Appendix B

List of Supplemental Materials

DFO-3.2.1

Appendix DFO-3.2.1-1 Doris Lake, Doris Creek, and Little Roberts Outflow Fisheries Assessment Memorandum

Memorandum

Refer to File: B.1 - Doris Lake Creek and LRO Fisheries Model Memo.docx

Date:	January 8, 2016
To:	John Roberts, VP Environmental Affairs Katsky Venter, Environmental Advisor Sharleen Hamm, Consultant
From:	April Hayward (Ph.D.), Project Manager Marc Wen (M.Sc., R.P.Bio), Partner in Charge
Cc:	Fraser Ross (B.Sc., R.P.Bio.)
Subject:	**Doris Lake, Doris Creek, and Little Roberts Outflow Fisheries Assessment**

This memorandum was prepared at the request of TMAC Resources Inc. (TMAC) to present the fisheries fieldwork completed in 2015 for the Doris Lake, Doris Creek, and Little Roberts Outflow Fisheries Assessment. This work supports the application for amendment (the Amendment Application) to the Project Certificate (Nunavut Impact Review Board No. 003) and the Type A Water Licence (Nunavut Water Board No. 2AM-DOH1323). The hydraulic modelling results from Doris Creek and Little Roberts Outflow are presented in the Doris Creek and Little Roberts Outflow Fisheries Assessment – Hydraulic Modelling Results memorandum (ERM 2015a).

1. INTRODUCTION

The Amendment Application (ERM 2015e) predicted that infiltration into the underground workings while mining in a talik zone may reduce water levels in Doris Lake and its downstream creek. Consequently, fisheries may be impacted and according to the *Fisheries Protection Policy Statement* (DFO 2013a), if a project is likely to cause *serious harm to fish* as defined by the *Fisheries Act* (1985) after the application of avoidance and mitigation measures, then the proponent must develop a plan to undertake offsetting measures to counterbalance the unavoidable residual *serious harm* to fish. These offsetting measures are implemented with the goal of maintaining or improving the productivity of commercial, recreational or Aboriginal fisheries (DFO 2013b).

A Conceptual Freshwater Fisheries Offsetting Plan was included in the Amendment Application (ERM 2015e) outlining the procedural framework for offsetting. The proposed procedural framework was developed to satisfy the *Fisheries Protection Policy Statement* (DFO 2013a) and the federal *Fisheries Act* (1985) requirements, should offsetting be required.

The Effects Assessment of the Amendment Application used historical baseline data to predict potential effects, but data gaps limited the certainty of the conclusions. ERM Consultants Canada Ltd. (ERM) was retained by TMAC to collect additional data to validate the assumptions and conclusions of the Effects Assessment. This memo presents the results of the fisheries component of the 2015 Doris Lake, Doris Creek, and Little Roberts Outflow Fisheries Assessment (the Program). The results of hydraulic modelling in Doris Creek and Little Roberts Outflow are presented in ERM (2015a).

2. OBJECTIVES

The overall objective of the 2015 Doris Lake, Doris Creek, and Little Roberts Outflow Fisheries Assessment was to provide greater certainty to the results of the Effects Assessment in the Amendment Application. Specifically, the objective was to estimate the potential loss of fisheries productive capacity of Doris Lake, Doris Creek, and Little Roberts Outflow under a reduced flow level scenario.

2.1 Doris Lake Fisheries Assessment Objectives

The objective of the Doris Lake Fisheries Assessment was to map the distribution of spawning habitats for Lake Trout, Lake Whitefish, and Cisco in Doris Lake. The following specific tasks were set out to meet the overall objective of the program:

1. summarize historical fisheries data collected from Doris Lake;
2. complete a detailed habitat survey of Doris Lake, focusing on the section of the lake between 1 m and 4 m water depth;
3. sample the distribution of spawning salmonids during the fall spawning period; and
4. identify and quantify locations that may be sensitive to under-ice water drawdown.

2.2 Doris Creek and Little Roberts Outflow Fisheries Assessment Objectives

The objective of the Doris Creek and Little Roberts Outflow Fisheries Assessment was to determine the quantity and quality of fisheries in Doris Creek and Little Roberts Outflow. The following tasks were prescribed to meet the overall objective of the program:

1. map fish habitat along the length of the streams;
2. sample fish densities in each mesohabitat identified in the streams; and
3. survey stream channel cross-sections and collect stream discharge measurements at a series of sites between Doris Lake and Roberts Bay (these results are presented in the Doris Creek and Little Roberts Outflow Fisheries Assessment – Hydraulic Modelling Results memorandum (ERM 2015a).

3. METHODS

3.1 Doris Lake Fisheries Assessment

3.1.1 Historical Data Review

A complete summary of historical fisheries data available for the Doris-Roberts Watershed was provided in Section 2.4.1.1 of the Project Certificate/ Type A Water Licence Amendment Application (document P4-1). For this assessment, sources were reviewed for data pertinent to spawning behaviours or spawning habitats in Doris Lake and are provided below (Table 3.1-1).

Table 3.1-1. Historical Sampling of Freshwater Fish Habitats and Fish Communities in Doris Lake between 1995 and 2014

Year	Method	Species	Month	Spawning Data	Reference
2009	GN, MT	LT, LW, CL, NSB	August	No	(Rescan 2010b)
2005	EF, MT, AG	LT, LW, CL, NSB	September	Yes	(Golder 2006)
2003	FN, EF, GN, EF, BS	LT, LW, CL, NSB	July, August, September	No	(RL&L/Golder 2003)
1998	GN	CL	August	No	(RL&L/Golder 2002)
1997	GN	LT, LW, CL	August	No	(RL&L/Golder 2002)
1996	GN	LT, LW, CL	August	No	(RL&L/Golder 2002)
1995	GN	LT, LW, CL	August	No	(RL&L/Golder 2002)

Method: GN = Gillnet, MT = Minnow Trap, EF = Electrofisher, AG = Angling FN = Fyke Net, BS = Beach Seines.
Fish Species Codes: LT = Lake Trout, LW = Lake Whitefish, CL = Cisco[1], NSB = Ninespine Stickleback.
[1] It is difficult to identify Ciscoes to the species level, so these identifications should be interpreted with caution.

Fish use physical conditions within a lake to determine the quality of potential spawning sites (Scott and Crossman 1973; Esteve, McLennan, and Gunn 2008; Callaghan, Blanchfield, and Cott in press). To determine whether physical conditions present in Doris Lake may be affecting spawning site selection, historical data on three predominant parameters known to influence spawning were reviewed; dissolved oxygen (DO), water temperature, and wind speed data.

Dissolved Oxygen

Low DO concentrations have profound effects on developing eggs, with the degree of the effect directly related to the degree of hypoxia (Garside 1959; Sly 1988). In winter, the hypolimnion can become depleted of oxygen depending on many factors including currents, ice thickness and duration, inflows and outflows, biological oxygen demand, water temperature, bathymetry, and aquatic vegetation cover. In extreme cases (usually small, shallow lakes) the entire water column becomes oxygen-depleted, causing mass mortality, or winterkill, of aquatic life including fish. A common intermediate scenario in medium or large waterbodies such as Doris Lake is where the lower portion of the lake becomes oxygen-depleted gradually throughout winter, creating an inhospitable environment for aquatic life in the deepest section of the lake. Since the early stages of fish life are particularly sensitive to oxygen depletion, fish must avoid spawning in this hypoxic stratum to avoid detrimental effects. In freshwater lakes in cold-water environs the Canadian Council of Ministers of the Environment (CCME) water quality guidelines for DO are 9.5 mg/L for early life stages and 6.5 mg/L for non-early life stages (CCME 2014).

Historical late-winter DO profiles were reviewed to determine whether depleted oxygen levels in lower sections of the lake restricts the vertical range where fish can successfully spawn. Under-ice DO is sampled as part of the Aquatic Effects Monitoring Program (AEMP; Rescan 2010d) from two locations in Doris Lake in late winter (April, May, or early June) when DO concentrations are lowest and therefore pose the greatest concern to aquatic life. All DO profiles collected between 1998 and 2015 were reviewed. Since these samples were collected from water in the centre of the lake they are not a direct measure of interstitial conditions in spawning locations, but they do provide useful information on overall trends in oxygen concentrations with depths in the lake. See ERM (2015b) for a full account of water quality sampling methods in Doris Lake.

Temperature

Water temperature plays a critical role in egg development, as eggs develop and hatch more quickly in warmer temperatures (Garside 1959; Allen et al. 2005). Doris Lake is located close to the northern range limit of each species that inhabits the lake (McPhail and Lindsay 1970; Scott and Crossman 1973), where water temperatures barely exceed freezing for much of the winter (ERM 2015b). Trends in historical water temperature were reviewed to determine whether water temperature might influence spawning site selection in Doris Lake.

Wind

Several studies have found that wind is a predominant predictor of Lake Trout (*Salvelinus namaycush*) spawning site quality as it increases dissolved oxygen and decreases the abundance of fine sediments (DeRoche 1969; Esteve, McLennan, and Gunn 2008; Muir et al. 2012). If wind direction is somewhat consistent each year during the spawning period, Lake Tout may consistently select spawning sites that benefit the most from those winds. Historical wind direction data from a meteorological station adjacent to Doris Lake were reviewed (Rescan 2010c, 2011, 2012; ERM Rescan 2014b, 2014a; ERM 2015d). September wind direction data from 2010 to 2015 were reviewed since Lake Trout spawn throughout that month in this location. See ERM (2015d) for a description of the meteorological station and the approach to data preparation.

3.1.2 Fish Habitat Assessment

Habitat sampling was conducted to identify spawning locations that could be affected by under-ice drawdown caused by the mine. Fall-spawning fish in Doris Lake spawn prior to, or during the early stages of ice formation, but they must spawn below the maximum depth where ice and natural drawdown penetrate at a later date to guarantee that their eggs do not freeze or desiccate. Mine activities that cause under-ice drawdowns that stay within the lake's natural range are unlikely to affect spawning beds as these local populations of fish would be adapted to avoid these high-risk areas. However, drawdown that exceeds the natural range could be detrimental to egg survival, particularly if fish spawn immediately below where lake ice extends.

To determine the depth to which ice and natural drawdown penetrate (the upper limit where fish can safely spawn), historical ice thickness and lake water level data were reviewed. In eleven years of baseline data collection, the surface water level of Doris Lake varied naturally by an average of 0.54 m, and ranged from 0.34 m to 0.74 m. Ice thickness varied from 1.5 to 2.0 m. This baseline data suggests that the minimum combined depth of ice and natural water level drawdown is 1.84 m, the average is 2.29 m, and the maximum is 2.74 m. Therefore, fish must spawn deeper than 2.74 m to ensure they are beyond the zone where lethal effects from ice and natural drawdown may occur.

The hydraulic model predicted that the mine could cause a maximum under-ice drawdown of 23 cm if maximum mine water withdrawal and maximum water loss to the mine occurred simultaneously in winter (ERM 2015e). For this to cause an effect outside the natural range (i.e., beyond 2.74 m), these maximum values would need to coincide with near-maximum values of both ice thickness and natural drawdown. To determine what the potential effects of drawdown of 23 cm beyond the natural range would be, the habitat assessment focused on the shallow margins of the lake, between 1 and 4 m water depth.

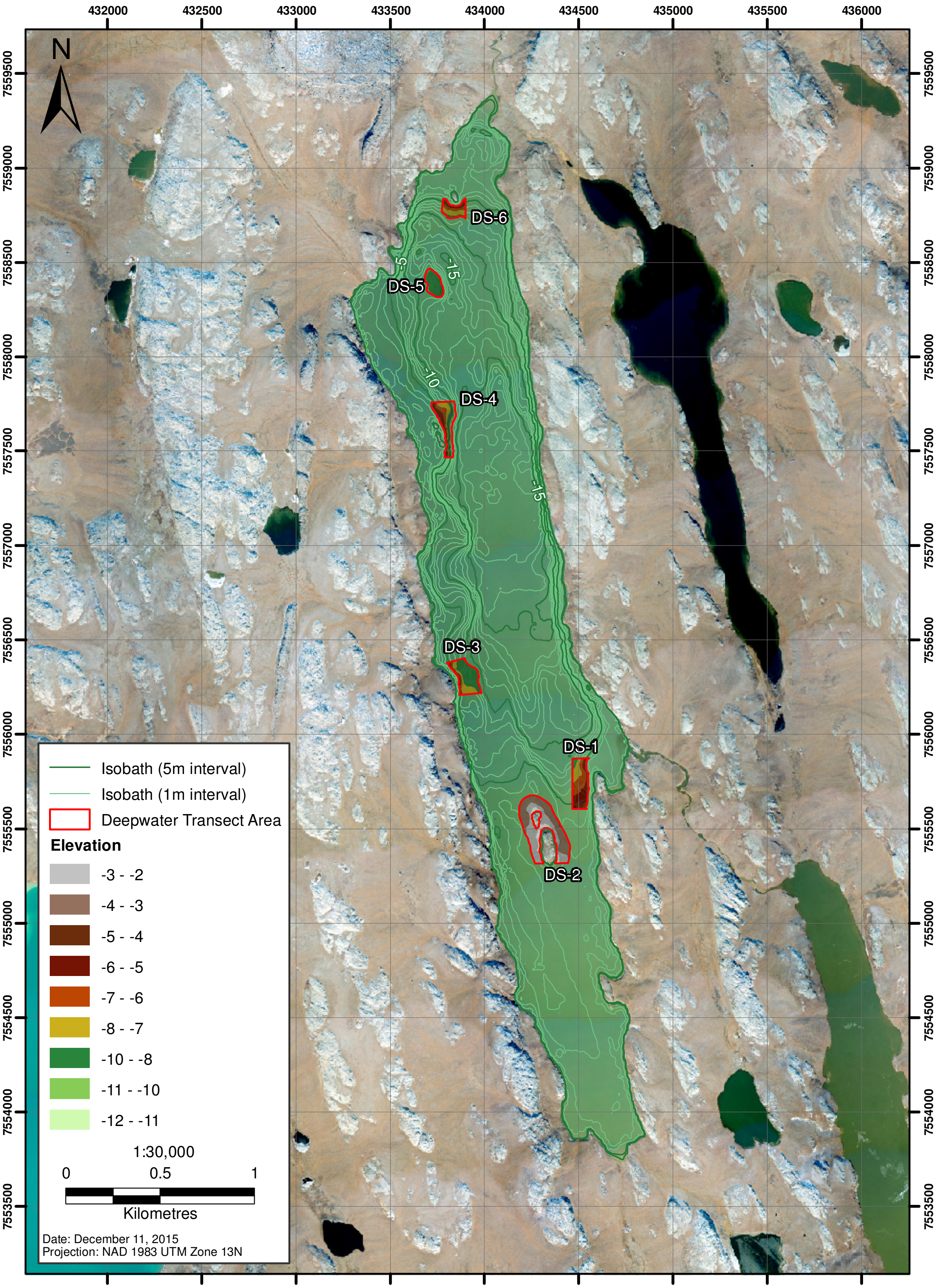
The 1 to 4 m depth zone was delimited into physically homogenous habitat units using underwater video (Deep Blue Pro Colour by Ocean Systems Inc.) and a Garmin CS60 GPS (Appendix 2). Dominant and subdominant substrate types were the primary criterion used to categorize habitats. Substrate types were defined by their average particle diameter: fines (less than 2 mm diameter), gravel (2 to 64 mm), cobble (64 to 256 mm), boulder (256 to 4,000 mm), and bedrock (greater than 4,000 mm). Lakebed slope, vegetation, proximity to inflows and outflows, and other pertinent habitat characteristics were also recorded. Each unit was later given a unique identifier, assigned sequentially following the lake perimeter.

In addition to the shallow-water assessment, deep-water video transects were completed in locations typically associated with spawning (islands, points of land, submerged peaks, and shelf drop-offs) to compare the quality of potential spawning habitats at these sites to shallower locations (Figure 3.1-1; Appendix 3).

The physical attributes of each habitat unit were compared to the spawning preferences for each fall-spawning fish species present in the lake to determine whether that unit was suitable spawning habitat for that species. Historical sampling indicates that Doris Lake is inhabited by Lake Trout, Lake Whitefish (*Coregonus clupeiformis*), cisco (*Coregonus sp(p).*), and Ninespine Stickleback (*Pungitius pungitius;* Table 3.1-1).

Accurate identification of cisco species in the field can be difficult or impossible due to excessive phenotypic plasticity - the ability for a species to change its shape based on environmental conditions (Scott and Crossman 1973). There remains doubt in the primary literature on whether cisco species are actually discrete species or conspecifics (Bodaly et al. 1991; Smith and Todd 1992; McPhail 2007). Doris Lake is within the geographic range of Arctic Cisco (*Coregonus autumnalis*), Cisco (*Coregonus artedi*; commonly called the Lake Cisco), and Least Cisco (*Coregonus sardinella*). The Arctic Cisco is an anadromous species that inhabits large rivers where they spawn in fast flowing sections over gravel. Since Doris Lake is isolated from the ocean by a waterfall and the lake’s inflows and outflow freeze in winter (i.e., they cannot provide spawning habitat) it is unlikely that this species inhabits Doris Lake. Lake-dwelling, resident Cisco and Least Cisco populations both may inhabit Doris Lake as these species inhabit the region and the habitats in Doris Lake are suitable for both species; thus, the habitat requirements of both were considered. Since genetic identification has not been completed in Doris Lake, both or either species may inhabit the lake; thus, Cisco will refer to either species for the remainder of this memorandum.

Figure 3.1-1
Locations of Deep-water Habitat Video Transects, Doris North Project, 2015



Lake Trout, Lake Whitefish, Cisco, and Least Cisco spawn in September and October in northern regions, primarily in shallow inshore portions of lakes (McPhail and Lindsay 1970; Scott and Crossman 1973). Lake Trout and Lake Whitefish usually spawn on shoals less than 7 m in locations near deep water, but in some instances they spawn in far deeper locations (Scott and Crossman 1973; Callaghan, Blanchfield, and Cott in press). These shoals consist of boulder, cobble, and large gravel slopes often in areas kept free of fine-grained sediments by wave action and water currents (McPhail and Lindsay 1970; Scott and Crossman 1973). Lake Trout spawning shoals usually contain 3 to 15 cm diameter, well sorted substrate (Martin and Olver 1980; Callaghan, Blanchfield, and Cott in press) and although Lake Whitefish typically spawn in similar locations they may also select areas with a higher fine sediment content (Scott and Crossman 1973). Both cisco species spawn in shallow lake margins over a range of substrate types, but most commonly over sand or gravel and rarely over mud. Since the eggs of Lake Trout, Lake Whitefish, Cisco, and Least Cisco incubate in the shallow margins of the lake throughout winter, they are potentially susceptible to the effects of under-ice drawdown beyond the natural range.

The Ninespine Stickleback spawns from May to late July and eggs hatch after six or seven days (Scott and Crossman 1973). Young-of-Year and adults spend summer months in shallow, vegetated areas then move from the littoral zone to deeper water in the fall to overwinter (McPhail and Lindsay 1970; Morrow 1980). Since Ninespine Stickleback eggs do not incubate through the winter and adults overwinter in deeper water, no direct effects to this species are expected; their spawning behaviour and habitat was not considered further in this assessment.

Habitat units were categorized for each species following a modified version of the spawning habitat categories in the Fish Habitat Assessment Procedures (Johnston and Slaney 1996):

- None (N) = no suitable spawning habitat in the habitat unit;
- Low (L) = little suitable spawning habitat (e.g., isolated pockets, poor quality habitat); and
- High (H) = extensive areas of good quality spawning habitat.

According to baseline data, the depth to which ice and natural drawdown penetrate ranges from 1.84 to 2.74 m. Since eggs deposited in water shallower than 1.84 m would be encased in ice every year, all habitat shallower than 1.84 m was categorized as N regardless of substrate type.

No habitats within the natural range of ice and natural drawdown (1.84 to 2.74 m) were rated as H due to the risks associated with spawning in these locations. Habitats within this range were rated as N or L, depending on the quality of the substrate and other physical characteristics. For depths beyond 2.74 m, it was assumed that ice and natural drawdown posed no risk to potential spawning habitats.

For Lake Trout, habitat units were classified H if, beyond the range of natural ice and water drawdown (i.e., deeper than 2.74 m), they contained large, continuous areas of well-sorted, clean boulder/cobble/large gravel substrates with medium or high gradient slopes that were located close to deep water. A rating of L was assigned to units with low quality Lake Trout spawning habitat or to units that had small patches of potential spawning habitat beyond the range of natural ice and water drawdown. A rating of N was assigned to units with no suitable spawning habitat.

For Lake Whitefish, areas were classified H that were large, continuous areas with medium or high gradient slopes of well-sorted, boulder/cobble/large gravel substrates that contained a minor fraction of fine sediments, that were located close to deep water, and were beyond the range of natural ice and water drawdown. A rating of L was assigned to areas deeper than 2.74 m with poor quality Lake Whitefish spawning habitat, but that contained some small patches of potential spawning habitat, or to areas within the natural range of ice that otherwise possessed good quality spawning habitat. A rating of N was assigned to units with no suitable spawning habitat.

For Cisco and Least Cisco, units with large, shallow sand and gravel areas beyond the range of natural ice and water drawdown were classified H. A rating of L was assigned to units with less desirable substrate (e.g. bedrock, boulder), but that contained some small patches of potential spawning habitat beyond the range of natural ice and water drawdown. A rating of N was assigned to units with no suitable spawning habitat.

3.1.3 Fish Community Assessment

Fish community sampling was completed to identify aggregations of spawning fish in the fall of 2015 with gillnets, angling, and hydroacoustics. Gillnets were set between September 2 and September 7, 2015 (Appendix 4; Figure 3.1-2). Nets were either set randomly, to target suspected spawning locations, or to target schools of fish that were visualized using a Biosonics MX Aquatic Habitat Echosounder (Figure 3.1-2; Plate 3.1-1). Short, small-mesh gillnets were set for brief durations to minimize the risk of incidental mortalities. Sinking gillnets 15.2 m long and 2.4 m deep with a stretched mesh size of 25 mm were set for durations between 25 and 100 min. Nets with small mesh sizes tend to entangle fish by their teeth and fins and cause less gill structure damage that is common with larger mesh sizes. The standard gillnet gangs recommended by the Resources Information Standards Committee (RIC 1997) were not used as these gangs include large mesh sizes that damage fish and increase incidental mortality.

A standard approach was followed when angling: two spinning rods were trolled simultaneously, one off each side of the boat travelling at 3 to 5 km/h (Appendix 5; Figure 3.1-3). Len Thompson's Yellow and Red (Five of Diamonds) and Red and White No. 4 (124 mm in length, 32 g in weight) lures were used with size 4/0 Gamakatsu Barbless Octopus hooks. Approximately 24 hours of angling was completed at an average speed of 4 km/h; a total of 99.6 km of angling transects were sampled. A Garmin CS60 GPS recorded the trolling routes and was used to mark the locations where fish were caught (Figure 3.1-3). Simultaneously, a Biosonics MX Aquatic Habitat Echosounder tracked water depth and highlighted congregations of fish.

Captured fish were identified to species, measured for fork length to the nearest 1 mm, and weighed to the nearest 1 g. The spawning condition of each fish was recorded, and then the fish was returned to the lake. Catch data were standardised as Catch-Per-Unit-Effort (CPUE). Gillnet data were calculated as the number of fish captured per 100 m^2 of net per hour. Angling data were calculated as the number of fish captured per rod per hour.

Figure 3.1-2
Distribution of Gillnet Set Locations in Doris Lake, Doris North Project, 2015

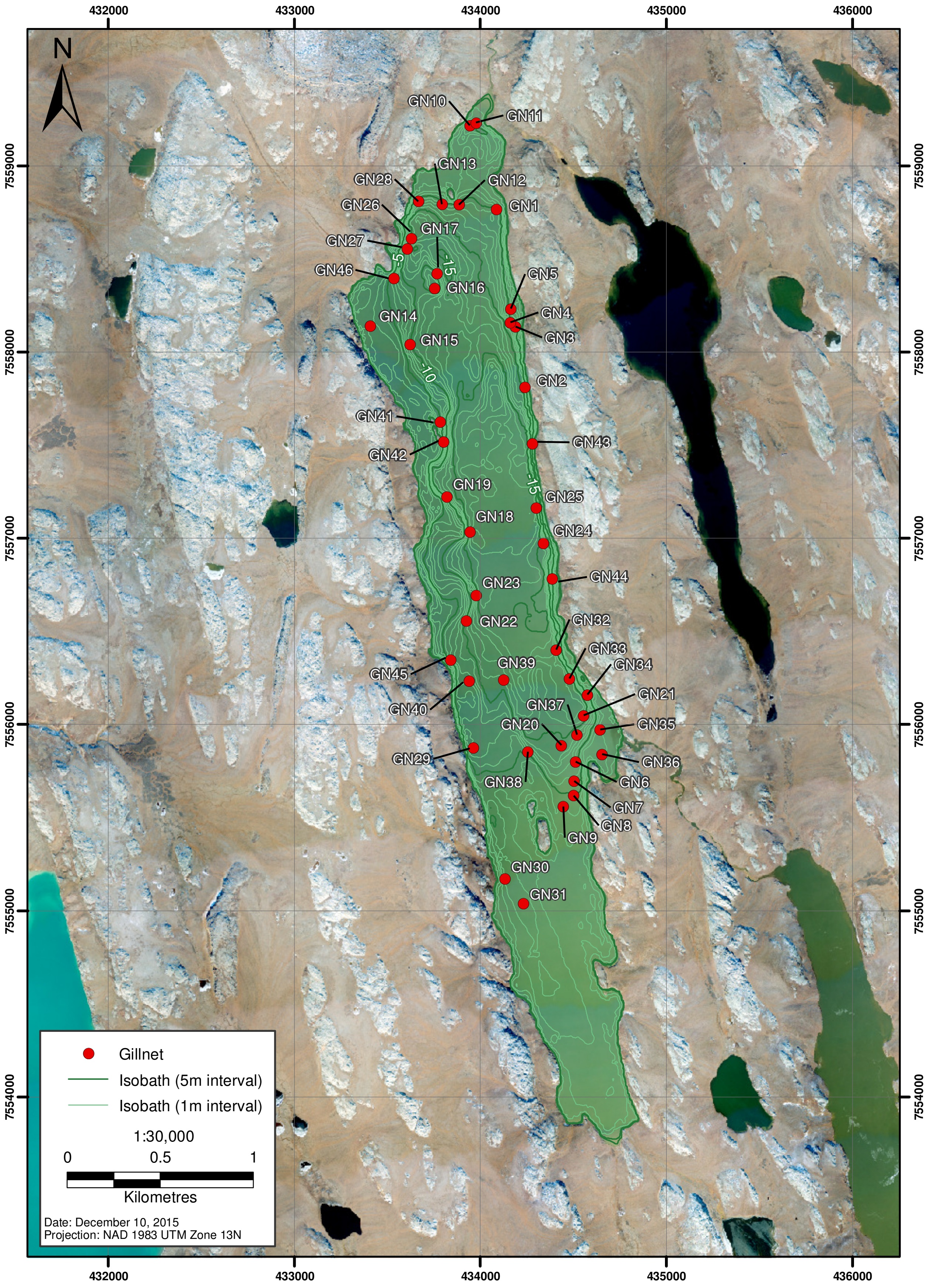
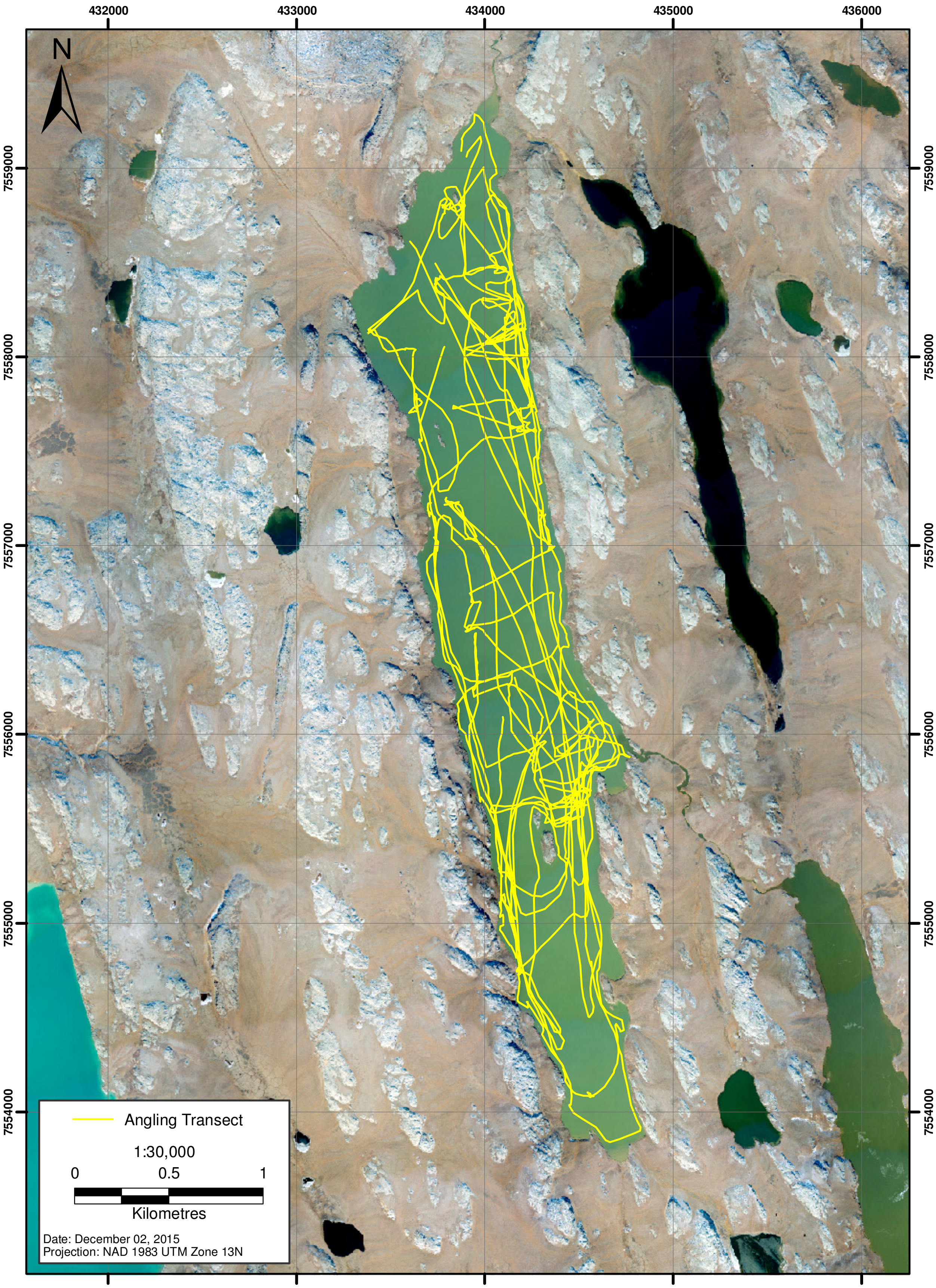


Figure 3.1-3
Angling Transects sampled in Doris Lake, Doris North Project, 2015



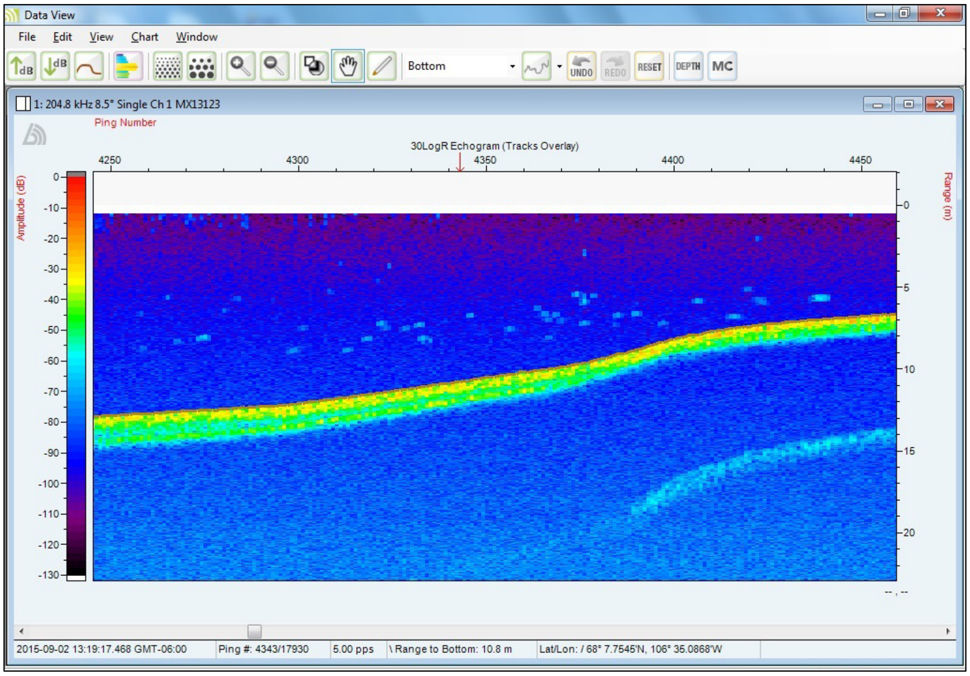


Plate 3.1-1. Echogram showing a cluster of fish located along a drop-off at the northeastern shoreline of Doris Lake, September 2, 2015.

3.2 Doris Creek and Little Roberts Outflow Fisheries Assessment

Hydraulic modelling predicted that mine-related drawdown of water from Doris Lake will reduce discharge in Doris Creek and Little Roberts Outflow and shorten the duration that these streams flow during the open-water season (ERM 2015e). The pathways of Effects Assessment concluded that that reductions in discharge may result in serious harm to fish, as defined by the *Fisheries Act* (1985). However, insufficient data were available to quantify the extent of these effects. Thus, hydrology, fish habitat, and fish community sampling programs were developed for Doris Creek and Little Roberts Outflow in 2015 to support the quantification of potential effects to fisheries in Doris Creek.

Fisheries fieldwork was designed to determine the quantity and quality of each meso-habitat type and then determine the densities of each fish species in each meso-habitat. However, a rainfall event in the latter half of July 2015 caused unseasonably high flow conditions in streams around the Project area. At the Doris Creek hydrology station, located downstream of Doris Lake, discharge was greater at that time than during spring freshet (3.24 m^3/s on July 29th whereas the freshet peak on June 15 was 2.92 m^3/s; ERM 2015c). In 2015, the average discharge in Doris Creek between July 15 and September 15 was 1.54 m^3/s, more than double the average discharge during the same period between 2009 and 2014 (0.60 m^3/s). These elevated in-stream discharge conditions made fish density sampling impossible and unsafe, so the fisheries component of the Doris Creek and Little Roberts Outflow Fisheries Assessment could not be completed. This component of the work has been rescheduled for the summer of 2016.

Two hydraulic models were developed to support the 2015 Doris Creek and Little Roberts Outflow Fisheries Assessment. The first was to assess flow connectivity and potential losses to fish habitat in Doris Creek with a 13% reduction in stream flow; and the second was to assess flow connectivity and potential losses to fish habitat in Little Roberts Outflow with a 6% reduction in stream flow. Methods and results are presented in the Doris Creek and Little Roberts Outflow Fisheries Assessment – Hydraulic Modelling Results memorandum (ERM 2015a).

3.3 Quality Assurance and Control

Quality assurance and quality control were implemented throughout of the field program to ensure accurate data collection and analysis. All data were reviewed at the end of each field day to ensure that sampling was complete and that the data were collected properly. Field notes were transcribed onto electronic spreadsheets upon return to the office, after which all such records were checked for accuracy against the field forms.

4. RESULTS AND DISCUSSION

4.1 Doris Lake Fisheries Assessment

4.1.1 Historical Data Review

Doris Lake is located in the Doris-Roberts watershed. The upper watershed drains through a series of lakes: Wolverine, Patch, P.O., Ogama, and then Doris Lake. Downstream of Doris Lake, Doris Creek flows over a 4 m high waterfall that creates a permanent barrier to upstream fish movement and isolates Doris Lake from ocean migrants. Doris Creek flows for 4 km and joins the Roberts Watershed in Little Roberts Lake (downstream of Roberts Lake). Little Roberts Lake Outflow flows from Little Roberts Lake northwest for approximately 1.5 km where it enters the ocean at Roberts Bay.

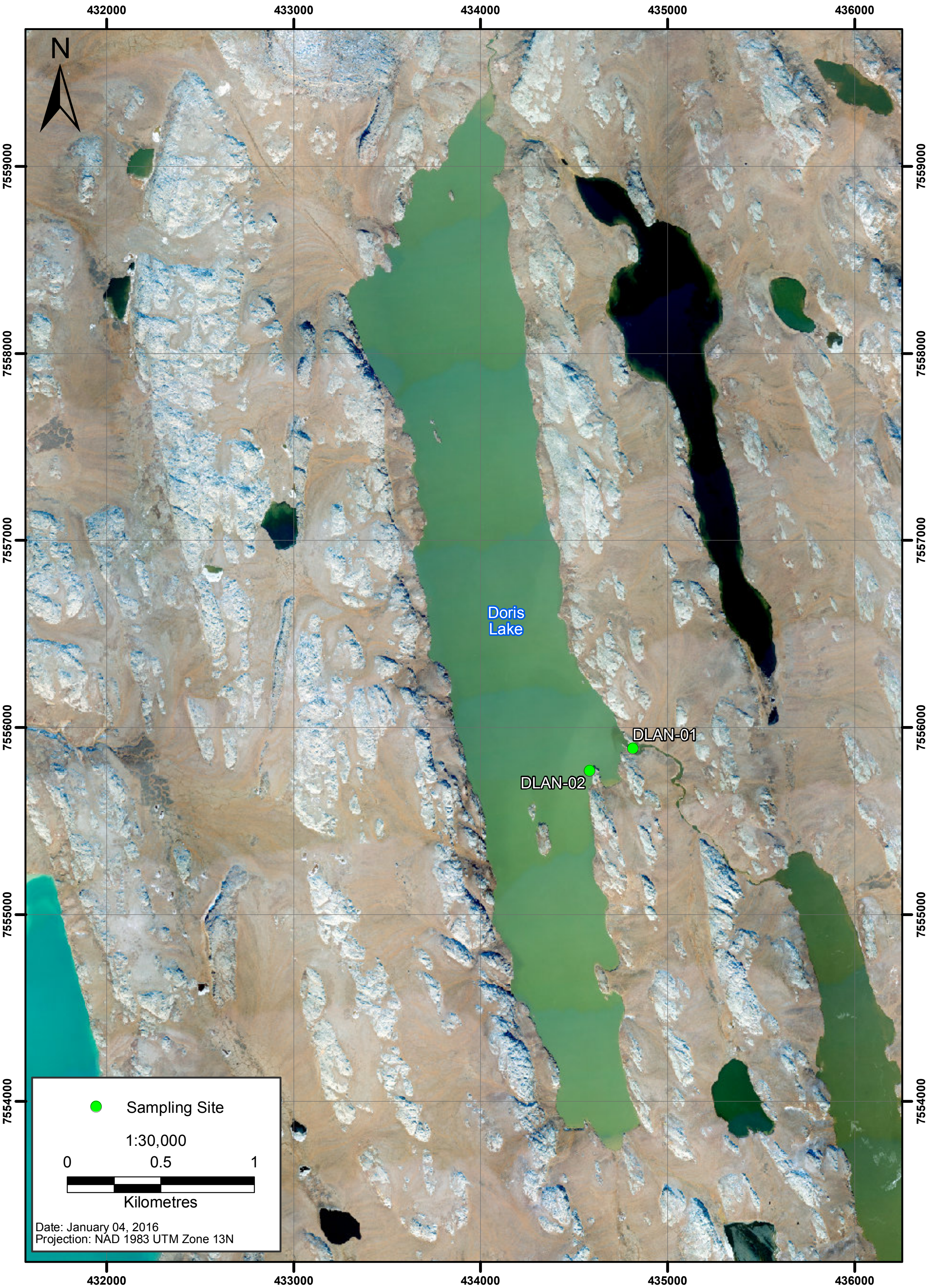
Doris Lake is a large, fish-bearing waterbody in the Doris-Roberts Watershed. It has a surface area of 337.8 ha, a volume of 27,275,094 m^3, an average depth of 8.1 m, and a maximum depth of 20.0 m (Rescan 2010a). The maximum length of the lake is 5.6 km, and the maximum width is 0.85 km.

The fish habitat and fish community of Doris Lake have been sampled extensively (Table 3.1-1), but these sampling programs lack the fine-scale resolution required to identify the locations and quality of spawning sites. Of the historic sampling events that have occurred, only one provides insight into spawning behaviour in Doris Lake. In 2005, 9.2 hours of angling targeted large-bodied species at two locations on the eastern shoreline of the lake (Figure 4.1-1). A total of 34 Lake Trout were angled at DLAN-02 in 6.6 hours of effort spread over three days (September 1, 2, and 4, 2005). In addition, five Lake Trout were angled at DLAN-01 in 2.6 hours of effort spread over three days (September 1, 5, and 16, 2005). All fish captured at DLAN-02 were in advanced stages of spawning, and of the fish captured at DLAN-01, one was ripe and one was spent. The concentration of ripe Lake Trout indicates that DLAN-02 is an active spawning site for that species. No ripe fish of other species were captured during the 2005 sampling program.

Of 17 Lake Trout stomachs collected from Doris Lake between 1995 and 1997, 94% of the diet was fish, primarily species within the genus *Coregonus* (RL&L/Golder 2002). Although not relevant to spawning habitat, this indicates that Lake Trout rely heavily on Lake Whitefish and Lake Cisco as prey. Impacts to these species from under-ice drawdown may have secondary effects on Lake Trout.

Figure 4.1-1

Angling Sites sampled in September 2005, Doris North Project



A review of wind direction data provided little insight on the location of potential spawning sites in Doris Lake. Between 2010 and 2015, the predominant wind directions were east and west, but the dominant direction in any one year varied (Figure 4.1-2). In 2010 wind direction was variable, when the predominant directions were northwest and east. In 2011, wind predominantly came from between the northeast and southeast, but a portion also came from due west (13%). The dominant wind direction in 2012 was due west, and subdominant directions were northwest and southeast. Eastern winds were dominant in September of 2013 and 2015, but western and northwestern winds dominated in 2014.

In any single year Lake Trout spawning site selection may be influenced by the dominant wind direction during the spawning period, but since the dominant wind direction varied substantially among years, wind direction cannot be used to reliably predict the locations long-term spawning sites. This is a similar finding to that of Callaghan, Blanchfield, and Cott (in press), which hypothesised that wind direction is too unpredictable to predict Lake Trout spawning sites in Boreal lakes.

Since egg and larval development is particularly slow in Arctic lakes due to cold water temperatures, fish may avoid spawning immediately below lake ice as water temperatures are typically coldest in that portion of the lake. A single study found that incubation time for Cisco increases from 37 days at 10°C to 236 days at 0.5°C, and the optimum temperature range for normal development is 2 to 8°C (Brooke and Colby 1970). This study also found that Cisco eggs remained unhatched when incubated at 0°C, and mortality was high at 0.5°C. In 11 years of under-ice sampling between 1998 and 2015, water temperatures throughout the water column typically ranged between 0°C and 2°C (Figure 4.1-3). In most years, water temperatures were coldest just beneath the ice, where mean temperature was 0.6°C at 2 m (including ice thickness). Water temperature increased with increasing depth to an average of 1.3°C at 6 m, beyond which it stayed somewhat consistent with increasing depth (Figure 4.1-3). These water temperatures are outside the optimal range for normal development reported by Brooke and Colby (1970), and temperatures close to lake ice resulted in high mortality. However, this work and virtually all other research on Cisco, Lake Whitefish, and Lake Trout captured fish from more southern latitudes, populations unaccustomed to extremely low temperatures. This provides little confidence when extending results to the Arctic, a region in which local fish populations have likely developed tolerances to extreme low water temperatures. But, even if Cisco in Doris Lake have adapted to spawn in cooler water temperatures, they would still likely avoid spawning in the coldest section of the lake, adjacent to the ice.

Dissolved oxygen concentrations typically decline during winter in ice-covered lakes, and water quality can deteriorate to levels that affect fish, particularly vulnerable early life stages (Garside 1959; Brooke and Colby 1980; BC MOE 1997). Depleted oxygen levels in deeper portions of lakes can limit the vertical range within which fish can spawn. A review of historical under-ice trends in Doris Lake found that in most years DO concentrations remain constant from surface ice to below 10 m water depth, where in most years levels drop below CCME guidelines for the protection of early-stage aquatic life (Figure 4.1-4; CCME 2014). This indicates that oxygen concentrations only limit the spawning range of fish in Doris Lake beyond water depths of 10 m.

Figure 4.1-2

September Wind Speed and Direction for Doris Lake Meteorological Station, 2010 to 2015, Doris North Project

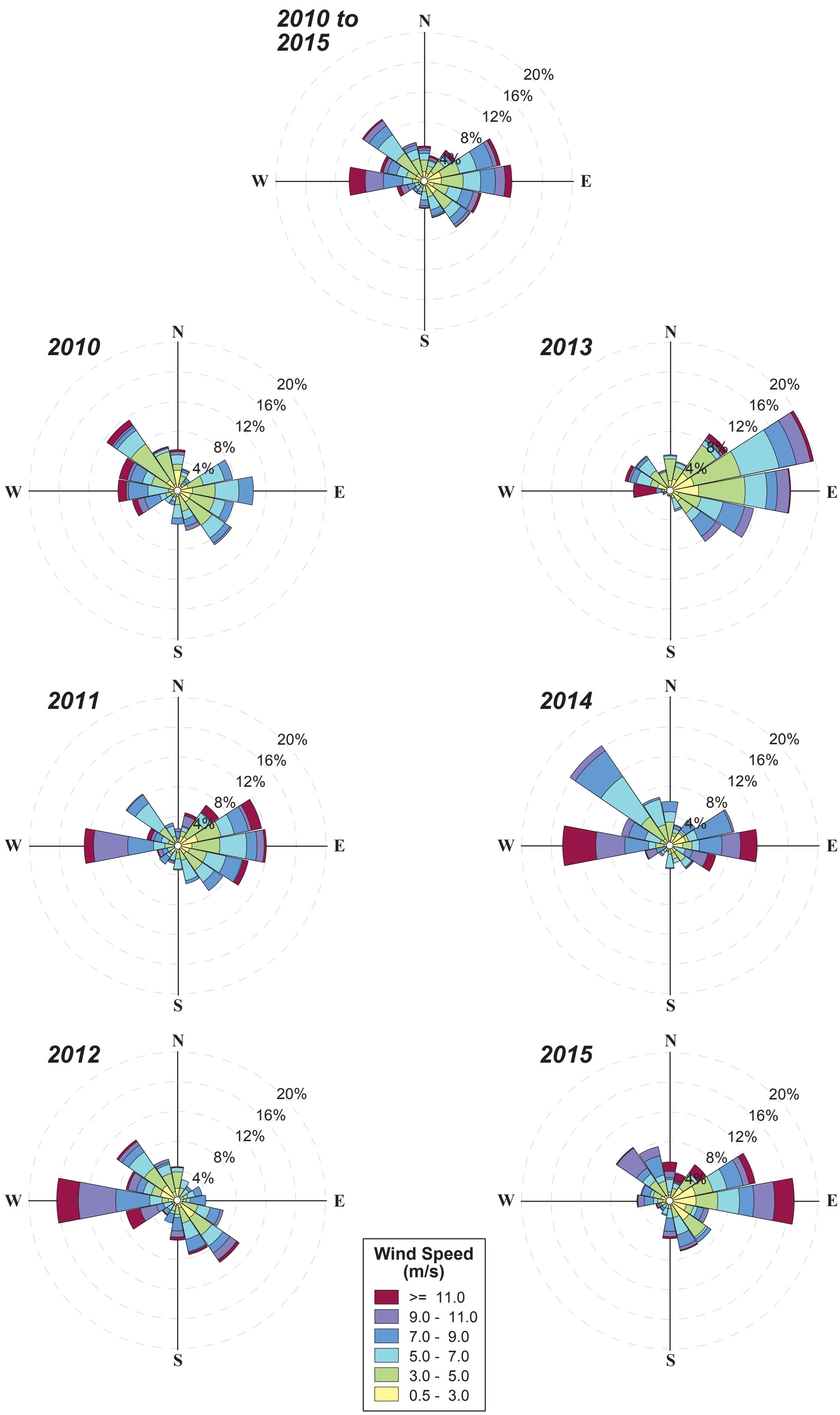


Figure 4.1-3

Under-ice Temperature Profiles,
Doris Lake North and South, 2009 to 2015, Doris North Project

ERM

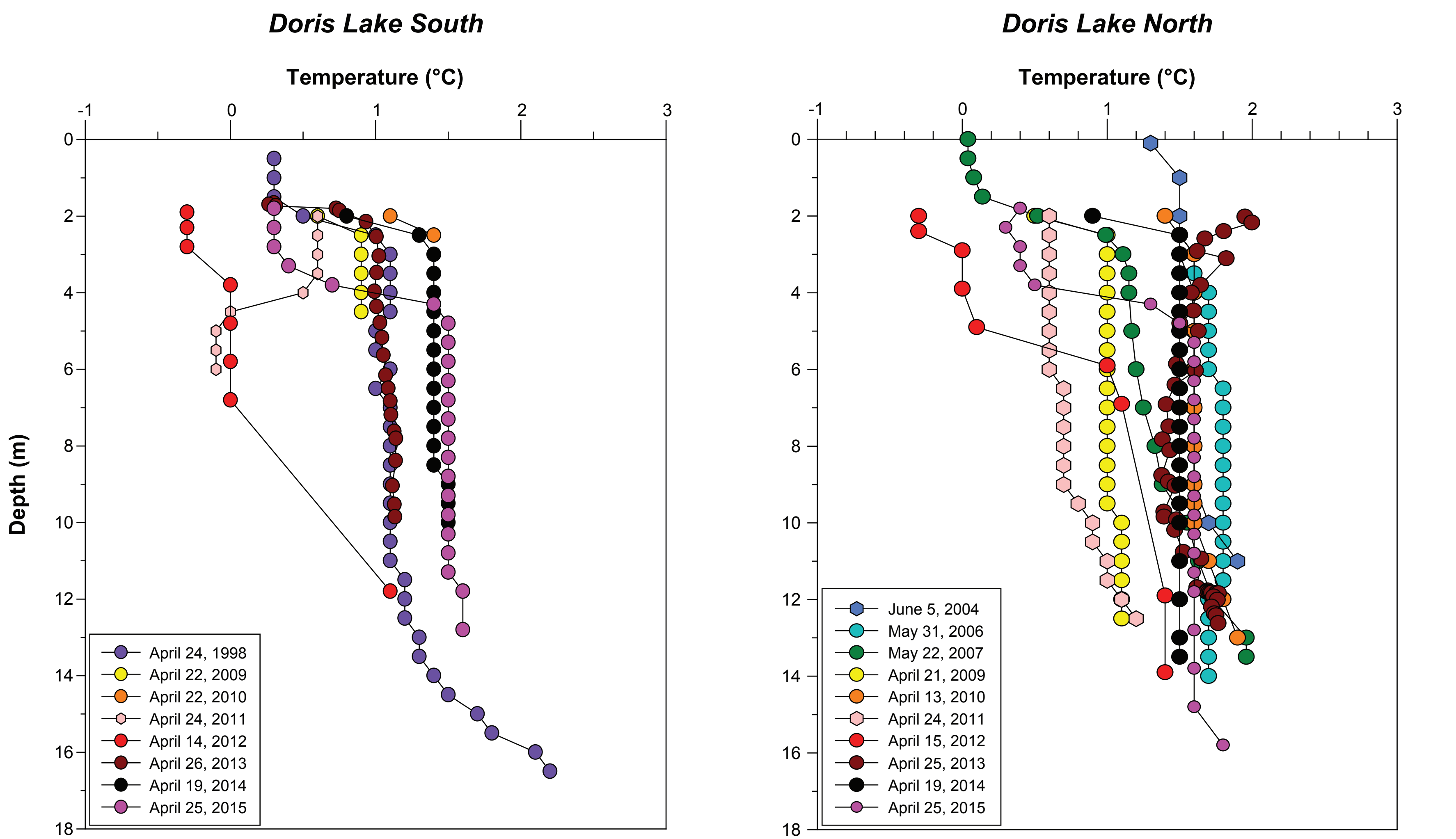
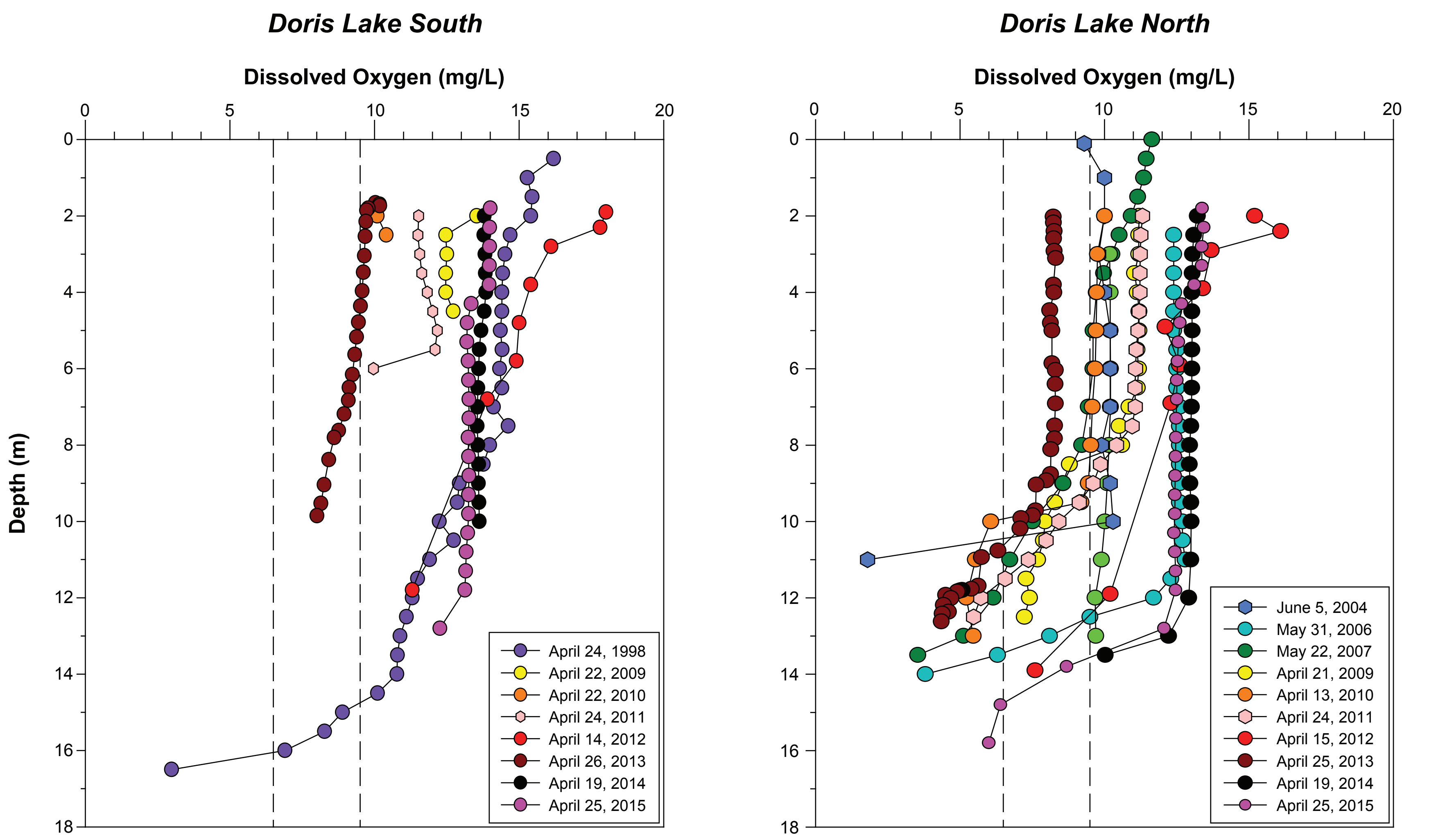


Figure 4.1-4

Under-ice Dissolved Oxygen Profiles,
Doris Lake North and South, 2009 to 2015, Doris North Project

ERM



Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg/L for early life stages; 6.5 mg/L for other life stages.

4.1.2 *Fish Habitat Assessment*

Habitat sampling identified locations where proposed under-ice drawdown related to mine development could affect Lake Trout, Lake Whitefish, and Cisco spawning sites. The section of the lake between 1 and 4 m water depth was divided into 47 contiguous habitat units and each unit was rated for its value as spawning habitat for each species (Figure 4.1-5; Appendix 2).

Lake Trout Spawning Habitat

Much of the study area (1 to 4 m water depth) does not offer suitable spawning habitat for Lake Trout (Figure 4.1-6). The shore of the lake contains a diverse mixture of substrates, but in 23 of 47 habitat units the substrate type transitions to fine sediments within the range of natural ice thickness and natural drawdown (Plate 4.1-1; Appendix 2). A total of 33 habitat units were classified as N (no spawning habitat present) due to abundant fine sediments and/or bedrock. The poor quality locations dominated by fine sediments are located primarily at the north and south of the lake, and poor-quality bedrock-dominated substrate is primarily along the east and west shores. Nine habitat units were classified as L (little suitable spawning habitat) where the units contained small pockets of suitable habitat, but overall habitat was of poor quality. The remaining five units were classified as H (extensive areas of good quality spawning habitat) as each had sloping cobble/boulder shoals that dropped off to deep water. Although all sites rated H do provide much of the physical requirements for spawning Lake Trout, fine sediments and dense periphyton growth were present at levels that could reduce the quality of those habitats at all locations except HU20 (Plate 4.1-2).

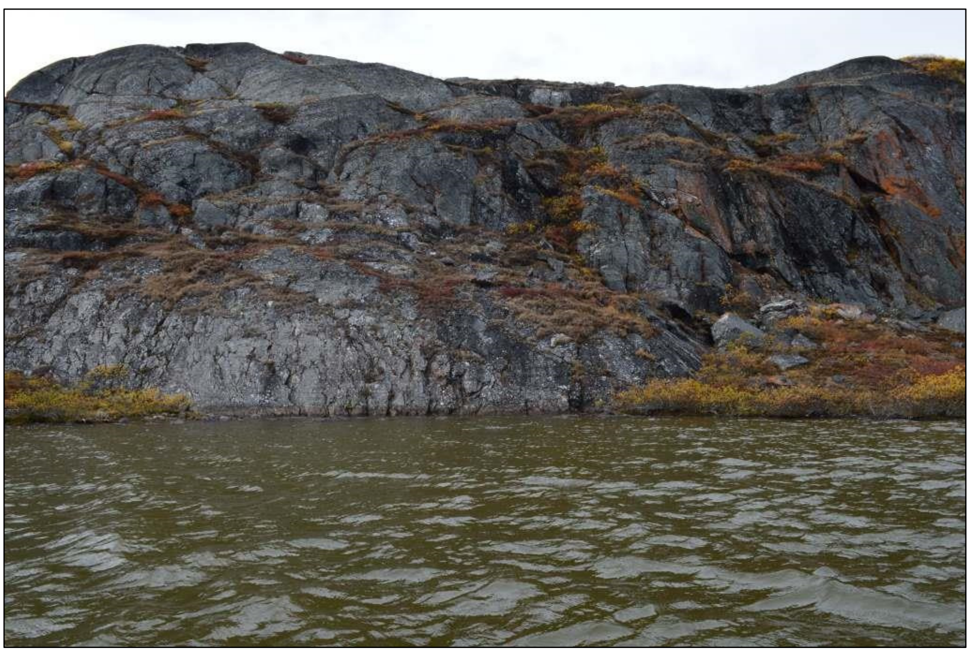


Plate 4.1-1. Steep bedrock in HU38 transitions abruptly to fine sediments at around 1.5 m water depth, September 7, 2015.

Figure 4.1-5

Habitat Units in the Littoral Zone of Doris Lake, Doris North Project

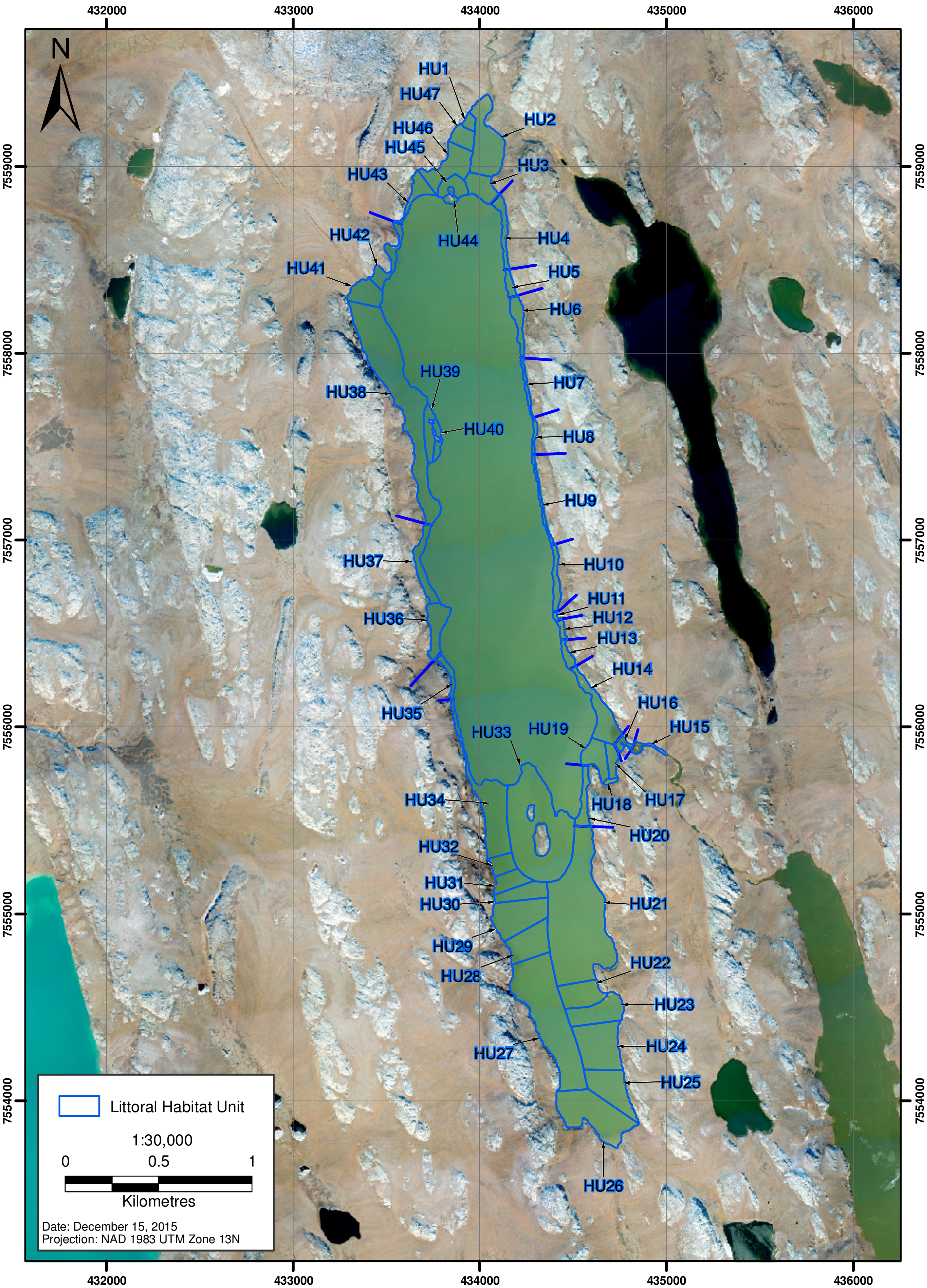


Figure 4.1-6
Spawning Value of Shallow-water Habitats for Lake Trout in Doris Lake, Doris North Project

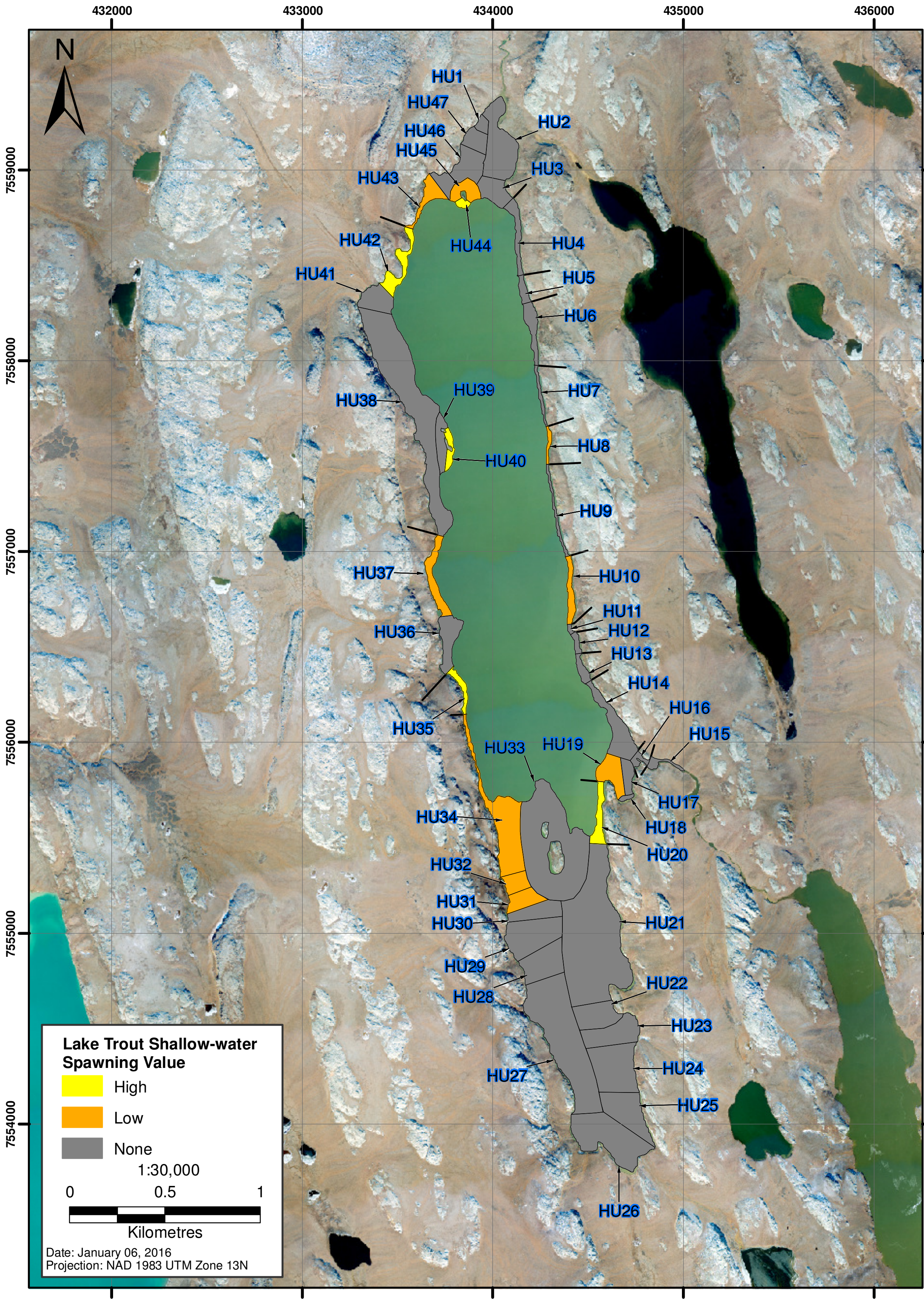


Plate 4.1-2. Heavy periphyton growth at HU42 suggests currents are minimal at this location, September 7, 2015.

Of the five locations categorized H for Lake Trout spawning, two were associated with islets (HU 40 and 44) and the remaining sites were associated with projections of land (HU 20, 35, and 42), which conforms to typical spawning site selection documented in the literature by this species (McPhail and Lindsay 1970; Scott and Crossman 1973). These sites were distributed around the lake but none were associated with shallow, gently sloping bays (e.g., north and south ends of the lake).

Lake Whitefish Spawning Habitat

Similar to the results for Lake Trout, the 1 to 4 m section of Doris Lake does not provide extensive spawning habitats for Lake Whitefish (Figure 4.1-7). A total of 42 of 47 habitat units were classified as N or L for Lake Whitefish spawning due to the predominance of bedrock and fine sediments. The remaining five units that were classified as H for Lake Whitefish spawning were the same five units that were rated H for Lake Trout due to the similar spawning preferences of these species. Compared to Lake Trout, two additional units were classified as L for Lake Whitefish because this species has a greater tolerance of fine sediments as a constituent of spawning substrates.

Cisco Spawning Habitat

Cisco spawning habitats in Doris Lake are concentrated in locations with small diameter substrates and low slopes, predominantly at the north and south ends of the lake (Figure 4.1-8). In addition, one bay on the western shoreline (HU41) and two bays on the eastern shore (HU15 and 18) were rated H, and several sites around the lake were rated L. Overall, 27 habitat units were rated N as Cisco spawning habitat, 13 were rated L, and seven were rated H.

Figure 4.1-7
Spawning Value of Shallow-water Habitats for Lake Whitefish in Doris Lake, Doris North Project

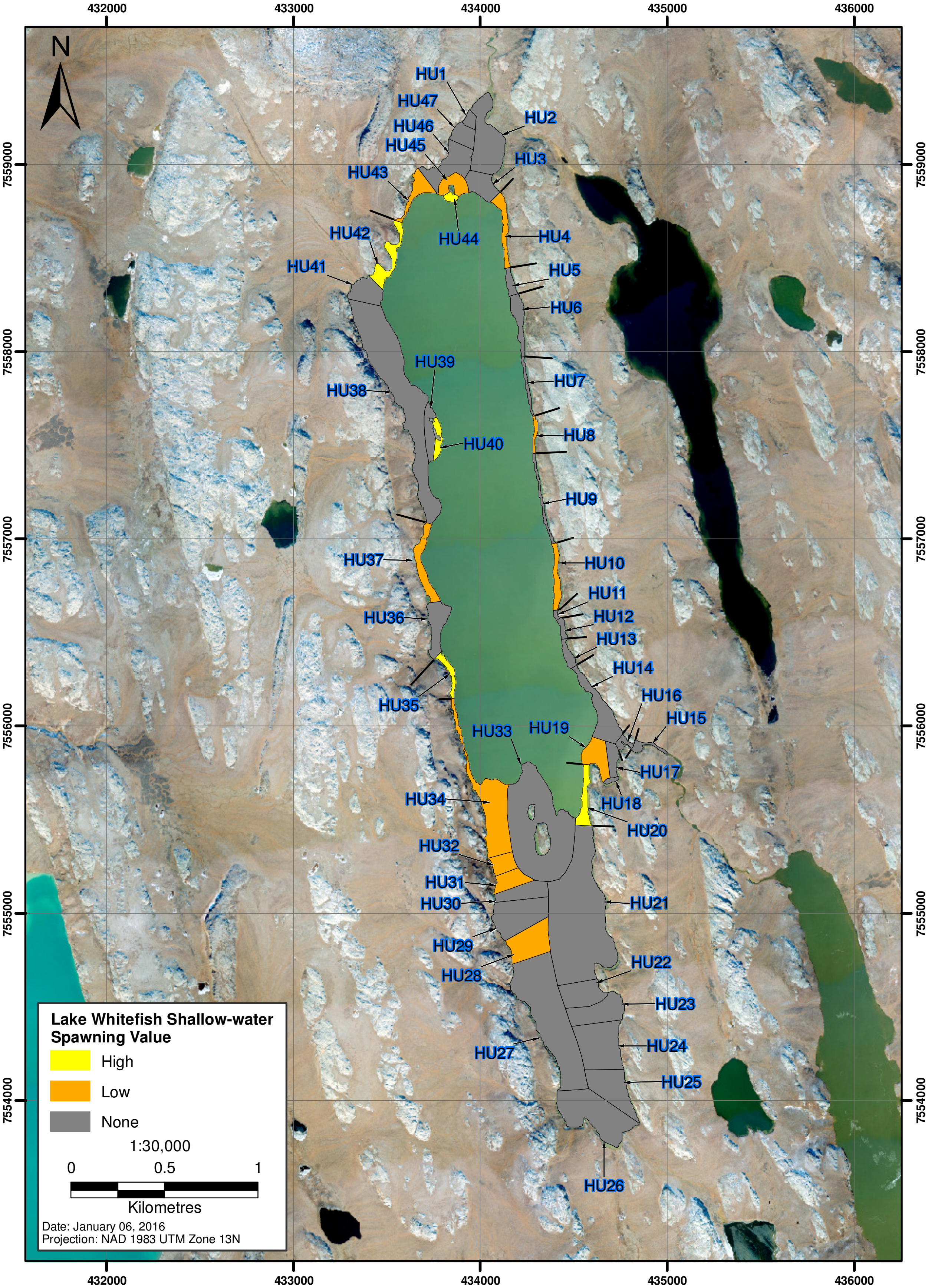
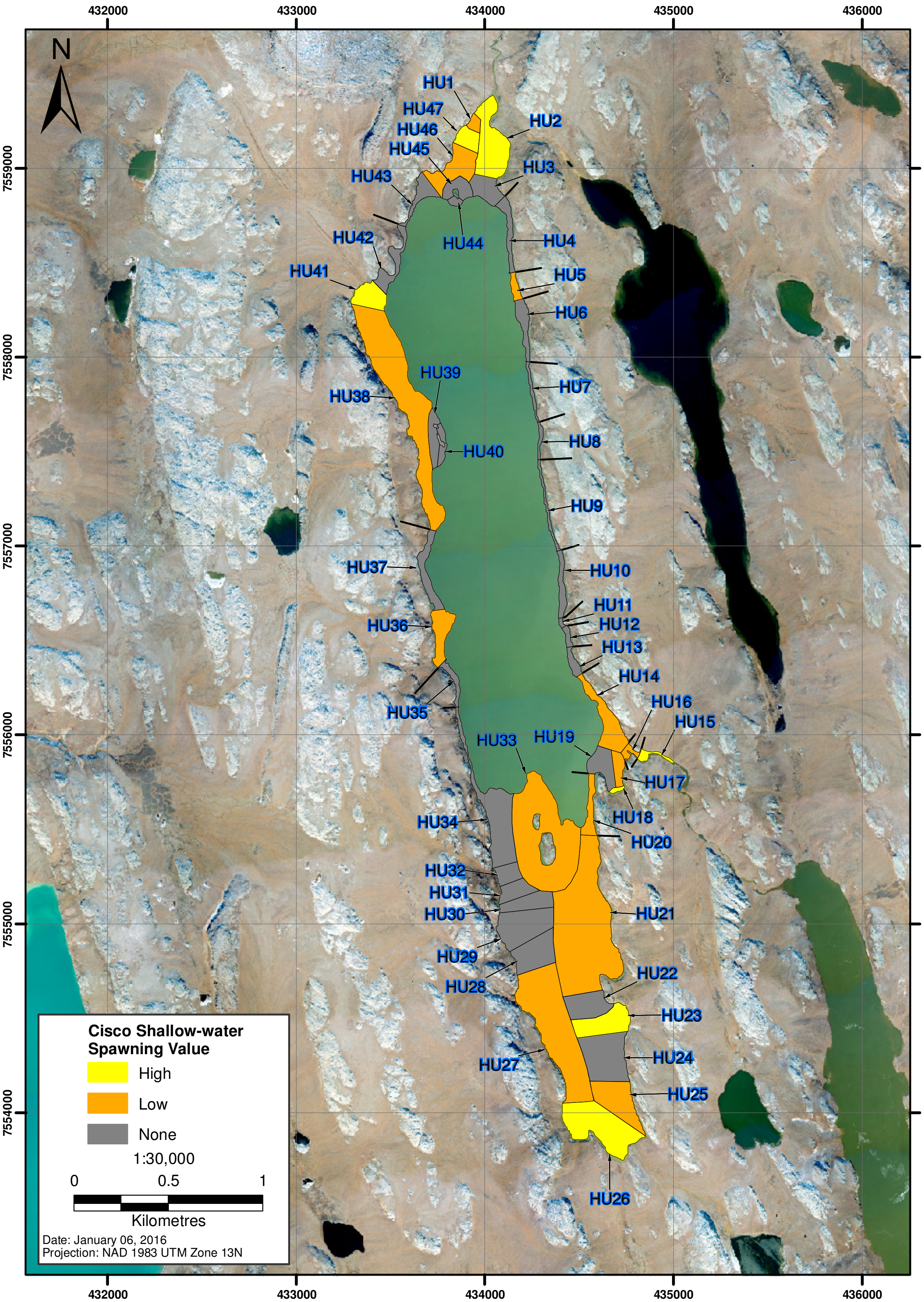


Figure 4.1-8
Spawning Value of Shallow-water Habitats for Cisco in Doris Lake, Doris North Project



Suitable Cisco spawning habitats in Doris Lake appear to be restricted to shallower sections of the lake than are the spawning habitats of Lake Trout and Lake Whitefish. Cisco are known to choose a range of spawning substrates, but preferentially select sand and gravel (Scott and Crossman 1973). Gravels are a minor constituent of the substrate around the periphery of Doris Lake, so much of the suitable spawning habitats are in sandy bays (Appendix 2). However, the substrate in many of the sandy bays transitions from sand to mud beyond 3 m, limiting the useful spawning habitat to the section of the lake adjacent to ice.

Deep-water Habitat Surveys

Deep-water video transects beyond the lower limit of the lake perimeter survey were completed at six locations including four of the habitat units rated H for Lake Trout and Lake Whitefish (HU20, HU35, HU40, and HU44; Figure 3.1-1). The quality of spawning habitats at each of these sites was as good as or better than the value around the natural limit of ice.

A deep-water survey (DS-1; Figure 3.1-1) was completed along the perimeter of HU20; the northern two thirds of this habitat unit provides ideal spawning habitat for Lake Trout and Lake Whitefish between 4 and 7 m water depths. In 1 to 4 m water depths, the substrate is dominated by bedrock and large boulders that are larger than the typical lakeshore spawning substrates selected by these species (Scott and Crossman 1973), but beyond 4 m substrate transitions to a mix of boulder, cobble, and gravel with little fine sediment content (Plate 4.1-3). This shoal is located on the outside of a point of land where it slopes to deeper water, which is a typical configuration for a spawning site for these species.

Plate 4.1-3. HU20 between 5 and 6 m water depth provides ideal habitat for spawning Lake Trout and Lake Whitefish, September 7, 2015.

An assessment around the southern group of islets in Doris Lake (DS-2) found that the lake bed stays shallow around the perimeter; inadequate water depths existed to complete a deep-water survey.

Substrate at HU35 (DS-3) is suitable for Lake Trout and Lake Whitefish spawning from 1 m to 8 m water depths; the steep sloping lakebed consists of a mix of bedrock, boulders, and cobbles. Beyond 8 m, fine sediments comprise a significant portion of the lakebed, limiting its use as spawning habitat.

Adjacent to HU40, a deep-water survey (DS-4) found an extensive area of suitable Lake Trout and Lake Whitefish spawning habitat between 4 and 12 m water depth. In this location, sediment became less abundant with depth, particularly to the east of the northern islet, where a shallow, lower-gradient shelf contained a higher portion of fine sediments. Lake Trout and Lake Whitefish may spawn through much of this site, but poor DO concentrations may prevent spawning below 10 m.

A deep-water habitat survey (DS-5) located ideal Lake Trout and Lake Whitefish spawning habitat at a submerged peak at the northern end of Doris Lake (Figure 3.1-1). This site appears to be a glacial deposit, where mainly boulder and cobble, with some gravel form a submerged peak. The site slopes to deeper water towards the centre of the lake. There is no associated shallow-water survey site for this location as the peak rises to between 7 and 8 m, beyond the lower limit of that survey.

A deep-water survey (DS-6) at the southern slope of the northernmost islet in Doris Lake (HU44; Figure 3.1-1) identified more suitable spawning habitats for Lake Trout and Lake Whitefish outside the range of the shallow-water survey. This site contains a shoal of bedrock, boulders, and cobble with a medium slope that drops off to deep water.

The deep-water surveys identified extensive good-quality spawning habitats for Lake Trout and Lake Whitefish beyond the range of potential mine-related under-ice drawdown. Since DO concentrations are suitable for spawning to 10 m and water temperatures are coldest near the ice and consistent thereafter, it is likely that these species do utilize habitats far beyond the narrow range where effects may occur (from 2.74 to 2.97 m). Little is known of the spawning habits of these species in the Arctic, but in more southern latitudes these species commonly spawn to 7 m and in some cases far deeper (McPhail and Lindsay 1970; Scott and Crossman 1973), so a spawning range of 3 to 10 m in Doris Lake would be consistent with the behaviour for these species in other locales.

4.1.3 Fish Community Assessment

In total, 95 Cisco, 35 Lake Trout, and 18 Lake Whitefish were captured in gillnets, of which 24 Lake Trout and one Lake Whitefish were in spawning condition (Appendix 4; Figure 4.1-9). Fourteen Lake Trout were captured by angling, seven of which were in spawning condition (Figure 4.1-10).

Figure 4.1-9

Distribution of Lake Trout captured in Gill Nets in Doris Lake, Doris North Project

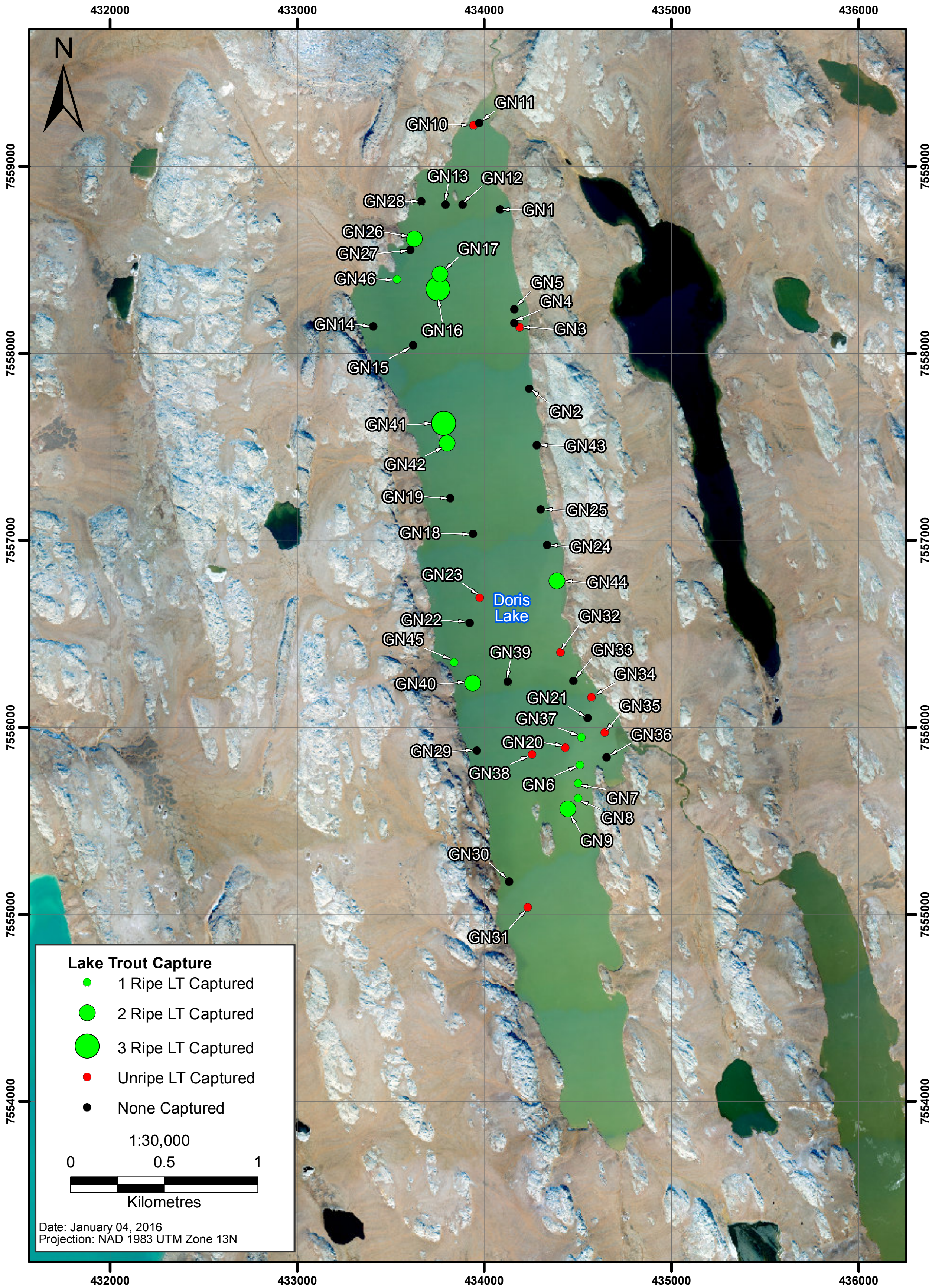
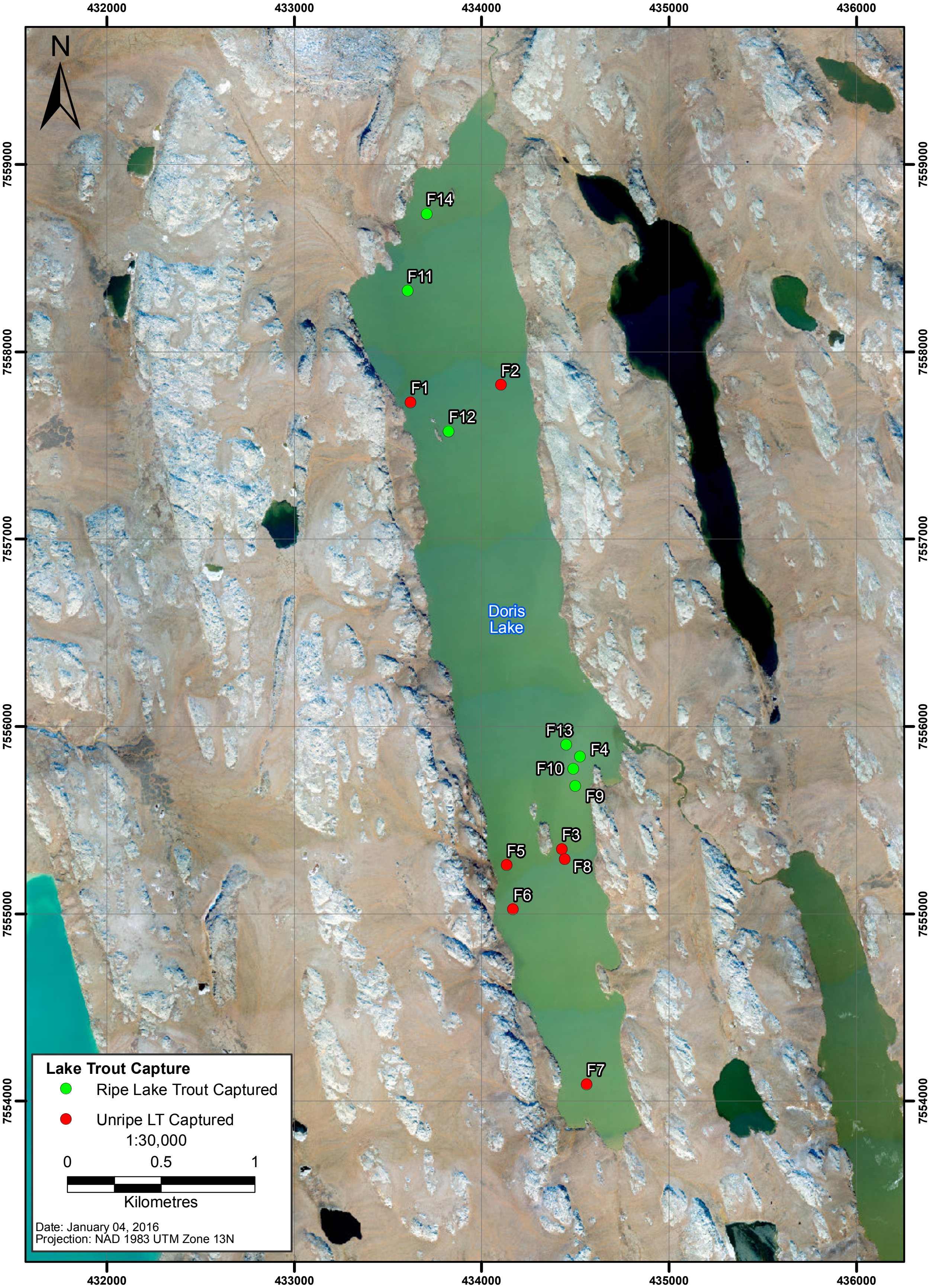


Figure 4.1-10

Distribution of Lake Trout captured by Angling in Doris Lake, Doris North Project



Ripe Lake Trout were closely associated with highly rated habitat units, confirming that spawning occurs at these locations. Mature Lake Trout captured in gillnets and by angling were clustered in six locations around Doris Lake (Table 4.1-1; Figure 4.1-9; Figure 4.1-10). All but one of these clusters were centred on habitat units that are highly rated for Lake Trout spawning (HU20, 35, 40, 42, and DS-5). Two ripe Lake Trout were also captured at HU10, located on the mid-eastern shoreline of the lake. This habitat unit was rated L for Lake Trout spawning because the distribution of quality habitat beyond 2 m water depth was intermittent, as fine sediments were abundant in places. However, the presence of two ripe Lake Trout either suggests that fish are spawning in this section of the lake despite suboptimal conditions, or that fish are spawning in deeper water beyond the end of the shallow-water survey (4 m). Unripe Lake Trout were distributed more uniformly around the lake, occurring in most habitat types (Figure 4.1-9 and 4.1-10).

Table 4.1-1. Summary of Ripe Lake Trout Captured in Gillnets and by Angling in Doris Lake, September 2015

Spawning Location	No. of Ripe Lake Trout Captured	Habitat Type	Lake Trout Habitat Value	Comments
HU10	2	Boulder cobble slope, patches of fines beyond 2 m	L	This unit was rated L due to the patchy distribution of suitable spawning substrate beyond 2 m
HU20	10	Bedrock/boulder to 4 m, boulder/cobble/gravel beyond	H	The highest number of ripe fish was captured at this site.
HU35	3	Bedrock/Boulder/Cobble	H	
HU40	6	Bedrock/Boulders/Cobble	H	Eastern slope of islets
HU42	4	Bedrock/Boulders	H	
Submerged Peak	6	Bedrock/Boulders/Cobble w. some gravel	H	

One habitat unit was rated H but no ripe Lake Trout were captured at that site. Two gillnets set at HU44 caught no fish, but one ripe fish was angled near to this location, possibly indicating that is does support spawning.

The highest density of ripe Lake Trout were captured at HU20, located on the eastern shoreline of the lake off a point of land (Figure 4.1-5, 4.1-9, and 4.1-10). Ideal Lake Trout and Lake Whitefish spawning habitats were recorded at this location, primarily in water depths beyond the range that might be affected by under-ice drawdown (optimal habitat was 4 to 7 m). In addition, 34 ripe Lake Trout were captured at this location during September 2005 sampling, confirming its importance as a Lake Trout spawning site.

Six ripe Lake Trout were captured at a submerged mound that peaks between 7 and 8 m. A deep-water survey at this site (DS-5) found ideal spawning habitat. These results indicate that Lake Trout do spawn at water depths greater than 7 m in Doris Lake.

The single ripe Lake Whitefish was captured at HU20, where habitat was rated H for Lake Whitefish spawning. The combination of quality habitat and one ripe fish suggests that this location may be utilized by Lake Whitefish for spawning.

No ripe Cisco were captured during current or historical sampling in Doris Lake. Cisco tend to spawn several weeks after Lake Trout and Lake Whitefish, at a time when lake ice is forming and sampling is extremely difficult (McPhail and Lindsay 1970). Given the lack of ripe Lake Whitefish and Cisco captures in both current and historical data, the distribution of spawning habitats for these species (with the possible exception of HU20) can be judged based only on physical attributes. Physical attributes are a useful component for determining the distribution of spawning sites, but the lack of catch data introduces uncertainty to these conclusions.

4.2 Doris Creek and Little Roberts Outflow Fisheries Assessment

The fisheries component of the Doris Creek and Little Roberts Outflow Fisheries Assessment could not be completed in 2015 due to unseasonably high stream discharge levels. This program component has been rescheduled to summer 2016.

The hydraulic assessment of Doris Creek and Little Roberts Outflow modelled reductions in stream discharge of 13% and 6% respectively. The largest reductions in discharge are observed during freshet, when fish passage is not impeded (unless velocity barriers exist) and fish populations are less vulnerable to effects of diminished flows. There is a riffle / boulder garden in Doris Creek that may naturally be an impediment to upstream-migrating adult fish in the fall, so a concurrent reduction in water level could exacerbate the severity of the restriction. However, there is no accessible overwintering habitat upstream of this location due to a large waterfall, so adult anadromous fish do not typically run up the creek in fall.

The hydraulic model predicted that potential reductions in connectivity through the riffle / boulder garden feature of Doris Creek will have little or no impact throughout a majority of the open water season (June - October; ERM 2015a).

Potential reductions in flow connectivity through the riffle / boulder garden feature of Little Roberts Outflow were also estimated to have limited impact throughout the majority of the open water season (June - October; ERM 2015a). Changes in maximum channel depth throughout Little Roberts Outflow are estimated to have a potential mean monthly reduction of 2.1%, a mean monthly decrease in top width of 0.26 m, and the greatest effects observed during freshet.

Adult anadromous Arctic Char and Lake Trout migrate upstream through Little Roberts Outflow in the fall when travelling to overwintering habitats in Roberts Lake. These large-bodied fish are at greater risk of stranding than are small-bodied fish. The hydraulic model predicted a reduction in maximum channel depth of 2 cm, or 3.5%, when the majority of upstream migration occurs in September.

Model estimates suggest that the anticipated flow reductions account for small reductions in maximum channel depth ($\leq$ 5%) and top width (<0.50 m) throughout the year in both Doris Creek and Little Roberts Outflow, and these reductions would have limited impact on flow connectivity. However, effects to fish are most likely to be caused by reductions in the open-water season of Doris Creek (average of 15 days) and Little Roberts Outflow (average of three days; ERM 2015e). Should Fisheries and Oceans Canada conclude that serious harm will result and offsetting is required, the results of the hydraulic model can be used to calculate the habitat-based effects to each stream. Once fisheries sampling is completed in summer 2016, the data can be combined with the hydraulic model results to predict the effects to productive capacity.

5. SUMMARY

Potential effects of the revised mine plan were assessed in the Amendment Application using historical baseline data, and recognised that data gaps existed that limited the certainty of the conclusions. The 2015 Doris Lake, Doris Creek, and Little Roberts Outflow Fisheries Assessment was completed to validate the assumptions and conclusions of the Effects Assessment.

5.1 Doris Lake Fisheries Assessment

The Effects Assessment presented in the Amendment Application (document P4-1) concluded that under-ice drawdown would likely not cause serious harm to fisheries in Doris Lake, primarily because the maximum effect is predicted to exceed the natural range in extreme years, and the short mine life (6 years) suggest the probability of this occurring is low. However, it also concluded that drawdown beyond the natural range could affect eggs and alevins of fall-spawning species.

Additional sampling in 2015 and a review of historical data were completed to validate the Effects Assessment of Doris Lake. Historical and current sampling identified locations where Lake Trout (and likely Lake Whitefish) spawn. Within the range of potential drawdown effects, five sites had high quality spawning habitat, but sampling at four of these sites found that spawning habitat value was as good or better in deeper water adjacent to the site. Ripe fish captured at a submerged peak in water greater than 7 m deep suggests that fish can and do exploit deeper spawning habitats. Since dissolved oxygen and water temperatures do not restrict spawning habitat suitability until at least 10 m, and since there is elevated risk associated with spawning within or immediately adjacent to the natural range of ice occurrence, it is unlikely that Lake Trout and Lake Whitefish would choose to spawn within 23 cm of the natural range of lake ice, and instead would select water depths between 3 and 10 m where conditions are more favourable. These results validate the conclusion of the Effects Assessment that drawdown within the natural range will not result in serious harm, as these local populations would be adapted to avoid these high-risk areas. In addition, it is unlikely that drawdown outside the natural range up to the maximum predicted level will affect Lake Trout or Lake Whitefish.

In concordance with the results of the Effects Assessment, mine-related drawdown that remains within the natural range is unlikely to cause serious harm to Cisco. However, this species may be vulnerable to under-ice drawdown beyond the natural range as suitable spawning habitats are primarily found in less than 3 m of water depth in Doris Lake. Historical water temperatures measured immediately below lake ice are within the range that causes mortality for this species in more southern latitudes, so Cisco in Doris Lake may be forced to spawn in deeper locations outside the range of predicted drawdown. Given the lack of Arctic-based literature, it is unclear if

Cisco in the Arctic spawn in deeper locations over coarser grained substrate or if they do spawn just beneath the ice and are more tolerant of low temperatures than fish from farther south.

5.2 Doris Creek and Little Roberts Outflow Fisheries Assessment

Fisheries sampling could not be completed in Doris Creek and Little Roberts Outflow in 2015 as unseasonably high flow conditions made data collection impossible and conditions unsafe for work. This component of the Doris Creek assessment has been rescheduled for summer 2016.

The hydraulic assessment of Doris Creek and Little Roberts Outflow modelled reductions in stream discharge to predict effects to fish passage and to fish habitat. The largest reductions in discharge are expected during freshet, when fish passage is not impeded and fish populations are less vulnerable to effects of diminished flows. The model predicted that potential reductions in connectivity through Doris Creek and Little Roberts Outflow will have little or no impact throughout a majority of the open water season including when adult Arctic Char and Lake Trout travel upstream through Little Roberts Outflow in the fall.

Model estimates suggest that the anticipated flow reductions will account for small reductions in habitat, as maximum channel depth decreases by less than 5% and top width decreases by less than <0.50 m throughout the year in both Doris Creek and Little Roberts Outflow.

The Amendment Application Effects Assessment predicted that there may be reductions in the open-water season of Doris Creek and Little Roberts Outflow by 15 and 3 days, respectively. Should Fisheries and Oceans Canada conclude that serious harm will result and offsetting is required, the results of the hydraulic model can be used to calculate the habitat-based effects to each stream. Once fisheries sampling is completed in summer 2016, the data can be combined with the hydraulic model results to predict the effects to productive capacity.

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— Appendix 1 —

Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AEMP	Aquatic Effects Monitoring Program
BC MOE	British Columbia Ministry of Environment
CCME	Canadian Council of Ministers of the Environment
CPUE	Catch-Per-Unit-Effort
DS	Deep-water Survey
ERM	ERM Consultants Canada Ltd.
H	Habitat rating: extensive areas of good quality spawning habitat
HU	Habitat Unit
L	Habitat rating: little suitable spawning habitat (e.g., isolated pockets, poor quality habitat)
N	Habitat rating: no suitable spawning habitat in the habitat unit
NIRB	Nunavut Impact Review Board
NWB	Nunavut Water Board
the Amendment Application	Doris North Project: Revisions to TMAC Resources Inc. Amendment Application No. 1 of Project Certificate No. 003 and Water License 2AM-DOH1323.
the Program	The Doris Lake, Doris Creek and Little Roberts Outflow Fisheries Assessment
the Project	The Doris North Project
the Project Certificate	NIRB Project Certificate No. 003
TMAC	TMAC Resources Inc.
the Type A Water Licence	NWB Type A Water Licence No. 2AM-DOH1323

— Appendix 2 —

Doris Lake Littoral Habitat Units, Doris North Project, 2015

Appendix 2. Doris Lake Littoral Habitat Units, Doris North Project, 2015

Habitat Unit	GPS Start Identifier	UTM Coordinates (Zone 13 W)		GPS End Identifier	UTM Coordinates (Zone 13 W)		Substrate Stratum 1	Slope	Substrate Stratum 2 (if present)	Slope	Habitat Unit Length (m)
		Easting	Northing		Easting	Northing					
1	884	433956	7559280	894	433918	7559206	Bedrock	high	Fines beyond 1 m	low	80
2	874	434036	7558954	884	433956	7559280	Fines	low			550
3	864	434072	7558821	874	434036	7558954	Bedrock	high	Fines beyond 1 m	low	135
4	854	434147	7558448	864	434072	7558821	Boulder/Cobble	high	embedded boulder cobble beyond 2 m	high	400
5	844	434187	7558309	845	434147	7558448	Bedrock	high	Fines beyond 1 m	low	145
6	834	434223	7557950	844	434187	7558309	Boulder/cobble/fines	high	fines w some B,C beyond 2m	medium	330
7	824	434279	7557654	834	434223	7557950	Bedrock	high			325
8	814	434278	7557456	824	434279	7557654	Bedrock with boulders	high			200
9	804	434364	7556966	814	434278	7557456	Bedrock	high			500
10	794	434397	7556620	804	434364	7556966	Boulder Cobble	high	Fines beyond 2m in places, shoal in others.	high	360
11	784	434415	7556568	794	434397	7556620	Bedrock	high			50
12	774	434445	7556466	784	434415	7556568	Boulder Cobble	high	Fines beyond 2m	medium	110
13	524	434497	7556315	774	434445	7556466	Bedrock/Fines	high			160
14	524	434497	7556315	534	434786	7555912	Bedrock	high	Fines beyond 2m	low	465
15	534	434786	7555912	544	434818	7555890	Fine Sediment	low			200
16	544	434818	7555890	554	434733	7555886	Bedrock	high	Fines beyond 1 m	low	135
17	554	434733	7555886	564	434737	7555739	Bedrock/Boulder	high	Fines beyond 1.5 m	low	180
18	564	434737	7555739	574	434682	7555703	Fine sediment	low			85
19	574	434682	7555703	584	434573	7555795	Bedrock	high	Fines beyond 1.5 m	low	230
20	584	434573	7555795	594	434577	7555469	Bedrock/Boulder	high			320
21	764	434607	7554649	594	434577	7555469	Boulder/Cobble/Gravel/Fines	high	Fines beyond 1 m	low	875
22	754	434661	7554519	764	434607	7554649	Bedrock	high	Fines beyond 1 m	low	120
23	744	434726	7554424	754	434661	7554519	Fines	low			130
24	734	434750	7554165	744	434726	7554424	Boulder/Cobble/Gravel/Fines	high	Fines beyond 2m	low	260
25	724	434810	7553897	734	434750	7554165	Bedrock/boulders	high	Fines beyond 1 m	low	240
26	714	434459	7554045	724	434810	7553897	Fines	low			425
27	704	434189	7554737	714	434459	7554045	Bedrock	high	Fines beyond 1 m	low	745
28	674	434146	7554864	704	434189	7554737	Boulder/Cobble/w some Fines	high	Fines beyond 3 m	low	140
29	664	434086	7555060	674	434146	7554864	Boulder/Cobble/Fines	high	Fines beyond 2m	low	205
30	654	434082	7555105	664	434086	7555060	Bedrock	high	Fines beyond 1.5m	low	55
31	644	434102	7555206	654	434082	7555105	Boulder/Cobble/Fines	medium			100
32	634	434083	7555307	644	434102	7555206	Cobble/Boulder	medium			105
33	684	434402	7555349	694	434268	7555355	Bedrock/w some boulders	high	Fines beyond 1.5m	low	990
34	624	433856	7556147	634	434083	7555307	Bedrock with boulders	high	Fines beyond 2.5 m, some small patches of shoal	low	890
35	974	433768	7556371	624	433856	7556147	Bedrock/Boulders/Cobble	high			260
36	964	433729	7556660	974	433768	7556371	Bedrock/boulder/cobble/fines	high	Fines beyond 1.5 m	medium	290
37	954	433736	7557081	964	433729	7556660	Bedrock with boulders	high			450
38	944	433311	7558278	954	433736	7557081	Bedrock	high	Fines beyond 1.5 m	low	1,275
39	1005	433776	7557654	1015	433776	7557654	Bedrock/Fines, w some Boulders/Cobble	medium			290
40	1005	433754	7557492	1015	433754	7557492	Bedrock/Boulders/Cobble	high			230
41	934	433427	7558383	944	433311	7558278	Fines	low			160
42	924	433548	7558701	934	433427	7558383	Bedrock/Boulders	high			415
43	914	433666	7558985	924	433548	7558701	Bedrock/Boulders wih fines	high			300
44	984	433874	7558834	994	433810	7558832	Bedrock/Boulders/Cobble	high			70
45	984	433874	7558834	994	433810	7558832	Bedrock/Boulders/Cobble	medium			220
46	904	433878	7559121	914	433666	7558985	Bedrock/boulders	high	Fines beyond 1.5 m	medium	285
47	894	433918	7559206	904	433878	7559121	Fines w some boulder/cobble embedded	medium			110

Notes

N = None, L = Low, H = High

Appendix 3.1-1. Doris Lake Littoral Habitat Units, Doris North Project, 2015

Habitat Unit	Habitat Unit Area (m^2)	Lake Trout Spawning Potential	Lake Whitefish Spawning Potential	Cisco Spawning Potential	Comments
1	4,856	N	N	L	
2	51,647	N	N	H	Includes lake outflow. Large sandy bay, but transitions to mud at 2.5 or 3 m.
3	18,857	N	N	N	Bedrock outcrop
4	12,630	N	L	N	
5	5,484	N	N	L	
6	13,307	N	N	N	
7	4,616	N	N	N	
8	3,121	L	L	N	Primarily bedrock
9	6,048	N	N	N	
10	10,558	L	L	N	
11	1,121	N	N	N	
12	3,289	N	N	N	
13	6,074	N	N	N	
14	31,673	N	N	L	
15	4,585	N	N	H	Inflow
16	3,945	N	N	L	
17	9,569	N	N	L	
18	1,830	N	N	H	Sandy bay, but mud beyond 3 m
19	20,240	L	L	N	Peninsula
20	12,878	H	H	L	
21	198,058	N	N	L	
22	28,895	N	N	N	
23	33,513	N	N	H	Transitions to mud between 2 and 3 m
24	55,372	N	N	N	
25	40,058	N	N	L	
26	71,210	N	N	H	Sandy bay at southern end of lake, becomes mud at 3 m.
27	133,118	N	N	L	
28	34,700	N	L	N	
29	46,712	N	N	N	
30	21,556	N	N	N	
31	15,440	L	L	N	
32	12,189	L	L	N	
33	146,042	N	N	L	Entire perimeter of Southern group of islets
34	61,931	L	L	N	Mostly bedrock
35	6,680	H	H	N	
36	22,125	N	N	L	Looks good from shore but good substrate ends at a shallow depth
37	17,914	L	L	N	Mostly bedrock
38	147,225	N	N	L	Large section of eastern shoreline where steep bedrock transitions quickly to fine sediments
39	13,753	N	N	N	West side of islands. Mostly flat.
40	6,385	H	H	N	East side of islands
41	19,980	N	N	H	Sandy bay
42	16,449	H	H	N	Boat launch
43	13,379	L	L	N	
44	2,921	H	H	N	South side of islands
45	13,250	L	L	N	North side of islands
46	33,393	N	N	L	
47	12,278	N	N	H	

Notes

N = None, L = Low, H = High

— Appendix 3 —

Deep-water Habitat Surveys, Doris North Project, 2015

Appendix 3. Deep-water Habitat Surveys, Doris North Project, 2015

Deepwater Survey	Adjacent Shallow-water Habitat Unit	UTM Coordinates (Zone 13 W)		UTM Coordinates (Zone 13 W)		Habitat Type	Substrate	Slope	Depth (m)	Lake Trout Spawning Potential	Lake Whitefish Spawning Potential	Cisco Spawning Potential	Comments
		Easting	Northing	Easting	Northing								
DS-1	HU20	434637	7555814	434534	7555497	Point of land	Boulder/cobble/gravel	Medium-high	4 - 8 m	H	H	N	
DS-2	HU33	434350	7555255	434250	7555639	Islets	Bedrock/fines	Low	2 - 3 m	N	N	L	No deep water present around these islets
DS-3	HU35	433787	7556368	433893	7556186	Drop-off	Bedrock/Boulders/Cobble	High	4 - 9 m	H	H	N	
DS-4	HU40	433755	7557456	433717	7557718	Islets	Bedrock/Boulders/Cobble	High	4 - 12 m	H	H	N	
DS-5	No associated HU	433710	7558438	433720	7558247	Submerged peak	Bedrock/Boulders/Cobble w. some gravel	High	7 - 10 m	H	H	N	
DS-6	HU44	433826	7558781	433857	7558926	Islets	Bedrock/Boulders/Cobble	High	4 - 8 m	H	H	N	

Notes

N = None, L = Low, H = High

— Appendix 4 —

Gillnet Data from Doris Lake, Doris North Project, 2015

Appendix 4. Gillnet Data from Doris Lake, Doris North Project, 2015

	UTM Coordinates (Zone 13 W)							Lake Trout		Cisco		Lake Whitefish		Total		
Gillnet Identifier	Easting	Northing	Date	Time In	Time Out	Duration (h)	Water Depth (m)	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	Comments
GN1	434085	7558770	2-Sep-15	12:20	12:45	0:25	5	0	0.0	0	0.0	1	6.6	1	6.6	
GN2	434240	7557813	2-Sep-15	12:23	12:55	0:32	7	0	0.0	1	5.1	0	0.0	1	5.1	
GN3	434190	7558140	2-Sep-15	13:21	14:06	0:45	5	1	3.7	0	0.0	0	0.0	1	3.7	
GN4	434161	7558162	2-Sep-15	14:03	15:05	1:02	7	0	0.0	1	2.7	0	0.0	1	2.7	
GN5	434163	7558236	2-Sep-15	14:27	15:12	0:45	4	0	0.0	0	0.0	0	0.0	0	0.0	
GN6	434512	7555801	2-Sep-15	16:00	17:03	1:03	5	1	2.6	5	13.1	0	0.0	6	15.7	Lake Trout Ripe
GN7	434502	7555701	2-Sep-15	16:05	17:20	1:15	6	1	2.2	3	6.6	1	2.2	5	11.0	Lake Trout and Lake Whitefish Ripe
GN8	434502	7555623	2-Sep-15	17:35	18:20	0:45	4	1	3.7	2	7.3	0	0.0	3	11.0	Lake Trout Ripe
GN9	434446	7555563	2-Sep-15	17:48	18:40	0:52	4	2	6.3	3	9.5	0	0.0	5	15.8	Lake Trout Ripe
GN10	433943	7559218	3-Sep-15	15:15	16:01	0:46	3	1	3.6	0	0.0	0	0.0	1	3.6	
GN11	433974	7559233	3-Sep-15	15:20	16:15	0:55	4	0	0.0	1	3.0	1	3.0	2	6.0	
GN12	433884	7558795	3-Sep-15	16:18	17:10	0:52	6	0	0.0	0	0.0	0	0.0	0	0.0	
GN13	433793	7558796	3-Sep-15	16:22	17:15	0:53	6	0	0.0	2	6.2	0	0.0	2	6.2	
GN14	433407	7558144	3-Sep-15	17:24	18:08	0:44	3	0	0.0	0	0.0	0	0.0	0	0.0	
GN15	433620	7558044	3-Sep-15	17:28	18:16	0:48	9	0	0.0	1	3.4	1	3.4	2	6.9	
GN16	433753	7558345	4-Sep-15	8:20	9:10	0:50	9	3	9.9	1	3.3	1	3.3	5	16.4	Lake Trout Ripe
GN17	433763	7558424	4-Sep-15	8:25	9:25	1:00	11	2	5.5	3	8.2	1	2.7	6	16.4	Lake Trout Ripe
GN18	433941	7557036	4-Sep-15	13:50	14:52	1:02	16	0	0.0	1	2.7	1	2.7	2	5.3	
GN19	433818	7557225	4-Sep-15	13:55	15:00	1:05	11	0	0.0	3	7.6	0	0.0	3	7.6	
GN20	434434	7555891	4-Sep-15	15:06	16:10	1:04	9	1	2.6	4	10.3	1	2.6	6	15.4	
GN21	434554	7556051	4-Sep-15	15:10	16:22	1:12	11	0	0.0	2	4.6	0	0.0	2	4.6	
GN22	433922	7556561	4-Sep-15	16:32	17:22	0:50	10	0	0.0	3	9.9	0	0.0	3	9.9	
GN23	433976	7556696	4-Sep-15	16:37	17:27	0:50	14	1	3.3	2	6.6	0	0.0	3	9.9	
GN24	434337	7556977	4-Sep-15	17:40	18:25	0:45	14	0	0.0	0	0.0	0	0.0	0	0.0	
GN25	434301	7557167	4-Sep-15	17:44	18:31	0:47	15	0	0.0	0	0.0	0	0.0	0	0.0	
GN26	433626	7558611	6-Sep-15	15:12	16:03	0:51	11	2	6.4	4	12.9	0	0.0	6	19.3	Lake Trout Ripe
GN27	433606	7558555	6-Sep-15	15:14	16:10	0:56	10	0	0.0	0	0.0	0	0.0	0	0.0	
GN28	433665	7558812	6-Sep-15	15:25	16:15	0:50	6	0	0.0	0	0.0	0	0.0	0	0.0	
GN29	433960	7555877	6-Sep-15	16:25	17:20	0:55	7	0	0.0	2	6.0	0	0.0	2	6.0	
GN30	434133	7555175	6-Sep-15	16:35	17:28	0:53	3	0	0.0	1	3.1	0	0.0	1	3.1	
GN31	434232	7555039	6-Sep-15	16:40	17:32	0:52	4	1	3.2	2	6.3	0	0.0	3	9.5	
GN32	434407	7556403	7-Sep-15	8:37	10:02	1:25	11	1	1.9	7	13.5	2	3.9	10	19.3	
GN33	434477	7556249	7-Sep-15	8:41	10:12	1:31	11	0	0.0	4	7.2	0	0.0	4	7.2	
GN34	434574	7556162	7-Sep-15	8:47	10:27	1:40	5	2	3.3	4	6.6	3	4.9	9	14.8	
GN35	434643	7555974	7-Sep-15	10:38	11:38	1:00	2	2	5.5	0	0.0	0	0.0	2	5.5	
GN36	434654	7555842	7-Sep-15	10:48	11:50	1:02	2	0	0.0	1	2.7	0	0.0	1	2.7	
GN37	434519	7555948	7-Sep-15	10:53	12:00	1:07	9	1	2.5	2	4.9	0	0.0	3	7.4	Lake Trout Ripe
GN38	434254	7555856	7-Sep-15	12:10	13:12	1:02	6	1	2.7	9	23.9	0	0.0	10	26.5	
GN39	434126	7556244	7-Sep-15	12:15	13:30	1:15	11	0	0.0	5	11.0	0	0.0	5	11.0	
GN40	433937	7556237	7-Sep-15	12:20	13:40	1:20	7	2	4.1	7	14.4	0	0.0	9	18.5	Lake Trout Ripe
GN41	433783	7557626	7-Sep-15	1:35	2:32	0:57	7	3	8.7	0	0.0	0	0.0	3	8.7	Lake Trout Ripe
GN42	433802	7557521	7-Sep-15	1:40	2:48	1:08	6	2	4.8	0	0.0	0	0.0	2	4.8	Lake Trout Ripe
GN43	434281	7557511	7-Sep-15	1:55	2:58	1:03	5	0	0.0	2	5.2	3	7.8	5	13.1	
GN44	434388	7556784	7-Sep-15	3:09	4:02	0:53	6	2	6.2	6	18.6	1	3.1	9	27.9	Lake Trout Ripe
GN45	433839	7556349	7-Sep-15	3:18	4:16	0:58	5	1	2.8	1	2.8	0	0.0	2	5.7	Lake Trout Ripe
GN46	433533	7558397	7-Sep-15	3:29	4:28	0:59	5	1	2.8	0	0.0	1	2.8	2	5.6	Lake Trout Ripe

Notes:

CPUE = Catch-Per-Unit-Effort

— Appendix 5 —

Angling Data from Doris Lake, Doris North Project, 2015

Appendix 5. Angling Data from Doris Lake, Doris North Project, 2015

Fish ID	Species	UTM Coordinates (Zone 13 W) Easting	UTM Coordinates (Zone 13 W) Northing	Date	Time	Water Depth (m)	Comments
F1	Lake Trout	433621	7557732	3-Sep-15	17:40	2	
F2	Lake Trout	434103	7557825	4-Sep-15	10:04	15	
F3	Lake Trout	434428	7555347	4-Sep-15	14:27	3	
F4	Lake Trout	434524	7555840	4-Sep-15	15:18	6	Ripe
F5	Lake Trout	434133	7555261	4-Sep-15	15:38	3	
F6	Lake Trout	434168	7555025	5-Sep-15	11:23	3	
F7	Lake Trout	434559	7554092	5-Sep-15	12:17	2	
F8	Lake Trout	434443	7555293	6-Sep-15	17:48	2	Note: The identifier F8 was missed and used at a later point, so the time and date do not follow sequentially. This is not an error.
F9	Lake Trout	434499	7555683	5-Sep-15	12:28	5	Ripe
F10	Lake Trout	434488	7555776	5-Sep-15	12:59	6	Ripe
F11	Lake Trout	433605	7558328	5-Sep-15	13:40	10	Ripe
F12	Lake Trout	433825	7557577	6-Sep-15	14:20	15	Ripe
F13	Lake Trout	434452	7555905	6-Sep-15	15:03	8	Ripe
F14	Lake Trout	433706	7558738	6-Sep-15	15:50	12	Ripe