Stantec

Memo

To:	Nicola Banton KGHM Ajax Mine Kamloops, BC	From:	Peter Reid Stantec Consulting Ltd. Kamloops, BC
File:	123510762	Date:	March 29, 2016

Reference: Response to MEMO NUMBER SLR005

MEMO NUMBER SLR005 dated 22/02/2016 asks for clarification on specific items concerning the CALMET files. The review comments are broken up in order to facilitate the responses.

Comment SLR005-1a:

The landuse used in the GEO.DAT files show that the majority of the domain (54.2%) is characterized as deciduous forest (code 41). Review Tables C-3 through C-6 indicate that the surface roughness for this landuse category should change through seasons (e.g., 0.5 to 1.0 to 1.3 to 0.5 for winter though fall, respectively). However the surface roughness value remains at 1.3 throughout all the seasons. Either this landuse was intended to be categorized as evergreen forest (constant surface roughness of 1.3) or the geophysical parameters were incorrectly mapped during the conversion into CALMET landuse categories.

Response SLR005-1a:

The correct values of surface roughness length, albedo, Bowen ratio, soil heat flux parameter, leaf area index and anthropogenic heat flux are in the gridded fields of the six surface parameters. These are the actual values used by the CALMET model, not the landuse codes in the GEO.DAT files.

The land use data was correctly input into the CALMET model in accordance with the both the model plan and the British Columbia Air Quality Modelling Guideline and properly characterizes both the land use in the study area and seasonal variation in parameters. The domain as modelled does not consist of 54.2% deciduous forest.

CALMET was run using gridded fields of six surface parameters including surface roughness length, albedo, Bowen ratio, soil heat flux parameter, leaf area index and anthropogenic heat flux. The CALMET model allows the user to either input the roughness length, Bowen ratio, albedo, leaf area index and heat flux data as either gridded fields of values or, as a second option, allow CALMET to compute the value based upon the provided land use codes in the GEO.DAT file. For this Project, as indicated in the GEO.DAT file, CALMET was run using gridded fields for each parameter. CALMET does not use the land use codes in the GEO.DAT file to determine surface parameters. CALMET only uses the land use to determine if a CALMET grid cell is over land or over water.

Gridded fields of roughness length, Bowen ratio, albedo, leaf area index and heat fluxes in the GEO.DAT files were generated based upon the CEC 2010 land-cover data set using the MAKEGEO pre-processor. Figure 1 below shows the land use map that correspond to the GEO.DAT file. All values of surface parameters in CALMET Appendix tables C-3 to C-6 are correct and consistent with section 9.3.2 of the British Columbia Air Quality Modelling Guideline (BC MOE 2008) and CALMET User Guide (Scire et al. 2000). The latter was used in the absence of specific recommendation in the

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Guidelines (BC MOE 2008). Table 2 below indicates that the majority of the study area is in fact temperate or sub-polar needleleaf forest.

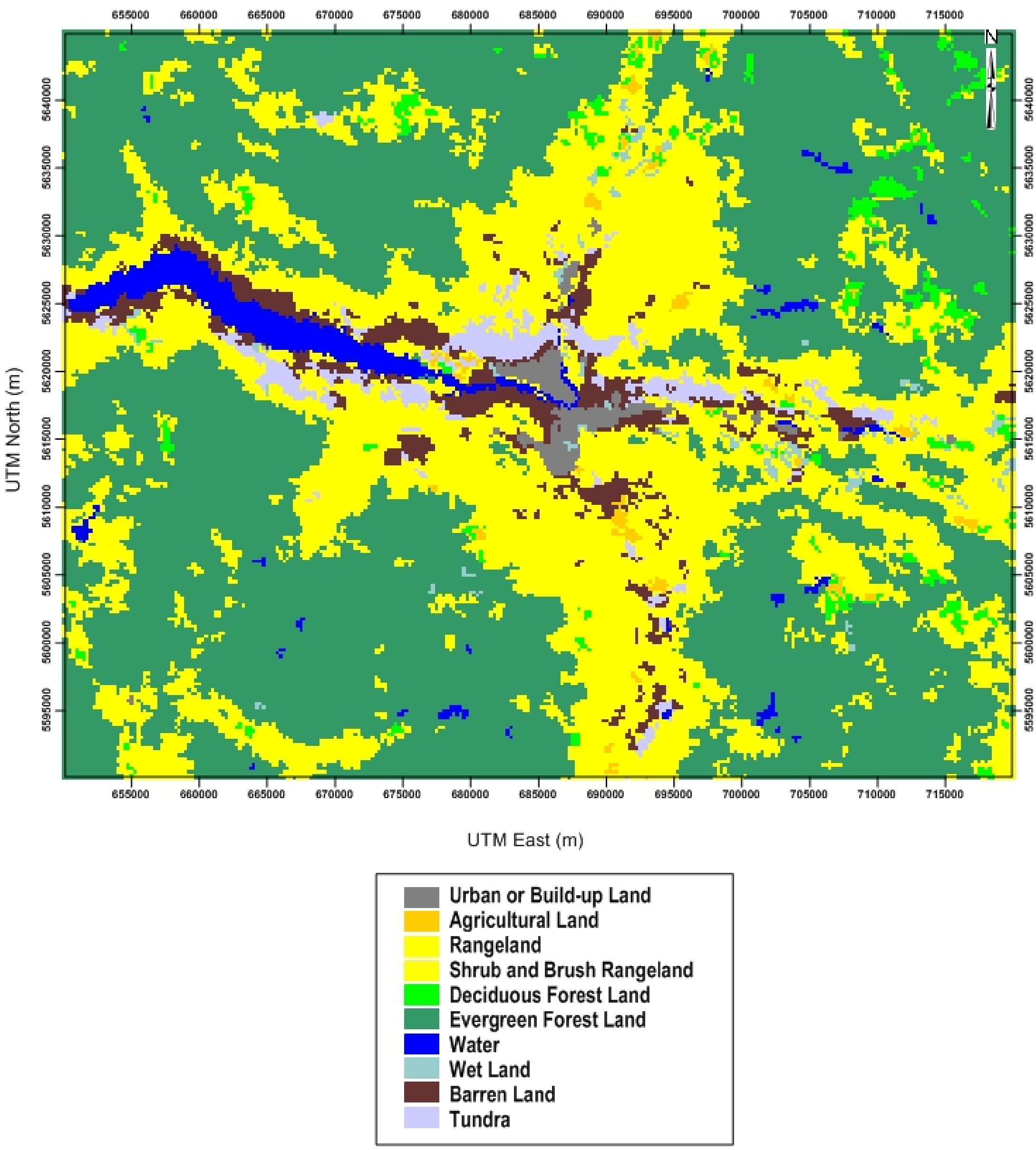

Figure 1. Land Use Map within CALMET Model Domain

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Table 1 CEC 2010 Land Use Types (250 m resolution) Counts at CALMET Grids

CEC 2010 Land cover code	CEC 2010 Land cover type	CALMET code**	CALMET Land Use category	Count of cells	Count (percentage)
1	Temperate or sub-polar needleleaf forest	42	Evergreen Forest Land	33411	54.24%
5	Temperate or sub-polar broadleaf deciduous forest	41	Deciduous Forest Land	1133	1.84%
8	Temperate or sub-polar shrubland	32	Shrub and Brush Rangeland	15438	25.06%
10	Temperate or sub-polar grassland	30	Rangeland	5527	8.97%
12	Sub-polar or polar grassland-lichen-moss	80	Tundra	23	0.04%
13	Sub-polar or polar barren-lichen-moss	80	Tundra	1200	1.95%
14	Wetland	60	Wet Land	360	0.58%
15	Cropland	20	Agricultural Land	328	0.53%
16	Barren lands	70	Barren Land	2239	3.63%
17	Urban	10	Urban or Build-up Land	591	0.96%
18	Water	50	Water	1350	2.19%

Comment SLR005-1b:

In addition, portions of the domain (near the urban areas) are categorized as tundra when rangeland or shrub rangeland may be more appropriate based on aerial photographs and the elevation/climate of the area. The proper landuse characterization is critical for the model to generate the proper planetary boundary layer parameters and dispersion profiles.

Response SLR005-1b:

The British Columbia Air Quality Modelling Guideline and the CALMET user manual do not include either sub-polar grassland-lichen-moss or sub-polar barren-lichen-moss land cover types in the provided tables of surface parameters. As a result, it was necessary to classify these two land cover types as another more generalized land use code with similar roughness length, Bowen ratio, albedo and leaf area index values. As these specific areas have minimal vegetation or are barren areas, it is reasonable to apply the roughness length, Bowen ratio, albedo and leaf area index values typical of "tundra" to these specific grid cells.

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Gridded fields of roughness length, Bowen ratio, albedo, leaf area index and heat fluxes in the GEO.DAT files were generated based upon the CEC 2010 land-cover data set using the MAKEGEO pre-processor. The CEC 2010 land-cover dataset is a remote-sensing generated dataset that provides high resolution land cover data at a level of accuracy suitable for meteorological modelling.

The CEC 2010 land-cover dataset indicated that small portions of the domain were classified as either sub-polar grassland-lichen-moss or sub-polar barren-lichen-moss. The corresponding definitions of the land cover classifications are areas dominated by grassland with lichen and moss typically accounting for at least 20 percent of total vegetation cover and areas dominated by a mixture of bare areas with lichen and moss that typically account for at least 20 percent of total vegetation cover, respectively.

It is noted that the surface parameters that influence meteorology (roughness length, albedo and Bowen ratio) for the tundra and rangeland land cover types in the CALMET user manual are in fact similar. Due to the similarity in land cover parameters, regardless of which land cover is assumed for these specific grid points, it is unlikely to have any meaningful effect on the air quality modelling.

Stantec believes the use of the “tundra” land use to these specific grid cells is appropriate. Regardless, this land use constitutes only 2% of the total land cover. The substitution of tundra with a similar alternate land use will have no meaningful effect on the results.

Comment SLR005-2a:

The PRECIP.DAT file contains 3 stations that average 183 mm/yr; 682 mm/yr; and 297 mm/yr, which indicates a significant range within a small domain. The Detailed Modeling Plan (March 4, 2015) indicates that the Walloper site was removed due to anomalous precipitation rates, but review of the PRECIP.DAT file indicates the site is still modeled and averages 682 mm/yr, well above the climatological range of the area. In agreement with the modeling plan’s description for its removal, the first portion of the data record in 2003 shows precipitation rates much higher than the rest of the period. This may overstate the amount of wet deposition and scavenging and understate the ambient air concentrations.

Response SLR005-2a:

The reviewer calculated average precipitation is based on incomplete data from Afton and Walloper stations. Table 2 shows the missing hours of data for all of three stations for 2003 to 2005. 42%, 50% data were missing at Walloper and Afton stations, respectively.

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Table 2 Missing hours of measured precipitation

	Afton	Walloper	Kamloops Airport
2003	4,386	3,787	0
2004	4,369	3,673	0
2005	4,345	3,700	0

In the BC Southern Interior topography exerts a major effect on Climate. In general, the uplands receive much more precipitation than the valley bottoms (BC Wildfire Service, accessed 2015). The new model Guidelines (BC MOE 2015: section 5.9.3) indicates that the use of precipitation data collected at airports may underestimate the orographic enhancement of precipitation at higher elevations, or the precipitation data may not be representative of the whole domain.

The Kamloops Airport Weather Station is located at elevation of 345 m in the Thompson River valley, while the Walloper weather station is located at an elevation of 1,300 m approximately 10 km SW of the proposed Ajax open pit. It follows that the Walloper station site receives more precipitation due to orographic enhancement of precipitation than Kamloops Airport.

The Afton station is missing precipitation data for four months (January to April) in 2003. Without using the 2003 precipitation data from Walloper station, it would have been necessary to use Kamloops Airport precipitation data alone for January to April in 2003. Table 3 shows the elevations of the project site relative to the elevations of Walloper, Afton and Kamloops airport stations. The proposed project is at a much higher elevation than the airport and would experience increased precipitation. Thus it is preferable to use the high elevation station data instead of using Kamloops Airport station precipitation alone for January to April, 2003.

Table 3 Elevation (m asl) of Project Site and Three Precipitation Stations

Ajax Site	Afton	Walloper	Kamloops Airport
850 to 1,100	780	1,300	345

The stations with high precipitations (e.g. Walloper) are generally located in the part of the study area in high terrain and the stations with low precipitation (e.g. Kamloops Airport) are located in the portion of the study area at low elevation, thus it was preferred to allow CALMET to create the precipitation field using all of the station data to more realistically account for the influence of terrain on precipitation. Stantec believes the best approach is to include valid data from all three stations to create a gridded two dimensional precipitation field. For this assessment, the default $1/r^2$ weighting option along with radius of influence (r) default 100 km was applied.

BC Wildfire Service, accessed 2015 http://bcwildfire.ca/aboutus/organization/kamloops/climate/

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Comment SLR005-2b:

An illustration of the hourly precipitation rates (in mm) for January 14, 2003 at hour ending 7 am is show below and demonstrates the heterogeneous precipitation fields.

Response SLR005-2b:

This heavy gradient is likely a result of the coarse precipitation observation network. The CALMET precipitation field would be much smoother if there were more precipitation stations between Walloper and Kamloops airport stations in 2003-2005.

Comment SLR005-3:

Generally, there is some concern about the self-consistency within CALMET with the noted precipitation issues (the project site experiences 343 hours of precipitation during January 2003, while the airport experiences 34 hours of precipitation). For instance, there are several occurrences of cloud cover (only available at the airport) being very low (< 2/10), but precipitation being recorded at the Project site (due to the precipitation site south of the Project area). An example of this is on January 6, 2003 with several occurrences of precipitation but low fractional cloud cover). If the MM5 data has the fields available, use of that data for cloud cover and precipitation would provide a level of self-consistency within CALMET and eliminate these issues.

Response SLR005-3:

Precipitation hours and amounts at Environment Canada (EC) weather stations are generally underestimated by them not recording trace precipitation less than 0.2 mm/hr (EC climate glossary) due to their measurement standard. The precipitation measurements from BC Wildfire Service network include amounts less than 0.2 mm/hr (e.g. there are 1,274 hours with 0.1 mm/hr precipitation at Walloper weather station in 2003). Therefore precipitation data at Project site extracted CALMET output normally show much more precipitation hours than those from EC Kamloops airport station. For example, in January 2003, CALMET predicted 166 hours with less than 0.2 mm/hr at the AJAX project site. For this same reason there are inconsistencies between measured cloud cover and measured/CALMET predicted.

Stantec is confident that the choice to include the Walloper data is preferable to excluding the Walloper data. Given the limited influence these data have on the region of the proposed Project, and in particular the City of Kamloops, the expected differences in deposition and concentration predictions in this region is immaterial.

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References:

Adjusted Precipitation Data Access https://ec.gc.ca/dccha-ahccd/default.asp?lang=en&n=9AA530BE-1

EC Climate glossary http://climate.weather.gc.ca/glossary_e.html

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