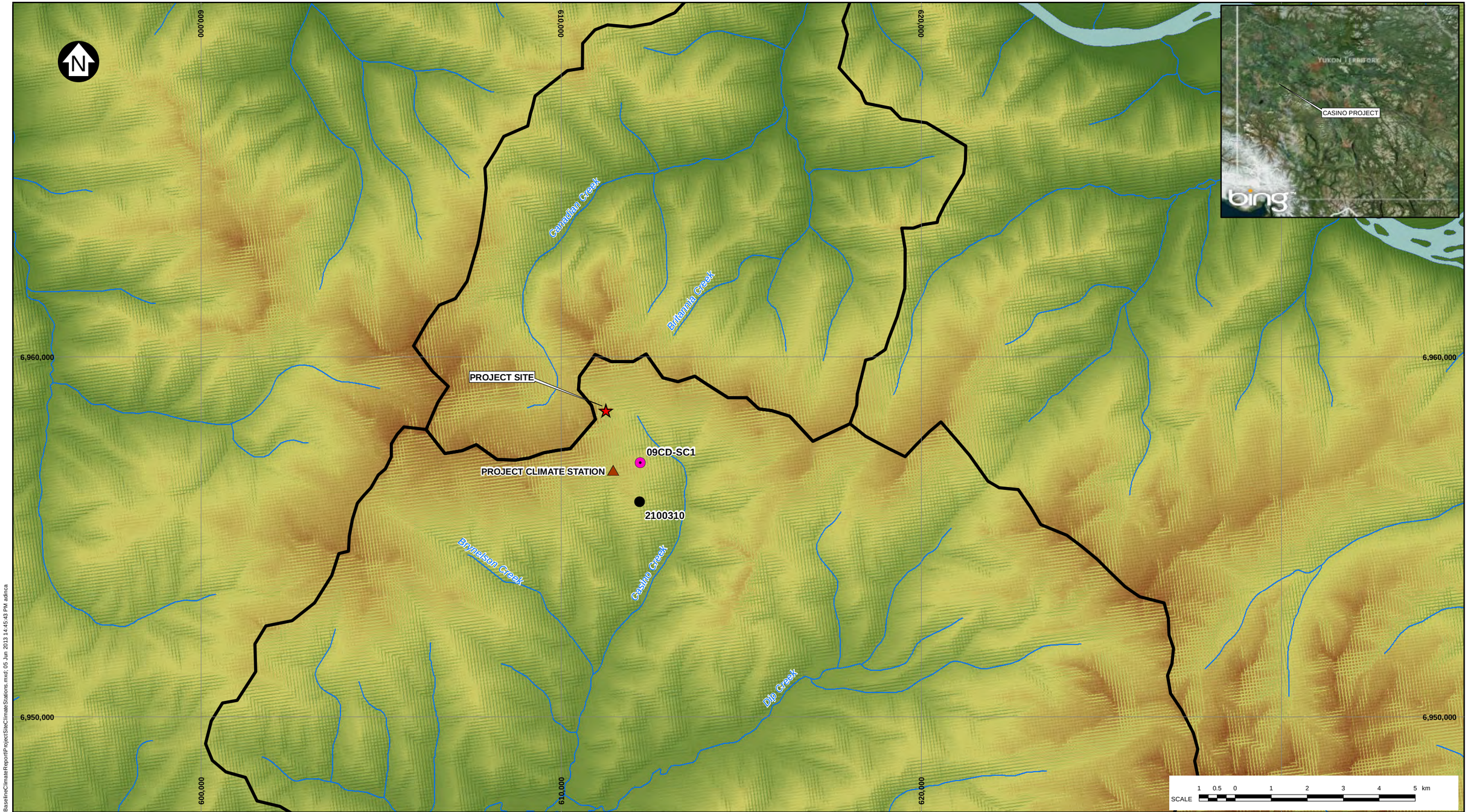

LEGEND:

- PROJECT LOCATION
- ACTIVE PROJECT CLIMATE STATION
- DISCONTINUED MSC CLIMATE STATION
- ACTIVE YUKON ENVIRONMENT SNOW COURSE
- RIVER/CREEK
- WATERSHED BOUNDARY

ELEVATION RANGE (M)

- < 500
- 500 - 1000
- 1000 - 1500
- 1500 - 2000
- > 2000

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	07MAY'13	ISSUED WITH REPORT	AMD	AMD	KT	KJB

NOTES:

1. BASE MAP: NATURAL RESOURCES CANADA DEM.

2. COORDINATE GRID IS IN METRES/DEGREES.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:100,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

CASINO MINING CORPORATION

CASINO PROJECT

PROJECT SITE CLIMATE STATION AND SNOW COURSE LOCATIONS

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FIGURE 2.1-3 REV 0

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2.2 TEMPERATURE

2.2.1 Region

Mean monthly temperature values for the long-term regional climate stations are presented in Table 2.2-1, along with values for the Casino Creek MSC Station. The regional sites range in elevation from 370 m to 649 m. Temperatures are warmest in July, with mean monthly temperatures ranging from 14°C to 16°C. Temperatures are coldest in January, with mean monthly temperatures ranging from -25°C to -28°C.

Table 2.2-1 Mean Monthly Temperatures at Regional Climate Stations

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MSC Station Name	Station ID.	Elevation (m)	Period of Record	Complete Years of Record	Temperature (°C)												
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mayo A	2100700	504	1925-2012	80	-25.5	-19.2	-10.7	0.1	8.1	13.6	15.3	12.5	6.5	-2.2	-15.4	-22.4	-3.3
Pelly Ranch	2100880	454	1951-2012	51	-27.5	-20.7	-11.7	0.3	7.9	13.6	15.4	12.6	6.6	-2.6	-15.9	-24.1	-3.8
Carmacks	2100300	525	1963-2007	31	-26.6	-17.6	-10.5	0.5	7.6	13.5	15.2	12.7	6.6	-1.8	-13.7	-22.0	-3.0
Beaver Creek A	2100160	649	1968-2012	29	-27.3	-21.1	-12.6	-1.4	6.3	12.1	13.8	11.2	4.6	-6.4	-19.7	-24.6	-5.4
Dawson A	2100402	370	1976-2012	26	-26.3	-22.0	-11.6	0.1	8.3	13.8	15.5	12.5	5.9	-4.6	-17.9	-24.4	-4.2
McQuesten	2100719	457	1986-2012	24	-25.0	-18.3	-10.9	1.0	8.3	13.7	15.2	12.2	5.8	-3.8	-16.3	-21.9	-3.3
Snag A	2101000	587	1943-1966	21	-27.8	-22.4	-13.7	-2.9	6.5	11.8	13.9	11.3	5.1	-5.6	-18.9	-27.4	-5.8
Casino Creek	2100310	1100	1969-1995	0	-17.2	-16.7	-12.3	-6.8	2.5	9.6	11.8	9.4	3.2	-5.6	-15.4	-14.8	-4.4

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NOTES:
1. DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA.
2. MEAN MONTHLY TEMPERATURES DERIVED FROM COMPLETE YEARS ONLY, EXCEPT CASINO CREEK.

2.2.2 Project Site

2.2.2.1 Long-Term Synthetic Series Generation

The long-term temperature record at Pelly Ranch (2100880) was used as the basis for generating a long-term synthetic series of monthly temperature values for the Casino Project climate station. The Pelly Ranch record was missing twelve months of temperature data between 2008 and 2012, so the missing months were estimated by regression analysis of monthly temperatures between Pelly Ranch and Dawson A. Separate analyses were performed for each month in which estimated values were required at Pelly Ranch. Monthly temperatures were found to be well-correlated at Pelly Ranch and Dawson A, with coefficients of determination (R^2) values ranging from 0.91 to 0.97. The result is a complete 55-year temperature record for Pelly Ranch. The concurrent temperature records from the Pelly Ranch and Casino Project climate stations were then correlated using a standard linear regression approach, as shown on Figure 2.2-1. The concurrent monthly temperature values used in the regression analysis are summarized in Table 2.2-2.

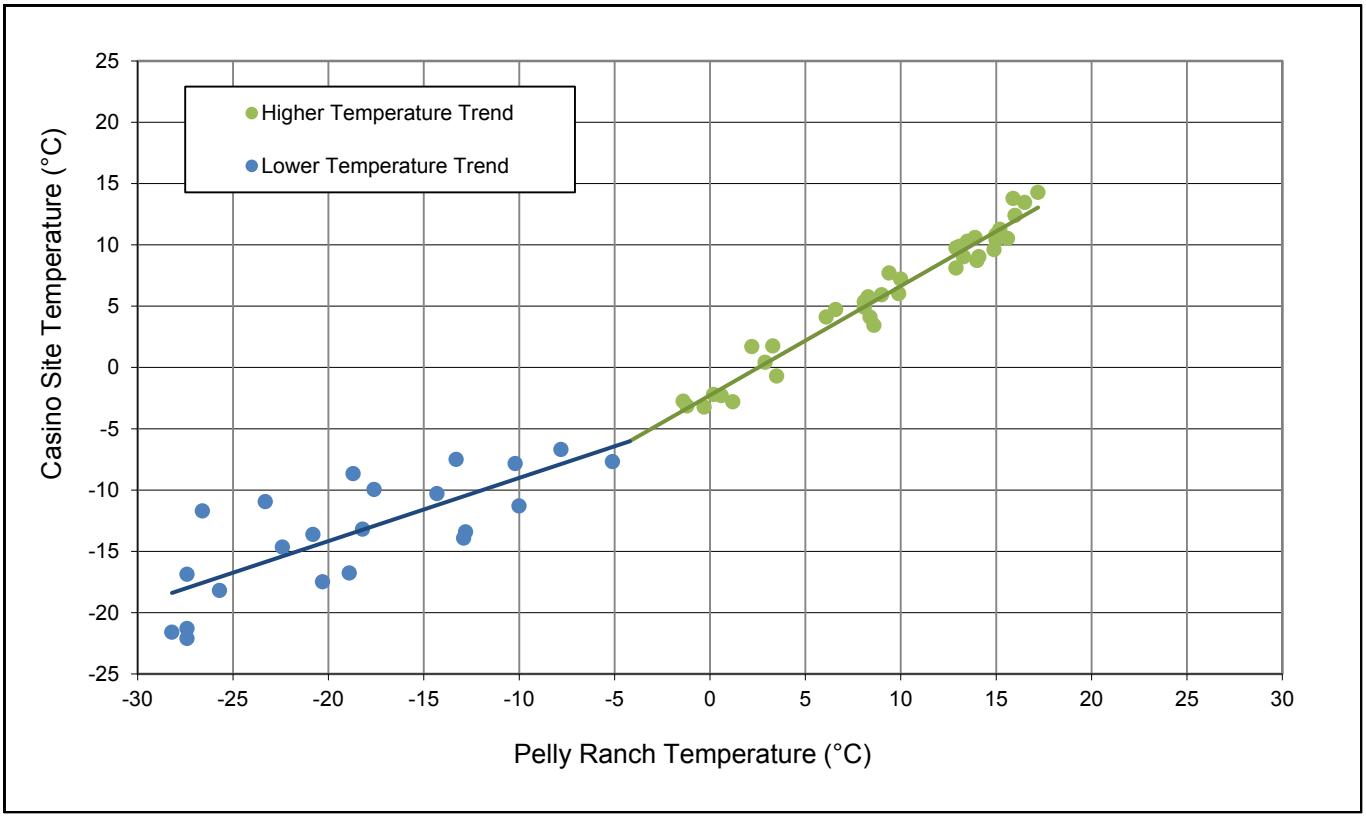

Figure 2.2-1 Concurrent Pelly Ranch and Casino Temperature Relationship

Table 2.2-2 Monthly Temperature Data used for Regression Analysis

Climate Station	Elevation (m)	Temperature (°C)													
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pelly Ranch	454	1993	-	-	-	2.2	9.4	13.9	16.0	12.9	6.6	0.6	-14.3	-18.2	-
		1994	-27.4	-27.4	-7.8	3.3	8.3	13.5	16.5	15.9	6.1	-1.4	-18.9	-26.6	**-3.8**
		1995	-23.3	-	-	-	-	-	-	-	-	-	-	-	-
		2008	-	-	-	-	-	-	-	-	-	-	-15.5	-27.4	-
		2009	-25.7	-22.4	-12.9	0.2	9.0	15.0	17.2	13.3	8.1	-0.3	-12.8	-18.7	**-2.5**
		2010	-20.8	-13.3	-5.1	3.5	10.0	14.1	15.2	14.0	6.6	-1.2	-10.5	-26.7	**-1.2**
		2011	-	-	-15.4	1.2	9.9	14.0	15.6	12.9	8.1	-0.1	-20.3	-17.8	-
		2012	-28.2	-	-	2.9	8.6	14.9	15.0	13.1	8.4	-	-	-	-
		Concurrent Average	**-25.1**	**-21.0**	**-10.3**	**2.2**	**9.2**	**14.2**	**15.9**	**13.7**	**7.3**	**-0.5**	**-15.4**	**-22.6**	**-2.7**
Casino Project Site	1200	1993	-	-	-	-0.3	6.1	10.1	12.0	9.2	3.6	-1.7	-11.2	-13.2	-
		1994	-18.0	-18.0	-7.9	0.7	5.1	9.8	12.4	11.9	3.2	-3.5	-13.6	-17.6	**-3.0**
		1995	-15.9	-	-	-	-	-	-	-	-	-	-	-	-
		2008	-	-	-	-	-	-	-	-	-	-	-11.8	-18.0	-
		2009	-17.1	-15.4	-10.5	-2.1	5.7	11.1	13.0	9.6	4.9	-2.5	-10.4	-13.5	**-2.3**
		2010	-14.6	-10.7	-6.5	0.9	6.6	10.3	11.3	10.2	3.6	-3.3	-9.3	-17.6	**-1.6**
		2011	-	-	-11.8	-1.2	6.5	10.2	11.6	9.2	4.9	-2.3	-14.3	-13.0	-
		2012	-18.4	-2.3	-2.3	0.3	5.4	11.0	11.1	9.4	5.2	-	-	-	-
		Concurrent Average	**-16.8**	**-14.7**	**-9.2**	**-0.3**	**5.9**	**10.4**	**11.9**	**9.9**	**4.2**	**-2.7**	**-11.8**	**-15.5**	**-2.4**
		Long-term est.	**-18.0**	**-14.2**	**-9.7**	**-1.9**	**4.9**	**9.9**	**11.4**	**9.0**	**3.7**	**-4.4**	**-12.1**	**-16.3**	**-3.2**

M:\1\01\00325\14\A\Data\Task 370 - Climate Air Quality and Noise\Climate\[Temperature.xlsx]TABLE 2.2

NOTE:
1. THE LONG-TERM TEMPERATURE VALUES WERE ESTIMATED BASED ON A REGRESSION ANALYSIS WITH CONCURRENT CASINO AND PELLY RANCH DATA.

The monthly temperatures for the two stations were found to be strongly correlated in the warmer months (April through October), but only weakly correlated in the colder months (November through March). For April through October, temperatures at the Project site were generally 1°C to 4°C cooler than at Pelly Ranch, which is consistent with the higher elevation of the Project site. For November to March, the temperatures at the Project site were warmer compared to Pelly Ranch by an average of 5°C, and up to 15°C in some months. This substantial difference and wide variability is attributed to the settling of cold air in valley bottoms during the winter and the consequent temperature inversions that are often experienced between valley bottom sites (e.g. Pelly Ranch) and ridges (e.g. Casino) under such conditions. In contrast, June and July temperatures at Pelly Ranch are approximately 5°C to 5.5°C warmer than those at the Casino Site station, which is consistent with a typical adiabatic lapse rate of 6°C per 1000 m.

For the regression analysis, two relationships were developed using a Pelly Ranch temperature threshold of -4.2°C to partition the data. In the warmer months with average temperatures greater than -4.2°C at Pelly Ranch (approximately April through October), the coefficient of determination (R^2) was 0.96. In the colder months with average temperatures less than -4.2°C at Pelly Ranch (approximately November through March), the coefficient of determination (R^2) was 0.59. A 55-year synthetic series of monthly temperature values for the Project site climate station was generated by applying the two regression relationships to the Pelly Ranch monthly temperature record.

2.2.2.2 Mean Annual and Monthly Temperature

Long-term mean annual and monthly temperatures at the Casino climate station, estimated from the synthetic temperature series, are presented in Table 2.2-2. The mean annual temperature for the Project site is -3.2°C (round to -3°C). For comparison, the mean annual temperature recorded at the Casino climate station, for the eight years of intermittent record between 1993 and 2012, was -2.0°C. The mean July temperature at the Project site is 11.4°C (round to 11°C), which is 3°C to 5°C cooler than the regional stations discussed in Section 2.2.1 and shown in Table 2.2-1. The mean January temperature at the Project site is -18.0°C, which is 8°C to 11°C warmer than the regional stations discussed in Section 2.2.1 and shown in Table 2.2-1.

As there is only one climate station on site, it is difficult to characterize site wide lapse rates. Lapse rates within the project site are expected to follow typical trends as the project is located in hilly terrain with narrow valleys; geography that is typically not prone to temperature inversions in the winter. A lapse rate of 6.5°C per 1000 m was used in the calibration of the watershed model developed for the Casino Project.

2.2.2.3 Extreme Temperatures

The extreme maximum and minimum recorded temperatures at Pelly Ranch, according to the 1971-2000 climate normal, are 35°C and -60°C, respectively. According to the regression relationships described in Section 2.2.2.1, the corresponding maximum temperature at the Casino climate station would be around 30°C. The corresponding minimum temperature at the Casino station is more difficult to estimate due to the weaker correlation of winter temperatures, but it would likely be warmer than -60°C, although still extremely cold.

The maximum and minimum temperatures recorded at the Casino climate station between 2008 and 2012 are 26°C and -40°C, respectively. Based on the site data and the Pelly Ranch estimates, the estimated long-term extreme temperatures for the Casino climate station are 30°C and -50°C.

2.3 PRECIPITATION

2.3.1 Region

Mean monthly and annual rainfall, snowfall and total precipitation values for the long-term regional climate stations are presented in Table 2.3-1. The mean monthly precipitation at all stations is greatest during the summer months of June through August and lowest during the late winter months of February through April. Most of the precipitation falls in the form of snow during the months of November through March, and in the form of rain during the months of May through September. During the shoulder months of April and October, mixed rain and snow conditions occur, although typically snow is more common. The fractions of annual precipitation occurring as rain/snow at the regional stations ranges from 56%/44% to 71%/29%.

Table 2.3-1 Mean Monthly Precipitation at Regional Climate Stations

MSC Station Name	Station ID.	Period of Record	Elevation (m)	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Beaver Creek	2100160	1969 - 2012	649	rain (mm)	0.0	0.0	0.0	1.2	30.2	73.0	102.3	57.5	27.5	2.9	0.0	0.0	294.7
				% annual precip.	0.0%	0.0%	0.0%	0.3%	7.3%	17.5%	24.5%	13.8%	6.6%	0.7%	0.0%	0.0%	70.7%
				snow (mm)	14.3	10.3	11.8	12.2	5.9	0.1	0.0	1.2	9.9	24.3	18.5	13.8	122.2
				% annual precip.	3.4%	2.5%	2.8%	2.9%	1.4%	0.0%	0.0%	0.3%	2.4%	5.8%	4.4%	3.3%	29.3%
				precip.(mm)	14.3	10.3	11.8	13.4	36.2	73.1	102.3	58.7	37.4	27.2	18.5	13.8	416.8
				% annual precip.	3.4%	2.5%	2.8%	3.2%	8.7%	17.5%	24.5%	14.1%	9.0%	6.5%	4.4%	3.3%	100.0%
Snag A	2101000	1944 - 1965	587	rain (mm)	0.1	0.0	0.2	2.1	24.1	56.0	74.9	48.1	22.5	1.8	0.3	0.0	230.2
				% annual precip.	0.0%	0.0%	0.1%	0.6%	6.5%	15.1%	20.1%	12.9%	6.0%	0.5%	0.1%	0.0%	61.9%
				snow (mm)	21.7	16.2	15.8	13.2	6.1	0.7	0.0	0.3	5.8	18.6	21.9	21.8	141.9
				% annual precip.	5.8%	4.4%	4.2%	3.5%	1.6%	0.2%	0.0%	0.1%	1.6%	5.0%	5.9%	5.9%	38.1%
				precip.(mm)	21.7	16.2	16.0	15.3	30.2	56.7	74.9	48.4	28.3	20.3	22.2	21.8	372.0
				% annual precip.	5.8%	4.4%	4.3%	4.1%	8.1%	15.2%	20.1%	13.0%	7.6%	5.5%	6.0%	5.9%	100.0%
Pelly Ranch	2100880	1955 - 2012	454	rain (mm)	0.1	0.0	0.2	3.7	22.6	36.7	53.9	39.5	26.7	7.2	0.4	0.0	190.9
				% annual precip.	0.0%	0.0%	0.1%	1.2%	7.4%	12.0%	17.6%	12.9%	8.7%	2.4%	0.1%	0.0%	62.4%
				snow (mm)	19.8	14.7	11.9	6.6	0.5	0.0	0.0	0.0	2.1	15.5	24.0	20.1	115.2
				% annual precip.	6.5%	4.8%	3.9%	2.2%	0.1%	0.0%	0.0%	0.0%	0.7%	5.1%	7.8%	6.6%	37.6%
				precip.(mm)	19.9	14.7	12.1	10.4	23.0	36.7	53.9	39.5	28.8	22.7	24.4	20.1	306.2
				% annual precip.	5.4%	3.9%	3.2%	2.8%	6.2%	9.9%	14.5%	10.6%	7.8%	6.1%	6.6%	5.4%	100.0%
Dawson A	2100402	1977 - 2012	370	rain (mm)	0.0	0.0	0.3	2.2	25.9	40.4	50.6	41.6	32.9	8.9	0.1	0.4	203.3
				% annual precip.	0.0%	0.0%	0.1%	0.6%	7.1%	11.1%	13.9%	11.5%	9.0%	2.4%	0.0%	0.1%	56.0%
				snow (mm)	25.3	17.6	12.8	7.0	2.3	0.0	0.0	0.4	3.9	25.9	35.7	28.8	159.7
				% annual precip.	7.0%	4.9%	3.5%	1.9%	0.6%	0.0%	0.0%	0.1%	1.1%	7.1%	9.8%	7.9%	44.0%
				precip.(mm)	25.3	17.7	13.1	9.2	28.2	40.4	50.6	42.0	36.8	34.7	35.8	29.2	363.0
				% annual precip.	7.0%	4.9%	3.6%	2.5%	7.8%	11.1%	13.9%	11.6%	10.1%	9.6%	9.9%	8.0%	100.0%

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NOTE:

1. ONLY COMPLETE YEARS OF RECORD WERE USED.

2.3.2 Project Site

2.3.2.1 Long-Term Synthetic Series Generation

The long-term precipitation record at Pelly Ranch (2100880) was used as the basis for generating a long-term synthetic series of monthly precipitation for the Casino climate station. The Pelly Ranch record was missing nine months of precipitation data between 2008 and 2011, so these were

estimated by regression analysis of monthly precipitation between Pelly Ranch and two other stations: Dawson A and Mayo. Monthly precipitation at Pelly Ranch and the two other stations were not well-correlated, with coefficient of determination (R^2) values of 0.28 and 0.49 for Dawson A and Mayo, respectively. However, in the absence of any other available regional data, the missing monthly precipitation values at Pelly Ranch were estimated by taking the average of the values predicted by the Dawson A and Mayo regression relationships for each given month.

The concurrent precipitation records from the Pelly Ranch and Casino climate stations were correlated using a comparison of cumulative precipitation, as shown in Figure 2.3-1. The comparison was completed using only the more recent precipitation data as it is likely of higher quality due to advances in rain gauge instrumentation over the last 15 years. The rain gauge at the Casino climate station is not equipped to record snowfall, and rainfall measurements during the winter and shoulder months were likely affected from snow and ice interference. Therefore, only the Project site precipitation records for the months of May through September were considered in the analysis. It is assumed that any snow that fell during these months was captured in the rain gauge and recorded as the snow melted, so that the recorded rainfall in the months of May through September can be considered to represent total precipitation. The monthly precipitation values from Pelly Ranch and Casino that were used in the analysis are summarized in Table 2.3-2.

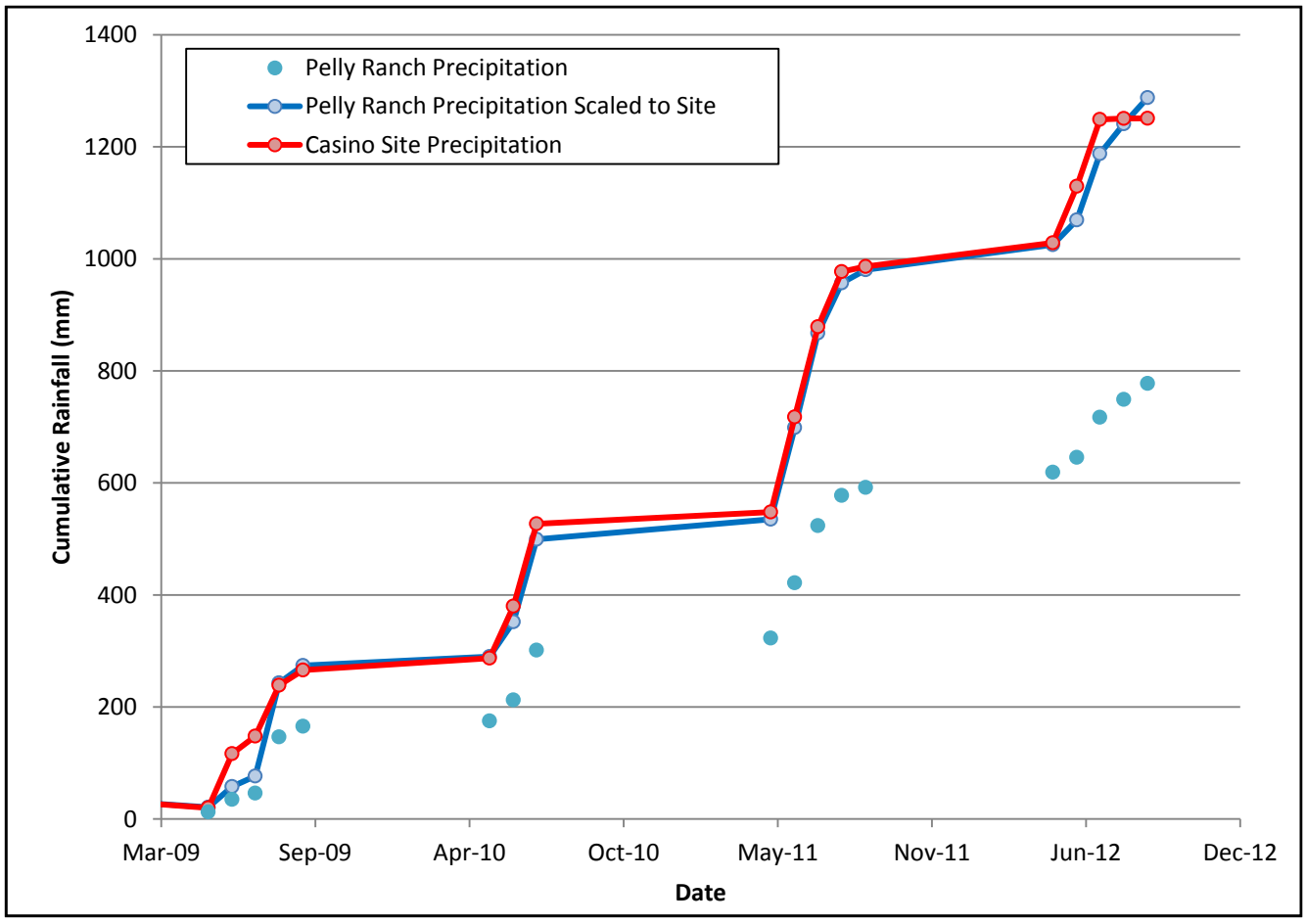

Figure 2.3-1 Comparison of Cumulative Precipitation at Pelly Ranch and Casino Site

Table 2.3-2 Monthly Precipitation Data

Climate Station	Elevation (m)	Measured Precipitation (mm)												
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pelly Ranch	454	1993	24.9	6.8	34.4	8.8	18.4	16.8	61.9	40.0	20.8	28.1	34.8	7.0	**303**
		1994	24.6	4.8	15.9	7.7	37.8	53.6	36.2	8.6	21.6	27.4	27.4	3.6	**269**
		2009	34.6	16.6	24.1	13.2	12.6	22.4	11.2	100.4	18.8	20.4	26.6	12.9	**314**
		2010	18.5	2.4	7.0	4.0	9.6	37.4	89.0	-	-	-	-	-	-
		2011	-	26.4	2.5	4.4	21.6	98.7	102.0	54.0	14.2	-	56.7	-	-
		2012	39.4	29.0	29.5	7.8	27.0	26.7	71.4	32.1	28.3	25.6	-	23.5	-
		Average (2009-2012)	**30.8**	**18.6**	**15.8**	**7.4**	**17.7**	**46.3**	**68.4**	**62.2**	**20.4**	**23.0**	**41.7**	**18.2**	**370**
Casino Project Site	1200	1993	-	-	-	-	30.5	27.8	102.5	66.3	34.5	-	-	-	-
		1994	-	-	-	-	62.6	88.8	60.0	14.2	35.8	-	-	-	-
		2009	-	-	-	-	20.9	37.1	18.6	166.3	31.1	-	-	-	-
		2010	-	-	-	-	15.9	62.0	147.4	63.6	18.1	-	-	-	-
		2011	-	-	-	-	35.8	163.5	169.0	89.5	23.5	-	-	-	-
		2012	-	-	-	-	44.7	44.2	118.3	53.2	46.9	-	-	-	-
		Average (2009-2012)	-	-	-	-	**29.3**	**76.7**	**113.3**	**93.1**	**29.9**	-	-	-	-
		Long-term est.	**25**	**19**	**15**	**13**	**37**	**62**	**91**	**67**	**48**	**28**	**31**	**24**	**460**
		Rainfall est.	**0**	**0**	**0**	**0**	**37**	**62**	**91**	**67**	**48**	**0**	**0**	**0**	**305**
		Snowfall est.	**25**	**19**	**15**	**13**	**0**	**0**	**0**	**0**	**0**	**28**	**31**	**24**	**155**

M:\1\01\00325\14\A\Data\Task 370 - Climate Air Quality and Noise\Climate\[Precipitation.xlsx]Table 2.5

NOTES:

1. THE CASINO SITE METEOROLOGICAL STATION, BOTH HISTORICALLY AND PRESENTLY, WAS ASSUMED TO COLLECT ONLY RAINFALL DATA DUE TO THE INSTRUMENT SET-UP, THEREFORE THE PRECIPITATION DATA COLLECTED IN THE MONTHS OF OCTOBER TO APRIL IS PRESENTED FOR INFORMATION PURPOSES ONLY BUT WAS NOT USED IN THE ANALYSIS OF MEAN ANNUAL PRECIPITATION FOR THE SITE.
2. IT WAS ASSUMED THAT PRECIPITATION COLLECTED DURING MAY TO SEPTEMBER FELL AS RAIN, SINCE THE AVERAGE MONTHLY TEMPERATURES DURING THESE MONTHS WAS ABOVE ZERO.
3. THE LONG-TERM PRECIPITATION VALUES WERE ESTIMATED BASED ON A REGRESSION ANALYSIS OF CONCURRENT CASINO AND PELLY RANCH DATA.

The monthly precipitation at the two locations was found to be moderately well-correlated. The elevation difference between Pelly Ranch (454 m elevation) and the Project site climate station (1,200 m elevation) is 746 m. If the difference in precipitation between the two climate stations is entirely attributable to orographic effects, then the corresponding orographic factor is 7% per 100 m elevation, which is generally consistent with typical annual average orographic rates of 5% to 10%, as computed by KP for many locations in B.C. and the Yukon. Accordingly, this orographic factor was applied to the entire precipitation record at Pelly Ranch to generate a preliminary long-term synthetic series precipitation at the Project site climate station. In doing so, it was assumed that the observed precipitation trend between the two sites in the months of May through September is also applicable to the winter months. Some difference between summer and winter precipitation orographic precipitation rates would be expected, but given the lack of suitable data and the inaccuracy of winter precipitation data in general, a consistent rate was considered appropriate for the preliminary modelling.

The long-term synthetic precipitation series was then refined using the Casino Watershed Model. Specifically, the initial record produced higher spring runoff than was measured at site. A better freshet runoff match was achieved by reducing the snowfall by 25% within the model. As there wasn't any winter data used to develop the precipitation relationship, this reduction was incorporated into the final long-term synthetic monthly precipitation series for the Project climate station.

2.3.2.2 Mean Annual and Monthly Precipitation

The long-term estimated mean annual and monthly precipitation values at the Casino climate station are summarized in Table 2.3-2. The mean annual precipitation for the Project site is estimated to be approximately 460 mm, of which 305 mm (66%) falls as rain in May through September and 155 mm

(34%) falls as snow during October through April. For comparison, the average precipitation for the months of May through September recorded at the Casino climate station from 1993 to 2012 was 321 mm. The estimates of long-term mean monthly precipitation for the Project site range from 13 mm in April to 91 mm in July.

The distribution of precipitation between rainfall and snowfall at the Project site was estimated by assuming that 100% of precipitation in the months of May through September falls as rain, and 100% of precipitation in the months of October through April falls as snow. The resultant values are nearly identical to the mean annual rainfall and snowfall values output from the monthly watershed model, which assumes that all precipitation that occurs when the mean monthly temperature is below -2°C falls as snow, when above 2°C falls as rain, and proportions vary linearly when temperatures are between -2°C and 2°C. The regional rainfall/snowfall distributions presented in Table 2.3-1 generally agree with the distribution derived for Casino.

In summary, the estimated values for mean annual rainfall, snowfall, and total precipitation for the Casino climate station are 305 mm, 155 mm, and 460 mm, respectively.

2.3.2.3 Extreme 24-Hour Rainfall

Environment Canada presents return period rainfall values for Pelly Ranch, which is the closest long-term MSC station to the site. The return period 24-hour extreme rainfall values were transferred to the Casino climate station using an orographic factor of 1.07 per 100 m to the Project site (according to the regression relationship for annual precipitation), and the results are presented in Table 2.3-3. The 24-hour rainfall depths range from 32 mm for a 2-year return period to 71 mm for a 100-year return period.

Table 2.3-3 Extreme 24-Hour Rainfall at the Project Site Climate Station

Climate Station	Elevation (m)	Return Period (years)	24-Hr Rainfall (mm)
Casino Project Site	1200	2	32
		5	42
		10	49
		25	58
		50	64
		100	71

M:\1\01\00325\14\A\Data\Task 370 - Climate Air Quality and Noise\Climate\[Snowpack & IDF.xlsx]Table 2.3-3

NOTE:
1. 24-HOUR RAINFALL DEPTHS ESTIMATED USING RETURN PERIOD RAINFALL AMOUNTS PRESENTED FOR PELLY RANCH BY ENVIRONMENT CANADA AND TRANSLATED TO SITE USING AN OROGRAPHIC FACTOR OF 1.07/100 m.

For comparison, the maximum daily rainfall recorded at the Project site from 2009 to 2012 was 31.5 mm, which corresponds to a return period of 2 years according to the site estimates. The maximum daily rainfall recorded at Pelly Ranch according to the 1971-2000 climate normals is 34.8 mm. Scaled by an orographic factor of 1.07 to the Project site, this would equate to 58 mm at the Project site, or a 25-year return period event. Both of the above comparisons are taken to indicate that the extreme 24-hour rainfall estimates are reasonable and appropriate.

Additionally, the Rainfall Frequency Atlas of Canada (Hogg and Carr, 1985) provides a methodology for estimating the mean and standard deviations for the annual extreme 24-hour rainfall values. The resulting return period values were estimated using a Gumbel distribution. Using this methodology, the site estimates for the 10 year and 100 year 24-hour rainfall extremes are 49 mm and 66 mm, which are generally consistent with the values in Table 2.3-3.

2.4 SUBLIMATION

Sublimation is the process by which moisture is returned to the atmosphere directly from snow and ice without passing through the liquid phase (Liston and Sturm, 2004). Sublimation can play a significant role in the annual hydrologic water balance in areas where winter precipitation comprises a large proportion of annual precipitation. The processes causing and influencing sublimation are not well understood, and many estimates and methods of estimation found in the literature are site-specific, subject to significant uncertainty, and are not easily extrapolated.

It is known that sublimation values can vary substantially according to a number of factors, most notably terrain characteristics, vegetation cover, wind speed and humidity. The project site is located on the western side of the Boreal Cordillera ecozone and near two northern research facilities, Kluane Lake and Wolf Creek research basins. Although both stations are currently active, the most recent published sublimation study was done in Wolf Creek in 1999 (Pomeroy, 1999). This study looked at snowfall and snow accumulation over three distinct zones: alpine tundra, shrub tundra and boreal forest. By looking at snow interception by forest canopies and snow redistribution due to wind, the authors were able to estimate sublimation as a percentage of mean annual snowfall in each region: alpine tundra (39-79%), shrub tundra (17-46%) and boreal forest (38-45%). The results of the Wolf Creek study are considered to be reasonably applicable to the project area with most of the project site falling into the boreal forest classification with some shrub and alpine tundra on the hilltops and in low-elevation permafrost zones. Accordingly, a mean annual sublimation value of 40% of the mean annual snowfall was selected for the project catchments. Sublimation was assumed to be distributed fairly evenly over the period of October through April, when precipitation is expected to predominantly occur as snow. The rounded estimate of 60 mm is based on a general sublimation rate of 40% of the average winter snowfall of 155 mm (Section 2.3.2.2), which equates to approximately 9 mm/month during the winter period.

2.5 WIND SPEED AND DIRECTION

Wind speed and direction are measured on-site at the Casino climate station and data are available for the period from November 2008 through September 2012. A regional analysis to account for long-term variability in wind conditions was not deemed necessary as the measured site data are considered to be reasonably representative of expected long-term conditions.

The Project site wind speed data are presented in Table 2.5-1. The mean annual wind speed is 2.3 m/s (8.3 km/hr). The mean monthly wind speeds are higher in the spring, summer and autumn and lower in the winter, with values ranging from 1.7 m/s in November to 2.7 m/s in May. The maximum hourly wind speed recorded between 2008 and 2012 was 14.9 m/s (53.6 km/hr). The predominant wind direction was northerly, followed by south-westerly.

Table 2.5-1 Monthly Wind Speed at the Project Site Climate Station

Climate Station	Elevation (m)	Wind Speed (m/s)													
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Site	1200	2008	-	-	-	-	-	-	-	-	-	-	1.8	1.5	-
		2009	2.0	2.0	2.9	2.2	2.5	2.7	2.5	2.4	2.2	2.3	1.6	1.5	**2.2**
		2010	1.7	1.8	3.0	2.8	2.6	2.5	2.4	2.2	2.4	2.4	1.7	2.1	**2.3**
		2011	-	-	2.0	2.7	2.9	2.4	2.2	2.3	2.5	1.9	1.7	2.2	-
		2012	1.8	2.3	2.2	2.4	2.9	2.4	2.4	2.4	3.1	-	-	-	-
		Average	**1.8**	**2.0**	**2.5**	**2.5**	**2.7**	**2.5**	**2.4**	**2.3**	**2.5**	**2.2**	**1.7**	**1.8**	**2.3**

M:\1\01\00325\14\A\Data\Task 370 - Climate Air Quality and Noise\Climate\[Wind and RH.xlsx]Table 2.5-1

2.6 RELATIVE HUMIDITY

Relative humidity is measured on-site at the Casino climate station and data are available for the period from November 2008 through September 2012. A regional analysis to account for long-term variability in humidity conditions was not deemed necessary as the measured site data are considered to be reasonably representative of long-term conditions.

The Project site relative humidity data are presented in Table 2.6-1. The mean annual relative humidity is 68%. Mean monthly relative humidity values are lowest in the spring (54% to 65% in the months of March through May) and higher throughout the rest of the year (66% to 76% in the months of June through February).

Table 2.6-1 Monthly Relative Humidity at the Project Site Climate Station

Climate Station	Elevation (m)	Relative Humidity (%)													
		Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Site	1200	2008	-	-	-	-	-	-	-	-	-	-	71	69	-
		2009	72	67	71	56	51	62	53	75	71	80	78	70	**67**
		2010	77	67	64	57	49	71	72	71	71	76	79	79	**69**
		2011	-	-	55	62	56	77	77	75	64	73	78	72	-
		2012	72	64	71	59	60	71	70	68	66	-	-	-	-
		Average	**74**	**66**	**65**	**59**	**54**	**70**	**68**	**72**	**68**	**76**	**76**	**72**	**68**

M:\1\01\00325\14\A\Data\Task 370 - Climate Air Quality and Noise\Climate\[Wind and RH.xlsx]Table 2.6-1

2.7 EVAPOTRANSPIRATION

In the 2012 hydrometeorology report (KPL, 2012), the Thornthwaite Equation was selected as the preferred method for estimating monthly and annual potential evapotranspiration (PET) at the Project site. The Thornthwaite equation (Thornthwaite, 1948) only requires mean monthly temperature as an input, as shown below. The equation assumes that PET is zero when the mean monthly temperature is below 0 C.

$$ET_0 = \begin{cases} 0, T < 0 \deg C \\ 16\left(\frac{10T_i}{I}\right)^a, 0 \le T \le 26.5 \deg C \\ -415.85 + 32.24T_i - 0.43T_i^2, T \ge 26.5 \deg C \end{cases}$$

Where:

PET_0 = Potential evapotranspiration (mm/month)
T_i = Mean monthly temperature (°C)
I = Heat index, sum of 12 monthly index values (i)
i = Monthly heat index
a = Empirically derived exponent, which is a function of I

And:

$$i = \left(\frac{T}{5}\right)^{1.514}$$

$$a = 6.75*10^{-7} I^3 - 7.71*10^{-5} I^2 + 1.79*10^{-2} I + 0.49$$

Monthly PET values based on measured temperatures at the Casino climate station, and long-term mean monthly PET values based on the synthetic temperature series for the Casino climate station, are presented in Table 2.7-1. Potential evapotranspiration values generally provide reasonable estimates of lake evaporation rates, and therefore the long-term values in Table 2.7-1 are assumed to be appropriate for estimating evaporation from lakes and ponds in the Project area.

Table 2.7-1 Monthly Potential Evapotranspiration at the Project Site Climate Station

Climate Station	Elevation (m)	Method	Year	Evapotranspiration (mm)												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Casino Project Site	1200	Thornthwaite Equation	1993	0	0	0	20	57	71	80	67	40	0	0	0	335
			1994	0	0	0	19	44	68	83	84	35	0	0	0	332
			1995	0	0	0	19	53	76	78	62	52	0	0	0	341
			2008	0	0	0	0	52	74	73	66	39	0	0	0	305
			2009	0	0	0	0	47	71	88	64	44	0	0	0	314
			2010	0	0	0	0	57	66	77	74	36	0	0	0	310
			2011	0	0	0	0	0	53	68	76	64	46	0	0	308
			2012	0	0	0	9	36	71	77	73	41	0	0	0	307
			Measurement Period Average	0	0	0	8	43	69	78	71	44	6	0	0	319
			Long-term Est.	**0**	**0**	**0**	**2**	**43**	**72**	**79**	**68**	**37**	**1**	**0**	**0**	**303**

M:\1\01\00325\14\A\Data\Task 370 - Climate Air Quality and Noise\Climate\[PET.xlsx]Table 2.9

NOTE:

1. POTENTIAL EVAPOTRANSPIRATION VALUES WERE CALCULATED BASED THE THORNTHWAITE EQUATION AND USING THE SYNTHETIC TEMPERATURE SERIES FOR THE PROJECT CLIMATE STATION. THE SYNTHETIC SERIES CONTAINS MEASURED DATA WITHIN THE MEASUREMENT PERIOD.

The mean annual PET calculated for the period of site temperature data collection is 319 mm. The estimated long-term mean annual PET is 303 mm. To reflect the uncertainties involved in estimating this value, the recommended value of mean annual PET at the Project site climate station is 300 mm.

Using the synthetic temperature and precipitation data series as inputs to a watershed model and calibrating to site streamflow data, an estimate of PET to AET was developed. In order to calibrate the model to summer streamflows, AET is estimated to be 205 mm, giving an AET/PET ratio of 0.68.

2.8 SNOW ACCUMULATION AND MELT

The SWE measurements recorded at the Yukon Environment snow course 09CD-SC01 are presented in Table 2.8-1. The snow course survey is located in a shrub tundra zone near the Casino Airstrip. The annual maximum SWE was typically recorded at the start of April or the start of May, with an approximately even distribution of occurrences between the two dates. The mean annual maximum SWE over the period of record is 142 mm. This value is higher than the estimated values

of mean annual snowfall and sublimation (155 mm and 60 mm, respectively) that were discussed in Sections 2.3 and 2.4. The snow course survey is located in a shrub tundra zone and is likely a net accumulator of blown snow. As noted in Section 2.4, shrub tundra areas experience lower rates of sublimation than areas with forest canopy. As the majority of the site is forested, site sublimation is expected to be higher and the resulting SWE lower than that measured at the snow survey course.

The proportions of snowmelt in April and May were determined from the SWE measurements by calculating monthly differences in SWE from the point of maximum SWE onwards in each year and assuming that all snow is melted by the start of June. This method may underestimate April snowmelt because it does not account for temporary snow accumulation and corresponding melt between the early April and early May measurement dates. Conversely, this method may overestimate May snowmelt because the complete snowpack might not melt before the start of June in some years.

The estimated mean monthly snowmelt volumes for the Casino snow survey station in April and May are 22 mm and 120 mm, respectively. These values represent 17% and 83%, respectively, of the annual melt after the date of maximum SWE accumulation.

Using the calibrated watershed model, a site wide estimate of mean monthly snowmelt at an elevation of 1200 m was produced. The model predicts a mean monthly May snowmelt of 87 mm. Using this value, and rounded mean monthly percent snowmelt (15% in April and 85% in May), the mean annual SWE is 100 mm. The watershed model value generally agrees with the value calculated from mean annual snowfall and sublimation and the recommended, rounded value for mean annual maximum SWE is 95 mm for the project area.

Table 2.8-1 Monthly Snowpack and Snowmelt at the Casino Creek Snow Course

Snow Course	Elevation (m)	Year	Annual Maximum SWE (mm)	Monthly Snow Melt (mm)		Monthly Snow Melt (%)	
				April	May	April	May
Casino Creek (09CD-SC01)	1164	1977	125	0	125	0%	100%
		1978	98	12	86	12%	88%
		1979	170	25	145	15%	85%
		1980	95	0	95	0%	100%
		1981	88	0	88	0%	100%
		1982	173	0	173	0%	100%
		1983	120	40	80	33%	67%
		1984	139	0	139	0%	100%
		1985	180	0	180	0%	100%
		1986	168	0	168	0%	100%
		1987	117	0	117	0%	100%
		1988	99	45	54	45%	55%
		1989	136	56	80	41%	59%
		1990	144	44	100	31%	69%
		1991	225	58	167	26%	74%
		1992	207	0	207	0%	100%
		1993	190	0	190	0%	100%
		1994	110	54	56	49%	51%
		1995	104	0	104	0%	100%
		1996	118	8	110	7%	93%
		1997	149	55	94	37%	63%
		1998	88	88	0	100%	0%
		1999	126	0	126	0%	100%
		2000	158	9	149	6%	94%
		2001	147	0	147	0%	100%
		2002	118	0	118	0%	100%
		2003	90	21	60	23%	67%
		2004	152	0	152	0%	100%
		2005	199	106	93	53%	47%
		2006	134	13	121	10%	90%
		2007	124	0	124	0%	100%
		2008	122	111	0	91%	0%
		2009	208	0	208	0%	100%
		2010	128	22	106	17%	83%
		2011	182	0	182	0%	100%
		2012	182	22	160	12%	88%
		Mean	**142**	**22**	**120**	**17%**	**83%**

M:\1\01\00325\14\A\Data\Task 370 - Climate Air Quality and Noise\Climate\[Snow pack & IDF.xlsx]Table 2.8-1

NOTES:

1. THE CASINO CREEK SNOW COURSE IS OPERATED BY YUKON ENVIRONMENT.
2. SWE = SNOW WATER-EQUIVALENT.
3. MONTHLY SNOWMELT WAS ESTIMATED BY SUBTRACTION OF CONSECUTIVE SWE MEASUREMENTS. MELT WAS ASSUMED TO BE ZERO IN CASES WHERE SWE INCREASED IN THE LATTER MEASUREMENT.
4. THE SNOWMELT ESTIMATES ASSUME THAT 100% OF SNOW MELTS BY THE END OF MAY, WHICH IS LIKELY NOT VALID IN ALL YEARS, ESPECIALLY IN THOSE YEARS WHERE MAXIMUM SWE OCCURRED IN MID-MAY.
5. MONTHLY SNOWMELT (%) REFERS TO THE FRACTION OF ANNUAL MAXIMUM SWE THAT MELTED IN A GIVEN MONTH.

3 – CONCLUSIONS

The recommend values for key climatic parameters, referenced to the Project site climate station at 1,200 m elevation, are presented below:

CLIMATIC PARAMETERS (1,200 M ELEVATION)	VALUE
Mean Annual Temperature	-3 C
Mean January Temperature	-18 C
Mean July Temperature	11 C
Extreme Minimum Temperature	-50 C
Extreme Maximum Temperature	30 C
Mean Annual Precipitation	460 mm
Mean Annual Rainfall	305 mm
Mean Annual Snowfall (Water-Equivalent)	155 mm
Mean Annual Rainfall/Snowfall Distribution	66% / 34%
2-Year 24-Hr Rainfall	32 mm
100-Year 24-Hr Rainfall	71 mm
Mean Annual Sublimation	60 mm
Mean Annual Wind Speed	2.3 m/s
Maximum Wind Gust Speed	14.9 m/s
Prevailing Wind Direction	Northerly
Mean Annual Relative Humidity	68%
Mean Annual Potential Evapotranspiration	300 mm
Mean Annual Maximum Snow Water-Equivalent	100 mm
Mean Monthly Snowmelt for May (Water-Equivalent)	85 mm

Temperature and precipitation can be adjusted to reflect conditions at different elevations according to the following guidelines:

CLIMATIC PARAMETER ELEVATION ADJUSTMENTS	VALUE
Mean Monthly Temperature)	- 0.65 °C per 100 m
Mean Annual Precipitation	+7% per 100 m

4 – REFERENCES

Environment Canada, 2013a. National Climate Data and Information Archive. http://climate.weatheroffice.gc.ca/climate_normals/index_1961_1990_e.html, downloaded March 2013.

Environment Canada, 2013b. Boreal Cordillera Ecozone. http://ecozones.ca/english/zone/BorealCordillera/ecoregions.html, downloaded January 2013.

Hallam Knight Piésold Ltd. (HKPL), 1993. Casino Project, Environmental Monitoring Program, Baseline Environmental and Socioeconomic Studies. Pacific Sentinel Gold Corporation, November 18, 1993.

Hogg, W.D. and Carr, D.A., 1985. Rainfall Frequency Atlas of Canada. Ministry of Environment, Canadian Climate Program.

Janowicz, J.R., Hedstrom, N., Pomeroy, J., Granger, R., and Carey, S.(2004). *Wolf Creek Research Basin water balance studies*, Northern Research Basins Water Balance (Proc. of a workshop held at Victoria, Canada, March 2004), IAHS Publication 290.

Knight Piésold Ltd. (KPL), 2012. Casino Copper-Gold Project – Hydrometeorology Report. Ref. No. 101-325/8-11, Rev. 0. July 9, 2012.

Knight Piésold Ltd. (KPL), 2013. Casino Project – Baseline Hydrology Report. Ref. No. 101-325/14-5, Rev. 0. June, 2013.

Liston, G.E. and M. Sturm, 2004. *The role of winter sublimation in the Arctic moisture budget*, Department of Atmospheric Science. Colorado, USA.

Pomeroy, J.W., Bewley, D.S., Essery, R.L.H., Hedstrom, N.R., Link, T., Granger, R.J., Sicart, J.E., Ellis, C.R., and Janowicz, J.R. (2006). *Shrub tundra snowmelt,* Hydrological Processes, 20, 923-941.

Pomeroy, J.W., Hedstrom, N.R. and Parviaien, J. (1999). *The snow mass balance of Wolf Creek, Yukon: effects of snow sublimation and redistribution.* In: Wolf Creek Research Basin – Hydrology, Ecology, Environment (Proc. workshop held in Whitehorse, Yukon, Canada, 5-7 March, 1998), 15-29. NHRI publication 37-121/1999E, Saskatoon, Saskatchewan, Canada.

RWDI Air Inc. (RWDI), 2012. *Meteorological, Dustfall and Noise Data Summary Report – Casino Western Copper*. Ref. No. 1011858. January 20, 2012.

Thornthwaite, C.W., 1948. *An approach toward a rational classification of climate,* Geographical Review (American Geographical Society) 38 (1): 55–94.

Yukon Government, 2012. Ecoregions of the Yukon Territory, Part 2. http://www.emr.gov.yk.ca/oilandgas/pdf/bmp_boreal_cordillera_ecozone_wt.pdf, downloaded May 2013.

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