Kiggavik Project

Environmental Impact Statement

Tier 3 Technical Appendix 5N

Hydrology Assessments

December 2011

APPENDIX 5N

Technical Memos - Hydrology

TECHNICAL MEMORANDUM

DATE June 7, 2011 **PROJECT No.** 09-1362-0010

TO Nicola Banton/Fredric Guerin
AREVA Resources

CC

FROM Ashley Dubnick/Brent Topp **EMAIL** ashley_dubnick@golder.com
brent_topp@golder.com

POND DEWATERING PLAN FOR THE KIGGAVIK AND SISSONS SITES

Areva Resources (AREVA) is currently completing an Environmental Assessment for the Kiggavik Project (the Project). The Project includes two properties; the Kiggavik site and the Sissons site. Although diversion channels have been designed to route water around the sites, during construction, minor ponds and standing water underlying the proposed project footprint will require dewatering. This technical memorandum describes recommended dewatering process and corresponding potential effects to surface hydrology.

The hydrograph in the vicinity of the Project is characterised by a steep rising limb in mid-June from snowmelt runoff followed by receding flows through the remainder of the open water period. Small streams draining several square kilometres may periodically cease to flow in July or August until the following spring freshet. However, during persistent rainfall events, the small streams may temporarily activate. Consequently, the minor ponds and standing water requiring dewatering are predicted to be at their peak level during mid-June, for approximately two weeks, while snow packs melt. Therefore, it is recommended that dewatering occur after the spring freshet has passed, when dewatering volumes have declined and receiving water bodies downstream have the capacity to accommodate the additional inflow.

Aerial photos of the Kiggavik and Sissons sites were used to identify the ponds and standing water in the Project footprint associated with each site. A mean depth of 0.5 m and the approximate surface area of the pond at the time of the photo were used to estimate the total dewatering volume of each pond. A maximum pumping rate of 0.15 m^3/s is applied for all dewatering activities.

Kiggavik Site Ponds

Twelve minor ponds and standing water have been identified under the project footprint associated with the Kiggavik Site (Table 1; Figure 1) with an estimated combined volume of 23,000 m^3. Table 1 indicates the pond location and the preferred receiving stream or engineered channel most suitable for receiving the pumped volumes. KP1-11 can be dewatered into the east channel passing through the site (SF3), or into the east diversion channel pending its completion. The east diversion channel is designed for a maximum discharge of 4.3 m^3/s at the headwater (Golder, 2011a) and therefore has ample capacity to receive pond water at a rate of

0.15 m^3/s. The east stream also has sufficient channel capacity to receive pond water. The east stream was monitored at SF3 during baseline studies (Golder, 2011b) near the south side of the project footprint (Figure 1). In 2007, a bank-full flow of 0.46 m^3/s was measured in mid-June at SF3 along the east stream. During baseline studies, flows typically ceased by mid July at SF3. If dewatering occurs during July or August, when natural discharge is close to zero, there is sufficient channel capacity for dewatering at a rate of 0.15 m^3/s.

Although KP-12 can be dewatered into the east stream or diversion channel, it may be preferable to discharge this into the pond approximately 200 m to the west. Although this location has not been previously monitored, the stream was monitored immediately downstream (SF11; Figure 1) during baseline studies in 2007-2009 (Golder, 2011b). SF11 has an effective drainage area of 3.16 km^2 and an observed peak flow of 1.44 m^3/s during the spring freshet of 2007. The pond 200 m west of KP-12 has an effective drainage area of 1.6 km^2; by prorating SF11 discharge based on drainage area, the pond has an estimated peak discharge of 0.73 m^3/s. Dewatering KP-12 into the pond 200 m to the west during July or August when natural discharge is near zero will main flow rates below peak levels.

Sissons Site Ponds

Five ponds with a combined volume of 13,800 m^3 were identified under the project footprint associated with the Sissons Site (Figure 2). SP1 is a small pond of approximately 2,440 m^3 and can be discharged into the pond approximately 300 m to the east. This receiving waterbody has an area approximately 40 times the area of SP-1. If dewatering occurs after the spring peak, it is very likely that the pond will remain below spring water levels.

SP2 and SP3 can be discharged to the nearby diversion channel, or in the event that the diversion channel is not completed at the time of dewatering, it can be discharged into a poorly defined drainage system located approximately 250 m southeast of SP3 (Figure 2). This diversion channel has been designed for flows up to 5.6 m^3/s and therefore has ample capacity for water receiving water at 0.15 m^3/s. Similarly, SP5 can be discharged to either the nearby east or west diversion channels. The west diversion channel is designed for flow up to 14 m^3/s.

Due to its proximity, SF4 can be discharged to Andrew Lake. Andrew Lake has a total volume of approximately 95,800 m^3 suggesting that the estimated 2,970 m^3 from SP4 will not result in a measureable change in level Andrew Lake.

Table 1: Kiggavik and Sissons pond volumes and dewatering time

Pond	Location		Receiving location	Estimated Volume (m^3)	Estimated Dewatering time (hrs)
	Easting	Northing			
Kiggavik Site Ponds					
KP-1	564948	7148406	Kiggavik east diversion channel or the east stream	1710	3.2
KP-2	565751	7148149		1260	2.3
KP-3	565248	7148257		4100	7.6
KP-4	566111	7148216		300	0.6
KP-5	565612	7147069		5800	10.8
KP-6	565708	7147218		1120	2.1
KP-7	566438	7147422		1180	2.0
KP-8	565903	7147774		390	0.7
KP-9	565551	7147861		1430	2.7
KP-10	565892	7147884		520	1.0
KP-11	564920	7148102		4240	7.8
KP-12	564595	7146585	Pond approximate 200 m to the west	1090	2.0
Sissons Site Ponds					
SP-1	553157	7136764	Pond approximate 300 m to the east of SP1	2440	4.5
SP-2	553284	7135803	Diversion channel approximately 300 m to the east	1780	3.3
SP-3	553438	7135631	Diversion channel approximately 100 m to the east	3530	6.5
SP-4	553290	7135076	Andrew Lake	2970	5.5
SP-5	554156	7135983	Stream approximately 300 m to the east of SP 5 or nearby diversion channel	3080	5.7

Closure

The ponds described in this document were identified using SPOT imagery from 2006 and therefore may differ from those present at the time of construction. If additional ponds are identified, they may be discharged to any of the receiving locations discussed above.

References

Golder Associates Ltd. (Golder). 2011a. Conceptual freshwater Diversions and Wasterock collection channels for Kiggavik and Sissons Sites. Kiggavik Project

Golder Associates Ltd. (Golder). 2011b. The Kiggavik Project: Environmental Impact Statement Hydrology Baseline. *Revised Draft Report*.

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MEMORANDUM

TO Fredric Guerin and Nicola Banton **DATE** September 30, 2011

CC

FROM Ashley Dubnick and Brent Topp **PROJECT No.** 09-1362-0610/8000

HYDROLOGICAL ASSESSMENT OF THE PHYSICAL EFFECTS OF EFFLUENT DISCHARGE INTO JUDGE SISSONS LAKE AT THE KIGGAVIK PROJECT SITE

AREVA Resources Canada Inc (AREVA) is currently exploring options for effluent release at the Kiggavik Project near Baker Lake, Nunavut. Previously, Golder Associates (Golder) conducted a hydrological assessment that explored the potential for effluent discharge on a seasonal basis into Pointer Lake. However, AREVA has recently decided that the effluent storage requirements and release rates make this option unfeasible. Therefore, an alternative option for continuous effluent discharge is required. AREVA has estimated treated effluent discharge at a base case of 4,407 m^3/day for Sissons and Kiggavik sites combined; however, to incorporate environmental conservatism and potential variability in discharge, 0.054 m^3/s (4,700 m^3/day) will be assessed; 0.035 m^3/s (3,000 m^3/day) from the Kiggavik Site and 0.012 m^3/s (1,700 m^3/day) from the Sissons Site.

Currently, Judge Sissons Lake is the preferred location for effluent discharge from both the Kiggavik and Sissons sites. Effluent from both sites may be discharged into the Judge Sissons Lake at one location in the east basin, or at two separate locations in the east basin (Figure1). As both discharge locations remain hydraulically connected throughout the year, resultant effects to flow rates, water levels, and water volumes will be equivalent under both scenarios. This document provides a streamflow and lake level assessment for Judge Sissons Lake, its outflow, and the downstream environment under the conditions of continuous effluent release.

1.0 BACKGROUND

Several hydrological characteristics of Judge Sissons Lake make it a preferred location for effluent discharge. First, Judge Sissons Lake is one of the largest lakes in the vicinity of the Kiggavik Project Site, with a total volume of 439,000,000 m^3 and a surface area of 9,550 ha (Golder, 2011). The large waterbody results in a greater assimilative capacity, and consequently, a relatively small change in depth and outflow from effluent discharge. Second, Judge Sissons Lake is relatively deep, with a mean depth of 4.6 m) (Golder, 2011). Accordingly, Judge Sissons Lake provides suitable discharge locations at depth, substantial under-ice volume, and potential to maintain dilution of effluent during winter. Third, Judge Sissons Lake has a large watershed (approximately 705 km^2) (Golder, 2011) and consequently experiences high annual volume yields which make it effective for diluting and exporting treated effluent. And lastly, the Judge Sissons Lake outlet is broad, ranging from about 130 m to 70 m, unconfined, and well armoured with large gravel/cobble/boulder sized material throughout the initial 1.5 km section below Judge Sissons Lake.

During the open water periods of 2007-2010, continuous water level sensors were installed in the outflow channel of Judge Sissons Lake and a number of instantaneous stage and discharge measurements were taken (Golder, 2011) to build stage-discharge curves. An average hydrograph for natural flow conditions at Judge

Sissons Outflow (Figure 1) was created from four years of continuous flow data (2007-2010; Golder, 2011). Sharp fluctuations observed in the average hydrograph at the beginning and end of the open water period are due to differences in the time period for the four datasets; for example, flow on August 24 is an average of all four years while flow on September 2 is derived from 2007 data exclusively. Regardless of these fluctuations, the average hydrograph is characterized by a steep rising limb in mid June, due to the onset of spring melt, reaching peak flow conditions of over 30 m^3/s. 30 m^3/s lies between an estimated 1.01 and 2 year predicted flood frequency (Golder, 2011) and therefore represents near mean conditions. Flow subsequently drops throughout the remainder of the open water season, with discharges typically less than 5 m^3/s in August.

Observations at this site suggest that there is very little to no flowing water during the winter (Golder, 2011; Beak 1992). Therefore, during the winter (mid-September to mid-June), the lake is effectively a closed system, while during the open water period (mid-June to mid-September) it is considered an open system. As effluent can have considerably different physical effects on hydrology in open and closed systems, these two periods are analyzed separately in this assessment.

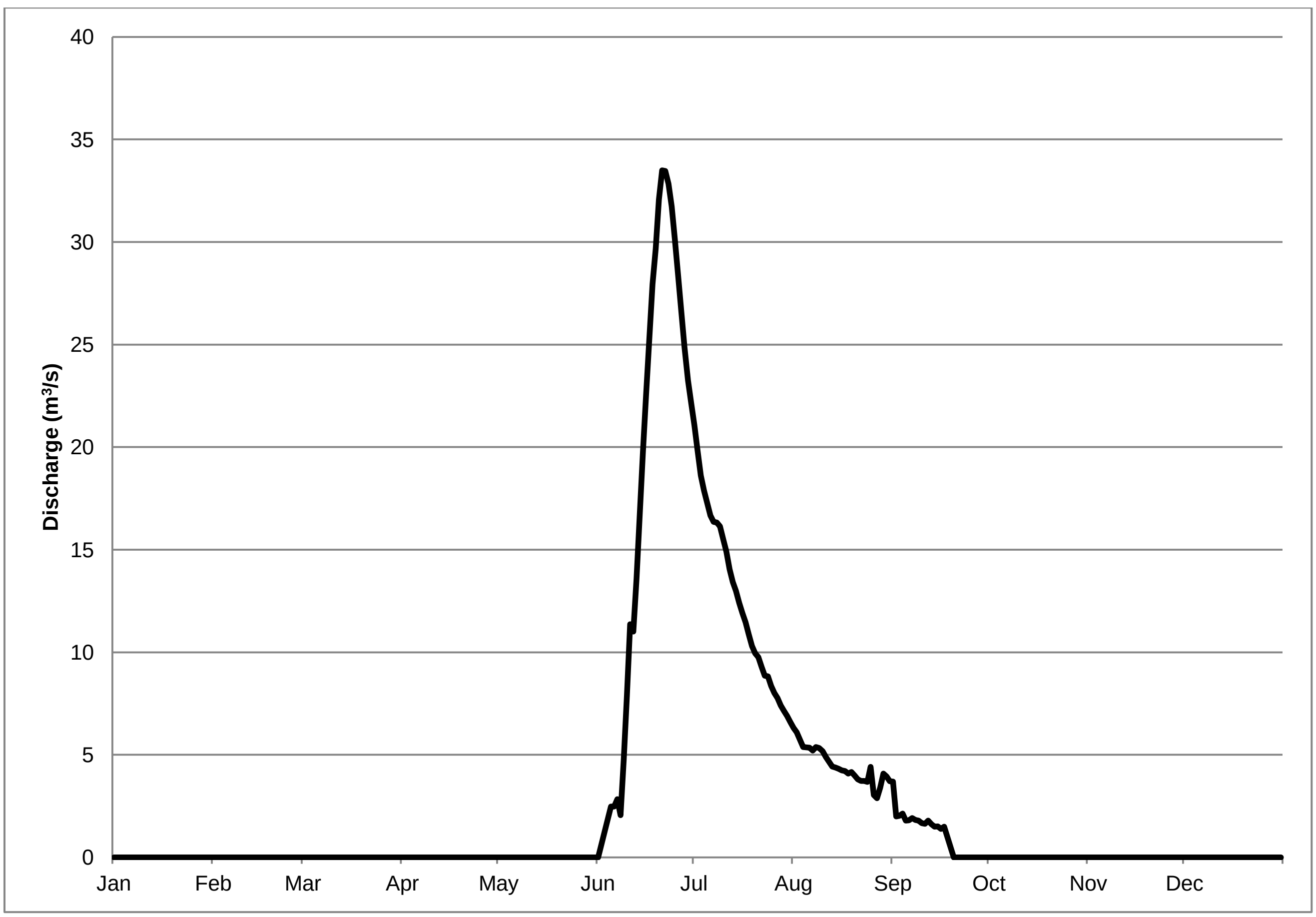

Figure 1: Estimated mean annual hydrograph for Judge Sissons Outflow

Judge Sissons Lake is comprised of three major basins (Figure 2): a northwest basin, a southwest basin, and an east basin with under-ice volumes (assuming 2 m ice thickness) of 771,000 m^3, 9,579,000 m^3, and 271,469,000 m^3, respectively (Figure 3). Because additional bathymetric data were used, the under-ice volumes reported here differ slightly from those in the baseline report. The three basins are separated by ridges less than 1 m deep and are therefore expected to be hydraulically separated for a portion of the year. Modeled ice thicknesses for Judge Sissons Lake exceed 1 m in January (Golder, 2011). Therefore, the basins are predicted to be hydraulically disconnected for the period January through mid-June when ice thickness exceeds 1 m and inflows and outflows are inactive.

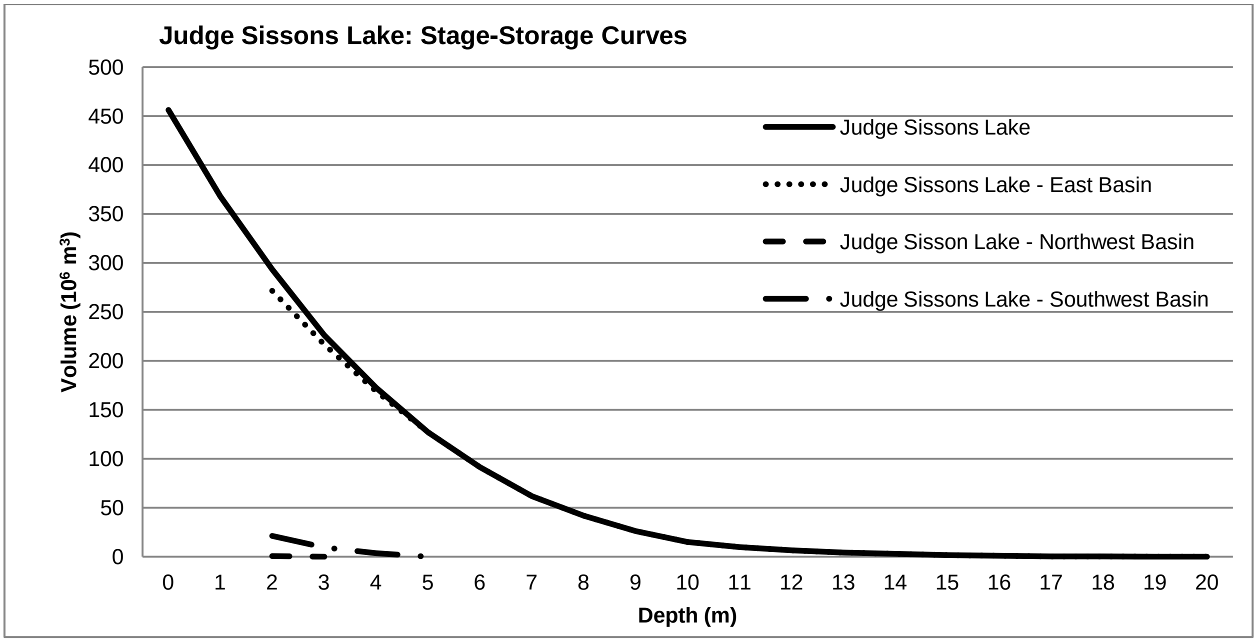

Figure 3: Judge Sissons Lake East Basin stage-storage volume curve

2.0 OPEN WATER SEASON

During the open water season (mid-June to mid-September), effluent can potentially affect both Judge Sissons Outflow channel and Judge Sissons Lake. Effluent discharged into the lake can result in elevated water levels and discharge rates.

2.1 Judge Sissons Outflow Channel

To assess for changes in discharge, the effluent discharge rate of 0.054 m^3/s was added to the average natural flow conditions at Judge Sissons Outflow for the open water period. Under these conditions, effluent consistently accounts for less than 4% of natural discharge and is therefore unlikely to be measureable, particularly during spring freshet when effluent consists of less than 0.5% of the natural discharge (Figure 3).

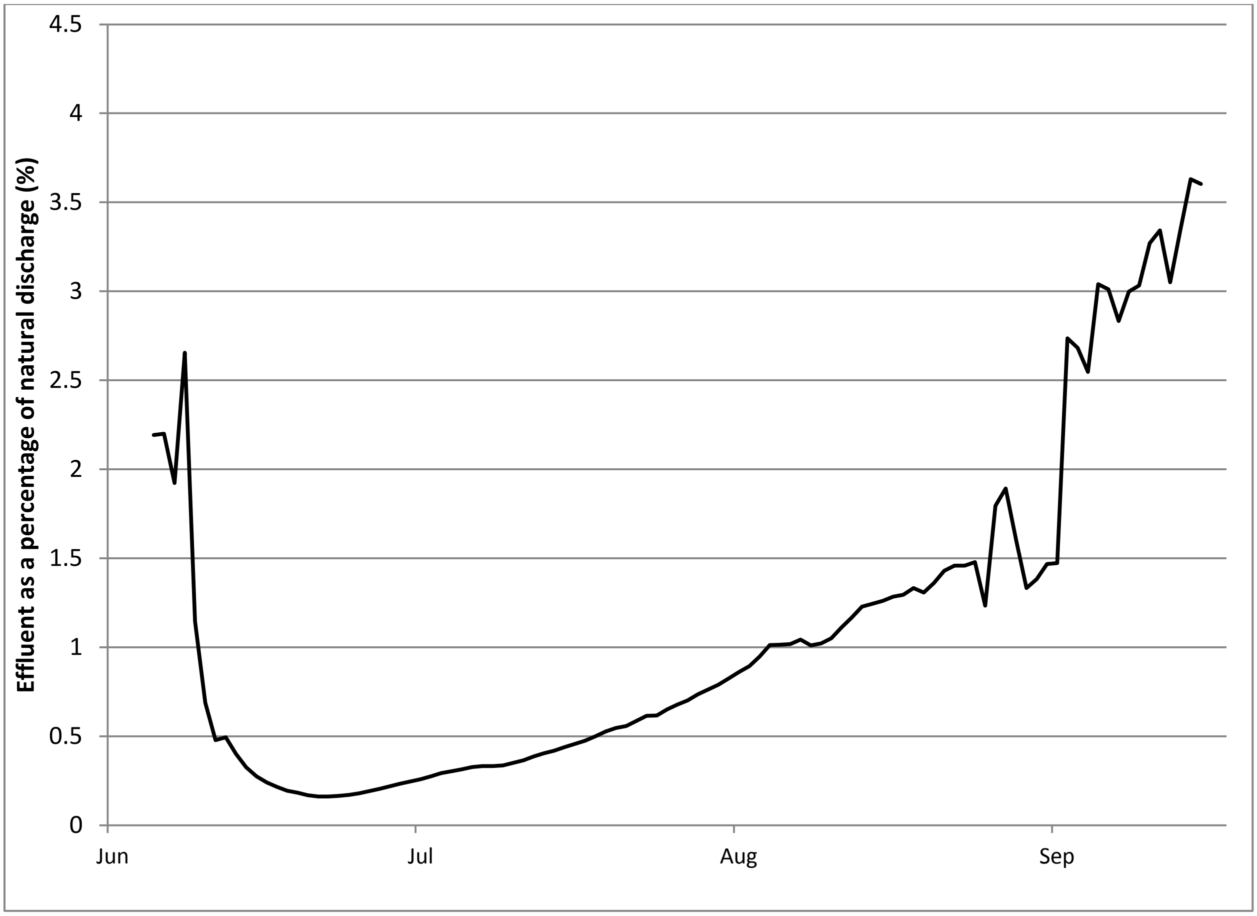

Figure 3: Effluent as a percentage of natural discharge under normal and maximum discharge conditions.

Changes in stream water level were assessed using the Judge Sissons outflow stage-discharge curve developed from twelve coincident measurements taken during baseline studies (Golder, 2011). Effluent discharge results in a predicted increase in stream level of less than 3 mm at Judge Sissons Outflow. As natural inter and intra-annual stream level fluctuations are of the magnitude of 10s of centimetres, this increase is well within natural variability, and not likely measurable. .

2.2 Judge Sissons Lake

Potential effects to the water levels in Judge Sissons Lake are also assessed during the open water period. To evaluate these effects, the relationship between outflow and lake water levels were examined. Nine coincident Judge Sissons Lake discharge and water level measurements were recorded during 2007-2010 baseline studies and were used to develop a lake level-discharge rating curve (Golder, 2011).

Using the Judge Sissons Lake stage-discharge curve and the mean discharge during natural conditions and mean discharge under conditions of effluent release, the lake level is predicted to increase 0.5 mm due to effluent discharge. The predicted increase in lake level is considerably lower than the approximately 50 cm natural fluctuation in water level over an open water season, and not likely measurable.

3.0 WINTER SEASON

During winter, when the natural inflows and outflows from Judge Sissons Lake effectively cease, the lake is considered to be a closed system. Consequently, all the effluent discharged into the lake during this time is stored within the lake.

Judge Sissons Lake is comprised of three basins with divides approximately 1 m deep. According to the modelled and measured ice thickness for Judge Sissons Lake and inflow/outflow rates (Golder, 2011), the basins are predicted to be hydraulically disconnected during January through mid-June when ice thickness exceeds 1 m and inflows and outflows are inactive. Therefore during early winter (mid-September through December), when the basins are hydraulically connected, the effects of effluent discharge are dispersed throughout the lake, while during late winter (January through mid-June), when the basins are hydraulically disconnected, the effects of effluent discharge are concentrated in the east basin.

The hydrological effects of effluent discharge will result in an increase in lake level and volume, with maximum changes observed immediately prior to spring melt. The linear depth-volume relationship for the under-ice uppermost two data points (depth = 2 m and depth = 3 m; Figure) were used to calculate mean volume and level increases immediately prior to spring melt, in each basin under conditions of effluent discharge; results are presented in Table 1.

Table 1: Volume and level changes in Judge Sissons Lake due to effluent discharge

	Increase in under-ice volume (%)	Increase in under-ice water level (cm)
East Basin	0.46	2.18
Northwest Basin	0.17	0.75
Southwest Basin	0.17	0.75

During winter, under ice water level conditions approximately equal to those observed at the time of the bathymetry surveys, the under ice water level increase due to effluent discharge during the winter is estimated at 2.18 cm; this is considerably lower than the approximately 50 cm intra-annual natural fluctuations in lake level. The cumulative discharge over the nine winter months accounts for an increase in under ice volume of approximate 0.46% in the east basin.

4.0 DOWNSTREAM ENVIRONMENT

Potential effects to water quantity from effluent discharge may also exist in the downstream environment. Judge Sissons Lake discharges into the Anigaq River, which passes through Audra Lake and eventually flows into Baker Lake. While Judge Sissons Lake Outflow has an estimated drainage area of 705 km^2, the Anigaq River has an estimated drainage area of 2,740 km^2 (Golder, 2011). The increasing downstream drainage area results in higher natural flow rates and consequently a greater dilution potential and a smaller percentage change in water levels and discharge rates. For example, the mean annual discharge at the monitoring station on the Anigaq River is an estimated 17.1 m^3/s. The effluent discharge rate of 0.0544 m^3/s is a mere 0.3% of the mean annual discharge.

5.0 SUMMARY

The analyses performed in this assessment suggest that effluent discharge at 0.0544 m^3/s is unlikely to pose measureable hydrological effects on Judge Sissons Lake. Moreover, changes due to effluent release, water levels and flow rates are predicted to remain well below the seasonal variability in lake and stream levels, and discharge from the lake. The effects downstream will lessen as the contributing drainage area increases and more natural runoff is generated.

References

Golder Associates Ltd. (Golder). 2011. The Kiggavik Project: Environmental Impact Statement Hydrology Baseline. *Revised Draft Report*.

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TECHNICAL MEMORANDUM

DATE September 30, 2011 **PROJECT No.** 09-1362-0610/8000/8300

TO Nicola Banton/Fredric Guerin
AREVA Resources Canada Inc.

CC

FROM Ashley Dubnick/Brent Topp **EMAIL** ashley_dubnick@golder.com
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ASSESSMENT OF POTENTIAL EFFECTS OF WATER WITHDRAWAL NEAR THE KIGGAVIK PROJECT

Golder Associates Ltd. (Golder) is pleased to present a hydrologic assessment that examines the potential effects of the proposed water withdrawal for the Kiggavik Project (Kiggavik) near Baker Lake, NU. AREVA Resources Canada Inc. (AREVA) plans to develop two sites at this project: the Kiggavik Site and the Sissons Site, both of which will require independent water sources. Preliminary analyses identified Siamese Lake and Mushroom Lake as preferred options for water supply at the Kiggavik and Sissons sites, respectively. This assessment investigates the effects of water withdrawal on water quantity at the two locations and determines whether sufficient water resources are available to meet demands. AREVA has estimated water withdrawal rates for the Kiggavik and Sissons site at 0.0926 m^3/s (8,000 m^3/day) and 0.00868 m^3/s (75 m^3/day), respectively.

1.0 BASELINE CONDITIONS

Hydrographs for streams in the area are typically characterized by a steep rising limb, peaking in mid June due to the onset of spring snowmelt, followed by receding flows for the remainder of the open water period. The inflows and outflows for most lakes in the area cease during the winter months.

1.1 Siamese Lake

Siamese Lake and its outflow were monitored in 2007-2010 during baseline studies. Continuous discharge records were created for Siamese Lake outflow for the open water periods during 2007-2010. Although in 2007 and 2008 discharge was only monitored for the periods August 2 – September 20 and July 24 - September 1, respectively, June peak flows of 2.8 m^3/s and 6.25 m^3/s were captured in 2009 and 2010, respectively. A second peak is observed in early July of 2010, likely due to high summer precipitation rates. The 2009 peak is close to the estimated 1.01 year peak flow (Golder, 2011) and therefore, for the purposes of this assessment, represents an environmentally conservative baseline condition. The baseline hydrograph for Siamese Lake consists of 2009 discharge data for the period June 8- August 25 and 2007 data for August 26 – September 20 (Figure 1). Discharge is predicted to cease by October, and remain at 0 m^3/s until June.

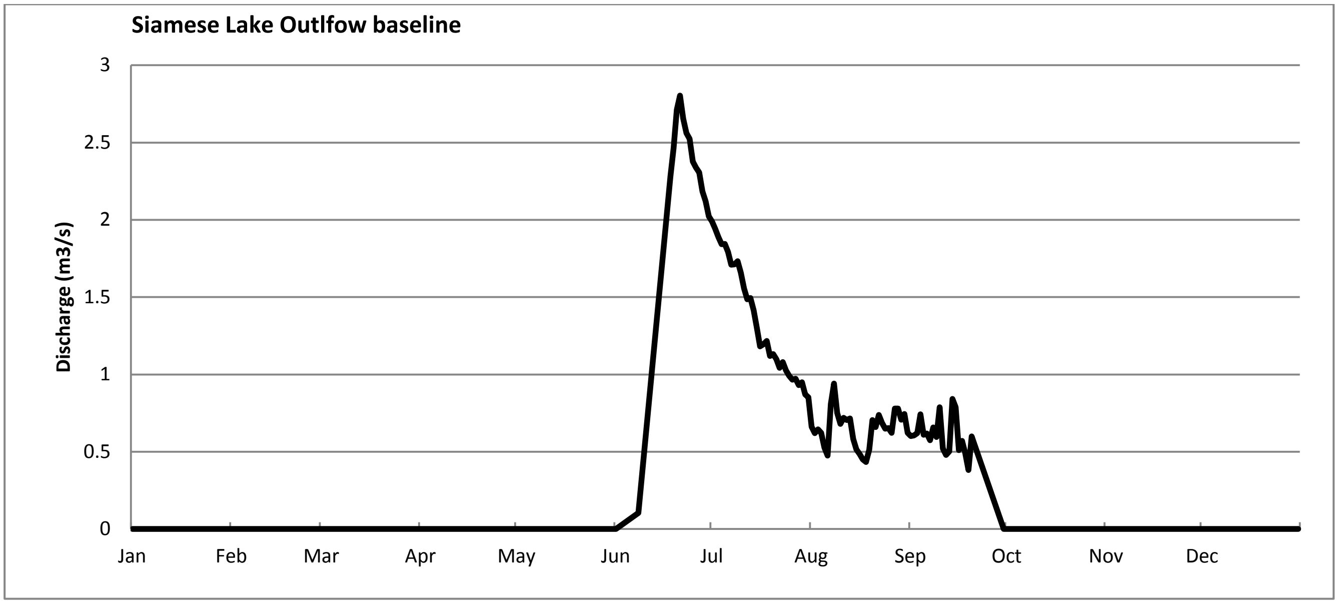

Figure 1: Siamese Lake Outflow baseline discharge

Siamese Lake has an approximate volume of 115,000,000 m^3, and is predicted to fluctuate an estimated 26 cm during an open water season. Siamese Lake is comprised of two basins; an east basin and a west basin. The divide between the two basins has a maximum depth of approximately 2.5 m suggesting that the basins only have potential to become hydraulically disconnected during late in the winter, most likely for example during April and May. Although the mean maximum modeled ice thickness for Siamese Lake is approximately 2 m, with a corresponding west basin under ice volume of 28,000,000 m^3, maximum ice thicknesses are predicted to reach up to approximately 2.5 m (Golder, 2011).

1.2 Mushroom Lake

Mushroom Lake Outflow has an effective drainage area of 4.03 km^2 and therefore has a relatively small basin yield of approximately 946,080 m^3/year. Although continuous discharge was not monitored at Mushroom Lake Outflow, six instantaneous discharge measurements were collected in 2009 and 2010, with a maximum flow of 0.34 m^3/s measured in mid June 2010; this value is between an estimated 1.01 year (0.21 m^3/s) and a 2 year (1.10 m^3/s) peak discharge and thus represents close to mean conditions. Discharge at Mushroom Lake Outflow was observed at 0.02 m^3/s in July and August of 2009, and like all other small streams in the area, reaches near zero flow in early-mid July until the following spring freshet. The rising limb of small streams such as that from Mushroom Lake typically lasts less than a week. These predicted flow characteristics for Mushroom Lake Outflow were used to create a hypothetical hydrograph for the stream, with a steep rising limb, occurring over a period of approximately 5 days, a peak discharge of 0.21 m^3/s, and falling limb resulting in near zero flow by early July.

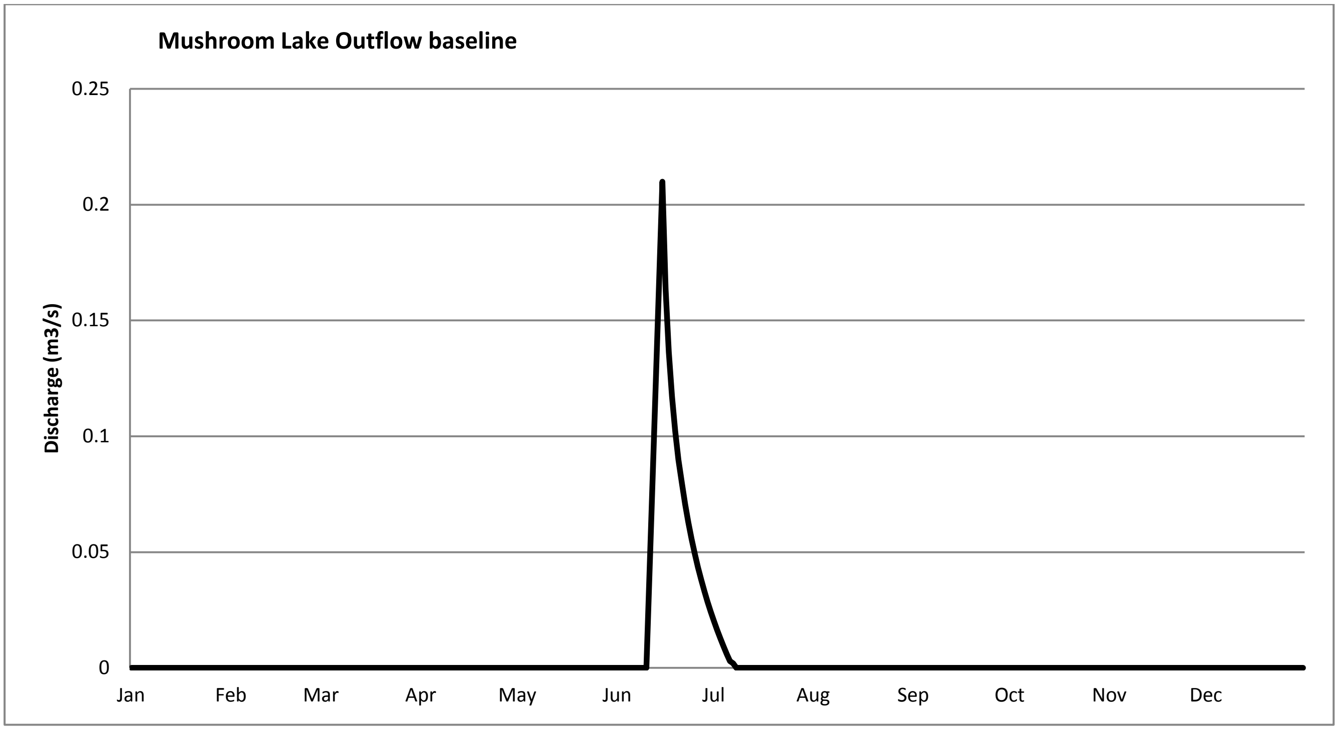

Figure 2: Mushroom Lake Outflow baseline discharge

Mushroom Lake has an approximate volume of 587,000 m^3. According to the lake-stage discharge curve established during baseline studies and hypothetical mean discharge record (Figure 2), Mushroom Lake is predicted to fluctuate approximately 20 cm during an open water season. Ice thickness is predicted to reach a mean maximum thickness of approximately 2 m by May, with a corresponding under ice volume of 284,000 m^3.

2.0 METHODS

Discharge from Siamese and Mushroom Lakes is seasonal; during winter months, the inflow and outflow channels freeze to the bed and flow ceases, while during summer months the channels are active (Figure 1; Figure 2). Lake levels respond to inflow and outflow characteristics, and consequently, this analysis examines summer conditions and winter conditions separately.

Summer conditions are applied when lake discharge is less than the corresponding withdrawal rate. Consequently, summer conditions are applied to Siamese Lake for June through mid September while summer conditions are applied to Mushroom Lake for the month of June. During the summer season, changes in lake level were calculated using the lake elevation-outflow rating curve produced during baseline studies (Golder, 2011). Changes in discharge were predicted by superimposing the water withdrawal rates on the discharge record.

In this study, winter conditions are applied for the remainder of the year when the lakes are effectively closed systems. Under a closed-system, water supplies are provided by lake storage exclusively and thus lake levels will continually decrease until spring when inflow replenishes water supplies. Water withdrawal during winter is typically permitted to be 10% of under-ice volume for lakes that have a depth of at least 1.5 m during maximum ice thickness (DFO, 2010). Therefore, for winter conditions, cumulative water withdrawal is calculated as a percentage of under-ice volume and the resultant drop in under-ice water level is estimated using bathymetric data and ice thickness models as presented in Golder (2011). The two basins of Siamese Lake are assumed to separate for April and May and effects from water withdrawal during this time are only compounded in the west basin.

3.0 RESULTS

3.1 Siamese Lake

If steady state conditions are reached in Siamese Lake, natural discharge rates will decrease by a maximum of 0.0926 m^3/s (Figure 3). During the period June through September, withdrawal rates may result in a decrease of approximately 3% in peak discharge rates and approximately 20% during low discharge rates in the fall.

During summer while Siamese Lake inflows and outflow are active, lake levels will be moderated by through-flow. During this time, changes in lake level due to water withdrawal are estimated to reach 2 cm. During winter, when Siamese Lake is effectively a closed system, cumulative water withdrawal (196,000 m^3) is predicted to reach a maximum of 3% of the under ice volume over the entire lake immediately prior to spring melt. If the east and west basins of Siamese Lake become disconnected during the winter and withdrawal occurs from the west basin exclusively during April and May, withdrawal reaches a maximum of 4% of the under ice volume in the west basin. This estimate is environmentally conservative in that it assumes that the two basins are disconnected for the entire winter season, which is unlikely the case.

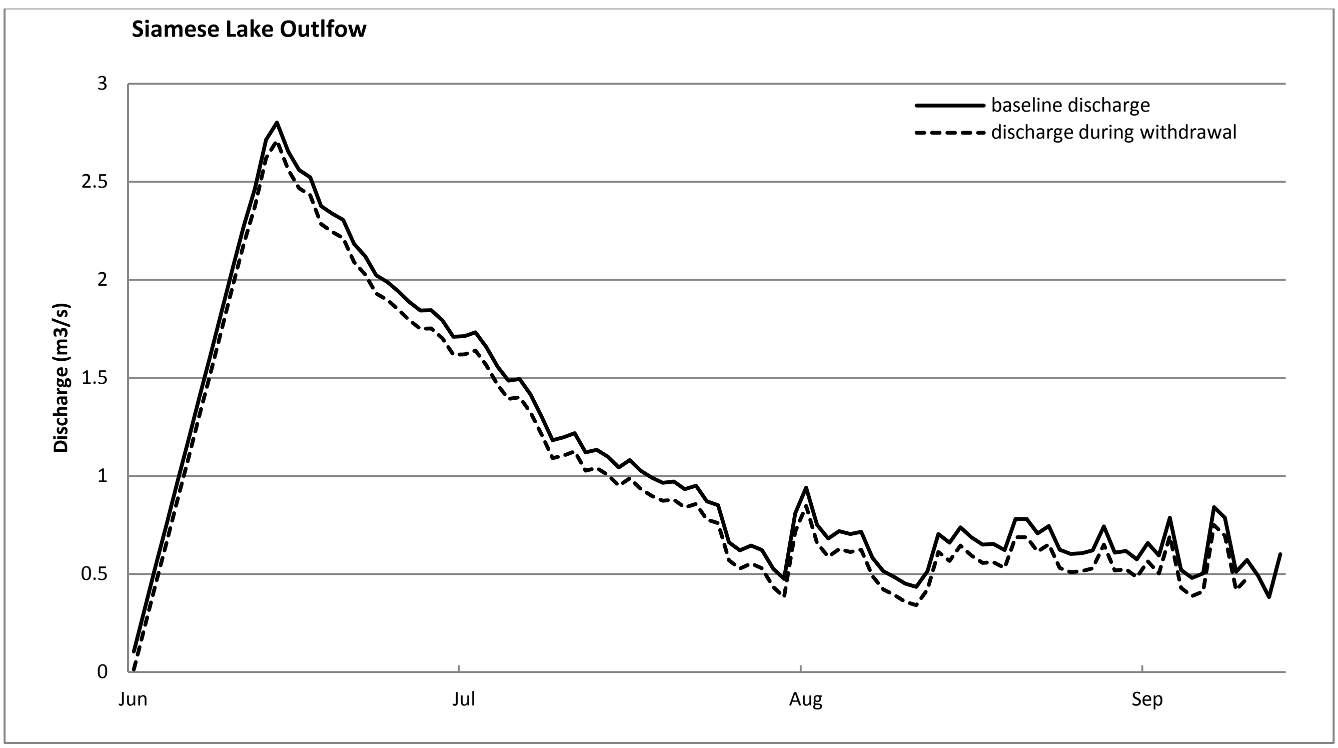

Figure 3: Siamese Lake Outflow during summer water withdrawal

3.2 Mushroom Lake

If steady state conditions are reached in Mushroom Lake, natural discharge will decrease by a maximum of 0.000868 m^3/s (Figure 4). A withdrawal rate of 0.00868 m^3/s is approximately 0.08% of the peak discharge at Mushroom Lake Outflow. While inflows and outflows are active, withdrawal is predicted to result in a 2 mm change in lake level from natural levels.

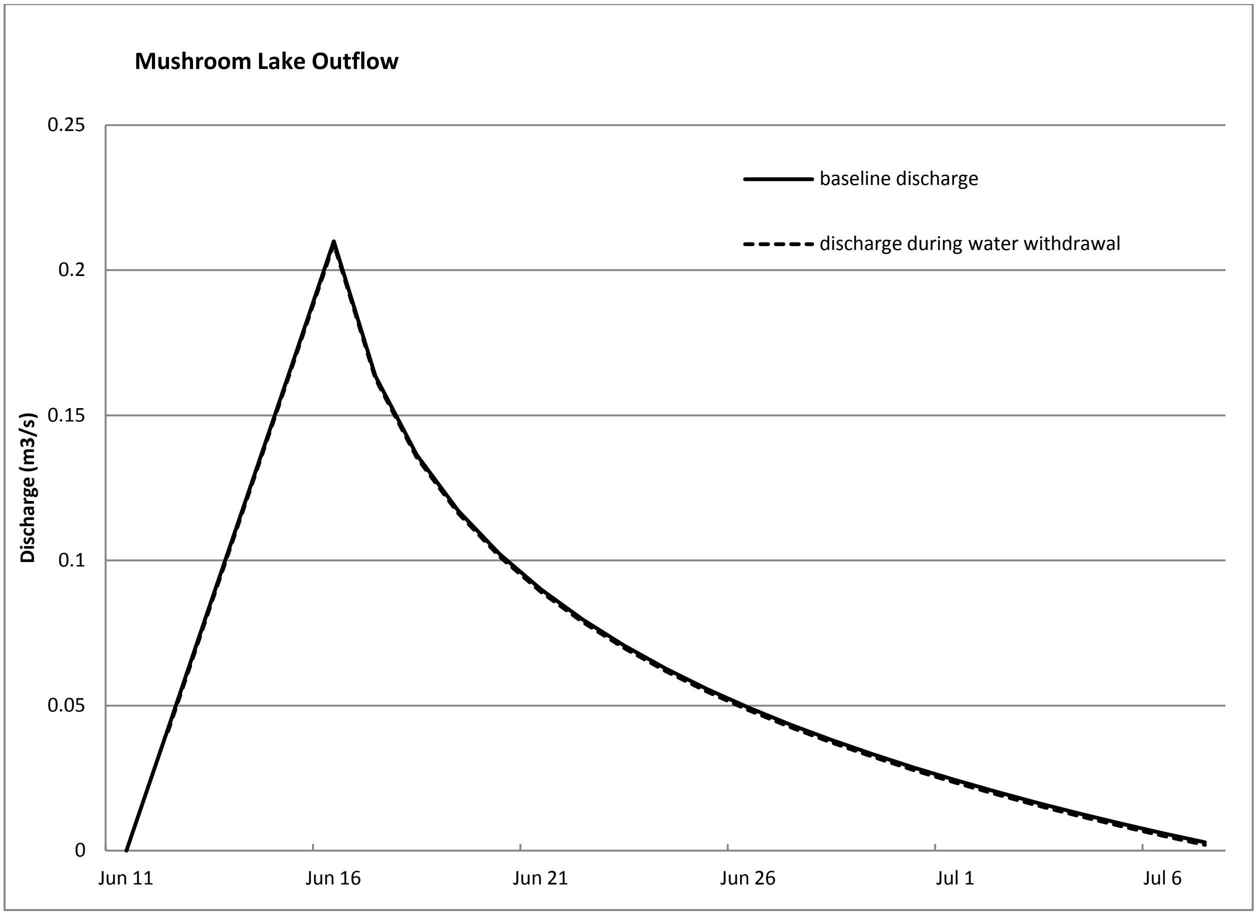

Figure 4: Mushroom Lake Outflow during summer water withdrawal

For July though May, Mushroom Lake is effectively a closed system. Cumulative water withdrawal is 25,125 m^3, which is 4% of the total volume and 9% of the approximate late-winter under-ice volume.

4.0 SUMMARY

Predicted effects of water withdrawal at Siamese Lake and Mushroom Lake remain below 10% of the estimated under ice volumes. Table 1 provides a summary of effects to discharge rates, water levels, and waterbody volumes.

Table 1: Water withdrawal effects to water levels, discharge rates, and waterbody volumes during mean conditions

	Siamese Lake	Mushroom Lake
Maximum change in discharge (m^3/s)	-0.0926	-0.000868
Maximum change in water level during the active flow period (cm)	2	0.2
Maximum change in under-ice volume (%)	4	9

5.0 REFERENCES

AREVA Resources Canada Inc. (AREVA). 2008. The Kiggavik Project: Project Proposal.

Fisheries and Oceans Canada (DFO). 2010. DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut.

Golder Associates Ltd. (Golder). 2011. The Kiggavik Project: Environmental Impact Statement Hydrology Baseline. *Revised Draft Report*.

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TECHNICAL MEMORANDUM

DATE September 30, 2011 **PROJECT No.** 09-1362-0610

TO Nicola Banton
Areva Resources Canada Inc

CC Brian Christensen

FROM Ashley Dubnick/Brent Topp **EMAIL** ashley_dubnick@golder.com
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HYDROLOGICAL ASSESSMENT ON THE DOWNSTREAM EFFECTS OF SITE RUNOFF AND DIVERSIONS

AREVA Resources Canada Inc (AREVA) is currently exploring the development of the Kiggavik Project (the Project) near Baker Lake, Nunavut. The Project includes two mine development sites and associated site footprint areas. Both the Kiggavik Site and the Sissons Site have detailed water management plans which are designed to minimize the amount of fresh water that comes in contact with the developed areas, and thus limiting potential effects on water quantity and quality, sedimentation and erosion, fish and fish habitat. A key feature of the water management plan is diversion channels which have been designed to collect and divert freshwater runoff generated from upstream drainage areas around the sites. Diverted water is reintroduced to the same pre-development channels to maintain streamflow connectivity within the drainage area that development occurs. A second element involves the collection of runoff within the project footprint that has come in contact with site features such as clean waste rock, where runoff may contain elevated suspended solids but is otherwise uncontaminated. This runoff from the waste rock pile is collected in perimeter channel and routed to sedimentation pond to settle solids prior to the water entering the downstream drainage system. As clean waste rock piles comprise a substantial portion of the surface area with each footprint, the collection and release from these sources helps maintain the downstream flow regime. Runoff generated from areas within the footprint that could be contaminated will be treated and released to Judge Sissons Lake.

Figure 1 and 2 indicate the three water management strategies associated with the project footprints:

a) Diversion Channel or natural drainage (D/N): water from upstream drainage areas will either follow its natural drainage pattern or will be collected and diverted around the site and immediately re-introduced to natural drainage pathways. Although diversion channels have been designed to maintain natural drainage patterns, small portions of some sub-basins and thus effective drainage areas may be altered.
b) Clean Waste Rock Channel/Sedimentation Pond (WR/SP): Runoff from the clean waste rock piles will be collected in a constructed perimeter channel, pass through the sedimentation ponds, and be released immediately downstream. Water passed through sedimentation ponds may affect water quantity by somewhat attenuating flows due to a longer flowpath through the collection ditches and residence time in the sedimentation pond. Ponds may fill during high flow periods and be discharged during low flow periods, which will attenuate flows originating in the clean waste rock areas. Although these flows may

also be subject to higher evaporative losses while stored in the sedimentation ponds, a control structure at the pond outlet will reduce residence times when appropriate, and thus help to minimize these losses.

c) Water Treatment Plant (WTP): water from these drainage areas will be collected, passed through the water treatment plant, and release at Judge Sissons Lake. Water passed through the water treatment plant can affect water quantity between the sites and Judge Sissons Lake by removing runoff from the drainage area and reintroducing these flow further downstream in Judge Sissons Lake.

Table 1 indicates the total D/N, WR/SP and WTP water management strategy areas corresponding with the four drainage areas within or adjacent to the Kiggavik footprint area and two drainage areas which encompass the Sissons Site.

Table 1: D/N, SP and WTP water management areas associated with the Kiggavik and Sissons watersheds

	Natural drainage area (km²)[1]	Modified drainage area (km²)					Change in effective drainage area[7] (%)	Percent WR/SP[8] (%)
		WTP[2]	WR/SP[3]	D/N[4]	Total[5]	Effective drainage area[6]		
Kiggavik Site								
Watershed 1	10.9	2.2	1.5	9.2	12.9	10.7	-2	14
Watershed 2	1.6	0.0	0.0	0.9	0.9	0.9	-44	0
Watershed 3	1.2	0.0	0.0	0.8	0.8	0.8	-33	0
Watershed 4	1.5	0.0	0.0	1.1	1.1	1.1	-27	0
Pointer Lake Outflow	79.1	2.2	1.5	76.9	80.6	78.4	-1	2
Sissons Site								
Watershed 1	8.2	0.5	0.0	7.4	7.9	7.4	-10	0
Andrew Lake Outflow	33.7	0.9	1.3	31.5	33.7	32.8	-3	4

[1] Drainage area associated with watershed boundaries prior to site development
[2] Area of the modified watershed in which water reports to the WTP
[3] Area of the modified watershed in which water reports to the WR/SP
[4] Area of the modified watershed in which water reports to D/N
[5] Total area of the modified watershed
[6] Total area of the modified watershed minus area reporting to WTP
[7] Percent change from natural drainage area to modified effective drainage area
[8] Percent of the modified effective drainage area reporting to the WR/SP

According to Figure 1 and Table 1, portions of Kiggavik Watersheds 1 to 4 are modified by project activities. Although the total area associated with Kiggavik Watershed 1 increases from 10.9 km^2 to 12.9 km^2, part of this area reports to the WTP, leaving a 2% decrease in effective drainage area. Fourteen percent of the runoff generated in this watershed reports to the WR/SP, suggesting that this portion of the basin yield may undergo attenuation while stored in the WR/SP. However, downstream at Pointer Lake Outflow, there is only a 1% reduction in effective drainage area and thus basin yield. Of the remaining basin yield, only 2% will be subject to attenuation effects or a very small increase in evaporation losses while stored in the WR/SP.

Kiggavik Watersheds 2, 3, and 4 will experience a reduction in effective drainage area of between 27-44%. All flow in the remaining modified effective drainage area will experience natural or diverted flow and none will be routed through WR/SP and will therefore none will be subject to attenuation.

According to Figure 2 and Table 1, Sissons watershed 1 will experience a reduction in effective drainage area of 10%, of which none of the remaining flow will be routed through WR/SP and therefore be subject to evaporation or attenuation. Similarly, the watershed associated with Andrew Lake Outlfow, there is a 3% reduction in effective drainage area, suggesting that this stream will experience a 3% reduction in basin yield. Of the remaining flow through Andrew Lake Outflow, 4% is subject to attenuation processes or small increases in evaporation while routed through the WR/SP.

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