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March 31, 2015
File: 121413300

Attention: Giselle Cotta, Manager – Northern Contaminated Sites
Public Works and Government Services Canada
5th Floor, Telus Tower, 10025 Jasper Avenue
Edmonton, AB T5J 1S6

Dear Ms. Cotta:

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

Stantec Consulting Ltd. (Stantec) was retained by Public Works and Government Services Canada – Northern Contaminated Sites Group (PWGSC-NCSG) to complete a Preliminary Remedial Action Plan for the nine former mine sites that comprise the Gordon Lake Project. On March 31, 2014, Stantec submitted the following report: "Review of SSRTs, Summary, and Conclusions of the HHERA for Nine Former Mine Sites, Gordon Lake, Northwest Territories" dated March 31, 2014 (Stantec, 2014a). Further to this report, Stantec submitted, on December 15, 2014, a draft supplemental assessment of the site-specific remedial targets (SSRTs) proposed by Stantec in March 2014. FCSAP Expert Support has now reviewed that supplemental assessment, providing written comments as well as additional comments communicated during a teleconference held on March 16, 2015. This letter report updates the December 15, 2014, draft supplemental assessment by incorporating revisions which address the comments and input provided by Health Canada. Appended hereto, as Appendix A, is a table which itemizes Health Canada's comments and indicates the specific revisions that were introduced.

BACKGROUND

In March 2014, Stantec completed a technical review of the draft report titled "Gordon Lake Mine Sites, Gordon Lake, Northwest Territories: DRAFT Human Health and Ecological Risk Assessment", prepared by SLR Consultants Ltd. dated February 7, 2014 (SLR, 2014a).

Based on this review, a variety of major and minor issues were identified, including Stantec's opinion that a number of the SSRTs derived by SLR were overly conservative. The results of the technical review are summarized in the Stantec report, "Technical Review of HHERA for Nine Former Mine Sites, Gordon Lake, Northwest Territories" dated March 7, 2014 (Stantec, 2014b) and new SSRTs (with justification) were presented in the Stantec report, "Review of SSRTs, Summary, and Conclusions of the HHRA for Nine Former Mine Sites, Gordon Lake, Northwest Territories" dated March 31, 2014.

The purpose of the current report is to outline the new SSRTs proposed by Stantec for the nine mine sites, detail the rationale behind the new values, and provide details of the risk calculations that demonstrate the reasoning behind the new SSRTs.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

REVISED SITE-SPECIFIC REMEDIAL TARGETS TO PROTECT HUMAN HEALTH

It is Stantec's opinion that the SSRTs derived by SLR for the Gordon Lake Mine sites were based on overly-conservative assumptions. As such, Stantec has derived new SSRTs as described in the following sections.

SSRTs were derived for the contaminants of potential concern (COPCs) identified by SLR in their final March 2014 HHERA (SLR, 2014b). Human health COPCs included arsenic, cobalt, lead, mercury, petroleum hydrocarbon (PHC) F1 and PHC F2. Ecological COPCs included arsenic, PHC F2 and PHC F3.

Although SLR derived human health SSRTs for antimony and PHC F3, these COPCs were determined to have acceptable human health risks in the HHERA. Therefore, Stantec did not derive human health SSRTs for antimony and PHC F3.

Stantec is confident that antimony will present no human health risks at any of the nine mine sites included in the Gordon Lake group. SLR master data tables were re-examined; antimony was measured at all nine mine sites. Zero soil samples with concentrations greater than the soil quality guideline (SQG = 20 mg/kg) were found at five of the sites. Of the remaining four sites (Goodrock, Kidney Pond, Burnt Island, Camlaren), a total of only 18 samples out of 994 samples across all sites combined, contained antimony levels greater than the SQG. The maximum percent of samples with antimony concentrations greater than the health-based soil quality guideline (SQG) was found at Goodrock mine, where only 5.6%, (5 of 90 samples) exceeded the SQG. This low number of exceedances is not indicative of risk. The average soil antimony concentrations were: Goodrock = 4.9 mg/kg; Kidney Pond = 1.0 mg/kg; Burnt Island = 1.0 mg/kg; and Camlaren = 2.4 mg/kg. All of these average concentrations are well below the antimony SQG of 20 mg/kg.

With respect to PHC F3, it is planned that the SSRT for this substance will be based on SLR's determination of a background PHC F3 concentration of 2910 mg/kg. This background level is five times lower than the lowest human health SSRT developed by SLR for the Gordon Lake group of mines, and is only slightly greater than the CCME management limit for PHC F3 of 2500 mg/kg. It is therefore anticipated that the final SSRT for PHC F3 will ensure protection of human receptors.

RECEPTORS AND EXPOSURE DURATIONS

Human health SSRTs were originally derived by SLR based on the human receptors and exposure durations as follows:

- First Nations residents (24 hours/day, 7 days/week, 52 weeks per year)
- First Nations Site visitors (24 hours/day, 7 days/week, 4 weeks per year)
- Onsite construction/remediation workers (24 hours/day, 7 days/week, 12 weeks per year)

- Offsite construction/remediation workers (24 hours/day, 7 days/week, 12 weeks per year)

Note: the onsite construction/remediation worker was considered protective of an offsite construction/ remediation worker. Therefore, Stantec did not derive an SSRT for the offsite construction/remediation worker.

Where applicable, toddlers were used to assess exposure to threshold (non-carcinogenic) COPCs due to their larger intakes relative to body size, and adults were used to assess exposure to non-threshold COPCs (i.e., carcinogens). Exposure frequencies and durations were based on the assumptions presented in Health Canada (2010a). However, Stantec noted that future residents at the Gordon Lake mine sites will not be exposed to soil throughout the entire year. Climate data for Yellowknife, NT (Environment Canada, 2014), the nearest weather station, indicates that the ground is covered with at least 5 cm of snow for an average of 177.6 days per year. Therefore, when re-assessing SSRTs, Stantec assumed that the exposure duration to soil was 26 weeks (half the year), rather than the full year (52 weeks).

EXPOSURE PATHWAYS

Based on current and future land use at the Gordon Lake Mine sites, the following human health exposure pathways were considered by SLR:

- Direct soil contact (i.e., soil ingestion, dermal contact, particulate inhalation) for First Nations residents, First Nations Site visitors and construction/remediation workers.
- Ingestion of country foods (i.e., berries, Labrador tea, game species) for First Nations residents and First Nations Site visitors.
- Indoor air infiltration for First Nations residents.

Stantec considers that the country food pathways can be omitted from SSRT calculations for the Gordon Lake mine sites. The factors considered with respect to omitting the country food pathways are provided in the following sections.

Ingestion of Country Foods

Gordon Lake Fish

Consumption of fish was omitted by SLR from the derivation of SSRTs for the Gordon Lake Mine sites. As discussed in SLR's 2014 HHERA, COPC concentrations in fish in Gordon Lake were similar to concentrations in fish in other areas of the NWT and Northern Canada generally. Therefore, the fish consumption pathway was excluded by SLR in the assessment of country foods. Stantec concurs with this conclusion, as described below.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

Arsenic

There are three lines of evidence supporting the exclusion of the fish consumption pathway for arsenic:

1. Research that demonstrates that arsenic is not bioaccumulated or biomagnified in freshwater fish;
2. Levels of arsenic in fish collected from Gordon Lake, near the mine sites, were reflective of background levels observed across Canada's north; and
3. Consideration of the form of arsenic generally found in freshwater fish.

The levels of arsenic reported for fish (lake trout) collected by SLR from Gordon Lake ranged from 0.037 to 0.186 mg/kg wet weight in whole fish, and ranged from 0.045 to 0.251 mg/kg wet weight in fish muscle. Average concentrations were 0.10 mg/kg and 0.13 mg/kg, for whole fish and fish muscle respectively. These arsenic levels are well within the range (< 0.4 μg/g) generally found in Canada (EC/HC, 1993) and elsewhere (Eisler, 1988) in fish from remote and uncontaminated lakes. SLR collected fish from off-shore areas of Gordon Lake, adjacent to five mine sites (Treacy, West Bay, Camlaren, Goodrock and Burnt Island) as well as from two "background" locations. Concentrations of arsenic in whole fish and fish muscle were not significantly different between the mine and background locations. This is not unexpected, given that arsenic does not generally bioaccumulate in freshwater fish, and since lake trout may range over areas up to 10 km^2 in large lakes such as Gordon Lake (Flavelle et al., 2001).

If mining was impacting arsenic levels in fish, higher levels would be expected, with maximum concentrations perhaps ranging from 2 to 5 mg arsenic/kg (fw) [Gemmill, 1977; Azcue, 1992; Dale and Freedman, 1982]. The concentrations of arsenic observed in Gordon Lake fish reflect levels in remote uncontaminated waters, not those impacted by mine operations. Arsenic in landlocked Arctic char from lakes within the Canadian Arctic Archipelago, distant from industrial inputs, had a similar range in concentrations as observed for Gordon Lake – 0.005 to 0.15 mg/kg (Muir et al. 2005). Landlocked Arctic char from the Kuhulu Lake on Baffin Island averaged 0.5 mg/kg in muscle, with a range of 0.3 to 0.8 mg/kg (Bohn and Fallis 1978). McCarthy et al. (1997) reported arsenic in fish from the Slave River, NWT. The arsenic levels, considered to be natural in origin by the authors, ranged from 0.005 to 0.176 mg/kg (similar to levels observed at Gordon Lake) for walleye, northern pike, whitefish and burbot. Lockhart et al. (1992) summarized arsenic levels in fish from other parts of northern Canada, again all data reflecting levels similar to that observed at Gordon Lake. Evans et al. (2005) summarized data on arsenic levels in four fish species collected from the McKenzie River Basin; again, fish arsenic concentrations (reported as means and standard deviations from 31 lakes) were in the range observed at Gordon Lake.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

Arsenic does not biomagnify in the Arctic freshwater aquatic food chain (Evans et al. 2005). Nor does it bioaccumulate in freshwater fish (Eisler 1988), except perhaps under conditions of extreme pollution. In a 28 day laboratory study of uptake from water into rainbow trout (Spehar et al. 1980), arsenic concentrations in muscle of treated rainbow trout were generally the same as those in control fish (approximately 0.75 µg/g wet weight). In a study of dietary uptake into lake whitefish, Pedlar et al. (2002) noted no accumulation in fish muscle.

The primary inorganic forms of arsenic (AsIII, AsV) in tissues of five fish species collected from Yellowknife Bay, NWT, represented ≤ 7.5% of the total arsenic measured in muscle (de Rosemond et al. 2008). Due to contamination from Giant Mine, fish from this location are expected to reflect higher levels of inorganic arsenic in their tissues relative to background (unpolluted) waters. The remaining organic forms included arsenobetaine and dimethylarsenic acid (DMA), but the majority of organic arsenic (>50%) were forms that could not be directly identified. Organic forms of arsenic are considered to be much less toxic than the inorganic forms (ATSDR 2007).

In summary, arsenic is not generally bioaccumulated or biomagnified in freshwater fish. Arsenic levels in Gordon Lake fish reflect background levels of arsenic common to northern Canada. Fish tissue arsenic levels are not elevated as might be expected if mine impacts to lake water and sediment were significant. The toxic inorganic forms of arsenic in fish tissues likely represent <10% of total arsenic in Gordon Lake fish. As a result of these factors, Stantec is confident that there is no impact of Gordon Lake mines on the inorganic arsenic levels in Gordon Lake fish, and fish consumption, as a pathway of exposure to mine-related arsenic, can be omitted from the assessment of human health risks and the derivation of health-based SSRTs.

Mercury

For the Gordon Lake mine sites, mercuric mercury (Hg^{2+}) will predominate in soil, sediment and surface water. Levels in fish, however, will be methyl mercury (MeHg). The prediction of uptake and bioaccumulation/bioconcentration of MeHg in the freshwater aquatic environment, based on Hg^{2+} levels in sediments or surface water, is exceedingly complex, and simple projection of accumulation using bioaccumulation factors (BAFs) or bioconcentration factors (BCFs) is very uncertain. Factors such as lake surface area, lake depth, water chemistry (particularly dissolved organic carbon), local geology, and trophic food chain relationships, among other factors, all influence fish tissue levels of MeHg (Richardson 1994; Doetzel 2007).

Be that as it may, SLR collected fish from off-shore areas of Gordon Lake, adjacent to five mine sites as well as from two "background" locations. Concentrations of mercury in whole fish and fish muscle were not significantly different between the mine and background locations. This is not unexpected, given that lake trout may range over areas up to 10 km^2 in large lakes such as Gordon Lake (Flavelle et al., 2001). The levels of mercury measured in lake trout collected by SLR from Gordon Lake ranged from 0.06 to 0.42 mg/kg wet weight in whole fish, and ranged from

0.084 to 0.53 mg/kg wet weight in fish muscle. Average concentrations were 0.18 mg/kg and 0.25 mg/kg, for whole fish and fish muscle respectively. These mercury levels are well within the range generally found in fish from Canada's Arctic. Gantner et al. (2010) measured mercury in landlocked Arctic char from lakes in Canada's Arctic islands, distant from industrial sources. Mean levels ranged from 0.073 to 1.787 mg/kg across 18 lakes. Lockhart et al. (2005) reported on average mercury levels in various fish species from lakes in Northern Canada, lakes considered to be pristine (Evans and Talbot 2012). Average levels ranged from 0.031 to 0.47 mg/kg.

If mining was impacting mercury levels in fish of Gordon Lake, higher levels would be expected. However, the concentrations of mercury observed in Gordon Lake fish reflect levels in remote uncontaminated waters, not those impacted by mine operations. It is apparent, therefore, that the Gordon Lake mines are not influencing mercury levels in fish, and the fish consumption pathway can be omitted as a pathway of exposure to mine-related mercury, for both the assessment of human health risks and the derivation of health-based SSRTs.

Large game (moose, caribou)

As discussed by Stantec (2014b) in the peer review of the SLR risk assessment, the areal extent of the Gordon Lake Mine sites is too small relative to the feeding territories of moose and caribou to contribute significantly to the body burdens of contaminants in these species. The total areal extent of all mine sites combined is 149 ha, or 1.49 km2. This is much smaller than the feeding/home range for large game species such as moose (40 km2 (Stenhouse et al., 1995; Cluff 2005). Likewise, the migratory range for the Bathurst caribou herd, the herd found during winter in the vicinity of Gordon Lake (Boulanger et al. 2004), extends over thousands of km2 (Nesbitt and Adamczewski 2013); the migration distance between summer and winter feeding grounds for this herd can exceed 1000 km for individual herd members (Gun et al. 2011). As a result, the Gordon Lake Mine sites have no potential to contribute significantly to the concentrations of COPCs that might accumulate in meat of moose or caribou.

Small game (snowshoe hare, ptarmigan)

For snowshoe hare and ptarmigan, population densities of these game species, relative to the areal extent of each of the mine sites, is likely too small to present a significant source of hunted game that might be contaminated with mine COPCs. The population density of hare in this region is 1 hare/ha (Dehcho Wildlife Workshop 2004). The population density for ptarmigan is lower, at just 0.1 animal/ha (Smith et al. 2005; data for control plots).

Bioaccumulation potential for arsenic into small game is minimal. The uptake of arsenic from tailings and soils into small mammals at Giant Mine, NWT, was investigated by Hough (2001; data are effectively summarized by Ollson 2003). These data are considered to be the best surrogate for conditions at the Gordon Lake group of mines, owing to similar geology, and exploitation of

similar mineral resources (i.e., gold deposits). The Gordon Lake group of mines did not involve on-site ore-roasting, as conducted at Giant Mine. Ore roasting aerially deposits the most soluble form of arsenic to area soils; therefore, data on bioaccumulation of arsenic in small mammals at Giant Mine will likely over-estimate the bioaccumulation at the Gordon Lake mines. From the data of Hough (2001), bioaccumulation factors (BAFs) were calculated from the soil (dry weight)-to-small mammals (wet weight) as 0.0024, 0.013 and 0.0019 for tailings, impacted organic soils (through atmospheric deposition) and for background (non-impacted) soils, respectively.

Consumption rates for these small game species are also low and further reduce the probability of significant risk from consumption. Yellowknife First Nation communities are those in closest proximity to the Gordon Lake group of mines; therefore, country food consumption patterns for these communities are the most appropriate for consideration here. Daily intake of small mammals and game birds was researched specifically for FN communities in and around Yellowknife by Batal et al. (2005) and Receveur et al. (1996, 1998). These studies were effectively summarized by SENES (2006). Small mammals represented just 1% of total country food consumption, with the average daily intake equating to 4.6 g/day. Game birds, including ptarmigan and other species, represented only 0.2% of total country food consumption, with the average daily intake equating to 1.1 g/day. Assuming a BAF of 0.013 for arsenic at the Gordon Lake Mines, an average small mammal intake rate by FN receptors of 4.6 g/day, and an average soil arsenic concentration of 69 mg/kg (the proposed SSRT for these sites; see Table 4, below), the resulting dose would not exceed 20% of the threshold TRV for arsenic of 0.0003 mg/kg-day.

Finally, a record of traditional knowledge of the mines and areas around Gordon Lake (YKDFN 2014), indicates that FN community members predominantly travel past Gordon Lake and its various mine sites on route to winter caribou hunting grounds located further northeast near Courageous and MacKay Lakes. Historically, trappers were active in the area, with a few derelict trappers' cabins and camp sites being known. However, there are no permanent residences in this area currently. Camping for short durations (likely 1 or 2 nights), while travelling to or home from hunting grounds, is feasible. Hunting for small game (hare, ptarmigan) may occur during these camps, but most likely only for immediate consumption. Storage and transport capacity for game would be reserved for caribou meat, rather than for small game.

Plant country foods

It is also unlikely that the identified COPCs will accumulate in plants that may serve as country foods or as foods for wildlife species that may be harvested for food. The accumulation of arsenic from soil into terrestrial plant species is generally low, with the exception of rice plants which appear to be a hyper-accumulator of arsenic. Mean values for the ratio of Plant[As] (wet weight):Soil[As] (dry weight) (also known as the bioaccumulation factor or BAF) generally range between 0.004 and 0.096 for grasses and forbs on arsenic-contaminated soils at Giant Mine in Yellowknife (Ollson, 2003), where the more soluble forms of arsenic are found in area soils. For

above-ground vegetation from backyard gardens in Yellowknife, the maximum reported BAF for arsenic was 0.018 (ESG, 2001; as reported by SENES, 2006). For lead, due to its immobility in soil, there is minimal or no translocation from soil into the roots, shoots or fruits of plants (Bacigalupo and Hale, 2011). For mercury, mean ratios of plant mercury concentration (dry weight) to soil mercury concentration (dry weight) range from 0.002 to 0.085 (USEPA, 1996). When plant mercury concentrations are converted to wet weight (the average moisture content of plants is greater than 90% of total wet weight (USEPA, 1996)), it is apparent that little accumulation of inorganic mercury occurs from soils to above-ground plant parts.

From a review of photographs for the various Gordon Lake mine sites (see the 2014 HHERA conducted by SLR) granitic rock outcrops predominate the terrain of the mine sites and vegetation is generally sparse, particularly on the contaminated areas of the mines. As a result, country food harvesting and consumption of vegetation from these sites is considered unlikely to be significant, and these pathways can be omitted from consideration when determining appropriate SSRT values to guide remediation. Likewise, this sparse vegetation is unlikely to support significant population densities of small game species that might be harvested for food.

Country food summary

Based on the foregoing discussion and considerations, country foods will present insignificant contributions to Site-related exposures. Therefore, the derivation of SSRTs for the Gordon Lake mine sites excluded the ingestion of country foods including berries, vegetation (e.g., Labrador tea), game birds, small mammals and large game. However, it should be noted that extensive remediation is still planned for these sites, on the basis of SSRTs presented in Table 4 below. Remediation will include the removal of an estimated 22,000 m3 of contaminated material, which will further reduce any possible impact to local flora and fauna.

Indoor Air Infiltration

According to the 2014 SLR HHERA, risks posed by indoor infiltration of vapours from PHC F1 and/or PHC F2 contamination were reported for the following sites: Camlaren, Burnt Island, Kidney Pond, Treacy and West Bay. However, only the Camlaren and Kidney Pond sites might contain a sufficient mass of PHC contaminated soil to warrant remedial attention for the indoor infiltration pathway. In the assessment of indoor infiltration risks and derivation of SSRTs, SLR assumed that the source of PHC contamination (the mass of PHCs in the contaminated soils at each mine site) was infinite; this is a common and inherent assumption of the methods used. However, it is apparent from the limited extent of PHC contamination and the shallow soil depth at each of the mines that this infinite assumption is not valid or appropriate for these sites.

Based on these observations, there is likely insufficient mass of PHCs at Burnt Island, Treacy and West Bay to generate the mass or quantity of vapour necessary to contaminate a hypothetical

slab-on-grade residence for 80 years (or longer). Even for Camlaren and Kidney Pond, the availability of sufficient PHC F1 and F2 vapours is questionable.

Development of the Gordon Lake Mine sites as residential land use is not currently planned, and might only occur at some undetermined time in the medium to long-term future. Since volatile subfractions of PHC F1 and PHC F2 will continue to dissipate during the intervening years, it is recommended that if land use changes to residential land use, the assessment of the risks of vapour infiltration be assessed at that time. Alternatively, it is recommended that future residential structures be situated on those areas of the mine sites where PHC contamination does not exist. In the meantime, it is the opinion of Stantec that the SSRTs for the remediation of PHC soil contamination should be set to the CCME (2008) Management Limits for PHC F1 (700 mg/kg) and PHC F2 (1,000 mg/kg), with no long-term risk of vapour exposure for current Site conditions and use. For PHC F3, it is planned that the SSRT for this substance will be based on SLR's determination of a background PHC F3 concentration of 2910 mg/kg. This background level is five times lower than the lowest human health SSRT developed by SLR for the Gordon Lake group of mines, and is only slightly greater than the CCME management limit for PHC F3 of 2500 mg/kg. It is therefore anticipated that the final SSRT will ensure protection of human receptors.

TOXICOLOGICAL REFERENCE VALUES

For the derivation of SSRTs, the tolerable daily intake was set equal to the toxicological reference values (TRVs) selected for each COPC. For the assessment of residential receptors, the chronic TRVs selected are shown in Table 1.

SSRTs were not derived for PHC F1 and PHC F2; therefore, TRVs are not provided for these COPCs. Instead, it is recommended by Stantec that the SSRTs for remediation of PHC soil contamination be set to the CCME (2008) Management Limits for PHC F1 (700 mg/kg) and PHC F2 (1,000 mg/kg), and that if future land use changes to residential land use, a risk assessment of indoor air infiltration be conducted at that time. Alternatively, it is recommended that future residential structures be situated on those areas of the mine sites where PHC contamination does not exist.

To derive SSRTs for sub-chronic exposures (i.e., for exposure less than 90 days) for First Nations Site visitors and construction/remediation workers, Stantec has derived or identified suitable sub-chronic TRVs for threshold effects of arsenic, cobalt and mercury (shown in Table 2), following available direction provided by Health Canada. A short-term TRV could not be located for lead; however, it is anticipated that the SSRT established for potential chronic exposure (site residents, including toddlers) to lead will also be protective of shorter duration (sub-chronic) exposures and risks.

For short-term exposure durations, COPCs are only assessed for non-carcinogenic (threshold) effects. Risks and resulting SSRTs for non-threshold COPCs (i.e., arsenic and arsenic) derived for

chronic exposure for the assumed residential exposure scenario will be adequately protective of any non-threshold effects associated with shorter duration exposures in Site visitors and construction/remediation workers. Note that lead is now considered a non-threshold substance (Health Canada, 2013; Wilson and Richardson, 2013), although the effects do not relate to cancer.

Table 1 Chronic Toxicological Reference Values

COPC	Chronic TRV	Critical Health Effect(s)	Reference
Carcinogenic COPCs			
Arsenic	1.8 $(mg/kg\text{-}d)^{-1}$	Bladder, lung and liver cancer	Health Canada, 2010b
Non-Carcinogenic COPCs			
Arsenic	0.0003 mg/kg-d	Hyperpigmentation, keratosis and possible vascular complications	USEPA, 1993
Cobalt	0.0014 mg/kg-d	Cardiomyopathy	RIVM, 2001
Lead (toddler)	0.0006 mg/kg/d	1 IQ point decrement	JECFA, 2011
Lead (adult)	0.0012 mg/kg/d	1 mmHg increase in systolic blood pressure	JECFA, 2011
Mercury, inorganic	0.0003 mg/kg-d	Nephrotoxicity	Health Canada, 2010b

Table 2 Sub-Chronic Toxicological Reference Values

COPC	Sub-Chronic TRV	Critical Health Effect(s)	Duration of Study, Test Species	Reference and Comments
Arsenic[a]	0.005 mg/kg-d	Unknown	Unknown	ORNL 2013[b]
Cobalt	0.01 mg/kg-d	Polycythemia	22 days, humans	ATSDR, 2004 (Intermediate MRL)
Mercury, inorganic	0.003 mg/kg-d [c]	Nephrotoxicity	1 – 12 weeks, rats	USEPA, 1995

Notes:

[a] Non-carcinogenic effects of arsenic.

[b] Background information was not available regarding the sub-chronic oral Provisional Peer Reviewed Toxicity Value (PPRTV) presented on the Oak Ridge National Laboratory's Risk Assessment Information System (RAIS), but originally derived by the EPA Superfund Health Risk Technical Support Center.

[c] The toxicity study underlying the USEPA chronic RfD was of subchronic duration; therefore, the uncertainty factor (UF) for sub-chronic to chronic extrapolation was omitted to determine the TRV for short-term exposure to inorganic mercury

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

HUMAN HEALTH SSRTS

Human health SSRTs were derived for each receptor based on the equations from the Canadian Council of Ministers of the Environment (CCME, 2006) and are shown in Table 3. See Attachment A for calculations. Note that, for short-term exposure SSRTs, exposures were not amortized over a time period greater than the assumed duration of exposure.

Table 3 Human Health SSRTs

COPC	SSRT (mg/kg)		
	First Nations Residential Receptor[a]	First Nations Site Visitor[b]	Construction/ Remediation Worker[b]
Arsenic (carcinogenic effects)	86[c]	na[d]	na[d]
Arsenic (non-carcinogenic effects)	69	245	2475
Cobalt	130[e]	425	5526
Lead	332	na[d]	na[d]
Mercury, inorganic	13	67	217
PHC F1	700[f,g]	na[f]	na[f]
PHC F2	1000[f,g]	na[f]	na[f]
PHC F3	2910[h]	na	na

Notes:

[a] Chronic exposure; >90 days.

[b] Short-term exposure; <90 days.

[c] Value slightly different from Stantec (2014) owing to correction for 60 year duration of adulthood, rather than 80 years.

[d] Short-term exposure not assessed for non-threshold effects of COPCs (i.e., lead and the carcinogenic effects of arsenic).

[e] Value slightly different from Stantec (2014) owing to correction for TRV of 0.0014 mg/kg-day rather than the rounded TRV of 0.001 mg/kg-day used previously.

[f] Not assessed for indoor air infiltration.

[g] CCME (2008) Management Limit (coarse-grain soil, agricultural and residential land use; not risk-based).

[h] Based on measured background concentration; discussed in greater detail with respect to Ecological SSRTS.

The proposed SSRTs based on human health assume no practical difference between soils and tailings materials. Both are particulate in nature, both will adhere to skin surfaces for dermal

absorption and, due to each having a small particle size fraction, both can be inadvertently ingested via hand-to-mouth transfer. It was assumed that the bioavailability of COPCs from tailings would be equivalent to that from soil. However, at least for arsenic, bioavailability is generally lower from tailings than from proper soils (Ollson 2003), owing to the insoluble mineral forms that are typically found in tailings. As a result of assuming that tailings and soils are equivalent with respect to exposure, it is likely that SSRTs applied to tailings deposits will be conservative; it is likely that more cleanup than necessary may be conducted for tailings deposits.

SITE-SPECIFIC REMEDIAL TARGETS TO PROTECT ECOLOGICAL HEALTH

ECOLOGICAL SSRTS

As discussed in the report, "Review of SSRTs, Summary, and Conclusions of the HHERA for Nine Former Mine Sites, Gordon Lake, Northwest Territories", Stantec has not attempted to reproduce the derivation of ecological SSRTs. Due to the small area of each mine site, the limited extent of contamination and the location of the Gordon Lake mine sites in a rather vast natural (wild lands) area, risks to various ecological receptors will not be the sole determinant of remediation targets.

The driving ecological receptor for SSRTs for arsenic, PHC F2 and PHC F3 (the only COPCs considered for ecological SSRTs) were soil invertebrates. Toxicity bioassays of these COPCs to soil invertebrates are predominated by tests of various species of earthworms (see Tables V2-4, V2-5 and V2-6, Appendix V, SLR HHERA for Gordon Lake Mine Sites). Earthworms are not common biota of soils in the North. The Northwest Territories has no native earthworm species and only two reports have been made concerning invading earthworm species (Addison, 2009). Therefore, the relevance of bioassays of COPC toxicity to earthworm species, for the protection of terrestrial soil invertebrates of the Northwest Territories, is unknown.

Ecological soil quality guidelines (SQGs) and SSRTs are generally designed to protect the overall population of organisms, while recognizing that some individual organisms may be harmed. For this reason, generic SQGs are routinely prescribed on the basis of EC10 or EC20 concentrations (the effective concentration expected to impact 10% or 20% of exposed organisms, respectively). The limited spatial extent of contamination at each of the mine sites, relative to the large expanses of undisturbed habitat surrounding each of these sites, indicates that no harm will be presented to populations of soil invertebrate biota even if the contamination remains untreated or not remediated.

Based on the foregoing discussion, Stantec considers that the SSRTs developed by SLR to protect soil invertebrates are overly conservative and an inappropriate basis for remediation of the remote Gordon Lake mine sites. Based on a review of the spatial extent of contamination at each of the mine sites, and consideration of other receptors (particularly human receptors), Stantec proposes that final Site SSRTs be based on protection of human health. The resulting residual

contamination remaining after remediation will present little or no actual risks to local populations of plants, soil invertebrates, avian or mammalian wildlife. With respect to PHC F3, the proposed SSRT is based on the measured background concentration in the Gordon Lake area, rather than on human or ecological risk. However, the SSRT of 2910 mg/kg is much less than the human health risk-based SSRTs developed by SLR. For this COPC, the measured background concentration is a reasonable target level to also protect ecological health.

FINAL SSRTS

The final SSRTs recommended for the Gordon Lake mine sites are shown in Table 4. The lowest calculated SSRT for each COPC was compared to the CCME guideline protective of human health and the regional background value calculated by SLR in the 2014 HHERA. If the SSRT was lower than the CCME guideline, the SSRT defaulted to the guideline value; however, if the guideline was less than background, the SSRT defaulted to the background value.

Table 4 Final Human Health SSRTs (mg/kg)

COPC	Lowest Calculated SSRT	CCME SGQ_{HH} (Residential)	Background	Final SSRT
Arsenic	69	31	44.4	69
Cobalt	130	n/a	15.6	130
Lead	332	140	17.9	332
Mercury, inorganic	13	6.6	0.085	13
PHC F1	--	700[a]	--	700
PHC F2	--	1,000[a]	111	1,000
PHC F3	--	2,500[a]	2,910	2,910

Notes:

[a] CCME (2008) Management Limit (coarse-grain soil, agricultural and residential land use; not risk-based).

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

CLOSURE

This report documents work that was performed in accordance with generally accepted professional standards at the time and location in which the services were provided. No other representations, warranties or guarantees are made concerning the accuracy or completeness of the data or conclusions contained within this report.

This report provides an evaluation of selected environmental conditions associated with the reviewed report at the time the work was conducted and is based on information obtained by and/or provided to Stantec at that time. There are no assurances regarding the accuracy and completeness of this information. All information received from the client or third parties in the preparation of this report has been assumed by Stantec to be correct. Stantec assumes no responsibility for any deficiency or inaccuracy in information received from others.

The opinions in this report can only be relied upon as they relate to the condition of the report that was reviewed. Conclusions made within this report consist of Stantec's professional opinion as of the time of the writing of this report, and are based solely on the scope of work described in the report, the limited data available and the results of the work. This report should not be construed as legal advice.

This report has been prepared for the exclusive use of the client identified herein and any use by any third party is prohibited. Stantec assumes no responsibility for losses, damages, liabilities or claims, howsoever arising, from third party use of this report.

This report is limited by the following:

- The information provided in the reviewed report.

The conclusions are based on the report reviewed by Stantec. As the purpose of this report is to technically review a report, the identification of non-environmental risks to structures or people on the site is beyond the scope of this assessment.

Should additional information become available which differs significantly from our understanding of conditions presented in this report, Stantec specifically disclaims any responsibility to update the conclusions in this report.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

STANTEC QUALITY MANAGEMENT PROGRAM

This report, entitled *Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories* prepared for Public Works and Government Services Canada, dated March 31, 2015, was produced by Stantec Consulting Ltd.

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Appendix A: Response to Comments From Health Canada

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APPENDIX A – RESPONSE TO COMMENTS FROM HEALTH CANADA

HC Comment	Response
Comments in letter dated February 19, 2015	
1. In the current Supplemental Assessment report SSRTs were developed for human health Chemicals of Potential Concern (COPC) arsenic, cobalt, lead, mercury, petroleum hydrocarbon (PHC) F1 and PHC F2. Human health SSRTs were not developed for antimony and PHC F3 since these chemicals were determined to have acceptable human health risks in the SLR HHERA. However, HC has previously expressed concerns with the SLR risk methodology (from the SLR HHERA) used to conclude that antimony and PHC F3 do not pose an unacceptable human health risk at the Gordon Lake sites (see HC March 5, 2014 letter cited above) but to HC's knowledge these have not yet been addressed. Therefore, the exclusion of antimony and PHC F3 as COPCs at this point may be premature.	To address this comment, the following text has been added to Stantec's re-assessment of the SSRTs. Stantec is confident that antimony will present no human health risks at any of the nine mine sites included in the Gordon Lake group. SLR master data tables were re-examined; antimony was measured at all nine mine sites. Zero soil samples with concentrations greater than the soil quality guideline (SQG = 20 mg/kg) were found at five of the sites. Of the remaining four sites (Goodrock, Kidney Pond, Burnt Island, Camlaren), a total of only 18 samples out of 994 samples across all sites combined, contained antimony levels greater than the SQG. The maximum percent of samples with antimony concentrations greater than the SQG was found at Goodrock mine, where only 5.6%, (5 of 90 samples) exceeded the SQG. This low number of exceedences is not indicative of risk. The average soil antimony concentrations were: Goodrock = 4.9 mg/kg; Kidney Pond = 1.0 mg/kg; Burnt Island = 1.0 mg/kg; and Camlaren = 2.4 mg/kg. All of these average concentrations are well below the antimony SQG of 20 mg/kg. With respect to PHC F3, it is planned that the SSRT for this substance will be based on SLR's determination of a background PHC F3 concentration of 2910 mg/kg. This background level is five times lower than the lowest human health SSRT developed by SLR for the Gordon Lake group of mines, and is only slightly greater than the CCME management limit for PHC F3 of 2500 mg/kg. It is therefore anticipated that the final SSRT will ensure protection of human receptors.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

2i. This Stantec report states *'As discussed in the 2014 HHERA, COPC concentrations in fish in Gordon Lake were similar to concentrations in fish in other areas of Northern Canada, and were therefore not included in the assessment of country foods.'* However, even though the 2014 [SLR] HHERA report does conclude that it is unclear if levels of arsenic and methylmercury in fish are related to the mine sites or regional background conditions, the Stantec report may oversimplify the SLR conclusion by not acknowledging the uncertainty in arsenic and methylmercury sources, and omitting the HHERA recommendations for further study. Specifically, SLR recommends further studies on the forms of these chemicals present in Gordon Lake fish, on the human consumption rates of Gordon Lake fish and on an overview of arsenic and methylmercury concentrations in fish in other areas of NWT. The SLR 2014 HHERA only compares COPC concentrations in fish taken from Gordon Lake, which includes fish collected from off-shore areas adjacent to five of the Gordon Lake mine sites, to fish collected from two background locations that were collected within a relatively short distance (~1.5 km) of the mine sites. HC concurs with the SLR 2014 HHERA recommendation for further study in the area, and suggests that the current Stantec report provide additional scientifically-based rationale for excluding country foods from the derivation of SSRTs.	Mercury and arsenic found in fish from Gordon Lake are reflective of naturally-occurring background levels. To this end, extensive additional text has been added, complete with citations, regarding background levels of arsenic and mercury in fish from Canada's North, and comparison to levels in fish from Gordon Lake. Given that mercury and arsenic levels in Gordon Lake fish do reflect natural background levels, Stantec is also confident that additional study is not necessary to further investigate this issue. However, further research may be pursued, at the discretion of AANDC or PWGSC.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

2ii. This Supplemental Assessment report also states that *'..., the Gordon Lake Mine Sites have no potential to contribute significantly to the concentrations of COPCs that might accumulate in large game meat.'* The report discusses that this conclusion is reached since the areal extent of the Gordon Lake mine sites, with a combined total of 1.49 km^2, is too small relative to the feeding/home range for large game species, which can be around 40 km^2 in the NWT. Utilizing this justification does not appear to be sufficient to rule out this pathway for these sites. For example, assuming that the ratio of the areal extent of the Gordon Lake mine sites to the feeding/home range of a large game animal is approximately 3.7% (as discussed above), and that the animal spends an equal amount of time throughout this range, adjustment of the Hazard Quotient of 340 for Cobalt for the game ingestion pathway (for toddler First Nation Receptor in Table 8-9: Kidney Pond – Kidney Pond Area - Summary of Risks from page 174 of SLR 2014 HHERA) would still result in a HQ of 12.6. This result points to the potential for a human health risk to cobalt (at Kidney Pond) for the game consumption pathway. Therefore, further assessment and justification for exclusion of this pathway is recommended, which could include collection and analysis of game tissue samples and/or site-specific observation of animal behaviors, rather than relying on the above assumptions based on home ranges. Please consult Health Canada (2010) Federal Contaminated Site Risk Assessment in Canada: Supplemental Guidance on Human Health Risk Assessment for Country Foods for more information.	Stantec is confident that the Gordon Lake Mine sites do not present a human health risk due to potential uptake into country foods. To this end, extensive additional text has been added, complete with citations, to demonstrate that hunting of large game, hunting of small game, and harvesting of plant country foods will be insignificant contributors to receptor exposure to site COPCs.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

2iii. The human ingestion of small game was also not considered in the Supplemental Assessment report, for calculation of SSRTs. This report discusses that this pathway was excluded for two main reasons: (1) average intake of small mammals and game birds, constituted only 1% (4.6g/day) and 0.2% (1.1 g/day) of total dietary intake, respectively, based on a 2006 SENES study for First Nation (FN) communities in the Yellowknife area; and (2) there is likely insufficient population size of small mammal game (such as the snowshoe hare), '*to comprise a significant annual harvest for any single individual or family to present a risk of contaminant uptake via small mammal consumption. Based on population density from the general area of Yellowknife, snowshoe hare density was only approximately one animal per hectare in 2001 and 2002 (Dehcho Regional Wildlife Workshop, 2004).'* The SENES 2006 study was based on a Tier II Risk Assessment for the Giant Mine site, while the 2004 Wildlife Workshop was for the Dehcho Region in the NWT. It is not clear how representative of the Gordon Lake mine sites, the data from these studies may be. Specifically, these studies were from locations that are likely more populated with humans (urban settings like Yellowknife and Fort Simpson) while the Gordon Lake former mine sites are isolated, undeveloped sites that are primarily accessible by float plane or by an ice road during the winter months (SLR 2014 HHERA). HC recommends providing additional scientifically-based rationale to support the exclusion of this pathway in the SSRT calculations.	Yellowknife is the closest community to the Gordon Lake Mines. As stated by Stantec in our December 2014 report, the cited SENES report summarizes available game consumption data for FN communities in and around Yellowknife, and since it is these communities that are in closest proximity to the Gordon Lake Mines, their consumption data are directly relevant (the most relevant) to the risk assessment. The Dehcho Regional Wildlife Workshop (2004) is also relevant to the risk assessment. Dehcho RWED ([Department of] Resources, Wildlife & Economic Development) continues to be part of the NWT-wide hare and small mammal monitoring program. Data on hare population densities are presented for numerous areas of the NWT including Inuvik, Norman Wells, Fort Simpson, Fort Smith, Fort Providence and Yellowknife. These location names should not be interpreted to imply that research was conducted only in urban areas. The 2002 hare density numbers for 'Yellowknife' are equal to or greater than those for all other regions/areas for which data were presented. Therefore, Stantec is confident that the data relied upon is relevant, robust, and still conservative with respect to the population density of hare in and around the Gordon Lake Mines. Should HC be aware of any other relevant data of this type, covering recent years, Stantec would appreciate receiving it and will be pleased to incorporate it into our re-assessment of SSRTs for the Gordon Lake mine sites.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

2iv. Finally, the Supplemental Assessment report discusses that '*It is also unlikely that the identified COPCs will accumulate in plants that may serve as country foods or as foods for wildlife species that may be harvested for food.*' However, in the 2014 SLR HHERA, detectable concentrations of arsenic, lead and mercury were measured in samples of berries and Labrador tea from some of the Gordon Lake sites. The 2014 HHERA also concludes that unacceptable risks were determined based on measured berry concentrations, specifically for arsenic and lead in berries. As a result, HC recommends that further assessment of the vegetation consumption pathway and/or further justification be provided prior to its exclusion in the development of SSRTs for the Gordon Lake sites.	The 2014 SLR risk assessment incorrectly assumed that 100% of annual consumption of berries, Labrador Tea, etc. would be harvested from these sites. Stantec discussed the lack of sufficient vegetation, based on examination of photographs from these sites, in its December 2014 supplemental assessment report. Also, Stantec clearly explained, complete with references, why uptake of metals into plants at the sites will be of little or no concern. It should also be noted that these sites are accessible only by float plane during seasons when berry and other plant country food harvesting would be feasible. It is very unlikely that such a trip would be planned to facilitate the harvesting of a year's worth of produce, even if vegetative cover at these sites were sufficient. Ice road access during winter months would not be relevant as berries and other country food produce would not be available. Labrador tea may retain its leaves into the winter, but distance from Yellowknife via ice road would make Labrador tea harvesting trips unlikely in the winter.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

3. Application of SSRTs at the Gordon Lake former mine sites was not detailed in the Supplemental Assessment report. Paragraphs 5, 6 and 7 from the attached HC August 7, 2014 email, regarding the Gordon Lake SSRT Discussion, outlines how HC does not have any guidelines specific to mine tailings and that any screening or risk-management of tailings based upon SQGs or SSRTs derived in similar fashion or background concentrations of soils and tailings presents considerable uncertainty. As discussed in the e-mail, *"the physico-chemical characteristics of tailings are quite different from soil' and 'Even if the deposited tailings currently meet the relevant SQGs or SSRTs … or are similar to background concentrations, and AANDC determines the uncertainty around use of SQGs or SSRTs for screening the tailings is acceptable, the potential for migration and contamination of other media (dust in air, impacts to sediments, ground or surface water) remains for at least some of the sites."* Therefore, HC suggests that risk management of tailings and waste rock for at least some of these mine sites, may need to be considered regardless of the SSRTs derived.	Stantec is currently formulating a remedial action plan that will detail how and where the proposed SSRTs would be implemented. The bioavailability/bioaccessibility of arsenic and other metals has been repeatedly demonstrated to be greater from soils than from tailings materials (see Ollson C. 2003 (Arsenic Risk Assessments: The Importance of Bioavailability. Ph.D. thesis, Royal Military College of Canada. October 2003) as one example). The risk assessment guidance that was followed, that from HC, defines bioavailability of metals from terrestrial surface materials on the basis of soil, not tailings. Therefore, Stantec is confident that the application of proposed SSRTs to tailings material will be conservative; the risk assessment methods and assumptions are more likely to over-estimate rather than under-estimate the human uptake and exposure to metals from this tailings material.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

Additional comments provided during teleconference of March 16, 2015	
Explain why the 95% UCLM concentrations of chemicals in soil are applicable to COPC screening	Mention of using the 95% UCLM for COPC screening was contained in Stantec's March 2014 report on the peer review of the SLR HHERA. Despite no residential land use on the Gordon Lake mine sites, Stantec ultimately retained the residential receptor (as per SLR's HHERA) to be conservative with respect to setting SSTRs. All individual mine sites have sufficient data quantity that the EPC would be based on the 95% UCLM concentration rather than the maximum concentration in soil. Exposure calculations (and SSRT derivations) used the standard residential receptor exposure equations and assumptions prescribed by Health Canada (which are also used by CCME in SQG derivation). As such, if the EPC for exposure calculations is less than the SQG, then estimated exposures using that EPC will be less than 20% of the TRV, or less than a cancer risk of 1 in 100,000 if the COPC is carcinogenic. As a result, in situations where there is sufficient data to justify the 95% UCLM as the EPC, then screening of COPCs with that 95% UCLM will effectively achieve the same purpose – identify contaminants whose exposure doses will be less than or greater than the acceptable level of risk. All this being said, Stantec has now reverted to COPC screening using the maximum concentrations for all FCSAP-related HHRAs.
Better describe the small game consumption scenario with respect to eliminating this as a significant exposure pathway.	Extensive text has been added to this report regarding consumption of small game, large game and plant country foods, and why Stantec is confident that these pathways can be excluded for the Gordon Lake mine sites.

Reference: Supplemental Assessment of Site-Specific Remedial Targets for Nine Former Mine Sites, Gordon Lake, Northwest Territories

Add information from FN traditional knowledge survey, particularly regarding passing by the Gordon Lake mines on route to caribou winter hunting grounds	Relevant information has been added to Stantec's report from a traditional knowledge research report prepared by the YKDFN regarding the Gordon Lake Mine sites. This YKDFN report indicates that the mine sites are not inhabited, and currently the only use of these sites might be for temporary camps while on route to caribou hunting grounds near Courageous and MacKay Lakes, located north and east of Gordon Lake.
Add a discussion regarding the uncertainties of assuming that tailings and soil can be treated equally with respect to soil ingestion rates	Text added to report with respect to the differential bioavailability of metals from soil versus tailings.
Provide additional citations concerning background levels of arsenic and mercury in fish from unpolluted lakes in Canada's North	Extensive additional text, complete with citations, has been added to the Stantec report regarding background levels of arsenic and mercury in fish from Canada's North generally, and the NWT specifically, to demonstrate that the levels of these substances in Gordon Lake fish do reflect typical background levels.