Water Quality Monitoring 2019 at the former Nanisivik Mine, Nanisivik, Nunavut, Canada

Final Report

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Prepared for:

Canzinco Mines Limited
c/o Nyrstar Sales & Marketing AG
Tessinerplatz 7
8002 Zurich
Switzerland 2282062

Prepared by:

Stantec Consulting Ltd.
845 Prospect Street
Fredericton, NB E3B 2T7

Project No. 121622846

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Executive Summary

This report provides a summary of the 2019 water quality monitoring results for the Nanisivik Mine located on the Borden Peninsula of northern Baffin Island in Nunavut, Canada. The water quality monitoring program has been conducted as required under Nunavut Water Licence 1AR-NAN1419. The effectiveness and adequacy of mine reclamation is to be demonstrated through monitoring key water quality parameters at key sampling stations. Results for the Final Discharge Point of the West Twin Disposal Area (Station 159-4) are compared to the authorized criteria stated in the Water Licence, while parameters at the remaining sampling stations are compared to non-regulatory, station-specific 95th percentile Action Levels (calculated from historical data) as indicated in the Contingency Plan for Water Quality Exceedances, Former Nanisivik Mine Site (Stantec 2015).

Water quality monitoring of the decommissioned Nanisivik Mine in 2019 was completed in July, August and September. Water quality monitoring of the decommissioned Nanisivik Mine in 2019 indicates that the mine decommissioning is meeting its objectives, and that conditions in the freshwater environment at the site are returning to a state similar to conditions that existed prior to the mine development.

The results indicated compliance with all maximum authorized concentrations at Station 159-4, the final discharge point of the West Twin Disposal Area. Similarly, there were no exceedances of the site-specific Action Levels at Stations159-6 and 159-6 Temp near the mouth of Twin Lakes Creek.

Sulphate concentrations greater than the site-specific Action Level were recorded at Station NML-23 (Twin Lakes Creek upstream of Station 159-4) in July and September, however, similar values were also recorded at Station ELO (the true outlet of East Twin Lake) on those dates. This indicates that the sulphate originated in the watershed of East Twin Lake and was not related to the former Nanisivik Mine. It is possible that the warm summer of 2019 caused deeper than usual thawing of the surface permafrost, leading to a release of solutes that would normally remain trapped in the permafrost.

Sampling at Station 159-14 in the Chris Creek watershed found an exceedance of the site-specific Action Level for total suspended solids in July 2019 (not repeated in the August or September sampling) that may have been caused by erosion during the spring freshet. Exceedances of the site-specific Action Levels for total zinc and total sulphate in September, 2019, occurred only once, and similar to the observation at East Twin Lake, may have been caused by seasonal thawing of near-surface permafrost.

Sampling near the Landfill (Stations NML-29 and NML-30) showed flow at NML-30 in each month, but flow was only observed at NML-29 in July and September, 2019. A single low-level exceedance of the site-specific Action Level for total zinc (0.09 mg/L as compared to the action level of 0.03 mg/L) was observed at Station NML-30 at the west end of the Landfill in July, 2019. Concentrations of zinc at this station were <0.01 mg/L in both August and September. No further action is indicated with respect to the zinc exceedance at Station NML-30. Several exceedances of site-specific Action Levels were detected at NML-29, located at the east end of the Landfill. These included total zinc in July and August; total sulphate in August and September, and TSS in August, 2019. There was no flow observed at NML-29 in August 2019, and the water sample was collected from pooled or standing water. Disturbance of sediment may explain the high TSS and slightly elevated zinc value in August, but does not explain the high zinc value (0.96 mg/L) in July, or the high sulphate concentrations in August (467 mg/L) and September (347 mg/L).

As outlined in the *Contingency Plan for Water Quality Exceedances* (Stantec, 2015), if the non-regulatory Action Level is exceeded for any key parameter at the same monitoring station on two consecutive occasions, an investigation will be initiated to determine the cause of the exceedance. The summer of 2019 was unusually warm at Nanisivik, and it is possible that the seasonal thawing of surface permafrost could have released water containing dissolved zinc and sulphate either from the Landfill, or from native materials located upgradient of or adjacent to NML-29. However, the Landfill was inspected in 2019, and no abnormal geotechnical conditions were observed. A personal communication with Scott Garrison of BGC Engineering indicated that (1) monitoring of thermistors and frost gauges shows that the Landfill contents remained frozen throughout 2019 and that cover performance was comparable to previous years despite the warmer air conditions at site; and (2) no water was observed seeping directly from the landfill cover during the inspection. Therefore, it is recommended that during the monitoring event in August 2020, a hand-held conductivity meter should be used to explore water quality in flowing or standing water in the vicinity of NML-29, in an effort to determine whether water quality exceedances observed at NML-29 in 2019 may have originated from the Landfill, or from other nearby natural or man-made source(s).

1.0 INTRODUCTION

1.1 GENERAL INTRODUCTION

Stantec Consulting Ltd. (Stantec) is pleased to provide Canzinco Mines Ltd. with a review of the 2019 water quality monitoring data for the former Nanisivik Mine (the Mine) in the territory of Nunavut, Canada. The monitoring program is required under Water Licence 1AR-NAN1419 (the Water Licence, Nunavut Water Board, 2015) and is intended to help assess the overall performance of reclamation and closure activities at the former Nanisivik Mine.

1.2 SITE DESCRIPTION

The Mine is located 750 kilometres north of the Arctic Circle at an approximate latitude of 73 degrees north, approximately 33 kilometres by road from the hamlet of Arctic Bay, on the southern shore of Strathcona Sound, on the Borden Peninsula, part of northern Baffin Island (Drawing A-1, Appendix A). In 1998, Canzinco Ltd., a wholly owned subsidiary of Breakwater Resources Ltd., took possession of the Mine, and operated it until 2002. Breakwater Resources Ltd., was acquired by Nyrstar Sales & Marketing AG in 2011.

The Mine facilities, which are now decommissioned, consisted of an underground mine and a 2,200 tonne per day concentrator that used conventional crushing, rod and ball mill grinding, differential lead and zinc flotation, and concentrate drying. Between 1976 and 2002, the underground facility extracted and shipped zinc and lead concentrates. Ore concentrates were shipped from a concentrate storage shed located adjacent to Strathcona Sound, where a deepwater wharf allowed ocean-going vessels to moor. Concentrates were transferred to ships using a ship-loader. Process tailings were transported to and deposited at the West Twin Disposal Area (WTDA), where resulting effluent was discharged into Twin Lakes Creek. The Mine was in full operation from its opening in 1976 until closure in September 2002.

Reclamation activities began at Nanisivik in 2002. On July 30, 2006, Environment Canada approved Nanisivik as having achieved “recognized closed mine” status under the *Metal Mining Effluent Regulations* and therefore, mine effluent and environmental effects monitoring requirements under those regulations were no longer required. On October 1, 2008, reclamation of the site was completed and a post-closure monitoring period began. Water quality monitoring continued during 2019 under Nunavut Water Licence 1AR-NAN1419, issued by the Nunavut Water Board (2015). This Water Licence remained in effect until December 22, 2019.

1.3 SAMPLING LOCATIONS

There are six identified water quality sampling locations in Schedule I, Table 2 of Water Licence 1AR-NAN1419, and two voluntary stations near the Mine. These stations are described in Table 1.1 and shown in Drawing A-2 (Appendix A).

Voluntary station ELO is located upstream of NML-23 and was added during the 2012 program to confirm that elevated sulphate concentrations that were sporadically being detected originate from the watershed of East Twin Lake, and not from seepage proximal to NML-23 that could indicate a release from the WTDA.

Voluntary station 159-6 Temp was added in 2016 when an independent contractor's laydown and storage area was identified within 30 m of Twin Lakes Creek, and within 10 m of the usual sampling Station 159-6. Station 159-6 Temp was established approximately 120 m upstream of Station 159-6, and 30 m upstream of the laydown area, to confirm that water monitoring results at the Station 159-6 were not influenced by activities or events at the laydown area.

Table 1.1 Surface Water Quality Sampling Locations Tested in 2019

Group	Station	Distance Downstream of Headwaters (m)	Description
Twin Lakes Creek Watershed	ELO	100	Outflow of East Twin Lake upstream of NML-23
	NML-23	400	Outflow of East Twin Lake
	159-4	750	Outflow from WTDA
	159-6	7,200	Outlet of Twin Lakes Creek into Strathcona Sound
	159-6 Temp	7,050	Outlet of Twin Lakes Creek into Strathcona Sound, upstream of the wharf construction laydown area*
Chris Creek Watershed	159-14	2,600	Chris Creek downstream of K-Baseline
Landfill Watershed	NML-29	75	Downstream of Landfill - east drainage system
	NML-30	75	Downstream of Landfill - west drainage system

Note:
Sampling locations as detailed by Gartner Lee Ltd. (2004), except as otherwise noted in the text.
* Contractors for the Department of National Defence/Defence Construction Canada at the Nanisivik wharf.

1.4 PREVIOUS WATER QUALITY MONITORING PROGRAMS

1.4.1 Water Licences

Since 1976, the Mine has operated under five different Water Licences issued by the Northwest Territories Water Board and the Nunavut Water Board:

- Northwest Territories Water Licence N5L3-0159 - Northwest Territories Water Board (July, 1976; renewed in 1978, 1983, 1988 and 1991);
- Nunavut Water Licence NWB1NAN9702 - Nunavut Water Board (July, 1997; the original term of five years was extended until closure in September, 2002);
- Nunavut Water Licence NWB1NAN0208 - Nunavut Water Board (October, 2002 to May, 2008);
- Nunavut Water Licence NWB1AR-NAN0914 - Nunavut Water Board (April, 2009 to December, 2014); and
- Nunavut Water Licence 1AR-NAN1419 - Nunavut Water Board (renewal for the period December 23, 2014 through December 22, 2019).

On November 15, 2019, the Nunavut Water Board approved a short-term renewal of the existing Water Licence, identified as 1AR-NAN1420, valid from December 22, 2019 to June 19, 2020. This preceded and facilitated the approval by the Board on January 9, 2020, of a new Water Licence, 1AR-NAN2030, valid from January 9, 2020 to January 8, 2030. The new Water Licence authorizes and establishes the conditions for continued post-closure

maintenance and monitoring, including water quality monitoring, that may be needed to ensure the continued integrity and functionality of completed reclamation works.

In comparison with previous Water Licences, and consistent with the progression of the decommissioning and post-closure monitoring, the conditions of Water Licence 1AR-NAN1419 (Schedule I, Table 2) implemented a reduction in sampling locations, frequency and parameters required for analysis. The Water Licence (Part F, Sections 1 and 2) contained maximum authorized concentrations of certain water quality parameters at Station 159-4, the final discharge point for the decommissioned WTDA (Table 1.2). For the period 2020 to 2030, the new Water Licence (1AR-NAN2030) supports a further reduction in sampling locations, frequency, and parameters required for analysis. This Water Quality Monitoring report for the year 2019 represents the final year of reporting under Water Licence 1AR-NAN1419.

Table 1.2 provides the regulatory standards for water quality at Station 159-4, the final discharge point for the WTDA. Data for the remaining water quality monitoring stations are compared to station-specific 95th percentile action levels (Table 1.3) that were presented to the Nunavut Water Board in the Contingency Plan for Water Quality Exceedances (Stantec, 2015). These are non-regulatory values calculated from historical data for each key parameter (*i.e.*, cadmium, lead, zinc, sulphate, total suspended solids, and pH). If the 95th percentile value is exceeded for any key parameter at the same monitoring station on two consecutive occasions, an investigation will be initiated to determine the cause of the exceedance. Action levels have not been identified for other parameters because they are of lesser concern from a toxicological perspective (*e.g.*, major ion concentrations such as calcium and chloride), or because there was insufficient data to develop an estimate of the 95th percentile value. For pH, values are compared to the acceptable range listed in the Water Licence limits for Station 159-4 (*i.e.*, 6.0 to 9.5).

Table 1.2 Effluent Quality Requirements for the West Twin Disposal Area, Station 159-4

Parameter	Maximum Authorized Concentration
Total Arsenic (mg/L)	0.25
Total Cadmium (mg/L)	0.005
Total Copper (mg/L)	0.10
Total Lead (mg/L)	0.10
Total Nickel (mg/L)	0.50
Total Zinc (mg/L)	0.25
Total Suspended Solids (mg/L)	15.0
pH (units)	6.0 - 9.5 (pH units)
Note: Where a visible sheen has been observed in effluent the maximum authorized concentration of oil and grease shall not exceed 15.0 mg/L.	

Table 1.3 Non-Regulatory Station-Specific Action Levels

Parameter	Station				
	Twin Lakes Creek Watershed		Chris Creek Watershed	Landfill Watershed	
	159-6	NML-23	159-14	NML-30	NML-29
Total Cadmium (mg/L)	0.014	0.0044	0.0005	0.00025	0.00025
Total Lead (mg/L)	0.044	0.016	0.0022	0.0050	0.0050
Total Zinc (mg/L)	4.6	0.12	0.13	0.03	0.03
Total Sulphate (mg/L)	463	25	408	240	240
Total Suspended Solids (mg/L)	53	10	32	22	22
pH (units)	6.0 - 9.5 (pH units)				
Note: NML-29 flow is intermittent. Action Levels in case of flow are the same as at NML-30.					

The Water Licence (Schedule I, Table 2) provides details of the expected Stations, monitoring parameters, and sampling frequency for the period 2015 to 2019. Details of the monitoring requirements are provided in Table 1.4.

Table 1.4 Water Quality Monitoring Schedule for Post-Closure Period, 2015 to 2019

Water Quality Monitoring Stations 2015 to 2019				
Station Number	**Station Description**	**Purpose**	**Parameters to be Measured**	**Monitoring Frequency**
Twin Lakes Creek Watershed				
ELO	Outflow of East Twin Lake upstream of NML-23	Voluntary Water Quality at the Outlet to East Twin Lake (Control)	NAN-1	Monthly
NML-23	Outflow from East Twin Lake	Upstream Control Station	NAN-1	Monthly
159-4	Outflow from WTDA	Final Discharge Point	NAN-1	Monthly
			NAN-4	Annually
159-6	Outlet of Twin Lakes Creek into Strathcona Sound	General Monitoring	NAN-1 NAN-2	Monthly
			NAN-4	Annually
159-6 Temp	Outlet of Twin Lakes Creek into Strathcona Sound upstream of the wharf construction laydown area and ground disturbing activities and upstream of 159-6 Temp	Voluntary General Monitoring	NAN-1 NAN-2	Monthly
Chris Creek Watershed				
159-14	Chris Creek downstream of K-Baseline	K-Baseline Monitoring	NAN-1	Monthly
Landfill Watershed				
NML-29	Downstream of Landfill - East Drainage System	Landfill Monitoring	NAN-1 NAN-2	Monthly
NML-30	Downstream of Landfill - West Drainage	Landfill Monitoring	NAN-1 NAN-2	Monthly

Notes:
Monthly monitoring to be carried out during periods of flow or July 1 to September 1, annually.
NAN-1 includes: Metals analysis (total cadmium, lead and zinc), major cations (calcium, magnesium, sodium, potassium, ammonia, and hardness), major anions (chloride, sulphate, bicarbonate, carbonate, nitrate+nitrite, and alkalinity), TSS, and field-measured parameters (specific conductivity, temperature, pH and visual observation for hydrocarbon sheen).
NAN-2 includes: Petroleum hydrocarbon analysis of F2 to F4 hydrocarbons.
NAN-4 includes: ICP (trace metal) scan.

1.4.2 Summary of Water Quality Monitoring Prior to 2019

In the years of monitoring following the decommissioning of the Mine, two main themes have emerged.

- Of greatest importance, the Mine decommissioning appears to have achieved its objectives with respect to overall water quality. Key areas that were decommissioned, such as the WTDA, Chris Creek, and Landfill watersheds showed consistently good water quality results over the period 2008 to 2018.

- Sampling stations lower in the Twin Lakes Creek drainage system show substantial improvement and have stabilized since decommissioning activities ceased in 2008. The area remains subject to occasional upset conditions due to the unpredictable nature of erosion and weathering in the zone where the creek valley cuts through the natural mineral outcrop. Stations located within the Chris Creek drainage, where natural mineralization exists at or close to the ground surface, are similarly subject to occasional upsets, but have likewise produced results that are consistent with conditions that prevailed before mining occurred.

2.0 REVIEW OF 2019 WATER QUALITY DATA

Water samples were collected from the Twin Lakes Creek, Chris Creek and Landfill watersheds during the 2019 open flow sampling season (*i.e.*, early July to early September). A summary of the 2019 water quality monitoring results is presented in tabular format in Appendix B. Three full rounds of sampling were completed for the 2019 program, on July 4-5, August 10-12, and September 4, respectively. Duplicate samples were collected at several Stations during the 2019 water quality monitoring program for quality assurance and control purposes.

2.1 STATION 159-4 (FINAL DISCHARGE POINT)

Only the data for Station 159-4 are compared to the effluent quality requirements for the final discharge point (from the Water Licence, Part F, Item 1). The water quality data for the parameters specified in the Water Licence at Station 159-4 are presented in Table 2.1. Full data are provided in Table B1 (Appendix B). Temporal trends are shown graphically in Figure C1 (Appendix C).

Concentrations of the regulated parameters (*i.e.*, arsenic, cadmium, copper, lead, nickel, zinc and total suspended solids) remained below the maximum authorized concentrations throughout 2019. The field and laboratory measured pH values were all within the preferred range (pH 6.0 to 9.5).

For the additional, non-regulated parameters, sulphate concentrations at Station 159-4 ranged between 153 mg/L and 530 mg/L (Table B1 and Figure C1), below the station-specific action level of 1,471 mg/L. No visible hydrocarbon sheen was observed during the 2019 sampling program at Station 159-4, and therefore hydrocarbon fractions F2 through F4 were not measured.

Table 2.1 Concentrations of Water Licence Regulated Parameters at Station 159-4

Parameter	Maximum Authorized Concentration	05-Jul-19	11-Aug-19	04-Sep-19
Total Arsenic (mg/L)	0.25	<0.001	<0.001	<0.001
Total Cadmium (mg/L)	0.005	<0.0001	0.0001	0.0001
Total Copper (mg/L)	0.10	<0.001	0.001	<0.001
Total Lead (mg/L)	0.10	<0.001	0.001	0.002
Total Nickel (mg/L)	0.50	<0.005	<0.005	<0.005
Total Zinc (mg/L)	0.25	0.02	0.04	0.06
Total Suspended Solids (mg/L)	15.0	<2	<2	2
pH (units) Field Measured	6.0-9.5	7.9	8.0	8.2
pH (units) Laboratory Measured	6.0-9.5	7.97	8.17	7.91
Petroleum Hydrocarbons	visible sheen	--- /nvs	--- /nvs	--- /nvs

Notes:
--- = data not required.
nvs = no visible hydrocarbon sheen observed.

2.2 TWIN LAKES CREEK WATERSHED (EXCLUDING STATION 159-4)

Two stations (Station 159-6, located in Twin Lakes Creek, immediately before it discharges into Strathcona Sound; and Station NML-23, located in the upper reach of the Twin Lakes Creek watershed near the outlet of East Twin Lake) are identified in the Water Licence for post-closure monitoring within the Twin Lakes Creek watershed. In addition, Canzinco voluntarily samples Station ELO at the outlet to East Twin Lake, and Station 159-6 Temp upstream of Station 159-6 (see Drawing A-2, Appendix A). Selected water quality data for Stations 159-6, 159-6 Temp, NML-23 and ELO are presented in Tables 2.2 and 2.3, with the full data provided in Tables B2-1 and B2-2, in Appendix B. Temporal trends are shown graphically in Appendix C, Figures C2 (Station 159-6) and C3 (Station NML-23).

There were no exceedances of the site-specific Action Levels at either Station 159-6 or 159-6 Temp during the 2019 sampling program (Table 2.2). As anticipated and in line with trends observed over the past several years, both total suspended solids (TSS) and sulphate were reported at both stations at levels well below the action levels. Concentrations of TSS at both locations were generally low (2 mg/L or less), although a TSS concentration of 11 mg/L was observed at Station 159-6 in early September. The value at Station 159-6 Temp just upstream from 159-6 was <2 mg/L. Sulphate concentrations ranged between 24 and 246 mg/L at both Station 159-6 and 159-6 Temp, well below the site-specific Action Level of 463 mg/L.

No visible sheen from petroleum hydrocarbons was observed at either Station 159-6 or 159-6 Temp, and no trace of any hydrocarbon fraction was detected during 2019.

Table 2.2 Concentrations of Selected Parameters at Stations 159-6 and 159-6 Temp

Parameter	Action Level for Station 159-6	159-6			159-6 Temp		
		04-Jul-19	10-Aug-19	04-Sep-19	04-Jul-19	10-Aug-19	04-Sep-19
Total Cadmium (mg/L)	0.014	0.0001	0.0005	0.0011	0.0001	0.0005	0.0010
Total Lead (mg/L)	0.044	0.002	<0.001	<0.001	0.002	<0.001	<0.001
Total Zinc (mg/L)	4.6	0.04	0.15	0.78	0.04	0.17	0.72
Total Sulphate (mg/L)	463	24	102	246	24	104	242
Total Suspended Solids (mg/L)	53	2	<2	11	<2	<2	<2
pH (units) Field Measured	6.0-9.5	8.1	7.9	n/a	8.1	7.8	n/a
pH (units) Laboratory Measured	6.0-9.5	8.11	8.04	7.64	7.89	7.99	7.64
Petroleum Hydrocarbons	visible sheen	n.d./nvs	n.d./nvs	n.d./nvs	n.d./nvs	n.d./nvs	n.d./nvs

Notes:
n/a = data not available.
n.d. = results for F2, F3 and F4 below analytical detection limits of 0.02, 0.05 and 0.05 mg/L, respectively.
nvs = no visual sheen observed.

Stations NML-23 and ELO at the outflow of the tailings ponds both recorded two exceedances of the site-specific action level for sulphate during the 2019 sampling program (Table 2.3), although the exceedances were not

consecutive (occurring in July and September, but not in August). Station NML records water quality data in Twin Lakes Creek just upstream from the discharge point for the WTDA. Station ELO records water quality data at the outlet to East Twin Lake, and is located upstream from potential effects of the historical mine operations. As the elevated sulphate concentrations were found to be originating from East Twin Lake, with similar values occurring at NML-23, these observations are viewed as being of natural origin, presumably due to the weathering and/or erosion of sulphide deposits located in the watershed upstream from East Twin Lake. With the exception of a trace of zinc (0.02 - 0.03 mg/L) in the July, 2019 sampling event, none of the heavy metal parameters (*e.g.*, cadmium, lead, zinc) showed evidence of increase in association with the elevated sulphate concentrations. Due to the presumed natural origin of the observed sulphate concentrations, as well as the fact that the occurrences were not consecutive, no further action or investigation is indicated at the present time.

Table 2.3 Concentrations of Selected Parameters at Stations NML-23 and ELO

Parameter	Action Level for Station NML-23	NML-23			ELO		
		05-Jul-19	11-Aug-19	04-Sep-19	05-Jul-19	11-Aug-19	04-Sep-19
Total Cadmium (mg/L)	0.0044	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Lead (mg/L)	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Zinc (mg/L)	0.12	0.02	<0.01	<0.01	0.03	<0.01	<0.01
Total Sulphate (mg/L)	25	**152**	18	**38**	**163**	17	**37**
Total Suspended Solids (mg/L)	10.0	<2	<2	<2	<2	<2	<2
pH (units) Field Measured	6.0-9.5	7.9	7.3	n/a	7.5	7.8	n/a
pH (units) Laboratory Measured	6.0-9.5	8.06	7.40	7.09	7.90	7.81	7.33
Petroleum Hydrocarbons	visible sheen	--- /nvs	--- /nvs	--- /nvs	--- /nvs	--- /nvs	--- /nvs

Notes:
Bold = exceedance of 95th percentile site-specific action level.
n/a = data not available.
--- = data not required.
nvs = no visual sheen observed.

2.3 CHRIS CREEK WATERSHED

The Water Licence required sampling at Station 159-14 during the period 2015 to 2019. Station 159-14 is located on Chris Creek approximately 1.6 km upstream of its discharge to Strathcona Sound. Selected water quality data for Station 159-14 in 2019 are presented in Table 2.4, with the full data provided in Table B3, in Appendix B. Temporal trends are shown graphically in Figure C4 (Appendix C).

Flow was present at Station 159-14 during all three sampling events in 2019. Three exceedances of site-specific action levels were observed at Station 159-14 in 2019. These were:

- a TSS value of 41 mg/L in July, which exceeded the site-specific Action Level of 32 mg/L. Elevated concentrations of TSS are not uncommon during spring melt conditions, and TSS values in August and September returned to the normal range;
- a total zinc concentration of 0.25 mg/L in September, which exceeded the site-specific Action Level of 0.13 mg/L; and
- a sulphate concentration of 742 mg/L in September, which exceeded the site-specific Action Level of 408 mg/L.

The elevated concentrations of sulphate and zinc occurred together, which suggests a natural weathering process involving sulphide minerals within the watershed. Only a single occurrence was recorded during 2019, therefore no follow-up action is triggered. However, water quality for sulphate and zinc at Station 159-14 should be carefully scrutinized in 2020 to be sure that this is not an ongoing process.

Table 2.4 Concentrations of Selected Parameters at Station 159-14

Parameter	Action Level for Station 159-14	05-Jul-19	10-Aug-19	04-Sep-19
Total Cadmium (mg/L)	0.0005	0.0002	<0.0001	0.0002
Total Lead (mg/L)	0.0022	0.001	<0.001	<0.001
Total Zinc (mg/L)	0.13	0.08	0.08	**0.25**
Total Sulphate (mg/L)	408	50	284	**742**
Total Suspended Solids (mg/L)	32	**41**	<2	6
pH (units) Field Measured	6.0-9.5	8.8	8.2	n/a
pH (units) Laboratory Measured	6.0-9.5	8.18	8.29	8.04
Petroleum Hydrocarbons	visible sheen	--- /nvs	--- /nvs	--- /nvs

Notes:
Bold = exceedance of 95th percentile site-specific action level.
n/a = data not available.
--- = data not required.
nvs = no visual sheen observed.

2.4 LANDFILL WATERSHED

The former Landfill is located west of the Mine, with primary drainage systems that flow intermittently to the east and west, monitored at Stations NML-29 and NML-30, respectively. Flow has only occasionally been observed at Station NML-29, but is regularly observed at Station NML-30. Stations NML-29 and NML-30 are located north of the Landfill, down gradient of the Landfill cell on intermittent drainage channels (Drawing A-2, Appendix A) that connect to Twin Lakes Creek approximately 1 km from Station NML-29 and 1.25 km from Station NML-30.

Samples were collected on July 5, August 12, and September 4, 2019. No flow was observed at NML-29 during the sampling event on August 12, 2019, but standing water was present and was sampled. Samples were collected during all three sampling events at Station NML-30 in 2019. Results from the 2019 samples at both NML-29 and NML-30 are compared to a non-regulatory site-specific Action Level based on data previously

collected at Station NML-30 as presented in Table 2.5. Full data are provided in Table B4, in Appendix B. Temporal trends are shown graphically for Station NML-30 in Figure C5 (Appendix C).

Several exceedances of site-specific Action Levels for key parameters were detected at NML-29, located at the east end of the Landfill. These included exceedances for total zinc in July and August, 2019; for total sulphate in August and September, 2019, and for TSS in August, 2019. There was no flow observed at NML-29 in August 2019, and the water sample was collected from pooled or standing water. Sampling from pooled (rather than flowing) water may explain the high TSS and slightly elevated zinc value in August, but does not explain the very high zinc value in July, or the high sulphate concentrations in August and September.

Table 2.5 Concentrations of Selected Parameters at Stations NML-29 and NML-30

Parameter	Action Level for Stations NML-29 and NML-30	NML-29			NML-30		
		05-Jul-19	12-Aug-19	04-Sep-19	05-Jul-19	12-Aug-19	04-Sep-19
Total Cadmium (mg/L)	0.00025	0.0008	0.0002	<0.0001	0.0002	<0.0001	<0.0001
Total Lead (mg/L)	0.0050	0.002	<0.001	<0.001	0.001	<0.001	<0.001
Total Zinc (mg/L)	0.03	**0.96**	**0.04**	0.01	**0.09**	<0.01	<0.01
Total Sulphate (mg/L)	240	128	**467**	**347**	55	108	234
Total Suspended Solids (mg/L)	22	<2	**37**	2	<2	4	<2
pH (units) Field Measured	6.0-9.5	8.2	8.1	n/a	8.5	8.3	n/a
pH (units) Laboratory Measured	6.0-9.5	8.35	8.29	8.13	8.30	8.40	8.16
Petroleum hydrocarbons	visible sheen	n.d./nvs	n.d./nvs	n.d./nvs	n.d./nvs	n.d./nvs	n.d./nvs

Notes:
Bold = exceedance of 95th percentile site-specific action level.
n/a = data not available.
nvs = no visible sheen observed.
n.d. = results for F2, F3 and F4 below analytical detection limits of 0.02, 0.05 and 0.05 mg/L, respectively.

As outlined in the *Contingency Plan for Water Quality Exceedances* (Stantec, 2015), if the non-regulatory Action Level is exceeded for any key parameter at the same monitoring station on two consecutive occasions, an investigation will be initiated to determine the cause of the exceedance. The summer of 2019 was unusually warm at Nanisivik, and it is possible that the seasonal thawing of surface permafrost could have released water containing dissolved zinc and sulphate either from the Landfill, or from native materials located upgradient of or adjacent to NML-29. However, the Landfill was inspected in 2019, and no abnormal geotechnical conditions were observed. A personal communication with Scott Garrison of BGC Engineering indicated that (1) monitoring of thermistors and frost gauges shows that the Landfill contents remained frozen throughout 2019 and that cover performance was comparable to previous years despite the warmer air conditions at site; and (2) no water was observed seeping directly from the landfill cover during the inspection. Therefore, it is recommended that during the monitoring event in August 2020, a hand-held conductivity meter should be used to explore water quality in flowing or standing water in the vicinity of NML-29, in an effort to determine whether water quality exceedances

observed at NML-29 in 2019 may have originated from the Landfill, or from other nearby natural or man-made source(s).

A single low-level exceedance of the Action Level for total zinc (0.09 mg/L as compared to the action level of 0.03 mg/L) was observed at Station NML-30 during July, 2019. Subsequent zinc concentrations at this station were <0.01 mg/L in both August and September. No further action is indicated with respect to the zinc exceedance at Station NML-30.

There were no visible hydrocarbon sheens, and no detected residues of petroleum hydrocarbon fractions F2, F3 or F4 at either NML-29 or NML-30 during 2019.

2.5 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC) DISCUSSION

The Quality Assurance/Quality Control (QA/QC) sampling program consisted of the collection and analysis of field duplicate and field blank samples for quality assurance purposes. The QA/QC program permits the evaluation of the efficiency of quality control measures implemented during sampling to limit potential contamination and produce reliable results.

Six field duplicate samples (representing Stations 159-4, 159-6, and NML-30 in one or more sampling months) were submitted for analysis during the 2019 program. Relative Percent Difference (RPD) of each duplicate parameter measured is provided in Table 2.6. Higher RPDs are typically observed when analyte concentrations are very low (*i.e.*, close to their respective laboratory detection limit). There are no firm guidelines for the degree of correlation expected between duplicates due to the potential for natural heterogeneity within and between samples, as well as potential contaminant distribution. In general, the duplicate results for the 2019 program agree closely with their corresponding parent samples and confirm the representativeness of sampling procedures. Overall, the 2019 program reported 10 of the 126 tested parameters had a calculated RPD of 40% or greater, with a maximum reported RPD value of 138%. However, most of the RPD values greater than 40% resulted from very small analytical differences, close to the analytical detection limits, and/or represented parameters of low concern (*e.g.*, potassium results of 1 mg/L and 2 mg/L for NML-30 in September, 2019; or zinc concentrations of 0.02 and 0.03 mg/L for 159-4 in July, 2019). None of the RPD values were identified as representing a material concern with respect to the reliability or representativeness of the data.

One field blank sample (September 2019) was also submitted to complete the QA/QC program. The field blank sample returned non-detectable values for all parameters except pH, which was measured as 7.03 by the analytical laboratory.

The data quality is considered acceptable.

March 10, 2020

Table 2.6 Results of QA/QC Samples and Associated Relative Percent Differences

Parameter	Twin Lakes	Twin Lakes	RPD	Twin Lakes	Twin Lakes	RPD	Twin Lakes	Twin Lakes	RPD	Landfill	Landfill	RPD	Landfill	Landfill	RPD	Landfill	Landfill	RPD	Greater Than
Station	159-4	159-4 DUP		159-6	159-6 DUP		159-6 Temp	159-6 Temp DUP		NML-30	NML-30 DUP		NML-30	NML-30 DUP		NML-30	NML-30 DUP		
Date	5-Jul-19	5-Jul-19	(%)	10-Aug-19	10-Aug-19	(%)	4-Sep-19	4-Sep-19	(%)	5-Jul-19	5-Jul-19	(%)	12-Aug-19	12-Aug-19	(%)	4-Sep-19	4-Sep-19	(%)	40% RPD
pH	7.9	7.49	5.33%	7.9	7.8	1.27%				8.47	8.47	0.00%	8.3	8.3	0.00%				0
lab pH	7.97	8.05	1.00%	8.04	7.98	0.75%	7.64	7.61	0.39%	8.3	8.41	1.32%	8.4	8.41	0.12%	8.16	8.13	0.37%	0
Conductivity (mS)				0.328	0.329	0.30%	0.55	0.55	0.00%				0.519	0.519	0.00%	0.66	0.66	0.00%	0
lab Conductivity	0.365	0.368	0.82%	0.328	0.328	0.00%	0.601	0.601	0.00%	0.261	0.26	0.38%	0.516	0.518	0.39%	0.698	0.699	0.14%	0
Temperature (°C)	14	5.7	84.26%	11.55	11.55	0.00%	4.6	4.6	0.00%	9.3	9.3	0.00%	10.5	10.5	0.00%	4.9	4.9	0.00%	1
TSS (mg/L)	<2	<2	0.00%	<2	<2	0.00%	11	<2	138.46%	<2	6	100.00%	4	<2	66.67%	<2	<2	0.00%	3
Sulphate (mg/L)	153	161	5.10%	102	103	0.98%	246	245	0.41%	55	55	0.00%	108	108	0.00%	234	233	0.43%	0
Aluminum total (mg/L)	<0.01			0.02			0.02												0
Antimony total (mg/L)	<0.0005			<0.0005			<0.0005												0
Arsenic total (mg/L)	<0.001			<0.001			<0.001												0
Barium total (mg/L)	0.01			0.03			0.06												0
Beryllium total (mg/L)	<0.0005			<0.0005			<0.0005												0
Boron total (mg/L)	0.23			0.08			0.13												0
Cadmium total (mg/L)	<0.0001	<0.0001	0.00%	0.0005	0.0005	0.00%	0.0011	0.0011	0.00%	0.0002	0.0002	0.00%	<0.0001	<0.0001	0.00%	<0.0001	<0.0001	0.00%	0
Chromium total (mg/L)	<0.001			<0.001			<0.001												0
Cobalt total (mg/L)	<0.0002			0.0003			0.0016												0
Copper total (mg/L)	<0.001			<0.001			0.002												0
Iron total (mg/L)	<0.03			0.03			0.09												0
Lead total (mg/L)	<0.001	<0.001	0.00%	<0.001	<0.001	0.00%	<0.001	<0.001	0.00%	0.001	0.002	66.67%	<0.001	<0.001	0.00%	<0.001	<0.001	0.00%	1
Manganese total (mg/L)	<0.01			<0.01			0.02												0
Molybdenum total (mg/L)	<0.005			<0.005			<0.005												0
Nickel total (mg/L)	<0.005			<0.005			<0.005												0
Selenium total (mg/L)	<0.001			<0.001			<0.001												0
Silicon total (mg/L)	0.2			0.6			0.8												0
Silver total (mg/L)	<0.0001			<0.0001			<0.0001												0
Strontium total (mg/L)	0.224			0.101			0.195												0
Thallium total (mg/L)	<0.0001			<0.0001			<0.0001												0
Titanium total (mg/L)	<0.01			<0.01			<0.01												0
Uranium total (mg/L)	<0.001			<0.001			0.001												0
Vanadium total (mg/L)	<0.001			<0.001			<0.001												0
Zinc total (mg/L)	0.02	0.03	40.00%	0.15	0.17	12.50%	0.78	0.79	1.27%	0.09	0.1	10.53%	<0.01	<0.01	0.00%	<0.01	<0.01	0.00%	0
Alkalinity (as CaCO3) (mg/L)	44	43	2.30%	46	45	2.20%	49	48	2.06%	98	108	9.71%	159	164	3.10%	137	131	4.48%	0
Chloride (mg/L)	3	3	0.00%	6	6	0.00%	8	5	46.15%	3	3	0.00%	7	8	13.33%	4	8	66.67%	2
Ammonia (as nitrogen) (mg/L)	<0.010	<0.010	0.00%	<0.010	<0.010	0.00%	<0.010	<0.010	0.00%	<0.010	<0.010	0.00%	0.03	0.01	100.00%	<0.010	<0.010	0.00%	1

March 10, 2020

Table 2.6 Results of QA/QC Samples and Associated Relative Percent Differences

Parameter	Twin Lakes	Twin Lakes	RPD	Twin Lakes	Twin Lakes	RPD	Twin Lakes	Twin Lakes	RPD	Landfill	Landfill	RPD	Landfill	Landfill	RPD	Landfill	Landfill	RPD	Greater Than
Station	159-4	159-4 DUP		159-6	159-6 DUP		159-6 Temp	159-6 Temp DUP		NML-30	NML-30 DUP		NML-30	NML-30 DUP		NML-30	NML-30 DUP		
Date	5-Jul-19	5-Jul-19	(%)	10-Aug-19	10-Aug-19	(%)	4-Sep-19	4-Sep-19	(%)	5-Jul-19	5-Jul-19	(%)	12-Aug-19	12-Aug-19	(%)	4-Sep-19	4-Sep-19	(%)	40% RPD
NO2 + NO3 as N (mg/L)	<0.10	<0.10	0.00%	0.29	0.29	0.00%	0.5	0.5	0.00%	0.26	0.27	3.77%	0.23	0.23	0.00%	0.47	0.47	0.00%	0
Hardness (as CaCO3) (mg/L)	198	202	2.00%	160	160	0.00%	329	320	2.77%	142	142	0.00%	279	279	0.00%	398	401	0.75%	0
HCO3 as CaCO3 (mg/L)	44	43	2.30%	46	45	2.20%	49	48	2.06%	96	105	8.96%	155	160	3.17%	137	131	4.48%	0
Calcium (mg/L)	43	43	0.00%	31	31	0.00%	61	59	3.33%	32	32	0.00%	59	59	0.00%	82	83	1.21%	0
Magnesium (mg/L)	22	23	4.44%	20	20	0.00%	43	42	2.35%	15	15	0.00%	32	32	0.00%	47	47	0.00%	0
Potassium (mg/L)	2	2	0.00%	1	1	0.00%	2	2	0.00%	<1	<1	0.00%	2	2	0.00%	2	1	66.67%	1
Sodium (mg/L)	<2	<2	0.00%	<2	<2	0.00%	3	3	0.00%	3	3	0.00%	2	2	0.00%	3	3	0.00%	0
F1 (mg/L)							<0.020									<0.020	<0.020	0.00%	0
F2 (mg/L)				<0.020	<0.020	0.00%	<0.020			<0.020	<0.020	0.00%	<0.020			<0.020	<0.020	0.00%	0
F3 (mg/L)				<0.050	<0.050	0.00%	<0.050			<0.050	<0.050	0.00%	<0.050			<0.050	<0.050	0.00%	0
F4 (mg/L)				<0.050	<0.050	0.00%	<0.050			<0.050	<0.050	0.00%	<0.050			<0.050	<0.050	0.00%	0

Notes:

1. F2, F3, F4 represent petroleum hydrocarbon fractions by increasing molecular weight.
2. Dup = Field Duplicate.
3. RPD = Relative Percent Difference.
4. Concentrations of parameters are reported in mg/L unless otherwise specified.
5. Red font represents RPDs of 40% or greater.

3.0 DISCUSSION

Water quality monitoring of the decommissioned Nanisivik Mine was completed in July, August and September, 2019 (*i.e.*, the required three rounds of sampling were completed within the prescribed sampling season). The results from 2019 indicated compliance with maximum authorized concentrations at Station 159-4, the final discharge point of the WTDA. Similarly, there were no exceedances of the site-specific Action Levels at Stations 159-6 and 159-6 Temp near the mouth of Twin Lakes Creek.

Sulphate concentrations greater than the site-specific Action Level were recorded at Station NML-23 (Twin Lakes Creek upstream of Station 159-4) in July and September, however, similar values were also recorded at Station ELO on those dates. This indicates that the sulphate originated in the watershed of East Twin Lake and was not related to the former Nanisivik Mine. It is possible that the warm summer of 2019 caused deeper than usual thawing of the surface permafrost, leading to a release of solutes that would normally remain trapped in the permafrost.

Sampling at Station 159-14 in the Chris Creek watershed found an exceedance of the site-specific Action Level for total suspended solids in July 2019 (not repeated in the August or September sampling) that may have been caused by erosion during the spring freshet. Exceedances of the site-specific Action Levels for total zinc and total sulphate in September, 2019, occurred only once, and similar to the observation at East Twin Lake, may have been caused by thawing of near-surface permafrost.

Sampling near the Landfill (Stations NML-29 and NML-30) showed flow at NML-30 in each month, but flow was only observed at NML-29 in July and September, 2019. A single low-level exceedance of the site-specific Action Level for total zinc (0.09 mg/L as compared to the action level of 0.03 mg/L) was observed at Station NML-30 in July, 2019. Concentrations of zinc at this station were <0.01 mg/L in both August and September. No further action is indicated with respect to the zinc exceedance at Station NML-30.

Several exceedances of site-specific Action Levels were detected at NML-29, located at the east end of the Landfill. These included total zinc in July and August; total sulphate in August and September, and TSS in August, 2019. There was no flow observed at NML-29 in August 2019, and the water sample was collected from pooled or standing water. Disturbance of sediment during sampling may explain the high TSS and slightly elevated zinc value in August, but does not explain the very high zinc value in July, or the high sulphate concentrations in August and September.

As outlined in the *Contingency Plan for Water Quality Exceedances* (Stantec, 2015), if the non-regulatory Action Level is exceeded for any key parameter at the same monitoring station on two consecutive occasions, an investigation will be initiated to determine the cause of the exceedance. The summer of 2019 was unusually warm at Nanisivik, and it is possible that the seasonal thawing of surface permafrost could have released water containing dissolved zinc and sulphate either from the Landfill, or from native materials located upgradient of or adjacent to NML-29. However, the Landfill was inspected in 2019, and no abnormal geotechnical conditions were observed. A personal communication with Scott Garrison of BGC Engineering indicated that (1) monitoring of thermistors and frost gauges shows that the Landfill contents remained frozen throughout 2019 and that cover performance was comparable to previous years despite the warmer air conditions at site; and (2) no water was observed seeping directly from the landfill cover during the inspection. Therefore, it is recommended that during

the monitoring event in August 2020, a hand-held conductivity meter should be used to explore water quality in flowing or standing water in the vicinity of NML-29, in an effort to determine whether water quality exceedances observed at NML-29 in 2019 may have originated from the Landfill, or from other nearby natural or man-made source(s).

4.0 CLOSING

This report has been prepared for the sole benefit of Canzinco Mines Ltd., a subsidiary of Nyrstar Sales & Marketing AG. The report may not be used by any other person or entity, other than for its intended purposes, without the consent of Nyrstar Sales & Marketing AG and Stantec Consulting Ltd.

The information and conclusions contained in this report are based upon work undertaken in accordance with generally accepted engineering and scientific practices current at the time the work was performed. The information provided in this report was compiled from existing documents, information provided by Canzinco Mines Ltd., data provided by analytical laboratories, and others. Information obtained from these sources has been assumed to be correct. Stantec Consulting Ltd. accepts no responsibility for damages or liability that may arise from use of this data.

The conclusions presented in this report represent the best technical judgment of Stantec based on the data obtained from the work. The conclusions are based on samples collected by field personnel contracted by Canzinco Mines Ltd. at the time the work was performed, at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. Samples were obtained by others and submitted directly to Eurofins for laboratory analysis. Due to the nature of the investigation and the limited data available, Stantec cannot warrant against undiscovered environmental liabilities.

If any conditions become apparent that deviate from our understanding of conditions as presented in this report, Stantec Consulting Ltd. requests to be notified immediately, and permitted to reassess the conclusions provided herein.

This report was prepared by Malcolm Stephenson, Ph.D. and Annick St-Amand, Ph.D., and was reviewed by Clayton Barclay, Ph.D., P.Eng., and Shereen Ismael, P.Eng. Should you have any questions or comments on the contents of this report, please contact the undersigned.

We trust that the above information fulfills your needs at this time. Should you require additional information, please do not hesitate to contact us.

Sincerely,

STANTEC CONSULTING LTD.

Digitally signed by Annick St-Amand
Date: 2020.03.11 10:28:06 -03'00'

Malcolm Stephenson
Digitally signed by Malcolm Stephenson
Date: 2020.03.11 11:58:24 -03'00'

Annick St-Amand, Ph.D.	Malcolm Stephenson, Ph.D.
Environmental Scientist, Organic Chemist	Senior Principal, Project Manager

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5.0 REFERENCES

Gartner Lee Limited. 2004. Nanisivik Mine Reclamation and Closure Monitoring Plan. February, 2004.

Nunavut Water Board. 2015. Water Licence No: 1AR-NAN1419. Approved by the Minister of Aboriginal Affairs and Northern Development Canada on January 29, 2015.

Stantec. 2015. Contingency Plan for Water Quality Exceedances, Former Nanisivik Mine Site. Prepared by Stantec Consulting Ltd. (Stantec) on behalf of Nyrstar, dated March 24, 2015.

Appendix A
DRAWINGS

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

SITE LOCATION

WATER QUALITY MONITORING

NANISIVIK MINE, NUNAVUT

Client: CANZINCO LTD. c/o NYRSTAR CANADA (HOLDINGS) LTD.

Job No.:	121622846
Scale:	1 : 250,000
Date:	19-FEB-2020
Dwn. By:	JL
App'd By:	MS

Dwg. No.: A-1

Stantec

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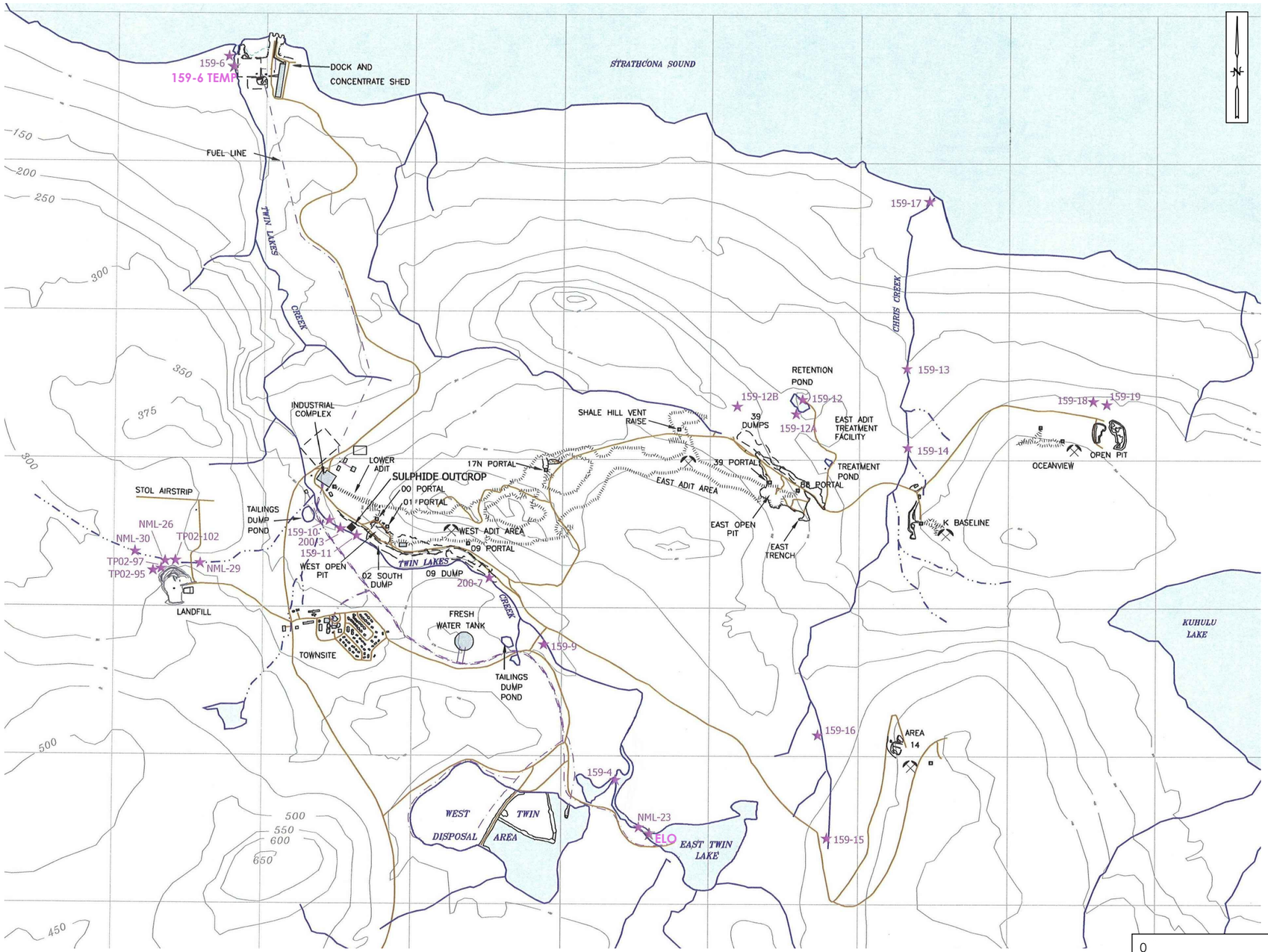

LEGEND:

- ROAD
- GROUND CONTOUR (50 m INTERVAL)
- SHORELINE, DRAINAGE, STREAMS
- INTERMITTENT DRAINAGE
- HIGH TIDE LINE – SURVEYED
- TOP OF BANK
- PIPELINE
- EXTENT OF UNDERGROUND WORKINGS
- MINING AREA
- ADIT, RAISE
- ★ NML-16 WATER SAMPLING LOCATION

WATER QUALITY MONITORING STATIONS 2014-2019

STATION	LATITUDE	LONGITUDE
ELO	73.022543 N	-84.470025 W
NML-23	73.022970 N	-84.472946 W
159-4	73.025644 N	-84.477130 W
NML-29	73.038523 N	-84.555158 W
NML-30	73.038580 N	-84.574106 W
159-6	73.069603 N	-84.557824 W
159-14	73.047278 N	-84.418062 W
159-6 TEMP	73.069141 N	-84.556367 W

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:
ORIGINAL FIGURES PROVIDED BY NANISIVIK MINE

WATER SAMPLING LOCATIONS - MINE AREA

WATER QUALITY MONITORING
NANISIVIK MINE, NUNAVUT

Client: CANZINCO LTD. c/o NYRSTAR CANADA (HOLDINGS) LTD.

Job No.:	121622846
Scale:	1 : 30,000
Date:	21-FEB-2020
Dwn. By:	JL
App'd By:	MS

Dwg. No.: A-2

Stantec

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Appendix B
2019 SUMMARY DATA TABLES

Table B1: Final Discharge Point (Station 159-4)

Parameter	Authorized Licence Limit (mg/L; unless otherwise specified)	Concentration (mg/L; unless otherwise specified)			
		05-Jul-19	05-Jul-19	11-Aug-19	04-Sep-19
		159-4	159-4DUP	159-4	159-4
Laboratory pH (units)	6 - 9.5	7.97	8.05	8.17	7.91
Field pH (units)	6 - 9.5	7.9	7.5	8.0	8.2
Laboratory Conductivity (mS)	N/A	0.365	0.368	1.04	1.11
Field Conductivity (mS)	N/A	---	---	1.027	1.06
Field Temperature (°C)	N/A	14	5.7	8.65	6
Total Suspended Solids	15	<2	<2	<2	2
Sulphate	1,471	153	161	466	530
Aluminum	N/A	<0.01	---	0.02	<0.01
Antimony	N/A	<0.0005	---	<0.0005	<0.0005
Arsenic	0.25	<0.001	---	<0.001	<0.001
Beryllium	N/A	<0.0005	---	<0.0005	<0.0005
Boron	N/A	0.23	---	0.54	0.66
Cadmium	0.005	<0.0001	<0.0001	0.0001	0.0001
Chromium	N/A	<0.001	---	<0.001	<0.001
Cobalt	N/A	<0.0002	---	<0.0002	<0.0002
Copper	0.1	<0.001	---	0.001	<0.001
Iron	N/A	<0.03	---	0.06	0.04
Lead	0.1	<0.001	<0.001	0.001	0.002
Manganese	N/A	<0.01	---	<0.01	<0.01
Molybdenum	N/A	<0.005	---	0.006	0.007
Nickel	0.5	<0.005	---	<0.005	<0.005
Selenium	N/A	<0.001	---	<0.001	<0.001
Silicon	N/A	0.2	---	0.5	0.6
Silver	N/A	<0.0001	---	<0.0001	<0.0001
Strontium	N/A	0.224	---	0.587	0.681
Thallium	N/A	<0.0001	---	<0.0001	<0.0001
Titanium	N/A	<0.01	---	<0.01	<0.01
Uranium	N/A	<0.001	---	0.002	0.002
Vanadium	N/A	<0.001	---	<0.001	<0.001
Zinc	0.25	0.02	0.03	0.04	0.06
Alkalinity (as $CaCO_3$)	N/A	44	43	85	85
Chloride	N/A	3	3	13	9
Ammonia (as N)	N/A	<0.010	<0.010	0.01	0.01
Nitrate + Nitrite (as NO_2+NO_3)	N/A	<0.10	<0.10	<0.10	0.14
Hardness (as $CaCO_3$)	N/A	198	202	579	665
Bicarbonate (as $CaCO_3$)	N/A	44	43	85	85
Calcium	N/A	43	43	123	141
Magnesium	N/A	22	23	66	76
Potassium	N/A	2	2	6	7
Sodium	N/A	<2	<2	4	4
F2 ($C_{>10}$-C_{16})	N/A	---	---	---	---
F3 ($C_{>16}$-C_{34})	N/A	---	---	---	---
F4 ($C_{>34}$-C_{50})	N/A	---	---	---	---

Notes:

Authorized Licence Limit – Monthly Measurement (most conservative)

A station specific action level of 1,471 mg/L is also available for sulphate based on 95th percentile calculated from Station specific historical data.

--- = Analysis not required NR = Not Reported

N/A = Not applicable, Authorized Licence Limit not defined.

Bold = Value exceeds Authorized Licence Limit, as listed within the Water Licence requirements.

Table B2-1: Twin Lakes Creek Water Quality Data (Stations 159-6 and 159-6 Temp)

Parameter	Action Level (mg/L; unless otherwise specified)	Concentration (mg/L; unless otherwise specified)				
		04-Jul-19	04-Jul-19	10-Aug-19	10-Aug-19	10-Aug-19
		159-6	159-6 Temp	159-6	DUP Stn 159-6	159-6 Temp
Laboratory pH (units)	6 - 9.5	8.11	7.89	8.04	7.98	7.99
Field pH (units)	6 - 9.5	8.1	8.1	7.9	7.8	7.8
Laboratory Conductivity (mS)	N/A	0.100	0.096	0.328	0.328	0.328
Field Conductivity (mS)	N/A	---	---	0.328	0.329	0.329
Field Temperature (°C)	N/A	10.0	10.0	11.6	11.6	11.9
Total Suspended Solids	53	2	<2	<2	<2	<2
Sulphate	463	24	24	102	103	104
Aluminum	N/A	0.08	0.08	0.02	---	0.02
Antimony	N/A	<0.0005	<0.0005	<0.0005	---	<0.0005
Arsenic	N/A	<0.001	<0.001	<0.001	---	<0.001
Beryllium	N/A	<0.0005	<0.0005	<0.0005	---	<0.0005
Boron	N/A	0.04	0.03	0.08	---	0.09
Cadmium	0.014	0.0001	0.0001	0.0005	0.0005	0.0005
Chromium	N/A	<0.001	<0.001	<0.001	---	<0.001
Cobalt	N/A	<0.0002	<0.0002	0.0003	---	0.0004
Copper	N/A	<0.001	<0.001	<0.001	---	<0.001
Iron	N/A	0.08	0.09	0.03	---	<0.03
Lead	0.044	0.002	0.002	<0.001	<0.001	<0.001
Manganese	N/A	<0.01	<0.01	<0.01	---	<0.01
Molybdenum	N/A	<0.005	<0.005	<0.005	---	<0.005
Nickel	N/A	<0.005	<0.005	<0.005	---	<0.005
Selenium	N/A	<0.001	<0.001	<0.001	---	<0.001
Silicon	N/A	0.4	0.5	0.6	---	0.6
Silver	N/A	<0.0001	<0.0001	<0.0001	---	<0.0001
Strontium	N/A	0.034	0.034	0.101	---	0.1
Thallium	N/A	<0.0001	<0.0001	<0.0001	---	<0.0001
Titanium	N/A	<0.01	<0.01	<0.01	---	<0.01
Uranium	N/A	<0.001	<0.001	<0.001	---	<0.001
Vanadium	N/A	<0.001	<0.001	<0.001	---	<0.001
Zinc	4.6	0.04	0.04	0.15	0.17	0.17
Alkalinity (as $CaCO_3$)	N/A	31	28	46	45	45
Chloride	N/A	1	1	6	6	6
Ammonia (as N)	N/A	<0.010	<0.010	<0.010	<0.010	0.02
Nitrate + Nitrite (as NO_2+NO_3)	N/A	<0.10	<0.10	0.29	0.29	0.29
Hardness (as $CaCO_3$)	N/A	50	50	160	160	160
Bicarbonate (as $CaCO_3$)	N/A	31	28	46	45	45
Calcium	N/A	10	10	31	31	31
Magnesium	N/A	6	6	20	20	20
Potassium	N/A	<1	<1	1	1	1
Sodium	N/A	<2	<2	<2	<2	<2
F2 ($C_{>10}$-C_{16})	N/A	<0.020	<0.020	<0.020	<0.020	<0.020
F3 ($C_{>16}$-C_{34})	N/A	<0.050	<0.050	<0.050	<0.050	<0.050
F4 ($C_{>34}$-C_{50})	N/A	<0.050	<0.050	<0.050	<0.050	<0.050

Notes:

Station specific action levels based on 95th percentile calculated from Station specific historical data.

--- = Analysis not required

N/A = Not applicable, station specific action level not defined.

Bold = Value exceeds Action Level.

Table B2-1: Twin Lakes Creek Water Quality Data (Stations 159-6 and 159-6 Temp)

Parameter	Action Level (mg/L; unless otherwise specified)	Concentration (mg/L; unless otherwise specified)		
		04-Sep-19	04-Sep-19	04-Sep-19
		159-6	DUP Stn 159-6	159-6 Temp
Laboratory pH (units)	6 - 9.5	7.64	7.61	7.64
Field pH (units)	6 - 9.5	---	---	---
Laboratory Conductivity (mS)	N/A	0.601	0.601	0.595
Field Conductivity (mS)	N/A	0.550	0.550	0.550
Field Temperature (°C)	N/A	4.6	4.6	4.8
Total Suspended Solids	53	11	<2	<2
Sulphate	463	246	245	242
Aluminum	N/A	0.02	---	0.02
Antimony	N/A	<0.0005	---	<0.0005
Arsenic	N/A	<0.001	---	<0.001
Beryllium	N/A	<0.0005	---	<0.0005
Boron	N/A	0.13	---	0.13
Cadmium	0.014	0.0011	0.0011	0.001
Chromium	N/A	<0.001	---	<0.001
Cobalt	N/A	0.0016	---	0.0015
Copper	N/A	0.002	---	<0.001
Iron	N/A	0.09	---	0.08
Lead	0.044	<0.001	<0.001	<0.001
Manganese	N/A	0.02	---	0.02
Molybdenum	N/A	<0.005	---	<0.005
Nickel	N/A	<0.005	---	<0.005
Selenium	N/A	<0.001	---	<0.001
Silicon	N/A	0.8	---	0.8
Silver	N/A	<0.0001	---	<0.0001
Strontium	N/A	0.195	---	0.191
Thallium	N/A	<0.0001	---	<0.0001
Titanium	N/A	<0.01	---	<0.01
Uranium	N/A	0.001	---	<0.001
Vanadium	N/A	<0.001	---	<0.001
Zinc	4.6	0.78	0.79	0.72
Alkalinity (as $CaCO_3$)	N/A	49	48	49
Chloride	N/A	8	5	8
Ammonia (as N)	N/A	<0.010	<0.010	<0.010
Nitrate + Nitrite (as NO_2+NO_3)	N/A	0.5	0.5	0.48
Hardness (as $CaCO_3$)	N/A	329	320	325
Bicarbonate (as $CaCO_3$)	N/A	49	48	49
Calcium	N/A	61	59	61
Magnesium	N/A	43	42	42
Potassium	N/A	2	2	2
Sodium	N/A	3	3	3
F2 ($C_{>10}$-C_{16})	N/A	<0.020	---	<0.020
F3 ($C_{>16}$-C_{34})	N/A	<0.050	---	<0.050
F4 ($C_{>34}$-C_{50})	N/A	<0.050	---	<0.050

Notes:

Station specific action levels based on 95th percentile calculated from Station specific historical data.

--- = Analysis not required

N/A = Not applicable, station specific action level not defined.

Bold = Value exceeds Action Level.

Table B2-2: Twin Lakes Creek Water Quality Data (Stations NML-23 and ELO)

Parameter	Action Level (mg/L; unless otherwise specified)	Concentration (mg/L; unless otherwise specified)					
		05-Jul-19	05-Jul-19	11-Aug-19	11-Aug-19	04-Sep-19	04-Sep-19
		NML-23	ELO	NML-23	ELO	NML-23	ELO
Laboratory pH (units)	6 - 9.5	8.06	7.90	7.40	7.81	7.09	7.33
Field pH (units)	6 - 9.5	7.9	7.5	7.3	7.8	---	---
Laboratory Conductivity (mS)	N/A	0.355	0.370	0.070	0.076	0.121	0.126
Field Conductivity (mS)	N/A	---	---	0.112	0.069	0.080	0.080
Field Temperature (°C)	N/A	14.4	5.7	12.5	11.9	5.4	5.0
Total Suspended Solids	10	<2	<2	<2	<2	<2	<2
Sulphate	25	**152**	**163**	18	17	**38**	**37**
Arsenic	N/A	---	---	---	---	---	---
Cadmium	0.0044	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	N/A	---	---	---	---	---	---
Lead	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	N/A	---	---	---	---	---	---
Zinc	0.12	0.02	0.03	<0.01	<0.01	<0.01	<0.01
Alkalinity (as $CaCO_3$)	N/A	45	42	12	15	9	14
Chloride	N/A	3	3	5	5	2	5
Ammonia (as N)	N/A	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrate + Nitrite (as NO_2+NO_3)	N/A	<0.10	<0.10	0.11	0.11	0.2	0.2
Hardness (as $CaCO_3$)	N/A	198	202	31	31	54	54
Bicarbonate (as $CaCO_3$)	N/A	45	42	12	15	9	14
Calcium	N/A	43	43	6	6	10	10
Magnesium	N/A	22	23	4	4	7	7
Potassium	N/A	2	2	<1	<1	<1	<1
Sodium	N/A	<2	<2	<2	<2	<2	<2
F2 ($C_{>10}$-C_{16})	N/A	---	---	---	---	---	---
F3 ($C_{>16}$-C_{34})	N/A	---	---	---	---	---	---
F4 ($C_{>34}$-C_{50})	N/A	---	---	---	---	---	---

Notes:

Station specific action levels based on 95th percentile calculated from Station specific historical data.

--- = Analysis not required

N/A = Not applicable, station specific action level not defined.

Bold = Value exceeds Action Level.

Table B3: Chris Creek Water Quality Data (Station 159-14)

Parameter	Action Level (mg/L; unless otherwise specified)	Concentration (mg/L; unless otherwise specified)		
		05-Jul-19	10-Aug-19	04-Sep-19
		159-14	159-14	159-14
Laboratory pH (units)	6 - 9.5	8.18	8.29	8.04
Field pH (units)	6 - 9.5	8.8	8.2	---
Laboratory Conductivity (mS)	N/A	0.215	0.753	1.360
Field Conductivity (mS)	N/A	---	0.746	1.300
Field Temperature (°C)	N/A	11.0	11.9	7.6
Total Suspended Solids	32	**41**	<2	6
Sulphate	408	50	284	**742**
Arsenic	N/A	---	---	---
Cadmium	0.0005	0.0002	<0.0001	0.0002
Copper	N/A	---	---	---
Lead	0.0022	0.001	<0.001	<0.001
Nickel	N/A	---	---	---
Zinc	0.13	0.08	0.08	**0.25**
Alkalinity (as $CaCO_3$)	N/A	74	113	107
Chloride	N/A	1	7	7
Ammonia (as N)	N/A	<0.010	0.01	<0.010
Nitrate + Nitrite (as NO_2+NO_3)	N/A	<0.10	0.19	0.3
Hardness (as $CaCO_3$)	N/A	119	419	876
Bicarbonate (as $CaCO_3$)	N/A	74	113	107
Calcium	N/A	23	72	148
Magnesium	N/A	15	58	123
Potassium	N/A	<1	1	2
Sodium	N/A	<2	2	4
F2 ($C_{>10}$-C_{16})	N/A	---	---	---
F3 ($C_{>16}$-C_{34})	N/A	---	---	---
F4 ($C_{>34}$-C_{50})	N/A	---	---	---

Notes:

Station specific action levels based on 95th percentile calculated from Station specific historical data.

--- = Analysis not required

N/A = Not applicable, station specific action level not defined.

Bold = Value exceeds Action Level.

Table B4: Landfill Water Quality Data (Stations NML-29 and NML-30)

Parameter	Action Level (mg/L; unless otherwise specified)	Concentration (mg/L; unless otherwise specified)								
		05-Jul-19	05-Jul-19	05-Jul-19	12-Aug-19	12-Aug-19	12-Aug-19	04-Sep-19	04-Sep-19	04-Sep-19
		NML-29	NML-30	NML-30-DUP	NML-29	NML-30	NML-30 DUP	NML-29	NML-30	NML-30-DUP
Laboratory pH (units)	6 - 9.5	8.35	8.30	8.41	8.29	8.40	8.41	8.13	8.16	8.13
Field pH (units)	6 - 9.5	8.2	8.5	8.5	8.1	8.3	8.3	---	---	---
Laboratory Conductivity (mS)	N/A	0.400	0.261	0.260	1.070	0.516	0.518	0.896	0.698	0.699
Field Conductivity (mS)	N/A	---	---	---	1.064	0.519	0.519	0.890	0.660	0.660
Field Temperature (°C)	N/A	6.4	9.3	9.3	11.4	10.5	10.5	6.8	4.9	4.9
Total Suspended Solids	22	<2	<2	6	**37**	4	<2	2	<2	<2
Sulphate	240	128	55	55	**467**	108	108	**347**	234	233
Arsenic	N/A	---	---	---	---	---	---	---	---	---
Cadmium	0.00025	**0.0008**	0.0002	0.0002	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	N/A	---	---	---	---	---	---	---	---	---
Lead	0.005	0.002	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	N/A	---	---	---	---	---	---	---	---	---
Zinc	0.03	**0.96**	**0.09**	**0.1**	**0.04**	<0.01	<0.01	0.01	<0.01	<0.01
Alkalinity (as $CaCO_3$)	N/A	104	98	108	124	159	164	140	137	131
Chloride	N/A	5	3	3	6	7	8	4	4	8
Ammonia (as N)	N/A	<0.010	<0.010	<0.010	<0.010	0.03	0.01	<0.010	<0.010	<0.010
Nitrate + Nitrite (as NO_2+NO_3)	N/A	<0.10	0.26	0.27	0.4	0.23	0.23	0.26	0.47	0.47
Hardness (as $CaCO_3$)	N/A	229	142	142	615	279	279	536	398	401
Bicarbonate (as $CaCO_3$)	N/A	102	96	105	124	155	160	140	137	131
Calcium	N/A	52	32	32	111	59	59	104	82	83
Magnesium	N/A	24	15	15	82	32	32	67	47	47
Potassium	N/A	1	<1	<1	4	2	2	2	2	1
Sodium	N/A	<2	3	3	3	2	2	3	3	3
F2 ($C_{>10}$-C_{16})	N/A	<0.020	<0.020	<0.020	<0.020	<0.020	---	<0.020	<0.020	<0.020
F3 ($C_{>16}$-C_{34})	N/A	<0.050	<0.050	<0.050	<0.050	<0.050	---	<0.050	<0.050	<0.050
F4 ($C_{>34}$-C_{50})	N/A	<0.050	<0.050	<0.050	<0.050	<0.050	---	<0.050	<0.050	<0.050

Notes:

Station specific action levels based on 95th percentile calculated from Station specific historical data.

--- = Analysis not required

N/A = Not applicable, station specific action level not defined.

Bold = Value exceeds Action Level.

Appendix C
TEMPORAL TREND FIGURES

Figure C1: Temporal trends at Station 159-4

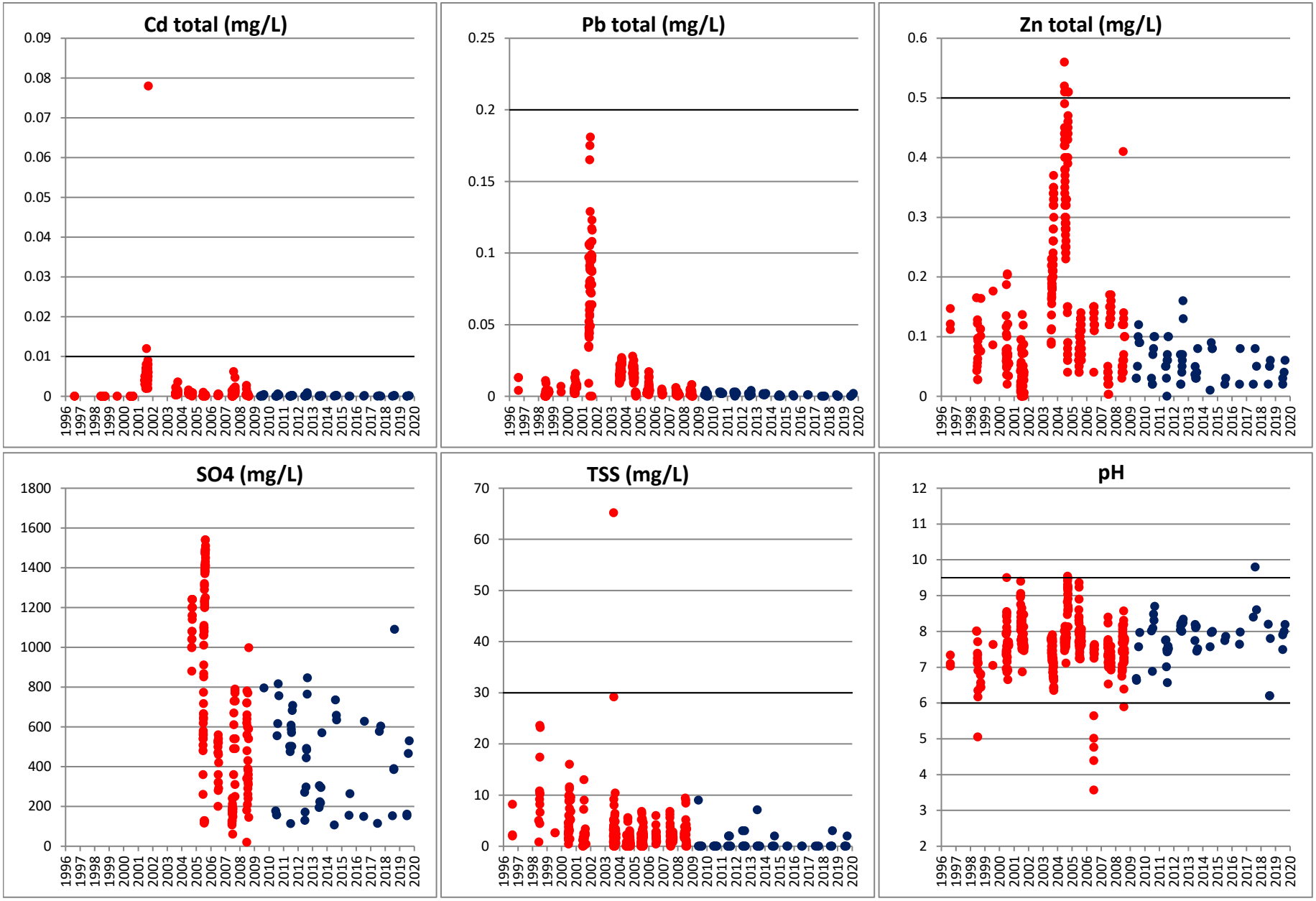


Figure C2: Temporal trends at Station 159-6

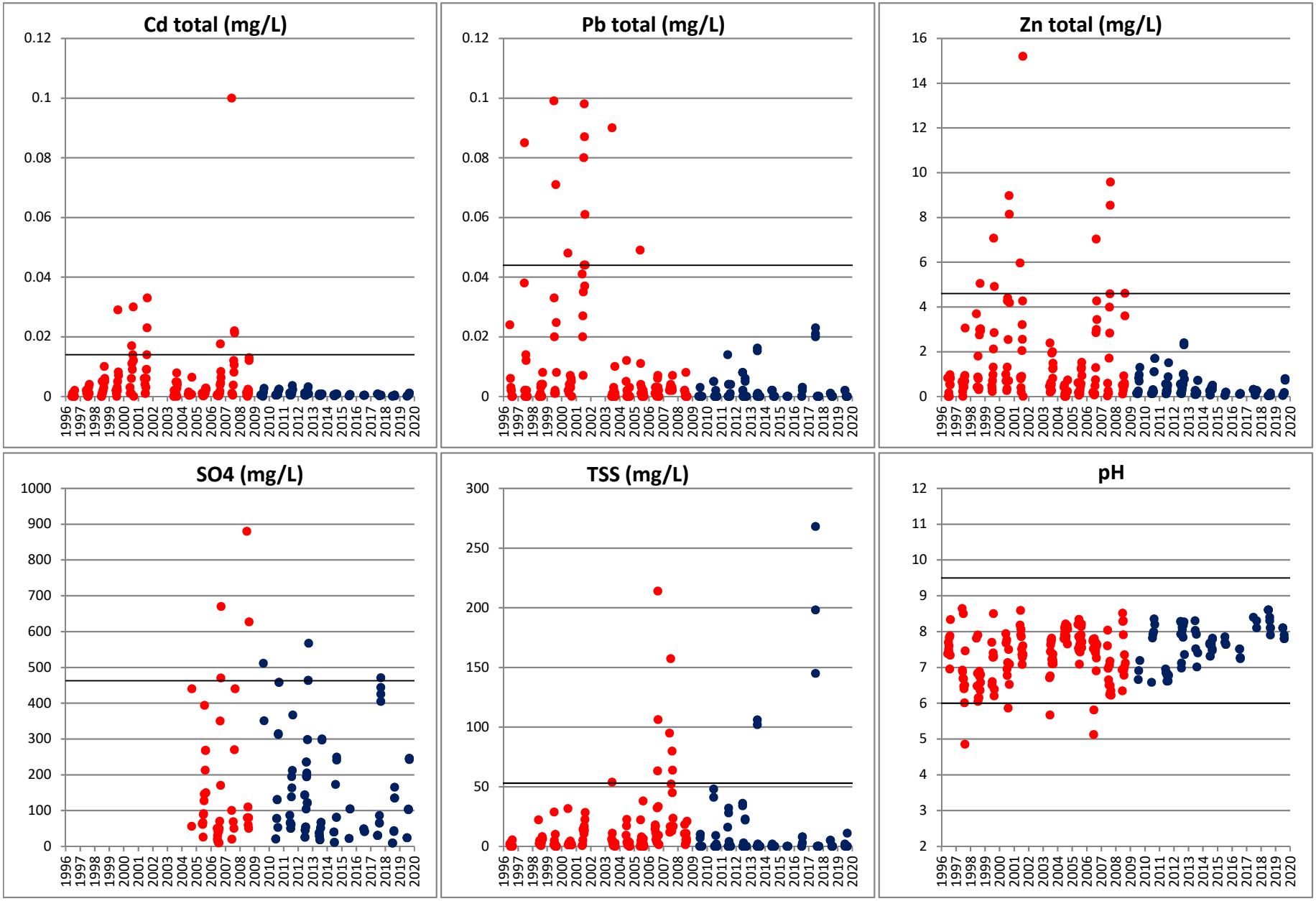


Figure C3: Temporal trends at Station NML-23

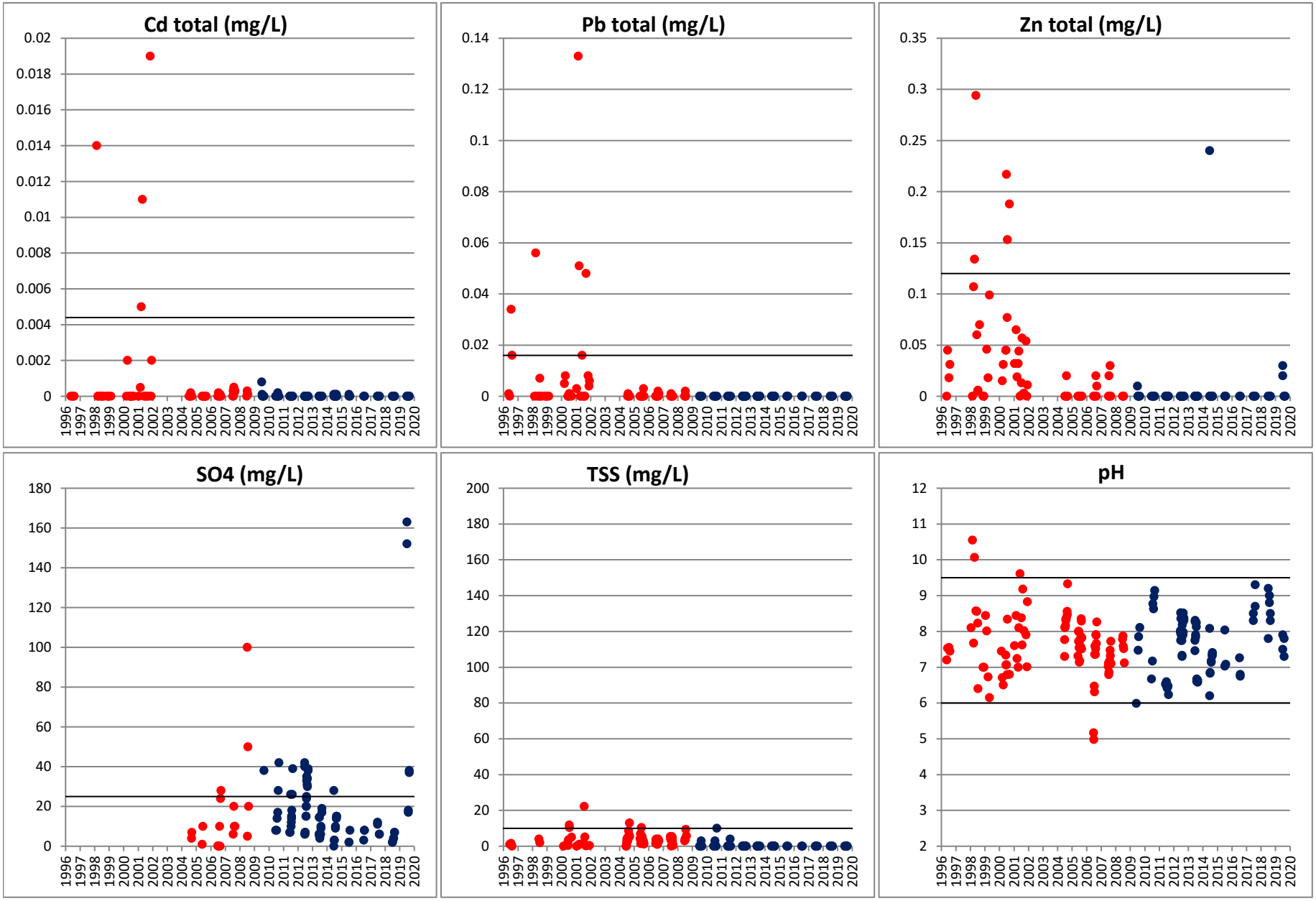


Figure C4: Temporal trends at Station 159-14

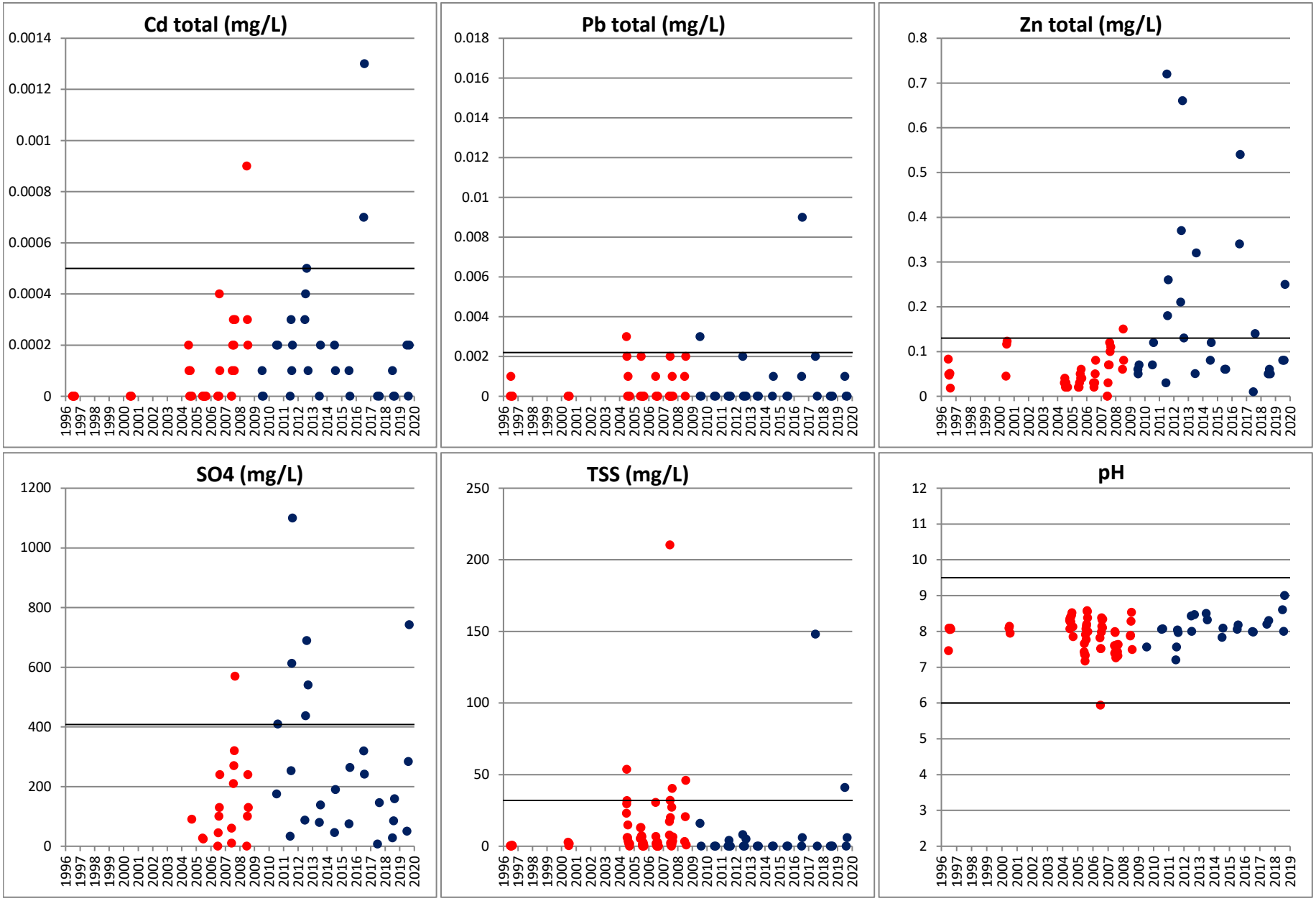
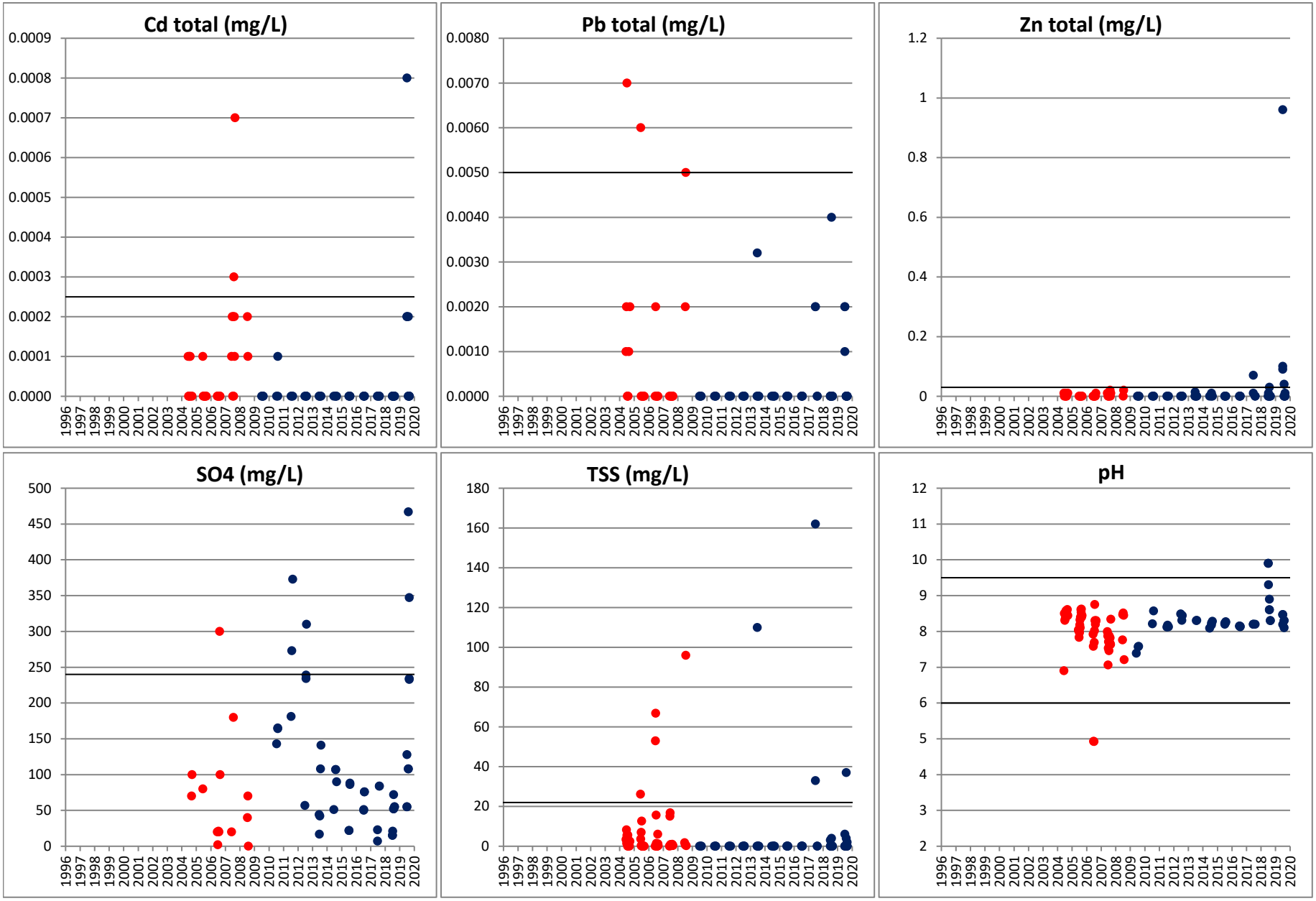


Figure C5: Temporal trends at Station NML-30



Appendix D
2020 FIELD PLAN

Nanisivik Mine

Water Quality Monitoring Program 2020

To the User,

The following pages include simplified field forms for the 2020 water sampling program.

The regulatory requirements for the 2020 sampling program are significantly reduced from previous years. Sampling will take place under a new Water Licence (No. 1AR-NAN2030) issued by the Nunavut Water Board.

- There will be only one monitoring event during the calendar year 2020. The week of August 10 - 14 is recommended. This timing avoids potentially anomalous water quality conditions that could be caused by sampling during spring freshet (late June or early July), or problems with freezing conditions that can begin in early September. In addition, mid-August allows for the measurement of the maximum active layer thaw depth, which is important for the assessment of the performance of thermal covers on historical mine tailings, etc.

- There are 3 prescribed sampling stations within Twin Lakes Creek. These are NML-23 (Outflow from East Twin Lake), 159-4 (Outflow from West Twin Disposal Area), and 159-6 (Outlet of Twin Lakes Creek into Strathcona Sound).
- There is one sampling station in Chris Creek Watershed (159-14, Chris Creek downstream of K-Baseline).
- There are two sampling stations in the Landfill Watershed (NML-29, downstream of Landfill, east drainage system; and NML-30, downstream of Landfill, west drainage system).
- Although not required under the Water Licence it is recommended that water quality monitoring be continued at voluntary station ELO (the true outlet of East Twin Lake). Several water quality anomalies of natural origin have been detected in the past, originating within the watershed of East Twin Lake where no historical mine activity took place. Station ELO provides information related to natural variations of water quality in the undisturbed headwater area of Twin Lakes Creek.

- The Water License requires measurement of field parameters, and one or two laboratory analytical test groups as follow:

    - Field parameters include measurement of specific conductivity, temperature, pH, and visual observations for hydrocarbon sheen if present.
    - NAN-1 includes certain trace metals (total cadmium, total lead, total zinc), major cations (calcium magnesium, sodium, potassium, hardness), major anions (chloride, sulphate, bicarbonate, carbonate, nitrate+nitrite, alkalinity), ammonia, and total suspended solids. In addition, it is strongly recommended that laboratory measurements of pH, and specific conductivity be requested.
    - NAN-2 includes petroleum hydrocarbon analysis of F2 - F4 hydrocarbons.

A couple of important sampling notes:

- Pre-sampling coordination with the analytical laboratory (Eurofins Environment Testing Canada in Ottawa) is strongly recommended, as they will provide a cooler containing all required sampling bottles, as well as distilled water for use as a field blank sample. Sample submission sheets, and chain of custody documents should also be obtained from Eurofins.
- It is very important that photographs of the completed field forms and FIRST AIR shipping information are e-mailed to Johan Skoglund (Nyrstar), and to the analytical laboratory in a timely manner. This greatly helps with shipment tracking and lets both Johan and the laboratory know that the shipment is on its way.
- Before going to the field ensure that field meters used for pH, conductivity, and temperature measurement are working properly, have fresh battery, and have been calibrated. Calibration solutions should also be taken to the field, for daily calibration/validation, as required.

Analytical Information

It is expected that the performing analytical laboratory will be the Eurofins Lab in Ottawa, Ontario. The key contact is:

Rebecca Koshy, Client Services Supervisor/Project Manager
Eurofins Environment Testing Canada
8-146 Colonnade Road
Ottawa, Ontario
K2E 7Y1
Phone: 1-613-727-5692 ext. 310
Email: rebeccakoshy@eurofins.com

Analytical Test Groups

Analytical test groups **NAN-1** and **NAN-2** have changed slightly from previous years. The Analytical Test Groups as required by the Water Licence are the following:

Group	Parameters
Field Parameters	• Specific conductivity, temperature, pH, visual observations for hydrocarbon sheen.
NAN-1	• Total cadmium, lead, zinc • Calcium, magnesium, sodium, potassium, ammonia, hardness • Chloride, sulphate, bicarbonate, carbonate, nitrate+nitrite, alkalinity • Total suspended solids • Specific conductivity and pH (recommended although not required by the Water Licence)
NAN-2	• Canada Wide Standards petroleum hydrocarbon fractions F2, F3 and F4.

Water Quality Monitoring Station Locations

Station	Latitude	Longitude
ELO	73.022543 N	-84.470025 W
NML-23	73.022970 N	-84.472946 W
159-4	73.025644 N	-84.477130 W
159-6	73.069603 N	-84.557824 W
159-14	73.047278 N	-84.418062 W
NML-29	73.038523 N	-84.555158 W
NML-30	73.038580 N	-84.574106 W

Proposed Sampling Week: August 10-14, 2020 **Sampler's Name/Signature**

Sample Date: _____ **Calibration Date:** _____ pH meter ☐ Conductivity meter: ☐

First Air Tracking No: _____ **Date Shipped:** _____

Sampling Station ID/Description	Date & Time Sample Collected	Temperature °C	pH	Specific Conductivity	Analytical Test Groups Required	**Comments:** *Is there any unusual activity at the site? Is there flow at the Station? Visible hydrocarbon sheen? Weather? Take photos.*
Twin Lakes Creek Watershed						
Station: NML-23 Outflow from East Twin Lake					**Field Parameters, NAN-1**	
Station: ELO True Outflow from East Twin Lake					**Field Parameters, NAN-1**	
Station: 159-4 Outflow from West Twin Disposal Area					**Field Parameters, NAN-1**	
Station: 159-6 Outlet of Twin Lakes Creek at Strathcona Sound					**Field Parameters, NAN-1, NAN-2**	
Station: FIELD-DUP 159-6 Field Duplicate					**Field Parameters, NAN-1, NAN-2**	
Chris Creek Watershed						
Station: 159-14 Outflow from East Twin Lake					**Field Parameters, NAN-1**	
Landfill						
Station: NML-29 East side of Landfill					**Field Parameters, NAN-1, NAN-2**	
Station: NML-30 West side of Landfill					**Field Parameters, NAN-1, NAN-2**	
Quality Control						
Station: _____ Field Blank		Not applicable	Not applicable	Not applicable	**NAN-1, NAN-2**	

A hand-held conductivity meter should be used to explore water quality in flowing or standing water in the vicinity of NML-29, in an effort to determine whether water quality exceedances observed at NML-29 in 2019 may have originated from the Landfill, or from other nearby natural or man-made source(s). Search for areas where water with high specific conductivity (>1,000 µS) may originate upgradient of NML-29, and record data along with GPS coordinates.