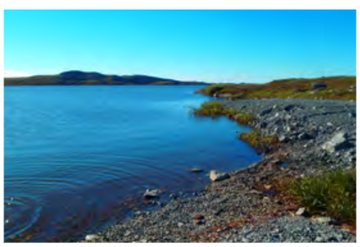

Prepared for:

TMAC RESOURCES

DORIS NORTH PROJECT

2014 Aquatic Effects Monitoring Program

April 2015

The world's leading sustainability consultancy

ERM

TMAC Resources Inc.

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EXECUTIVE SUMMARY

The 2014 Aquatic Effects Monitoring Plan Compliance Monitoring Program (the Program) was conducted in accordance with the approved *Doris North Gold Mine Project: Aquatics Effects Monitoring Plan* (the Plan; Rescan 2010c). The Program represents the fifth year of monitoring. No adverse Project-related effects were detected at stream, lake, or marine exposure sites with respect to dissolved oxygen (DO) concentrations, Secchi depths, water quality, sediment quality, periphyton or phytoplankton biomass, or benthic invertebrate communities in 2014.

Three stream sites (Doris Outflow, Roberts Outflow, and Little Roberts Outflow), three lake sites (Doris Lake North, Doris Lake South, and Little Roberts Lake), and two marine exposure sites (Roberts Bay East and Roberts Bay West) were monitored in addition to two reference stream sites (Reference B Outflow and Reference D Outflow), two reference lake sites (Reference B Lake and Reference D Lake), and one marine reference site (REF-Marine 1). Aquatic components evaluated in 2014 included lake and marine under-ice DO concentrations; lake Secchi depth; stream, lake, and marine water and sediment quality; stream periphyton biomass; lake and marine phytoplankton biomass; stream, lake, and marine benthic invertebrate community density, taxa richness, evenness, diversity, and Bray-Curtis Index. Lake and marine fish communities were last surveyed in 2010 (Rescan 2011) and were not surveyed in 2014, in accordance with the Plan.

Statistical and/or graphical analyses were performed to determine whether Project activities might have affected exposure sites in 2014. The analyses included comparisons of baseline data to current (2014) data and/or comparisons of reference sites to exposure sites through time. Data were considered to be from the baseline period if they were collected prior to 2010, except in the case of under-ice DO for which 2010 data were also considered baseline.

DO concentrations were greater than Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life at all marine sites and in all lakes except Little Roberts Lake. In Little Roberts Lake, DO concentrations were within the range of concentrations observed in baseline years.

Mean 2014 water quality concentrations were less than CCME guidelines at stream, lake, and marine exposure sites with two exceptions. First, total aluminum concentrations were greater than CCME guidelines in many exposure streams in 2014. However, total aluminum concentrations also exceeded CCME guidelines in baseline years. Second, in Little Roberts Lake the mean 2014 total iron concentration was greater than the CCME guideline, which was likely related to sample contamination during under-ice sampling. Open-water total iron concentrations in Little Roberts Lake were less than the CCME guideline.

No significant differences in water quality concentrations were found between baseline and 2014 concentrations at any of the stream or marine exposure sites. In lakes, significant differences in concentrations were observed between baseline years and 2014 in water hardness (increase) in Doris Lake South and in total arsenic (decrease) and total molybdenum (increase) at Doris Lake North. However, these differences were also observed in reference lakes. A significant increase in under-ice water hardness concentrations was also observed in Little Roberts Lake. Although comparisons to trends in reference lakes were not possible because no baseline data was available for Reference Lake D, open-water season concentrations were within the range of baseline means in Little Roberts Lake.

Mean 2014 sediment quality concentrations were less than CCME Interim Sediment Quality Guidelines (ISQGs) and Probable Effects Levels (PELs) at all exposure stream, lake, and marine sites with four exceptions. In lakes, total arsenic at Doris Lake South, total chromium at all exposure and reference sites, and total copper at Doris Lake North and Doris Lake South exceeded the ISQG. The mean total arsenic concentration also exceeded the PEL at Doris Lake South. The total copper concentration at Roberts Bay West (RBW) was greater than the ISQG, but less than the PEL.

Some differences in sediment particle size composition were observed at Doris and Little Roberts Outflow and at Doris Lake South and Little Roberts Lake, which likely reflect natural spatial heterogeneity in stream and lake sediments and are unrelated to Project activities. A shift toward finer sediments was also observed at site RBW and REF-Marine 1. Shifts toward finer sediments likely explain observed increases in some sediment quality variables at some sites in 2014 compared to baseline years, including Total Organic Carbon (TOC) content and lead and mercury concentrations in Little Roberts Outflow; TOC levels at Doris Lake North; arsenic and zinc concentrations in Little Roberts Lake; TOC content and arsenic, chromium and copper concentrations at sites RBW and REF-Marine 1; and significantly increased mercury and zinc concentrations at REF-Marine-1. The similarity in changes in silt-content, TOC, and metal concentrations from baseline years to 2014 at sites RBW and REF-Marine 1 suggests that the observed changes at RBW were naturally occurring and unrelated to damage to the jetty that occurred in 2013, jetty repair that took place in the winter of 2013/2014, or other Project activities. Copper concentrations were significantly lower in 2014, compared to baseline years, at Doris Lake North and Doris Lake South.

There was no evidence of Project-related effects on periphyton or phytoplankton biomass or benthos community density, richness, evenness, diversity, or the Bray-Curtis index at stream, lake, or marine exposure sites. Though some significant differences were found between baseline and 2014 benthic community metrics when comparing exposure and reference sites, the lack of Project-related changes in water quality, sediment quality, and primary producer biomass suggests that these differences likely resulted from natural variability rather than Project-related effects.

Mitigation measures aimed at reducing potential adverse effects on stream, lake, and marine habitats in the Project area included surface water runoff management, dust abatement measures, site water management, quarry and waste rock management, and waste management. Results of the Program indicate that these mitigation measures were effective in preventing adverse effects on aquatic communities.

AULAPKAIYIINI NAITTUQ

Tamna 2014 Imarmiutat Pipkaidjutiuyut Munariniq Ihumaliurutimik Angirutautimut Munariniq Pinahuarut (tamna Pinahuarut) havaktauhimayuq malikhugu angirutinga *Doris Tununngani Gold-mik Uyarakhiurniq Havaakhauhiq: Imarmiutat Pipkaidjutiuyut Munariniq Ihumaliurutimik* (tamna ihumaliurut; Rescan 2010c). Tamna Pinahuarut pipkaidjutigiyaa hitamanik ukiunik munariniqmik. Piqangittuq hukhaungittunik Havaakhauhiqmut pihimayunut ayurhautinik takunnaittuq kuugalaannuat, Tahiq, imaqmiluuniit nuitangayut nayugangani pitqutiquplugit piiqhimayut anirhaarutiuyut (qablunaatitut naittumik taiyauyuq DO-mik) hakugingningit, Secchi itinnautinga, qanuraaluk imaqarninnga, ilakungit qanuraaluk ittaakhaanik, nunavaluit nauhimayullu nunamit ukunaluuniit nunamit nauhimayunik tariup qaangani avatinganit, unaluuniit mikitqiyauninnga tariuqmi ittuq qitimini hauniqaqtunik nayuqtut 2014mi.

Pingahuuyut kuugalaannuat uyarakhiurviuyut (Doris Avatquhimaninnga, Roberts Avatquhimaninnga, uumanilu Little Roberts Avatquhimaninnga), pingahuuyut Tahiq uyarakhiurviuyut (Doris Tahiq Tununngani, Doris Tahiq Hivuraani, unalu Little Roberts Tahiq), unalu malruuk imanga naunaipkaiyuq uyarakhiurviuyut (Roberts Bay Kivataani uumanilu Roberts Bay Uataani) munariyauyut uumanilu malruuk naunaitkutinga kuugalaannuat uyarakhiurviuyut (Naunaitkutinga B Avatquhimaninnga unalu Naunaitkutinga D Avatquhimaninnga), malruuk naunaitkutinga Tahiq uyarakhiurviuyut (Naunaitkutinga B Tahiq unalu Naunaitkutinga D Tahiq), atauhiqlu imanga naunaitkutinga nayugaa (REF-Imanga 1). Tariuqmi pipkaidjutingit ihivriuqtauyut 2014mi ilaliutihimayuq Tahiq imangalu hikup ataani DO hakugingningit; Tahiq Secchi itikninnga; kuugalaannuat, Tahiq, tariup imangalu unalu ilakungit qanuraaluk ittaakhaanik; kuugalaannuat aqayat avatinganit; Tahiq tariuqmi nauttiat nauhimayut imaqmi avatinganit; kuugalaannuat, Tahiq, tariuqlu mikitqiyauninnga tariuqmi ittuq qitimini hauniqaqtunik nayuqtut hilikninnga, taxa amigaittut, aadjikutauyut, aadlatqiinguyullu, unalu Bray-Curtis Naunaitkutaq. Tahiq tariuqmilu iqalungit ihivriuqhimayuugaluat 2010mi (Rescan 2011) ihivriuqtaunngittut 2014mi, maliquplugu Ihumaliurutinga.

Naunaiyariami qaffiuyut unalu / unaluuniit humi ittaakhaanik ihivriuqtaallu naunairiami hapkuat Havaakhauhiq hulilukaarutingit ihuirniarumiuk naunaipkaiyuq uyarakhiurviuyut 2014mi. Tamna naunaiyaininnga ilaliutihimayuq aadlanit kiklingani nampangit nutaamut (2014) nampangit unalu / unaluuniit naunaiyariamik aadlanik naunaitkutinga uyarakhiurviuyut naunaipkaigiami uyarakhiurviuyut qakunnguraangat. Nampangit ihumagiyauyut ittut kiklinganit pikmata katitiqtaugumik 2010nguqtinnagu, kihimi pigumi hikup ataani DO taimaa 2010 nampangit ihumagiyauyullu kiklingani .

DO hakugingningit angitqiyauyut Kaanatamiutat Katimayiingit Ministauyunut Avatiliriyiitkunnut (qablunaatitut naittumik taiyauyuq CCME-mik) maliktakhangit nunguttailininnganut Tariuqmiutanik tamainni tariuqmi uyarakhiurviuyut tamainnilu Tahiqmi pingittuq uumani Little Roberts Tahiq. Uumani Little Roberts Tahiq, DO hakugingningit uumani hakugingningit qun’ngiaqtauyut kiklingani ukiut.

Qitqani 2014 qanuraaluk imaqarninnga hakugingningit ikitqiyauyuq CCME maliktakhanginni kuugalaannuanganit, Tahiq, imangalu naunaipkaiyuq uyarakhiurviuyut malruuknik ilaliutingittut. Hivulliqpaami, atauttimut aluumaningit hakugingningit angitqiyauyut uumannga CCME maliktakhanginni amihuni naunaipkaiyuq kuugalaannuats 2014mi. Kihimi, atauttimut aluumaningit hakugingningit qaangitqiyautiyaa CCME maliktakhanginni kiklingani ukiut. Tugliani, Little Roberts Tahiqmi qitqani 2014 atauttimut iron hakugikninngit angitqiyauyuq uumannga CCME maliganganit, taimaa piyuq uuktuutimut halumailrunganut pitillugu una hikup ataani uuktuutinganit. Hikuilruq atauttimut iron hakugingningit uumani Little Roberts Tahiq ikitqiyauyuq uumannga CCME maliganganit.

Aadlatqiingittuq qanuraaluk imaqarninnga hakugingningit nalvaaqtangit kiklingani uumanilu 2014 hakugingningit ukunani kuugalaannuat imaqmiluuniit naunaipkaiyuq uyarakhiurviuyut. Tahiqmi, amihuuyut aadlatqiingit hakugingningit qun’ngiaqtauyut ukunanit kiklingani ukiut uumanilu 2014 imangani naptuninnga (angikliyuumiqtuq) Doris Tahiq Hivuraani uumanilu atauttimut puisiuyunik (ikikliyuumiqtuq) unalu atauttimut havigaliktut ittut (angikliyuumiqtuq) Doris Tahiq Tununngani. Kihimi, hapkuat aadlatqiingit qun’ngiaqtauyut naunaitkutinga Tahiqmi. Amigaittut angikliyuumiqtuq hikup ataani imanga naptuninnga hakugingningit qun’ngiaqtauyullu Little Roberts Tahiqmi. Taimaa aadjikutariikninnga qanuriliurutinginnut naunaitkutinga Tahiqmi pilimaittut taimaa piqangittut kiklingani nampangit piqarmat Naunaitkutinga Tahiq D, hikuilruraangat hakugingningit inmata kiklingani qitqaninginni uumani Little Roberts Tahiq.

Qitqani 2014 ilakungit qanuraaluk ittaakhaanik hakugingningit mikitqiyauyut uumani CCME Tadjakaffuk Ilakungit Qanuraaluk ittaakhaanik Maliktakhanginni (ISQGngit) Piqaruknaqhiuqlu Ayurhautigiyauyut Pidjutingit (PELngit) tamainni naunaipkaiyuq kuugalaannuat, Tahiq, unalu imanga uyarakhiurviuyut piqarhuni hitamanik pidjutikhanginnik. Tahiqmi, atauttimut puisiuyut Doris Tahiq Hivuraani, atauttimut uyaraunguyuq tamainni naunaipkaiyuq unalu naunaitkutinga uyarakhiurviuyut, unalu atauttimut kannuyaq Doris Tahiq Tununngani uumanilu Doris Tahiq Hivuraani qaangiutigiyaa ISQG. Tamna qitqani atauttimut puisiuyut hakugikninngit qaangiutiyaalu PEL uumani Doris Tahiq Hivuraani. Tamna atauttimut kannuyaq hakugikninngit Roberts Bay Uataani (RBW) angitqiyauyuq uumani ISQG, kihimi ikitqiyauyuq PEL-mi.

Ilangit aadlatqiingit ilakungit pidjutinga aktikkulaanga hunavalungit qun’ngiaqtauyut uumani Doris uumanilu Little Roberts Avatquhimaninnga uumanilu Doris Tahiq Hivuraani uumanilu Little Roberts Tahiq, taimaatut naunaipkaqtaa pilluaqhimaninnga pingahunit takunnaqtunik ihivriuqninnganit aadlatqiyauniaqtuq kuugalaannuat uumanilu Tahiq ilakungit pingittut ukununnga Havaakhauhiq hulilukaarutingit. Nuutiqniq nakuutqiyauyumut ilakungit qun’ngiaqtauyullu nayugaani RBW uumanilu REF-Imanga 1. Nuutiqniq nakuutiqyauyunut ilakungit naunaiqtitaa qun’ngiaqtauyut angikliyuumiqtuqs ilangani ilakungit qanuraaluk ittaakhaanik ihivriuqninngit ilangani uyarakhiurviuyut 2014mi uumannga kiklingani ukiunit, ukunaniklu Atauttimut Ittunik Carbon-mik (qablunaatitut naittumik taiyauyuq TOC-mik) piqaqtuq aqilruqmik mercury-miklu hakugingningit Little Roberts Avatquhimaninnga; TOC piqarningit uumani Doris Tahiq Tununngani; puisiuyut uuminngalu zinc hakugingningit Little Roberts Tahiq; TOC piqaqtut puisiuyut, chromium-mik kannuyaqmiklu hakugingningit uumani uyarakhiurviuyut RBW uumanilu REF-Imanga 1; akhuraaluklu angikliyuumiqtuq mercury-mik zinc-miklu hakugingningit uumani REF-Imanga-1. Aadjikutauyut himmautingani hiuraqaqtumi, TOC, havigaliklu hakugingningit ukunanit kiklingani ukiunit 2014-mut uumani uyarakhiurviuyut RBW uumanilu REF-Imanga 1 pitquyait qun'ngiaqtauyut himmautingit RBW-mi piliqtut pingittutlu hukhaungiqninnganut qikiqtaliurhimayunik piyut 2013mi, qikiqtaliurhimayut ihuarhainingit ihuaqhaqtauyut ukiumi 2013/2014, aatlatluuniit Havaakhauhiq hulilukaarutingit. Kannuyaq hakugingningit mikitqiyaulluaqtuq 2014mi, ukunanit kiklingani ukiunit, Doris Tahiq Tununngani uumanilu Doris Tahiq Hivuraani.

Takunnaittuq Havaakhauhiq-piyut pipkaidjutauyut uumani aqayat nunamit nauhimayunik tariup qaangani avatinganit tariup natingani hilikninnga, amigaittut, aadjikutauyut, aadlatqiinguyullu, unaluuniit Bray-Curtis naunaitkutinga kuugalaannuat, Tahiq, imaqmiluuniit naunaipkaiyuq uyarakhiurviuyut. Ilangit amigaittunik aadlatqiininngit takunnaqtut uumani kiklingani uumanilu 2014 mikitqiyauninnga tariuqmi ittuq nayugangani naunaiyainiq aktikkulaanganik piliraangat naunaipkaiyuq unalu naunaitkutinga uyarakhiurviuyut, piqalluanginmat Havaakhauhiq-piyut aadlangurninngit uumani qanuraaluk imaqarninnga, ilakungit qanuraaluk ittaakhaanik, hivulliqpaangalu piliurutininnga avatinganit ihumagiyait hapkuat aadlatqiingit pivaktut aadlangurmata unaunngittuq Havaakhauhiq-piyut pipkaidjutinginnik.

Ikikliyuumiutingit piyut ikikliyuumiriami piniaruknaqhiyut pipkaidjutihimayut uumunnga kuugalaannuat, Tahiq, imarmiutallu uumayut uumani Havaakhauhiqmi ilaliutihimayuq qaanga imaup kuugalaanginik munariniq, puyuqpallaarnaittumiklu, nayugaa imanga munariniq, uyarakhiurvinga ilakungillu uyaqqanik munariniq unalu iqqakunik munariniq. Qanuritaakhaanik tamna Pinahuarut naunaiqtaa hapkuat ikikliyuumiutingit piyut pittailigiami nakuungittumik pipkaidjutingit Tariuqmi nunallaanginnut.

ᐊᐅᓚᖅᓯᐋ ᑐᑭᓯᒋᐊᕈᑎᖏᑦ

ᐅᓇ 2014 ᐃᒪᖅᓂᑦ ᐊᒃᑐᖅᑕᐅᔪ ᒥᐊᓂᕆᓂᖅᒧᑦ ᐸᖅᓇᐅᑎ ᒪᓕᑦᑎᐊᖅᒪᖔᑦ ᒥᐊᓂᕆᔾᔪᑕᐅᔪᖅ ᐱᓕᕆᑎᑦᑎᔾᔪᑕᐅᔪᖅ (ᐅᓇ ᐱᓕᕆᑎᑦᑎᔾᔪᑕᐅᔪᖅ) ᐱᓕᕆᔭᐅᓚᐅᖅᑐᖅ ᒪᓕᒡᓗᓂ ᐊᖕᖏᖅᑕᐃᐅᓯᒪᔪᒥᒃ ᑐᐊᓕᔅ ᐅᐊᓈᖕᒐᓂ ᒍᑐᒥᒃ ᐅᔭᕆᖕᓂᐊᖅᑐᑦ: ᐃᒪᖅᓂᒃ ᐊᒃᑐᐃᔪ ᒥᐊᓂᕆᔾᔪᑕᐅᔪᖅ ᐸᖅᓇᐅᑖ (ᐅᓇ ᐸᖅᓇᐅᑎ; ᓯᓕᔅᑳᓐ 2010c). ᐅᓇ ᐱᓕᕆᑎᑦᑎᔾᔪᑕᐅᔪᖅ ᐊᐅᓚᑕᐅᓕᖅᑐᖅ ᑕᓪᓕᒪᒋᓕᖅᑕᖓ ᐊᕐᕆᒍ ᒥᐊᓂᕆᔭᐅᓪᓗᓂ. ᐊᒃᑐᐃᖅᑰᒃᓯᓂᐊᖕᖏᑦᑐᖅ ᓇᓂᔭᐅᓯᒪᖕᖏᑦᑐᑦ ᑰᓚᓖᓂ, ᑕᓯᖅᓂ, ᐅᕝᕙᓘᓐᓃᑦ ᐃᒪᖅᓂ ᐃᓂᖏᑦ ᐃᒃᐱᒋᑦᑎᐊᖅᑲᓗᒍ ᐊᐅᒃᐸᓪᓚᐊᔪᖅ ᐳᓪᓚᖅᑲᐅᖅᑐᑦ ᐊᐅᕝᕙᓪᓚᐊᔪᑦ ᐱᑕᖅᑳᖅᑐᑦ, ᐃᖅᑲᖓᑕ ᑕᑯᒃᓴᐅᓂᖓᑕ ᐃᑎᓂᖓ, ᐃᒪᖓ ᖃᓄᓇᑑᓂᖓ ᐃᒪᑦᑎᐊᕙᐅᖕᒪᖔᑦ, ᐃᖅᑲᖓ ᖃᓄᐃᓕᖓᓂᖓ, ᖁᐱᕐᕈᑦ ᐱᕈᖅᑐᓂ ᐊᑕᔪᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐃᒪᕐᒥᐅᑕᐃᑦ ᐱᕈᖅᑐᑦ ᐊᑦᑕᑎᖅᑳᖕᖏᑦᑐᑦ ᑲᑎᖓᔪᑦ ᐅᓄᖅᑐᒻᒪᕆᐋᓗᐃᑦ, ᐅᕝᕙᓘᓐᓃᑦ ᐊᓗᐊᓂᕐᒥᐅᑕᐃᑦ ᐃᒪᐅᑉ ᖃᒥᖅᓗᖅᑳᖕᖏᑦᑐᑦ ᑲᑎᖓᔪᑦ 2014-ᒥ.

ᐱᖕᒐᓱᑦ ᑰᓚᓖᑦ ᐃᓂᕗᑦ (ᑐᐊᓚᔅ ᑰᒃᑐᑦ, ᐅᓖᐳᔅ ᑰᒃᑐᑦ, ᐊᒻᒪᓗ ᓕᑐ ᐅᓖᐳᔅ ᑰᒃᑐᖅ), ᐱᖕᒐᓱᑦ ᑕᓰᑦ ᐃᓂᖏᑦ (ᑐᐊᓚᔅ ᑕᓯᖅ ᐅᐊᖕᓇᖕᒐᓂ, ᑐᐊᓚᔅ ᑕᓯᖅ ᓂᕆᐊᓂ, ᐊᒻᒪᓗ ᓕᓯ ᐅᓖᐳᔅ ᑕᓯᖅ) ᐊᒻᒪᓗ ᒪᖀᒃ ᐃᒫᓃᑦ ᐊᕙᓗᔭᐅᓯᒪᔪᑦ ᐃᓂᖓ (ᐅᓚᐳᔅ ᐸᐃ ᑲᓇᖅᓇᖅᓚ ᐊᒻᒪᓗ ᐅᓖᐳᑦ ᐸᐃ ᐱᓇᓇᖅᓚ) ᒥᐊᓂᕆᔭᐅᓪᓗᑎᒃ ᑖᒃᑯᐊᓗ ᒪᖀᒃ ᖃᐅᔨᒪᑎᑦᑎᔾᔪᑕᐅᓪᓗᑎᒃ ᑕᓯᖅ ᐃᓂᖏᑦ (ᖃᐅᔨᒪᑎᑦᑎᔾᔪᑕᐅᔪᖅ B ᑕᓯᖅ ᐊᒻᒪᓗ ᖃᐅᔨᒪᑎᑦᑎᔾᔪᑕᐅᔪᖅ D ᑕᓯᖅ), ᐊᒻᒪᓗ ᐊᑕᐅᓯᖅ ᐃᒫᓄᑦ ᖃᐅᔨᒪᑎᑦᑎᔾᔪᑕᐅᔪᖅ ᐃᓂᖓ (ᖃᐅᔨᒪᑎᑦᑎᔾᔪᑕᐅᔪᖅ ᐃᒫᓂ 1). ᐃᒫᓃᑐᑦ ᐃᓚᖏ ᖃᐅᔨᔭᐅᓇᓯᑦᑎᐊᖅᓱᑎᒃ ᑕᐃᖅᑲᓂ 2014 ᐃᓚᒋᔭᐅᓪᓗᓂ ᑕᓯᖅ ᐊᒻᒪᓗ ᐃᒪᖅ ᐊᑖᓂ ᓯᑯ ᐳᓪᓚᖅᑲᐅᖅᑐᑦ ᐊᐅᕝᕙᓪᓚᐊᔪᑦ ᐱᑕᖅᑲᖅᒪᖔᑦ; ᑕᓯᖅ ᐃᖅᑲᖓ ᑕᑯᒃᓴᐅᔪᖅ ᐃᑎᓂᖓ; ᑰᓚᓖᑦ, ᑕᓯᖅ, ᐊᒻᒪᓗ ᐃᒪᖓ ᐃᒪᐅᑉ ᐊᒻᒪᓗ ᐃᖅᑲᖓ ᖃᓄᐃᓕᖓᓂᖓ; ᑰᓚᓖᓂ ᖁᐱᕐᕈᑦ ᐱᕈᖅᑐᓂ ᐊᑕᔪᑦ ᐊᒥᓱᒻᒪᕆᐋᓗᐃᑦ; ᑕᓯᖅ ᐊᒻᒪᓗ ᐃᒪᖓᓂ ᖁᐱᕐᕈᖅ ᐊᒥᓱᒻᒪᕆᐋᓗᐃᑦ ᑲᑎᖓᔪ; ᑰᓚᓖᒃ, ᑕᓯᖅ, ᐊᒻᒪᓗ ᐃᒫᓂ ᐃᖅᑲᖓᓂᕐᒥᐅᑕᐃᑦ ᖃᒥᖅᓗᖅᑳᖕᖏᑦᑐᑦ ᓄᓇᖅᑲᑎᒌᑦ ᐃᔾᔪᓂᖅᒥ, ᐆᒪᔪᖅᑲᖅᑐᖅ ᒥᑭᔫᑎᓂᒃ, ᓇᓕᖅᑲᓃᑦᑎᐊᖅᑐᖅ ᐊᔾᔨᕇᑦᑎᐊᖅ, ᐃᔾᔪᓂᖕᒐ, ᐊᒻᒪᓗ ᐳᓚᐃ-ᑰᑎᔅ ᓇᑐᓇᐃᒃᑯᖅᑑᑎᖏᑦ. ᑕᓯᖅ ᐊᒻᒪᓗ ᐃᒫᓂ ᐃᖅᑲᓗᖕᒥᑦ ᑭᖑᓪᓕᖅᐹᒥᒃ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᓯᒪᔪᑦ 2010 (ᐅᓕᔅᑳᓐ 2011) ᐊᒻᒪᓗ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑎᒃ 2014-ᒥ, ᒪᓕᒡᓗᒍ ᐸᖅᓇᐅᑖᑦ.

ᓈᓴᖅᑕᐅᓯᒪᔪᓐᑦᑐᑦ ᐊᒻᒪᓗ -ᐆᕝᕙᓘᓐᓃᑦ ᓄᓇᖏᑦᑎᒍᑦ ᖃᐅᔨᓴᐅᓇᓱᒃᓯᒪᔪᑦ ᐱᓕᕆᔭᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᓇᓱᒡᓗᑎᒃ ᖃᓄᖅ ᐱᓕᕆᐊᖑᔪᖅ ᖃᓄᐃᓕᐅᖅᑕᐅᔪᑦ ᐊᒃᑐᐃᓇᔭᕐᒪᖔᑕ ᓴᕿᔮᕈᓂ ᐃᓂᖓ 2014. ᐅᑯᐊ ᖃᐅᔨᓇᓱᒃᑐᑦ ᐃᓚᓚᐅᖅᑐᖅ ᖃᓅᑎᒋᖕᒪᖔᑕ ᐊᕙᑖᓃᑦ ᐃᓂᖏᓐᓂᒃ ᑭᒡᓕᖏᓐᓂᒃ ᖃᐅᔨᓇᓱᒃᑕᐅᓯᒪᔪᑦ ᒫᓇᐅᔪᖅ (2014) ᖃᐅᔨᓴᕈᑎᑖᑦ ᐊᒻᒪᓗ - ᐅᕝᕙᓘᓐᓃᑦ ᖃᓅᑎᒋᒪᖔᑕ ᖃᐅᔨᓇᓱᒍᑕᐅᓯᒪᔪᓃᑦ ᐃᓂᖏᓐᓂ ᑕᒪᔮᐅᔪᓂᒃ ᐃᓂᖓᓂ ᑕᐃᑲᓃᓐᓂᓕᖕᒋᓐᓂ. ᖃᐅᔨᓴᕈᑎ·ᑦ ᐃᓱᒪᒋᔭᐅᔪᑦ ᑭᒡᓕᖓᓂᖕᖑᓂᖕᖏᓐᓂᑦ ᓄᐊᑦᑎᕕᐅᓚᐅᖅᑐᑦ ᑎᑭᐅᑎᓚᐅᖅᑎᓐᓇᒍ 2010, ᑭᓯᐊᓂ ᑕᐃᑲᓂ ᐊᑖᒍᑦ ᓯᑯᐃᑦ ᐳᓛᖅᑐᖅᑐᑦ ᐊᐅᕝᓚᓕᐊᔪᑦ ᑕᐃᑲᓂ 2010 ᖃᐅᔨᓴᕈᑎᑖᑦ ᐃᓱᒪᒋᔭᐅᓚᐅᖅᑐᑦ ᐱᒋᐊᖅᓯᕕᐅᓯᒪᓗᑎᒃ.

ᐳᓚᖅᑐᖅᑐᑦ ᐊᐅᕝᓚᓕᐊᔪᑦ ᐱᑕᖅᑐᖅᓂᖓ ᐅᓄᖅᓂᖅᓴᐅᔪᑦ ᑖᑉᑯᓇᖓ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖅ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᑦ ᓴᐳᓂᐊᕈᑎᒋᓪᓗᒋᑦ ᐃᒪᕐᒥᐅᑕᓂᒃ ᐆᒪᔪᓂᒃ ᑕᒪᕐᒥᒃ ᐃᒪᖅᑐᑦ ᐃᓂᖏᑦ ᐊᒻᒪᓗ ᑕᒪᕐᒥᒃ ᑕᓰᑦ ᑭᓯᐊᓂ ᐱᓇᓂ ᓕᑐ ᐅᓖᐸᓯ ᑕᓯᖓ. ᑕᐃᑲᓂ ᓕᑐ ᐅᓖᐸᓯ ᑕᓯᖅ, ᐳᓚᖅᑐᖅᑐᑦ ᐊᐅᕝᓚᓕᐊᔪᑦ ᐱᑕᖅᑐᖅᓂᖓ ᖃᓂᒋᔭᓂ ᐱᑕᖅᑐᖅᑐᖅᑲᓂ ᑕᑯᔭᐅᓯᒪᔪᓂ ᐱᒋᐊᖅᕕᒋᓯᒪᔭᖏᓐᓂᑦ ᐊᖅᑯᓄᑦ.

ᑐᑭᖃᖅᑐᖅ 2014 ᐃᒪᑦᑎᐊᕙᖃᖅᓂᖓ ᑐᖓᓃᑦᑐᑦ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᑦᑎᒍᑦ ᒨᒪᓛᓂ, ᑕᓯᖅ, ᐊᒻᒪᓗ ᐃᒪᓖᑦ ᐃᓂᖏᓐᓂ ᑕᐃᒃᐊ ᒪᖀᒃ ᐱᓇᒋᑦ. ᓯᕗᓪᓕᖅ,ᑲᑎᓪᓗᒍ ᓴᕝᕋᔭᒃᓴᖅ ᐊᓅᒥᓇᒻ ᐱᑕᖃᖅᒪᑦ ᐊᖅᖏᓂᖅᓴᐅᓪᓗᓂ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᓄᑦ ᐊᒥᓲᔪᓂ ᒨᒪᓛᓂ 2014-ᖑᑎᓪᓗᒍ. ᑕᐃᒪᓐᓇᐅᓚᐅᕐᑎᓪᓗᒍ, ᑲᑎᓪᓗᒍ ᐊᓅᒥᓇᒻᖃᖅᓂᖓ ᐅᖓᑖᓃᑦᑐᖅ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᓄᑦ ᐃᓂᑐᖃᖏᑦ ᐊᖏᒍᓂᓂᑦ. ᐱᖃᑖ, ᓕᑐ ᐅᓚᐳᐦ ᑕᓯᖅ ᑐᑭᖃᖅᑐᖅ 2014 ᑲᑎᓪᓗᒋᑦ ᓴᕝᕋᔭᒃᓴᖏᑦ ᐱᑕᖃᖅᑐᖅ ᐅᖓᑖᓃᑦᑐᒥᒃ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᑦᑎᒍᑦ, ᐅᑯᐊᓗ ᐃᓚᒋᔭᒃᓴᓇᔭᖓ ᖃᐅᔨᓴᕈᑎᑖᖑᓯᒪᔪᑦ ᐱᑕᖃᖅᑐᑦ ᐊᑖᓂ ᓯᑯᑦ ᖃᐅᔨᓴᕈᑎᑖᖑᓯᒪᔪᓂ. ᒪᑐᐃᖓᔪᖅ ᓯᑯᖃᓐᖏᑦᑐᖅ ᑲᑎᓪᓗᒍ ᓴᕝᕋᔭᒃᓴᖃᖅᑐᖅ ᓕᑐ ᐅᓛᐳᐦ ᑕᓯᖓ ᒥᑭᓂᖅᓴᐅᓪᓗᓂ ᑖᑯᑎᒍᑦ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᑦᑎᒍᑦ.

ᐊᖏᔪᒥᒃ ᐊᔾᔨᒌᓐᖏᑦᑐᑦ ᐃᒪᑦᑎᐊᕙᐅᓂᖏᑕ ᐃᓗᓕᖏ ᓇᓂᔭᐅᓯᒪᔪᑦ ᐃᓂᖏᓐ ᐊᒻᒪᓗ 2014 ᐱᑕᖃᖅᑐᑦ ᓇᓪᓕᐊᖕᓂᑐᐃᓐᓇᖅ ᒨᒪᓛᓂ ᐅᑦᕙᓘᓐᓃᑦ ᐃᒪᖃᖅᑐᓂ ᐃᓂᖏᓐᓂ. ᑕᓲᖅᓂ, ᐊᖏᔪᒥᒃ ᐊᔾᔨᒋᓐᖏᑦᒥᔭᖓ ᐱᑕᖃᖅᑐᖅ ᑕᑯᔭᐅᓯᒪᔪᖅ ᐱᒋᐊᖅᕙᓂᖓᓂ ᐊᖏᒍᓂᓂ ᐊᒻᒪᓗ 2014 ᐃᒪᖅᓂ ᑎᓯᔪᑦ (ᐅᓇᖅᕙᓪᓕᐊᔪᖅ) ᑕᐃᒃᑯᓂ ᑐᐊᓕᒃ ᑕᓯᖅ ᓂᕆᐊᓂ ᐊᒻᒪᓗ ᑲᑎᓪᓗᒋᑦ ᑐᖅᑯᓇᖅᑐᖃᖅᑐᑦ (ᑐᖅᑰᑎᓲᑦ) ᐊᒻᒪᓗ ᑲᑎᓪᓗᖑ ᓴᕝᕋᔭᒃᓴᖃᖅᑐᑦ (ᐅᓇᖅᓯᕙᓪᓕᐊᔪᑦ) ᑕᐃᒃᑯᓂ ᑐᐊᓕᒃ ᑕᓯᖅ ᐅᐊᖕᓇᖕᓂ. ᑕᐃᒪᓐᓇᐅᓚᐅᕐᑎᓪᓗᒍ, ᐅᑯᐊ ᐊᔾᔨᒋᓐᖏᑕᖏᑦ ᑕᑯᔭᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᒪᑎᑦᑎᔾᔪᑕᐅᔪᒥᑦ ᑕᓯᖅᓂᑦ. ᐊᖏᓛᖅ ᐅᓇᖅᓰᖑᔪᖅ ᐊᑖᓂ ᓯᑯᐃᑦ ᐃᒪᖏᓐᓂ ᑎᓯᒃᑎᓯᒪᔪᑦ ᐱᑕᖃᖅᑐᑦ ᑕᑯᔭᐅᓚᐅᖅᑐᑦ ᓕᑐ ᐅᓛᐳᐦ ᑕᓯᖅ. ᑕᐃᒪᓐᓇᐅᓚᐅᕐᑎᓪᓗᒍ ᖃᓄᖅ ᐊᔾᔩᓐᖏᓂᖏᑦ ᐊᓯᕌᖅᑕᖃᑦᑕᖅᓂᖓ ᖃᐅᔨᒪᔾᔪᑕᐅᔪᓂ ᑕᓯᖅᓂ ᐊᔪᖅᓇᓚᐅᖅᑐᖅ ᐃᓂᖃᖅᕕᐅᔪᓂ ᖃᐅᔨ,ᔾᔪᑎᖃᖅᑎᒃ ᐊᑐᐃᓐᓇᖅᑕᖃᖅᑕᓂ ᑕᐃᑯᖓ ᖃᐅᔨᒪᔾᔪᑕᐅᔪᒧᑦ ᑕᓯᖅ D, ᓯᑯᓯᒪᓐᖏᑦᑐᖅ ᒪᑐᐃᖓᔪᖅ ᐃᒪᖓ ᐱᑕᖃᐅᓇᓪᓗᓕ ᖃᓂᒋᔭᖓᓂ ᐃᓂᒋᔭᐅᔪᓂ ᑕᐃᒃᑯᓂ ᓕᑐ ᐅᓛᐳᐦ ᑕᓯᖅ.

ᑐᑭᖓ 2014 ᐃᖃᖓᓂ ᐃᒪᐅᑉ ᖃᐅᓇᕗᓂᖅᑎᑦ ᑲᑎᖓᔪ ᐊᑦᑎᖅᓂᖅᓴᐅᔪᑦ ᑖᑦᑯᓇᖓᑦ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᑦ ᓖᓐᓇᐅᔪᒥᒃ ᐃᖃᖓ ᖃᐅᓇᕗᔭᓇᐊᖃᖅᓂᖓ ᑐᑭᒧᐊᒍᑎᑦ ᐊᒻᒪᓗ ᐊᒃᑐᕋᔭᖅᑕᖏᓄᑦ ᐳᖅᑐᓂᖏᑦ ᖃᓅᑎᒋᓂᖏᑦ ᑕᒪᐃᓐᓂᒃ ᐊᐃᑐᖅᐅᔪᑦ ᒨᒪᓛᑦ, ᑕᓲᑦ, ᐊᒻᒪᓗ ᐃᒪᖏᓂ ᐃᓂᒋᔭᖏᑦ ᑎᓴᒪᑦ ᐱᓇᑎᒃ. ᑕᐃᒃᑯᓂ ᑕᓲᑦ, ᑲᑎᓪᓗᒋᑦ ᑐᖅᑯᓇᖅᑐᖃᖅᑐᑦ ᑐᐊᓕᒃ ᑕᓯᖅ ᓂᕆᐊᓂ, ᑲᑎᓪᓗᒋᑦ ᒪᖅᖏᒃᑐᖑᕈᓐᓇᓐᖏᑦᑐᖅ ᓴᕝᕋᔭᒃᓴᖅ ᖃᑯᖅᑐᖅ ᓇᓂᑐᐃᓐᓈᖅᑐᑦ ᐊᐃᑦᑐᐃᔪ ᐊᒻᒪᓗ ᖃᐅᔨᒪᑎᑦᑎᔾᔪᑕᐅᔪᑦ ᐃᓂᖏᑦ, ᐊᒻᒪᓗ ᑲᑎᓪᓗᒋᑦ ᑲᓐᓄᔭᒃ ᑐᐊᓕᒃ ᑕᓯᖅ ᐅᐊᖕᓇᖕᓂ ᐊᒻᒪᓗ ᑐᐊᓕᒃ ᑕᓯᖅ ᓂᕆᐊᓂ ᐅᖓᑎᓗᐊᖕᓂ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᓄᑦ ᓖᓐᓇᐅᔪᒥᒃ ᐃᖃᖓ ᖃᐅᓇᕗᔭᓇᐊᖃᖅᓂᖓ ᑐᑭᒧᐊᒍᑎᑦ. ᐅᓇ ᑐᑭᖃᖅᑐᖅ ᑲᑎᓪᓗᒋᑦ ᑐᖅᑯᓇᖅᑐᑕᓖᑦ ᐅᖓᑖᓃᑦᑐᑦ ᐊᒃᑐᕋᔭᖅᑕᖏᓄᑦ ᐳᖅᑐᓂᖏᑦ ᑕᐃᒃᑯᓂ ᑐᐊᓕᒃ ᑕᓯᖅ ᓂᕆᐊᓂ. ᑲᑎᓪᓗᒋᑦ ᑲᓐᓄᔭᖅ ᐱᑕᖃᖅᑐᖅ ᐅᓛᐳᐦ ᐸᐃ ᐱᓇᖕᓇᖓᓂ ᐊᖏᖕᓂᖅᓴᐅᔪᖅ ᑖᑯᓇᖓ ᑲᓇᑕᐅᑉ ᑲᑎᒪᔨᖏ ᒥᓂᔅᑕᐃᑦ ᐊᕙᑎᓕᕆᓂᖏᑦ ᑐᑭᒧᐊᒍᑎᖏᑦ ᓖᓐᓇᐅᔪᒥᒃ ᐃᖃᖓ ᖃᐅᓇᕗᔭᓇᐊᖃᖅᓂᖓ ᑐᑭᒧᐊᒍᑎᖏᓂᑦ, ᑭᓯᐊᓂ ᒥᑭᓂᖅᓴᐅᕆᓪᓗᑎᒃ ᐊᒃᑐᕋᔭᖅᑕᖏᓄᑦ ᐳᖅᑐᓂᖏᓂᑦ.

ᑲᑎᓪᓗᖑ ᐆᒻᒪᕈᓐᓇᖅᑐᓂ ᐸᐅᖅ ᐃᓗᓕᖓ ᐊᒻᒪᓗ ᐊᕿᑦᑐᖅ ᓴᕝᕋᔭᒃᓴᖅ ᐊᒻᒪᓗ

ᐃᓚᖏᑦ ᐊᔾᔨᒌᓐᖏᔾᔪᑎᖏᑦ ᐃᖃᖓᓂᑦ ᐊᖅᖏᓂᖏᑦ ᑕᑯᓪᓗᒋᑦ ᑐᐊᓕᒃ ᐊᒻᒪᓗ ᓕᑐ ᐅᓛᐳᐦ ᑰᓂᖏᓐᓂᑦ ᐊᒻᒪ ᑐᐊᓕᒃ ᑕᓯᖅ ᓂᕆᐊᓂ ᐊᒻᒪᓗ ᓕᑐ ᐅᓚᐅᒃ ᑕᓯᖅ, ᐅᑯᐊᓗ ᐱᓯᒪᔪᒃᓴᐅᓚᒥᒃ ᐃᓕᖅᑯᓯᓇᓪᓗᒍ ᖁᓛᓂᑦ ᖃᐅᓇᑦᑐᑐᐃᓐᓇᐅᓂᖅ ᒨᒪᓛᓂ ᐊᒻᒪᓗ ᑕᓲᑦ ᐃᖃᖏᓐᓂ ᐊᒻᒪᓗ ᐊᑕᐅᒻᒥᖏᑦᑎᐊᖅᑐᑦ ᐱᓕᓇᐊᖑᔪᓄᑦ ᖃᐅᐃᓕᐅᖅᑕᐅᔪᓄᑦ. ᓄᒃᑎᖅᒥᖓ ᓯᖃᓕᕆᐊᓪᓚᒃᓯᒪᓂᖅᓴᐅᔪᑦ ᐃᖃᖓᓂ ᑕᑯᔭᐅᓚᐅᖅᒥᔪᑦ ᐅᓛᐳᐦ ᐸᐃ ᐱᓇᖕᓇᖓᓂ ᐊᒻᒪᓗ ᐅᓛᐳᐦ ᑲᓇᖕᓇᖓᒥ - ᐃᓖᓂ 1. ᓄᒃᑕᖅᓂᖓ ᑕᒪᐅᖓ ᓯᖃᓕᓯᒪᓂᖅᓴᐅᔪᑦ ᐃᖃᖓᓂ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖃᓱᒋᔭᑦ ᑕᑯᔭᒥᒍᑦ ᐅᓇᖅᓯᖅᑭᓐᓄᑦ ᐊᓱᖏᑦ ᖄᖃᖓᓂ ᑭᓱᖏᑦ ᖃᐅᓇᑦᑐᑐᐃᓐᓇᐃᑦ ᐃᓚᖏᓐᓂ

ᐃᓂᖏᓐᓂᒃ 2014 ᐊᔾᔨᒋᓇᒍ ᐃᓂᒋᓚᐅᖅᑕᖓ ᐊᕐᕌᒍᓂ, ᐃᓚᒋᔭᐅᓪᓗᓂ ᐊᑭᕐᕉᔭᒃᓴᖅ ᐱᑕᓕᒃ ᓕᓗ ᐅᓛᐸᔅ ᑰᕕᖏᓐᓂ; ᑲᑎᑦᓱᒍ ᐆᒻᒪᕈᓐᓇᖅᑐᓂ ᐸᐅᖅ ᐳᖅᑐᓂᖓ ᑕᐃᑲᓂ ᑐᐊᓕᒃ ᑕᓯᖅ ᐅᐊᖕᓇᖕᖓᓂ; ᑐᖁᓐᓇᖅᑐᖅ ᐊᒻᒪᓗ ᒪᒥᐊᖅ ᐱᑕᖃᖅᑐᑦ ᓕᓗ ᐅᓛᐸᔅ ᑕᓯᖅ; ᑲᑎᑦᓱᒍ ᐆᒻᒪᕈᓐᓇᖅᑐᓂ ᐸᐅᖅ ᐃᓗᓕᖓ ᐊᒻᒪᓗ ᑐᖁᓐᓇᖅᑐᑦ, ᒪᖏᑐᓇᑦᑐᓐᓇᙱᑦᑐᖅ ᓴᕈᔭᒃᓴᖅ ᖃᑯᖅᑐᖅ ᐊᒻᒪᓗ ᖃᓐᓄᔭᖅ ᐱᑕᓕᑦ ᐃᓂᖓᓂ ᐅᓛᐸᔅ ᐸᐃ ᐱᓇᖕᓇᖓᓂ ᐊᒻᒪᓗ ᐅᓛᐸᔅ ᐸᐃ ᑲᓇᖕᓇᖓᓂ - ᐃᒪᖓᓂ 1. ᐊᔾᔨᕉᐸᓗᐃᑦ ᐊᓯᔾᔨᕐᓂᖏᑦ ᐃᓂᖏᓐᓂ ᐃᓗᓕᖏᑦ, ᐃᓱᓕᖅᓯᒪᔪᖅ ᑕᑯᑎᑎᓯᒪᔪᖅ ᐊᓯᔾᔨᖅᓯᒪᓂᖓᓂ ᐅᓛᐸᔅ ᐸᐃ ᐱᓇᖕᓇᖓᓂ ᑲᑎᑦᓱᒍ ᐆᒻᒪᕈᓐᓇᖅᑐᓂ ᐸᐅᖅ ᐃᓗᓕᖓ, ᐊᒻᒪᓗ ᓴᕙᖃᔭᒃᓴᐃᑦ ᐱᑕᖃᖅᑐᖅ ᐃᓂᑐᖃᖓᓂ ᐊᕐᕌᒍᓂ ᑎᑭᓪᓗᒍ 2014 ᑕᐃᑲᓂ ᐅᓛᐸᔅ ᐸᐃ ᐱᓇᖕᓇᖓᓂ ᐊᒻᒪᓗ ᐅᓛᐸᔅ ᐸᐃ ᑲᓇᖕᓇᖓᓂ ᐃᒪᖓᓂ 1 ᐃᓱᓕᖅᓯᓯᒪᔪᖅ ᑕᑯᑎᑎᓯᒪᒐᒥ ᐊᓯᑦᓯᕐᓂᖓᓂ ᑕᐃᖓᓂ ᑕᐃᒪᓐᓇᑐᖅᑲᐅᔾᔪᓯᔪᖓ ᓄᓇᒥ ᐊᒻᒪᓗ ᐃᓚᒋᓐᖏᑦᑎᐊᖅᑕᖓᓂ ᓱᕋᖅᑕᐅᓚᒥ ᑐᓚᒃᑲᖓᑦ ᑕᐃᑲᓂ 2013, ᑐᓚᒃᑲᖓᑦ ᐊᕿᒃᑕᐅᑦᑎᐊᖅᓗᓂ ᑕᐃᑲᓂ ᐅᑭᐅᖓᓂ 2013-2014, ᐅᕝᕙᓘᓐᓃᑦ ᐊᓯᖏᓐᓄᑦ ᐱᓕᕆᐊᖑᔪᓄᑦ. ᑲᓐᓄᔭᖅ ᐱᑕᖃᖅᑐᖅ ᐊᑦᑎᒃᓯᓯᒪᔫᒥᓚᐅᖅᑐᑦ 2014-ᒥ, ᒪᓕᒡᓗᒍ ᐃᓂᒋᓚᐅᖅᑕᑐᖅᑲᖏᑦ ᐊᕐᕌᒍᓄᑦ, ᑕᐃᑲᓂ ᑐᐊᓕᒃ ᑕᓯᖅ ᐅᐊᖕᓇᖕᖓᓂ ᐊᒻᒪᓗ ᑐᐊᓕᒃ ᑕᓯᖅ ᓂᒋᐊᓂ.

ᓴᖅᑮᔭᖅᑐᖅᑲᓐᖏᑦᑐᖅ ᐱᓕᕆᐊᖑᔪᓄᑦ ᐊᑕᐅᔪᓄᑦ ᐊᒃᑐᐃᓃᑦ ᑕᒪᒃᑯᓄᖓ ᖁᐱᕐᕈᑦ ᐱᕈᖅᑐᓂ ᐊᑕᔪᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐃᒪᕐᒥᐅᑕᐃᑦ ᐱᕈᖅᑐᑦ ᐊᑦᑕᑎᖃᓐᖏᑦᑐᑦ ᑲᑎᙵᔪᑦ ᐅᓄᖅᑐᓪᓚᕇᓗᐃᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐊᓗᐊᓂᕐᒥᐅᑕᐃᑦ ᐃᒪᐅᑉ ᐱᑕᖃᖅᑐᑦ ᐃᔾᔪᑎᒋᓂᖏ, ᖃᓅᑎᒋᓂᖏᑦ, ᓇᓕᖅᑲᓈᖕᓂᖏᑦ, ᖃᓄᓇᑦᑐᑐᐃᓐᓇᐅᓂᖏᑦ, ᐅᕝᕙᓘᓐᓃᑦ ᐳᓚᐃ-ᑰᑎᔅ ᓇᓗᓴᐃᖅᓯᒪᔭᖏᑦ ᑕᐃᑲᓂ ᑰᒐᓛᓂ, ᑕᓯᖅ, ᐅᕝᕙᓘᓐᓃᑦ ᐃᒪᓕᑦ ᐃᓂᖏᑦ. ᑕᒪᐅᓇ ᐃᓚᖏᑦ ᐊᖏᓗᐊᖅᑐᑦ ᐊᓯᔾᔨᐅᑎᔪᑦ ᓇᓂᔭᐅᓯᑦ ᐃᓂᑐᖃᓐᖏᓂᑦ ᐊᒻᒪᓗ 2014 ᐃᖃᖅᓚᓂᕐᒥᐅᑕᐃᑦ ᓄᖅᑲᑎᕇᑦ ᐆᒃᑐᕋᖅᓯᒪᔪᑦ ᖃᓅᑎᒋᓂᖓ ᖃᐅᔨᓴᖅᑐᒍ ᑕᐅᑦᑐᐊᒍ, ᐊᒻᒪᓗ ᖃᐅᔨᒪᔾᔪᑕᐅᔪᑦ ᐃᓂᖏᓐᓂᑦ, ᐱᑕᖃᓐᖏᑦᑐᖅ ᐱᓕᕆᐊᖑᔪᑦ ᐊᓯᔾᔨᓇᔭᓇᐊᖅᓴᖅ ᐃᒪᖓᓂᒃ ᖃᓄᓇᑑᓂᖓᓂ, ᐃᖃᖓᑕ ᖃᓄᓇᑑᓂᖓᓂ, ᐊᒻᒪᓗ ᐱᓗᐊᖅᑐᓂᒃ ᐃᑎᓂᐊᓐᖏᑦᑐᖅ ᐱᔭᕋᖅᑐᓂᒃ ᐃᓱᓕᖅᓯᒪᔪ ᑯᐊ ᐊᔾᔨᕆᓐᖏᑐᑕᐅᔪᑦ ᓄᓇᒥ ᑕᐃᒪᓐᓇᐅᓂᖓ ᐱᓕᕆᐊᖑᔪᓄᑦ ᐱᓯᒪᓇᑎᒃ.

ᐊᒃᑐᐊᖅᑕᐃᓕᑎᑦᑎᔾᔪᑕᐅᔪᑦ ᑐᕌᖅᑐᑦ ᐅᓄᑐᐊᕈᓐᓃᕐᓗᑎᒃ ᐊᒃᑐᐃᕐᓗᒐᔭᖅᑐᑦ ᑰᒐᓛᓂᒃ, ᑕᓯᕐᓂᒃ ᐊᒻᒪᓗ ᐃᒪᕐᒥᐅᑕᓂᒃ ᐱᓕᕿᐊᕐᔪᐊᒥ ᓄᓇᖓᒥ ᐃᓚᒋᔭᐅᓪᓗᑎᒃ ᖄᖓ ᐃᒪᐅᑉ ᐃᖏᕐᕋᓂᖓ ᐊᐅᓚᑕᐅᓪᓗᓂ, ᓯᑭᖅ ᖃᓅᑎᒋᓂᖓ ᐆᒃᑐᕋᖅᑕᐅᓪᓗᓂ, ᐃᓂᖓᑕ ᐃᒪᖓ ᐊᐅᓚᑕᐅᓪᓗᓂ, ᓴᓇᕝᕙᒐᒃᓴᐃᑦ ᐊᒻᒪᓗ ᐊᒃᑕᑯᐃᑦ ᐅᔭᖅᑲᑦ ᐊᐅᓚᑕᐅᓪᓗᑎᒃ, ᐊᒻᒪᓗ ᐊᒃᑕᖅᑕᐅᔪᑦ ᐊᐅᓚᑕᐅᓪᓗᑎᒃ. ᐋᖅᑭᒍᑎᔪᑦ ᐱᓕᕆᑎᑦᑎᔾᔪᑕᐅᔪᒥᑦ ᓇᓗᓇᐃᖅᑐᑦ ᑕᒪᒃᑯᐊ ᐊᒃᑐᐊᖅᑕᐃᓕᒪᑎᑦᑎᔾᔪᑕᐅᔪᑦ ᐊᑑᑎᖅᑐᑦ ᓱᕋᐃᓂᐊᖅᑎᒃ ᐃᒪᕐᒥᐅᑕᓂᒃ.

SOMMAIRE

Le plan 2014 de surveillance des répercussions sur le milieu aquatique du programme de surveillance de la conformité (le Programme) a été mené conformément au projet *Doris North Gold Mine* : *Plan de surveillance des répercussions sur le milieu aquatiqu*e (le Plan, Rescan 2010c). Le Programme représente la cinquième année de surveillance. Aucun effet négatif lié au projet n'a été détecté dans les sites de cours d'eau, de lacs ou d'exposition marine en ce qui concerne les concentrations d'oxygène dissous (OD), les profondeurs d'après le disque de secchi, la qualité de l'eau, la qualité du sédiment, le périphyton ou la biomasse du phytoplancton, ou les communautés d'invertébrés benthiques en 2014.

Trois sites de cours d'eau (l'exutoire Doris, l'exutoire Roberts et l'exutoire Little Roberts), trois sites de lacs (le lac Doris Nord, le lac Doris Sud et le lac Little Roberts) et deux sites d'exposition marine (la baie Roberts Est et la baie Roberts Ouest) ont été surveillés, en plus de deux sites de cours d'eau de référence (l'exutoire Référence B et l'exutoire Référence D), deux sites de lacs de référence (lac Référence B et lac Référence D) et un site d'exposition marine (REF-Marine 1). Les composantes aquatiques évaluées en 2014 comprenaient les concentrations d'OD sous la glace dans les milieux lacustres et marins, la profondeur d'après le disque de secchi des lacs, la qualité de l'eau des cours d'eau, des lacs, des milieux marins et du sédiment, la biomasse de périphyton des cours d'eau, la biomasse du phytoplancton des milieux lacustres et marins, la densité de la communauté d'invertébrés benthiques des cours d'eau, des lacs et des milieux marins, la richesse taxonomique, l'homogénéité, la diversité et l'indice de Bray-Curtis. Les communautés des poissons lacustres et marins ont été examinées pour la dernière fois en 2010 (Rescan 2011) et n'ont pas été examinées en 2014, conformément au Plan.

Des analyses statistiques et graphiques ont été menées pour déterminer si les activités du projet avaient pu affecter les sites d'exposition en 2014. Les analyses comprenaient des comparaisons des données de référence aux données actuelles (2014) ou à des comparaisons de sites de référence aux sites d'exposition dans le temps. Les données sont considérées comme étant issues de la période de référence si elles ont été recueillies avant 2010, sauf dans le cas de l'OD sous la glace dont les données sont considérées comme étant de référence.

Les concentrations d'OD étaient supérieures aux recommandations du Conseil canadien des ministres de l'Environnement (CCME) pour la protection de la vie aquatique dans tous les sites marins et dans tous les lacs, sauf le lac Little Roberts. Dans le lac Little Roberts, les concentrations d'OD correspondent aux concentrations observées dans les années de référence.

Les concentrations moyennes de la qualité d'eau en 2014 étaient inférieures aux recommandations du CCME pour les sites de cours d'eau, de lacs et d'exposition marine, sauf deux exceptions. Premièrement, les concentrations d'aluminium totales étaient supérieures aux recommandations du CCME dans plusieurs cours d'eau d'exposition en 2014. Cependant, les concentrations d'aluminium totales dépassaient aussi les recommandations du CCME dans les années de référence. Deuxièmement, la concentration de fer moyenne totale dans le lac Little Roberts en 2014 était supérieure aux recommandations du CCME, ce qui était probablement lié à la contamination

d'échantillon lors de l'échantillonnage sous la glace. Les concentrations de fer totales en eau libre dans le lac Little Roberts étaient inférieures aux recommandations du CCME.

Aucune différence notable dans les concentrations de qualité d'eau n'a été trouvée entre les concentrations de référence et de 2014 dans les sites de cours d'eau ou d'exposition marine. Dans les lacs, des différences importantes de concentrations entre les années de référence et 2014 ont été observés pour la dureté d'eau (augmentation) dans le lac Doris Sud, pour l'arsenic total (diminution) et pour le molybdène total (augmentation) dans le lac Doris Nord. Cependant, ces différences ont aussi été observées dans les lacs de référence. Une augmentation importante de la dureté de l'eau sous la glace a aussi été observée dans le lac Little Roberts. Bien que les comparaisons aux tendances dans les lacs de référence étaient impossibles parce qu'il n'y avait pas de données de référence disponibles pour le lac de Référence D, les concentrations saisonnières domaine en eau libre correspondaient aux références moyennes dans le lac Little Roberts.

Les concentrations moyennes de la qualité du sédiment en 2014 étaient inférieures aux Recommandations provisoires sur la qualité des sédiments (RPQS) et au Niveau d'effets probables (NEP) du CCME dans tous les cours d'eau, les lacs et les sites marins d'exposition, sauf quatre exceptions. Dans les lacs, l'arsenic total dans le lac Doris Sud, le chrome total dans tous les sites d'exposition ou de référence, et le cuivre total dans le lac Doris Nord et le lac Doris Sud surpassaient les RPQS. Les concentrations d'arsenic total moyennes ont aussi surpassé les NEP dans le lac Doris Sud. La concentration totale de cuivre dans la baie Roberts Ouest (BRO) était supérieure aux RPQS, mais inférieure aux NEP.

Quelques différences dans la composition granulométrique des sédiments étaient observées dans les exutoires Doris et Little Roberts, ainsi que dans les lacs Doris Sud et Little Roberts, ce qui reflète probablement l'hétérogénéité spatiale naturelle dans les sédiments des cours d'eau et des lacs et ne sont pas liées aux activités du projet. Un virage vers des sédiments plus fins a également été observé aux sites BRO et REF-Marine 1. Ce virage explique probablement les augmentations observées dans quelques variables de la qualité des sédiments à certains sites en 2014 comparées aux années de référence, y compris la teneur en Carbone organique total (COT) et les concentrations de plomb et de mercure dans l'exutoire Little Roberts, les niveaux de COT dans le lac Doris Nord, les concentrations d'arsenic et de zinc dans le lac Little Roberts, la teneur en COT et les concentrations d'arsenic, de chrome et de cuivre aux sites BRO et REF-Marine 1, et des augmentations importantes des concentrations de mercure et de zinc au REF-Marine 1. La similarité des changements de teneur en éléments fins, de COT et de concentrations de métaux des années de référence à 2014 aux sites BRO et REF-Marine 1 suggère que les changements observés à BRO étaient présents naturellement et n'étaient pas liés aux dommages à la jetée survenus en 2013, aux réparations à la jetée effectuées durant l'hiver de 2013-2014 ou aux autres activités du projet. Les concentrations de cuivre étaient sensiblement inférieures en 2014, comparées aux années de référence, aux lacs Doris Nord et Doris Sud.

Il n'y avait aucune preuve d'effets liés au projet sur le périphyton, la biomasse de phytoplancton ou la densité de la communauté benthique, sur la richesse, l'homogénéité, la diversité ou l'indice Bray-Curtis aux sites d'exposition de cours d'eau, de lacs ou de milieux marins. Bien que certaines différences importantes aient été trouvées dans les mesures de la communauté benthique entre les années de référence et 2014 en comparant les sites d'exposition et de référence, l'absence de changements dans la qualité de l'eau, la qualité des sédiments et la biomasse du producteur primaire liés au projet suggère que ces différences sont probablement le résultat d'une variabilité naturelle plutôt que d'effets liés au projet.

Des mesures d'atténuation des effets visant à réduire les effets nocifs probables sur les habitats de cours d'eau, de lacs et de milieux marins dans la région du projet comprenaient la gestion du ruissellement des eaux de surface, des mesures de réduction des poussières, la gestion des carrières et des résidus miniers, et la gestion des déchets. Les résultats du Programme indiquent que ces mesures de prévention étaient efficaces pour prévenir les effets nocifs sur les communautés aquatiques.

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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 Plan
ALS	ALS Laboratory Group
ANOVA	Analysis of Variance
BA	Before-after
BACI	Before-after-control-impact
BC	Bray-Curtis Dissimilarity Index (also known as Bray-Curtis Similarity Index) or British Columbia
Benthos	Benthic invertebrates
CCME	Canadian Council of Ministers of the Environment
Censored value	A value that is only partially known, e.g., a variable concentration that is reported as being below a specified detection limit, although the actual concentration is not known.
Chl *a*	Chlorophyll *a*
Chlorophyll *a*	An essential light-harvesting pigment for photosynthetic organisms including phytoplankton. Because of the difficulty involved in the direct measurement of plant carbon, chlorophyll *a* is routinely used as a 'proxy' estimate for plant biomass in aquatic studies.
CTD	Conductivity, temperature, depth probe
D	Simpson's Diversity Index
DO	Dissolved oxygen
D_s	Secchi depth
E	Simpson's Evenness Index
EEM	Environmental Effects Monitoring
Epontic	Occurring in or on the bottom of the ice layer.
ERM	ERM Consultants Canada Ltd.

Exposure areas	Areas anticipated to be potentially influenced by mining-related activities as part of the Doris North Project.
F	Family richness
GA	Graphical analysis
HBML	Hope Bay Mining Limited
ILBT	Impact level-by-time
ISQG	Interim sediment quality guideline
k	Light extinction coefficient
MMER	Metal Mining Effluent Regulations
NA	Not applicable
NC	Not collected
NIRB	Nunavut Impact Review Board
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
OF	Outflow
PEL	Probable effects level
the Plan	the Doris North Gold Mine Project: Aquatics Effects Monitoring Plan
the Program	the Aquatic Effects Monitoring Program
the Project	the Doris North Project
QA/QC	Quality assurance/quality control
RBE	Roberts Bay East
RBW	Roberts Bay West
RDL	Realized detection limit
Reference areas	Areas located beyond any Project influence.
Salinity	No units, dimensionless. Historically, many units have been assigned to salinity, for example, parts per thousand (ppt or ‰), Practical Salinity Units (PSU), and Practical Salinity Scale (PSS 78). Salinity is defined on the Practical Salinity Scale (PSS) as the conductivity ratio of a sea water sample to a standard KCl solution. As PSS is a ratio, it has no units.

SD	Standard deviation
SE	Standard error of the mean
TIA	Tailings Impoundment Area
TMAC	TMAC Resources Inc.
TOC	Total organic carbon
TSS	Total suspended solids
$Z_{1\%}$	The 1% euphotic depth, i.e., the depth of the water column at which 1% of the surface irradiance reaches.

1. INTRODUCTION

The Doris North Project (the Project) is located on the Hope Bay Belt (the Belt), an 80 by 20 km property along the south shore of Melville Sound in Nunavut (Figure 1-1). The property consists of a greenstone belt (the Belt) that contains three main gold deposits. The Doris and Madrid deposits are located in the northern portion of the belt, and the Boston deposit is at the southern end. The Project is located approximately 125 km southwest of Cambridge Bay (Iqaluktuttiaq) on the southern shore of Melville Sound. The nearest communities are Umingmaktok (75 km to the southwest of the property), Cambridge Bay and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

TMAC Resources Inc. (TMAC) acquired the Hope Bay Belt Project from Newmont Corporation in March 2013. The acquisition included exploration and mineral rights over the Hope Bay Belt, including the Doris North Gold Mine and its permits, licences and authorizations for development received by previous owners. In late 2012, prior to the sale, the Hope Bay Belt Project was placed into care and maintenance, and the Project was seasonally closed during the winter of 2012/2013. TMAC re-opened the Doris North Camp in March of 2013 for the purposes of conducting site water management and environmental compliance programs and to support exploration activities which have continued through 2014. The Project remains in care and maintenance at this time.

ERM Consultants Canada Ltd. (ERM) was contracted to develop an Aquatic Effects Monitoring Plan (AEMP) to fulfil requirements set out in the Doris North Nunavut Water Board (NWB) Type A Water Licence (No. 2AM-DOH0713 Type A, issued September 19, 2007; NWB 2007) as follows:

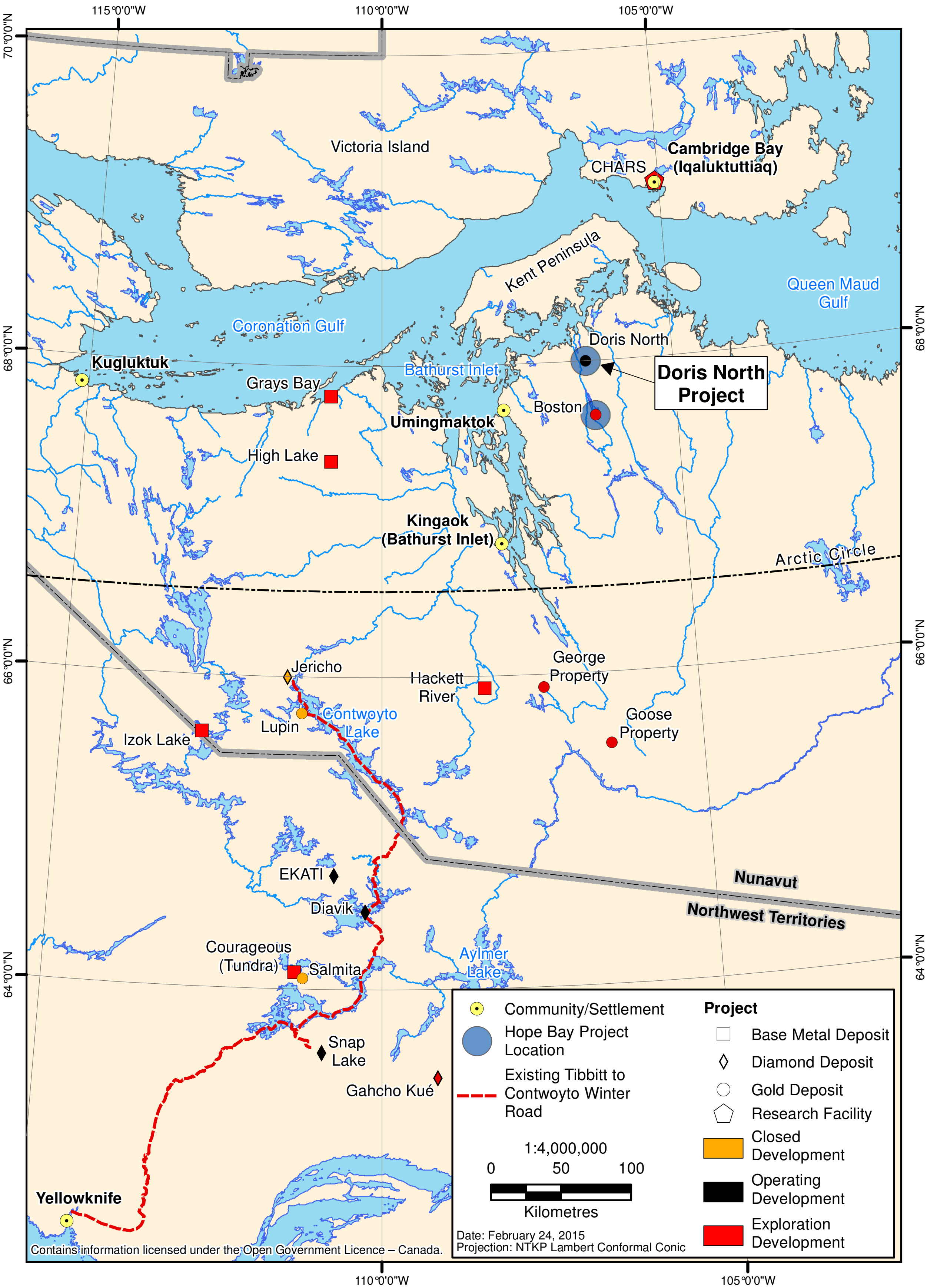
- Part K, Item 7. *The Licensee shall submit to the Board for approval..., a proposal for the development of an Aquatic Effects Monitoring Plan (AEMP) in consultation with Environment Canada. The proposal for an AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the Metal Mining Effluent Regulations (MMER);*
- Part K, Item 8. *The Licensee and Environment Canada shall coordinate with the NWB to ensure that the advanced submission of the AEMP meets the requirements of MMER.*

In compliance with Part K, Item 7, Hope Bay Mining Ltd. (HBML) submitted an AEMP on February 24, 2010, following consultation with Environment Canada. The *Doris North Gold Mine Project: Aquatics Effects Monitoring Plan* (the Plan; Rescan 2010c), was approved by the Nunavut Water Board (NWB) on March 25, 2010, under Motion 2009-23-L04. This document conformed to the methodologies and practices laid out in the MMER (2002), thus complying with Part K, Item 8 of the Type A Water Licence, and was designed to assess the potential effects of Project development on the aquatic environment.

On September 12, 2013, a renewed and amended Type A Water Licence was issued to TMAC. The following text outlines the requirements of the current Type A Water Licence (NWB Licence #2AM-DOH1323):

- Part K, Item 7. *The Licensee shall submit to the Board for review, six (6) months prior to Operations, a revised Doris North Gold Mine Project: Aquatic Effects Monitoring Plan (AEMP) that has been developed in consultation with Environment Canada. The revised AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the MMER.*

Figure 1-1
Doris North Project Location



Operations have yet to commence and the Project remains in care and maintenance at this time. Consequently, the 2014 Aquatic Effects Monitoring Program (the Program) was conducted in accordance with the Plan approved on March 25, 2010. The Program has been conducted annually in accordance with the Plan since 2010, and this report presents the results from the fifth year of the Program. Although some construction activities occurred in 2008 to support the camp development, the construction initiated in 2010 was more relevant in terms of potential aquatic effects. Thus, 1995-2009 was considered the baseline period for most parameters. In the case of under-ice dissolved oxygen (DO), 2010 data were also considered to be part of the baseline period.

This report presents the results of the 2014 Program. All other requirements pertaining to water quality monitoring (e.g., Quarry Rock Seepage Monitoring and Management) are monitored by TMAC and reported elsewhere.

1.1 OBJECTIVES

The Plan design was driven by the requirements of the MMER and the anticipated location of Project activities during the construction, operation, and closure phase of the mine. The MMER stipulates that mines are required to conduct Environmental Effects Monitoring (EEM) if effluent discharge rates exceed 50 m^3 per day and/or deleterious substances are discharged into any waterbody as per subsection 36(3) of the *Fisheries Act*. The primary objective of the mining EEM program is to evaluate the effects of mining effluents on fish, fish habitat, and the use of fisheries resources. Thus, the objectives of the Program were to monitor and evaluate potential effects of Project activities on the following components in waterbodies in the Project area:

- water quality and water column structure;
- sediment quality;
- primary producer biomass (phytoplankton and periphyton);
- benthic invertebrate community (density and taxonomy); and
- fish.

Fish were last sampled in 2010 (Rescan 2011). The second year of fish monitoring was postponed from 2013 in accordance with the modified mine development schedule because the Project remains in care and maintenance at this time. The Plan will be revised prior to the discharge of effluent from the Tailings Impoundment Area (TIA) and a new fish monitoring schedule will be outlined.

1.2 2014 PROJECT ACTIVITIES

As of 2014, existing Project infrastructure included the following: the Roberts Bay jetty, the 5,000,000 L tank and berm at Roberts Bay, the 15,000,000 L tank farm at Roberts Bay, the Roberts Bay laydown areas, the road and associated airstrip between Roberts Bay and Doris Camp, the access road to the Doris Lake pump house, the 7,500,000 L tank farm at Doris Camp, Doris Camp Pads X and Y (including the camp, construction power house, and sewage and water treatment system), Doris Camp Pads B, C, E/P, F, G, H/J, I, Q, the helipad, the upper and lower reagent pads, the primary vent raise, permanent power house, partially developed Quarry 2, the secondary road to the TIA, and the North Dam (Figure 1.2-1). Windy Road and Quarries A, B and D are depicted on Figure 1.2-1 but are permitted outside of the Doris North Project Certificate (Land Use Licence KTL303C056 and Quarry Permit Agreement KTP308Q010).

The Project remained in care and maintenance during 2014, and site activities with the potential to affect the aquatic environment were therefore limited. Project activities that could have affected the Doris North aquatic environment in 2014 included winter drilling on Doris Lake and re-armouring of the jetty in Roberts Bay. On-ice drilling occurs seasonally on Doris Lake; however water quality is sampled before and after drilling in accordance with Water Licence 2BE-HOP1222 Part F Item 7. In winter 2014, the Roberts Bay jetty was re-armoured to prevent erosion caused by storm and wave action. The work was completed in accordance with the application submitted to and approved by Fisheries and Oceans Canada (DFO), and involved construction activities during mid-winter when the ocean was frozen to bottom in the vicinity of the jetty. Ice was removed prior to placement of rock, and minimal disruption to and mobilization of sediments in relation to these improvements was ensured by working on the frozen sea bed.

On-going site water management involved the discharge of water from the TIA into Doris Creek to manage water levels in the lake. This discharge has been occurring seasonally since 2011, and was unlikely to affect the aquatic environment because discharged water was closely monitored to ensure that established discharge criteria were met.

The main potential interactions between the Project and the aquatic freshwater and marine environment over the lifetime of the Project are anticipated to be:

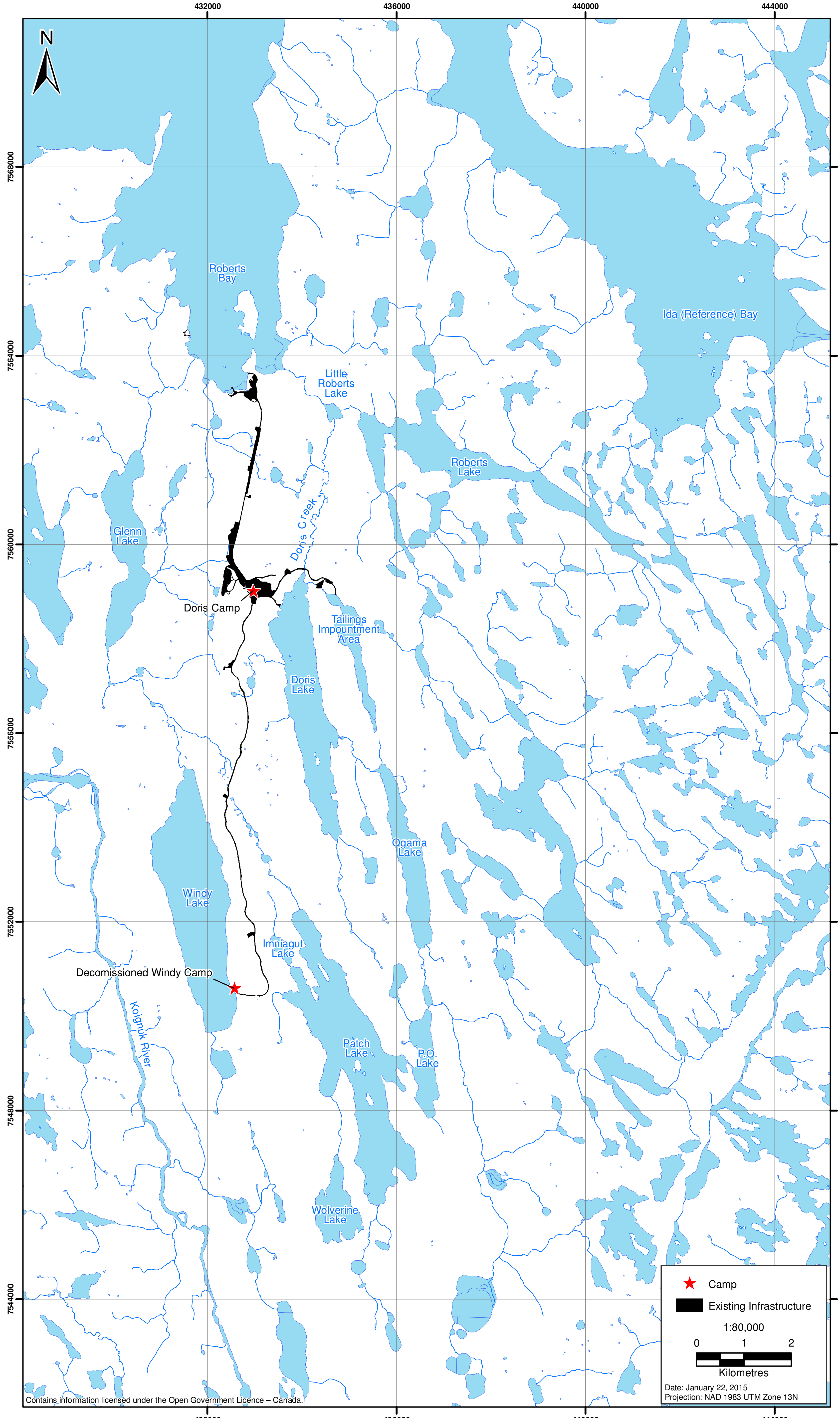
- the operation of the Tailings Impoundment Area (TIA; formerly Tail Lake): treated effluent from this facility is expected to be released into Doris Outflow where it would flow successively through Little Roberts Lake and into Little Roberts Outflow before entering Roberts Bay. However, no tailings have been placed in this facility to date;
- shipping activity at the marine jetty in southern Roberts Bay;
- construction of roads and infrastructure;
- runoff from site infrastructure, roads, waste rock, explosives facility; and
- accidental spills.

Mitigation measures to reduce the potential for adverse effects to stream, lake, and marine habitats in the Project area included surface water runoff management, dust abatement measures, site water management, tailings management, quarry and waste rock management, and waste management.

1.3 REPORT STRUCTURE

This document presents the methods, effects analysis, and conclusions of the 2014 Program. Source data and results from the 2014 Program (including water column structure, water quality, sediment quality, primary producers, and benthic invertebrates) are provided in Appendix A, and supplemental information relevant to the 2014 effects analysis is provided in Appendix B.

Figure 1.2-1
Existing Infrastructure, Doris North Project



2. METHODS

2.1 SUMMARY OF STUDY DESIGN

The 2014 Program was conducted in accordance with the Doris North Gold Mine Project: Aquatic Effects Monitoring Plan (Rescan 2010c).

2.1.1 Study Area and Sampling Locations

The Program study area included those areas anticipated to be potentially influenced by mining-related activities as part of the Project (exposure areas) and those areas beyond any Project influence (reference areas). Three lake and three stream sites were sampled in the exposure areas and two lakes and two streams were sampled as reference sites (Table 2.1-1; Figure 2.1-1). Two marine exposure sites and one marine reference site were also sampled (Table 2.1-1; Figure 2.1-1). Sampling sites, the aquatic components sampled, Project infrastructure, and the projected flow path of the treated TIA effluent to be released into Doris Outflow are shown in Figure 2.1-1.

Table 2.1-1. AEMP Sampling Locations, Descriptions, and Purposes, Doris North Project, 2014

Sampling Location	Coordinates (13W)	Description	Purpose
Doris Outflow	434177E 7559910N	Immediately downstream of discharge point from the TIA	First exposure site downstream of TIA discharge location
Little Roberts Lake	434665E 7562826N	Small lake downstream of Doris Outflow	First and only lake exposed to upstream TIA discharge
Little Roberts Outflow	434367E 7563094N	Stream downstream of Little Roberts Lake	Second exposure stream downstream of TIA discharge location
Roberts Bay East (RBE)	433430E 7563850N	Marine bay into which Little Roberts Lake drains	Marine receiving environment for freshwater system downstream of TIA discharge location
Roberts Outflow	435129E 7562881N	Stream upstream of Little Roberts Lake, which drains the much larger Roberts Lake	To characterize any influence of an abandoned silver mine and past neighbouring exploration activity (North Arrow Minerals Inc.) on Roberts Outflow and potentially downstream in Little Roberts Lake and Little Roberts Outflow, and to be able to differentiate this from potential effects of TIA discharge upstream
Doris Lake North	433815E 7558222N	Large lake located south of main Project site. North part of lake is adjacent to Project infrastructure.	Potential exposure site due to close proximity of Project infrastructure and explosives storage
Doris Lake South	434288E 7555935N	Large lake located south of main Project site. South part of lake is 4 km away from Project infrastructure.	South site can be used to characterize any potential changes to the lake (whether local or lake-wide)

(continued)

Table 2.1-1. AEMP Sampling Locations, Descriptions, and Purposes, Doris North Project, 2014 (completed)

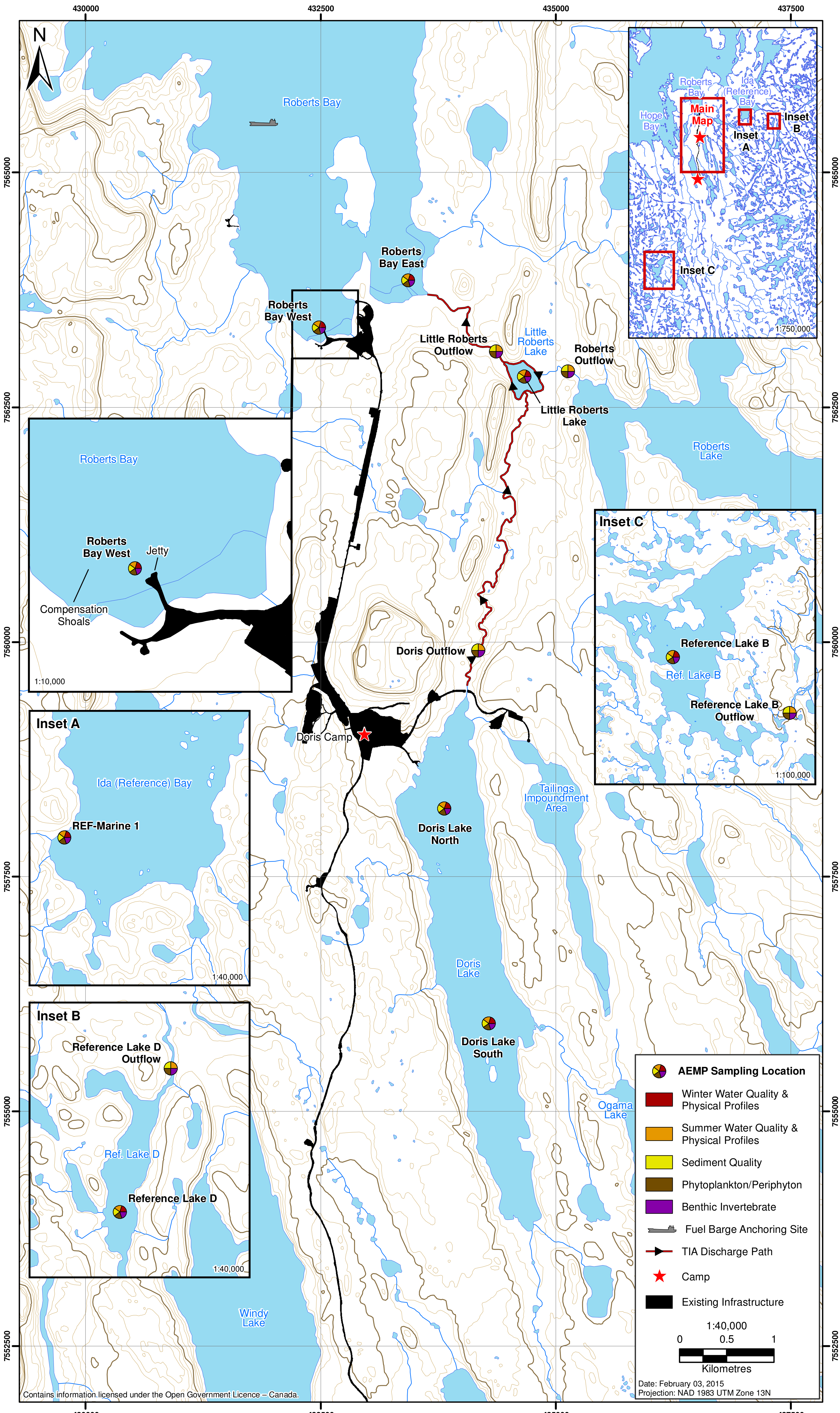
Sampling Location	Coordinates (13W)	Description	Purpose
Roberts Bay West (Jetty; RBW)	432479E 7563346N	Small marine bay where jetty is located	Potential exposure marine area due to marine activities and infrastructure
Reference Lake D	447566E 7561301N	Small reference lake located west of the Project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Little Roberts Lake
Reference D Outflow	448109E 7562830N	Reference outflow located west of the Project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Little Roberts Outflow
Reference Lake B	424050E 7532000N	Large reference lake located southwest of the Project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Doris Lake
Reference B Outflow	427150E 7530515N	Reference outflow located southwest of the Project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Doris Outflow
Ida (Reference) Bay (REF-Marine 1)	441152E 7563018N	Marine bay located west of the Project	Marine reference area meant to provide a reference for the two potential marine exposure sites (Roberts Bay East, Roberts Bay West (Jetty))

2.1.1.1 *Exposure Sites*

The principal exposure sites in the Program study area are those waterbodies located downstream of discharge from the TIA. From upstream to downstream, these locations include: Doris Outflow, Little Roberts Lake, Little Roberts Outflow, and Roberts Bay East (RBE; Figure 2.1-1). The Doris Outflow sampling site is within 100 m of the discharge location to best measure the potential effects of the TIA discharge. Little Roberts Lake, a small, shallow lake (0.1 km^2, <5 m depth) receiving outflow from Doris Lake and Roberts Lake, is the only lake along the TIA discharge path. A receiving environment site is in eastern Roberts Bay where Little Roberts Outflow enters the marine habitat (Roberts Bay East).

In addition to the sampling sites that could potentially be affected by TIA discharge, sites were also selected to capture other potential effects of the Project. These sites include two sampling locations in Doris Lake (adjacent to site infrastructure and roads), and a single site in western Roberts Bay (Roberts Bay West; RBW) near the marine jetty (roads, site infrastructure, marine loading/unloading activities). In all, there are three stream exposure sites, three lake exposure sites, and two marine exposure sites. Note that the 2010 Doris South sampling location was moved approximately 800 m to the north to a deeper basin (> 10 m deep) for 2011 to 2014 sampling for improved comparability with the Doris North sampling location, which is also in a deep basin (> 10 m deep; Figure 2.1-1). The Little Roberts Lake sampling location was moved approximately 90 m in 2014 to a deeper location to facilitate the collection of representative samples under-ice. The 2014 sampling location in Little Roberts Lake was consistent with the 1995 to 1997 and 2003 to 2009 baseline sampling location (Figure 2.1-1).

Figure 2.1-1
AEMP Sampling Locations, Doris North Project, 2014



2.1.1.2 *Reference Sites*

Three reference areas were included in the Program: two lake/stream outflow systems (Reference Lakes/Outflows B and D) and one marine site (Ida Bay; Figure 2.1-1). The two lake/stream outflow areas (Reference Lake B/Reference B Outflow and Reference Lake D/Reference D Outflow) were used as reference sites for comparability with exposure freshwater sites. Reference Lake D (area: 0.6 km^2) was selected as a suitable reference analogue for Little Roberts Lake (area: 0.1 km^2) based on its size and a direct linkage to the marine environment. Reference Lake B (7.7 km^2) was selected as a comparable lake to Doris Lake (3.4 km^2). A marine reference site in southern Ida Bay (REF-Marine 1) was selected for comparability with the two marine exposure sites in Roberts Bay. These reference areas were chosen with two features in mind:

- the reference areas were sufficiently far away from the influence of Project activity; and
- the reference areas resemble, as much as possible, the hydrological and habitat features of the exposure areas.

There were no Project activities near the selected reference sites. The major consideration in reference site selection was to ensure the reference sites were located beyond any potential wind-borne particulates from mine sources. Reference Lake D is located 15 km from Doris North infrastructure, Reference Lake B is located 25 km away, and the marine reference site in Ida Bay is 10 km away.

2.1.2 2014 Sampling Schedule

Sampling was conducted in accordance with the schedule outlined in the Plan and is summarized in Table 2.1-2 (Rescan 2010c). For 2014, sampling commenced in April with the under-ice, physical limnology/oceanography and water quality collection, and ended in late September. Physical characteristics (e.g., temperature, dissolved oxygen [DO], salinity) and water quality (e.g., nutrients and metals) were collected in streams, lakes, and the marine environment four times during the sampling period, at least one month apart (whenever possible), thereby complying with MMER guidelines (Schedule 5, s.7 [1-2]). Phytoplankton and periphyton biomass (as chlorophyll *a*) were also collected during these surveys. Sediment quality and benthos samples were collected once in August.

Table 2.1-2. Sampling Schedule Summary, Doris North Project, 2014

Waterbody	Variable	Sampling Dates
Streams	Water Quality	June 18-19
		July 16-17
		August 14-16
		September 17-18
	Sediment Quality	August 14-16
	Periphyton Biomass	July 16-17*
		August 14-16*
		September 17-18*
	Benthos	August 14-16

(continued)

Table 2.1-2. Sampling Schedule Summary, Doris North Project, 2014 (completed)

Waterbody	Variable	Sampling Dates
Lakes	Physical Limnology	April 19-24
		July 19-20
		August 17-23
		September 18-20
	Water Quality	April 19-24
		July 19-20
		August 17-23
		September 18-20
	Sediment Quality	August 17-23
	Phytoplankton Biomass	April 19-24
		July 19-20
		August 17-23
		September 18-20
	Benthos	August 17-23
Marine	Physical Oceanography	April 20-24
		July 20-21
		August 13-21
		September 21
	Water Quality	April 20-24
		July 20-21
		August 13-21
		September 21
	Sediment Quality	August 13-21
	Phytoplankton Biomass	April 20-24
		July 20-21
		August 13-21
		September 21
	Benthos	August 13-21

** Periphyton biomass sampling dates indicate the dates of sample retrieval. Artificial samplers were installed in streams for approximately one month.*

2.2 DETAILED METHODS

Table 2.2-1 presents a summary of the Program components and methods, including the variables assessed, the within-year sampling frequency, sampling replication, sampling dates, and the sampling devices used.

Table 2.2-1. Sampling Program Summary, Doris North Project, 2014

Monitoring Variable	Sampling Frequency	Sample Replication and Depths	Sampling Dates / Timing	Sampling Device
Physical Limnology and Oceanography, Lake and Marine Water Quality				
Dissolved oxygen/temperature profile, Secchi depth, salinity profile (marine sites only), Physical parameters, anions, nutrients, cyanides, organic carbon, total metals, radium-226	4×	n = 1 profile/site throughout water column OR Lakes: n = 1 sample/site @ 1 m below the surface and 2 m above water-sediment interface (large lakes only) + 20% replication; Marine: n = 2 samples/site @ 1 m	April, July, August, September	DO meter; Conductivity-Temperature-Depth (CTD) probe; GO-FLO sampling bottle
Lake and Marine Phytoplankton				
Biomass (chlorophyll *a*)	4×	n = 3/site @ 1 m below the surface	April, July, August, September; coincident with lake and marine water quality	GO-FLO sampling bottle
Lake and Marine Benthos				
Density and taxonomy	1×	n = 5/site (3 composite subsamples/replicate)	August; coincident with August lake and marine survey	Ekman grab (lake); Petite Ponar grab (marine); 500 µm sieve
Lake and Marine Sediment Quality				
Physical, particle size, organic carbon, nutrients, metals	1×	n = 3/site	August; coincident with August lake and marine survey	Ekman grab (lake); Petite Ponar grab (marine)
Stream Water Quality				
Temperature, physical parameters, anions, nutrients, cyanides, organic carbon, total metals, radium-226	4×	n = 2/site	June, July, August, September	Clean water sampling bottles; temperature meter
Stream Periphyton				
Biomass (chlorophyll *a*)	3×	n = 3/site	June-July, July-August, August-September; coincident with stream water quality	Artificial samplers (Plexiglas plates) installed for ~1 month

(continued)

Table 2.2-1. Sampling Program Summary, Doris North Project, 2014 (completed)

Monitoring Variable	Sampling Frequency	Sample Replication and Depths	Sampling Dates / Timing	Sampling Device
Stream Benthos				
Density and taxonomy	1×	n = 5/site (3 composite subsamples/replicate)	August; coincident with August stream survey	Hess sampler; 500 µm sieve
Stream Sediment Quality				
Physical, particle size, organic carbon, nutrients, metals	1×	n = 3/site	August; coincident with August lake and marine survey	Plastic bowl and spoon

2.2.1 Physical Limnology and Oceanography

2.2.1.1 Lakes

<u>Under Ice</u>

The underlying lake water at the April sampling sites was accessed by drilling a 25 cm diameter hole through the ice using a motorized auger. The ice thickness was then recorded and the lake bottom depth measured using a depth sounder. Water column profiling and water quality sampling depths were calculated based on bottom depth.

Measurements of water column structure (including temperature and dissolved oxygen) were collected using a YSI Pro-ODO temperature and optical dissolved oxygen meter. Temperature and dissolved oxygen values were recorded at 0.5 m intervals (depth ≤ 10 m) or 1 m intervals (depth > 10 m). The profiles extended from the surface to approximately 1 m above the sediment surface to reduce suspension of bottom sediments.

<u>Open-water</u>

Summer temperature and dissolved oxygen profiles were measured at the same locations using the same equipment as in winter, and were collected from an aluminum boat or inflatable boat. In addition, light attenuation was estimated in each lake using a Secchi disk. Measurements were collected at each site by lowering the 20 cm black and white disk on a metred line through the water column on the shaded side of the boat until it disappeared from sight. The depth of disappearance was recorded as the Secchi depth (D_s). The 1% euphotic zone depth ($Z_{1\%}$) was computed by first calculating the light extinction coefficient (k) from D_s, and then calculating the euphotic zone depth based on the appropriate light extinction coefficient. The 1% euphotic zone depth is the depth of the water column to which 1% of the surface irradiance reaches. It represents the depth at which the integrated gross water column photosynthetic production is equivalent to the integrated gross water column respiration; thus, there is net photosynthesis above this depth. The 1% euphotic zone depth is often referred to as the compensation depth, and is calculated as follows (Parsons, Takahashi, and Hargrave 1984):

Light extinction coefficient:

$$k\ (m^{-1}) = 1.7/D_s$$

Euphotic Depth (1%):

$$Z_{1\%}\ (m) = 4.6/k$$

2.2.1.2 Marine

<u>Under Ice</u>

Marine under-ice water was accessed by drilling a 25 cm diameter hole through the ice using a motorized auger. Ice thickness was recorded and the bottom depth measured using a depth sounder. A vertical profile of temperature, salinity, and conductivity was collected using an in situ conductivity, temperature, and depth probe (CTD; model RBR-420). The probe was lowered through the water column on a cable at approximately 0.5 m/s to within 1 m of the sea floor. The data logged during this process were immediately transferred to a computer in the field. Data from the downcast were used to derive physical profiles.

Measurements of temperature and dissolved oxygen were collected using a YSI Pro-ODO temperature and optical dissolved oxygen meter. Temperature and dissolved oxygen values were recorded at 0.5 or 1 m intervals. The profiles extended from the surface to approximately 1 m above the sediment surface to reduce suspension of bottom sediments.

<u>Open-water</u>

CTD and dissolved oxygen profiles were collected over the side of an aluminum boat using the same equipment and methods as described for the under-ice season. Light penetration at each site was measured by lowering a 30 cm white Secchi disk over the shaded side of the boat until it disappeared from sight. This was recorded as the Secchi depth. The 1% euphotic zone depth was calculated from the Secchi depth as described above for lakes.

2.2.2 Water Quality

Water quality samples were collected at the lake and marine sites during the under-ice season in April, and the open-water season in July, August, and September 2014. Stream water quality samples were collected during the June freshet in addition to the three open-water months listed above. Whenever possible, samples at a specific site were collected at least one month apart to conform to MMER/EEM recommendations. The sampling dates and depths for all sites are presented in Table 2.2-2 and the analyzed variables are summarized in Table 2.2-3. Sampling locations are presented in Figure 2.1-1. The sampling procedures used for each aquatic habitat are described below.

Table 2.2-2. Stream, Lake, and Marine Physical Limnology, Oceanography and Water Quality Sampling Dates and Depths, Doris North Project, 2014

Habitat	Site	Sampling Date	Water Quality Sampling Depth(s) (m)	Physical Limnology and Oceanography Sampling Depths
Stream	Doris Outflow	19-Jun-14	Surface	Surface
		17-Jul-14	Surface	Surface
		16-Aug-14	Surface	Surface
		17-Sep-14	Surface	Surface
	Roberts Outflow	18-Jun-14	Surface	Surface
		17-Jul-14	Surface	Surface
		16-Aug-14	Surface	Surface
		18-Sep-14	Surface	Surface
	Little Roberts Outflow	18-Jun-14	Surface	Surface
		16-Jul-14	Surface	Surface
		15-Aug-14	Surface	Surface
		17-Sep-14	Surface	Surface
	Reference B Outflow	19-Jun-14	Surface	Surface
		16-Jul-14	Surface	Surface
		15-Aug-14	Surface	Surface
		18-Sep-14	Surface	Surface
	Reference D Outflow	18-Jun-14	Surface	Surface
		16-Jul-14	Surface	Surface
		14-Aug-14	Surface	Surface
		17-Sep-14	Surface	Surface
Lake	Doris Lake North	19-Apr-14	3.0, 12	Throughout water column
		20-Jul-14	1.0, 12.0	Throughout water column
		19-Aug-14	1.0, 12.0	Throughout water column
		20-Sep-14	1.0, 12.0	Throughout water column
	Doris Lake South	19-Apr-14	2.0, 9.0	Throughout water column
		20-Jul-14	1.0, 9.0	Throughout water column
		19-Aug-14	1.0, 8.0	Throughout water column
		20-Sep-14	1.0, 9.0	Throughout water column
	Little Roberts Lake	23-Apr-14	2.0	Throughout water column
		19-Jul-14	1.0	Throughout water column
		17-Aug-14	1.0	Throughout water column
		19-Sep-14	0	Throughout water column
	Reference Lake B	20-Apr-14	3.0, 9.0	Throughout water column
		19-Jul-14	1.0, 8.0	Throughout water column
		23-Aug-14	1.0, 9.0	Throughout water column
		18-Sep-14	1.0, 8.5	Throughout water column
	Reference Lake D	24-Apr-14	2.5	Throughout water column
		19-Jul-14	1.0	Throughout water column
		18-Aug-14	1.0	Throughout water column
		19-Sep-14	1.0	Throughout water column

(continued)

Table 2.2-2. Stream, Lake, and Marine Physical Limnology, Oceanography and Water Quality Sampling Dates and Depths, Doris North Project, 2014 (completed)

Habitat	Site	Sampling Date	Water Quality Sampling Depth(s) (m)	Physical Limnology and Oceanography Sampling Depths
Marine	RBE (Roberts Bay)	23-Apr-14	2.0	Throughout water column
		21-Jul-14	0	Throughout water column
		14-Aug-14	0.2	Throughout water column
		21-Sep-14	0.2	Throughout water column
	RBW (Roberts Bay)	20-Apr-14	2.0	Throughout water column
		21-Jul-14	1.0	Throughout water column
		13-Aug-14	1.0	Throughout water column
		21-Sep-14	1.0	Throughout water column
	REF-Marine 1 (Ida Bay)	24-Apr-14	3.0	Throughout water column
		20-Jul-14	1.0	Throughout water column
		21-Aug-14	1.0	Throughout water column
		21-Sep-14	1.0	Throughout water column

Note: April sample depths are recorded as depths below the water surface and are equal to approximately 0-1 m below ice.

2.2.2.1 *Streams*

During the open-water season, water quality samples were collected from three streams within the Doris watershed (Doris, Roberts, and Little Roberts outflows), and two reference streams far from Project activities (Reference B and Reference D outflows). Samples were collected on four separate occasions (June, July, August, and September) at each sampling site from June 18 to September 18, 2014. Stream sampling locations are presented in Figure 2.1-1.

Stream water quality samples were collected at one midstream point in the cross section of the flow, with care being taken to prevent sampling artifacts associated with disturbing bottom sediments and collecting particulate material. Sampling personnel stood facing upstream to minimize sample contamination from re-suspended sediments. Samples were collected using appropriate verified-clean bottles provided by ALS Laboratory Group, Burnaby, BC (ALS). Samples were collected in duplicate and the appropriate preservatives provided by ALS were added in the field after sample collection.

All samples were kept cold and in the dark while in the field, and were refrigerated at Doris camp prior to transport. Samples were transported in coolers with freezer packs to ALS in Burnaby, BC for analysis. The analyzed variables and their realized detection limits are presented in Table 2.2-3.

2.2.2.2 *Lakes and Marine*

Lake water quality were collected from three sites in two lakes within the Doris and Roberts watersheds (Doris Lake South, Doris Lake North, Little Roberts Lake), and from two reference lakes (Reference Lake B and Reference Lake D). Marine water quality samples were collected from two sites in Roberts Bay (RBE and RBW) and at one reference site in the adjacent inlet, Ida (Reference) Bay (REF-Marine 1). Lake and marine sampling sites are presented in Figure 2.1-1.

Table 2.2-3. Water Quality Variables and Realized Detection Limits, Doris North Project, 2014

Variable	Units	Realized Detection Limits		Variable	Units	Realized Detection Limits	
		Freshwater	Marine			Freshwater	Marine
Physical Tests				**Organic Carbon**			
pH	pH	0.1	0.1	Total Organic Carbon	mg/L	0.5 to 1	0.5
Alkalinity, Total (as $CaCO_3$)	mg/L	1.0	2.0	**Total Metals**			
Hardness (as $CaCO_3$)	mg/L	0.5	0.5 to 4.3	Aluminum (Al)	mg/L	0.003	0.005
Conductivity	µS/cm	2.0	-	Antimony (Sb)	mg/L	0.00001	0.0005
Total Suspended Solids	mg/L	1.0	2.0	Arsenic (As)	mg/L	0.00005	0.0004
Total Dissolved Solids	mg/L	10 to 20	10 to 80	Barium (Ba)	mg/L	0.0001	0.001
Turbidity	NTU	0.1	0.1	Beryllium (Be)	mg/L	0.000005 to 0.00001	0.0005
Salinity		-	1.0	Bismuth (Bi)	mg/L	0.00005	0.0005
Anions				Boron (B)	mg/L	0.005	0.1
Bromide (Br)	mg/L	0.05 to 1	0.05 to 5.0	Cadmium (Cd)	mg/L	0.000005 to 0.00001	0.00002
Chloride (Cl)	mg/L	0.5 to 10	0.5 to 50	Calcium (Ca)	mg/L	0.05	0.05 to 0.5
Fluoride (F)	mg/L	0.02 to 0.4	0.02 to 1.0	Cesium (Cs)	mg/L	0.000005 to 0.00001	0.0005
Sulphate (SO_4)	mg/L	0.5 to 10	0.5 to 50	Chromium (Cr)	mg/L	0.0005	0.0005
Nutrients				Cobalt (Co)	mg/L	0.00005	0.00005
Ammonia (as N)	mg/L	0.005	0.005	Copper (Cu)	mg/L	0.0005	0.00005
Nitrate (as N)	mg/L	0.005 to 0.1	0.005 to 0.25	Gallium (Ga)	mg/L	0.00005	0.0005
Nitrite (as N)	mg/L	0.001 to 0.02	0.001 to 0.05	Iron (Fe)	mg/L	0.03	0.01
Total Kjeldahl Nitrogen	mg/L	0.05 to 0.25	0.05	Lead (Pb)	mg/L	0.00005	0.00005
Orthophosphate-Dissolved (as P)	mg/L	0.001	0.001	Lithium (Li)	mg/L	0.0002	0.02
Total Phosphorus	mg/L	0.002	0.002	Magnesium (Mg)	mg/L	0.1	0.1 to 1.0
Cyanides				Manganese (Mn)	mg/L	0.0002	0.00005
Cyanide Total	mg/L	0.001	0.001 to 0.05	Mercury (Hg)	µg/L	0.0005	0.0005
Cyanide, Free	mg/L	0.001	0.001 to 0.05	Molybdenum (Mo)	mg/L	0.00005	0.002

(continued)

Table 2.2-3. Water Quality Variables and Realized Detection Limits, Doris North Project, 2014 (completed)

Variable	Units	Realized Detection Limits		Variable	Units	Realized Detection Limits	
		Freshwater	Marine			Freshwater	Marine
Total Metals ***(cont'd)***				**Total Metals** ***(cont'd)***			
Nickel (Ni)	mg/L	0.0002	0.00005	Tin (Sn)	mg/L	0.0002	0.001
Phosphorus (P)	mg/L	0.30	1.0	Titanium (Ti)	mg/L	0.0002	0.005
Potassium (K)	mg/L	2.0	2.0 to 20	Tungsten (W)	mg/L	0.00001	0.001
Rhenium (Re)	mg/L	0.000005 to 0.00001	0.0005	Uranium (U)	mg/L	0.000002	0.00005
Rubidium (Rb)	mg/L	0.00002	0.005	Vanadium (V)	mg/L	0.00005	0.0005
Selenium (Se)	mg/L	0.0002	0.0005	Yttrium (Y)	mg/L	0.000005 to 0.00001	0.0005
Silicon (Si)	mg/L	0.05	0.05 to 0.5	Zinc (Zn)	mg/L	0.003	0.0008
Silver (Ag)	mg/L	0.000005 to 0.00001	0.0001	Zirconium (Zr)	mg/L	0.00005	0.0005
Sodium (Na)	mg/L	2.0	2.0 to 20	**Speciated Metals**			
Strontium (Sr)	mg/L	0.00005	0.005 to 0.05	Total Methyl Mercury	µg/L	-	0.00005
Tellurium (Te)	mg/L	0.00001	0.0005	**Radiochemistry**			
Thallium (Tl)	Mg/L	0.000002	0.00005	Radium-226	Bq/L	0.010	0.010
Thorium (Th)	mg/L	0.000005 to 0.00001	0.0005				

Note:
"-" indicates not applicable (variable not measured)

Samples were collected once during the ice-covered season (April), and three times during the open-water season (July, August, September) from April 19 to September 21, 2014. Within each lake, samples were collected at approximately 1 m depth over the deepest part of the lake. At the deepest lake sites (Doris Lake North, Doris Lake South, and Reference Lake B), samples were collected both at approximately 1 m below the surface and 2 m above the sediment.

In April, the underlying water was accessed through a hole in the ice following the temperature, CTD, and dissolved oxygen profiles. An adapted 2.5 L Niskin bottle was used to collect water during winter sampling. This bottle was designed to "trip" and collect discrete samples during freezing temperatures. To avoid metal contamination, the tripping mechanism used acid-cleaned silicone tubing within the interior of the bottle. A dual rope system was used to trigger the bottle to close and to ensure the collection of discrete samples.

During open-water season sampling, water samples were collected using an acid-washed, Teflon-lined 5 L GO-FLO sampling bottle. The GO-FLO was securely attached to a metred line and lowered to the appropriate sampling depth. It was then triggered to close using a Teflon-coated brass messenger and brought aboard the boat for distribution into sample containers.

Samples for the various water quality components (e.g., physical variables/major ions, nutrients, and total metals) were drawn from the GO-FLO/Niskin bottles, with care being taken not to bring the bottle or cap into contact with the plastic spigot or other possible sources of contamination. The appropriate preservatives provided by ALS were added in the field after sample collection.

All samples were kept cold and in the dark while in the field and were refrigerated at camp prior to transport. Samples were transported in coolers with freezer packs to ALS, Burnaby for analysis as described for stream water quality samples. The variables analyzed and their realized detection limits are summarized in Table 2.2-3. Realized detection limits were occasionally higher than the theoretical detection limits in freshwater samples due to interference from other variables. Marine samples were consistently diluted to reduce matrix effects from the high concentrations of cations (e.g., sodium). One bottle from the duplicate sample collected at Reference Lake B in April 2014 was inadvertently preserved with nitric acid; therefore, conductivity, pH, total and dissolved solids, turbidity, alkalinity, bromide, chloride, fluoride, sulphate, nitrate, nitrite, dissolved ortho-phosphate, and total phosphorus results were removed from the dataset used in the effects analysis for that sample based on the recommendation of ALS.

2.2.2.3 Quality Assurance and Quality Control

The quality assurance and quality control (QA/QC) program for water quality sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples. A set of travel, field, and equipment blanks (~20% of total samples) was also processed during each trip and submitted with the water samples as part of the QA/QC program. These blanks were used to identify potential sources of contamination to the field samples. Results for water quality QA/QC blanks are provided in Appendix A.

2.2.3 Sediment Quality

Sediment quality samples were collected at stream, lake, and marine sites during the open-water season in August 2014. This sampling coincided with benthic invertebrate sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and the analyzed variables are summarized in Table 2.2-5. Sampling locations are presented in Figure 2.1-1. Sampling procedures for each aquatic habitat are described below.

Table 2.2-4. Stream, Lake, and Marine Sediment Quality and Benthic Invertebrate Sampling Dates and Depths, Doris North Project, 2014

Habitat	Site	Sampling Date	Depth (m)
Stream	Doris Outflow	16-Aug-14	NA
	Roberts Outflow	16-Aug-14	NA
	Little Roberts Outflow	15-Aug-14	NA
	Reference B Outflow	15-Aug-14	NA
	Reference D Outflow	14-Aug-14	NA
Lake	Doris Lake North	20-Aug-14	14.0
	Doris Lake South	19-Aug-14	10.0
	Little Roberts Lake	17-Aug-14	3.0
	Reference Lake B	23-Aug-14	11.0
	Reference Lake D	18-Aug-14	4.5
Marine	RBE (Roberts Bay)	20-Aug-14	0.5
	RBW (Roberts Bay)	13-Aug-14	4.5
	REF-Marine-1 (Ida Bay)	21-Aug-14	6.0

Note: NA = not applicable

2.2.3.1 Streams

Three replicate sediment samples were collected at each stream site. At each site, a replicate sample consisted of a 1 L composite of several spoonfuls (plastic) of sediments, with replicates collected three times the channel width apart from each other whenever possible. The sediment was fully homogenized, slowly drained of excess water, and transferred into separate pre-labelled Whirl-Pak bags: one for particle size analysis, and one for sediment chemistry analysis. Each bag was then placed into another Whirl-Pak bag as a protective measure.

Samples were refrigerated (in darkness) until they were shipped to ALS (Burnaby, BC) on the first available flight out of camp. The sediment quality variables that were analyzed and their corresponding detection limits are presented in Table 2.2-5.

Table 2.2-5. Sediment Quality Variables and Realized Detection Limits, Doris North Project, August 2014

		Realized Detection Limit				Realized Detection Limit	
Variable	**Units**	**Freshwater**	**Marine**	**Variable**	**Units**	**Freshwater**	**Marine**
Physical Tests				**Total Metals** ***(cont'd)***			
Moisture	%	0.25	0.25	Chromium (Cr)	mg/kg	0.5	0.5
pH	pH	0.1	0.1	Cobalt (Co)	mg/kg	0.1	0.1
Particle Size				Copper (Cu)	mg/kg	0.5	0.5
% Gravel (>2 mm)	%	0.1	0.1	Iron (Fe)	mg/kg	50	50
% Sand (2.0 - 0.063 mm)	%	0.1	0.1	Lead (Pb)	mg/kg	0.5	0.5
% Silt (0.063 mm - 4 µm)	%	0.1	0.1	Lithium (Li)	mg/kg	5.0	5.0
% Clay (<4 µm)	%	0.1	0.1	Magnesium (Mg)	mg/kg	20	20
Organic Carbon				Manganese (Mn)	mg/kg	1.0	1.0
Total Organic Carbon	%	0.1	0.1	Mercury (Hg)	mg/kg	0.005	0.005
Leachable Nutrients				Molybdenum (Mo)	mg/kg	0.5	0.5
Total Nitrogen	%	0.02	0.02	Nickel (Ni)	mg/kg	0.5	0.5
Plant Available Nutrients				Phosphorus (P)	mg/kg	50	50
Available Ammonium-N	mg/kg	1.0 to 6.4	2.4 to 6.4	Potassium (K)	mg/kg	100	100
Available Nitrate-N	mg/kg	2.0 to 6.0	2.0 to 6.0	Selenium (Se)	mg/kg	0.2	0.2
Available Nitrite-N	mg/kg	0.4 to 1.2	0.4 to 1.2	Silver (Ag)	mg/kg	0.1	0.1
Available Phosphate-P	mg/kg	2.0	2.0 to 4.0	Sodium (Na)	mg/kg	100	100
Total Metals				Strontium (Sr)	mg/kg	0.5	0.5
Aluminum (Al)	mg/kg	50	50	Sulphur (S)	mg/kg	500	500
Antimony (Sb)	mg/kg	0.1	0.1	Thallium (Tl)	mg/kg	0.05	0.05
Arsenic (As)	mg/kg	0.05	0.05	Tin (Sn)	mg/kg	2.0	2.0
Barium (Ba)	mg/kg	0.5	0.5	Titanium (Ti)	mg/kg	1.0	1.0
Beryllium (Be)	mg/kg	0.2	0.2	Uranium (U)	mg/kg	0.05	0.05
Bismuth (Bi)	mg/kg	0.2	0.2	Vanadium (V)	mg/kg	0.2	0.2
Cadmium (Cd)	mg/kg	0.05	0.05	Zinc (Zn)	mg/kg	1	1
Calcium (Ca)	mg/kg	50	50				

2.2.3.2 *Lakes*

Lake sediments were obtained in the deepest section of the lake (except Doris Lake South) using an Ekman grab sampler with the replicates collected approximately 5 to 20 m apart. Sampling depths are provided in Table 2.2-4. The Ekman was carefully set open, lowered gradually onto the sediment surface using a metred cable line, and triggered to close with a messenger. The sample was carefully raised and inspected to ensure the collection of an intact, undisturbed sample. Each sediment sample was carefully transferred onto a tray, and the top 2 to 3 cm of sediment was homogenized in a plastic bowl using a plastic spoon and placed into two Whirl-Pak bags: one for particle size, and one for sediment chemistry. Samples were refrigerated (in darkness) until they were shipped to ALS (Burnaby, BC) on the first available flight out of camp. The sediment quality variables that were analyzed and their corresponding detection limits are presented in Table 2.2-5.

2.2.3.3 *Marine*

Marine sediment quality samples were collected in triplicate using a Petite Ponar grab sampler (surface sampling area of 0.023 m^2), with replicates spaced approximately 5 to 20 m apart. Sampling depths are provided in Table 2.2-4. Each sediment sample was carefully transferred onto a tray, and the top 2 to 3 cm of sediment was homogenized in a plastic bowl using a plastic spoon and placed into two Whirl-Pak bags: one for particle size, and one for sediment chemistry. Samples were refrigerated (in darkness) until they were shipped to ALS (Burnaby, BC) on the first available flight out of camp. The sediment quality variables that were analyzed and their corresponding detection limits are presented in Table 2.2-5.

2.2.3.4 *Quality Assurance and Quality Control*

The QA/QC program for sediment quality sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples.

2.2.4 Primary Producers

Primary producer biomass (as chlorophyll *a*) samples were collected in streams, lakes, and the marine habitat to assess potential changes in their standing stocks due to eutrophication (i.e., excess nutrients) or toxicity (i.e., presence of deleterious substances). Periphyton biomass samples were collected in streams during the open-water season in July, August, and September. Phytoplankton biomass samples were collected in lakes and the marine environment both under-ice, in April, and during the open-water season in July, August, and September.

2.2.4.1 *Stream Periphyton*

Stream periphyton samples were collected using artificial substrate samplers. The samplers were installed in each study stream for approximately one month before sample collection and processing (i.e., the plates collected in July, August, and September, were installed in June, July, and August, respectively). The complete installation and retrieval schedule is outlined in Table 2.2-6.

Table 2.2-6. Periphyton Sampling Dates, Doris North Project, 2014

Stream Site	Installation Date	Retrieval Date	# of Days Submerged
Doris Outflow	19-Jun-14	17-Jul-14	28
	17-Jul-14	16-Aug-14	30
	16-Aug-14	17-Sep-14	32
Roberts Outflow	18-Jun-14	17-Jul-14	29
	17-Jul-14	16-Aug-14	30
	16-Aug-14	18-Sep-14	33
Little Roberts Outflow	18-Jun-14	17-Jul-14	29
	17-Jul-14	15-Aug-14	29
	15-Aug-14	17-Sep-14	33
Reference B Outflow	19-Jun-14	16-Jul-14	27
	16-Jul-14	15-Aug-14	30
	15-Aug-14	18-Sep-14	34
Reference D Outflow	18-Jun-14	16-Jul-14	28
	16-Jul-14	14-Aug-14	29
	14-Aug-14	17-Sep-14	34

The samplers were 10 cm × 10 cm Plexiglas® plates that were affixed to rocks with fishing line and placed in the stream such that they remained submerged until retrieval. Overall, six plates were submerged per site, but only three plates were processed. These extra plates were used to increase the likelihood that at least three plates were available to process after a month's time. The plates were installed a minimum distance of three times the channel width apart from each other whenever possible. At Roberts Outflow only one plate was processed in July as the remaining plates were found exposed above the water surface and were not considered appropriate for sampling.

Upon collection, the sample plates were scraped using a razor blade, and rinsed into a 500 mL wide-mouth plastic jar. The samples were then filtered at Doris camp onto 47 mm diameter, 0.45 µm pore-size membrane filters, folded carefully in half and placed into a black plastic tube to prevent light penetration. A label was then attached to the tube indicating sampling information. The filters were kept frozen and sent to ALS Burnaby for analysis.

2.2.4.2 Lake and Marine Phytoplankton

Lake and marine phytoplankton biomass samples were collected in triplicate at approximately 1 m depth using a 5 L GO-FLO water sampler during July, August, and September. In April, a 2.5 L Niskin bottle was used to collect a sample from approximately 1 m beneath the ice layer. For each sample, the water sampler was lowered to the appropriate depth using a metred cable line and triggered to close with a messenger. Once retrieved, a subsample was drawn for a chlorophyll *a* sample. The GO-FLO/Niskin was set, lowered, and triggered three times (i.e., once for each replicate).

Subsamples for chlorophyll *a* were obtained by rinsing and filling a clean 1 L bottle. The samples were kept cold and dark and transported to Doris camp, where the samples were filtered using gentle vacuum filtration (hand pump). The samples were filtered onto 47 mm diameter, 0.45 µm pore size nitrocellulose membrane filters, folded carefully in half, and placed into a black plastic tube to prevent light penetration. A label was then attached to the tube indicating sampling information. The filters were kept frozen and sent to ALS Burnaby for analysis.

2.2.4.3 Quality Assurance and Quality Control

The QA/QC program for phytoplankton and periphyton biomass sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples.

2.2.5 Benthos

Benthic invertebrate (benthos) samples were collected at the stream, lake, and marine sites during the open-water season in August 2014. This coincided with the sediment quality sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and sampling locations are indicated in Figure 2.1-1.

All field sampling devices and methods for the AEMP benthos sampling were designed to comply with EEM guidance documents (Environment Canada 2011). Sampling procedures for each aquatic habitat are described below.

2.2.5.1 Streams

Benthos samples were collected at AEMP streams from August 14 to August 16, 2014. To comply with EEM requirements, three separate subsamples were collected and pooled for each replicate sample, and five replicates were collected at each site. Samples were collected in riffle habitats using a Hess sampler (surface sampling area of 0.096 m^2) fitted with a 500 µm mesh size net and terminal cod-end. Replicate samples were collected a minimum distance of three times the channel width apart from each other whenever possible.

For each subsample, the bottom of the Hess sampler was placed firmly on the sediment bottom making sure sediment contact was continuous along the bottom rim. The encircled sediment was then swept by hand and all rocks lifted and scrubbed to make sure the entire sediment surface was agitated. After sweeping, the collected debris was transferred from the cod-end into a 500 mL wide-mouthed plastic jar. Three subsamples were combined to make one sample and this was preserved with buffered formalin to a final concentration of 10%. Benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification.

Several community descriptors were calculated from the taxonomic results, including benthos family richness, Simpson's Diversity and Evenness indices, and the Bray-Curtis Index. In addition, densities were calculated. Cladocerans and cyclopoid and calanoid copepods were not included in the community metrics or density calculations as these groups are generally planktonic. Nematodes and harpacticoid copepods were also excluded from the community metrics and density calculations as they are typically considered to be meiofauna (invertebrates ranging in size between 63 µm and 500 µm) and are not adequately sampled using a 500 µm sieve bucket. Immature/damaged organisms that were not identifiable to the family level (certain Gastropoda and Hydracarina) were excluded from the community analysis but included in the density calculations. Organisms belonging to the groups Hydracarina, Ostracoda, and Microturbellaria were not identifiable to the family level but were included in both the community metrics and density calculations at the next highest taxonomic category. Any terrestrial organisms or fish that were identified in the benthos samples were also excluded from the calculations of community descriptors.

Benthos counts were normalized to three times the surface area of the of the Hess sampler (i.e., 3 × 0.096 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Hess samples).

Family richness was calculated as the total number of benthic invertebrate families present in each replicate sample.

The Simpson's Diversity Index (D) was calculated as:

$$\textit{Simpson Diversity Index } (D) = 1 - \sum_{i=1}^{F} p_i^2$$

where F was the number of families present (i.e., family richness), and p_i was the relative abundance of each family calculated as n_i/N, where n_i is the number of individuals in family i, and N was the total number of individuals. Simpson's Evenness Index (E) was calculated as:

$$\textit{Simpson Evenness Index } (E) = 1/\sum_{i=1}^{F} p_i^2/F$$

A complete dissimilarity matrix was also generated that included pairwise comparisons of all samples using the Bray-Curtis Index. The Bray-Curtis Index compares the community composition within a benthos sample to the median reference community composition (Environment Canada 2011). This reference composition is generated from the median abundance of each represented family from all of the reference site replicates. Since the median reference composition is generated from the combined reference site replicates, the comparison of a single reference site replicate community to the median reference community composition will produce a dissimilarity value (although generally a much lower value than exposure sites). Because the Bray-Curtis Index measures the percent difference between sites, the greater the dissimilarity value between a site and the median reference community, the more dissimilar those benthos communities are. The Bray-Curtis Index ranges from 0 to 1, with 1 representing completely dissimilar communities, and 0 representing identical communities. This index is calculated as:

$$\textit{Bray-Curtis Index (BC)} = \sum_{i=1}^{n} |y_{i1} - y_{i2}| \,/ \sum_{i=1}^{n} (y_{i1} + y_{i2})$$

where BC is the Bray-Curtis distance between sites 1 and 2, n is the total number of families present at the two sites, y_{i1} is the count for family i at site 1, and y_{i2} is the count for family i at site 2. Replicate data from the two reference locations (Reference B and D outflows) were combined for the determination of the "median reference composition".

Standard summary statistics (minimum, maximum, median, mean, standard deviation, and standard error) were calculated for all 2014 benthic invertebrate endpoints described above. These summary statistics are presented in Appendix A.

2.2.5.2 Lakes

Lake benthos samples were collected during the summer season from August 17 to August 23, 2014. Like streams, lake benthos sampling was designed to meet EEM criteria (i.e., three subsamples/replicate; five replicates/site). With the exception of Doris Lake South, lake benthos samples were obtained in the deepest section of the lake using an Ekman grab sampler (surface sampling area of 0.0225 m^2), with replicates collected approximately 5 to 20 m apart. The Ekman was carefully set open, lowered gradually onto soft sediment using a metred cable line, and triggered to close with a messenger. Sampling depths are provided in Table 2.2-4.

At the surface, each sediment sample was transferred into a 500 µm sieve bucket and rinsed with site-specific water until free of sediments. The material retained within the sieve was then placed into a labelled plastic jar and preserved with buffered formalin to a final concentration of 10%. Benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification. Benthos counts were normalized to three times the surface area of the Ekman sampler (i.e., 3 × 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Ekman samples). Community descriptors, Bray-Curtis dissimilarity distances, and summary statistics were calculated as described for stream benthos with the following exception: Because lakes can have dramatically different physico-chemical and biological function based on their morphologies, median reference compositions were created for each reference lake (large lake: Reference Lake B; small lake: Reference Lake D) for Bray-Curtis analysis. Bray-Curtis distances were then calculated by comparing the Reference Lake B median community to the large lake sites, Doris Lake North and Doris Lake South, and the Reference Lake D median community to Little Roberts Lake.

2.2.5.3 Marine

Benthos samples were collected at the two sites in Roberts Bay (RBW and RBE) and at the reference site in Ida Bay (REF-Marine 1) between August 13 and 21, 2014. Samples were collected with a Petite Ponar grab sampler (surface sampling area of 0.023 m^2). Five replicates were collected approximately 5 to 20 m apart at each site, with each replicate consisting of three pooled grab samples. At RBE, the substrate was hard and sandy and Petite Ponar grabs yielded very little sediment, so the method was modified at this site. Several (more than three) grab samples were collected at RBE until the sediment volume collected was comparable to the sediment volume of replicates collected at the other marine sites (~3 L). Each sediment sample was transferred into a 500 µm sieve bucket and rinsed with site-specific water until free of sediments. The material retained within the sieve was then placed into a labelled plastic jar and preserved with saline, buffered formalin to a final concentration of 10%. Benthos samples were sent to Columbia Science (Courtenay, BC) for enumeration and identification. Benthos counts were normalized to three times the surface area of the of the Petite Ponar sampler (i.e., 3 × 0.023 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Petite Ponar grab samples).

Community descriptors and summary statistics were calculated as described for stream benthos. Nematodes and harpacticoid copepods were excluded from the calculations of density and community metrics as these groups are typically considered to be meiofauna (invertebrates ranging in size between 63 µm and 500 µm) and are not adequately sampled using a 500 µm sieve bucket. Immature/damaged organisms that were not identifiable to the family level (unidentified invertebrate egg cases, certain individuals of the phylum Nemertea) were excluded from the community analysis. Nemertea were included in the density calculations. Any terrestrial organisms or fish that were identified in the benthos samples were also excluded from the calculations of density and community descriptors. Community descriptors, Bray-Curtis dissimilarity distances, and summary statistics were calculated as described for stream benthos, with the REF-Marine 1 median community composition compared to the RBW and RBE benthos communities in the Bray-Curtis analysis.

2.2.5.4 *Quality Assurance and Quality Control*

The QA/QC program for benthos sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples.

A re-sorting of randomly selected sample residues was conducted by taxonomists on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. The criterion for an acceptable sorting was that more than 90% of the total number of organisms was recovered during the initial sort. The number of organisms initially recovered from the sample was expressed as a percentage of the total number after the re-sort (total of initial and re-sort count). Any sample not meeting the 90% removal criterion was re-sorted a third time. The 90% minimum efficiency was always attained. Results for benthos QA/QC are provided in Appendix A.

2.3 EVALUATION OF EFFECTS

Select baseline data collected between 1995 and 2009 in the Project area were compared against 2014 data to determine whether there were adverse changes to the aquatic environment that could be directly attributed to 2014 Project activities. Data from 2010, 2011, 2012, and 2013 were not included in the baseline years for the effects analysis because Project construction began in 2010. The only exception to this was for the evaluation of under-ice dissolved oxygen concentrations in lake and marine sites; 2010 was considered a baseline year for this assessment for reasons described below. No suitable baseline data were available for benthos, thus analyses of non-parallelisms in trends over time from 2010 to 2014 between reference and exposure sites were conducted.

2.3.1 Variables Subjected to Evaluation

Table 2.3-1 presents the physical, chemical, and biological variables that were evaluated for 2014. Water quality variables associated with the various components of the MMER (e.g., Schedule 4 Deleterious Substances, Effluent Monitoring Conditions (Division 2), EEM's Effluent Characterization) were assessed for potential effects. Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life exist for many of the assessed variables. As per the MMER and EEM requirements, the benthic invertebrate community and associated sediment variables (sediment particle size and total organic carbon content) were evaluated. Additional sediment variables for which there are CCME sediment quality guidelines for the protection of aquatic life were also included in the assessment. Periphyton and phytoplankton biomass were also evaluated.

Table 2.3-1. Variables Subjected to Effects Analysis, Doris North Project, 2014[a]

Category	Variable
Physical Limnology	
Effluent Characterization and Water Quality Variables[c]	Dissolved Oxygen[d] Secchi Depth
Water Quality	
Deleterious Substances[b]	Total Suspended Solids[d] Cyanide, Total[d] Arsenic, Total[d] Copper, Total[d] Lead, Total[d] Nickel, Total[d] Zinc, Total[d] Radium-226
Effluent Characterization and Water Quality Variables[c]	pH[d] Alkalinity, Total Hardness Ammonia (as N)[d] Nitrate (as N)[d] Aluminum, Total[d] Cadmium, Total[d] Iron, Total[d] Mercury, Total[d] Molybdenum, Total[d]
Sediment Quality	
	Particle Size[e] Total Organic Carbon[e] Arsenic[d] Cadmium[d] Chromium[d] Copper[d] Lead[d] Mercury[d] Zinc[d]
Biology	
	Phytoplankton and Periphyton Biomass Benthic Invertebrate Density[e] Taxa Richness[e] Simpson's Evenness Index[e] Simpson's Diversity Index[e] Bray-Curtis Index[e]

Notes:
[a] *2010 was year 1 of fish data collection. Fish sampling was not undertaken in 2014.*
[b] *Variables regulated as deleterious substances as per Schedule 4 of the MMER.*
[c] *Variables required for effluent characterization and water quality monitoring as per Schedule 5 of the MMER.*
[d] *Variables that have CCME water or sediment quality guidelines for the protection of aquatic life.*
[e] *Variables required as part of the benthic invertebrate surveys as per Schedule 5 of the MMER.*

2.3.2 Baseline Data and Effects Analysis

Baseline physical, chemical, and biological data have been collected in the Doris North Project area since 1995. Historical samples have been collected from a variety of locations and depths within each of the AEMP stream, lake, and marine environments. The frequency and seasonal timing of sampling has also varied since 1995, as have sampling methodologies. For these reasons, professional judgment was used in the selection of baseline data that could be used for comparison with the 2014 data.

The approaches used to assemble the appropriate baseline datasets and to determine whether there were any effects on evaluated variables in 2014 are discussed below. Key determining factors for the inclusion of baseline data included the proximity of baseline sampling sites to 2014 sampling sites, the depth of sampling (for sediment quality and benthos), and sampling methodology (for sediment quality, periphyton, phytoplankton, and benthos). In the case of benthos, baseline data were not available and therefore 2010 to 2013 data were incorporated into the effects analysis. Historical data used for the effects analyses were from the following reports: Klohn-Crippen Consultants Ltd. (1995), Rescan (1997, 1998, 1999, 2001, 2010a, 2010b, 2011, 2012, 2013, 2014), RL&L Environmental Services Ltd. and Golder Associates Ltd. (2003a, 2003b), and Golder Associates Ltd. (2005, 2006, 2007, 2008, 2009). Full details of the rationale used in the selection of baseline data that could be used for comparison with the 2014 data are provided in Appendix B.

All statistical analyses were run using R version 2.15.2. To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was primarily used when reviewing the results. A complete description of the statistical analyses used to assess the evaluated variables, including lists of outliers and detailed methodology and results, is presented in Appendix B.

2.3.2.1 Under-ice Dissolved Oxygen

<u>Data Selection</u>

Potential effects on physical limnology and oceanography were evaluated using April, May, or early June under-ice dissolved oxygen since concentrations are lowest during this period, and therefore pose the greatest concern for aquatic life. Although temperature and salinity (marine) were also measured, they were not evaluated for effects since they are largely determined by climatic variability, and no TIA effluent was discharged into the aquatic environment in 2014.

Ice cover usually forms in October or November in the Doris North region, and remains until June or July of the following year. Waterbodies in the Doris North area would not be exposed to any atmospheric inputs such as dust that could be generated by Project activities while they are covered in ice. Therefore, the under-ice water column that is profiled in April or May reflects activities from the previous year. For example, profiles collected in April 2010 reflect activities from 2009 rather than 2010. For this reason, profiles collected in the spring of 2010 are included in the baseline dataset despite 2010 being considered year one of construction.

Baseline under-ice dissolved oxygen measurements have been collected several times at the exposure lake sites since 1998. Under-ice dissolved oxygen data are available from 2009 and 2010 for Reference Lake B, and from 2010 for Reference Lake D.

In the marine environment, baseline under-ice dissolved oxygen profiles were collected at RBE in 2006 and 2010, and at RBW in 2009 and 2010. No baseline under-ice dissolved oxygen data exists for REF-Marine 1.

Effects Analysis

The potential for effects on under-ice dissolved oxygen levels was assessed by graphical analysis. For winter dissolved oxygen levels to warrant concern and be considered an effect, concentrations from 2014 had to be noticeably different from all available baseline years. For example, if 2014 dissolved oxygen levels were different from 2005, but similar to 2007, it was concluded that there were no 2014 Project effects at that exposure site. Dissolved oxygen concentrations and inter-annual trends at the reference sites were also considered in the effects analysis. Dissolved oxygen concentrations were compared against CCME guidelines for the protection of aquatic life (CCME 2014a) to determine if baseline or 2014 concentrations dropped below recommended levels.

2.3.2.2 Secchi Depth

Data Selection

Secchi depths have been measured at lake sites in the Doris North Project area since 1995. The selection of historical lake data to include in the effects analysis was based on similarity of baseline sampling locations to 2014 sampling locations. At least three years of baseline Secchi depth data are available for Doris Lake South, Doris Lake North, and Little Roberts Lake. Baseline Secchi depth was recorded once in August 2009 at Reference Lake B, and no baseline data were available for Reference Lake D.

Marine sites RBE and RBW are shallow (< 5 m) and typically contain low levels of phytoplankton biomass. At site RBE, all Secchi depths measured in 2014 reached the bottom sediments, while at site RBW, all but one Secchi depth reached the bottom (Appendix A), indicating that water clarity was high and that the euphotic zone typically extended throughout the entire water column. The purpose of evaluating Secchi depth is to determine whether there is any evidence of reduced water clarity caused by either an increase in phytoplankton biomass as a result of eutrophication or an increase in suspended sediments. As water clarity at marine sites was high in 2014, Secchi depth was not evaluated for the Roberts Bay sites RBW and RBE.

Effects Analysis

Graphical analysis of annual mean Secchi depths were used to compare before (baseline)-after (2014) trends at the exposure sites to before-after trends at the reference sites and to supplement the results of the statistical analyses.

For each lake site, a before-after comparison between the mean baseline Secchi depth and the mean Secchi depth for 2014 was conducted. A mixed model ANOVA was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season*, and a random effect of *year* to account for variability in the Secchi depth data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1995 to 2009) or *after* the start of construction (2014). For the *season* effect, data were grouped into one of three seasons depending on the timing of Secchi depth measurement: 1) July, 2) August, 3) September, since Secchi depth can vary over the open-water season depending on sediment and nutrient inputs and phytoplankton growth. A reduced significance level (e.g., 0.01) was primarily used when reviewing the results. Significance levels of 0.01 to 0.05 for exposure sites were considered marginally non-significant and were also discussed in the effects analysis.

If the before-after comparison revealed that the mean Secchi depth in 2014 was significantly different (or marginally non-significant) from the baseline mean, a before-after-control-impact (BACI) analysis, which is a standard method used to assess an environmental effect, was conducted. The BACI analysis compares the before-after trend apparent at the exposure site with the before-after trend at a corresponding reference site, to see if the trends are parallel and, thus, attributable to a natural process. A BACI analysis could only be performed if baseline and 2014 data were available for both the exposure site and the reference site. Because there was no baseline data available for Secchi depth in Reference Lake D, it was not possible to conduct a BACI analysis for Secchi depth in Little Roberts Lake.

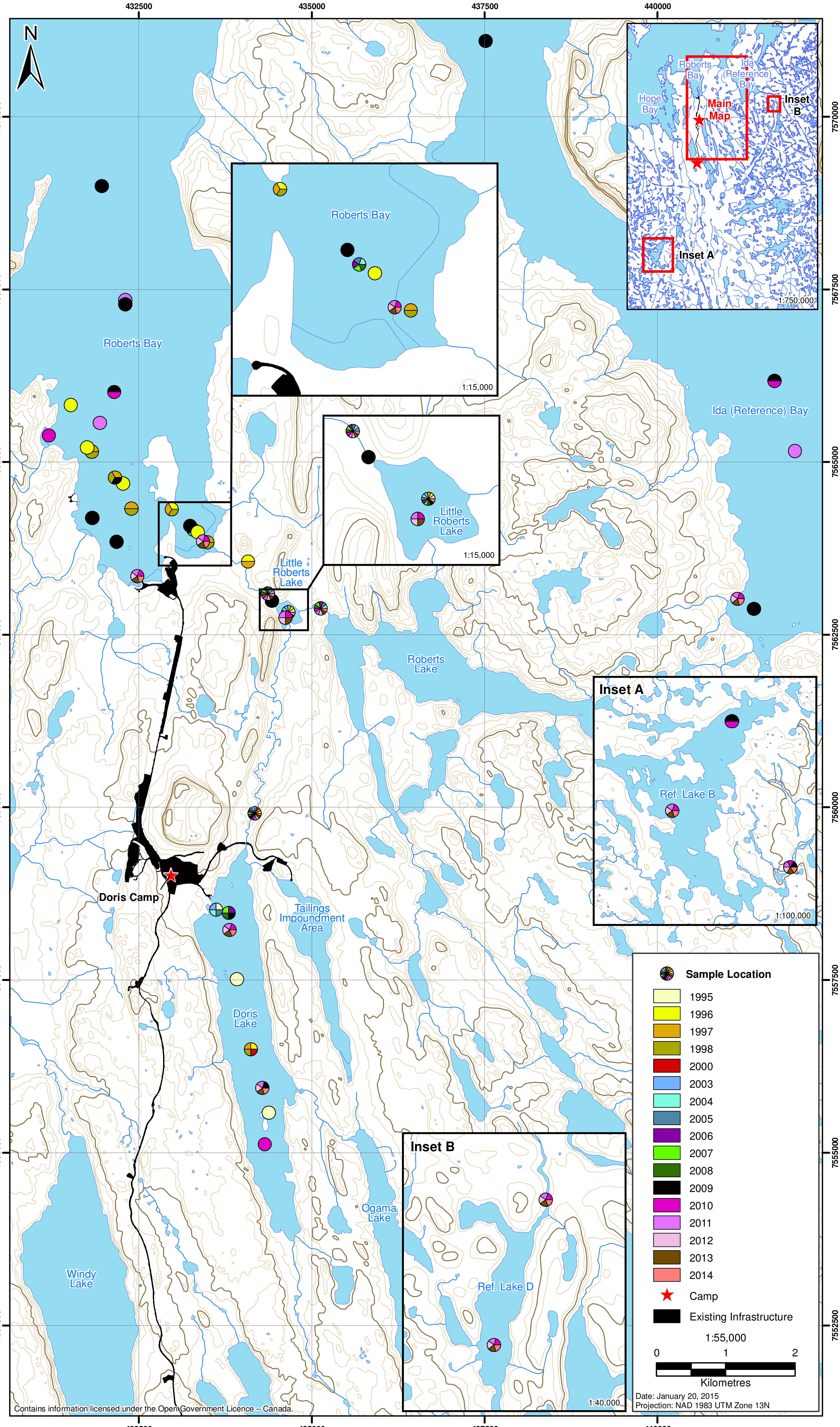
The BACI analysis introduces a *class* effect to the mixed model ANOVA, which is the classification of the waterbody as an exposure or a reference site. The interaction between the *period* (before vs. after) and *class* (exposure vs. reference) effects reveals whether any before-after change in the mean Secchi depth that occurred in the exposure site also occurred in the reference site. If a change in the mean was detected by the before-after comparison, but the BACI analysis revealed that a parallel change also occurred at the reference site, the change likely resulted from a natural phenomenon and was unrelated to the 2014 Project activities. Note that BACI results are only discussed in the text if a significant or marginally non-significant difference was detected by the before-after analysis for exposure sites, but all BACI results are included in Appendix B and presented in the report figures.

2.3.2.3 Water Quality

Data Selection

Water quality samples have been collected in the Project area since 1995 (Figure 2.3-1). The selection of historical data to include in the effects analysis was based on the similarity of baseline sampling locations to 2014 sampling locations, methodology (e.g., shoreline grabs were excluded from dataset), sampling depth (e.g., for marine data, baseline samples collected from just above the sediment were excluded because all 2014 samples were collected from the surface zone), and professional judgement. Note that for Doris Lake South, historical water quality data collected between 1996 and 2000 were excluded from the effects analysis presented in the 2010 Program report (Rescan 2011) because the 1996 to 2000 sampling site was more than 1 km north of the 2010 Doris Lake South sampling site (Figure 2.3-1). In 2011, the Doris Lake South sampling site was moved into deeper water approximately 500 m away from the 1996 to 2000 sampling site, and has remained at this location for 2014 sampling. Therefore, these historical data were considered comparable to the 2014 water quality data and were included in the 2014 effects analysis for Doris Lake South. The Little Roberts Lake sampling location was moved approximately 90 m in 2014 to a deeper location in order to improve the ability to obtain representative samples under-ice. The 2014 sampling location is consistent with the 1995 to 1997 and 2003 to 2009 baseline sampling location for Little Roberts Lake and these baseline data were therefore retained in the effects analysis.

Figure 2.3-1
Waer Quality Sampling Stations, Doris North Project, 1995 to 2014



Effects Analysis

All 18 evaluated water quality variables presented in Table 2.3-1 were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2014a). For each variable, a graph showing annual mean variable concentrations for all available years is presented alongside a graph comparing before-after trends at the exposure sites to before-after trends at the reference sites. This graphical analysis was used to identify trends and to supplement the results of the statistical analyses. Relevant CCME guidelines were included on these graphs and also in Appendix A.

For each waterbody, a before-after comparison between the baseline mean and the 2014 mean was conducted for each of the 18 evaluated variables (provided that baseline data were available). A mixed model ANOVA was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season* (early vs. late, see below), and a random effect of *year* to account for variability in water quality data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1995 to 2009) or *after* the start of construction (2014). For the *season* effect, samples were grouped into one of two seasons depending on the timing of sampling: *early* (i.e., June or earlier, which included freshet or under-ice sampling) or *late* (i.e., July or later, which included open-water season sampling). A reduced significance level (e.g., 0.01) was primarily used when reviewing the results. Significance levels of 0.01 to 0.05 for exposure sites were considered marginally non-significant and were also discussed in the effects analysis.

The interpretation of the before-after analyses, the conditions under which a subsequent BACI analyses was conducted, the BACI methodology, and the interpretation and presentation of the BACI results are described in Section 2.3.2.2. Details specific to the water quality analyses are described below.

For lake and marine water quality variables, the before-after trend for each exposure site was compared against the trend at the corresponding reference site for the BACI analysis. For stream water quality variables, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2014 contributed some information on the year effect, which improved the precision of the BACI analysis.

All sample replicates collected on the same date and from the same depth in the water quality dataset were treated as pseudo-replicates and were averaged prior to graphical and statistical analysis. In some large lake sites, the dataset included samples that were collected from multiple depths within the water column. Because there was little evidence of vertical chemical stratification, the data were pooled for the calculation of the variable mean regardless of sampling depth. For all effects analyses, statistical results were considered unreliable if > 70% of the values in the dataset for a variable were less than analytical detection limits (i.e., censored data). These statistical results are not presented in this report (though statistical results for these data do appear in the statistical outputs provided in Appendix B).

A value equal to half of the detection limit was substituted for censored data that were included in the analyses. Similar results were obtained regardless of whether half the detection limit or the full detection limit was substituted for these censored values. If the substitution of half versus the full detection limit affected the conclusions of the effects assessment, differences were discussed in the text. Values determined to be outliers were excluded from the statistical analyses. In most cases, outliers were baseline values that were less than very high detection limits. These and other anomalous historical values were removed to reduce artificial inflation of the variance, which would lead to reduced power to detect effects. Lists of outliers identified for water quality variables are available in Appendix B.

2.3.2.4 Sediment Quality

Data Selection

Baseline sediment quality sampling has been conducted six times in the freshwater and marine study area since 1997 (Figure 2.3-2). The most important criterion in the historical sediment quality data selection process was that baseline (1995-2009) samples had to be collected from the same depth strata as the 2014 samples, since greater metal concentrations are often associated with greater proportions of fine sediments (silts and clays; e.g., Lakhan, Cabana, and LaValle 2003), and this, in turn, is affected by the depth of sampling (i.e., deeper samples tend to contain greater proportions of fine sediments). Because the Doris Lake South sampling location was moved from a shallow site in 2010 (< 5 m deep) to a deep site in 2011 (> 10 m deep) for improved comparability with the Doris Lake North site (which is also a deep site), only baseline data collected from the deep depth strata were included in the comparison to 2014 Doris Lake South data.

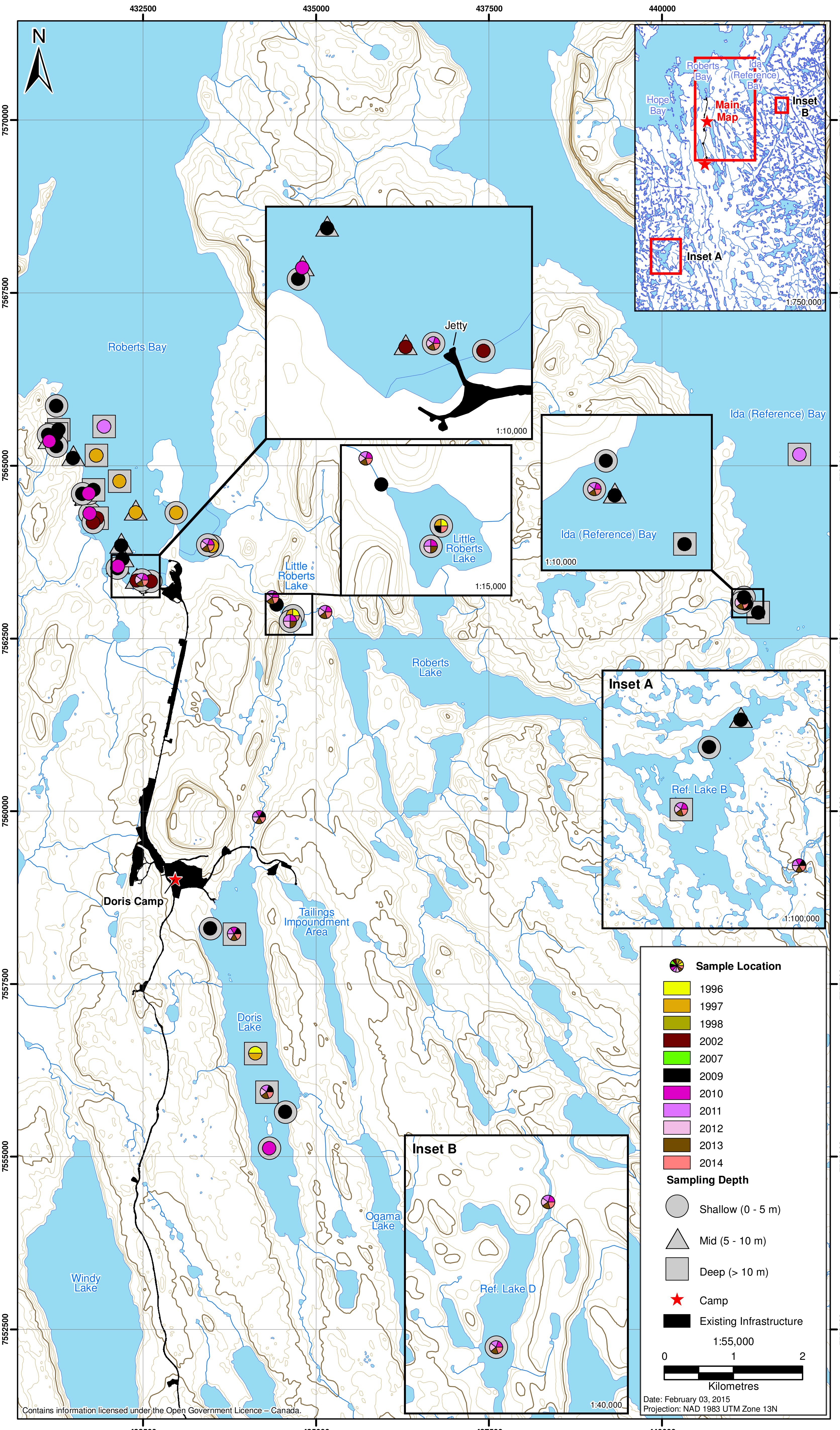
The selection of historical data was also based on the proximity of baseline sampling sites to the 2014 sites and the similarity of sampling techniques.

Effects Analysis

The nine sediment quality variables presented in Table 2.3-1 were evaluated using graphical analysis, before-after comparisons, and BACI analysis. All evaluated sediment quality variables were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2014b). Relevant CCME guidelines were included on effects analysis graphs, and also in Appendix A.

Before-after comparisons were used to determine if mean 2014 sediment quality concentrations differed from baseline means. A mixed model ANOVA was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and a random effect of *year* to account for variability in sediment quality data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1996 to 2009) or *after* the start of construction (2014). Each waterbody was treated independently and each variable was treated separately. A reduced significance level (e.g., 0.01) was primarily used when reviewing the results. Significance levels of 0.01 to 0.05 for exposure sites were considered marginally non-significant and were also discussed in the effects analysis.

Figure 2.3-2
Sediment Quality Sampling Stations, Doris North Project, 1996 to 2014



The interpretation of the before-after analyses, the conditions under which a subsequent BACI analyses was conducted, the BACI methodology, and the interpretation and presentation of the BACI results are described in Section 2.3.2.2. Details specific to the sediment quality analyses are described below.

For lakes sites, there was no appropriate baseline sediment data available for the reference lakes; therefore, BACI comparisons of lake sediment quality variables were not possible, and only before-after comparisons were performed.

The key effect of interest in this BACI design is the interaction effect. If exposure site variables increase or decrease over time relative to reference sites (i.e., there is a significant interaction effect), the implication is that the Project may be having an effect on the surrounding sediments (i.e., a non-parallel effect). However, the change over time at exposure sites could also be due to natural episodic events (e.g., higher than average stream flow) or slight differences in sampling locations (leading to differences in grain size composition). Thus, professional judgment was used to determine if a statistically significant (or marginally non-significant) interaction effect was likely attributable to Project activities. For the marine environment, the baseline data used for before-after comparisons of exposure and reference sites were from different years (2002 data were used for the exposure site, RBW, and 2009 data were used for the reference site, REF-Marine 1).

For marine sediment quality variables, the before-after trend for each exposure site was compared against the trend at the corresponding reference site (REF-Marine 1) for the BACI analysis. For stream sediment quality variables, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2014 contributed some information on the year-effect, which improved the precision of the BACI analysis.

Like water quality, highly censored variables (i.e., > 70% of data less than the detection limit) were considered unreliable and were not subjected to effects analysis. Censored data that were included in the analyses were substituted with a value equal to one half the detection limit.

2.3.2.5 Primary Producers

<u>Data Selection</u>

Primary producer (phytoplankton and periphyton) biomass sampling has been conducted in the Doris North Project area since 1997 (Figure 2.3-3). The main criteria for the selection of historical periphyton and phytoplankton biomass data for inclusion in the effects analysis was the proximity of baseline sampling sites to 2014 sampling sites, and the comparability of sampling methodologies (e.g., phytoplankton biomass samples collected throughout the euphotic zone using an integrated sampler were excluded from the effects analysis as these were not comparable to the discrete surface samples collected in 2014).

For Doris Lake South, historical phytoplankton biomass data collected in 1997 and 2000 were excluded from the effects analysis presented in the 2010 Program report because the 1997 and 2000 sampling site was more than 1 km away to the north of the 2010 Doris Lake South sampling site (Figure 2.3-3). However, the Doris Lake South sampling site was moved slightly further to the north in 2011, and approximately 500 m away from the 1997 and 2000 sampling site. Therefore, these historical data were considered comparable to the 2014 phytoplankton biomass data and were included in the 2014 effects analysis for Doris Lake South.

Effects Analysis

Graphical analysis of annual mean phytoplankton or periphyton biomass and the comparison of before-after trends at the exposure sites to before-after trends at the reference sites were used to identify trends and to supplement the results of the statistical analyses.

For each waterbody, a before-after comparison between the mean baseline biomass and 2014 mean biomass was conducted (provided that baseline data were available). A mixed model ANOVA was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season*, and a random effect of *year* to account for variability in primary producer data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1996 to 2009) or *after* the start of construction (2014). For the *season* effect, samples were grouped into one of four seasons depending on the date of sample collection to account for within-year variability in biomass levels: 1) April or May (under-ice), 2) July, 3) August, and 4) September. A reduced significance level (e.g., 0.01) was primarily used when reviewing the results. Significance levels of 0.01 to 0.05 for exposure sites were considered marginally non-significant and were also discussed in the effects analysis.

The interpretation of the before-after analyses, the conditions under which a subsequent BACI analyses was conducted, the BACI methodology, and the interpretation and presentation of the BACI results are described in Section 2.3.2.2. Details specific to the phytoplankton and periphyton analyses are described below.

For lake and marine phytoplankton biomass, the before-after trend for each exposure site was compared against the trend at the corresponding reference site for the BACI analysis. For stream periphyton biomass, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2014 contributed some information on the year-effect, which improved the precision of the BACI analysis.

All phytoplankton and periphyton biomass replicates collected on the same date were treated as pseudo-replicates and were averaged prior to graphical and statistical analysis.

2.3.2.6 Benthos

Data Selection

Benthos data have been collected since 1996 in the Project area (Figure 2.3-4). Prior to 2010, historical benthos sampling consisted of collecting one to five replicates per site with no composite sampling. Starting in 2010, this approach was changed to accommodate the EEM methodologies as required under the Type A Water Licence for the Doris North Project.

Figure 2.3-3
Phytoplankton and Periphyton Sampling Stations, Doris North Project, 1996 to 2014

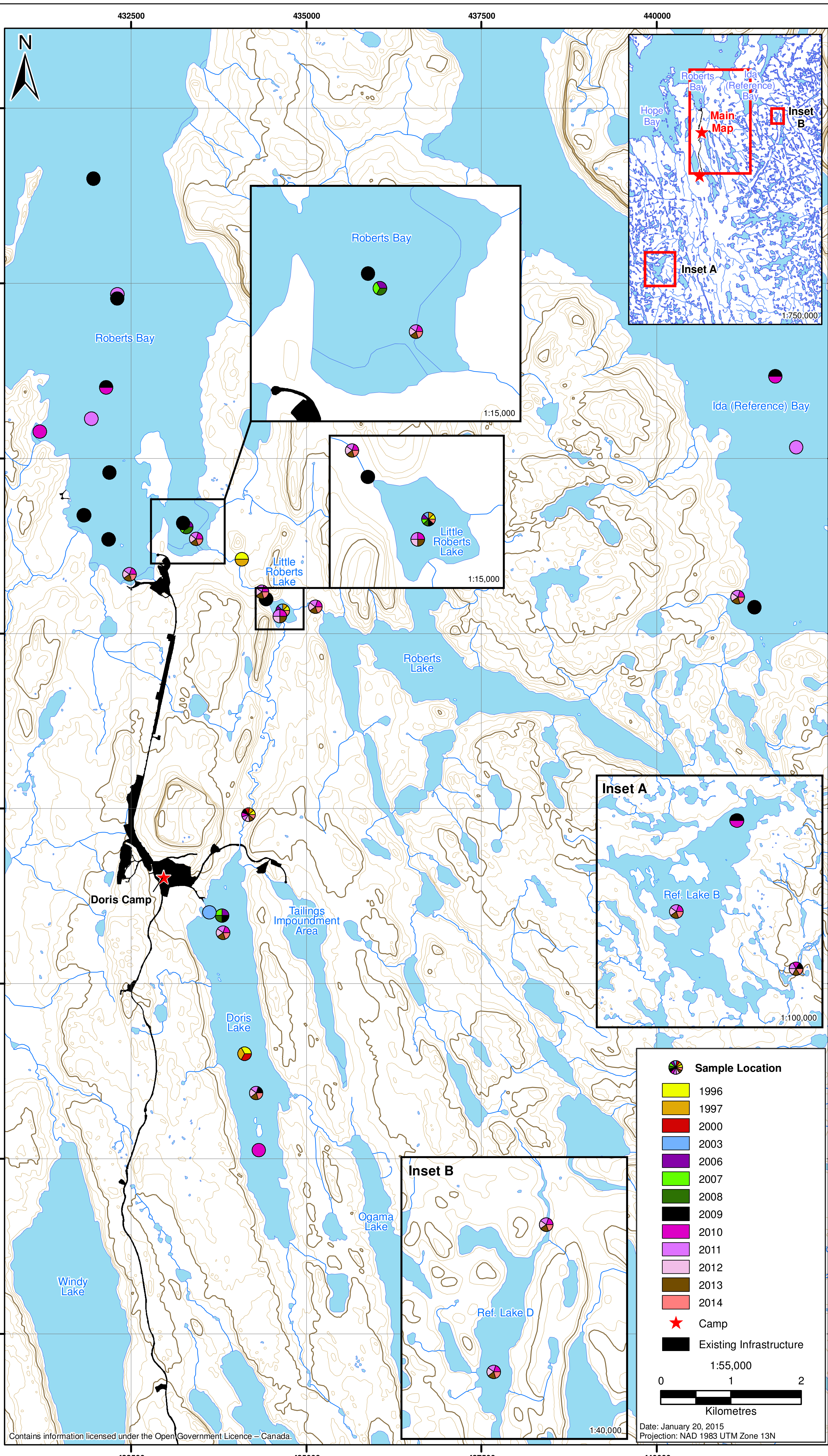
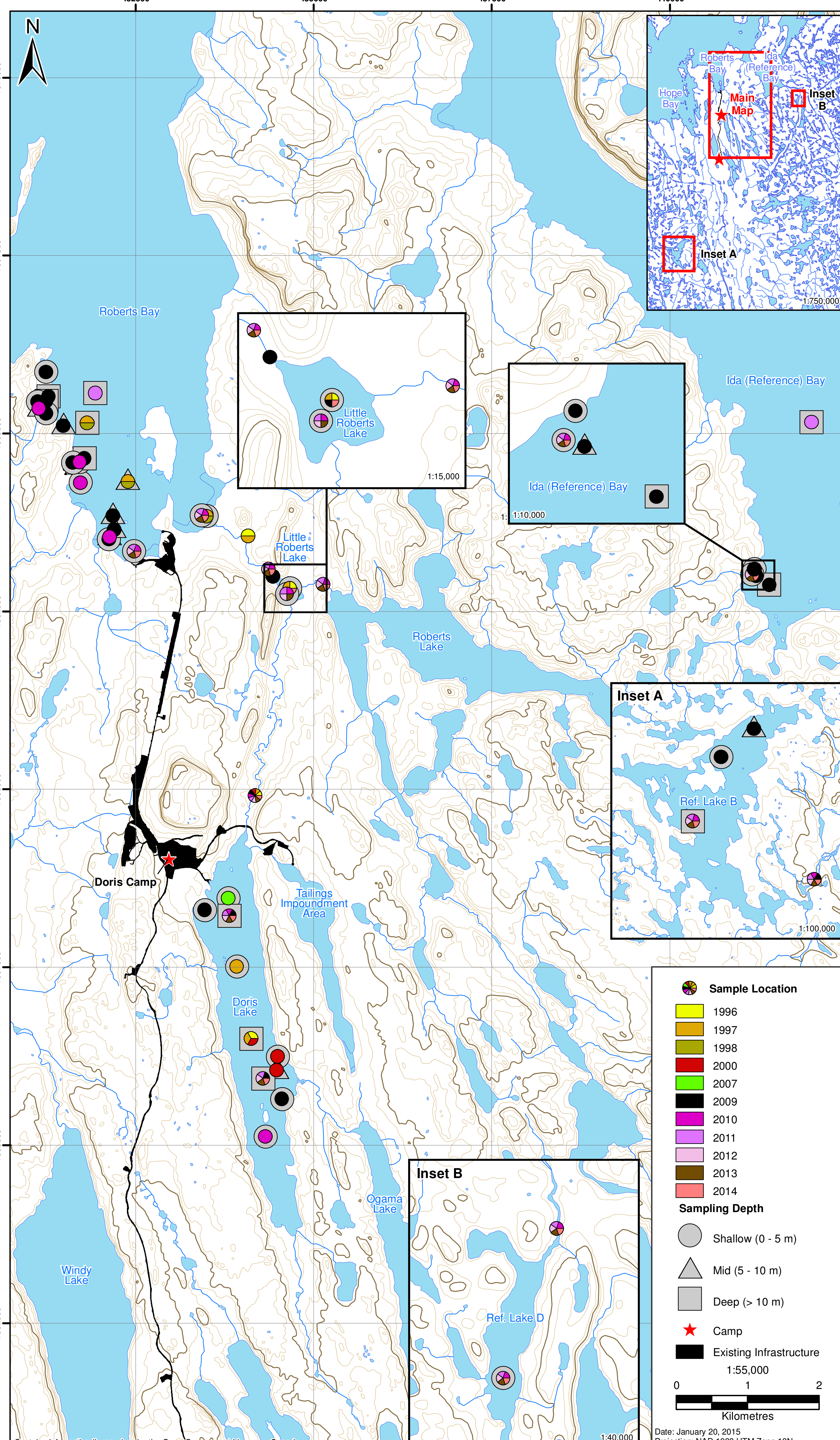


Figure 2.3-4
Benthic Invertebrate Sampling Stations, Doris North Project, 1996 to 2014



The 2010 to 2014 sampling procedure required the pooling of three subsamples per replicate, and the collection of five replicates per site. Because the pooling of subsamples for each replicate affects sample variability, as well as various diversity components (e.g., richness and evenness), baseline (1995-2009) benthos data were not considered comparable to data collected from 2010 to 2014.

Effects Analysis

Because of methodological differences, no baseline benthos data were available for comparison against 2014 data; therefore, neither before-after nor BACI analyses were possible for benthos data. The absence of appropriate baseline data for benthos complicates the determination of potential effects of the Project on benthos community descriptors. Comparing reference site data to exposure site data is not an ideal approach because of the potential natural differences between sites that are unrelated to Project activities. A preferred approach recommended by Wiens and Parker (1995) is an impact level-by-time analysis, where the benthos trends at exposure sites are compared to the trends at reference sites to determine if there is evidence of non-parallelism over time (in this case, from 2010 to 2014). Because of the limited data available, evidence of non-parallelism between 2010 and 2014 may simply indicate patchiness in the environment or natural yearly variation and does not necessarily imply a Project-related effect. As more years of data become available, trends (if present) would become more apparent.

The impact level-by-time model included a *year* effect, a *class* effect (i.e., the classification of the waterbody as an exposure or a reference site), and a *year*class* interaction term, which was the effect of interest representing non-parallelism over time between the two classes of sites. A reduced significance level (e.g., 0.01) was primarily used when reviewing the results. Significance levels of 0.01 to 0.05 for exposure sites were considered marginally non-significant and were also discussed in the effects analysis.

For lake and marine benthos data, the 2010 to 2014 trend for each exposure site was compared against the trend at the corresponding reference site for the impact level-by-time analysis. For stream benthos data, the 2010 to 2014 trend for each exposure site was compared against the 2010 to 2014 trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the impact level-by-time analysis.

3. EVALUATION OF EFFECTS

3.1 UNDER-ICE DISSOLVED OXYGEN

Potential effects on lake and marine dissolved oxygen concentrations were evaluated using under-ice dissolved oxygen concentrations, since concentrations are lowest during this period and pose the greatest concern for aquatic life. Minimum oxygen levels are required for critical life stages of fish and other freshwater and marine organisms (CCME 2014a). Ice cover usually forms in October or November in the Doris North region, and under-ice oxygen profiles were collected in April 2014. The formation of ice cover in November 2013 isolated lakes, streams, and Roberts Bay from any atmospheric inputs such as dust that could have been generated by Project activities between November 2013 and June/July 2014. Therefore, the water column that was profiled in April 2014 reflects activities from 2013 rather than 2014.

Figures 3.1-1 and 3.1-2 present the 2014 and historical under-ice dissolved oxygen profiles for lake and marine sites. 2014 under-ice profiles were collected in late April, and historical under-ice profiles were collected between late April and early June.

3.1.1 Lakes

The 2014 under-ice dissolved oxygen concentrations in Doris Lake North and South were within the range, (or higher than), concentrations observed during baseline years. At both Doris Lake sites, dissolved oxygen concentrations throughout the water column were greater than the CCME guideline for freshwater cold-water, early life stages (9.5 mg/L; Figure 3.1-1). In Reference Lake B, dissolved oxygen concentrations were also higher than concentrations observed during most previous years. Dissolved oxygen concentrations decreased with depth in Reference Lake B, dropping below the 9.5 mg/L CCME guideline mid water column and below the 6.5 mg/L CCME guideline for freshwater cold-water non-early life stages at deeper depths, which was consistent with historical observations for this lake (Figure 3.1-1). This dissolved oxygen decrease at depth is a common phenomenon in seasonally stratified lakes. The trends in under-ice dissolved oxygen concentrations observed in Doris Lake North and South were generally similar to the trend seen in Reference Lake B; hence, no adverse changes were detected.

Baseline winter dissolved oxygen concentrations varied widely in the shallow exposure site, Little Roberts Lake, between 2006 and 2010 (range: < 1 mg/L in May 2007 to 17.6 mg/L in May 2009; Figure 3.1-1). In 2014, dissolved oxygen concentrations in Little Roberts Lake were relatively low and below the CCME freshwater cold-water guideline for non-early life stages (6.5 mg/L) but fell within the wide range of baseline measurements. Thus, no adverse changes to 2014 winter dissolved oxygen concentrations were apparent in Little Roberts Lake. In the shallow reference lake, Reference Lake D, under-ice dissolved oxygen concentrations also varied widely over time. Concentrations measured in April 2014 were similar to concentrations measured in Little Roberts Lake and below the CCME freshwater cold-water guideline for non-early life stages (6.5 mg/L). Ice-covered shallow lakes are prone to large fluctuations in dissolved oxygen concentrations, particularly late in the ice-covered season, because of increases in epontic and benthic photosynthesis and the respiratory consumption of organic material in the sediments.