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Final Environmental Impact Statement (FEIS) – Meliadine Gold Project, Nunavut

REPORT

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ᐅᓂᒃᑳᓗᒃᑖᒧᑦ ᓇᐃᓈᖅᓯᒪᔪᖅ

ᐱᕝᕕᑎᒋᔭᐅᔪᖅ

5-ᒋᔭᖓᑦ ᑭᒍᓪᓕᖅᐹᓕᐊᑉ ᓄᓇᒥᑦ ᐊᒻᒪ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᐅᖃᐅᓯᐅᔪᖅ (FEIS) ᑕᓯᕝᕙᖅ ᒨᓗᒧᑦ ᐅᔭᕋᒃᑕᕐᕕᒧᑦ ᐱᓕᕆᕝᕕᒧᑦ (ᐱᓕᕆᐊᖅ) ᐃᓯᒪᒃᓴᖅᓯᐅᕈᑎᖃᖅᑐᖅ ᓄᓇᕝᕙᑉ ᓯᓚᖓᓂᑦ. ᐱᕝᕕᑎᒋᔭᖓ 5-ᒋᔭᖓᑦ ᐱᓕᕆᐊᕆᕙᒪᑉᓗᒍ ᒪᓕᒃᑕᐅᔪᒃᓴᐃᑦ ᓴᕿᑎᑕᐅᔪᖅ ᓄᓇᕗᒻᒥᑦ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᕐᒋᓐᓄᑦ ᐱᓕᕆᐊᒧᑦ ᐊᑐᖅᑐᒃᓴᖅ, ᐊᒻᒪ ᐊᒃᑐᐊᓗᐊᖅᑐᑦ ᐊᒃᑐᖅᓯᕝᕙᑕᐅᔪᓐᓇᖅᑐᓄᑦ ᐱᓕᕆᐊᒧᑦ ᐊᓂᖅᖠᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ, ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕝᕙᑉᓗ ᓯᓚᖓ, ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓᑕ ᐊᓯᐊᕈᖅᐸᓪᓕᐊᓂᖓ (ᐃᓚᐅᑉᓗᓂ ᐳᕙᐃᑦ (GHG) ᓯᓚᒧᐊᖅᐸᓪᓕᐊᕝᕙ), ᐊᒻᒪ ᓂᐸᓕᐊᕝᕙ.

ᓄᓇᕝᕙᑉ ᓯᓚᑖᓄᑦ ᖃᐅᔨᓴᐃᓂᖕᒥᑦ ᐃᓚᐅᕝᕙ ᐊᓯᐊᕈᕐᓂᐅᕝᕙᖅᑐᑦ ᐱᓕᕆᐊᒧᑦ ᐊᒃᑐᐊᕝᕕᒃ ᐱᓕᕆᐊᑉᓘᓃᑦ ᓯᓚᑖᓃᓖᖅᑐᓂᒃ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᕆᓐᓄᑦ, ᐊᒻᒪ ᖃᐅᔨᓴᖅᑕᐅᓗᒃᑖᖅᓗᓂ ᐱᓕᕆᐊᑉ ᐊᐅᓚᓂᕐᓂᕆᔭᖓ, ᐃᓚᐅᑉᓗᑎᒃ ᓴᓇᕐᓪᓕᐊᓂᖅ ᐃᒡᓗᕝᕙᕋᓗᕐᓂᑦ; ᐊᐅᓚᓂᕐᓂᖓᓂᒃ; ᐋᕿᐅᒪᑎᑦᑎᓂᐅᕝᕕᒃ; ᐊᒻᒪ ᐅᒃᑯᐊᓚᐅᐱᓪᓚᕐᓂᖅ, ᑭᒍᓪᓕᖅᐹᒃᑯᑦ ᐅᒃᑯᐊᕐᓂᖓ, ᐊᒻᒪ ᐅᒃᑯᐊᖅᑕᐅᓯᒪᓕᖅᑎᓪᓗᒍ. ᐊᕐᕆᒡᓕᕋᓪᓕᐊᕝᕙ ᐊᒃᑐᖅᓰᑦ ᐱᓕᕆᐊᓄᑦ ᐊᒻᒪ ᐱᓕᕆᐊᒃᓴᐅᔪᓄᑦ ᐱᓕᕆᐊᒥᑦ ᑲᑎᑕᐅᓚᐅᖅᑐᑦ, ᐱᔭᕆᐊᖃᕌᖓᑦ.

ᖃᐅᔨᓴᐃᓃᑦ

ᖃᓄᖅ ᐊᕐᕆᑎᒋᓂᖓ ᐊᒻᒪ ᑭᒡᓕᐅᕝᕙ ᓇᓗᓇᐃᔭᖅᑕᐅᓚᐅᖅᑐᑦ ᐃᓚᓕᐅᑎᕙᒪᑉᓗᒍ ᖃᐅᔨᓴᐃᓂᖅ ᐊᒻᒪ ᑐᑭᓕᐅᕐᓂᖅᒧᑦ ᐊᒃᑐᖅᓯᓂᐅᕝᕙᖅᑐᓂᒃ ᐊᒃᑐᐊᕝᕙᓄᑦ ᐱᓕᕆᐊᒧᑦ ᓄᓇᕝᕙᑉ ᓯᓚᖓᓂᑦ. ᖃᓄᖅ ᐊᕐᕆᑎᒋᓂᖓᓄᑦ ᑭᒡᓕᓕᐅᖅᑕᐅᕝᕙ ᐋᕿᒃᑕᐅᑎᐊᓚᐅᖅᑐᑦ ᐊᑐᕐᒍᕆᑦ ᓇᓚᐅᑖᖅᑕᐅᕝᕙ ᐊᕐᕆᓂᕆᔭᖓᓂᒃ ᐱᓕᕆᐊ`ᒨᖓᔪᑦ ᐊᒃᑐᖅᓯᕝᕕᑦ ᐊᒻᒪ ᓄᓇᕝᕙᑉ ᓯᓚᑖᑕ ᐃᓕᑦᑯᓯᕆᓐᓄᑦ ᐆᒪᓂᕆᔭᕆᓈᖓᔪᑦ ᐊᒃᑐᐊᕝᕙ ᓄᓇᒧᑦ (VECs) ᐱᓕᕆᐊᒧᑦ ᖃᓄᐃᖓᓕᕈᑕᐅᕝᕙᖅᑐᑦ.

ᖃᐅᔨᓴᐃᓂᖅᑕᖃᓚᐅᖅᑐᖅ ᓄᓇᕝᕙᑉ ᓯᓚᑖᓂᑦ ᐊᒃᑐᖅᓯᓂᐅᕝᕙᖅᑐᓂᒃ ᓯᑕᒪᐅᓗᐊᖅᑐᓂᒃ ᐱᓕᕆᐊᖑᔪᓂᒃ: ᐅᔭᕋᒃᑕᕐᕕᐊᑉ ᖃᓂᑖᓂᑦ (ᐊᒻᒪ ᐊᒃᑐᐊᕝᕙ ᐱᖁᑎᒋᔭᐅᕝᕙ); ᐋᕿᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᑉᖁᑎᒥᒃ (AWAR); ᑲᖏᖅᖠᓂᖅᒥᑦ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓃᑦ; ᐊᒻᒪ ᑕᓇᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᖅᑲᑦᑕᕐᓂᖅ. ᐅᑯᐊ ᐱᖓᓲᔪᑦ ᖃᓄᖅ ᐊᕐᕆᑎᒋᓂᖓᓄᑦ ᑭᒡᓕᓕᐅᖅᑕᐅᕝᕙ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᑐᑦ:

- ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA) ᐊᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᖃᐅᔨᓴᐃᓂᕐᒥᒃ ᐊᕐᕆᒡᓕᕋᓪᓕᐊᕗᓄᑦ ᐊᒃᑐᖅᓯᓂᐅᕝᕙ ᐱᓕᕆᐊᒥᑦ.
- (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᕝᕕᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᖅ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᖃᓂᑦᑐᒥᑦ ᐊᕐᕆᒡᓕᕋᓪᓕᐊᕗᓄᑦ ᐊᒃᑐᖅᓯᓂᐅᕝᕙ ᐱᓕᕆᐊᒥᑦ.
- ᐊᑕᐅᔾᔪᐃᓐᓇᖅᓗᒍ (RSA) ᐊᕐᕆᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᑭᕙᓪᓕᕐᒥᑦ ᐊᕐᕆᒡᓕᕋᓪᓕᐊᕗᓄᑦ ᐊᒃᑐᖅᓯᓂᐅᕝᕙ ᐱᓕᕆᐊᒥᑦ.

ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA) ᓇᓗᓇᐃᖅᑕᐅᓚᐅᕆᑦᑐᖅ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕝᕙᑉ ᓯᓚᖓᓄ, ᐅᕙᓗᓃᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓᑕ ᐊᓯᐊᕈᖅᐸᓪᓕᐊᓂᖓᓄᑦ. ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA) ᐊᓂᖅᖠᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᖓᓂᕆᔭᖓᓂᑦ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᑐᖅ ᓄᓇᒥᑦ ᐊᑐᖅᑕᐅᕝᕕᒥᑦ ᐃᓗᐃᓗᑕᓕᐅᕐᓂᕐᒧᑦ ᐊᒃᑐᐊᕝᕙ ᓴᓇᕐᓪᓕᐊᕝᕙᐅᓂᕆᓐᓄᑦ ᐊᒻᒪ ᐊᐅᓚᓂᕐᓂᕐᒧᑦ ᐅᔭᕋᒃᑕᕐᕕᐊ ᐃᓂᖓᓂᒃ, ᐊᒻᒪ ᑎᑭᓗᓂ ᓯᓚᑖᓄᑦ 500 ᒦᑕᒥᑦ ᐅᖓᓯᖕᓂᓕᕐᒧᑦ. ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA) ᓂᐱᖃᕐᓂᕐᒧᑦ ᐃᓚᐅᕝᕙ ᐊᓂᖅᖠᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᖓᓂᕆᔭᖓ ᐊᒻᒪ ᐋᕿᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᑉᖁᑎᒥᒃ (AWAR) ᐊᒻᒪ ᖃᓄᐃᓕᐅᕐᓂᐅᕝᕙ ᑲᖏᖅᖠᓂᐅᑉ ᐃᓗᐊᓂᑦ. ᐊᓂᖅᖠᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᖓᓂᕆᔭᖓ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᕆᑦᑐᖅ ᐋᕿᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᑉᖁᑎᒥᒃ (AWAR)ᒧᑦ, ᑲᖏᖅᖠᓂᕐᒧᑦ ᖃᓄᐃᓕᐅᕐᓃᑦ ᐅᕙᓗᓃᑦ ᑕᓇᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᓂᐅᕝᕙ, ᓂᐱᖃᕐᓂᕐᒧᑦ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ ᓇᓗᓇᐃᖅᑕᕆᐊᓂ ᑕᓇᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᖅᑲᑦᑕᕐᓂᐅᕝᕙ.

ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᖓᓂᕆᔭᖓᓄᑦ (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᑦ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᑐᑦ ᐅᔭᕋᒃᑕᕆᐊᐸ ᐃᓂᖓᓄᑦ, ᐊᕐᕋᒍᓄᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᐸᖁᑎᒥᒃ (AWAR)ᒧᑦ, ᑲᖏᖅᖠᓂᖕᒥᑦ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᖅ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᕐᒋᑦᑐᖅ ᑕᕆᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᖃᑦᑕᕐᓂᐅᔪᑦ):

- ᐅᔭᕋᒃᑕᕆᐊᖅ: ᑭᐸᑉᕆᒃᑐᖅ 21x30 ᑭᓛᒥᑕᒥᒃ ᐊᖏᓂᓕᒃ, ᑎᑭᐅᑎᐸᓗᓂ 5 ᑭᓛᒥᑕᒥᒃ ᐅᖓᓯᒃᑎᒋᔪᒥᑦ ᐊᕙᓗᓗᒃᑖᖓᓂᑦ ᐅᔪᕋᒃᑕᕆᐊᐸ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ.
- ᐊᕐᕌᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᐸᖁᑎᒥᒃ (AWAR): 3 ᑭᓛᒥᑕ ᓯᓕᖕᓂᖓ, ᑎᑭᐅᑎᐸᓗᓂ 1.5 ᑭᓛᒥᑕᒥᒃ ᐅᖓᓯᒃᑎᒋᔪᒥᑦ ᐃᒡᓗᒃᑐᑦ ᐃᖏᕐᕋᖒᐅᖃᑦᑕᖅᑑᐸ ᐊᐸᖁᑎᒋᔭᐅᔫᐸ. ᐊᕐᕌᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᐸᖁᑎᒥᒃ (AWAR) (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᖅ ᐃᓱᒪᕆᔭᐅᔪᖅ ᐱᕆᐊᕐᓂᐊᕐᓂᖓ ᑭᒡᓕᖓᓂᑦ ᐅᔭᕋᒃᑕᕆᐊᐸ (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ, ᑎᑭᐅᑎᓗᓂ ᓂᕆᖅᐸᓯᖕᒧᑦ ᑲᖏᖅᖠᓂᖕᒧᑦ.
- ᑲᖏᖅᖠᓂᖅ: ᑭᒡᓕᕆᔭᐅᔪᑦ ᑲᖏᖅᖠᓂᐅᐸ ᓄᓇᓕᐊᓂᑦ.

(LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᖅ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᕐᒋᑦᑐᖅ ᓯᓚᐅᐸ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᐸᓗ ᓯᓚᖓᓄ, ᐅᑯᓄᖓᑦ ᓯᓚᐅᐸ ᖃᓄᐃᓂᕆᔭᖓ ᐊᓯᐊᖑᖅᐸᓪᓕᐊᓂᖓᓄᑦ. (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᖅ ᓂᐱᖃᕐᓂᕐᒧᑦ ᑎᑭᐅᑎᔪᖅ 5 ᑭᓛᒥᑕᓪᓗᐊᕐᒥᒃ ᓂᐱᖃᕐᓂᕐᒥᒃ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ, ᐊᒻᒪ ᐊᕙᓗᐸᓗᒍ ᐃᒃᐱᖕᓂᐊᓂᕐᒨᖓᔪᓄᑦ ᓄᓇᓄᑦ ᓂᕆᐅᕆᔭᐅᔪᒥᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᒃ ᐱᓕᕆᐊᐸ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᖓᓄᑦ ᐊᒃᑐᖅᓯᔪᖕᓇᖅᑐᖅ ᐃᓄᖕᓂᒃ. ᓂᐱᖃᕐᓂᕐᒧᑦ (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᖅ ᑕᕆᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᓂᐅᔪᒥᒃ ᐃᓚᐅᔪᖃᙱᑦᑐᖅ ᐱᔾᔪᑎᒋᐸᓗᒍ ᐅᖓᓯᖕᓂᕆᔭᖏᑦ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓂᐅᔪᑦ ᐊᒻᒪ ᓇᓗᓇᐃᖅᓯᐸᓗᓂ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐃᒃᐱᒋᔭᐅᔫᓄᑦ ᓄᓇᓕᖕᓂᑦ.

ᐊᑕᐅᓰᑐᐃᓐᓇᖅᓗᒍ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᑐᖅ, 40x45 ᑭᓛᒥᑕᒥᒃ ᐊᖏᓂᖅᑲᖅᑐᖅ, ᕿᑎᐊᓂᑦ ᐅᔭᕋᒃᑕᕆᐊᐸ, ᐊᒻᒪ ᐃᓚᐅᐸᓗᓂ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓ ᖃᓄᖅ ᐊᖏᓂᖅᑲᕐᓂᐊᕋᓯᒋᔭᐅᓂᖓ ᓇᓚᐅᑖᖅᑕᐅᓚᐅᖅᑐᖅ. ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓᓄᑦ ᐊᒃᑐᖅᓲᓂᑦ ᐊᒃᑐᐊᔪᑦ ᑕᕆᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᑲᑕᕐᓂᒃᑯᑦ, ᐃᓚᐅᐸᓗᑎᒃ ᑕᕆᐅᑦ ᑲᖏᖅᖠᓂᐅᐸ ᖃᓂᑕᖓᓂᑦ ᐊᒻᒪ ᓯᒡᔭᐃᑦ ᑲᓇᑕᐅᐸ ᐃᒪᕐᑯᑎᖏᓐᓂᑦ ᐅᒥᐊᕐᔪᐊᑦ ᐃᖏᕋᓂᕆᖃᑦᑕᕐᓂᐊᖅᑕᖏᑦ ᑲᖏᖅᖠᓂᖕᒧᑦ ᑲᖏᖅᖠᓂᖕᒥᓪᓗ, ᐃᓱᒪᕆᔭᐅᓚᐅᖅᑐᑦ ᐅᖓᑖᓅᖓᓂᐊᕐᓂᖓ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓᓂᑦ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ.

ᓇᓗᓇᐃᖅᑕᐅᑎᐊᓪᓚᑦᑖᖅᑐᒥᒃ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᖃᓪᓚᐅᕐᒋᑦᑐᖅ ᓯᓚᐅᐸ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᐸᓗ ᓯᓚᖓᓂᒃ, ᐅᑯᓄᖓᑦ ᓯᓚᐅᐸ ᖃᓄᐃᓂᕆᔭᖓᑕ ᐊᓯᐊᖑᖅᐸᓪᓕᐊᓂᖓᓄᑦ. ᑭᓯᐊᓂ, (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᖅ ᐃᓱᒪᒃᓴᖅᓯᐅᕈᑎᒋᔭᐅᔪᖕᓇᖅᑐᖅ ᓄᓇᓄᑦ ᐊᑐᖅᑐᓂᒃ ᓯᓚᐅᐸ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᐸᓗ ᓯᓚᖓᓄ, ᐊᒻᒪ ᐋᕿᒃᓯᓗᓂ ᐃᓂᒃᓴᐅᓂᐊᖅᑐᒥᒃ ᓯᓚᐅᐸ ᐃᓕᖁᓯᕆᕙᓚᐅᖅᑕᖓᓂᒃ ᖃᓄᐃᓂᕆᔭᖓᑕ ᐊᓯᐊᖑᖅᐸᓪᓕᐊᓂᖓ (ᓲᕐᓗ, ᖃᒪᓂᒡᑐᐊᖅ ᐊᒻᒪ ᑲᖏᖅᖠᓂᖅ).

(RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᖃᓪᓚᑦᑖᓚᐅᕐᒋᑦᑐᖅ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᐸ ᓂᐱᖃᖅᑎᑦᑎᓂᕆᔭᖕᓇᖅᑕᖓᓄᑦ ᐊᒃᑐᖅᓯᓂᕐᒥᒃ ᓂᕆᐅᒋᔭᐊᖕᒪᑦ ᐊᒃᑐᐊᓂᖃᑐᐃᓐᓇᕐᓂᐊᕐᓂᖓᓂᒃ (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒧᑦ ᐊᒻᒪ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ. ᑭᓯᐊᓂ, ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒃᑐᖅᓲᓂᑦ ᑎᑭᐅᑎᔪᑦ (LSA) ᖃᓂᒡᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ ᐃᓱᒪᕆᔭᐅᔪᑦ ᑎᑭᐅᑎᓂᐊᖅᑐᑦ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒧᑦ. ᑕᕆᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᑲᑕᖕᓂᑦ ᐱᑕᖃᖃᑦᑕᖅᑐᑦ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ.

ᑭᒡᓕᐅᔪᑦ ᓄᓇᕐᔪᐊᐸ ᓯᓚᑖᓄᑦ ᓴᕿᑦᑎᔪᖅ ᖃᑯᒍ ᑕᐃᑲᙵᓂᑦ, ᑕᐃᑲᙵᓪᓚᑦᑖᖑᕐᒋᑦᑐᖅ ᐅᑯᓄᖓᑦ ᑲᑎᖅᓱᖅᓯᒪᔪᓂᒃ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᐅᔪᓂᒃ. ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᖓᓂᖓ ᐊᒻᒪ ᓂᐱᖃᕐᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓂᑦ ᑐᕌᖓᔪᑦ ᐊᐅᓛᕐᓂᕆᔭᖓᓂᒃ ᐱᓕᕆᐊᐸ, ᖃᓄᐃᓕᐅᕐᓂᑦ ᓇᓃᓐᓂᖏᑦ ᐊᒻᒪ ᐳᔪᐃᑦ ᓯᓚᒧᐊᖅᑐᑦ ᓂᕆᐅᒋᔭᐅᔪᑦ ᐊᖏᓂᖅᐹᕆᔪᓐᓇᖅᑕᖓᓃᓐᓂᐊᖅᑎᓪᓗᒋᑦ.

ᓇᓄᓇᐃᔭᖅᑕᐅᓂᖏᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᐊᑐᖅᑐᖅ ᖄᖏᖅᑐᓂᒃ ᑲᑎᑕᐅᓯᒪᔪᓂᒃ ᐊᑯᓂᐅᔪᒥᒃ (30 ᐅᑭᐅᑦ ᐅᖓᑖᓅᕋᔪᒃᑐᖅ). ᓯᓚᐅᑉ ᐊᓯᐊᙳᕐᓂᖓᓄᑦ, ᐊᔾᔨᒋᔭᖕᓃᖅᑲᑦᑕᖕᓂᐅᔪᑦ ᐃᑲᕐᖃᒃᑯᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᖅ ᐅᑭᐅᓄᑦ ᑕᓪᓕᒪᓄᑦ ᐊᑐᖅᑕᐅᔪᑦ.

ᐊᒃᑐᖅᓯᓂᐅᔪᓐᓇᖅᑐᑦ ᐱᓕᕆᐊᒧᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᐱᓕᕆᐊᖅ ᐊᐅᓛᖕᓂᓗᒃᑖᖓᓂᐅᔪᖅ, ᐊᒃᑐᖅᓯᓂᐅᔪᓐᓇᖅᑐᓪᓕ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓᑕ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᐱᓕᕆᐊᒧᑦ ᑎᑭᐅᑎᑉᓗᓂ ᐊᐅᓛᖕᓂᓗᒃᑖᖓᓂᑦ ᐅᒃᑯᐊᖅᓯᒪᓕᖅᑎᓪᓗᒍ.ᒧᑦ ᐅᑭᐅᑦ 30 ᐅᖓᑖᓄᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ ᑲᑎᖅᓱᐃᓂᖅ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓂᖏᑦ ᖃᐅᔨᔪᒪᑉᓗᒋᑦ, ᓯᕗᓂᖕᒥᑦ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᓂᖏᑦ ᓇᓚᐅᑖᖅᑕᐅᑎᓪᓗᒋᑦ 50 ᐅᑭᐅᓂᑦ ᐅᖓᑖᓄᑦ ᖃᐃᔪᓂᑦ.

ᐊᒃᑐᓯᓂᐅᔪᓄᑦ ᖃᐅᔨᓴᐃᓂᖅ

ᐊᒃᑐᓯᓂᐅᔪᓄᑦ ᖃᐅᔨᓴᐃᓂᖅ ᖃᐅᔨᓴᐃᓂᐅᖃᑦᑕᖅᑐᖅ ᐱᓕᕆᐊᓅᖓᔪᓂᒃ ᐊᒻᒪ ᐊᖏᒡᓕᕗᓪᓕᐊᔪᓂᒃ (ᐱᔭᕆᐊᖃᙱᖕᒐᑦ) ᐊᒃᑐᖅᓯᓂᐅᔪᓂᒃ ᓄᓇᕐᔪᐊᑉ ᓯᓚᑖᓂᑦ. ᐊᒃᑐᓯᓂᐅᔪᓄᑦ ᖃᐅᔨᓴᐃᓂᖅ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᖓᓂᕆᔭᖓᓂᒃ ᐊᑐᖃᑦᑕᖅᑐᖅ ᖃᐅᔨᓴᐃᓂᖅ ᐊᑐᖅᑕᐅᖃᑦᑕᖅᑐᖅ 4-ᒋᔭᖓᓂᑦ ᐊᒃᑐᖅᓯᓂᖕᒧᑦ ᐅᖃᐅᓯᐅᔪᖅ (FEIS)ᒥᑦ.

ᖃᐅᔨᓴᐃᓂᖕᒧᑦ ᑐᕌᖓᔪᖅᑕᖃᙱᑦᑐᖅ ᐊᒃᑐᖅᓯᓂᐅᔪᓄᑦ ᐱᓕᕆᐊᑉ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᑉᓗ ᓯᓚᖓᓂᒃ, ᓯᓚᐅᑉᓗ ᐊᓯᐊᙳᕐᓂᖓᓄᑦ ᖃᐅᔨᓴᐃᓂᐅᔪᓂᒃ. ᖃᐅᔨᒪᓂᖃᔭᐅᔪᓂᒃ ᒪᓕᖕᓂᐊᕐᓗᓂ, ᐊᑐᖅᑕᐅᔪᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᑉᓗ ᓯᓚᖓᓄᑦ ᓇᓄᓇᐃᖅᑕᐅᑎᐊᓚᐅᖅᑐᖅ ᐊᑐᖅᓱᓂ ᖃᐅᔨᓴᐃᓂᕐᒥᒃ ᐊᔾᔩᖏᖅᑎᑐᓂᒃ ᐊᒃᑐᖅᓯᓂᐅᔪᓂᒃ ᐱᓕᕆᐊᒥᑦ ᐊᕝᕕᑎᑉᑎᓐᓄᑦ, ᐊᒻᒪ ᐃᑲᔪᐃᓂᖕᒧᑦ ᐱᓕᕆᐊᖅ ᖃᓄᐃᑑᓂᐊᕐᓂᖓᓂᒃ.

ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᐊᒃᑐᖅᓯᓂᖕᒧᑦ ᖃᐅᔨᓴᐃᓃᑦ ᒪᓕᓚᐅᖅᑐᑦ ᒪᓕᒃᑕᐅᔭᕆᐊᓖᑦ ᐊᑐᖅᓱᒋᑦ ᑲᓇᑕᒥᑦ-ᐊᕙᒃᑐᖅᓯᒪᔪᖅᑯᑎᖏᓐᓄᑦ ᑲᑎᒪᔨᐊᓖᑦ ᓯᓚᐅᑉ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᐊᒻᒪ ᐊᕝᕕᑎᕆᔭᑉᑎᓐᓄᑦ ᖃᐅᔨᓴᐃᓂᖕᒧᑦ. ᐱᓄᐊᖅᑐᒥᑦ, ᖃᐅᔨᓴᐃᓂᖅ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ ᓄᓇᕐᔪᐊᑉᓗ ᓯᓚᖓᓂᒃ ᐃᓚᐅᔪᑦ ᖃᐅᔨᓴᐃᓂᖅ ᐊᒃᑐᖅᓯᓂᐅᑐᐃᓇᓇᐊᖃᖅᑐᓂᒃ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᔪᒥᒃ ᐱᓕᕆᐊᒧᑦ, ᐊᒻᒪ ᖃᐅᔨᓴᐃᓂᖅ ᑎᑭᐅᑎᑉᓗᓂ ᐱᓕᕆᐊᖅ ᐃᑲᔫᑎᖃᑐᐃᓐᓇᓇᐊᖃᕐᓂᖓᓄᑦ ᐊᓯᐊᙳᕈᑕᐅᑐᐃᓐᓇᓇᐊᖃᖅᑐᓂᒃ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᔪᒥᒃ ᐳᔪᐃᑦ ᓯᓚᒧᐊᖅᐸᓪᓕᐊᔪᑦ (GHG)-ᑎᒍᑦ. ᑕᒪᓐᓇ ᐱᓕᕆᐊᖑᓚᐅᖅᑐᖅ ᐃᓕᑉᐳᒍ ᐳᔪᐃᑦ ᓯᓚᒧᐊᖅᐸᓪᓕᐊᔪᑦ (GHG) ᐊᓂᐊᔪᑦ ᐊᒃᑐᐊᔪᓄᑦ ᑕᒪᐃᓄᑦ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᒥᑦ ᐊᕙᒃᑐᖅᓯᒪᔪᖅᑯᑎᖏᓐᓄᑦ ᑲᓇᑕᒥᓗ ᐊᓂᐅᔪᓄᑦ, ᐃᓚᐅᑉᐳᑎᒃ ᐱᓕᕆᐊᑉ ᐃᑲᔪᖅᓂᑎᑐᐃᓐᓇᓇᐊᖅᑕᖏᓐᓄᑦ ᓯᕗᓂᑉᑎᓐᓂᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᐊᖅᑐᓄᑦ.

ᐊᒃᑐᖅᓲᑦ ᐱᓕᕆᐊᒥᑦ ᓄᓇᕐᔪᐊᑉ ᓯᓚᑖᓄᑦ

ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖓ

ᖃᐅᔨᓴᐃᓂᖅ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ ᑕᐅᑐᒐᖃᓚᐅᖅᑐᖅ ᓇᓚᐅᑖᖅᑕᐅᔪᓂᒃ ᐊᓯᐊᙳᕐᓂᐅᔪᓂᒃ ᑲᑎᖅᓱᖅᓯᒪᔪᓂᒃ ᓇᓄᓇᐃᑯᑕᓂᒃ ᓂᕆᐅᒋᔭᐅᔪᑦ ᐊᓂᑕᐅᓂᖏᓐᓄᑦ ᐱᓕᕆᐊᒧᑦ, ᓈᒻᒪᒋᔭᐅᖃᑦᑕᖅᑐᑦ ᓇᓄᓇᐃᖅᓯᓂᖕᒧᑦ ᐊᓯᐊᙳᕐᓂᐅᔪᓂᒃ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ, ᐊᒻᒪ ᐊᔾᔨᖅᑕᖓ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖏᑦᑕᐅᔪᑦ ᐱᑕᖃᖅᑐᓄᑦ. ᓇᓄᓇᐃᑯᑏᑦ ᐅᑯᓄᒻᒫᖓᔪᑦ:

- ᒥᑭᓗᐊᒧᑦ ᑕᑯᒃᓴᐅᖏᑦᑐᑦ: ᑲᑎᖕᒍᑦ ᓄᖅᑲᖓᔪᑦ ᒥᑭᒃᑐᑯᓗᐃᑦ (TSP), ᒥᑭᒃᑐᑯᓗᐃᑦ ᐊᖏᓂᓛᑦ 10 µm ᐊᖕᒪᓗᖅᑑᑉ ᑭᒡᓕᖓᓄᑦ (PM_{10}), ᐊᒻᒪ ᒥᑭᒃᑐᑯᓗᐃᑦ ᒥᑭᓂᖅᓴᐃᑦ 2.5 µm ᐊᖕᒪᓗᖅᑑᑉ ᑭᒡᓕᖓᓄᑦ ($PM_{2.5}$); ᐊᒻᒪ
- ᐃᑯᐅᓪᓚᒍᖕᓇᖅᑐᑦ ᐅᖅᓯᐃᑦ: ᓇᐃᑦᕿᔾᔨᓐ ᑕᐃᐋᒃᓴᐃᑦ (NO_2), ᓵᓪᕗ ᑕᐃᐋᒃᓴᐃᑦ (SO_2), ᐊᒻᒪ ᑳᐸᓐ ᒪᓈᒃᓴᐃᑦ (CO).

ᐊᖏᓂᓇᔭᖓ ᕿᒪᒃᑎᑦᑐᖅ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖓ ᐊᒃᑐᖅᓲᑦ ᖃᐅᔨᔭᐅᓚᐅᖅᑐᑦ ᖃᓄᐃᓂᖅᓴᐅᓂᖏᓐᓄᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᑲᑎᖅᓱᖅᓯᒪᔪᑦ ᐊᓯᐊᙳᕐᓂᖓᓄᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖓᓄᑦ ᒪᓕᒃᑕᐅᔭᖅᓴᑦ ᓄᓇᕗᒻᒧᑦ, ᐊᒻᒪ ᑲᓇᑕᒥᑦ ᑐᕌᓚᓂᔭᐅᔪᑦ ᐅᑭᐅᖅᑕᖅᑐᒧᑦ ᒪᓕᒃᑕᐅᔭᖅᓴᐃᑦ ᒪᓂᒪᓚᐅᖅᑐᑦ.

ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓ ᖃᐅᔨᓴᐃᓂᕐᓂᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᐊᑐᖅᑐᓂ ᐊᓂᖅᓵᖅᑐᖅᑕᕗᑦ ᑲᑎᖅᓱᖅᑕᐅᓯᒪᔪᓂᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᓂᑦ ᐊᒻᒪ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᑲᑎᖅᓱᖅᑕᐅᓯᒪᔪᑦ ᐱᕝᕕᐅᔪᖕᓇᖅᑐᓂᒃ. ᑲᑎᖅᓱᖅᑕᐅᓯᒪᔪᑦ ᓇᓗᓇᐃᓚᐅᖅᑐᖅ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᐃᓱᒪᑦᔭᐅᓇᔭᖅᑐᖅ ᐃᓕᖁᓯᑐᖃᖓᓃᓐᓂᖓᓂᒃ, ᐊᒻᒪ ᐊᒃᑐᖅᑕᐅᓯᒪᙱᕈᓂ ᐃᓄᖕᓂᙶᖅᑐᓂᒃ ᐊᓂᐊᔪᓄᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑎᓐᓄᑦ. ᑲᖏᖅᖠᓂᕐᒥᑦ, ᐊᓂᖅᓵᖅᑐᖅᑕᐅᔪᖅ ᐱᐅᔪᖅ ᓱᓕ, ᑭᓯᐊᓂ ᐱᑕᖃᖅᑐᖅ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑎᓐᓄᑦ ᐊᓂᐊᑎᑦᑎᔪᑦ ᐃᓄᐃᑦ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᕆᓐᓄᑦ.

ᐊᒃᑐᖅᓯᓃᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓᓂᒃ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ ᐅᔭᕋᖅᑕᕆᐊᒥᑦ ᑕᐅᑐᒐᖅᑲᖅᑐᑦ ᐊᐅᓛᖅᑎᑦᑎᓂᕐᒥᒃ, ᐊᓂᐊᔪᑦ ᐊᒻᒪ ᖃᓄᐃᓕᐅᕐᓃᑦ ᖁᑦᑎᒃᓯᓯᒪᓂᖅᑮᕝᒍᓂᐊᖅᑐᑦ. ᐊᑐᖅᑐᓂ ᓯᐊᒪᒃᑎᕆᓂᕐᒧᑦ ᖃᓄᐃᖓᓂᐅᔪᓂᒃ, ᓇᓗᓇᐃᖅᓯᔪᓐᒃᑖᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᐊᑦᑎᒃᑐᒥᑦ ᐊᖏᓂᐅᔪᒥᒃ ᐊᒃᑐᖅᓯᓂᖃᖕᓂᐊᕐᓂᕐᒧᑦ ᑕᒪᐃᓄᑦ ᐃᓗᐊᓄᑦ ᓯᓚᑖᓄᓪᓗ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ, ᐃᓚᐅᕆᔪᒍᓗ ᐃᑲᕐᕋᓄᑦ 24ᓄᑦ ᑲᑎᔪᒥᑦ ᓄᖃᖓᔪᑦ ᒥᑭᑐᑯᓗᐃᑦ (TSP), PM_{10}, ᐊᒻᒪ $PM_{2.5}$, ᐊᒻᒪ ᐊᑕᐅᓯᕐᒥᒃ ᐃᑲᕐᕋᒥᑦ (ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)-ᒧᑐᐃᓇᖅ) ᐊᒻᒪ ᐃᑲᕐᕋᓄᑦ 24ᓄᑦ NO_2, ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᑉ ᐊᒻᒪ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᑉ ᐃᓗᐊᓂᑦ. ᓇᓚᐅᑖᖅᑕᐅᔪᖅ 24ᓄᑦ ᐃᑲᕐᕋᓄᑦ ᑲᑎᔪᒥᑦ ᓄᖃᖓᔪᑦ ᒥᑭᑦᑐᑯᓗᐃᑦ (TSP) ᐊᒻᒪ PM_{10} ᑲᑎᖅᓱᖅᓯᒪᔪᑦ ᖃᐅᔨᔭᐅᔪᑦ ᖁᑦᑎᒃᑐᒥᒃ ᐊᒃᑐᖅᓯᓂᐅᔪᓂᒃ ᐊᖏᓂᕆᔭᕆᓐᓄᑦ ᑕᒪᐃᓄᑦ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ ᐊᒻᒪ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ, 24ᓄᑦ ᐃᖅᑲᕐᕋᓄᑦ $PM_{2.5}$ᓄᑦ ᐊᒃᑐᖅᓯᓂᖅ ᐊᖏᓂᕆᔭᕆᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᖁᑦᑎᒃᑐᒥᑦ ᕿᑎᕋᔪᐅᓅᓂᕆᓐᓄᑦ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ ᐊᒻᒪ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ. ᓇᓚᐅᑖᖅᑕᐅᔪᖅ ᐊᑕᐅᓯᕐᒥᒃ ᐃᑲᕐᕋᒥᑦ NO_2 ᑲᑎᖅᓱᖅᓯᒪᔪᓄᑦ ᕿᑎᕋᔪᐊᓂᑦ ᐊᖏᓂᐅᔫᑉ ᐊᒃᑐᖅᓯᓂᖃᖕᓂᐊᖅᑐᖅ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ, ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᐃᑲᕐᕋᓄᑦ 24ᓄᑦ NO_2ᒧᑦ ᑲᑎᖅᓯᓯᒪᔪᑦ ᑕᑯᒃᓴᐅᑎᑦᑎᑉᓗᓂ ᕿᑎᕋᔪᐊᓂᑦ ᐊᖏᓂᐅᔫᑉ ᐊᒃᑐᖅᓯᓂᖃᖕᓂᐊᖅᑐᖅ ᑕᒪᐃᓂᑦ ᓄᓇᓕᐊᓛᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ ᐊᒻᒪ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ. ᑭᓯᐊᓂ, ᕿᒪᒃᑎᑦᑐᓂᑦ ᐊᒃᑐᖅᓯᓂᓗᒃᑖᑦ ᖃᐅᔨᓴᖅᑕᐅᖃᑦᑕᖅᑐᑦ ᑐᕌᖓᑉᓗᑎᒃ ᓈᒻᒪᙱᑦᑑᓂᖏᓐᓄᑦ, ᕿᑎᕋᔪᐊᓄᑦ ᑕᑭᓂᖃᖅᓗᑎᒃ, ᐊᒻᒪ ᐅᑎᕈᕐᓇᑦᑎᐊᖅᓗᑎᒃ ᐃᓕᖅᑯᓯᕆᓚᐅᖅᑕᖏᓐᓄᑦ ᐱᓕᕆᐊᒥᑦ ᐊᓂᕙᓕᐊᔪᑦ ᓄᖃᑐᐊᖅᐸᑕ. ᑕᐃᒪᓕ, ᕿᒪᒃᑎᑦᑐᓂᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᖕᓇᖅᑐᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓᓄᑦ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ ᐅᔭᕋᖅᑕᕆᐊᒥᑦ ᖃᐅᔨᔭᐅᓚᐅᖅᑐᑦ ᐅᔾᔨᕐᓇᙱᓐᓂᖏᓐᓄᑦ.

ᑕᐃᑲᙵᑦ ᐊᒃᑐᖅᓯᓃᑦ ᐊᕐᕌᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔫᒃᓴᖅ ᐊᑉᖁᑎᒥᒃ (AWAR)ᒥᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓᓄᑦ ᑕᐅᑐᒐᖃᓚᐅᖅᑐᖅ ᐊᐅᓛᕐᓂᕐᓘᖓᔪᒧᑦ, ᐊᓂᐊᕙᓕᐊᔪᑦ ᐊᒻᒪ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᑦ ᖁᑦᑎᖕᓂᖅᑮᕝᒍᑎᓪᓗᒥᑦ. ᑕᒪᐃᓂᑦ ᓇᓗᓇᐃᑯᑕᐃᑦ, ᐃᓚᐅᕆᔪᒍ ᐃᑲᕐᕋᓄᑦ 24ᓄᑦ ᑲᑎᔪᒥᑦ ᓄᖃᖓᔪᑦ ᒥᑭᑐᑯᓗᐃᑦ (TSP) ᐊᒻᒪ PM_{10}, ᐊᒃᑐᖅᓯᓃᑦ ᑕᒪᐃᓄᑦ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ ᐊᒻᒪ (RSA) ᐊᖏᓂᖅᓴᒥᒃ ᓄᓇᒥᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᒥᑭᑑᓂᐊᕐᓂᕆᓐᓄᑦ ᐊᖏᓂᕆᔭᖓᓂᑦ. ᐊᒃᑐᖅᓯᓃᑦ ᕿᑎᕋᔪᐊᓃᑦ ᐊᖏᓂᕆᔭᖓᓄᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ TSP ᐊᒻᒪ PM_{10}. ᑕᒪᐃᓂᒃ ᕿᒪᒃᑎᑦᑐᓄᑦ ᐊᒃᑐᖅᓯᓃᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᑐᕌᖅᑲᓗᑎᒃ ᓈᒻᒪᙱᑦᑐᒧᑦ, ᕿᑎᕋᔪᐊᓂᑦ ᐊᑯᓂᐅᑎᒋᔪᒥᑦ, ᐊᒻᒪ ᐅᑎᕈᕐᓇᑦᑎᐊᖅᑲᓂ ᐃᓕᖅᑯᓯᕆᓚᐅᖅᑕᖓᓄᑦ ᐊᓂᕙᓕᐊᔪᑦ ᐱᓕᕆᐊᒥᑦ ᓄᖃᖅᐸᑦ ᐱᓕᕆᐊᖅ ᐊᐅᓛᕈᕐᓃᕐᓂᖓᓄᑦ. ᑕᐃᒪᓕ, ᕿᒪᒃᑎᑦᑐᓄᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᖕᓇᖅᑐᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᕆᔭᖓᓄᑦ ᐊᕐᕌᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔫᒃᓴᖅ ᐊᑉᖁᑎᒥᒃ (AWAR)ᒧᑦ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᑦ ᖃᐅᔨᔭᐅᓚᐅᖅᑐᑦ ᐅᔾᔨᕐᓇᔾᔭᕆᓐᓂᕆᓐᓄᑦ.

ᐊᓂᐊᔪᑦ ᐊᒃᑐᐊᔪᑦ ᐱᓕᕆᐊᑉ ᖁᓄᐃᓕᐅᕐᓂᕆᔭᕆᓐᓄᑦ ᑲᖏᖅᖠᓂᕐᒥᑦ ᐊᒻᒪ ᑕᕆᐅᑯᑦ ᐊᐅᓚᖅᑎᑦᑎᑲᑕᕐᓂᒃᑯᑦ ᓂᕆᐅᒋᔭᐅᔪᑦ ᑐᕌᖓᑉᓗᑎᒃ ᓈᒻᒪᙱᑦᑑᓂᕆᓐᓄᑦ, ᑭᓯᐊᓂ ᐅᔾᔨᕐᓇᙱᑦᑐᑎᒃ ᐊᖏᓂᔭᐅᔪᒃᑯᑦ. ᑕᐃᒪᓕ, ᕿᒪᒃᑎᑦᑐᓄᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᑕᒡᕙᙵᑦ ᑖᑉᑯᓇᓂ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓂᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑕ ᖃᓄᐃᓂᖅᓴᐅᓂᖓᓂᑦ ᖃᐅᔨᔭᐅᓚᐅᖅᑐᑦ ᐅᔾᔨᕐᓇᔾᔭᕆᓐᓂᖓᓄᑦ.

ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᑉᑐ ᓯᓚᖓ

ᐱᓕᕆᐊᑉ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᖓ ᓂᕆᐅᒋᔭᐅᖏᑦᑐᖅ ᐊᒃᑐᖅᓯᓂᖃᕆᐊᒃᓴᖓᓂᒃ ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᑉᑐ ᓯᓚᖓᓂᑦ. ᓯᓚᐅᑉ ᖃᓄᐃᓂᕆᔭᖓ ᓄᓇᕐᔪᐊᑉᑐ ᓯᓚᖓ ᓇᓗᓇᐃᔭᖅᑕᐅᑎᐊᓚᐅᖅᑐᑦ, ᐊᒻᒪ ᐊᑐᖅᑕᐅᑉᓗᑎᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒧᑦ ᐊᔾᔨᒌᖏᑦᑐᓄᑦ ᐱᓕᕆᐊᒧᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᓄᑦ ᐊᕙᑎᑉᑎᓐᓄᑦ.

ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᖓᓂᓚ ᐊᓯᐊᕐᒍᖅᐸᓪᓕᐊᓂᖓ

ᓱᕗᓂᑉᑎᓐᓂᑦ ᐊᒃᑐᖅᓯᓂᐅᑐᐃᓇᑎᐊᓖᑦ ᐊᓯᐊᕐᒍᕐᓂᖅᓯᓂᕐᒧᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᖓ ᐱᓕᕆᐊᒧᑦ ᐃᓚᐅᔪᑦ:

- ᐊᓯᐊᕐᒍᖅᐸᓪᓕᐊᓂᖅ ᑕᑯᐅᑉ ᖃᓄᐃᓐᓂᖓ, ᑕᑯᐅᖅ ᐃᓂᒋᔭᖓ ᖁᑦᑎᒃᓯᓯᒪᓂᖓᓄᑦ, ᐊᒻᒪ ᓯᒃᔭᐃᑦ ᓱᐳᖅᐸᓪᓕᐊᓂᕐᒧᑦ ᐊᒃᑐᖅᓯᓂᖃᑐᐃᓇᑎᐊᓕᒃ ᑎᑭᑉᐸᓪᓕᐅᔪᓄᑦ ᐊᐅᓚᖅᑎᑕᐅᕙᓪᓕᐊᔪᓄᓪᓗ ᐅᖅᓱᓂᒃ ᐊᒻᒪ ᐊᓯᖏᓐᓂᑦ ᑲᖏᖅᓵᓂᕐᒥᑦ.
- ᓯᓚᐅᑉ ᐆᓇᖅᓯᕚᓪᓕᐊᓂᖓ ᐊᒃᑐᖅᓯᓂᖃᑐᐃᓇᓇᐊᖃᖅᑐᖅ ᓄᓇ ᖁᐊᖅᓯᒪᐃᓐᓇᐅᔭᖅᑐᒥᒃ ᐱᓕᕆᐊᑉ ᐃᓂᒋᔭᖓᓂᑦ, ᐊᖏᓪᓕᕚᓪᓕᐊᑎᑦᑎᔪᓇᖅᑰᓂ ᐃᐸᔪᖅᑎᑉᐸᓪᓕᐊᓂᓇᔭᖓᓂᑦ. ᐊᒃᑐᖅᓯᓂᖃᕐᓇᖅᑐᖅ ᑖᒃᓇ ᐃᒡᓗᕐᔪᐊᓕᐅᖅᑕᐅᕚᓪᓕᐊᔪᑦ ᐱᓕᕆᐊᑉ ᐃᓂᒋᔭᖓᓂᑦ ᐊᑯᓂᐅᓗᓂᑦ.
- ᐊᒃᓱᕈᕐᓇᕈᑕᐅᑐᐃᓐᓇᓇᐊᖃᖅᑐᑦ ᐅᐸᓗᒥᐅᔪᖅ ᓄᓇᒥᒃ ᐊᑐᖃᑦᑕᖅᑐᓄᑦ.

ᐱᓕᕆᖃᑎᒌᖕᓂᖏᑦ ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᖓᓚ ᐅᓗᕆᐊᓇᕐᓂᑦ ᐃᓕᑕᕆᔭᐊᓯᒪᔪᑦ ᑕᒃᐱᒃᑯᓄᓂ ᐊᒻᒪ ᐱᓕᕆᐊᒧᑦ ᐱᖁᑎᑦ ᐅᕙᓃᑦ ᐊᐅᓛᕐᓂᕐᔫᖓᔪᑦ ᐅᖃᐅᓯᐅᔪᑦ ᐃᒻᒥᒃᑰᓕᖓᓪᓗᑎᒃ ᑭᖑᓪᓕᖅᐸᓪᓕᐊᕐᒥᑦ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᐅᖃᐅᓯᐅᔪᖅ (FEIS)ᒥᑦ. ᑭᓯᐊᓂ, ᐊᑐᖅᑲᒍ ᐱᓕᕆᐊᑉ ᐃᖏᕋᓂᕆᓂᐊᖅᑕᖓ, ᓂᕆᐅᒋᔭᐅᔪᖅ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᐊᓯᐊᕐᒍᖅᓯᓂᐅᔪᕐᓇᖅᑐᑦ ᓯᓚᐅᑉ ᐊᓯᐊᕐᒍᖅᐸᓪᓕᐊᓂᖓ ᖃᓄᐃᓐᓂᖓᓄᑦ ᐱᓕᕆᐊᒧᑦ ᐅᔾᔨᕐᓇᙱᑦᑐᑦ.

ᐱᓕᕆᐊᖅ ᐃᑲᔪᐃᓂᖃᕈᕐᓇᕐᒥᔪᖅ ᐊᓯᐊᕐᒍᕈᑕᐅᔪᕐᓇᖅᑐᒃ ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᖓ ᐳᔪᐃᑦ ᓯᓚᒧᐊᖅᐸᓪᓕᐊᔪᑦ (GHG)ᓄᑦ ᐊᓂᕙᓪᓕᐊᔪᑎᒍᑦ ᓄᓇᕐᔪᐊᑉ ᓯᓚᑖᓂᑦ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔪᕐᓇᖅᑐᓄᑦ ᐳᔪᐃᑦ ᓯᓚᒧᐊᖅᐸᓪᓕᐊᔪᑦ (GHG)-ᑎᒍᑦ ᐊᑐᖅᑕᐅᕚᔪᓂᑦ ᐊᒃᑐᐊᔪᓄᑦ ᓴᕿᑎᑦᑎᕙᓪᓕᐊᔪᓂᒃ, ᐆᓇᖅᑎᑦᑎᓂᕐᓄᑦ ᐊᒻᒪ ᐃᖏᕐᕋᔭᕐᓂᕐᓄᑦ. ᐊᕐᕌᒍᑕᒫᑦ ᑲᑎᕝᓗᒋᑦ ᐳᔪᐃᑦ ᓯᓚᒧᐊᖅᐸᓪᓕᐊᔪᑦ (GHG)ᓂᑦ ᐊᓂᐊᕙᓪᓕᐊᔪᑦ ᐱᓕᕆᐊᒥᙵᖅᑐᑦ ᐊᒻᒪ ᑕᑎᐊᕐᒥᑦ ᐊᐅᓚᑕᐅᔪᓂᑦ ᑲᖏᖅᓵᓂᕐᒥᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ 317 ᑭᓗᑕᓐᓂᒃ ᐅᖁᒪᐃᓂᓕᖕᓂᒃ (CO_2)ᒥᑦ ᐊᔾᔨᒋᓂᐊᕐᓂᖓᓄᑦ, ᑕᐃᒪᓐᓇᐃᑉ 18%ᖑᔪᖅ ᓄᓇᑦᑎᐊᕐᒥᑦ ᐊᒻᒪ ᓄᓇᕗᒻᒥᑦ ᐳᔪᐃᑦ ᓯᓚᒧᐊᖅᐸᓪᓕᐊᔪᑦ (GHG) ᖃᑉᓯᐅᓂᖏᓐᓄᑦ ᓈᓴᖅᑕᐅᓯᒪᔪᑦ ᐅᑭᐅᒥᑦ 2010ᒥᑦ, ᐅᕙᓃᑦ 0.05%ᖑᔪᖅ ᑲᓇᑕᒥᑦ ᖃᑉᓯᐅᓂᖏᓐᓄᑦ ᓈᓴᖅᑕᐅᓯᒪᔪᓂᑦ ᑕᐃᑲᓂᑦᑕᐃᓇᖅ ᐅᑭᐅᖑᔪᒥᑦ. ᓯᓚᕐᔪᐊᕐᒥᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᐊᓂᐅᔪᑦ ᐅᔾᔨᕐᓇᙱᓐᓂᖏᓐᓄᑦ ᐱᓕᕆᐊᒥᙵᖅᑐᓂᒃ, ᓂᕆᐅᒋᔭᐅᔪᖅ ᐱᓕᕆᐊᖅ ᐆᒃᑐᕋᖅᑕᐅᔪᕐᓇᖅᑐᓂᒃ ᐊᒃᑐᓯᓂᖅᑲᓂᐊᕐᓂᖓᓂᒃ ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᖓᓄᑦ, ᑕᐃᒪᓐᓇᒧᑦ, ᐊᒃᑐᖅᓯᓂᖓ ᐱᓕᕆᐊᑉ ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᖓᓄᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᖅ ᐅᔾᔨᕐᓇᖏᑦᑑᓂᐊᕐᓂᖓᓄᑦ.

ᓂᐱᖃᕐᓂᖅ

ᖃᐅᔨᓴᐃᓂᖅ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᖅᑐᓄᑦ ᐱᓕᕆᐊᑉ ᖃᓄᐃᓕᐅᕐᓂᖓᓄᑦ ᐃᓱᒪᔪᑦ ᐃᓄᖕᓄᑦ ᐃᓗᐃᓗᑕᓄᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᐊᒻᒪ ᑕᐅᑐᒐᖅᑲᖁᑎᒃ ᓄᓇᒋᔭᐅᔪᓂᒃ ᓂᕆᐅᒋᔭᐅᔪᓄᑦ ᐱᓕᕆᐊᖅ ᓂᐱᖃᕐᓂᖓ ᐊᒃᑐᖅᓯᓂᖃᕈᕐᓇᕐᓂᖓᓄᑦ ᐃᓄᖕᓂᑦ. ᐊᒃᑐᖅᓯᓂᐅᔪᖅᑐᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᔪᒐᒃᑎᑦᑎᓂᕐᓄᑦ ᐊᑐᐊᔪᑦ ᓄᓇᒧᑦ (VECs)ᓄᑦ ᐊᕙᑎᑉᑎᓐᓄᑦ ᑎᑭᐅᑎᔪᓄᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᓂᐱᖃᕐᓂᖅ ᓇᔪᓗᓃᓪᓗ ᐊᑐᐊᔪᑦ ᖄᖅᑕᖅᑎᑕᐃᓂᕐᒧᑦ ᐊᒻᒪ ᑕᑎᐅᒃᑦ ᐊᐅᓚᖅᑎᑦᑎᓂᕐᓄᑦ, ᐅᖃᐅᓯᐅᔪᑦ ᐃᒥᒃᑰᓕᖓᓪᓗᑎᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᖃᐅᔨᓴᐅᓂᕐᓂᑦ ᐃᓗᐊᓂᑦ ᑭᖑᓪᓕᖅᐹᓕᐊᕐᒥᑦ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᐅᖃᐅᓯᐅᔪᖅ (FEIS)ᑉ.

ᑭᒡᓕᓕᐅᖅᑕᐅᓯᒪᔪᖅ ᐃᑲᕋᑕᒫᑦ ᓂᐱᖃᖅᑐᓄᑦ ᐊᖏᓂᐅᔪᑦ ᐅᔭᕋᒃᑕᕆᐊᒥᑦ ᓂᕆᐅᒋᔭᐅᔪᑦ 35ᒦᓐᓂᐊᕐᓂᖓᓂᒃ “ᐅᖁᒪᐃᓂᒃᑰᖅᑕᐅᔪᖅ” ᓂᐱᖃᕐᓂᐅᑉ ᓴᙱᓂᖓ (ᐅᖁᒪᐃᓂᖅᓯᐅᖅᑕᐅᔪᑦ ᖃᑉᔾᔫᖅᑕᕐᓂᖓᓄᑦ ᐃᓅᑉ ᑐᓵᓂᖓᓄᑦ; dBA). ᑭᒡᓕᓕᐅᖅᑕᐅᓯᒪᔪᖅ ᓂᑉᓕᐊᓂᕐᔫᖓᔪᖅ ᐃᓚᐅᑉᓗᓂ ᐊᕐᕌᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᑉᖁᑎᒥᒃ (AWAR) ᐊᒃᑐᐊᓂᖅᑲᕐᓂᐊᖅᑐᖅ ᐅᖓᓯᖕᓂᐅᔪᖅ ᐃᓅᑉ ᖃᓄᐃᓕᐅᕐᓂᖓᓄᑦ. ᑲᖏᖅᓵᓂᐅᑉ ᖃᓂᑕᖓᓂᑦ, ᓂᑉᓕᐊᓂᖅ ᐊᔾᔨᐸᓗᒐᔭᖅᑕᖓ ᐊᖏᓂᖓᓚ ᑲᖏᖅᓵᓂᕐᒥᑦ. ᐊᒥᐊᑯᔪᑦ ᐊᕐᕌᒍᓗᒃᑖᒥᒃ ᐊᑐᖅᑕᐅᔪᒃᓴᖅ ᐊᑉᖁᑎᒥᒃ (AWAR)ᒧᑦ ᑎᑭᑕᐅᑕᐅᓗᐊᕐᒋᑦᑐᒦᑐᖅ, ᐊᒻᒪ ᑭᒡᓕᓕᐅᖅᑕᐅᓯᒪᔪᖅ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓂᕆᐅᒋᔭᐅᔪᖅ ᐊᔾᔨᐸᓗᒋᓂᐊᕐᓂᖓᓄᑦ ᐅᔭᕋᒃᑕᕆᐊᒥᑦ.

ᑕᐃᑲᓂ ᖃᐅᔨᓴᖕᓂᐅᔪᖅ ᐱᓕᕆᐊᖑᓚᐅᖅᑐᖅ ᐃᑲᔪᕈᒪᐸᓗᒍ ᖃᓄᐃᓂᐅᔪᖅ ᒫᓇᐅᔪᖅ ᓂᐱᖃᖕᓂᐅᔪᖅ ᐃᓂᐅᔪᓂᒃ ᐃᒃᐱᖕᓂᐊᓂᐅᔪᒧᑦ ᑲᖏᖅᖠᓂᐅᑉ ᐅᓗᐊᓂᑦ. ᖃᐅᔨᓴᐃᓂᖕᒥᑦ ᐃᓚᐅᓚᐅᖅᑐᑦ ᑲᔪᓯᑦ ᓂᐱᖃᖕᓂᐅᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᑖᓕᒪᐅᔪᓂᒃ ᓄᓇᒋᔭᐅᔪᑦ ᐃᓂᒋᔮᖅᒋᓐᓂᑦ, ᐊᒻᒪ ᐅᖕᓂᒍᑎᓯᒪᐸᒍᑎᒃ ᓂᐱᖃᖕᓂᖕᒧᑦ ᐆᒃᑐᕋᐅᑕᐅᔪᓄᑦ ᖃᑉᓯᐊᕐᔫᔪᓄᑦ ᑲᖏᖅᖠᓂᐅᑉ ᐃᓗᐊᓂᑦ ᐃᑲᔪᐃᓂᖃᖕᓂᖕᒧᑦ ᖃᐅᔨᓴᐃᓂᖕᒧᑦ ᐃᓂᐅᔪᓂᒃ. ᒫᓇᐅᔪᖅ ᓂᐱᖃᖕᓂᖕᒧᑦ ᐊᖏᓕᓐᖑᔪᑦ ᑲᖏᖅᖠᓂᐅᑉ ᐃᓗᐊᓂᑦ ᖃᐅᔨᓴᐃᓂᐅᑎᓪᓗᒍ ᓴᙱᓂᖃᓚᐅᖅᑐᑦ 45ᓗ 52ᓗ ᓂᐱᖅᑯᖅᑐᓂᐅᑉ ᐊᑯᓐᓂᖏᓐᓂᑦ ᐊᔾᔨᒌᖏᑦᑐᓂᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᓂᑦ.

ᐊᔾᔨᐸᓗᒋᔭᖓ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓂᕆᔭᖓᓄᑦ ᖃᐅᔨᓴᐃᓂᖅ, ᑕᐃᑲᖓᒻᒪᕆᒃ ᐱᓕᕆᐊᒥᑦ ᐊᒃᑐᖅᓯᓂᑦ ᓂᐱᖃᖕᓂᖕᒧᑦ ᑕᐅᑐᒐᖅᑕᐅᖅᑐᑦ ᐊᐅᓛᖕᓂᕆᔭᖓᓄᑦ ᐊᖏᓂᕆᔭᖓᓄᑦ ᖃᓄᐃᓕᐅᖕᓃᑦ, ᐊᖏᓂᕆᔭᖓ ᐱᖁᑏᑦ ᐊᒻᒪ ᐊᑐᖅᑕᐅᔪᑦ ᓅᑕᐅᑎᓪᓗᒋᑦ ᓂᕆᐅᒋᔭᐅᔪᑦ ᖁᑦᑎᖕᓂᖅᐹᖑᑎᓂᐊᖕᓂᖏᓐᓄᑦ, ᐊᒻᒪ ᑕᐃᒪᓐᓇᒧᑦ ᐊᖏᓂᖅᐹᒥᒃ ᐊᒃᑐᖅᓯᓂᖅᑭᖕᖓᖕᓂᐅᐸᓗᑎᒃ ᓂᐱᖃᖕᓂᐅᑉ ᐊᖏᓕᓐᖑᓂᕋᔭᖓᓄᑦ. ᑲᑎᓗᒃᑖᖅᓘᒋᑦ 25ᖑᔪᑦ ᓄᓇᐃᑦ ᐃᓕᑕᕆᔭᐅᓚᐅᖅᑐᑦ ᓄᓇᓕᐊᑖᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᓯᑦ ᐊᒻᒪ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ ᐃᒃᐱᖕᓂᐊᓂᖃᖕᓂᖅᐹᖑᓂᖏᓐᓄᑦ ᓂᐱᖃᖅᑐᓂᑦ. ᐊᖏᓂᖅᐹᒃᑯᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᖅ ᓂᐱᖃᖕᓂᖕᒧᑦ ᐊᖏᓕᓐᖑᓂᐅᔪᓄᑦ ᓄᓇᓕᐊᑖᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)-ᑯᑦ ᓂᐱᖃᖕᓂᒧᑦ ᐃᒃᐱᒍᓯᖕᓂᖕᒧᑦ ᐃᓂᒋᔭᐅᔪᑦ ᐱᔾᔪᑎᒋᐸᒍ ᐱᓕᕆᐊᐸ ᖃᓄᐃᓕᐅᖕᓂᕆᔭᖏᑦ 44.2ᒥᑦ ᓂᐱᖁᖅᑎᑎᒍᔪᖅ (dBA), ᐊᒻᒪ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ ᓂᐱᖃᖕᓂᒧᑦ ᐃᒃᐱᒍᓯᖕᓂᖕᒧᑦ ᐃᓂᒋᔭᐅᔪᓄᑦ ᐃᓂᒋᔭᐅᔪᑦ 40.6 ᓂᐱᖁᖅᑐᓂᖓᐅᐸᓗᓂ (dBA). ᐊᖏᓂᖅᐹᒃᑯᑦ ᐊᓯᐊᖑᖕᖔᑦ ᑮᓪᓕᓕᐅᖅᑕᐅᓯᒪᔪᑦ ᖃᓄᐃᓂᖏᓐᓄᑦ ᓄᓇᓕᐊᑖᒥᑦ ᖃᐅᔨᓴᐃᓂᖅ (SSA)ᒥᑦ ᐊᒻᒪ (LSA) ᖃᓂᑦᑐᒥᑦ ᓄᓇᐅᔪᒥᒃ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ ᐃᒃᐱᖕᓂᐊᓂᖕᒧᑦ ᓂᐱᖃᖅᑐᓂᑦ ᐃᓂᒋᔭᐅᔪᓄᑦ 9.7ᖑᔪᑦ dBA ᐊᒻᒪ 6.7 dBA. ᐊᖏᓂᖅᐹᒃᑯᑦ ᓂᐱᖃᖕᓂᖕᒧᑦ ᐊᖏᓕᓐᑦ ᑭᓪᓕᖓᓂᑦ 1.5 ᑭᓛᒥᑦ ᐋᕿᒃᑕᐅᓯᒪᔪᖅ ᓇᓚᐅᑖᖅᑕᐅᓚᐅᖅᑐᖅ ᐊᑦᑎᖕᓂᖅᓴᐅᓂᐊᖕᓂᐊᓂᒃ ᐃᒪᓈᖅᑐᖅᑕᐅᔪᒥᒃ ᐊᑐᓇᐊᓕᖓᒧᑦ 40 dBA, ᓄᓇᓕᐊᓖᓄᑦ, ᐱᕈᐊᓂᒃᓯᒪᙱᑦᑐᓄᑦ, ᓄᓇᐅᔪᓂᑦ.

ᕿᒪᒃᑎᑦᑐᓄᑦ ᐊᒃᑐᖅᓯᓃᑦ ᓂᐱᖃᖕᓂᐅᑉ ᐊᖏᓂᕆᔭᖏᓐᓄᑦ ᐃᓕᑕᕆᔭᐅᓚᐅᖅᑐᑦ ᐃᒃᐱᖕᓂᐊᓂᖅᑐᓄᑦ ᐃᓂᒋᔭᐅᔪᓄᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᑐᕌᖓᐸᓗᑎᒃ ᓈᒻᒪᙱᑦᑑᓂᖏᓐᓄᑦ, ᒥᑭᑑᓂᐊᖕᓂᖏᓐᓄᑦ ᕿᑎᕈᔪᐊᓄᑦ ᐊᖏᓂᕆᔭᖓᓄᑦ ᑎᑭᓪᓗᒍ, ᐊᑎᒃᑐᒥᑦ ᕿᑎᕈᔪᐊᓄᑦ ᓄᓇᐅᑉ ᐅᖓᓯᖕᓂᕆᔭᖓᓄᑦ ᑎᑭᐅᑎᓗᓂ, ᕿᑎᕈᔪᐊᓄᑦ ᑕᑭᓂᖅᑳᓗᓂ, ᕿᑎᕈᔪᐊᓂᑦ ᐱᒐᔪᖕᓂᖅᑳᓗᓂ, ᐊᒻᒪ ᐃᓕᖅᑯᓯᑐᖃᕆᓚᐅᖅᑕᖓᓄᑦ ᐅᑎᕈᖕᓇᖃᓗᓂ ᐱᓕᕆᐊᑉ ᖃᓄᐃᓕᐅᖕᓂᕆᔭᖏᑦ ᓄᖃᖅᐸᑕ. ᑕᐃᒪᓐᓇᒧᑦ, ᐊᒃᑐᖅᓯᓂᐅᑐᐃᓇᕆᐊᖠ ᕿᒪᐃᓂᖕᒧᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᑦ ᓂᐱᖃᖕᓂᖕᒧᑦ ᐃᒃᐱᒋᔪᓄᑦ ᐃᓂᒋᔭᐅᔪᓄᑦ ᐱᓕᕆᐊᖅ ᐱᔾᔪᑎᒋᐸᒍ ᖃᐅᔨᔭᐅᓚᐅᖅᑐᑦ ᐅᔾᔨᖕᓇᖅᑑᔾᔭᖏᓐᓂᖏᓐᓄᑦ.

ᐊᖏᒡᓕᕚᓪᓕᐊᔪᓄᑦ ᐊᒃᑐᖅᓯᓃᑦ

ᐊᓯᖏᓐᓂᑦ ᐱᕚᓪᓕᐊᔪᓂᒃ ᐊᖏᔪᓂᒃ ᒫᓇᐅᔪᖅ ᐅᕙᓗᓃᑦ ᑕᐅᑦᑕᐅᔪᓂᒃ, ᐱᓕᕆᐊᐸ ᐅᓗᐊᓂᑦ ᐱᑕᖅᑲᙱᑦᑐᖅ. Wolf-ᒥᑦ ᐅᔾᔮᖅᑲᐃᑦ, ᐅᐊᖕᓇᖅᐸᓯᖕᖓᓂᑦ-ᐱᖕᖓᖕᓇᖅᐸᓯᖕᖓᓃᑦᑐᖅ ᑎᓇᖓᓂᐊᕐᒥᑦ ᐅᔾᔮᖅᑲᐃᑦ, ᒫᓇᐅᔪᖅ ᖃᐅᔨᒪᔭᐅᔪᖅ, ᑭᓯᐊᓂ ᕿᓂᖅᓴᐃᕝᕕᐅᔭᓇᐊᖅᑲᕐᒪᑦ ᓯᓕ ᑐᑭᓕᐅᑎᐊᖅᑕᐅᑲᓐᓂᕐᓂᐊᕐᓗᓂ ᐃᓚᐅᑎᑕᐅᓗᓂᓗ ᐅᔭᕆᖕᓂᐊᕐᓂᕐᒧᑦ ᐸᕐᓇᐅᑎᒥᑦ. ᒫᓇᐅᔪᖅ, Wolf-ᒥᑦ ᐅᔾᔮᖅᑲᐃᑦ ᐊᑐᕈᖕᓇᕐᒪᖔᑕ ᓇᓗᓇᕐᒪᑦ ᓯᓕ ᐅᔭᕆᖕᓂᐊᖅᑕᐃᓂᐊᕐᓗᓂ ᑕᐃᒪᓐᓇᒧᑦ ᐃᓚᐅᑎᑕᐅᓚᐅᖏᑦᑐᖅ ᐱᕚᓪᓕᐊᓂᕐᒥᑦ, ᐅᕙᓗᓃᑦ ᐃᓚᒋᔭᐅᓂᕐᒧᑦ ᐱᓕᕆᐊᒧᑦ. ᐊᕙᑎᒧᑦ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓂᖅ (ᐃᓚᐅᑉᓗᓂ ᑲᑎᑉᐸᓪᓕᐊᔪᑦ ᖃᓄᐃᖓᓕᕈᑎᖃᕐᓂᖏᓐᓄᑦ ᖃᐅᔨᓴᐃᓂᖅ) Wolf ᐅᔾᔮᖅᑲᖏᓐᓄᑦ ᐱᐊᓂᒃᑕᐅᓂᐊᖅᑐᖅ ᓯᕗᓂᕐᒥᑦ ᐅᔾᔮᖅᑲᐃᑦ ᐊᑐᖅᑕᐅᔪᖕᓇᖅᓯᓇᔭᖅᐸᑕ ᐱᕚᓪᓕᐊᑎᑦᑎᓂᕐᒧᑦ.

ᐃᓚᓗᒍ, ᓯᑕᒪᐃᑦ ᐱᓕᕆᐊᒦᑦᑐᑦ ᓈᓪᓕᒃᓯᓯᒪᐸᓗᑎᒃ ᓯᐊᒪᒃᑕᐅᓯᒪᔪᑦ ᐊᖏᓂᖅᐹᒥᑦ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᖃᓕᓃᓕᖅᓯᒪᙱᑦᑐᑦ. ᑕᐃᒪᓐᓇᒧᑦ, ᐊᖏᒡᓕᕚᓪᓕᐊᔪᓄᑦ ᐊᒃᑐᖅᓯᓃᑦ ᐊᔾᔨᒋᔭᖏᑦ ᐱᓕᕆᐊᐸ ᐊᒃᑐᖅᓯᓂᕆᔭᖏᓐᓄᑦ.

ᖃᐅᔨᓴᐃᓂᖅ ᐊᒻᒪ ᖃᐅᔨᒋᐊᖃᓐᓂᖅᑖᖕᓂᖅ

ᖃᐅᔨᓴᐃᓂᖕᒨᖓᔪᑦ ᓴᕿᑕᐅᓚᐅᖅᑐᑦ ᐊᐅᓚᓂᖅᑲᖅᑎᓪᓗᒍ ᐱᓕᕆᐊᖅ ᐃᓚᓕᐅᑎᓯᒪᓂᐊᖅᑐᖅ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᑦ ᖃᓄᐃᖓᓂᐅᔪᓂᒃ ᐊᒻᒪ ᓴᕿᑦᑎᒃᑲᓐᓂᖕᓂᖕᒥᒃ ᒥᒃᓵᑎᓇᓂᖕᒥᒃ ᐱᔭᕆᐊᖃᖕᓂᖅ ᐊᑐᖅᓗᒍ, ᐊᒻᒪ ᖃᐅᔨᒋᐊᖃᑦᑕᖅᓗᓂ ᖃᐅᔨᓴᐃᓂᐅᔪᒥᒃ ᓇᓗᓇᐃᕈᒪᐸᓗᒍ ᓈᓪᓕᒃᑲᓗᐊᖕᒪᖔᑖ ᐊᒃᑐᖅᓯᓂᐅᔪᓄᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᐊᒻᒪ ᐊᑐᓕᖅᑎᓐᓂᐅᔪᖅ ᐃᓚᐅᓕᖅᑎᑦᑎᓂᖕᒧᑦ ᐊᒻᒪ ᐊᑐᓕᖅᑎᑦᑎᓂᖅ ᒥᒃᓵᓯᐊᖅᑎᑦᑎᓂᖕᒥᒃ ᐱᔭᕆᐊᖃᖕᓂᖅ ᒪᓕᒡᓗᒍ.

ᓈᒪᒋᔭᐅᒃᐸᑦ ᐱᓕᕆᐊᖅ, ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑎᓐᓂᒃ ᖃᓄᐃᖓᓂᖓᓄᑦ ᖃᐅᔨᓴᐃᓂᖅ ᐊᒪᓗ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐸᕐᓇᐃᓂᖅ ᐊᒪᓗ ᓂᐱᖃᕐᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓂᕐᒥᒃ ᐸᕐᓇᐃᓂᖅ ᓴᕿᑕᐅᓂᐊᖅᑐᖅ ᐊᒃᑐᖅᓯᓃᑦ ᐱᓕᕆᐊᒥᑦ ᑭᒡᓕᖃᖅᑎᑦᑐᒪᒧᑦ ᓄᓇᖁᐊᑉ ᓯᓚᑖᓅᖓᔪᓄᑦ, ᖃᐅᔾᔪᒪᓗᒍ ᐊᑐᕐᓂᖓ ᒥᒃᓵᕆᐊᖅᑎᑦᑎᓂᐅᑉ ᐊᒪᓗ ᐆᒃᑐᕋᕐᓗᕆᑦ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᓇᓚᐅᑖᖅᑕᐅᔪᑦ. ᑐᕌᒐᓇᔭᐅᓗᐊᖅᑐᖅ ᐸᕐᓇᐃᓂᐅᔪᒧᑦ ᑐᑭᓯᐅᒪᔾᔪᑎᓂᒃ ᐱᔭᕆᐊᖃᖅᑐᓂᒃ ᐊᑐᓕᖅᑎᑦᑎᓂᕐᒧᑦ ᐊᐅᓚᑕᐅᓂᖓᓄᑦ ᐱᓕᕆᐊᖅ ᒥᐊᓂᕆᔭᕆᐊᖃᕐᓂᕐᒧᑦ ᓄᓇᖁᐊᑉ ᓯᓚᑖ. ᐸᕐᓇᐃᓂᐅᔪᑦ ᓴᓇᔭᐅᓯᒪᔪᑦ ᐊᑐᕐᓂᐅᔪᒧᑦ ᐱᓕᕆᐊᑉ ᖃᓄᐃᑑᓂᖓᓄᑦ ᐊᒪᓗ ᐊᒃᑐᖅᓯᓂᐅᔪᓄᑦ ᐃᓕᑕᕆᔭᐅᔪᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᖓᓂᖕᒋᓐᓄᑦ ᐊᒪᓗ ᓂᐱᖃᕐᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓂᐅᔪᓅᖓᔪᓄᑦ, ᐊᒪᓗ ᐃᓚᐅᑎᑕᐅᔪᕐᓇᖅᑯᓂ ᖃᐅᔨᓴᐃᓂᖅ ᓄᓇᖁᐊᑉᓗ ᓯᓚᖕᒐᑕ ᖃᓄᐃᓂᕆᔭᖓᓂ, ᑲᑎᖅᓱᖅᓯᒪᔪᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑎᓐᓂᑦ ᐊᔾᔩᖕᒋᑦᑐᑦ ᐊᐅᓛᕐᓂᓇᔭᖕᒐᑕ ᐱᓕᕆᐊᑉ. ᓇᓗᓇᐃᔭᑦᑎᐊᖅᓯᒪᔪᑦ ᖃᐅᔨᓴᐃᓂᕐᒨᖓᔪᓄᑦ ᓴᕿᑕᐅᔪᒪᔪᑦ ᓇᓗᓇᐃᖅᑕᐅᓂᐊᖅᑐᑦ ᓇᓗᓇᐃᔭᖅᑕᐅᑎᐊᕐᓂᖓᔪᖓᑎᒍᑦ ᐱᓕᕆᐊᑉ.

AGNICO EAGLE Golder Associates

EXECUTIVE SUMMARY

Purpose

Volume 5 of the Final Environmental Impact Statement (FEIS) for the Meliadine Gold Project (Project) considers the atmospheric environment. The purpose of Volume 5 is to address the Guidelines issued by the Nunavut Impact Review Board (NIRB) for the Project, and specifically those relating to the potential impact of the Project on air quality, climate and meteorology, climate change (including Greenhouse Gas [GHG] Emissions), and noise.

The atmospheric environment assessment includes potential direct and indirect changes resulting from Project-related components and associated activities, and evaluates all Project phases, including construction; operation; maintenance; and temporary, final, and post-closure. Cumulative effects for existing and reasonably foreseeable projects in the Project area have been incorporated, where applicable.

Study Areas

Spatial and temporal boundaries were defined to facilitate the assessment and interpretation of potential effects associated with the Project on the atmospheric environment. The spatial boundaries were delineated based on the predicted spatial extent of the potential Project-related effects and attributes of atmospheric valued ecosystem components (VECs) potentially influenced by the Project.

The assessment of potential atmospheric effects was conducted for four primary Project areas: the Mine Site (and associated infrastructure); the All-weather Access Road (AWAR); Rankin Inlet activities; and Marine Shipping. The following three spatial boundaries were identified:

- A site study area (SSA) was used to assess incremental effects within the Project disturbance footprint.
- A local study area (LSA) was used to assess the local incremental effects from the Project.
- A single regional study area (RSA) was used to assess the regional incremental effects from the Project.

An SSA was not defined for either climate and meteorology, or climate change. The SSA for air quality was defined as the direct area of physical disturbance associated with the construction and operation of the Mine Site (disturbance footprint), and extends outward a distance of 500 m. The SSA for noise includes the air quality SSA and the physical footprint of the AWAR and the activities within Rankin Inlet. Air quality SSAs were not defined for the AWAR, Rankin Inlet activities or Marine Shipping, while a noise SSA was not defined for Marine Shipping.

The following air quality LSAs were defined for the Mine Site, AWAR, and Rankin Inlet activities (an LSA was not defined for Marine Shipping):

- Mine Site: A rectangle 21×30 km in size, which extends at least 5 km in all directions from the mine SSA.
- AWAR: A band 3 km in width, extending 1.5 km either side of the travel surface of the roadway. The AWAR LSA is considered to start at the edge of the Mine Site LSA, and extend south into Rankin Inlet.
- Rankin Inlet: The boundaries of the community of Rankin Inlet.

An LSA was not defined for either climate and meteorology, or climate change. The LSA for noise extends approximately 5 km from the noise SSA, and encompasses all receptor locations where it is expected noise effects from the Project activities could affect humans. The noise LSA does not include Marine Shipping activities due to the large distance between these activities and identified noise receptor locations.

A single air quality RSA was defined, 40×45 km in size, generally centred on the Mine Site, and includes the area where air quality dispersion modelling predictions were made. The areas where air quality effects associated with Marine Shipping occur, which includes the marine areas adjacent to Rankin Inlet and the offshore areas within Canadian waters where these vessels would travel to and from Rankin Inlet, were considered to be beyond the air quality RSA.

An explicit RSA was not defined for either climate and meteorology, or climate change. However, the RSA could be considered to enclose the areas used for characterizing the existing climate and meteorology, as well as stations used for characterizing historic climate change (i.e., Baker Lake and Rankin Inlet).

An RSA was not explicitly defined for noise as the potential Project noise effects are expected to be limited to the SSA and LSA. However, any noise effects that extend beyond the LSA are considered to extend into the RSA. Marine Shipping activities generally occur within the RSA.

The temporal boundaries for the atmospheric environment establish the timeframes for which the direct, indirect and cumulative effects are assessed. Generally, the air quality and noise assessments focussed on the operational phase of the Project, when activity levels and emissions are expected to be at their greatest.

The description of the existing environment for climate relies on historic observations collected over a long period of time (typically more than 30 years). For meteorology, variations in hourly conditions observed over a period of five years are relied on.

The potential effects of the Project on climate change occur primarily during the life of the Project, while the potential effects of climate change on the Project extend through the life of the Project and into post-closure. More than 30 years of historic climate data have been used to characterize historic climate trends, while future climate trends are projected more than 50 years into the future.

Effects Analysis

An effects analysis provides the general approach to analyzing potential Project-specific and cumulative (where applicable) effects on the atmospheric environment. The effects analysis for air quality and noise generally followed the assessment methodology described in Volume 4 of the FEIS.

No specific assessment of the effects of the Project on climate and meteorology was undertaken. In keeping with the Terms of Reference, existing climate and meteorology were fully described and used in assessing the various effects of the Project on the environment, as well as in supporting the Project design.

The climate change effects assessment followed the guidance provided by the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment. Specifically, the assessment of climate and meteorology included an assessment of the potential effects of a changing climate on the Project, and an assessment of the extent to which the Project may contribute to potential changes in climate through GHG emissions to the atmosphere. This was done by putting the Project GHG emissions into context relative to the overall Territorial and Canadian emissions, as well as characterizing the potential for the Project to contribute to future climate change.

Effects from the Project on the Atmospheric Environment

Air Quality

The assessment of air quality focused on predicting changes in the concentrations of selected indicator compounds that are expected to be emitted from the Project, that are generally accepted as indicative in changing air quality, and for which relevant air quality criteria exist. The indicator compounds fall into the following two general categories:

- Particulate matter: total suspended particulate (TSP), particles nominally smaller than 10 µm in diameter (PM_{10}), and particles nominally smaller than 2.5 µm in diameter ($PM_{2.5}$); and
- Combustion gases: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO).

The magnitude of residual air quality effects were determined by comparing the predicted concentrations to relevant air quality guidelines for Nunavut, and federal objectives where territorial guidelines were not available.

The existing air quality in the study areas was characterized using background air concentrations from available literature and monitoring data sources. The data confirmed existing air quality in much of the RSA would be considered pristine, and free of influence of anthropogenic air emissions. The exception would be Rankin Inlet, where local background air quality is still good, but reflects air emissions associated with human activity.

The direct effects on air quality of the activities at the Mine Site focused on the operating phase, when emissions and activities will be at their highest. Based on the maximum dispersion model results, all indicator compounds are predicted to have negligible to low effect magnitudes both within and beyond the RSA, and with the exception of 24-hour TSP, $PM_{10,}$ and $PM_{2.5}$, and 1-hour (SSA only) and 24-hour NO_2, within the SSA and LSA. The maximum predicted 24-hour TSP and PM_{10} concentrations are determined to have high effects magnitudes in both the SSA and LSA, while the 24-hour $PM_{2.5}$ effect magnitudes are predicted to be high and moderate in the SSA and LSA, respectively. The predicted 1-hour NO_2 concentrations represent a moderate effects magnitude in the SSA, while the maximum predicted 24-hour NO_2 concentrations represent moderate effects magnitudes in both the SSA and LSA. However, all residual effects are assessed to be of a negative direction, medium-term duration, and fully reversible once Project emissions cease. Therefore, the potential residual effects on air quality of Project activities at the Mine Site were determined to be not significant.

The direct effects of the AWAR on air quality also focused on the operating phase, when emissions and activities will be at their highest. For all indicator compounds, with the exception of 24-hour TSP and PM_{10}, effects in both the LSA and RSA are predicted to be of negligible magnitude. Effects of a moderate magnitude are predicted within the LSA for 24-hour TSP and PM_{10}. All residual effects were assessed to be of a negative direction, medium-term duration, and fully reversible once emissions from the Project cease. Therefore, the potential residual effects on air quality of AWAR activities were determined to be not significant.

Emissions associated with the Project activities in Rankin Inlet and Marine Shipping are expected to be negative in direction, but negligible in magnitude. Therefore, the direct residual effects of these activities on air quality were determined to be not significant.

Climate and Meteorology

The Project activities are not expected to have any effect on the existing climate and meteorology. The existing climate and meteorology have been fully described, and are used in the assessment of various Project effects on the environment.

Climate Change

Possible future effects of a changing climate on the Project include:

- Changing sea ice conditions, sea level rise, and coastal erosion may impact inbound and outbound shipping of fuel and product at Rankin Inlet.
- Warming temperatures may affect permafrost in the vicinity of the Project site, potentially leading to an increased active layer thickness. This could directly affect infrastructure at the Project site in the long-term.
- Potential challenges to modern subsistence land users.

The specific interactions between the climate risk factors identified above and Project infrastructure or operations are discussed in individual impact assessments elsewhere in the FEIS. However, based on the Project lifespan, it is anticipated that the effects of a potentially changing climate on the Project are not significant.

The Project may also contribute to potential changes in climate through direct GHG emissions to the atmosphere from combustion sources related to production, heating and transportation. Annual total GHG emissions from the Project site and marine operations at Rankin Inlet are estimated to be 317 kilotonnes of carbon dioxide (CO_2) equivalents, which represents approximately 18% of the Northwest Territories and Nunavut GHG inventory for 2010, or 0.05% of the Canadian inventory for that same year. Due to the global insignificance of the predicted emissions from this Project, it is anticipated that the Project will not have a measurable effect on climate, and therefore, the effect of the Project on climate was assessed as not significant.

Noise

The assessment of potential noise impacts as a result of Project activities considers human nuisance effects and focusses on locations where it is expected Project noise could affect humans. The potential effects of noise and vibrations on specific VECs in the receiving environment, including noise and vibrations associated with blasting and marine shipping, are discussed in individual impact assessments elsewhere in the FEIS.

The baseline average hourly noise level at the Mine Site is expected to be 35 “A weighted” decibels (weighted to account for the frequency response of the human ear; dBA). The baseline noise environment along the AWAR will be dependent on the proximity to human activity. Near Rankin Inlet, the noise environment would be similar to the levels in Rankin Inlet. The remainder of the AWAR is located in a remote area, and the baseline noise levels are expected to be similar to the Mine Site.

A field study was carried out to help characterize existing noise levels at specific points of reception within Rankin Inlet. This field study involved continuous noise monitoring at 5 different locations, and attended noise measurements at various locations within Rankin Inlet to supplement the monitoring locations. Existing noise levels within Rankin Inlet during the monitoring period ranged between 45 and 52 dBA at the various monitoring locations.

Similar to the air quality assessment, the direct Project effects on noise levels focused on the operating phase when the levels of activity, amount of equipment and materials moved are expected to be at their highest, and therefore have the greatest potential to affect noise levels. A total of 25 locations were identified within the SSA and LSA as being the most sensitive receptors for noise. The maximum predicted noise level at the SSA noise receptor locations as a result of Project activities is 44.2 dBA, and at LSA noise receptor locations is 40.6 dBA. The maximum change from baseline conditions at the SSA and LSA noise receptor locations are 9.7 dBA and 6.7 dBA, respectively. The maximum noise level at the edge of a 1.5 km buffer zone was predicted at the recommended value of 40 dBA for remote, undeveloped areas.

The residual effects on noise levels at the identified receptor locations were assessed to be of a negative direction, negligible to moderate magnitude, low to moderate geographic extent, medium-term duration, moderate frequency, and reversible once Project activities cease. Therefore, the potential direct residual effects on the identified noise receptor locations as a result of the Project were determined to be not significant.

Cumulative Effects

There are no other industrial developments either existing or reasonably foreseeable, in the vicinity of the Project. The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development, or as part of the Project. An environmental impact assessement (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed

In addition, the 4 Project areas are sufficiently dispersed that their maximum effects do not overlap.

Monitoring and Follow-up

Monitoring programs implemented during the life of the Project will be a combination of environmental monitoring to track conditions and implement further mitigation as required, and follow-up monitoring to verify the accuracy of effect predictions and adaptively manage and implement further mitigation as required.

Upon approval of the Project, an Air Quality Monitoring and Management Plan and a Noise Monitoring Plan will be implemented to limit Project effects to the atmospheric environment, determine the effectiveness of mitigation, and test impact predictions. The principal goal of the plans will be to provide information required to adaptively manage the Project to protect the atmospheric environment. The plans will be designed to be appropriate to the scale of the Project and the effects identified through the air quality and noise assessment process, and will likely include physical monitoring of local meteorological conditions, air concentrations, and noise levels during the various phases of the Project. Details of the proposed monitoring programs will be confirmed during detailed design of the Project.

Abbreviation and Acronym List

AEM	Agnico Eagle Mines Limited
AEUB	Alberta Energy and Utilities Board
AWAR	All-weather Access Road
CadnaA	Computer Aided Noise Attenuation

CCME	Canadian Council of Ministers of the Environment
CO	Carbon Monoxide
dB	Decibel
dBA	"A weighted" decibels
FEIS	Final Environmental Impact Statement
EIS	Environmental Impact Statement
ERCB	Alberta Energy Resources Conservation Board
GCM	Global Climate Models
GHG	Greenhouse gas
GNWT	Government of Northwest Territories
Golder	Golder Associates Ltd.
IPCC	Intergovernmental Panel on Climate Change
IQ	Inuit Qaujimajatuqangit (see note [1])
ISO	International Organization for Standardization
L_{Aeq}	An equivalent A-weighted noise level measured or predicted over a specified time period
L_{eq}	An energy equivalent noise level over a given time period
LSA	Local Study Area
MOE	Ontario Ministry of the Environment
NAAQO	National Ambient Air Quality Objective
NAMP	Noise Abatement and Monitoring Plan
NAP	Noise Abatement Plan
NIRB	Nunavut Impact Review Board
NMP	Noise Monitoring Plan
NO_x	Nitrogen Oxides
NO_2	Nitrogen Dioxide
NT	Northwest Territories
O_3	Ozone
PDR	Project Description Report
pg I-TEQ/m^3	pico-grams of International Toxic Equivalency Quotients per cubic metre
PM_x	Particulate matter nominally smaller than x µm in diameter
POR	Point(s) of Reception
Project	Meliadine Gold Project
RSA	Regional Study Area
SO_2	Sulphur Dioxide
SSA	Site Study Area
TSP	Total suspended particulates
VEC	Valued Ecosystem Component
VOC	Volatile Organic Compound
VSEC	Valued Socio-economic Component

*Note: [1] IQ symbol appearing in right hand margin denotes where IQ is referenced in the assessment.

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TABLES

FIGURES

APPENDICES

5.0 ATMOSPHERIC ENVIRONMENT

5.1 Spatial and Temporal Boundaries

Spatial and temporal boundaries were defined to facilitate the assessment and interpretation of potential effects associated with the Meliadine Gold Project (the Project) on the atmospheric environment. The spatial boundaries were delineated based on the predicted spatial extent of the Project-related effects and attributes of atmospheric valued ecosystem components (VECs) potentially influenced by the Project.

5.1.1 Spatial Boundaries

5.1.1.1 Air Quality

To assess the air quality effects associated with the spatialy isolated elements of the Project, the assessment of air quality effects was conducted separately for each of the following primary Project areas:

- Mine Site (and associated infrastructure);
- All-weather Access Road (AWAR);
- Rankin Inlet activities; and
- marine shipping.

Spatial boundaries define the geographical extents within which environmental effects of the Project can be reasonably expected, and are considered. For each of the primary Project areas, up to three study areas were defined for the air quality assessment, namely a Site Study Area (SSA), a Local Study Area (LSA), and a Regional Study Area (RSA). The boundaries for these areas were based on the following factors:

- location and concentration of emission sources;
- potentially sensitive receptor locations; and
- the extent of the dispersing plume(s).

An SSA (Figure 5.1-1) was defined for the Mine Site (and associated infrastructure) that encompasses all of the operational areas, the open pits, and the interconnecting mine roads. This includes the direct area of physical disturbance associated with the construction and operation of the Project (disturbance footprint), and extends outward a distance of 500 metres (m). This is the area where non-Project related activities would be restricted during the life of the Project, and public access to these areas would be limited. Site Study Areas were not defined for the AWAR, Rankin Inlet activities, or Marine Shipping.

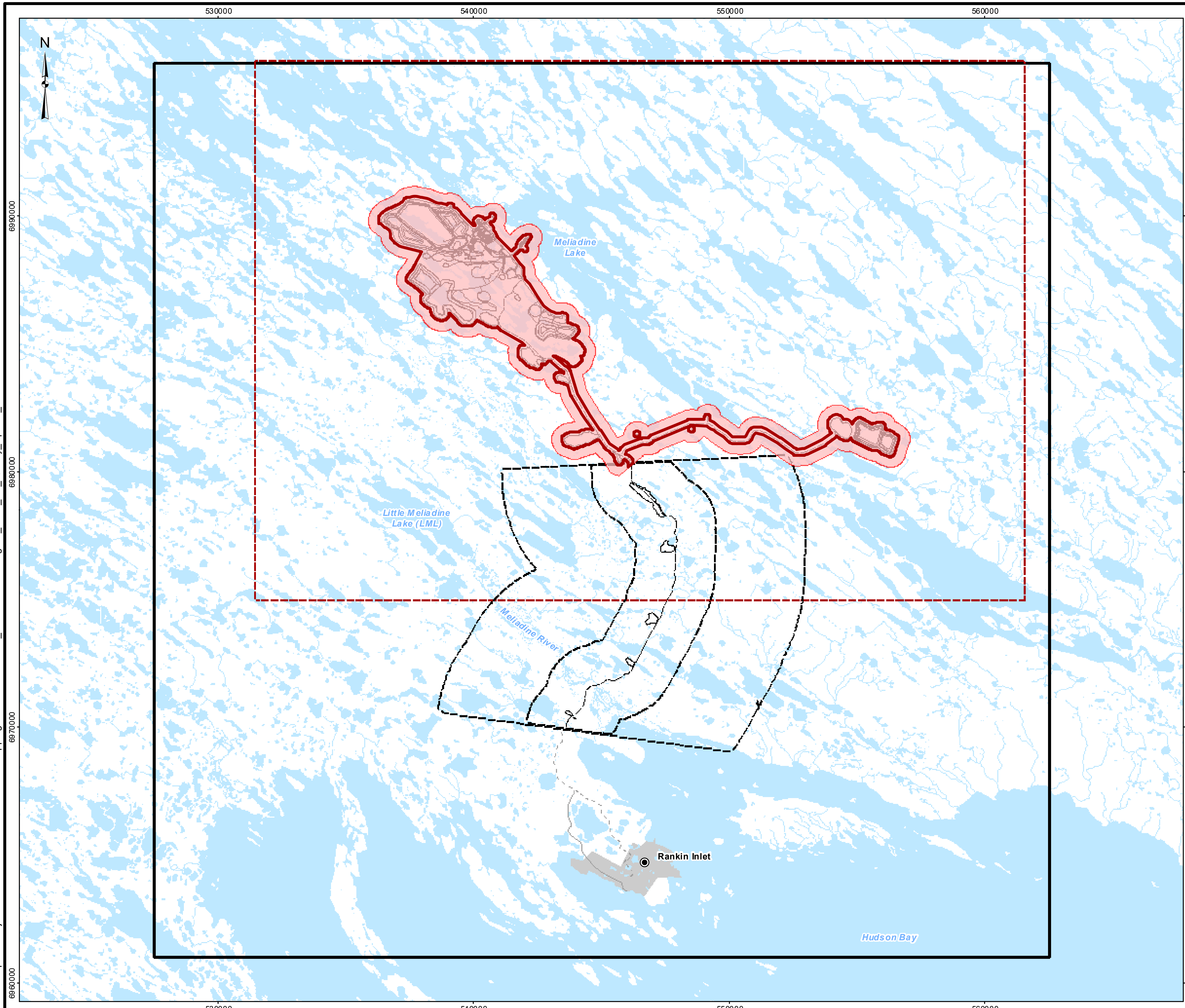
Separate LSAs (Figure 5.1-1) were defined for the Mine Site, the AWAR, and the Rankin Inlet activities. These areas generally correspond to the extents where most of the air quality effects associated with the Project elements are expected to occur, and can be predicted or measured with a reasonable degree of accuracy. The following define the LSAs used for assessing air quality:

- Mine Site: A rectangle 21×30 kilometre (km) in size, generally centred on the Mine Site activities.

- AWAR: A band 3 km in width, extending 1.5 km either side of the travel surface of the roadway. The AWAR LSA is considered to start at the edge of the mine LSA and extend south into Rankin Inlet.
- Rankin Inlet: The boundaries of the community of Rankin Inlet.

An LSA was not defined for Marine Shipping.

A single RSA (Figure 5.1-1) was defined for the mine site (and associated infrastructure), the AWAR, and Rankin Inlet activities. The RSA is 40×45 km in size, generally centred on the mine site, and includes the area where the dispersion modelling predictions were made. The areas where Marine Shipping activities occur, which includes the marine areas adjacent to Rankin Inlet and the off-shore areas within Canadian waters where these vessels would travel to and from Rankin Inlet, were considered to be "beyond the RSA".



LEGEND

- Disturbed Area (Mine Site)
- Site Study Area (Mine Site)
- Local Study Area (Mine Site)
- Regional Study Area (Mine Site)
- Local Study Area (AWAR)
- Local Study Area (Rankin)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

AIR QUALITY SPATIAL BOUNDARIES

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	TH	09 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	09 Nov. 2012	FIGURE 5.1-1	
CHECK	GA	11 Jan. 2013		
REVIEW	DW	11 Jan. 2013		

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_5\Main Volume\Figure_5.1-1_Air_Quality_Spatial_Boundaries.mxd

5.1.1.2 Climate and Meteorology

An SSA and LSA were not defined for climate and meteorology. In addition, no explicit RSA was defined for climate and meteorology. However, the areas that enclose the stations used for describing the existing climate and meteorology, as well the 50×50 km domain over which the dynamic (3-D) dispersion meteorology was generated, could be considered as the RSA for this discipline.

5.1.1.3 Climate Change

An SSA and LSA were not defined for climate change. In addition, no explicit RSA was defined for climate change. However, the areas that enclose the stations used for describing the historic climate trends (Baker Lake and Rankin Inlet), as well as the grid cells used for defining future climate trends, could be considered as the RSA for this discipline.

5.1.1.4 Noise

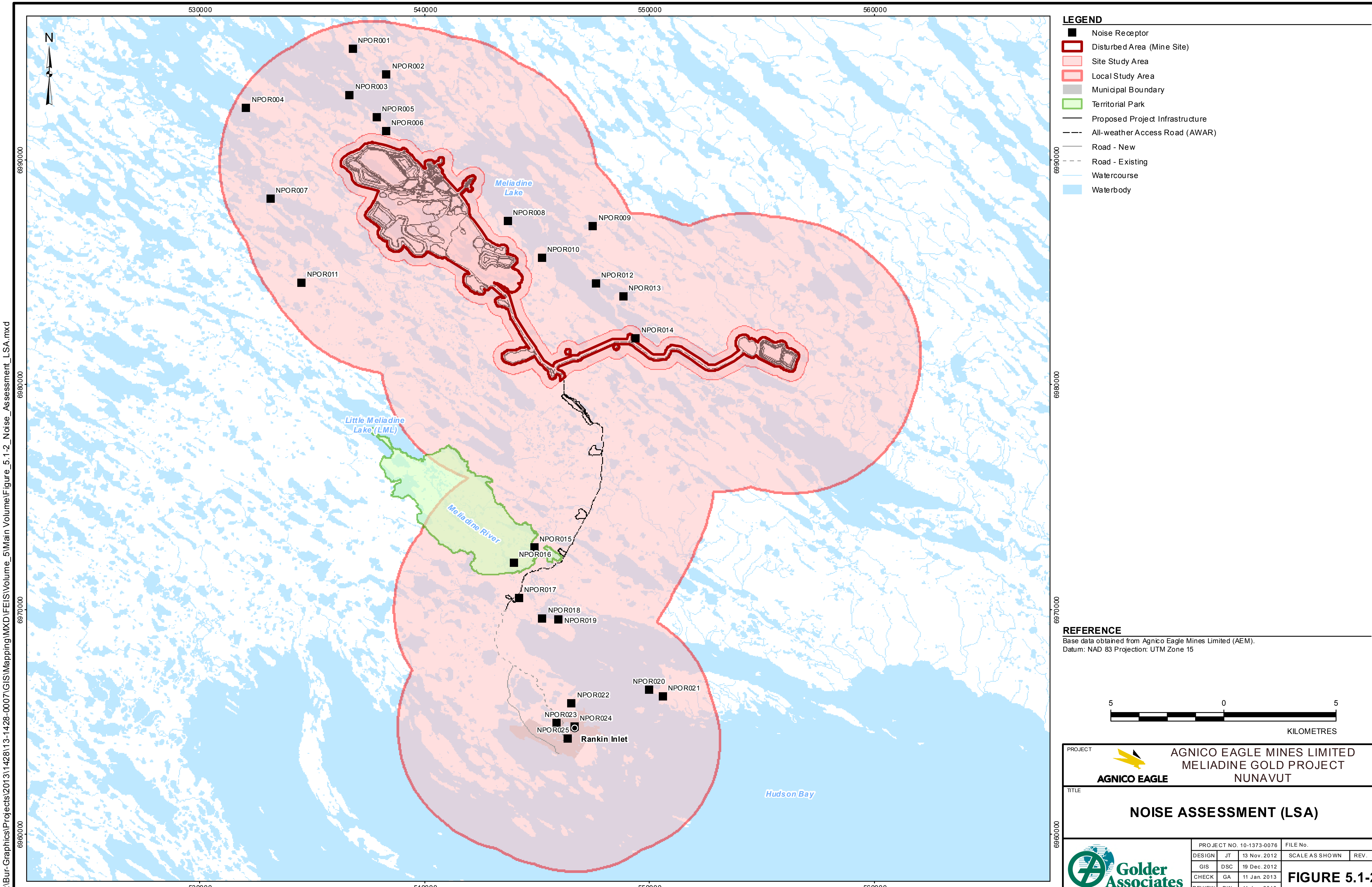
The assessment of noise effects was carried out collectively for the following primary Project areas:

- Mine Site (and associated infrastructure);
- AWAR;
- Rankin Inlet activities; and
- Marine Shipping.

Three study areas were defined incorporating the above Project areas, namely an SSA, an LSA, and an RSA. The boundaries for these areas were based on the following factors:

- location and emission levels of sources;
- potentially sensitive receptor or Point(s) of Reception (POR)(s) locations; and
- noise propagation.

A single SSA (Figure 5.1-2) was defined to include the Mine Site (and associated infrastructure), the AWAR, and Rankin Inlet activities. Within the Mine Site area, the SSA encompasses the operational area of the Project; including the direct area of physical disturbance associated with the construction and operation of the Project (disturbance footprint), and extends outward a distance of 500 m. This is the area where non-Project related activities would be restricted during the life of the Project, and public access to these areas would be limited. Along the AWAR and in Rankin Inlet, the extent of the SSA is limited to the disturbance footprint. The SSA does not include Marine Shipping activities due to the relative distance of these activities to PORs.



NOISE ASSESSMENT (LSA)

FIGURE 5.1-2

An LSA (Figure 5.1-2) was defined, which extends approximately 5 km from the SSA, and encompasses identified sensitive PORs. The LSA generally corresponds to the extents to which most of the noise effects associated with the Project are expected to occur, and can be predicted or measured with a reasonable degree of accuracy. The LSA does not include Marine Shipping activities due to the large distance between these activities and identified PORs.

An RSA was not explicitly defined for noise as the potential Project noise effects are expected to be limited to the SSA and LSA. However, any noise effects that extend beyond the LSA are considered to extend into the RSA. Marine Shipping activities generally occur within the RSA.

5.1.2 Temporal Boundaries

The temporal boundaries were defined by the amount of time between the start and end of a relevant Project activity, plus the duration required for the effect to be reversed, and were related to the various Project phases (preconstruction, construction, operations, maintenance, temporary closure, final closure, and post-closure). The temporal boundaries were selected to establish the timeframes for which the direct, indirect, and cumulative effects are assessed. Generally, the air quality and noise assessments focussed on the operational phase of the Project, when activity levels and emissions are expected to be at their greatest. The air quality and noise effects during the other phases are anticipated to be lower than those associated with the mining operations. No explicit temporal boundaries were defined for climate and meteorology. The description of the existing environment for climate relies on historic observations collected over a long period of time (typically more than 30 years). For meteorlogy, variations in hourly conditions observed over a period of 5 years are relied on.

The temporal boundaries for climate change are the same as for the other atmospheric components, with the potential effects of the Project on climate change occurring primarily during the life of the Project, and the potential effects of climate change on the Project extending through the life of the Project and into post-closure. However, climate is a long-term phenomenon that describes expected weather patterns over a minimum 30-year period. Therefore, more than 30 years of historic climate data have been used to characterize historic climate trends, whereas future climate trends are projected more than 50 years into the future, consistent with the Intergovernmental Panel on Climate Change (IPCC 2007) protocols.

5.2 Air Quality

5.2.1 Purpose and Scope

The air quality component of the Atmospheric Environment assessment has been prepared with regard to the NIRB Guidelines (NIRB 2012), with the following objectives:

- Evaluating the potential air emissions and corresponding air quality effects of the Project. The evaluation included the following:
  - quantify emissions from the fuel combustion in mobile equipment, such as haul trucks and marine vessels, stationary equipment such as diesel generators, and other combustion sources;
  - quantify the fugitive dust emissions from extraction and ore processing, tailings, waste rock, ore stockpiles, quarries, and other Project components and works;

  - quantify the fugitive dust emissions from ground transportation and wind erosion at various Project components including the AWAR, access roads, and mine haul roads;
  - predict the dispersion of Project emissions using the CALPUFF dispersion model;
  - predict the dispersion, chemical transformation, and deposition of emissions that may contribute to the potential for acidic input, and provide the results to relevant aquatic and terrestrial disciplines for the evaluation of associated effects; and
  - assess the predicted effects of Project emissions on air quality during various Project stages.
- Proposing follow-up monitoring, mitigation, and management strategies to minimize any impacts, where required.

5.2.1.1 Concordance with Guidelines

The purpose of this section is to address Guidelines issued by the Nunavut Impact Review Board (NIRB) for the Project (NIRB 2012) specifically relating to the impact of the Project on air quality. Specific requirements set out in the Guidelines relating to the baseline and the impact assessment for air quality are presented in Volume 1, Appendix 1.0-A, respectively.

The air quality assessment focuses on the changes in air quality as a result of Project activities. These changes in air quality also can have an effect on other disciplines, such as human health and surface water quality. The effects of changes in air quality are assessed as indirect effects in the pathways for those other disciplines, and are discussed in detail in their respective sections.

The air quality assessment is supported by the following appendices:

- Appendix 5.2-A – Air Emission Details
- Appendix 5.2-B – Dispersion Modelling Methodology
- Appendix 5.2-C – Dispersion Meteorology

5.2.2 Valued Ecosystem Components

Valued ecosystem components and valued socio-economic components (VSECs) represent physical, biological, cultural, social, and economic properties of the environment that are either legally, politically, publically, or professional recognized as important to a particular region, community, or by society as a whole. VECs and VSECs are selected based on their role in the ecosystem, and value placed on them by humans for traditional use and cultural connection, where appropriate. Air quality has been identified as a valued ecosystem component for the atmospheric environment.

5.2.3 Methods and Approach

The general approach used in the air quality assessment includes the following steps:

- Identify suitable air quality indicators to use for evaluating the effects of the Project on air quality. These indicators represent compounds that will be emitted in measureable amounts and for which relevant air quality criteria are available. In addition to the air quality indicators, identify the other compounds that may be emitted in trivial amounts, or which no criteria are available, but that are important from the perspective of other disciplines (e.g., human health).

- Identify the existing air quality conditions for the indicator compounds in the vicinity of the Project.
- Complete a pathways analysis that identifies those elements of the Project that have the potential to affect air quality.
- Evaluate the potential air quality effects of the Project using the following steps:
  - Estimate the air emissions from the Project for the phase of activity (i.e., construction, operations, and closure and reclamation) determined to have the highest (i.e., bounding) quantity of air emissions.
  - Predict the concentrations and deposition rates of indicator compounds released from the bounding phase of the Project dispersion modelling.
  - Use dispersion modelling to predict the concentrations and deposition rates required as inputs to other disciplines affected by changes in air quality (e.g., human health).
  - Compare the predicted indicator compound concentrations to available criteria and standards, and assess the relevant significance of these effects.
- Prepare monitoring, mitigation, and adaptive management strategies that reflect the nature of the Project, in the area where the Project is situated and the predicted air impacts.

The spatial and temporal boundaries for the air quality assessment are defined in Section 5.1. During the operations phase, the Project will have a number of open pit mines. The timing of when these open pits will be developed will vary depending on the actual blend of ore mined. However, the maximum amount of ore mined at any one time from open pits is 6500 tonnes per day. To provide flexibility in operations, and to fully assess the potential effects of mining on air quality, the assessment for the Mine Site considers 6 separate cases. The first case considers only the support operations (e.g., power plant) and underground mining (Tiriganiaq Underground at a rate of 2000 tonnes per day). The next 5 cases consider the emissions from the initial case in combination with the emissions due to mining in one of the open pits at the maximum throughput for the facility (8500 tonnes per day). As the quanitity of material transferred from each open pit mined is limited by the mobile equipment available, it was assumed that the entire mobile fleet was in operation for the pit modelled. In reality, mining is likely to occur at a lower rate, with operations distributed over more than one open pit. If activities were to occur at a lesser rate in multiple pits, the individual effects would be less than those bounded by the following cases considered in this assessment (i.e., assessment is conservative):

- Case 1: Processing plant operating at a maximum capacity, underground mining at Tiriganiaq, power generation, and ancillary supporting operations;
- Case 2: All sources in Case 1, plus open pit mining at Tiriganiaq;
- Case 3: All sources in Case 1, plus open pit mining at F Zone;
- Case 4: All sources in Case 1, plus open pit mining at Pump;

- Case 5: All sources in Case 1, plus open pit mining at Discovery; and
- Case 6: All sources in Case 1, plus open pit mining at Wesmeg.

5.2.3.1 Indicator Compounds

The assessment of air quality focused on predicting changes in the concentrations of selected indicator compounds. These indicator compounds represent compounds that are expected to be emitted from the Project, and are generally accepted as indicative in changing air quality, and for which relevant air quality criteria exist. These indicator compounds fall into the following 2 general categories:

- **Particulate matter**, including total suspended particulate (TSP) (referred to as dust in the Guideline), particles nominally smaller than 10 micormetres (µm) in diameter (PM_{10}), and particles nominally smaller than 2.5 µm in diameter ($PM_{2.5}$); and
- **Combustion Gases**: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO).

Two compounds identified in the Guidelines have not been selected as indicator compounds, namely volatile organic compounds (VOCs) and ozone (O_3). The Project activities may result in small quantities of VOC emissions from the combustion of diesel fuel; however, there are no ambient air quality criteria for VOCs. Notwithstanding that VOCs are not considered indicator compounds, concentrations of VOCs have been predicted, and the results used as inputs to the human health assessment (FEIS Volume 10, Section 10.2). Ozone is not directly emitted from Project activities; however, the Project activities will result in the emission of precursor compounds (i.e., NO_X and VOC), which can contribute to ozone formation under ideal meteorological conditions (i.e., extended periods of low wind speeds with temperatures greater than 25 °C). Given the rarity of ideal meteorological conditions, ozone was not considered to be a suitable indicator compound for the Project.

The relevant air quality criteria used for assessing the air quality effects of the Project include the Nunavut guidelines, and federal objectives where territorial guidelines are not available. The Nunavut Department of Environment has set guidelines related to ambient air concentrations, and these are summarized in the *Environmental Guideline for Ambient Air Quality* (Government of Nunavut 2011). There are 2 sets of federal objectives and criteria: the National Ambient Air Quality Objectives (NAAQOs) and the Canada-Wide Standards. The NAAQOs are benchmarks that can be used to facilitate air quality management on a regional scale, and provide goals for outdoor air quality that protect public health, the environment, or aesthetic properties of the environment (CCME 1999). The federal government has established the following levels of NAAQOs (Environment Canada 2010):

- the maximum *Desirable* level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for unpolluted parts of the country and for the continuing development of control technology; and
- the maximum *Acceptable* level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being.

The Canada-Wide Standards are standards that have been developed under the Canada-wide Accord on Environmental Harmonization that provides common environmental standards across the country that are agreed upon by the individual Provinces and Territories. The Canada-Wide Standards process has been progressing for a limited set of compounds, namely ozone and fine particulate matter ($PM_{2.5}$), with the first for air quality ratified by the Canadian Council of Ministers of Environment (CCME) in 2000.

A summary of the applicable Nunavut guidelines, Canada Wide Standards, and federal objectives for the indicator compounds are listed in Table 5.2-1.

Table 5.2-1: Nunavut and Canadian Regulatory Criteria for the Indicator Compounds

Substance	Averaging Period	Nunavut Ambient Air Quality Guidelines[a]	Canada-Wide Standards[b]	National Ambient Air Quality Objectives[c]	
				Desirable	Acceptable
TSP (µg/m³)	24-Hour	120	—	—	120
	Annual	60[d]	—	60	70
PM_{10} (µg/m³)	24-Hour	—	—	—	—
$PM_{2.5}$ (µg/m³)	24-Hour	30	30[e]	—	—
NO_2 (µg/m³)	1-Hour	400	—	—	400
	24-Hour	200	—	—	200
	Annual	60[f]	—	60	100
SO_2 (µg/m³)	1-Hour	450	—	450	900
	24-Hour	150	—	150	300
	Annual	30[f]	—	30	60
CO (µg/m³)	1-Hour	—	—	15 000	35 000
	8-Hour	—	—	6 000	15 000

[a] Government of Nunavut (2011)

[b] CCME (2000)

[c] Environment Canada (2010)

[d] Geometric Mean Value

[e] Compliance with the Canada Wide Standard is based on the 98th percentile of the annual monitored data averaged over 3 years of measurements.

[f] Arithmetic mean value

— = No guideline available; µg/m³ = micrograms per cubic metre

5.2.3.2 Existing Air Quality Methods

The existing air quality was characterized using background air concentrations from available literature and monitoring data sources. Much of the RSA could be considered free of concentrated anthropogenic air emissions. For this reason, it is likely that background air concentrations around the Mine Site would be very low. The exception would be Rankin Inlet, where local background air quality would likely reflect the concentrated human activity and corresponding anthropogenic air emissions.

Field studies were not undertaken to characterize the existing air quality in Rankin Inlet because adequate data were available from existing literature and data sources. Specifically, data are available from both the Environment Canada National Air Pollution Surveillance Network and the Government of Northwest Territories (GNWT) air monitoring network. The stations identified as being most relevant at this northern location are listed in Table 5.2-2.

Table 5.2-2: Existing Northern Air Quality Monitoring Stations

Station Name	Location	Latitude	Longitude
Iqaluit	Nunavut	63.7500°N	68.5500°W
Yellowknife	Northwest Territories	62.4439°N	114.3964°W
Inuvik	Northwest Territories	68.3617°N	133.7306°W
Fort Liard	Northwest Territories	60.2408°N	123.4697°W
Norman Wells	Northwest Territories	65.2831°N	126.8494°W

Although the communities are located at substantial distances from Rankin Inlet, they are considered to be indicative Rankin Inlet background air quality, as they are also northern communities, have similar sources of electrical power, are similar in size, and are expected to have similar anthropogenic activities.

While data are available in communitiesd, there are no available monitoring data at remote locations within NWT or Nunavut, with the exception of the background monitoring completed for the Fortune Minerals NICO Project (Fortune Minerals 2011). This monitoring quantified the levels of NO_2 and SO_2, which are indicative measures of relative anthropogenic air quality. These results show that anthropogenic sources have little or no influence on the background air quality at these remote locations.

5.2.3.3 Pathway Analysis Methods

Pathway analysis identifies the possible linkages between the Project components or activities and the potential residual effects on air quality. Potential pathways through which the Project could affect air quality were identified from a number of sources including the following:

- the Project Description;
- potential effects identified in the Guidelines (NIRB 2012);
- scientific knowledge and experience with other mines in Nunavut and NWT; and
- engagement with the regulatory bodies.

As part of the air quality pathways analysis, a list of all potential effects pathways for the Project was developed. For each of these pathways, environmental design features and mitigation options that could be incorporated into the Project were considered either to remove the pathway or to limit (mitigate) the effects of the activity on air quality. Environmental design features include Project design elements, environmental best practices, and management policies and procedures.

Knowledge of the environmental design features were then applied to each of the pathways to determine the expected Project related changes to the environment and associated residual effects on air quality. For an effect to occur, there has to be a source (Project component or activity) that results in a measureable environmental change (pathway) and correspondent effect on air quality.

5.2.3.4 Methods for Predicting Residual Effects

The residual air quality effects of the Project represent those effects that remain after mitigation measures have been incorporated. The air quality assessment uses dispersion models to predict the potential concentrations of indicator compounds resulting from the air emissions at the Project. In calculating the air emissions used as inputs to the dispersion model, consideration was given to Project design elements that reduce emissions, as well as in-design mitigation. Therefore, the predicted effects (i.e., concentrations of indicator compounds) represent the residual effects of the Project.

5.2.3.4.1 Emission Methods

The methods used for calculating and quantifying the air emissions are as follows:

- **Identify emissions sources**: The identification of emission sources were based on the activity data provided in the Project Description (FEIS Volume 2, Section 2.0) and detailed information provided by Agnico Eagle Mines Limited (AEM).
- **Calculated emission rates:** Air emission rates were calculated using accepted methods, such as emission factors, and were based on the activity data provided in the Project Description (FEIS Volume 2, Section 2.0).
- **Summarize overall emissions:** The calculated emissions were summarized by assessment case and by activity type.

Details of the specific emission calculation methods and resulting emissions are provided in Appendix 5.2-A.

5.2.3.4.2 Dispersion Modelling Methods

Air dispersion models were used to predict concentrations and deposition rates associated with the Project emissions. The same models were used in predicting concentrations of indicator compounds as was used in predicting concentrations and deposition rates of non-indicator compounds (those compounds used by other disciplines in assessing the indirect effects of air quality). Specifically, the fully capable CALPUFF dispersion model (i.e., run in dynamic [3-D] mode with a fine resolution meteorological data set) was used in predicting concentrations and deposition rates. This model was selected for the following reasons:

- It is widely accepted in northern Canada, as well as nationally and internationally, for assessing the effects of mining projects. The CALPUFF model has been demonstrated as an accepted model in numerous environmental assessments reviewed by NIRB.
- It can be used to accurately predict concentrations and deposition rates at distances as small as 10s of metres and extending out far enough to enclose the entire modelling domain (i.e., 35×35 km).
- It is capable of simulating both wet and dry deposition of gaseous and particulate compounds. In addition, CALPUFF has the ability to model the atmospheric chemistry necessary to predict potential acid inputs.

To use the full capabilities of the CALPUFF model, a dynamic (3-D) meteorological data set must be developed covering the area where predictions are required. This 3-D dispersion meteorological data set allows the meteorological conditions to vary across the modelling domain for each hour that is modelled. The data file is generated using the CALMET pre-processor. To include a full range of possible meteorological conditions, a 5-year data set covering the period from 2006 to 2010 was generated, as detailed in Appendix 5.2-B.

The assessment of effects looked at the highest predicted concentrations. As there is no air modelling guidance for Nunavut; the dispersion modelling approach is based on the Air Quality Model Guidance developed by Alberta Environment (AENV 2009). In accordance with this modelling guidance (AENV 2009), the maximum concentrations were determined excluding meteorological anomalies.

5.2.3.5 Methods for Residual Impact Classification

The residual air quality effects predicted using the CALPUFF dispersion model were then used to assess whether the air quality effects of the Project would be significant. Significance of air quality effects considered the following criteria:

- direction or nature of the impacts;
- magnitude and complexity;
- geographic extent;
- frequency;
- duration;
- reversibility; and
- likelihood or probability of effects.

The criteria of direction and likelihood are not explicitly addressed for air quality, as all predicted air quality effects are assumed to be of a negative direction, and likely to occur. The majority of the remaining criteria are specific to air quality. The one exception is reversibility, which uses the generic definitions used consistently across all VEC endpoints. The scales of classification for magnitude, geographic extent, frequency, duration, and reversibility are dependent on each VEC endpoint, and the associated effects statement. Although professional judgment is inevitable in some cases, a strong effort was made to classify effects using scientific principles, supporting evidence, and a conservative approach where uncertainties exist. Definitions for each criterion are provided below, and details of the selected impact classification criteria for air quality are presented in Table 5.2-3.

In assigning magnitude for air quality, consideration is given to the maximum prediction outside the disturbance footprint. If the predicted maximum concentrations exceeded the relevant criteria, the effect was considered to be of high magnitude. A moderate magnitude is assigned when the maximum prediction was between 50% and 100% of the relevant criteria. Maximum predictions that were less than background (see Section 5.2.2) were considered to be of negligible magnitude. Non-negligible effects, where the maximum predictions were less than 50% of the relevant criteria, are considered to be of a low magnitude. Table 5.2-4 presents the criteria for assigning magnitude to the predicted residual adverse air quality effects.

Table 5.2-3: Effects Criteria and Levels for Determining Significance for Air Quality

Effects Criteria	Effects Level Definition			
Magnitude (of effect)	**Negligible**	**Low**	**Moderate**	**High**
	The effects level definitions for magnitude are provided in Table 5.2-6			
Geographic Extent (of effect)	**Site**	**Local**	**Regional**	**Beyond Regional**
	Effect is restricted to the SSA	Effect extends into the LSA	Effect extends into the RSA	Effect beyond the RSA
Frequency[a] (of conditions causing effect)	**Isolated**	**Periodic**	**Continuous**	
	Conditions or phenomena causing the effect occur infrequently (e.g., <2% of the time).	Conditions or phenomena causing the effect occur at regular, although infrequent intervals (e.g., approximately 10% of the time).	Conditions or phenomena causing the effect occur at regular and frequent intervals (i.e., >10% of the time).	
Duration (of conditions causing the effect)	**Short-Term**	**Medium-Term**	**Long-Term**	
	Conditions causing effect are short-term and evident during the construction or decommissioning and reclamation phases	Conditions causing effect are evident for an extended period, and last throughout the operational phase	Conditions causing effect extend over several phases, and extend into the decommissioning and reclamation phase.	
Reversibility (of effect)	**Reversible**	**Irreversible**		
	Effect is readily reversible once the stressor is removed.	Effect cannot be reversed, or will take and extended time after the removal of the stressor for the effects to be reversed.		

[a] The percentiles for separating low and medium frequency effects were based on accepted values for ambient air quality, specifically the 98^{th} percentile is used in the Canada-Wide Standard for PM$_{2.5}$ so as to exclude outliers. The percentiles used to distinguish between moderate and high frequencies were based on accepted practices for determining background air quality. Specifically, the 90^{th} percentile is considered to be representative of background conditions; therefore, affects that occur more often than 10% of the time would be considered of a high frequency.

Table 5.2-4: Effects Magnitude Levels for Air Quality

Contaminant	Averaging Period	Magnitude Level Definition			
		Negligible	**Low**	**Moderate**	**High**
TSP	24- hour (µg/m^3)	<30	≤60	≤120	>120
	Annual (µg/m^3)	<20	≤35	≤70	>70
PM$_{10}$	24- hour (µg/m^3)	<15	≤25	≤50	>50
PM$_{2.5}$	24- hour (µg/m^3)	<7.5	≤15	≤30	>30
NO_2	1-hour (µg/m^3)	<13	≤200	≤400	>400
	24-hour (µg/m^3)	<11	≤100	≤200	>200
	Annual (µg/m^3)	<6	≤50	≤100	>100
SO_2	1- hour (µg/m^3)	<5	≤450	≤900	>900
	24- hour (µg/m^3)	<3	≤150	≤300	>300
	Annual (µg/m^3)	<1	≤30	≤60	>60
CO	1- hour (µg/m^3)	<350	≤17 500	≤35 000	>35 000
	8- hour (µg/m^3)	<150	≤7 500	≤15 000	>15 000

Notes: The threshold between low and moderate was set at 50% of the relevant criteria.
The threshold between moderate and high was set to the relevant criteria

5.2.3.6 Methods for Assigning Environmental Significance

The level of significance is assigned by using professional judgment and combining the criteria of magnitude, geographic extent, timing and duration, frequency, and reversibility. Residual effects were assigned either a "not significant" or "significant" rating if professional judgement suggested it was clear that there would be no significant effects or significant effects, respectively. In those cases where professional judgement suggested that no significant effects are likely, but that had high magnitude predictions, a rating of "significant" was conservatively assigned.

Generally, the following guiding principles were used when assigning significance:

- All effects of a negligible or low magnitude would be considered "not significant". Negligible effects include maximum predictions that are less than 1 µg/m³, while low magnitudes are assigned when the maximum predicted concentrations are less than half of the respective criteria.
- Effects with a moderate magnitude were classified as either "not significant", or "significant" depending on the geographic extent and frequency.
  - Effects with a moderate magnitude that are restricted to either the SSA or LSA would be considered "not significant".
  - Effects of a moderate magnitude that extend into the RSA would be classified as
    - "not significant" if they are isolated or periodic in frequency
    - "significant" if they are continuous in frequency
  - Effects with a moderate magnitude that extend beyond the regional study area would be classified as "significant".
- Effects with a high magnitude were classified as "not significant" or "significant" depending on the geographic extent, frequency, and duration.
  - Effects with a high magnitude that are restricted to the SSA would be considered "not significant".
  - Effects with a high magnitude that extend into the LSA would be considered
    - "not significant" if they are isolated in frequency
    - "significant" if they are periodic or continuous in frequency
  - Effects with a high magnitude that extend into the RSA would be considered "significant"
  - Effects with a high magnitude that extend beyond the RSA would be considered "significant".

5.2.4 Description of the Existing Air Quality

Existing air quality, based on background air concentrations from available monitoring stations, is summarized in Table 5.2-5. The readings are typically very low and well below the given air quality standards. The values shown include local community emission sources. It is expected that Rankin Inlet will have similar existing air quality; however, existing air quality along the AWAR would be expected to be lower than existing data from northern monitoring stations.

Table 5.2-5: Existing Air Quaity Data (µg/m³)

Indicator Compound	Iqaluit	Inuvik	Fort Liard	Norman Wells	Yellowknife	Average
TSP – 24-hour	—	—	—	—	—	—
TSP – Annual	—	—	—	—	—	—
PM_{10} – 24-hour	—	40.68	18.41	34.26	30.21	30.89
$PM_{2.5}$ – 24-hour	—	4.81	9.07	7.02	9.23	7.53
NO_2 – 1-hour	—	—	3.76	5.64	28.22	12.54
NO_2 – 24-hour	—	—	3.90	6.42	22.58	10.97
NO_2 – Annual	—	—	1.91	3.24	11.64	5.60
SO_2 – 1-hour	—	5.24	2.62	2.62	2.62	3.27
SO_2 – 24-hour	—	5.03	4.04	2.62	3.35	3.76
SO_2 – Annual	—	1.89	0.74	0.86	1.23	1.18
CO – 1-Hour	—	—	—	—	343.56	343.56
CO – 8-Hour	—	—	—	—	372.19	372.19

Notes: All values, with the exception of annual averages are based on 90th percentile

— = not available

The mine site is located in a remote location, approximately 25 km north of Rankin Inlet. There are currently no existing anthropogenic (man-made) sources of air emissions in the vicinity of the mine site. The existing air quality data collected in communities in the Arctic (see above table) are not representative of remote locations such as the mine site due to the influence of local activities such as power generation and vehicle movements. It is expected that air quality in remote locations will be lower than the available measured values.

There are limited monitoring data available for the Fortune Minerals NICO Project (Fortune Minerals 2011). These data were air quality measurements at a remote northern location, similar to the mine site, during the pre-development stages of the NICO Project, when activity levels were low. The average of these data, which were collected monthly using passive monitors, is summarized in Table 5.2-6. Published data are not available for any other indicator compounds.

Table 5.2-6: Average of Existing Air Quality Data for Fortune Minerals NICO Project, NWT

Indicator Compound	Average Concentration
NO_2	1 µg/m³
SO_2	0.5 µg/m³

5.2.5 Description of Project Effects

5.2.5.1 Pathways Analysis

As described in Section 5.2.2.5, the pathway analysis identifies the possible linkages between the Project components or activities and the potential residual effects on air quality. Pathways determined to be likely to have a measurable effect on air quality were classified as “primary”, and were carried forward for the prediction of residual effects, classification of impacts, and determination of environmental significance. Pathways determined to have little potential for affecting air quality, or those whose effects that were bounded by another "primary" pathway, were classified as being "minor". Minor pathways were not assessed further.

The pathways analysis for air quality is presented in Table 5.2-7, and includes 4 "primary" pathways and 3 "minor" pathways. The air quality effects associated with the construction phase, as well as the decommissioning and post-closure phase, were classifies as being minor pathways because the effects during these phases would be bounded by the effects associated with the operations phase of the mine site. The reason they are bounded by the effects during operations is that the levels of activity, amount of equipment, and materials moved are higher during the operations phase. In a similar manner, the air quality effects associated with the construction of the AWAR were considered to be a minor pathway, as they would be bounded by the air quality effects during the operations of the AWAR, when travel and activity along the road would be at its maximum.

Table 5.2-7: Pathways Table – Air Quality

Valued Component	Project Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis
Air Quality	Mine Site (construction)	Construction activities result in air emissions, which may cause short-term changes in air concentrations. Fuel combustion will result in air emissions, which may contribute to territorial and national greenhouse gas emissions.	Best management practices to control fugitive particulate emissions. Exhaust emissions from non-road vehicles will be managed through purchasing equipment that meet Tier 3 emission standards. Exhaust emissions from non-road vehicles will be managed through regular and routine maintenance of vehicles. SO_2 emissions from non-road vehicles and stationary equipment will be reduced through the use of diesel fuel with less than 15 ppm of sulphur.	Minor (bounded by operation effects)
	Mine Site (operations)	Project activities will result in air emissions, which may cause changes in air concentrations and atmospheric deposition rates. Fuel combustion will result in air emissions, which may contribute to territorial and national greenhouse gas emissions.	Best management practices to control fugitive particulate emissions from haul roads and material handling. Sources of particulate emissions at the processing facility are controlled through the use of baghouses. Enclosures are used to reduce fugitive emissions at the processing facility. Exhaust emissions from non-road vehicles will be managed through purchasing equipment that meet Tier 3 emission standards. Exhaust emissions from non-road vehicles will be managed through regular and routine maintenance of vehicles. SO_2 emissions from non-road vehicles and stationary equipment will be reduced through the use of diesel fuel with less than 15 ppm of sulphur.	Primary
Air Quality	Mine Site (decommissioning and reclamation)	Decommissioning activities result in air emissions, which may cause short-term changes in air concentrations. Fuel combustion will result in air emissions, which may contribute to territorial and national greenhouse gas emissions.	Best management practices to control fugitive particulate emissions. Exhaust emissions from non-road vehicles will be managed through purchasing equipment that meet Tier 3 emission standards. Exhaust emissions from non-road vehicles will be managed through regular and routine maintenance of vehicles. SO_2 emissions from non-road vehicles and stationary equipment will be reduced through the use of diesel fuel with less than 15 ppm of sulphur.	Minor (bounded by operation effects)
	Phase II AWAR (construction)	Construction activities result in air emissions, which may cause short-term, localized changes in air concentrations.	Best management practices to control fugitive particulate emissions from construction activities	Minor (bounded by operation effects)

Table 5.2-7: Pathways Table – Air Quality (continued)

Valued Component	Project Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis
	Phase II AWAR (operations)	Project vehicles along the AWAR will result in air emissions, which may cause changes in air concentrations and atmospheric deposition rates. Fuel combustion will result in air emissions, which may contribute to territorial and national greenhouse gas emissions.	Best management practices to control fugitive particulate emissions from vehicles travelling along the AWAR.	Primary
Air Quality	Rankin Inlet	Activities associated with material receipt, storage, and transfer to the Project will result in air emissions, which may cause short-term, localized changes in air concentrations. Fuel combustion will result in air emissions, which may contribute to territorial and national greenhouse gas emissions.	Best management practices to control fugitive particulate emissions. Exhaust emissions from non-road vehicles will be managed through purchasing equipment that meet Tier 3 emission standards. Exhaust emissions from non-road vehicles will be managed through regular and routine maintenance of vehicles. SO_2 emissions from non-road vehicles and stationary equipment will be reduced through the use of diesel fuel with less than 15 ppm of sulphur. Best management practices to control fugitive emissions from fuel handling and storage.	Primary
	Marine Shipping	Marine shipping will results in air emissions, which may contribute to territorial and national greenhouse gas emissions.	Marine vessels will remain on-station only as long as required for off-loading delivered materials.	Primary

5.2.5.2 Project Effects — Mine Site

5.2.5.2.1 Prediction of Residual Effects — Mine Site

The direct effects on air quality of the Project activities at the mine site focused on the operating phase of activities, when emissions and activities were identified as being at their highest. Effects on air quality during the construction and decommissioning/post-closure phases of the Project were identified as minor pathways whose effects would be bounded by the effects during operations. The assessment explicitly considered the effects associated with the following activities:

- **Mining Operations** – the removal of ore from the open pits and underground mines. This will result the release of fugitive dust emissions, which includes TSP, $PM_{10,,}$ and $PM_{2.5}$. The mining operations are considered to include the emissions associated with haul trucks travelling on roadways. In addition, equipment involved in the mining operations will cause the release of tailpipe emissions.
- **Processing** – The processing of ore will result in fugitive dust (TSP, PM_{10}, and $PM_{2.5}$) from activities such as the crushing of ore and material handling.
- **Support Operations** – Support operations include the power plant, incinerator, and other ancillary supporting operations. These activities will include a range of particulate and gaseous emissions.

5.2.5.2.1.1 Emissions — Mine Site

The Project has a number of potential open pit mines, which are located over the extent of the mine site, and will be operated at various times and rates. As described in Section 5.2.3, 6 distinct cases were defined to characterize the variable mining operations. Each of the cases includes the emissions from support operations and underground mining that occur throughout the life of the Project. The first case assumes no open pit mining operations. The 5 remaining cases assume mining occurs in one of the open pits at a rate of 6500 tonnes per day. If activities were to occur at a lesser rate, in multiple pits, the individual effects would be less than those bounded by the cases below. The emissions of indicator compounds for each of the 6 air quality cases are summarized in Table 5.2-8.

Table 5.2-8: Indicator Compound Emission Rates (Tonnes/year) – Mine Operational Phase

Operational Case	Open Pit Mine in Operation	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO
Case 1	None	130.44	127.92	124.25	1871.41	4.92	1169.22
Case 2	Tiriganiaq	509.41	276.26	162.83	2475.17	5.73	1627.18
Case 3	F Zone	634.29	332.77	171.20	2475.17	5.73	1627.15
Case 4	Pump	603.61	324.29	170.36	2475.17	5.73	1627.15
Case 5	Discovery	741.64	346.40	170.52	2475.17	5.73	1627.18
Case 6	Wesmeg	524.06	290.18	162.38	2367.91	5.60	1558.81

Note: In each of the above listed phases, all processing, support, and underground mining operations are included.

Details of the emissions calculations are provided in Appendix 5.2-A.The individual activity emission rates for the indicator compounds are summarized in Tables 5.2-9 through 5.2-14.

Table 5.2-9: Criteria Emissions for Case 1 Activities

Case 1 - Activities	SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Material Handling Open Pits	0.00	0.00	0.00	0.00	0.00	0.00
Unpaved Roads	0.00	0.0	0.0	0.0	0.0	0.0
Drilling and Blasting - Open Pits	0.00	0.0	0.0	0.0	0.0	0.0
Mobile Equipment Open Pit	0.00	0.0	0.0	0.0	0.0	0.0
Mobile Exhaust Open Pit	7.10	7.1	6.9	103.7	0.2	121.3
Mobile Exhaust Underground	1.32	0.6	0.1	0.0	0.0	0.0
Drilling and Blasting - Underground	0.75	0.3	0.1	0.6	0.0	6.6
Mobile Exhaust Haul Roads	0.00	0.0	0.0	0.0	0.0	0.0
Open Pit Support Equipment	0.00	0.0	0.0	0.0	0.0	0.0
Power Generation	59.97	60.0	58.2	1,676.2	1.6	1,039.6
Baghouses	4.61	4.6	4.6	0.0	0.0	0.0
Incinerator	53.30	53.3	53.3	3.8	3.0	1.5
Storage Pile Wind Erosion	1.56	0.8	0.2	0.0	0.0	0.0
Storage Pile Maintenance	0.00	0.0	0.0	0.0	0.0	0.0
Crushing Plant Generators	0.71	0.7	0.7	85.9	0.1	0.1
Crushing Operations	0.55	0.2	0.0	0.0	0.0	0.0
Tanks	0.00	0.0	0.0	0.0	0.0	0.0
Paste Backfill Plant	0.52	0.2	0.1	0.0	0.0	0.0
Process - Acid Wash Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - Kiln Exhaust	0.06	0.1	0.1	1.1	0.1	0.2
Process - Electrowinning Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - HCN Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Total Emission Rate [Tonnes/year]	**130.4**	**127.9**	**124.3**	**1,871.4**	**4.9**	**1,169.2**

Table 5.2-10: Criteria Emissions for Case 2 Activities

Case 2 - Activities	SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Material Handling Open Pits	125.34	59.28	8.98	0.00	0.00	0.00
Unpaved Roads	221.65	61.8	6.2	0.0	0.0	0.0
Drilling and Blasting - Open Pits	8.52	3.8	0.7	5.1	0.0	58.4
Mobile Equipment Open Pit	22.49	22.5	21.8	589.0	0.7	389.8
Mobile Exhaust Open Pit	7.10	7.1	6.9	103.7	0.2	121.3
Mobile Exhaust Underground	1.32	0.6	0.1	0.0	0.0	0.0
Drilling and Blasting - Underground	0.75	0.3	0.1	0.6	0.0	6.6
Mobile Exhaust Haul Roads	0.00	0.0	0.0	0.0	0.0	0.1
Open Pit Support Equipment	0.97	1.0	0.9	9.7	0.1	9.7
Power Generation	59.97	60.0	58.2	1,676.2	1.6	1,039.6
Baghouses	4.61	4.6	4.6	0.0	0.0	0.0
Incinerator	53.30	53.3	53.3	3.8	3.0	1.5
Storage Pile Wind Erosion	1.56	0.8	0.2	0.0	0.0	0.0
Storage Pile Maintenance	0.00	0.0	0.0	0.0	0.0	0.0
Crushing Plant Generators	0.71	0.7	0.7	85.9	0.1	0.1
Crushing Operations	0.55	0.2	0.0	0.0	0.0	0.0
Tanks	0.00	0.0	0.0	0.0	0.0	0.0
Paste Backfill Plant	0.52	0.2	0.1	0.0	0.0	0.0
Process - Acid Wash Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - Kiln Exhaust	0.06	0.1	0.1	1.1	0.1	0.2
Process - Electrowinning Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - HCN Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Total Emission Rate [Tonnes/year]	**509.4**	**276.3**	**162.8**	**2,475.2**	**5.7**	**1,627.2**

Table 5.2-11: Criteria Emissions for Case 3 Activities

Case 3 - Activities	SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Material Handling Open Pits	237.06	112.12	16.98	0.00	0.00	0.00
Unpaved Roads	234.82	65.4	6.5	0.0	0.0	0.0
Drilling and Blasting - Open Pits	8.52	3.8	0.7	5.1	0.0	58.4
Mobile Equipment Open Pit	22.49	22.5	21.8	589.0	0.7	389.8
Mobile Exhaust Open Pit	7.10	7.1	6.9	103.7	0.2	121.3
Mobile Exhaust Underground	1.32	0.6	0.1	0.0	0.0	0.0
Drilling and Blasting - Underground	0.75	0.3	0.1	0.6	0.0	6.6
Mobile Exhaust Haul Roads	0.00	0.0	0.0	0.0	0.0	0.0
Open Pit Support Equipment	0.97	1.0	0.9	9.7	0.1	9.7
Power Generation	59.97	60.0	58.2	1,676.2	1.6	1,039.6
Baghouses	4.61	4.6	4.6	0.0	0.0	0.0
Incinerator	53.30	53.3	53.3	3.8	3.0	1.5
Storage Pile Wind Erosion	1.56	0.8	0.2	0.0	0.0	0.0
Storage Pile Maintenance	0.00	0.0	0.0	0.0	0.0	0.0
Crushing Plant Generators	0.71	0.7	0.7	85.9	0.1	0.1
Crushing Operations	0.55	0.2	0.0	0.0	0.0	0.0
Tanks	0.00	0.0	0.0	0.0	0.0	0.0
Paste Backfill Plant	0.52	0.2	0.1	0.0	0.0	0.0
Process - Acid Wash Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - Kiln Exhaust	0.06	0.1	0.1	1.1	0.1	0.2
Process - Electrowinning Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - HCN Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Total Emission Rate [Tonnes/year]	**634.3**	**332.8**	**171.2**	**2,475.2**	**5.7**	**1,627.1**

Table 5.2-12: Criteria Emissions for Case 4 Activities

Case 4 - Activities	SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Material Handling Open Pits	237.41	112.29	17.00	0.00	0.00	0.00
Unpaved Roads	203.79	56.8	5.7	0.0	0.0	0.0
Drilling and Blasting - Open Pits	8.52	3.8	0.7	5.1	0.0	58.4
Mobile Equipment Open Pit	22.49	22.5	21.8	589.0	0.7	389.8
Mobile Exhaust Open Pit	7.10	7.1	6.9	103.7	0.2	121.3
Mobile Exhaust Underground	1.32	0.6	0.1	0.0	0.0	0.0
Drilling and Blasting - Underground	0.75	0.3	0.1	0.6	0.0	6.6
Mobile Exhaust Haul Roads	0.00	0.0	0.0	0.0	0.0	0.0
Open Pit Support Equipment	0.97	1.0	0.9	9.7	0.1	9.7
Power Generation	59.97	60.0	58.2	1,676.2	1.6	1,039.6
Baghouses	4.61	4.6	4.6	0.0	0.0	0.0
Incinerator	53.30	53.3	53.3	3.8	3.0	1.5
Storage Pile Wind Erosion	1.56	0.8	0.2	0.0	0.0	0.0
Storage Pile Maintenance	0.00	0.0	0.0	0.0	0.0	0.0
Crushing Plant Generators	0.71	0.7	0.7	85.9	0.1	0.1
Crushing Operations	0.55	0.2	0.0	0.0	0.0	0.0
Tanks	0.00	0.0	0.0	0.0	0.0	0.0
Paste Backfill Plant	0.52	0.2	0.1	0.0	0.0	0.0
Process - Acid Wash Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - Kiln Exhaust	0.06	0.1	0.1	1.1	0.1	0.2
Process - Electrowinning Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - HCN Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Total Emission Rate [Tonnes/year]	**603.6**	**324.3**	**170.4**	**2,475.2**	**5.7**	**1,627.2**

Table 5.2-13: Criteria Emissions for Case 5 Activities

Case 5- Activities	SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Material Handling Open Pits	153.27	72.49	10.98	0.00	0.00	0.00
Unpaved Roads	425.96	118.7	11.9	0.0	0.0	0.0
Drilling and Blasting - Open Pits	8.52	3.8	0.7	5.1	0.0	58.4
Mobile Equipment Open Pit	22.49	22.5	21.8	589.0	0.7	389.8
Mobile Exhaust Open Pit	7.10	7.1	6.9	103.7	0.2	121.3
Mobile Exhaust Underground	1.32	0.6	0.1	0.0	0.0	0.0
Drilling and Blasting - Underground	0.75	0.3	0.1	0.6	0.0	6.6
Mobile Exhaust Haul Roads	0.00	0.0	0.0	0.0	0.0	0.1
Open Pit Support Equipment	0.97	1.0	0.9	9.7	0.1	9.7
Power Generation	59.97	60.0	58.2	1,676.2	1.6	1,039.6
Baghouses	4.61	4.6	4.6	0.0	0.0	0.0
Incinerator	53.30	53.3	53.3	3.8	3.0	1.5
Storage Pile Wind Erosion	1.56	0.8	0.2	0.0	0.0	0.0
Storage Pile Maintenance	0.00	0.0	0.0	0.0	0.0	0.0
Crushing Plant Generators	0.71	0.7	0.7	85.9	0.1	0.1
Crushing Operations	0.55	0.2	0.0	0.0	0.0	0.0
Tanks	0.00	0.0	0.0	0.0	0.0	0.0
Paste Backfill Plant	0.52	0.2	0.1	0.0	0.0	0.0
Process - Acid Wash Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - Kiln Exhaust	0.06	0.1	0.1	1.1	0.1	0.2
Process - Electrowinning Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - HCN Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Total Emission Rate [Tonnes/year]	**741.6**	**346.4**	**170.5**	**2,475.2**	**5.7**	**1,627.2**

Table 5.2-14: Criteria Emissions for Case 6 Activities

Case 6 - Activities	SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Material Handling Open Pits	190.62	90.16	13.65	0.00	0.00	0.00
Unpaved Roads	174.96	48.8	4.9	0.0	0.0	0.0
Drilling and Blasting - Open Pits	8.52	3.8	0.7	5.1	0.0	58.4
Mobile Equipment Open Pit	18.55	18.5	18.0	481.7	0.6	321.5
Mobile Exhaust Open Pit	7.10	7.1	6.9	103.7	0.2	121.3
Mobile Exhaust Underground	1.32	0.6	0.1	0.0	0.0	0.0
Drilling and Blasting - Underground	0.75	0.3	0.1	0.6	0.0	6.6
Mobile Exhaust Haul Roads	0.00	0.0	0.0	0.0	0.0	0.0
Open Pit Support Equipment	0.97	1.0	0.9	9.7	0.1	9.7
Power Generation	59.97	60.0	58.2	1,676.2	1.6	1,039.6
Baghouses	4.61	4.6	4.6	0.0	0.0	0.0
Incinerator	53.30	53.3	53.3	3.8	3.0	1.5
Storage Pile Wind Erosion	1.56	0.8	0.2	0.0	0.0	0.0
Storage Pile Maintenance	0.00	0.0	0.0	0.0	0.0	0.0
Crushing Plant Generators	0.71	0.7	0.7	85.9	0.1	0.1
Crushing Operations	0.55	0.2	0.0	0.0	0.0	0.0
Tanks	0.00	0.0	0.0	0.0	0.0	0.0
Paste Backfill Plant	0.52	0.2	0.1	0.0	0.0	0.0
Process - Acid Wash Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - Kiln Exhaust	0.06	0.1	0.1	1.1	0.1	0.2
Process - Electrowinning Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Process - HCN Exhaust	0.00	0.0	0.0	0.0	0.0	0.0
Total Emission Rate [Tonnes/year]	**524.1**	**290.2**	**162.4**	**2,367.9**	**5.6**	**1,558.8**

In determining the air emissions associated with the Project, consideration was given to those mitigation measures that were considered to be integral to the design and implementation. The following mitigation measures, which are considered to be typical and consistent with best practices, were incorporated into the emission estimates, and, therefore, were incorporated in the effects predictions:

- Use of dust suppression methods as outlined in the *Nunavut Environmental Protection Act*.
- Use of coarse rock in roads, building pads, and laydown areas to minimize dust during construction.
- Driving at designated speed limits on all on-site roads.
- Application of water to roadways during periods where water application would not result in any safety hazards.

- Installation of enclosures and baghouses on crushing equipment.
- Liquid tailings will avoid particulate releases from tailings areas during deposition. Dust management on the tailings beach areas and final capping of tailings area during decommissioning and reclamation phase will also help minimize particulate releases.
- Installation of incinerator that complies with *Nunavut Environmental Protection Act* standards for dioxin and furans.
- Mine equipment and haul vehicles will be maintained to reduce emissions and maximize fuel efficiency.
- Low sulphur fuel (15 parts per million by weight) will be used in all fleet vehicles and stationary combustion equipment.
- Wastes will be screened and segregated to remove food and chlorinated organic waste. The waste incinerator will be designed to meet the CCME emission standards for dioxins and furans (CCME 2001).
- All mobile vehicles and mine equipment will meet the applicable emission standards at time of purchase. Newer equipment was assumed to comply with Tier 3 emission standards.
- Consider energy conservation initiatives, such as maintaining mine fleet to improve the efficiency of the fleet.

5.2.5.2.1.2 Dispersion Modelling — Mine Site

Concentrations of indicator compounds were predicted using the CALPUFF dispersion model. The approach to modelling was previously outlined in Section 5.2.3.4. Detailed model inputs are provided in Appendix 5.2-B. Due to the geographical and temporal variability in the open pit mines, each of the cases, as described in the section above, was run individually in the CALPUFF modelling system to determine the case with largest predicted concentrations. This maximum would be a conservative assessment for any of the individual cases. The results predicted within the SSA, LSA, and RSA, for each air quality indicator, are summarized in Table 5.2-15. This includes the maximum predicted concentration (excluding meteorological anomalies), as well as the peak concentration. The results for each individual case are provided in Tables 5.2-16 through 5.2-21.

Table 5.2-15: Predicted Air Concentrations of Indicator Compounds

Compound	Averaging Period	Relevant Criteria (µg/m³)	Concentration (µg/m³) in SSA		Concentration (µg/m³) in LSA		Concentration (µg/m³) in RSA	
			Maximum	Peak	Maximum	Peak	Maximum	Peak
SPM	24-hour	120	213.7	396.3	122.3	245.0	20.5	25.4
SPM	Annual	60	16.8	28.0	17.0	17.0	1.0	1.0
PM_{10}	24-hour	50	104.0	206.3	58.2	127.8	11.9	14.8
$PM_{2.5}$	24-hour	30	55.2	76.8	19.6	33.9	6.4	9.0
NO_2	1-hour	400	336.4	978.6	177.4	235.5	103.6	118.8
NO_2	24-hour	200	151.0	178.8	106.5	130.6	68.0	92.3
NO_2	Annual	60	43.9	59.7	22.8	30.7	3.6	3.6
SO_2	1-hour	450	6.3	8.7	2.2	2.9	0.7	1.0
SO_2	24-hour	150	3.0	4.2	0.8	1.1	0.3	0.4
SO_2	Annual	30	0.3	0.3	0.0	0.1	0.0	0.0
CO	1-hour	35,000	1,597.3	5,585.7	759.0	1,259.7	159.2	256.3
CO	8-hour	15,600	1,327.8	1,649.7	662.2	890.9	143.0	143.0

Table 5.2-16: Case 1- Predicted Air Concentrations of Indicator Compounds

Compound	Averaging Period	Maximum Concentration (µg/m³) in	Maximum Concentration (µg/m³) in	Maximum Concentration (µg/m³) in	Maximum Concentration (µg/m³)
		SSA	LSA	RSA	Beyond RSA
TSP	24-hour	149.8	87.3	16.2	15.8
TSP	Annual	9.1	5.0	0.8	0.7
PM_{10}	24-hour	71.1	45.2	11.4	10.3
$PM_{2.5}$	24-hour	55.2	19.6	6.4	5.4
NO_2	1-hour	336.4	172.7	103.6	102.1
NO_2	24-hour	151.0	106.5	68.0	67.6
NO_2	Annual	43.9	20.0	3.6	3.2
SO_2	1-hour	6.3	2.2	0.7	0.6
SO_2	24-hour	3.0	0.8	0.3	0.2
SO_2	Annual	0.3	0.0	0.0	0.0
CO	1-hour	1,597.3	581.5	159.2	148.3
CO	8-hour	1,327.8	424.7	143.0	134.6

Table 5.2-17: Case 2- Predicted Air Concentrations of Indicator Compounds

Compound	Averaging Period	Maximum Concentration (µg/m³) in SSA	Maximum Concentration (µg/m³) in LSA	Maximum Concentration (µg/m³) in RSA	Maximum Concentration (µg/m³) Beyond RSA
TSP	24-hour	149.8	87.3	16.2	15.8
TSP	Annual	9.1	5.0	0.8	0.7
PM10	24-hour	71.1	45.2	11.4	10.3
PM2.5	24-hour	55.2	19.6	6.4	5.4
NO2	1-hour	336.4	172.7	103.6	102.1
NO2	24-hour	151.0	106.5	68.0	67.6
NO2	Annual	43.9	20.0	3.6	3.2
SO2	1-hour	6.3	2.2	0.7	0.6
SO2	24-hour	3.0	0.8	0.3	0.2
SO2	Annual	0.3	0.0	0.0	0.0
CO	1-hour	1,597.3	581.5	159.2	148.3
CO	8-hour	1,327.8	424.7	143.0	134.6

Table 5.2-18: Case 3- Predicted Air Concentrations of Indicator Compounds

Compound	Averaging Period	Maximum Concentration (µg/m³) in SSA	Maximum Concentration (µg/m³) in LSA	Maximum Concentration (µg/m³) in RSA	Maximum Concentration (µg/m³) Beyond RSA
TSP	24-hour	191.2	116.1	20.5	16.4
TSP	Annual	11.3	8.0	0.8	0.7
PM_{10}	24-hour	93.9	58.2	11.9	10.9
$PM_{2.5}$	24-hour	54.6	19.5	5.7	5.3
NO_2	1-hour	335.7	177.4	103.3	101.7
NO_2	24-hour	150.4	106.2	64.1	60.4
NO_2	Annual	39.3	22.8	3.2	3.0
SO_2	1-hour	6.2	2.2	0.6	0.6
SO_2	24-hour	3.0	0.8	0.2	0.2
SO_2	Annual	0.3	0.0	0.0	0.0
CO	1-hour	1,591.4	759.0	155.2	146.1
CO	8-hour	1,318.5	662.2	137.8	125.8

Table 5.2-19: Case 4- Predicted Air Concentrations of Indicator Compounds

Compound	Averaging Period	Maximum Concentration (µg/m³) in SSA	Maximum Concentration (µg/m³) in LSA	Maximum Concentration (µg/m³) in RSA	Maximum Concentration (µg/m³) Beyond
TSP	24-hour	191.2	116.1	20.5	16.4
TSP	Annual	11.3	8.0	0.8	0.7
PM_{10}	24-hour	93.9	58.2	11.9	10.9
$PM_{2.5}$	24-hour	54.6	19.5	5.7	5.3
NO_2	1-hour	335.7	177.4	103.3	101.7
NO_2	24-hour	150.4	106.2	64.1	60.4
NO_2	Annual	39.3	22.8	3.2	3.0
SO_2	1-hour	6.2	2.2	0.6	0.6
SO_2	24-hour	3.0	0.8	0.2	0.2
SO_2	Annual	0.3	0.0	0.0	0.0
CO	1-hour	1,591.4	759.0	155.2	146.1
CO	8-hour	1,318.5	662.2	137.8	125.8

Table 5.2-20: Case 5- Predicted Air Concentrations of Indicator Compounds

Compound	Averaging Period	Maximum Concentration (µg/m³) in SSA	Maximum Concentration (µg/m³) in LSA	Maximum Concentration (µg/m³) in RSA	Maximum Concentration (µg/m³) Beyond
TSP	24-hour	213.7	122.3	17.4	9.2
TSP	Annual	16.8	17.0	1.0	0.5
PM_{10}	24-hour	104.0	58.1	7.9	5.5
$PM_{2.5}$	24-hour	52.5	19.5	5.0	4.4
NO_2	1-hour	335.7	172.7	99.1	99.8
NO_2	24-hour	150.8	105.7	62.9	52.7
NO_2	Annual	41.7	18.8	2.5	2.5
SO_2	1-hour	6.2	2.2	0.6	0.6
SO_2	24-hour	2.9	0.8	0.2	0.2
SO_2	Annual	0.3	0.0	0.0	0.0
CO	1-hour	1,591.4	580.5	125.1	129.6
CO	8-hour	1,318.4	501.9	118.5	101.1

Table 5.2-21: Case 6- Predicted Air Concentrations of Indicator Compounds

TSP	Averaging Period	Maximum Concentration (µg/m³) in	Maximum Concentration (µg/m³) in	Maximum Concentration (µg/m³) in	Maximum Concentration (µg/m³)
		SSA	LSA	RSA	Beyond
TSP	24-hour	52.5	20.0	4.8	4.2
TSP	Annual	5.0	1.0	0.2	0.2
PM_{10}	24-hour	52.5	19.9	4.8	4.2
$PM_{2.5}$	24-hour	52.5	19.5	4.8	4.3
NO_2	1-hour	335.7	172.7	98.5	99.1
NO_2	24-hour	150.3	105.6	59.8	52.5
NO_2	Annual	33.9	11.9	2.1	2.1
SO_2	1-hour	6.2	2.2	0.6	0.6
SO_2	24-hour	2.9	0.8	0.2	0.2
SO_2	Annual	0.3	0.0	0.0	0.0
CO	1-hour	1,591.4	580.5	121.1	124.9
CO	8-hour	1,318.2	424.5	113.5	100.6

Table 5.2-22 provides the predicted maximum concentrations of NO_2 for each case calculated using the OLM method and Yellowknife ozone data, NO_2 calculated using the OLM method and default Alberta ozone values, and the maximum NO_X concentrations.

Table 5.2-22: Predicted Maximum NO_2 and NO_X Concentrations

Compound	Averaging Period	Concentration (µg/m³) in SSA			Concentration (µg/m³) in LSA			Concentration (µg/m³) in RSA		
		NO_2 (O_3 from Yellowknife)	NO_2 (O_3 from AENV 2009)	NO_X	NO_2 (O_3 from Yellowknife)	NO_2 (O_3 from AENV 2009)	NO_X	NO_2 (O_3 from Yellowknife)	NO_2 (O_3 from AENV 2009)	NO_X
Case 1	1-hour	335.7	350.7	2,566.8	172.7	187.7	937.3	98.5	113.5	195.2
	24-hour	150.3	146.6	713.6	105.6	101.8	266.0	59.8	59.8	59.8
	Annual	33.9	33.9	33.9	11.9	11.9	11.9	2.1	2.1	2.1
Case 2	1-hour	336.4	351.4	2,574.0	172.7	187.7	937.3	103.6	118.7	246.5
	24-hour	151.0	147.2	720.0	106.5	102.7	275.1	68.0	68.0	68.0
	Annual	43.9	43.9	43.9	20.0	20.0	20.0	3.6	3.6	3.6
Case 3	1-hour	335.7	350.7	2,566.8	217.0	232.1	1,380.7	100.7	115.7	217.2
	24-hour	155.6	151.8	765.8	125.6	121.8	466.1	71.7	71.7	71.7
	Annual	59.7	59.7	59.7	30.7	30.7	30.7	3.2	3.2	3.2
Case 4	1-hour	335.7	350.7	2,566.8	177.4	192.4	984.1	103.3	118.4	243.5
	24-hour	150.4	146.7	714.7	106.2	102.4	271.8	64.1	64.1	64.1
	Annual	39.3	39.3	39.3	22.8	22.8	22.8	3.2	3.2	3.2
Case 5	1-hour	335.7	350.7	2,566.8	172.7	187.7	937.3	99.1	114.2	201.4
	24-hour	150.8	147.0	718.2	105.7	101.9	267.0	62.9	62.9	62.9
	Annual	41.7	41.7	41.7	18.8	18.8	18.8	2.5	2.5	2.5
Case 6	1-hour	335.7	0.0	2,566.8	172.7	187.7	937.3	103.4	118.4	243.9
	24-hour	150.5	146.7	714.8	106.1	102.3	271.2	63.5	63.5	63.5
	Annual	42.1	42.1	42.1	19.1	19.1	19.1	3.3	3.3	3.3

5.2.5.2.2 Impact Classification — Mine Site

Although the emissions from the Project were predicted to result in an increase in concentrations of indicator compounds, the direction of the air quality effects is considered to be negative. Because all of the directions for air quality are considered negative, this category has not been summarized further.

The dispersion model predictions were made at all receptor locations within the modelling domain. Therefore, magnitudes of effects can be assigned to each of the study areas based on the model results within those study areas. Table 5.2-23 provides a summary of the effect magnitudes for air quality in each of the relevant study areas. These magnitudes were assigned in accordance with the methods described in Section 5.2.3.5.

Table 5.2-23: Predicted Impact Magnitudes — Mine Site

Indicator Compound	Magnitude in SSA	Magnitude in LSA	Magnitude in RSA	Magnitude in beyond RSA
TSP – 24-hour	High	High	Negligible	Negligible
TSP – Annual	Negligible	Negligible	Negligible	Negligible
PM_{10} – 24-hour	High	High	Negligible	Negligible
$PM_{2.5}$ – 24-hour	High	Moderate	Negligible	Negligible
NO_2 – 1-hour	Moderate	Low	Low	Low
NO_2 – 24-hour	Moderate	Moderate	Low	Low
NO_2 – Annual	Low	Low	Negligible	Negligible
SO_2 – 1-hour	Low	Negligible	Negligible	Negligible
SO_2 – 24-hour	Low	Negligible	Negligible	Negligible
SO_2 – Annual	Negligible	Negligible	Negligible	Negligible
CO – 1-Hour	Low	Low	Negligible	Negligible
CO – 8-Hour	Low	Low	Negligible	Negligible

LSA = local study area; RSA = regional study area; SSA = site study area

The geographic extent of effects is assigned based on the magnitude of the predicted effects. Specifically, the geographic extent of a particular magnitude is determined to be the largest area of that magnitude. If effects of a particular magnitude are predicted to occur in more than one of the study areas (e.g., LSA and RSA both have a moderate magnitude), the extent is determined to be the larger of the 2 extents. The geographic extents for effects magnitudes predicted for the indicator compounds have been summarized in Table 5.2-24.

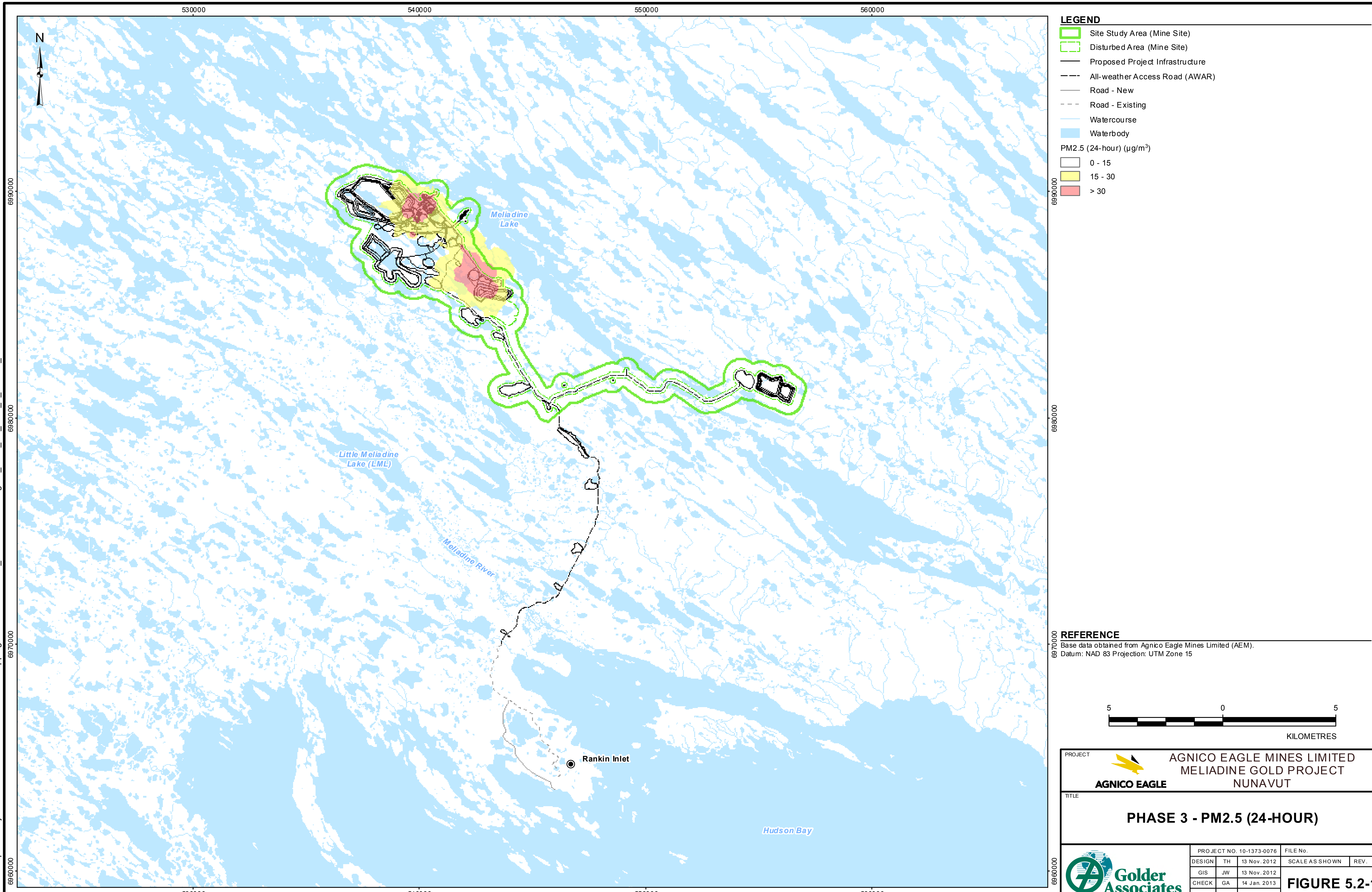
Table 5.2-24: Geographic Extents for Predicted Effects Magnitudes — Mine Site

Indicator Compound	Effects of a Negligible Magnitude	Effects of a Low Magnitude	Effects of a Moderate Magnitude	Effects of a High Magnitude
TSP – 24-hour	RSA	—	—	LSA
TSP – Annual	SSA	—	—	—
PM_{10} – 24-hour	RSA	—	—	LSA
$PM_{2.5}$ – 24-hour	RSA	—	LSA	SSA
NO_2 – 1-hour	—	LSA	SSA	—
NO_2 – 24-hour	—	RSA	SSA	—
NO_2 – Annual	RSA	SSA	—	—
SO_2 – 1-hour	LSA	SSA	—	—
SO_2 – 24-hour	LSA	SSA	—	—
SO_2 – Annual	SSA	—	—	—
CO – 1-Hour	RSA	SSA	—	—

LSA = local study area; RSA = regional study area; SSA = site study area

For all indicator compounds, with the exception of 24-hour TSP, 24-Hour PM_{10}, and 24-hour $PM_{2.5}$ (SSA only), effects are of a moderate magnitude or lower, with the highest predictions occurring within the SSA. For 24-Hour TSP and PM_{10}, effects of high magnitude are predicted to occur in a small geographic area of the LSA. In fact, the predicted concentrations decrease to a moderate magnitude within 200 m of the SSA. The limited areas where high concentrations were predicted to extend beyond the SSA are evident on the contour plots (i.e., isopleth plots) of the predicted emission concentrations for each indicator compound and averaging period (Figures 5.2-1 through 5.2-11).

The frequency of conditions causing the effect is classified as isolated, periodic, or continuous. For all indicators where the averaging period is annual, the frequency is considered to be continuous. For 1-hour, 8-hour, and 24-hour indicators, the frequency will be isolated, periodic, or continuous depending on whether effects of a particular magnitude occur less than 2% of the time, less than 10% of the time, or more than 10% of the time, respectively, in a particular geographic area.



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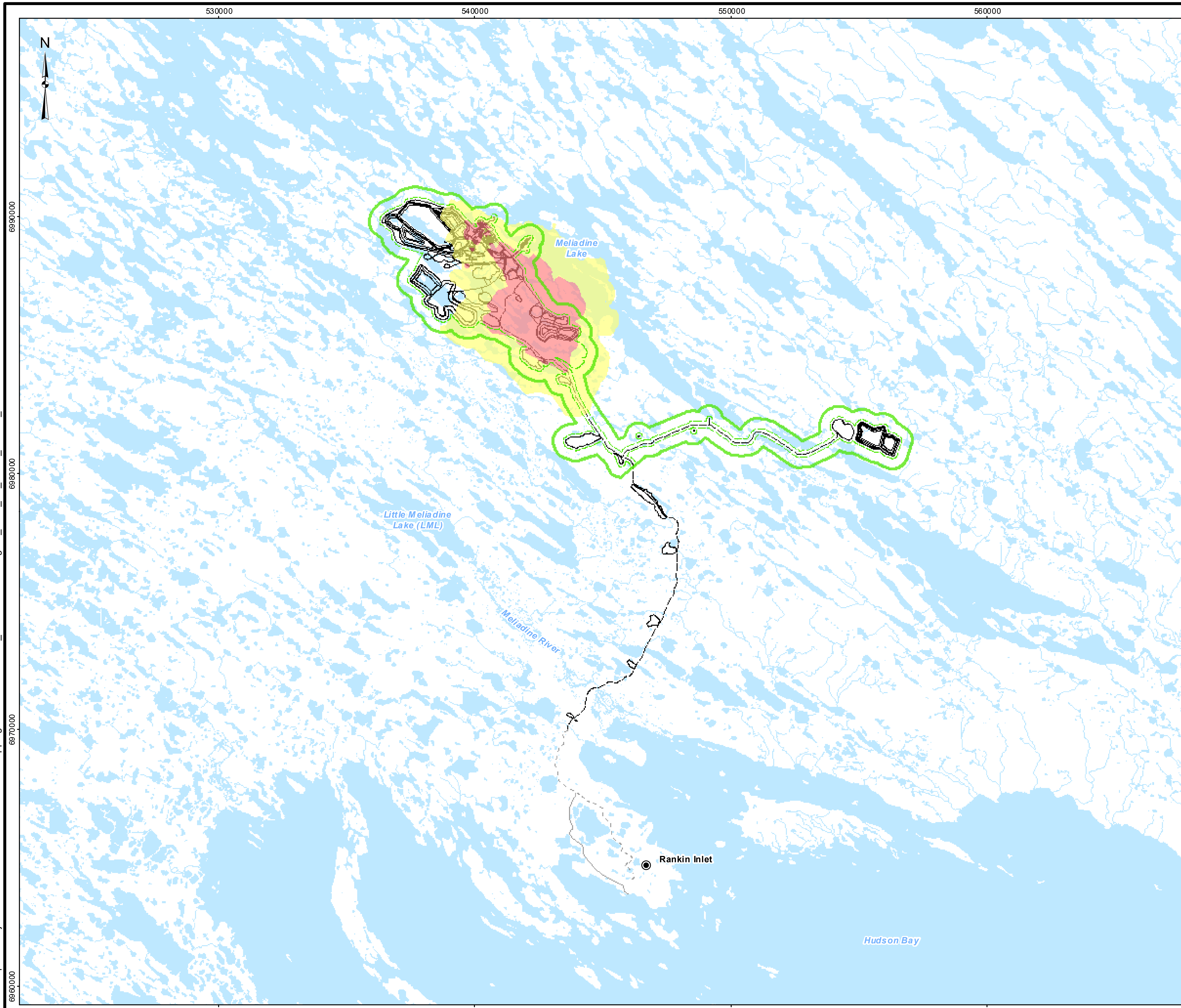

LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

PM10 (24-hour) (µg/m³)

- 0 - 25
- 25 - 50
- > 50

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5
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PHASE 3 - PM10 (24-HOUR)

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DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	14 Nov. 2012		
CHECK	GA	14 Jan. 2013	**FIGURE 5.2-2**	
REVIEW	DW	14 Jan. 2013		

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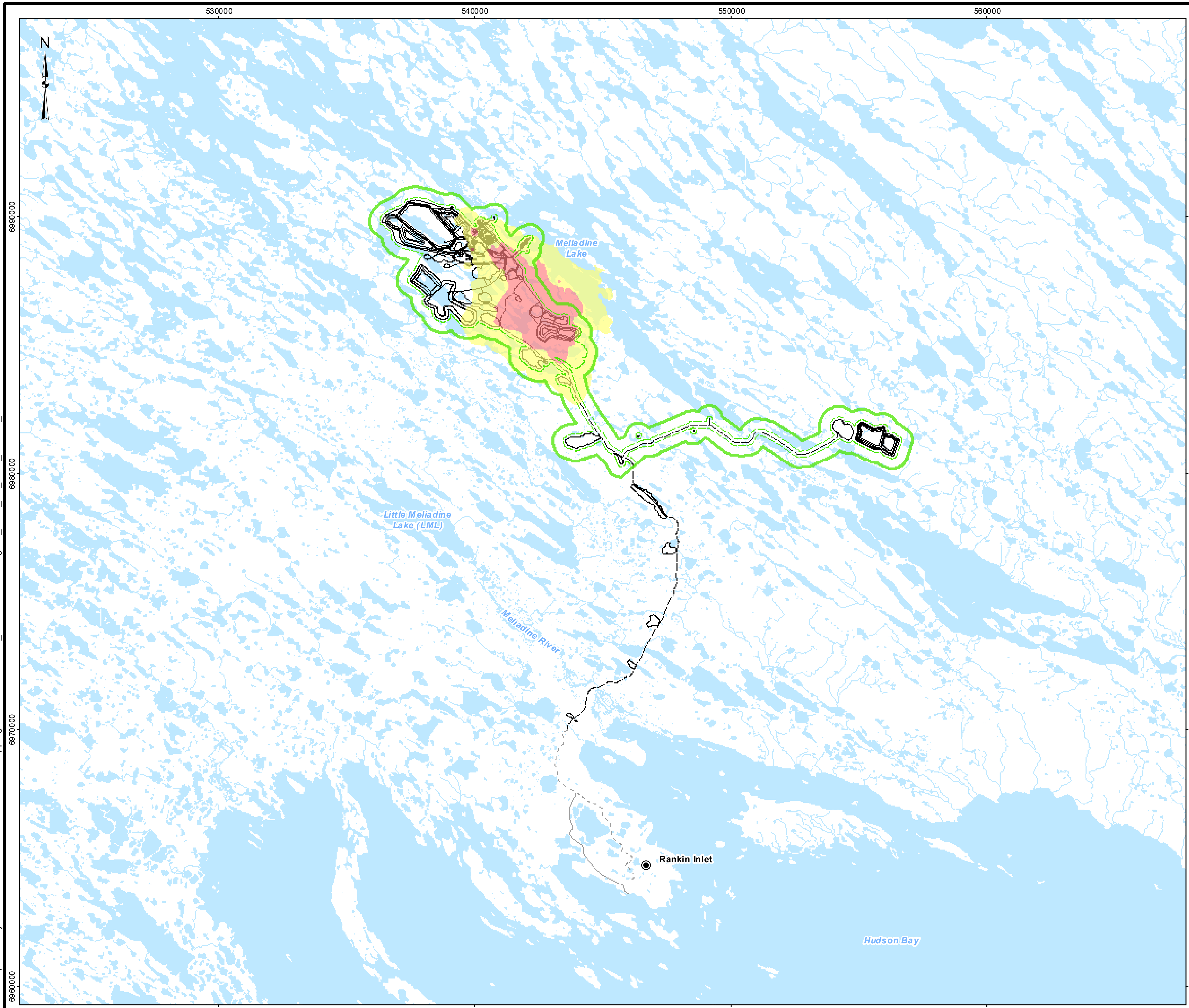

LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

SPM (24-hour) ($\mu g/m^3$)

- 0 - 60
- 60 - 120
- > 120

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

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GIS	JW	14 Nov. 2012		
CHECK	GA	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 5.2-3

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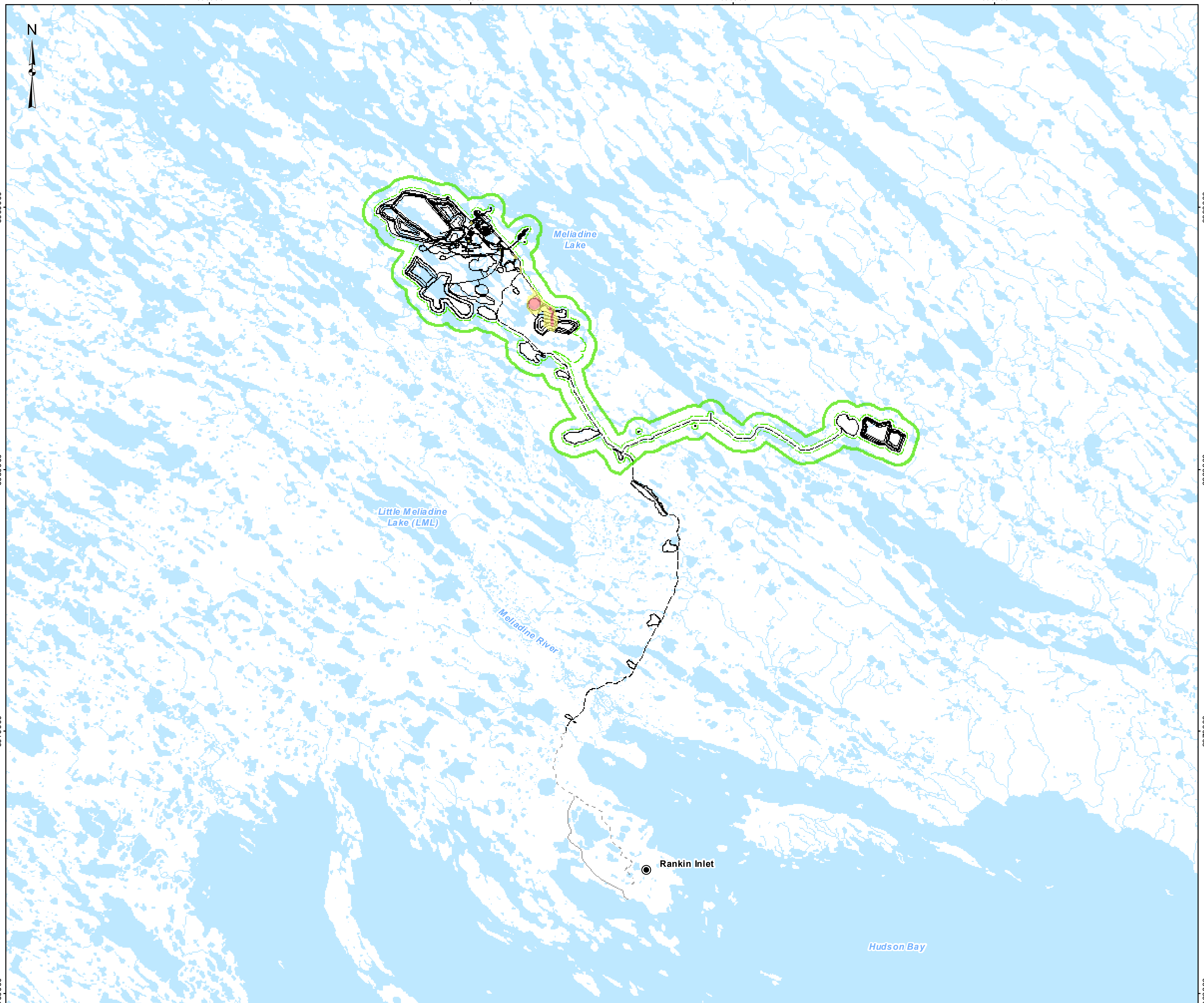

LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

SPM (Annual) ($\mu g/m^3$)

- 0 - 35
- 35 - 70
- > 70

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

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PROJECT NO. 10-1373-0076			FILE No.
DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN REV. 0
GIS	JW	14 Nov. 2012	
CHECK	GA	14 Jan. 2013	**FIGURE 5.2-4**
REVIEW	DW	14 Jan. 2013	

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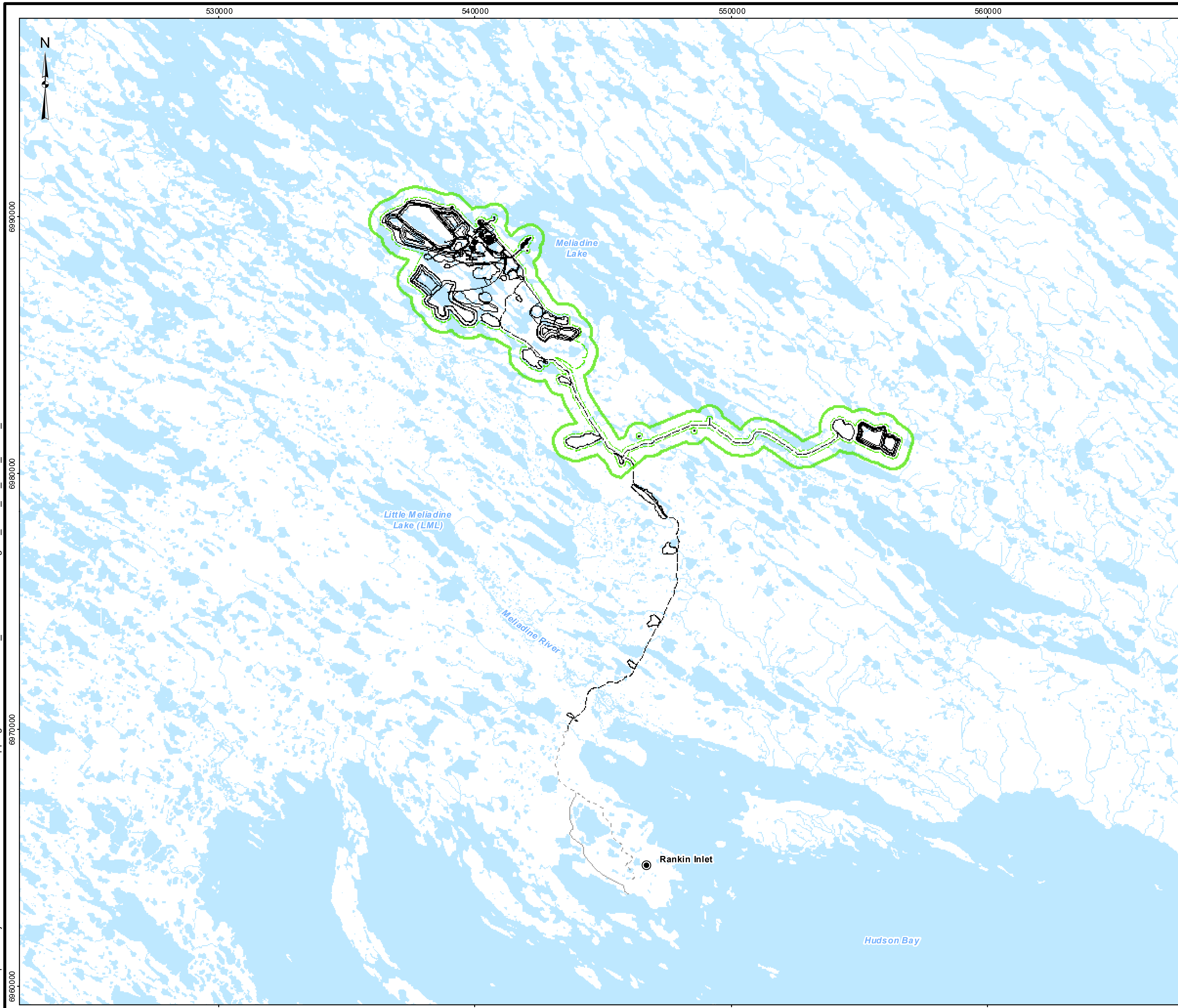

N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_5\Main Volume\Figure_5.2-5_Air_SO2_1Hour_Phase3.mxd

LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

SO_2 (1-hour) (µg/m^3)
- 0 - 450
- 450 - 900
- > 900

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

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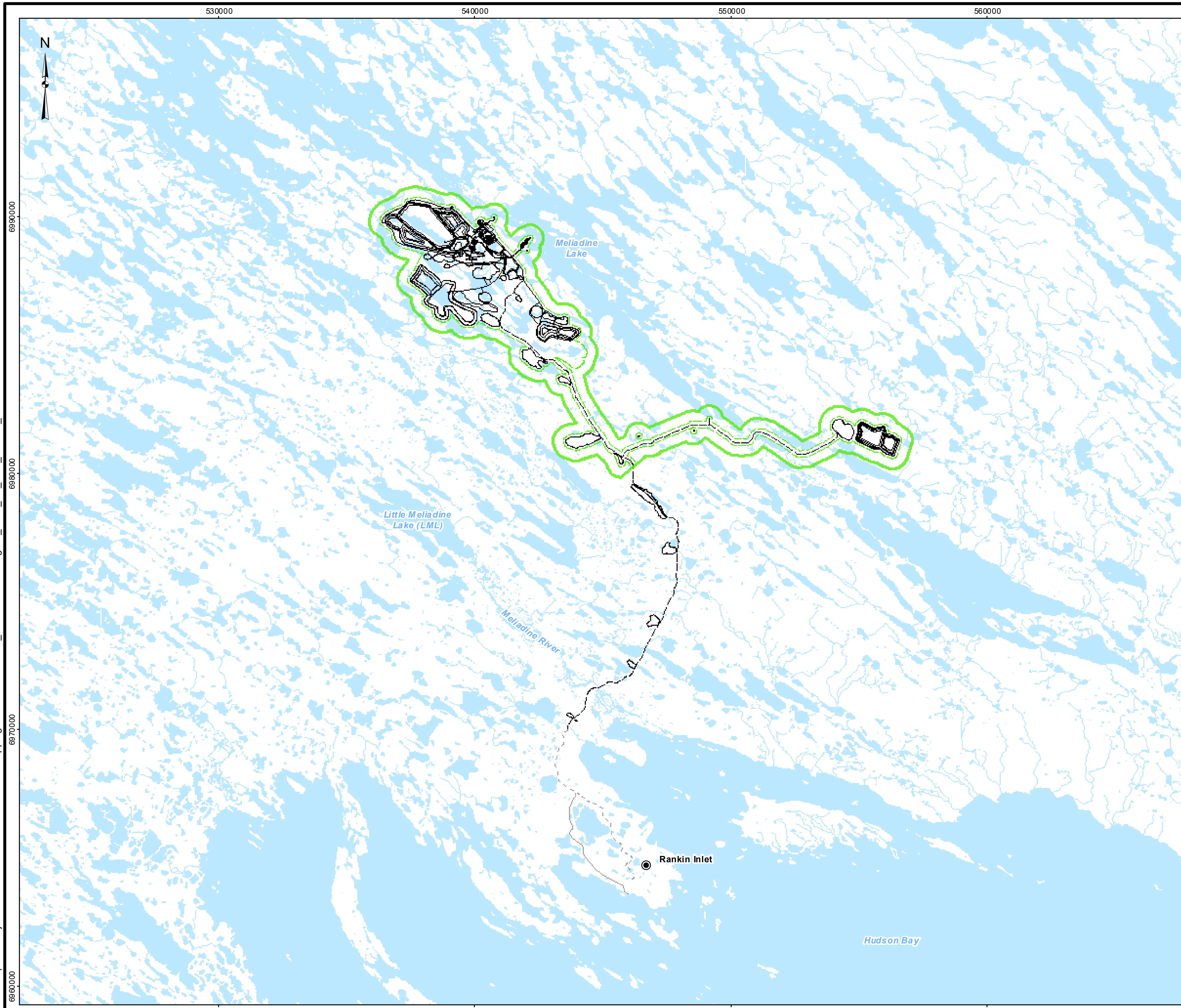
DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	14 Nov. 2012		
CHECK	GA	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 5.2-5



LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

SO_2 (24-hour) ($\mu g/m^3$)

- 0 - 150
- 150 - 300
- > 300

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

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PHASE 3 - SO_2 (24-HOUR)

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PROJECT NO. 10-1373-0076			FILE No.
DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN REV. 0
GIS	JW	14 Nov. 2012	
CHECK	GA	14 Jan. 2013	**FIGURE 5.2-6**
REVIEW	DW	14 Jan. 2013	

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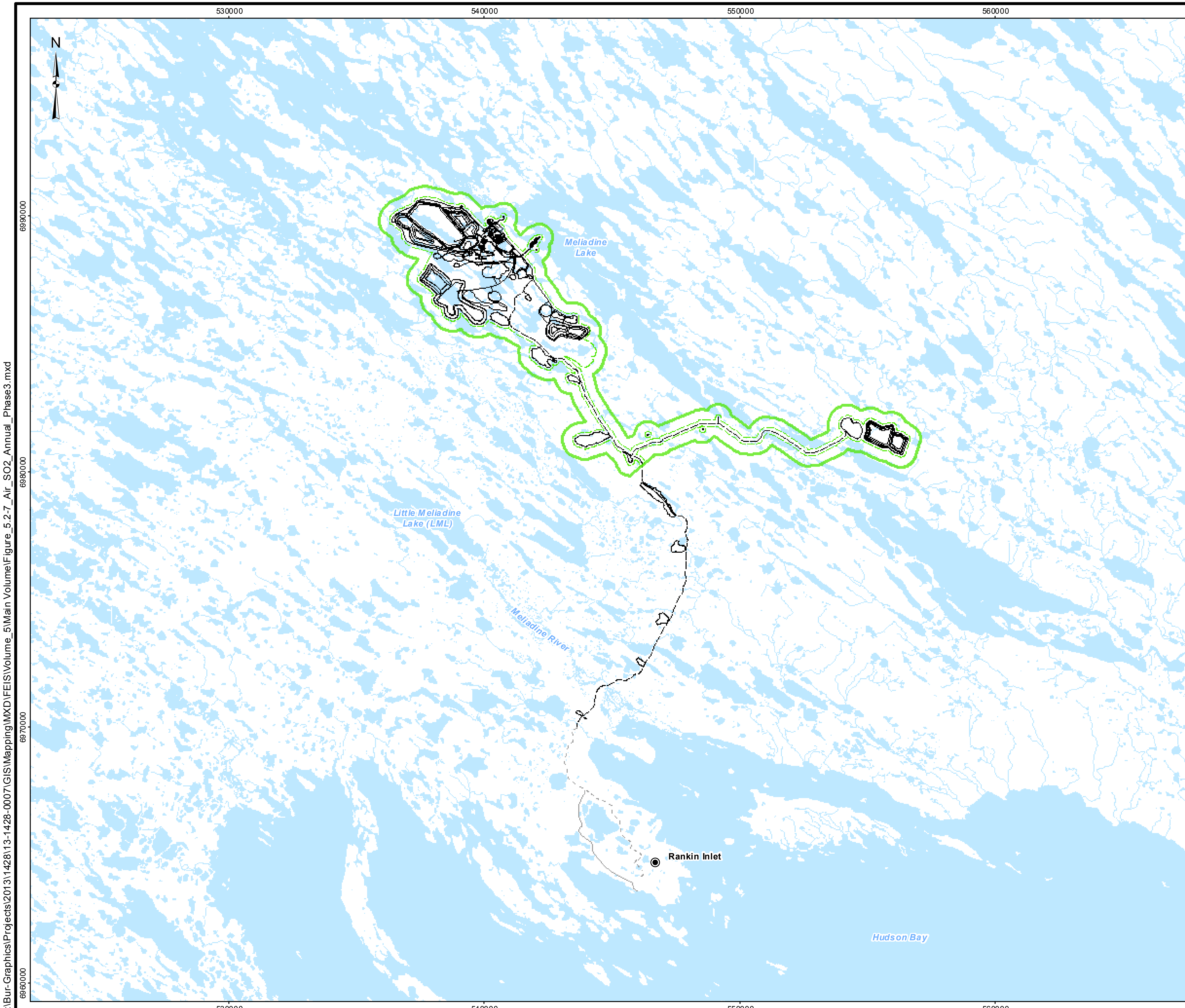

LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

SO_2 (Annual) ($\mu g/m^3$)

- 0 - 30
- 30 - 60
- > 60

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5

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PHASE 3 - SO_2 (ANNUAL)

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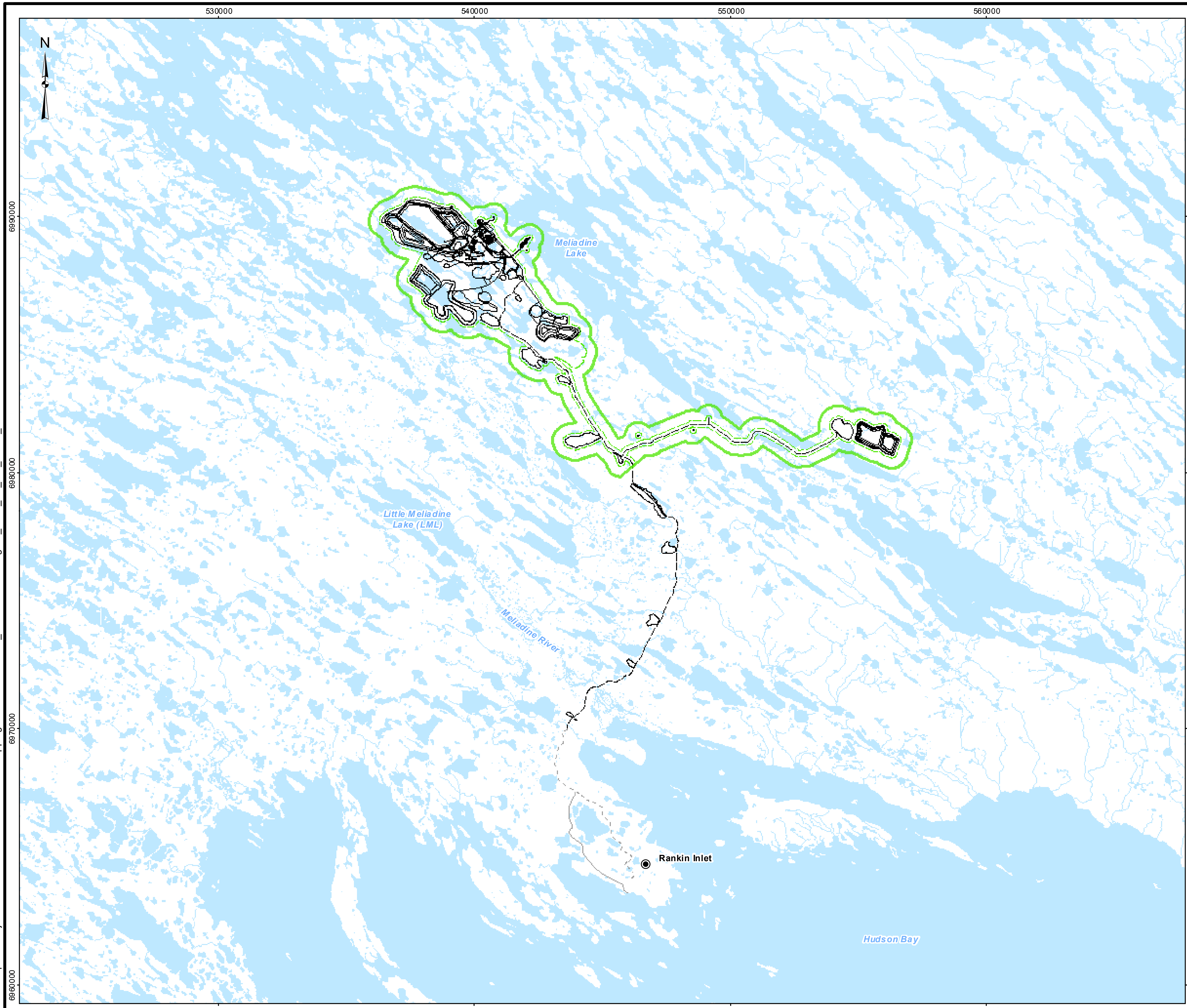
DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN REV. 0
GIS	JW	14 Nov. 2012	
CHECK	GA	14 Jan. 2013	FIGURE 5.2-7
REVIEW	DW	14 Jan. 2013	



LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

CO (1-hour) (µg/m³)

- 0 - 17500
- 17500 - 35000
- > 35000

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5

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PHASE 3 - CO (1-HOUR) (µG/M³)

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DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	14 Nov. 2012		
CHECK	GA	14 Jan. 2013	FIGURE 5.2-8	
REVIEW	DW	14 Jan. 2013		

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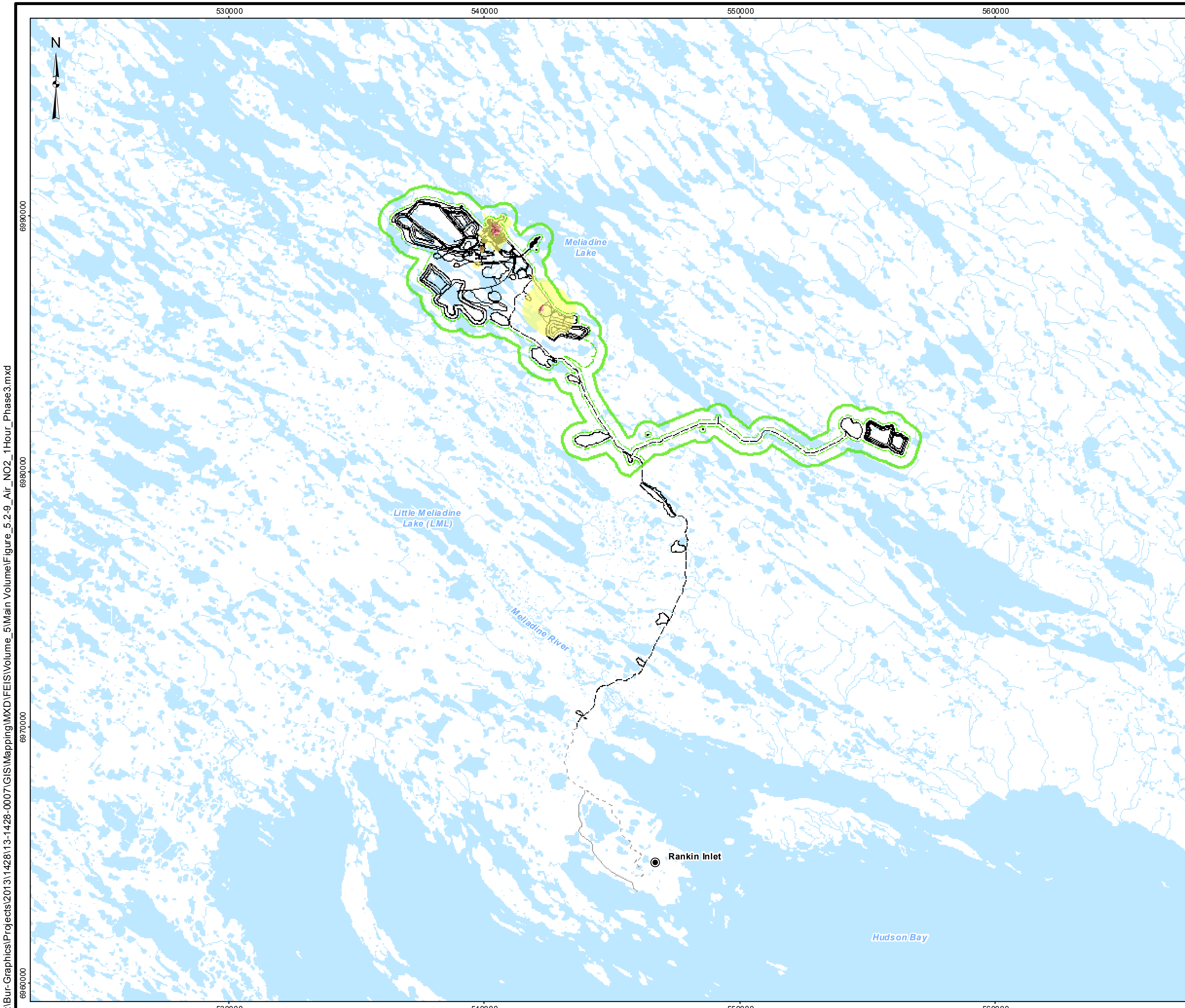

LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

NO_2 (1-hour) (µg/m^3)

- 0 - 200
- 200 - 400
- > 400

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5
KILOMETRES

PROJECT

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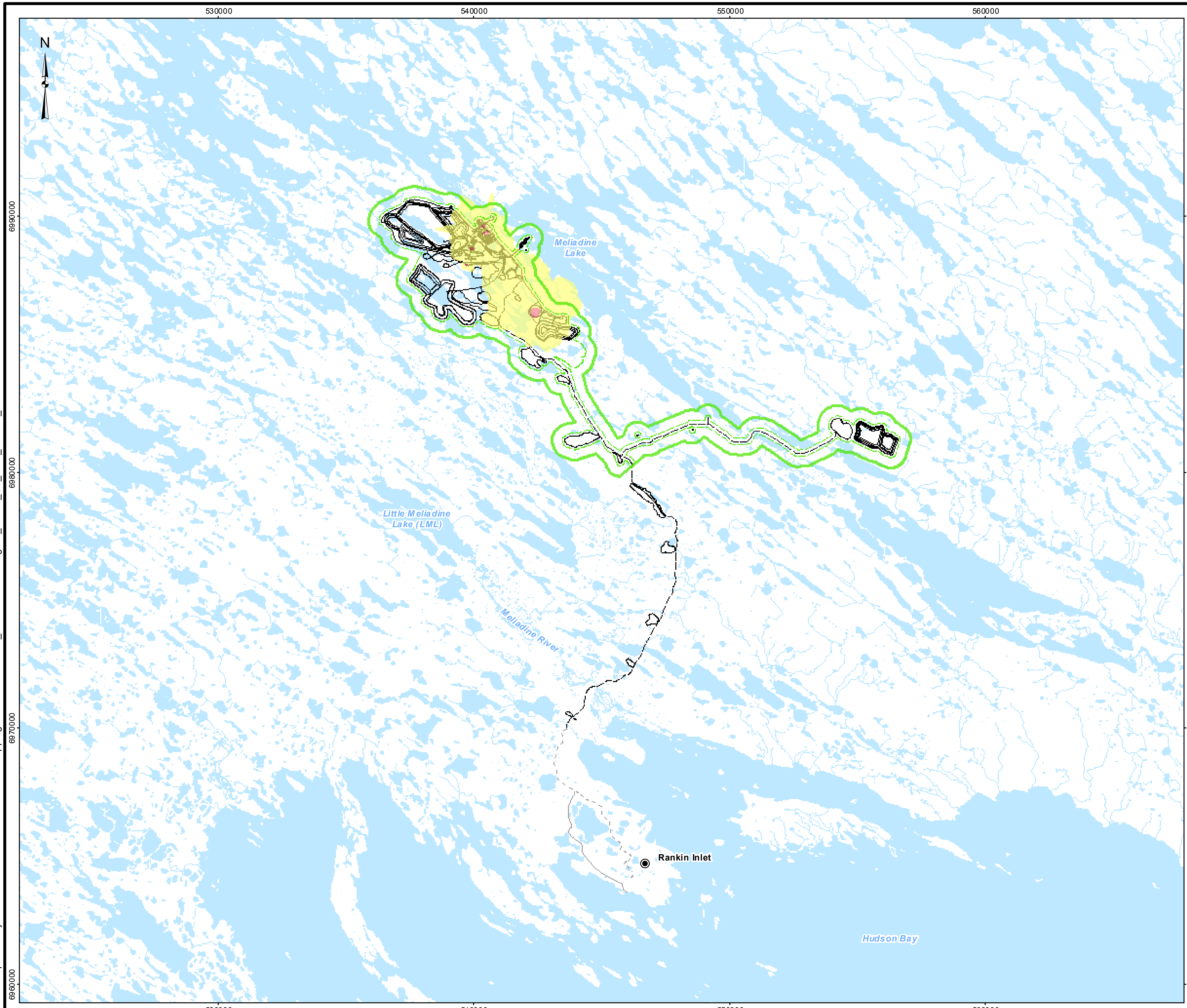
PHASE 3 - NO_2 (1-HOUR)

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	14 Nov. 2012		
CHECK	GA	14 Jan. 2013	**FIGURE 5.2-9**	
REVIEW	DW	14 Jan. 2013		



LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

NO_2 (24-hour) ($\mu g/m^3$)

- 0 - 100
- 100 - 200
- > 200

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5
KILOMETRES

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PHASE 3 - NO_2 (24-HOUR)

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PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	14 Nov. 2012		
CHECK	GA	14 Jan. 2013	**FIGURE 5.2-10**	
REVIEW	DW	14 Jan. 2013		

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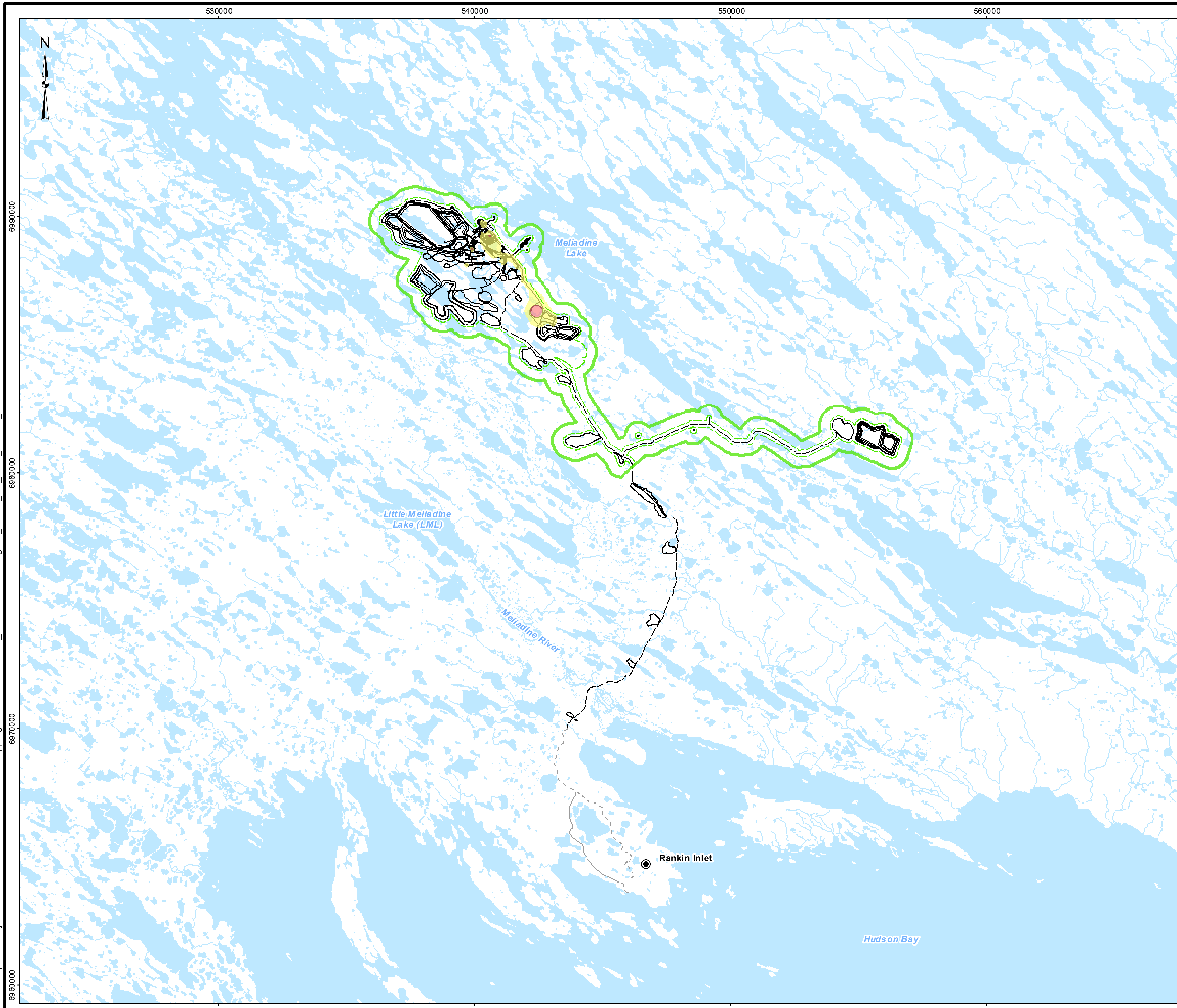

LEGEND

- Site Study Area (Mine Site)
- Disturbed Area (Mine Site)
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

NO_2 (Annual) (μg/m^3)

- 0 - 50
- 50 - 100
- > 100

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5

KILOMETRES

PROJECT

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AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

PHASE 3 - NO_2 (ANNUAL)

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	TH	14 Nov. 2012	SCALE AS SHOWN	REV. 0
GIS	JW	14 Nov. 2012		
CHECK	GA	14 Jan. 2013		
REVIEW	DW	14 Jan. 2013		

FIGURE 5.2-11

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The duration of effects is assigned based on the length of time that the predicted effects are likely to occur. Specifically, the duration of a particular magnitude is determined to be the largest area of that magnitude. If effects of a particular magnitude are predicted to occur in more than one of the study periods (e.g., short-term, medium-term, or long-term), the extent is determined to be the larger of the 2 extents.

For all cases evaluated, the duration is considered to be medium-term, where conditions causing the effect are evident for an extended period of time, and last throughout the operational phase. Although air quality impacts can occur in both the construction and decommissioning and reclamation phases, the total emissions released during the bounding phase are much higher than those during other phases. For the purposes of this assessment, only the bounding case (operational) was considered. Because all of the duration for air quality are considered medium-term, this category has not been summarized further.

In the case of the mining activities, once the mining and processing operations cease, the effect of the impact on air quality are reversible. Because all of the impacts for air quality are considered reversible, this category has not been summarized further.

5.2.5.2.3 Environmental Significance — Mine Site

The classification of significance for residual effects was determined following the procedure outlined in Section 5.2.3.6, using the assessment measures described previously. For air quality, all residual effects are considered to be of a negative direction (Section 5.2.5.2.2). In addition, the duration of the residual effects for air quality are all considered to be medium-term, lasting throughout the operations phase (Section 5.2.5.2.2). Finally, all air quality effects are considered to be fully reversible, as air quality will return to background conditions once emissions from the Project cease (Section 5.2.5.2.2. Therefore, significance for adverse air quality effects will rely on the measures of magnitude, geographic extent, and frequency.

As detailed in Section 5.2.3.6, effects that are of a negligible or low magnitude would be classified as “not significant”, as were those effects of a moderate or high magnitude, but restricted to the SSA. Effects that are of a moderate magnitude, but are restricted to the LSA are also considered “not significant”. A summary of the environmental significance for air quality effects associated with the mine site is provided in Table 5.2-25.

Table 5.2-25: Environmental Significance for Air Quality — Mine Site

Indicator Compound	Magnitude	Geographic Extent	Frequency	Study Area Significance	Overall Significance
TSP – 24-hour	Negligible	RSA	—	Not Significant	Not Significant
	High	SSA	—	Not Significant	
TSP – Annual	Negligible	LSA	—	Not Significant	Not Significant
	Low	SSA	—	Not Significant	
PM_{10} – 24-hour	Negligible	RSA	—	Not Significant	Not Significant
	Moderate	LSA	—	Not Significant	
	High	SSA	—	Not Significant	
$PM_{2.5}$ – 24-hour	Negligible	RSA	—	Not Significant	Not Significant
	High	SSA	—	Not Significant	
NO_2 – 1-hour	Low	LSA	—	Not Significant	Not Significant
	Moderate	SSA	—	Not Significant	
NO_2 – 24-hour	Negligible	RSA	—	Not Significant	Not Significant
	Low	SSA	—	Not Significant	
NO_2 – Annual	Negligible	RSA	—	Not Significant	Not Significant
	Low	SSA	—	Not Significant	
SO_2 – 1-hour	Negligible	LSA	—	Not Significant	Not Significant
	Low	SSA	—	Not Significant	
SO_2 – 24-hour	Negligible	LSA	—	Not Significant	Not Significant
	Low	SSA	—	Not Significant	
SO_2 – Annual	Negligible	SSA	—	Not Significant	Not Significant
CO – 1-Hour	Negligible	RSA	—	Not Significant	Not Significant
	Low	SSA	—	Not Significant	

LSA = local study area; RSA = regional study area; SSA = site study area

5.2.5.2.4 Uncertainty

The air quality assessment relies on dispersion models in predicting the effects of the Project. As with all models, there is a potential for uncertainty to exist in the model predictions. Uncertainty in the predictions used in the air quality assessment of the Project has been managed through a combination of the following:

- **Use widely accepted models**. Air dispersion modelling completed to support the air quality assessment used the CALPUFF model, which has been widely accepted for applications such as this in northern Canada, as well as elsewhere nationally and internationally.
- **Use the best available meteorological data**. In generating the dispersion meteorology in the air quality assessment, a review was made of the available meteorology and the best data selected. The resulting dispersion meteorology was compared to available data in the RSA to confirm that actual conditions are accurately portrayed (Appendix 5.2-B).
- **Model the bounding phase**. The air quality assessment determined that emissions and activity levels would be greatest during the operations phase. Therefore, the dispersion modelling was conducted for the

operations phase only, and the results assumed to conservatively apply to the construction phase and the decommissioning and reclamation phase.

- **Identify bounding cases**. Six distinct cases were identified to represent different configurations during the operations phase of the Project. The initial case included only the support operations (e.g., power plant) and Tiriganiaq underground mining. The remaining 5 cases included the emissions from the initial case plus one of the open pits operating a full capacity. Each case represents the bounding effects when operations are occurring at any of the open pits. If activities were to occur at a lesser rate, at multiple pits, the individual effects would be less than those bounded by the cases below.
- **Emissions based on full capacity**. The emissions used in the modelling were based on the assumption that most equipment will be operating at maximum capacity on a continuous basis. This assumption can lead to an overestimation of the potential Project effects.
- **Assess the maximum result.** In determining residual effects and assigning magnitude and significance, the highest of the modelled predictions for each indicator compound were used.

By applying the above to manage the prediction uncertainty inherit in the modelling provides confidence that the actual concentrations likely to result from the proposed Project will be lower than the predictions used to assess the effects of the Project on air quality.

There have been numerous other studies conducted to validate the performance of the CALPUFF model, including:

- US EPA studies on CALPUFF validation entitled *Documentation of the Evaluation of CALPUFF and Other Long Range Transport Models Using Tracer Field Experiment Data*. Prepared by ENVIRON International Corporation for the US EPA under Contract No. EP-D-07-102. (U.S. EPA 2012).
- CALPUFF Near-Field Validation, Presented by Roger W. Brode, U.S. EPA/OAQPS Air Quality Modelling Group. 10th Conference on Air Quality Modelling, Research Triangle Park, NC.
- Fishwick, Scott and Scorgie, Yvonne (2011). *Performance of CALPUFF in Predicting Time-Resolved Particulate Matter Concentrations from a Large Scale Surface Mining Operation*. Clean Air Society of Australia and New Zealand Annual Conference 2011.
- Levelton Consultants Ltd. (2005). *CALPUFF Modelling for the Williams Lake Airshed.* Prepared for the Ministry of the Environment, Cariboo Region, British Columbia, Canada

All of these studies demonstrate that the CALPUFF model tends to overpredict concentrations within a reasonable amount of error; therefore, it can typically be considered a conservative model.

To conduct an appropriate model validation using monitoring data is complex, and requires a significant level of effort to complete. For the monitored period, the source activity data as well as the meteorological conditions, and other natural events (e.g. brush fires) must be available. This level of information is not publically available for other projects in the Canadian North (incl. the Ekati Diamond Mine or the Meadowbank Project).

5.2.5.3 Project Effects — All-weather Access Road

5.2.5.3.1 Prediction of Residual Effects — All-weather Access Road

5.2.5.3.1.1 Emissions — All-weather Access Road

The effect of the transportation activities on the AWAR were based on projected Project and public traffic flows during the life of the Project. This included increased traffic during periods when the barge is in operation. Based on the information provided by AEM, the operations vehicle fleet will change depending on the season (i.e., frozen period and unfrozen period), as well as day of the week (i.e., weekday and weekend). A summary of the AWAR Project fleet traffic is provided in Table 5.2-26. The assessment also considered potential seasonal and weekday variations in public use of the road.

Table 5.2-26: All-weather Access Road Project Fleet Traffic

Vehicle Type	Total Number of Trips Per Day			
	Frozen Weekdays	Frozen Weekends	Unfrozen weekdays	Unfrozen Weekends
Pickup	10	4	14	8
Cube Van	2	1	3	1
Passenger Van	2	1	2	1
Fuel Truck	2	0	2	0
Transport Truck	1	1	1	1
Transport Trucks On Periods when Barge Arrival Occur	10	10	10	10
Snow Plow	1	1	0	0
Public Pickups	2	5	5	10
Public ATVs/Snowmobiles	10	20	5	10

The expected emissions from vehicles along the AWAR include fugitive dust, as well as exhaust emissions. These emissions will vary by the time of week, as well as the time of year. On an annual basis, there will be a combination of winter weekdays, winter weekends, summer weekdays, summer weekends, days without barge traffic, and days when additional traffic is required due to barge unloading and transport. Using the information provided by AEM, the annual emissions from the AWAR (assuming dust mitigation during the unfrozen period) were calculated and summarized in Table 5.2-27. Details of the emission calculation methods are provided in Appendix 5.2-A.

Table 5.2-27: Indicator Compound Emission Rates for All-weather Access Road

Operational Phase	TSP (kg/year)	PM_{10} (kg/year)	$PM_{2.5}$ (kg/year)	NO_X (kg/year)	SO_2 (kg/year)	CO (kg/year)
AWAR	3609.2	1426.3	163.8	371.4	0.8	1089.1

The air emissions will be greatest during the operations of the AWAR, when traffic along the access road is at its peak (i.e., on days when additional traffic is required due to barge unloading and transport). Since air emissions will be lower during the construction activities than during operations, the air quality effects during the construction of the AWAR were classified as a minor pathway. As such, no prediction of residual effects during the construction of the AWAR was undertaken.

5.2.5.3.1.2 Dispersion Modelling — All-weather Access Road

The CALPUFF model was used to determine the decrease in concentration and deposition values with distance from the centre of the AWAR. Through this modelling, it was determined that the predicted concentrations decrease rapidly with distance from the roadway. Predicted concentrations decrease by 90% within 700 m of the centre of the roadway. The same pattern in emission decreases occurs for deposition values as well. However, the rate of deposition falls off more rapidly than concentrations, dropping by 90% within 300 m of the centre of the roadway (see Figure 5.2-12).

Using the emission estimates for the maximum daily scenario (unfrozen weekdays), concentrations for all indicator compounds are predicted to be below their respective ambient air quality criteria. Beyond the AWAR LSA (i.e., 1.5 km from centre of roadway), impacts are minimal. These results are summarized in Table 5.2-28. These values are likely conservative given the conservative nature of the modelling and emissions used in the predictions.

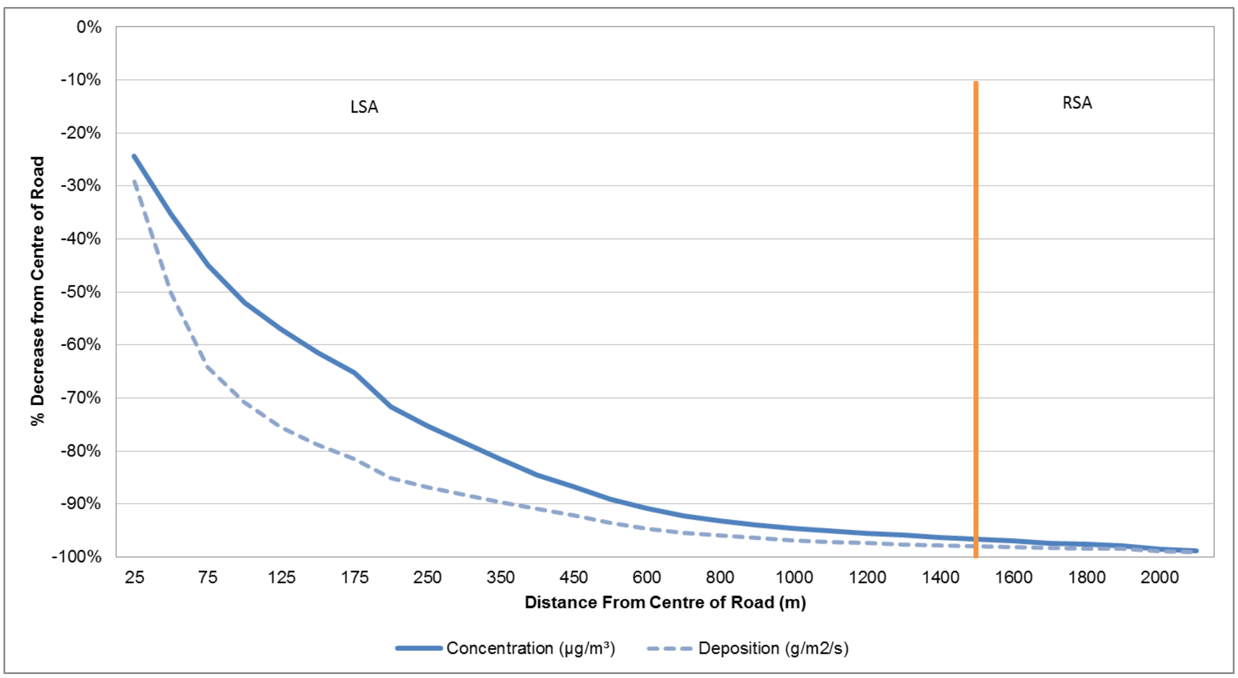


Figure 5.2-12: Predicted Decline in Concentrations and Deposition Rates with Distance

Table 5.2-28: Dispersion Modelling Results for All-weather Access Road (Maximum Scenario)

Distance from Roadway (m)		Maximum Predicted Concentration (µg/m³)							
		TSP 24-Hour	PM_{10} 24-Hour	$PM_{2.5}$ 24-Hour	NO_2 1-Hour	NO_2 24-Hour	SO_2 1-Hour	SO_2 24-Hour	CO 1-Hour
LSA	25	75.61	29.80	3.32	11.51	6.21	0.03	0.01	14.92
	50	57.13	22.52	2.51	11.02	4.69	0.03	0.01	14.28
	75	48.98	19.30	2.15	10.03	4.02	0.02	0.01	13.01
	100	41.65	16.42	1.83	8.91	3.42	0.02	0.01	11.54
	150	32.51	12.81	1.43	7.05	2.67	0.02	0.01	9.14
	200	26.24	10.34	1.15	5.73	2.15	0.01	0.01	7.43
	300	18.63	7.34	0.82	5.19	1.53	0.01	0.00	6.72
	400	13.89	5.47	0.61	4.02	1.14	0.01	0.00	5.21
	500	10.06	3.97	0.44	3.03	0.83	0.01	0.00	3.93
	600	8.25	3.25	0.36	2.18	0.68	0.01	0.00	2.83
	700	6.93	2.73	0.30	1.81	0.57	0.00	0.00	2.35
	800	5.90	2.32	0.26	1.59	0.48	0.00	0.00	2.06
	900	5.11	2.02	0.22	1.42	0.42	0.00	0.00	1.84
	1000	4.52	1.78	0.20	1.27	0.37	0.00	0.00	1.64
RSA	1500	2.82	1.11	0.12	0.89	0.23	0.00	0.00	1.16
	2000	1.61	0.64	0.07	0.67	0.13	0.00	0.00	0.87
	3000	0.86	0.34	0.04	0.37	0.07	0.00	0.00	0.48

5.2.5.3.2 Impact Classification — All-weather Access Road

The dispersion model predictions were made at all receptor locations within the modelling domain. Therefore, magnitudes of effects can be assigned to each of the study areas based on the model results within those study areas. Table 5.2-29 provides a summary of the effect magnitudes for air quality in each of the relevant study areas. These magnitudes were assigned in accordance with methods described in Section 5.2.3.7.

Table 5.2-29: Predicted Impact Magnitudes — All-weather Access Road

Indicator Compound	Magnitude in LSA	Magnitude in RSA	Magnitude in beyond RSA
TSP – 24-hour	Moderate	Negligible	Negligible
TSP – Annual	Negligible	Negligible	Negligible
PM_{10} – 24-hour	Moderate	Negligible	Negligible
$PM_{2.5}$ – 24-hour	Negligible	Negligible	Negligible
NO_2 – 1-hour	Negligible	Negligible	Negligible
NO_2 – 24-hour	Negligible	Negligible	Negligible
NO_2 – Annual	Negligible	Negligible	Negligible
SO_2 – 1-hour	Negligible	Negligible	Negligible
SO_2 – 24-hour	Negligible	Negligible	Negligible
SO_2 – Annual	Negligible	Negligible	Negligible
CO – 1-Hour	Negligible	Negligible	Negligible
CO – 8-Hour	Negligible	Negligible	Negligible

LSA = local study area; RSA = regional study area

The geographic extent of effects is assigned based on the magnitude of the predicted effects. Specifically, the geographic extent of a particular magnitude is determined to be the largest area of that magnitude. If effects of a particular magnitude are predicted to occur in more than one of the study areas (e.g., LSA and RSA both have a moderate magnitude), the extent is determined to be the larger of the 2 extents. For all indicator compounds, with the exception of 24-Hours TSP and PM_{10}, effects in both the LSA and RSA are of a negligible magnitude. For the 24-Hour TSP and PM_{10}, effects of a moderate magnitude extend to the RSA.

For all indicators where the averaging period is annual, the frequency is considered to be continuous. For 1-hour, 8-hour, and 24-hour indicators, the frequency will be isolated, periodic, or continuous depending on whether effects of a particular magnitude occur less than 2% of the time, less than 10% of the time, or more than 10% of the time, respectively, in a particular geographic area.

The duration of effects is assigned based on the length of time that the predicted effects are likely to occur. Specifically, the duration of a particular magnitude is determined to be the largest area of that magnitude. If effects of a particular magnitude are predicted to occur in more than one of the study periods (e.g., short-term, medium-term, or long-term), the extent is determined to be the larger of the 2 extents.

For all cases evaluated, the duration is considered to be medium-term, where conditions causing the effect are evident for an extended period of time, and last throughout the operational phase. Although air quality impacts can ocurr in both the construction and decommissioning and reclamation phases, the total emissions released during the bounding phase are much larger than those during other phases. For the purposes of this assessment, only the bounding case (operational) was considered. Because all of the duration for air quality are considered medium-term, this category has not been summarized further.

As described in Table 5.2-3, the reversibility of an effect is defined as either “reversible” or irreversible”. In the case of the mining activities and use of the AWAR, once the mining and processing operations cease, the effect of the impact on air quality are reversible. Because all of the reversibility for air quality are considered reversible, this category has not been summarized further.

5.2.5.3.3 Environmental Significance — All-weather Access Road

The classification of significance for residual effects was determined following the procedure outlined in Section 5.2.3.6, using the assessment measures described previously. For air quality, all residual effects are considered to be of a negative direction (Section 5.2.3.5). In addition, the duration of the residual effects for air quality are all considered to be medium-term, lasting throughout the operations phase (Section 5.2.5.3.2). Finally, all air quality effects are considered to be fully reversible, as air quality will return to background conditions once emissions from the Project cease (Section 5.2.5.3.2). Therefore, significance for adverse air quality effects will rely on the measures of magnitude, geographic extent, and frequency. In addition, all compounds, with the exception of 24-Hour TSP and PM_{10} are negligible in magnitude; therefore, significance has only been assigned for these 2 indicator compounds (Table 5.2-30).

Table 5.2-30: Summary of Significance

Indicator Compound	Magnitude	Geographic Extent	Frequency	Study Area Significance	Overall Significance
TSP – 24-hour	Negligible	RSA	—	Not Significant	Not Significant
	Moderate	LSA	—	Not Significant	
PM_{10} – 24-hour	Negligible	RSA	—	Not Significant	Not Significant
	Moderate	LSA	—	Not Significant	

LSA = local study area; RSA = regional study area

5.2.5.3.4 Uncertainty

As discussed in Section 5.2.5.2.4, the use of air dispersion models for predicting the air quality effects introduces the potential for uncertainty with the model results. Uncertainty is to be expected with any predictive model, but the uncertainty was managed through a combination of the following measures:

- Using a widely accepted dispersion model (i.e., CALPUFF), which has been used for applications such as this in northern Canada as well as elsewhere nationally and internationally.
- Running the dispersion model using the best available meteorological data. A specific set of dispersion meteorology was generated for the air is assessment (see Appendix 5.2-B).
- Use conservative emissions that reflect the maximum activity levels.
- Assess the maximum dispersion modelling results when assigning effect magnitudes.

By applying the above to manage the prediction uncertainty inherit in the modelling provides confidence that the actual concentrations likely to result from the proposed Project will be lower than the predictions used to assess the effects of the Project on air quality.

5.2.5.4 Project Effects — Rankin Inlet Activities

5.2.5.4.1 Prediction of Residual Effects— Rankin Inlet Activities

The Project activities that take place in Rankin are primarily associated with the laydown area. All of these emissions come from the exhaust of non-road vehicle activities, including cranes and loaders, as summarized in Table 5.2-31.

Table 5.2-31: Indicator Compound Emission Rates for Rankin Inlet

Activity	TSP (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	NO_X (t/year)	SO_2 (t/year)	CO (t/year)
Laydown Area	<1	<1	<1	<1	<1	<1

The emissions from the Rankin Inlet laydown area are small in comparison to other activities associated with the proposed Project, and within the community. Table 5.2-32 contrasts the emissions from the activities at the laydown area to the emissions from the electrical generating station operated by Nunavut Power in Rankin Inlet, and the emissions from the AWAR. This table shows that the emissions from the laydown area are negligible when compared either the power plant or the AWAR. As a result, dispersion modelling was not completed as the resulting concentrations from these negligible emissions would be insignificant.

Table 5.2-32: Comparison of Nunavut Power, All-weather Access Road, and Rankin Inlet Laydown Emissions for Indicator Compounds

Indicator Compound	Nunavut Power 2010 Annual Emission Rate (tonnes per year)	All-weather Access Road (tonnes per year)	Rankin Inlet Laydown Area (tonnes per year)
SO_2	20	<1	<1
CO	65	1.09	<1
NO_X	300	0.37	<1
TSP	21	3.61	<1
PM_{10}	25	1.43	<1
$PM_{2.5}$	21	0.16	<1

5.2.5.4.2 Impact Classification— Rankin Inlet Activities

While the emissions associated with the Project activities in Rankin Inlet are expected to be negative in direction, the magnitude of the effects will be negligible. The emissions from the activities at the laydown area are insignificant compared to the emissions associated with the local power plant and the AWAR.

5.2.5.4.3 Environmental Significance— Rankin Inlet Activities

Because the effects of the Rankin Inlet activities on air quality were classified as having a negligible magnitude, these effects were determined to be not significant.

5.2.5.5 Project Effects — Marine Shipping

5.2.5.5.1 Prediction of Residual Effects — Marine Shipping

The receipt of goods in remote locations in the Arctic is typically by plane or marine shipping. Larger shipments of dry cargo and fuel are typically received via ships. In Nunavut, the sealift of dry cargo and bulk fuel is coordinated by the Government of Nunavut, and carried out by various commercial shipping companies. These services resupply the eastern Arctic from Churchill and Montreal.

In 2006, ports in Nunvut handled more than 150 000 tonnes of cargo from domestic ships, which is approximately 4 times that of the cargo handled in the GNWT (Statistics Canada 2009). The largest volumes of shipments occur in Iqaluit.

Marine engines are contributors to SO_2, $PM_{2.5}$, and NO_X emissions, as well as greenhouse gases (GHGs). The ships use either marine diesel or marine heavy fuel oil, both of which have higher sulphur contents than other transportation fuels for land-based equipment. For SO_2, this is typically in the range of 1 to 3% sulphur content, in comparison to 0.0015% sulphur content diesel fuel used in the power generators and non-road equipment at the mine site.

Fuel and other dry goods for the Project will be received at Rankin Inlet via ship. Fuel will be shipped in a tanker ship that will anchor offshore in Hudson Bay. A second low draft tanker or barge will then be used to deliver the fuel into the Itivia harbour site from where the fuel will be pumped directly into the Project fuel tank farm. Dry goods will be moved from Itivia harbour to the spud barge. Based on information provided by AEM, marine activities associated with Project can be summarized as follows:

- Two barges and 2 tug boats arriving at Itivia Harbour in late July and stay for duration of open-water season.
- One spud barge and one tug boat at Itivia Harbour for duration of Project (construction, operations, and decommissioning).
- Four large fuel tankers (each carrying ~ 20 000 m³ of fuel) will arrive in Itivia Harbour in late July. They will moor outside the harbour, as they are too large to come in the harbour for ship to shore transfer of fuel. Several small fuel tankers (each capable of carrying 7500 to 10 000 m³ of fuel) will accompany the larger tankers and will transfer fuel from the large tankers to the tank farm (holding capacity of 80 000 m³). Fuel tankers will depart the region once fuelling of the tank farm is complete. In addition, 1 to 2 large fuel tankers will also be required in late summer/early fall, to top off the tank farm prior to winter. In total, up to 6 large fuel tankers will be required per year.
- Four to six dry cargo ships during Year 1 for general transport.

The annual marine shipping emissions (see Table 5.2-33) were determined using published emission factors and the above activity levels. The emissions are quantified separately for periods when vehicles would be anchored at Rankin Inlet, and for those periods when the vessels are underway (i.e., travelling to and from Rankin Inlet).

Table 5.2-33: Indicator Compound Emission Rates for Marine Shipping

Activity	TSP (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	NO_X (t/year)	SO_2 (t/year)	CO (t/year)
Auxiliary Engines (in port)	1.0	0.9	0.8	25.8	7.4	1.9
Main Engines (underway)	19.7	17.9	16.2	238.7	71.6	18.8

While the emissions associated with the marine shipping element of the Project are not trivial, they will be dispersed over a large area as the vessels travel to and from Rankin Inlet. Therefore, the effects on local air quality are expected to be negligible. As a result, dispersion modelling was not completed as the resulting concentrations from these dispersed emissions would be very low.

5.2.5.5.2 Impact Classification— Marine Shipping

While the emissions associated with the marine shipping element of the Project are expected to be negative in direction, the magnitude of the effects will be negligible. The emissions from the marine shipping activities will be dispersed along the travel corridors to and from the port at Rankin Inlet.

5.2.5.5.3 Environmental Significance— Marine Shipping

Because the effects of the marine shipping activities on air quality were classified as having a negligible magnitude, these effects were determined to not significant.

5.2.6 Cumulative Effects

The 4 Project areas assessed for air quality are sufficiently dispersed that thier maximum effects do not overlap. There are no other industrial developments in the vicinity of the Mine Site for which effects would overlap either temporally and spatially with those of the Project. The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development, or as part of the Project. An environmental impact assessement (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed

The assessment of the air quality associated with the AWAR includes all expected activities, including those not related to the Project. In Rankin Inlet, air quality effects of the Project were shown to be negligible with respect to the existing sources in the community. Finally, the effects of marine shipping on air quality will be negligible in magnitude as the emissions will occur over a widely dispersed area. Therefore, the Project effects described in the previous section are the same as the cumulative effects for air quality.

5.2.7 Mitigation and Monitoring

The guidelines stipulate that the need for, and the requirements of, any follow-up program for the Project be identified. A follow-up program may be required to determine that the environmental and cumulative effects of the Project are consistent with predictions reported in the Environmental Impact Statement (EIS). It can also be used to verify that mitigation measures are effective once implemented and determine whether there is a need for additional mitigation measures.

The monitoring and follow-up program is designed to be appropriate to the scale of the Project and the effects identified through the environmental assessment process. The predicted ambient air quality concentrations will be considered in the design of an appropriate monitoring program and the development of mitigation and adaptive management strategies. These programs and strategies are intended confirm the effectiveness of mitigation measures assumed in the Project, and in doing so, determine if alternative mitigation strategies are required to minimize emissions from the Project and their impacts.

The monitoring program and mitigation and adaptive management strategy will include the following components:

- regulatory review that identifies legislation, regulatory and policy requirements considered in the program;
- scope that provides a description of the scope of the program;
- goals that outline all of the goals of the program;
- air quality monitoring program;
- emissions monitoring program;

- mitigative and adaptive strategies;
- response planning describing strategies for responding to events of higher than expected emission rates or air quality impacts (including the development of thresholds that would elicit a response depending on the severity); and
- annual report describing procedures for the preparation of annual reports and their ancillary components.

A brief summary of the mitigation measures and the air quality monitoring program are summarized in the sections below.

5.2.7.1 Mitigation Measures

Design aspects, operational measures, and other mitigation measures have been incorporated into the current Project plans to minimize Project associated emission. Mitigation measures that will be applied to the Project can be classified into 3 stages:

- Design Based Mitigation;
- General Mitigation; and
- Activity Specific Mitigation.

Through its Project design, AEM has identified a series of best management practices that will be employed to minimize air quality changes. For example, within the Project, design specification, such as the purchase of vehicles that meet Tier III emission standards, have been incorporated to the emission assumptions. Other mitigation will include the development of general migration practices, such as routine maintenance and housekeeping programs, as well as activity specific mitigation, such as incinerator management programs and fugitive dust best management plans. In relation to the Project, AEM will take into consideration the 3 stages of mitigation, as outlined above, and develop emission reduction plans and consider pollution prevention and best management practices where required. Details of these plans are included in SD 5-1 Air Quality Monitoring Plan.

5.2.7.2 Regulatory Emission Requirements

The Project will meet CCME emission requirements for boilers and heaters, fuel storage tanks, and waste incinerators, as well as the Nunavut guidelines for the incineration of solid waste. These requirements are summarized as follows:

- National Emission Guidelines for Commercial/Industrial Boilers and Heaters (CCME 1998a): This documents sets out the emission limits from boilers and heaters. The limits are frequently referenced by regulatory agencies as targets that need to be achieved for approval and permit compliance.
- Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Aboveground Storage Tanks (CCME 1995): This document is intended to provide consistency in controlling volatile organic compound emissions from fuel storage tanks.

- Canada-Wide Standards for Dioxins and Furans (CCME 2001): This documents sets out the emission limits from incinerators. Emission limits are expressed as a concentration in the exhaust gas exiting the stack of the facility and will be met using generally available incineration and emission control technology and waste diversion. An emission concentration limit of 80 pico-grams of International Toxic Equivalency Quotients per cubic metre (pg I-TEQ/m^3) is applicable to the Project for hazardous waste and sewage sludge incineration.
- Environmental Guideline for the Burning and Incineration of Solid Waste (Nunavut 2012): This document sets out practices, methods and limits with respect to the combustion of solid waste in Nunavut. The guideline includes a specific limit of 80 picograms of International Toxic Equivalency Quotients per cubic metre (pg I-TEQ/m^3), which is consistent with the CCME limit above. The guideline also sets a limit of 20 micrograms per cubic metre (µg/m^3).

5.2.7.3 Air Quality Monitoring Program

Table 5.2-34 summarizes the recommended follow-up monitoring programs for the air quality assessment. The recommendations identify the general timeframe for follow-up and monitoring (operations and construction or post-closure phase). The preliminary follow-up monitoring program has been prepared and is submitted along with the Final EIS (SD 5-1 Air Quality Monitoring Program).

Table 5.2-34: Summary of Monitoring Programs

Component	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
Air Quality	Construction and Operations	• To verify that the TSP, PM_{10}, and $PM_{2.5}$ emission rates used in the assessment were reasonable, but conservative • To verify the predicted concentrations of TSP, PM_{10}, and $PM_{2.5}$ • To verify that the mitigation measures considered integral to the Project are being incorporated as planned, and are effective	• Development of fugitive dust management plan during construction activities • Installation of 1 continuous TSP/PM_{10} sampling unit • Installation of dust fall jars, as appropriate
Meteorological Data	Construction and Operations	• Installation of appropriate on-site meteorological station to collect relevant data that can assist to support ongoing study at the site	• real time sampling

Evaluation of local conditions and predicted air concentrations should be considered when defining the monitoring requirements. The proposed air quality monitoring plan will include the following tasks:

- Identification of monitoring requirements, including the following:
  - the location of the meteorological station;
  - air quality parameters to be monitored; and
  - frequency and location of sampling.
- Proposal of Monitoring Techniques and Equipment appropriate to meet the monitoring requirements.
- Data Analysis Requirements: Defining procedures for the compilation and analysis of the monitoring data

- Quality Assurance/Quality Control Procedures: Describing procedures for conducting quality assurance/quality control on the monitoring results.
- Implementation of the Monitoring Program: Describing the schedule and resources (including training) necessary to implement the monitoring program.
- Record Keeping: Describing the procedures for record keeping for the information related to the Monitoring Program, for the purpose of audits and continuous improvement of the monitoring program.
- Monitoring Program Review: Describing the procedures for the periodic review of the monitoring program (continuous improvement), including stages to reduce the monitoring requirements.

5.2.7.4 Emission Monitoring Program

Along with the evaluation of local conditions and predicted air concentrations through physical monitoring, ongoing validation of the Project emissions also should be considered in developing this component of the monitoring program. This validation program may include the following:

- Project Emissions: Developing the methods for describing and quantifying the emissions from the Project (annual reporting).
- Fuel Use Summary: Developing methods for the use of annual fuel consumption data to calculate the Project emissions.

5.2.7.5 Mitigation and Adaptive Strategies

A plan to address the predicted impacts from the Project emissions will be developed. It is expected to include the following:

- identifying mitigation and adaptive strategies to minimize the impacts of the Project emissions on local air quality;
- implementing the mitigation and adaptive strategies;
- describing the schedule and resources necessary to implement the mitigation and adaptive strategies; and
- describing the procedures for the periodic review of the mitigation and adaptive strategies (continuous improvement).

5.3 Climate and Meteorology

5.3.1 Introduction

The purpose of this section is to address Guidelines issued by the NIRB for the preparation of a FEIS for the Project (NIRB 2012), and specifically those relating to baseline climate and meteorology. Volume 1 Appendix 1.0-A provides the specific requirements set out in the Guidelines to the baseline for climate and meteorology.

5.3.2 Background

Long-term local and regional climatic conditions in the Project area are presented in SD 7-1 2009 Aquatics Synthesis Baseline Report Section 4.1. The most proximate long-term climate station to the Project site is Rankin Inlet A (Station 2303401) operated by Meteorological Services of Canada, located approximately 25 km south of the Project site. In preparing the long-term local and regional climatic conditions presented in SD 7-1 2009 Aquatics Synthesis Baseline Report Section 4.1, the Rankin Inlet station was considered to be close enough to represent the climate conditions at the Project site.

In addition to the long-term climate, meteorology is important to understand, as it describes the variability of atmospheric surface layer, and influences how emissions from the Project will be dispersed in the environment. The assessment of air quality effects (see Section 5.2) relies on dispersion models for predicting air quality. A key element of the dispersion modelling is a suitable set of dispersion meteorological data. The process of selecting and developing the dispersion meteorology used in the air quality assessment is detailed in Appendix 5.2-C, a summary of which is included in this section.

As part of the preliminary design studies for the Project, on-site meteorological data were collected by Hubert and Associates Ltd. (Hubert) over the period from 1997 through 2001 (Hubert 2001). A review was undertaken to compare the available on-site meteorological information to data from the Meteorological Services of Canada station at Rankin Inlet to determine whether the available on-site meteorological data for the period 1997 through 2001 accurately represents the current meteorological conditions in the Project area, and whether the Rankin Inlet data adequately represent the expected meteorological conditions at the Project site. The results of this review, which are presented in Appendix 5.2-C, concluded that the available on-site data were not suitable for use in characterizing the dispersion meteorology; however, the meteorological conditions at the mine site were comparable to those at Rankin Inlet.

5.3.3 Summary of Dispersion Meteorology

The climate and meteorology summarized in this section supports the atmospheric assessment, and covers the terrestrial areas and the final portion of the shipping route near to to Rankin Inlet where the highest potential air impacts can be expected (Section 5.1.1.2, Figure 5.1-1). Further details on the general climate characteristics in Hudson Bay are presented in FEIS Volume 8, Section 8.2.2.2.1.

A 5-year (for the period 2006 to 2010) meteorological data set of temperature, precipitation, and wind was developed for the Project area using the MM5 and CALMET meteorological processors after it was determined that available monitoring data were insufficient to meet the needs for a dispersion modelling assessment (Appendix 5.2-C). Validation was done on the MM5 prognostic data to ensure that the created data set was representative of the region and would be suitable for the assessment of the Project. The resulting CALMET data set was summarized to provide an overview of the predicted weather conditions over the 5-year period used for the air quality modelling described in Section 5.2. The CALMET meteorological data set was demonstrated to be similar to available monitoring data for the same period and reasonable compared to the regional climate normals. These data, therefore, were considered well-suited for the air quality dispersion modelling assessment of the Project area.

The modelled temperature, precipitation, and wind meteorological data for the Project area are summarized below. Further details on the modelling of dispersion meteorological data are provided in Appendix 5.2-C.

5.3.3.1 Temperature

The 5-years of modelled hourly temperature data are summarized on a monthly basis in Table 5.3-1. The coldest month, on average, over the period of 2006 through 2010, was February (-23.4 °C), whereas July had the highest average temperature (13.8 °C).

Table 5.3-1: Modelled Temperature (2006 to 2010) at the Project Site

Month	Daily Average (°C)	Daily Maximum (°C)	Daily Minimum (°C)	Extreme Maximum (°C)	Extreme Minimum (°C)
January	-22.3	-19.6	-25.1	-4.2	-34.7
February	-23.4	-20.4	-26.4	-8.5	-40.0
March	-19.2	-15.5	-23.2	0.3	-36.2
April	-8.4	-5.5	-11.9	2.4	-30.5
May	-3.3	-1.0	-5.9	10.7	-18.4
June	7.2	10.3	3.9	22.9	-4.8
July	13.8	17.0	10.4	27.4	5.1
August	11.8	14.7	8.7	28.9	2.6
September	4.6	7.0	2.2	19.6	-4.0
October	-1.7	-0.2	-3.3	12.1	-17.1
November	-13.2	-10.8	-15.6	0.6	-26.2
December	-19.6	-17.2	-22.1	0.9	-35.0

Figure 5.3-1 shows the range of daily temperatures generated over the 2006 – 2010 period. The graph shows that the modelled hourly temperature data for the period generally fall within the extreme climate normals for 1971 through 2000 (shown as dashed lines), with the exception of the maximum temperature for October and December, which were above the extremes. This demonstrates that the model has successfully produced a temperature field that is within the expected values for temperature in the Project region.

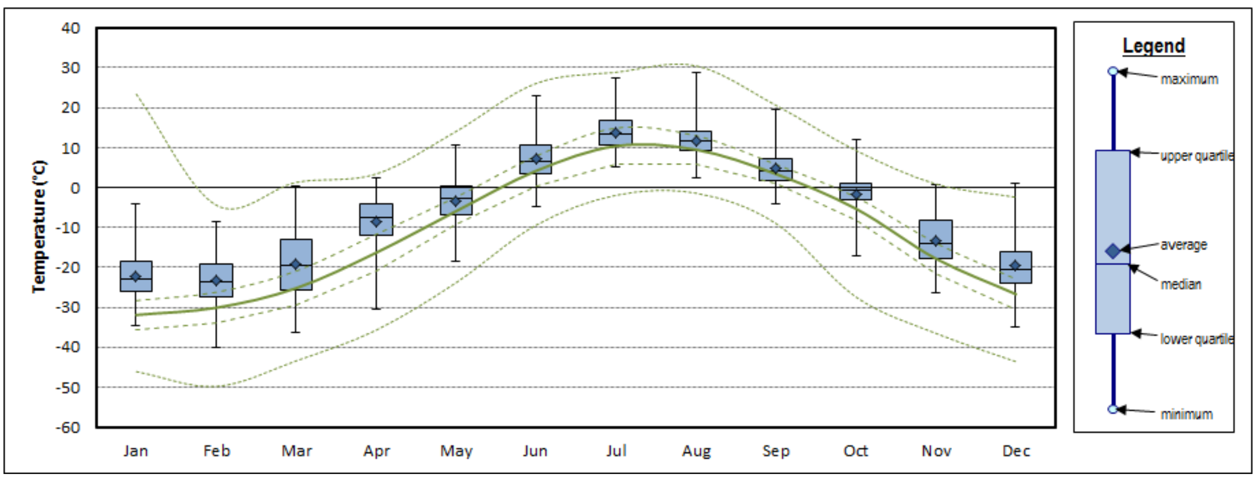


Figure 5.3-1: Range of Modelled Daily Temperatures (2006 to 2010) at Project Site

5.3.3.2 Precipitation

The 5-year modelled monthly averages of precipitation for the dispersion meteorology are tabulated in Table 5.3-2. However, the models used to produce hourly precipitation rates do not distinguish between the solid and liquid phase; therefore, temperature was used to determine whether the predicted precipitation is rain or snow. Rainfall accounted for about 49.3% of total precipitation at the Project site between 2006 and 2010. The month with the greatest rainfall, on average, was July (49.4 millimetres [mm]).

Table 5.3-2: Modelled Precipitation (2006 to 2010) at the Project Site

Month	Rainfall (mm)	Water Equivalent Snowfall (mm)	Total Precipitation (mm)	Extreme Daily Precipitation (mm)	Days with Measurable Precipitation
January	0.0	21.9	21.9	6.3	16
February	0.0	11.2	11.2	6.3	8
March	0.0	17.3	17.3	9.5	11
April	0.1	47.6	47.6	17.8	11
May	10.7	14.1	24.8	11.5	11
June	18.1	5.5	23.5	18.3	6
July	49.4	0.0	49.4	37.4	5
August	40.5	0.0	40.5	30.4	7
September	32.9	0.2	33.1	19.8	9
October	29.0	20.7	49.6	15.7	14
November	1.7	26.6	28.3	9.8	12
December	0.8	23.6	24.4	7.9	15

Figure 5.3-2 compares the modelled dispersion meteorology precipitation at the mine site to the long-term climate normals. The precipitation values in the dispersion meteorology are approximately 25% higher than the long-term climate normals. The 5-year average of annual precipitation at the mine site from the dispersion meteorology was 371.6 mm, whereas the 30-year average of annual precipitation at Rankin Inlet is 297 mm. That said, the precipitation amounts in the dispersion meteorology for the period from 2006 to 2010 period were closer to those observed at Rankin Inlet for the same period (331 mm), indicating that this period may have been one of greater precipitation than average.

The following are the notable differences between the dispersion meteorology precipitation and the long-term climate normal at Rankin Inlet:

- The average January water equivalent snowfall (21.9 mm) was more than triple the average amount of water equivalent snowfall (6.6 mm) for that month;
- The average April water equivalent snowfall (47.6 mm) was more than triple the average amount of water equivalent snowfall (13.3 mm) for that month;
- The average June total precipitation (23.5 mm) was 21% less than the average amount of total precipitation (29.8 mm) for that month;
- The average July rainfall (49.4 mm) was 25% more than the average amount of total precipitation (39.5 mm) for that month.

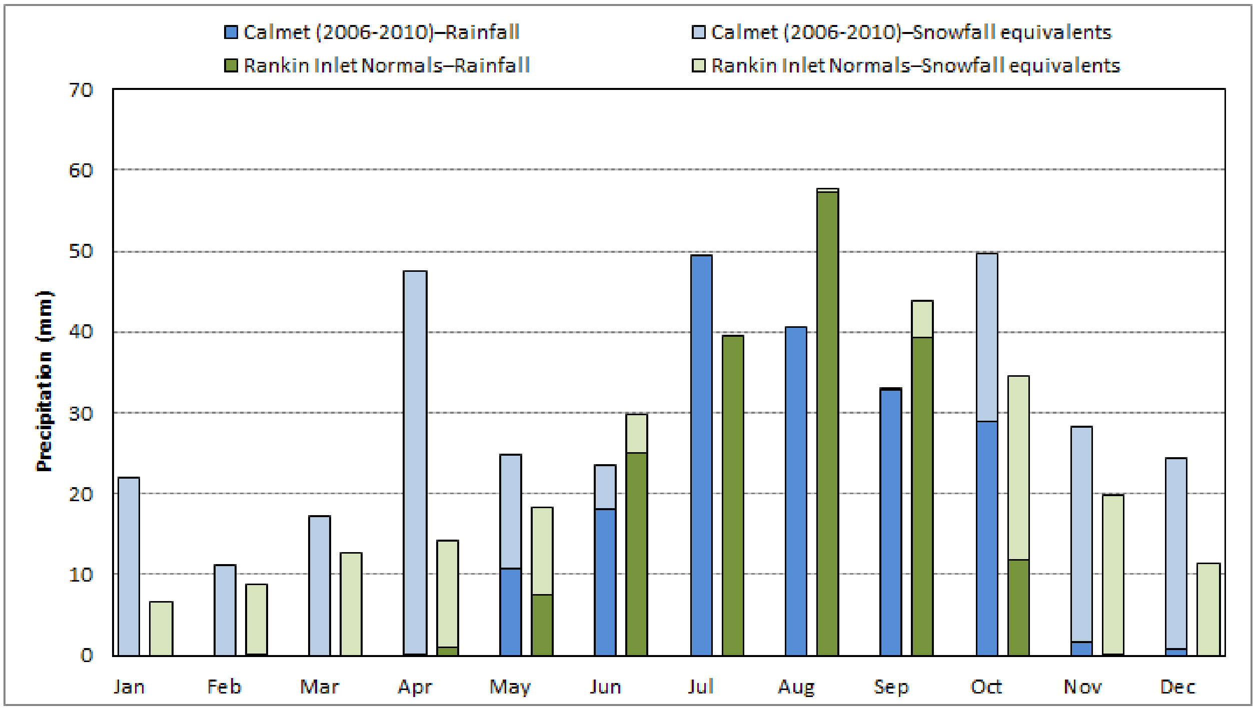


Figure 5.3-2: Comparison of Modelled (CALMET) Precipitation to Rankin Inlet Normals (1971-2000)

5.3.3.3 Wind

Figure 5.3-3 provides the modelled wind-rose for the Project site used in the air quality dispersion modelling. Overall, the modelled wind data were comparable to the monitoring data from Rankin Inlet for the same period.

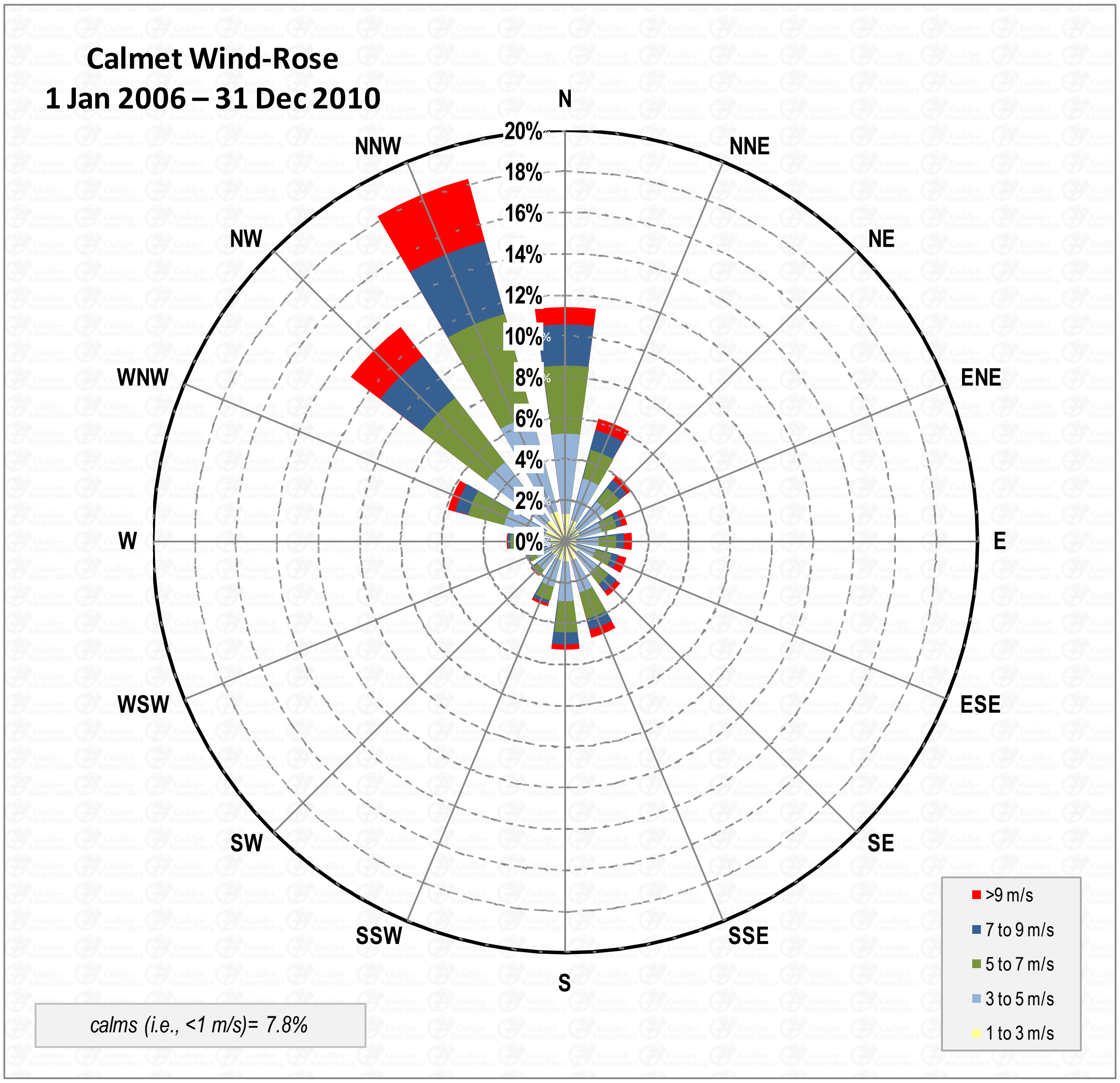


Figure 5.3-3: Modelled (CALMET) Windrose at the Project Site

5.4 Greenhouse Gases and Climate Change

5.4.1 Introduction

5.4.1.1 Purpose and Scope

The need to consider the effects of a changing climate in the assessment of the Project is required by Guidelines issued by the NIRB for the Project (NIRB 2012). The process followed in this assessment is defined by the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA), which has prepared a general guidance document for practitioners to use when incorporating climate change issues into environmental assessments (FPTCCCEA 2003). The requirement of the FPTCCCEA guidelines to consider climate change is addressed through the following considerations:

- How will potential changes in climate affect the infrastructure associated with the Project?
- How will the operation of the Project affect climate change (e.g., the Project's contribution to climate through the emission of GHGs)?

The assessment presented herein includes how climate change may affect the Project infrastructure and identifies which aspects of the Project may need to be assessed in greater detail because of a potential changing climate. To understand how the climate has been changing, and may change in the future, climate trends were analyzed by:

- describing the current climate;
- documenting how the climate has changed over the past 40 years (1970-2010) in the region;
- discussing the range of future climate projections (2011-2040, 2041-2070 and 2071-2100); and
- presenting a climate risk matrix.

In addition, the annual GHG emissions from the Project were estimated for a worst case operating year, and these emissions were compared to the Territorial and Canadian emissions to assess the relative contribution of the Project to GHG emissions in Canada. The possible contribution of the Project to future climate change was assessed by comparing the Project GHG emissions to the Global GHG emissions used in future climate predictions to gain an appreciation of the relative magnitude and likely effects of the Project on climate.

5.4.1.2 Concordance with Project Guidelines

The purpose of this section is to address Guidelines issued by NIRB for the Project (NIRB 2012), and specifically those relating to the potential impact of the Project on climate and meteorology. Volume 1 Appendix 1.0-A provides the specific requirements set out in the Guidelines for the climate and meteorology impact assessment.

5.4.2 Historic Climate Trends

The Project (63°1'23.8''N, 92°13'6.42''W) is located on Inuit Owned Land, approximately 25 km north of Rankin Inlet in the Kivalliq Region of Nunavut (Figure 5.4-1).

The climate change analysis presented herein relies on the use of climate normals, which are long-term (30-year) averages of observed climate for set periods of time. An analysis and summary of the current climate conditions for the region for both the 1971 through 2000 period (the currently recognized climate period by Environment Canada), and the longer period of 1971 through 2010 where data are available, was conducted. Historic climate data earlier than 1971 have not been considered in this assessment.

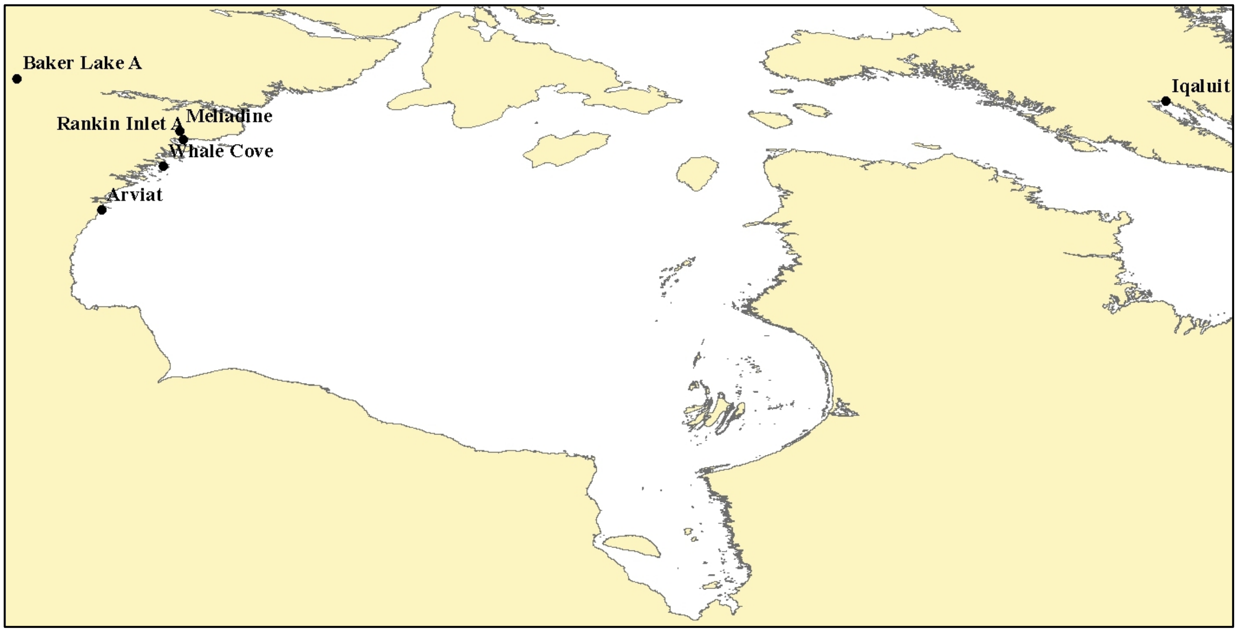


Figure 5.4-1: Hudson Bay with all the Sites Considered in the Climate Trend Analysis for the Project

5.4.2.1 Climate Station Selection

Climate station selection for the climate change analysis was based upon the specific recommendations from Environment Canada's Canadian Climate Change Scenarios Network (CCCSN) (http://www.cccsn.ec.gc.ca/, accessed 8 May 2012). The CCCSN is Environment Canada's interface for distributing climate change scenarios and adaptation research. The CCCSN sets guidelines on how to select a climate station to represent a study area of interest and how climate data should be used when calculating trends.

The criteria used to select the station used in this assessment were based on the following CCCSN selection factors:

- the length of record (minimum 30 years of data);
- a continuous record;
- records are up to date; and
- proximity to the area of interest.

There may be a number of climate stations that fall within the boundaries of the study area of interest. As a result, it is often not practical from a detailed analysis perspective to use all of the available climate stations within a study area. The available climate data from each station must be compared to, and pass, the selection criteria mentioned above. Data from most climate stations is constrained by low numbers of observations and limited life span of the station (data quantity), and varying data quality.

The climate change assessment completed for the Project used data from 2 climate stations to describe historic climate conditions, climate variability, and longer-term trends. Based on the CCCSN criteria and the defined study area, the selected stations are Rankin Inlet A and Baker Lake A (Table 5.4-1). In the following sections, Rankin Inlet A and Baker Lake A are noted as Rankin Inlet and Baker Lake, respectively.

Table 5.4-1: Selected Stations to Represent the Study Area

Station Name	Station Climate ID	Latitude	Longitude	Elevation [masl]
Rankin Inlet	2303401	62.82 °N	92.12 °W	32.30
Baker Lake	2300500	64.30°N	96.08°W	18.60

The Rankin Inlet station is located approximately 25 km south of the Project site, whereas the Baker Lake station is located approximately 250 km to the northwest. Available daily meteorological data from each station were collected for the period from 1971 through to 2010. Once the datasets passed the QA/QC process (e.g., data checks, ranges, missing data), they were prepared for climate normals and trend analysis.

The ranges of available data for the Rankin Inet and Baker Lake stations are shown in Table 5.4-2, and the percentage of missing data for varying periods of interest between 1971 and 2010 is shown in Table 5.4-3.

Table 5.4-2: Data Availability from Environment Canada Website at Selected Stations

Station Name	Daily Observations Availability
Rankin Inlet	1981-2010
Baker Lake	1950-2010

Table 5.4-3: Percentage of Missing Data at Selected Stations

Climate parameter	Rankin Inlet		Baker Lake	
	1981-2010	1971-2000	1971-2010	1971-2000
Mean temperature	0%	34%	2%	2%
Total precipitation	0%	34%	2%	2%

5.4.2.2 Background to Trend Analysis

Traditionally, the review of changing climate considers past weather records to provide guidance for predicting future conditions. Historic climate trends at Rankin Inlet and Baker Lake were assessed using data from the climate data archives (National Climate Data and Information Archive 2012) available at http://climate.weatheroffice.gc.ca/Welcome_e.html (accessed 8 May 2012). Two periods were assessed:

- The defined climate normals over the period from 1971 through 2000 to form a baseline for future model projection comparison; and
- All available information from 1971 through 2010.

Potential trends in temperature and precipitation are evaluated by fitting a model to the data using the Sen's nonparametric model (Sen 1968). The statistical significance of the observed trends is determined using the Mann-Kendall test (Salmi et al. 2002). The Mann-Kendall test is applicable to the detection of a monotonic trend of a time series with no seasonal cycle. The analysis uses a 2-tail test to determine statistical significance at the 90^{th}, 95^{th}, 99^{th}, and 99.9^{th} percentile levels. A trend that is not determined to be significant at the 90^{th} percentile is classified as being "not significant." A trend that is determined to be significant at the 99.9^{th} percentile level indicates that there is a 99.9% probability that the direction of the trend is correct. This methodology was developed by the Finnish Meteorological Institute and is widely used to assess climate changes predicted from weather data. Both the Mann-Kendall test and Sen's Method were applied to the available climate data.

5.4.2.3 Result of Trend Analysis

Rankin Inlet and Baker Lake are located in the Southern Arctic. This region experiences short summers, which are cool and moist, and long winters, which are cold and dry. Annual precipitation is greater in the eastern parts of the zone; notably, Rankin Inlet has greater annual precipitation rates than does Baker Lake.

The historic trends in climate for the annual and seasonal mean temperature and total precipitation were computed for both of the available data sets. The trend analysis returns 2 pieces of information for each climate indices: the climate normal and the climate trend. The climate normal is calculated as the average of a given climate index over the selected period, and the climate trend is calculated as the average change in the climate index per year. The decadal trend (change per decade) is calculated from the yearly trend (change per year).

5.4.2.3.1 Rankin Inlet Analysis

As indicated in Section 5.4.2.1, the Rankin Inlet monitoring station is missing a significant amount of data and, therefore, there is insufficient information to perform a full 30-year climate normal trend analysis for this station. However, the results of the trend analysis for the period from 1981 through 2010 (30 years) may be considered qualitatively (Table 5.4-4). As specified by the QA/QC procedures of the CCCSN, stations with more than 10% of the data missing should not be included for quantitative variation and trend analyses. Given the incomplete record at Rankin Inlet, only climate data from Baker Lake were used for the future climate trend analysis.

The results of the Rankin Inlet trend analysis show that the average annual, spring, and winter temperatures have been experiencing a statistically significant increase (i.e., warming). An increase in winter precipitation was also significant, but this trend was not borne out in other seasons.

Table 5.4-4: Rankin Inlet Trend Analysis Results

Climate Indices	1981 – 2010 average	1981 – 2010 Trend (Change per year)	1981 – 2010 Trend (Change per decade)	Level of Statistical Significance
Annual Total Precipitation [mm (equiv.)]	310.2	+1.33	+13.3	not statistically significant
Spring Total Precipitation [mm (equiv.)]	51.7	+0.33	+3.3	not statistically significant
Summer Total Precipitation [mm (equiv.)]	126.0	-0.26	-2.6	not statistically significant
Fall Total Precipitation [mm (equiv.)]	102.6	+0.50	+5.0	not statistically significant
Winter Total Precipitation [mm (equiv.)]	29.5	+0.63	+6.3	significant at the 99^{th} percentile
Average Annual Temperature [°C]	-10.3	+0.11	+1.1	significant at the 99.9^{th} percentile
Average Spring Temperature [°C]	-15.4	+0.11	+1.1	significant at the 95^{th} percentile
Average Summer Temperature [°C]	8.2	+0.03	+0.3	not statistically significant
Average Fall Temperature [°C]	-5.9	+0.12	+1.2	not statistically significant
Average Winter Temperature [°C]	-28.7	+0.17	+1.7	significant at the 99^{th} percentile

Appendix 5.4-A presents the historic climate analysis for Rankin Inlet and includes plots showing the annual and seasonal mean temperatures and total precipitation from 1981 through 2010.

5.4.2.3.2 Baker Lake Analysis

The results of the Baker Lake trend analysis indicate that only annual and wintertime temperatures have a statistically significant warming trend from 1971 through 2010 (40 years). None of the precipitation indices indicate a statistically significant trend (Table 5.4-5).

Table 5.4-5: Baker Lake Trend Analysis Results

Climate Indices	1971 – 2010 Averages	1971 – 2010 Trend (Change per year)	1971 – 2010 Trend (Change per decade)	Level of Statistical Significance
Annual Total Precipitation [mm (equiv.)]	265.0	-0.22	-2.2	not statistically significant
Spring Total Precipitation [mm (equiv.)]	40.1	-0.05	-0.5	not statistically significant
Summer Total Precipitation [mm (equiv.)]	110.9	+0.06	+0.6	not statistically significant
Fall Total Precipitation [mm (equiv.)]	89.9	-0.20	-2.0	not statistically significant
Winter Total Precipitation [mm (equiv.)]	24.1	-0.12	-1.2	not statistically significant
Average Annual Temperature [°C]	-11.2	+0.06	+0.6	significant at the 99th percentile
Average Spring Temperature [°C]	-16.6	+0.04	+0.4	not statistically significant
Average Summer Temperature [°C]	8.7	+0.02	+0.2	not statistically significant
Average Fall Temperature [°C]	-7.9	+0.06	+0.6	not statistically significant
Average Winter Temperature [°C]	-30.0	+0.11	+1.1	significant at the 99th percentile

Appendix 5.4-B presents the historic climate analysis for Baker Lake and includes plots showing the annual and seasonal mean temperature and total precipitation from 1971 through 2010. The analysis of the 30 year period from 1971 to 2000 was used for the future climate trend analysis.

5.4.2.4 Traditional Knowledge of Climate Change in Nunavut IQ

The Baker Lake and Arviat communities participated in a study to collect Inuit Traditional Knowledge (TK or IQ) on climate change. Experiences were documented using semi-directed interviews, workshops and radio programs. The TK shared by the participants provides a link between scientifically recorded information and how these findings have been interpreted and observed by the Nunavummiut (Government of Nunavut, 2005). The following presents a summary of the TK shared by the participants and provides a comparison with climate historic trend analysis from Baker Lake.

Generally, the traditional six Inuit seasons have been observed by the participants to be changing in duration by changes in the environmental benchmarks and subsistence activities associated with a season. Weather within the seasons has been observed to show greater instability than before with warmer temperatures, stronger winds, wind shifting and changes in storm behaviour. Previously, there were more and longer periods of calm but the wind shifts without intervening calm periods and the wind has been blowing stronger than in the past. A decrease in precipitation has also been observed. Snowfall is occurring later in the year, with a much slower accumulation, while rain and thunderstorms have been much less or absent. All the changes observed by the particpants were reported to be having an impact on the surrounding land, vegetation and animals, such as lower water levels, movement of the treeline northwards, undernourished and diseased species, and loss of species availability for hunting, fishing, and gathering activities. Further, unstable weather has become common, jeopardizing traditional weather forecasting methods (Government of Nunavut, 2005)

The TK observations generally match the historic trend analysis from Baker Lake presented in Section 5.4.2.3.2. A general decrease in precipation is noted in almost all the seasons, although none of the trends are statistically significant. Temperatures are seen to increase, similar to what is indicated by TK, with a statistically significant increasing trend in winter.

5.4.3 Future Climate Change

In 1988, the Intergovernmental Panel on Climate Change (IPCC) was formed by the World Meteorological Organization and the United Nations Environment Program to review international climate change data. A series of improved global climate models have since been developed to respond to the concerns over future climate trends and the impact of human activities on climate (Solomon et al. 2007).

Climate modelling is a complex process that involves the mathematical representation of global land, sea, and atmosphere interactions over a long period. The results of global climate models are subject to many uncertainties and interpretations. The assessment presented herein used various climate scenarios to partially address this concern. In addition, since the models are susceptible to inter-decadal variability, the assessment used the average of 30 years of data, centred on the decade of interest.

The data are presented in following 3 formats in the following sections:

- "Scatter plots" – to show the range in the projected annual absolute change in temperature and precipitation from the current climate normal for all the models;
- "Cloud graphs" – to show the range of the minimum to maximum predictions for each model in comparison to the observed annual variation over the climate normal; and
- 'Histogram" – to show the distribution of the model predictions in comparison to the observed annual data.

5.4.3.1 Global Climate Models

Creating predictions of future climate require the use of sophisticated mathematical computer programs called Global Climate Models (GCMs). Numerous GCMs have been developed by government laboratories and academic institutions around the World. The IPCC has been charged with providing state-of-the-art reviews of climate change science produced by researchers at these international institutions.

Climate simulations produced by these models vary because each model uses a different combination of algorithms to describe and couple Earth's atmospheric, oceanic, and terrestrial processes. Thus, an ensemble approach or combining the results from multiple GCMs provides the best, unbiased approach to evaluating climate change predictions.

The GCMs used in this assessment (Table 5.4-6) are highly regarded, have been validated against observations, and the interpretation of their results has been peered reviewed. Rather than selecting a single model, the climate change projections from all the models were included in the assessment. This ensemble approach is used to delineate the probable range of results and should capture the actual outcome, which is an inherent unknown.

Table 5.4-6: Global Climate Models Used in the Future Climate Trend Assessment

Centre, Country	Models
Bjerknes Centre for Climate, Norway	BCM2.0
Canadian Centre for Climate Modelling and Analysis	CGCM3T47, CGCM3T63
Centre National de Recherches Météorologiques, France	CNRMCM3
Commonwealth Scientific and Industrial Research Organisation, Australia	CSIROMk3, CSIROMk3.5
Max-Planck Institute fuer Meteorologie, Germany	ECHAM5OM
Meteorological Institute, University of Bonn Meteorological Research Institute of KMA Model and Data Group at MPI-M	ECHO-G
State key Laboratory Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics, China	FGOALS-g1.0
Geophysical Fluid Dynamics Laboratory, US	GFDLCM2.0, GFDLCM2.1
Goddard Institute for Space Studies, US	GISS-AOM, GISS-EH, GISS-ER
Met Office, UK	HADCM3, HADGEM1
National Institute of Geophysics and Volcanology, Italy	INGV-SXG-Run1
Institute for Numerical Mathematics, Russia	INMCM3.0-Run1
Institut Pierre Simon Laplace, France	IPSLCM4-Run1
National Institute for Environmental Studies, Japan	MIROC3.2hires, MIROC3.2medres
Meteorological Research Institute, Japan Meteorological Agency, Japan	MRICGCM2.3.2a
National Center for Atmospheric Research, US	NCARCCSM3, NCARPCM

5.4.3.2 Climate Scenarios

Global climate models require extensive inputs to characterize the physical and social developments that could alter climate in the future. To represent the possible wide range in the GCM inputs, IPCC has established a series of socio-economic scenarios that help define the future levels of global GHG emissions. While the IPCC identifies many scenarios, the following 3, namely A1B, A2, and B1, were selected for this study and are the most common scenarios used for impact assessment:

- Scenario A1B — the A1 family of scenarios describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The A1 family includes 3 groups of scenarios that describe alternative directions in the energy system. The A1B group is distinguished by a balance across all sources of energy – green and fossil.
- Scenario A2 — the A2 scenario family describes a world with an underlying theme of self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is regionally oriented and per capita economic growth and technological change are more fragmented and slower than for other scenarios.
- Scenario B1 — the B1 scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter (similar to the A1 scenarios). The B1 family has rapid change in economic structures toward a service and information economy, with reductions in raw material use intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global

solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

Most GCMs (not all) produce the above 3 emission scenarios. The A1B and A2 scenarios represent a focus on economic growth, whereas the B1 scenario represents a shift towards more environmentally conscious solutions to growth. Both scenarios A1B and B1 include a shift towards global solutions, whereas the A2 scenario includes growth based on regional models.

These 3 socio-economic scenarios have been described more fully by IPCC in the Special Report on Emission Scenarios (SRES) (IPCC 2000). Although IPCC has not stated which of these scenarios are most likely to occur, the A2 scenario most closely reflects the current global socio-economic situation. In relation to the A2 scenario, scenarios A1B and B1 result in lower long-term GHG emissions over the next century. Of the A1 scenarios, A1B yields high emissions in the first half of the 21st century due to increasing population and high dependence on fossil fuels for energy.

5.4.3.3 Longer-term Effects of Climate Change

The Project operations are anticipated to last for approximately 15 years, starting in 2015 with closure activities commencing during operations and being completed 2 years after closure. Three periods covered by the IPCC Climate Scenarios, the 2020s, 2050s and the 2080s, were selected for analysis to bound the operations and closure activities. Longer-term effects of climate change (beyond 2100) are highly dependent on the emissions scenario (A1B, A2, B1, etc.) being considered, and are not discussed since they are highly variable and well beyond the scope of the Project.

5.4.3.4 Understanding Climate Projections and Their Limitations

The GCMs used for this assessment have inherent limitations that are important to recognize when evaluating variability and the potential rate of climate change (i.e., when comparing future projections to historical observations). These limitations are dependent on the research institutions' approach to overcoming model uncertainty. Since no one model or climate scenario can be viewed as completely accurate, the IPCC recommends that climate change assessments use as many models and climate scenarios as possible. For this reason, the ensemble approach described above was used for this assessment.

The following provides a brief discussion on model limitations in the context of spatial and temporal scales, unpredictability, changes to our understanding of climate change drivers and processes, and variations in the baseline selected for comparison.

5.4.3.4.1 Scale

Due to limitations on computing power, GCM outputs are limited to grid cells of 1^{o} to 2.5^{o} (approximately 110 to 275 km) and a small number of vertical layers in the atmosphere. The grid cells represent a mathematically defined "region" and differ between many the models. Although the appropriate grid cell was selected from each model to represent the Project location, the scale of the cell is much larger than that of weather processes (e.g., convective thunder storms), and local changes in topography cannot be represented at this scale.

Temporally the GCMs simulations are run at monthly time scales and only monthly average temperature and precipitation are available as outputs.

The process of "downscaling" is a method to overcome limitations on scale. Downscaling may decrease uncertainty for regions where the regional topography and/or geography is complex compared to the GCM grid-scale, or where diurnal fluctuations in local meteorology are important. While this technique can improve comparisons between historical observations and simulations of past climate for a specific GCM model, it does not address uncertainty in the models as noted in the following sections.

5.4.3.4.2 Unpredictable Events

Climate model simulations represent average conditions and typically do not consider the influence of inherently unpredictable "stochastic" or episodic events (e.g., volcanic eruptions, earthquakes, and tsunamis). In other words, events of a certain magnitude tend to occur at a certain frequency; however, their actual magnitude and timing is unknown and are not currently predictable within a specific GCMs' model outputs.

Though large events are rare, they have the potential to invalidate climate model projections both globally and regionally. For example, the 1991 eruption of Mount Pinatubo is well known to have decreased the average planetary surface temperature by ~1 ^{o}C for at least 1 year; a significant offset to predictions of ~3 ^{o}C of warming over the next century. The Pinatubo eruption ranks as a 6 of 8 on the logarithmic-based volcanic explosivity index, and events such as Pinatubo have return periods on the order of 100 years. Larger events have return periods of 1000 years or more; however, their plumes can reach altitudes of greater than 40 km and inject sufficient amounts of sulphur into the stratosphere to suppress global temperature from years to decades (Robock et al. 2009).

5.4.3.4.3 Changes to our Understanding of the Processes

The Earth's system process and feedbacks are very complex and, therefore, have to be approximated into the model simulations. Mathematical parameterizations of these processes are required to reduce the computational burden within the simulations. Each of the independent processes that drive climate change can be assigned a rank based on the current level of scientific understanding (LOSU). For example, the contribution of aerosols to climate change were ranked as a very-low LOSU in the 2001 IPCC report (IPCC 2001) and were upgraded to a medium to low LOSU in the 2007 IPCC report.

In addition, new discoveries can change the inputs to GCMs and the interrelationship of these drivers within GCMs. For example, the 1988 discovery of *Prochlorococcus,* the most abundant photosynthetic organism in the ocean, lead to change in the understanding of ocean biology, the carbon cycle, and atmospheric CO_2 (Chisholm et al. 1988). Similarly, the 2001 discovery of ubiquitous atmospheric N_2-fixation by the marine cyanobacterium *Trichodesmium* changed the understanding of the effects of ocean biology and our understanding of the Earth's nitrogen cycle (Berman-Frank et al. 2001).

5.4.3.4.4 Variation in Baseline Normal

In keeping with accepted climate practices, the description of historical climate was based on the 30 year period from 1971 to 2000, and the climate normals from this period were compared to the climate change projections to assess the significance of the potential change. However, it should be noted that the potential changes identified are dependent on length of period selected for comparison. For example, Chen and Grasby (2009) note that analyses of hydro-meteorological time series have identified decadal and inter-decadal quasi-cyclic oscillations, and that these natural variations can affect Mann-Kendall tests such as those presented herein. Chen and Grasby further recommend that trend analysis for hydro-meteorological time series be restricted to data sets with records >60 years due to the predominance of 45 to 60-year climate cycles observed in instrumental records.

Longer term data from local stations were not available for this assessment. Therefore, the results of the trend analysis presented herein should be interpreted with the understanding that they may be influenced by natural large scale decadal and inter-decadal quasi-cyclic oscillations.

5.4.3.5 Climate Projections for Baker Lake

Climate forecast data for Baker Lake (i.e., for the appropriate GCM grid square) were extracted from the CCCSN website (http://www.cccsn.ec.gc.ca/, accessed 14 May 2012) for all available GCMs (24) and the 3 forecast scenarios (A1B, A2, and B1), and were summarized for trend and magnitude of change from the climate normal baseline for the following 3 time horizons:

- 2011 to 2040 (noted as the 2020s);
- 2041 to 2070 (noted as 2050s); and
- 2071 to 2100 (noted as 2080s).

To graphically represent the individual model output in a comparable and meaningful way, the data must have a consistent baseline. For each model, the change in temperature and precipitation was calculated relative to the respective modelled baseline values, which are unique to each model. This change was then imposed onto the historic climate baseline for Baker Lake.

The following sections summarize the trend and magnitude of model predicted change during the 2020s, 2050s and 2080s from the climate normal baseline.

5.4.3.5.1 Scatter Plot Assessment

Scatter plot assessment is used to allow comparison between the range of future model forecasts. When model results are clustered very close together, this shows a greater consistency between the various GCMs and scenario assessments. Conversely, when the grouping is more spread out or divergent, and members are in 2 or 3 quadrants, confidence is lower in the outcome of the future projections.

Figure 5.4-2 presents a scatter plot showing the annual absolute change for temperature and precipitation from all available model projections for the 3 scenarios discussed in section 5.4.3.2 for the period 2011-2040 (2020s). The grouping of model projection scenarios indicates that all of the GCMs forecast a warmer and wetter climate for the projection period of 2011-2040 (2020s). The GCM outputs provide similar results for the period 2041-

2070 (2050s) and 2071-2100 (2080s; Figures 5.4-3 and 5.4-4) with an increasing range in the model outputs. This shows that the 2020s are bounded by the later model periods. However, the GCMs predict a different future climate than the climate projected from historic observations. Historic observations suggest a trend towards a warmer and drier climate (as shown by the black diamond in Figure 5.4-2). The climate normal is represented by the intersection of the axes.

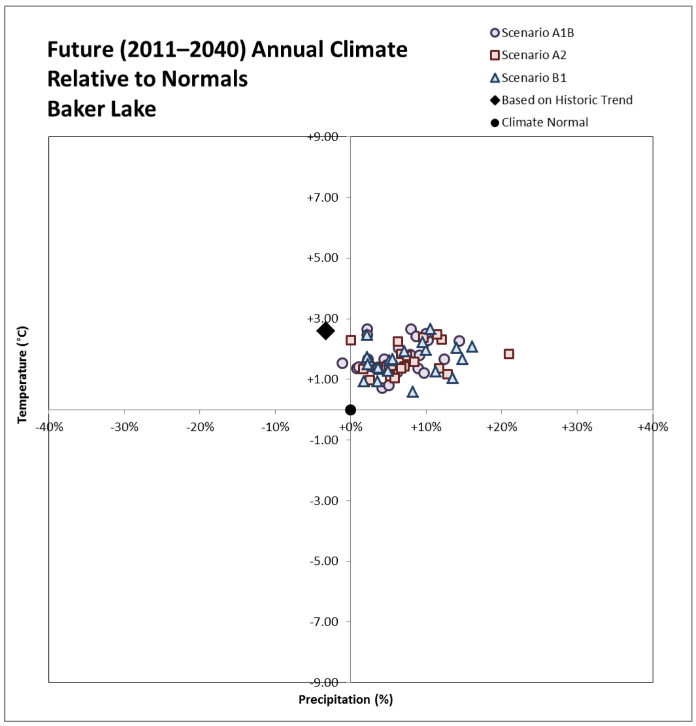


Figure 5.4-2: 1971-2000 to 2011-2040 (2020s) Annual Absolute Change for Baker Lake

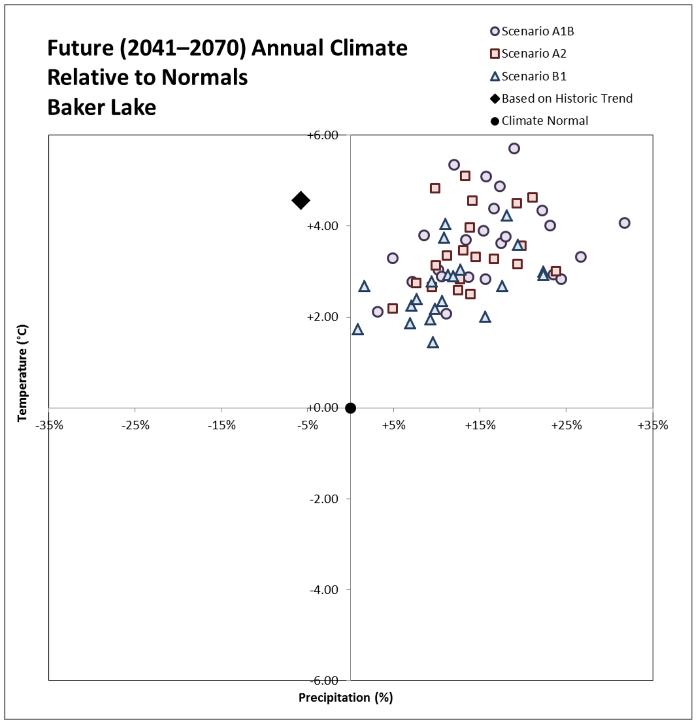


Figure 5.4-3: 1971-2000 to 2041-2070 (2050s) Annual Absolute Change for Baker Lake

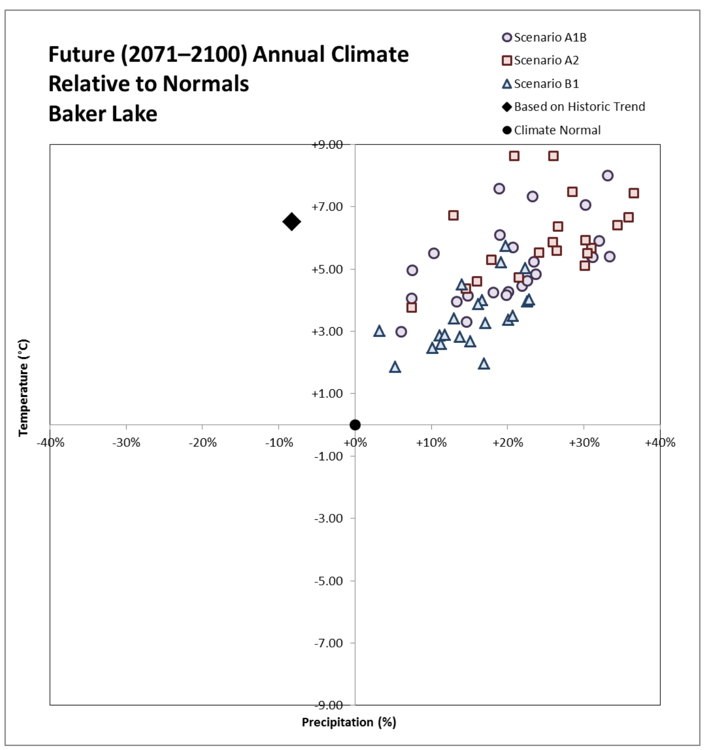


Figure 5.4-4: 1971-2000 to 2071-2100 (2080s) Annual Absolute Change for Baker Lake

5.4.3.5.2 Cloud Graph Assessment

To allow comparison between a range of historic observations and future forecasts, changes in climate are also presented as a time series of the range of model forecasts. This time series is called a "cloud" graph, as it shows a shaded area covering the range from the minimum to maximum forecast for each point in the time series.

Figures 5.4-5 to 5.4-7 provide a cloud graph showing the model forecast range for annual temperature for the 2020, 2050s and 2080s, respectively. The historic observations and historic normal are overlaid on the figures to provide context. The shaded area shows the range covered by the individual annual forecasts. The absolute maximum (100th percentile) and absolute minimum (zero percentile) of the modelled forecast values are also shown. Differences between the range of the historic observations and the future forecast cloud indicate projected changes in climate. If the historic observations are not well captured by the cloud of model forecasts, any infrastructure designed for the historic range may become vulnerable in the future. For Baker Lake, the cloud of model forecasts indicates an increase in annual temperatures compared to the historic record. The overall range of the cloud is higher than the range of the historic observations (1971-2000) for the 2080s, but are similar for the 2020s with the 2050 falling within these ranges.

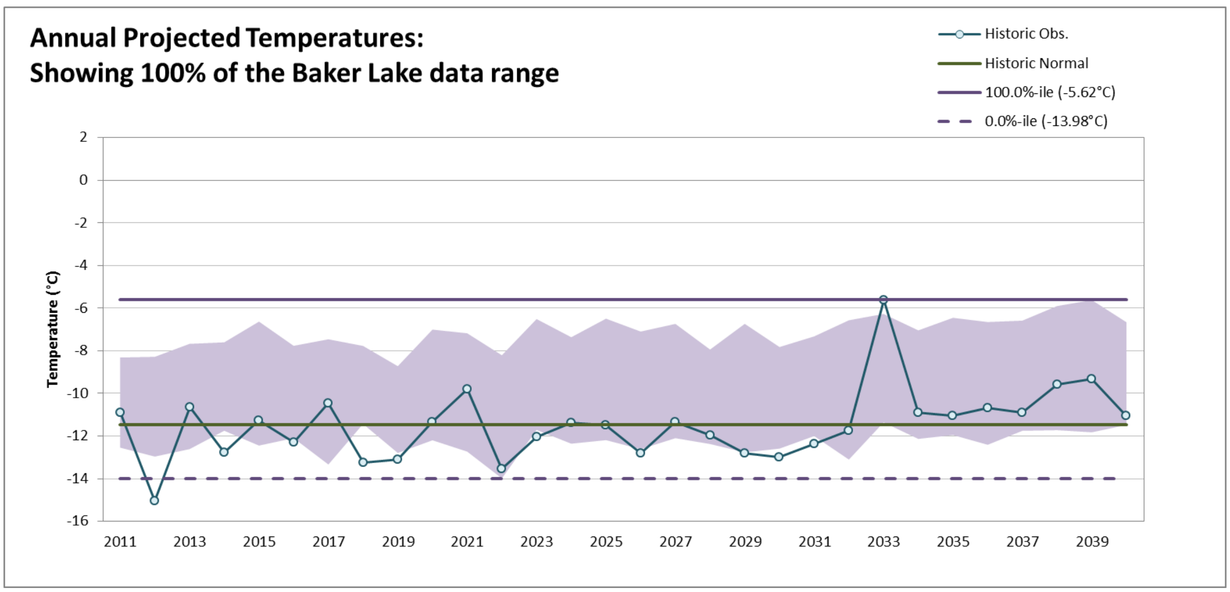


Figure 5.4-5: Annual Projected Temperature for Baker Lake for 2011-2040 (2020s)

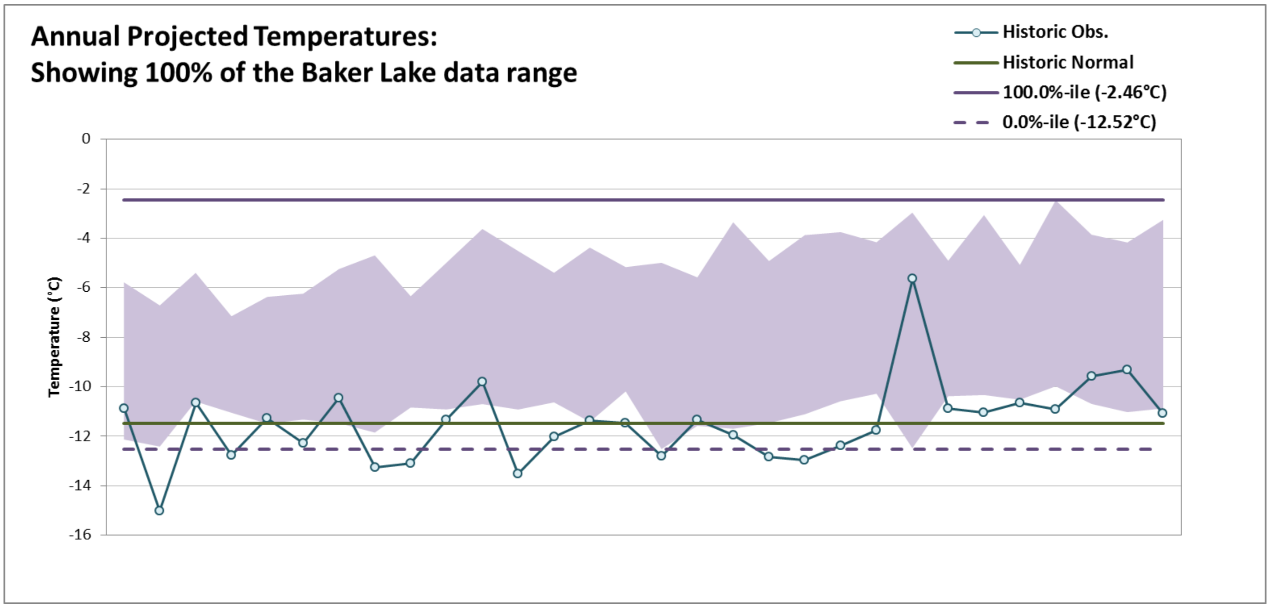


Figure 5.4-6: Annual Projected Temperature for Baker Lake for 2041-2070 (2050s)

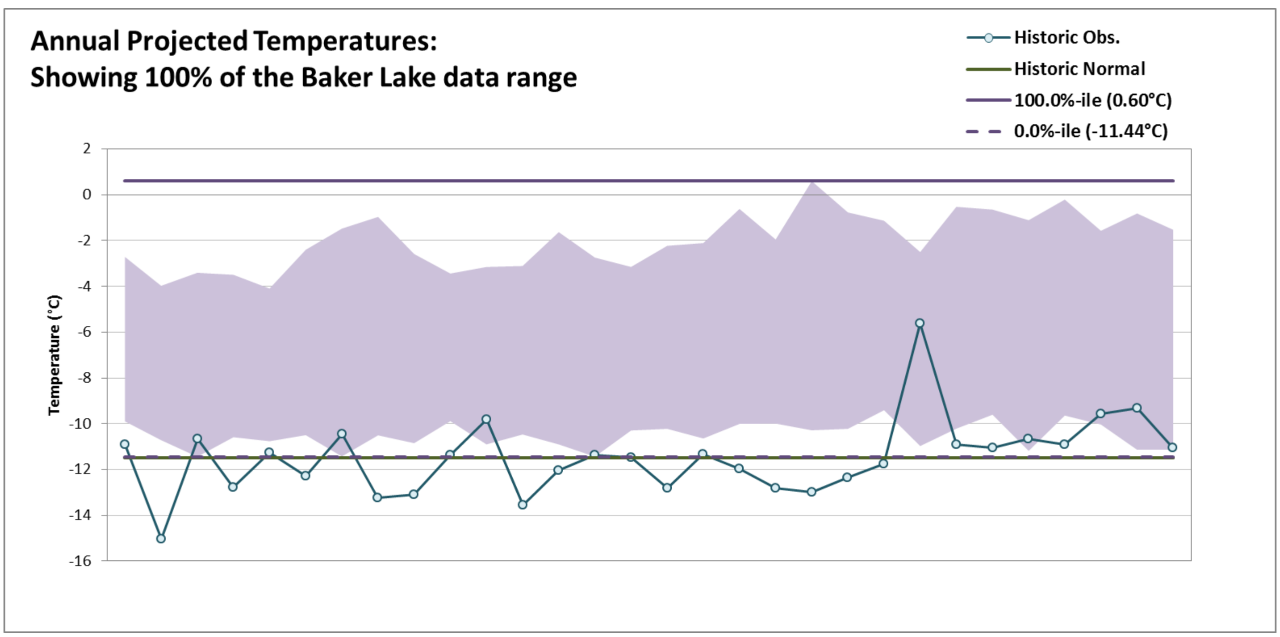


Figure 5.4-7: Annual Projected Temperature for Baker Lake for 2071-2100 (2080s)

Figures 5.4-8 to 5.4-10 provide cloud graphs showing the model forecast range (the shaded area) for annual precipitation, as well as the maximum and minimum of the annual forecasts, for the 2020s, 2050s and 2080s, respectively. The historic observations and normals for the 1971-2000 period are overlaid on the figures for comparison. GCM results suggest that total annual precipitation for Baker Lake may not likely change significantly in the future relatively to the observed climate over the past 30 years. This is evident from the figures, as the range of the forecasts encompasses nearly all the past observations.

The percentiles are included on these figures to show the range of projections not to imply a confidence interval in accuracy of the data.

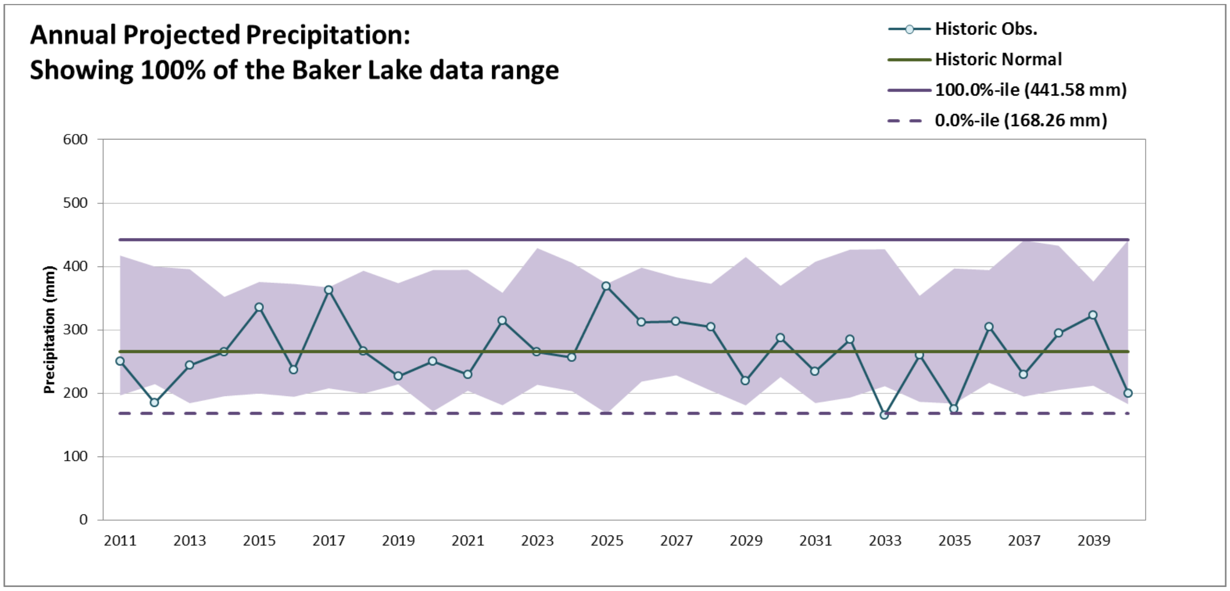


Figure 5.4-8: Annual Projected Precipitation for Baker Lake for 2011-2040 (2020s)

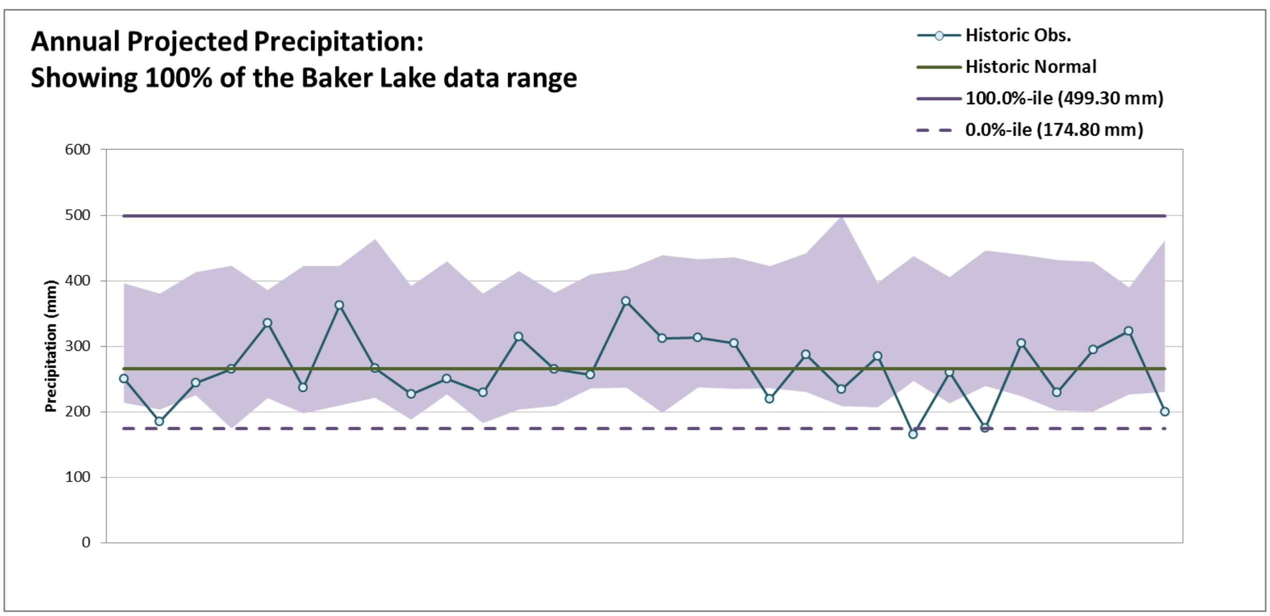


Figure 5.4-9: Annual Projected Precipitation for Baker Lake for 2041-2070 (2050s)

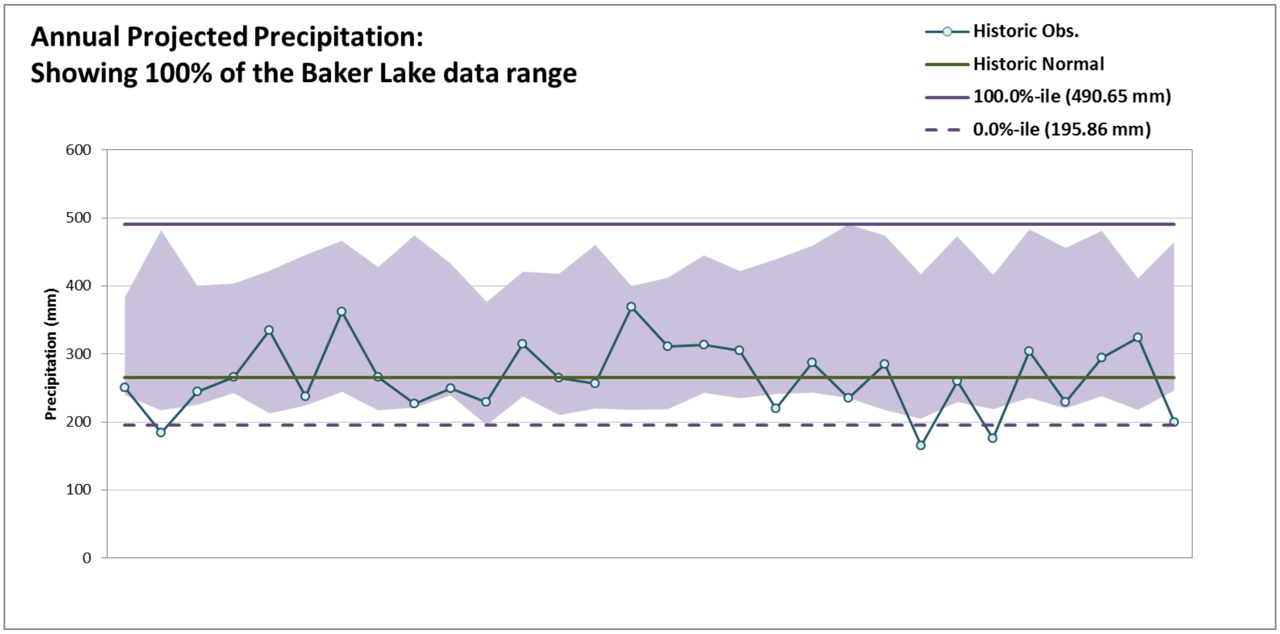


Figure 5.4-10: Annual Projected Precipitation for Baker Lake for 2071-2100 (2080s)

5.4.3.5.3 Histogram Assessment

The number of times that the models forecast temperatures or precipitation amounts that fall within a certain range can be shown graphically. Such a graph is called a histogram. The height of each bar in the histogram indicates how often the models forecast values (i.e., temperatures or precipitation) that fall into the ranges shown below the bottom axis. The higher a bar, the more often values in that range were forecasted by the models.

Figures 5.4-11 through 5.4-13 provide histograms for annual temperature and precipitation in Baker Lake for all future projections for the 2020s, 2050s and 2080s. The figures also show a dashed line, which represents the normalized distribution of the model forecasts. The distribution is a theoretical curve representing how often forecast temperature (or precipitation) is expected to occur. The forecast distributions and forecast data in the figures show good agreement. The solid line in the figures represents the distribution of historic weather observations based on data from 1971 to 2000. The projected and historic distributions represent normal probability curves mathematically fitted to the forecast and historic data sets. For display purposes, these distributions have been exaggerated vertically to facilitate comparison with the histogram bars.

Figures 5.4-11 shows a noticeable difference between the forecast distribution and the historic distribution of annual temperature, with forecast temperatures being approximately 1.5 to 2.0 °C higher during the 2020s. Similarly the forecast temperatures are approximately 3.0 to 3.5 °C and 4.5 to 5 C higher during the 2050s and 2080s, respectively (Figures 5.4-12 and 5.4-13).

Figure 5.4-14 show a noticeable difference between the forecast and historic distributions of precipitation, with annual forecast amounts being approximately 20 to 40 mm higher during the 2020s. Similarly the forecast precipitation is approximately 30 to 50 mm and 35 to 55 mm higher during the 2050s and 2080s, respectively (Figures 5.4-15 and 5.4-16).

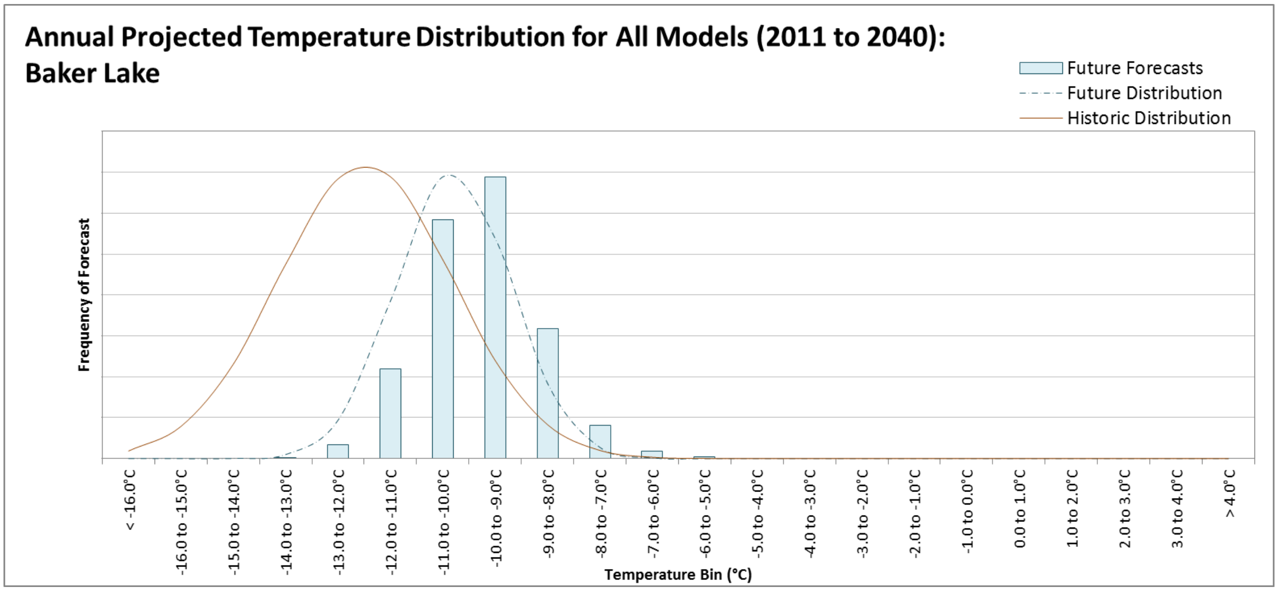


Figure 5.4-11: Annual Projected Temperature Distribution for all GCMs for Baker Lake for the 2020s

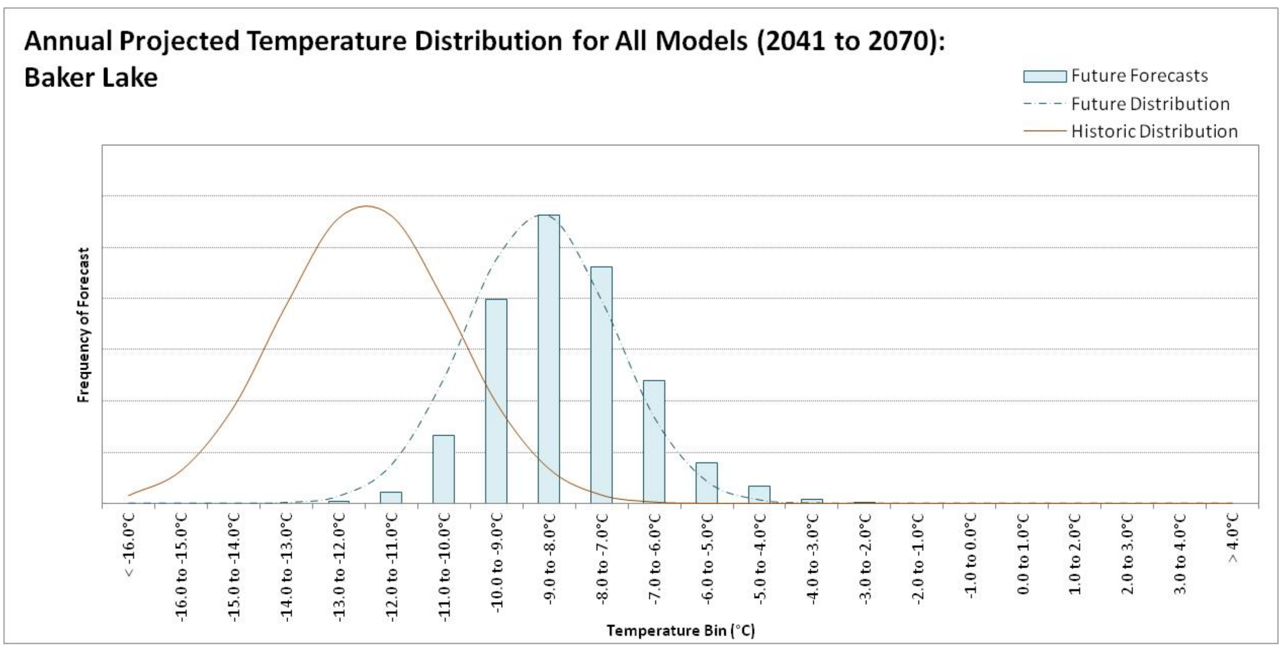


Figure 5.4-12: Annual Projected Temperature Distribution for all GCMs for Baker Lake for the 2050s)

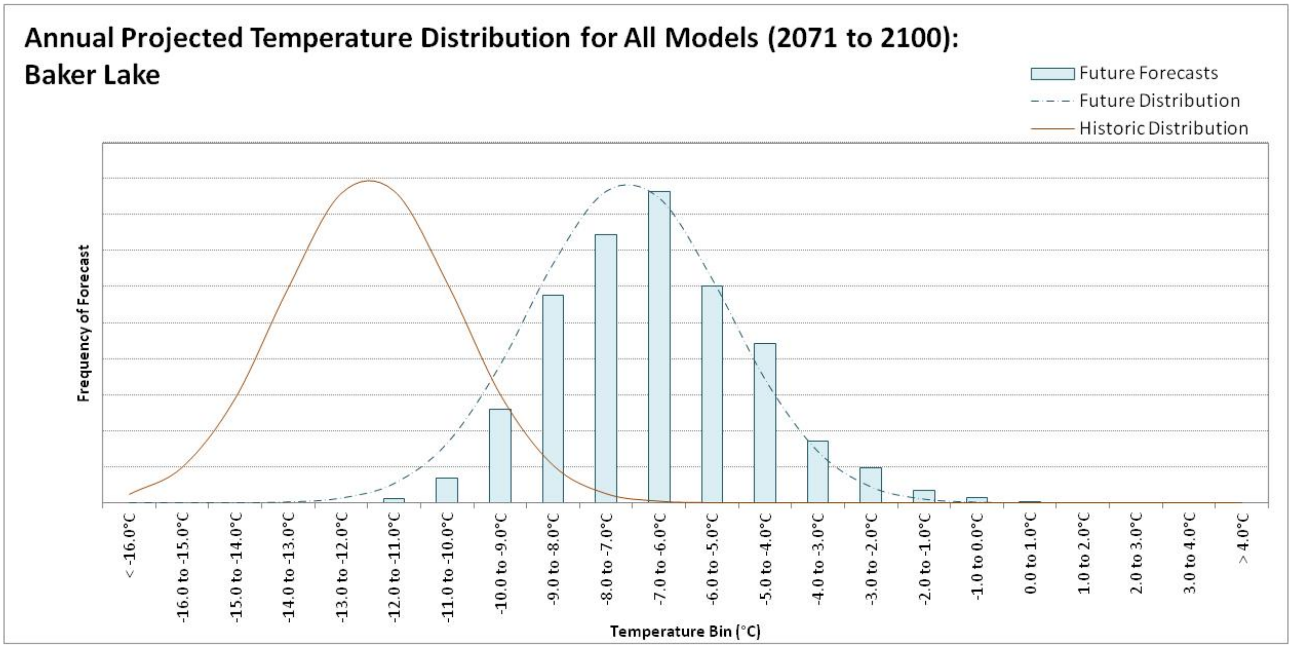


Figure 5.4-13: Annual Projected Temperature Distribution for all GCMs for Baker Lake for the 2080s)

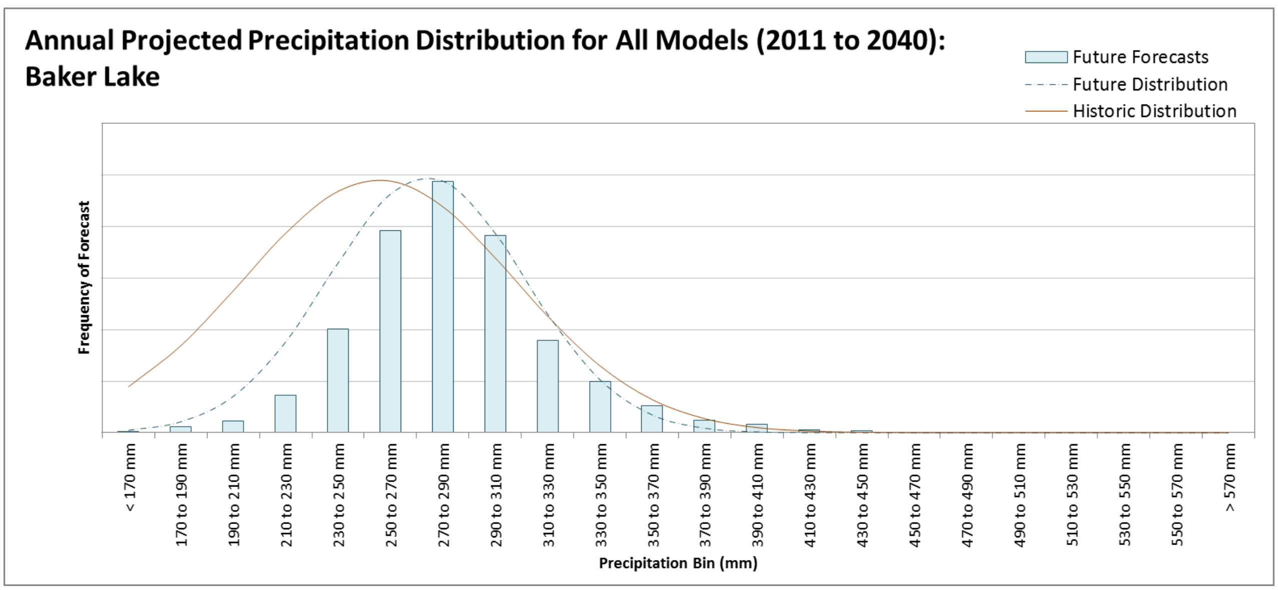


Figure 5.4-14: Annual Projected Precipitation Distribution for all GCMs for Baker Lake for the 2020s

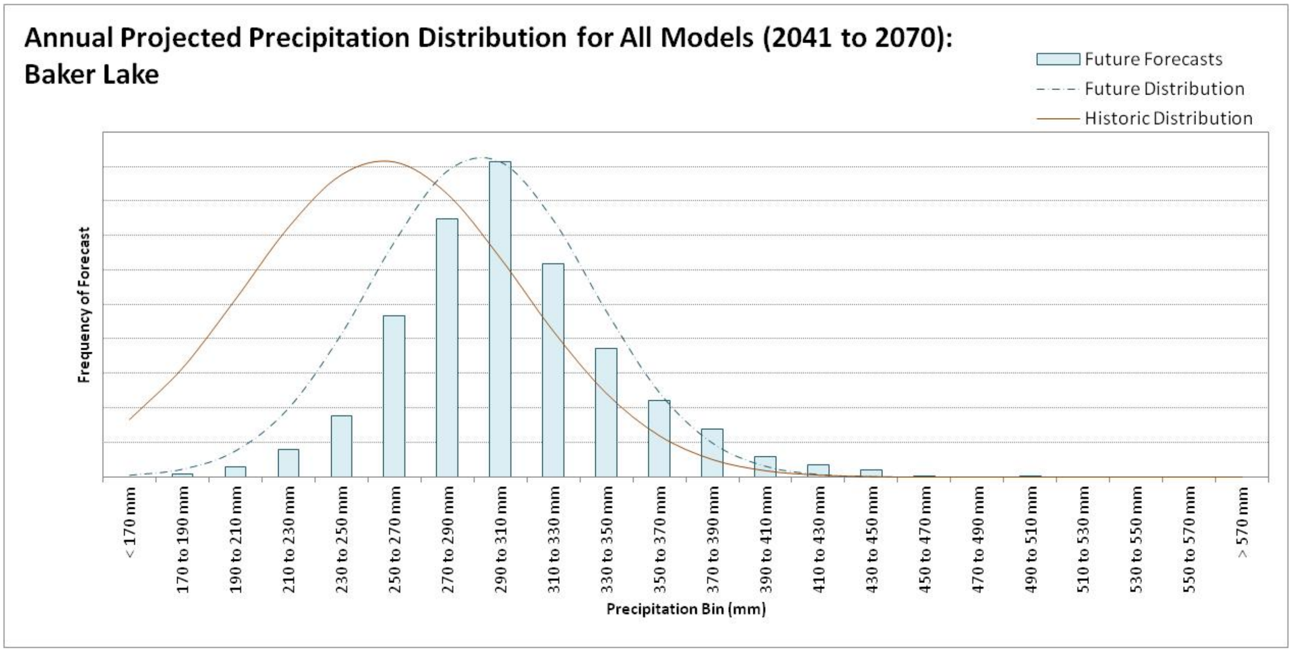


Figure 5.4-15: Annual Projected Precipitation Distribution for all GCMs for Baker Lake for the 2050s

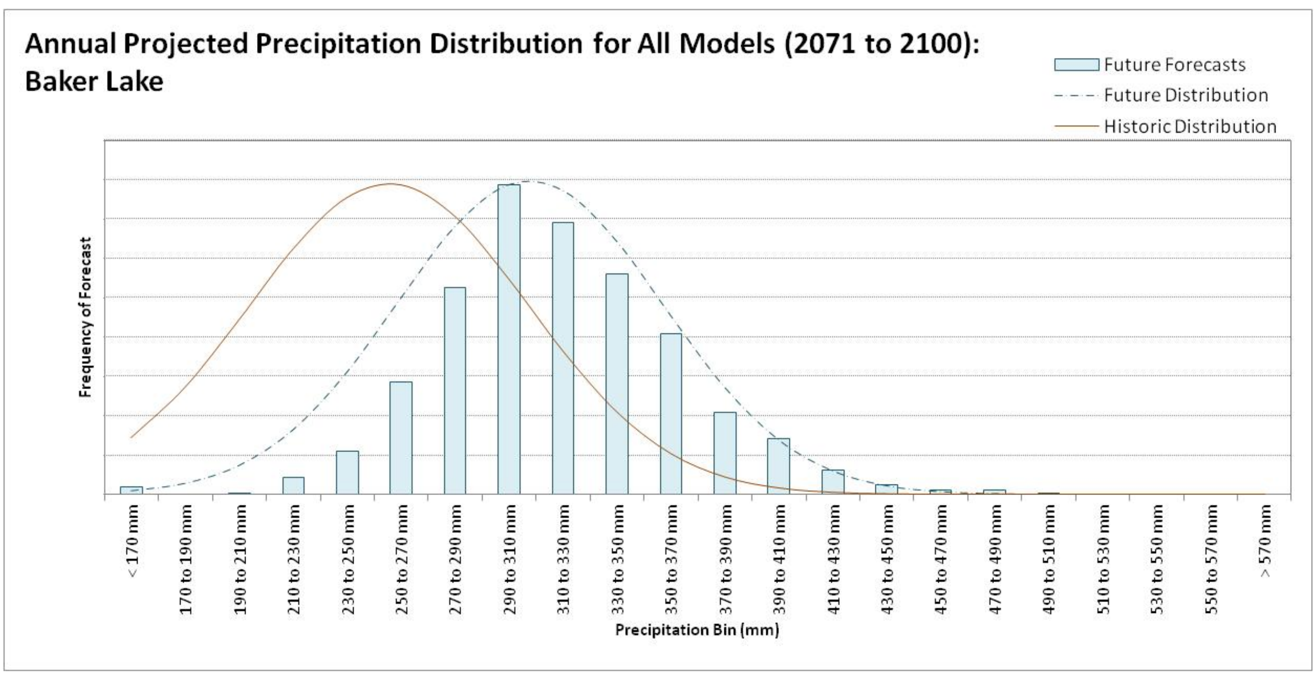


Figure 5.4-16: Annual Projected Precipitation Distribution for all GCMs for Baker Lake for the 2080s

5.4.3.5.4 Summary of Climate Trends

In general, the climate in the Project region is projected to be warmer for the 2020s, 2050s and 2080s time horizons when compared to the observed historic values. Precipitation shows a larger per cent increase compared to historical values, but the majority of projections are not significantly different from the annual recorded precipitation values. In general, by the 2080s, the fall and winter periods show the largest projected increases in temperature, whereas the fall and summer show the largest increases in precipitation.

The average projected climate trend deviations from the observed historic values are provided in Table 5.4-7. The deviations are calculated as the shift in the peak of the normal distribution of the historic dataset to the future forecasts in the histograms for the given periods of interest.

Table 5.4-7: Summary of Average Projected Climate Trend Deviations from Observed Historic Values

Station & Period			Temperature [°C]	Precipitation [mm (equiv.)]
Baker Lake	2020s	Annual	+ 1.5 to 2.0	+ 20 to 40
		Spring	+ 2 to 2.5	+ 5 to 10
		Summer	+ 1 to 1.5	+ 10 to 15
		Fall	+ 2 to 2.5	+ 10 to 15
		Winter	+ 2 to 2.5	+ 5 to 10
	2050s	Annual	+ 3 to 3.5	+ 30 to 50
		Spring	+ 3 to 3.5	+ 5 to 10
		Summer	+ 2 to 2.5	+ 10 to 15
		Fall	+ 3 to 3.5	+ 15 to 20
		Winter	+ 4.5 to 5	+ 0 to 5
	2080s	Annual	+ 4.5 to 5	+ 35 to 55
		Spring	+ 4 to 4.5	+ 5 to 10
		Summer	+ 2 to 2.5	+ 10 to15
		Fall	+ 5 to 5.5	+ 15 to 20
		Winter	+ 7 to 7.5	+ 5 to 10

5.4.4 Climate and Project Infrastructure Interactions

Climate change may result in an environment that is different from the current environment; less severe winters, changing precipitation patterns or other considerations may impact future operations and effect the operation of infrastructure associated with the Project.

A qualitative assessment of how the Project may affect global climate change, and how the changing climate may affect Project aspects, was completed. Table 5.4-8 presents a climate risk matrix for the Project for the 2050s and 2080s, based on the Climate Trends described above. This table identifies those climate change risk factors that may impact the Project, those that are unlikely to have an impact on the Project, and those for which the potential impact on the Project is unknown.

Table 5.4-8: Climate Risk Matrix

Climate Factor Description		Trend	Comments on Future Trends
Rain	Drought	Increase	Likely increase according to the IPCC (Solomon et al., 2007) Summer droughts may increase due to higher temperatures (ACIA, 2005)
Rain	Amount of rain	Increase	Increase in mean annual precipitation, greatest in autumn and winter, smallest in summer (ACIA, 2005).
Rain	Frequency of rain	Increase	Likely increase in frequency and/or duration of wet periods (ACIA, 2005)
Rain	Amount of rainfall per event	Increase	Rainfall is likely to become very heavy (Solomon et. al., 2007)
Snow	Changes in snowfall	Variable	Shorter snow season leading to substantial decrease in snow; higher temperatures likely to contribute to acceleration of hydrological cycle and increase in snowfall in regions consistently below freezing (ACIA, 2005).
Snow	Changes in snowpack	Decrease	Decrease in duration of snow cover (earlier disappearance); decrease in terrestrial snow extents; decrease in areal coverage of snow; possible decrease in snow depth (ACIA, 2005)
Temperature	Freeze-thaw events	Increase	Increased frequency of freeze-thaw cycles and freezing rain events (ACIA, 2005)
Temperature	High temperatures	Increase	Increase in average surface air temperatures by amounts greater than average global temperature increases; greater increase at high northern latitudes (ACIA, 2005)
Temperature	Warmer winters	Increase	Continuation of strong warming trend; largest changes in winter months; average winter temperatures projected to rise 3 to 5°C over most arctic land areas (ACIA, 2005)
Other Events	Extreme events (e.g., tornados)	Increase	Increase in flood events likely if increased precipitation during winter accelerates ice breakup; enhanced precipitation and an increase in precipitation due to increased evapotranspiration, is likely to increase river levels and flooding risk (ACIA, 2005)
Other Events	Rainfall on snowpack	Decrease	Projected increases in temperature will decrease the time for snowpack accumulation (Lemmen et al., 2008)
Other Events	Ice storms	Increase	May become more frequent in association with milder winters (Lemmon and Warren, 2004)
Other Events	Changes in evaporation	Increase	Increase predicted throughout the Arctic with little change in the Atlantic sector where there is little increase in the sea surface temepraturе. Increased evaportation rates may lead to decreases in water levels, imparing pathways for fish migration and movement (ACIA, 2005).
Other Events	Changes in evapotranspiration	Increase	Increase due to projected temperature increases; could result in drying of soils during warm season, lower water levels during summer affecting river navigation, hydropower generation, and resulting in an increase threat from forest fires (ACIA, 2005)
Other Events	Ice condition	Thinning; decrease	Retreat and thinning of sea ice; reduced ice cover and thickness; decrease of summer sea ice by more than 50% over the 21st century (ACIA, 2005)
Wind	Wind speeds	Decrease	Decrease in surface wind speeds and a weakening of large scale circulation patterns (Blunden and Arndt, 2013)
Wind	Occurrences of wind	Increase	Increase in wind over northern waterbodies (Yao et. Al., 2012) and a weakening of large scale circulation patterns (Blunden and Arndt, 2013).

The Project does not rely on an ice road or other highly weather-related infrastructure for its operations. Specific interactions between the climate risk factors and Project infrastructure or operations are discussed in the individual impact assessment and supporting documents to the FEIS. The following sections highlight the significant climate infrastructure interactions.

5.4.4.1 Future Sea-level Rise and Coastal Erosion

With melting polar ice due to increased temperatures, it is predicted that sea levels will continue to rise and there is a possibility of increased or changing coastal erosion. The Project site is located approximately 25 km from the shore of Hudson Bay, therefore changes in sea-level and coastal erosion dynamics are not likely to impact the site directly. Since the Project will involve inbound and outbound shipping of fuel and product. However, these potential impacts could become important climate-related considerations at Rankin Inlet.

These impacts have been considered in the marine environment impact assessment (FEIS Volume 8, Section 8.3.9).

5.4.4.1.1 Changing Sea Levels and Sea Ice

Recent studies for Canada showed that relative sea-level at 2 communities on the western shore of Hudson Bay, namely Whale Cove and Arviat (Figure 5.4-1), has been falling in recent millennia (James 2012; James et al. 2011). A regional increase in local elevation is the result of glacial isostatic adjustment due to the retreat of the large ice sheets at the end of the last Ice Age.

There have been substantial revisions to global estimates of sea level rise since the 2007 publication of the IPCC report. These revisions generally include higher rates of sea level rise and typically display better agreement when compared to historical observations (e.g., Domingues et al. 2008). The analysis by James et al. (2011) consider some of these new results and choose +15 to +196 centimetres (cm) as the minimum and maximum range of global sea level rise by 2100, and +28 to +115 cm as the probable range. When combined with local rates of positive glacial isostatic adjustment, the probable range of sea-level changes for Arviat and Whale Cove is estimated by James et al. at -55 to +5 cm. However, other independent peer-reviewed studies not considered by James et al. suggest that the probable increase in sea-level by 2100 is closer to 160 cm (e.g., Church et al. 2004; Church and White 2006; Domingues et al. 2008). This value lies between the largest “probable” value and the maximum value of 196 cm considered by James et al. Thus “probable” sea level rise at the communities of Arviat and Whale Cove could be as high as -10 to +50 cm by 2100.

In addition, detailed analysis during the recent (2007/2008) International Polar Year has improved estimates of historical sea level rise due to collapses of the West Antarctic ice sheet (WAIS). While highly improbable (a 5% probability of the WAIS contributing 10 mm/year within 200 years), under fast-melt scenarios, the WAIS could contribute up to an additional 6.4 mm/year of sea level rise (Bamber et al. 2009).

Sea ice extent (or coverage) has been found to be decreasing since the 1970s. The 2007 IPCC report acknowledged that *“Arctic sea ice is likely to decrease in its extent and thickness. It is uncertain how the Arctic Ocean circulation will change”* (Christensen et al. 2007). Sea level and sea ice changes have the potential to affect marine operations at Rankin Inlet, potentially impacting the Project.

5.4.4.1.2 Changes in Coastal Erosion Dynamics

A recent report describes the circumpolar coastal zone as experiencing the "most rapid and severe environmental changes, which have serious implications for communities living on coastal resources" (Forbes 2011). In a recent review on Arctic coastal geomorphology in a warming climate, Strzelecki (2011) notes that climate change induced reductions in sea ice extent and duration, changes in the hydrological cycle, and, therefore, sediment transport in the coastal zone when combined with changes in sea level, have important but poorly understood implications for Arctic coastlines. Depending on whether the coastline is rocky, composed of poorly sorted glacial till, or tidal flats underlain by permafrost, the effects of climate change on coastlines can be profound. Strzelecki notes that longer ice-free conditions can lead to larger wind fetch over the ocean, creating higher surf in the coastal zone. This can result in a transition from ice-dominated dynamics to a regime dominated by wave dynamics and can enhance coastal erosion and affect sediment transport in coastal areas. Formation of durable "storm ridges" in the coastal zone can also lead to impoundment of water at river mouths and flooding of low-lying areas.

5.4.4.2 Permafrost

Increasing average temperatures and more frequent freeze thaw cycles have the potential to affect the land on which the Project is situated. The Project site is in a zone where most of the land is either bare rock or is frozen into permafrost.

The factors affecting permafrost can be broadly divided into 2 groups: climatic and terrain. Climatic factors that control the rate and duration of heat transfer to the ground surface include latitude, snow cover, temperature, cold air drainage, and temperature inversions. Terrain factors modify climatic factors and control permafrost distribution along the southern border of the permafrost zone.

The upper layer of the permafrost is the active layer, which thaws in summer and freezes in winter each year. In summer, it tends to produce a wet surface, since the underlying frozen layers prevent water from the melting snow and ground-ice from percolating downward to any great extent. Beneath the active layer is the upper surface of the permafrost, called the permafrost table. Changes in annual temperature could impact the active layer thickness and the depth of the permafrost table.

These potential changes are most likely to impact the closure phase of the Project and have been considered in FEIS Volume 6, Section 6.3 Permafrost.

5.4.5 Effects of the Project on Climate Change

The Project may also contribute to potential changes in climate (e.g., through changes in the levels of GHG emissions emitted to the atmosphere due to the Project).

5.4.5.1 Direct GHG emissions

The Project will emit GHGs from combustion sources related to production, heating, and transportation. A detailed assessment of the GHG emissions is provided in Appendix 5.2-A – Air Emission Details.

5.4.5.2 Indirect GHG emissions

Changes in land use can also be a source of indirect GHG emissions. As the Project is located in a tundra area underlain by permafrost, it will not involve the clearing of trees or substantial amounts of growing vegetation, which would remove a quantity of carbon from storage. Therefore, the Project will have negligible indirect GHG emissions.

5.4.5.3 Comparison of Project Greenhouse Gas Emissions to Canadian Emissions

The following table summarizes the estimated annual direct GHG emissions in kilotonnes (kt) of CO_2 equivalents (CO_2e) from the Mine Site and additional marine operations at Rankin Inlet due to the Project. Total GHG emissions from the Mine Site have been conservatively estimated to be not more than 304 kt/yr of CO_2e. Estimated GHG emissions from the additional marine operations at Rankin Inlet are approximately 13 kilotonnes annually.

For comparison purposes, the 2010 annual GHG emissions for Northwest Territories and Nunavut, as well as for Canada are also provided in Table 5.4-9. The direct Project emissions represent approximately 75% of the Nunavut GHG inventory for 2010[1] or 0.05% of the Canadian inventory for that same year.[2] This comparison is extremely conservative as the estimated emissions from the Project are based on maximum values that consider all sources operating at maximum capacity; the emmissions will be much less in reality. The reported values taken from the National Inventory Report on GHG sources and sinks in Canada are based on actual reported values.

Table 5.4-9: Comparison of Project GHG Emissions to Global Emissions

Source	Annual GHG Emissions (kt CO_2e/yr)	Project as a Relative Percentage
Meliadine Site (Operations)	304	-
Rankin Inlet shipping (Operations)	13	
Indirect Emissions	negligible	
Project Total	317	
Nunavut (2010)	422	75%
Canada (2010)	692 000	0.05%

5.4.5.4 Comparison of Project GHG Emissions to Global Emissions

A review of literature from the IPCC confirms that the majority of scientists feel that there is compelling evidence to link observed and forecast changes in climate to the release of man-made greenhouse gas emissions. However, the FPTCCCEA (2003) indicates that "…unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured."

To illustrate this, the GHG emissions associated with the Project are compared in Table 5.4-10 to the 2000 global GHG emissions associated with the forecast changes in climate expected over the Project life. The comparison reasonably supports the conclusion that the GHG emissions from the Project will not have a measurable effect on climate. Therefore, the potential effect of the Project on climate is considered to be negligible.

[1] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/7383.php (acessed December 19, 2013)

[2] http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=BFB1B398-1 (accessed 27 August 2012)

Table 5.4-10: Comparison of Project GHG Emissions to Changes used in the IPPC models

Parameter	SRES Scenario A1B	SRES Scenario A2	SRES Scenario B1	Project
Change in GHG emissions relative to the 2000 global baseline [a]	+59.7%	+109.3%	+18.6%	+0.0019%
Change in annual temperature for the 2041 to 2070 horizon [b]	+3 – 3.5 °C			Cannot be measured [c]
Change in annual precipitation for the 2041 to 2070 horizon [b]	+30 – 50 mm (or +11 – 18%)			Cannot be measured [d]

[a] The global baseline emissions for 2000 were listed by the IPCC as 16,927 MT CO_2e (Nakicenovic and Swart 2000)

[b] Changes were calculated as the difference between the baseline and scenario forecasts for the 2041 to 2070 time horizon. Changes are shown for the ensemble results rather than per scenario discussed in Section 5.4.3.5.

[c] On the basis of proportionality, the GHG emissions from the Project could represent an increase of less than 0.00007 °C in the annual temperature. Such a change would not be measurable.

[d] On the basis of proportionality, the GHG emissions from the Project could represent an increase of less than 0.0004% in the annual precipitation. Such a change would not be measurable.

5.4.6 Conclusions

This assessment identified how climate change may affect Project infrastructure and which aspects of the Project may need to be assessed in greater detail because of a potential changing climate.

Potential future effects of a changing climate on the Project include the following:

- Changing sea ice conditions, sea level rise, and coastal erosion may impact the harbour at Rankin Inlet, thereby affecting marine operations, possibly impacting the movement of fuel and equipment to/from the Project via this location.
- Warming temperatures may affect permafrost in the vicinity of the Project site, potentially leading to an increased active layer. This could directly affect infrastructure at the Project site in the long-term.

Based on the results of this assessment, it is concluded that the effects of a potentially changing climate on the Project is not significant. Due to the global insignificance of the predicted Project GHG emissions, the Project is anticipated to have virtually no impact on future global climate change.

5.5 Noise

5.5.1 Purpose and Scope and Concordance with NIRB Guidelines

The purpose of this section is to address Guidelines issued by the NIRB for the Project (NIRB 2012), specifically relating to the impact of the Project on noise. Specific requirements set out in the guidelines relating to the baseline and the impact assessment for noise and vibrations are presented in Volume 1 Appendix 1.0-A, respectively.

This section focuses on the potential noise impact on the environment as a result of Project activities. It considers the noise emissions associated with the Project, and assesses potential changes in airborne noise levels in the environment from existing conditions. The potential effects of noise associated with the Project have been assessed with consideration of human nuisance effects, consistent with the approaches set out in applicable noise regulations or guidelines.

The potential effects of noise and vibrations on specific VECs in the receiving environment, including human health, terrestrial wildlife, marine mammals, and fish in the freshwater and marine environments, are dealt with elsewhere in the FEIS as noted in the above tables.

5.5.2 Description of Technical Terminology

To help understand the analysis and discussions in this Section, the following is a brief discussion of technical noise terms. Further detailed information is provided in Appendix 5.5-A. Reference sound pressure levels are provided in Table 5.5.-1.

- Acoustic values can be described in terms of noise or sound. While noise is generally described as unwanted sound, the terms noise and sound are often used interchangeably. Noise and noise levels are used to describe ambient levels perceived by off-site receptors, while sound and sound emissions describe acoustic energy emitted by activities/equipment associated with the Project.
- Sound pressure level is expressed on a logarithmic scale in units of decibels (dB). Since the scale is logarithmic, a sound that is twice the sound pressure level as another will be 3 decibels (3 dB) higher. A change of 3 dB is generally barely perceptible by humans, while a 5 dB change is clearly perceptible and a 10 dB increase is perceived as a doubling of the sound pressure level.
- Noise data and analysis are primarily given in terms of frequency distribution. The levels are grouped into octave bands. Typically, the centre frequencies for each octave band are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hertz (Hz). The human ear responds to the pressure variations in the atmosphere that reach the ear drum. These pressure variations are composed of different frequencies that give each sound we hear its unique character.
- It is common practice to sum sound levels over the entire audible spectrum (i.e., 20 Hz to 20 kHz) to give an overall sound level. However, to approximate the hearing response of humans, each octave band measured has a weighting applied to it. The resulting “A-weighted” sound level (noted in units of dBA) is often used as a criterion to indicate a maximum allowable sound level. In general, low frequencies are weighted higher, as human hearing is less sensitive to low frequency sound.
- Environmental noise levels vary over time, and are described using an overall sound level known as the L_{eq}, or energy averaged sound level. The Leq is the equivalent continuous sound level, which in a stated time, and at a stated location, has the same energy as the time varying noise level;
  - 24 hour L_{Aeq} = An equivalent A-weighted noise level measured or predicted over 24-hours.

Table 5.5-1: Reference Sound Pressure Levels

Activity	Sound Pressure Level (dBA)
Loud shout	90
Busy Traffic Intersection	80
Highway traffic at 15 m away	75
Running water from a tap	62
Normal conversation at 1 m	60
Moderate rainfall	50
Quiet living room	40
Whispered speech	30

Notes: Energy Resources Conservation Board (ERCB) of Alberta Canada, specifically, Directive 038: Noise Control [ERCB 2007]

Generally, the noise assessment described in this section concentrates on locations where it is expected noise effects from the Project activities can affect humans. Specific PORs are identified as being representative of all sensitive PORs, which could be affected by noise emissions associated with Project activities. The PORs include permanent or seasonal residences, hotels/motels, nursing/retirement homes, rental residences, hospitals, camp grounds, and noise sensitive buildings such as schools and places of worship (Ontario Ministry of the Environment, Noise Pollution Control Documents [MOE 1995]). The PORs were identified through the review of traditional knowledge.

5.5.3 Methods

The following sections describe the methods implemented in carrying out the noise assessment.

5.5.3.1 Approach

The potential effects of the Project on noise were assessed using the following approach:

- Identify the study areas and time frames within which the effects of the Project on noise levels will be evaluated;
- Identify suitable noise indicators that will be used for evaluating the potential effects of Project activities on environmental noise;
- Design and carry out a program to characterize the existing noise environment and collect the necessary information to support assessing the effects of the Project on environmental noise levels;
- Complete a pathway analysis that identifies how the Project could affect the environmental noise levels;
- Identify parameters used to characterize how the Project could affect noise levels. Parameters are selected to focus the assessment on noise emissions associated with the Project;
- Establish suitable measures for assessing the effects of the Project on noise levels;
- Establish methods for predicting Project noise levels;

- Identify the bounding case or cases for the noise assessment;
- Characterize the Project noise emissions that will be used to assess the effects of the Project on noise levels;
- Predict how noise emissions from the Project will affect the parameters using numerical models;
- Determine the significance of the impacts of the Project on noise levels by applying the established assessment measures to the predicted effects on the parameters; and
- Identify suitable mitigation and/or monitoring for significant impacts.

The spatial and temporal boundaries for the noise assessment are described in Section 5.1. During the operations phase, the Project will have a number of open pit mines. The timing of when these open pits will be developed will vary depending on the actual blend of ore mined. However, the maximum amount of ore mined at any one time from open pits is 6500 tonnes per day. To provide flexibility in operations, and to fully assess the potential effects of the mining on noise levels, the assessment considers 5 separate cases. In each case, the support operations (e.g., power plant, activities along the AWAR, within Rankin Inlet and along the Marine Shipping route) and underground mining at the Mine Site (Tiriganiaq Underground at a rate of 2000 tonnes per day) will occur. The 5 cases listed below shows how the open pit mining activities were modelled, such that the full impact of mining at any of the pits has been captured.

- Case 1: Processing plant operating at a maximum capacity, underground mining at Tiriganiaq, power generation, ancillary supporting operations (on Mine Site and the AWAR, within Rankin Inlet, and along the Marine Shipping route), and open pit mining at Tiriganiaq;
- Case 2: Processing plant operating at a maximum capacity, underground mining at Tiriganiaq, power generation, ancillary supporting operations (on Mine Site and the AWAR, within Rankin Inlet, and along the Marine Shipping route), and open pit mining at F Zone;
- Case 3: Processing plant operating at a maximum capacity, underground mining at Tiriganiaq, power generation, ancillary supporting operations (on Mine Site and the AWAR, within Rankin Inlet, and along the Marine Shipping route), and open pit mining at Pump;
- Case 4: Processing plant operating at a maximum capacity, underground mining at Tiriganiaq, power generation, ancillary supporting operations (on Mine Site and the AWAR, within Rankin Inlet, and along the Marine Shipping route), and open pit mining at Discovery; and
- Case 5: Processing plant operating at a maximum capacity, underground mining at Tiriganiaq, power generation, ancillary supporting operations (on Mine Site and the AWAR, within Rankin Inlet, and along the Marine Shipping route), and open pit mining at Wesmeg.

Modelling results from all 5 modelled cases were combined spatially to identify the highest predicted noise level at any given location from any given operation phase. As it is not expected that all pits will be mined concurrently at full capacity, the predicted noise levels carried forward in the noise assessment are expected to be conservative. If activities were to occur at a lesser rate at multiple pits, the individual effects would be less than those bounded by the modelled cases.

5.5.3.2 Parameters

A number of parameters were selected for the assessment of noise levels from the Project activities; they include the following:

- 24-hour L_{eq} (dBA);
- Nighttime L_{eq} (dBA); and
- Daytime L_{eq} (dBA).

These parameters were selected as they are generally internationally accepted as being appropriate for nosie assessements. The definitions of daytime and nighttime, as set-out by both the draft National Guidelines for Environmental Assessment: Health Impacts of Noise from Health Canada (2005) and the MOE (1995) were used for the noise assessment. The nighttime period includes the hours of 23:00 through 07:00, whereas the daytime period includes 07:00 through 23:00.

The 24-hour L_{eq} (dBA) parameter was used for the noise assessment for rural, undeveloped areas whereas the nighttime and daytime period parameters were used for more developed areas (e.g., Rankin Inlet).

5.5.3.3 Methods for Describing the Existing Environment

The baseline noise environment represents the existing conditions before the introduction of activities associated with the Project. Typically, the existing noise environment contains naturally occurring sounds of the area and could include sounds from human activity.

The baseline noise environment was characterized through a combination of literature review and a field program. Limited site-specific data are available from previous noise assessments for any of the Project areas. Therefore, studies prepared for projects in other Canadian provinces and/or territories, where the baseline environment is expected to be similar, were included in the literature review. A field monitoring program also was carried-out to characterize the existing noise conditions in the community of Rankin Inlet. Although noise measurements were not carried out for certain areas near the Project, it is expected previous noise monitoring in other remote areas will be relevant to remote areas within the LSA based on known site information for these specific areas and knowledge that noise levels are similar in remote areas.

5.5.3.4 Pathway Analysis Methods

Pathway analysis identifies the possible linkages between the Project components or activities and the potential residual effects on noise levels. Potential pathways through which the Project could affect noise levels were identified from a number of sources including the following:

- the Project Description (FEIS Volume 2);
- potential effects identified in the Guidelines (NIRB 2012);

- scientific knowledge and experience with other mines in Nunavut and Northwest Territories; and
- engagement with the regulatory bodies.

As part of the noise level pathways analysis, a list of all potential effects pathways for the Project was developed. For each of these pathways, environmental design features and mitigation options that could be incorporated to the Project were considered either to remove the pathway or to limit (mitigate) the effects of the activity on noise levels. Environmental design features include Project design elements, environmental best practices, and management policies and procedures.

Knowledge of the environmental design features were then applied to each of the pathways to determine the expected Project related changes to the environment and associated residual effects on noise levels. For an effect to occur, there has to be a source (Project component or activity) that results in a measureable environmental change (pathway) and correspondent effect on noise levels.

5.5.3.5 Methods for Predicting Residual Effects

Any residual noise effects of the Project represent those effects that remain after mitigation measures have been incorporated. The noise assessment uses analytical modelling to predict the potential noise levels in the environment as a result of Project noise emissions. In developing the noise emissions used as inputs in the modelling, consideration was given to Project design elements that reduce noise emissions to the environment, as well as mitigation inherent in the Project design.

5.5.3.6 Methods for Assessing Effects

The residual noise effects predicted were then used to establish whether the noise effects from Project activities would be significant. The significance of noise effects considered the following criteria:

- direction;
- magnitude;
- geographic extent;
- timing and duration;
- frequency;
- likelihood; and
- reversibility.

The criteria of direction and likelihood are not explicitly addressed in the noise assessment as all predicted noise effects are assumed to be of a negative direction, and likely to occur. The majority of the remaining criteria are specific to the noise assessment. The one exception is reversibility, which uses the generic definitions used consistently across all VECs. The scales of classification for magnitude, geographic extent, frequency, duration and reversibility are dependent on each VEC endpoint, and the associated effects statement. Although professional judgment is inevitable in some cases, a strong effort was made to classify effects using scientific principles, supporting evidence, and a conservative approach where uncertainties exist. Definitions for each criterion are provided in FEIS Volume 4, Section 4.5.4; and details of the selected impact classification criteria for noise are presented in Table 5.5-2.

Table 5.5-2: Significance Criteria

Effects Criteria	Effects Level Definition		
Magnitude (of effect)	**Low**	**Moderate**	**High**
	The effects level definitions for magnitude are provided in Table 5.5-3.		
Geographic Extent (of effect)	**Low**	**Moderate**	**High**
	■ Effect is limited to SSA	■ Effect is limited to LSA	■ Effect is limited to RSA
Timing and Duration (of effect)	**Short (Low)**	**Moderate**	**Long (High)**
	■ Conditions are evident for approximately 3 years (e.g., limited to the Construction Phase	■ Conditions are evident throughout the Operation Phase	■ Conditions extend into the Post-Closure Phase
Frequency (of effect)	**Low**	**Moderate**	**High**
	Conditions causing the effect occur infrequently (i.e., < 1% of the time)	Conditions causing the effect occur regularly, although infrequently (i.e., approximately 10% of the time)	Conditions causing the effect occur regularly, and frequently (e.g., > 10% of the time)
Degree of Irreversibility (of effect)	**Low**	**Moderate**	**High**
	Effect is readily reversible (i.e., immediately)	Effect is reversible with time	Effect is not reversible (i.e., permanent)

In assigning magnitude for the noise assessment, change relative to existing noise levels at the POR locations was used as set out in in Table 5.5-3.

Table 5.5-3: Human Perception to Changes in Noise Level

Increase from Existing Noise Levels	Typical Human Response	Magnitude
Up to 3 dBA	Hardly perceptible	Negligible
>3 dBA to 6 dBA	Noticeable	Low
>6 dBA to 10 dBA	Readily noticeable	Moderate
> 10 dBA	Disturbing	High

Changes in noise levels at PORs for the period L_{Aeq} that would be hardly perceptible (i.e., less than or equal to 3 dBA) were not considered to result in an adverse effect and were assigned a negligible magnitude. A noticeable change at PORs in the period L_{Aeq} (i.e., greater than 3, but less than or equal to 6 dBA change) were classified as having a low magnitude. Readily noticeable changes at PORs for the period L_{Aeq} (i.e., greater than 6, but less than or equal to 10 dBA) were considered of moderate magnitude. Disturbing changes in the noise levels at PORs for the period L_{Aeq} (i.e., greater than 10 dBA) were classified as having a high magnitude.

In addition, a high magnitude is assigned when the predicted noise levels exceed 40 dBA at a distance of 1.5 km from the edge of the SSA. The Alberta Energy and Utilities Board recommends a design target of 40 dBA (night time) at a distance of 1.5 km from the fence line of new facilities. This AEUB value is applicable for rural, undeveloped areas, which was applied to the general LSA, but not to the identified PORs.

The level of significance is assigned by using professional judgment and combining the criteria of magnitude, geographic extent, timing and duration, frequency, and reversibility. Residual effects were assigned either a "not significant" or "significant" rating if professional judgement suggested it was clear that there would be no significant effects or significant effects, respectively. In those cases where professional judgement suggested that no significant effects are likely, but that had high magnitude predictions, a rating of "significant" is conservatively assigned.

Generally, the following guiding principles were used when assigning significance:

- All effects of a negligible or low magnitude would be considered "not significant". Negligible effects include changes from baseline levels less than 3 dB, while low magnitudes are assigned when the change in baseline levels is equal to or greater than 3 dB and less than 6 dB.
- Effects with a moderate magnitude were classified as either "not significant" or "significant" depending on the geographic extent.
  - Effects with a moderate magnitude that are restricted to either the SSA or LSA would be considered "not significant".
  - Effects of a moderate magnitude that extend into the RSA would be classified as "significant"
- Effects with a high magnitude were classified as "significant".

5.5.3.7 Characterizing the Project Noise Levels

Project activities at the Mine Site, on the AWAR, and associated quarry areas, within Rankin Inlet, and Marine Shipping activities will result in noise emissions to the environment. These emissions were used as inputs for the noise models, which provided estimates of off-site noise levels due to Project emissions. The modelling results, in turn, were compared to the existing noise level conditions and regulatory requirements or guidelines for noise.

Noise emissions were established using the Project design details, Golder's database of similar noise sources, manufacturer's specifications, and publicly available data. The emissions also relied on details regarding the proposed equipment and planned operating modes associated with the Project. Elements incorporated into the Project design, as well as operating practices that could avoid or reduce noise emissions were also considered. Additional information regarding the noise emissions for the Project is provided in Section 5.5.4.

5.5.3.8 Modelling

Consistent with accepted practice, quantitative and qualitative methods, including professional expertise and judgement, were used to predict and describe the Project-specific effects to allow for a detailed assessment.

The detailed Project Description Report (FEIS Volume 2, Section 2.0), prepared for the Project, was used to develop an understanding of the Project. The Project Description Report describes the Project phase and number, type, and location of noise sources. Noise source emissions were developed through a combination of predictions from first principles and Golder's database of similar noise sources.

The likely effects of the Project on noise levels were evaluated in accordance with the ISO 9613 Acoustics: *Attenuation of Sound during Propagation Outdoors (International Organization for Standardization 1993 and 1996)* [ISO 1993 and 1996] noise prediction algorithm. The ISO algorithm allows for the incorporation of the following environmental factors that can result in noticeable changes in noise levels:

- attenuation due to the distance between the noise source and receiver location;
- absorption of acoustic energy by the atmosphere;
- loss of acoustic energy as it travels around or over hills, or intervening buildings; and
- loss of acoustic energy as it passes over the ground (i.e., ground impedance).

The ISO 9613 prediction method is conservative as it assumes that all receptors are downwind from the noise source or that a moderate ground based temperature inversion always exists.

In addition to the attenuation factors listed above, constructed features can be used to reduce the noise levels further, including: buildings, weather/acoustic enclosures, noise barriers, silencers, and exhaust mufflers.

To accurately account for these factors and features, the noise assessment relies on numeric models. The selection of appropriate models to support the noise assessment ensures that the results of the assessment are credible and indicative of the conditions likely to occur should the Project proceed. The selection of this model considered several capabilities:

- incorporates site specific terrain data;
- evaluates the various source types associated with the Project;
- has a technical basis that is scientifically sound, and is in keeping with the current understanding of the propagation of sound in the outdoors;
- applies a prediction program that has undergone scrutiny for correct implementation of established ISO methods;
- makes predictions that are consistent with observations; and
- is recognized by regulators as one suitable for use.

The Computer Aided Noise Attenuation (CadnaA) prediction model (version 4.2.140), developed by DataKustik GmbH is widely accepted for evaluating noise from industrial projects world-wide, including mining projects. This model has been independently validated for its implementation of the ISO standard (Drew et al. 2005). The model has the ability to simulate emission sources including roads, vessels, and industrial facilities. Noise sources are characterized by entering the sound power and/or sound pressure octave band spectrum associated with each source. Other parameters including building dimensions, frequency of use, hours of operation, and enclosure attenuation ratings also define the nature of sound emissions.

In addition, ground cover and physical barriers, either natural (terrain-based) or constructed, and atmospheric absorption are included as they relate to the Project.

5.5.4 Description of the Existing Environment

Points of Reception(s) that could potentially be affected by the Project activities can be found in 3 of 4 distinct areas; the Mine Site, the AWAR, and Rankin Inlet. Due to the large distance between Marine Shipping activities and potential PORs, no PORs are located in the Marine Shipping area. The 3 distinct areas where PORs are located (e.g., the Mine Site, the AWAR, and Rankin Inlet) can have differing baseline environments, which are described in Sections 5.5.4.1 through Section 5.5.4.3. As no PORs are located in the Marine Shipping area, the baseline environment of the Marine Shipping area is not further discussed in this section.

5.5.4.1 Mine Site

The Mine Site will be located in a remote (undeveloped) area where the baseline noise environment is comprised of natural sounds with infrequent sounds associated with human activities. The determination of the baseline environment follows the assessment approach adopted by the Energy Resources Conservation Board (ERCB) of Alberta Canada (specifically, Directive 038: Noise Control (ERCB 2007)), and Health Canada (2005 guidelines). The expected ambient noise level in undeveloped areas is generally around 35 dBA (ERCB 2007) or higher depending on the amount of local activity. Ambient noise levels in undeveloped areas can fluctuate hourly, daily, monthly, and/or seasonally, and are generally influenced by the amount of wildlife activity and meteorological conditions.

Baseline noise monitoring data have been collected as part of the approval process for mining projects in the NWT, and subsequently used as being representative of baseline levels in Nunavut (Miramar Hope Bay Ltd. 2005). For the Diavik Diamond Project Environmental Impact Assessment (Diavik 1998), noise levels of 25 to 40 dBA were established as being representative of noise levels in a rural environment. Monitoring carried out for the Snap Lake Diamond Project (De Beers 2002) confirmed hourly noise levels ranging between 23 and 40 dBA, with an average hourly noise level of 35 dBA. It is expected the baseline noise levels at the Mine Site would likely be similar.

5.5.4.2 All-weather Access Road

The AWAR will connect Rankin Inlet and the Mine Site. The existing noise environment along the AWAR will be dependent on the proximity to human activity. Near Rankin Inlet, the noise environment along the AWAR would be similar to the levels in Rankin Inlet. The remainder of the AWAR is located in a remote area, and the existing noise levels are expected to be similar to those established for the Mine Site.

5.5.4.3 Rankin Inlet

Due to the lack of existing noise data for Rankin Inlet, and the abundance of human activity, a field study was carried out to help characterize existing noise levels at PORs within Rankin Inlet. This field study involved continuous noise monitoring, in general accordance with internationally accepted standards, at 5 different locations (Figure 5.5-1). In addition, attended noise measurements were carried out within the Rankin Inlet community. The following summarizes the field study:

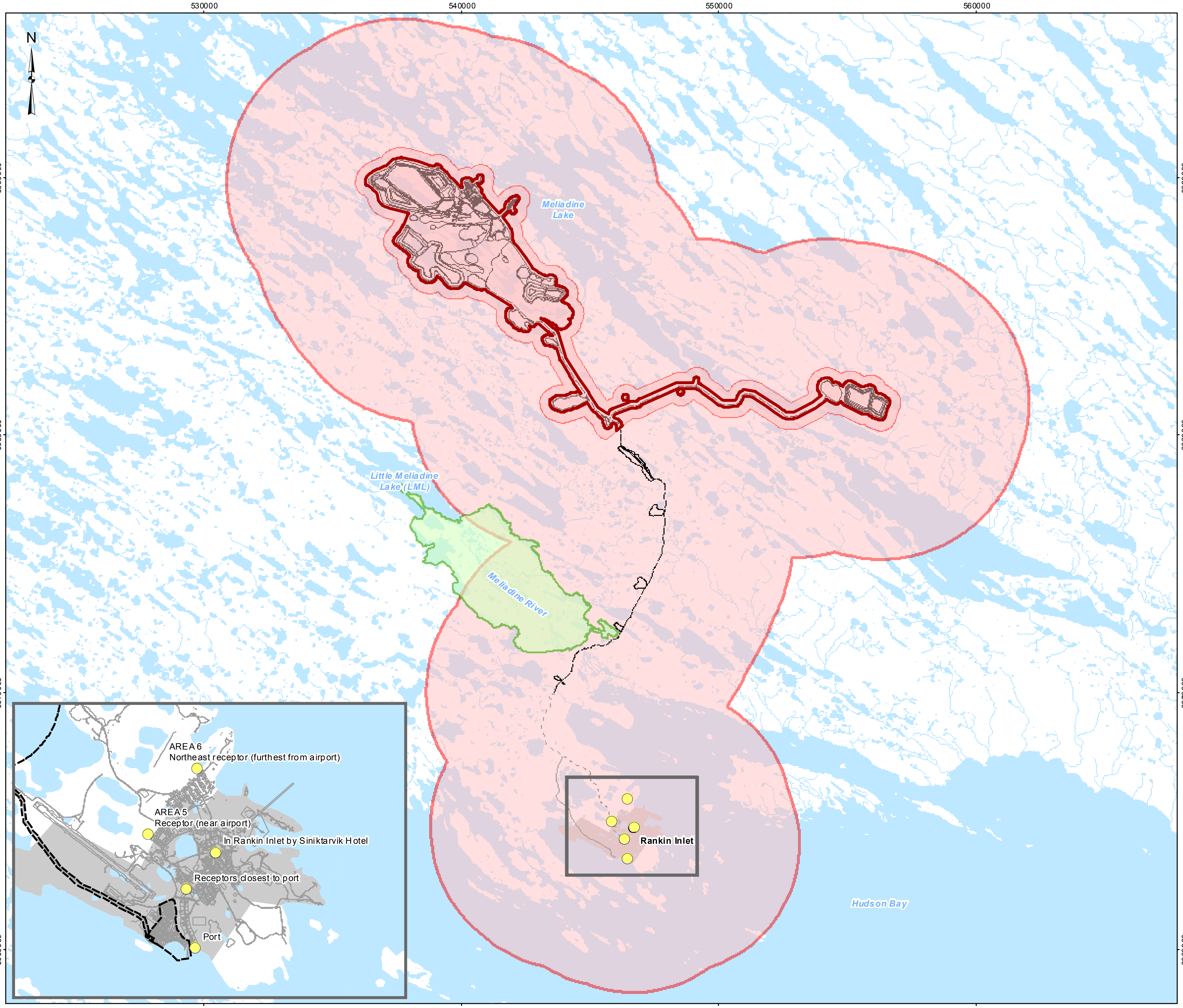
- Continuous noise monitoring was carried out at 5 locations within Rankin Inlet to collect the existing noise levels for daytime (07:00 to 23:00) and night-time (23:00 to 07:00) periods at sensitive POR(s). The monitoring program was carried out between 28 July and 31 July 2012. Equipment was located at locations expected to be representative of PORs in the community and was deployed for a minimum of 28 hours before it was moved to a different location. Noise data were logged continuously on a 1-minute basis for the duration of the monitoring period.

- Attended noise measurements were carried at out at various locations within Rankin Inlet to supplement the monitoring locations.

The locations where baseline noise monitoring was carried out are shown in Figure 5.5-1 and characterized in Table 5.5-4.

Table 5.5-4: Monitoring / Measurement Location

Monitoring Location	Monitoring Location Description	Monitor UTM Coordinates (NAD 83, Zone 15)		Monitored Baseline Noise Levels (dBA)		
		Easting	Northing	24-hour L_{eq}	Nighttime L_{eq}	Daytime L_{eq}
M1	AREA 6 northeast receptor (farthest from airport)	546460	6965866	54	48	55
M2	AREA 5 receptor (near airport)	545832	6965009	52	45	54
M3	Receptors closest to port	546327	6964295	61	46	62
M4	In Rankin Inlet by Siniktarvik Hotel	546709	6964775	63	52	64
M5	Port	546439	6963541	53	45	54



N:\Bur-Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_5\Main Volume\Figure_5.5-1_Noise_Monitoring_Locations.mxd

LEGEND

- Monitoring Location
- Disturbed Area (Mine Site)
- Site Study Area
- Local Study Area (Mine Site)
- Municipal Boundary
- Territorial Park
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
NOISE MONITORING LOCATIONS

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	SI	08 Jan. 2013	SCALE AS SHOWN	REV. 0
GIS	JW	08 Jan. 2013		
CHECK	JT	17 Jan. 2013		
REVIEW	GA	17 Jan. 2013		

FIGURE 5.5-1

5.5.4.4 Point(s) of Reception

A total of 25 PORs are identified within the LSA as being the most sensitive receptors (see Figure 5.1-2). Table 5.5-5 provides a summary of the PORs used in this assessment. The table identifies whether the PORs are near the Mine, AWAR, or Rankin area, describes the methods used in establishing the existing conditions, and summarizes the existing noise levels.

Table 5.5-5: Summary of Point(s) of Reception Locations

POR	Description	Project Area in Proximity	Study Area	Method Used to Establish Existing Conditions	Existing Noise Level L_{eq} (dBA)	Period
NPOR001	Cabin - Present Day	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR002	Cabin - Present Day	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR003	Present Day Cabin Ataniq	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR004	Cabin - Present Day	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR005	Present Day Cabin	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR006	Present Day Cabin	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR007	Present Day Cabin Tatty's	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR008	Cabin - Present Day	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR009	Cabin - Present Day	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR010	Present Day Cabin Peter's	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR011	Present Day Cabin Angioluk's	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR012	Present Day Cabin Barney Tootoo's	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR013	Cabin - Present Day	Mine	LSA	Literature	35	24-h L_{Aeq}
NPOR014	Present Day Cabin	Mine	SSA	Literature	35	24-h L_{Aeq}
NPOR015[a]	Iqalugaarjuup Nunanga Territorial Park	Iqalugaarjuup Nunanga Territorial Park	LSA	Literature	35	24-h L_{Aeq}
NPOR016[a]	Iqalugaarjuup Nunanga Territorial Park	Iqalugaarjuup Nunanga Territorial Park	LSA	Literature	35	24-h L_{Aeq}
NPOR017	Present Day Cabin Tommy's	AWAR	SSA	Literature	35	24-h L_{Aeq}
NPOR018	Present Day Cabin Ugjuk's	AWAR	LSA	Literature	35	24-h L_{Aeq}
NPOR019	Present Day Cabin Angutetuark's	AWAR	LSA	Literature	35	24-h L_{Aeq}
NPOR020	Present Day Cabin Ollie's	Rankin Inlet	LSA	Literature	35	Nighttime L_{Aeq}
NPOR021	Present Day Cabin Nattar's	Rankin Inlet	LSA	Literature	35	Nighttime L_{Aeq}
NPOR022	Rankin Inlet Receptor	Rankin Inlet	LSA	Monitoring (M1)	48	Nighttime L_{Aeq}
NPOR023	Rankin Inlet Receptor	Rankin Inlet	LSA	Monitoring (M2)	45	Nighttime L_{Aeq}
NPOR024	Rankin Inlet Receptor	Rankin Inlet	LSA	Monitoring (M4)	52	Nighttime L_{Aeq}
NPOR025	Rankin Inlet Receptor	Rankin Inlet	LSA	Monitoring (M3)	46	Nighttime L_{Aeq}

[a] Although the Iqalugaarjuup Nunanga Territorial Park does not meet the definition of a POR, a 'hypothetical' POR was located within the Iqalugaarjuup Nunanga Territorial Park to provide predictions for interested stakeholders, and as required in the Guidelines (NIRB 2012).

5.5.5 Description of Project Effects

5.5.5.1 Pathways Analysis

As described in Section 5.5.3.4, the pathway analysis identifies the possible linkages between the Project components or activities and the potential residual effects on noise levels. Pathways determined to be likely to have a measurable effect on noise levels were classified as “primary”, and were carried forward for the prediction of residual effects, classification of impacts, and determination of environmental significance. Pathways determined to have little potential for affecting noise levels, or those whose effects were bounded by another “primary” pathway, were classified as being “minor”. Minor pathways were not assessed further.

The pathways analysis for noise levels is presented in Table 5.5-6, and includes 3 “primary” pathways and 4 “minor” pathways. The noise effects associated with the construction phase of the mine site, as well as the decommissioning and post-closure phase, were classified as being minor pathways because the effects during these phases would be bounded by the effects associated with the operations phase of the Project. The reason they are bounded by the effects during operations is that the levels of activity, amount of equipment, and materials moved are higher during the operations phase. In a similar manner, the noise effects associated with the construction of the AWAR were considered to be a minor pathway as they would be bounded by the noise effects during the operations of the AWAR, when travel and activity along the road would be at its maximum. Likewise, the noise effects associated with the construction, as well as the decommissioning and post-closure phase of the Rankin Inlet facilities were considered to be a minor pathway, as they would be bounded by the noise effects during the operations within Rankin Inlet, when activity would be at its maximum. Finally, the potential noise effects associated with the Marine Shipping activities were considered to be a minor pathway as they occur at such a large distance from any identified POR.

Table 5.5-6: Pathways Table – Noise

Valued Component	Project Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Analysis
Noise	Mine Site (construction)	Construction activities will result in noise emissions, which may cause short-term changes in noise levels.	Best management practices to control noise emissions as described in the Noise Abatement and Monitoring Plan (NAMP). Equipment noise control systems will be maintained.	Minor (bounded by operation effects)
	Mine Site (operations)	Project activities will result in noise emissions, which may cause changes in noise levels	Best management practices to control noise emissions from haul roads as described in the NAMP. Noise controls will be designed inherent in the Project, which may include selection of quieter equipment, enclosures, silencers, etc. Equipment noise control systems will be maintained Blasting will be intermittent and of short duration No regular, or scheduled flights to the mine site Down-hole delays to minimize vibration levels	Primary
	Mine Site (decommissioning and reclamation)	Decommissioning activities will result in noise emissions, which may cause short-term changes in noise.	Best management practices to control noise emissions as described in the NAMP. Equipment noise control systems will be maintained.	Minor (bounded by operation effects)
	Phase II AWAR (construction)	Construction activities will result in noise emissions, which may cause short-term changes in noise levels.	Best management practices to control noise emissions as described in the NAMP. Equipment noise control systems will be maintained.	Minor (bounded by operation effects)
	AWAR (operations)	Project vehicles along the AWAR will result in noise emissions, which may cause changes in noise levels.	Best management practices to control noise emissions from vehicles travelling along the AWAR as described in the NAMP.	Primary
	Rankin Inlet	Activities associated with material receipt, storage and transfer to the Project will result in noise emissions, which may cause localized changes in noise levels.	Development of a bypass road to keep traffic in and near Rankin Inlet isolated from residences. Best management practices to control noise emissions from access roads and lay down area as described in the NAMP. Noise controls will be designed inherent in the Project, which may include selection of quieter equipment, enclosures, silencers, etc. Equipment noise control systems will be maintained. Limited Project air traffic, which is negligible compared to the existing air traffic	Primary
	Marine Shipping	Marine shipping will results in noise emissions, which may cause changes in noise levels	Marine vessels will travel and be anchored at least 3 km from sensitive points of reception. Tugs will remain 1 km from community except when delivering to the port.	Minor (due to large distance to PORs)

5.5.5.2 *Project Activities*

Activity levels and noise emissions for Project activities will vary during the life of the Project. It is likely that the noise emissions from the Construction Phase activity would lead to changes in noise levels. However, the emissions and resulting changes to noise levels due to these activities are expected to be similar to or less than those identified for the assessment of the Operation and Maintenance Phase. As the greatest quantity of equipment will be implemented within the Operation and Maintenance Phase, and the Operation and Maintenance Phase is expected to last 13 years, the Operation and Maintenance Phase is expected to be the Project Phase with the greatest potential to affect noise levels. It is also likely that the noise emissions from the Temporary, Final and Post-Closure Phase activity would lead to changes in noise levels. However, the emissions and resulting changes to noise levels due to these activities are expected to be similar to or less than those identified for the assessment of the Operation and Maintenance Phase.

The Project noise levels at a given location within the LSA are dependent on the location and number of equipment operating. As ore will be extracted from a number of open pits each extracted individually, the noise assessment included modelling each of the open pit operations. The predicted noise levels presented in this assessment are a summation of the predicted levels associated with each extraction phase. As the open pits will not be extracted concurrently, with the number of equipment assessed, the predicted levels are expected to be conservative.

5.5.5.3 *Noise Emissions*

The overall sound power data for each noise source associated with the Project activities, during the Operations and Maintenance Phase, are summarized in Table 5.5-7.

Table 5.5-7: Equipment List and Sound Power Data

Source	Area Equipment will be located (Mine Site, AWAR, or Rankin Inlet)	Number	Overall Sound Power Level (dBA)
Excavator Terex RH120	Mine Site	2	109
Wheel Loader	Mine Site	2	110
Excavator CAT 390 DL	Mine Site	2	109
Production Drill Sandvik DR560	Mine Site	5	119
Motor Grader CAT 16M	Mine Site	2	116
Wheel Dozer Cat 824 H	Mine Site	2	118
Track Dozer Cat D9T	Mine Site	4	109
Excavator CAT 345D L	Mine Site	1	109
Excavator CAT 345D L Rockbreaker	Mine Site	1	109
Compactor CAT C556	Mine Site	1	108
Tool Carrier - CAT IT62H	Mine Site	2	118
Intake Raise	Mine Site	1	110
Exhaust Raise	Mine Site	1	110
Intake Raise	Mine Site	1	110
Intake Raise	Mine Site	1	110
Fresh Water Pumping Station	Mine Site	1	105

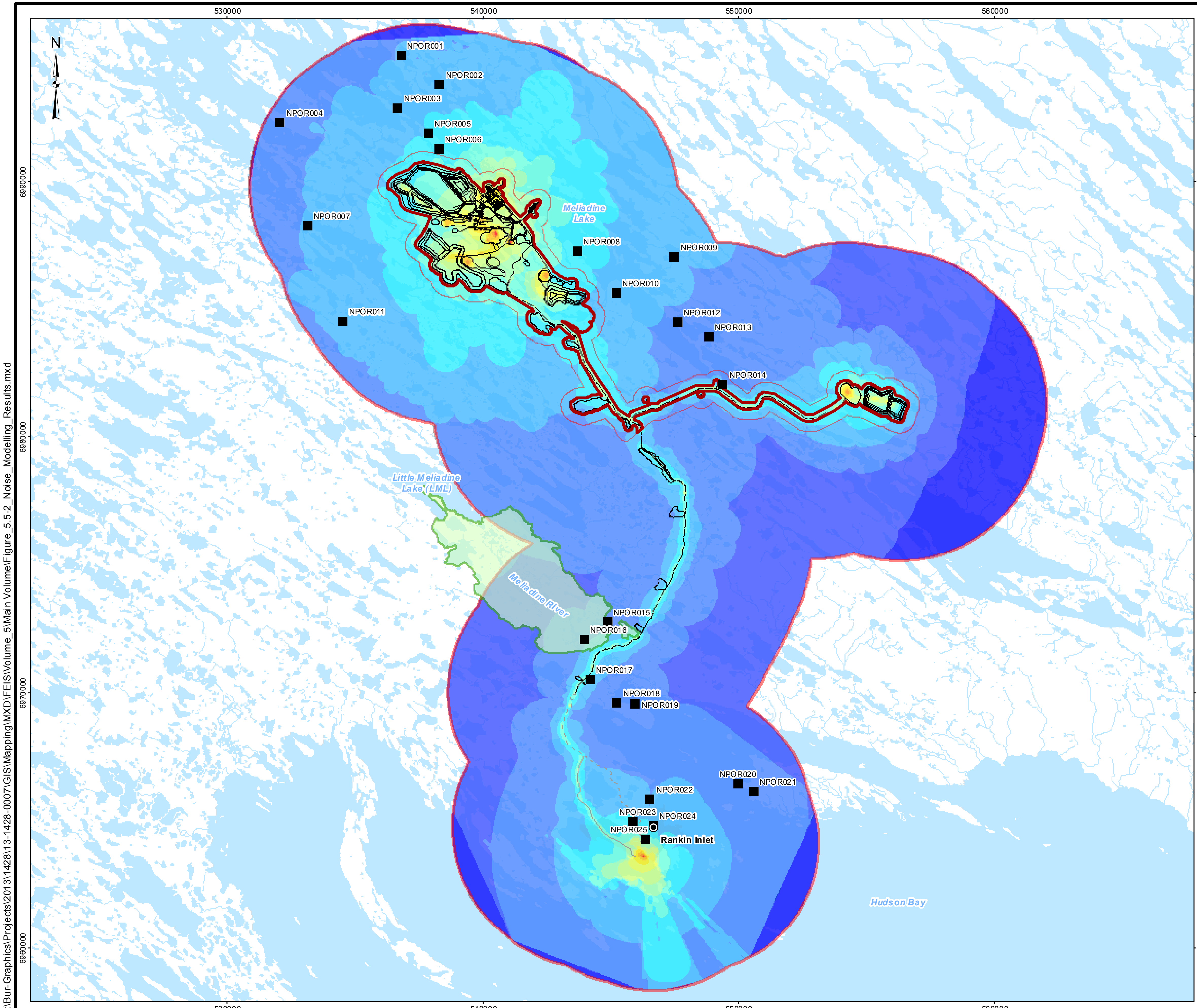
Table 5.5-7: Equipment List and Sound Power Data (continued)

Source	Area Equipment will be located (Mine Site, AWAR, or Rankin Inlet)	Number	Overall Sound Power Level (dBA)
Generator Exhaust	Mine Site	1	98[a]
Generator Exhaust	Mine Site	1	96[b]
Generator Exhaust	Mine Site	1	96[b]
Generator Exhaust	Mine Site	1	96[b]
Transport Truck	Mine Site, AWAR, Rankin Inlet	1-14	111
Mining Truck	Mine Site	20	111
Loader	Rankin Inlet	4	110
PORTAL	Mine Site	1	91
PORTAL	Mine Site	1	91
Process Plant	Mine Site	1	105
Paste Plant	Mine Site	1	99
Power Plant	Mine Site	1	93
Concrete Batch Plant	Mine Site	1	103
Primary Crusher	Mine Site	1	124
Compressor Building	Mine Site	1	117
Diverter	Mine Site	1	115
Secondary Crusher	Mine Site	1	91
Power Plant	Mine Site	1	109
Genset 100 KW	Mine Site	1	107

NOTES:
Blasting activities are intermittent and or short duration. The resulting acoustic energy, averaged over time, is negligible.
Regular or scheduled air traffic will not occur at the Mine Site.
Noise from Project related air traffic in Rankin Inlet will be negligible relative to existing air traffic.
[a] 3 Generator exhausts from power plant combined to 1 structure
[b] 2 Generator exhausts from power plant combined to 1 structure

5.5.5.4 Modelling Results

Noise prediction results for the Project activities are summarized in Table 5.5-8. The maximum predicted L_{eq} noise level from Project activities, at an identified POR in the SSA, is 44.2 dBA at NPOR014, whereas the maximum predicted L_{eq} noise level from Project activities, at an identified POR in the LSA, is 40.6 dBA at NPOR008. The maximum change from existing conditions for an off-site POR in the SSA is 9.7 dBA, occurring at NPOR014, whereas the maximum change from existing conditions for an off-site POR in the LSA is 6.7 dBA, occurring at NPOR008. The maximum L_{Aeq} noise level at the edge of a 1.5 km buffer zone was predicted to be 40 dBA, which is at the recommended value of 40 dBA for remote, undeveloped area. The predicted noise levels are shown in Figure 5.5-2.



LEGEND

- Noise Receptor
- Disturbed Area (Mine Site)
- Site Study Area
- Local Study Area
- Municipal Boundary
- Territorial Park
- Proposed Project Infrastructure
- All-weather Access Road (AWAR)
- Road - New
- Road - Existing
- Watercourse
- Waterbody

dBA

- < 30
- 30.1 - 35
- 35.1 - 40
- 40.1 - 45
- 45.1 - 50
- 50.1 - 55
- 55.1 - 60
- 60.1 - 65
- 65.1 - 70
- 70.1 - 75
- 75.1 - 80
- 80.1 - 85
- 85.1 - 90
- 90.1 - 95

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
Datum: NAD 83 Projection: UTM Zone 15

5 0 5
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
NOISE MODELLING RESULTS

Golder Associates

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	SI	04 Jan. 2013	SCALE AS SHOWN	REV. 0
GIS	CDB	14 Jan. 2013		
CHECK	JT	17 Jan. 2013		
REVIEW	GA	17 Jan. 2013		

FIGURE 5.5-2

Table 5.5-8: Prediction Results

POR	Study Area	Project Predicted Level (dBA)	Existing Noise Levels (dBA)	Ambient Noise Levels (dBA)	Change in Noise Levels (dBA)	Magnitude
NPOR001	LSA	25	35	35.4	0.4	negligible
NPOR002	LSA	28.3	35	35.8	0.8	negligible
NPOR003	LSA	27.8	35	35.8	0.8	negligible
NPOR004	LSA	21.7	35	35.2	0.2	negligible
NPOR005	LSA	30.4	35	36.3	1.3	negligible
NPOR006	LSA	38	35	39.8	4.8	low
NPOR007	LSA	26	35	35.5	0.5	negligible
NPOR008	LSA	40.6	35	41.7	6.7	moderate
NPOR009	LSA	28.6	35	35.9	0.9	negligible
NPOR010	LSA	34.4	35	37.7	2.7	negligible
NPOR011	LSA	28.1	35	35.8	0.8	negligible
NPOR012	LSA	27.7	35	35.7	0.7	negligible
NPOR013	LSA	28.4	35	35.9	0.9	negligible
NPOR014	SSA	44.2	35	44.7	9.7	moderate
NPOR015	LSA	25.3	35	35.4	0.4	negligible
NPOR016	LSA	31.5	35	36.6	1.6	negligible
NPOR017	SSA	42.7	35	43.4	8.4	moderate
NPOR018	LSA	25.3	35	35.4	0.4	negligible
NPOR019	LSA	23.3	35	35.3	0.3	negligible
NPOR020	LSA	16.6	35	35.1	0.1	negligible
NPOR021	LSA	15.9	35	35.1	0.1	negligible
NPOR022	LSA	19.8	48	48.0	0.0	negligible
NPOR023	LSA	32.4	45	45.2	0.2	negligible
NPOR024	LSA	27.1	52	52.0	0.0	negligible
NPOR025	LSA	39.6	46	46.9	0.9	negligible

Details of the calculations are provided in Appendix 5.5-A. Table 5.5-9 summarizes the POR in each of the applicable study areas (i.e., SSA and LSA) with the greatest change in noise level from existing conditions.

Table 5.5-9: Significance Criteria Summary Table

Study Area	Study Area	Change in Existing Noise Level (dBA)	Magnitude
SSA	NPOR014	9.7	Moderate
LSA	NPOR008	6.7	Moderate

5.5.5.5 Prediction Certainty

Acoustic systems are dynamic and influenced by a highly complex interaction of variables. The current level of professional understanding of these variables and their associated relationships is incomplete. Although predictions of future effects cannot be made with certainty, there is confidence in the predictions of noise levels associated with Project activities for the following reasons:

- Sufficient data for existing noise levels were collected in suitable weather conditions to enable the characterization of existing noise levels (e.g., within Rankin Inlet). The equipment used was accurate to within ±1 dB.
- When available, measurements of equipment similar to that proposed were used as inputs to the noise prediction model. When such measurements were unavailable, emission factors were determined from referenced sources and / or prediction methods. In these cases, a conservative approach was applied.
- The prediction modelling was carried out using CadnaA, an internationally recognized software that implements ISO 9613 methods in calculating noise levels. The model is as accurate as the inputs used; therefore, the conservatism applied in emission selection was carried through, but not amplified by, the model.
- Predicted Project noise levels are a summation/compilation of the predicted noise levels from all extraction activities from any given open pit. As the open pits will not be extracted concurrently, with the number of equipment assessed, the predicted levels are expected to be conservative.

The assessment does not account for variation in levels of existing conditions or changes in sound propagation due to changing or non-prevailing meteorological conditions; therefore, some variation in the predicted noise levels may occur. These variations are not anticipated to affect the overall assessment of effects or significance.

5.5.5.6 Cumulative Effects

As the potential noise effects from Project activities are limited to the LSA, a review was carried out of other known projects within the LSA. There are no known projects within the defined LSA. Therefore, the cumulative noise effects for PORs within the LSA will be limited to those predicted for this Project. The Wolf deposit, located north-west of the Tiriganiaq deposit, is currently known, but still requires some exploration work to be better defined and included in the mine plan. Currently, the Wolf deposit does not have sufficient proven reserves to be economically mined and so was not included as a development, or as part of the Project. An environmental impact assessement (including a cumulative effects analysis) for the Wolf deposit will be completed in the future if the deposit becomes economically feasible to be developed

5.5.6 Impact Classification

The assessment method for determining residual effects of the Project on noise levels uses the methods described in Section 5.5.3.6. Specifically, effects are classified using the following descriptors:

- direction;
- magnitude;
- geographic extent;

- timing and duration;
- frequency;
- likelihood; and
- reversibility.

5.5.6.1 Direction

Although the noise emissions from the Project were predicted to result in an increase in environmental noise levels, the direction of the noise effects is considered to be negative. Because all of the directions for noise are considered negative, this category has not been summarized further.

5.5.6.2 Magnitude

The noise model predictions were made at all receptor locations within the modelling domain. Therefore, magnitudes of effects can be assigned to each of the study areas based on the model results within those study areas. Magnitudes of effects at identified PORs range from 'Negligible' to 'Moderate' in accordance with Table 5.5-3. A majority of the PORs have a 'Negligible' magnitude, with 3 PORs having a 'Moderate' magnitude (NPOR008, NPOR014, and NPOR017) (Table 5.5-8).

The Project noise level criteria of 40 dBA at a distance of 1.5 km was met at all locations.

5.5.6.3 Geographic Extent

The geographic extent of effects is assigned based on the magnitude of the predicted effects. Specifically, the geographic extent of a particular magnitude is based on the location of the POR. The geographic extents for effects magnitudes in each of the applicable study areas (i.e., SSA and LSA) have been summarized in Table 5.5-10 below.

Table 5.5-10: Significance Criteria Summary Table

POR	Study Area	Magnitude	Geographic Extent
NPOR014	SSA	Moderate	Low
NPOR008	LSA	Moderate	Moderate

5.5.6.4 Timing and Duration

The duration of effects is assigned based on the length of time that the predicted effects are likely to occur. If effects of a particular magnitude are predicted to occur in more than one of the study periods (e.g., short-term, medium-term, or long-term), the extent is determined to be the larger of the 2 extents.

For all cases evaluated, the duration is considered to be medium-term, where conditions causing the effect are evident for an extended period of time, and last throughout the operational phase. Although noise impacts can occur in both the construction and temporary, final, and post-closure phases, the total noise emissions during the operations phase are expected to be much higher than those during other phases. For the purposes of this assessment, only the bounding case (i.e., operations) was considered. Because all of the durations for noise are considered medium-term, this category has not been summarized further.

5.5.6.5 Frequency

The frequency of effects is assigned based on how often the predicted effects are likely to occur. For all cases evaluated, the frequency is considered to be moderate, where conditions causing the effect are expected to occur regularly. Although noise impacts can occur in both the construction and temporary, final, and post-closure phases, the total noise emissions during the operations phase are expected to be much higher than those during other phases. For the purposes of this assessment, only the bounding case (i.e., operations) was considered. Because all of the frequency effects for noise are considered moderate, this category has not been summarized further.

5.5.6.6 Reversibility

As described in Table 5.5-2, the irreversibility of an effect is defined as either ‘low’, ‘moderate’, or ‘high’. In the case of the mining activities, once the mining and processing operations cease, the effect of the impact on noise levels are reversible. Because all of the effects for noise levels are considered reversible once the emissions cease, a ‘low’ level effect was assigned, and this category has not been summarized further.

5.5.7 Environmental Significance

The classification of significance for residual effects was determined following the procedure outlined in Section 5.5.3.6, using the assessment measures described previously. For noise, all residual effects are considered to be of a negative direction. In addition, the duration of the residual effects for noise is considered to be ‘moderate’, lasting throughout the operations phase. The frequency of the residual effects for noise is considered ‘moderate’. Finally, all noise effects are considered to have a ‘low’ degree of irreversibility, as noise levels will return to background conditions once emissions from the Project cease. Therefore, significance for adverse noise effects will rely on the measures of magnitude and geographic extent.

As detailed in Section 5.5.3.6, effects that are of a negligible or low magnitude would be classified as “not significant”. Effects that are of a moderate magnitude, but are restricted to the LSA are also classified as “not significant”. Effects that are of a moderate magnitude, and extend to the RSA are considered “significant”.

Overall, the potential impacts of the Project on environmental noise are classified as “not significant” based on the results on the assessment described above (Table 5.5-11).

Table 5.5-11: Summary of Significance

Geographic Extent	Magnitude	Overall Significance
SSA	Moderate	Not significant
LSA	Moderate	Not significant

5.5.8 Noise and Vibration Monitoring and Follow-Up

The preliminary follow-up monitoring program has been prepared and is submitted along with the Final EIS (SD 5-2 Noise Abatement and Monitoring Plan [NAMP]). The NAMP can be divided into 2 sections, a Noise Abatement Plan (NAP) and a Noise Monitoring Plan (NMP). The NMP describes the follow-up monitoring program required to confirm the environmental and cumulative effects of the Project are consistent with predictions reported in the EIS. The NMP will be used to verify that mitigation measures are effective once implemented and determine whether there is a need for additional mitigation measures.

Monitoring of blasting vibrations is addressed in SD 2-14 Explosives Management Plan.

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APPENDIX 5.2-A

Air Emission Details

1.0 INTRODUCTION

As described in Volume 5, the general approach used to evaluate the potential air quality effects of the Project included the following steps:

- Estimate the air emissions from the Project for the phase of activity (i.e., construction, operations, and closure and reclamation) determined to have the highest (i.e., bounding) quantity of air emissions.
- Predict the concentrations and deposition rates of indicator compounds released from the bounding phase of the project dispersion modelling.
- Use dispersion modelling to predict the concentrations and deposition rates of the non-indicator compounds required as inputs to other disciplines affected by changes in air quality (e.g., human health).
- Comparing the predicted indicator compound concentrations to available criteria and standards, and assess the relevant significance of these effects.
- Preparing monitoring, mitigation, and adaptive management strategies that reflect the nature of the Project, in the area where the Project is situated and the predicted air impacts.

This appendix outlines the first step, namely the estimation of air emissions estimations from the Project.

1.1 Project Emission Sources

The key steps in the gold mining process include extraction, processing, storage, and disposal. In each of these steps, there is a potential for air emission releases. Direct effects of the Project on the atmospheric environment were identified during each of the construction and operations, and post-closure phases of the Project. Specifically, the direct effects were identified for the following activities:

- **Mining Operations** – the removal of ore from the open pits and underground pits. This will result the release of fugitive dust emissions associated with the operational activities, as well as the release of tailpipe emissions from on-site equipment, including pit equipment and mine haul trucks.
- **Processing** – The processing of ore will result in fugitive dust as a results of crushing and material handling operations. Emissions of other constituents will be minimized through best management practices.
- **Support Operations** – Support operations include power plant, incinerator, and other ancillary supporting operations.

The primary sources of indicator compounds can be grouped based on the stage of the process, as outlined above. A summary of the emission sources and description of source activities is provided in Table 5.2-A1. A detailed description of the quantification method and assumptions for each of these sources is provided in the sections below.

Table 5.2-A1: Source Groups at the Meliadine Mine

Source Group	Source Activities
Open pit mining	Drilling
	Blasting
	Material transfers
	Storage piles
Underground mining	Drilling
	Blasting
	Material transfers
	Storage piles
Processing	Raw material storage
	Crushing
	Ore processing
	Storage
Disposal	Tailings disposal
Ancillary operations	General heating and ventilation
	Power generation
	Waste incineration

Emission rates for each of the above listed source groups were determine based on acceptable emission characterization methods. This included the following:

- emission factors;
- engineering calculations; and
- mass balance.

For each source, the maximum potential operating conditions were assumed. Most sources were to operate 24 hours a day and 365 days a year.

1.2 Emission Scenarios

For each of the Project areas, 4 distinct phases were considered, namely predevelopment phase, construction phase, operational phase, and decommissioning and reclamation phase. These timeframes are intended to be sufficiently flexible to capture the effects of the Project. The assessment of the atmospheric environment focuses on the operational phase of the Project, as the other phases are anticipated to have lower emission levels than when the mine is in full operation.

During the operations phase, the Project will have a number of open pit mines. The timing of when these open pits will be developed will vary depending on the actual blend of ore mined. However, the maximum amount of ore mined at any one time from open pits is 6500 tonnes per day. To provide flexibility in operations, and to fully assess the potential effects of the mining on air quality, the assessment considers 6 separate cases. In each case, the support operations (e.g., power plant) and underground mining (Tiriganiaq Underground at a rate of 2000 tonnes per day) will occur. The 6 cases listed below shows how the open pit mining activities were modelled, such that the full impact of mining at any of the pits has been captured. If activities were to occur at a lesser rate, at multiple pits, the individual effects would be less than those bounded by the cases below.

- Case 1: Processing plant operating at a maximum capacity, underground mining at Tiriganiaq, power generation, and ancillary supporting operations.
- Case 2: All sources in Case 1, plus open pit mining at Tiriganiaq
- Case 3: All sources in Case 1, plus open pit mining at F Zone
- Case 4: All sources in Case 1, plus open pit mining at Pump
- Case 5: All sources in Case 1, plus open pit mining at Discover
- Case 6: All sources in Case 1, plus open pit mining at Wesmeg

The individual emission sources associated with each of these scenarios are detailed in Table 5.2-A2.

Table 5.2-A2: Summary of Emission Sources and Quantification Methods

			Air Quality Indicator Compounds						
Activity	**Sub-Activity**	**Emission Source**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**NO_2**	**SO_2**	**CO**	**Estimation Methodology**
I - Open Pit Extraction	Drilling	Drill Holes	x	x	x				U.S. EPA AP-42 - 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing (8-04)
		Drill Rig Exhaust	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
	Blasting	Blast	x	x	x				U.S. EPA AP-42 - 11.9 Western Surface Coal Mining (7/98)
		Explosives				x		x	Australia NPI Explosives Detonation and Firing Ranges 3.0, January 2012
	Material Handling (ore and Waste Rock)	Material Drops	x	x	x				U.S. EPA AP-42 Chapter 13.2.4 – Aggregate Handling and Storage Piles (11-06)
		Vehicle Transport	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
	Support - Dewatering	Exhausts	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
	Support - Lighting	Exhausts	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
	Storage Piles	Exhausts	x	x	x	x	x	x	EPA-600/8-86-023 (Cowherd)
	Unpaved Roads	Roads	x	x	x				U.S. EPA AP-42 Chapter 13.2.2 – Unpaved Roads (11-06)
II - Underground Extraction	Drilling	Drill Holes	x	x	x				U.S. EPA AP-42 - 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing (8-04)
		Drill Rig Exhaust	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
	Blasting	Blast	x	x	x				U.S. EPA AP-42 - 11.9 Western Surface Coal Mining (7/98)
		Explosives				x		x	Australia NPI Explosives Detonation and Firing Ranges 3.0, January 2012
	Material Handling (ore and Waste Rock)	Material Drops	x	x	x				U.S. EPA AP-42 Chapter 13.2.4 – Aggregate Handling and Storage Piles (11-06)
		Vehicle Transport	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles

Table 5.2-A2: Summary of Emission Sources and Quantification Methods (continued)

			Air Quality Indicator Compounds						
Activity	**Sub-Activity**	**Emission Source**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**NO_2**	**SO_2**	**CO**	**Estimation Methodology**
II - Ore and Waste Rock Management	Transfer to Surge Piles/ Processing Plant	Material Drops	x	x	x				U.S. EPA AP-42 Chapter 13.2.4 – Aggregate Handling and Storage Piles (11-06)
		Vehicle Transport	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
III - Ore Processing	Material Transfers		x	x	x				Primary Crusher Dust Collector
	Crushing	Baghouses	x	x	x				Baghouse Outlet Loadings
	Processing Operations	Baghouses	x	x	x				Baghouse Outlet Loadings
	Leaching/Acid Wash/Desorption	Ventilation							No indicator compounds
	Carbon Regeneration	Ventilation							No indicator compounds
	Electrowinning	Ventilation							No indicator compounds
	Smelting	Ventilation							No indicator compounds
VIII - Support Activities	Power Generation	Powerhouse	x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
	Waste Incineration		x	x	x	x	x	x	U.S. EPA AP-42 Chapter 2.1 Refuse Combustion (10-96)
	Paste Plant		x	x	x				U.S. EPA AP-42 Chapter 11.12 Concrete Batching (06-06)
	Vehicles		x	x	x	x	x	x	Canadian Emission Standards Non-Road Vehicles
	Fuel Storage								U.S. EPA AP-42 Chapter 7 Liquid Storage Tanks (11-06)

1.3 Indicator Compounds

The assessment of air quality focused on predicting changes in the concentrations of selected indicator compounds. These indicator compounds represent compounds that are expected to be emitted from the Project, and are generally accepted as indicative in changing air quality, and for which relevant air quality criteria exist. These indicator compounds fall into the following 2 general categories:

- **Particulate matter**, including total suspended particulate (TSP), particles nominally smaller than 10 µm in diameter (PM_{10}), and particles nominally smaller than 2.5 µm in diameter ($PM_{2.5}$);
- **Combustion Gases**: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO);

Although not specific air quality indicators, additional compounds were assessed for use by other disciplines.

1.4 Emissions Estimation

Air emissions were estimated for the Project activities for which a measurable change is likely to occur. These air emissions were then used as inputs for the dispersion modelling that provided predicted ground-level concentrations at all locations within the receptor network.

Emissions were calculated using activity and equipment specifications provided in the Project Description (see FEIS Volume 2) and internationally accepted emission factors, most notably AP-42 (U.S. EPA 1995).

Consideration was also given to those elements incorporated into the Project design, as well as the construction and operation practices that could avoid or reduce emissions. These practices and design elements are considered to be an integral component of the Meliadine Project and were included as part of the assessment

The basic equation for calculating emissions is:

$$R = SE * E * (1 - c)$$

Where:

R = estimated mass emission rate in the specified unit

SE = source extent (e.g. production rate, exposed area, distance travelled)

E = uncontrolled emission factor in the specified particle range (i.e. mass of uncontrolled emission per unit of source extent)

C = fractional efficiency of control

From this formula, it can be seen that changing any of the variables will result in an increase or decrease in emissions. Inherently, reducing the source extent will result in reduction of emissions

The emission calculation approach for each of the sources/source groups for the Project is summarized in the sections below.

1.4.1 Open Pit Mining Operations

Mining operations consist of activities related to ore extraction and transfer from the pits to the processing plant. As outlined in the project description, there are 5 geographically distinct open-pit mines as follows:

- Tiriganiaq;
- F Zone;
- Pump;
- Discovery; and
- Wesmeg.

Based on information provided by Agnico Eagle Mines Limited (AEM), it is understood that the open-pit mines will not be mined concurrently, and that the maximum processing rate from any individual open pit mine is 6000 tonnes per day. The ability to mine and transfer material to the processing plant is bound by the availability of mining equipment; therefore, each mine was assessed individually to determine the maximum potential emissions from each individual pit. For open-pit mining, the primary activities that results in air emissions include drilling, blasting, material handling, material transport, and storage piles. The calculation methodology and assumptions used for each of these source groups are described in the sections below.

1.4.1.1 Drilling and Blasting

Open pit mining operations require the removal of material through drilling and blasting operations. In an open-pit, drill holes are drilled using a mobile drill rig. Emissions of particulate result from the drilling and blasting activity. In addition, combustion emissions arise from the combustion of fuels in the portable drill rig, as well as the use of emulsion as an explosive in the process.

Emission Calculation - Drilling

The compounds associated with drilling operations include TSP, PM_{10}, and $PM_{2.5}$. The drilling emission rate is based on emission factors (in kg/hole) are found in Table 11.19.2-1 of the U.S. EPA AP-42 emission factors (U.S. EPA 2005) from Chapter 11.19.2 - Crushed Stone Processing and Pulverized Mineral Processing (July 2004). The equation is as follows:

$$ER = EF \times Hourly\ Throughput \times \frac{1000\ g}{kg} \times \frac{1\ hr}{3600\ s}$$

where: *ER = emission rate (g/s)*

EF = emission factor (kg/Mg material processed) PM_{10} *= 4 x10^E-5*

In this equation, drilling emission factors are only available for PM_{10}. For the purpose of the assessment, it was assumed that TSP and $PM_{2.5}$ emission factors were the same as the ratio for emission factors for tertiary crushing.

For each individual open-pit mine, the maximum extraction rate of 120 000 tonnes per day was used in estimate the emissions from drilling activities.

Emission Calculation - Blasting

The compounds associated with blasting operations include TSP, PM_{10}, and $PM_{2.5}$. An equation from U.S. EPA AP-42 (U.S. EPA, 2005) Chapter 11.9 Western Surface Coal Mining (October 1998) was used to calculate the fugitive dust emissions associated with blasting activities. The equation is as follows:

$$E = 0.00022 \times \mathrm{A}^{1.5} \times \mathrm{SF}$$

where: *E = emission factor (kg/blast)*
A = horizontal area (m²)
SF = scaling factor for PM_{10} and $PM_{2.5}$ only

As the blasting emission factor was only available for SPM, PM_{10}, and $PM_{2.5}$, emission factors were estimated using scaling factors ratios based on the emission factors for tertiary crushing.

Emission Calculation – Blasting Explosives

The compounds associated with blasting explosives include CO and nitrogen oxides (NO_X). An equation from Australian National Pollutant Inventory document *Australia NPI Explosives Detonation and Firing Ranges 3.0, January 2012* was applied. The equation is as follows:

$$ER = EF \times Hourly\ Throughput \times \frac{1000\ g}{kg} \times \frac{1\ hr}{3600\ s}$$

where: *ER = emission rate (g/s)*
EF = emission factor (kg/Mg material processed)

1.4.1.2 Off-Road Vehicles – Exhaust Emissions

Vehicle engine emission rates for all off-road vehicles (i.e., open-pit and underground vehicles) were derived using the emission standards for off-road engines outlined in the *Canadian Off-Road Compression Engine Emission Regulation SOR/2005-32,* promulgated under the Canadian Environmental Protection Act (CEPA) (Environment Canada 2005). This regulation aligns engine certification values to those of U.S. EPA Tier 2, Tier 3, and Tier 4 standards. Although the Tier 4 standards came in to effect on 16 January 2012, as a conservative approach, it was assumed that all equipment for the Project will comply with the Tier 3 emission standard requirements. Underground mining equipment is exempt from this regulation, as it is governed under the CSA standards for mine ventilation rates (MMSL02-043); however, as a conservative measure it was assumed that all underground mining equipment will meet the Tier 3 standards.

Tier 3 emission standards are provided for non-methane hydrocarbons, NO_X, CO, and TSP. Within these limits, all TSP is in the form of PM_{10}, and $PM_{2.5}$ emissions are 97% of PM_{10} emissions.

The following equation was used to determine the emission rates for non-road vehicles:

$$ER = EF \times Engine\ Horsepower\ Rating \times Number\ of\ Vehicles \times LF \times \frac{Hours\ of\ Operation}{24\ hr} \times \frac{1\ hr}{3600\ seconds}$$

where:
ER = emission rate (g/s)
EF = emission factor (g/hp-hr)
LF – load factor

Load factors were derived from published literature for the respective vehicle categories.

For SO_2, emissions were calculated based on fuel consumption rates for each specific equipment type. The sulphur content of fuel was assumed to be 15 parts per million (ppm), and is based on the Sulphur in Diesel Fuel Regulations SOR/2002-254, dated June 2012, promulgated under CEPA (Environment Canada 2012). The following equation was used to determine the SO_2 emission factor:

$$ER = Fuel\ Density \times Sulphur\ Content \times \frac{MM\ SO_2}{MM\ Sulphur}$$

where:
MM = molar mass (g/mol)

For carbon dioxide (CO_2), emissions were calculated based on the emission factors used for Canada's National Inventory Report 1990-2009 for fuel combustion. The following equation was used to determine the SO_2 emission factor:

$$ER = Fuel\ Consumption\ \left(\frac{L}{hour}\right) \times CO_2\ EF\ \left(\frac{g}{L}\right) \times \frac{1\ hour}{3600\ seconds}$$

where:
EF = emission factor

1.4.1.3 Storage Piles

PM emissions from wind erosion on the storage piles were calculated based on the following equation:[1]

$$\text{ER (lb/day/acre)} = 1.7 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right)$$

Where,
ER = total suspended particulate emission rate (lb/day/acre)
s = silt content of aggregate (%)
p = number of days with at least 0.01 inch (i.e., 0.254 mm) of precipitation per year
f = percentage of time that the unobstructed wind speed exceeds 12 mph (5.36 m/s)

[1] Source: C. Cowherd, Jr., and J. S. Kinsey, *Identification, Assessment And Control Of Fugitive Particulate Emissions*, EPA-600/8-86-023, U. S. EPA, Cincinnati, Ohio, August 1986, Section 8.2.2.

Note that this equation is typically accepted by U.S. EPA for estimating wind erosion emissions. The emission rates were calculated based on the size of the pile, taking into account the typical active area. Where available, site specific silt content was used.

1.4.2 Material Handling

A primary source of fugitive dust in the gold mining process is the result of transfer of materials from one process to another. Emissions can occur at various points in the transfer process and include the following:

- material loading to the pile;
- material load-out from the pile; and
- transfer points between conveyors or equipment.

Both ore and waste rock are the primary materials that will be transferred around the site. The emission factors will vary depending on the moisture content of the material being moved. In addition speciation of compounds, such as metals speciation, will differ between waste rock and ore.

The emissions from material handing include TSP, PM_{10}, and $PM_{2.5}$. To quantify emissions from these activities, an equation in U.S. EPA AP-42 (U.S. EPA 2005) Chapter 13.2.4 – Aggregate Handling and Storage Piles (November 2006) was used to calculate the fugitive dust emission factors associated with material handling activities. The equation is as follows:

$$E = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where:
E = particulate emission factor (kg/Mg),
k = particle size multiplier for particle size range (see Table 5.2-A3),
U = Wind speed (m/s), and
M =moisture content of material (percent) (%)

Table 5.2-A3: Particle Size Multipliers - Material Handling

Size Range	Particle Size Multiplier (k)
$PM_{2.5}$	0.053
PM_{10}	0.35
TSP	0.74

Average wind speeds were obtained from local meteorological data.

1.4.3 Unpaved Road Dust

Emissions from unpaved roads occur as the result of the entrainment of dust from the road as a result of vehicle traffic. Particles are lifted from the surface and entrained. The turbulent wake behind the vehicle continues to act on the road after the vehicle has passed. The following equation can be used on unpaved road sections as well as for estimates of vehicles movements in storage pile areas.

Emission Calculation

The predictive emission equation in U.S. EPA AP-42 (U.S. EPA 2005) Chapter 13.2.2 – Unpaved Roads (November 2006) was used to calculate the emissions of TSP, PM_{10}, and $PM_{2.5}$ from unpaved roadways. The equation applicable to vehicles travelling on unpaved surfaces at industrial sites (Equation 1a) was used, and is as follows:

The emissions from unpaved roads can be estimated using the following U.S. EPA AP 42 Section 13.2.2 Unpaved Roads equation.

$$EF = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}$$

Where:

EF = emission factor (lb/VMT)
k = particle size multiplier (lb/VMT) (see Table 5.2-A4)
s = surface silt content (%)
W = mean vehicle weight (tons)
a = empirical constant (see Table 5.2-A4)
b = empirical constant (see Table 5.2-A4)
1 lb/VMT = 281.9 g/VKT

This emission factor is then be multiplied by the number of vehicles travelling the roadway and the length of the roadway to derive a TSP emission.

Table 5.2-A4: Particle Size Constants for Equation

Size Range	k (lb/VMT)	a	b	Surface Material Silt Content
$PM_{2.5}$	0.15	0.9	0.45	7.5%
PM_{10}	1.5	0.9	0.45	7.5%
TSP	4.9	0.7	0.45	7.5%

In addition, the effect of routine watering to control emissions was applied. This was calculated to be a control efficiency of 87%. Unpaved road dust emissions were calculated without an adjustment for natural mitigation.

For the All-weather Access Road, the predictive emission equation in U.S. EPA AP-42 (U.S. EPA 2005) Chapter 13.2.2 – Unpaved Roads (November 2006) was used to calculate the emissions of TSP, PM_{10}, and $PM_{2.5}$ from unpaved roadways. The equation applicable to vehicles travelling on unpaved surfaces on publically accessible roads (Equation 1b) was used, and is as follows:

$$EF = \frac{k\left(\frac{s}{12}\right)^{a}\left(\frac{S}{30}\right)^{d}}{(M/0.5)^{c}} - C$$

Where:

EF = emission factor (lb/VMT)
k = particle size multiplier (lb/VMT) (see table 1.4.10-1)
s = surface silt content (%)
a = empirical constant (see table 5.2-A5)
b = empirical constant (see table 5.2-A5)
c = empirical constant (see table 5.2-A5)
S = mean vehicle speed (mph)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear
1 lb/VMT = 281.9 g/VKT

Table 5.2-A5: Particle Size Constants for Equation

Size Range	k (lb/VMT)	a	b	c	d	Surface Material Silt Content
$PM_{2.5}$	0.15	0.9	0.45	0.2	0.5	4.8%
PM_{10}	1.5	0.9	0.45	0.2	0.5	4.8%
TSP	4.9	0.7	0.45	0.3	0.3	4.8%

In addition, the effect of routine watering to control emissions was applied. This was calculated to be a control efficiency of 87%. Unpaved road dust emissions were calculated without an adjustment for natural mitigation.

The emission rate calculation for unpaved roads was as follows:

$$ER = E \times Daily\ Vehicle\ Kilometres\ Travelled \times (1 - Control\ Efficiency) \times \frac{1\ day}{24\ hr} \times \frac{1\ hr}{3600\ s}$$

1.4.4 Underground Mining Operations

Under the current mine plan, the Tiriganiaq Mine is the only pit that will have underground mining operations. Based on the information provided by AEM, this mine will operate at a rate of 2500 tonnes per day. The emission associated with underground mining are the same as those with open-pit mining, with the exception of outdoor storage piles, and the addition of underground crushers. The difference is the in the release location of the emissions. Open-pits are fugitive in nature, whereas underground mine releases occur from specific point sources through the vent raises.

Emissions associated with the underground mine operations include the following:

- drilling and blasting; and
- material transfers.

The calculation methodologies are the same as those listed in Section 1.4.1.

1.4.4.1 Crushers

The underground mine will have crushers to reduce rock size prior to transport to the processing plant. To estimate emissions from this source, U.S. EPA AP-42 (U.S. EPA 2005) emission factors from Chapter 11.19.2 - Crushed Stone Processing and Pulverized Mineral Processing (July 2004) were used:

$$ER = EF \times Daily\ Throughput \times \frac{1000\ g}{kg} \times \frac{1\ day}{24\ hr} \times \frac{1\ hr}{3600\ s}$$

where: ER = emission rate (g/s)
EF = emission factor (kg/Mg)

1.4.5 Ore and Waste Rock Management

During the life of the Project, ore will be hauled from the open-pits to the processing plant. Waste rock will be hauled to one of the waste rock storage piles. The emissions associated with this activity were characterized in the same manner as outlined in the previous sections, specifically for each of the following:

- unpaved roads;
- material transfers;
- off-road vehicles; and
- storage piles.

1.4.6 Processing and Support Operations

Processing and support operations include those emission sources associated with the processing plant, or support activities, such as power generation or incineration.

1.4.6.1 Stationary Diesel Combustion

Stationary diesel combustion equipment will be used primarily for the following purposes at the Project:

- Power Plant - diesel generators to provide electricity for the process plant, rock handling underground, ancillary support loads, and camp requirements; and
- Underground mine crushers.

The current Canadian Non-road Diesel Engine Emission Standards were used (as previously described in Section 1.4.6.3).

1.4.6.2 Process Baghouses

Process baghouse emissions were calculated using an assumed emission outlet loading of 20 milligrams per cubic metre emission. This is an accepted level by various provincial and US government agencies. Due to the typical particle size distribution of baghouses (U.S. EPA 2005 it was assumed that particulate emissions were in the form of $PM_{2.5.}$ The emission factor was used in the following equation:

$$ER = EF \times Exhaust\ Flowrate \times \frac{1\ g}{1000\ mg} \times \frac{1\ hr}{3600\ s}$$

where: ER = emission rate (g/s)
EF = emission factor (mg/m³)

1.4.6.3 On-Road Vehicles – Exhaust Emissions

As part of the Project activities, there will be some vehicles that are classified as "on-road" emissions. These vehicles have different emission controls than those classified as non-road. To estimate emissions from the on-road sources, the MOBILE6 Vehicle Emission Modelling Software (MOBILE6) (U.S. EPA 2003) was used. Using this model, exhaust emission factors from on-road vehicles were calculated. This model was used to predict gram per vehicle kilometre travelled (VKT) emissions of CO, NO_X, CO_2, and TSP, PM_{10}, and $PM_{2.5}$. The following equation was used base on this model:

$$ER = EF \times Number\ of\ Vehicles \times Daily\ Distance\ Travelled \times \frac{1\ day}{24\ hr} \times \frac{1\ hr}{3600\ s}$$

where: ER = emission rate (g/s)
EF = emission factor (g/VKT)

1.4.7 Incinerator

The U.S. EPA AP-42 (U.S. EPA 2005) emission factors from Chapter 2.1 Refuse Combustion (October 1996) were used in the following equation to calculate the emissions associated with waste incineration:

$$ER = EF \times Waste\ Combustion\ Rate \times \frac{1\ g}{1000\ mg} \times \frac{1\ hr}{3600\ s}$$

where: ER = emission rate (g/s)
EF = emission factor (kg/Mg)

1.4.8 Diesel Fuel Storage Tank

Working loss emissions from the 5.8 million litre diesel fuel storage tank were calculated using the U.S. EPA Tanks 4.09d software program. The detailed methodology is provided in U.S. EPA AP-42 (U.S. EPA 2005) chapter 7 Liquid Storage Tanks (2006).

1.4.9 Paste Backfill Plant Emissions

The U.S. EPA AP-42 (U.S. EPA 2005) emission factors from Chapter 11.12 Concrete Batching (June 2006) were used in the following equation to calculate the particulate matter emissions associated with the Paste Backfill Plant:

$$ER = EF \times Hourly\ Throughput \times \frac{1000\ g}{kg} \times \frac{1\ hr}{3600\ s} \times (1 - R)$$

where: ER = emission rate (g/s)
EF = emission factor (kg/Mg)
R = reduction factor for controlled emissions (%)

As all Paste Backfill Plant operations occur indoors, it was assumed that all emissions are controlled. Where controlled emission factors were not available for specific operations, an average reduction percentage was applied to the uncontrolled emission factors. This average reduction percentage was calculated using the ratio between the available controlled and un-controlled emission factors.

A summary of emission sources and estimation methods is provided in Table 5.2-A2.

1.5 Emission Scenarios

As described in Section 1.2, operations for the Project were classified into 6 distinct cases. The activities associated with each of these cases are summarized in Table 5.2-A6.

Table 5.2-A6: Summary of Emission Scenarios for Assessment

Activity	Case 1	Case 2	Case 2	Case 3	Case 4	Case 5	Case 6
F-Zone Open Pit Mining	—	—	—	Yes	—	—	—
Discovery Open Pit Mining	—	—	—	—	—	Yes	—
Pump Open Pit Mining	—	—	—	—	Yes	—	—
Tiriganiaq Open Pit Mining	—	Yes	Yes	—	—	—	—
Wesmeg Open Pit Mining	—	—	—	—	—	—	Yes
Tiriganiaq O/P to Ore SP	—	Yes	Yes	—	—	—	—
Tiriganiaq O/P to B7 Waste SP	—	—	—	—	—	—	—
Tiriganiaq O/P to B4 Waste SP	—	Yes	Yes	—	—	—	—
Tiriganiaq U/G to Ore Stockpile	—	—	—	—	—	—	—
Tiriganiaq U/G to B7 Waste Stockpile	—	—	—	—	—	—	—
F-Zone to Ore SP	—	—	—	Yes	—	—	—
F-Zone to A45-2 Waste SP	—	—	—	Yes	—	—	—
Pump to Ore SPs	—	—	—	—	Yes	—	—
Pump to B4 Waste SP	—	—	—	—	Yes	—	—
Discovery to Ore SPs	—	—	—	—	—	Yes	—
Discovery to DE Waste SP	—	—	—	—	—	Yes	—

AGNICO EAGLE Golder Associates

Table 5.2-A6: Summary of Emission Scenarios for Assessment (continued)

Activity	Case 1	Case 2	Case 2	Case 3	Case 4	Case 5	Case 6
Wesmeg to Ore SPs	—	—	—	—	—	—	Yes
Wesmeg to B4 Waste SP	—	—	—	—	—	—	Yes
Material Handling	—	—	—	Yes	—	—	—
Material Handling	—	—	—	Yes	—	—	—
Material Handling	—	—	—	—	—	Yes	—
Material Handling	—	—	—	—	—	Yes	—
Material Handling	—	—	—	—	Yes	—	—
Material Handling	—	—	—	—	Yes	—	—
Material Handling	—	Yes	Yes	—	—	—	—
Material Handling	—	—	—	—	—	—	—
Material Handling	—	Yes	Yes	—	—	—	—
Material Handling	—	—	—	—	—	—	Yes
Storage Piles	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tiriganiaq Underground Emissions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Processing Plant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Storage Tank	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Power Plant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Paste Backfill Plant	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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APPENDIX 5.2-B

Dispersion Modelling Methodology

1.0 INTRODUCTION

As described in Volume 5, the general approach used to evaluate the potential air quality effects of the Project included the following steps:

- Estimate the air emissions from the Project for the phase of activity (i.e., construction, operations, and closure and reclamation) determined to have the highest (i.e., bounding) quantity of air emissions.
- Predict the concentrations and deposition rates of indicator compounds released from the bounding phase of the project dispersion modelling.
- Use dispersion modelling to predict the concentrations and deposition rates of the non-indicator compounds required as inputs to other disciplines affected by changes in air quality (e.g., human health).
- Comparing the predicted indicator compound concentrations to available criteria and standards, and assess the relevant significance of these effects.
- Preparing monitoring, mitigation, and adaptive management strategies that reflect the nature of the Project, in the area where the Project is situated and the predicted air impacts.

This appendix outlines the second and third step, namely the approach used for dispersion modelling.

2.0 AIR DISPERSION MODELLING

Air dispersion models were used to predict concentrations and deposition rates associated with the Project emissions. The same models were used in predicting concentrations of indicator compounds as was used in predicting concentrations and deposition rates of non-indicator compounds (those compounds used by other disciplines in assessing the indirect effects of air quality). Specifically, the fully capable CALPUFF dispersion model (i.e., run in dynamic [3D] mode with a fine resolution meteorological data set) was used in predicting concentrations and deposition rates. This model was selected for the following reasons:

- It is widely accepted in northern Canada for assessing the effects of mining project.
- The CALPUFF model can be used to accurately predict concentrations and deposition rates at distances as small as 10s of metres and extending out far enough to enclose the entire modelling domain (i.e., 35 x 35 kilometres [km]).
- The CALPUFF model is capable of simulating both wet and dry deposition of gaseous and particulate compounds. In addition, CALPUFF has the ability to model the atmospheric chemistry necessary to predict potential acid inputs.

The CALPUFF model was used in 2 ways. For assessing the effects of the mine site, all sources were input into the model for each of the 6 cases discussed in the previous section, and concentrations predicted at a grid of receptors (see Appendix 5.2-A). The assessment of effects looked at the highest predictions for each case, as well as for all of the cases. These predictions were provided outside of the disturbance footprint of the Project, and characterized as to the maximums within the site study area (SSA), local study area (LSA), and regional study area (RSA). In accordance with modelling guidance (AENV 2009), the maximum concentrations were determined excluding meteorological anomalies. As there is no air modelling guidance for Nunavut; the dispersion modelling approach is based on the Air Quality Model Guidance developed by Alberta Environment (AENV 2009).

In addition to modelling the indicator compounds, concentrations and deposition rates of non-indicator compounds (i.e., those compounds used as inputs to other disciplines) were calculated at a series of discrete and gridded receptors (see Appendix 5.2-A). The discrete receptors include locations within the Iqalugaarjuup Nunanga Territorial Park and at locations where prolonged human exposure is likely to occur.

Rationale for the use of CALPUFF and details of the modelling assessment are summarized in the sections below.

2.1 Regulatory Framework

Dispersion modelling guidelines have been established by several Provinces in Canada. In the absence of a dispersion modelling guideline for the Nunavut, the dispersion modelling approach for this assessment is based on current Air Quality Model Guidance issued by Alberta Environment (AENV 2009). The purpose of the guideline is to provide uniform benchmarks and a structured approach to the selection and application of dispersion models. Furthermore, it provides a sound scientific basis for the selection of alternatives. Issues considered in the guideline include the following:

- determination of model performance by comparing model predictions to air quality observations;
- meteorological data requirements;
- receptor placement;
- consideration of permanent structure (e.g., building) downwash effects;
- incorporation of complex terrain; and
- assumptions for consideration when preparing source information.

Based on this Guideline, as well as requirements of other jurisdictions such as the United States (U.S.) Environmental Protection Agency (EPA), the likely environmental effects for the air quality indicators were evaluated with the aid of the CALPUFF dispersion model. The CALPUFF modelling system is a non-steady state meteorological and air quality modelling system that has been recommended by the U.S. EPA for long-range transport (i.e., greater than 50 km) of air pollutants and associated effects. The CALPUFF model was developed with the following objectives:

- consideration of time varying point, line, area, and volume sources;
- suitability for modelling domains ranging from 10s of metres to hundreds of kilometres from a source;
- prediction of averages from 1-hour to full meteorological period;
- incorporation of building downwash effects;
- incorporation of horizontal and wind shear effects;

- applicability to inert pollutants and those subject to linear removal and chemical conversion mechanisms; and
- applicability to complex terrain scenarios.

Suitable application of the CALPUFF modelling system may include near field impacts associated with complex flow or drop areas (e.g., complex terrain, stagnation, calm wind conditions), long range transport of air pollutants, visibility assessment, criteria air pollutant modelling, buoyant area and line sources, and others.

In 3D mode, wind fields determined by the CALMET meteorological model can vary across the modelling domain on both horizontal and vertical scales. This variation often results in improved estimates of plume dispersion compared to non-varying wind fields. Additionally, terrain effects are incorporated into the wind field derivations to enable plumes to travel around or over terrain features, as appropriate, rather than impacting the terrain features directly.

2.2 Rationale

For assessing air quality effects from the on-site emission sources from the Project, CALPUFF was determined to be the most appropriate model, based on the following primary rational:

- CALPUFF has the applicability at a range of spatial scales from a few kilometres to more than 100 km (e.g., evaluating regional and local air emission effects);
- CALPUFF allows more accurate treatment of the effects due to complex terrain features and non-uniform land use, and effect of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal;
- CALPUFF has the ability to treat the combined effects of multiple processes (e.g., building downwash effects in complex terrain; dry deposition and chemical transformation, etc.);
- CALPUFF allows more accurate treatment of calm wind conditions, which are often associated with high POI concentrations; and
- CALPUFF considers secondary formation of pollutants and includes both sulphur dioxide (SO_2) and nitrogen oxides (NO_X) chemistry, which is required for predicting potential acid input (PAI);
- CALPUFF incorporates wet and dry removal processes (deposition);
- CALPUFF is based on principles that have been explicitly documented and undergone independent peer review; and
- CALPUFF incorporates plume rise model enhancement downwash algorithms.

The CALPUFF model was run in 3D mode for the purposes of assessing on-site emissions from the Project using a wind field developed specifically for the Project from regional surface meteorological data and mesoscale data for northern Canada. The RIVAD/ARM3 chemistry was used for calculations of wet and dry deposition of sulphate and nitrate compounds.

Despite many advancements of the CALPUFF modelling system over other available models, CALPUFF has some limitations. For example, predicted concentrations and deposition of airborne contaminants are known to be higher than observed near major area sources of SO_2 and NO_X, such as mine pits. This is likely due to the RIVAD/ARM3 chemical transformation algorithms used by the model (Staniaszek et al. 2006; Staniaszek and Davies 2006).

The CALPUFF model in dynamic mode was selected to meet the assessment Guidelines for the Project particularly with respect to deposition. Its use in environmental assessments in the Nunavut and the Northwest Territories has broad support from regulators and regional stakeholders.

2.3 CALPUFF Modelling System

The CALPUFF modelling system is made up of 3 main components:

- The CALMET meteorological model that generates meteorological input files;
- The CALPUFF transport and dispersion model that advects "puffs" of material emitted from sources to calculate hourly concentration/fluxes at receptors of interest; and
- CALPOST post processor (used to extract the data of interest from CALPUFF binary output files).

To predict concentrations using CALPUFF, a series of inputs are required. These inputs can be grouped into categories:

- dispersion meteorological data;
- terrain and receptors; and
- source configurations.

Each of these input categories are discussed separately in the following sections.

The following versions of the model were used:

- CALPUFF dispersion model (V5.8, level 070623);
- CALPOST post processor (5.6394, level 070622); and
- BPIP building downwash pre-processor (V04274).

2.4 Dispersion Meteorology

A 5-year meteorological data set was developed using the CALMET processor. CALMET is a diagnostic meteorological model that produces 3D wind fields based on parameterized treatments of terrain effects, such as slope flows, terrain blocking effects, and kinematic effects. In this model, meteorological observations are used to determine the wind field in areas where the observations are representative. The required gridded hourly meteorological data was developed using MM5. Specific details of the dispersion meteorology developed for this assessment are included in Appendix 5.2-C.

2.5 CALPUFF Dispersion Modelling Approach

The air quality assessment for the Project included several assumptions regarding assessment scenarios, emission rates, and dispersion modelling approaches. Whenever possible, assumptions were made conservatively so that model predictions were not underestimated. The main assumptions included in the air quality assessment are as follows:

- The dispersion modelling was performed per the Alberta Air Quality Model Guideline (AENV 2009). There is no air quality modelling guideline for Nunavut.
- For each on-site modelling scenario, it was assumed that all emission sources were emitting continuously at their maximum emission rates. In reality, some sources such as waste incinerators operate intermittently.
- The 2005 MM5 meteorological data were appropriate for use in preparing the 3D meteorological data set.
- It was assumed that 100% of the airborne sulphates and nitrates were in the form of secondary aerosols, resulting in conservative estimations of $PM_{2.5}$ concentrations.

2.5.1 Modelling Domain

The modelling domain was set to be 40×45 km in size to encompass all study areas for the Project (RSA, LSA, and SSA). This domain is large enough to capture the effects of the Project on the surrounding area. These areas are further defined as follows:

- Site Study Area
  - A SSA (see FEIS Volume 5, Figure 5.1-1) was defined for the Mine Site (and associated infrastructure) that encompasses the operational area of the Project. This includes the direct area of physical disturbance associated with the construction or operation of the Project (disturbance footprint), and extends outward a distance of 500 m. In discussions with AEM, this is the area where non-Project related activities would be restricted during the life of the Project, and public access to these areas would be limited. Site Study Areas were not defined for the All-weather Access Road (AWAR), Rankin Inlet activities, or marine shipping.
- Local Study Area:
  - Separate LSAs have been defined for the mine site, the AWAR, and the Rankin Inlet activities. These areas generally corresponds to the extents where most the air quality effects associated with the Project element are expected to occur, and can be predicted or measured with a reasonable degree of accuracy. The following define the LSAs used for assessing air quality:
    - Mine Site: A rectangle 21 × 30 km in size, which extends at least 5 km in all directions from the mine SSA

  - AWAR: A band 3 km in width, extending 1.5 km either side of the travel surface of the roadway. The AWAR LSA is considered to start at the edge of the mine LSA, and extend down into Rankin Inlet.
  - Rankin Inlet: The boundaries of the community of Rankin Inlet.
  - A Local Study Area was not defined for the marine shipping.
- Regional Study Area
  - A single RSA (see FEIS Volume 5, Figure 5.1-1) was defined for the mine site (and associated infrastructure), the AWAR, and Rankin Inlet activities. This RSA is 40×45 km in size, generally centred on the mine site, and includes the area where CALPUFF dispersion modelling predictions were made.

2.6 Model Receptors

Ambient concentrations resulting from on-site emissions were predicted at selected groups of receptors to provide a better understanding of the potential impacts of the Project. This included approximately 15 000 receptor locations. The receptor locations were based primarily on AENV modelling guidance (AENV 2009), which recommends the following receptor placement:

- spacing of 20 m in the general area of maximum impact and the property boundary;
- spacing of 50 m within 1 km of the sources of interest;
- spacing of 250 m within 5 km of the sources of interest; and
- spacing of 1000 m between 5 and 10 km from the sources of interest.

The Iqalugaarjuup Nunanga Territorial Park is included as part of this grid. For the use of other disciplines, 2 additional receptor grids were incorporated:

- Eco-Risk Grid: 35 km x 35 km grid centred on the mine site with 1 km spacing (see FEIS Volume 10, Figure 10.1-3); and
- Human Health Receptors: 27 discrete receptors (see FEIS Volume 10, Figure 10.2-4).

2.6.1 Model Options

The CALPUFF dispersion model is a sophisticated tool that uses numerous user-specified options. The selection of options used in the analysis requires great care and understanding of the underlying model algorithms. Most of the modelling options used in the model are U.S. EPA default CALPUFF model options as recommended by the Alberta Air Quality Model Guideline (AENV 2009). Table 5.2-B1 provides a sample of model input options.

Table 5.2-B1: CALPUFF Model Input Options

Flag	Default	Used Value	Comments
MGAUSS	1	1	Vertical distribution used in the near field
MCTADJ	3	3	Terrain adjustment method (3 used for partial plume path adjustment)
MCTSG	0	0	Subgrid-Scale complex terrain flag
MSLUG	0	0	Near-field puffs modelled as elongated
MTRANS	1	1	Transitional Plume Rise modelled
MTIP	1	1	Stack-tip downwash
MRISE	1	1	Plume rise for point sources not subject to building downwash 1 = Birggs plume rise, 2 = Numerical plume rise
MBDW	1	2	Method used to simulate building downwash 1 = ISC method; 2 = PRIME method
MSHEAR	0	0	Vertical wind shear modelled above stack top
MSPLIT	0	0	Puff splitting allowed 0 = No; 1 = Yes
MCHEM	1	0	Chemical Transformation Scheme 0 = chemical transformation not modelled 1 = transformation rates computed internally (MESOPUFF II scheme)
MAQCHEM	0	0	Aqueous phase transformation flag (only used if MCHEM =1 or 3)
MWET	1	1	Wet removal modelled 0 = No; 1 = Yes
MDRY	1	1	Dry deposition modelled 0 = No; 1 = Yes
MTILT	0	0	Gravitational settling (plume tilt) modelled
MDISP	3	2	Methods used to compute dispersion coefficients 2 = (dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.) 3 = PG dispersion coefficient for RURAL areas (computed using the ISCST multi-segment approximation) and MP coefficients in urban areas)
MTURBVW	3	3	Sigma measurements used (Used only if MDISP = 1or 5)
MDISP2	3	3	Back-up method used to compute dispersion when measured turbulence data are missing (Used only if MDISP=1 or 5)
MTAULY	0	0	[DIAGNOSTIC FEATURE] Method used for Lagrangian timescale for Sigma-y (used only if MDISP=1,2 or MSIDP2=1,2)
MTAUADV	0	0	[DIAGNOSTIC FEATURE] Method used for Advective-Decay timescale for Turbulence (used only if MDISP=2 or MDISP2=2)
MCTURB	1	1	Method used to compute turbulence sigma-v & sigma-w using micrometeorological variables (Used only if MDISP = 2 or MDISP2 = 2)
MROUGH	0	0	PG sigma y,z adjusted for roughness
MPARTL	1	1	Partial plume penetration of elevated inversion modeled for point sources; 0 = No, 1 = Yes
MPARTLBA	1	1	Partial plume penetration of elevated inversion modeled for buoyant area sources; 0 = No, 1 = Yes
MTINV	0	0	Strength of temp inversion provided in PROFILE.DAT extended records
MPDF	0	1	Probability Distribution Function used for dispersion under convective conditions 0 = No; 1 = Yes

Table 1: CALPUFF Model Input Options (continued)

Flag	Default	Used Value	Comments
MSGTIBL	0	0	Sub-grid TIBL module used for shore line
MBCON	0	0	Boundary conditions (concentration) modeled
MFOG	0	0	Configure for FOG Model output
MREG	1	0	Test options specified to see if they conform to regulatory values

2.6.2 Building Downwash

Building downwash is a phenomenon caused by air movement around buildings. Buildings or other solid structures may affect the flow of air in the vicinity of a source and cause eddies to form on the downwind side of a building. In some situations, the stack emissions may be trapped in the wake of a building or other structures, which may result in elevated ground-level concentrations. In this assessment, building downwash was simulated using the Plume Rise Model Enhancements model and Building Profile Input Program (BPIP).

2.6.3 Approach for Nitrogen Dioxide Conversion

Nitrogen oxides are comprised of nitric oxide (NO) and NO_2. High temperature combustion processes primarily produce NO that in turn can be converted to NO_2 in the atmosphere through reactions with tropospheric ozone:

$$NO + O_3 \rightarrow NO_2 + O_2$$

The CALPUFF dispersion model uses a modified version of the RIVAD/ARM3 SO_X and NO_X chemistry scheme that was adopted to allow NO_2 concentrations to be calculated from NO emissions within the model; however, the CALPUFF model chemistry scheme has been shown to overestimate ambient NO_2 concentrations, especially close to large area emission sources such as mine pits (Staniaszek and Davies 2006). For that reason, the NO_X ground-level concentrations obtained from the modelling were converted to NO_2 ground-level concentrations using the Ozone Limited Method according to AENV (2009). The Ozone Limited Method assumes that the conversion of NO to NO_2 in the atmosphere is limited by the ambient ozone concentration in the atmosphere. If the ozone concentration is greater than 90% of the modelled NO_X ground level concentration, the method assumes all NO_X is converted to NO_2. Otherwise, the NO_2 concentration is equal to the sum of the ozone available to oxidize NO_X and 10% of the modelled NO_X ground-level concentration:

$$NO_2 = O_3 + 0.1 \text{ X } NO_X$$

The ozone concentration used in the Ozone Limited Method calculations assessment was 0.042 ppm. This value was determined based on hourly ozone monitoring data collected in Yellowknife between 2007 through 2009 (GNWT 2010).

2.6.4 Approach for Acid Deposition

Acidifying emissions include oxides of sulphur and nitrogen, and ammonia, and are modelled with the CALPUFF model. Deposition of acidifying emissions can occur via wet and dry processes. Wet deposition results remove these atmospheric emissions by precipitation. Dry processes remove emissions by direct contact with surface features (e.g., vegetation, soils, and surface water).

Both wet and dry depositions are expressed as a flux in units of kilograms per hectare per year (kg/ha/y). Where more than one chemical species is considered, the flux is often expressed in terms of keq/ha/y where 'keq' refers to hydrogen ion equivalents (1 keq = 1 kmol H^+), the common acidic ion associated with various negatively charged ions. Potential acid input is used as a deposition measure of acidification and is defined as follows:

$$PAI = PAI_{sulphur} + PAI_{nitrogen} + PA_{background}$$

Where:

$PAI_{sulphur}$ is the model predicted PAI contributed by sulphur compounds;
$PAI_{nitrogen}$ is the model predicted PAI contributed by nitrogen compounds; and
$PAI_{background}$ is the background PAI.

2.6.5 Approach for Nitrogen Deposition

Deposition of nitrogen includes both wet (removal in precipitation) and dry (direct contact with surface features) processes. In the current approach, nitrate particulate is determined to be deposited by both wet and dry processes and is directly calculated by the dispersion model based on modelled annual average concentrations and an assumed deposition velocity.

The deposited nitrogen (expressed as a mass flux of nitrogen mass equivalent species) is scaled by the molecular weights of the deposited species as follows:

$$Nitrogen\ Deposition = \frac{NOdry \times 14}{30} + \frac{NO_2dry \times 14}{46} + \frac{(NO_{3,dry} + NO_{3,wet}) \times 14}{62} + \frac{(HNO_{3,dry} + HNO_{3,wet}) \times 14}{63}$$

Using this approach, nitrate deposition is accounted for in both acidification and eutrophication calculations.

2.6.6 Background Concentrations

Due to the remote nature of the site, background concentrations were not added to the model predicted concentrations.

2.7 Source Parameterization

The CALPUFF modelling system requires sources to be characterized as area, volume, or point. The source type will depend on the configuration of individual sources. A summary of these source types is provided in Table 5.2-B2.

Table 5.2-B2: Summary of Types of Sources for CALPUFF Modelling

Type	Description	Example
Point	Releases from a specific source such as a stack or isolated vent.	stacks, individual vents
Area	Used to model low-level or ground-level emissions with little or no plume rise. Input as square, rectangle, polygon, or circle	storage piles, open-pits
Volume	Sources that initially disperse 3-dimensionally with no plume rise.	windows, doors, conveying system transfer points, crushers/screeners, haul roads

Where appropriate, multiple sources can be combined to a single source. This is based on the following characteristics:

- the source characteristics of the individual stacks or vents must be similar;
- the emission rate from the individual release points must be similar;
- the sources must be located over an area of volume that can be reasonably well defined; and
- the property line must not be too far from the group of stacks or vents.

2.7.1 Point Sources

Point sources were used to model emissions from the Power Plant, Waste Incinerator, and underground mine ventilation raises.

2.7.2 Area Sources

Area sources are used to model low level or ground releases. In general, area sources result in much higher ground level concentrations than those of volume or point sources. To remain conservative, the open pit sources modelled as area sources. Each pit was modelled as a single area source.

2.7.3 Volume Sources

The haul roads and process plant were characterized as volume sources. The guidance for modelling emissions from haul roads outline the US EPA Technical memo entitled *Haul Road Workgroup Final Report Submission to EPA-OAQPS*, dated March 2012 was followed.

A summary of process by model source type is provided in Table 5.2-B3:

Table 5.2-B3: Summary of process by model source type

Process	Area Source	Volume Source	Point Source
Open Pits	X		
Haul Road		X	
Power Plant	X		X
Waste Incinerator			X
Material Handling		X	
Paste Plant		X	
Fuel Tanks		X	

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APPENDIX 5.2-C

Dispersion Meteorology

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FIGURES

1.0 INTRODUCTION

The air quality effects associated with the Project were determined using dispersion models. Specifically, the CALPUFF dispersion model was used in predicting concentrations and deposition rates resulting from emissions associated with the various Project areas and operations. To use the full capabilities of the CALPUFF model, it was run in the dynamic (i.e., 3D) mode. To run CALPUFF in the dynamic mode, a comprehensive dispersion meteorological data set is required. This Appendix describes the sources of data and the methods used for developing the data set, as well as providing a summary of the resulting meteorological conditions.

2.0 METEOROLOGICAL DATA SOURCES

Agnico-Eagle Mines Limited (AEM) is evaluating the development of the Meliadine Gold Project (the Project), located approximately 25 kilometres (km) North of Rankin Inlet, Nunavut. As part of the preliminary design studies for the Project, on-site meteorological data were collected at the site by Hubert and Associates Ltd. (Hubert) over the period from 1997 through 2001. These data were then used to compile a climate summary report (Hubert 2001). As part of the current environmental impact statement (EIS) being completed by Golder Associates Ltd. (Golder), a review was undertaken to compare the available on-site information to data from the Environment Canada meteorological station at Rankin Inlet to determine whether the available on-site data for the period 1997 through 2001 accurately represents the current meteorological conditions in the Project area.

The 3 primary questions addressed in this review are as follows:

- Are there significant differences between the most recent climate observations at Rankin Inlet, the observations at Rankin Inlet covering the period when on-site data were being collected (1997 through 2001), and long-term climate normals for the stations?
- Are the meteorological data collected at the on-site station between 1997 and 2001 consistent with the observations at Rankin Inlet for the same period of time?
- Can the meteorological data collected on-site be useful for developing the Project EIS, and can the differences between the on-site and Rankin Inlet observations provide sufficient information to describe the meteorological conditions at the site today?

Three sets of Rankin Inlet meteorological data were required to address these questions: hourly data for the most recent 5-year period (2006 through 2010), hourly data for the period 1997 through 2001 (the period concurrent with available on-site data), and Rankin Inlet long-term climate normals. The hourly 2006 through 2010 data were compared to the hourly 1997 through 2001 data to determine whether the latter were consistent with current meteorological conditions at Rankin Inlet. The hourly 1997 through 2001 on-site data were then compared to the hourly 1997 through 2001 Rankin Inlet data to identify any significant differences between the site and Rankin Inlet. Where significant differences were identified, long-term climate normal data were used to identify which of the 1997 through 2001 data sets were providing a more realistic representation of current conditions. Since the on-site meteorological data are only available in a limited form (either summarized in Hubert [2001] or as electronic daily summaries), the comparison of the Rankin Inlet to on-site meteorological data was restricted to temperature, precipitation, and wind data only.

2.1 Observed Temperatures

2.1.1 Rankin Inlet

The 30-year climate normals for Rankin Inlet (1971 to 2000) from Environment Canada indicate that temperatures range from a monthly low average of -31.9°C in January, to a monthly high average of 10.4°C in July. The extreme minimum and maximum temperatures span from -49.8°C to 30.5°C. The climate normals for temperatures at Rankin Inlet are presented in Table 5.2-C1.

Table 5.2-C1: Temperature Climate Normals (1971 to 2000) for Rankin Inlet

Month	Daily Average (°C)	Daily Maximum (°C)	Daily Minimum (°C)	Extreme Maximum (°C)	Extreme Minimum (°C)
January	-31.9	-28.3	-35.5	23.4*	-46.1
February	-30.1	-26.2	-33.9	-4.4	-49.8
March	-25.2	-20.9	-29.5	1.3	-43.4
April	-16.3	-11.7	-20.8	3.4	-35.7
May	-5.9	-2.4	-9.2	14.1	-23.8
June	4.2	7.9	0.4	26.1	-9.4
July	10.4	14.9	5.9	28.9	-1.9
August	9.5	13	5.9	30.5	-1.4
September	3.4	5.8	0.9	20.6	-9
October	-5.3	-2.4	-8.2	9.3	-27.4
November	-17.8	-13.9	-21.6	0.9	-36.5
December	-26.7	-22.9	-30.4	-2.4	-43.6

Note: * Extreme maximum temperature for January of +23.4°C was recorded on 5 January 1997.

The latest 5-years of hourly temperature data available for Rankin Inlet (i.e., 2006 through 2010) are tabulated in Table 5.2-C 2. The coldest month on average over the period from 2006 through 2010 was February (-28.1°C), with July having the highest average temperature (10.7°C).

Table 5.2-C2: Temperature Observations (2006 to 2010) for Rankin Inlet

Month	Daily Average (°C)	Daily Maximum (°C)	Daily Minimum (°C)	Extreme Maximum (°C)	Extreme Minimum (°C)
January	-26.1	-22.7	-29.4	-9.1	-40.0
February	-28.1	-25.1	-31.2	-9.6	-41.4
March	-23.6	-19.7	-27.6	0.2	-42.0
April	-12.0	-8.4	-16.2	2.2	-33.8
May	-5.2	-2.7	-8.4	9.0	-22.2
June	4.4	8.0	1.0	23.1	-6.7
July	10.7	14.6	7.1	24.9	2.0
August	10.3	13.3	7.5	21.2	2.6
September	4.4	6.8	2.1	16.2	-3.9
October	-2.0	-0.2	-4.3	11.7	-22.2
November	-14.9	-11.2	-18.6	1.3	-32.1
December	-22.8	-19.5	-25.8	0.8	-38.4

Figure 5.2-C1 graphically shows the range of hourly temperatures observed at Rankin Inlet over the latest complete 5-year period for which data are available (i.e., 2006 through 2010). The graph uses a "box-and-whisker" plot to show the range of temperatures. The box in the graph represents the middle 50% of the observations(i.e., from the 25th to 75th percentiles). The whiskers extend up to the maximum observation and

down to the minimum. The diamond represents the average of the observations in each month. The green lines on the graph represent the climate normals (see Table 5.2-C 1) for extreme maximum (dashed line above the average normal), daily maximum (dotted line above the average normal), average (solid line), daily minimum (dotted line below the average normal) and extreme minimum temperatures (dashed line below the average normal) for each month. The temperature data for the period generally fall within the extreme climate normals with 3 exceptions. The maximum temperatures for October, November and December were all above the extremes for the normals period from 1971 through 2000.

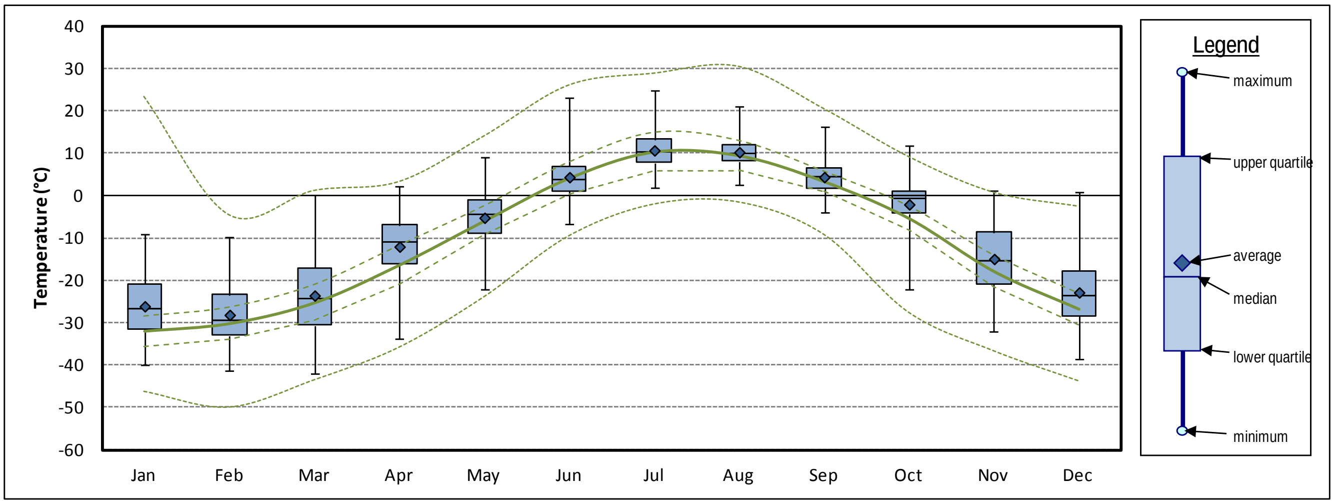

Figure 5.2-C1: Range of Hourly Temperatures for Rankin Inlet (2006 to 2010)

The 5-years of hourly temperature data for Rankin Inlet covering the period when on-site data were being collected (i.e., 1997 through 2001) are tabulated in Table 5.2-C 3. The coldest month on average over the period from 1997 through 2001 was January (-31.4°C), with July having the highest average temperature (11.0°C).

Table 5.2-C3: Temperature Observations (1997 to 2001) for Rankin Inlet

Month	Daily Average (°C)	Daily Maximum (°C)	Daily Minimum (°C)	Extreme Maximum (°C)	Extreme Minimum (°C)
January	-31.4	-28.1	-34.6	-3.0	-42.6
February	-28.2	-24.3	-31.9	-4.4	-43.0
March	-22.9	-19.5	-26.7	1.1	-41.3
April	-14.0	-10.4	-18.2	1.7	-33.0
May	-3.5	-1.0	-6.6	9.8	-19.7
June	4.7	8.2	1.4	20.7	-7.3
July	11.0	14.7	7.3	26.4	0.0
August	10.3	13.6	7.4	24.3	0.9
September	4.5	7.0	2.3	18.0	-6.7
October	-4.2	-1.8	-7.0	7.2	-21.3
November	-15.1	-11.7	-18.5	1.4	-30.8
December	-23.8	-20.0	-27.4	-2.5	-40.0

Figure 5.2-C2 graphically shows the range of hourly temperatures observed at Rankin Inlet over the period from 1997 through 2001 (i.e., the period over which data was being collected at the site). The graph shows that the hourly temperature data for the period generally fall within the extreme climate normals with the exception of the

maximum temperature for November, which was above the extremes for the normals period from 1971 through 2000.

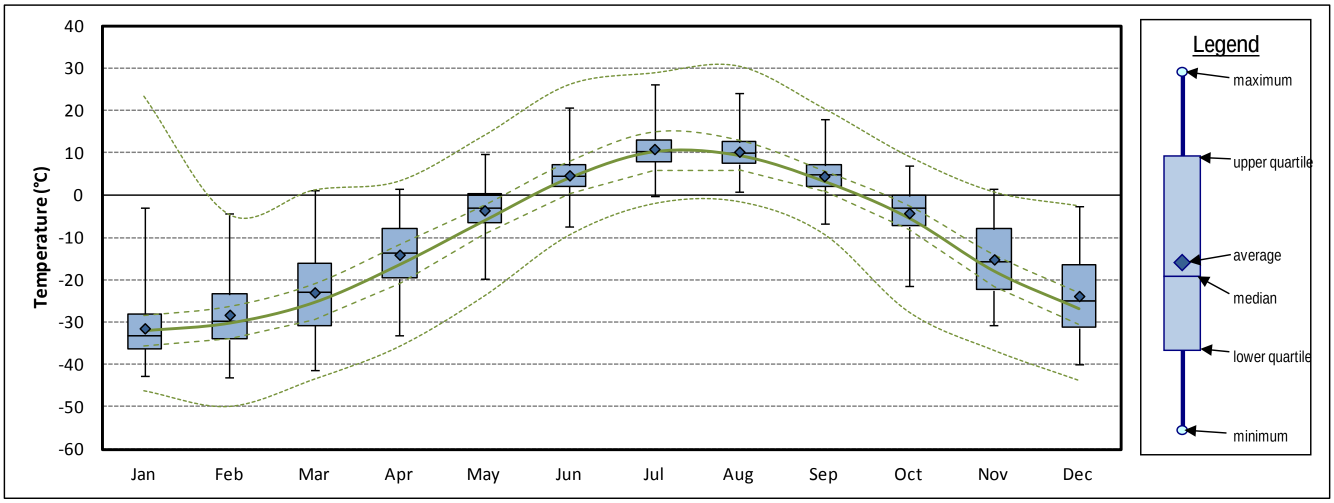

Figure 5.2-C2: Range of Hourly Temperatures for Rankin Inlet (1997 to 2001)

Figure 5.2-C3 compares the 2006 through 2010 hourly Rankin Inlet temperatures to the Rankin Inlet data for the period when on-site data were being collected (i.e., 1997 through 2001). There is good agreement; however, there are less of the coolest temperature readings in the most recent data set. This is consistent with literature and anecdotal observations.

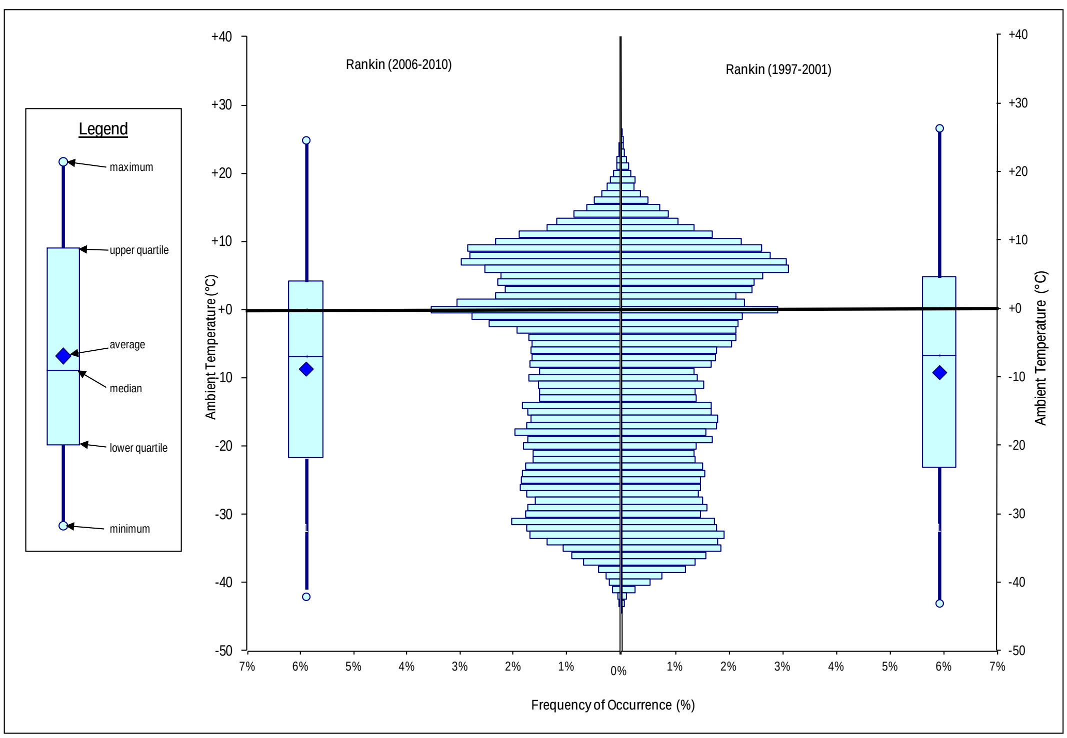

Figure 5.2-C3: Comparison of Hourly Temperatures at Rankin Inlet

2.1.2 Meliadine On-site Observations

On-site temperature data were collected intermittently at the site by Hubert over the period from 1997 through 2001. Although the collected temperature data were noted as being recorded on an hourly basis (Hubert 2001), only daily data were available electronically. Table 5.2-C 4 presents a summary of the daily on-site temperature data collected between 1997 and 2001. The coldest average month on-site, over the period from 1997 through 2001, was January (-31.4°C), with July having the highest average temperature (12.2°C).

Figure 5.2-C4 graphically shows the range of daily temperatures observed at the on-site stations over the period from 1997 through 2001. The graph shows that the hourly temperature data for the period generally fall within the extreme climate normals with the exception of the maximum temperature for November, which was above the extremes for the normals period from 1971 through 2000. Overall, the on-site temperatures were consistent with the climate normals for Rankin Inlet.

Table 5.2-C 5 provides a statistical comparison of the 1997 through 2001 on-site daily temperatures to the daily temperatures for the same period at Rankin Inlet. Despite the number of missing data and gaps present in the on-site data set, average values of daily temperature are within 0.6°C, while the extreme maximum and extreme minimum temperatures in both sets of data are within 1°C of each other (Figure 5.2-C5). This indicates good agreement between the 2 data sets.

Table 5.2-C4: Temperature Observations (1997 to 2001) for the On-Site Station

Month	Daily Average (°C)	Daily Maximum (°C)	Daily Minimum (°C)	Extreme Maximum (°C)	Extreme Minimum (°C)
January	-31.4	-29.3	-36.0	—	—
February	-27.8	-24.7	-33.9	—	—
March	-22.0	-17.9	-26.3	—	—
April	-12.9	-10.6	-21.4	—	—
May	-3.8	-0.1	-8.2	—	—
June	5.0	9.0	-0.1	—	—
July	12.2	16.9	6.9	—	—
August	10.6	14.6	7.5	—	—
September	4.8	7.8	2.5	—	—
October	-4.9	-3.4	-9.3	—	—
November	-15.1	-13.5	-21.8	—	—
December	-24.9	-21.8	-28.8	—	—

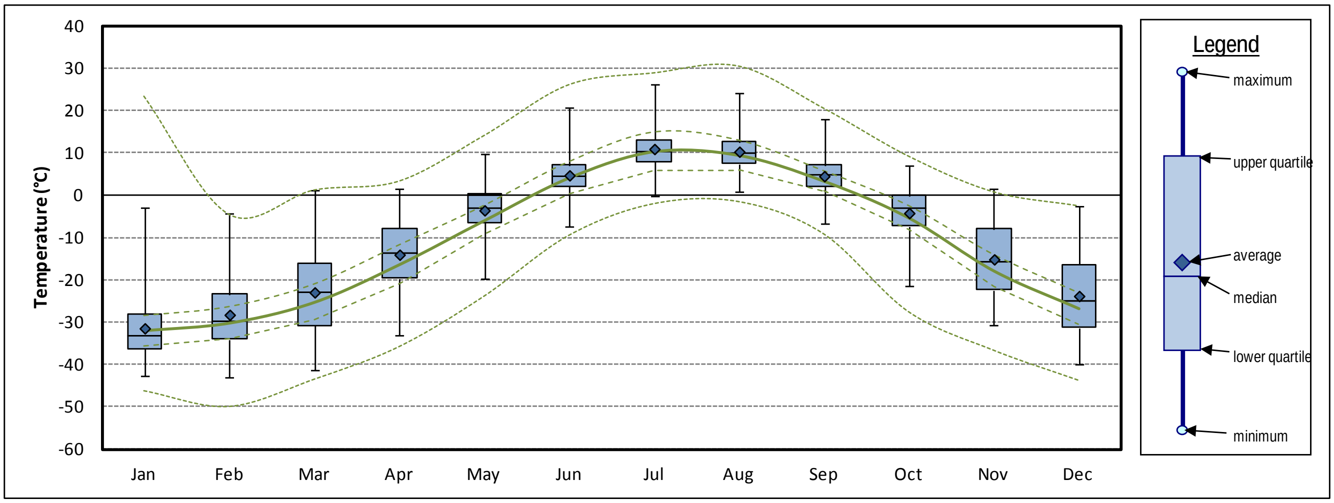

Figure 5.2-C4: Range of Daily Temperatures Observed On-Site (1997 to 2001)

Table 5.2-C5: Statistical Comparison of On-Site and Rankin Inlet Daily Temperatures (1997–2006)

Parameter	Rankin Inlet	On-Site Observations
Maximum	19.9	20.3
Upper Quartile	4.9	6.0
Median	-7.3	-6.4
Lower Quartile	-22.8	-22.6
Minimum	-41.4	-40.6
Average	-9.3	-8.7

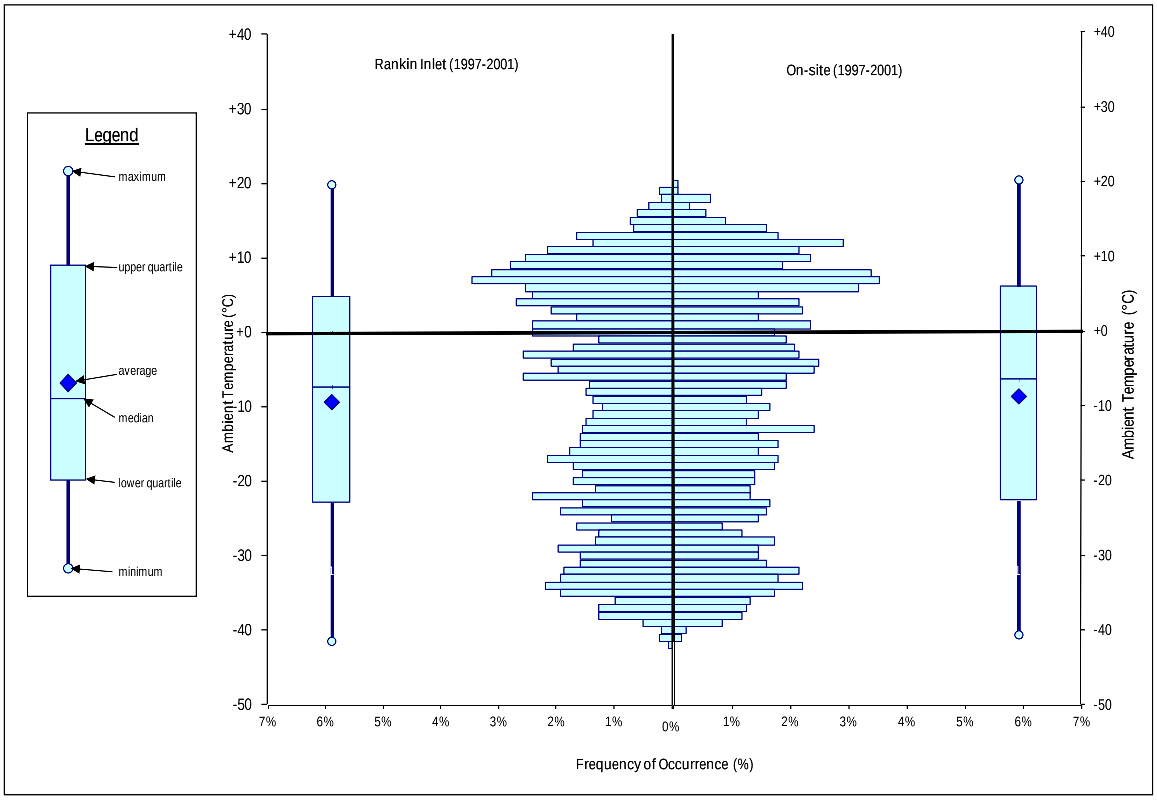

Figure 5.2-C5: Comparison of On-site and Rankin Inlet Daily Temperatures (1997-2001)

2.1.3 Conclusions Regarding the Rankin Inlet and On-Site Temperature Observations

The differences in temperatures between the 2006 through 2010, and the 1997 through 2001 observations at Rankin Inlet were generally small, and in keeping with the types of fluctuations typically seen between 2 separate periods at the same station. Although the latest 5 years of observations (i.e., 2006 through 2010) were slightly warmer than observed during the period from 1997 through 2001, the differences were small, less than 1°C, as discussed above. Therefore, the on-site temperature data collected between 1997 and 2001 are considered to be indicative of the current temperatures in the area.

The on-site temperature readings collected between 1997 and 2001 appear to be consistent with both the long-term climate normals for Rankin Inlet (1971 through 2000), as well as the Rankin Inlet daily observations covering the general period when on-site data was being collected (i.e., 1997 through 2001). Therefore, it is reasonable to assume that the other temperature related parameters collected between 1997 and 2001 (e.g., soil temperatures) would be consistent with the current conditions at the site.

The lack of hourly electronic data coupled with the large gaps in the data set limit the use of the on-site temperature data to general descriptions. Detailed statistical analyses would need to rely on the contiguous data sets available from the Environment Canada station at the airport in Rankin Inlet. However, the specialty monitoring data collected on-site (i.e., soil temperatures and permafrost depth) are likely still useful when describing the frozen soil conditions today.

2.2 Observed Precipitation

2.2.1 Rankin Inlet

The 30-year climate normals for Rankin Inlet (1971 to 2000) indicate that about 60% of the normal precipitation at Rankin Inlet falls in the form of rainfall. The month with the greatest rainfall, on average, is August (57.3 mm), which accounts for more than 31% of the normal yearly rainfall. Snowfall rates were normally highest in the months of October and November, with the rates remaining about the same from December through May. The climate normals for precipitation at Rankin Inlet are presented in Table 5.2-C6

The latest 5-years of daily precipitation data available for Rankin Inlet (i.e., 2006 through 2010) are tabulated in Table 5.2-C7. Rainfall accounted for about 57% of the precipitation at Rankin Inlet between 2006 and 2010. The month with the greatest rainfall, on average, was August (63.5 mm).

Table 5.2-C6: Precipitation Climate Normals (1971 to 2000) for Rankin Inlet

Month	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)	Extreme Daily Precipitation (mm)	Days with Measurable Precipitation	Average Snow Depth (cm)
January	0.0	6.7	6.6	6.4	6.8	27.0
February	0.1	9.3	8.9	17.4	7.1	30.0
March	0.0	12.9	12.6	11.6	9.0	36.0
April	1.0	13.6	14.3	14.0	8.4	38.0
May	7.4	11.5	18.4	31.2	8.8	20.0
June	25.0	4.9	29.8	45.8	7.4	1.0
July	39.5	0.0	39.5	41.4	10.2	0.0
August	57.3	0.3	57.6	41.2	13.2	0.0
September	39.2	4.6	43.8	45.0	12.8	0.0
October	11.9	23.1	34.6	33.0	14.3	3.0
November	0.1	20.9	19.8	23.2	11.9	14.0
December	0.0	11.9	11.3	8.6	9.5	23.0

Table 5.2-C7: Hourly Precipitation Observations (2006 to 2010) for Rankin Inlet

Month	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)	Extreme Daily Precipitation (mm)	Days with Measurable Precipitation	Average Snow Depth (cm)
January	0.0	18.1	18.0	13.2	11.2	28.2
February	0.0	7.0	7.0	6.0	6.6	33.0
March	0.2	10.5	10.6	7.0	7.6	35.6
April	1.5	33.1	33.3	16.0	9.4	36.2
May	2.6	13.6	15.4	10.6	8.0	21.3
June	12.6	3.5	16.2	12.2	8.8	1.3
July	56.0	0.0	56.0	38.4	10.6	0.0
August	63.5	0.0	63.5	24.0	13.2	0.0
September	34.8	1.0	35.8	10.6	11.4	0.0
October	15.8	23.4	38.9	15.0	14.6	1.4
November	1.0	21.8	22.2	7.4	12.0	11.5
December	0.2	13.7	13.9	7.0	11.2	20.5

Figure 5.2-C6 compares the daily precipitation observations at Rankin Inlet over the latest complete 5-year period for which data are available (i.e., 2006 through 2010) to the long-term climate normals. Generally, the recent observations are consistent with the long-term normals, with the following notable exceptions:

- The average January snowfall for the period between 2006 to 2010 (18.1 cm) was more than double the normal amount of snowfall (6.7 cm) for that month;
- The average April snowfall for the period between 2006 to 2010 (33.1 cm) was more than double the normal amount of snowfall (13.6 cm) for that month;
- The average rainfall in July for the period between 2006 to 2010 (56.0 mm) was 42% more than the normal amount of rainfall (39.5 mm) for that month; and
- The average June rainfall and precipitation for the period from 2006 to 2010 were 50% and 46% less, respectively, than the normals for that month.

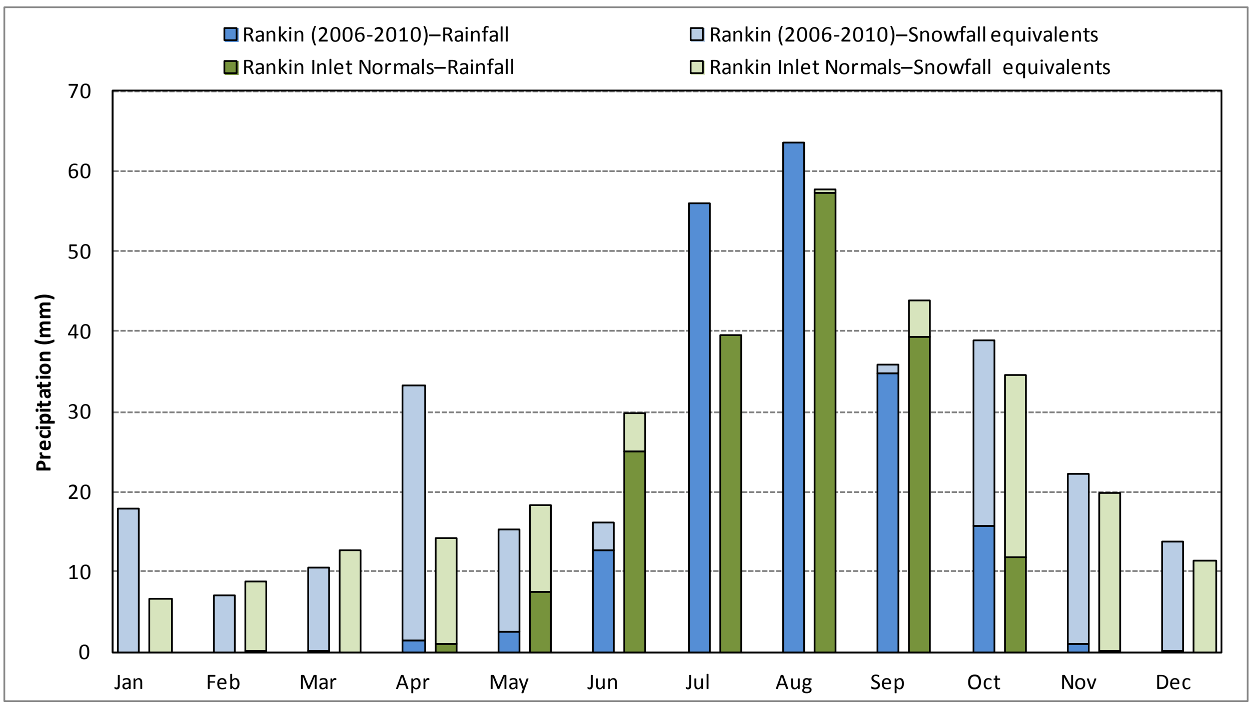

Figure 5.2-C6: Comparison of Daily Precipitation for Rankin Inlet (2006 to 2010) to Climate Normals

The 5-years of daily precipitation data for Rankin Inlet covering the period when on-site data were being collected (i.e., 1997 through 2001) are tabulated in Table 5.2-C8. Rainfall accounted for about 63% of the precipitation at Rankin Inlet between 1997 and 2001. The month with the greatest rainfall, on average, was August (57.4 mm).

Table 5.2-C8: Hourly Precipitation Observations (1997 to 2001) for Rankin Inlet

Month	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)	Extreme Daily Precipitation (mm)	Days with Measurable Precipitation	Average Snow Depth (cm)
January	0.0	6.2	6.2	2.2	7.8	23.4
February	0.2	10.6	10.7	6.6	7.8	26.4
March	0.0	13.9	13.4	6.2	9.8	31.4
April	2.3	7.8	10.1	7.0	7.0	26.0
May	14.8	12.6	27.4	31.2	9.8	7.4
June	26.8	0.4	27.2	45.8	7.4	0.2
July	39.4	0.5	40.0	23.8	10.4	0.0
August	57.4	0.0	57.4	40.4	13.4	0.0
September	34.4	0.8	35.1	18.2	11.4	0.0
October	16.9	28.4	45.5	33.0	15.8	3.3
November	0.3	17.4	17.2	8.0	12.0	12.2
December	0.0	16.9	16.2	8.6	11.2	18.5

Figure 5.2-C7 compares the daily precipitation observations for Rankin Inlet covering the period when on-site data were being collected (i.e., 1997 through 2001) to the long-term climate normals. Generally the 1997 to 2001 observations are consistent with the long-term normals with the exception of the total precipitation in May and October, which were 49% and 32%, respectively, higher than the respective normals.

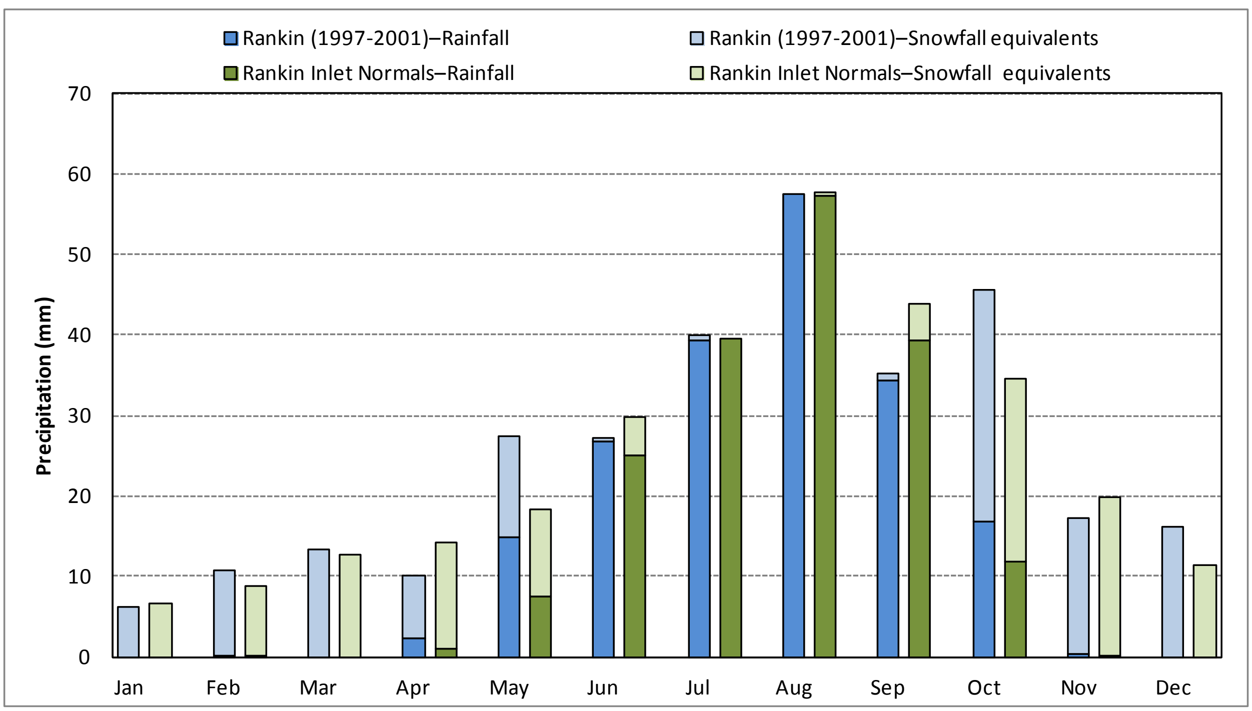

Figure 5.2-C7: Comparison of Daily Precipitation for Rankin Inlet (1997 to 2001) to Climate Normals

Figure 5.2-C8 compares the 2006 to 2010 and 1997 to 2001 (i.e., the period covering the collection of on-site data) daily precipitation observations at Rankin Inlet. Generally the 2 sets of observations are consistent, with the following notable exceptions:

- The average January snowfall for the period from 2006 to 2010 (18.1 cm) was nearly triple the amount of average January snowfall observed between 1997 and 2001 (6.2 cm);
- The average April snowfall for the period from 2006 to 2010 (33.1 cm) was more than 4 times the amount of average April snowfall observed between 1997 and 2001 (7.8 cm);
- The average rainfall in July for the period between 2006 to 2010 (56.0 mm) was 42% more than the average July rainfall observed between 1997 and 2001 (39.4 mm);
- The average total precipitation in May for the period between 2006 to 2010 (15.4 mm) was only 56% of the average May precipitation observed between 1997 and 2001 (27.4 mm); and
- The average total precipitation in June for the period from 2006 to 2010 (27.2 mm) was only 60% of the June precipitation observed between 1997 and 2001 (27.2 mm).

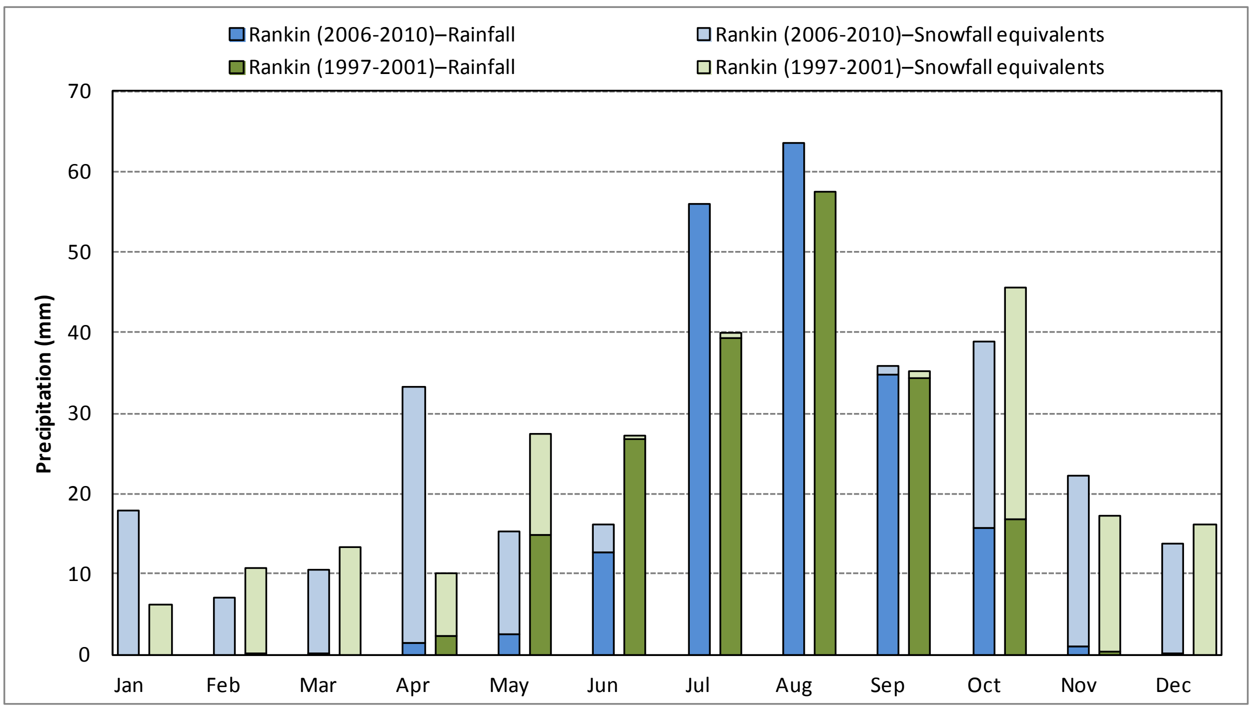

Figure 5.2-C8: Comparison of Daily Precipitation for Rankin Inlet

2.2.2 Meliadine On-site Observations

On-site precipitation data were collected intermittently at the site during the summer months over the period from 1997 through 2001 by Hubert (2001). Table 5.2-C9 presents a summary of the average monthly summertime (June, July, August, and September) precipitation collected between 1997 and 2001 at the on-site station. It was assumed that all of the collected precipitation was in the form of rainfall. However, there were a number of days missing in these months over the 5 years of record (6 days in June, 28 days in July, 13 days in August and 45 days in September). Since the missing days of data are likely to cause precipitation to be under reported, the observed precipitation values were increased to correct the error by scaling the recorded data by the ratio of days in these months (1997 to 2001) by the number of days for which data were available. The wettest month on-site was August (43.1 mm), which is also the wettest month in the long-term climate records (see Table 5.2-C6).

Figure 5.2-C9 provides a comparison of the available precipitation data from the on-site station to the daily observations at Rankin Inlet for the same period. Generally the on-site precipitation was about 70% of the observations at Rankin Inlet over the same period of time. However, there is not sufficient information to determine whether the difference in precipitation is the result of a local phenomenon, or an issue with monitoring methods employed on-site resulting in the precipitation being under represented.

Table 5.2-C9: Hourly Precipitation Observations (1997 to 2001) for Rankin Inlet

Month	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)	Extreme Daily Precipitation (mm)	Days with Measurable Precipitation	Average Snow Depth (cm)
January	—	—	—	—	—	—
February	—	—	—	—	—	—
March	—	—	—	—	—	—
April	—	—	—	—	—	—
May	—	—	—	—	—	—
June	20.5	—	20.5	—	—	—
July	28.1	—	28.1	—	—	—
August	43.1	—	43.1	—	—	—
September	30.2	—	30.2	—	—	—
October	—	—	—	—	—	—
November	—	—	—	—	—	—
December	—	—	—	—	—	—

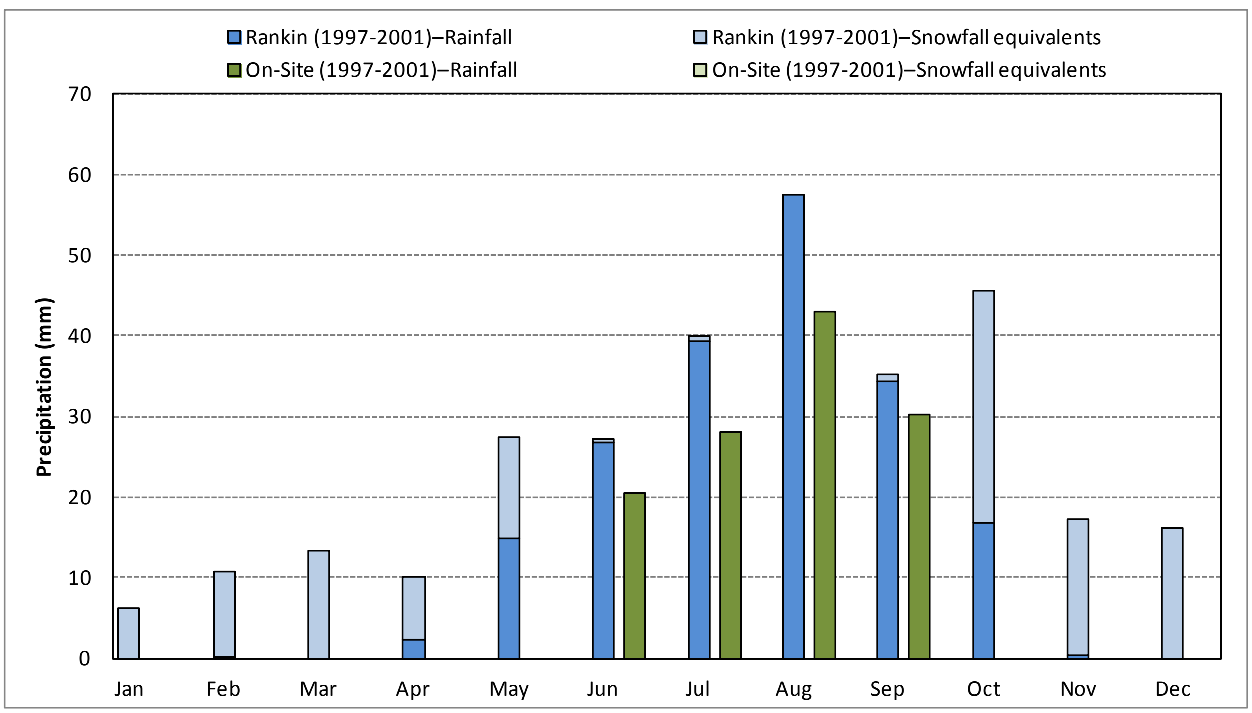

Figure 5.2-C9: Comparison of On-Site Precipitation to Rankin Inlet (1997-2001)

2.2.3 Conclusions Regarding Rankin Inlet and On-Site Precipitation Observations

The differences in precipitation between the 2006 through 2010, and the 1997 through 2001 observations at Rankin Inlet were generally small, and in keeping with the types of fluctuations typically seen between 2 separate periods at the same station. The latest 5 years of observations (i.e. 2006 through 2010) had slightly less (-2%) rainfall and slightly more total precipitation (+8%) than were observed during the period from 1997 through 2001. Therefore, the precipitation collected between 1997 and 2001 is considered to be indicative of the current precipitation in the area.

The on-site precipitation data were limited to collecting rainfall during the months of June, July, August, and September, 1997 through 2001. The limited precipitation data collected on-site were consistently lower than the long-term climate normals for Rankin Inlet (1971 through 2000) and the daily observations covering the same general period when on-site data were being collected (i.e., 1997 through 2001). It is not possible with the information available to determine whether the differences reflect local phenomena or are attributable to limitations in the on-site collection program.

The lack of hourly electronic data, the large gaps in the data, and the significant differences between the observations and the available data for the region suggest that even limited use of the on-site precipitation data is questionable. Without further insight as to the reason for the differences, precipitation analyses will need to rely on contiguous data sets available from the Environment Canada station at the airport in Rankin Inlet.

2.3 Observed Wind Speeds and Directions

2.3.1 Rankin Inlet

The 30-year climate normals for Rankin Inlet (1971 to 2000) indicate that wind speeds are relatively high, averaging more than 19 km/h every month. Winds blow most frequently from the northwest in each month of the year. The maximum recorded hourly speeds for the period of record were as high as 102 km/h (January and May). The extreme wind gusts were as high as 137 km/h. The climate normals for winds at Rankin Inlet are presented in Table 5.2-C10.

Table 5.2-C10: Wind Speed and Direction Climate Normals (1971 to 2000) for Rankin Inlet

Month	Average Speed (km/h)	Most Frequent Direction	Maximum Hourly Speed (km/h)	Direction of Maximum Hourly Speed	Maximum Gust (km/h)	Direction of Maximum Gust
January	23.9	NW	102	NW	132	NW
February	23.9	NW	93	NW	113	NE
March	23.4	NW	93	NW	111	NW
April	22.4	NW	93	NW	111	NW
May	22.1	NW	102	NW	117	NW
June	19.8	NW	74	E	111	E
July	19.2	NW	74	NW	106	NW
August	21.1	NW	93	NW	124	NW
September	24.2	NW	83	E	109	W
October	26.5	NW	93	W	137	W
November	25.3	NW	93	NW	124	N
December	24	NW	100	NW	124	NW

The latest 5-years of hourly wind speed and direction data available for Rankin Inlet (i.e., 2006 through 2010) are summarized in Table 5.2-C11. The table does not include information on wind gusts as these data were not available in the hourly data set obtained from Environment Canada. The most frequent wind direction varies by month, with winds from the north-northwest (NNW) being most frequent on a 16 point compass, and winds the north (N) being most frequent on an 8 point compass. Maximum hourly winds over the period from 2006 through 2010 were 83 km/h during October and November.

The latest 5-years of hourly wind speed and direction data available for Rankin Inlet (i.e., 2006 through 2010) are summarized as a wind rose in Figure 5.2-C10. A wind rose figure is often used to illustrate the frequency of wind direction and the magnitude of the wind speed. The lengths of the bars on the wind-rose indicate the frequency and speed of the wind. The wind direction (blowing from) is illustrated by the orientation of the bar in one of 16 cardinal directions. The predominant winds observed during the 2006 through 2010 period were from the north-northwest (NNW), followed by the northwest (NW) and north (N). The majority of the hourly winds speeds observed were greater than 25 km/h.

Table 5.2-C11: Wind Speed and Direction for Rankin Inlet (2006 to 2010)

Month	Average Speed (km/h)	Most Frequent Direction (8 point compass)	Most Frequent Direction (16 point compass)	Maximum Hourly Speed (km/h)	Direction of Maximum Hourly Speed (8 point)	Direction of Maximum Hourly Speed (16 point)
January	24.3	N	NNW	74	N	NNW
February	22.5	N	NNW	69	N	N
March	23.4	NW	NNW	69	NW	NNW
April	22.2	N	NNW	59	NW	NNW
May	22.0	N	NNW	65	NW	NNW
June	20.8	N	NNW	74	NE	NE
July	19.9	SE	ESE	56	N	NNW
August	20.4	N	NNW	70	N	N
September	22.9	NW	NNW	74	NW	WNW
October	25.2	N	NNE	83	NW	NW
November	23.5	N	NNW	83	NW	NNW
December	24.0	NW	NNW	70	NW	NW

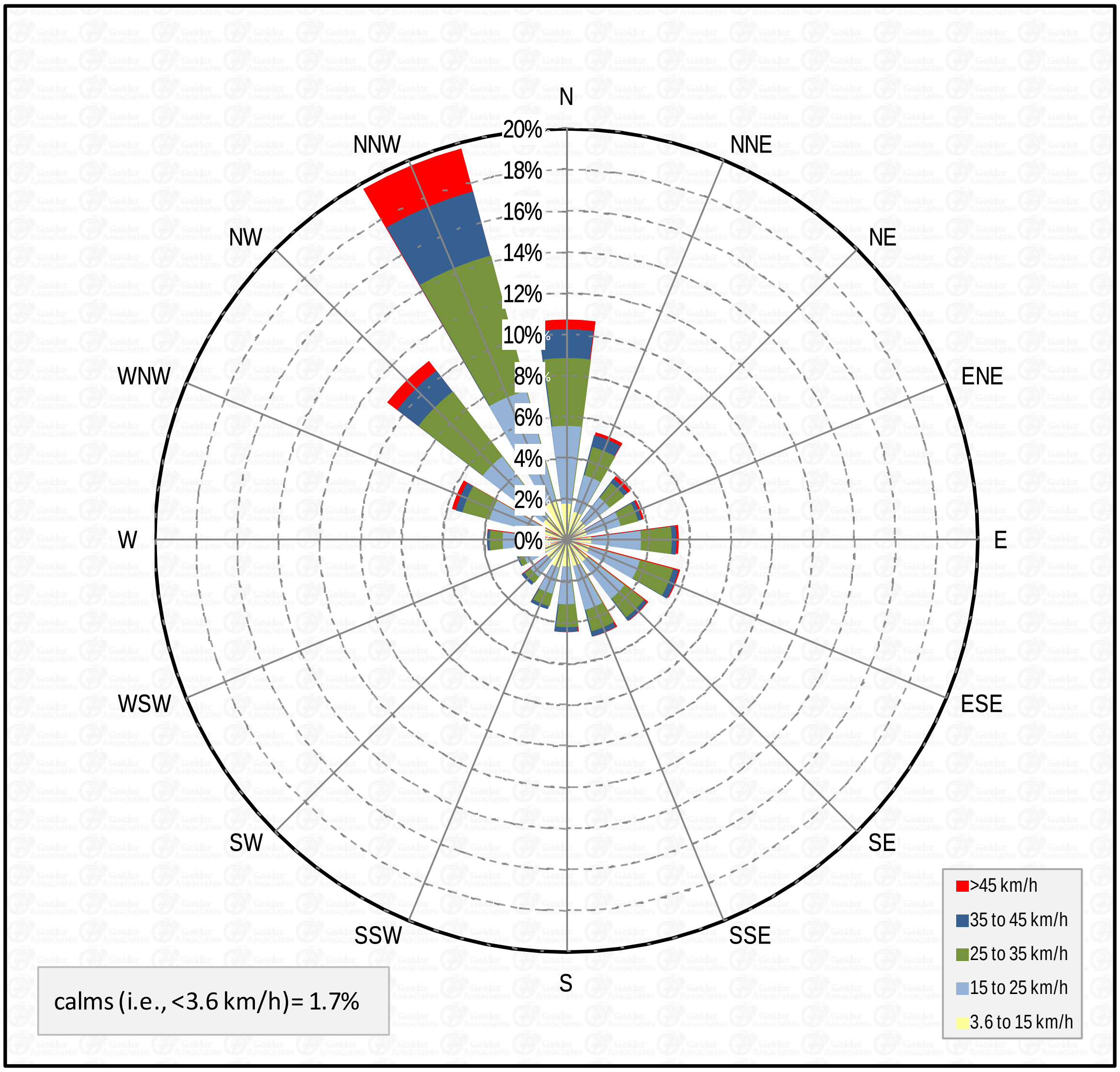

Figure 5.2-C10: Annual Windrose for Rankin Inlet (2006 to 2010)

Figure 5.2-C11 provides a comparison of the seasonal wind roses for Rankin Inlet (2006 to 2010), where the seasons are traditionally characterized as spring (March, April, and May), summer (June, July, and August), fall (September, October, and November) and winter (December, January, and February). Winds from the NNW are predominant in all seasons; however, winds are almost exclusively from the NNW during the winter months. During the summer months, winds blowing from the east-southeast (ESE) through to the south-southwest (SSW) are comparatively more frequent than during the other seasons.

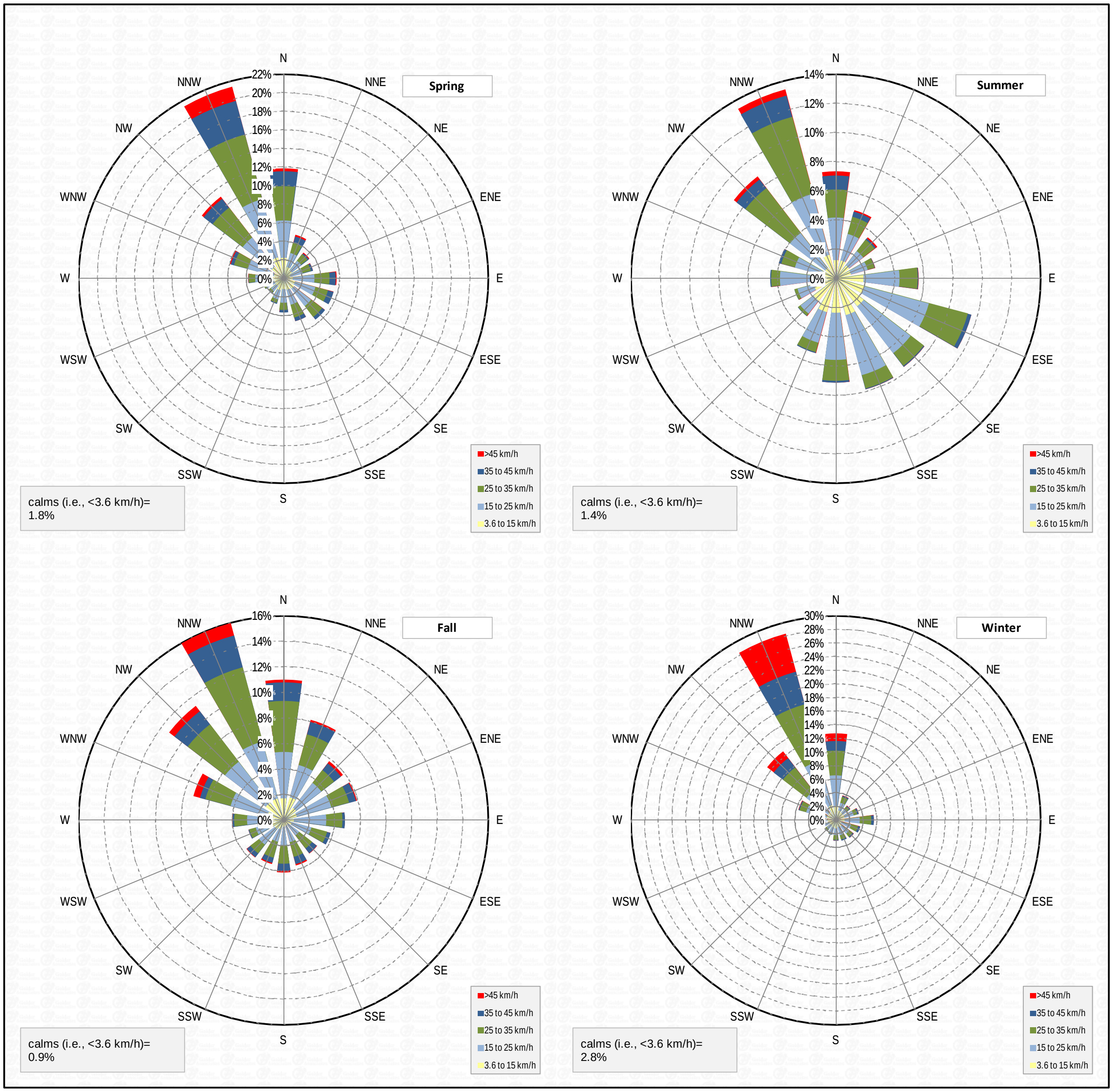

Figure 5.2-C11: Seasonal Windrose for Rankin Inlet (2006 to 2010)

Table 5.2-C12 summarizes the hourly wind speeds and directions available for Rankin Inlet over the period when on-site data were being collected (i.e., 1997 through 2001). The most frequent wind direction varied by month, with winds from the north-northwest (NNW) being most frequent on a 16 point compass, and winds from the northwest (NW) being most frequent on an 8 point compass. Maximum hourly winds over the period from 1997 through 2001 were 102 km/h during January.

Table 5.2-C12: Wind Speed and Direction for Rankin Inlet (1997 to 2001)

Month	Average Speed (km/h)	Most Frequent Direction (8 point compass)	Most Frequent Direction (16 point compass)	Maximum Hourly Speed (km/h)	Direction of Maximum Hourly Speed (8 point)	Direction of Maximum Hourly Speed (16 point)
January	24.7	N	NNW	102	N	NNW
February	26.3	NW	NNW	93	N	NNW
March	25.2	NW	NNW	78	NW	NNW
April	24.2	NW	NNW	93	NW	NNW
May	26.0	N	NNW	76	NW	NNW
June	21.8	N	NNW	74	E	E
July	21.2	SE	ESE	69	N	N
August	22.7	NW	NNW	74	NW	NNW
September	24.2	NW	NNW	74	N	NNW
October	28.6	NW	NNW	93	W	WNW
November	26.7	NW	NNW	70	NW	NW
December	27.5	NW	NNW	82	N	NNW

The wind rose for the 5-years of hourly wind data from Rankin Inlet covering the period when on-site data were being collected (i.e., 1997 through 2001) is presented in Figure 5.2-C12. The hourly wind data from Rankin Inlet for the period from 1997 to 2001 showed similar patterns to the winds observed during the latest 5-year period (i.e., 2006 through 2010). The predominant winds were from the north-northwest (NNW), with the next most prevalent winds from the northwest (NW) and north (N).

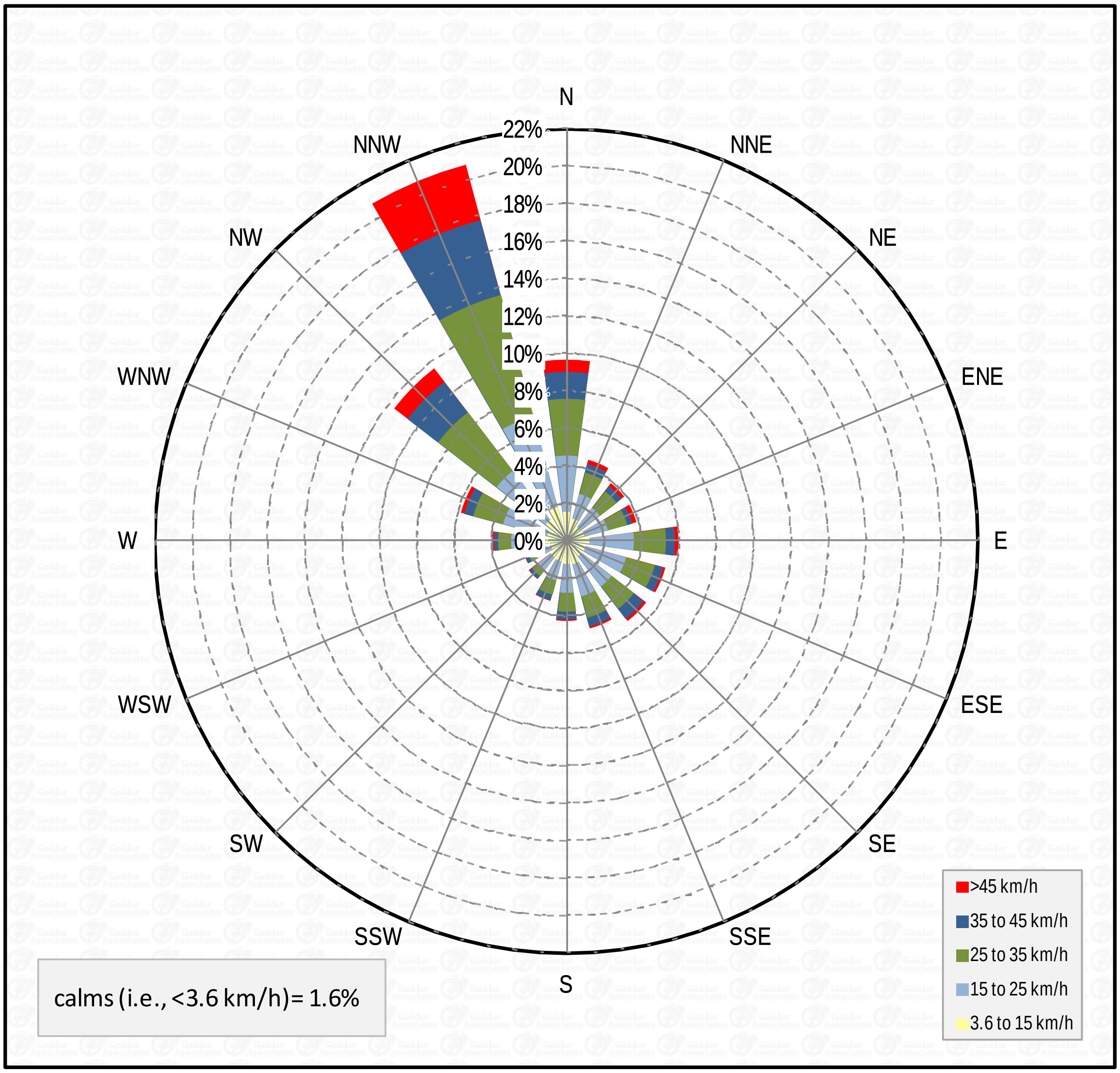

Figure 5.2-C12: Annual Wind Rose for Rankin Inlet (1997 to 2001)

The similarity between the 2 sets of hourly winds is further illustrated in Figure 5.2-C13, which compares the hourly wind roses for the two 5-year periods. Both sets of hourly data have a similar amount of low winds, and similar direction patterns. The average hourly speeds were slightly higher in the 1997 to 2001 period as shown in Figure 5.2-C14.

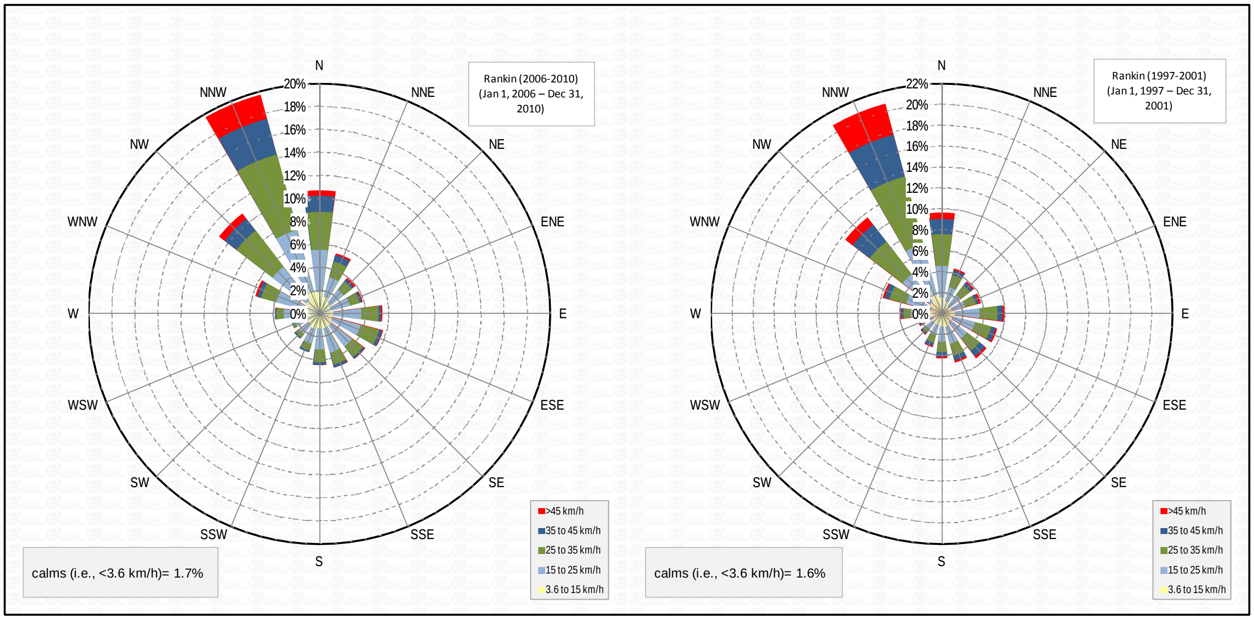

Figure 5.2-C13: Comparison of Windroses for Rankin Inlet (2006 to 2010 vs. 1997 to 2001)

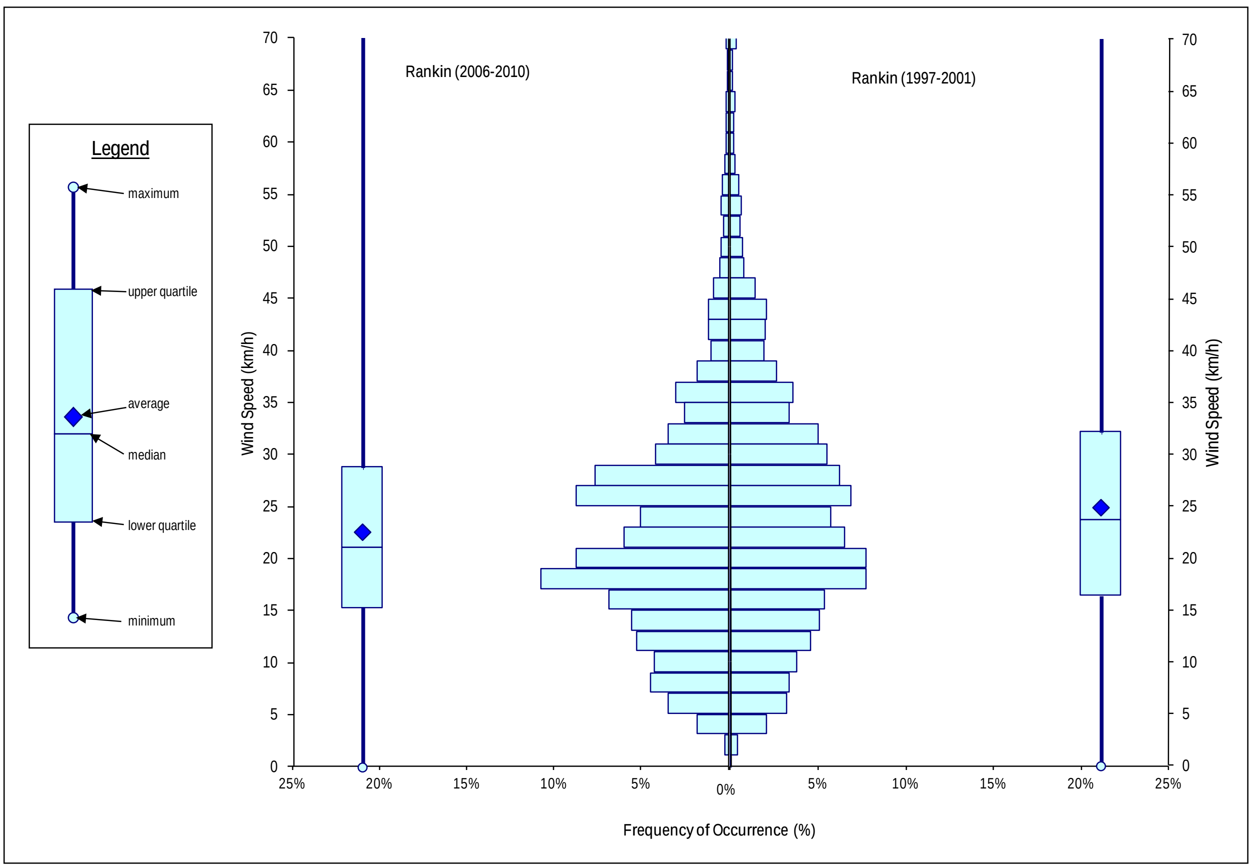

Figure 5.2-C14: Comparison of Hourly Wind Speeds for Rankin Inlet (2006 to 2010 vs. 1997 to 2001)

2.3.2 Meliadine On-site Observations

On-site wind data were collected at the site over the period from 1997 through 2001 by Hubert, with the data recorded on an hourly basis (Hubert 2001). However, only daily wind data were available electronically for the on-site station. Table 5.2-C13 summarizes the wind speed and direction data available for the on-site station over the period from 1997 through 2001. The most frequent wind direction varied by month, with winds from the north-northwest (NW) being most frequent on both a 16 point and 8 point compass. The maximum wind speed recorded at the site for the period of record was 115.2 km/h during October.

Table 5.2-C13: Wind Speed and Direction for the On-Site Station (1997 to 2001)

Month	Average Speed (km/h)	Most Frequent Direction (8 point compass)	Most Frequent Direction (16 point compass)	Maximum Hourly Speed (km/h)	Direction of Maximum Hourly Speed (8 point)	Direction of Maximum Hourly Speed (16 point)
January	17.2	NW	WNW	98.3	NW	WNW
February	19.0	NW	NW	83.0	NW	NNW
March	17.8	NW	NW	86.2	NW	WNW
April	17.8	NW	NW	77.0	NW	NNW
May	20.7	NW	NW	84.6	N	NNW
June	16.6	SE	SSE	76.3	NW	NW
July	16.9	SE	SE	74.9	E	E
August	18.9	W	NW	84.2	NW	NW
September	19.3	NW	NW	69.1	NW	NW
October	20.9	NW	WNW	115.2	NW	WNW
November	19.0	NW	NW	72.5	NW	NW
December	21.9	NW	NW	85.8	NW	WNW

The average monthly wind speeds recorded at the on-site station were consistently lower than the long-term normal wind speeds for Rankin Inlet, or the 5-years of wind data from Rankin Inlet covering the period when on-site data were being collected (i.e., 1997 through 2001). The most frequent wind directions through the year were from the northwest (NW), which is consistent with the long-term climate normals and similar to the hourly observations at Rankin Inlet from 1997 to 2001.

The average daily wind speeds observed on-site are consistently lower than those observed at Rankin Inlet over the same period, as is shown in Figure 5.2-C15. The average of the wind speeds observed on-site are nearly 5 km/h lower than observed in Rankin Inlet over the same period. However, the maximum daily wind speeds observed at the on-site station are consistent with the observations at Rankin Inlet (see Figure 5.2-C16). It is considered unusual to have significantly differing average speeds between 2 stations that have similar maximum speeds over the same period of record.

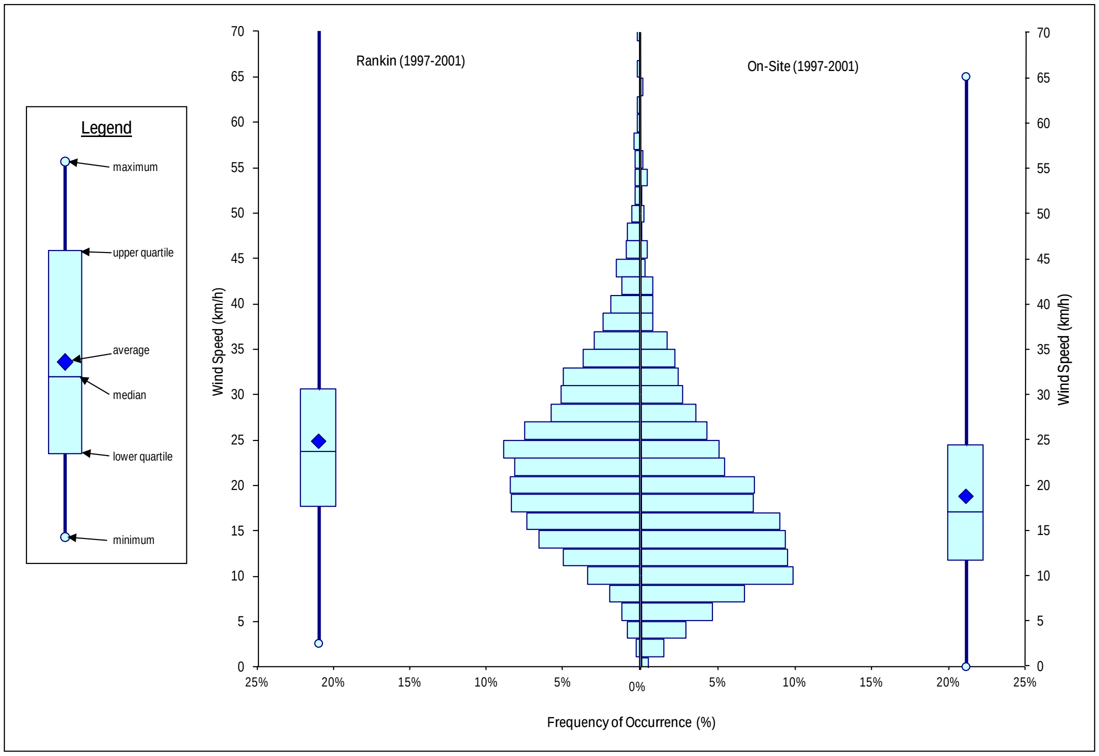

Figure 5.2-C15: Comparison of Average Daily Wind Speeds for Rankin Inlet and the On-Site Station (1997 to 2001)

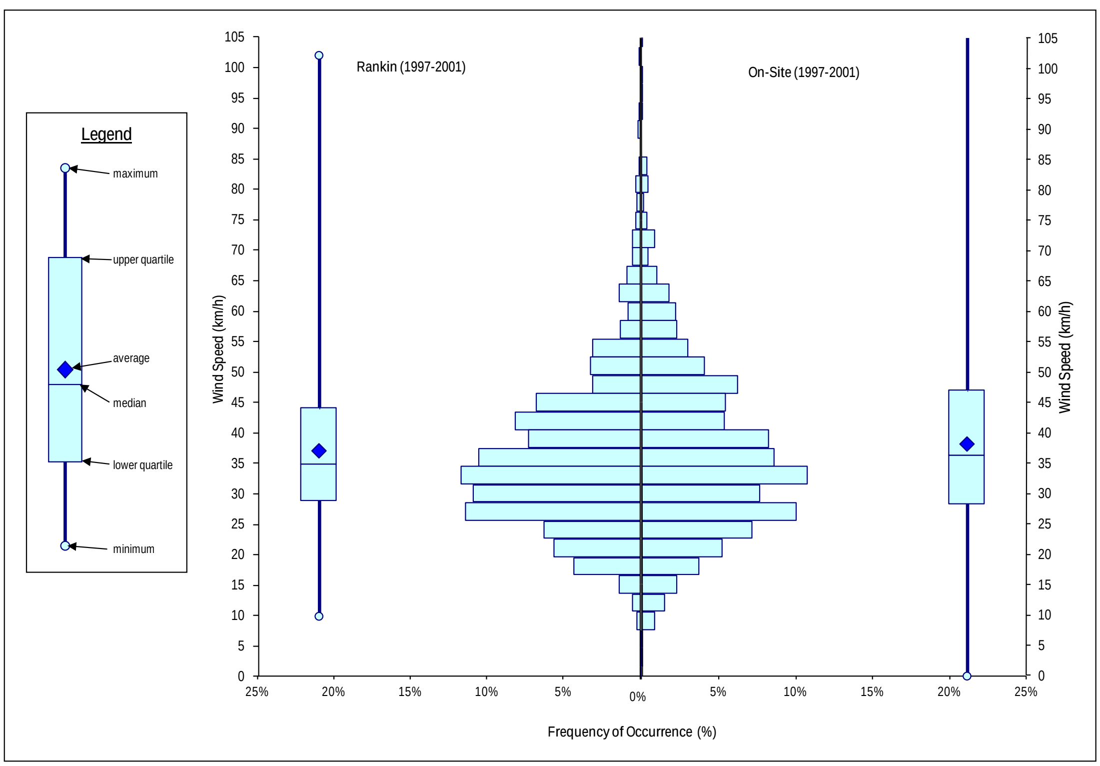

Figure 5.2-C16: Comparison of Maximum Daily Wind Speeds for Rankin Inlet and the On-Site Station (1997 to 2001)

2.3.3 Conclusions Regarding Rankin Inlet and On-Site Wind Observations

The differences between the 2006 through 2010, and the 1997 through 2001 wind observations at Rankin Inlet were small, and in keeping with the types of fluctuations typically seen between 2 separate periods at the same station. Predominant wind directions, the wind rose figures, and average wind speeds agree well. Therefore, the wind speeds and directions collected between 1997 and 2001 are considered indicative of the current wind conditions in the area.

The on-site wind data were limited to daily average and maximum readings making it difficult to provide a clear conclusion with respect to the on-site wind data. The daily average wind speeds collected at the site were, on average, more than 5 km/h lower than the daily average wind speed observations in Rankin Inlet over the same period. However, the maximum daily wind speeds for both sets of data agreed well, raising questions relating to the quality and/or consistency of the on-site wind observations. It is not possible with the information available to determine whether the differences in average wind speeds reflect local phenomena or are attributable to limitations in the on-site collection program.

The lack of hourly electronic data and possible inconsistencies with the on-site wind speed observations suggest that even limited use of the on-site wind data would be questionable. The use of wind data from the on-site station is not recommended, and wind analyses should rely on the contiguous data sets available from the Environment Canada station at Rankin Inlet.

2.4 Summary and Conclusions

The review of available on-site meteorological data indicates that there are no significant differences between the Rankin Inlet data collected 2006 through 2010, and the Rankin Inlet data collected 1997 through 2001 (i.e., the period when on-site data were being collected), indicating that there has not been a significant change in meteorological conditions between the periods of record, and the 1997 through 2001 Rankin Inlet data can be considered generally representative of current conditions. There are only small, less than 1°C, differences in temperatures between the 2006 through 2010, and the 1997 through 2001 observations at Rankin Inlet. The latest 5 years of precipitation observations had slightly less (-2%) rainfall and slightly more total precipitation (+8%) than were observed during the period from 1997 through 2001. Predominant wind directions, the wind rose figures, and average wind speeds agree well.

There are differences between the meteorological data collected at the on-site station between 1997 and 2001 and the observations at Rankin Inlet for the same period of time. While the temperatures showed general agreement, the on-site precipitation values (where available) were consistently lower than both hourly observations at Rankin Inlet and the long-term climate normals. However, it is not possible to determine whether these differences are valid given the limited nature of the on-site data. For winds, the average on-site daily wind speeds were more than 5 km/h less than observed at Rankin Inlet. However, the daily maximum winds at both stations showed good agreement raising questions with respect to the quality of the on-site wind speed observations.

Generally, the lack of hourly electronic data makes the use of the on-site meteorological observations in the environmental assessment difficult. For air quality modelling purposes, concurrent hourly observations of temperature, precipitation, wind speed and wind direction are essential. Therefore, the on-site observations cannot be relied on for air modelling. On-site observations of precipitation were limited to the summer months only, and showed consistently lower values than observed over the same period at Rankin Inlet, and the Rankin Inlet climate normals. Therefore, the on-site precipitation observations are considered to under represent the conditions expected to occur in the area and should be used with extreme caution. Finally, the limited wind observation data available for the on-site station suggest problems with the quality of data, which should discourage any considered use of the information.

While data are available from both an onsite station and from the Environment Canada meteorological station located at Rankin Inlet, it was decided to use data generated by MM5 (the Pennsylvania State University/National Center for Atmospheric Research Mesoscale Model version 5) and processed using the CALMET meteorological preprocessor for the dispersion modelling. The reasons for this decision are as follows:

- The onsite data were available only for a limited time scale (1997 through 2001) and did not include all the parameters required for the modelling;
- Rankin Inlet is located approximately 25 km from the Site, and is located on the coast of James Bay, raising concerns of the validity of these data for modelling an inland location;
- Using data from a single station, when modelling a domain of this size, does not provide a high level of detail; MM5 data are more suited to the needs of the 3D modelling domain.

The contiguous data sets available from the Environment Canada station at Rankin Inlet can, however, be used to characterize the climate conditions at the Project site.

3.0 DISPERSION METEOROLOGY DEVELOPMENT

This section describes the means by which meteorological data were generated for the Project location and compares the resulting data set to monitoring data from the nearest Environment Canada meteorological station, at Rankin Inlet, to demonstrate the validity. Two steps are required to generate the 3-dimensional meteorological fields as an input to CALMET model:

- MM5 must be initialized and executed for the modelling period; and
- The required surface and upper air CALMET meteorological fields must be extracted from MM5 data using the CALMM5 pre-processor.

These steps were followed for the 2006 to 2010 period over a 50×50 km domain, centred on the Project site. The data were then input into CALMET, the pre-processor that generates a single data file, which is used by the CALPUFF dispersion model. The CALMET model uses the 3-imensional meteorological data from MM5 as initial value to create surface and vertical meteorological fields such as winds, temperature, pressure and relative humidity. The CALMET modelling results are also presented here.

3.1 Mesoscale Meteorological Data Processing

The MM5 modelling domain consists of 3 nested domains at 36, 12, and 4 km resolution. A 2-way nesting technique was used, allowing the finer mesh to provide more detail to fill in the coarser mesh. One of the advantages of using 2-way nesting is smoother boundary values along the finer mesh, minimizing the noise that usually occurs on grid cells close to the boundary. As the finer mesh has a shorter time step than the coarser mesh, it allows the finer mesh to account for coarser mesh variations at a finer time scale.

In addition, grid nudging is used during modelling. This method uses the prognostic data from the model grid over the data assimilation period, linearly interpolated in time and the model relaxes its solution toward those analyses and their interpolated values. The analysis data has a 6 hour temporal resolution hence the interpolation in time.

3.1.1 Model Initialization

The National Center for Environmental Prediction (NCEP) FNL (Final) Operational Global Analysis data on 1×1 degree grids were used to initialize the MM5 model. The data have a 6 hour temporal resolution. The analyses are available on the surface, at 26 mandatory and other pressure levels from 1000 millibar (mb) to 10 mb, in the surface boundary layer, at some sigma layers, the tropopause, and a few others. Parameters include surface pressure, sea level pressure, geopotential height, temperature, sea surface temperature, soil values, ice cover, relative humidity, u- and v-winds, vertical motion, vorticity, and ozone.

The NCEP FNL analysis data provides the MM5 model with boundary and initial conditions. Since mesoscale modelling is an initial value problem, having superior boundary and initial conditions has a very high impact on the accuracy of model output. The above analysis was chosen because it has higher spatial resolution than the NCEP Re-analysis data, which has 2.5×2.5 degree resolution.

3.1.2 MM5 Modelling Domain

3.1.2.1 Terrain

The terrain height data used in the MM5 modelling was acquired from United States Geological Survey (USGS) at 6 spatial resolutions: 1-degree, 30-, 10-, 5-, 2-minute, and 30-second. Depending on the spatial resolution of each nested domain, best suited terrain height data are selected for that specific nest. For example, a 12 km resolution nest will use 5-minute terrain height data, which has approximately 9.25 km resolution. All lower resolution data (1 degree to 2 minutes) are created from 30-second USGS data.

3.1.2.2 Land Use

The vegetation/land-use data used in the MM5 modelling is 25-category, global coverage with resolution of 1-degree, 30-, 10-, 5-, 2-minutes, and 30-second and the land-water mask data are available from the same file.

3.1.2.3 Domain Size and Resolution

There are 3 nested domains with resolutions of 36, 12, and 4 km. The last nest (4 km domain) was extracted and post-processed using CALMM5 to produce CALMET-ready data. This 4 km domain covers an area of approximately 50x50 km with the domain centered at 62.98° N, 92.16° W. The modelling domain has 23 vertical levels with the last level above 12 000 m. However, the lowest 10 layers are below 1000 m. This approach is commonly used in air dispersion modelling to effectively characterize that portion of the boundary layer of greatest interest with respect to ground-level predictions.

3.1.3 Physics Configuration

The following physics options were applied during the MM5 modelling, except the cumulus parameterization, which was not applied to 4 km modelling domain.

1) Reisner graupel (Reisner2) explicit moisture scheme: This scheme is based on a mixed-phase scheme but with the addition of graupel and ice number concentration prediction equations.
2) Kain-Fritsch 2 cumulus scheme: This scheme predicts both updraft and downdraft properties and also detrains cloud and precipitation. A shallow convection is also included in this new version of the Kain-Fritsch scheme. The cumulus parameterization is not recommended for a grid size less than 5-10 km.
3) Hong-Pan or medium range forecast (MRF) planetary boundary layer scheme: This scheme is suitable for high resolution planetary boundary layer (PBL). This scheme uses the National Centers for Environmental Prediction/Oregon State University/Air Force/Hydrologic Research Lab (NOAH) land surface model and its vertical diffusion uses an implicit scheme to allow longer time steps.
4) Rapid Radiation Transfer Model (RRTM) longwave scheme: This scheme is combined with the cloud-radiation shortwave scheme.
5) NOAH Land-Surface-Model: This scheme is able to predict soil moisture and temperature in 4 layers, as well as canopy moisture and water-equivalent snow depth. It also handles sea-ice surfaces.

3.2 MM5 Model Output Validation

Prior to developing the detailed dispersion meteorological data set using the CALMET model, the MM5 model predictions were compared to hourly observations from the station at the Rankin Inlet Airport to validate the data. The Rankin Inlet Airport data presented here are from Canada's National Climate Archive, available online from Environment Canada Weather Office. The MM5 data used for this comparison were extracted from a grid cell closest to the Rankin Inlet Airport.

3.2.1 Temperature Summary

The MM5 model output illustrated in Figure 5.2-C17 shows that the modelled temperature field is within the expected monthly temperatures variations for such northern latitudes. The graph uses a "box-and-whisker" plot to show the range of temperatures. The box in the graph represents the middle 50% of the observations (i.e., from the 25th to 75th percentiles). The whiskers extend up to the maximum observation and down to the minimum. The diamond represents the average of the observations in each month. The green lines on the graph represent the climate normals at Rankin Inlet for extreme maximum (dashed line above the average normal), daily maximum (dotted line above the average normal), average (solid line), daily minimum (dotted line below the average normal), and extreme minimum temperatures (dashed line below the average normal) for each month. The temperature data for the period generally fall within the extreme climate normals except for October and December when the extreme maximum temperature were above the normal.

Although, temperatures obtained using the prognostic MM5 data show expected and reasonable monthly variability, corresponding well with expected seasonal variations, comparison to observed temperature at Rankin Inlet station shows that MM5 model generated slightly warmer temperatures. Table 5.2-C14 compares the monthly average temperature of MM5 model output to observed data at Rankin Inlet, while Table 5.2-C15 and Table 5.2-C16 compare the monthly minimum temperature and the monthly maximum temperature, respectively. Figure 5.2-C18 compares the hourly temperature modelled by MM5 and observed at Rankin Inlet station during the period of (2006 - 2010).

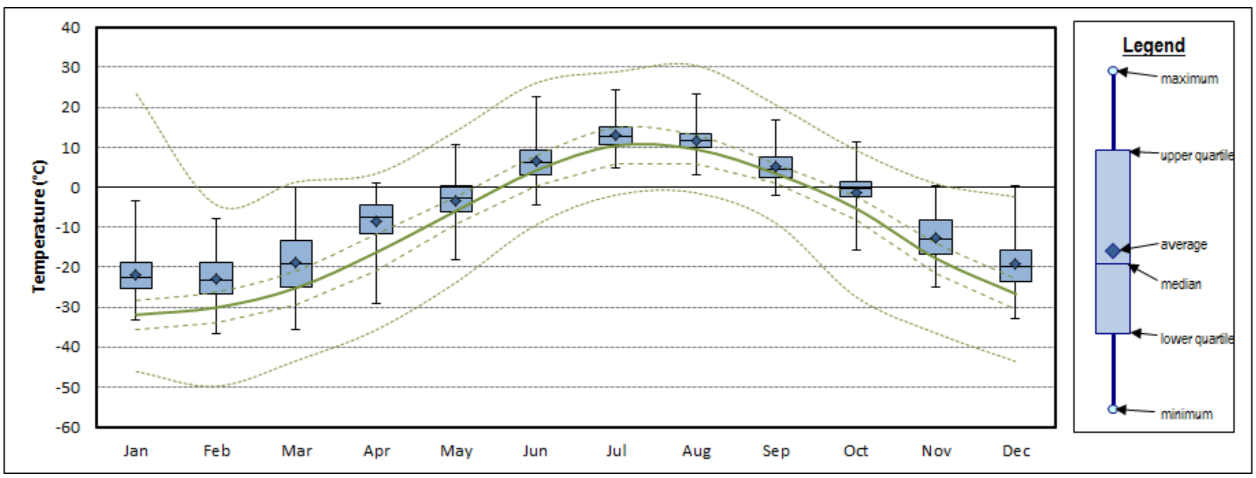

Figure 5.2-C17: Range of Hourly Temperatures in MM5 Model Output at Rankin Inlet (2006 – 2010)

Table 5.2-C14: Comparison of Monthly Average Temperature

Month	MM5 Model Output (2006 – 2010)	Rankin Inlet (2006 – 2010)
	Average Temperature (°C)	Average Temperature (°C)
January	-22.02	-26.07
February	-22.86	-28.10
March	-18.60	-23.66
April	-8.30	-12.27
May	-3.09	-5.53
June	6.88	4.49
July	13.25	10.85
August	12.02	10.43
September	5.31	4.45
October	-1.04	-2.24
November	-12.52	-14.89
December	-19.15	-22.65

Table 5.2-C15: Comparison of Monthly Minimum Temperature

Month	MM5 Model Output (2006 – 2010)	Rankin Inlet (2006 – 2010)
	Minimum Temperature (°C)	Minimum Temperature (°C)
January	-24.40	-29.41
February	-25.51	-31.16
March	-22.06	-27.63
April	-11.11	-16.18
May	-5.28	-8.38
June	4.19	1.01
July	10.79	7.12
August	9.59	7.56
September	3.28	2.13
October	-2.33	-4.33
November	-14.66	-18.54
December	-21.28	-25.83

Table 5.2-C16 – Comparison of Monthly Maximum Temperature

Month	MM5 Model Output (2006 – 2010)	Rankin Inlet (2006 – 2010)
	Maximum Temperature (°C)	Maximum Temperature (°C)
January	-19.63	-22.73
February	-20.22	-25.05
March	-15.14	-19.70
April	-5.48	-8.36
May	-0.89	-2.67
June	9.57	7.98
July	15.72	14.59
August	14.45	13.30
September	7.34	6.77
October	0.25	-0.15
November	-10.39	-11.24
December	-17.01	-19.47

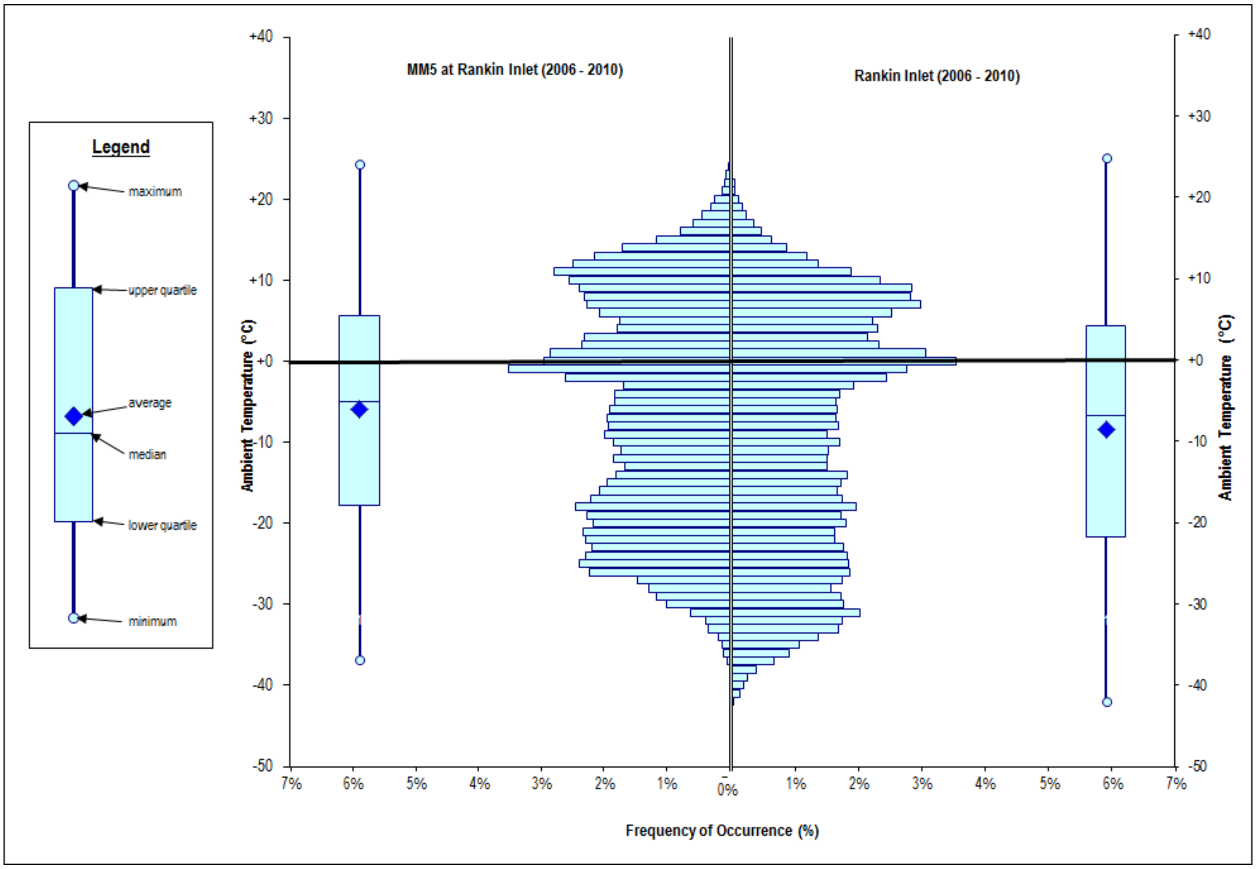

Figure 5.2-C18: Hourly Temperature Comparison

3.2.2 Precipitation Summary

Figure 5.2-C19 shows comparison of monthly average precipitation from MM5 model output to monthly normal precipitation for Rankin Inlet, while Table 5.2-C17 tabulates those monthly average values in detail. MM5 modelled precipitation for 2006 to 2010 period is approximately 22% wetter when compared to the long-term climate normals. The 5-year average of annual precipitation at Rankin Inlet modelled by MM5 is 362 mm while the 30-year average of annual precipitation at Rankin Inlet is 297 mm. However, observed precipitation at Rankin Inlet airport over the same period also indicates more precipitation than normal for the same period. The following are the notable differences between modelled precipitation and long-term normals:

- The average January water equivalent snowfall (20.3 mm) was more than triple the normal amount of water equivalent snowfall (6.6 mm) for that month;
- The average April water equivalent snowfall (50.2 mm) was more than triple the normal amount of water equivalent snowfall (13.3 mm) for that month;
- The average July rainfall (49.4 mm) was 25% more than the normal amount of total precipitation (39.5 mm) for that month; and
- The average August total precipitation (38.2 mm) was 33% less than the normal amount of total precipitation (57.6 mm) for that month.

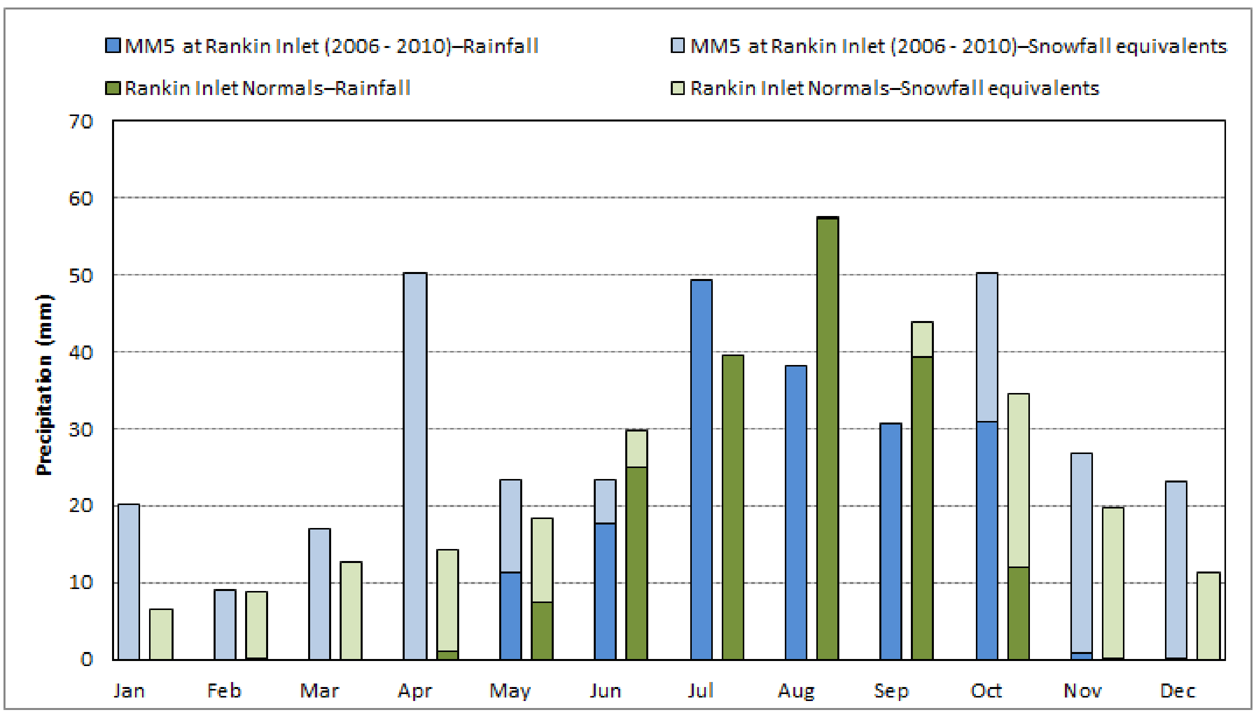

Figure 5.2-C19: Comparison of MM5 Precipitation to Rankin Inlet Normals (1971-2000)

Table 5.2-C17: MM5 Monthly Average Precipitation (2006 to 2010)

Month	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)	Extreme Daily Precipitation (mm)	Days with Measurable Precipitation	Average Snow Depth (cm)
January	0.0	20.3	20.3	6.7	13	—
February	0.0	9.1	9.1	5.0	8	—
March	0.0	17.0	17.0	9.0	11	—
April	0.0	50.2	50.2	21.1	12	—
May	11.3	12.2	23.5	15.5	10	—
June	17.7	5.8	23.5	15.1	6	—
July	49.4	0.0	49.4	28.8	7	—
August	38.2	0.0	38.2	30.1	8	—
September	30.7	0.0	30.7	23.1	9	—
October	30.9	19.4	50.3	22.2	13	—
November	0.8	26.0	26.8	9.5	12	—
December	0.3	22.8	23.0	8.1	13	—

3.2.3 Winds Summary

A wind rose for the 5-years of hourly wind speed and direction modelled by MM5 and extracted at a grid cell where Rankin Inlet is shown in Figure 5.2-C20. North-northwesterly and northwesterly winds predominate. Figures 21 through 25 show the winds for each year in the MM5 data set.

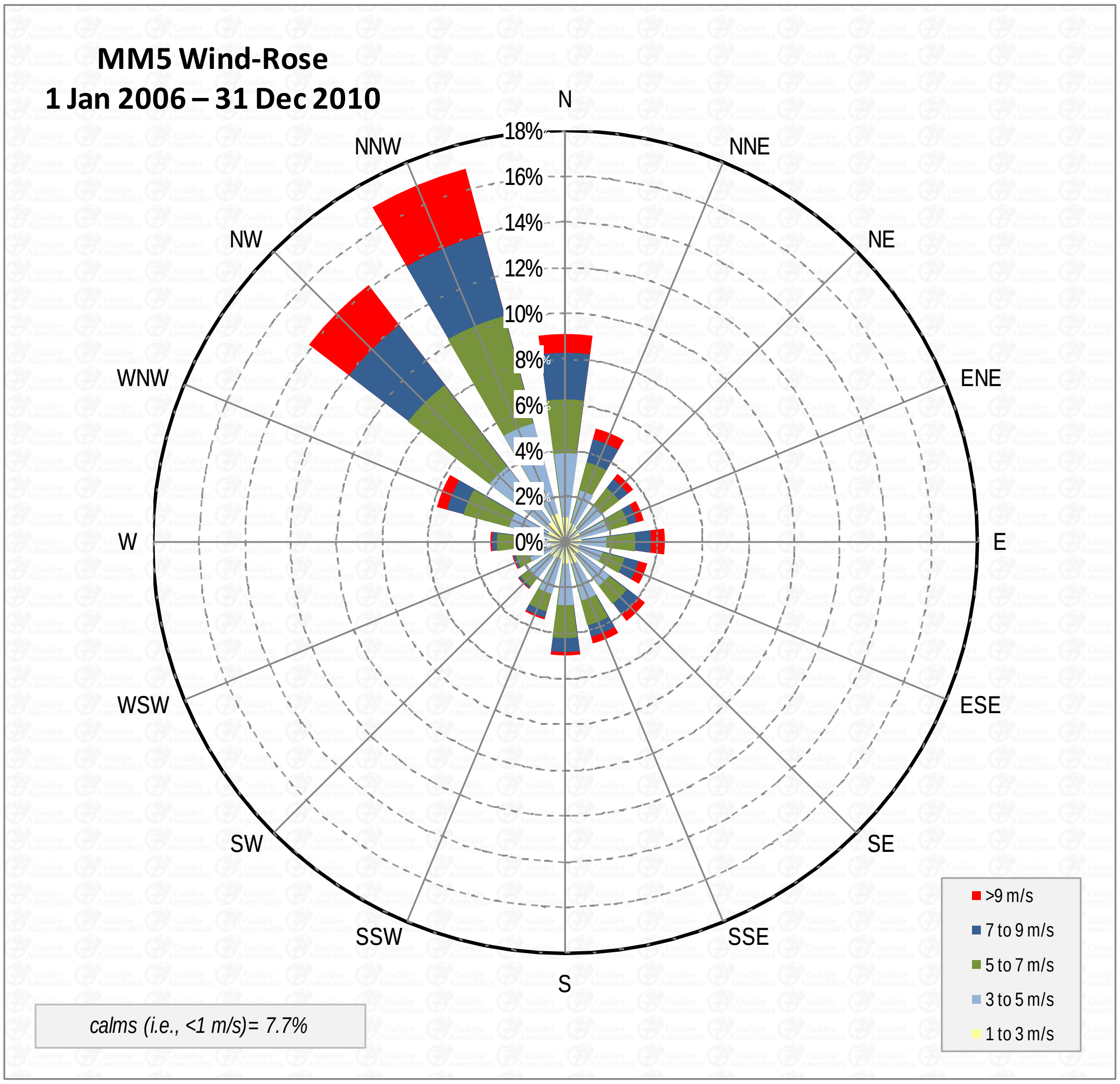

Figure 5.2-C20: MM5 Windrose at the Grid Point Closest to Rankin Inlet Airport

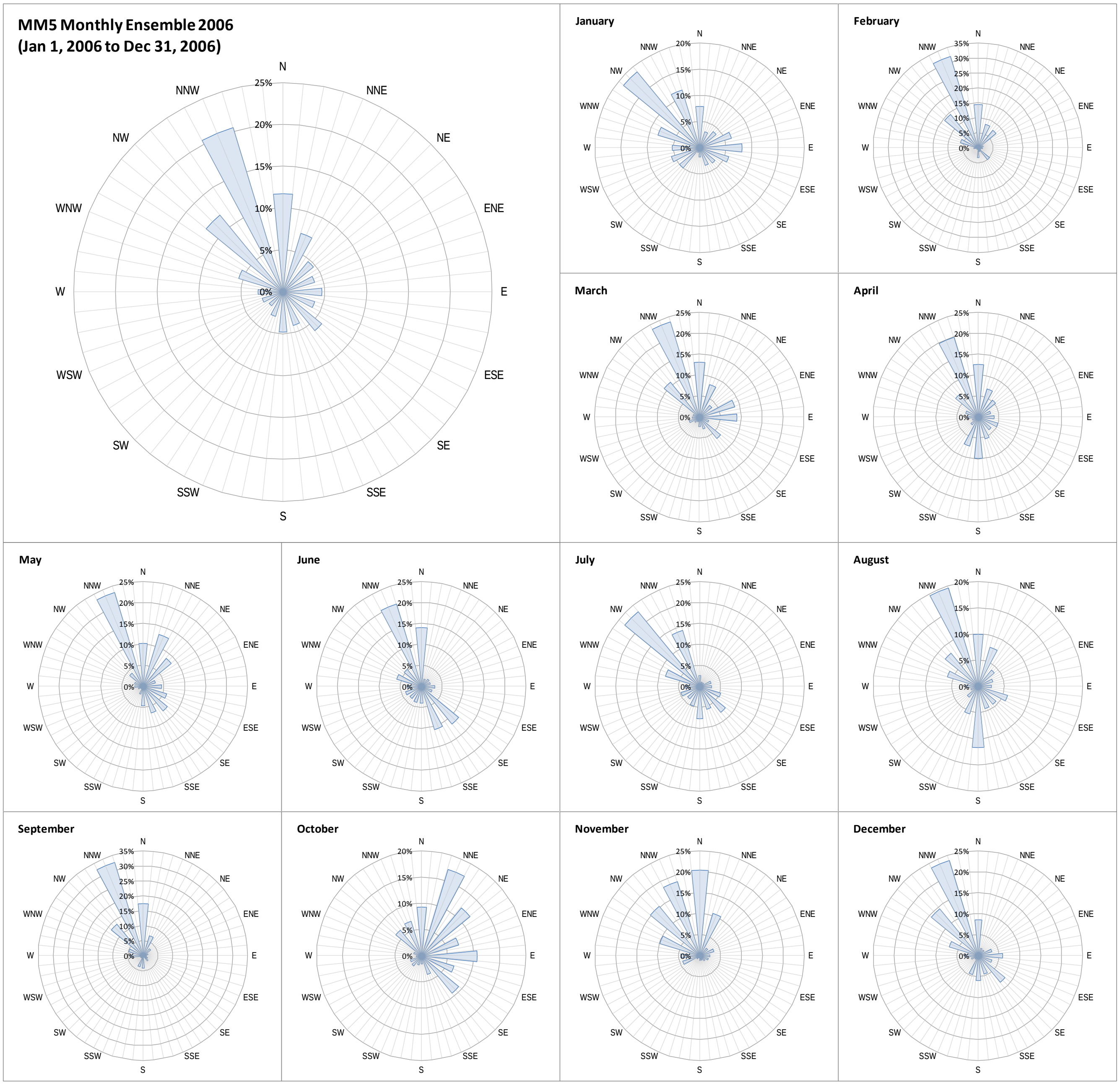

Figure 5.2-C21: 2006 Monthly MM5 Windroses at the Grid Point Closest to Rankin Inlet Airport

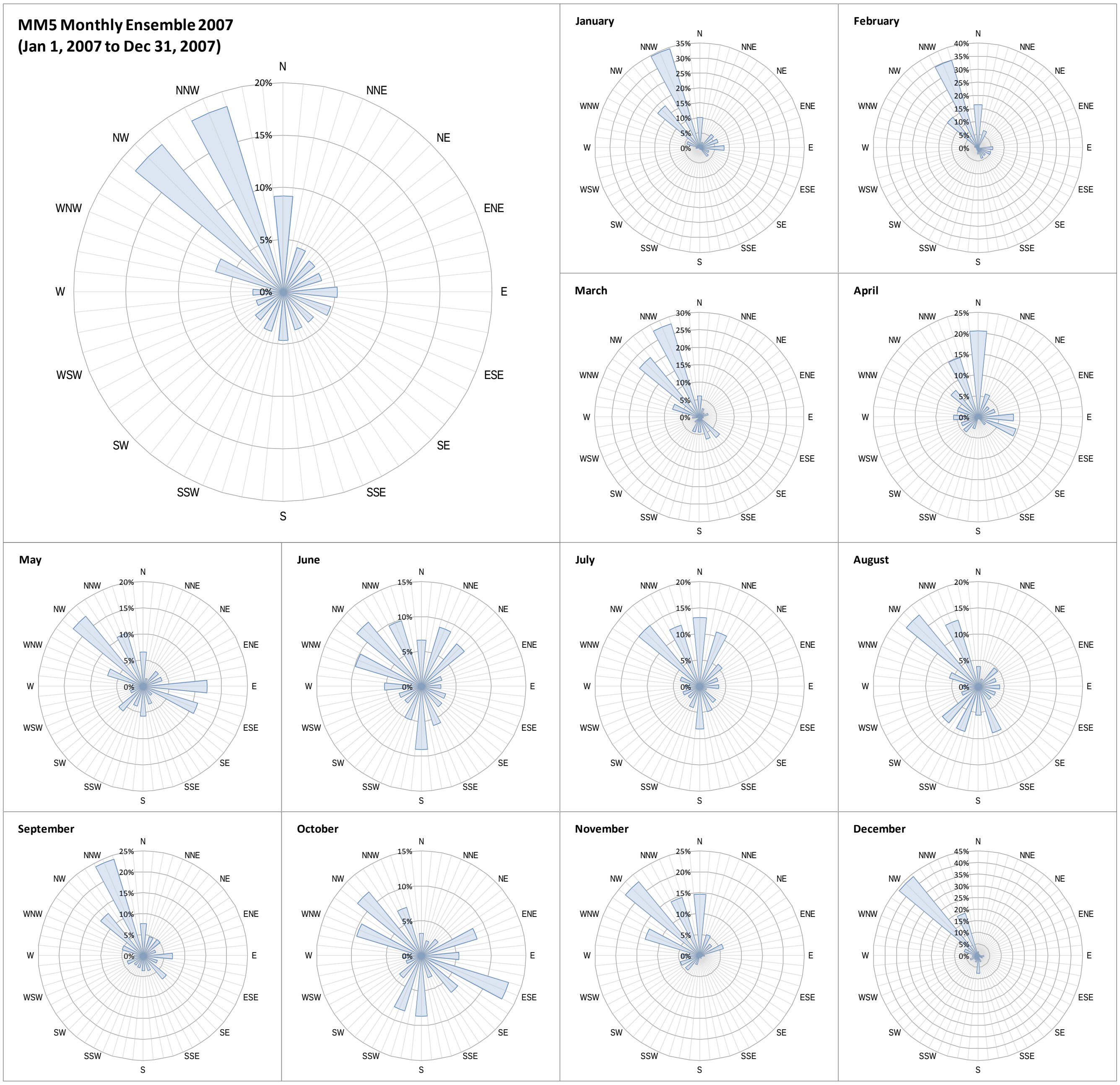

Figure 5.2-C22: 2007 Monthly MM5 Windroses at the Grid Point Closest to Rankin Inlet Airport

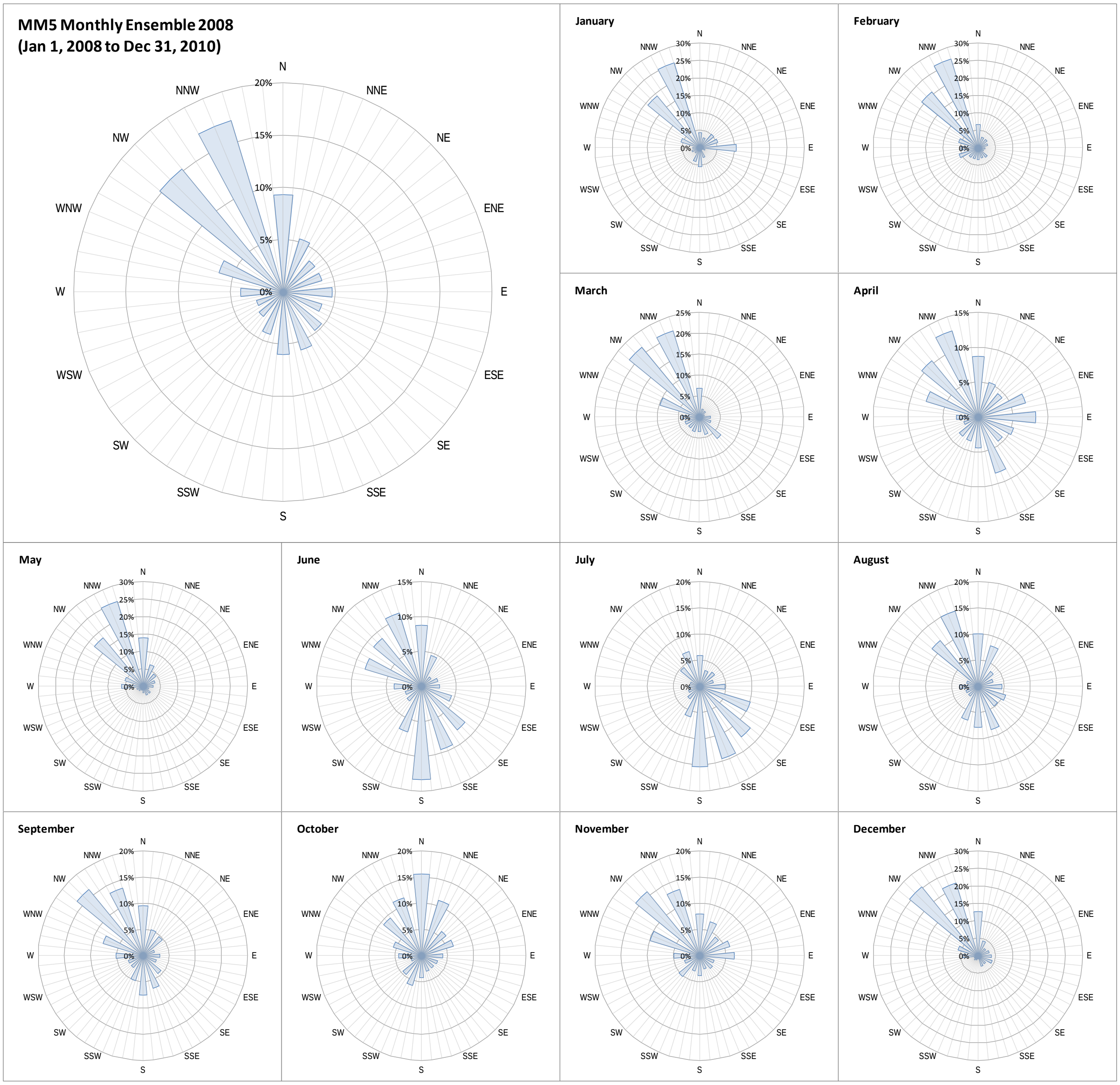

Figure 5.2-C23: 2008 Monthly MM5 Windroses at the Grid Point Closest to Rankin Inlet Airport

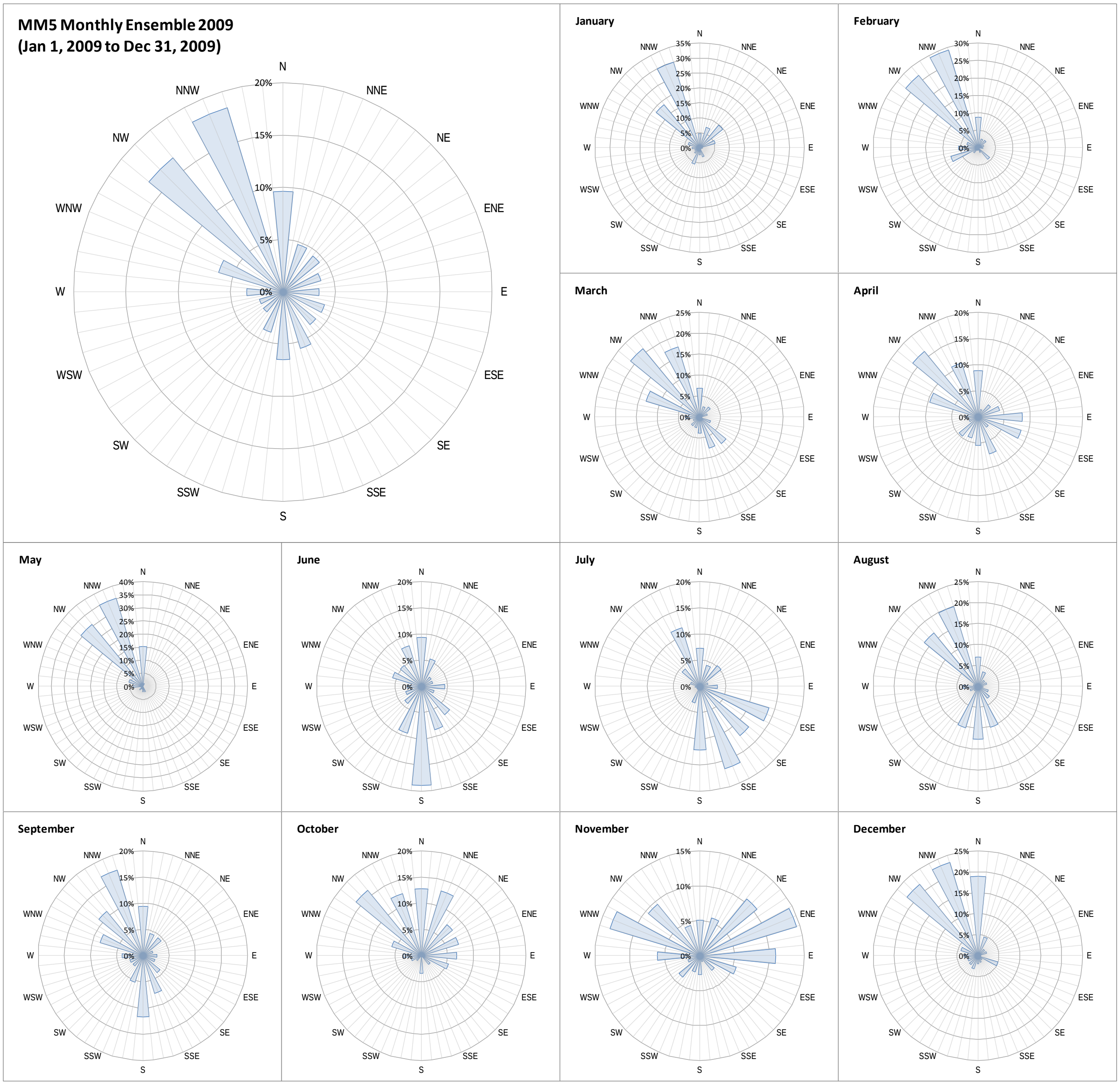

Figure 5.2-C24: 2009 Monthly MM5 Windroses at the Grid Point Closest to Rankin Inlet Airport

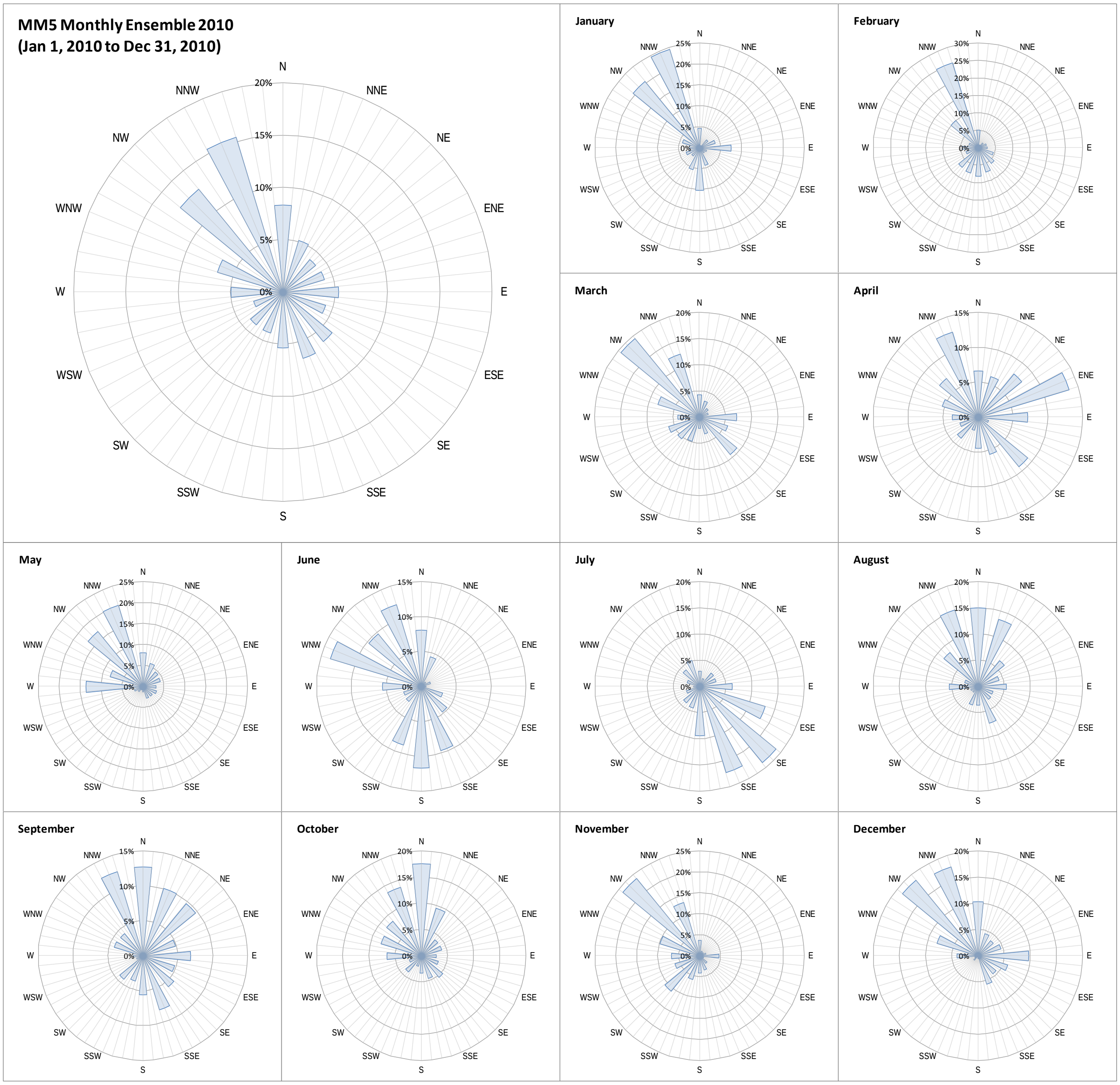

Figure 5.2-C25: 2010 Monthly MM5 Windroses at the Grid Point Closest to Rankin Inlet Airport

For comparison, windroses for Rankin Inlet are provided in Figure 5.2-C26 (for the 2006 – 2010 period) and Figures 5.2-C27 through 5.2-C31 (for each year of data).

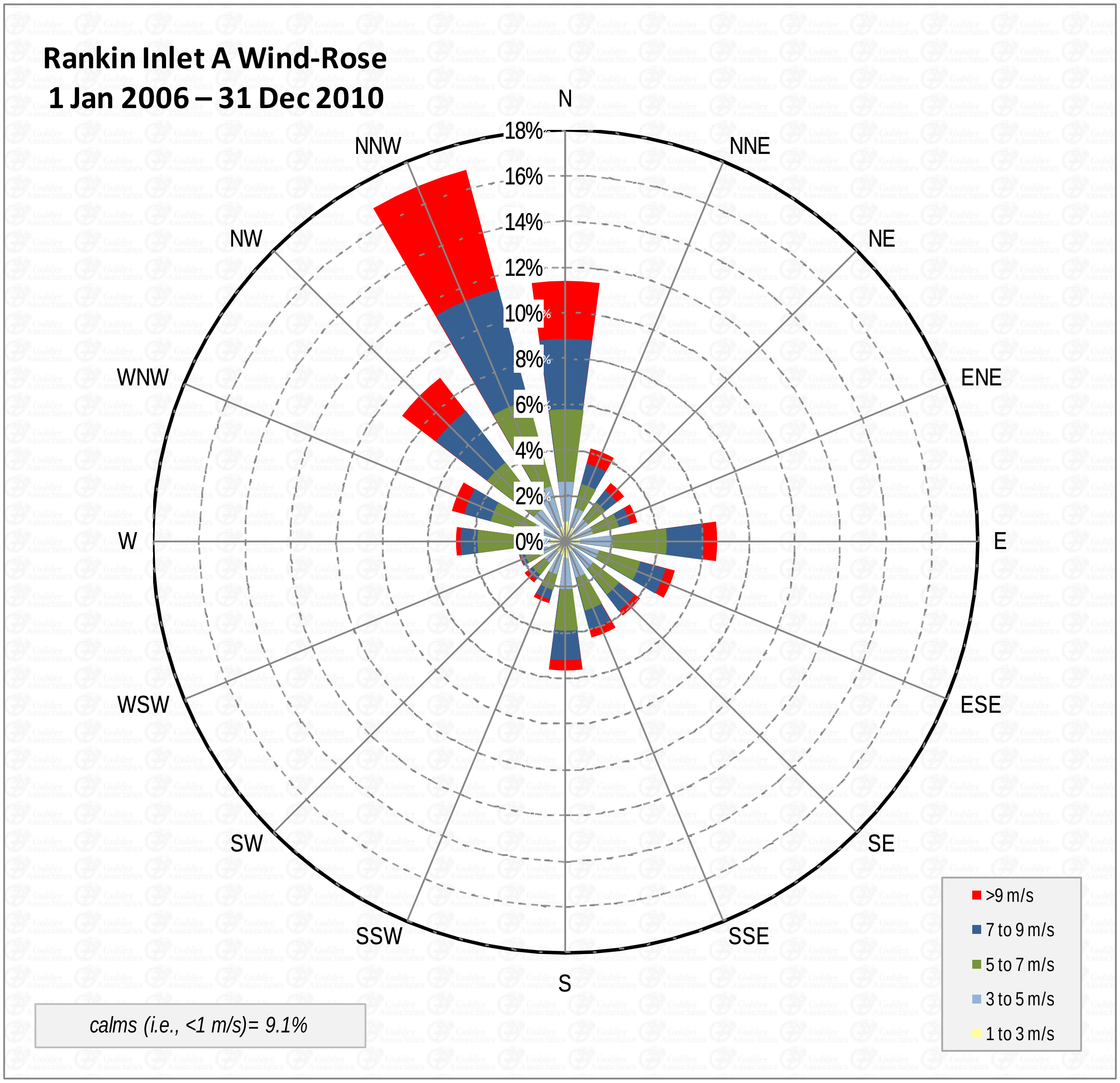

Figure 5.2-C26: MM5 Windrose for Rankin Inlet Airport

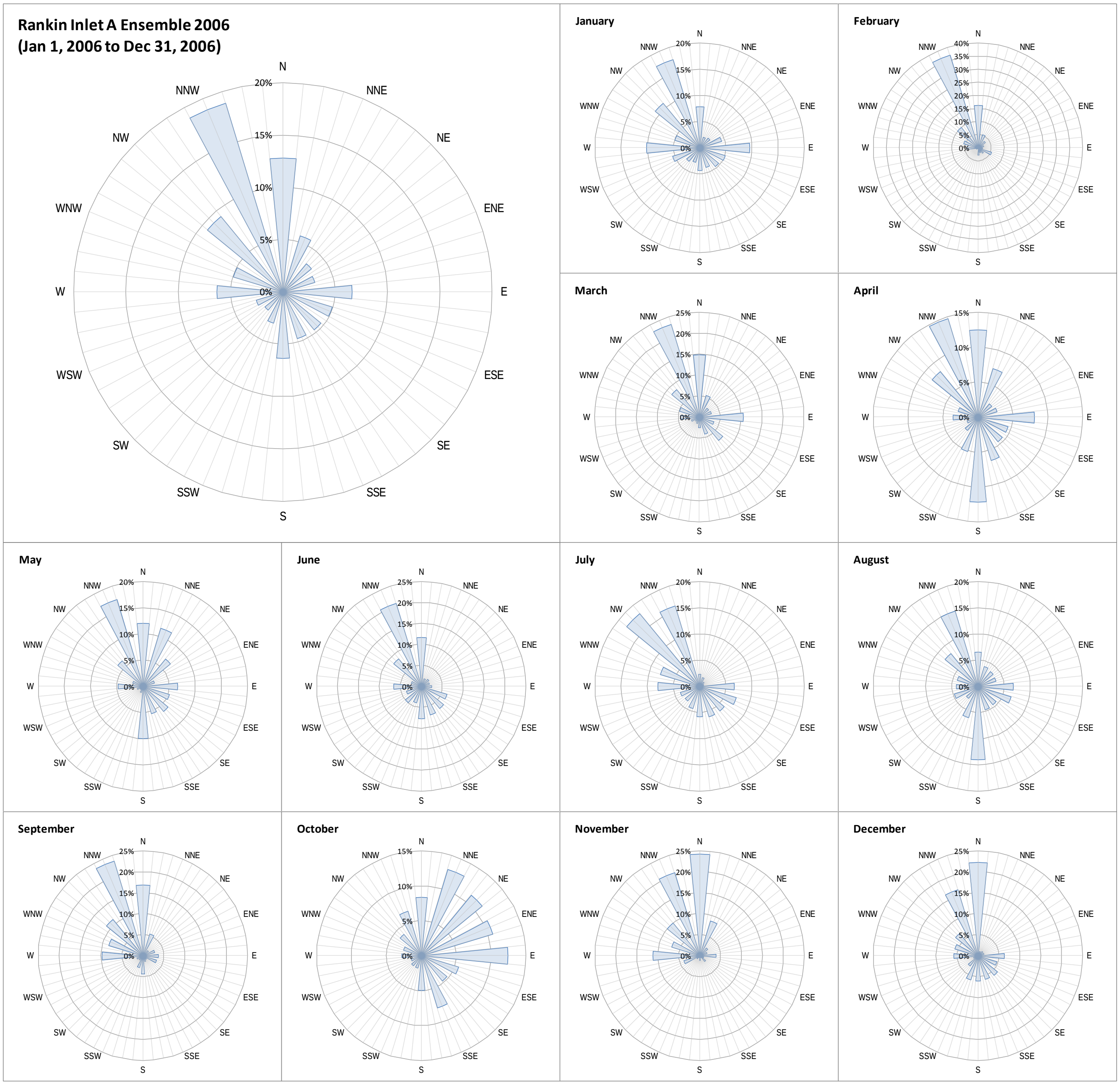

Figure 5.2-C27: 2006 Monthly Windroses at Rankin Inlet Airport

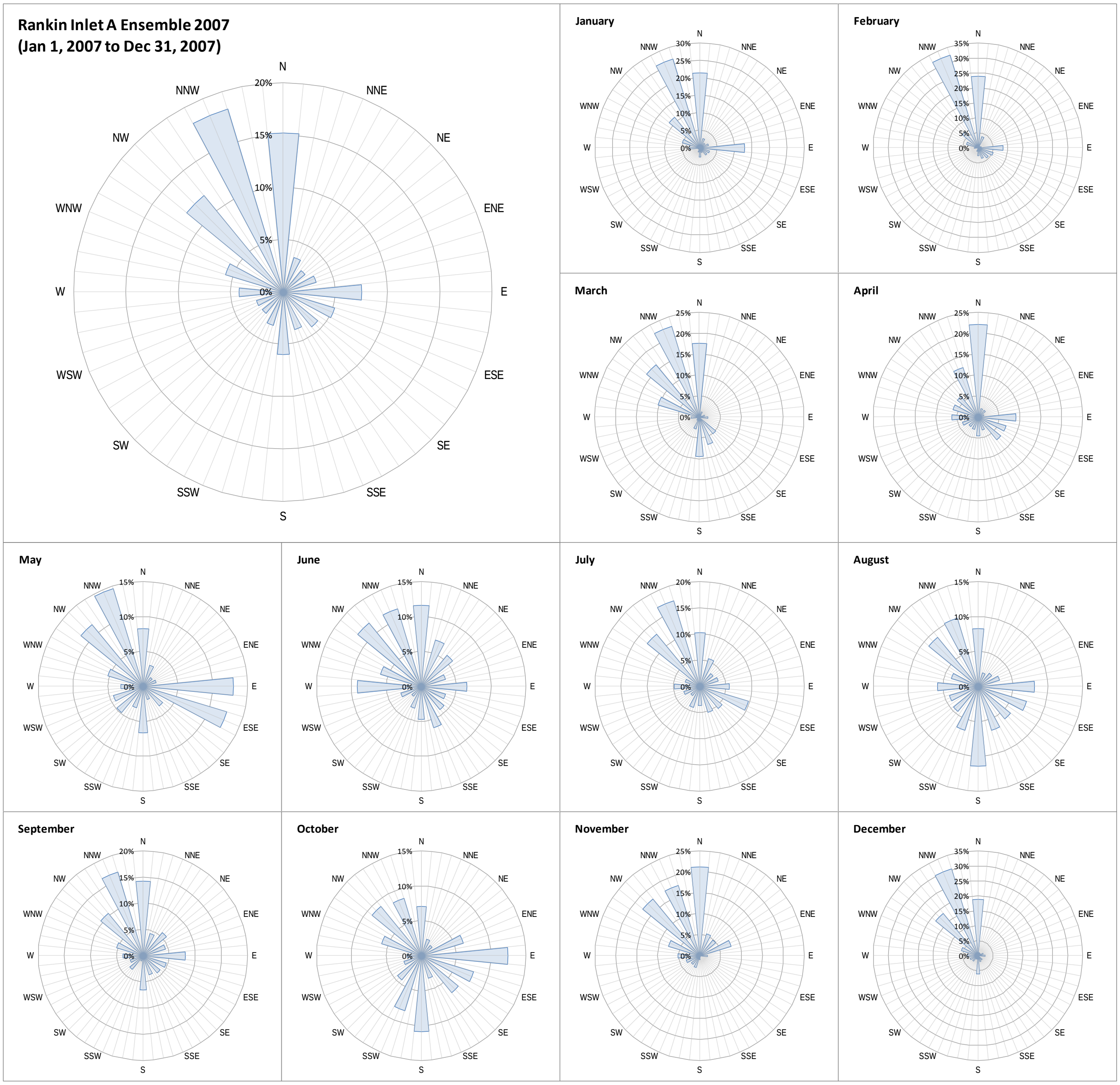

Figure 5.2-C28: 2007 Monthly Windroses at Rankin Inlet Airport

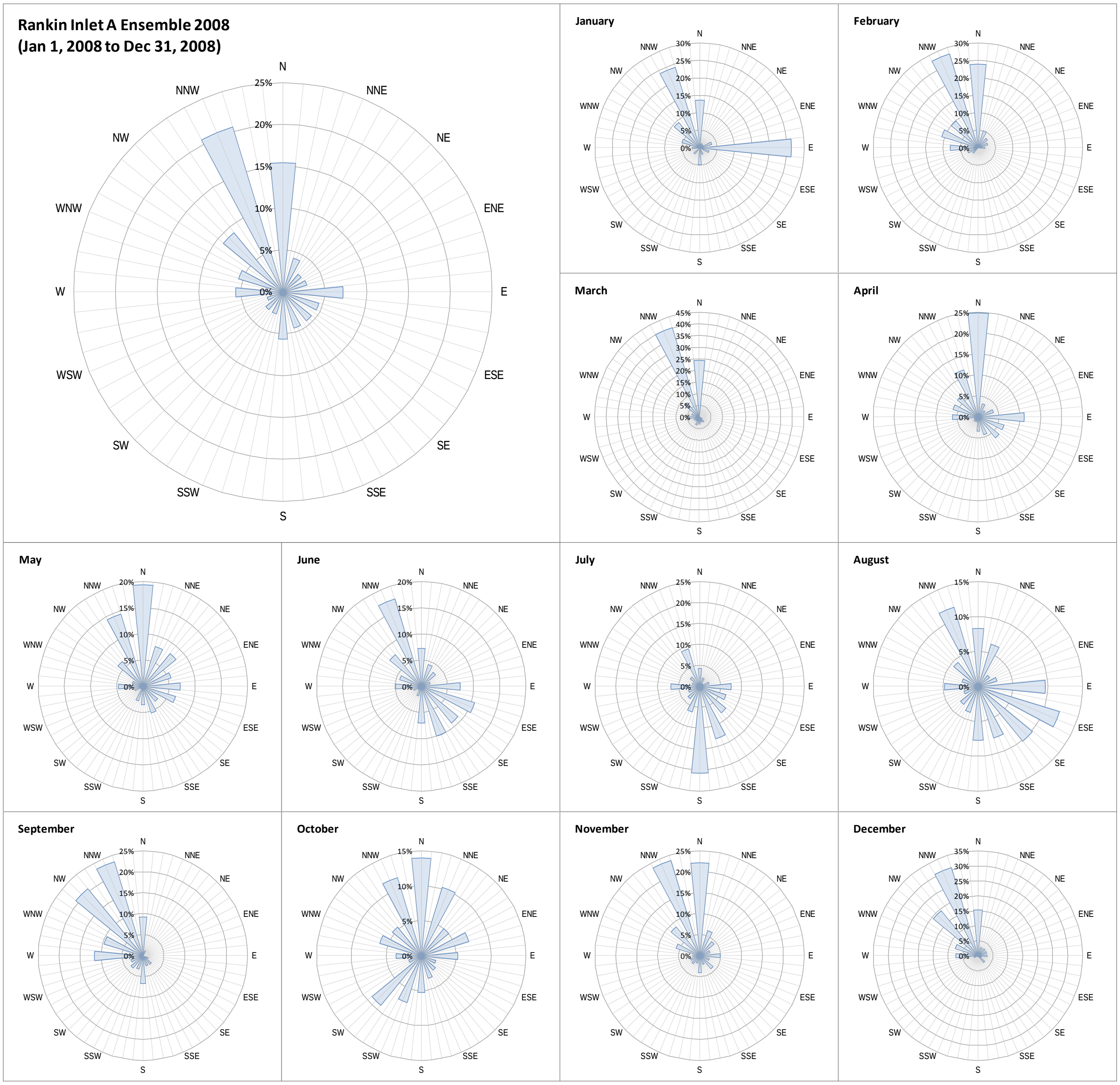

Figure 5.2-C29: 2008 Monthly Windroses at Rankin Inlet Airport

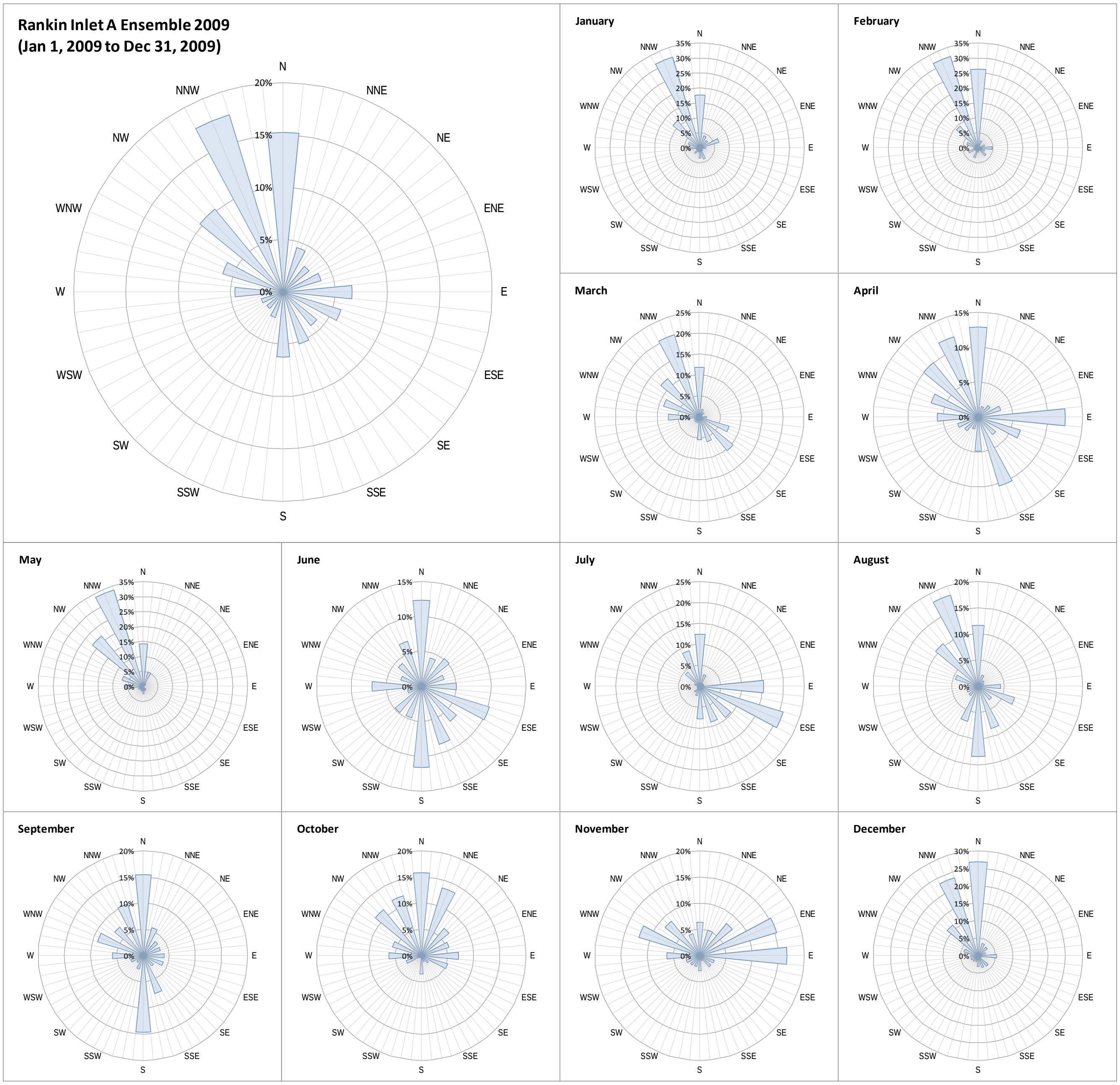

Figure 5.2-C30: 2009 Monthly Windroses at Rankin Inlet Airport

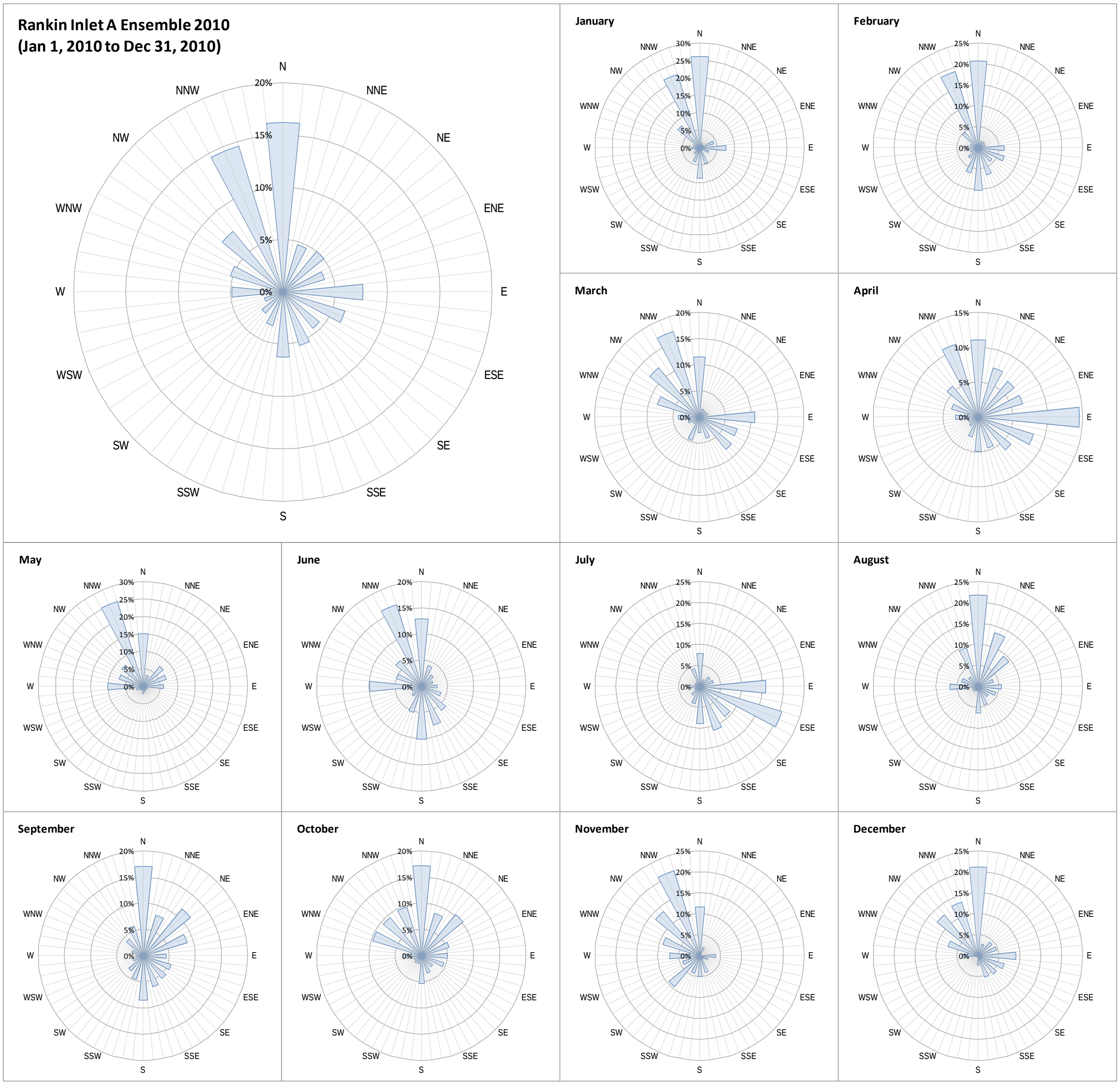

Figure 5.2-C31: 2010 Monthly Windroses at Rankin Inlet Airport

Overall, the MM5 wind data were comparable to the monitoring data from Rankin Inlet Airport. Predominant wind directions were similar for most months and the 5-year windroses showed that for the same period, MM5 adequately predicted winds for the Rankin Inlet locale.

4.0 CALMET MODELLING

The CALPUFF model, in 3D mode, requires a meteorological data set generated by the CALMET pre-processor, which is a diagnostic meteorological model that produces 3-dimensional wind fields based on parameterized treatments of terrain effects, such as slope flows, terrain blocking effects, and kinematic effects. Meteorological observations are used to determine the wind field in areas where the observations are representative. Gridded hourly meteorological data produced by MM5 can be used as the initial guess for the wind fields generated in CALMET. The diagnostic wind module in CALMET determines fine scale terrain effects.

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. When using large domains, the user has the option to adjust input winds to a Lambert Conformal Projection coordinate system to account for Earth's curvature. The diagnostic wind field module uses a 2-step approach to the computation of the wind fields. In the first step, an initial-guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. The prognostic grid of meteorological data can be used for the initial guess field. The second step consists of an objective analysis procedure to introduce observational data into the Step 1 wind field to produce a final wind field, if available.

The major features and options of the meteorological model are summarized below:

- Boundary Layer Modules of CALMET
- Overland Boundary Layer - Energy Balance Method
- Overwater Boundary Layer - Profile Method
- Diagnostic Wind Field Module of CALMET
- Terrain Blocking Effects
- Kinematic Terrain Effects
- Divergence Minimization
- Produces Gridded Fields of U, V, W Wind Components
- Inputs Include Domain-Scale Winds, Observations, and Coarse-Grid Prognostic Model Winds (optionally)
- Lambert Conformal Projection Capability.

4.1 Meteorological Data Requirements for CALMET

CALMET is composed of two main components: a wind field module and a boundary layer meteorological module. The wind field module has 2 steps. In Step 1 of the wind field module, the initial field is modified by kinematic effects of terrain, slope flows, and blocking effects. Observational data can be introduced in Step 2 through an objective analysis procedure but for the current project, only MM5 data were used to have a consistent wind field that better represents the regional flows.

The CALMET modelling systems require a physical description of the ground surface to determine meteorological parameters in the boundary layer. The geophysical parameters are land use category, terrain elevation, roughness length, albedo, Bowen ratio, surface heat flux parameter, anthropogenic heat flux and leaf area index (LAI).

4.1.1 Land Use

Each meteorological grid cell was assigned one (or more, in the case of mixed land use cells) land use categories defined by CALMET. The assignment of land uses was done within the CTGPROC land use pre-processor (part of the CALMET package) using mapping data available from the Landsat satellite data at 30 m resolution.

4.1.2 Terrain Elevation

Terrain is the vertical dimension of land surface. Terrain elevations in CALMET were initialized with data from the Shuttle Radar Topography Mission (SRTM). This data, a product from a joint project between the U.S. National Aeronautics and Space Administration (NASA) and the U.S. National Geospatial-Intelligence Agency (NGA), is available at 3 arc-second (approximately 90 m) horizontal resolution for the continent of North America (USGS, 2007). The SRTM data was processed by the CALPUFF pre-processor TERREL over the domains.

The processed Terrain Elevation data are shown in Figure 5.2-C32.

4.1.3 Roughness Length

Roughness length (zo) is a measure of the aerodynamic roughness of a surface and is related to the height, shape and density of the surface as well as the wind speed. Different land uses are assigned different roughness lengths within the MAKEGEO pre-processor (part of the CALMET package). Default values were used throughout.

4.1.4 Albedo

The albedo is a measure of the reflectivity of the Earth's surface and is defined as the ratio of reflected solar radiation to the total incoming solar radiation received at the surface. This is a very important parameter in meteorological dispersion modelling because it provides a measure of the amount of incident solar radiation that is absorbed by the Earth/atmosphere system. Absorbed solar radiation is one of the driving forces for local, regional, and global atmospheric dynamics. Different land uses are assigned different albedos within the MAKEGEO pre-processor (part of the CALMET package). Default values were used throughout.

4.1.5 Bowen Ratio

Bowen ratio is the ratio of the vertical flux of sensible heat to latent heat, where sensible heat is the transfer of heat from the surface to the atmosphere via convection, and latent heat is the transfer of heat required to evaporate liquid water from the surface to the atmosphere. The Bowen ratio gives a measure of the surface heat flux and how much moisture is injected into the atmosphere. The Bowen ratio is defined as the ratio of sensible heat flux to latent heat flux. Different land uses are assigned different Bowen Ratios within the MAKEGEO pre-processor (part of the CALMET package). Default values were used throughout.

4.1.6 Soil Heat Flux

The soil heat flux constant is a function of the surface properties and is used to compute the flux of heat into the soil. Anthropogenic heat flux is a function of population density and energy usage. Different land uses are assigned different soil heat fluxes within the MAKEGEO pre-processor (part of the CALMET package). Default values were used throughout.

4.1.7 Leaf Area Index

Leaf area index (LAI) is defined as the ratio of leaf area to soil surface area. Different land uses are assigned different leaf area indices within the MAKEGEO pre-processor (part of the CALMET package) utilizing the Landsat satellite data at 30 m resolution. Default values were used throughout.

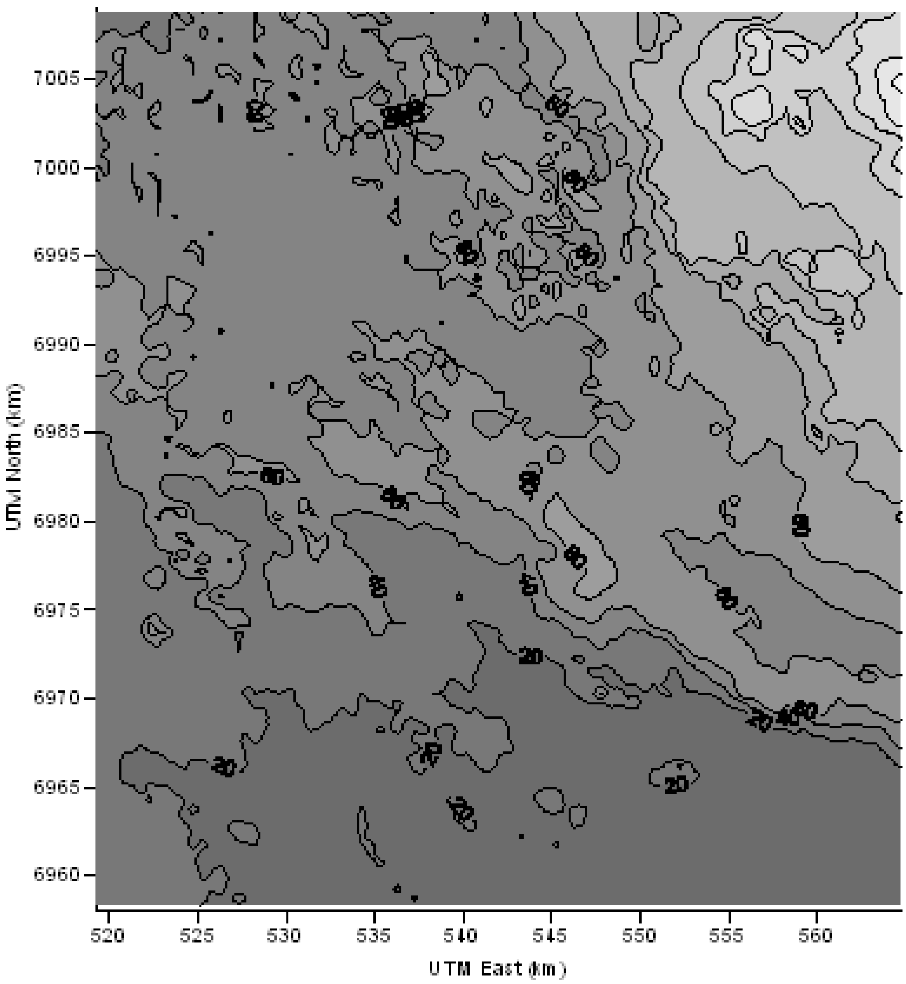

Figure 5.2-C32: Terrain Elevation Data in CALMET Modelling

4.2 Meteorological Data Processing

Five full years of 3-D dispersion meteorology data set for the years 2006 to 2010 were developed by the CALMET model using the MM5 data as input. The CALMET Options and Flags (other than default) used to process meteorology are presented in Table 5.2-C18. A dash indicates there is no default value. If a value has been changed away from the default, a brief explanation is provided in the description.

Table 5.2-C18: CALMET Options and Flags

Input Group	Parameter	Default	Project	Description
Input Group 1 – General Run Control Parameters	IBYR	-	2006	starting year
	IBMO	-	1	starting month
	IBDY	-	1	starting day
	IBHR	-	1	starting hour
	IBSEC	-	0	starting second
	IEYR	-	2010	ending year
	IEMO	-	1	ending month
	IEDY	-	31	ending day
	IEHR	-	23	ending hour
	IESEC	-	3600	ending second
	ABTZ	-	UTC-0500	UTC time zone (Eastern Standard Time)
	NSECDT	3600	3600	length of modelling timestep (seconds)
	IRTYPE	1	1	run type – computes wind fields and micrometeorological variables
	LCALGRD	T	T	do not compute special data fields required by CALGRID
	ITEST	2	2	continues with execution of computational phase after setup
	MREG	-	0	no checks for conformance with US EPA guidance
Input Group 2 – Map Projection and Grid Control Parameters	PMAP	UTM	UTM	map projection = Universal Transverse Mercator
	IUTMZN	-	15	UTM zone
	UTMHEM	N	N	northern hemisphere projection
	DATUM	WGS-84	NAR-B	datum region for output coordinates = NAR-C North American 1983 GRS 80 Spheroid
	NX	-	92	number of X grid cells
	NY	-	102	number of Y grid cells
	DGRIDKM	-	0.5	grid spacing (km)
	XORIGKM	-	519.000	X coordinate of southwest corner of domain (km)
	YORIGKM	6	6,958.000	Y coordinate of southwest corner of domain (km)
	NZ	-	10	number of vertical layers

Table 5.2-C18: CALMET Options and Flags (continued)

Input Group	Parameter	Default	Project	Description
	ZFACE	-	0, 20, 50, 100, 200, 400, 800, 1200, 1600, 2200, 3000	cell face heights in vertical grid (m)
Input Group 3 – Output Options	LSAVE	T	T	save meteorological fields in an unformatted output file
	IFORMO	1	1	CALPUFF/CALGRID type of unformatted output file
	LPRINT	F	F	do not print meteorological fields
	IPRINF	1	1	print interval (hours)
	IUVOUT	NZ*0	NZ*0	layers of U, V wind component to print (0=no, 1=yes)
	IWOUT	NZ*0	NZ*0	levels of W wind component to print (0=no, 1=yes)
	ITOUT	NZ*0	NZ*0	I (0=no, 1=yes)
	STABILITY	0	0	print PGT stability class
	USTAR	0	0	print friction velocity
	MONIN	0	0	print Monin-Obukhov length
	MIXHT	0	0	print mixing height
	WSTAR	0	0	print convective velocity scale
	PRECIP	0	0	print precipitation rate
	SENSHEAT	0	0	do not print sensible heat flux
	CONVZI	0	0	do not print convective mixing height
	LDB	F	F	do not print input meteorological data and internal variables
	NN1	1	1	first time step for which debug data are printed
	NN2	1	2	last time step for which debug data are printed
	LDBCST	F	F	do not print distance to land internal variables
	IOUTD	0	0	control variable for writing the test/debug wind fields to disk files
	NZPRN2	1	1	number of levels to print
	IPR0 to IPR8	0	0	do not print wind field components after each adjustment
Input Group 4 – Meteorological Data Options	NOOBS	0	2	no surface, overwater or upper air observations.
	NSSTA	-	0	number of surface stations
	NPSTA	-	-1	number of precipitation stations
	MCLOUD	0	3	Gridded cloud cover from Prognostic Rel. Humidity at 850 mb (Teixera), default is to use no cloud cover
	IFORMS	2	2	free-formatted user input for surface meteorological data file format

Table 5.2-C18: CALMET Options and Flags (continued)

Input Group	Parameter	Default	Project	Description
	IFORMP	2	2	free-formatted user input for precipitation data file format
	IFORMC	2	2	cloud data format
Input Group 5 – Wind Field Options and Parameters Input Group 5 – Wind Field Options and Parameters (continued)	IWFCOD	1	1	diagnostic wind module
	IFRADJ	1	1	compute Froude number adjustment effects
	IKINE	0	0	do not compute kinematic effects
	IOBR	0	0	do not use O'Brien procedure for adjustment of the vertical velocity
	ISLOPE	1	1	compute slope flows
	IEXTRP	-4	1	no extrapolation of surface data to upper levels is done (due to no surface station data being used)
	ICALM	0	0	do not extrapolate surface winds if calm
	BIAS	NZ*0	NZ*0	layer-dependant biases for modifying the weights of surface and upper air stations (no upper air stations used)
	RMIN2	4	4	minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station will be allowed. Set to -1 when all surface stations should be extrapolated
	IPROG	0	14	winds from MM5/M3D.dat used as initial guess field (default is not to use prognostic data but surface data)
	ISTEPPGS	3,600	3,600	timestep of the prognostic model input data (seconds)
	IGFMET	0	0	do not use CALMET fields as initial guess fields
	LVARY	F	F	do not use varying radius of influence
	RMAX1	-	20	maximum radius of influence over land in the surface layer (km)
	RMAX2	-	150	maximum radius of influence over land aloft (km)
	RMAX3	-	250	maximum radius of influence over water
	RMIN	0.1	0.1	minimum radius of influence used in the wind field interpolation (km)
	TERRAD	-	0.5	radius of influence of terrain features
	R1	-	10	relative weighting of the first guess field and observations in the surface layer (km)

Table 5.2-C18: CALMET Options and Flags (continued)

Input Group	Parameter	Default	Project	Description
Input Group 5 (continued)	R2	-	20	relative weighting of the first guess field observations in the layers aloft (km)
	RPROG	-	0	relative weighting parameter of the prognostic wind field data (km). Used only if IPROG=1.
	DIVLIM	0.000005	0.000005	maximum acceptable divergence in the divergence minimization procedure
	NITER	50	50	maximum number of iterations in the divergence minimization procedure
	NSMTH	2, (mxnz-1)*4	2,2,2,2,2,2,2,2	number of passes in the smoothing procedure
	NINTR2	NZ*99	NZ*99	maximum number of stations used in each layer for the interpolation of data to a grid point
	CRITFN	1	1	critical Froude number
	ALPHA	0.1	0.1	empirical factor controlling the influence of kinematic effects
	FEXTR2	NZ*0	NZ*0	multiplicative scaling factor for extrapolation of surface observations to upper layers. Used only if IEXTRP = 3 or -3.
	NBAR	0	0	number of barriers to interpolation of the wind fields
	IDIOPT1	0	0	compute surface temperature internally from hourly surface observations
	ISURFT	-	-1	2-D spatially varying surface temperatures
	IDIOPT2	0	0	compute domain-averaged temperature lapse rate internally from twice-daily upper air observations
	IUPT	-1	-1	2-D spatially varying lapse rate
	ZUPT	200	200	depth through which the domain-scale lapse rate is computed
	IDIOPT3	0	0	compute domain-averaged wind components internally from twice-daily upper air observations
	IUPWIND	-1	-1	3-D initial guess fields
	ZUPWND	1, 1000	1, 1000	bottom and top of layer through which the domain-scale winds are computed
	IDIOPT4	0	0	read wind speed and wind direction from a surface data file for observed surface wind components for wind field module

Table 5.2-C18: CALMET Options and Flags (continued)

Input Group	Parameter	Default	Project	Description
	IDIOPT5	0	0	read WS and WD from an upper air data file for observed upper air wind components for wind field module
	LLBREZE	F	F	do not use lake breeze module
Input Group 6 – Mixing Height, Temperature and Precipitation Parameters	CONSTB	1.41	1.41	constant for neutral mechanical equation
	CONSTE	0.15	0.15	constant for convective mixing height equation
	CONSTN	2,400	2,400	constant for stable mixing height equation
	CONSTW	0.16	0.16	constant for overwater mixing height equation
	FCORIOL	0.0001	0.0001	absolute value of Coriolis parameter
	IAVEZI	1	1	conduct spatial averaging of mixing heights
	MNMDAV	1	1	maximum search radius in averaging process (grid cells)
	HAFANG	30	30	half-angle of upwind looking cone for averaging
	ILEVZI	1	1	layer of winds used in upwind averaging
	IMIXH	1	1	convective mixing height option = Maul-Carson for land and water cells
	THRESHL	0	0	threshold buoyancy flux required to sustain convective mixing height growth overland (expressed as a heat flux per metre of boundary layer W/m^3)
	THRESHW	0.05	0.05	threshold buoyancy flux required to sustain convective mixing height growth overwater (expressed as a heat flux per metre of boundary layer W/m^3)
	ITWPROG	0	2	use prognostic lapse rates and prognostic delta T
	ILUOC3D	16	16	land use category ocean in 3D.dat datasets
	DPTMIN	0.001	0.001	minimum potential temperature lapse rate in the stable layer above the current convective mixing height (K/m)
	DZZI	200	200	depth of layer above current convective mixing height through which lapse rate is computed
	ZIMIN	50	50	minimum overland mixing height (m)

Table 5.2-C18: CALMET Options and Flags (continued)

Input Group	Parameter	Default	Project	Description
Input Group 6 (continued)	ZIMAX	3,000	3,000	maximum overland mixing height (m)
	ZIMINW	50	50	minimum overwater mixing height (m)
	ZIMAXW	3,000	3,000	maximum overwater mixing height (m)
	ICOARE	10	10	use COARE with no wave parameterization for overwater surface fluxes
	DSHELF	0	0	coastal/shallow water length scale (km) (COARE fluxes only)
	IWARM	0	0	COARE warm layer computation off
	ICOOL	0	0	COARE cool skin layer computation off
	IRHPROG	0	1	Use prognostic RH
	ITPROG	0	2	No surface or upper air observations Use MM5/3D.DAT for surface and upper air data
	IRAD	1	1	use 1/R for temperature interpolation
	TRADKM	500	500	radius of influence for temperature interpolation (km)
	NUMTS	5	5	maximum number of stations to include in temperature interpolation
	IAVET	1	1	conduct spatial averaging of temperatures
	TGDEFB	-0.0098	-0.0098	default temperature gradient below the mixing height over water (K/m)
	TGDEFA	-0.0045	-0.0045	default temperature gradient above the mixing height over water (K/m)
	JWAT1, JWAT2	-	55,55	beginning and ending land use categories for temperature interpolation over water
	NFLAGP	2	2	use 1/R2 for precipitation interpolation
	SIGMAP	100	100	radius of influence (km)
	CUTP	0.01	0.01	minimum precipitation rate cutoff (mm/hr)

Section 5 provides a summary of the resulting dispersion meteorological data.

5.0 RESULTING DISPERSION METEOROLOGY

CALMET produces a 3-dimensional meteorological data set for use in CALPUFF modelling. A 3-dimensional meteorological data set allows varying weather parameters from grid cell to grid cell in the modelling domain. Such varying weather parameters are possible since each grid cell within the vertical boundary layer is influenced by its terrain elevation and geophysical parameters. The CALMET modelling domain for the Project has a resolution of 500 m and covers a 45 x 50 km area.

Following is a description of the meteorological conditions extracted from the grid cell closest to the Project site.

5.1 Temperature Summary

The 5-years of hourly temperature data are tabulated in Table 5.2-C19. The coldest month, on average, over the period of 2006 through 2010, was February (-23.4°C), whereas July had the highest average temperature (13.8°C).

Table 5.2-C19: CALMET Modelled Temperature (2006 to 2010) at Project Site

Month	Daily Average (°C)	Daily Maximum (°C)	Daily Minimum (°C)	Extreme Maximum (°C)	Extreme Minimum (°C)
January	-22.3	-19.6	-25.1	-4.2	-34.7
February	-23.4	-20.4	-26.4	-8.5	-40.0
March	-19.2	-15.5	-23.2	0.3	-36.2
April	-8.4	-5.5	-11.9	2.4	-30.5
May	-3.3	-1.0	-5.9	10.7	-18.4
June	7.2	10.3	3.9	22.9	-4.8
July	13.8	17.0	10.4	27.4	5.1
August	11.8	14.7	8.7	28.9	2.6
September	4.6	7.0	2.2	19.6	-4.0
October	-1.7	-0.2	-3.3	12.1	-17.1
November	-13.2	-10.8	-15.6	0.6	-26.2
December	-19.6	-17.2	-22.1	0.9	-35.0

Figure 5.2-C33 shows the range of daily temperatures generated by CALMET over the 2006 – 2010 period. The graph shows that the hourly temperature data for the period generally fall within the extreme climate normals with the exception of the maximum temperature for October and December, which were above the extremes for the normals for 1971 through 2000. This demonstrates that the CALMET model has successfully produced a temperature field that is within the expected value for climate in the Project region.

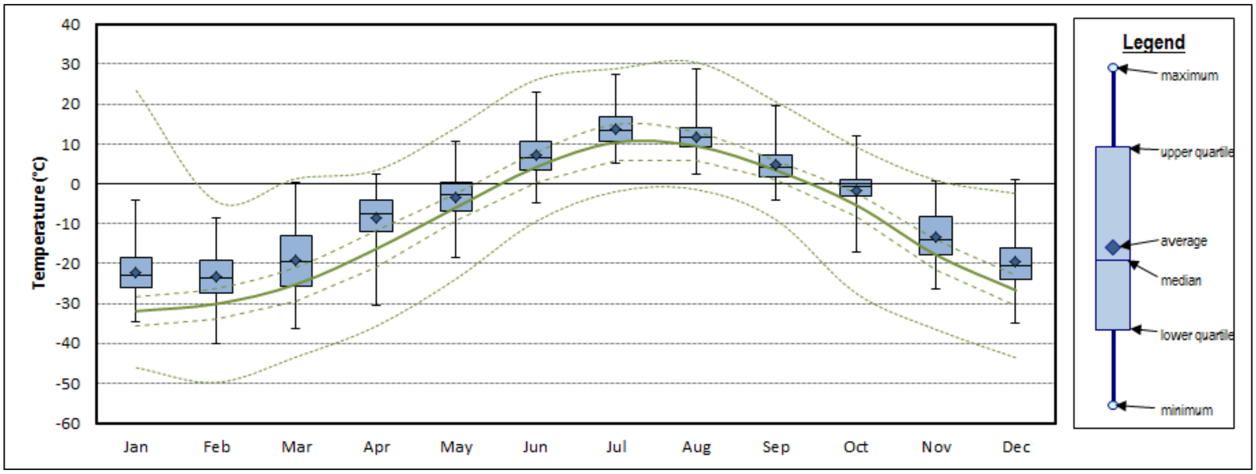

Figure 5.2-C33: Range of Daily Temperatures (2006 to 2010) at Project Site

5.2 Precipitation Summary

The 5 years of average monthly precipitation are tabulated in Table 5.2-C20. The CALMET model produces hourly precipitation rates without distinguishing between solid and liquid precipitation. Thus, temperature is used to determine whether the predicted precipitation is rain or snow. Rainfall accounted for about 49.3% of total precipitation at the Project site between 2006 and 2010. The month with the greatest rainfall, on average, was July (49.4 mm)

Table 5.2-C20: CALMET Hourly Precipitation (2006 to 2010)

Month	Rainfall (mm)	Water Equivalent Snowfall (mm)	Total Precipitation (mm)	Extreme Daily Precipitation (mm)	Days with Measurable Precipitation	Average Snow Depth (cm)
January	0.0	21.9	21.9	6.3	16	—
February	0.0	11.2	11.2	6.3	8	—
March	0.0	17.3	17.3	9.5	11	—
April	0.1	47.6	47.6	17.8	11	—
May	10.7	14.1	24.8	11.5	11	—
June	18.1	5.5	23.5	18.3	6	—
July	49.4	0.0	49.4	37.4	5	—
August	40.5	0.0	40.5	30.4	7	—
September	32.9	0.2	33.1	19.8	9	—
October	29.0	20.7	49.6	15.7	14	—
November	1.7	26.6	28.3	9.8	12	—
December	0.8	23.6	24.4	7.9	15	—

Figure 5.2-C34 compares the CALMET modelled precipitation, at the Project site, over the 5-year period from 2006 through 2010, to the long-term climate normals. The precipitation amounts predicted by CALMET are approximately 25% higher than the long-term climate normals. The predicted 5-year average of annual precipitation at the Project site from CALMET was 371.6 mm while the 30-year average of annual precipitation at Rankin Inlet is 297 mm. That said, the precipitation amounts predicted by CALMET for the 2006 to 2010 period

were closer to those observed at Rankin Inlet for the same period (331 mm) indicating that this period may have been one of greater precipitation than average.

The following are the notable differences between the modelled precipitation and long-term normals:

- The average January water equivalent snowfall (21.9 mm) was more than triple the average amount of water equivalent snowfall (6.6 mm) for that month;
- The average April water equivalent snowfall (47.6 mm) was more than triple the average amount of water equivalent snowfall (13.3 mm) for that month;
- The average June total precipitation (23.5 mm) was 21% less than the average amount of total precipitation (29.8 mm) for that month;
- The average July rainfall (49.4 mm) was 25% more than the average amount of total precipitation (39.5 mm) for that month.

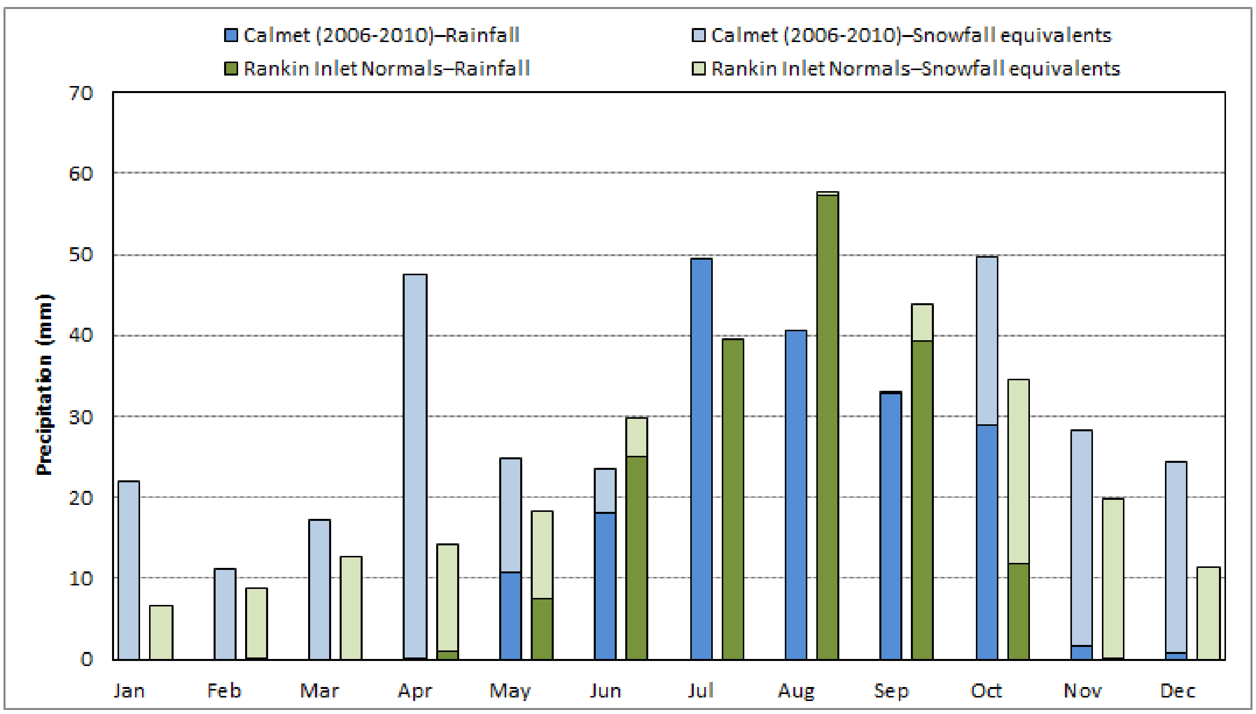

Figure 5.2-C34: Comparison of CALMET Precipitation to Rankin Inlet Normals (1971-2000)

5.3 Winds Summary

Figure 5.2-C35 provides the wind-rose generated using extracted data from CALMET at the Project site, located at approximately 6989000 Northing and 540000 Easting in UTM zone 15 or approximately 25 km inland from Rankin Inlet. Figures 36 to 40 illustrate the monthly variations of wind directions at the proposed mill area for each year in the data set.

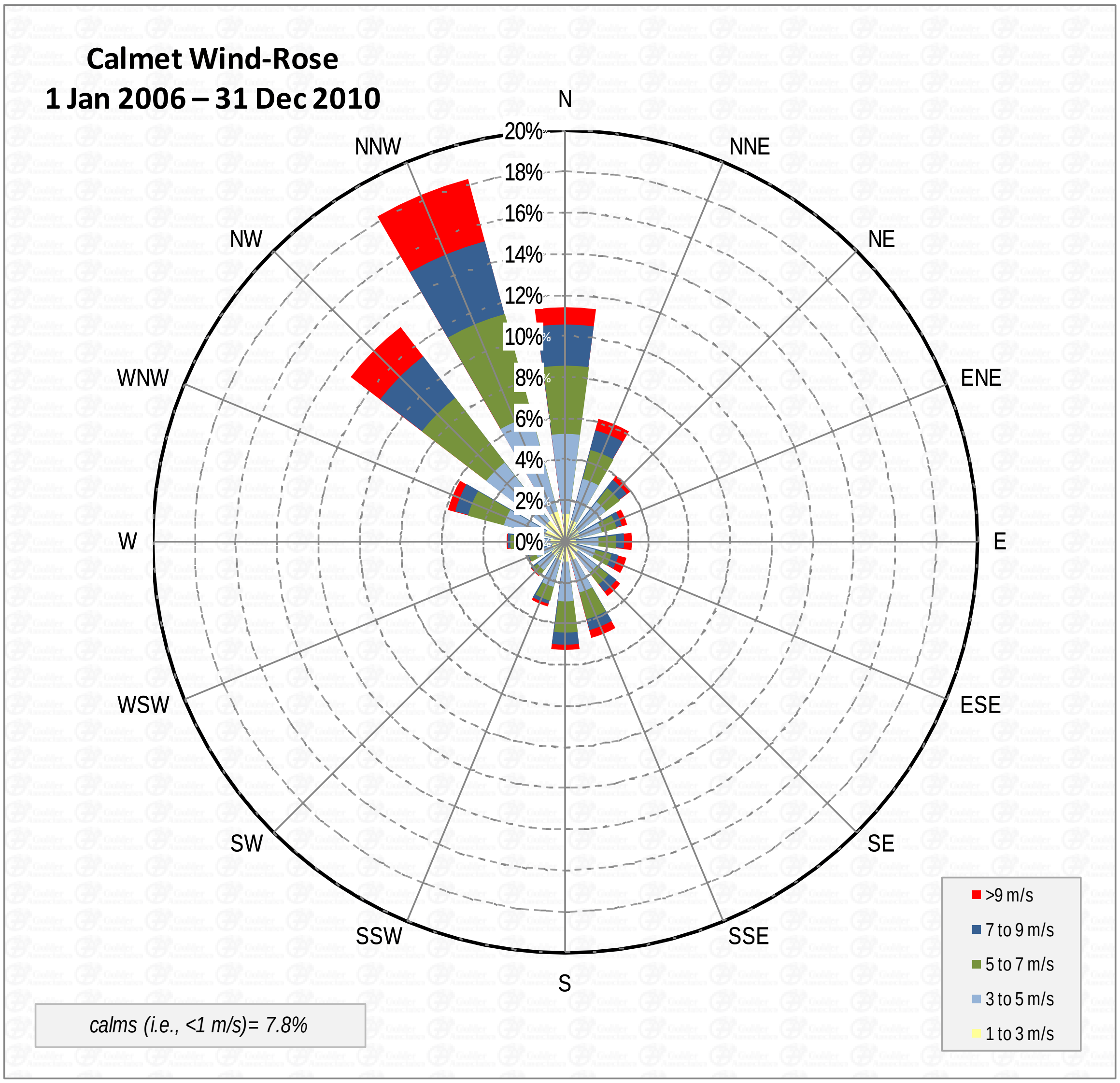

Figure 5.2-C35: CALMET Windrose at the Project Site

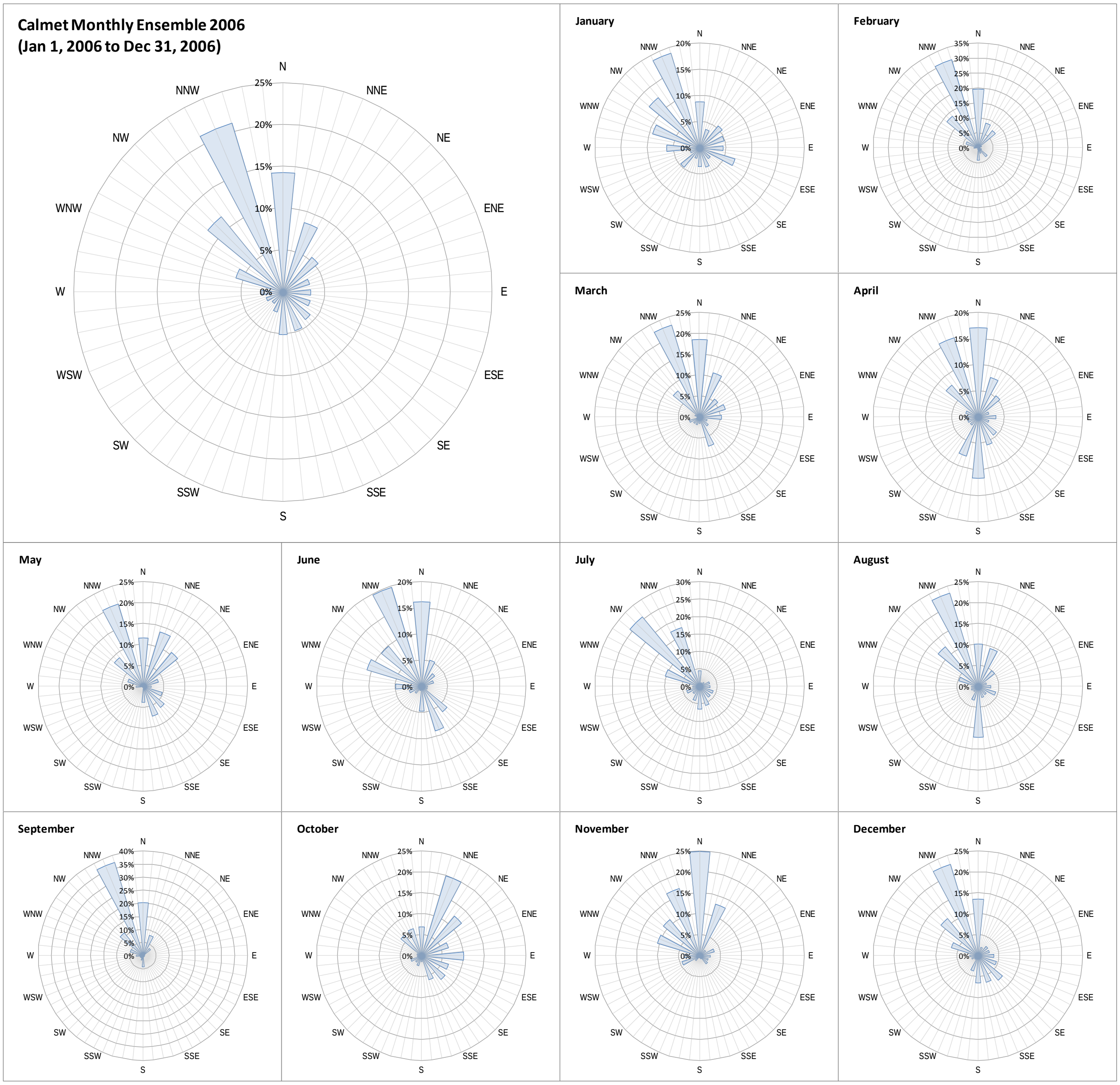

Figure 5.2-C36: 2006 Monthly CALMET Windroses at the Project Site

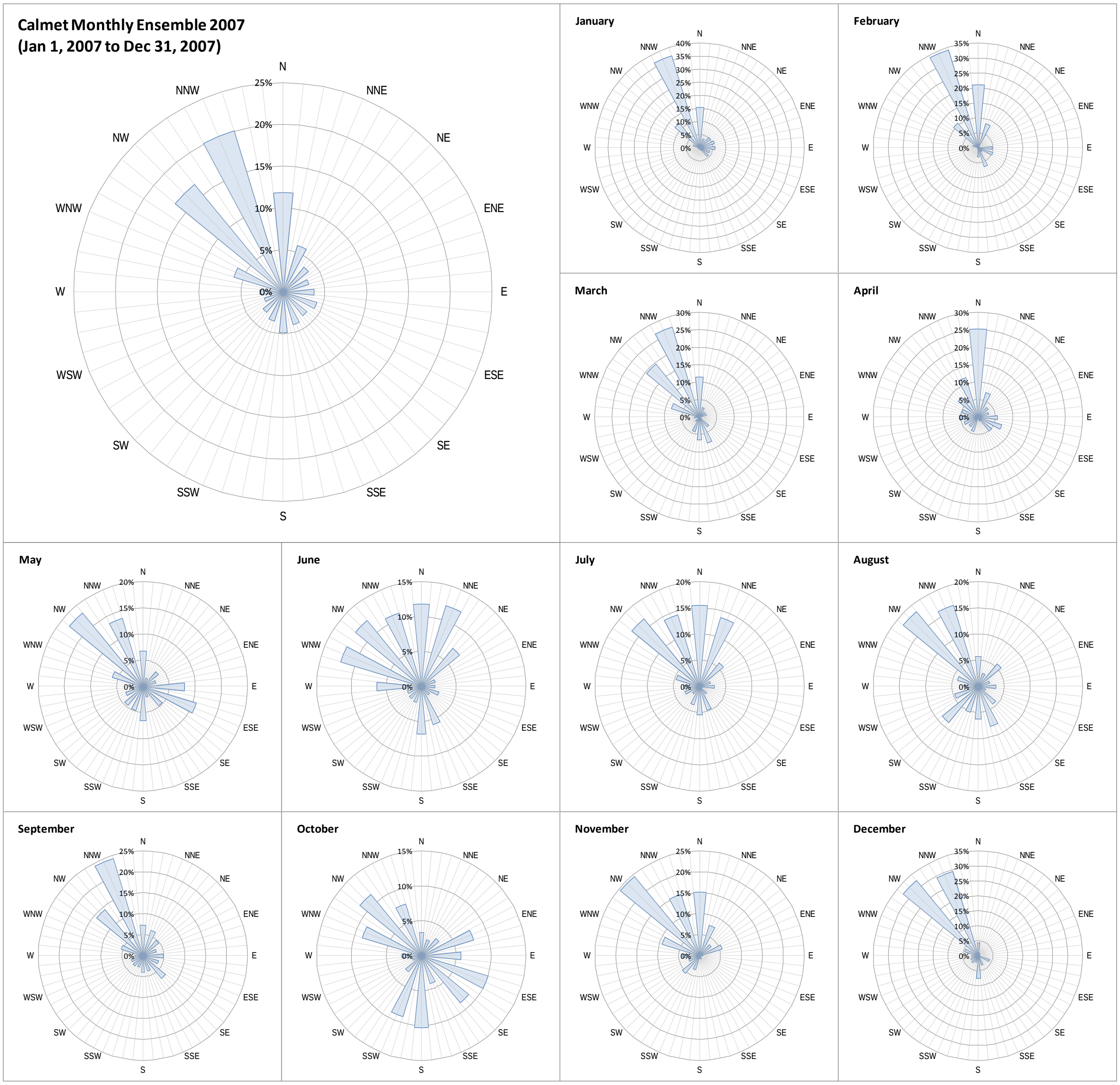

Figure 5.2-C37: 2007 Monthly CALMET Windroses at the Project Site

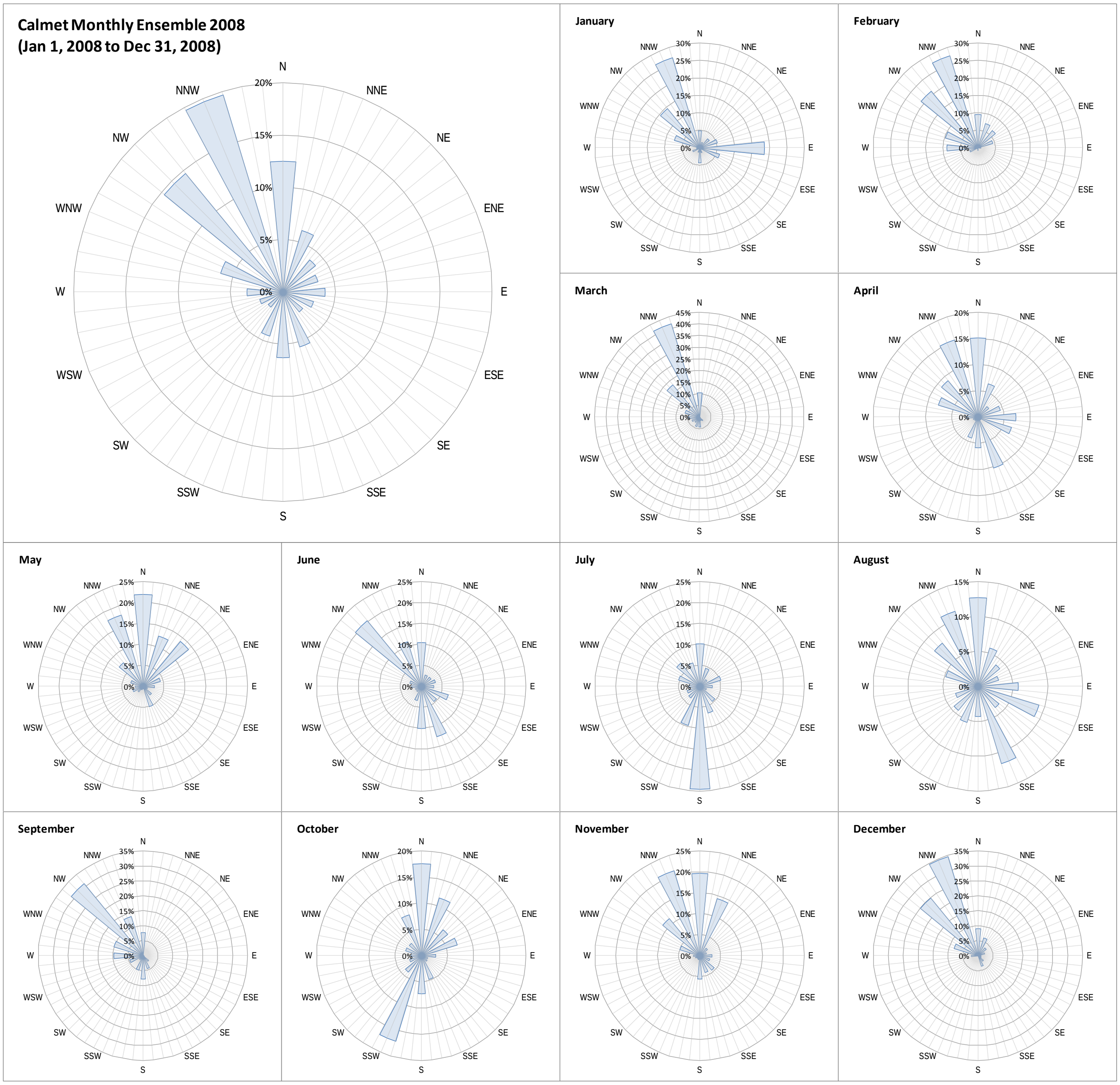

Figure 5.2-C38: 2008 Monthly CALMET Windroses at the Project Site

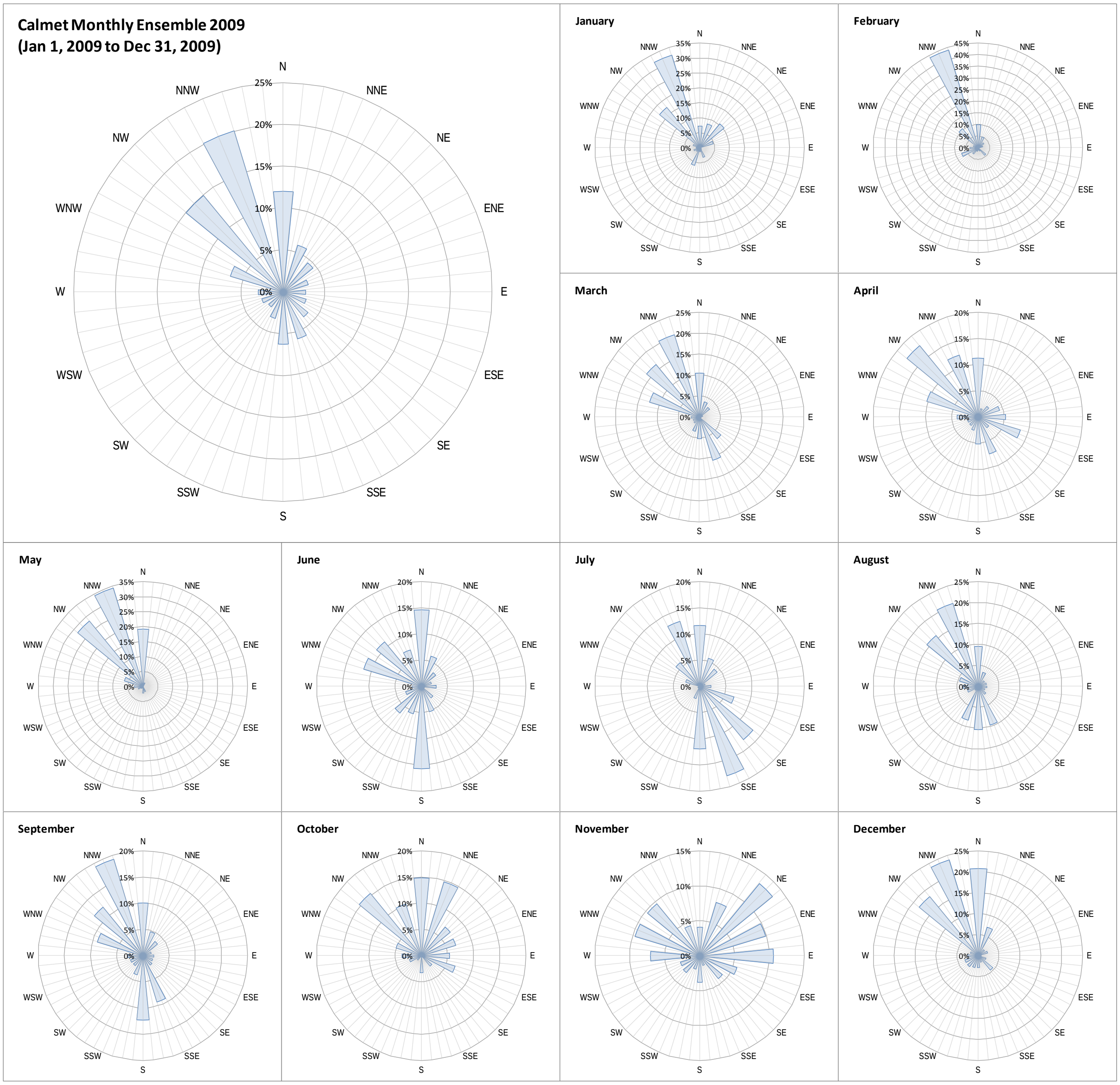

Figure 5.2-C39: 2009 Monthly CALMET Windroses at the Project Site

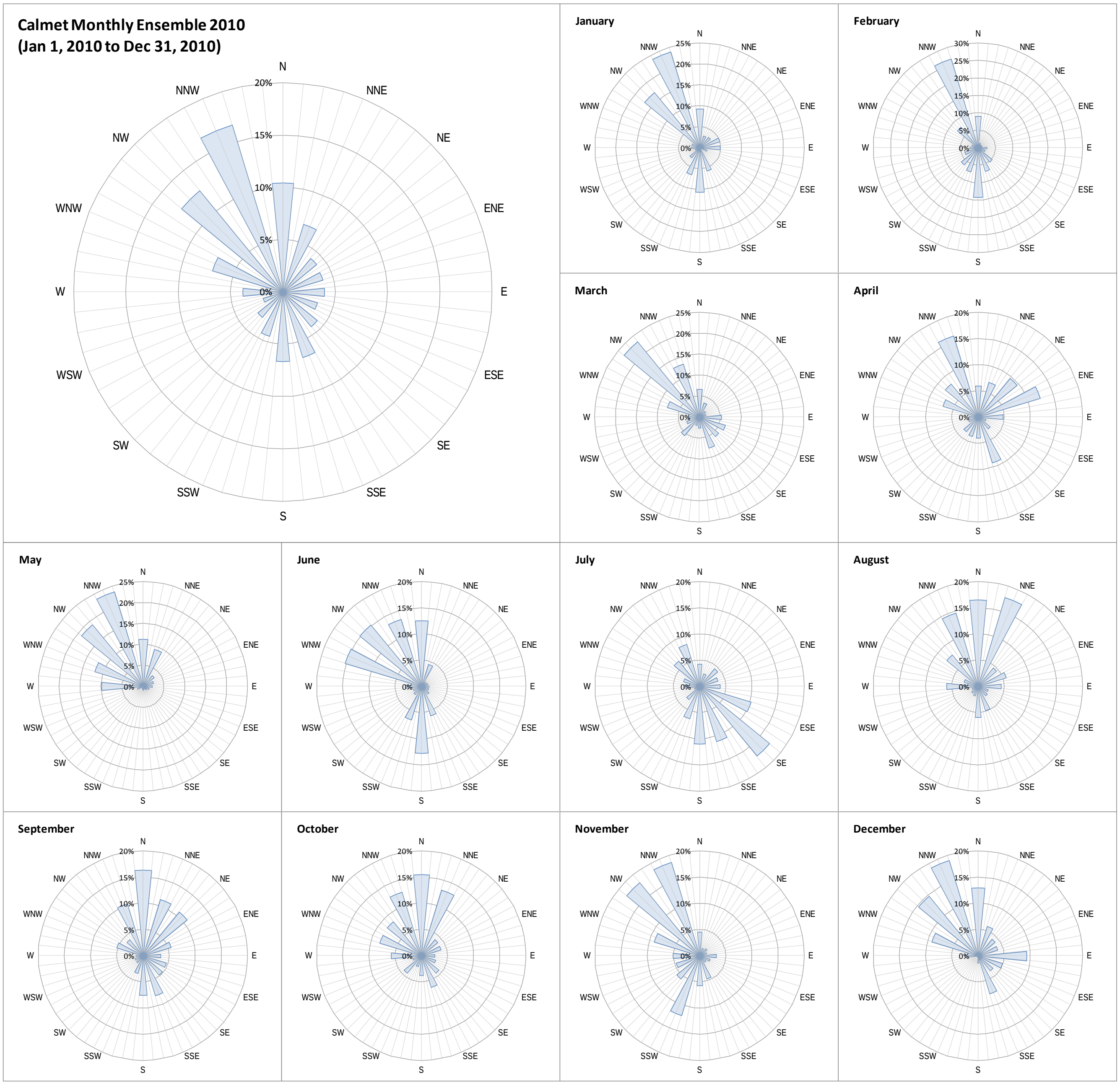

Figure 5.2-C40: 2010 Monthly CALMET Windroses at the Project Site

6.0 SUMMARY AND CONCLUSIONS

A 5-year meteorological data, for the period 2006 to 2010, was developed for the Project site using the MM5 and CALMET meteorological processors after it was determined that available monitoring data were insufficient to meet the needs for a dispersion modelling assessment. Validation was done on the MM5 prognostic data to ensure that the created data set was representative of the region and would be suitable for the assessment of the Project. The resulting CALMET data set was summarized to provide an overview of the predicted weather conditions over the 5-year period used for the modelling. The CALMET meteorological data set has been demonstrated to be very similar to available monitoring data for the same period and reasonable compared to the regional climate normal. These data, therefore, are well-suited for the dispersion modelling assessment of the Project site.

7.0 REFERENCES

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Hubert and Associates Ltd. 2001 Climate Studies at the Meliadine West Gold Project: 1997 – 2001 data report. December 2001.

USGS (United States Geological Survey). 2007. Land Processes Distributed Active Archive Center. Available at: https://lpdaac.usgs.gov. Accessed June 2009.

APPENDIX 5.4-A

Historic Climate Trend - Rankin Inlet

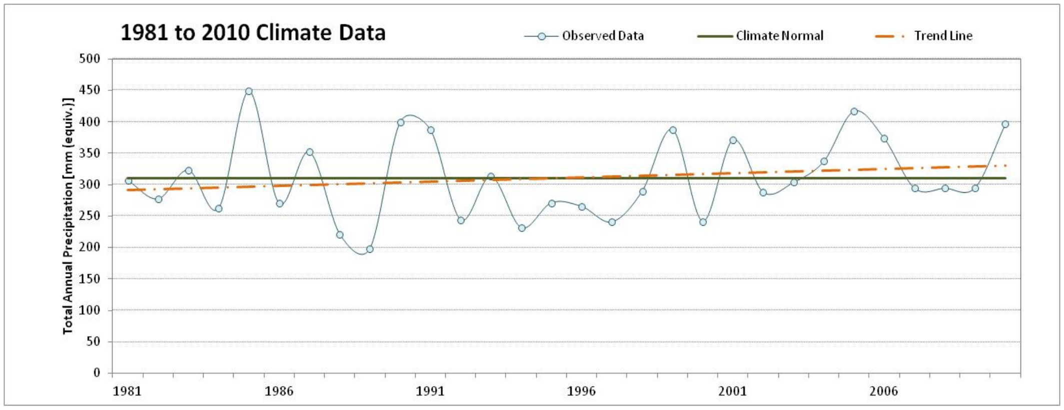

Figure 5.4-A1: Annual Total Precipitation [mm (equiv.)] for Rankin Inlet.

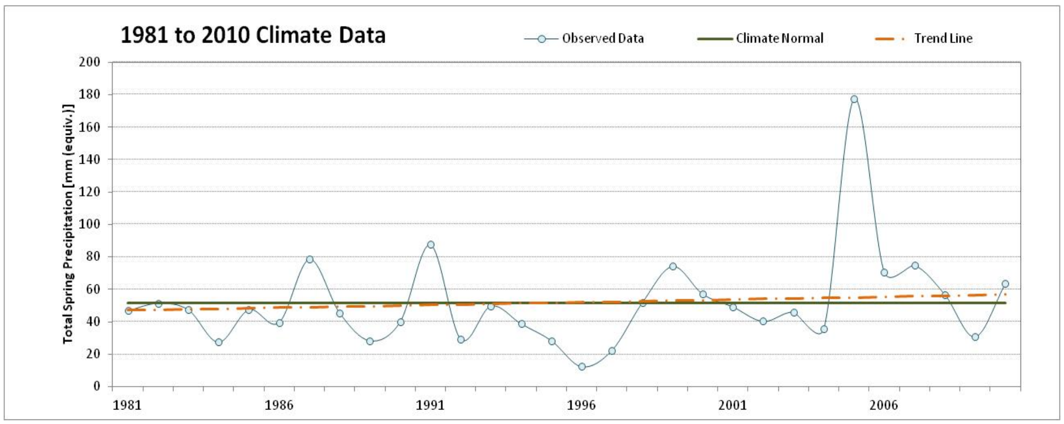

Figure 5.4-A2: Spring Total Precipitation [mm (equiv.)] for Rankin Inlet.

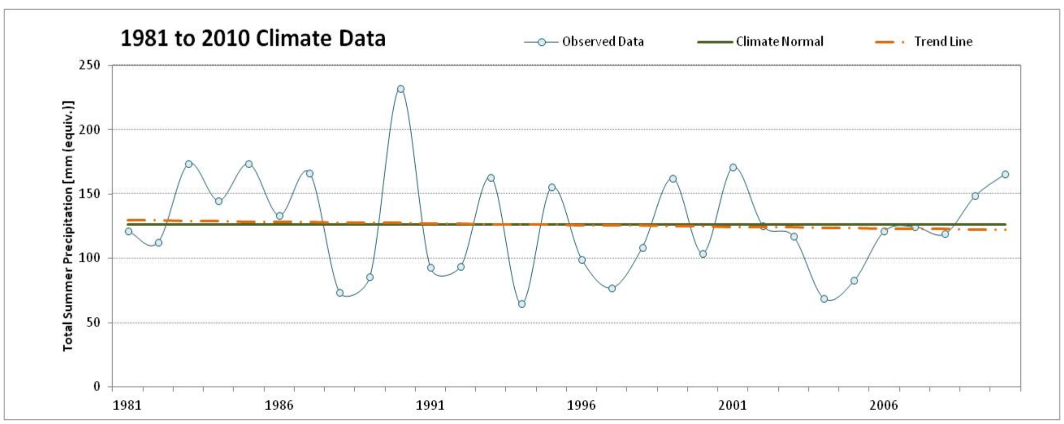

Figure 5.4-A3: Summer Total Precipitation [mm (equiv.)] for Rankin Inlet.

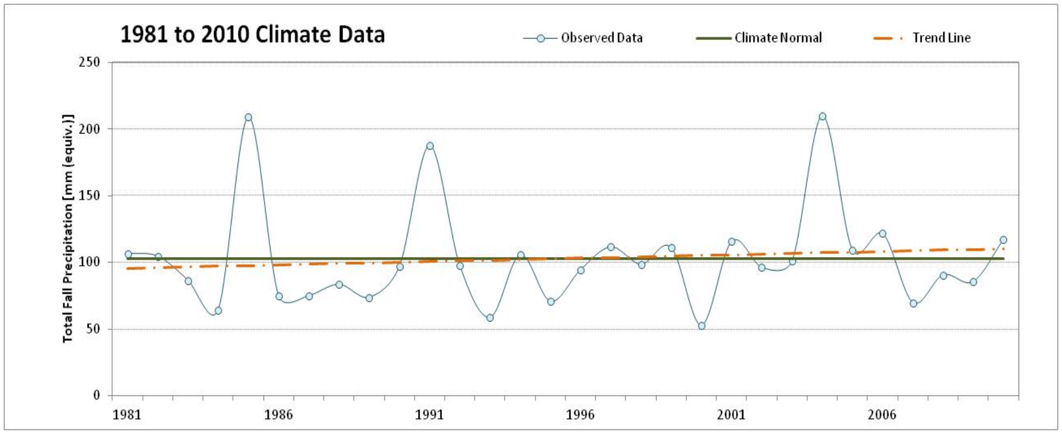

Figure 5.4-A4: Fall Total Precipitation [mm (equiv.)] for Rankin Inlet.

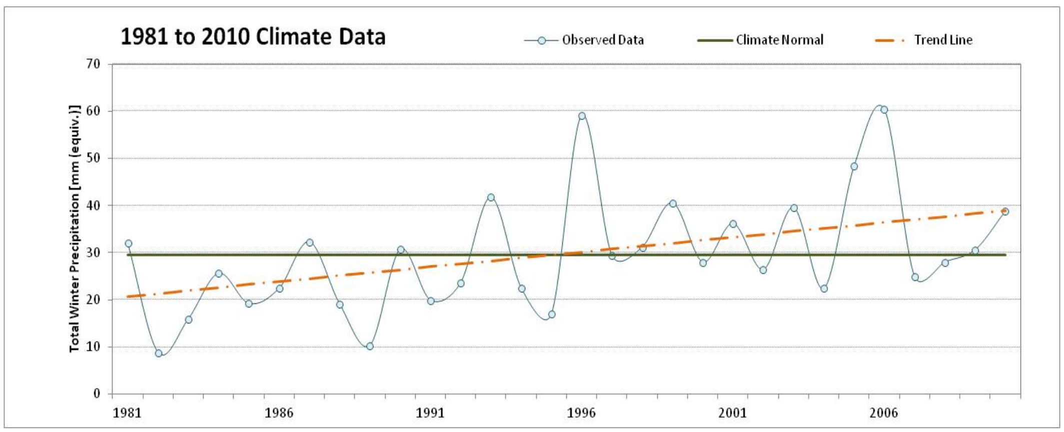

Figure 5.4-A5: Winter Total Precipitation [mm (equiv.)] for Rankin Inlet.

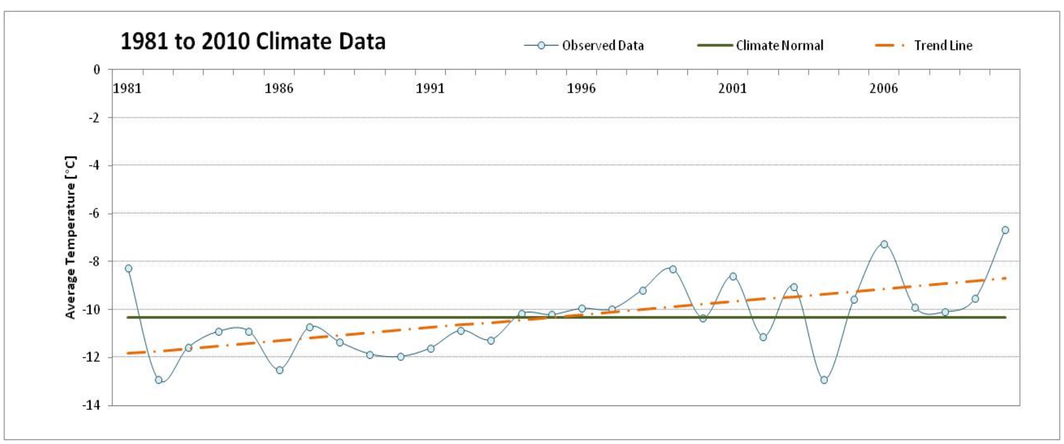

Figure 5.4-A6: Average Annual Temperature [oC] for Rankin Inlet.

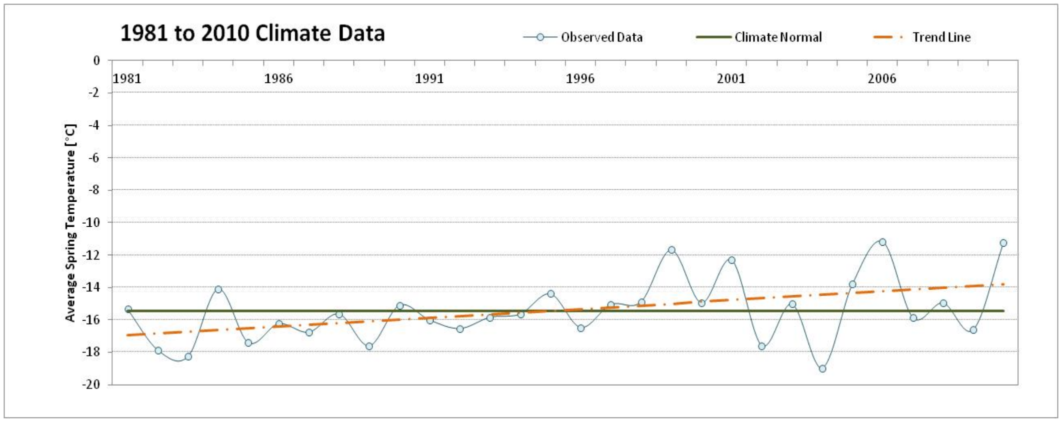

Figure 5.4-A7: Average Spring Temperature [oC] for Rankin Inlet.

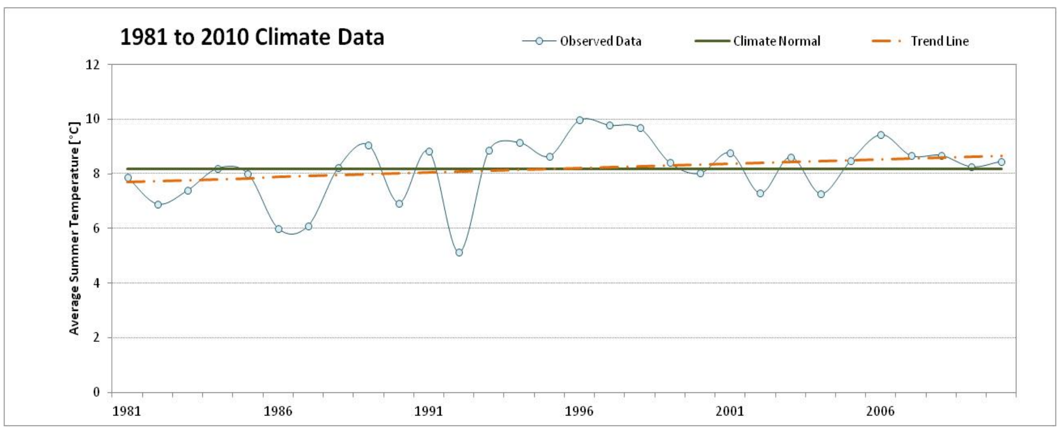

Figure 5.4-A8: Average Summer Temperature [oC] for Rankin Inlet.

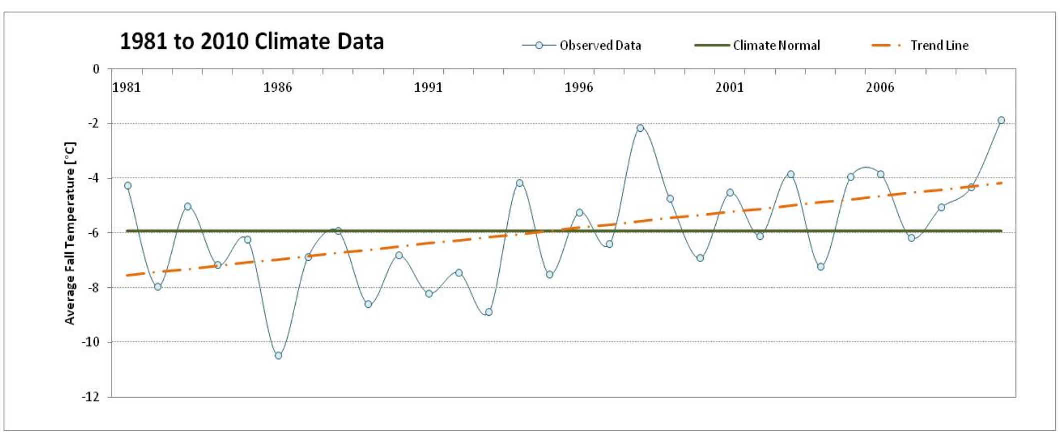

Figure 5.4-A9: Average Fall Temperature [oC] for Rankin Inlet.

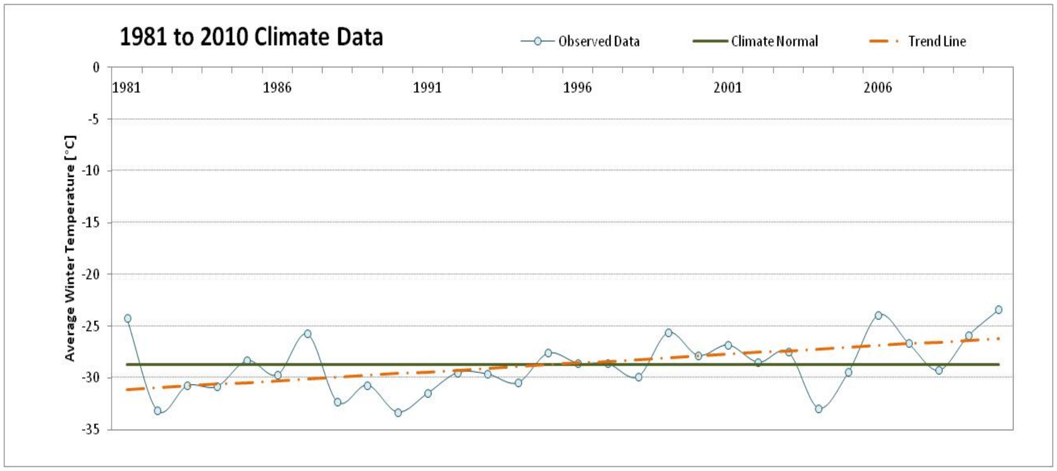

Figure 5.4-A10: Average Winter Temperature [oC] for Rankin Inlet.

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APPENDIX 5.4-B

Historic Climate Trend – Baker Lake

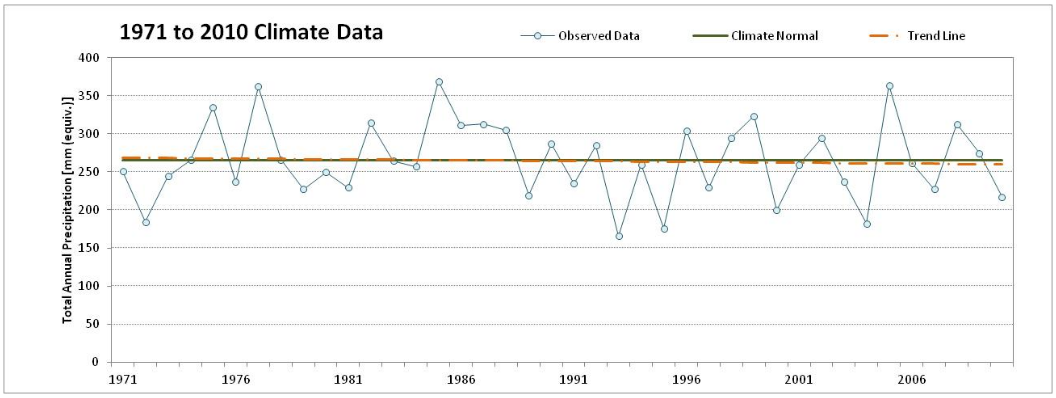

Figure 5.4-B1: Annual Total Precipitation [mm (equiv.)] for Baker Lake.

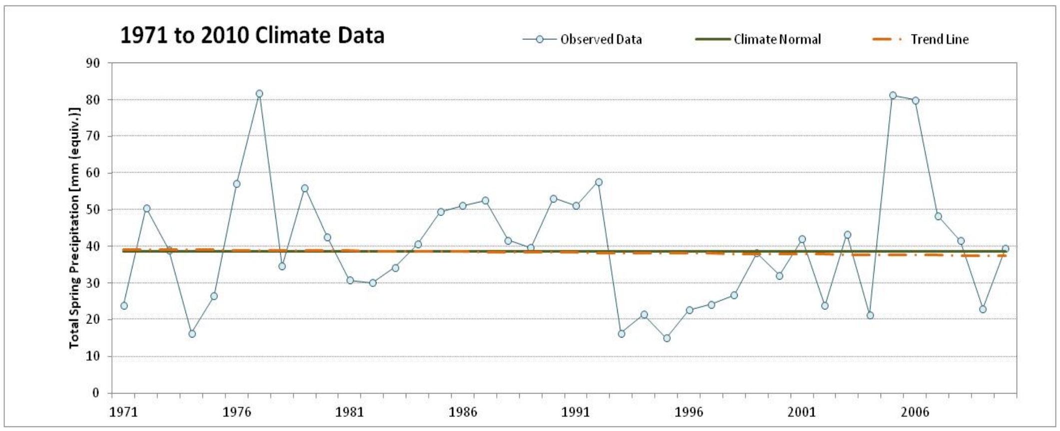

Figure 5.4-B2: Spring Total Precipitation [mm (equiv.)] for Baker Lake.

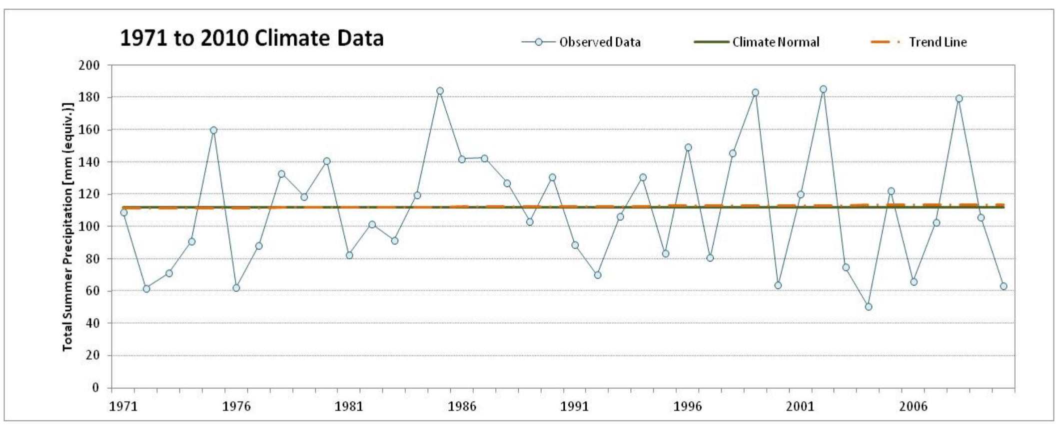

Figure 5.4-B3: Summer Total Precipitation [mm (equiv.)] for Baker Lake.

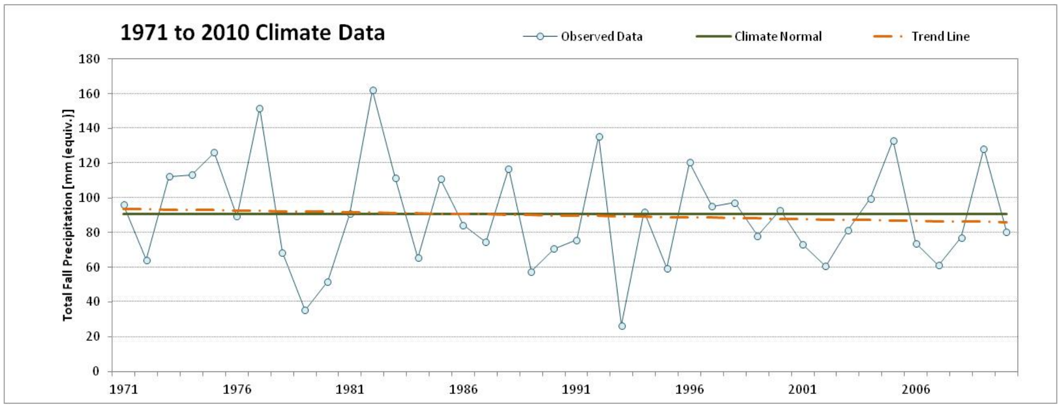

Figure 5.4-B4: Fall Total Precipitation [mm (equiv.)] for Baker Lake.

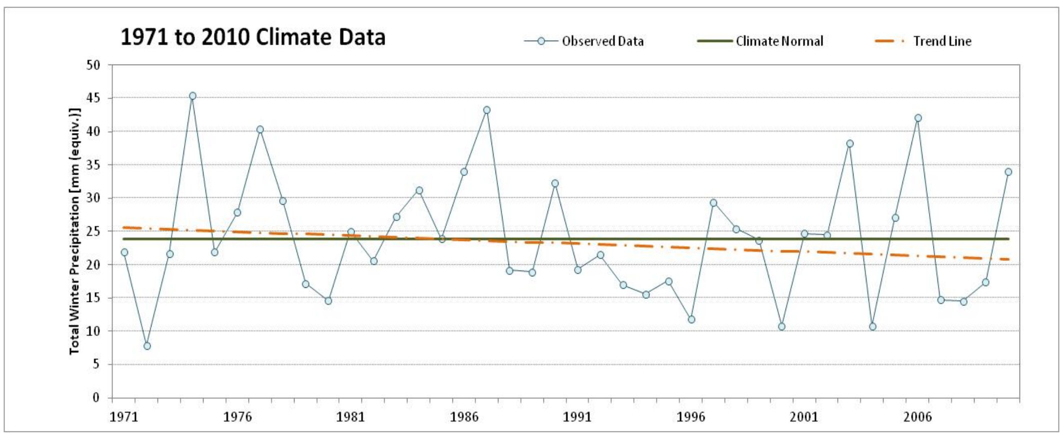

Figure 5.4-B5: Winter Total Precipitation [mm (equiv.)] for Baker Lake.

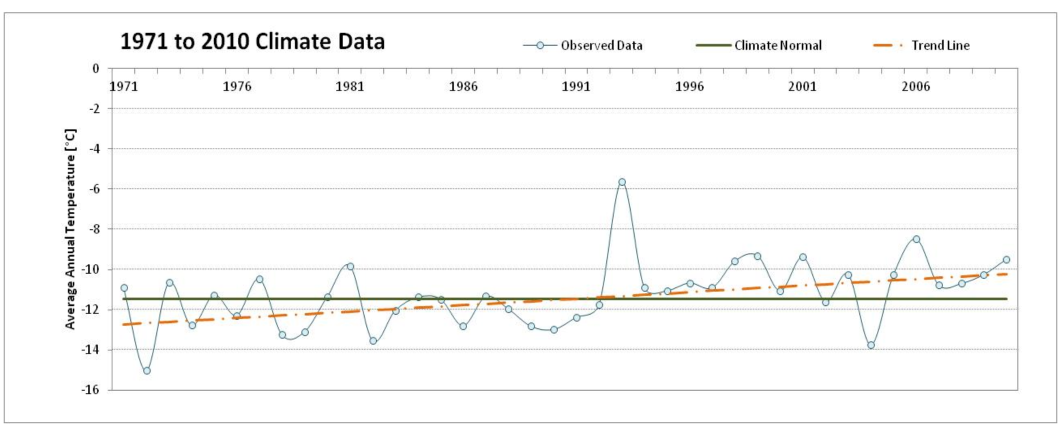

Figure 5.4-B6: Average Annual Temperature [oC] for Baker Lake.

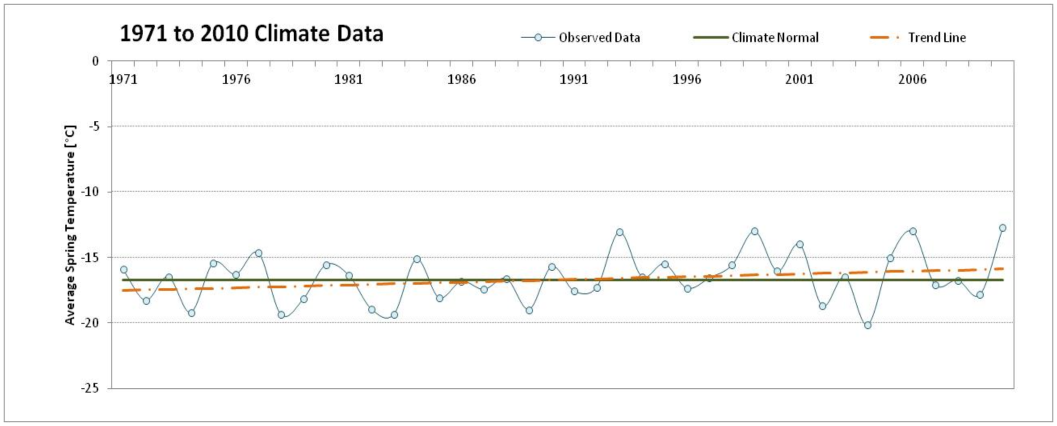

Figure 5.4-B7: Average Spring Temperature [oC] for Baker Lake.

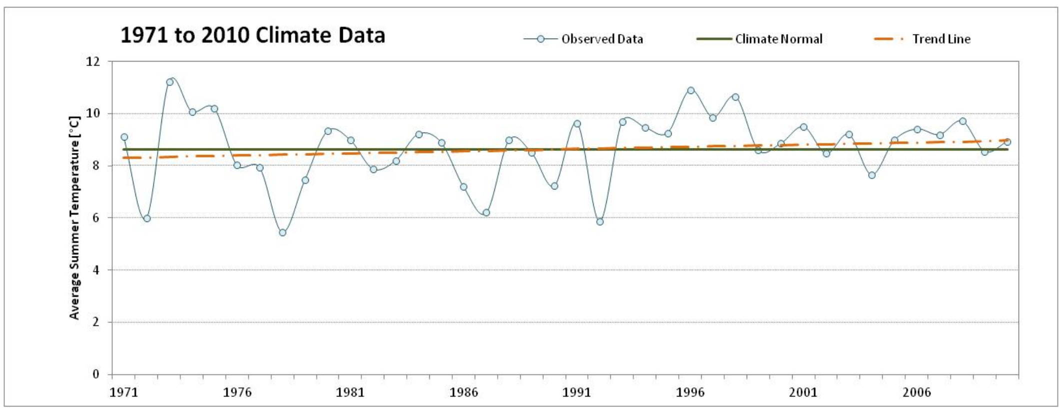

Figure 5.4-B8: Average Summer Temperature [oC] for Baker Lake.

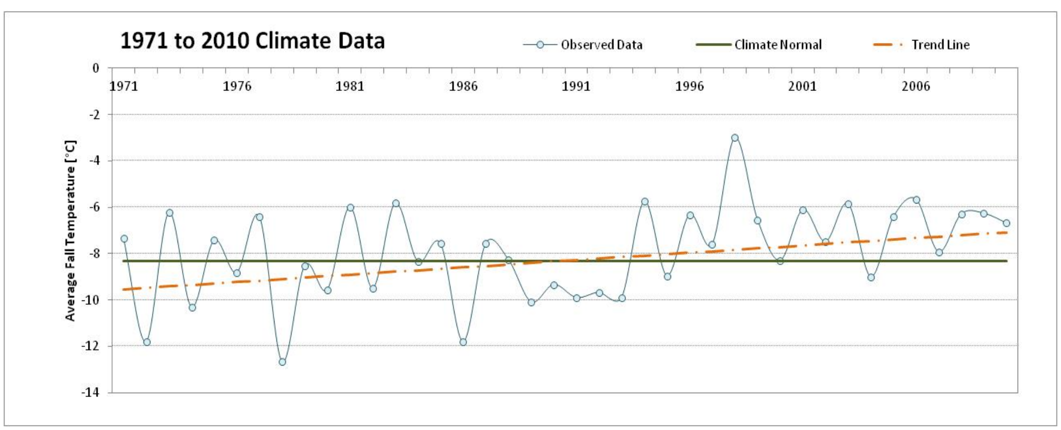

Figure 5.4-B9: Average Fall Temperature [oC] for Baker Lake.

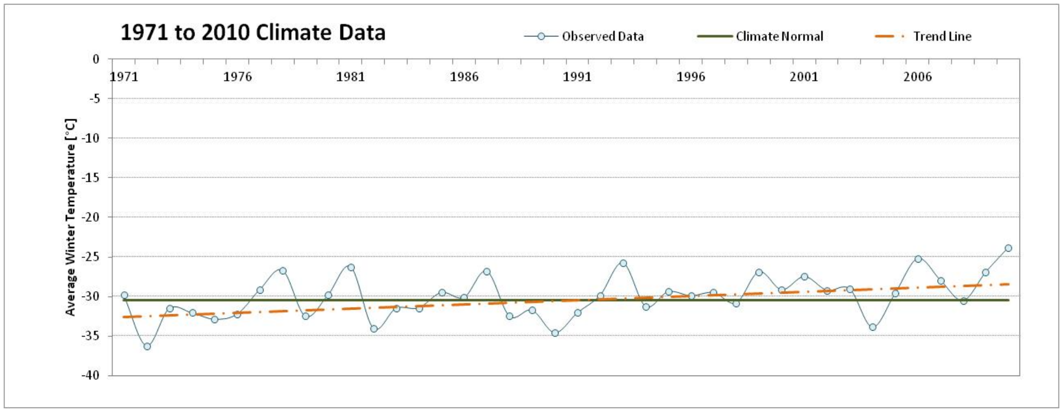

Figure 5.4-B10: Average Winter Temperature [oC] for Baker Lake.

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APPENDIX 5.5-A

CadnaA Modelling

1.0 INTRODUCTION

1.1 Noise Terminology and Concepts

To help the reader in understanding noise and the concepts used to assess noise impacts, the following has been prepared.

Noise levels are measured as pressure variations in the atmosphere. However, due to the extreme range in pressure levels, sound levels are expressed on a logarithmic scale, in units called decibels (dB). Since the scale is logarithmic, a sound that is twice that of another will only be 3 dB higher. For example, the addition of 2 noise sources that generate a sound level of 60 dB at a given location, when combined, will result in a sound level of 63 dB ***not*** 120 dB.

The character of a type of sound (e.g., car, a jet engine) is determined by its frequency content. The sound data are generally given in terms of octave band frequency distribution. Typically, each octave band is expressed in terms of its centre frequency, namely 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hertz (Hz).

The human ear does not respond to all frequencies in the same way. Human ears are sensitive to sound from 20 to 20 000 Hz, but are most sensitive in the frequency range between 500 to 4000 Hz. Above and below this range, the ear is progressively less sensitive to sound. Since sound measuring equipment are more uniformly sensitive, a weighting is typically applied to each octave band in order to express the measured sound levels in a manner that is more representative of the human hearing response. The most commonly used weighting is called “A-weighting”. “A-weighted” decibels (i.e., dBA) are often used for describing environmental noise levels when assessing the potential human response.

There are several sound level descriptors (e.g., L_{eq}, L_{max}, L_{min}, L_{10}, L_{90}, $L_{peak,}$ etc.). The L_{eq} or equivalent energy sound level is that constant sound level which has the same energy as a time-varying noise level for a specified duration.

The L_{eq} is commonly used in an environmental (outdoor) context as it takes into account natural variations in sound and the amount of time that the exposure occurs. This is also used to establish the noise level limits by many regulators.

Since noise levels are measured on a logarithmic scale, the combined effect of multiple sources is calculated accordingly. The following formula is used to combine multiple sources:

$$dBA = 10 \times \log\left(10^{\frac{dBA_1}{10}} + 10^{\frac{dBA_2}{10}} + 10^{\frac{dBA_3}{10}} + \ldots + 10^{\frac{dBA_n}{10}} \right)$$

The effects of adding sources of sound are illustrated in Figure 5.5-A1. If the sound emitted from a single piece of equipment results in noise levels of 50 dBA, then the emissions from two identical pieces of equipment would result in a noise level of 53 dBA at the same location. Therefore a doubling of the sound emissions would result in a 3 dB increase in the measured noise level. When the emissions from a third identical piece of equipment are added, the noise level increases to 54.8 dBA.

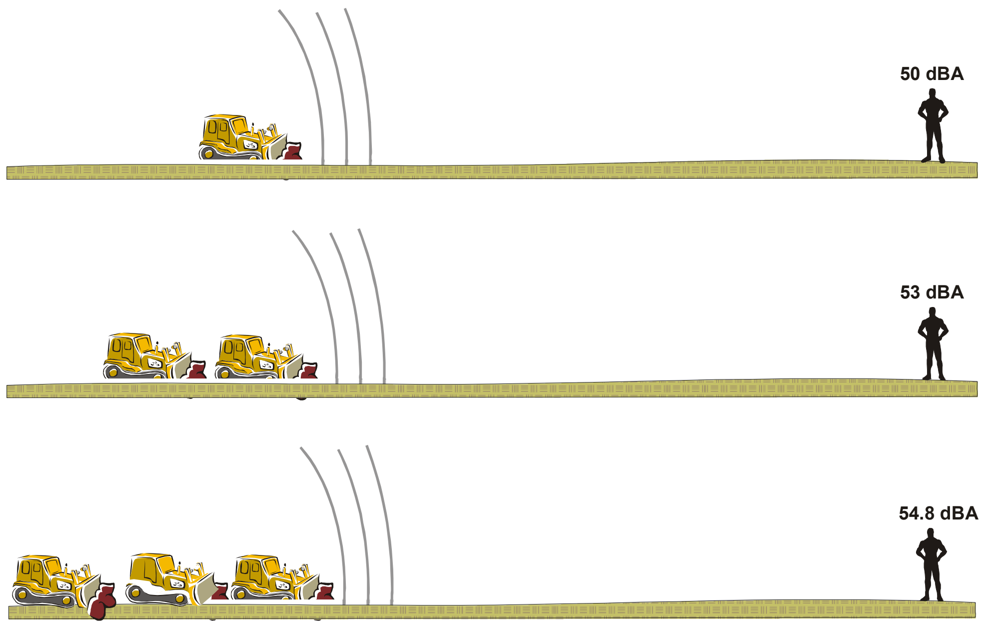

Figure 5.5-A1: Addition of Multiple Sources of Noise

There are a number of factors that can mitigate noise in the environment. The most important of these is the distance between the source and the receiver. As distance increases, noise levels decrease. The noise sources associated with the Project are considered to be point sources and radiate noise in accordance with the following formula:

$$dBA_{(X_1)} = dBA_{(X_{ref})} - 20 \times \log\left(\frac{X_i}{X_{ref}}\right)$$

The effect of distance on point source noise levels is illustrated in Figure 5.5-A2. The figure illustrates that a doubling of the distance from a point source results in a 6 dB reduction in the noise levels. Therefore, increasing the distance from 500 to 1000 metres (m) will drop the noise level from 50 to 44 dBA. Increasing the distance another 500 m from 1000 to 1500 m would decrease the noise level from 44 to 40.5 dBA.

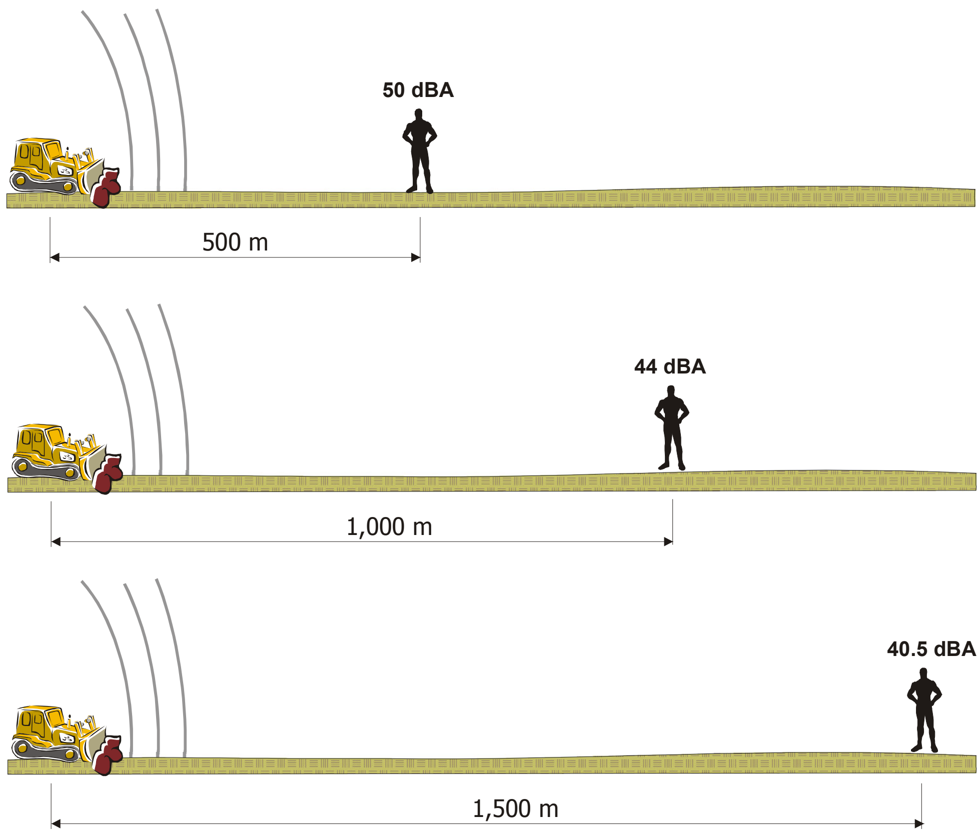

Figure 5.5-A2: Effect of Distance in Attenuating Noise Levels

A number of other environmental factors will result in attenuation of source emitted noise levels. These include the absorption of sound energy by the atmosphere, the effect of barriers or hills on noise levels, and the effect of the ground.

As sound passes through the atmosphere it collides with air molecules, converting some of the energy into heat. This transfer of energy results in a decrease in the sound energy. The amount of energy that the atmosphere absorbs varies with weather conditions and the frequency content of the sound. Low frequency sounds (those not readily detected by the human ear) are relatively unaffected by the atmosphere. The mid-range frequency sounds, which are most readily detected by the human ear, can lose significant energy to the atmosphere.

Barriers and hills can also attenuate sound in the environment. As the sound waves “refract” around obstructions, they lose energy. This phenomenon explains the use of barriers along major highways in urban areas. This also explains why people are less likely to hear sounds from sources that are behind hills. The amount of attenuation afforded by an obstruction is a function of the amount of refraction of the sound waves. Therefore, the attenuation is greatest when the barrier is located close to the source or receiver, and is less effective at greater distances. Figure 5.5-A3 illustrates how hills can attenuate industrial sounds and reduce the noise levels.

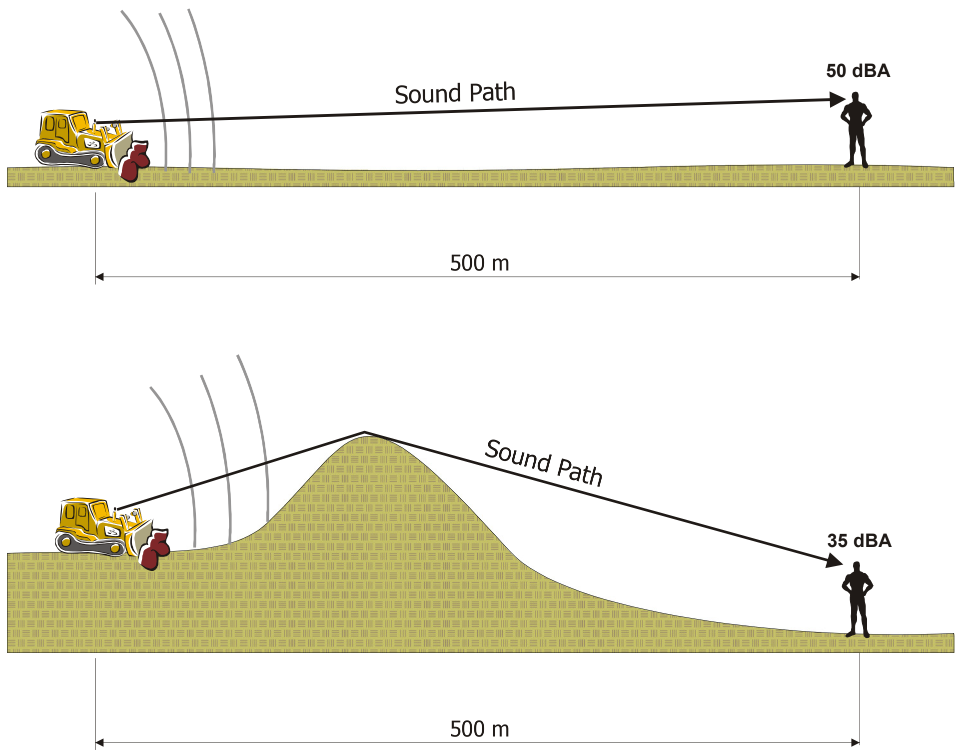

Figure 5.5-A3: Effect of Obstacles on the Attenuation of Sound

Another form of environmental attenuation deals with the interaction of noise with the ground (ground impedance). The degree of attenuation varies with the weather conditions and the vegetation (or lack of) covering the ground. This attenuation has been incorporated into the formulae used to model noise levels.

In addition to environmental attenuation from distance, ground obstructions, trees and other natural features, man-made features can also reduce sound levels. Buildings, weather/acoustic enclosures, noise barriers (i.e., earth berms and/or man-made barriers), exhaust mufflers, silencers, and other similar components reduce the amount of noise from facilities/sources.

1.2 Noise Predictions

A predictive analysis was carried out using the commercially available software package CadnaA V 4. Geometrical spreading, attenuation from barriers, ground effect and air absorption were included in the analysis as determined from ISO 9613 (part 2; ISO 1996), which is the current standard used for outdoor sound propagation predictions. It should be noted that this standard makes provisions to include a correction to address for downwind or ground based temperature inversion conditions. Noise predictions have been made conservatively assuming a downwind or moderate temperature inversion conditions for all Point(s) of Reception, a design condition consistent with the accepted practice of regulators, including the Ontario Ministry of the Environment (1995).

As described in ISO 9613 (part 2; ISO 1996), ground factor values that represent the effect of ground on sound levels range between 0 and 1. Based on the specific site conditions, the ground factor value used in the modelling was a ground factor value of 0 for bodies of water and 0.5 elsewhere.

1.3 Modelling Parameters

Parameters used in the numerical modelling software are provided below:

CadnaA-Berechnung		
Version 4.2.140 (32 Bit)		
Datei:	C:\Users\SIsono\Desktop\Meliadine\CADNA\26SEP12 full model.cna	
Start:	03.01.13	13:48:23
Berechnungsparameter:		
	General	
	Country	International
	Max. Error (dB)	0
	Max. Search Radius (m)	20000
	Min. Dist Src to Rcvr	0
	Partition	
	Raster Factor	0.5
	Max. Length of Section (m)	1000
	Min. Length of Section (m)	1
	Min. Length of Section (%)	0
	Proj. Line Sources	On
	Proj. Area Sources	On
	Ref. Time	
	Reference Time Day (min)	960
	Reference Time Night (min)	480
	Daytime Penalty (dB)	0
	Recr. Time Penalty (dB)	6
	Night-time Penalty (dB)	10
	DTM	
	Standard Height (m)	0
	Model of Terrain	Triangulation
	Reflection	
	max. Order of Reflection	0
	Search Radius Src	100
	Search Radius Rcvr	100
	Max. Distance Source - Rcvr	1000.00 1000.00
	Min. Distance Rvcr - Reflector	1.00 1.00

CadnaA-Berechnung		
	Min. Distance Source - Reflector	0.1
	Industrial (ISO 9613)	
	Lateral Diffraction	some Obj
	Obst. within Area Src do not shield	On
	Screening	Excl. Ground Att. over Barrier
		Dz with limit (20/25)
	Barrier Coefficients C1,2,3	3.0 20.0 0.0
	Temperature (−C)	10
	rel. Humidity (%)	70
	Ground Absorption G	0.5
	Wind Speed for Dir. (m/s)	3
	Roads (RLS-90)	
	Strictly acc. to RLS-90	
	Railways (Schall 03)	
	Strictly acc. to Schall 03 / Schall-Transrapid	
	Aircraft (???)	
	Strictly acc. to AzB	

REFERENCES

ISO (International Standard Organization). 1996. Acoustics – attenuation of sound during propagation outdoors – Part 2.

MOE (Ministry of the Environment, Ontario). 1995. NPC-232, Sound level limits for stationary sources in Class 3 Areas (Rural). Ontario, Canada

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Europe	+ 356 21 42 30 20
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solutions@golder.com
www.golder.com

Golder Associates Ltd.
500 - 4260 Still Creek Drive
Burnaby, British Columbia, V5C 6C6
Canada
T: +1 (604) 296 4200

Golder Associates