Mary River Project 2018 - 2019
Lake Sedimentation Monitoring

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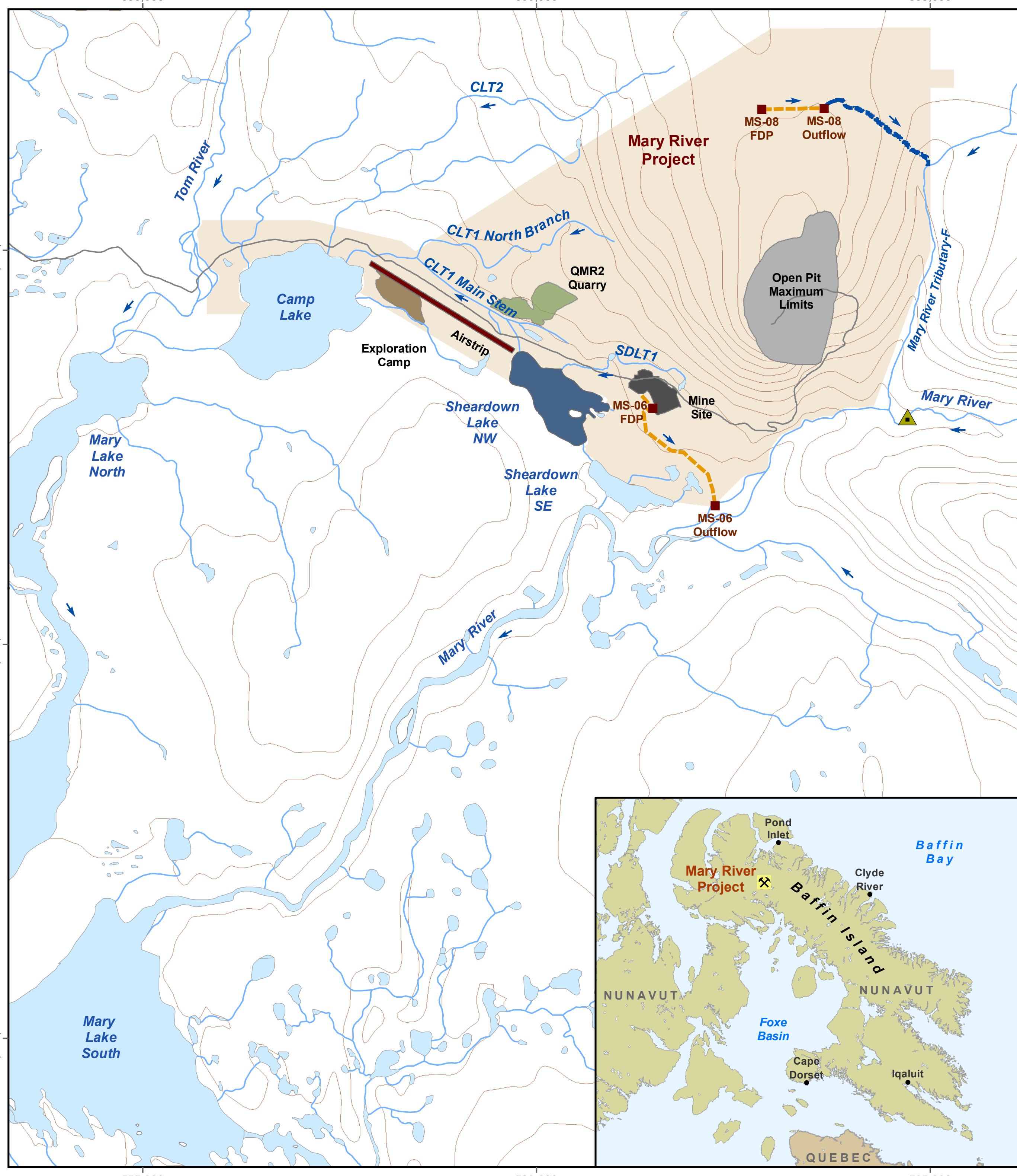
1 INTRODUCTION

The Mary River Project (the Project), owned and operated by Baffinland Iron Mines Corporation (Baffinland), is a high-grade iron ore mining operation located in the Qikiqtani Region of northern Baffin Island, Nunavut (Figure 1.1). Commercial mine operation, including open pit mining, ore haulage and stockpiling, and the crushing and screening of high-grade iron ore, commenced at the Project in mid-September 2014. The Project has the potential to result in increased sedimentation in mine area waterbodies from fugitive dust deposition and surface runoff/erosion from the mine site, as well as from increased biological productivity (e.g., eutrophication due to treated sewage discharge). In aquatic environments, these deposits may lead to physical habitat alteration (e.g., changes in substrate composition) and/or chemical alteration (e.g., changes in metal, nutrient, and/or organic content concentrations) that, in turn, could alter biotic assemblages and lead to adverse ecological effects (e.g., physical smothering of organisms residing in existing substrate, direct response of organisms to changes in substrate chemistry).

To better understand rates of sediment deposition associated with the Project and the potential implications of this sediment deposition on aquatic biota, Lake Sedimentation Monitoring was included as a special investigation component of the mine Aquatic Effects Monitoring Plan (AEMP; Baffinland 2015; NSC 2014a). The primary issue of concern regarding greater sedimentation in lakes related to the Project is the potential effects to arctic charr (*Salvelinus alpinus*) populations, which can possibly be affected by:

- Changes in benthic invertebrate community structure and/or density due to habitat alteration that, in turn, alter the arctic charr food base;
- Loss of arctic charr spawning habitat resulting from accumulation of fine material on, and/or greater embeddedness of, substrate used by arctic charr for spawning; and,
- Accumulation of fine material on substrate used by arctic charr for spawning that, in turn, could limit the amount of oxygen available in arctic charr spawning beds during the overwinter incubation period resulting in reduced egg hatching success and/or reduced larvae survival following hatch (Berry et al. 2003).

The Lake Sedimentation Monitoring study is a year-round sampling program that was designed to track sedimentation rate (i.e., total dry weight of deposited sediment) at Sheardown Lake NW separately over ice-cover and open-water periods (Baffinland 2015; NSC 2014a,b, 2015; Minnow 2016, 2017, 2018, 2019). Sheardown Lake NW is expected to receive the highest amounts of sediment inputs through dust deposits and site runoff compared to other waterbodies near the Project, and therefore this lake has served as the focus for the monitoring of lake sedimentation (Figure 1.1; NSC 2014b). Sedimentation monitoring was initiated at Sheardown Lake NW in



LEGEND

- Final Discharge Point (FDP)
- Mary River Cascade Barrier
- Discharge Line
- Overland Effluent Channel
- Sheardown Lake NW
- QMR2 Quarry
- Airstrip
- Exploration Camp
- Mine Site
- Mary River Project
- Open Pit Maximum Limits

Mary River Project Sheardown Lake NW Sedimentation Monitoring Location

0 1.25 2.5 5 km

Map Projection: UTM Zone 17N NAD 1983

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Project 197202.0032

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Figure 1.1

Document Path: S:\Projects\197202\197202.0032 - Baffinland 2019 CREMP and EEM SD\4 - GIS\Lake Sedimentation Report\19-32 Fig 1.1 Location.mxd

2013, with data collected from fall 2013 to fall 2014 serving as baseline for one full ice-cover period and one full open-water period. These baseline data, in turn, were intended to be used as a basis for the annual evaluation of potential effects of Project operations on lake sedimentation (Minnow 2016, 2017, 2018, 2019). This report presents the results of the 2018-2019 Lake Sedimentation Monitoring study, including the evaluation of potential Project-related influences on sedimentation at Sheardown Lake NW in the fifth year following the onset of commercial mine operation in 2015.

2 METHODS

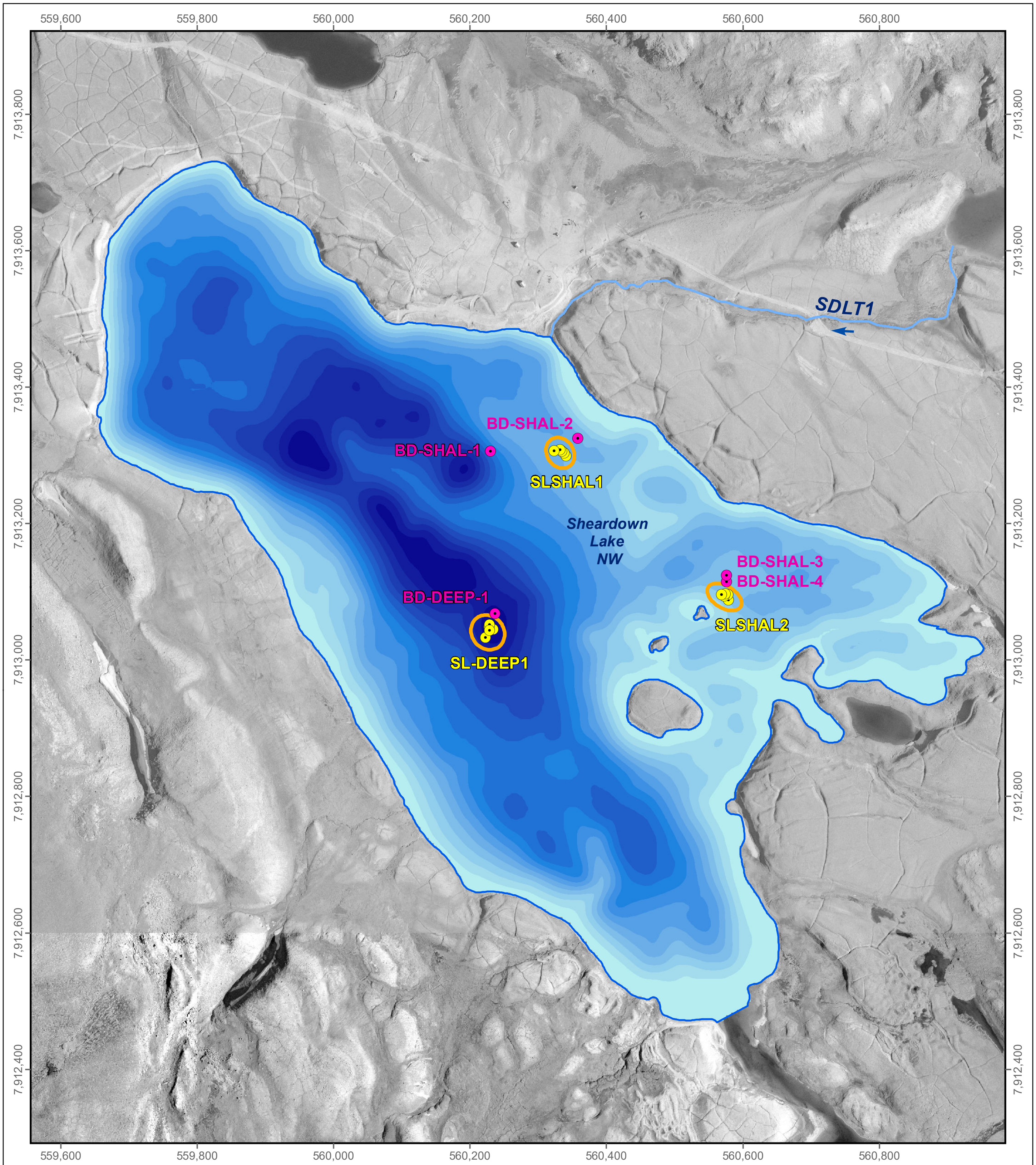
2.1 Overview

Sheardown Lake NW sedimentation studies have been used to estimate sedimentation rate and sediment accumulation over ice-cover and open-water periods in association with the Project (Baffinland 2015; NSC 2014a,b, 2015; Minnow 2016, 2017, 2018, 2019). The monitoring of sedimentation rate ($mg/cm^{-2} \cdot day^{-1}$) has been conducted using consistent monitoring station locations, sampling equipment, and approach since 2013 (Minnow 2019). Under the original study design, the methods specified did not provide sufficient sample volume to derive reliable estimates of sediment accumulation (i.e., deposit thickness) at Sheardown Lake NW. *In lieu* of sufficient sample volumes to determine sedimentation accumulation, dry bulk density (DBD) data from similar sedimentation studies conducted at Canadian Shield lakes in northern Ontario (Minnow Environmental Inc. unpublished data) or from a tributary to Sheardown Lake (referred to as SDLT1) were used to estimate the amount of sediment accumulation at Sheardown Lake NW in studies conducted prior to 2018 (Minnow 2016, 2017, 2018). Beginning with the 2017-2018 study, the Sheardown Lake NW sedimentation study design was modified to include methods for direct collection of DBD information from deposited sediment as the basis for allowing improved estimates of sediment accumulation. The methodology provided below reflects the updated study design for station locations, field and laboratory methods to evaluate sedimentation rate and sediment accumulation, and data analysis.

2.2 Station Locations

Sedimentation was monitored at the same three stations established at Sheardown Lake NW in the initial study design for the 2018-2019 study (Figure 2.1; Table 2.1). The initial selection of station locations in 2013 accounted for dominant benthic habitat types present in the lake as well as habitat considered important for supporting the resident arctic charr population. These considerations resulted in the establishment of Shallow Depositional, Shallow Hard-Bottom, and Deep Profundal stations for Sheardown Lake NW sedimentation monitoring based on the following rationale:

1. Shallow Depositional Station (SHAL1): Silt-loam represents the dominant substrate type in Sheardown Lake NW, and therefore increased sedimentation on habitat characterized by this substrate has the greatest potential to affect overall lake benthic invertebrate density and/or community structure. In turn, benthic invertebrate community changes in habitat of this type has a high potential to affect the arctic charr population of Sheardown Lake. Silt substrate in the lake littoral zone was targeted for placement of this station to represent a potentially high sediment deposition habitat. Because this station is located



LEGEND

- Dry Bulk Density Replicate Site
- Sedimentation Rate Replicate Site
- Sedimentation Monitoring Station

Bathymetry (m)

0- 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
18 - 20
20 - 22
22 - 24
24 - 26
26 - 28
28 - 30

Sheardown Lake NW Lake Sedimentation Monitoring Locations, 2018-2019

0 125 250 500 Meters

N E S W

Map Projection: UTM Zone 17N NAD 1983
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Figure 2.1

Table 2.1: Sedimentation Rate and Dry Bulk Density Trap Replicate Station Coordinates, Habitat Information, and Deployment and Retrieval Information, Sheardown Lake NW Sedimentation Monitoring Study, 2018 - 2019

Station	Station Replicate	Location (UTM; Zone 17W)		Station Depth (m)	Substrate	Ice - Cover Period (2018 - 2019)			Open-Water Period (2019)		
		Easting	Northing			Date Deployed	Date Retrieved	Set Duration (days)	Date Deployed	Date Retrieved	Set Duration (days)
Shallow 1 (SL SHAL1)	SL-SHAL-1A	560341	7913299	10.2	silt	21-Sep-18	10-Jul-19	292	10-Jul-19	10-Sep-19	62
	SL-SHAL-1B	560338	7913303	10.0	silt	21-Sep-18	10-Jul-19	292	10-Jul-19	10-Sep-19	62
	SL-SHAL-1C	560335	7913306	9.6	silt	21-Sep-18	17-Jul-19	299	17-Jul-19	10-Sep-19	55
	SL-SHAL-1D	560332	7913308	10.6	silt	21-Sep-18	10-Jul-19	292	10-Jul-19	10-Sep-19	62
	SL-SHAL-1E	560323	7913307	10.3	silt	21-Sep-18	16-Jul-19	298	16-Jul-19	10-Sep-19	56
Shallow 2 (SL SHAL2)	SL-SHAL-2A	560579	7913088	6.8	cobble	21-Sep-18	9-Jul-19	291	9-Jul-19	9-Sep-19	62
	SL-SHAL-2B	560578	7913096	6.7	cobble	21-Sep-18	9-Jul-19	291	9-Jul-19	10-Sep-19	63
	SL-SHAL-2C	560573	7913094	6.5	cobble	21-Sep-18	9-Jul-19	291	9-Jul-19	9-Sep-19	62
	SL-SHAL-2D	560574	7913097	6.9	cobble	21-Sep-18	9-Jul-19	291	16-Jul-19	10-Sep-19	56
	SL-SHAL-2E	560569	7913096	6.9	cobble	21-Sep-18	10-Jul-19	292	9-Jul-19	10-Sep-19	63
Deep 1 (SL DEEP1)	SL-DEEP-1A	560234	7913045	30.0	silt	21-Sep-18	17-Jul-19	299	17-Jul-19	11-Sep-19	56
	SL-DEEP-1B	560228	7913049	28.9	silt	21-Sep-18	17-Jul-19	299	17-Jul-19	11-Sep-19	56
	SL-DEEP-1C	560223	7913033	27.0	silt	21-Sep-18	10-Jul-19	292	10-Jul-19	11-Sep-19	63
	SL-DEEP-1D	560229	7913052	28.3	silt	21-Sep-18	12-Jul-19	294	12-Jul-19	11-Sep-19	61
	SL-DEEP-1E	560229	7913044	28.9	silt	21-Sep-18	10-Jul-19	292	10-Jul-19	11-Sep-19	63
Dry Bulk Density	BD-SHAL-1	560230	7913306	nc	silt	21-Sep-18	12-Aug-19	325	12-Aug-19	1-Oct-19	50
	BD-SHAL-2	560358	7913325	nc	silt	21-Sep-18	12-Aug-19	325	12-Aug-19	1-Oct-19	50
	BD-SHAL-3	560576	7913115	nc	silt	21-Sep-18	12-Aug-19	325	12-Aug-19	1-Oct-19	50
	BD-SHAL-4	560576	7913124	nc	silt	21-Sep-18	12-Aug-19	325	12-Aug-19	1-Oct-19	50
	BD-DEEP-1	560237	7913068	nc	silt	21-Sep-18	12-Aug-19	325	12-Aug-19	1-Oct-19	50

near the outlet from SDLT1, information acquired from this station also serves to evaluate the extent to which sediment releases from key lake tributaries affect sedimentation at Sheardown Lake NW.

2. Shallow Hard-Bottom Station (SHAL2): Increased sedimentation at hard-bottom areas could reduce the amount of habitat available to arctic charr for spawning and/or reduce arctic char within-year egg hatch/reproductive success. Therefore, this station was established on coarse substrate (i.e., gravel, cobble) in the lake littoral zone at an area considered to provide suitable spawning habitat for arctic charr.

3. Deep Profundal Station (DEEP1): Because the profundal area is the ultimate depositional zone within lakes, the highest sediment deposition rate can be expected to occur at the deepest point within the main basin of a lake. This station was established on silt substrate within the profundal zone of the main lake basin (approximately 30 m deep) to provide an estimate of 'maximum' sedimentation for Sheardown Lake NW.

2.3 Field and Laboratory Methods

2.3.1 Sedimentation Rate

Lake sedimentation rate was monitored at Sheardown Lake NW for the 2018-2019 ice-cover and 2019 open-water periods using sediment traps constructed of the same materials and dimensions as those employed since the initial study in 2013. Specifically, each sediment trap was constructed of three 50 cm long, 5 cm inside diameter polyvinyl chloride (PVC) pipes (i.e., 58.9 cm^2 surface area) sealed at the bottom and clamped together to create a single trap 'unit'. The sediment trap was designed to provide an aspect ratio of approximately 10:1, which meets the ≥ 5:1 aspect ratio generally recommended for cylindrical sediment traps to effectively monitor sediment deposition (Mudroch and MacKnight 1994). Each sediment trap unit was secured to a float-anchor system designed to maintain the trap in an upright position on the lake bottom for the duration of each deployment period. Under this system, the mouth of the sediment trap unit was situated approximately 1.5 m above the substrate.

Sedimentation was assessed separately for applicable ice-cover and open-water periods at Sheardown Lake NW. The seasonal timing of the ice breakup and freeze-up period at Sheardown Lake NW generally corresponds to mid-July and mid-September, respectively. For the 2018-2019 ice-cover period, five sediment traps were deployed at each Sheardown Lake NW station on September 21st, 2018 (Table 2.1). Sediment traps deployed over the ice-cover period were individually fitted with a marker buoy and lowered to the bottom such that the marker buoy was submerged approximately 2 to 3 m below the water surface to attempt to avoid entrapment of the buoy by ice during winter. Sediment traps for the 2018-2019 ice-cover period were retrieved from

July 9th to 17th, 2019 (291- to 299-day duration; Table 2.1). Because marker buoys were submerged, a grappling tool was required to secure the marker buoy and retrieve the sediment trap at the time of collection. Open-water period sediment traps were deployed as sediment traps became available in July 2019, and were retrieved from September 9th to 11th, 2019 (55- to 63-day duration; Table 2.1). For the open-water period, traps were lowered to the lake floor on individual lines fitted with a surface marker buoy so that they could be seen from the lake surface. Supporting information collected at the time of deployment of each sediment trap included Global Positioning System (GPS) coordinates and water depth.

Sediment trap retrieval involved pulling the entire unit to the surface very slowly to prevent sediment re-suspension in, and/or sediment loss from, each sediment trap. The entire contents of the trap, including all water and deposited sediment, were transferred into a 20 L plastic container pre-labelled with station identification and collection date information. Ambient water was used to rinse all sediment from each sediment trap, applied as a pressurized spray when appropriate. Upon complete removal of all material within the sediment trap, the sediment traps were redeployed at approximately the same locations of retrieval. Following collection of all sediment from individual traps, the sample containers were sealed and stored upright in a dark location until submission to the analytical laboratory. The lake sedimentation samples were shipped to ALS Canada Ltd. (ALS; Waterloo, ON) for analysis of sediment total dry weight. At the laboratory, the sedimentation samples were filtered through a pre-weighed 0.70 µm glass fiber filter. The filter apparatus and container were rinsed three times to ensure complete removal of all sediment. The filter and residual sample material were dried at 105°C for two hours, allowed to cool for one hour, and then weighed to the nearest milligram using an appropriate electronic balance with draft shield. As in previous studies, low sample volumes were encountered for each sediment trap replicate, and each station, for the 2018-2019 ice-cover period and 2019 open-water period samples, precluding any additional analysis of the sedimentation material (e.g., sediment metal concentrations, DBD).

2.3.2 Sediment Accumulation (DBD)

Sediment DBD information, collected in order to estimate the amount of sediment accumulation for separate ice-cover and open-water periods, was collected for the 2018-2019 ice-cover period and 2019 open-water period using sediment traps of differing dimensions to those used for the collection of sedimentation rate data. The DBD sediment traps were constructed of a single 75 cm long, 15.2 cm inside diameter acrylonitrile-butadiene-styrene (ABS) pipe (i.e., 182 cm^2 surface area) that was capped at the bottom end.[1] Each sediment trap unit was secured to a float-anchor

[1] The resulting DBD sediment traps had an aspect ratio of 5:1, meeting the recommended aspect ratio for cylindrical sediment traps to effectively monitor sediment deposition (Mudroch and MacKnight 1994).

system designed to maintain the trap in an upright position on the lake bottom for the duration of the deployment period. The mouth of the DBD sediment trap was designed to sit approximately 1.5 m above the substrate, mirroring the same distance above bottom that the mouth of sediment traps used to monitor sedimentation rate were situated.

Five DBD sediment traps were deployed in Sheardown Lake NW for the ice-cover period and the open-water period (Table 2.1; Figure 2.1). For the 2018-2019 ice-cover period, the DBD sediment traps were deployed on September 21st, 2018 and retrieved on August 12th, 2019 (325-day duration; Table 2.1). Similar to sediment traps deployed for sedimentation rate determination, DBD sediment traps deployed over the ice-cover period were individually fitted with a marker buoy that was submerged approximately 2 to 3 m below the water surface so as to avoid entrapment of the buoy by ice during winter, and required use of a grappling tool for trap retrieval. Open-water period DBD sediment traps were deployed and retrieved on August 12th and October 1st, 2019, respectively (50-day duration; Table 2.1). For the open-water period, the DBD sediment traps were lowered to the lake floor on individual lines fitted with a surface marker buoy so that they could be seen from the lake surface. At the time of deployment, GPS coordinates were taken at each DBD sediment trap location.

The retrieval process involved pulling each DBD sediment trap to the surface very slowly to prevent sediment re-suspension in, and/or sediment loss from, each trap. The entire contents of the trap, including all water and deposited sediment, was transferred into a 4 L plastic container pre-labelled with the replicate identification code. The removal of residual material in each DBD sediment trap was accomplished using a plastic spatula and/or a pressurized stream of water. The DBD samples were transported to an on-site laboratory and left undisturbed for a period of approximately 48 hours to allow the sediment to settle. After 48 hours, the overlying water was siphoned and/or pipetted from the sediment, and the sediment transferred into a 50 mL glass collection jar. To ensure sufficient sample volume for DBD analysis, sediment was composited to create a single sample from the two replicate DBD sediment traps at each shallow station for the ice-cover period sample event. Similarly, the four replicate DBD sediment traps set at the shallow stations for the open-water period sample event were composited to create a single sample. Sufficient sample volume required for DBD analysis was acquired from the single replicate DBD sediment trap deployed at the deep station (BD-DEEP-1) during each sampling event. Following collection of all sediment, the sample containers were sealed and stored cool in an upright position until submission to the Saskatchewan Research Council (SRC; Saskatoon, SK). At SRC, the analysis of DBD was conducted using the pycnometer method.

2.4 Data Analysis

Sedimentation (deposition) rate was calculated for each replicate sediment trap using the equation (Kemp et al. 1974):

$$Sedimentation\ rate\ (mg/cm^{-2}day^{-1}) = \frac{dry\ weight\ (mg)}{total\ area\ (cm^2)} \div deployment\ time\ period\ (day)$$

The sedimentation rate information was evaluated statistically as follows: 1) spatial comparisons among the three stations for separate ice-cover and open-water periods; 2) comparisons between the ice-cover and open-water periods at each station; and, 3) temporal comparisons at each station among baseline and years of mine operation separately for ice-cover and open-water periods. For the statistical analysis, raw data were assessed for normality and homogeneity of variance and log-transformed as necessary to meet test assumptions prior to conducting Analysis-of-Variance (ANOVA) and *post hoc* tests, where appropriate. In instances where normality could not be achieved through data transformation, non-parametric Mann-Whitney U-test statistics were used for pair-wise comparisons, and Kruskal-Wallis H-tests were used for multiple group (i.e., station or year) comparisons using raw data. Similarly, in instances in which normal data exhibited unequal variance despite log transformation, Student's t-tests assuming unequal variance were used for pair-wise comparisons. For multiple station or year comparisons, Tukey's Honestly Significant Difference (HSD) or Tamhane's *post hoc* tests were conducted in cases in which normal data with equal and unequal variance, respectively, were encountered. All statistical comparisons were conducted using SPSS Version 12.0 software (SPSS Inc., Chicago, IL).

Estimation of the uncompacted thickness (mm) of sediment accumulation was calculated separately for each of the ice-cover and open-water periods using the equation (Kemp et al. 1974):

$$Accumulation\ thickness\ (mm/period^{-1}) = \frac{Sedimentation\ rate\ (mg/mm^{-2}period^{-1})}{Dry\ bulk\ density\ (mg/mm^{-3})}$$

Sedimentation DBD results were used to separately estimate sediment accumulation at Sheardown Lake NW shallow and deep stations for each of the 2018-2019 ice-cover and 2019 open-water periods. The sediment accumulation information was evaluated statistically between littoral and profundal habitat separately for the ice-cover and open-water periods, and between the ice-cover and open-water periods separately for each habitat type, using the same methods described above that were used for comparing sedimentation rates.

Adverse effects on fish egg survival have been documented for a sediment accumulation thickness exceeding approximately 1 mm during the egg incubation period (Morgan et al. 1983;

Fudge and Bodaly 1984; Berry et al. 2011). Therefore, an accumulation thickness of 1 mm was used as a threshold for identifying potential effects to arctic charr egg incubation associated with sediment deposits at the Project. On Baffin Island, arctic charr spawning occurs in autumn (September-October) and although egg hatch occurs in early April, larval emergence generally does not occur until ice breakup in mid-July (Scott and Crossman 1998). Because this period essentially mirrors the ice-cover period used in this study, accumulation thickness for the ice-cover period was used to evaluate the potential effects of depositing sediment on arctic charr egg survival at Sheardown Lake NW.

3 RESULTS

3.1 Sedimentation Rates

3.1.1 2018 – 2019 Ice-Cover and Open-Water Periods

Within Sheardown Lake NW, sedimentation rates were significantly lower at the littoral stations (i.e., SHAL1 and SHAL2) than at the profundal station (i.e., main basin Station DEEP1) during both the 2018-2019 ice-cover and 2019 open-water periods (Figure 3.1; Appendix Tables A.1 to A.4). The occurrence of highest sedimentation rate at the deepest area of Sheardown Lake NW was consistent with normal lake deposition patterns (see Wetzel 2001) and previous sedimentation studies (Minnow 2016, 2017, 2018, 2019; Figure 3.1). Sedimentation rates at the two shallow littoral stations (Stations SHAL1 and SHAL2) did not differ significantly from each other for the ice-cover period, but were significantly higher at the area of hard-bottomed substrate near the outlet of SDLT1 (Station SHAL1) than at the area of silt substrate (Station SHAL2) over the open-water period (Appendix Tables A.2 to A.4). In turn, this suggested greater sediment inputs with closer proximity to the SDLT1 outlet.

Sedimentation rates were significantly higher during the open-water period compared to the ice-cover period at all Sheardown Lake NW sedimentation monitoring stations (Appendix Table A.5). Sedimentation rates ranged from 2.6 to 3.2 times greater during the open-water period than during the ice-cover period, potentially reflecting greater surface runoff sources of sediment generated by the mine and/or naturally greater amounts of autochthonous material generated (e.g., settling/decay of plankton) during the open-water period. Nevertheless, on average, approximately 63% of the total sediment deposited at the Sheardown Lake NW stations from September 2018 to September 2019 occurred over the ice-cover period, reflecting the much longer time of ice-cover compared to open-water through a typical year in the arctic.

Annual sedimentation extrapolated from the 2018-2019 Sheardown Lake NW data indicated approximately 18.0 and 16.5 mg/cm^2/year of sediment deposition at the SHAL1 and SHAL2 littoral stations, respectively, and 29.1 mg/cm^2/year of sediment deposition at the DEEP1 profundal station. These annual rates were within the range of those observed at other Canadian arctic lakes (e.g., 7 to 50 mg/cm^2/year; Lockhart et al. 1998) and much lower than at proglacial lakes in south-east Greenland (e.g., mean of 790 mg/cm^2/year; Hasholt et al. 2000). Therefore, the annual sedimentation rate at Sheardown Lake NW over the study period was within a range that is typical for Canadian arctic lakes.

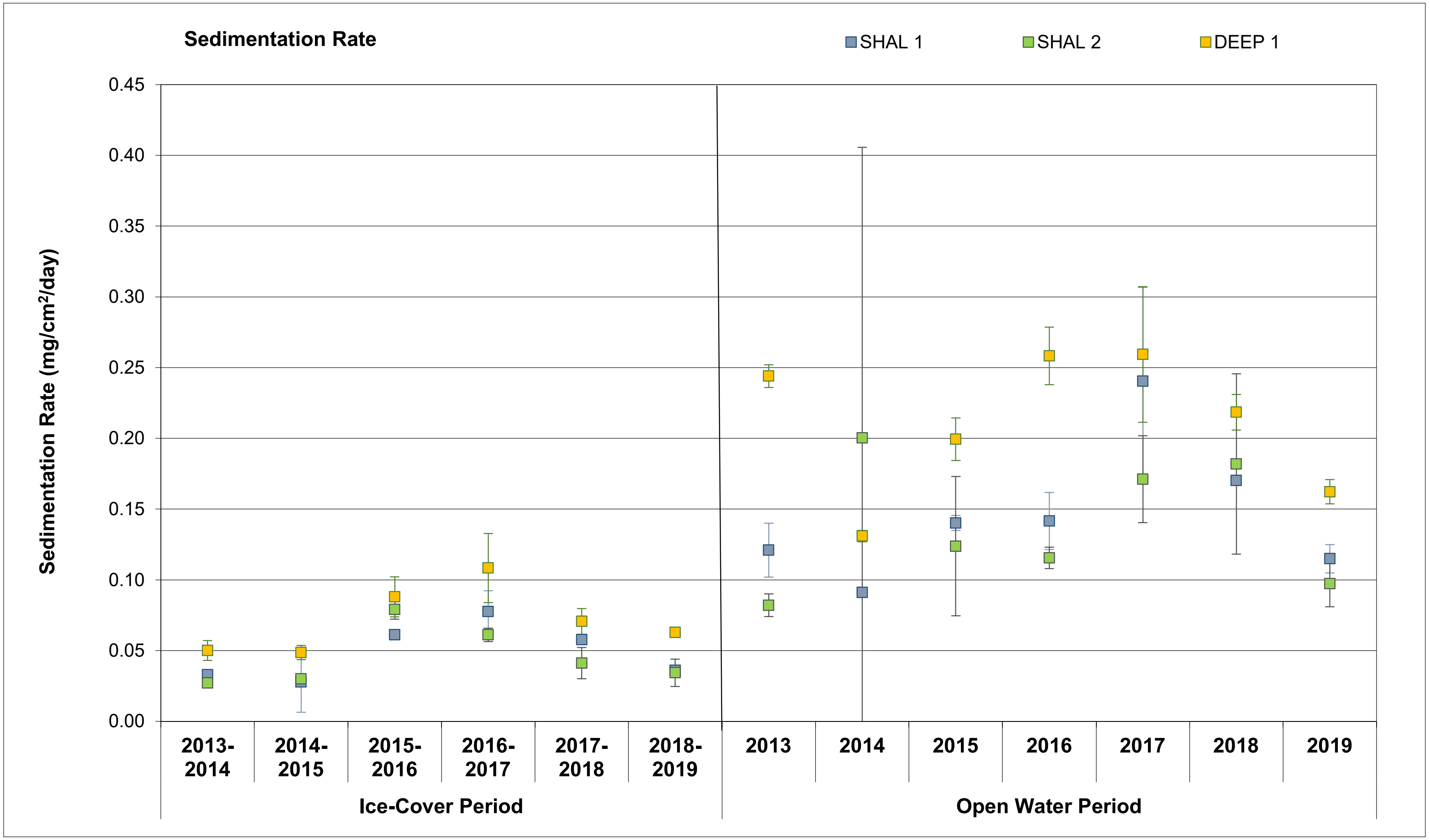

Figure 3.1: Sedimentation Rates During Ice-Cover and Open-Water Periods at Sheardown Lake NW over Mine Baseline (2013 to 2014) and Operational (2015 to 2019) Phases, Sheardown Lake NW Sedimentation Monitoring Study

3.1.2 Temporal Comparisons

Sedimentation rates over the ice-cover period at littoral stations SHAL1 and SHAL2 did not differ significantly between the mine baseline (2013-2014) and 2018-2019 mine operational studies (Figure 3.1; Appendix Tables A.6 to A.8). Because Station SHAL2 is located at representative arctic charr spawning habitat, the absence of differences in sedimentation rate between the 2018-2019 ice-cover period and the baseline ice-cover period at this station indicated that adverse effects to arctic charr spawning/reproductive success due to sedimentation were unlikely over the 2018-2019 egg incubation period. Ice-cover period sedimentation rates at the profundal Station DEEP1 were significantly higher in the 2018-2019 study than during the baseline study (Figure 3.1; Appendix Table A.9). Ice-cover period sedimentation rates were lower in 2018-2019 than in each of the previous three years of mine operation at all littoral and profundal stations, with visual evaluation of the data indicating lower sedimentation rates since 2016-2017 (Figure 3.1). These results may reflect dust suppression initiatives, such as installation of hoods and shrouds on crusher conveyors, that have been taken at the Project in recent years.

Open-water period sedimentation rates at littoral Station SHAL2 and profundal Station DEEP1 were generally within the range of baseline conditions shown in 2013 and 2014 for all years of mine operation from 2015 to 2018, as well as in 2019, for each respective station (Figure 3.1).[2] Although higher sedimentation rates were indicated at Station SHAL1 in 2017 and 2018 compared to baseline, the average sedimentation rate shown in 2019 at this station was comparable to that shown in the baseline studies for the open-water period (Figure 3.1). Overall, sedimentation rates over the 2019 open-water period were within the natural range of baseline conditions at all Sheardown Lake NW stations.

Annual sedimentation rates at Sheardown Lake NW shallow littoral stations were comparable between 2018-2019 (16.5 to 18.0 mg/cm^2/year) and total annual rates shown during 2013-2014 baseline monitoring (13.9 to 16.5 mg/cm^2/year; from NSC 2014a) and during 2014-2015 monitoring (15.2 to 15.5 mg/cm^2/year) at the onset of commercial mine operations (Figure 3.2).[3] The annual sedimentation rate at profundal Station DEEP1 was lower in 2018-2019 (29.1 mg/cm^2/year) than in all previous years of mine operation beginning in 2015-2016 (range from 34.7 to 45.0 mg/cm^2/year), indicating lower mine-related input of sediment to the lake most recently (Figure 3.1). Nevertheless, the annualized sedimentation rate at Station DEEP1

[2] Temporal statistical analysis of open-water period sedimentation rates was not able to include 2013 baseline data as the replicate data for this year were not reported. The results of temporal statistical analysis for open-water periods from the 2014 baseline and 2015 to 2019 mine operational years are provided in Appendix Tables A.6 to A.8.

[3] Annual sedimentation data calculated as the sum of the September to July ice-cover period data and July to September open-water period data.

remained higher in 2018-2019 than during baseline (21.2 mg/cm^2/year) and near the onset of commercial mine operations (24.5 mg/cm^2/year; Figure 3.2). Overall, the temporal data indicated higher total annual sedimentation rates at Sheardown Lake NW since commercial production commenced in 2015-2016 only at profundal habitat, but there was no indication of an increasing trend in annual sedimentation rates over time at either littoral or profundal habitat within the lake.

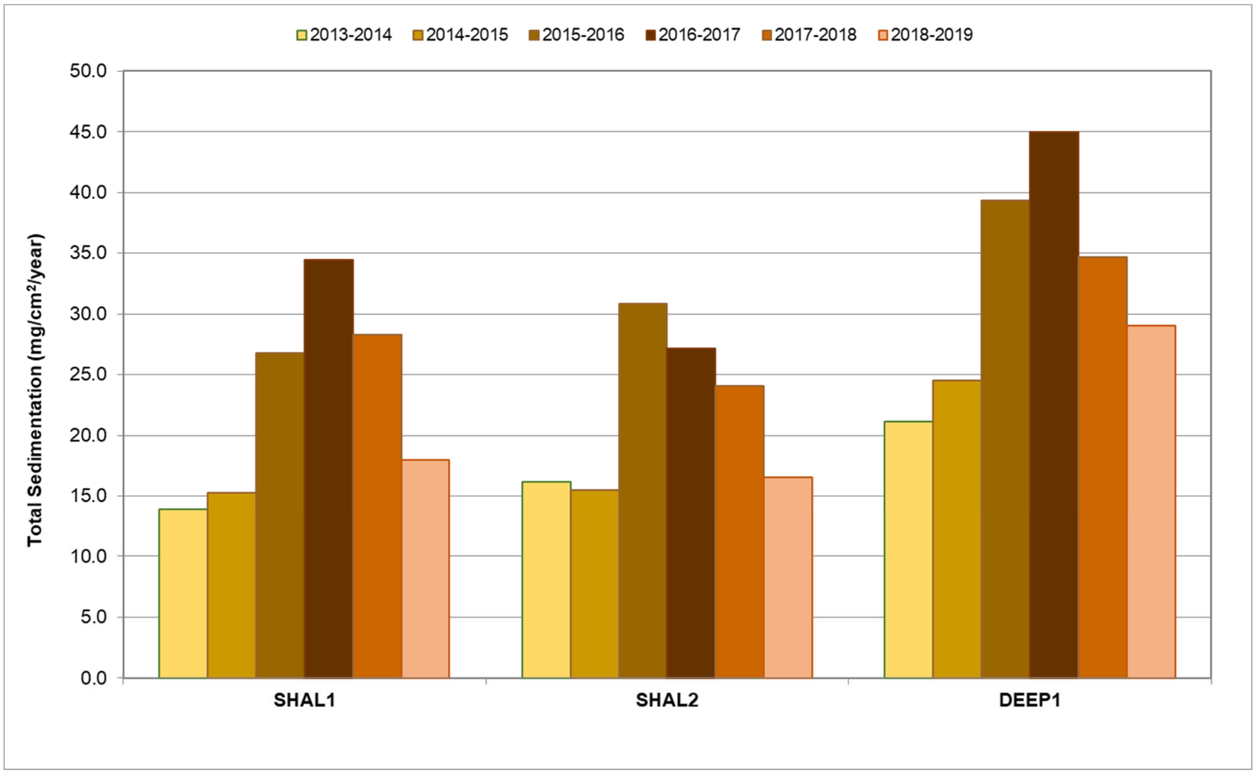

Figure 3.2: Temporal Comparison of Total Annual Sedimentation Rates at Sheardown Lake NW, 2013 to 2019

Note: Annual sedimentation data calculated as the sum of the September to July ice-cover period data and July to September open-water period data.

3.2 Sediment Accumulation Estimate

Sedimentation material DBD collected from Sheardown Lake NW over the ice-cover and open-water periods in 2018-2019 ranged from 2.53 to 2.76 g/cm^3, and was comparable to the DBD shown for the composite sample collected during the open-water period in 2018 (i.e., 2.94 g/cm^3; Appendix Table A.11).[4] Similar sediment DBD was indicated between the littoral and profundal

[4] The DBD values used to derive sediment accumulation (thickness) previously were lower (i.e., 0.197 g/cm^3 based on data from sediment traps set at Canadian Shield lakes in Northern Ontario, and 1.284 g/cm^3 based on sediment collected in-stream and along the shoreline of a tributary to Sheardown Lake NW) than bulk density information for sedimentation material collected directly from Sheardown Lake in 2018 and 2019. The derivation of sediment

stations in 2018-2019, suggesting that the source of sedimentation material was similar between shallow and deep stations within the lake.

Sediment accumulation estimates derived for the 2018-2019 ice-cover and open-water periods using the DBD and corresponding sedimentation rate data ranged from 0.06 mm/year at littoral Station SHAL2, to 0.11 mm/year at profundal Station DEEP1 (Figure 3.3).[5] Within Sheardown Lake NW, sediment accumulation was significantly lower at littoral habitat (i.e., Stations SHAL1 and SHAL2) than at profundal habitat (i.e., Station DEEP1) during both the 2018-2019 ice-cover and 2019 open-water periods (Appendix Table A.12). The occurrence of highest sediment accumulation at the deepest area of the lake was consistent with normal lake deposition patterns (see Wetzel 2001). Sediment accumulation at littoral and profundal stations was significantly higher over the ice-cover period than over the open-water period (Appendix Table A.13), reflecting the much longer duration of the ice-cover period (i.e., 325 versus 50 days; Table 2.1). The sediment accumulation thicknesses estimated at all Sheardown Lake NW stations for the September 2018 to September 2019 period were comparable to annual sediment accumulation reported at profundal depths of an Alaskan arctic lake (0.16 ± 0.08 mm/year; Cornwell 1985), but were otherwise low compared to other arctic lakes. For instance, annual sediment accumulation ranged from 0.27 ± 0.12 to 1.2 ± 0.32 mm/year (average of 0.54 mm/year) among seven arctic lakes in western Greenland (Sobek et al. 2014), which was in line with annual sediment accumulation reported globally for lakes located north of approximately 65˚ latitude with maximum depths greater than 10 m (range from 0.3 to 1.5 mm/year; see Brothers et al. 2008).

Adverse effects on fish egg survival have been reported at sediment accumulation thicknesses greater than approximately 1 mm during the egg incubation period (Morgan et al. 1983; Fudge and Bodaly 1984; Berry et al. 2011). The sediment accumulation thickness estimated for the 2018-2019 arctic charr egg incubation/larval pre-emergence period (i.e., approximately mid-September to mid-July; Scott and Crossman 1998) at Sheardown Lake NW varied from 0.036 ± 0.010 mm at the littoral hard-bottomed station (i.e., SHAL2) to 0.038 ± 0.003 mm at the littoral silt-bottomed station (i.e., SHAL1) when derived using the Sheardown Lake NW sedimentation DBD data (Figure 3.3). Therefore, 2018-2019 sediment accumulation over the duration of the expected arctic charr egg incubation period was well below the 1 mm sediment thickness reported to influence egg hatch/larval pre-emergence success. Accordingly, no

accumulation estimates using site-specific DBD information provides more reliable estimatesthan those derived using the methods presented in past studies. For this reason, the sediment accumulation estimates provided in Minnow (2018) and herein supersede all estimates presented in previous reports.

[5] Annual sedimentation accumulation estimates reflect September to July ice-cover period data (2018-2019) and July to September (2019) open-water period data.

adverse effects to arctic charr reproductive success were likely at Sheardown Lake NW as a result of sedimentation/sediment accumulation over the 2018-2019 incubation period.

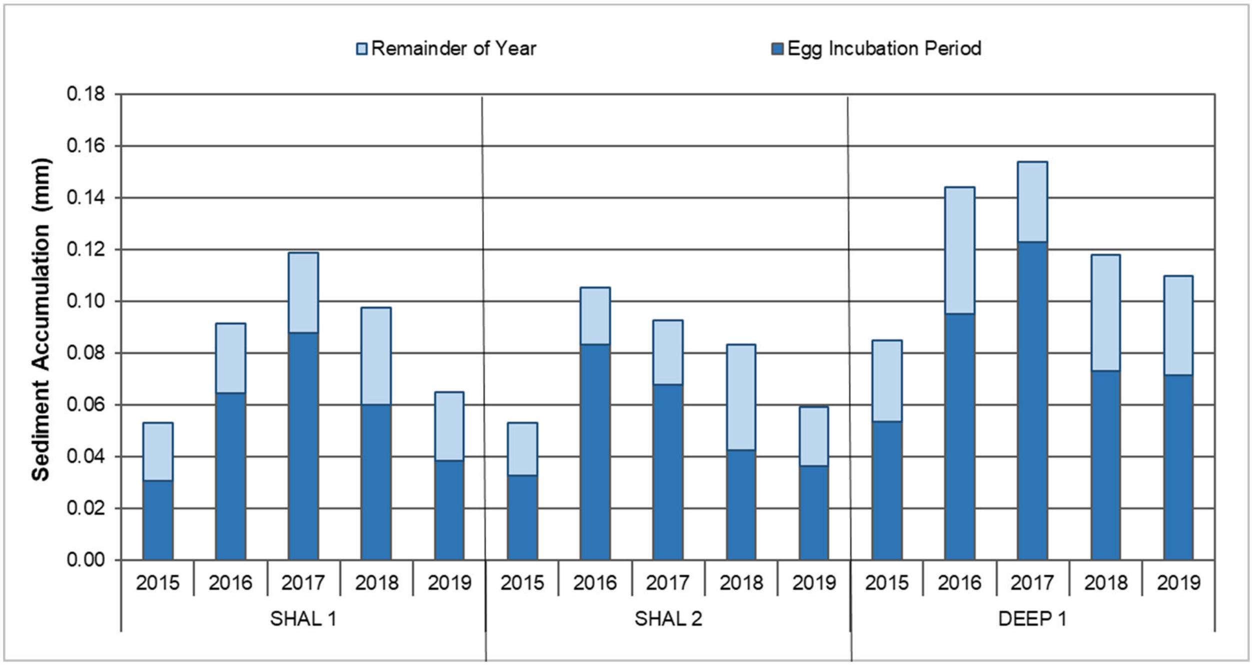

Figure 3.3: Sediment Accumulation Estimates for the Arctic Charr Egg Incubation Period and Total Year Calculated using Sedimentation Rate Information together with Sediment DBD Data, 2015 to 2019

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Lake Sedimentation Monitoring has been included as a special investigation component of the Project AEMP since 2013–2014. The objective of this monitoring is to track sedimentation and evaluate the potential for adverse influences on resident arctic charr populations due to sedimentation at a representative lake (Sheardown Lake NW) within the immediate area of mine influence. The principal conclusions of the 2018–2019 lake sedimentation monitoring study are:

- Sheardown Lake NW sedimentation rates over the ice-cover and open-water periods in 2018-2019 were similar to those during the mine baseline (2013-2014) at littoral areas, including at habitat likely to be used by arctic charr for spawning. Although sedimentation rates over the ice-cover period in 2018-2019 at profundal habitat were significantly higher than during baseline, rates during the open-water period in 2019 were within the range observed during baseline. Annual sedimentation rates for the combined 2018-2019 ice-cover and 2019 open-water periods were similar to baseline at littoral habitat, but higher than baseline at profundal habitat. The current data do not indicate increasing sedimentation rates since the onset of commercial mine production in 2015 at Sheardown Lake NW. Despite higher annual sedimentation in 2018-2019 compared to baseline at profundal habitat, sedimentation rates at Sheardown Lake NW in 2018-2019 (as well as for all previous study years) were within the range observed among typical Canadian arctic lakes that have not been influenced by anthropogenic activities.
- Annual sediment accumulation thickness estimates for Sheardown Lake NW in 2018-2019 were comparable to or lower than annual estimates for arctic lakes of comparable size and/or depth. The sediment accumulation thickness estimated for the 2018–2019 arctic charr egg incubation/larval pre-emergence period at Sheardown Lake NW was well below the threshold level of 1 mm of sediment deposition. Overall, these results indicated no effects on arctic charr reproductive success were likely at Sheardown Lake NW as a result of sedimentation rates/accumulation over the 2018-2019 egg incubation/larval pre-emergence period.

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APPENDIX A

SUPPORTING SEDIMENTATION INFORMATION

Table A.1: Sedimentation and Sediment Accumulation Data for the 2018 - 2019 Ice-Cover Period at Sheardown Lake NW

Station	Station Replicate	Original Set Location (UTM; Zone 17W)		Station Depth (m)	Date Deployed	Date Retrieved	Set Duration (days)	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sediment Accumulation (mm)
		Easting	Northing							
Shallow 1 (SL SHAL1)	SL-SHAL-1A	560341	7913299	10.2	21-Sep-18	10-Jul-19	292	0.539	0.031	0.033
	SL-SHAL-1B	560338	7913303	10.0	21-Sep-18	10-Jul-19	292	0.669	0.039	0.041
	SL-SHAL-1C	560335	7913306	9.6	21-Sep-18	17-Jul-19	299	0.654	0.037	0.040
	SL-SHAL-1D	560332	7913308	10.6	21-Sep-18	10-Jul-19	292	0.600	0.035	0.037
	SL-SHAL-1E	560323	7913307	10.3	21-Sep-18	16-Jul-19	298	0.666	0.038	0.041
	Average						**295**	**0.626**	**0.036**	**0.038**
	Standard Deviation						**3.6**	**0.056**	**0.003**	**0.003**
Shallow 2 (SL SHAL2)	SL-SHAL-2A	560579	7913088	6.8	21-Sep-18	9-Jul-19	291	0.534	0.031	0.033
	SL-SHAL-2B	560578	7913096	6.7	21-Sep-18	9-Jul-19	291	0.500	0.029	0.031
	SL-SHAL-2C	560573	7913094	6.5	21-Sep-18	9-Jul-19	291	0.593	0.035	0.036
	SL-SHAL-2D	560574	7913097	6.9	21-Sep-18	9-Jul-19	291	0.868	0.051	0.053
	SL-SHAL-2E	560569	7913096	6.9	21-Sep-18	10-Jul-19	292	0.623	0.026	0.028
	Average						**291**	**0.624**	**0.034**	**0.036**
	Standard Deviation						**0.4**	**0.145**	**0.010**	**0.010**
Deep 1 (SL DEEP1)	SL-DEEP-1A	560234	7913045	30.0	21-Sep-18	17-Jul-19	299	1.089	0.062	0.071
	SL-DEEP-1B	560228	7913049	28.9	21-Sep-18	17-Jul-19	299	1.162	0.066	0.076
	SL-DEEP-1C	560223	7913033	27.0	21-Sep-18	10-Jul-19	292	1.102	0.064	0.072
	SL-DEEP-1D	560229	7913052	28.3	21-Sep-18	12-Jul-19	294	1.132	0.065	0.074
	SL-DEEP-1E	560229	7913044	28.9	21-Sep-18	10-Jul-19	292	0.980	0.057	0.064
	Average						**295**	**1.093**	**0.063**	**0.072**
	Standard Deviation						**3.6**	**0.069**	**0.004**	**0.005**

Table A.2: Sedimentation and Sediment Accumulation Data for the 2019 Open-Water Period at Sheardown Lake NW

Station	Station Replicate	Original Set Location (UTM; Zone 17W)		Station Depth (m)	Date Deployed	Date Retrieved	Set Duration (days)	Total Dry Weight (g)	Sedimentation Rate ($mg/cm^2/day$)	Sediment Accumulation (mm)
		Easting	Northing							
Shallow 1 (SL SHAL1)	SL-SHAL-1A	560341	7913299	10.2	10-Jul-19	10-Sep-19	62	0.379	0.104	0.025
	SL-SHAL-1B	560338	7913303	10.0	10-Jul-19	10-Sep-19	62	0.446	0.122	0.029
	SL-SHAL-1C	560335	7913306	9.6	17-Jul-19	10-Sep-19	55	0.348	0.108	0.023
	SL-SHAL-1D	560332	7913308	10.6	10-Jul-19	10-Sep-19	62	0.414	0.113	0.027
	SL-SHAL-1E	560323	7913307	10.3	16-Jul-19	10-Sep-19	56	0.422	0.128	0.028
						Average	**59**	**0.402**	**0.115**	**0.026**
						Standard Deviation	**3.6**	**0.038**	**0.010**	**0.003**
Shallow 2 (SL SHAL2)	SL-SHAL-2A	560579	7913088	6.8	9-Jul-19	9-Sep-19	62	0.309	0.084	0.020
	SL-SHAL-2B	560578	7913096	6.7	9-Jul-19	10-Sep-19	63	0.303	0.082	0.020
	SL-SHAL-2C	560573	7913094	6.5	9-Jul-19	9-Sep-19	62	0.390	0.107	0.026
	SL-SHAL-2D	560574	7913097	6.9	9-Jul-19	10-Sep-19	63	0.306	0.093	0.020
	SL-SHAL-2E	560569	7913096	6.9	10-Jul-19	10-Sep-19	62	0.448	0.121	0.029
						Average	**62**	**0.351**	**0.097**	**0.023**
						Standard Deviation	**0.5**	**0.065**	**0.016**	**0.004**
Deep 1 (SL DEEP1)	SL-DEEP-1A	560234	7913045	30.0	17-Jul-19	11-Sep-19	56	0.540	0.164	0.036
	SL-DEEP-1B	560228	7913049	28.9	17-Jul-19	11-Sep-19	56	0.514	0.156	0.034
	SL-DEEP-1C	560223	7913033	27.0	10-Jul-19	11-Sep-19	63	0.617	0.166	0.041
	SL-DEEP-1D	560229	7913052	28.3	12-Jul-19	11-Sep-19	61	0.624	0.174	0.042
	SL-DEEP-1E	560229	7913044	28.9	10-Jul-19	11-Sep-19	63	0.564	0.152	0.038
						Average	**60**	**0.572**	**0.162**	**0.038**
						Standard Deviation	**3.6**	**0.048**	**0.009**	**0.003**

Table A.3: Sedimentation (mg/cm^{-2}·day^{-1}) Summary Statistics for Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2018-2019

Study Period	Station	Sample Size	Mean	Standard Deviation	Standard Error	95% Confidence Interval		Minimum	Maximum
						Lower Bound	Upper Bound		
Ice-Cover 2018 - 2019	SHAL 1	5	0.036	0.003	0.001	0.032	0.040	0.031	0.039
	SHAL 2	5	0.034	0.010	0.004	0.022	0.046	0.026	0.051
	DEEP1	5	0.063	0.004	0.002	0.058	0.067	0.057	0.066
Open-Water 2019	SHAL 1	5	0.115	0.010	0.004	0.102	0.127	0.104	0.128
	SHAL 2	5	0.097	0.016	0.007	0.077	0.118	0.082	0.121
	DEEP1	5	0.162	0.009	0.004	0.152	0.173	0.152	0.174

Table A.4: Statistical Comparison of Sedimentation Rate among Sheardown Lake NW Stations for Ice-Cover and Open-Water Periods, Lake Sedimentation Monitoring Study, 2018 - 2019

Study Period	Overall 3-group Comparison			Pair-wise comparisons[a]				
	Significant Difference Among Areas?	p-value	Statistical Test[b]	(I) Area	(J) Area	Significant Difference Between 2 Areas?	p-value	Statistical Test[a,b]
Ice-Cover 2018 - 2019	YES	0.00001	ANOVA	SHAL1	SHAL2	NO	0.9001	Tukey's HSD
				SHAL1	DEEP1	YES	0.0000	
				SHAL2	DEEP1	YES	0.0000	
Open-Water 2019	YES	0.00001	ANOVA	SHAL1	SHAL2	YES	0.0938	Tukey's HSD
				SHAL1	DEEP1	YES	0.0001	
				SHAL2	DEEP1	YES	0.0000	

[a] Statistical tests include Analysis of Variance (ANOVA) for normal, homogeneous data, t-test assuming unequal variance ($t\text{-test}_{UEV}$) for normal, non-homogeneous data, and Mann-Whitney U-test (MW U-test) for non-normal data sets.

[b] Untransformed data were normally distributed and homogenous, and therefore no data transformation was used for pair-wise comparisons.

Table A.5: Statistical Comparison of Sedimentation (mg/cm^2/day) Between the 2018-2019 Ice-Cover and 2019 Open-Water Periods at Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2018 - 2019

Station	Statistical Test Results			Summary Statistics						
	Significant Difference Between Areas?	*p*-value	Statistical Analysis[a]	Period	N	Mean	Standard Deviation	Standard Error	Minimum	Maximum
SHAL1	YES	0.00002	α , ε	Ice-Cover 2018-2019	5	0.036	0.003	0.001	0.031	0.039
				Open-Water 2019	5	0.115	0.010	0.004	0.104	0.128
SHAL2	YES	0.00007	α , γ	Ice-Cover 2018-2019	5	0.034	0.010	0.004	0.026	0.051
				Open-Water 2019	5	0.097	0.016	0.007	0.082	0.121
DEEP1	YES	<0.00001	α , γ	Ice-Cover 2018-2019	5	0.063	0.004	0.002	0.057	0.066
				Open-Water 2019	5	0.162	0.009	0.004	0.152	0.174

[a] Data analysis included: α - data untransformed; β - data log transformed; γ - single factor ANOVA test conducted; δ - Mann-Whitney U-test conducted; and, ε - t-test assuming unequal variance conducted.

Highlighted values indicate significant difference between study areas based on ANOVA p-value less than 0.10.

Table A.6: **Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2019) Phases at Sheardown Lake NW Shallow Station 1 (SHAL1) during Ice-Cover and Open-Water Periods, Lake Sedimentation Monitoring Study, 2013 - 2019**

Seasonal Period	Overall 5-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Statistical Test[b]	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Ice-Cover	YES	0.00015	ANOVA[b]	2013 - 2014	2014 - 2015	NO	0.9483	Tamhane's [b]
				2013 - 2014	2015 - 2016	YES	0.0000	
				2013 - 2014	2016 - 2017	YES	0.0170	
				2013 - 2014	2018 - 2019	NO	0.8830	
				2014 - 2015	2015 - 2016	NO	0.2118	
				2014 - 2015	2016 - 2017	YES	0.0889	
				2014 - 2015	2018 - 2019	NO	0.8750	
				2015 - 2016	2016 - 2017	NO	0.6233	
				2015 - 2016	2018 - 2019	YES	0.0001	
				2016 - 2017	2018 - 2019	YES	0.0177	
Open-Water	YES	0.00037	KW H-test[c]	2014	2015	YES	0.0079	MW U-test [c]
				2014	2016	YES	0.0159	
				2014	2017	YES	0.0079	
				2014	2019	YES	0.0079	
				2015	2016	NO	0.9048	
				2015	2017	YES	0.0079	
				2015	2019	YES	0.0079	
				2016	2017	YES	0.0159	
				2016	2019	YES	0.0635	
				2017	2019	YES	0.0079	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Untransformed data were normally distributed, and thus un-transformed data used for statistical tests.

[c] Log transformed data remained non-normally distributed, and thus statistical tests conducted using non-parametric KW H-test and MW U-tests, as appropriate.

Table A.7: Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2019) Phases at Sheardown Lake NW Shallow Station 2 (SHAL2) during the Ice-Cover Period, Lake Sedimentation Monitoring Study, 2013 - 2019

Seasonal Period	Overall 6-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Statistical Test	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Ice-Cover	YES	< 0.001	ANOVA[b]	2013 - 2014	2014 - 2015	NO	0.8387	Tamhane's [b]
				2013 - 2014	2015 - 2016	YES	0.0007	
				2013 - 2014	2016 - 2017	YES	0.0006	
				2013 - 2014	2017 - 2018	NO	0.9311	
				2013 - 2014	2018 - 2019	NO	0.9532	
				2014 - 2015	2015 - 2016	YES	0.0003	
				2014 - 2015	2016 - 2017	YES	0.0002	
				2014 - 2015	2017 - 2018	NO	0.9761	
				2014 - 2015	2018 - 2019	NO	0.9993	
				2015 - 2016	2016 - 2017	YES	0.0267	
				2015 - 2016	2017 - 2018	NO	0.1819	
				2015 - 2016	2018 - 2019	YES	0.0008	
				2016 - 2017	2017 - 2018	NO	0.6872	
				2016 - 2017	2018 - 2019	YES	0.0228	
				2017 - 2018	2018 - 2019	NO	0.9998	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Untransformed data were normally distributed, and thus un-transformed data used for statistical tests.

Table A.8: Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2019) Phases at Sheardown Lake NW Shallow Station 2 (SHAL2) during the Open-Water Period, Lake Sedimentation Monitoring Study, 2013 - 2019

Seasonal Period	Overall 6-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Statistical Test	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Open-Water	NO	0.47872	ANOVA[b]	2014	2015	NO	1.0000	Tamhane's [b]
				2014	2016	NO	0.9999	
				2014	2017	NO	1.0000	
				2014	2018	NO	1.0000	
				2014	2019	NO	0.9994	
				2015	2016	NO	1.0000	
				2015	2017	NO	0.9219	
				2015	2018	NO	0.9902	
				2015	2019	NO	0.9990	
				2016	2017	NO	0.1840	
				2016	2018	NO	0.9721	
				2016	2019	NO	0.6606	
				2017	2018	NO	1.0000	
				2017	2019	NO	0.0451	
				2018	2019	NO	0.9023	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Untransformed data were normally distributed, and thus un-transformed data used for statistical tests.

Table A.9: Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2019) Phases at Sheardown Lake NW Deep Station (DEEP1) during the Ice-Cover Period, Lake Sedimentation Monitoring Study, 2013 - 2019

Seasonal Period	Overall 5-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Statistical Test	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Ice-Cover	YES	0.00064	Kruskal-Wallis H-test [b]	2013 - 2014	2014 - 2015	NO	0.9048	Mann-Whitney U-test [b]
				2013 - 2014	2015 - 2016	YES	0.0286	
				2013 - 2014	2016 - 2017	YES	0.0286	
				2013 - 2014	2017 - 2018	YES	0.0571	
				2013 - 2014	2018 - 2019	YES	0.0317	
				2014 - 2015	2015 - 2016	YES	0.0159	
				2014 - 2015	2016 - 2017	YES	0.0159	
				2014 - 2015	2017 - 2018	YES	0.0159	
				2014 - 2015	2018 - 2019	YES	0.0079	
				2015 - 2016	2016 - 2017	NO	0.3429	
				2015 - 2016	2017 - 2018	YES	0.0286	
				2015 - 2016	2018 - 2019	YES	0.0159	
				2016 - 2017	2017 - 2018	NO	0.1143	
				2016 - 2017	2018 - 2019	YES	0.0159	
				2017 - 2018	2018 - 2019	NO	0.1905	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Log transformed data remained non-normally distributed, and thus statistical tests conducted using non-parametric KW H-test and MW U-tests, as appropriate.

Table A.10: Statistical Comparison of Sedimentation Rates Between Mine Baseline (2013-2014) and Operational (2015-2019) Phases at Sheardown Lake NW Deep Station (DEEP1) during the Open-Water Period, Lake Sedimentation Monitoring Study, 2013 - 2019

Seasonal Period	Overall 5-group Comparison			Pair-wise, post-hoc comparisons[a]				
	Significant Difference Among Periods?	p-value	Statistical Test	(I) Area	(J) Area	Significant Difference Between Periods?	p-value	Statistical Test
Open-Water	YES	0.00000001	ANOVA[b]	2014	2015	YES	0.0045	Tamhane's [b]
				2014	2016	YES	0.0015	
				2014	2017	NO	0.1729	
				2014	2018	YES	0.0057	
				2014	2019	YES	0.0062	
				2015	2016	YES	0.0157	
				2015	2017	NO	0.7298	
				2015	2018	NO	0.7000	
				2015	2019	YES	0.0375	
				2016	2017	NO	1.0000	
				2016	2018	NO	0.1313	
				2016	2019	YES	0.0019	
				2017	2018	NO	0.9547	
				2017	2019	NO	0.3215	
				2018	2019	YES	0.0081	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons.

[b] Untransformed data were non-normally distributed; log-transformation resulted in normally distributed data. and thus the log-transformed data were used for statistical tests.

Table A.11: Dry Bulk Density of Sedimentation Samples Collected at Sheardown Lake NW, 2018 - 2019

Period	Sample Identification	Collection Date	Density (g/cm^3)
Open-Water 2018	SDNW DBD	September 21, 2018	2.94
Ice-Cover 2018-2019	BD-SHAL-A	August 12, 2019	2.76
	BD-SHAL-B	August 12, 2019	2.76
	BD-Deep	August 12, 2019	2.88
Open-Water 2019	BD-SHAL	October 1, 2019	2.53
	BD-DEEP	October 1, 2019	2.59

Table A.12: Statistical Comparison of Sediment Accumulation (mm) Between Shallow and Deep Stations [a] for the 2018-2019 Ice-Cover and 2019 Open-Water Periods at Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2018 - 2019

Study Period	Statistical Test Results			Summary Statistics						
	Significant Difference Between Areas?	*p*-value	Statistical Analysis [b]	Station Type	N	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Ice-Cover 2018 - 2019	YES	< 0.00001	α , γ	Littoral (shallow)	10	0.037	0.007	0.002	0.028	0.053
				Profundal (deep)	5	0.072	0.005	0.002	0.064	0.076
Open-Water 2019	YES	<0.00001	α , γ	Littoral (shallow)	10	0.025	0.004	0.001	0.020	0.029
				Profundal (deep)	5	0.038	0.003	0.001	0.034	0.042

[a] Composite samples were created using DBD information collected at both shallow stations (SHAL1 and SHAL2), and therefore the shallow station data were combined for statistical analyses.

[b] Data analysis included: α - data untransformed; β - data log transformed; γ - single factor ANOVA test conducted; δ - Mann-Whitney U-test conducted; and, ε - t-test assuming unequal variance conducted.

Highlighted values indicate significant difference between study areas based on ANOVA p-value less than 0.10.

Table A.13: Statistical Comparison of Sediment Accumulation (mm) Between 2018-2019 Ice-Cover and 2019 Open-Water Periods for Shallow and Deep Stations[a] at Sheardown Lake NW, Lake Sedimentation Monitoring Study, 2018 - 2019

Station Type	Statistical Test Results			Summary Statistics						
	Significant Difference Between Areas?	*p*-value	Statistical Analysis [b]	Study Period	N	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Littoral (shallow)	YES	0.00011	α , γ	Ice-Cover 2018-2019	10	0.037	0.007	0.002	0.028	0.053
				Open-Water 2019	10	0.025	0.004	0.001	0.020	0.029
Profundal (deep)	YES	<0.00001	α , γ	Ice-Cover 2018-2019	5	0.072	0.005	0.002	0.064	0.076
				Open-Water 2019	5	0.038	0.003	0.001	0.034	0.042

[a] Composite samples were created using DBD information collected at both shallow stations (SHAL1 and SHAL2), and therefore the shallow station data were combined for statistical analyses.

[b] Data analysis included: α - data untransformed; β - data log transformed; γ - single factor ANOVA test conducted; δ - Mann-Whitney U-test conducted; and, ε - t-test assuming unequal variance conducted.

Highlighted values indicate significant difference between study areas based on ANOVA p-value less than 0.10.