March 14, 2019

Dana Pandolfi, Project Officer
Wastes and Decommissioning Division
280 Slater Street
P.O. Box 1046, Station B
Ottawa, Ontario
K1P 5S9

Dear Dr. Lange:

Re: Serpent River Watershed Monitoring Program – Year Four of Cycle 4

Denison Mines Inc. and Rio Algom Limited are pleased to submit one copy of the Serpent River Watershed Monitoring Program Year Four of Cycle 4 Annual Water Quality Report for 2018.

If you have any questions or comments, please do not hesitate to contact the undersigned.

Yours very truly,

Denison Mines Inc.

Janet Lowe,
General Manager

Rio Algom Limited

David Hewitt,
Site Superintendent Elliot Lake

cc: Distribution List

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Denison Mines

Rio Algom

Serpent River Watershed Monitoring Program
2018 Annual Water Quality Report

Submitted to the
Canadian Nuclear Safety Commission
March 31, 2019

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1 INTRODUCTION

As part of the closure and decommissioning process, Rio Algom Limited (RAL) and Denison Mines Inc. (DMI) developed a focused and integrated performance monitoring network for legacy sites within the Serpent River Watershed (SRW). The comprehensive monitoring and management strategy clearly defined and delineated the purpose for all monitoring activities through three integrated programs; the Tailings Management Area (TMA), the Operational Monitoring Program (TOMP), the Source Area Monitoring Program (SAMP), and the Serpent River Watershed Monitoring Program (SRWMP) (Minnow Environmental Inc. (Minnow), 2016). An integrated assessment of the results from all of these programs is prepared every five years in a *State of the Environment Report* (SOE) in compliance with license requirements and in accordance to Canadian Standards Association (CSA) N288.4-10 (2010). The regulatory review draft of the most recent SOE covering data collection and monitoring for the period of January 1, 2010 – December 31, 2014 was issued to the Canadian Nuclear Safety Commission (CNSC) as well as other members of the Joint Regulatory Review Group (JRG) on March 10, 2016 with response to regulatory comments issued September 30, 2016. The final SOE report with regulatory approval was distributed in November 2017.

The SRWMP was initiated in 1999 as a joint initiative of RAL and DMI with the objectives of evaluating the effectiveness of mine decommissioning plans and assessing long-term environmental quality trends in the watershed (Beak International Incorporated (Beak), 1999). Evolution of the program, key outcomes, program modification decisions, and associated references are summarized in Appendix I. In 2018, the SRWMP followed the 2016 approved program modifications recommendations described in the document submission entitled *Cycle 4 Study Design for the SRWMP, SAMP and TOMP* (Minnow, 2016).

The SRWMP Annual Water Quality Report for 2018 provides water quality data from shared RAL and DMI watershed monitoring locations from January 1, 2018 through December 31, 2018. This report should be read in conjunction with the Annual Operating, Care and Maintenance (OCM) reports prepared independently by each company, that incorporate upstream SAMP and TOMP data, and discuss operational activities of each company (RAL, 2019; DMI, 2019). The objective of the SRWMP annual data review is to identify anomalous data and provide visual evaluation of short-term data trends at key locations. Step changes and anomalies are identified in this report by reviewing and compiling the last five years of annual average data for all SRWMP monitoring locations, and visually reviewing the information for any noticeable changes. Significant changes and unusual results are investigated in accordance with the *Water Quality Assessment and Response Plan*, which is found in Appendix A of the most recent SOE Report (Minnow, 2017).

The SRWMP Annual Water Quality Report for 2018 also provides a summary of the quality management program and water quality results for the period January 1, 2018 through December 31, 2018.

As part of the 2015 SOE review, CNSC instructed RAL and DMI to include annual reporting of a representative radiation dose to the public associated with their closed uranium mine sites in the Serpent River Watershed. Details on this topic are included in Section 4.4 of this report.

2 METHODOLOGY

2.1 2018 Program Requirements

The 2018 SRWMP followed program requirements (sampling locations, frequencies, parameters, and analytical protocols) as recommended and approved in the *Cycle 4 Study Design for the SRWMP, SAMP and TOMP* (Minnow, 2016) as well as Certificate of Approvals issued by the

Ministry of Environment, Conservation and Parks (MECP), formerly the Ministry of Environment (MOE), for Nordic (Certificate of Approval #2382-7WBGN5, 2009) and Stanrock (Certificate of Approval #4-0067-74-766, 2009). Table 2.1 provides a brief description of each monitoring location, the frequency and parameters monitored, as well as non-regulatory parameters, and Figure 2.1 provides a map of the stations included in the water quality monitoring program.

Table 2.1 2018 SRWMP Water Quality Monitoring Requirements

Sampling Station	Location / Description	Sample Type	Purpose	Flow (L/s)	Field pH	Sulphate (mg/L)	Radium-226 (Bq/L total)	Urnaium (mg/L)	Barium (mg/L)	Cobalt (mg/L)	Iron (mg/L)	Manganese (mg/L)	Hardness[3] (mg/L)
SR-16[2]	Fox Creek at Highway 108	Wetland/stream reference	SAMP		4	4	4	4	4	4	4	4	4
SR-17[2]	Unnamed Creek Drain Lake 3 @ Hwy 108	Wetland/stream reference	SAMP		4	4	4	4	4	4	4	4	4
SR-18	Outlet of Jim Christ Lake	Lake reference	SRWMP		2	2	2	2	2	2	2	2	2
SR-19	Inlet to Elliot Lake	Lake reference	SRWMP		4	4	4	4	4	4	4	4	2
SR-08	Nordic Lk Outlet	far field	SRWMP & MOE		4	4	4	4	4	4	4	4	4
SR-15	May Lake Outlet	far field	SRWMP/ Internal	2	2	2	2	2	2	2	2	2	2
M-01[1]	Sherriff Ck @ Hwy 108	near field	SRWMP		4	4	4	4	4	4	4	4	4
Q-09	Serpent River Below Q Effluent	near field	SRWMP	4	4	4	4	4	4	4	4	4	4
Q-20	Evans Lk Outlet to Dunlop Lk	near field	SRWMP	1	1	1	1	1	1	1	1	1	1
SC-01	Westner Lk Outlet	near field	SRWMP&MOE		1	1	1	1	1	1	1	1	1
SR-06	McCabe Lk Outlet	near field	SRWMP	2	2	2	2	2	2	2	2	2	2
FBR5	Field Blank Rio	QA/QC	SRWMP		2	2	2	2	2	2	2	2	2
BSR5	Blind Sample Rio	QA/QC	SRWMP		2	2	2	2	2	2	2	2	2
Rio Algom total excluding field blanks & blind samples				**9**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**30**
D-4	Dunlop Lk Outlet	Lake reference	SRWMP		2	2	2	2	2	2	2	2	2
D-5	Serpent R. between Q and D	near field	SRWMP	4	4	4	4	4	4	4	4	4	4
D-6[1]	Cinder Lk Outlet	near field	SRWMP	4	4	4	4	4	4	4	4	4	4
DS-18	Halfmoon Lk Outlet	near field	SRWMP&MOE	4	4	4	4	4	4	4	4	4	4
SR-01	Quirke Lk Outlet	far field	SRWMP		1	1	1	1	1	1	1	1	1
FBD2	Field Blank Denison	QA/QC	SRWMP		2	2	2	2	2	2	2	2	2
BSD2	Blind Sample Denison	QA/QC	SRWMP		2	2	2	2	2	2	2	2	2
Denison total excluding field blanks & blind samples				**12**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**
Total QA/QC samples				0	8	8	8	8	8	8	8	8	8
TOTAL SAMPLES				**21**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**45**
QA/QC Fraction of Total				0%	17%	17%	17%	17%	17%	17%	17%	17%	18%
Denison Fraction of Total				57%	32%	32%	32%	32%	32%	32%	32%	32%	33%

Notes

1. Field QA-QC designated stations.
2. SR-16 and SR-17 are part of SAMP program Cycle 4 but are historically SRWMP locations.
3. Hardness is an ancillary parameter used to assess Mn and SO4 as both parameters are hardness dependent (BCMOE, 2006, 2013)

Figure 2.1

Serpent River Watershed Monitoring Program

Water Sample Collection Locations
February 2018

SR18 Christman Lake
Semiwite Lake
Ten Mile Lake
639
PANEL TMA
Rochester Lake
Q09
QUIRKE TMA
D5
Dunlop Lake
Evans Lake
Q20
Quirke Lake
SR01
DENISON TMA 1,2
D4
D6
Cinder Lake
SPANISH AMERICAN TMA
STANROCK TMA
108
Bear Lake
Halfmoon Lake
DS18
Arm of the Bear Lake
SR-17
SR06
Whiskey Lake
May Lake
STANLEIGH TMA
McCabe Lake
SR-15
Gullbeak Lake
MILLIKEN TMA
Sheriff Lake
Canyon Lake
Hough Lake
SR19
M01
LACNOR TMA
Elliot Lake
Horne Lake
SC01
Westner Lake
NORDIC TMA
Serpent River
Pecors Lake
Quimby Lake
Nordic Lake
Esten Lake
SR08
Depot Lake
Trout Lake
McCarthy Lake
Marshland Lake
Grandeur Lake
CITY OF ELLIOT LAKE
TOWNSHIP OF THE NORTH SHORE
Tweedle Lake
Shedden Lake
TOWN OF SPANISH
Camp Lake
SR-16
PRONTO TMA
17
Grassy Lake
North Channel (Lake Huron)
Serpent River First Nation

0 1 2 5 km.
SCALE

N
W E
S

- Tailings Management Areas (TMA).
- Exposure Lakes (included in SRWMP).
- Reference Lakes (included in SRWMP).
- Water Sample Location (Exposure).
- Water Sample Location (Reference).
- Direction of flow.
- Exterior limit of the Serpent River Watershed.

\2005\205-018\srwmp\2018\srwmp2018-1

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2.2 2018 Program Conformance

All Cycle 4 approved sampling, field measurement, and analytical requirements were met during the 2018 reporting period. Hardness continues to be monitored as an ancillary parameter at all SRWMP stations. According to the most recent Ambient Water Quality Guidelines from the British Columbia Ministry of Environment (BCMOE), manganese and sulphate are hardness dependent (BCMOE, 2006, 2013). Semi-annual response monitoring also continued downstream at the outlet of May Lake (SR-15) effective January 1, 2016. In 2018, response monitoring was also performed at the outlet of McCabe Lake (SR-06) and the outlet of Pecors Lake (SR-03). Response monitoring is discussed in further detail in Section 4.1.

2.3 Field Measurements

Field measurement requirements and protocols for the 2018 SRWMP are presented in detail in the *Cycle 4 Study Design for the SRWMP, SAMP and TOMP* (Minnow, 2016). Field Staff have been thoroughly trained and have reviewed procedures associated with the proper calibration and use of field equipment for the measurement of field parameters. The models and accuracy for equipment used in measuring SRWMP field parameters are provided in Table 2.3.

Table 2.3 SRWMP Field Equipment Models and Accuracy

Parameter	Meter	Accuracy	Unit
pH	YSI Pro 10	+/- 0.02	pH units
flow	Global Flow Probe	0.1	feet per second

2.4 Data Quality Objectives

Field and laboratory data quality objectives (DQOs) for the 2018 SRWMP are presented in detail in the *Cycle 4 Study Design for the SRWMP, SAMP and TOMP* (Minnow, 2016). Table 2.4.a. provides a summary of field DQOs and Table 2.4.b. provides a summary of laboratory methods, detection limits and DQOs.

Data quality assessment results are covered in Section 3 of this report.

Table 2.4.a. 2018 SRWMP Field Data Quality Objectives

Parameter	Units	Assessment Criteria [1]		Data Quality Objectives[2]			
		PWQO BCMOE	Background	Detection Limit	Minimum [3] Detectable Difference	Field Blank Criteria	Field Precision
Field Parameters[3]							
Flow	L/s	-	-	method	method	-	30%
pH				0.1	0.01 or 0.02	-	10%
Lake Stations		6.5	-				
Wetland/Streams		-	5.2				
Laboratory Parameters							
Barium	mg/L	1.0	-	0.005	-	0.01	20%
Cobalt	mg/L	0.0025	-	0.0005	-	0.001	20%
Iron	mg/L	-	-		-		
Lake Stations		-	0.49	0.02	-	0.04	20%
Wetland/Streams		-	1.69	0.02	-	0.04	20%
Manganese [4]	mg/L	0.8	-	0.002	-	0.004	20%
Radium (total)	Bq/L	1.0	-	0.005	-	0.01	20%
Sulphate [4]	mg/L	128-429	-	0.1	-	0.2	20%
Uranium	mg/L	0.015	-	0.0005	-	0.001	20%
Hardness	mg/L	-	-	0.5	-	1.0	20%

Notes:

1. Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)
2. Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)
3. Minimum detectable difference as identified in instrument manual
4. Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

Table 2.4.b. 2018 SRWMP Laboratory Methods and Data Quality Objectives

Parameter	Units	Assessment Criteria [1]		Method	Laboratory Data Quality Objectives[2]				
		PWQO BCMOE	Background		Detection Limit	Laboratory Blank	Precision	Spikes	Accuracy (CRM)
Barium	mg/L	1.0	-	ICP-MS	0.005	0.01	10%	20%	20%
Cobalt	mg/L	0.0025	-	ICP-MS	0.0005	0.001	10%	20%	20%
Iron	mg/L	-		ICP-OES					
Lake Stations			0.49		0.02	0.04	10%	20%	20%
Wetland/Streams			1.69		0.02	0.04	10%	20%	20%
Manganese [3]	mg/L	0.8	-	ICP-MS	0.002	0.004	10%	20%	20%
Radium (total)	Bq/L	1.0	-	Alpha Spectroscopy	0.005	0.01	20%	20%	-
Sulphate [3]	mg/L	128-429	-	Ion Chromatography	0.1	0.2	10%	20%	20%
Uranium	mg/L	0.015	-	ICP-MS	0.0005	0.001	10%	20%	20%
Hardness	mg/L	-	-	ICP-OES	0.5	0.1	10%	-	-

Notes:

1. Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)
2. Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)
3. Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

2.5 Changes in Analytical Methods

There were no changes in analytical methodology in 2018.

2.6 Reporting of Method Detection Limits

Program method detection limits (MDLs) are presented in Tables 2.4.a. and 2.4.b. The target MDL for radium-226 (0.005 Bq/l) was not met on all samples analysed in 2018 due to decreased sample throughput of the analytical laboratory. There was no change in method during this period; however, the laboratory was only able to claim an MDL of 0.007 Bq/L as a result of a higher standard deviation on the previous year's QC samples.

2.7 Data Screening and Assessment Conventions

Data validation was conducted on SRWMP water quality data throughout the year. The assessment-screening process flags all data points outside a rolling minimum 12 value mean $\pm$ 3 standard deviations.

Flagged data and short-term response plans for the SRWMP are reported quarterly to the regulatory agencies as part of the water quality report. Data validation of "flagged data" for the year 2018 can be found in Appendix II.

Annual water quality reporting is designed to be concise and focused on the presentation of data in a standardized format with limited interpretation, as per Section 14.2 of the Implementation Document (Beak, 1999c). Data validation ensures prompt response to upset conditions or unusual results, as documented in *Data Validation Procedures* in conjunction with *Water Quality Assessment and Response Plan*, which is included in Appendix B of the SOE (Minnow, 2017). Assessment criteria as outlined in Table 2.4.a. and 2.4.b. of this report, are standardized to approved benchmarks selected, rationalized and presented in Tables 4.3 and 4.5 of the *Cycle 4 Study Design for the SRWMP, SAMP and TOMP (*Minnow, 2016*).*

Approved program modifications implemented in January of 2015 focused water quality monitoring on lakes located immediately downstream of the decommissioned TMAs. A more in-depth and detailed statistical evaluation of water quality trends is included in the SOE every five years (Minnow 2009, 2011, 2017).

A SRWMP location summary of all annual average concentrations is reviewed and compared to assessment criteria in this report in Table 3.2. In addition, the most recent five-year annual concentrations of mine indicator parameters at key downstream locations are reviewed in this report in Figures 3.1.a to 3.1.c. Detailed statistical analysis of the SRW water quality reported between January 1, 2010 – December 31, 2014 is included in Appendix E of the final SOE Report issued to the CNSC and other members of the JRG in November 2017.

3 RESULTS

3.1 Data Quality Results and Assessment

Detailed laboratory quality assurance and quality control (QA/QC) results are provided in Appendix III, and detailed field QA/QC results are provided in Appendix IV. Field quality control results are summarized in Table 3.1. Data quality assessments for each type of data quality objective are provided in the following sections.

3.1.1 Laboratory Quality Assurance and Quality Control

In 2018, all analytical requirements for the SRWMP were contracted to laboratories with Canadian Association for Laboratory Accreditation Inc. (CALA) accreditations. Detailed laboratory QA/QC results are provided in Appendix III. The 10% objective for QA/QC was met by both labs. SGS performed 8703 analyses with 7109 QC checks, which represents 82% QC for sample analysis (Appendix III). The Elliot Lake Research Field Station (ELRFS) analyzed 122 batches totaling 1426 radium samples with each batch incorporating blank, certified reference material (CRM), duplicate, and spiked samples providing greater than 20% quality control checks. All quality control samples were within control limits (mean +/- 3SD) (Appendix III).

3.1.2 Quality Assurance and Quality Control Resolution of Key Issues

There were no major issues with laboratory analysis requiring resolution in 2018. However, the radium target MDL of 0.005 Bq/L was not achieved by ELRFS, but the MDL still remained below the laboratory Data Quality Objective (DQO) of 0.01 Bq/L at <0.007 Bq/L (Appendix II).

3.1.3 Analytical Blank Performance

Laboratory quality control results confirm that blank data quality objectives were met for all parameters in all samples (Appendix III).

3.1.4 Analytical Duplicate Performance

Laboratory quality control results confirm that duplicate data quality objectives of 20% for radium and 10% for all other remaining parameters were achieved in all samples (Appendix III).

All analytical duplicate results were within the data quality objectives (Appendix III).

3.1.5 Analytical Laboratory Spike Performance

Laboratory quality control results confirm that the spike data quality objective of 20% was achieved for all parameters in all samples (Appendix III). It should be noted that the required SRWMP reporting detection limit for barium is 0.005 mg/L while the reporting limit for iron is 0.02 mg/L. However, the SGS reporting detection limit for barium is 0.0001 mg/L with a spike concentration of 0.005 mg/L and the reporting limit for iron is 0.007 mg/L with a spike concentration of 0.01 mg/L (Appendix III). As a result, the spike concentrations are equivalent to the reporting detection limits so most spikes result in non-detects. This results in the statistics indicating that the spike data quality objectives were not met; however, when the lower detection limit is applied, the spike data quality objective is achieved, indicating that the method is sound and reliable.

3.1.6 Analytical Certified Reference Material Performance

Laboratory quality control results confirm that the CRM data quality objective of 20% accuracy was achieved for all parameters in all samples in 2018 (Appendix III).

3.1.7 Field Blank Performance

Field Blank quality control results confirm that SRWMP field blank data quality objectives were achieved in 2018 (Appendix IV).

3.1.8 Field Precision Performance

Field precision quality control results confirm that SRWMP field precision data quality objectives were achieved in 2018 (Appendix IV).

Table 3.1 2018 SRWMP Field Quality Control Results Summary

QA/QC	pH	SO4 (mg/L)	Ra(T) (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn (mg/L)
MDL[1]	-	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002
Field Blank Statistics								
Count	4	4	4	4	4	4	4	2
Average	5.7	<0.1	<0.007	<0.0005	<0.005	<0.0005	<0.02	0.002
Max	5.9	<0.1	<0.007	<0.0005	<0.005	<0.0005	<0.02	0.002
Min	5.2	<0.1	<0.007	<0.0005	<0.005	<0.0005	<0.02	0.002
Field Blank Exceedances								
Criteria[1]	-	0.2	0.01	0.001	0.01	0.001	0.04	0.004
Exceedance	0	0	0	0	0	0	0	0
Field Precision Statistics								
Count	4	4	4	4	4	4	4	2
Average	0.0%	2.4%	8.6%	0.8%	3.6%	0.0%	2.6%	4.9%
Max	0.0%	7.4%	18.2%	3.4%	8.0%	0.0%	6.1%	13.3%
Min	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Field Precision Exceedances								
Criteria[1]	20%	20%	20%	20%	20%	20%	20%	20%
Exceedance	0	0	0	0	0	0	0	0

Notes:

[1] Data Quality Objectives taken from Table 5.2 af the Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

Bold indicates an exceedance in the Data Quality Objectives (DQO's)

3.2 Location Summary

Annual average concentrations of SRWMP parameters for 2018 in comparison to the *Cycle 4 Study Design* (Minnow, 2016) receiving environment assessment criteria are provided in Table 3.2. Annual detailed results and five-year summaries of annual average concentrations in comparison to assessment criteria are provided in Appendix V.

Water quality throughout the Serpent River Watershed continues to meet and remain well below the assessment criteria established for the protection of aquatic life. Annual average concentrations for all parameters in 2018 were better than assessment criteria at all locations, with the exception of iron at station D-6 (Cinder Lake Outlet) and cobalt concentrations at all stations remained close to or below the detection levels, with the exception of D-6 and SR-17 However, cobalt concentrations at these stations remained below the assessment criteria of 0.0025 mg/L(Appendix V).

The annual average iron concentration at D-6 (0.82 mg/L) exceeded the water quality benchmark applied to lake stations (0.49 mg/L). This can be attributed to a seasonal spike (2.69 mg/L) that occurred in September when flow was very low (2.0 L/s) due to hot and dry conditions in the summer of 2018. Iron concentrations are generally influenced by the particulate matter within the sample during periods of very low flow. The remaining concentrations throughout the year were more than an order of magnitude lower and more typical of expected values when flow is generally higher (Appendix V). In addition, no impact was observed further downstream at D-5, located in the Serpent River between the Denison and Quirke Tailings management Areas (TMAs), where the annual average concentration was 0.07 mg/L.

The annual average barium concentration at SR-06 (McCabe Lake Outlet) appears elevated (0.682 mg/L) compared to other SRWMP stations, however, it is below the assessment criteria of 1.0 mg/L and well below levels considered to be toxic to the aquatic environment (8.0 mg/L; WHO 2001). The elevated level is attributable to the increased barium chloride addition rates that were required to maintain control of radium concentrations upstream at the Stanleigh final discharge (CL-06). No acute or chronic toxic effects to aquatic biota were observed at SR-06 (Appendix V) or at CL-06 as a result of increased barium concentrations (RAL, 2019). In addition, annual average barium concentrations downstream of SR-06 at SR-15 (May Lake Outlet) are significantly lower (0.213 mg/L), although response monitoring since 2016 indicates a gradual increasing trend.

The annual average sulphate concentration at SR-08 (Nordic Lake Outlet) also appears elevated (137.5 mg/l) compared to other SRWMP stations. However, as initially noted in section 2.2, according to the most recent Ambient Water Quality Guidelines from the BCMOE, manganese and sulphate are hardness dependent (BCMOE, 2006, 2013). Toxicity studies for both parameters demonstrated amelioration of toxicity with increasing water hardness and were used to develop new water quality guidelines in the province of British Columbia for these substances. Therefore, based on this information, a specific assessment criterion for sulphate has been established for each station in the SRWMP. In this case, the mean hardness concentration at SR-08 was determined to be 223.9 mg/L (Minnow, 2016) and thus, the resulting criteria for sulphate at this location is 429 mg/L. In 2018, all results at SR-08 fell within BCMOE guidelines for the protection of aquatic life (BCMOE, 2013). A review of the data also indicates that sulphate annual concentrations have continued to decrease over the past five years (Figure 3.1.a.). Sulphate assessment criteria for individual stations is included in Appendix V of this report along with the detailed data, as well as in Table B-1, Appendix B, of the *Cycle 4 Study Design for the SRWMP, SAMP, and TOMP* (Minnow, 2016).

Figures 3.1.a to 3.1.c show five-year trends of annual average concentrations for the mine-related parameters sulphate, radium, and uranium at the following key locations:

- SR-01, Quirke Lake Outlet;
- SR-06, McCabe Lake Outlet;
- SR-08, Nordic Lake Outlet;
- DS-18, Halfmoon Lake Outlet.

Based on a review of 5 years of data, annual sulphate concentrations at all key lake outlets are well below the assessment criterion of between 128-429 mg/L as established for each station. Furthermore, annual concentrations have been gradually decreasing at stations SR-06 and SR-08 (Figure 3.1.a).

With the exception of DS-18, radium concentrations at the remaining three key locations are an order of magnitude below the assessment criteria of 1.0 Bq/L, and stations SR-01 and SR-08 appear to have reached relatively stable levels based on review of the data (Figure 3.1.b). At station DS-18, the 2017 annual average radium concentration of 0.193 Bq/L appears elevated compared to other annual concentrations in the last five years (Appendix V). This was likely due to a spike observed in August of that year when a heavy rain event may have caused flushing through the historic tailings spill upstream in the Halfmoon wetland area. However, the annual average concentration in 2018 indicates a return to more typical averages at 0.152 Bq/L.

Radium concentrations at SR-06 appear to be gradually increasing. This can be attributed to the increase in radium concentrations observed upstream at the Stanleigh final discharge (CL-06). Steps to mitigate this trend are discussed further in section 4.1 of this report and in detail in the 2018 Rio Algom Annual OCM Report (RAL, 2019). All radium concentrations, however, have consistently remained well below 1.0 mg/L (Figure 3.1.b).

Annual uranium concentrations at all four key locations appear to be relatively stable and all values in 2018 remained well below assessment criteria of 0.0150 mg/L (Figure 3.1.c).

Table 3.2 2018 SRWMP Location Annual Average Results Summary

Parameters			pH	SO4 [5] (mg/L)	Ra(T) (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness mg/L as $CaCO_3$
Assessment Criteria [1]	Wetland and lake benchmarks		**6.5**	**128-429**	**1.000**	**0.0150**	**1.000**	**0.0025**		**0.800**	-
	Wetland/Stream benchmark [2]		**5.2**						**1.69**		
	Lake benchmark [3]								**0.49**		
MDL [4]				0.1	0.005	0.0005	0.005	0.0005	0.02	0.005	0.5
Location		# of samples collected									
Reference	**Type**										
D-4	Lake	2	6.7	3.4	<0.007	<0.0005	0.012	<0.0005	0.04	0.014	9.3
SR-18	Lake	2	6.8	4.5	<0.007	<0.0005	0.045	<0.0005	0.04	0.011	9.9
SR-19	Lake	4	6.7	3.2	0.009	<0.0005	0.025	0.0006	0.35	0.060	17.9
SR-16	Wetland/Stream	4	5.4	1.2	<0.007	<0.0005	0.008	<0.0005	0.66	0.043	9.0
SR-17	Wetland/Stream	4	5.5	2.4	0.007	<0.0005	0.027	0.0013	1.08	0.081	14.2
Near Field											
D-5		4	6.7	13.8	0.073	0.0015	0.106	<0.0005	0.07	0.039	26.6
D-6		4	6.6	34.8	0.015	<0.0005	0.017	0.0020	**0.82**	0.481	49.0
DS-18		4	7.1	56.8	0.152	0.0008	0.021	<0.0005	0.28	0.022	80.2
M-01		4	6.7	8.9	0.015	0.0020	0.015	0.0006	0.78	0.079	30.0
Q-09		4	6.7	50.5	0.100	0.0022	0.119	<0.0005	0.37	0.102	66.6
Q-20		1	6.6	19.0	<0.007	<0.0005	0.019	<0.0005	<0.02	0.025	38.2
SC-01		1	6.6	18.0	0.009	<0.0005	0.011	<0.0005	0.14	0.015	31.5
SR-06		13[6]	7.0	30.2	0.100	0.0006	0.682	<0.0005	0.05	0.011	44.7
Far Field											
SR-15[7]		3	7.1	30.3	0.058	<0.0005	0.213	<0.0005	0.02	0.006	44.5
SR-01		1	6.7	29.0	0.017	0.0011	0.034	<0.0005	<0.02	0.004	35.4
SR-08		4	6.8	137.5	0.028	0.0007	0.017	<0.0005	0.05	0.036	186.3

Notes:

[1] Assessment criteria as per Table 4.5, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland/stream stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

[6] Sample frequency was increased as part of response monitoring due to elevated radium concentrations upstream at the Stanleigh final discharge (CL-06). The Stanleigh discharge radium is detailed further in the Rio Algom Annual Care & Maintenance Report 2018.

[7] Station SR-15 was put back in the program voluntarily as part of response monitoring and is not part of the regulatory requirement for the Cycle 4 Monitoring Program.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates an exceedance of the evaluation criteria value

Figure 3.1.a. Annual Average Sulphate Concentrations at SR-01, SR-06, SR-08, and DS-18, 2014-2018

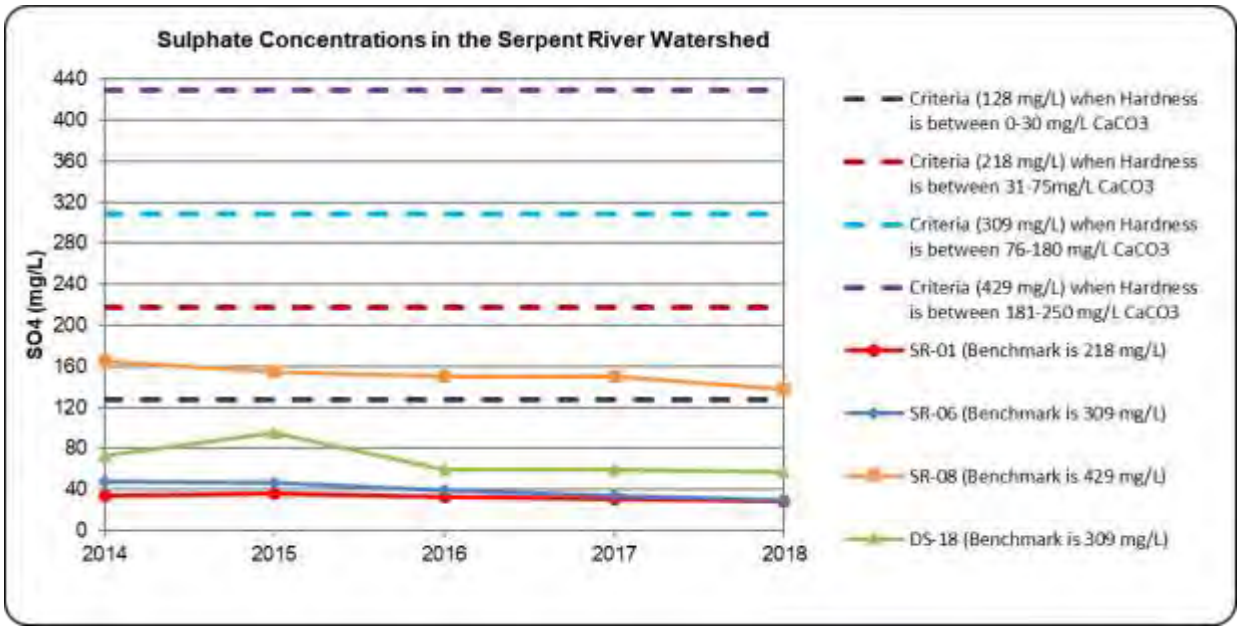


Figure 3.1.b. Annual Average Radium Concentrations at SR-01, SR-06, SR-08, and DS-18, 2014-2018

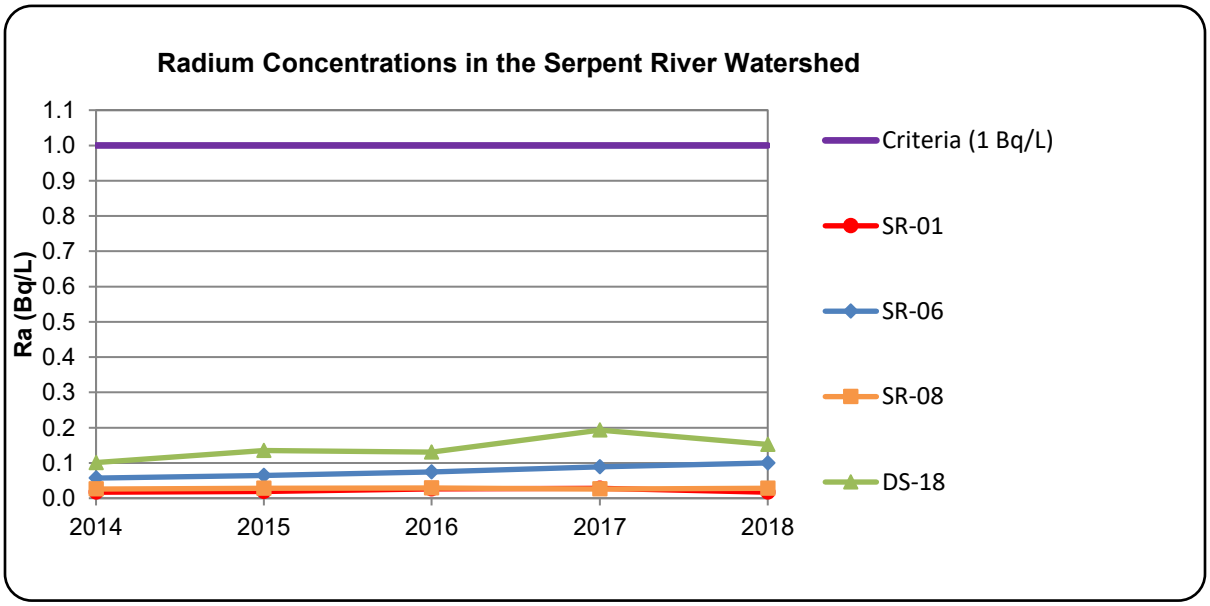
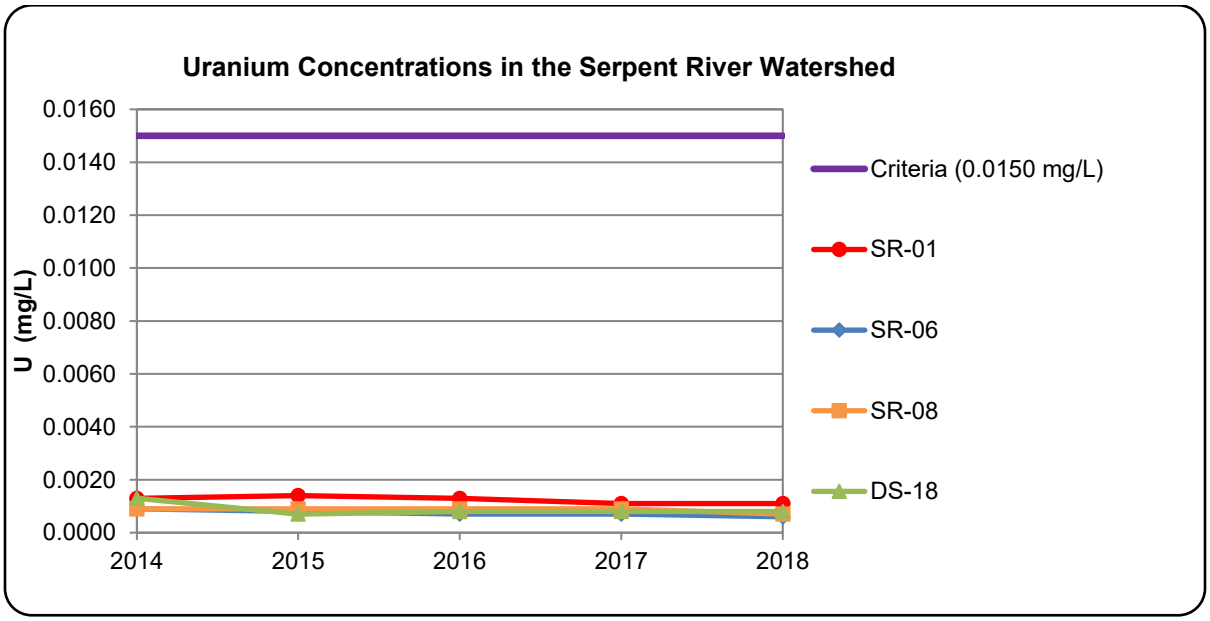


Figure 3.1.c. Annual Average Uranium Concentrations at SR-01, SR-06, SR-08, and DS-18, 2014-2018



4 DISCUSSION

4.1 Response Monitoring

Beginning in 2016, monitoring at the outlet of May Lake (SR-15) was voluntarily re-established in response to gradually increasing barium and radium concentrations upstream at the outlet of McCabe Lake (SR-06); it was previously removed in the SRWMP Cycle 3 Study Design (Minnow 2009). This station will likely remain in the monitoring program in the next Cycle study design (beginning 2020) to aid in the assessment of any long-term impacts to the receiving environment as a result of these increasing trends. Response monitoring was also initiated in December 2017 due to a non-compliance of the monthly mean radium concentration at the Stanleigh final discharge location (CL-06). As a result, supplemental monitoring was implemented at the first receiving station, SR-06, and much further downstream of the Serpent River at the outlet of Pecors Lake (SR-03). This included increased monitoring frequency at SR-06 as well as re-establishing monitoring at station SR-03, which had also been removed in the Cycle 3 Study Design (Minnow, 2009). Both locations also included twice-monthly toxicity monitoring. Response monitoring at these locations continued through most of 2018 until radium control was achieved at the CL-06 final discharge, and concentrations fell below compliance limits. The non-compliance at CL-06 and the measures taken to ameliorate the increasing radium and barium trends at CL-06, and subsequently SR-06, is described in further detail in the 2018 Rio Annual OCM Report (RAL, 2019). All water quality results from supplemental and regulatory monitoring for SR-15, SR-06 and SR-03 are provided in Appendix V of this report.

4.2 SRWMP Performance Monitoring Program Changes

There were no changes to methodology in 2018.

4.3 Changes to Location Classification and Frequency

Other than the addition of the SRWMP stations SR-15 and SR-03 (for the purpose of short-term monitoring), and the increased monitoring frequency at SR-06, there were no other changes to location classification or frequencies in 2018. Following completion of the 2016 Serpent River Watershed Cycle 4 State of the Environment Report, analysis for cobalt, iron, and manganese were reintroduced at all SRWMP stations to help support future interpretations of the loadings of these substances into the watershed (Minnow, 2016). In addition, hardness was added as an ancillary parameter to all SRWMP stations as it assists in interpretation of water quality concentrations for manganese and sulphate, as discussed in the approved *Cycle 4 Study Design for the SRWMP, SAMP and TOMP* (BCMOE, 2006, 2013, and Minnow, 2016). These additions are outlined in Table 2.1.

4.4 Interim Assessment in Support of Representative Public Radiation Dose Estimation

The Canadian Nuclear Safety Commission (CNSC) requested that Rio Algom Limited and Denison Mines Inc. provide annual reporting of the radiation dose to the public associated with the closed uranium mine sites in the Serpent River Watershed. Historically, estimates of the public dose had been based on the use of very conservative values to demonstrate that public dose in the vicinity of Elliot Lake did not exceed the upper dose limit. Measurements of radon and gamma collected during mine operations resulted in dose estimates less than 5% of the annual public dose limit of 1 mSv/a.

However, to determine an updated and more realistic representative annual public dose estimation for a person residing in Elliot Lake, a preliminary design monitoring program to support public dose estimation was prepared in early 2016. Details of the design program were provided in the document entitled *Preliminary Design Monitoring Program to Support Public Dose Estimation* (Ecometrix Incorporated (Ecometrix), 2016), which was included as an appendix in the *SRWMP Annual Water Quality Report 2016* (RAL, DMI, 2017)

In 2016, components of the design monitoring program were completed. This included quarterly site-specific radiation surveys of public walking trails (for radon and direct Gamma specifically), analysis of radionuclides in drinking water, and a community survey. The community survey was conducted to determine the amount of time a representative person spent hiking on the mining properties as well as information about their consumption of fish from local lakes. Based on the interim public dose calculations using the data collected in 2016, it can be concluded that the public dose to the representative person is approximately 0.012 mSv/a, after correction for background exposure. This interim public dose estimation is intended to provide annual interim dose values until 2019. Details of the interim dose are provided in the document entitled *Interim Public Dose Estimation for the Closed Mines of the Serpent River Watershed* (Ecometrix, 2017), which is included in Appendix VI of this report.

The public dose estimation is expected to be updated as part of the 2020 State of the Environment report when changes to the monitoring data used to calculate the interim dose are projected to include updated sport fish tissue analysis. The annual dose reporting will be based on periodic updates undertaken as part of the five-year SOE Report.

REFERENCES

Beak International Incorporated 1999. Serpent River Watershed Monitoring Program Framework Document. February 1999.

Ecometrix Incorporated, 2016. Preliminary Design for a Monitoring Program to Support Public Dose Estimation, Prepared for Rio Algom and Denison Mines, September, 2016

Ecometrix Incorporated, 2017. Interim Public Dose Estimation for the Closed Mines of the Serpent River Watershed. February 2018.

Denison Mines Inc., 2018. Annual Operating Care & Maintenance Report. March 2019.

Minnow Environmental Inc., 2009a. Serpent River Watershed State of the Environment. Prepared for Rio Algom Limited and Denison Mines Inc. January 2009.

Minnow Environmental Inc., 2009b. Serpent River Watershed Monitoring Program, Cycle 3 Study Design. Prepared for Rio Algom Limited and Denison Mines Inc. May 2009.

Minnow Environmental Inc., 2009c. Monitoring Framework for Closed Uranium Mines, Near Elliot Lake. Prepared for Rio Algom Limited and Denison Mines Inc. May 2009.

Minnow Environmental Inc., 2011. Serpent River Watershed State of the Environment Report. Prepared for Rio Algom Limited and Denison Mines Inc. July 2011.

Minnow Environmental Inc., 2016a. Cycle 4 Study Design for the SRWMP, SAMP and TOMP. Prepared for Rio Algom Limited and Denison Mines Inc. February 2016.

Minnow Environmental Inc., 2016b. Serpent River Watershed Cycle 4 State of the Environment Report. Prepared for Rio Algom Limited and Denison Mines Inc. November 2017.

Rio Algom Limited, 2018. Annual Operating Care Maintenance Report. March 2019.

Rio Algom Limited and Denison Mines Inc., 2017. Serpent River Watershed Monitoring Program 2017 Annual Water Quality Report. March 2018.

APPENDIX I
Performance Monitoring Changes 2015 - 2019
Evolution of Programs

March 9, 2016
via e-mail

Karina Lange
Project Officer for Wastes and Decommissioning Division
Canadian Nuclear Safety Commission
280 Slater Street
P.O. Box 1046, Station B
Ottawa, ON, K1P 5S9

Dear Ms. Lange:

Re: Serpent River Watershed Cycle 4 State of the Environment Report

Denison Mines Inc. (DMI) and Rio Algom Limited (RAL) are pleased to submit the Serpent River Cycle 4 State of the Environment (SOE) Report (2010 to 2014). The report presents and integrates the monitoring data obtained through the Elliot Lake closed mines monitoring programs, namely the Serpent River Watershed Monitoring Program (SRWMP), the Source Area Monitoring Program (SAMP) and the TMA Operational Monitoring Program (TOMP). The report covers the period of January 1, 2010 to December 31, 2014 although historical data has been considered for trend analysis.

This report represents the completion of the fourth cycle of the SRWMP. A complete list of all study design and interpretive reports prepared since the start of Cycle 1 is provided in Table 5.1. This table also summarizes the time frame covered for each cycle and the key changes to each of the monitoring programs over time.

We are also distributing this Cycle 4 State of the Environment Report to the members of the Joint Regulatory Review Group (JRG; distribution attached). We look forward to your review of the report and the opportunity to address and any questions or comments you may have.

Yours very truly,

Denison Mines Inc.

Ian Ludgate,
Manager

Rio Algom Limited

Debbie Berthelot,
Reclamation Manager

cc: Distribution List

Table 5.1: Summary of the Elliot Lake monitoring programs; documents produced and changes to the programs during each cycle.

Cycle	Report Title	Year	Period Covered	Description Of Changes To The Monitoring Programs Within Each Cycle
Cycle 1	Serpent River Watershed Monitoring Program Framework Document.	1999	historical monitoring data	SRWMP, IBMP, SAMP and TOMP were developed based on program objectives and existing monitoring data collected over the period of operations and decommissioning.
	In-Basin Monitoring Program Report	1999		
	Serpent River Watershed and In-Basin Monitoring Program – Implementation Document.	1999		
	Serpent River Watershed Monitoring Program -1999 Study	2001	1999 - 2000	
	In-Basin Monitoring Program for the Uranium Tailings Areas - 1999 Study.	2001		
Cycle 2	Overview of Elliot Lake Monitoring Programs and Source Area Monitoring Program Design.	2002	2000 -2004	**Changes only SRWMP** most associated with optimization after first cycle of program was complete: - monitoring substances reduced to mine indicator parameters (barium, cobalt, DOC, iron, manganese, Ra-226, selenium, silver, sulphate and uranium), - addition of two lake reference stations (Summers and Semiwite lakes) and 3 stream reference areas (SR-16, SR-17 and SR-18); - removal of shallow lakes for sediment and benthic sampling (Westner, Grassy, Halfmoom, Upper Cinder and Horne lakes); - removal of some stream sediment and benthic stations (D-15, SC-03 and SR-07); - removal of Depot Lake and Serpent Harbour; addition of May Lake; - the transfer of some SRWMP stations to SAMP or TOMP (N-12, ECA-131, P-11, MPE and Q-23); - fish health assessment eliminated based on performance, fish community assessment added for McCabe Lake and fish tissue monitoring reduced in scope based on performance.
	TMA Operational Monitoring Program Design (TOMP).	2002		
	Cycle 2 Study Design – Serpent River Watershed and In-Basin Monitoring Programs.	2004		
	Serpent River Watershed Monitoring Program: Cycle 2 Interpreative Report	2005		
	Serpent River In-Basin Monitoring Program: Cycle 2 Interpretive Report - 2004 Study.	2005		
	Serpent River Watershed State of the Environment	2009		
Cycle 3	Monitoring Framework For Closed Uranium Mines Near Elliot Lake	2009	2005- 2009	**IBMP** eliminated based on objectives of program being achieved. **SAMP and TOMP:** - removal of silver, selenium based on performance and removal of conductivity based on redundancy with sulphate; - DOC, hardness and flow added at selected stations. **SRWMP:** - removal of selenium and sliver based on performance, - removal of station SR-12, ELO, SR-09, SR-15, SR-02, SR-03, SR-11, P-01, QL-01 and SR-16 and SR-17 based on performance; - monthly monitoring frequency reduced to quarterly; - sediment and benthic monitoring removed from Whiskey, Evans and Cinder Lakes based on redundancy, - depositional streams (Q-20, D-6, SR-06, M-01 and SR-08) based on very high natural variability masking results; - fishing in McCabe Lake and fish tissue monitoring eliminated based on performance.
	In Basin Monitoring Program, Cycle 3 Study Design	2009		
	Serpent River Watershed Monitoring Program: Cycle 3 Study Design	2009		
	Source Area Monitoring Program Revised Study Design.	2009		
	Tailing Management Area Monitoring Program (TOMP) Revised Study Design	2009		
	Serpent River Watershed State of the Environment Report.	2011		
Cycle 4	Cycle 4 Study Design For the SRWMP, SAMP and TOMP.	2014[a]	2010 - 2014	Minor changes to SAMP and TOMP. **SRWMP:** - elimination of reference stations SR-05, P-222 and SR-14; - removal of cobalt as substance for monitoring, addition of DOC; - far-field lakes removed from the program (Hough, Pecors and McCarthy); - removal of Rochester Lake as a sediment and benthic reference area; - reduction in benthic and sediment sampling to 1/10 years based on measured deposition rates.
	Serpent River Watershed Cycle 4 State of the Environment	2016		

[a] Study Design was submitted to CNSC and JRG in 2014 but reissued with agency comments in 2016.

APPENDIX II
Flagged Data Results

Location	Analyte	Date	Low	Hi	Result	Comment
SR-03	pHF	2018-02-08	6.9	6.9	6.8	All parameter results are consistent with values prior to 2010. This station had been removed from the monitoring program after 2009, but was re-established as part of a response monitoring program that was initiated in December 2017. A non-compliance in the monthly mean radium concentration occurred upstream at the Stanleigh final discharge (CL-06). As a result, this station was used to assess and evaluate any environmental impacts to the receiving environment.
		2018-02-21	6.9	6.9	7.0	
	Ra	2018-02-08	0.010	0.015	0.025 Bq/L	
		2018-02-21	0.010	0.015	0.020 Bq/L	
	SO4	2018-02-21	21.6	25.1	27.0 mg/L	
	Ba	2018-02-21	0.034	0.040	0.049	Result is slightly above the high flag limit but consistent with a gradually increasing trend that is occurring much further upstream at stations SR-15 (May Lake Outlet) and SR-06 (McCabe Lake Outlet).
SR-06	Fe	2018-01-24	0.00	0.05	0.07 mg/L	Results are historic highs both confirmed by repeat analysis. It is possible the increased concentrations may reflect the elevated concentrations that were observed upstream at the Stanleigh final discharge (CL-06) when ferric sulphate reagent was used periodically between 2015-2018. Ferric sulphate addition was part of an approved pilot testing program that had taken place due to increasing radium concentrations at CL-06. The latest result (Feb 24) indicates a decrease to more typical concentrations at 0.04 mg/L.
		2018-02-07	0.00	0.08	0.23 mg/L	

Denison Mines

Rio Algom

Report Form: RC8.7.3.01

SRWMP Data Flags
ANNUAL FLAGS 2018
Revision 2015-01

Location	Analyte	Date	Low	Hi	Result	Comment
SR-08	hard	2018-02-22	108.7	247.8	250.0 mg/L	Result is slightly above the high flag limit but still consistent with previous values at this location over the last five years.
SR-03	pHF	2018-05-29	6.6	7.1	7.2	Result is slightly above the high flag limit, but still consistent with historic values prior to 2010 when this station was removed. Will continue to monitor at the current bi-weekly frequency. This station was only re-introduced in 2018 for short-term response monitoring.
SR-15	Ba	2018-05-30	0.087	0.200	0.209 mg/L	Result is slightly above the high flag limit, but consistent with increasing trends upstream at SR-06 (McCabe Lake Outlet) and at the Stanleigh final discharge (CL-06). Barium concentrations have been climbing due to the increased barium chloride addition rates required to control elevated radium concentrations in the Stanleigh final discharge.
	Fe	2018-05-30	0.02	0.02	0.03 mg/L	Result is slightly above the high flag limit, but close to previous values since re-initiation of this station in 2016. The result is also consistent with historic values prior to 2010 when the station was removed.

Denison Mines

Rio Algom

Report Form: RC8.7.3.01

SRWMP Data Flags

ANNUAL FLAGS 2018

Revision 2015-01

Location	Analyte	Date	Low	Hi	Result		Comment
D-5	Ba	2018-08-22	0	0.254	0.287	mg/L	Results are slightly above the high flag limits, but still consistent with seasonal values in the last five years and low flow.
	hard	2018-08-22	4	43	44	mg/L	
	Mn	2018-08-22	0	0.087	0.089	mg/L	Result is only slightly above the high flag limit, will continue to monitor at the current quarterly frequency.
D-6	Co	2018-08-22	0	0.002	0.0094	mg/L	Results were originally reported in the August Water Quality Report. However, all values were removed from the data set after investigation revealed that the sample was likely contaminated by particulate matter caused by trying to sample during a period of extremely low flow (well below 1 L/s). A second sample collected in early September indicated a significant decrease in all parameter concentrations even at a flow of just 2 L/s. Although some concentrations were still elevated, values were consistent with seasonal spikes that generally occur during periods of lower flow.
	Fe	2018-08-22	0	1.76	3.43	mg/L	
	Mn	2018-08-22	0	1.512	2.320	mg/L	
M-01	Co	2018-08-22	0.0005	0.0005	0.0008	mg/L	Results are above the high flags limits, but consistent with seasonal spikes observed during hot, dry conditions and low water levels.
	Fe	2018-08-22	0	1.17	1.68	mg/L	

Denison Mines

Rio Algom

Report Form: RC8.7.3.01

SRWMP Data Flags
ANNUAL FLAGS 2018
Revision 2015-01

Location	Analyte	Date	Low	Hi	Result		Comment
Q-09	Fe	2018-08-22	0.01	0.34	0.95	mg/L	Results are above the high flag limits, confirmed by repeat analysis. Spikes in iron and manganese concentrations have been observed across all sites, likely due to the sustained hot, dry conditions this summer and low water levels.
	Mn	2018-08-22	0	0.150	0.215	mg/L	
SR-08	Fe	2018-08-22	0	0.13	0.15	mg/L	Results are above the high flag limits, confirmed by repeat analysis. Spikes in iron and manganese concentrations have been observed across all sites, likely due to the sustained hot, dry conditions this summer and low water levels.
	Mn	2018-08-22	0	0.080	0.150	mg/L	
Sr-15	pHF	2018-08-30	6.5	7.4	7.5		Result is only slightly above the high flag limit. Will continue to monitor at the current semi-annual frequency.
SR-19	Co	2018-08-22	0.0005	0.0005	0.0007	mg/L	Result is a 10-year high, but only slightly above the high flag limit. Will continue to monitor at the current quarterly frequency.

Location	Analyte	Date	Low	Hi	Result		Comment
SR-03	Mn	2018-11-14	0	0.012	0.022	mg/L	Result is a 10-year high, but still consistent with historic values (2009 and earlier). Monitoring of this station ceased in 2009, but was re-initiated in Dec 2017 as part of a short-term response monitoring program due to a non-compliance at the Stanleigh site discharge.
SR-16	SO4	2018-11-26	0	2.9	3.1	mg/L	Result is slightly above the high flag limit, but still consistent with previous values in the last six years.

APPENDIX III
Laboratory QA/QC Results

SGS

Environment, Health & Safety

REPORT CODE: *DEN-ANN18*

REPORT TITLE: *Annual 2018 Data Quality Report*

REVISION: *1.0*

ISSUED BY:

Quality Coordinator,
SGS Environment, Health & Safety

AUTHORIZED BY:

Technical Manager,
SGS Environment, Health & Safety

DATE: *01 Mar. 2019*

Table of Contents

1. BACKGROUND

SGS Laboratory entered into an agreement with Denison Environmental Services for the analytical lab to provide analysis according to RFT #05-016. Please find below a summary of the laboratory quality management system, key actions taken by the laboratory, as well as a summary of numbers of samples analyzed.

2. QUALITY MANAGEMENT SYSTEM

SGS Environment, Health & Safety is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation (CALA), for specific tests listed in the scope of accreditation. ISO/IEC 17025 addresses both quality management and the technical aspects of operating a testing laboratory.

The quality management system at SGS Environment, Health & Safety consists of a documented quality system, which is directed by the Quality Coordinator who is independent of the production area. All appropriate documentation (quality manual, methods, written instructions, standard operating procedures, and data approval criteria) is in place and includes both general and method specific quality control requirements.

The quality control procedures include duplicate samples, spiked blanks, spiked replicates, reagent/instrument blanks, preparation control samples, certified reference material analysis, and instrument control samples, as appropriate for the individual methods. Matrix matching of reference materials to samples is always attempted. Frequency of insertion of control samples is method specific and follows legislated guidelines. A summary of the quality control recoveries is presented in the tables following.

3. QUALITY CONTROL PARAMETERS

All QC parameters are taken directly from SGS LIMS. Denison Environmental Services samples are processed as part of our "worksheet" batch system. A compilation of all QC data appropriate to the parameters tested has been compiled below.

4. NOTABLE OCCURANCES/ACTIONS

- SGS Environment, Health & Safety Lakefield laboratory performed 8703 analyses with 7109 QC checks, which represents 82% QC for sample analysis. **Corrective Action**: N/A
- All blank data results were within the data quality objectives. *Note: Laboratory deionized water is used for the acidity blank. Deionized water is slightly acidic at approximately pH 5.5 to 5.8.* **Corrective Action**: N/A
- All CRM data results were within the data quality objectives. **Corrective Action**: N/A
- No duplicate value exceeded the data quality objectives. **Corrective Action:** N/A

- No spike blanks exceeded the data quality objectives. *Note: Barium (Ba) reporting limit as per the Denison reports is set at 0.005 mg/L, the detection limit normally reported for Ba by SGS is 0.0001 mg/L. The concentration of the Ba spike is 0.005 mg/L. The Ba spikes all passed under lab limits; however, with the detection limit set at 0.005 mg/L for the Denison reports and number of the spikes appear to fail when taking into account the detection level.* **Corrective Action**: N/A
- No spike duplicates fell outside of the data quality objectives. **Corrective Action**: N/A

5. QC DATA SUMMARY

5.1. Blank Data

Parameter	Unit	Required Limit	Mean Blank Result	Number of Blanks	Number greater than Limit	Number Outside +/- Limit
Acidity	mg/L as CaCO3	1	1.58	100	47	11
Silver	mg/L	0.0001	0.0000015	10	0	0
Alkalinity	mg/L as CaCO3	2	0.319	6	0	0
Arsenic	mg/L	0.0005	0.00008	1	0	0
Barium	mg/L	0.005	0.00212	193	0	0
Cobalt	mg/L	0.0005	0.000217	152	0	0
Copper	mg/L	0.0005	0.000011	11	0	0
DOC low	mg/L	0.5	0.178	42	0	0
Iron ICP-MS	mg/L	0.007	0.00814	223	0	0
Hardness ICP-MS	mg/L as CaCO3	0.5	0.164	96	1	0
Manganese	mg/L	0.002	0.000806	167	0	0
Nickel	mg/L	0.002	0.000025	8	0	0
Lead	mg/L	0.00002	0.000015	7	0	0
Selenium	mg/L	0.0005	0.000010	8	0	0
Sulphate	mg/L	0.1	0.054	245	0	0
Total Dissolved Solids	mg/L	10	12.5	11	11	0
Total Suspended Solids	mg/L	1	0.439	385	0	0
Uranium	mg/L	0.0005	0.000204	154	0	0
Zinc	mg/L	0.001	0.000500	8	0	0

5.2. CRM Data

Parameter	Unit	Certified Value	Lower Limit (at 20% Rel. Error)	Upper Limit (at 20% Rel. Error)	Number of CRM's	Mean Value	% RSD (Precision)	Number QC CRM outside of DQO
Acidity	mg/L as CaCO3	50	45	55	93	50.1	3.69	3
Silver	mg/L	0.1	0.09	0.11	10	0.101	0.28	0
Alkalinity	mg/L as CaCO3	47.2	42.5	51.9	6	49.6	0.79	1
Arsenic	mg/L	0.1	0.09	0.11	1	0.106	0.00	0
Barium	mg/L	0.1	0.09	0.11	200	0.101	2.82	0
Cobalt	mg/L	0.1	0.09	0.11	154	0.101	2.22	0
Copper	mg/L	0.1	0.09	0.11	11	0.100	0.34	0
DOC low	mg/L	5	4.5	5.5	38	5.068	3.18	1
Iron ICP-MS	mg/L	0.1	0.09	0.11	218	0.101	6.33	14
Hardness ICP-MS	mg/L as CaCO3	1.5	1.8	2.2	70	1.466	12.38	7
Manganese	mg/L	0.1	0.09	0.11	165	0.103	2.26	0
Nickel	mg/L	0.1	0.09	.011	7	0.102	0.37	0
Lead	mg/L	0.1	0.09	0.11	7	0.100	0.60	0
Selenium	mg/L	0.1	0.09	0.11	7	0.101	0.37	0
Sulphate	mg/L	5	4.5	5.5	247	4.826	2.23	0
Total Suspended Solids	mg/L	100	90	110	166	97.73	3.26	0
Uranium	mg/L	0.1	0.09	0.11	153	0.099	4.16	0
Zinc	mg/L	0.1	0.09	0.11	8	0.101	0.17	0

5.3. Duplicate Data

Parameter	Unit	Expected Recovery (Rel. %)	Lower Limit (Rel. %)	Upper Limit (Rel. %)	Number of Duplicates	Mean Recovery (%)
Acidity	mg/L as CaCO3	100	90	110	92	99.1
Silver	mg/L	100	90	110	8	98.8
Alkalinity	mg/L as CaCO3	100	90	110	6	100.9
Arsenic	mg/L	100	90	110	1	99.0
Barium	mg/L	100	90	110	199	96.4
Cobalt	mg/L	100	90	110	154	95.0
Copper	mg/L	100	90	110	7	98.4
DOC low	mg/L	100	90	110	41	101.1
Iron ICP-MS	mg/L	100	90	110	219	97.2
Hardness ICP-MS	mg/L as CaCO3	100	90	110	80	99.1

Manganese	mg/L	100	90	110	166	97.5
Nickel	mg/L	100	90	110	6	98.1
Lead	mg/L	100	90	110	6	95.7
Selenium	mg/L	100	90	110	6	97.8
Sulphate	mg/L	100	90	110	171	97.7
Total Dissolved Solids	mg/L	100	90	110	10	98.0
Total Suspended Solids	mg/L	100	90	110	380	98.4
Uranium	mg/L	100	90	110	153	96.2
Zinc	mg/L	100	90	110	6	98.7

5.4. Spike Blank Data

Parameter	Unit	Certified Value	Lower Limit (at 30% Rel. Error)	Upper limit (at 30 % Rel. Error)	Number of Spike Blank's	Mean % Recovery	Precision (%RSD)	Number Spike Blank outside of DQO
Acidity	mg/L as CaCO3	10	7	13	80	111.4	7.15	0
Silver	mg/L	0.0002	0.00014	0.00026	9	79.0	1.46	0
Alkalinity	mg/L as CaCO3	9.4	6.58	12.22	5	96.6	1.55	0
Arsenic	mg/L	0.0064	0.00448	0.00832	1	98.4	0.00	0
Barium	mg/L	0.005	0.0035	0.0065	180	54.5	20.63	68*
Cobalt	mg/L	0.002	0.0014	0.0026	139	98.1	6.75	1
Copper	mg/L	0.016	0.00112	0.00208	10	109.6	8.79	2
DOC low	mg/L	10	7	13	34	100.1	1.60	0
Iron ICP-MS	mg/L	0	0	0	143	121.2	30.17	31
Hardness ICP-MS	mg/L as CaCO3	0	0	0	56	101.2	4.33	0
Manganese	mg/L	0.003	0.0021	0.0039	138	111.8	16.27	11
Nickel	mg/L	0.005	0.0035	0.0065	7	95.3	0.94	0
Lead	mg/L	0.0032	0.00224	0.00416	7	99.2	0.19	0
Selenium	mg/L	0.0008	0.00056	0.00104	7	94.0	1.75	0
Sulphate	mg/L	5	4.5	5.5	235	97.6	2.07	0
Uranium	mg/L	0.0008	0.00056	0.00104	133	92.8	7.76	1
Zinc	mg/L	0.006	0.0042	0.0078	6	113.3	4.04	1

*Barium spike concentration is below the required detection limit.

5.5. Spike Duplicate Data

Parameter	Unit	Certified Value	Lower Limit (at 30% Rel. Error)	Upper limit (at 30% Rel. Error)	Number of Spike Rep's	Mean % Recovery	Precision (%RSD)	Number Spike Rep outside of DQO
Silver	mg/L	0.16	0.112	0.208	6	100.2	0.93	0
Arsenic	mg/L	0.64	0.448	0.832	1	98.3	0.00	0
Barium	mg/L	4	2.8	5.5	151	104.6	11.79	12
Cobalt	mg/L	2	1.4	2.6	120	99.5	7.55	2
Copper	mg/L	1.6	1.12	2.08	7	110.3	9.03	2
DOC low	mg/L	100	70	130	36	102.1	5.39	0
Iron ICP-MS	mg/L	0	0	0	15	89.4	18.42	0
Hardness ICP-MS	mg/L as CaCO3	4.55	3.185	5.915	0			
Manganese	mg/L	3.2	2.24	4.16	118	106.9	8.73	0
Nickel	mg/L	4.8	3.36	6.24	6	99.6	1.05	0
Lead	mg/L	3.2	2.24	4.16	6	101.1	0.23	0
Selenium	mg/L	0.8	0.56	1.04	6	94.4	2.11	0
Sulphate	mg/L	100	70	130	227	98.1	5.50	0
Uranium	mg/L	0.8	0.56	1.04	116	93.2	6.23	2
Zinc	mg/L	5.6	3.92	7.28	5	121.2	3.94	2

5.6. QC Frequency

Total Number of Blanks:	1827
Total Number of Reference Materials:	1561
Total Number of Duplicate Samples:	1711
Total Number of Spiked Blanks:	1190
Total Number of Spiked Duplicate Samples:	820
Sum of QC Insertion:	**7109**
Total Analysis:	**8703**

6. CONCLUSION AND SIGNIFICANT FINDINGS

SGS Environment, Health and Safety - Lakefield analyzed quality control samples for this project beyond the laboratory standard of 20% QC insertion. Where the data quality objectives for the laboratory were exceeded, the additional quality control samples analyzed within the run supported the data values and data was released on this basis.

SGS Environment, Health and Safety remains committed to delivering data that meets and/or exceeds the data quality objectives for Denison Environmental Services and staff will continue

to work closely with Denison Environmental Services staff to ensure all objectives are achieved in 2019.

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An ISO:17025 Accredited Laboratory

^{226}Ra DATA QUALITY REPORT

2018 Annual

Prepared by:

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Troy Maki - Analytical Chemist

Reviewed by:

Dr. Graeme Spiers - Director

Elliot Lake Research Field Station of Laurentian University
Date: March 12, 2019

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1 Background

Elliot Lake Research Field Station (ELRFS) entered into an agreement with Denison Environmental Services (DES) for the analytical laboratory to provide ^{226}Ra analysis according to the ELFRS Offer of Services document submitted to DES on December 3, 2010. Please find below the summaries of the 2018 annual Quality Control (QC) results for blanks, duplicates, certified reference material (CRM), and spiked sample analysis.

The Analytical Services Laboratory of the Elliot Lake Research Field Station (ELRFS) was established in 1992. The initial work of the laboratory was to support research into the effects of low-level radioactivity on the environment resulting from regional uranium mining activities.

From this base, the laboratory has provided analytical services in support of local decommissioning and environmental monitoring programs, and in support of academic research. While the laboratory specializes in **radionuclide** analysis, it also provides a wide range of **inorganic** services for environmental samples, including solid wastes, effluents, receiving waters, ground waters, soils, sediments, geological materials, plant tissues and animal and fish tissues. The ELRFS analytical team will also complete specialty analyses outside of the scope of accreditation, following good laboratory practice procedures, using similar QA/QC protocols.

2 Quality Management System

ELRFS is ISO/IEC 17025:2005 accredited by the Canadian Association of Laboratory Accreditation (CALA) for specific environmental tests listed in the Scope of Accreditation. Accreditation is the formal recognition of the competence of a laboratory to achieve and demonstrate the highest levels of scientific and management excellence through the combined principles of Competence, Consistency, Credibility and Communication.

The quality management system at ELRFS consists of a documented quality system stating the quality policy, quality system and quality practices designed to demonstrate quality control operations are being carried out, to ensure accountability of data, to assure traceability of reported data, and to show that reasonable precautions are being taken against the possibility of falsification of data. Within this manual, Quality Assurance Procedures and Standard Operation Procedures define the laboratory operational duties that guide the analytical QC data. This includes a minimum target of 20% of the samples analysed being distributed as blanks, duplicate analysis, CRMs, and spiked samples. The sample and QC results are logged into excel spread sheets and Envista data management systems with monthly and annual QC reports generated.

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3 Quality Control Parameters

All QC parameters are taken directly from the Excel spread sheets and Envista. DES samples are processed as part of the worksheet batch system. A compilation of all QC data appropriate to the parameters tested has been compiled below.

The QC summary reports are presented as control charts with the mean +/- 1 standard deviation illustrated as the SD Level, the mean +/- 2 standard deviations illustrated as the Warning Level and the mean +/- 3 standard deviations illustrated as the Control Level.

Control Level - If the Control Level is exceeded, the analysis of standards and samples must be repeated and if the repeat analysis exceeds the Control Level again, corrective action is required.
Warning Level – If 2 or more consecutive points exceed the Warning Level, another standard must be analyzed and if this analysis exceeds the Warning Level again, corrective action is required.
SD Level – If 4 consecutive results exceed the SD Level, analyse the next sample and if the SD Level is exceeded again, corrective action is required.

4 Notable Occurrences /Actions

In late 2017, ELRFS purchased a new NIST traceable Ra-226 standard from Eckert & Ziegler to replace the existing ERA #RAD-A. The intent was to implement the new standard for the start of the 2018 calendar year but due to larger than anticipated sample volume there was insufficient time to process the necessary test samples to generate adequate statistics for control chart generation. The testing process involved 32 independently processed CRM samples (0.050Bq/L) which yielded an average recovery of 0.048Bq/L (96.38%, St-dev. = 0.0035Bq/L) and 33 independently processed Spike samples (0.250Bq/L) which yielded an average recovery of 0.237Bq/L (94.67%, St-dev. = 0.0113Bq/L). Implementation of the new QC CRM and QC Spike standards occurred on March 1st, 2018.

Through the year of 2018, ELRFS analyzed 122 batches totaling 1426 samples for ^{226}Ra. The first 24 batches (320 samples) occurred using the old ERA CRM & Spike standards and the following 98 batches (1106 samples) utilized the new Eckert & Ziegler CRM and Spike standards. Each batch incorporated blank, CRM, duplicate, and spiked samples providing greater than 20% quality control samples. All quality control samples are within control limits (mean +/- 3SD).

Twelve quality control samples exceeded the warning (mean +/- 2SD) levels. This included seven QC Blank (Figure 1a) samples, two QC Duplicate (Figure 2) samples, two QC CRM (Figure 3a) samples and one QC Spike (Figure 4a) samples. All samples exceeding the warning level were not consecutive, with the next consecutive QC sample falling within the warning level (mean +/- 2SD) limit, thus no corrective actions were required. No QC samples exceeded objectives.

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5 QC Data Summary

Table 1. Summary of QC results for old standard from ERA #RAD-A for January – February 2018.

Quality Element	Unit	Objective	Total Number of QC Samples	Expected Value	Mean	Number Outside Warning Limit	Number Outside Control Limit	Number Exceeding Objective
Blank	Bq/L	0.01	24	0	0.00063	1	0	0
Duplicate % error	%	20	24	0	5.67	0	0	0
CRM	Bq/L	20	24	0.044	0.046	2	0	0
Spike	Bq/L	20	24	0.249	0.258	1	0	0

Table 2. Summary of QC results for new standard from Eckert & Ziegler for March – December 2018.

Quality Element	Unit	Objective	Total Number of Samples QC Samples	Expected Value	Mean	Number Outside Warning Limit	Number Outside Control Limit	Number Exceeding Objective
Blank	Bq/L	0.01	98	0	0.00063	6	0	0
Duplicate % error	%	20	98	0	6.59	2	0	0
CRM	Bq/L	20	98	0.050	0.047	0	0	0
Spike	Bq/L	20	98	0.250	0.239	0	0	0

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1 Blanks

The blank sample is composed of ultra pure water and is treated in an identical manner, including all of the added reagents, as normal samples. The criterion of the blank sample is 0.01 Bq/L which is equal to 6 counts per 100 min (0.06 cpm). The 2018 mean blank value is 1.02 counts per 100min (0.00063 Bq/L). ELRFS uses counts to monitor the blank quality control data.

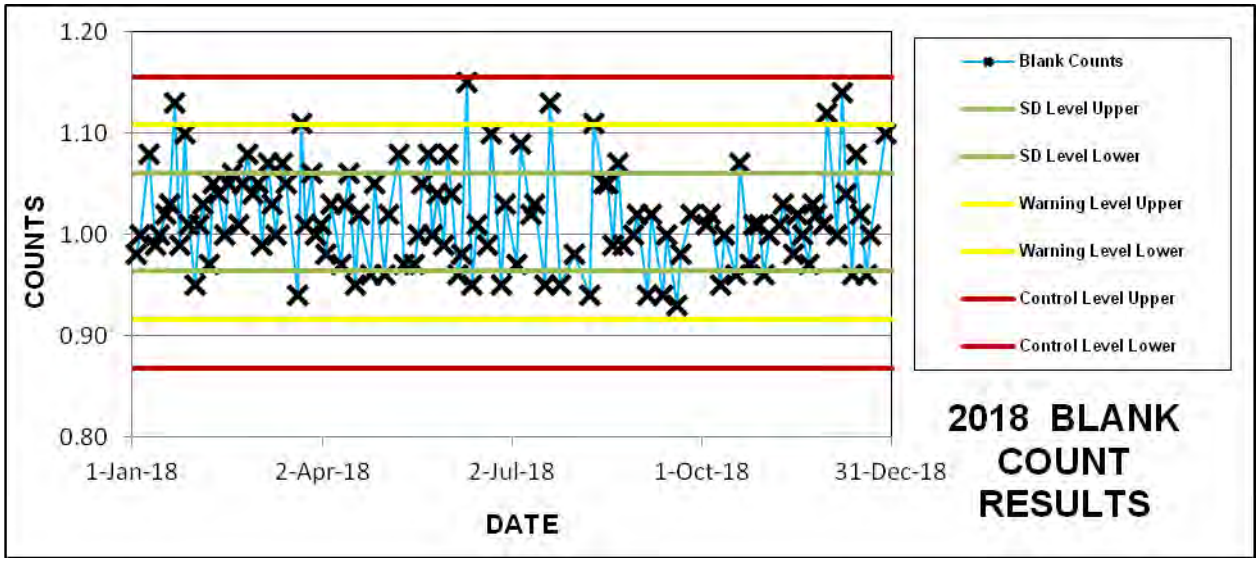

Figure 1a: Blank quality control results for the 2018 year.

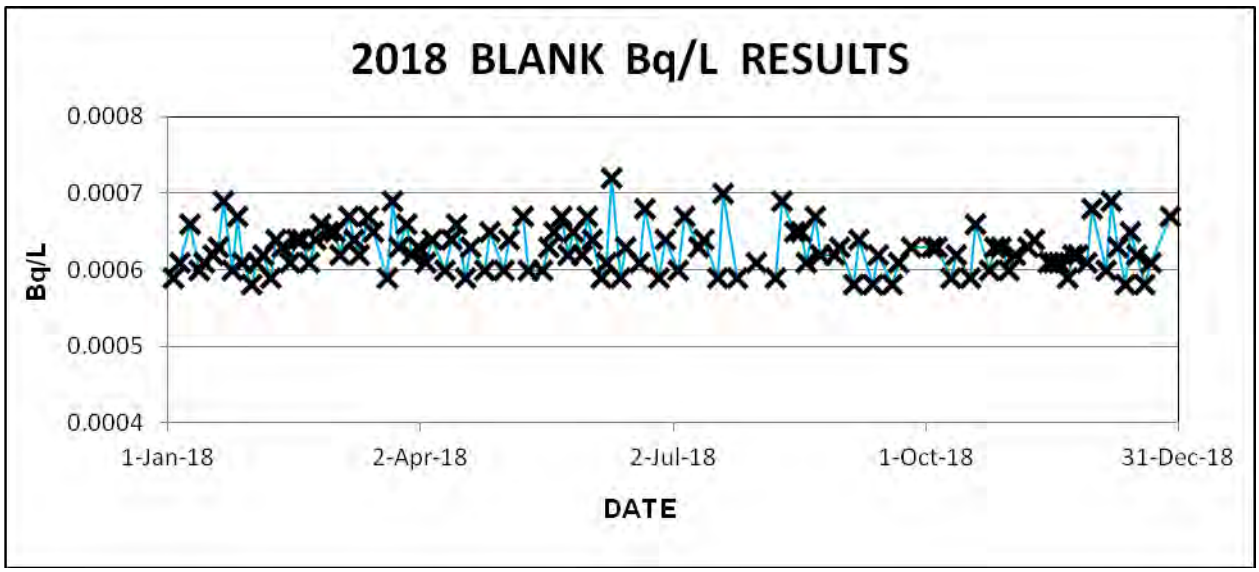

Figure 1b: Blank quality control concentrations for the 2018 year. Note maximum concentrations are 10 times lower than the 0.01 Bq/L criteria.

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2 Duplicates

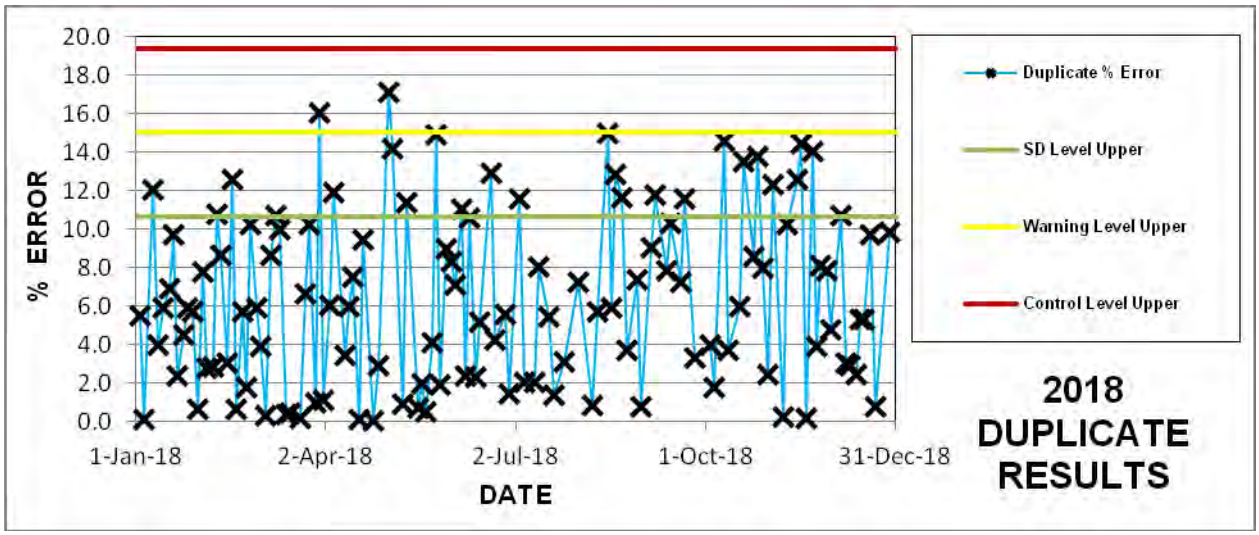

Figure 2: Duplicate quality control results for the 2018 year.

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3 CRM

The CRM material used from January 1st through February 28th 2018 is from ERA # RAD-A (0.044 Bq/L) and from March 1st through December 31st 2018 from Eckert & Ziegler (0.050Bq/L).

.

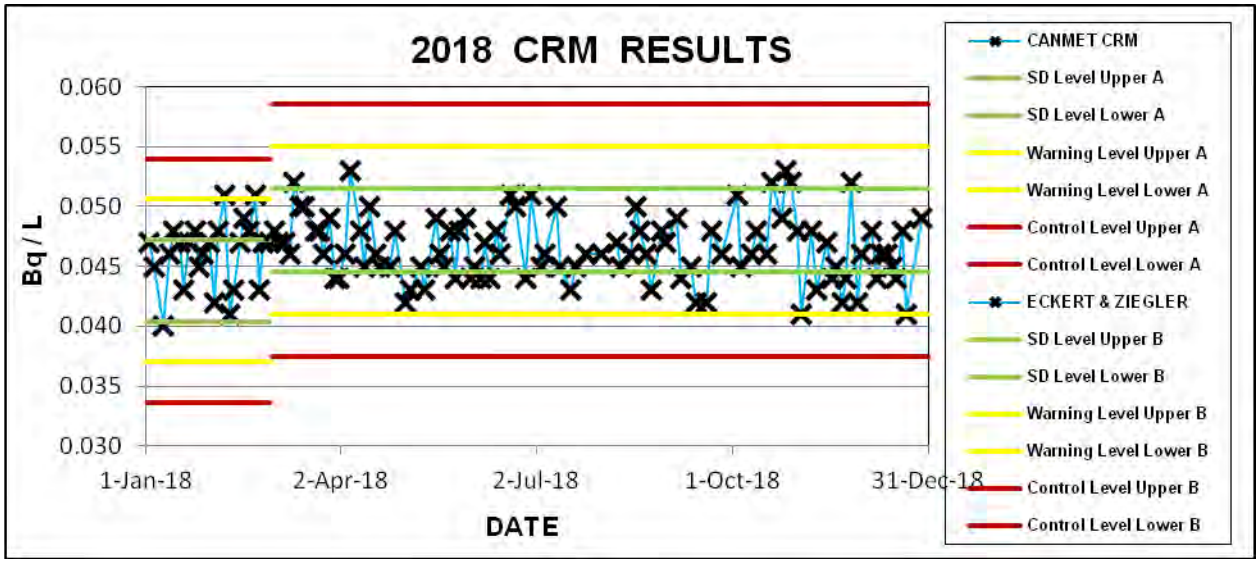

Figure 3a: CRM quality control results for the 2018 year.

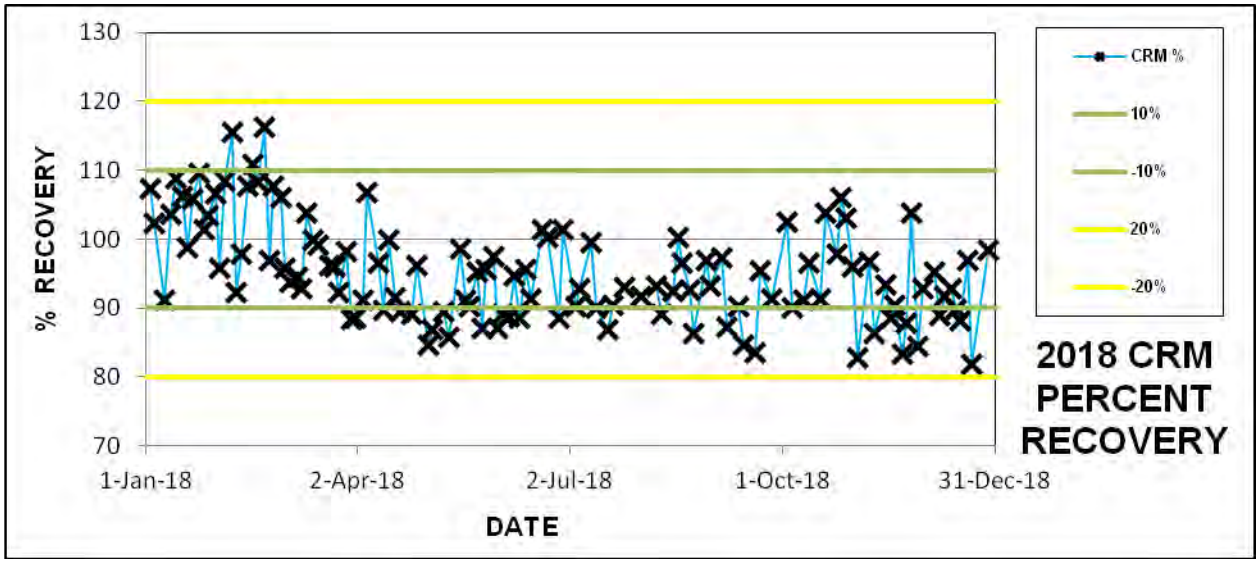

Figure 3b: CRM percent recovery quality control results for the 2018 year.

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4 Spikes

The spike standard used from January 1st through February 28th 2018 is from ERA #RAD-A (0.249Bq/L) and from March 1st through December 31st is from Eckert & Ziegler (0.250Bq/L) .

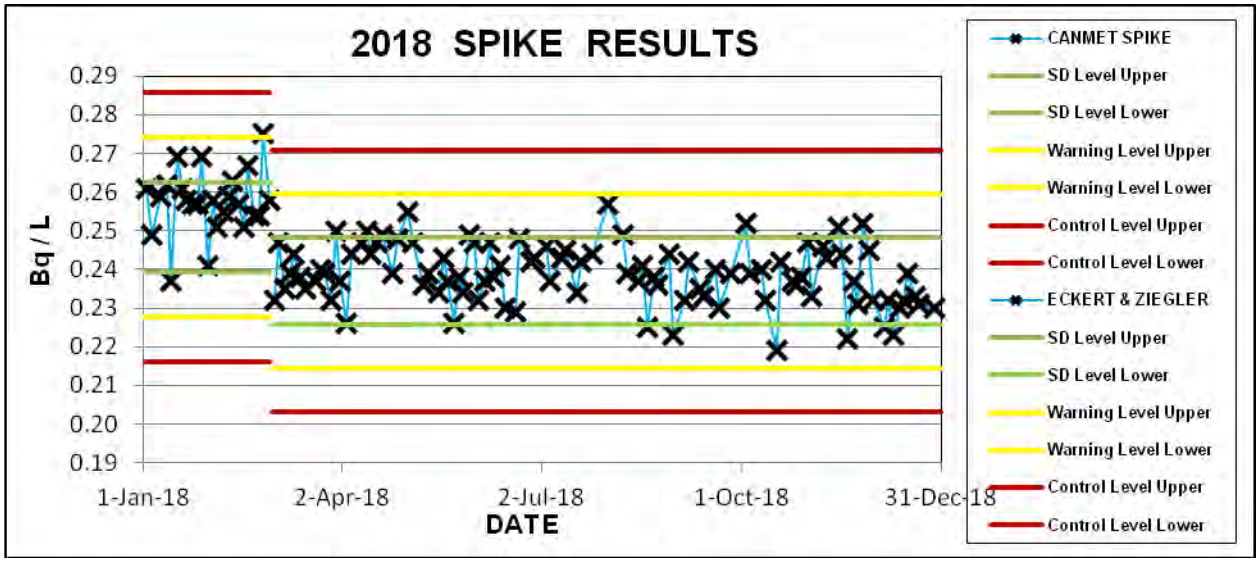

Figure 4a: Spike recovery quality control results for the 2018 year

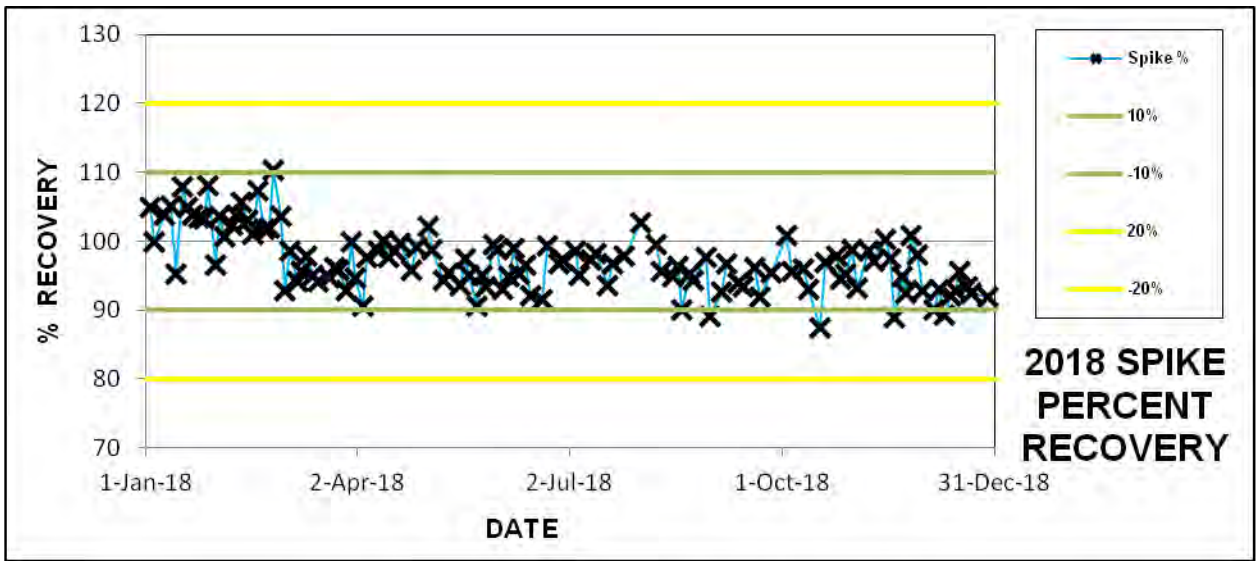

Figure 4b: Percent spike recovery quality control results for the 2018 year.

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QC Frequency

Through the 2018 year, ELRFS analyzed 122 batches totaling 1426 samples for ^{226}Ra. Each batch incorporated blank, CRM, duplicate, and spiked samples providing greater than 20% quality control samples.

APPENDIX IV
Field QA/QC Results

Month	Sample	pH	Sulphate	Radium (T)	Uranium	Barium	Cobalt	Iron	Manganese
			mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L	mg/L
2018-05	BSR5	6.7	9.1	0.020	0.0018	0.015	< 0.0005	0.41	0.127
	M-01	6.7	8.9	0.017	0.0018	0.016	< 0.0005	0.41	0.124
	variance	0.0%	2.2%	16.2%	0.0%	6.5%	0.0%	0.0%	2.4%
2018-05	BSD2	6.5	16.0	0.007	< 0.0005	0.012	< 0.0005	0.18	0.098
	D-6	6.5	16.0	< 0.007	< 0.0005	0.013	< 0.0005	0.18	0.098
	variance	0.0%	0.0%	0.0%	0.0%	8.0%	0.0%	0.0%	0.0%
2018-11	BSR5	6.8	11.0	0.015	0.0030	0.015	< 0.0005	0.46	0.040
	M-01	6.8	11.0	0.018	0.0029	0.015	< 0.0005	0.48	0.035
	variance	0.0%	0.0%	18.2%	3.4%	0.0%	0.0%	4.3%	13.3%
2018-11	BSD2	6.6	14.0	< 0.007	< 0.0005	0.012	< 0.0005	0.16	0.079
	D-6	6.6	13.0	< 0.007	< 0.0005	0.012	< 0.0005	0.17	0.082
	variance	0.0%	7.4%	0.0%	0.0%	0.0%	0.0%	6.1%	3.7%
Count		4	4	4	4	4	4	4	4
Average		0.0%	2.4%	8.6%	0.8%	3.6%	0.0%	2.6%	4.9%
Max		0.0%	7.4%	18.2%	3.4%	8.0%	0.0%	6.1%	13.3%
Min		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SRWMP[1] Target		20%	20%	20%	20%	20%	20%	20%	20%
# Exceedances		0	0	0	0	0	0	0	0

[1] Field Precision criteria as per Table 5.2 in the Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

Bold indicates an exceedance in the field precision criteria

Denison Mines

SRWMP DATA QUALITY REPORTING
Field Blank 2018
Revision: 2016-01

Rio Algom

Report Form: RC8.5.4.01b

Date		pH	Sulphate	Radium (T)	Uranium	Barium	Cobalt	Iron	Manganese
			mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L	mg/L
SRWMP [1]		1	0.2	0.01	0.001	0.01	0.001	0.04	0.004
2018.05	FBR5	5.6	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002
2018.05	FBD2	5.2	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002
2018.11	FBD2	5.9	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002
2018.11	FBR5	5.9	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002
Count		4	4	4	4	4	4	4	4
# Exceedances		4	0	0	0	0	0	0	0
Average		5.7	< 0.10	< 0.007	< 0.0005	< 0.0050	< 0.0005	< 0.02	< 0.0020
Max		5.9	< 0.10	< 0.007	< 0.0005	< 0.0050	< 0.0005	< 0.02	< 0.0020
Min		5.2	< 0.10	< 0.007	< 0.0005	< 0.0050	< 0.0005	< 0.02	< 0.0020

[1] SRWMP Field Blank criteria as per Table 5.2 in the Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

Bold indicates an exceedance in the Field Blank criteria

APPENDIX V
Location Results

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

BSD2

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-05	23.3	6.5	16.0	0.007	0.012	<0.0005	0.18	0.098
2018-11	22.2	6.6	14.0	<0.007	0.012	<0.0005	0.16	0.079
Count	2	2	2	2	2	2	2	2
High	23.3	6.6	16.0	0.007	0.012	<0.0005	0.18	0.098
Low	22.2	6.5	14.0	<0.007	0.012	<0.0005	0.16	0.079
Mean	22.8	6.5	15.0	0.007	0.012	<0.0005	0.17	0.088
High Limit			309	1.000	1.000	0.0025	0.49	0.800
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-05	<0.0005
2018-11	<0.0005
Count	2
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

BSR5

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-05	34.2	6.7	9.1	0.020	0.015	<0.0005	0.41	0.127
2018-11	32.0	6.8	11.0	0.015	0.015	<0.0005	0.46	0.040
Count	2	2	2	2	2	2	2	2
High	34.2	6.8	11.0	0.020	0.015	<0.0005	0.46	0.127
Low	32.0	6.7	9.1	0.015	0.015	<0.0005	0.41	0.040
Mean	33.1	6.8	10.1	0.018	0.015	<0.0005	0.43	0.084
High Limit			218	1.000	1.000	0.0025	1.69	0.800
Low Limit		5.2						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-05	0.0018
2018-11	0.0030
Count	2
High	0.0030
Low	0.0018
Mean	0.0024
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018
Performance Monitoring Monthly Average Results 2018

D-4 Dunlop Lake Outlet

Month	hard mg/L	pHF	SO4 mg/L	Ra Bq/L	Ba mg/L	Co mg/L	Fe mg/L	Mn mg/L
2018-05	9.5	6.5	3.4	<0.007	0.012	<0.0005	0.04	0.013
2018-11	9.2	6.8	3.4	<0.007	0.012	<0.0005	0.03	0.015
Count	2	2	2	2	2	2	2	2
High	9.5	6.8	3.4	<0.007	0.012	<0.0005	0.04	0.015
Low	9.2	6.5	3.4	<0.007	0.012	<0.0005	0.03	0.013
Mean	9.3	6.7	3.4	<0.007	0.012	<0.0005	0.04	0.014
High Limit			128.0	1.000	1.000	0.0025	0.49	0.800
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U mg/L
2018-05	<0.0005
2018-11	<0.0005
Count	2
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

D-5 Serpent R. between Denison and Quirke TMAs

Month	FLOW L/s	hard mg/L	pHF	SO4 mg/L	Ra Bq/L	Ba mg/L	Co mg/L	Fe mg/L
2018-02	2225.00	30.2	6.8	17.0	0.032	0.061	<0.0005	0.07
2018-05	3235.00	18.8	6.6	11.0	0.040	0.052	<0.0005	0.06
2018-08	108.00	44.0	6.7	22.0	0.209	0.287	<0.0005	0.10
2018-11	2692.00	13.2	6.7	5.2	0.010	0.025	<0.0005	0.05
Count	4	4	4	4	4	4	4	4
High	3235.00	44.0	6.8	22.0	0.209	0.287	<0.0005	0.10
Low	108.00	13.2	6.6	5.2	0.010	0.025	<0.0005	0.05
Mean	2065.00	26.6	6.7	13.8	0.073	0.106	<0.0005	0.07
High Limit				128.0	1.000	1.000	0.0025	0.49
Low Limit			6.5					
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	Mn mg/L	U mg/L
2018-02	0.022	0.0015
2018-05	0.024	0.0012
2018-08	0.089	0.0027
2018-11	0.020	<0.0005
Count	4	4
High	0.089	0.0027
Low	0.020	<0.0005
Mean	0.039	0.0015
High Limit	0.800	0.0150
Lim Ex	0	0
Frequency	0%	0%
10x Lim Ex	0	0
Frequency	0%	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018
Performance Monitoring Monthly Average Results 2018

D-6 Cinder Lake Outlet

Month	FLOW L/s	hard mg/L	pHF	SO4 mg/L	Ra Bq/L	Ba mg/L	Co mg/L	Fe mg/L
2018-02	50.00	26.2	6.6	17.0	<0.007	0.015	<0.0005	0.26
2018-05	75.00	22.9	6.5	16.0	<0.007	0.013	<0.0005	0.18
2018-09	2.00	124.0	6.5	93.0	0.039	0.028	0.0064	2.69
2018-11	390.00	22.7	6.6	13.0	<0.007	0.012	<0.0005	0.17
Count	4	4	4	4	4	4	4	4
High	390.00	124.0	6.6	93.0	0.039	0.028	0.0064	2.69
Low	2.0	22.7	6.5	13.0	<0.007	0.012	<0.0005	0.17
Mean	103.60	49.0	6.6	34.8	0.015	0.017	0.0020	0.82
High Limit				309	1.000	1.000	0.0025	0.49
Low Limit			6.5					
Lim Ex	0	0	0	0	0	0	1	1
Frequency	0%	0%	0%	0%	0%	0%	25%	25%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	Mn mg/L	U mg/L
2018-02	0.115	<0.0005
2018-05	0.098	<0.0005
2018-09	1.630	<0.0005
2018-11	0.082	<0.0005
Count	4	4
High	1.630	<0.0005
Low	0.082	<0.0005
Mean	0.481	<0.0005
High Limit	0.800	0.0150
Lim Ex	0	0
Frequency	25%	0%
10x Lim Ex	0	0
Frequency	0%	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

DS-18 Halfmoon Lake Outlet

Month	FLOW L/s	hard mg/L	pHF	SO4 mg/L	Ra Bq/L	Ba mg/L	Co mg/L	Fe mg/L
2018-02		108.0	7.1	68.0	0.103	0.023	<0.0005	0.28
2018-05	262.00	76.3	7.0	64.0	0.183	0.023	<0.0005	0.31
2018-08	56.60	45.8	7.3	25.0	0.148	0.015	<0.0005	0.34
2018-10	404.00	90.8	6.9	70.0	0.173	0.022	<0.0005	0.17
Count	4	4	4	4	4	4	4	4
High	404.00	108.0	7.3	70.0	0.183	0.023	<0.0005	0.34
Low	56.60	45.8	6.9	25.0	0.103	0.015	<0.0005	0.17
Mean	240.87	80.2	7.1	56.8	0.152	0.021	<0.0005	0.28
High Limit				309	1.000	1.000	0.0025	1.69
Low Limit			5.2					
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	Mn mg/L	U mg/L
2018-02	0.028	<0.0005
2018-05	0.018	<0.0005
2018-08	0.029	0.0009
2018-10	0.011	0.0014
Count	4	4
High	0.029	0.0014
Low	0.011	<0.0005
Mean	0.022	0.0008
High Limit	0.800	0.0150
Lim Ex	0	0
Frequency	0%	0%
10x Lim Ex	0	0
Frequency	0%	0%

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Performance Monitoring Monthly Average Results 2018

FBD2

Month	hard	pHF	SO4	Ra	Ba	Fe	Mn	U
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-05	<0.5	5.2	<0.1	<0.007	<0.005	<0.02	<0.002	<0.0005
2018-11	<0.5	5.9	<0.1	<0.007	<0.005	<0.02	<0.002	<0.0005
Count	2	2	2	2	2	2	2	2
High	<0.5	5.9	<0.1	<0.007	<0.005	<0.02	<0.002	<0.0005
Low	<0.5	5.2	<0.1	<0.007	<0.005	<0.02	<0.002	<0.0005
Mean	<0.5	5.6	<0.1	<0.007	<0.005	<0.02	<0.002	<0.0005

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

FBR5

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-05	<0.5	5.6	<0.1	<0.007	<0.005	<0.0005	<0.02	<0.002
2018-11	<0.5	5.9	<0.1	<0.007	<0.005	<0.0005	<0.02	<0.002
Count	2	2	2	2	2	2	2	2
High	<0.5	5.9	<0.1	<0.007	<0.005	<0.0005	<0.02	<0.002
Low	<0.5	5.6	<0.1	<0.007	<0.005	<0.0005	<0.02	<0.002
Mean	<0.5	5.8	<0.1	<0.007	<0.005	<0.0005	<0.02	<0.002

Month	U
	mg/L
2018-05	<0.0005
2018-11	<0.0005
Count	2
High	<0.0005
Low	<0.0005
Mean	<0.0005

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Performance Monitoring Monthly Average Results 2018

M-01 Sherriff Creek @ Hwy 108

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-02	41.7	6.5	13.0	0.019	0.019	<0.0005	0.57	0.081
2018-05	32.6	6.7	8.9	0.017	0.016	<0.0005	0.41	0.124
2018-08	13.0	6.7	2.6	<0.007	0.009	0.0008	1.68	0.075
2018-11	32.5	6.8	11.0	0.018	0.015	<0.0005	0.47	0.035
Count	4	4	4	4	4	4	4	4
High	41.7	6.8	13.0	0.019	0.019	0.0008	1.68	0.124
Low	13.0	6.5	2.6	<0.007	0.009	<0.0005	0.41	0.035
Mean	30.0	6.7	8.9	0.015	0.015	0.0006	0.78	0.079
High Limit			218	1.000	1.000	0.0025	1.69	0.800
Low Limit		5.2						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-02	0.0029
2018-05	0.0018
2018-08	<0.0005
2018-11	0.0029
Count	4
High	0.0029
Low	<0.0005
Mean	0.0020
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018
Performance Monitoring Monthly Average Results 2018

Q-09 Serpent R. below Quirke TMA Effluent

Month	FLOW	hard	pHF	SO4	Ra	Ba	Co	Fe
	L/s	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L
2018-02	2325.00	72.4	6.7	56.0	0.041	0.060	<0.0005	0.20
2018-05	3325.00	31.6	6.6	22.0	0.057	0.061	<0.0005	0.19
2018-08	168.00	113.0	6.6	85.0	0.283	0.324	<0.0005	0.95
2018-11	2822.00	49.3	6.7	39.0	0.021	0.031	<0.0005	0.17
Count	4	4	4	4	4	4	4	4
High	3325.00	113.0	6.7	85.0	0.283	0.324	<0.0005	0.95
Low	168.00	31.6	6.6	22.0	0.021	0.031	<0.0005	0.17
Mean	2160.00	66.6	6.7	50.5	0.100	0.119	<0.0005	0.37
High Limit				218	1.000	1.000	0.0025	0.49
Low Limit			6.5					
Lim Ex	0	0	0	0	0	0	0	1
Frequency	0%	0%	0%	0%	0%	0%	0%	25%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	Mn	U
	mg/L	mg/L
2018-02	0.064	0.0019
2018-05	0.075	0.0026
2018-08	0.215	0.0033
2018-11	0.052	0.0011
Count	4	4
High	0.215	0.0033
Low	0.052	0.0011
Mean	0.102	0.0022
High Limit	0.800	0.0150
Lim Ex	0	0
Frequency	0%	0%
10x Lim Ex	0	0
Frequency	0%	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

Q-20 Evans Lake Outlet to Dunlop Lake

Month	FLOW L/s	hard mg/L	pHF	SO4 mg/L	Ra Bq/L	Ba mg/L	Co mg/L	Fe mg/L
2018-11	10.00	38.2	6.6	19.0	<0.007	0.019	<0.0005	<0.02
Count	1	1	1	1	1	1	1	1
High	10.00	38.2	6.6	19.0	<0.007	0.019	<0.0005	<0.02
Low	10.00	38.2	6.6	19.0	<0.007	0.019	<0.0005	<0.02
Mean	10.00	38.2	6.6	19.0	<0.007	0.019	<0.0005	<0.02
High Limit				218	1.000	1.000	0.0025	0.49
Low Limit			6.5					
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	Mn mg/L	U mg/L
2018-11	0.025	<0.0005
Count	1	1
High	0.025	<0.0005
Low	0.025	<0.0005
Mean	0.025	<0.0005
High Limit	0.800	0.0150
Lim Ex	0	0
Frequency	0%	0%
10x Lim Ex	0	0
Frequency	0%	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SC-01 Westner Lake Outlet

Month	hard mg/L	pHF	SO4 mg/L	Ra Bq/L	Ba mg/L	Co mg/L	Fe mg/L	Mn mg/L
2018-11	31.5	6.6	18.0	0.009	0.011	<0.0005	0.14	0.015
Count	1	1	1	1	1	1	1	1
High	31.5	6.6	18.0	0.009	0.011	<0.0005	0.14	0.015
Low	31.5	6.6	18.0	0.009	0.011	<0.0005	0.14	0.015
Mean	31.5	6.6	18.0	0.009	0.011	<0.0005	0.14	0.015
High Limit			218	1.000	1.000	0.0025	1.69	0.800
Low Limit		5.2						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U mg/L
2018-11	<0.0005
Count	1
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SR-01 Quirke Lake Outlet

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-10	35.4	6.7	29.0	0.017	0.034	<0.0005	<0.02	0.004
Count	1	1	1	1	1	1	1	1
High	35.4	6.7	29.0	0.017	0.034	<0.0005	<0.02	0.004
Low	35.4	6.7	29.0	0.017	0.034	<0.0005	<0.02	0.004
Mean	35.4	6.7	29.0	0.017	0.034	<0.0005	<0.02	0.004
High Limit			218	1.000	1.000	0.0025	0.49	0.800
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-10	0.0011
Count	1
High	0.0011
Low	0.0011
Mean	0.0011
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

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Performance Monitoring Monthly Average Results 2018

SR-03 Pecors Lake Outlet[1]

Month	hard	pHF	SO4	TOXCD	TOXDM	TOXRT	Ra	Ba
	mg/L		mg/L	IC25	%	%	Bq/L	mg/L
2018-01	36.0	6.9	23.0	55	0	0	0.013	0.037
2018-02	41.0	6.9	25.5	100	0	0	0.022	0.044
2018-03	33.3	7.0	25.0	100	0	0	0.018	0.040
2018-04	36.8	6.8	24.5	100	0	0	0.017	0.043
2018-05	31.1	7.2	22.0	100	0	0	0.014	0.038
2018-06	31.6	7.2	21.5	100	0	0	0.012	0.035
2018-07	33.1	7.0	22.5	67	0	0	0.016	0.047
2018-10	30.6	7.1	21.0	100	0	0	0.013	0.043
2018-11	34.1	6.6	21.0	76	0	0	0.015	0.042
Count	14	14	14	14	14	14	14	14
High	43.8	7.3	27.0	100	0	0	0.025	0.053
Low	30.6	6.6	21.0	10	0	0	0.007	0.034
Mean	34.7	7.0	23.1	87	0	0	0.016	0.041
High Limit			128.0				1.000	1.000
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	Co	Fe	Mn	U
	mg/L	mg/L	mg/L	mg/L
2018-01	<0.0005	0.02	0.007	0.0009
2018-02	<0.0005	0.02	0.005	0.0009
2018-03	<0.0005	0.02	0.003	0.0009
2018-04	<0.0005	0.03	0.004	0.0010
2018-05	<0.0005	0.03	0.005	0.0008
2018-06	<0.0005	0.03	0.005	0.0009
2018-07	<0.0005	0.02	0.007	0.0009
2018-10	<0.0005	<0.02	0.007	0.0007
2018-11	<0.0005	<0.02	0.022	0.0007
Count	14	14	14	14
High	<0.0005	0.03	0.022	0.0010
Low	<0.0005	<0.02	0.003	0.0007
Mean	<0.0005	0.02	0.007	0.0008
High Limit	0.0025	0.49	0.800	0.0150
Lim Ex	0	0	0	0
Frequency	0%	0%	0%	0%
10x Lim Ex	0	0	0	0
Frequency	0%	0%	0%	0%

[1] This station was removed from the program in 2009 but re-introduced as part of a response monitoring program in 2018. Response monitoring was initiated to assess impacts on the receiving environment that may have occurred due to a non-compliance in the monthly mean radium concentrations upstream at the Stanleigh final discharge. The non-compliance first occurred in November 2017 (detailed in the 2017 Rio Care & Maintenance Annual Report) and continued until the end of January 2018.

SRWMP ANNUAL WATER QUALITY REPORT 2018
Performance Monitoring Monthly Average Results 2018

SR-06 McCabe Lake Outlet[1]

Month	FLOW	hard	pHF	SO4	TOXCD	TOXDM	TOXRT	Ra
	L/s	mg/L		mg/L	IC25	%	%	Bq/L
2018-01	780.00	47.5	7.0	28.5	83	0	0	0.086
2018-02	401.45	41.5	6.8	25.0	100	0	0	0.096
2018-03	319.00	44.6	7.1	36.0	100	0	0	0.093
2018-04	583.50	43.3	6.8	27.5	100	0	0	0.095
2018-05	778.00	44.1	7.0	33.0	100	0	0	0.121
2018-06	439.00	46.3	6.9	32.0	100	0	0	0.107
2018-07	56.95	45.4	7.1	33.0	100	0	0	0.112
2018-10	1086.13	44.9	7.2	32.0	100	0	0	0.100
Count	13	13	13	13	13	13	13	13
High	1086.13	49.1	7.2	36.0	100	0	0	0.121
Low	39.10	34.2	6.7	19.0	67	0	0	0.072
Mean	515.76	44.7	7.0	30.2	97	0	0	0.100
High Limit				128.0				1.000
Low Limit			6.5					
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	Ba	Co	Fe	Mn	U
	mg/L	mg/L	mg/L	mg/L	mg/L
2018-01	0.658	<0.0005	0.04	0.009	0.0006
2018-02	0.704	<0.0005	0.13	0.010	0.0005
2018-03	0.776	<0.0005	0.04	0.007	0.0006
2018-04	0.703	<0.0005	0.07	0.012	0.0006
2018-05	0.667	<0.0005	0.03	0.013	0.0007
2018-06	0.643	<0.0005	<0.02	0.010	0.0006
2018-07	0.684	<0.0005	<0.02	0.012	0.0006
2018-10	0.642	<0.0005	<0.02	0.010	0.0006
Count	13	13	13	13	13
High	0.972	<0.0005	0.23	0.018	0.0007
Low	0.436	<0.0005	<0.02	0.006	<0.0005
Mean	0.682	<0.0005	0.05	0.011	0.0006
High Limit	1.000	0.0025	0.49	0.800	0.0150
Lim Ex	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%

[1] Sample frequency increased to twice monthly in 2018 as part of a response monitoring program. Response monitoring was initiated to assess impacts on the receiving environment that may have occurred due to a non-compliance in the monthly mean radium concentration upstream at the Stanleigh final discharge. The non-compliance first occurred in November 2017 (detailed in the 2017 Rio Care & Maintenance Annual Report) and continued until the end of January 2018.

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SR-08 Nordic Lake Outlet

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-02	250.0	7.0	160.0	0.028	0.022	<0.0005	0.04	0.020
2018-05	136.0	7.1	110.0	0.036	0.018	<0.0005	0.09	0.040
2018-08	160.0	6.6	120.0	0.031	0.017	<0.0005	0.15	0.150
2018-11	190.0	6.7	160.0	0.018	0.019	<0.0005	0.03	0.051
Count	4	4	4	4	4	4	4	4
High	250.0	7.1	160.0	0.036	0.022	<0.0005	0.15	0.150
Low	136.0	6.6	110.0	0.018	0.017	<0.0005	0.03	0.020
Mean	184.0	6.8	137.5	0.028	0.019	<0.0005	0.07	0.065
High Limit			429	1.000	1.000	0.0025	0.49	0.800
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-02	0.0007
2018-05	0.0007
2018-08	<0.0005
2018-11	0.0008
Count	4
High	0.0008
Low	<0.0005
Mean	0.0007
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SR-15 May Lake

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-05	44.2	6.8	30.0	0.050	0.209	<0.0005	0.03	0.008
2018-08	42.3	7.5	31.0	0.070	0.224	<0.0005	<0.02	0.005
2018-10	46.9	7.0	30.0	0.054	0.207	<0.0005	0.02	0.006
Count	3	3	3	3	3	3	3	3
High	46.9	7.5	31.0	0.070	0.224	<0.0005	0.03	0.008
Low	42.3	6.8	30.0	0.050	0.207	<0.0005	<0.02	0.005
Mean	44.5	7.1	30.3	0.058	0.213	<0.0005	0.02	0.006
High Limit			218	1.000	1.000	0.0025	0.49	0.800
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-05	<0.0005
2018-08	<0.0005
2018-10	<0.0005
Count	3
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SR-16 Fox Creek @ Hwy 108

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-02	9.0	5.5	0.9	<0.007	0.008	<0.0005	1.08	0.034
2018-05	6.4	5.6	0.7	<0.007	0.006	<0.0005	0.35	0.031
2018-08	12.4	5.4	0.2	<0.007	0.010	<0.0005	0.66	0.067
2018-11	8.2	5.2	3.1	<0.007	0.007	<0.0005	0.57	0.039
Count	4	4	4	4	4	4	4	4
High	12.4	5.6	3.1	<0.007	0.010	<0.0005	1.08	0.067
Low	6.4	5.2	0.2	<0.007	0.006	<0.0005	0.35	0.031
Mean	9.0	5.4	1.2	<0.007	0.008	<0.0005	0.66	0.043
High Limit			128.0	1.000	1.000	0.0025	1.69	0.800
Low Limit		5.2						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-02	<0.0005
2018-05	<0.0005
2018-08	<0.0005
2018-11	<0.0005
Count	4
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SR-17 Unnamed Creek Drain Lake 3 @ Hwy 108

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-02	17.7	5.7	2.8	<0.007	0.030	0.0014	0.94	0.096
2018-05	11.1	5.4	2.6	<0.007	0.026	0.0013	0.98	0.079
2018-08	16.7	5.6	0.5	<0.007	0.032	0.0015	1.91	0.102
2018-11	11.3	5.4	3.6	0.009	0.020	0.0008	0.47	0.048
Count	4	4	4	4	4	4	4	4
High	17.7	5.7	3.6	0.009	0.032	0.0015	1.91	0.102
Low	11.1	5.4	0.5	<0.007	0.020	0.0008	0.47	0.048
Mean	14.2	5.5	2.4	0.007	0.027	0.0013	1.08	0.081
High Limit			128.0	1.000	1.000	0.0025	1.69	0.800
Low Limit		5.2						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-02	<0.0005
2018-05	<0.0005
2018-08	<0.0005
2018-11	<0.0005
Count	4
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SR-18 Jim Christ Lake Outlet

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-05	9.2	6.7	3.7	<0.007	0.044	<0.0005	0.04	0.011
2018-11	10.6	6.9	5.3	<0.007	0.047	<0.0005	0.04	0.011
Count	2	2	2	2	2	2	2	2
High	10.6	6.9	5.3	<0.007	0.047	<0.0005	0.04	0.011
Low	9.2	6.7	3.7	<0.007	0.044	<0.0005	0.04	0.011
Mean	9.9	6.8	4.5	<0.007	0.045	<0.0005	0.04	0.011
High Limit			128.0	1.000	1.000	0.0025	0.49	0.800
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-05	<0.0005
2018-11	<0.0005
Count	2
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

SRWMP ANNUAL WATER QUALITY REPORT 2018

Performance Monitoring Monthly Average Results 2018

SR-19 Inlet to Elliot Lake

Month	hard	pHF	SO4	Ra	Ba	Co	Fe	Mn
	mg/L		mg/L	Bq/L	mg/L	mg/L	mg/L	mg/L
2018-02	18.3	6.6	3.4	<0.007	0.027	<0.0005	0.31	0.018
2018-05	15.6	6.8	3.2	<0.007	0.020	<0.0005	0.15	0.022
2018-08	25.0	6.7	3.3	0.010	0.035	0.0007	0.74	0.181
2018-11	12.8	6.7	3.1	0.010	0.018	<0.0005	0.19	0.020
Count	4	4	4	4	4	4	4	4
High	25.0	6.8	3.4	0.010	0.035	0.0007	0.74	0.181
Low	12.8	6.6	3.1	<0.007	0.018	<0.0005	0.15	0.018
Mean	17.9	6.7	3.2	0.009	0.025	0.0006	0.35	0.060
High Limit			128.0	1.000	1.000	0.0025	0.49	0.800
Low Limit		6.5						
Lim Ex	0	0	0	0	0	0	1	0
Frequency	0%	0%	0%	0%	0%	0%	25%	0%
10x Lim Ex	0	0	0	0	0	0	0	0
Frequency	0%	0%	0%	0%	0%	0%	0%	0%

Month	U
	mg/L
2018-02	<0.0005
2018-05	<0.0005
2018-08	<0.0005
2018-11	<0.0005
Count	4
High	<0.0005
Low	<0.0005
Mean	<0.0005
High Limit	0.0150
Lim Ex	0
Frequency	0%
10x Lim Ex	0
Frequency	0%

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station D-4

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	128.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.05
2014		7.2	4.6	< 0.005	< 0.0005	0.013	< 0.0005	0.03	0.010	10.0
2015		6.9	3.9	< 0.007	< 0.0005	0.013	< 0.0005	0.03	0.017	9.3
2016		6.8	3.8	< 0.008	< 0.0005	0.013	< 0.0005	0.04	0.016	10.8
2017		6.8	3.5	< 0.007	< 0.0005	0.013	< 0.0005	0.04	0.021	9.6
2018		6.7	3.4	< 0.007	< 0.0005	0.012	< 0.0005	0.04	0.014	9.3

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.
Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-18

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	128.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.50
2014		6.9	4.3	< 0.005	< 0.0005	0.043	< 0.0005	0.07	0.013	10.5
2015		6.9	4.6	< 0.007	< 0.0005	0.048	< 0.0005	0.07	0.030	10.4
2016		7.0	4.5	< 0.008	< 0.0005	0.048	< 0.0005	0.05	0.015	11.5
2017		6.8	4.0	< 0.007	< 0.0005	0.043	< 0.0005	0.07	0.025	10.4
2018		6.8	4.5	< 0.007	< 0.0005	0.045	< 0.0005	0.04	0.011	9.9

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 202016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-19

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	128.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.50
2014		7.0	3.7	< 0.005	< 0.0005	0.022	< 0.0005	0.31	0.038	15.0
2015		7.1	4.0	< 0.007	< 0.0005	0.025	< 0.0005	0.40	0.050	18.2
2016		6.8	4.0	< 0.008	< 0.0005	0.026	< 0.0005	0.35	0.054	16.0
2017		7.0	3.0	0.008	< 0.0005	0.019	< 0.0005	0.36	0.031	14.4
2018		6.7	3.2	0.009	< 0.0005	0.025	0.0006	0.35	0.060	17.9

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.
Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-16

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	128.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		5.5	1.1	< 0.005	< 0.0005	0.007	0.0007	0.77	0.045	6.9
2015		5.6	1.1	< 0.007	< 0.0005	0.006	0.0007	0.97	0.044	7.2
2016		5.8	1.3	< 0.008	< 0.0005	0.007	0.0006	0.67	0.032	8.0
2017		5.7	1.1	< 0.007	< 0.0005	0.007	0.0007	0.94	0.038	7.4
2018		5.4	1.2	< 0.007	< 0.0005	0.008	< 0.0005	0.66	0.043	9.0

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland/stream stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.
Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-17

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	128.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		5.4	2.8	< 0.005	< 0.0005	0.018	0.0011	1.19	0.067	10.2
2015		5.6	2.6	< 0.007	< 0.0005	0.017	0.0010	1.11	0.061	10.2
2016		5.8	2.5	0.009	< 0.0005	0.022	0.0010	1.32	0.064	12.8
2017		5.8	2.8	0.007	< 0.0005	0.022	0.0008	0.73	0.048	11.8
2018		5.5	2.4	0.007	< 0.0005	0.027	0.0013	1.08	0.081	14.2

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland/stream stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station D-5

YEAR		FLOW (L/s)	pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks		6.5	128.0	1.000	0.0150	1.000	0.0025		0.800	
	Wetland benchmark [2]		5.2						1.69		
	Lake benchmark [3]								0.49		
MDL [4]			0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		5672.0	7.1	14.9	0.053	0.0017	0.059	< 0.0005			
2015		2144.3	6.9	13.8	0.057	0.0015	0.068	< 0.0005			
2016		1884.0	6.8	14.1	0.069	0.0015	0.047	< 0.0005	0.08	0.047	26.6
2017		4843.0	6.8	11.3	0.040	0.0013	0.045	< 0.0005	0.07	0.026	20.5
2018		2065.0	6.7	13.8	0.073	0.0015	0.106	< 0.0005	0.07	0.039	26.6

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station D-6

YEAR		FLOW (L/s)	pHF	SO4 [5] (mg/L)		Ra (Bq/L)		U (mg/L)	Ba (mg/L)		Co (mg/L)	Fe (mg/L	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks		6.5	309.0		1.000		0.0150	1.000		0.0025		0.800	-
	Wetland benchmark [2]		5.2									1.69		
	Lake benchmark [3]											0.49		
MDL [4]			0.1	0.1		0.005		0.0005	0.005		0.0005	0.02	0.002	0.5
2014		396.4	6.6	33.0		0.006	<	0.0005	0.017		0.0006	0.34	0.215	42.2
2015		167.9	6.7	22.8		0.007	<	0.0005	0.017		0.0007	0.45	0.267	53.3
2016		95.3	6.6	88.8		0.011	<	0.0005	0.022		0.0013	0.54	0.458	100.9
2017		151.9	6.7	18.8	<	0.007	<	0.0005	0.013	<	0.0005	0.19	0.102	28.7
2018		129.3	6.6	34.8		0.015	<	0.0005	0.017		0.0020	**0.82**	0.481	49.0

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland/stream stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station BSD2

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	309.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005		0.02	0.002	0.5
2014		6.7	15.0	< 0.005	< 0.0005	0.012	**<** 0.0005	0.16	0.072	21.3
2015		6.8	21.0	< 0.007	< 0.0005	0.012	**<** 0.0005	0.13	0.066	26.1
2016		6.6	54.0	0.010	< 0.0005	0.017	0.0006	0.28	0.160	64.6
2017		6.7	18.0	< 0.007	< 0.0005	0.013	**<** 0.0005	0.17	0.099	27.2
2018		6.5	15.0	0.007	< 0.0005	0.012	**<** 0.0005	0.17	0.088	22.8

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station FBD2

YEAR		pHF	SO4 [5] (mg/L	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness mg/L
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	309.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		5.4	< 0.1	< 0.005	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002	< 0.5
2015		5.4	0.3	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002	< 0.5
2016		5.7	< 0.1	< 0.008	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002	< 0.5
2017		5.2	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002	<0.5
2018		5.6	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002	<0.5

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station DS-18

YEAR		FLOW (L/s)	pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks		6.5	309.0	1.000	0.0150	1.000	0.0025		0.80	-
	Wetland benchmark [2]		5.2						1.69		
	Lake benchmark [3]								0.49		
MDL [4]			0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		286.3	6.8	73.5	0.101	0.0013	0.016	0.0007	1.68		141.8
2015		126.9	7.0	94.8	0.135	0.0007	0.020	< 0.0005	0.39		93.0
2016		118.5	7.0	58.8	0.131	0.0006	0.018	< 0.0005	0.34	0.020	80.6
2017		338.7	6.8	59.8	0.193	0.0008	0.017	< 0.0005	0.60	0.037	83.5
2018		240.9	7.1	56.8	0.152	0.0008	0.021	< 0.0005	0.28	0.022	80.2

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.
Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station M-01

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)		Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	218.0	1.000	0.0150	1.000		0.0025		0.800	-
	Wetland benchmark [2]	5.2							1.69		
	Lake benchmark [3]								0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005		0.0005	0.02	0.002	0.5
2014		6.9	10.3	0.014	0.0032	0.015	<	0.0005	0.82		
2015		6.8	11.1	0.013	0.0025	0.015	<	0.0005	0.50		
2016		6.7	11.4	0.021	0.0026	0.017	<	0.0005	0.43	0.017	44.4
2017		6.8	10.0	0.016	0.0034	0.015	<	0.0005	0.58	0.070	36.3
2018		6.7	8.9	0.015	0.0020	0.015		0.0006	0.78	0.079	30.0

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station BSR5

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	218.0	1.000	0.0050	1.000	0.0025		0.8	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		7.3	10.1	0.015	0.0033	0.016	< 0.0005	0.32		31.1
2015		6.9	11.0	0.014	0.0026	0.014	< 0.0005	0.33		
2016		6.7	13.0	0.026	0.0021	0.018	< 0.0005	0.41	0.136	38.8
2017		6.8	9.1	0.014	0.0031	0.014	< 0.0005	0.32	0.064	34.5
2018		6.8	10.1	0.018	0.0024	0.015	< 0.0005	0.43	0.084	33.1

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent. Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station FBR5

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	218.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		5.6	< 0.1	< 0.005	< 0.0005	< 0.005	< 0.0005	< 0.02		
2015		5.6	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02		
2016		5.3	< 0.1	< 0.008	< 0.0005	< 0.005	< 0.0005	< 0.02	< 0.002	< 0.5
2017		5.3	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	<0.002	<0.5
2018		5.8	< 0.1	< 0.007	< 0.0005	< 0.005	< 0.0005	< 0.02	<0.002	<0.5

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station Q-09

YEAR		FLOW (L/s)	pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks		6.5	218.0	1.000	0.0150	1.000			0.800	-
	Wetland benchmark [2]		5.2						1.69		
	Lake benchmark [3]								0.49		
MDL [4]			0.1	0.1	0.005	0.0005	0.005		0.02	0.002	0.5
2014		5819.50	7.0	37.0	0.068	0.0021	0.073	< 0.0005			47.4
2015		2187.75	6.8	47.8	0.069	0.0027	0.095	< 0.0005			59.0
2016		1956.25	6.6	82.3	0.077	0.0027	0.097	< 0.0005	0.08	0.034	92.8
2017		2531.30	6.7	44.8	0.052	0.0015	0.055	< 0.0005	0.17	0.036	55.6
2018		2160.00	6.7	50.5	0.100	0.0022	0.119	< 0.0005	0.37	0.102	66.6

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station Q-20

YEAR		FLOW (L/s)	pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks		6.5	218.0	1.000	0.0150	1.000			0.800	
	Wetland benchmark [2]		5.2						1.69		
	Lake benchmark [3]								0.49		
MDL [4]			0.1	0.1	0.005	0.0005	0.005		0.02	0.002	
2014		57.3	7.0	21.0	< 0.005	< 0.0005	0.018	< 0.0005			
2015		4.0	7.0	21.0	< 0.008	< 0.0005	0.018	< 0.0005			
2016		2.0	6.8	22.0	< 0.008	< 0.0005	0.020	< 0.0005	< 0.02	0.014	40.0
2017		45.0	6.9	19.0	< 0.007	< 0.0005	0.018	< 0.0005	0.04	0.030	37.1
2018		10.0	6.6	19.0	< 0.007	< 0.0005	0.019	< 0.0005	<0.02	0.025	38.2

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SC-01

YEAR		pHF	SO4 [5] (mg/L)		Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	218.0		1.000	0.0150	1.000	0.0025		0.800	
	Wetland benchmark [2]	5.2							1.69		
	Lake benchmark [3]								0.49		
MDL [4]		0.1	0.1		0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		7.0	21.0		0.006	< 0.0005	0.010	< 0.0005	0.12		
2015		7.0	21.0	<	0.008	< 0.0005	0.010	< 0.0005	0.07		
2016		6.9	20.0	<	0.008	< 0.0005	0.010	< 0.0005	0.06	0.008	31.0
2017		6.9	16.0	<	0.007	< 0.0005	0.009	< 0.0005	0.07	0.010	26.1
2018		6.6	18.0		0.009	< 0.0005	0.011	< 0.0005	0.14	0.015	31.5

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.
Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-06

YEAR		FLOW (L/s)	pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks		6.5	309.0	1.000	0.0150	1.000	0.0025		0.8	
	Wetland benchmark [2]		5.2						1.69		
	Lake benchmark [3]								0.49		
MDL [4]			0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		953.9	6.8	47.5	0.057	0.0009	0.313	< 0.0005			
2015		276.0	7.2	46.5	0.064	0.0008	0.450	< 0.0005			
2016		494.5	6.9	39.3	0.074	0.0007	0.512	< 0.0005	0.03	0.014	53.2
2017		842.1	7.0	35.5	0.089	0.0007	0.606	< 0.0005	0.03	0.011	52.6
2018		515.8	7.0	30.2	0.100	0.0006	0.682	< 0.0005	0.05	0.011	44.7

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-15

YEAR		pHF	SO4[5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	128.0	1.000	0.0050	1.000	0.0025		0.8	
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2016		7.0	36.5	0.049	< 0.0005	0.139	< 0.0005	< 0.02	0.005	51.8
2017		6.9	32.0	0.069	<0.0005	0.149	<0.0005	<0.02	0.005	52.3
2018		7.1	30.3	0.058	<0.0005	0.213	<0.0005	0.02	0.006	44.5

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow,2016). Parameters are hardness dependent. Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-01

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	218.0	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1	0.1	0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		6.9	34.0	0.017	0.0013	0.038	< 0.0005			
2015		6.9	36.0	0.019	0.0014	0.039	< 0.0005			
2016		6.8	33.0	0.026	0.0013	0.036	< 0.0005	< 0.02	0.003	40.0
2017		6.9	31.0	0.028	0.0011	0.035	< 0.0005	<0.02	0.003	38.3
2018		6.7	29.0	0.017	0.0011	0.034	< 0.0005	<0.02	0.004	35.4

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent.

Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

Rio Algom Limited and Denison Mines Inc.
2018 Serpent River Watershed Water Quality Monitoring Results
Five Year Annual Average Station SR-08

YEAR		pHF	SO4 [5] (mg/L)	Ra (Bq/L)	U (mg/L)	Ba (mg/L)	Co (mg/L)	Fe (mg/L)	Mn [5] (mg/L)	Hardness (mg/L)
Assessment Criteria [1]	Wetland and lake benchmarks	6.5	429	1.000	0.0150	1.000	0.0025		0.800	-
	Wetland benchmark [2]	5.2						1.69		
	Lake benchmark [3]							0.49		
MDL [4]		0.1		0.005	0.0005	0.005	0.0005	0.02	0.002	0.5
2014		7.0	165.0	0.026	0.0009	0.018	< 0.0005			176.3
2015		7.1	155.0	0.028	0.0009	0.018	< 0.0005			170.0
2016		6.8	150.0	0.029	0.0009	0.017	< 0.0005	0.05	0.033	178.5
2017		7.1	150.0	0.026	0.0009	0.017	< 0.0005	0.05	0.036	186.3
2018		6.8	137.5	0.028	0.0007	0.019	< 0.0005	0.07	0.065	184.0

Notes:

[1] Assessment criteria as per Table 4.5 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[2] Benchmark applies to wetland stations: M-01, DS-18, SC-01.

[3] Benchmark applies to lake stations: D-5, D-6, Q-09, Q-20, SR-01, SR-06, SR-08.

[4] Method Detection Limits as per Table 5.2 Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016)

[5] Sulphate and Manganese criteria taken from Table B.1, Appendix B, Cycle 4 Study Design for the SRWMP, SAMP and TOMP (Minnow, 2016). Parameters are hardness dependent. Variation in number of significant figures reflect MDL's at the time of reporting. In 2006, laboratory reported MDL's were standardized to achieve consistency and meet program requirements, as per Cycle 2 Interpretive Report (Minnow 2005).

Bold indicates exceedance of evaluation criteria value

APPENDIX VI
Interim Public Dose Estimation for the Closed Mines of the Serpent River Watershed

INTERIM PUBLIC DOSE ESTIMATION FOR THE CLOSED MINES OF THE SERPENT RIVER WATERSHED

Report prepared for:

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INTERIM PUBLIC DOSE ESTIMATION FOR THE CLOSED MINES OF THE SERPENT RIVER WATERSHED

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EXECUTIVE SUMMARY

The Canadian Nuclear Safety Commission (CNSC) has asked Rio Algom Limited and Denison Mines Inc. to undertake annual reporting of radiation dose to the public associated with their closed uranium mine sites in the Serpent River Watershed. The annual dose reporting will be based on periodic updates undertaken as part of the five-year State of the Environment (SOE) reports.

This interim public dose estimation is intended to provide interim dose values for the period 2017 – 2020 when the next SOE is scheduled for completion. The intention is to estimate realistic doses for a representative person residing in the City of Elliot Lake to be included in annual Serpent River Watershed Monitoring reports effective 2017. Elliot Lake is the only lake in the watershed with an urban community. The residents of the City are potentially exposed to radioactive substances via both Elliot Lake water and recreational use of mine properties, and are considered to be the population with the greatest potential for exposure to radiation and radioactive materials from the closed mine sites.

Ingestion of drinking water from Elliot Lake, and ingestion of fish caught in this and other lakes downstream of the Tailings Management Areas (TMAs) were identified as key ingestion pathways based on upper bound public dose estimates prepared for SOE reports for the Serpent River Watershed. Radon and direct gamma pathways were identified as key pathways based on upper bound dose estimates for people walking near TMAs prepared by the CNSC.

Site-specific surveys of residents were undertaken by Rio Algom in 2016 to characterize resident exposure pathways and habits relevant to exposure, and monitoring was undertaken to characterize mine site gamma and radon fields, as well as drinking water radionuclide concentrations, to update the characterization of the levels of public exposure. This report includes the results of the 2016 site-specific surveys and monitoring programs, as well as an interim public dose estimation, based on current understanding of human receptors and key exposure pathways.

The interim monitoring program to support public dose estimation for a representative Elliot Lake resident included:

- Surveys of City of Elliot Lake residents to refine estimates of time spent on roads and trails near the TMAs and estimates of fish consumption from different lakes in the Serpent River watershed;
- Monitoring of radon and gamma on roads and trails near TMAs often used by walkers and hikers; and
- Monitoring of appropriate U-238 series radionuclides in drinking water from the City of Elliot Lake Water Treatment Plant, after treatment.

The 2016 data from these surveys and monitoring programs were used in the interim public dose estimation. Available data for radionuclides in sport fish from 2005 were also used. The sport fish data pertain to the lakes most used for fishing but should be updated.

Based on the interim public dose calculations, it may be concluded that:

- Public dose to the representative person is approximately 0.012 mSv/a, after correction for background exposure.
- This value is based on available measurements of radon and direct gamma near TMAs, and U-238 series radionuclides in treated drinking water and sport fish, as well as survey information and several assumptions for exposure factors.

The public dose estimation will next be updated as part of the 2020 State of the Environment report. Changes to the monitoring data are projected to include updated sport fish tissue analysis.

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1.0 INTRODUCTION

1.1 Background

The Canadian Nuclear Safety Commission (CNSC) has asked Rio Algom Limited and Denison Mines Inc. to undertake annual reporting of radiation dose to the public associated with their closed uranium mine sites in the Serpent River Watershed.

State of the Environment (SOE) reports for the watershed have focused on demonstrating upper bounds of public dose, using rather conservative assumptions for hypothetical human residents on lakes downstream of the Tailings Management Areas (TMAs). The CNSC (2002) also estimated upper bound doses from recreational use of TMAs in and around Elliot Lake, based on conservative use assumptions. Neither of these dose estimates are considered to be realistic estimates of public dose.

The intention of this report is to present a more realistic public dose for a representative person exposed to radioactivity from the closed mine properties. This will be included in annual Serpent River Watershed Monitoring reports effective 2017. The value reported in the 2017 annual report will be interim, based on the radon and gamma survey data along with two rounds of drinking water quality data collected in 2016. In the 2017, 2018 and 2019 annual reports, the interim public dose value from 2017 will continue to be reported. Updates to the public dose estimation will be included in the next State of the Environment report whose field program is scheduled for the fall of 2019.

Elliot Lake is the only lake in the watershed with an urban community. The residents of the city are potentially exposed to radioactive substances via consumption of Elliot Lake water and recreational use of mine properties, and are considered to be the population with the greatest potential for exposure to radiation and radioactive materials from the closed mine sites.

A preliminary design for a monitoring program to support public dose estimation was prepared in early 2016 (EcoMetrix, 2016). Based on this plan, site-specific surveys of residents were completed in 2016 to characterize their exposure pathways and habits relevant to exposure. Additional radiological monitoring in 2016 included radon and gamma monitoring on roads and trails near TMAs often used by walkers and hikers and radionuclide monitoring of drinking water. This information has been used in conjunction with historic fish tissue data to estimate an interim public dose for a representative resident of the City of Elliot Lake.

1.2 Objectives

The objective of this report is to document interim survey and monitoring data relevant to public exposure, and use it to derive an interim realistic public dose estimate for a representative person in the population group living near the closed mine properties in the

Serpent River watershed. It is recognized that some revisions to the estimated public dose may be appropriate once additional data become available, and these will be addressed as part of the updates to the representative public dose in the 2020 State of the Environment Report.

2.0 THE REPRESENTATIVE PERSON AND MAIN EXPOSURE PATHWAYS

2.1 The Representative Person

In estimating public dose for comparison to a dose constraint, the dose is estimated for a "representative person" with characteristics that reflect those of the group that receives the highest dose (ICRP, 2007). The representative person is equivalent to, and replaces, the "average member of the critical group" which was previously used for determining compliance with a public dose constraint (ICRP, 1986).

The critical group within which the representative person is defined must be large enough to support reliable characterization of typical habits relevant to exposure, and should be relatively homogeneous. ICRP (1986) has defined homogeneity to mean that the individual doses within the group lie substantially within a range of a factor of ten, provided that the mean is less than one-tenth of the dose limit. The preliminary survey of 300 Elliot Lake residents indicates that, of those using TMAs for walking and hiking, the use rates vary within a factor of ten. Since this is the dominant exposure pathway of dose, the Elliot Lake group was considered to be homogeneous.

The group size and homogeneity conditions imply that the representative person should not be characterized based on single individuals or households with extreme behaviors. Rather, the representative person can reflect an average across distinct practices within the group. Site-specific surveys on habits relevant to exposure should be conducted to characterize the representative person. Surveys should address the use of local food and water resources, as appropriate. The Elliot Lake survey addressed local fish consumption, as well as TMA use for walking and hiking.

In characterizing the representative person, averaging should not occur across age classes. The ICRP (2007) considers three age classes, for which intake rates and dose coefficients have been defined. Nominal ages are 1 year (age 0 to 5), 10 years (age 6-15) and adult (age 16 to 70). These age classes may be designated infant, child and adult (CSA, 2014). Since Elliot Lake is a retirement community, the adult age class is dominant, with only 10% of the population in the 0-14 age group according to the 2011 census. The preliminary survey of 300 residents indicated that only 6 out of 300 respondents had children under the age of 16 who walk or hike around the closed mine properties, and only 7 had children who eat locally caught fish. The small sample sizes make it difficult to reliably characterize TMA or local fish use rates for child or infant age groups. Therefore, only adult doses were estimated.

2.2 Main Exposure Pathways

Upper bound ingestion doses to hypothetical human residents on lakes downstream of the TMAs were estimated by EcoMetrix (2011) and included in Appendix F of the 2011 SOE

report (Minnow, 2011). While these estimates are conservative, and are not considered suitable as public dose estimates, they provide a preliminary indication of key ingestion pathways. The dose estimate for a hypothetical resident on Elliot Lake, after correction for background, was 0.0244 mSv/a. The ingestion dose estimates were based on 1.5 L/day of lake water intake, 2.92 kg/year of local fish consumption, 1 kg/year of local waterfowl (mallard) consumption and 1 kg/year of local moose meat consumption. Of the pathways considered, intake of drinking water and fish accounted for almost 99% of the incremental dose (73% from drinking water, 26% from fish). These two main exposure pathways have been included in the interim public dose calculations.

Upper bound doses arising from exposure to radon and gamma radiation while walking near TMAs were estimated by the CNSC (2002) as 0.04 and 0.06 mSv/a (incremental), respectively, based on an assumed 200 hours each year at the location of highest measured radon and gamma radiation (Lacnor and Nordic TMAs). The gamma dose estimate makes no allowance for the cover that was placed on the tailings after the gamma survey. The incremental dose from radon was estimated as 0.016 mSv/a for a person at Nordic Lake. The radon dose estimates assume full progeny ingrowth. While these estimates are overly conservative, and not suitable as public dose estimates, they suggest that radon and direct gamma pathways should be included in the public dose calculations.

The assumed water ingestion rate of 1.5 L/day (Health Canada, 1995) is an average value for adults in the general population. The water supply for Elliot Lake residents comes from Elliot Lake. Water consumption rates are physiologically driven, thus it is reasonable to apply this rate to the Elliot Lake water supply for Elliot Lake residents.

The assumed fish ingestion rate of 2.92 kg/year (8 g/day, U.S. EPA, 1997) is a value for freshwater anglers. The U.S. EPA (2011) also cites a value of 5 g/day for anglers around Lake Ontario. The assumption that all fish are taken from Elliot Lake is probably overly conservative. While Elliot Lake and other local lakes may be used, it is likely that much of the fish consumption is not of local origin. The 2016 site-specific survey has been used in the present assessment to clarify local amounts of fish consumption.

The concentrations of radionuclides in water that have been used in historical dose calculations are either measured values in Elliot Lake water, or values estimated from sediments and partition coefficients. The water quality monitoring data are often reported as “non-detects”, which are values below the reporting limit. The use of water quality monitoring data for Elliot Lake means that there has been no accounting for water treatment. 2016 treated water monitoring results have been used in the present assessment for the calculation of dose from municipal drinking water.

The concentrations of radionuclides in sport fish that have been used in the dose calculations are either measured values in sport fish from Elliot Lake, or values estimated from water and bioaccumulation factors. The fish chemistry data are often reported as non-detects. Only Unat and Ra-226 have actually been measured in sport fish. Some of the bioaccumulation factors used for sport fish were estimated from forage fish values.

Measured activities in sport fish should be considered for the calculation of dose from fish ingestion.

3.0 SURVEYS AND MONITORING TO CHARACTERIZE EXPOSURE

The site-specific surveys and monitoring programs support the estimation of realistic public dose to a representative person residing in the City of Elliot Lake. Based on the main exposure pathways identified in Section 2.2, the surveys and monitoring program included the following components: surveys to refine estimates of time spent hiking at TMAs, surveys to refine estimates of fish consumed from lakes downstream of TMAs, monitoring of radon and gamma where people walk, hike or otherwise use trails and roads at TMAs, and monitoring of radionuclides in drinking water. Historic data have been used for sport fish tissue concentrations, though measured activities in sport fish will be collected as part of the 2019 biological component of the Cycle 5 State of the Environment study and a revised public dose included in the 2020 Cycle 5 State of the Environment report. The design of surveys and monitoring programs is discussed in the following sections.

3.1 Survey of Habits Relevant to Exposure

The intent of the site-specific surveys of residents is to characterize exposure pathways and habits relevant to exposure. The survey form for trail users and fishers was designed to address the following questions:

- How many hours do residents use trails and roads at the TMAs?
- How do people divide their trail use time among the TMAs?
- Where do people fish and how much fish do they consume from each lake?
- Which fish species are consumed?

The answers provided in the survey informed the estimation of public dose and the design of the monitoring programs for radon, gamma and sport fish. The survey was administered to residents of the Elliot Lake area as part of a larger community survey conducted on behalf of Rio Algom Limited by Globescan. A screening question was included at the beginning of the survey to determine whether the respondent is a resident of Elliot Lake. Data were collected from one respondent per household who responded on behalf of the entire household.

The survey questions and results are provided in Appendix A.

It is expected that most people in Elliot Lake will be on municipal water, which is drawn from Elliot Lake and treated prior to distribution. There are some homeowners and cottage owners on the lakefront, who take water directly from the lake, and Quirke Lake is the main area for development. There may also be some people who drink bottled water. In characterizing the representative Elliot Lake resident, it would be reasonable to assume

that this person drinks water from the municipal system. Surveys to investigate the frequency of use of drinking water sources other than the municipal water supply could be considered at a later date, based on information about these sources.

3.2 Measurements of Radon and Direct Gamma

The intent of the radon and direct gamma monitoring program is to characterize levels of exposure to radon and direct gamma for trail users at the TMAs.

Denison Environmental Services (DES, 2016a,b) conducted an initial monitoring program in December 2015 to measure radon and direct gamma radiation during walking surveys at the Lacnor, Milliken, Stanleigh, Quirke, Panel, Nordic, Pronto, Denison and Stanrock TMAs. In 2016, the surveys were repeated quarterly and extended to include the Buckles tailings and the Spanish American TMA. DES provided the data. The surveys were conducted quarterly to assess seasonal variability. Figures showing the location of the walking surveys are provided in **Appendix B**. The Esten Lake boat launch trail was surveyed to estimate background radiation in areas uninfluenced by TMAs. Radon decay products were collected on filter paper with an air sampling pump and then alpha radiation was measured using a scintillometer. Gamma radiation was measured using an SEI Inspector USB multi-radiation detector.

Radon was typically highest in October or December and lowest in April or July, with a maximum/minimum ratio ranging between 8 and 28. The gamma field was typically highest in July or October, but was much less variable, and was the dominant component of exposure for a walker near any TMA. The maximum/minimum ratio for the total exposure ranged between 1.1 and 1.9, and averaged 1.4. Since there was little seasonality in total exposure, it was considered acceptable to characterize TMA use on an annual basis.

3.3 Monitoring of Concentrations in Drinking Water and Fish

The intent of the monitoring program for drinking water and sport fish is to characterize levels of exposure to radionuclides through the ingestion pathway.

The water treatment plant for the City of Elliot Lake provides annual reporting on concentrations of uranium in treated water. Recent annual reports indicate that uranium concentrations in municipal drinking water were 0.172 µg/L on 31 January 2014 and 0.149 µg/L on 22 July 2015 (City of Elliot Lake, 2014, 2015). Uranium concentrations in municipal drinking water are approximately one tenth of uranium concentrations in untreated water from Elliot Lake, based on 2010 lake water quality used in the previous dose assessment for Elliot Lake (EcoMetrix, 2011).

Health Canada (2009) has suggested that the measured levels of radionuclides in the Elliot Lake water supply likely represent natural background. Although drinking water in Elliot Lake may not be different from background, monitoring of radionuclides in municipal

drinking water was completed in August 2016 and November 2016 to confirm this and provide data to support the estimation of annual public dose.

Detection limits for radionuclides in drinking water were 0.1 µg/L for U, 0.01 Bq/L for Th-230, 0.005 Bq/L for Ra-226, 0.02 Bq/L for Pb-210, and 0.005 Bq/L for Po-210. Certificates of Analysis for drinking water are provided in **Appendix C**.

Radionuclides in the Th-232 series were not detected in lake waters during the special investigation study (EcoMetrix, 2011). They were elevated in sediments relative to background only in Quirke and May lakes. Using partitioning estimates of concentrations in water, the drinking water dose from the Th-232 series contributed less than 5% of the total ingestion dose for the representative human at Elliot Lake. The analysis of Th-232 radionuclides in drinking water was not considered to be warranted because of its small contribution to total dose.

Concentrations of uranium and Ra-226 were measured in 2004 in northern pike, smallmouth bass and lake trout from lakes downstream of the TMAs (Elliot Lake, Quirke Lake and McCarthy Lake) and in reference lakes (Minnow, 2005).

As part of the 2019 update, the following radionuclides should be analyzed in sport fish: Unat, Th-230, Ra-226, Pb-210 and Po-210. Based on the results of the survey of Elliot Lake residents, fish should be collected from Elliot, Quirke and McCarthy lakes, as these were the lakes in the Serpent River watershed most used by sport fishers. Lake trout and walleye should be targeted as they were identified as the species most consumed by Elliot Lake residents; smallmouth bass and northern pike were next in order of preference, and may also be considered. Radionuclide concentrations in fish are likely to change slowly, following the gradual improvement of water quality in the lakes.

Low detection limits will be needed to obtain quantitative results for radionuclides in fish tissue. Suggested detection limits for fish tissue are: 0.001µg/g for U, 0.0001 Bq/g for Th-230, 0.0006 Bq/g for Ra-226, 0.001 Bq/g for Pb-210, and 0.0002 Bq/g for Po-210. Prior to collecting fish tissue samples, the analytical laboratory should be consulted regarding detection limits, sample size and other sampling requirements. It may be possible to achieve lower detection limits by increasing the sample volume.

Radionuclides in the Th-232 series were not measured in sport fish during the special investigation study (EcoMetrix, 2011). They were elevated in sediments relative to background only in Quirke and May lakes. Using bioaccumulation estimates of concentrations in sport fish, the sport fish dose from the Th-232 series contributed less than 1% of the total ingestion dose for the representative human at Quirke Lake and 3% of the total ingestion dose for the representative human at May Lake. The analysis of Th-232 radionuclides in sport fish is not considered to be warranted because of its small contribution to total dose.

4.0 INTERIM ESTIMATION OF PUBLIC DOSE

4.1 Overview of Approach

The approach to public dose estimation is intended to capture the main exposure pathways for Elliot Lake residents, as discussed in Section 2.2. Those pathways are exposure to radon and direct gamma radiation while walking near TMAs, ingestion of drinking water from Elliot Lake, and ingestion of fish caught in lakes downstream of the TMAs. The approach is intended to produce a realistic dose estimate, and uses 2016 survey and monitoring data to improve the estimate. An interim dose estimation for adult residents is presented here to illustrate the approach. The adult age class is dominant in Elliot Lake, as noted in Section 2.1; therefore, only adult dose was calculated. The use of survey and monitoring data and the assumptions made in this initial dose estimation are discussed by pathway in the following sections.

4.2 Radon and Direct Gamma Measurements

Measurements of dose from radon progeny in air and from direct gamma radiation while walking on roads and trails near the TMAs were obtained by Denison Environmental Services during four surveys in 2016 (April, July, October, December) (data provided by DES). Radon decay products were collected on filter paper with an air sampling pump and then alpha radiation was measured using a scintillometer. Gamma radiation was measured using an SEI Inspector USB multi-radiation detector. **Table 4-1** summarizes the results.

Measurements at the Esten Lake boat launch trail provide an estimate of background dose while walking in areas uninfluenced by TMAs. The Esten Lake area was chosen because it has similar environmental characteristics to the TMAs, but has no tailings nearby.

A survey of Elliot Lake residents conducted by Rio Algom Limited in 2016 (Appendix A) provides an estimate of the actual number of hours per year spent walking near TMAs for the representative person, and the proportion of that time spent at each TMA. The measured doses recorded for a nominal 200 hours per year at each TMA were adjusted for actual hours, and a weighted average dose across TMAs was calculated using the proportion of time at each TMA. The average number of hours per year walking at TMAs was 110.76 hours (2.13 hours per week) for a typical Elliot Lake resident.

The survey of Elliot Lake residents indicated that Milliken/Sheriff Creek Park was most used for walking and hiking, followed by the Quirke TMA. The use proportions for the TMAs, as reported in the survey, were adjusted up to account for the people who did not know the TMA used. The resulting proportions (45.3% Milliken, 12.6% Quirke, 9.5% Stanleigh, 9.5% Nordic, 8.4% Panel, 7.4% Denison, and 7.4% Stanrock) were used to allot the time spent walking among TMAs, making a weighted average dose from casual access at TMAs for the typical Elliot Lake resident.

Table 4.1: Radon and Direct Gamma Doses from Walking Near TMAs (2016)

Site	Route	Radon Dose (mSv/a*)	Gamma Mean Dose (mSv/a*)	Total Annual Dose (mSv/a*)	Annual Dose for TMA (mSv/a*)
Denison	William's Lake ETP to Settling Pond Berm	0.003818	0.058728	0.062545	0.04687
	TMA 1 Treatment Plant to Dam 10	0.001430	0.029773	0.031203	
Stanrock	Main Gate to Rooster Rock	0.004158	0.043343	0.047501	0.04657
	Main Gate to Dam A Gate	0.003121	0.042525	0.045646	
Lacnor	Dumbell Lake gate to Dam A	0.001476	0.060696	0.062172	0.062172
Milliken	Tailing Management Area (Sheriff Creek Sanctuary)	0.001902	0.028084	0.029986	0.029986
Stanleigh	Gate 1 to Gate 2	0.002274	0.032206	0.034480	0.053916
	Tailing Management Area	0.001935	0.071417	0.073353	
Quirke	Gate to gate	0.006848	0.041048	0.047896	0.047896
Panel	Gate 1 to peninsula	0.004803	0.066627	0.071430	0.063754
	Tailing Management Area	0.003384	0.052695	0.056079	
Nordic	Gate to past Treatment Plant	0.001451	0.063308	0.064759	0.064759
Buckles		0.001883	0.046327	0.048210	0.048210
Pronto	Gate to Treatment Plant	0.002134	0.040689	0.042822	0.04005
	Tailing Management Area	0.003638	0.03363	0.037268	
Spanish American	Tailing Management Area	0.00169	0.036063	0.037753	0.037753
Esten Lake	Esten Boat Launch trail	0.001866	0.024304	0.026170	0.026170

*Based on a radiation exposure period of 200 hours.

The casual access dose from measured radon and direct gamma radiation includes a background component. In order to calculate an incremental dose from walking near the TMAs, the dose as measured at Esten Lake must be subtracted from the dose measured at each TMA.

4.3 Radionuclides in Drinking Water and Fish

Measurements are available for some radionuclides in Elliot Lake drinking water (City of Elliot Lake, 2014, 2015), and in flesh samples from sport fish collected in lakes downstream

of the TMAs (Elliot Lake, Quirke Lake and McCarthy Lake) and in reference lakes (Minnow, 2005). Additional samples of treated drinking water were obtained by DES in August and November of 2016 and analyzed by SRC Environmental Analytical Laboratories for U-238 series radionuclides.

Based on the City of Elliot Lake measurements of uranium in treated drinking water (0.149 and 0.172 µg/L), and the two DES measurements (both <0.1 µg/L), the average uranium concentration in the treated water was 0.13 µg/L, or approximately one thirteenth of the lake water concentrations used in previous dose assessments for Elliot Lake (EcoMetrix, 2011), where uranium was 1.7 µg/L. Those concentrations included measured values for uranium and Pb-210, and detection limit values (<0.01 Bq/L) for Th-230, Ra-226 and Po-210. For the interim public dose assessment, the treated water concentration of uranium was 0.13 µg/L and the concentrations of Th-234 and Th-230 were assumed to have the same ratios to U as reported for lake water by EcoMetrix (2011). Ra-226 in treated drinking water was estimated from the uranium concentration, based on the Ra/U ratio reported by Health Canada (2009) for the Elliot Lake water supply (0.015 Bq/L Ra per µg/L U). Pb-210 and Po-210 were estimated from the Ra-226, based on the ratios for Elliot Lake water reported by EcoMetrix (2011). All the estimated radionuclide concentrations were below their limits of detection.

Health Canada (2009) has reported historical data for the Elliot Lake water supply (before treatment). The data show that concentrations of uranium and Ra-226 were relatively constant in 1995-96 when the record ends, at about 0.6 µg/L and 0.007 Bq/L respectively. The concentrations for treated water, at present, are about one third of this level.

The treated drinking water concentrations include a background component. It is unclear what the background levels are in treated water. However, Health Canada (2009) reports that concentrations in Canadian water supplies range from <0.1 to 1 µg/L for uranium, and from <0.005 to 0.02 Bq/L for Ra-226. In order to calculate an incremental dose from treated drinking water at Elliot Lake, a background uranium concentration of 0.1 µg/L was assumed, and background concentrations of other radionuclides were estimated using ratios as described above. This implies a background concentration of 0.0015 Bq/L for Ra-226, which is unlikely to be detectable. Incremental dose can be calculated by subtracting the dose based on background concentrations from the dose based on Elliot Lake concentrations.

Using this low level of background is conservative, resulting in calculation of a small incremental exposure. Health Canada (2009) has suggested that the measured levels of radionuclides in the Elliot Lake water supply likely represent natural background rather than effects from uranium mining operations.

Average measured concentrations of uranium and Ra-226 in sport fish collected in 2004 from Elliot Lake (Minnow, 2005) were used in the interim public dose assessment. These concentrations, on a fresh weight basis, were, respectively, 0.0132 mg/kg and 0.20 Bq/kg for Elliot Lake fish, 0.0144 mg/kg and 0.238 Bq/kg for Quirke Lake fish, and 0.0148 mg/kg

and 0.32 Bq/kg for McCarthy Lake fish. Concentrations of Th-230 were estimated from uranium, and concentrations of Pb-210 and Po-210 were estimated from Ra-226, using the isotope ratios that were previously found in forage fish (EcoMetrix, 2011).

The survey of Elliot Lake residents by Rio Algom Limited in 2016 indicates that Elliot Lake, Quirke Lake and McCarthy Lake are the lakes most used for local fish consumption. The use proportions for these lakes from the survey were adjusted up to account for the people who did not know the lake fished, and to include the small fraction of people who used May Lake or Nordic Lake (collectively only 4% of users who knew the lake fished). The resulting proportions (50.4% Elliot, 28.3% Quirke, and 21.2% McCarthy) were used to weight the fish flesh concentrations across lakes, making a set of average concentrations for fish taken from exposed lakes, i.e. those downstream of TMAs.

The survey information also provided an estimate of the number of meals per year of fish from lakes downstream of TMAs (Elliot, Quirke, Nordic, McCabe, May and McCarthy), and this was converted to an intake rate for the representative person. The survey indicated an average of 7 meals per year for the typical Elliot Lake resident. For the interim dose estimate, using a meal size of 0.227 kg (fresh weight) (OMOECC, 2015), the intake rate of local fish was estimated at 1.59 kg/a.

The sport fish concentrations include a background component. Background levels were taken from sport fish collected in Dunlop Lake in 2004 (Minnow, 2005). For uranium and Ra-226, these levels were 0.01 mg/kg and 0.1 Bq/kg, respectively, on a fresh weight basis. Background concentrations for other radionuclides were estimated as described above. Incremental dose can be calculated by subtracting the dose based on background concentrations from the dose based on exposed lake concentrations in fish flesh.

4.4 Interim Public Dose Estimate

The interim public dose estimate for a representative person (adult) at Elliot Lake was calculated using radon and direct gamma measurements near TMAs, and radionuclide concentrations in treated drinking water and in sport fish flesh, as described above in Sections 4.2 and 4.3.

The casual access dose was calculated assuming 110.76 hours per year spent walking near the TMAs. The adult water intake of 1.5 L/d (Health Canada, 1995) was assumed to occur 365 days per year. This intake rate was applied to treated Elliot Lake drinking water. The adult intake of sport fish flesh from affected lakes was assumed to be 1.59 kg/year on a fresh weight basis.

Using these access and ingestion rates, the dose to human receptors was calculated as follows:

$$D_h = D_{r+g} + (C_w \bullet I_w + C_f \bullet I_f) \bullet DCF_i$$

where:
- D_h = human radiation dose (Sv/a)
- D_{r+g} = dose from radon and gamma, with TMA-specific values weighted by proportion of local walking time spent at each TMA (Sv/a)
- C_w = activity concentration in drinking water (Bq/L)
- I_w = drinking water intake rate (L/a)
- C_f = concentration in sport fish flesh, with lake-specific values weighted by proportion of local intake arising from each lake (Bq/kg fw)
- I_f = intake of sport fish flesh from affected lakes (kg fw / a)
- DCF_i = ingestion dose coefficient (Sv/Bq)

Ingestion dose coefficients were taken from ICRP Publication 72 (ICRP, 1996). The values provided by ICRP include dose contributions from progeny that may grow in over a lifetime following radionuclide ingestion. In addition, the values listed for parents and short-lived progeny have been combined to account for environmental ingrowth of progeny.

The dose limit for people (members of the public) is 1 mSv/a, as recommended in ICRP Publication 60 (ICRP, 1991). This is an incremental dose. Background radiation exposure, including natural and anthropogenic sources, is typically about 2 mSv/a (Health Canada, 2014). In addition, Health Canada (2014) has defined a dose constraint of 0.3 mSv/a as an incremental value above which dose management may be needed for naturally occurring radioactive materials. This is a conservative value which allows for exposure from other sources while still ensuring that incremental dose to a member of the public does not exceed the public dose limit.

The human doses calculated from measured radon, direct gamma, and radionuclide concentrations in affected areas include a natural background component. Therefore, the background component must be removed before comparison to the public dose limit, or to a dose constraint. The background component was estimated as described above, but using background values for radon, direct gamma and radionuclide concentrations, as described in **Sections 4.2** and **4.3.**

The interim total dose estimate, including background, as outlined in **Table 4-2**, is 0.030 mSv/a. The interim background dose estimate, as outlined in **Table 4-3**, is 0.018 mSv/a, and the incremental dose is 0.012 mSv/a. This is well below the public dose limit of 1 mSv/a, and also well below the dose constraint of 0.3 mSv/a.

Table 4.2: Estimation of Background-Inclusive Dose for a Representative Adult in Elliot Lake

Parameter	Units	U238/234	Th234+	Th230	Ra226	Rn222+	Pb210+	Po210	TOTAL
Water concentration	Bq/L	0.0032*	0.0026	0.0008	0.0020	0.0020	0.0059	0.0020	
Sport fish tissue conc.	Bq/kg (fw)	0.342#	0.169	0.099	0.237	0.024	0.430	0.624	
Ingestion rate water	L/a	547.5	547.5	547.5	547.5	547.5	547.5	547.5	
Ingestion rate fish	kg/a	1.59	1.59	1.59	1.59	1.59	1.59	1.59	
Exposure via water	Bq/a	1.75	1.41	0.42	1.07	1.07	3.20	1.07	
Exposure via fish	Bq/a	0.54	0.27	0.16	0.38	0.04	0.68	0.99	
Ingestion DCF adult	Sv/Bq	4.70E-08	3.40E-09	2.10E-07	2.80E-07	2.50E-10	6.91E-07	1.20E-06	
Dose via water	mSv/a	8.23E-05	4.80E-06	8.79E-05	2.99E-04	2.67E-07	2.21E-03	1.28E-03	3.97E-03
Dose via fish	mSv/a	2.56E-05	9.11E-07	3.31E-05	1.05E-04	9.41E-09	4.73E-04	1.19E-03	1.83E-03
Total ingestion dose	mSv/a	1.08E-04	5.72E-06	1.21E-04	4.04E-04	2.76E-07	2.69E-03	2.47E-03	5.80E-03
Casual access dose	mSv/a								2.39E-02
Total dose	mSv/a								2.97E-02

* mg/L U x 24.6 Bq/mg # mg/kg x 24.6 Bq/mg

+ indicates that progeny contributions are included in the DCF

Table 4.3: Estimation of Background Dose for a Representative Adult

Parameter	Units	U238/234	Th234+	Th230	Ra226	Rn222+	Pb210+	Po210	TOTAL
Water concentration	Bq/L	0.0025*	0.0020	0.0006	0.0015	0.0015	0.0045	0.0015	
Sport fish tissue conc.	Bq/kg (fw)	0.246#	0.121	0.071	0.100	0.010	0.182	0.264	
Ingestion rate water	L/a	547.5	547.5	547.5	547.5	547.5	547.5	547.5	
Ingestion rate fish	kg/a	1.59	1.59	1.59	1.59	1.59	1.59	1.59	
Exposure via water	Bq/a	1.35	1.09	0.32	0.82	0.82	2.46	0.82	
Exposure via fish	Bq/a	0.39	0.19	0.11	0.16	0.02	0.29	0.42	
Ingestion DCF adult	Sv/Bq	4.70E-08	3.40E-09	2.10E-07	2.80E-07	2.50E-10	6.91E-07	1.20E-06	
Dose via water	mSv/a	6.33E-05	3.70E-06	6.76E-05	2.30E-04	2.05E-07	1.70E-03	9.86E-04	3.05E-03
Dose via fish	mSv/a	1.84E-05	6.56E-07	2.38E-05	4.45E-05	3.98E-09	2.00E-04	5.03E-04	7.90E-04
Total ingestion dose	mSv/a	8.17E-05	4.35E-06	9.15E-05	2.74E-04	2.09E-07	1.90E-03	1.49E-03	3.84E-03
Casual access dose	mSv/a								1.45E-02
Total dose	mSv/a								1.83E-02

* mg/L U x 24.6 Bq/mg # mg/kg x 24.6 Bq/mg

+ indicates that progeny contributions are included in the DCF

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the interim public dose calculations, it may be concluded that:

- Public dose to the representative person is approximately 0.012 mSv/a, after correction for background exposure.
- This value is based on available measurements of radon and direct gamma near TMAs, and U-238 series radionuclides in treated drinking water and sport fish, as well as critical group survey information and several assumptions for exposure factors.

The public dose estimation may be refined in the future based on information from critical group surveys and from the monitoring program.

Preliminary recommendations for the monitoring program to support future public dose estimates include:

- Prior to the next reporting cycle, update the sampling and analysis of U-238 series radionuclides in sport fish collected from lakes of the Serpent River watershed most used by sport fishers (Elliot, Quirke and McCarthy lakes); target lake trout and walleye, which were the species most consumed according to the survey of Elliot Lake residents. Smallmouth bass and northern pike were next in order of preference, and may also be used.
- In subsequent cycles, consider whether the resident survey or components of the monitoring program may need to be updated, based on possible demographic changes in the community, changes in waste management operations, or trends observed in the watershed monitoring program.

The information from the resident survey and monitoring programs is expected to be used in public dose estimation as described in Section 4.4. Public dose estimates may be revised in the future as the relevant information is updated.

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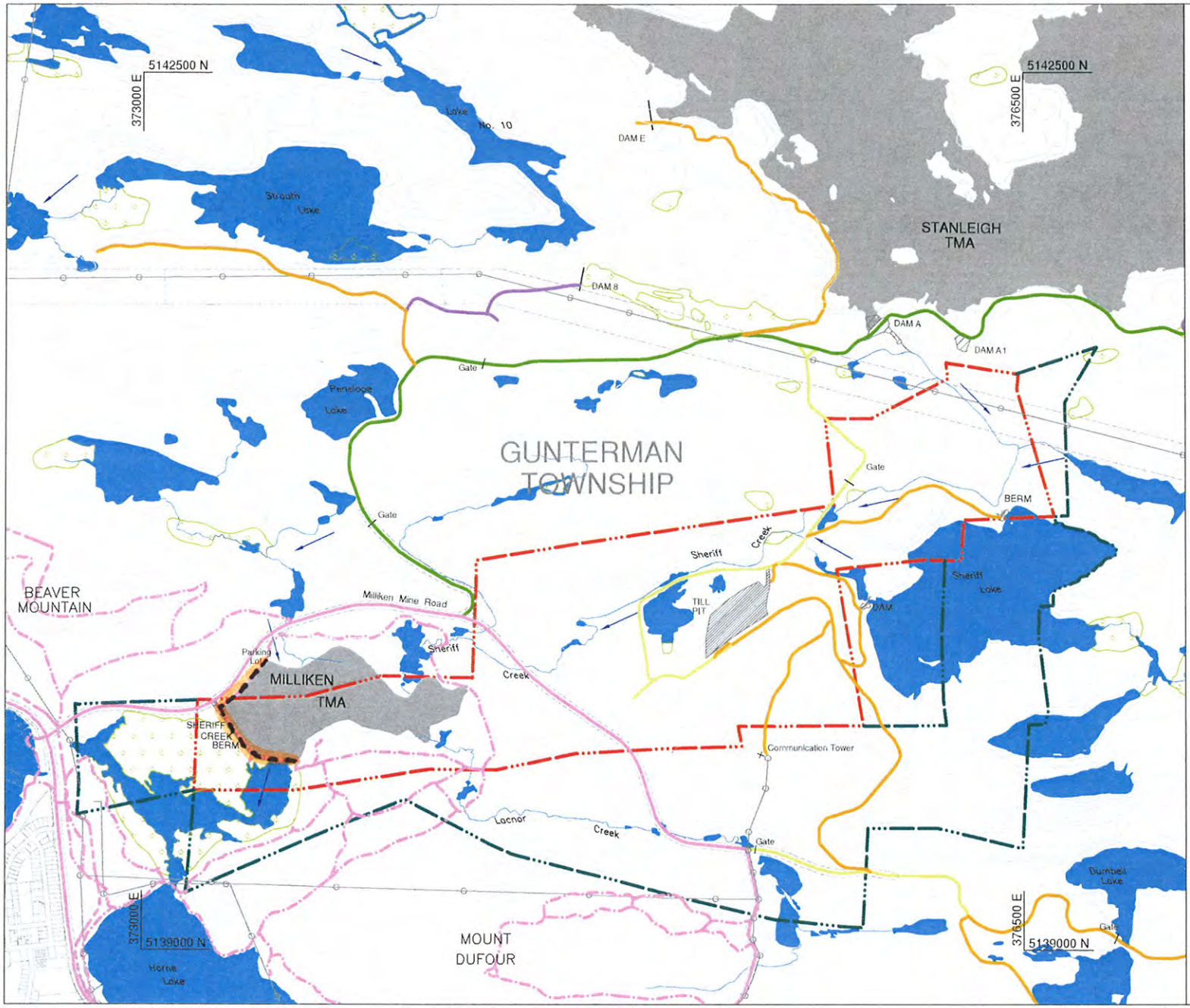
Appendix A Questionnaire and Results for Survey of Elliot Lake Residents

q5.1t recode. How many years have you lived in the area around Elliot Lake?												
Sample Size	300											
Less than 1												
Column %	1											
1 - 5												
Column %	8											
6 - 10												
Column %	9											
11 - 15												
Column %	9											
16 - 20												
Column %	14											
21 - 25												
Column %	8											
26 - 30												
Column %	6											
31 - 35												
Column %	6											
36+												
Column %	37											
DK/NA												
Column %	1											
q5.1t_mean. How many years have you lived in the area around Elliot Lake?												
Sample Size	296											
Mean	29											
Std. Dev.	18											
Q5.2. Do you ever eat fish that was caught in local lakes - in other words, from either Elliot Lake, McCarthy Lake, May Lake, Nordic Lake or Quirke Lake?												
Sample Size	300	Meals/Year		Weighted Average Meals per Year								
Yes - at least three times a week or more												
Column %	1	156		7								
Yes - around once a week on average over the year												
Column %	8	52										
Yes - about once a month on average over the year												
Column %	14	12										
Yes - a few times a year												
Column %	41	3										
No, never												
Column %	31	0										
DK/NA												
Column %	5	0										
Q5.3. Of the lakes I just mentioned, where would you say most of the local fish that you eat comes from?												
Sample Size	192	% of those that know										
Elliot Lake												
Column %	30	48.3	50.4									
McCarthy Lake												
Column %	13	20.3	21.2									
McCabe Lake												
Column %	0	0.0										
May Lake												
Column %	2	3.4	omit									
Nordic Lake												
Column %	1	0.8	omit									
Quirke Lake												
Column %	17	27.1	28.3									
DK/NA												
Column %	39											

Q5.4. What species of fish caught from local lakes would you say you eat most often?	
Sample Size	192
Lake trout	
Column %	43
Brook/Speckle trout	
Column %	2
Rainbow trout	
Column %	4
Northern pike	
Column %	6
Smallmouth bass	
Column %	7
Walleye/Pickerel	
Column %	21
Splake	
Column %	1
Perch	
Column %	3
Whitefish	
Column %	1
Sturgeon	
Column %	1
Other	
Column %	13
Q5.5. Do you have any children under the age of 16 in your household that eat fish that was caught in local lakes - in other words, from either Elliot Lake, McCarthy Lake, McCabe Lake, May Lake, Nordic Lake or Quirke Lake?	
Sample Size	300
Yes	
Column %	7
No	
Column %	92
DK/NA	
Column %	2

q5.7 recode. How many hours per week would you say you spend walking or hiking around the closed mine properties in the area? (this would include Quirke, Panel, Spanish American, Stanleigh, Milliken and Sheriff Creek Park, Lacnor, Nordic, Buckles, Pronto, Denison and Stanrock)			
Sample Size	300		
Zero			
Column %	59		
1 - 5			
Column %	18		
6 - 10			
Column %	7		
11 - 15			
Column %	3		
16 - 20			
Column %	1		
21+			
Column %	1		
DK/NA			
Column %	12		
q5.7_mean. How many hours per week would you say you spend walking or hiking around the closed mine properties in the area...?			
Sample Size	264	Hours per Year	
Mean	2.13	110.76	
Std. Dev.	5.39		
Q5.8. Considering the mine properties I just mentioned, on which one would you say you walk or hike the most?			
Sample Size	124	% of those that know	
Quirke			
Column %	10	12.6	
Panel			
Column %	6	8.4	
Spanish American			
Column %	0	0.0	
Stanleigh			
Column %	7	9.5	
Milliken / Sheriff Creek Park			
Column %	35	45.3	
Lacnor			
Column %	0	0.0	
Nordic			
Column %	7	9.5	
Buckles			
Column %	0	0.0	
Pronto			
Column %	0	0.0	
Denison			
Column %	6	7.4	
Stanrock			
Column %	6	7.4	
DK/NA			
Column %	23		
Q5.9. Do you have any children under age 16 who spend time walking or hiking around the closed mine properties in the area...?			
Sample Size	300		
Yes			
Column %	6		
No			
Column %	92		
DK/NA			
Column %	2		

Appendix B Site Maps with Walking Surveys for Radon and Gamma



Rio Algom Milliken Site Map

SCALE
0 0.5 1.0 kms

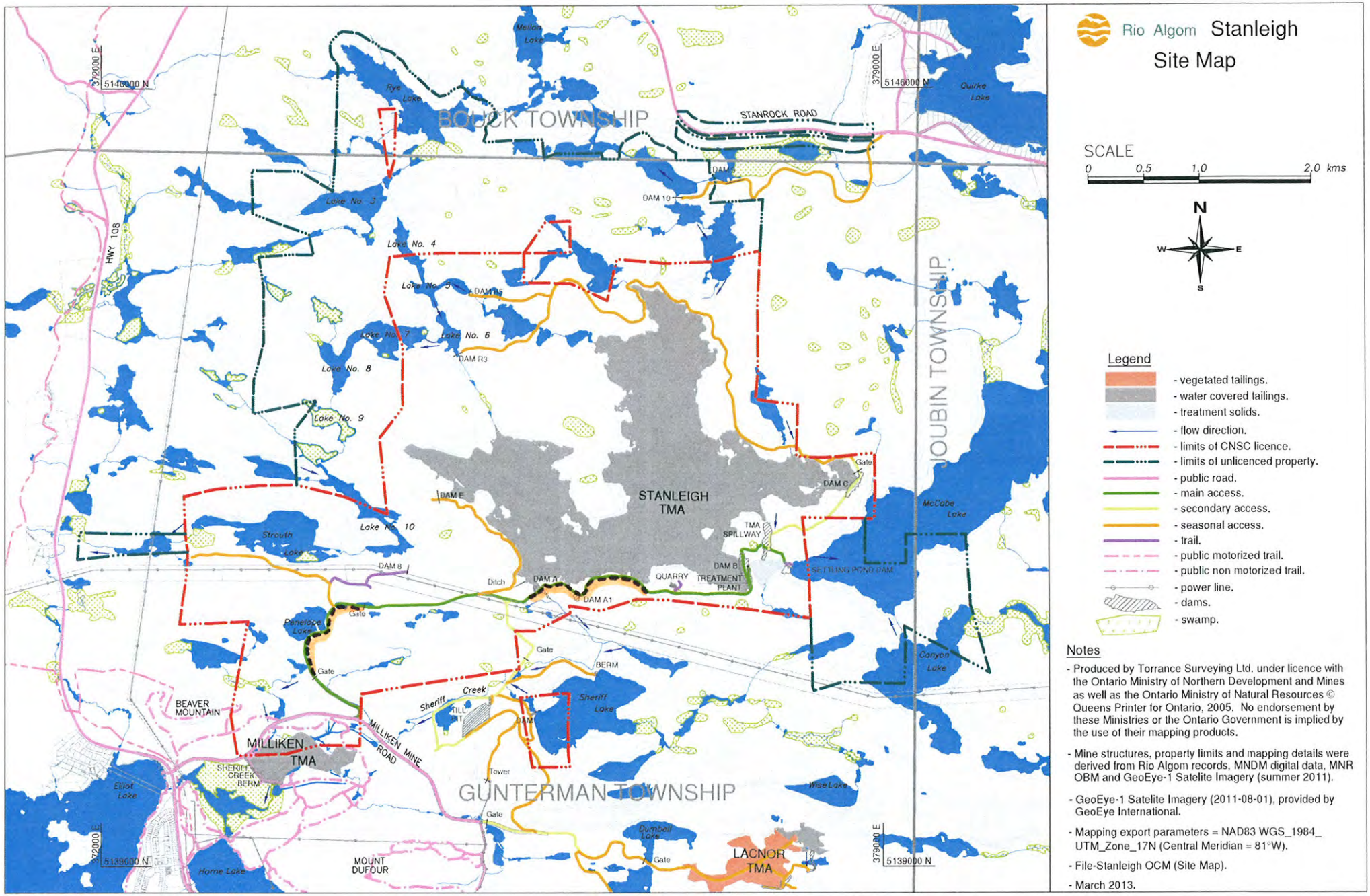
N
W E
S

Legend

- vegetated tailings.
- water covered tailings.
- treatment solids.
- flow direction.
- limits of CNSC licence.
- limits of unlicenced property.
- public road.
- main access.
- secondary access.
- seasonal access.
- trail.
- public motorized trail.
- public non motorized trail.
- power line.
- dams.
- swamp.

Notes

- Produced by Torrance Surveying Ltd. under licence with the Ontario Ministry of Northern Development and Mines as well as the Ontario Ministry of Natural Resources © Queens Printer for Ontario, 2005. No endorsement by these Ministries or the Ontario Government is implied by the use of their mapping products.
- Mine structures, property limits and mapping details were derived from Rio Algom records, MNDM digital data, MNR OBM and GeoEye-1 Satelite Imagery (summer 2011).
- GeoEye-1 Satelite Imagery (2011-08-01), provided by GeoEye International.
- Mapping export parameters = NAD83 WGS_1984_ UTM_Zone_17N (Central Meridian = 81°W).
- File-Milliken OCM (Site Map).
- March 2013.


Rio Algom Stanleigh
Site Map
SCALE
0 0.5 1.0 2.0 kms
N
W E
S
Legend
- vegetated tailings.
- water covered tailings.
- treatment solids.
- flow direction.
- limits of CNSC licence.
- limits of unlicenced property.
- public road.
- main access.
- secondary access.
- seasonal access.
- trail.
- public motorized trail.
- public non motorized trail.
- power line.
- dams.
- swamp.
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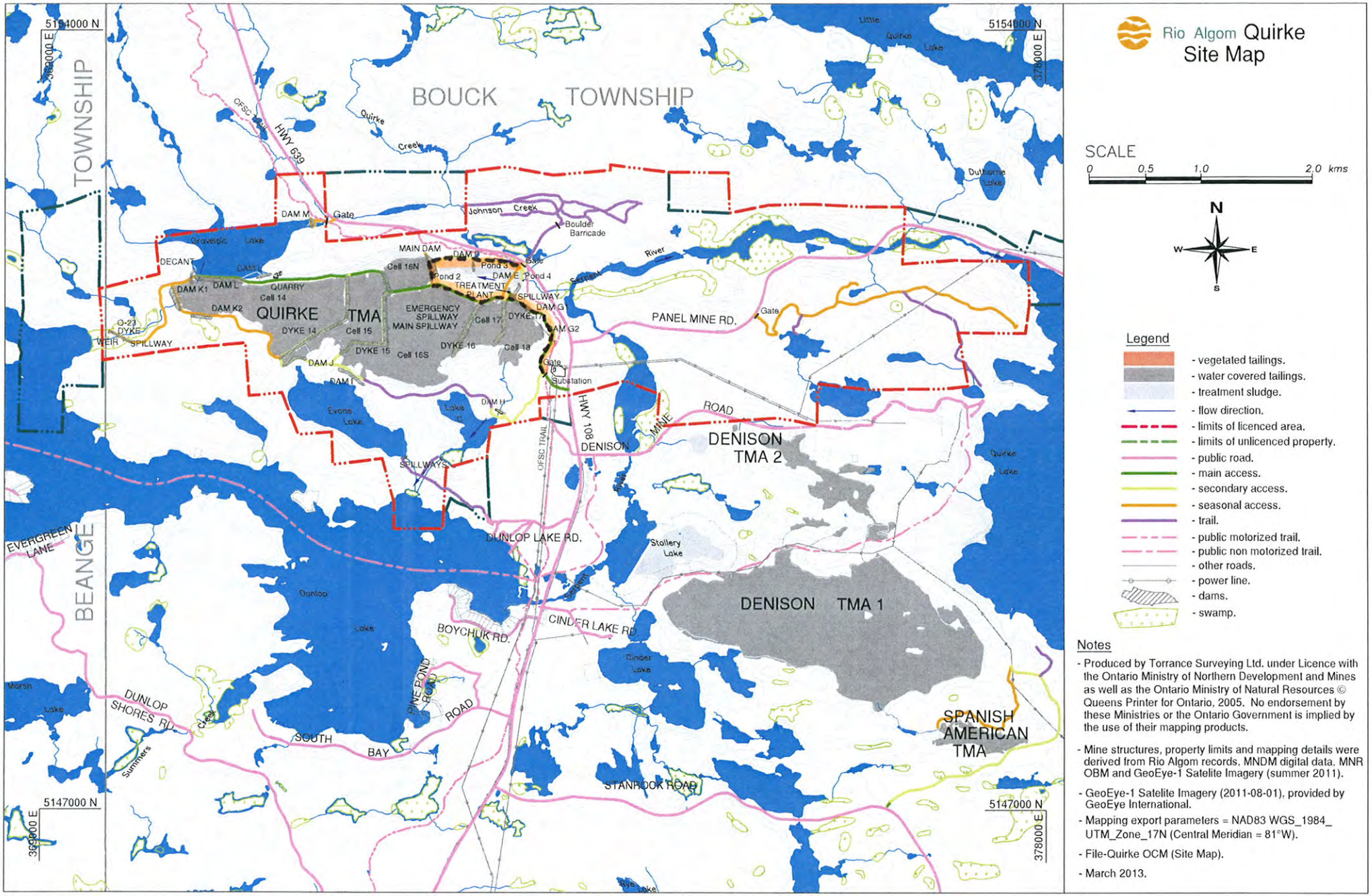
- GeoEye-1 Satelite Imagery (2011-08-01), provided by GeoEye International.
- Mapping export parameters = NAD83 WGS_1984_ UTM_Zone_17N (Central Meridian = 81°W).
- File-Stanleigh OCM (Site Map).
- March 2013.
372000 E
5146000 N
379000 E
5146000 N
372000
5139000 N
379000 E
5139000 N
BOUCK TOWNSHIP
JOUBIN TOWNSHIP
GUNTERMAN TOWNSHIP
STANROCK ROAD
HWY 108
Mellon Lake
Rye Lake
Quirke Lake
Lake No. 3
Lake No. 4
Lake No. 5
Lake No. 6
Lake No. 7
Lake No. 8
Lake No. 9
Lake No. 10
DAM 10
DAM R5
DAM R6
STANLEIGH TMA
DAM E
DAM C
Gate
McCabe Lake
TMA SPILLWAY
DAM B
SETTLING POND DAM
TREATMENT PLANT
QUARRY
DAM A
DAM A1
DAM 8
Ditch
Stroutn Lake
Penelope Lake
BERM
Canyon Lake
Sheriff Creek
TILL PIT
DAM
Sheriff Lake
BEAVER MOUNTAIN
MILLIKEN TMA
MILLIKEN MINE ROAD
SHERIFF CREEK BERM
Tower
Wise Lake
Elliot Lake
Home Lake
MOUNT DUFOUR
Dumbell Lake
LACNOR TMA


Rio Algom Quirke
Site Map
SCALE
0 0.5 1.0 2.0 kms
N
W E
S
Legend
- vegetated tailings.
- water covered tailings.
- treatment sludge.
- flow direction.
- limits of licenced area.
- limits of unlicenced property.
- public road.
- main access.
- secondary access.
- seasonal access.
- trail.
- public motorized trail.
- public non motorized trail.
- other roads.
- power line.
- dams.
- swamp.
Notes
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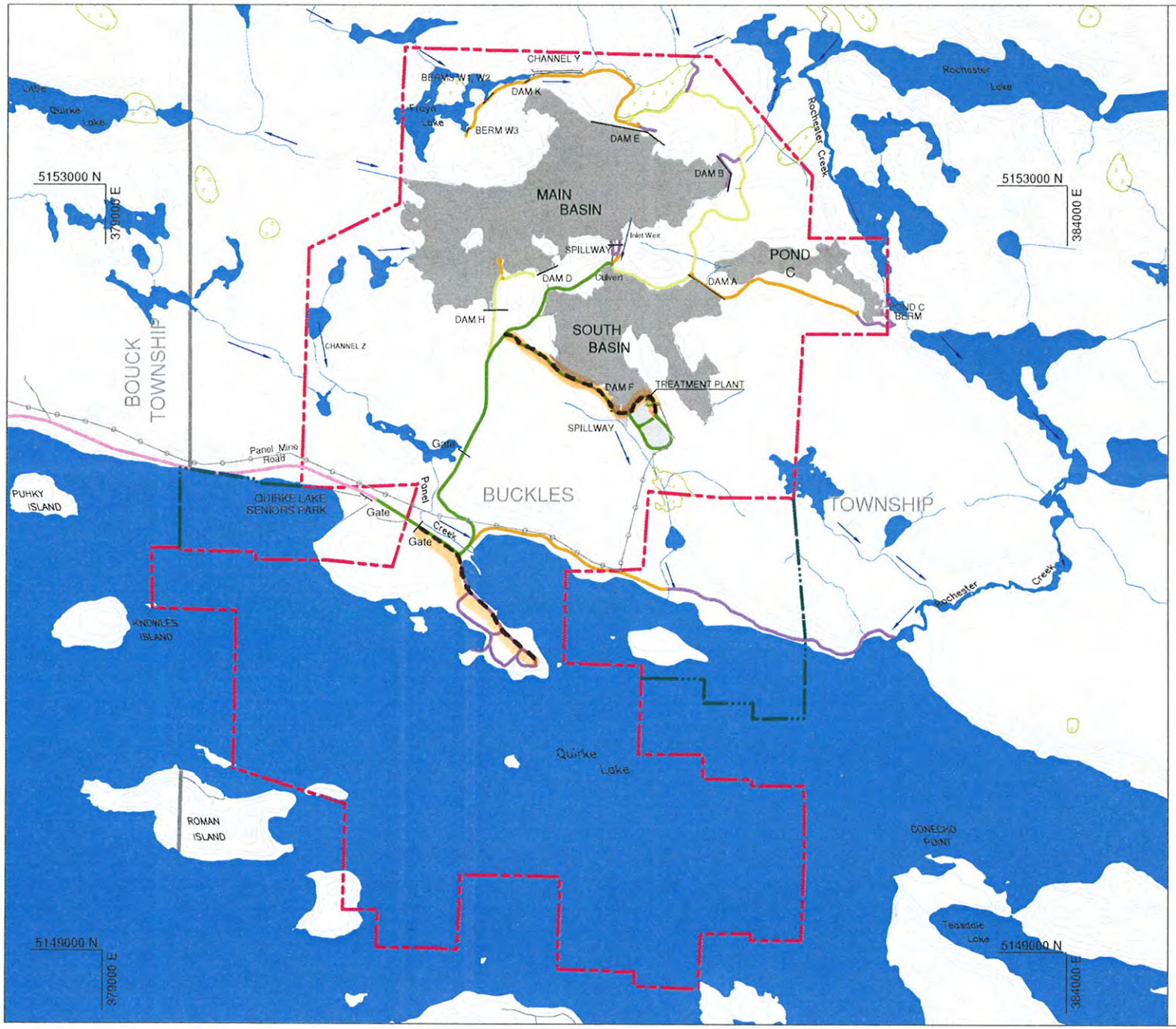
- GeoEye-1 Satelite Imagery (2011-08-01), provided by GeoEye International.
- Mapping export parameters = NAD83 WGS_1984_ UTM_Zone_17N (Central Meridian = 81°W).
- File-Quirke OCM (Site Map).
- March 2013.
5154000 N
369000 E
378000 E
5147000 N
TOWNSHIP
BEANGE
BOUCK TOWNSHIP
HWY 639
OFSC Trail
Quirke Creek
Little Quirke Lake
Dutchmans Lake
Johnson Creek
Boulder Barricade
Gravel pit Lake
DAM M
Gate
DECANT
MAIN DAM
DAM B
Cell 16N
Pond 3
Pond 2
DAM E
Pond 4
TREATMENT PLANT
SPILLWAY
DAM G
DAM G2
DAM K1
DAM L
QUARRY
Cell 14
DAM K2
QUIRKE TMA
EMERGENCY SPILLWAY
MAIN SPILLWAY
Cell 17
DYKE 17
DYKE 14
Cell 15
DYKE 15
Cell 16S
DYKE 16
Cell 18
O-23 DYKE WEIR
SPILLWAY
DAM J
DAM I
DAM H
Evans Lake
Lake C
Gate
Substation
PANEL MINE RD.
Gate
HWY 108
DENISON MINE ROAD
DENISON
DENISON TMA 2
DENISON TMA 1
SPILLWAYS
OFSC TRAIL
Quirke Lake
EVERGREEN LANE
DUNLOP LAKE RD.
Stollery Lake
Dunlop Lake
BOYCHUK RD.
CINDER LAKE RD.
Cinder Lake
PINE POND ROAD
DUNLOP SHORES RD.
Marsh Lake
Summers Creek
SOUTH BAY ROAD
STANROCK ROAD
SPANISH AMERICAN TMA
Raye Lake



Rio Algom Panel Site Map

SCALE

0 0.5 1.0 1.5 kms

N

W E

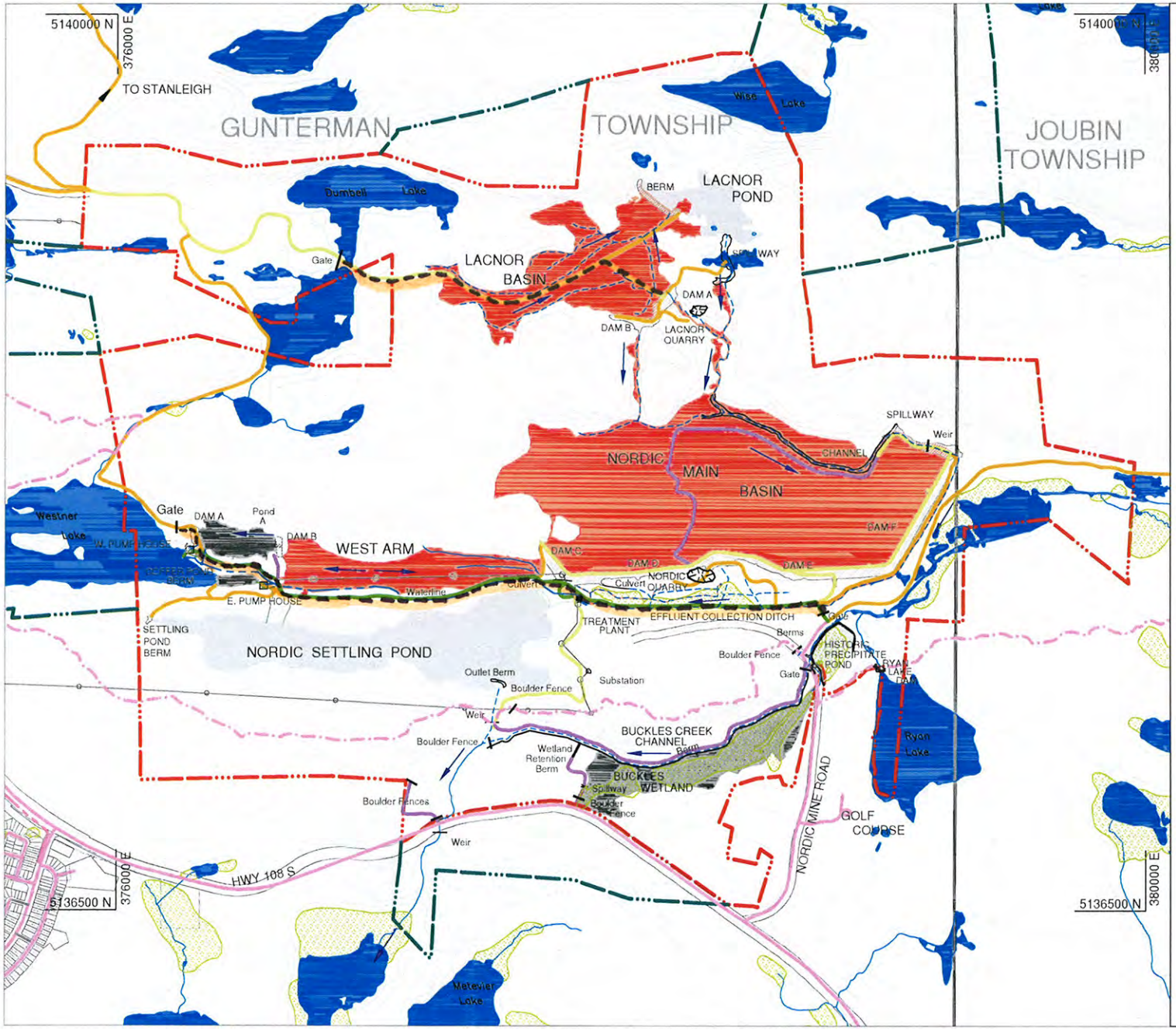
S

Legend

- vegetated tailings.
- water covered tailings.
- treatment solids.
- flow direction.
- limits of CNSC licence.
- limits of unlicenced property.
- public road.
- main access.
- secondary access.
- seasonal access.
- trail.
- public motorized trail.
- public non motorized trail.
- power line.
- dams.
- swamp.

Notes

- Produced by Torrance Surveying Ltd. under licence with the Ontario Ministry of Northern Development and Mines as well as the Ontario Ministry of Natural Resources © Queens Printer for Ontario, 2005. No endorsement by these Ministries or the Ontario Government is implied by the use of their mapping products.
- Mine structures, property limits and mapping details were derived from Rio Algom records, MNDM digital data, MNR OBM and GeoEye-1 Satelite Imagery (summer 2011).
- GeoEye-1 Satelite Imagery (2011-08-01), provided by GeoEye International.
- Mapping export parameters = NAD83 WGS_1984_ UTM_Zone_17N (Central Meridian = 81°W).
- File-Panel OCM (Site Map).
- March 2013.



Rio Algom

Lacnor, Nordic and Buckles Site Map

SCALE

0 0.5 1.0 kms

N

W E

S

Legend

- vegetated tailings.
- water covered tailings.
- treatment sludge.
- flow direction.
- limits of licenced area.
- limits of unlicenced property.
- public road.
- main access.
- secondary access.
- seasonal access.
- trail.
- public motorized trail.
- public non motorized trail.
- power line.
- collection ditch or channel.
- diversion berm.
- wetlands.
- dams.

Notes

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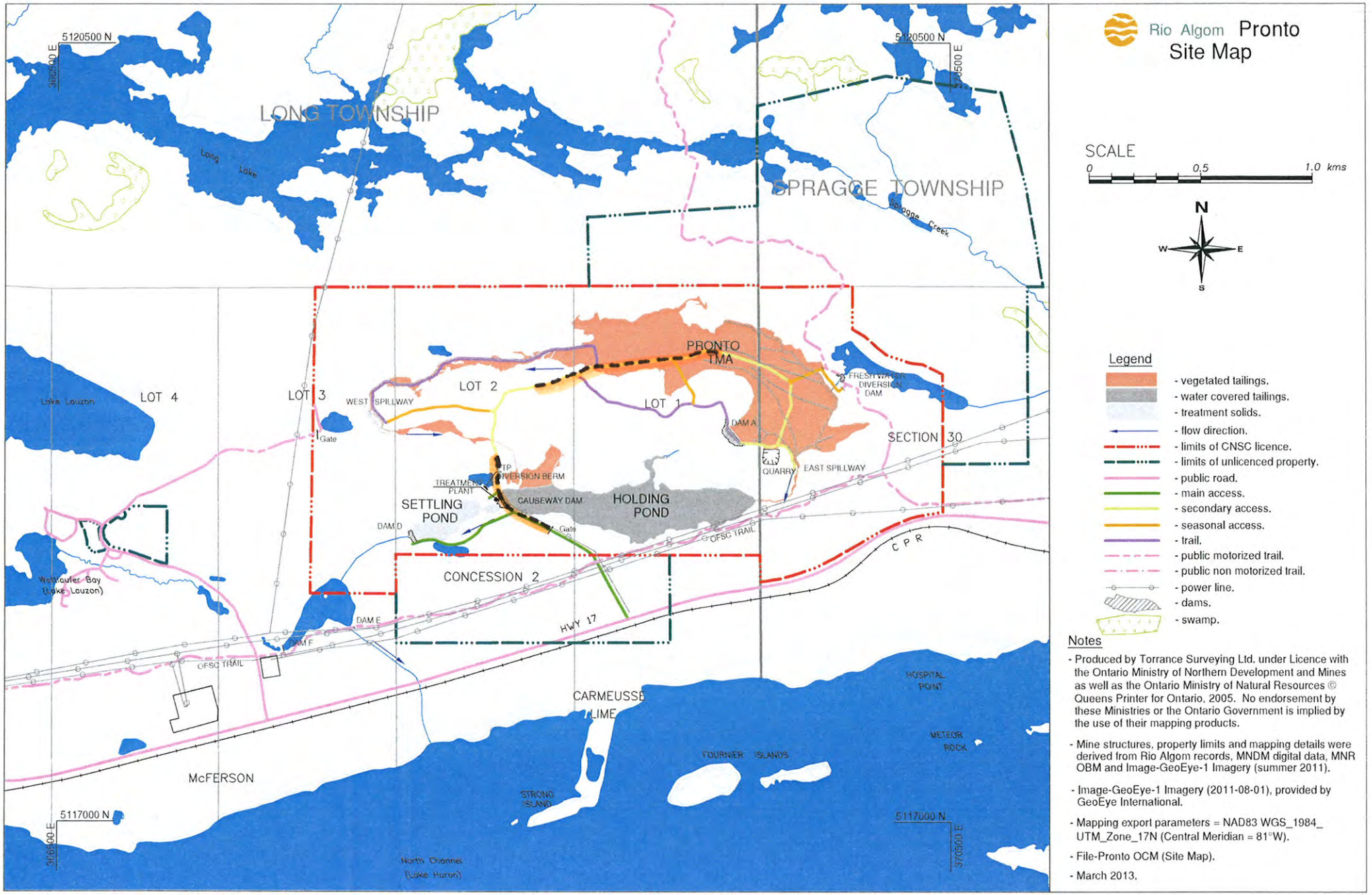
- GeoEye-1 Satelite Imagery (2011-08-01), provided by GeoEye International.
- Mapping export parameters = NAD83 WGS_1984_ UTM_Zone_17N (Central Meridian = 81°W).
- File-LNB OCM (Site Map).
- March 2013.



Notes

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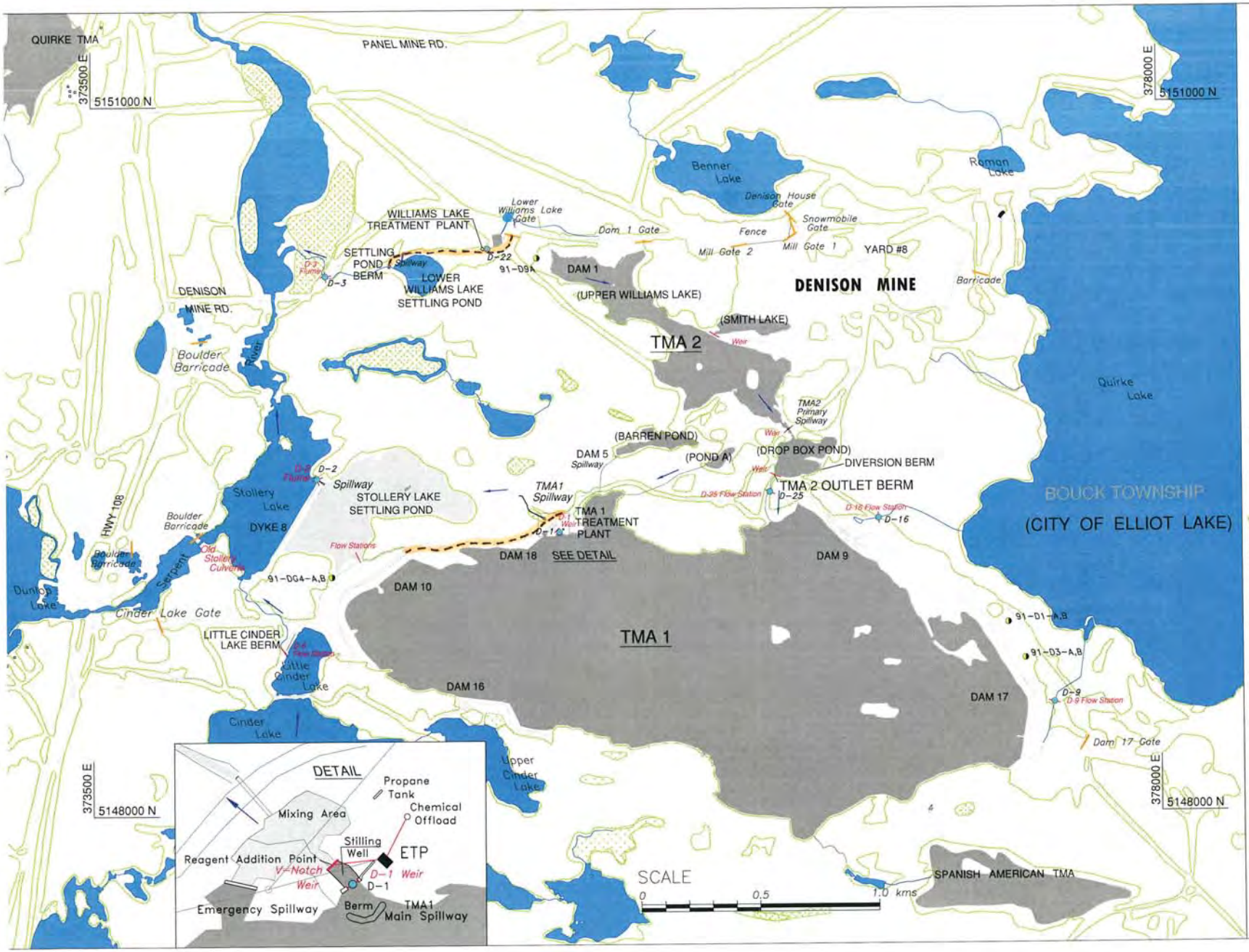
- Mine structures, property limits and mapping details were derived from Rio Algom records, MNDM digital data, MNR OBM and Image-GeoEye-1 Imagery (summer 2011).
- Image-GeoEye-1 Imagery (2011-08-01), provided by GeoEye International.
- Mapping export parameters = NAD83 WGS_1984_ UTM_Zone_17N (Central Meridian = 81°W).
- File-Pronto OCM (Site Map).
- March 2013.



DENISON MINES

Denison Mines Inc.
Denison
SAMPLE LOCATION MAP

Rev. 2015-01
November 2015

Legend

- water covered tailings.
- settling ponds.
- surface water sample location.
- groundwater sample location.
- flow direction.
- roads or trails.
- power line.
- flow station or weir.
- pipeline.
- gate.
- wetlands.

Notes

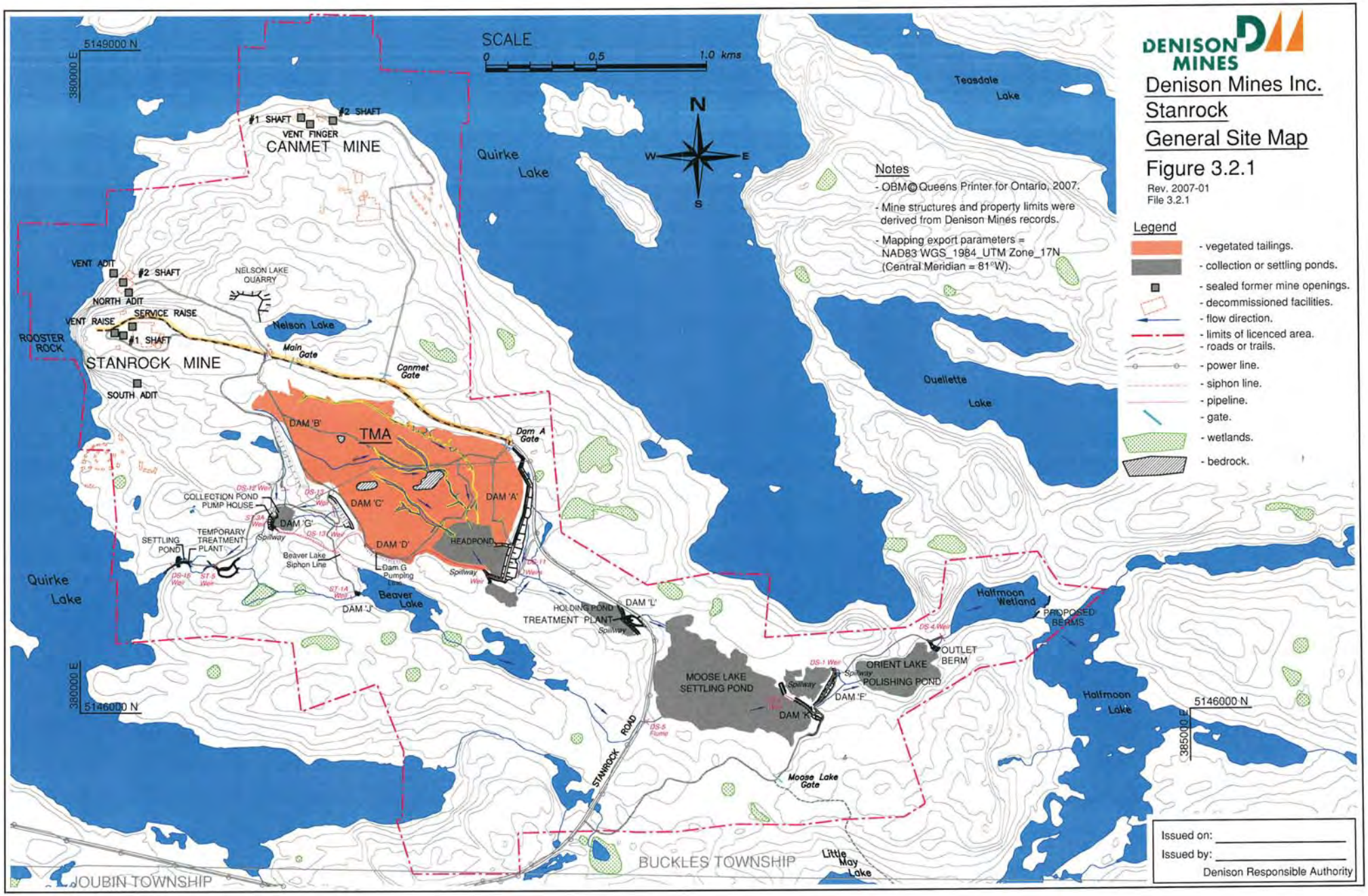
- OBM© Queens Printer for Ontario, 2008.
- Mine structures and property limits were derived from Denison Mines records.
- Mapping export parameters = NAD83 WGS_1984_UTM Zone_17N (Central Meridian = 81°W).
- Contour Interval = 10 metres.
- File 9.3.2 (Sample Location Map).

N
W E
S

Issued on: _____

Issued by: _____

Denison Responsible Authority


DENISON MINES
Denison Mines Inc.
Stanrock
General Site Map
Figure 3.2.1
Rev. 2007-01
File 3.2.1
SCALE
0
0.5
1.0 kms
N
S
E
W
Notes
- OBM © Queens Printer for Ontario, 2007.
- Mine structures and property limits were derived from Denison Mines records.
- Mapping export parameters = NAD83 WGS_1984_UTM Zone_17N (Central Meridian = 81°W).
Legend
- vegetated tailings.
- collection or settling ponds.
- sealed former mine openings.
- decommissioned facilities.
- flow direction.
- limits of licenced area.
- roads or trails.
- power line.
- siphon line.
- pipeline.
- gate.
- wetlands.
- bedrock.
5149000 N
380000 E
5146000 N
385000 E
#1 SHAFT
#2 SHAFT
VENT FINGER
CANMET MINE
VENT ADIT
#2 SHAFT
NORTH ADIT
VENT RAISE
SERVICE RAISE
#1 SHAFT
ROOSTER ROCK
STANROCK MINE
SOUTH ADIT
NELSON LAKE QUARRY
Nelson Lake
Main Gate
Canmet Gate
Quirke Lake
Teasdale Lake
Quellette Lake
TMA
DAM 'A'
DAM 'B'
DAM 'C'
DAM 'D'
DAM 'G'
Dam A Gate
HEADPOND
COLLECTION POND PUMP HOUSE
SETTLING POND
TEMPORARY TREATMENT PLANT
Beaver Lake Siphon Line
Dam G Pumping Line
Beaver Lake
DAM 'J'
HOLDING POND TREATMENT PLANT
DAM 'L'
MOOSE LAKE SETTLING POND
DAM 'K'
DAM 'F'
ORIENT LAKE POLISHING POND
OUTLET BERM
Halfmoon Wetland
PROPOSED BERMS
Halfmoon Lake
STANROCK ROAD
Moose Lake Gate
Little May Lake
BUCKLES TOWNSHIP
JOUBIN TOWNSHIP
Issued on:
Issued by:
Denison Responsible Authority

Appendix C Certificates of Analysis for Drinking Water

SASKATCHEWAN RESEARCH COUNCIL

Environmental Analytical Laboratories
102 - 422 Downey Road, Saskatoon, SK Canada S7N 4N1

T: 306-933-6932 **F:** 306-933-7922
Toll-free: 1-800-240-8808
E: analytical@src.sk.ca

www.src.sk.ca/analytical

SRC Group # 2016-10582

Sep 21, 2016

Denison Environmental Services
1 Horne Walk, Suite 200
Elliot Lake, ON P5A 2A5
Attn: Valerie Kilp

Date Samples Received: Sep-06-2016 Client P.O.: 107732

This is a final report.

Lab Section 1 results have been authorized by Keith Gipman, Supervisor

Lab Section 2 results have been authorized by Melissa Tackaberry-Syed, Supervisor

Lab Section 3 results have been authorized by Pat Moser, Supervisor

Lab Sections 4 and 5 results have been authorized by Vicky Snook, Supervisor

Lab Section 6 results have been authorized by Marion McConnell, Supervisor

---

* Test methods and data are validated by the laboratory's Quality Assurance Program.

* Routine methods follow recognized procedures from sources such as

    * Standard Methods for the Examination of Water and Wastewater APHA AWWA WEF
    * Environment Canada
    * US EPA
    * CANMET

* The results reported relate only to the test samples as provided by the client.

* Samples will be kept for 30 days after the final report is sent. Please contact the lab if you have any special requirements.

* Additional information is available upon request.

SASKATCHEWAN RESEARCH COUNCIL

Environmental Analytical Laboratories
102 - 422 Downey Road, Saskatoon, SK Canada S7N 4N1

T: 306-933-6932 **F:** 306-933-7922
Toll-free: 1-800-240-8808
E: analytical@src.sk.ca

www.src.sk.ca/analytical

SRC Group # 2016-10582

Sep 21, 2016

Denison Environmental Services

1 Horne Walk, Suite 200
Elliot Lake, ON P5A 2A5
Attn: Valerie Kilp

Date Samples Received: Sep-06-2016 Client P.O.: 107732

27799 08/31/2016 DWW *WATER*

Analyte	Units	27799
Lab Section 2 (ICP)		
Uranium	ug/L	<0.1
Lab Section 4 (Radiochemistry)		
Lead-210	Bq/L	<0.02
Polonium-210	Bq/L	<0.005
Radium-226	Bq/L	<0.005
Thorium-230	Bq/L	<0.01

Symbol of "<" means "less than". This indicates that it was not detected at level stated above.

SASKATCHEWAN RESEARCH COUNCIL

Environmental Analytical Laboratories
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Toll-free: 1-800-240-8808
E: analytical@src.sk.ca

www.src.sk.ca/analytical

SRC Group # 2016-14713

Dec 14, 2016

Denison Environmental Services
1 Horne Walk, Suite 200
Elliot Lake, ON P5A 2A5
Attn: Valerie Kilp

Date Samples Received: Dec-01-2016 Client P.O.: 107732

This is a final report.

Lab Section 1 results have been authorized by Keith Gipman QP, Supervisor
Lab Section 2 results have been authorized by Melissa Tackaberry-Syed QP, Supervisor
Lab Section 3 results have been authorized by Pat Moser QP, Supervisor
Lab Sections 4 and 5 results have been authorized by Vicky Snook QP, Supervisor
Lab Section 6 results have been authorized by Marion McConnell QP, Supervisor

QP: Qualified Person in accordance with the Saskatchewan Environmental Code, Corrective Action Plan Chapter, for the purposes of certifying a laboratory analysis

---

* Test methods and data are validated by the laboratory's Quality Assurance Program.

* Routine methods follow recognized procedures from sources such as
    * Standard Methods for the Examination of Water and Wastewater APHA AWWA WEF
    * Environment Canada
    * US EPA
    * CANMET

* The results reported relate only to the test samples as provided by the client.

* Samples will be kept for 30 days after the final report is sent. Please contact the lab if you have any special requirements.

* Additional information is available upon request.

SASKATCHEWAN RESEARCH COUNCIL

Environmental Analytical Laboratories
102 - 422 Downey Road, Saskatoon, SK Canada S7N 4N1

T: 306-933-6932 **F:** 306-933-7922
Toll-free: 1-800-240-8808
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www.src.sk.ca/analytical

SRC Group # 2016-14713

Dec 14, 2016

Denison Environmental Services

1 Horne Walk, Suite 200
Elliot Lake, ON P5A 2A5
Attn: Valerie Kilp

Date Samples Received: Dec-01-2016 Client P.O.: 107732

40387 11/29/2016 DWW *WATER*

Analyte	Units	40387
Lab Section 2 (ICP)		
Uranium	ug/L	<0.1
Lab Section 4 (Radiochemistry)		
Lead-210	Bq/L	<0.02
Polonium-210	Bq/L	<0.005
Radium-226	Bq/L	<0.005
Thorium-230	Bq/L	<0.01

Symbol of "<" means "less than". This indicates that it was not detected at level stated above.