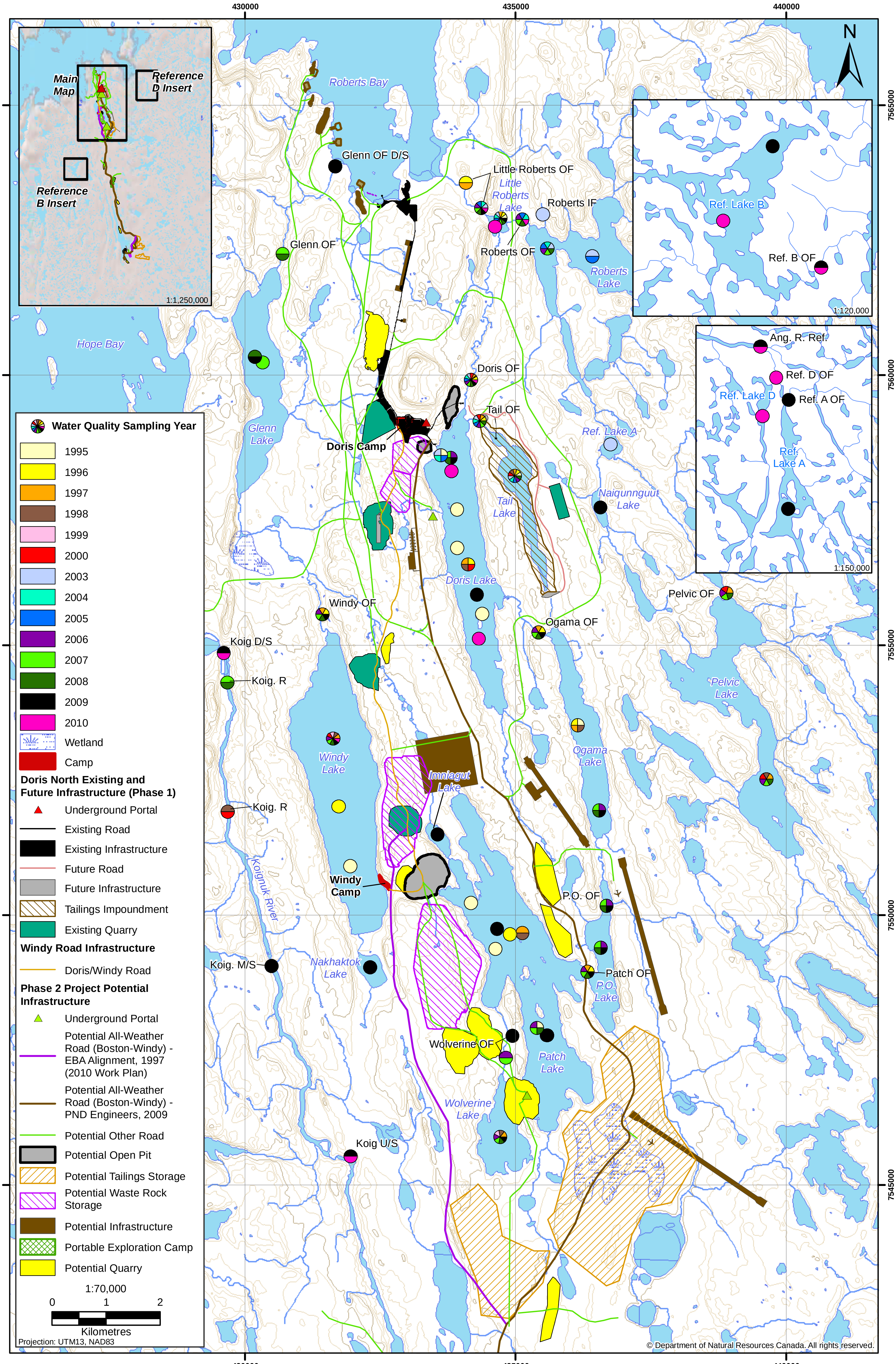

Figure 2.14-1a

Historical Water Quality Sampling Locations, Hope Bay Belt Project, North End of the Belt

NEWMONT NORTH AMERICA

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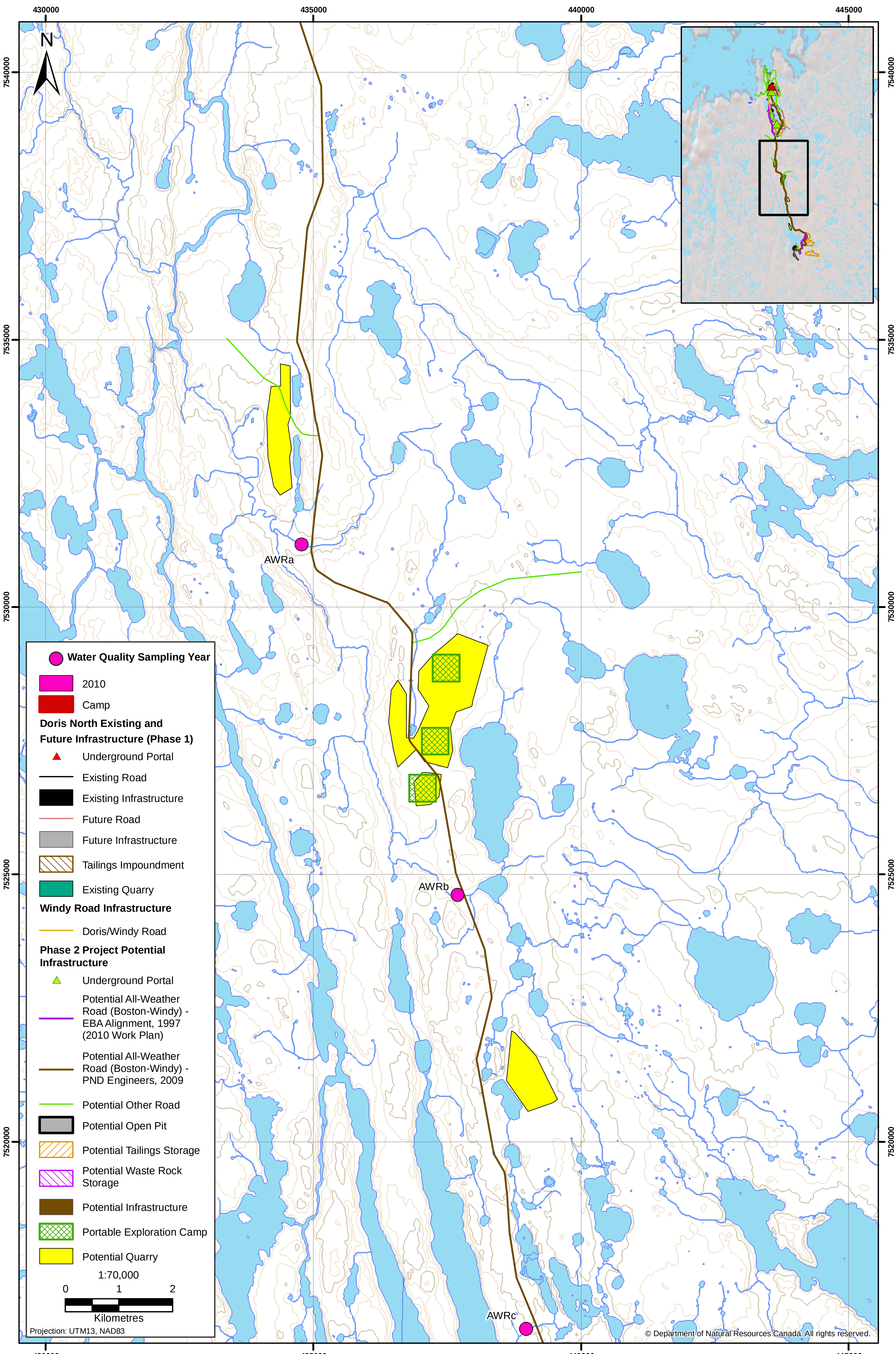

Figure 2.14-1b

NEWMONT NORTH AMERICA

Historical Water Quality Sampling Locations, Hope Bay Belt Project, Central Area of the Belt

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PROJECT #1009-002-05 GIS # HB-01-032c July 15 2011

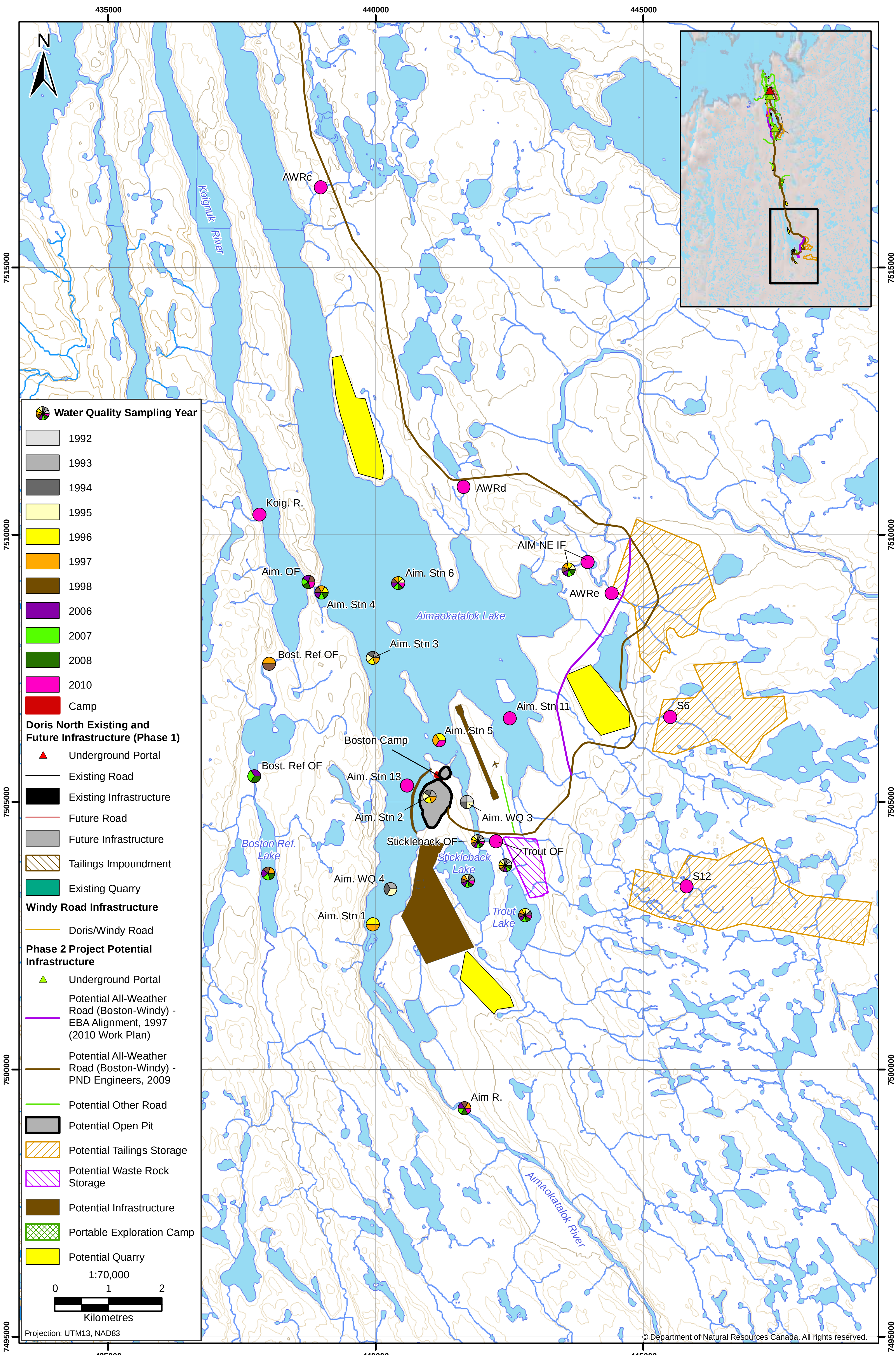

Figure 2.14-1c

NEWMONT NORTH AMERICA

Historical Water Quality Sampling Locations, Hope Bay Belt Project, South End of the Belt

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Figure 2.14-1c

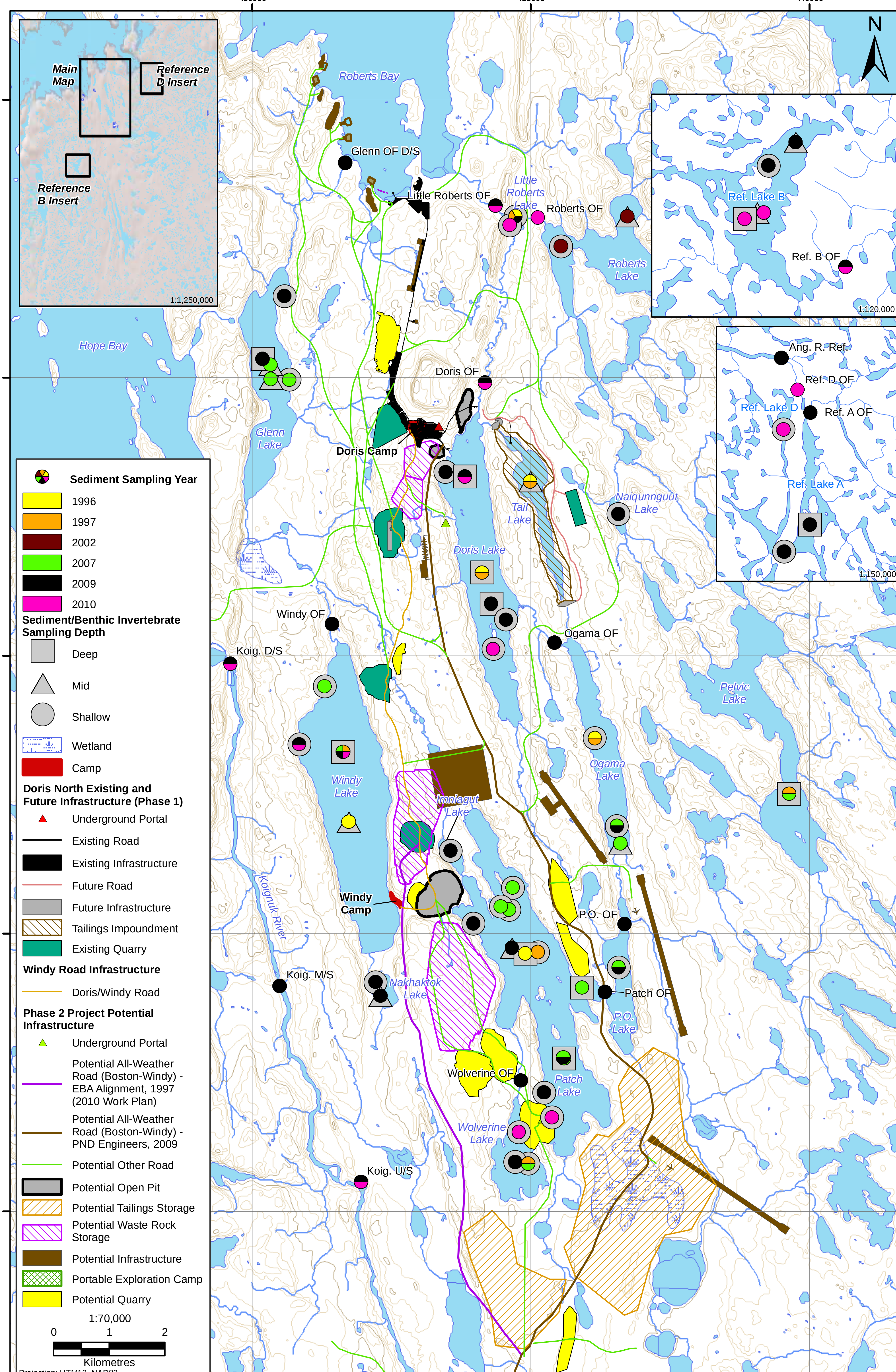

Figure 2.14-2a

Historical Sediment Quality Sampling Locations, Hope Bay Belt Project, North End of the Belt

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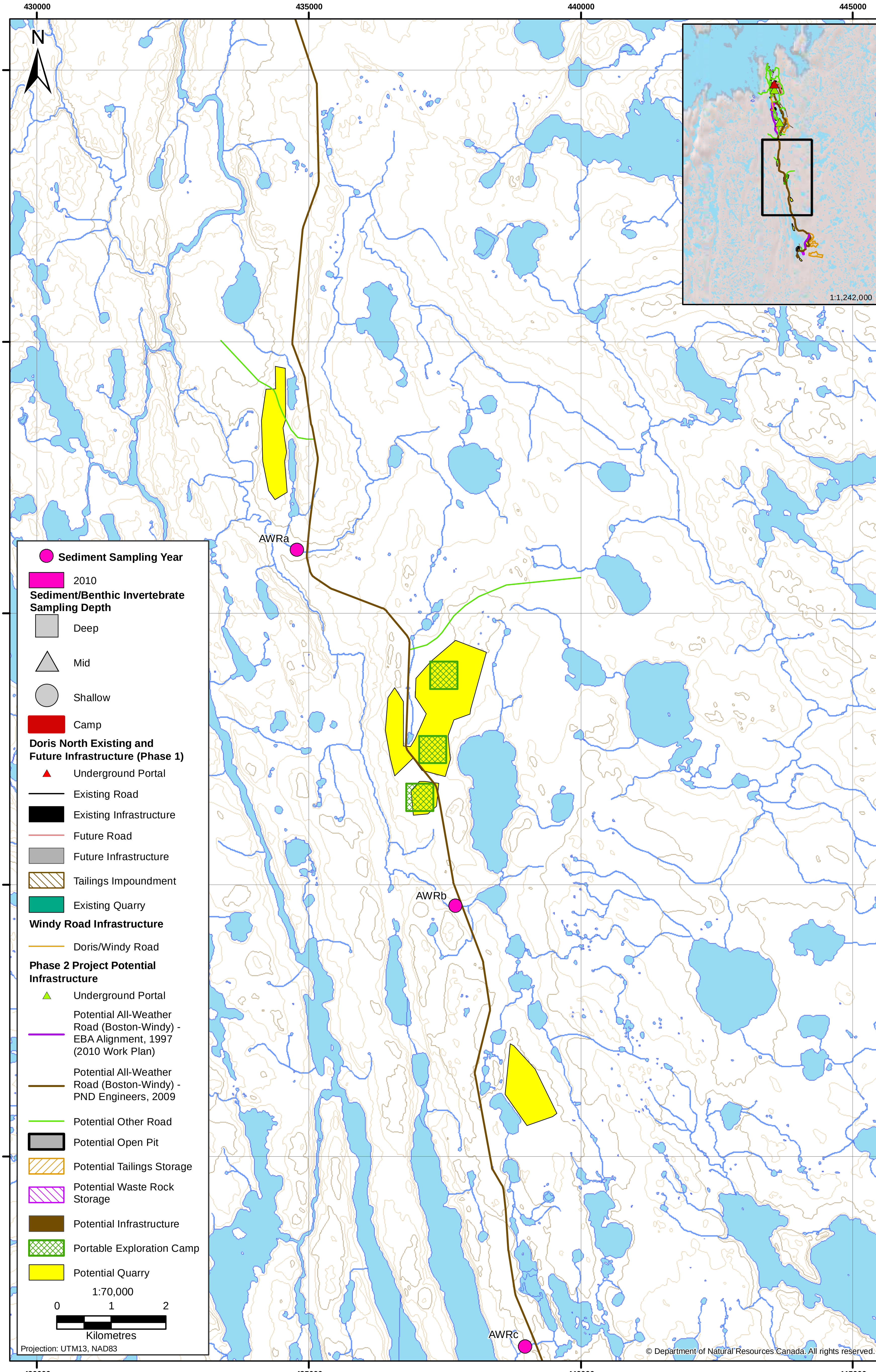

Figure 2.14-2b

NEWMONT NORTH AMERICA

Historical Sediment Quality Sampling Locations, Hope Bay Belt Project, Central Area of the Belt

Figure 2.14-2b

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PROJECT #1009-002-05 GIS # HB-01-033c December 7, 2010

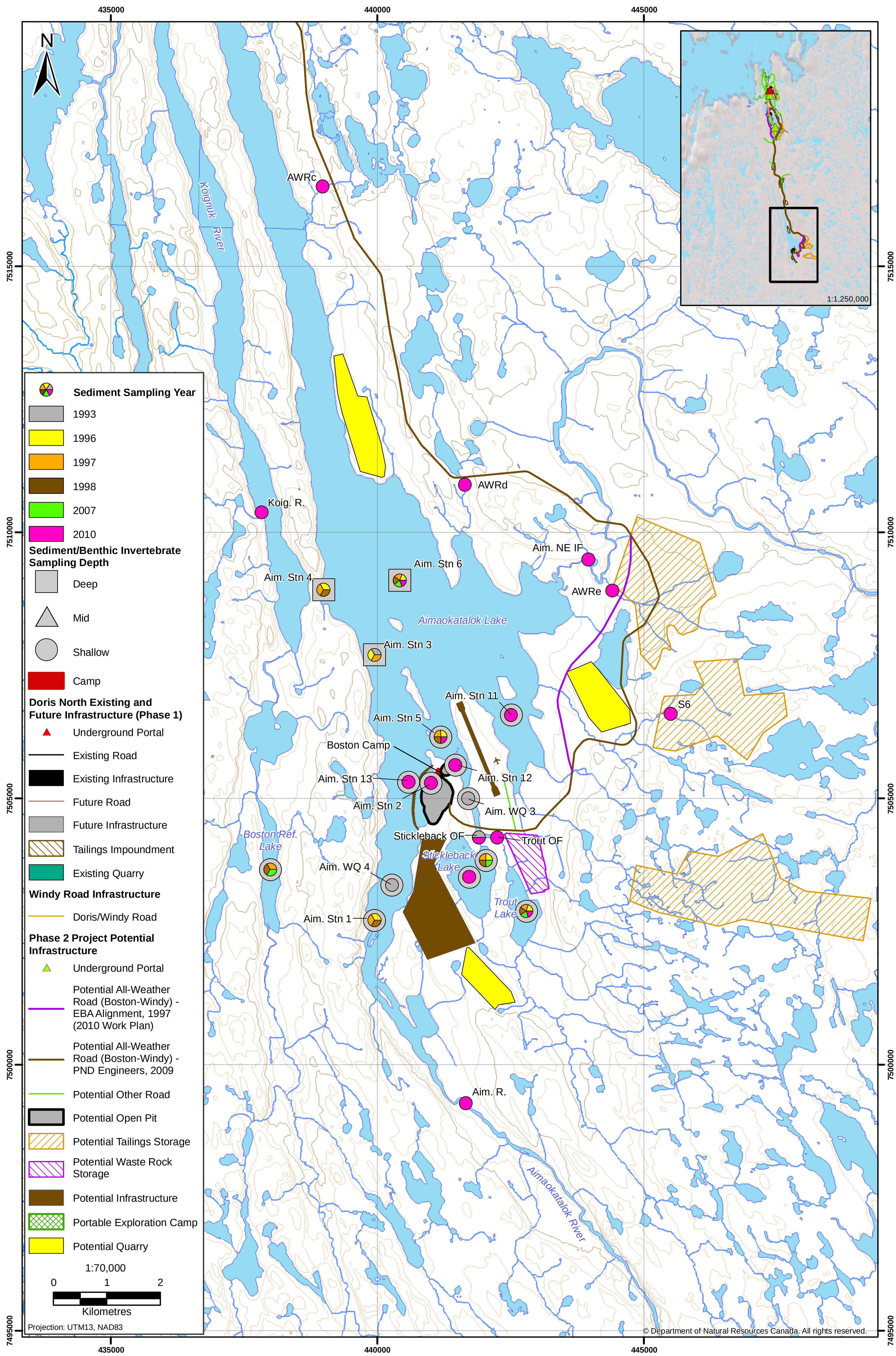

Figure 2.14-2c

NEWMONT NORTH AMERICA

Historical Sediment Quality Sampling Locations, Hope Bay Belt Project, South End of the Belt

Figure 2.14-2c

Rescan Engineers & Scientists

PROJECT #1009-002-05 GIS # HB-01-034a December 7, 2010

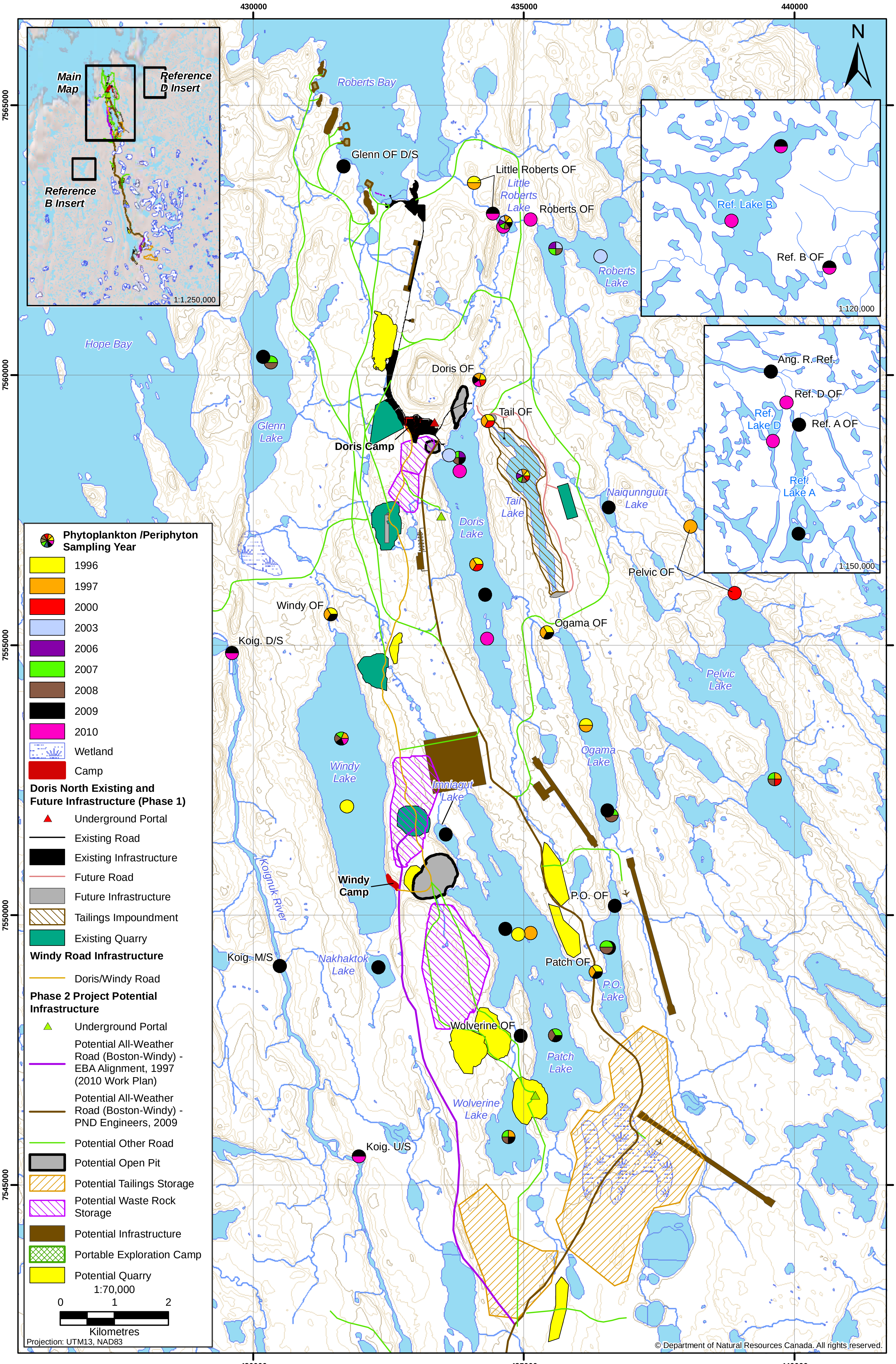

Figure 2.14-3a

NEWMONT NORTH AMERICA

Historical Phytoplankton and Periphyton Sampling Locations, Hope Bay Belt Project, North End of the Belt

Figure 2.14-3a

Rescan Engineers & Scientists

PROJECT #1009-002-05 GIS # HB-01-034b December 7, 2010

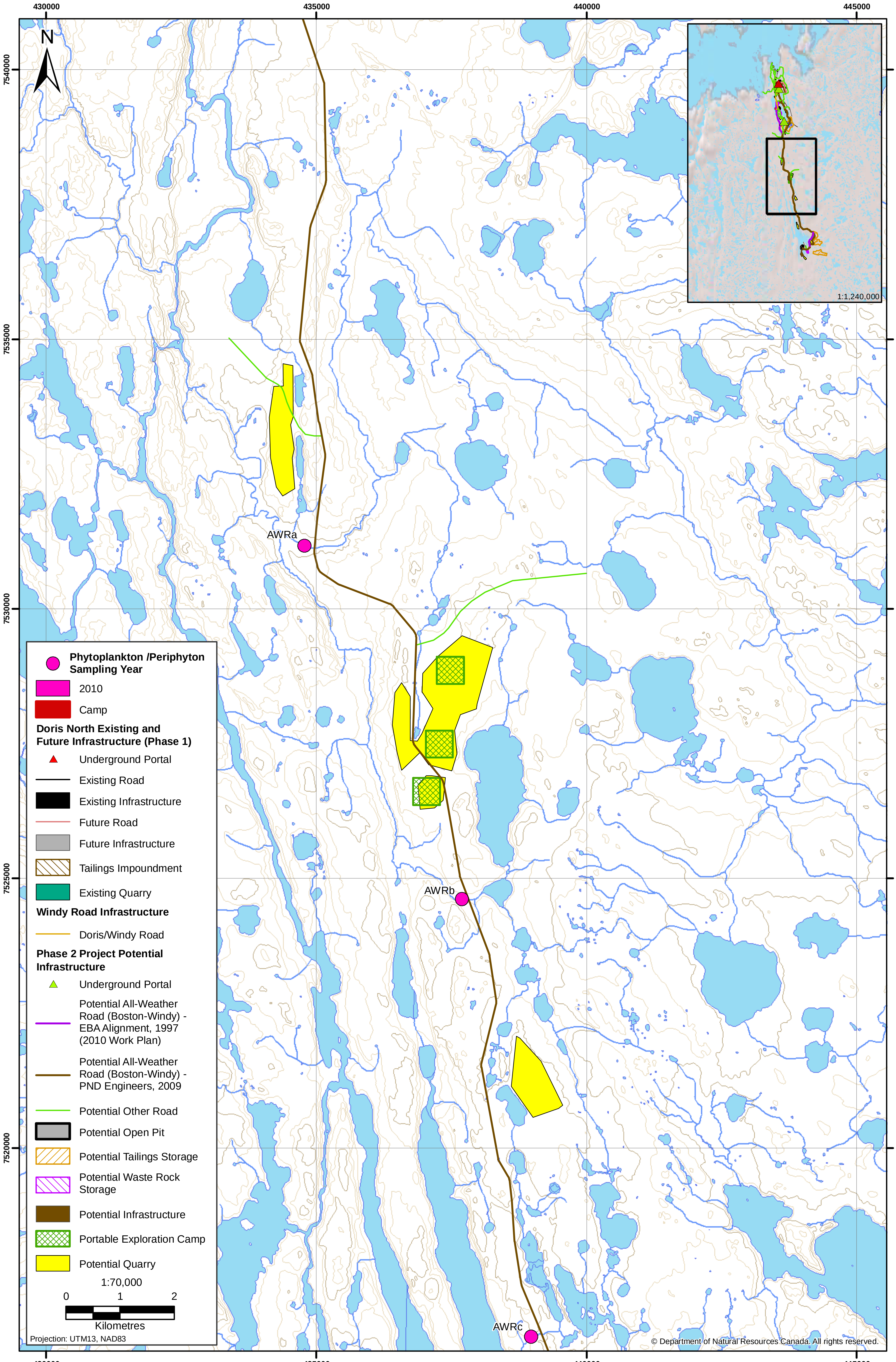

Figure 2.14-3b

NEWMONT NORTH AMERICA

Historical Phytoplankton and Periphyton Sampling Locations, Hope Bay Belt Project, Central Area of the Belt

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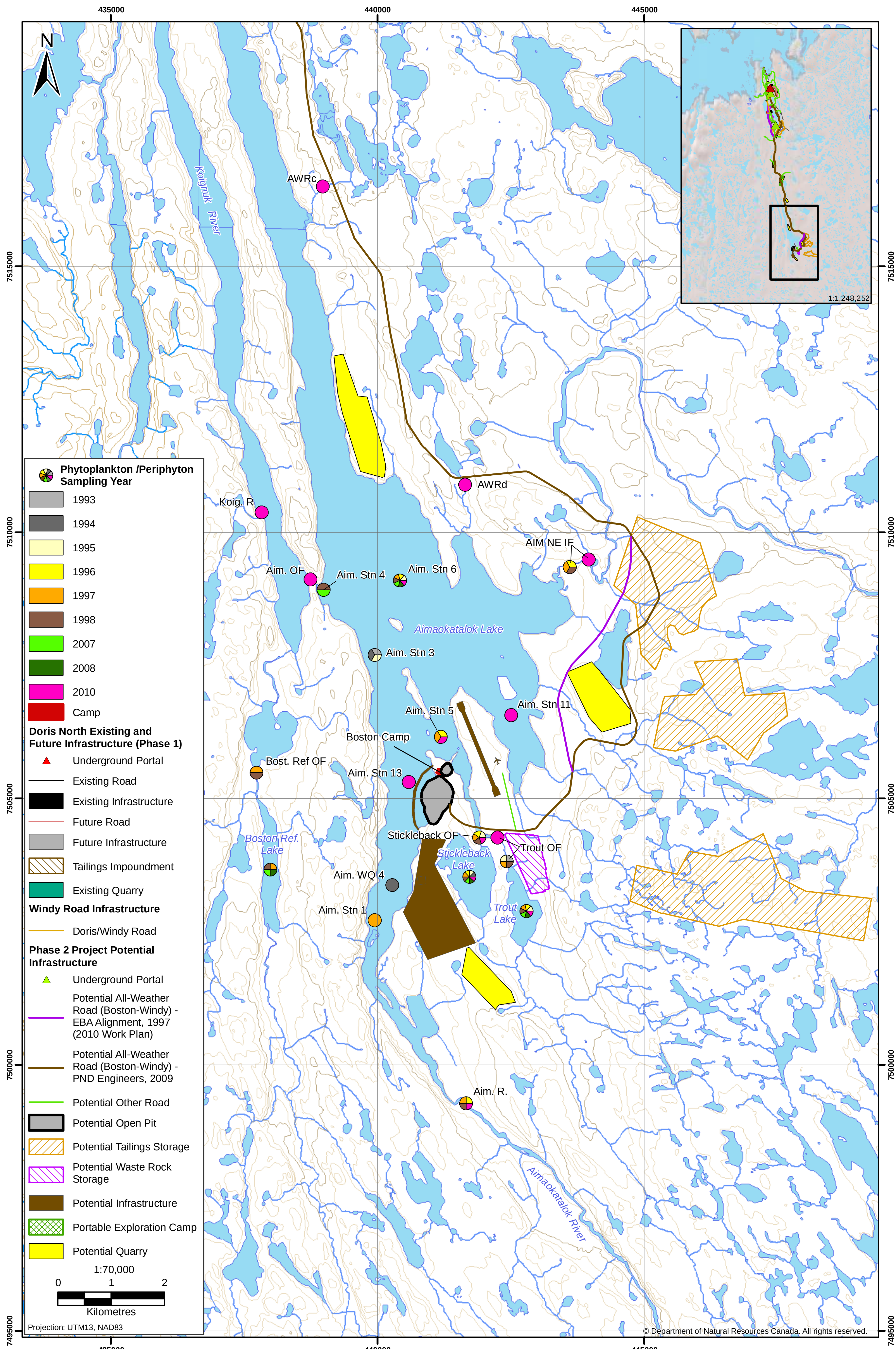

Figure 2.14-3c

NEWMONT NORTH AMERICA

Historical Phytoplankton and Periphyton Sampling Locations, Hope Bay Belt Project, South End of the Belt

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Figure 2.14-3c

PROJECT #1009-002-05 GIS # HB-01-035a December 7, 2010

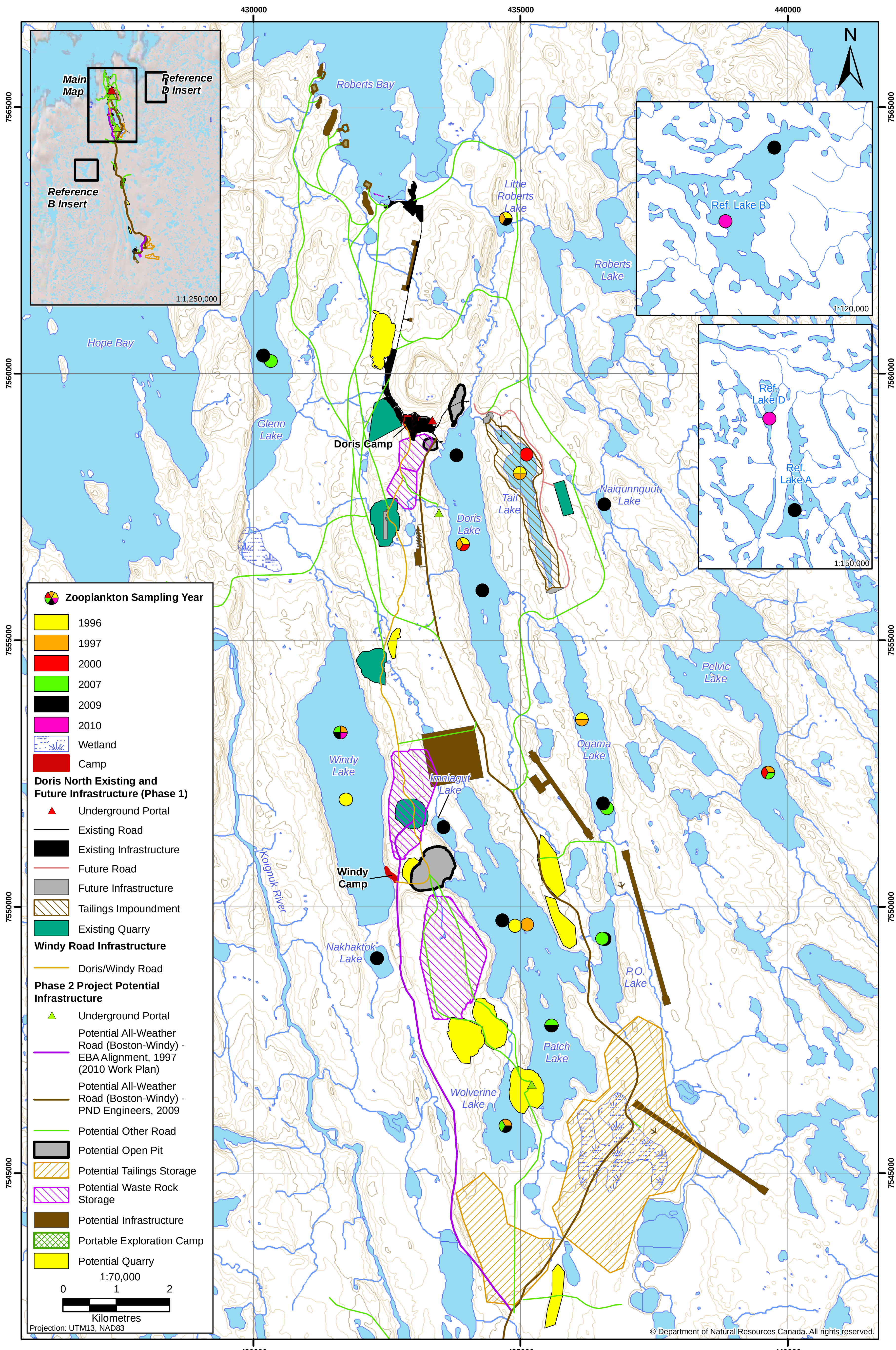

Figure 2.14-4a

NEWMONT NORTH AMERICA

Historical Zooplankton Sampling Locations, Hope Bay Belt Project, North End of the Belt

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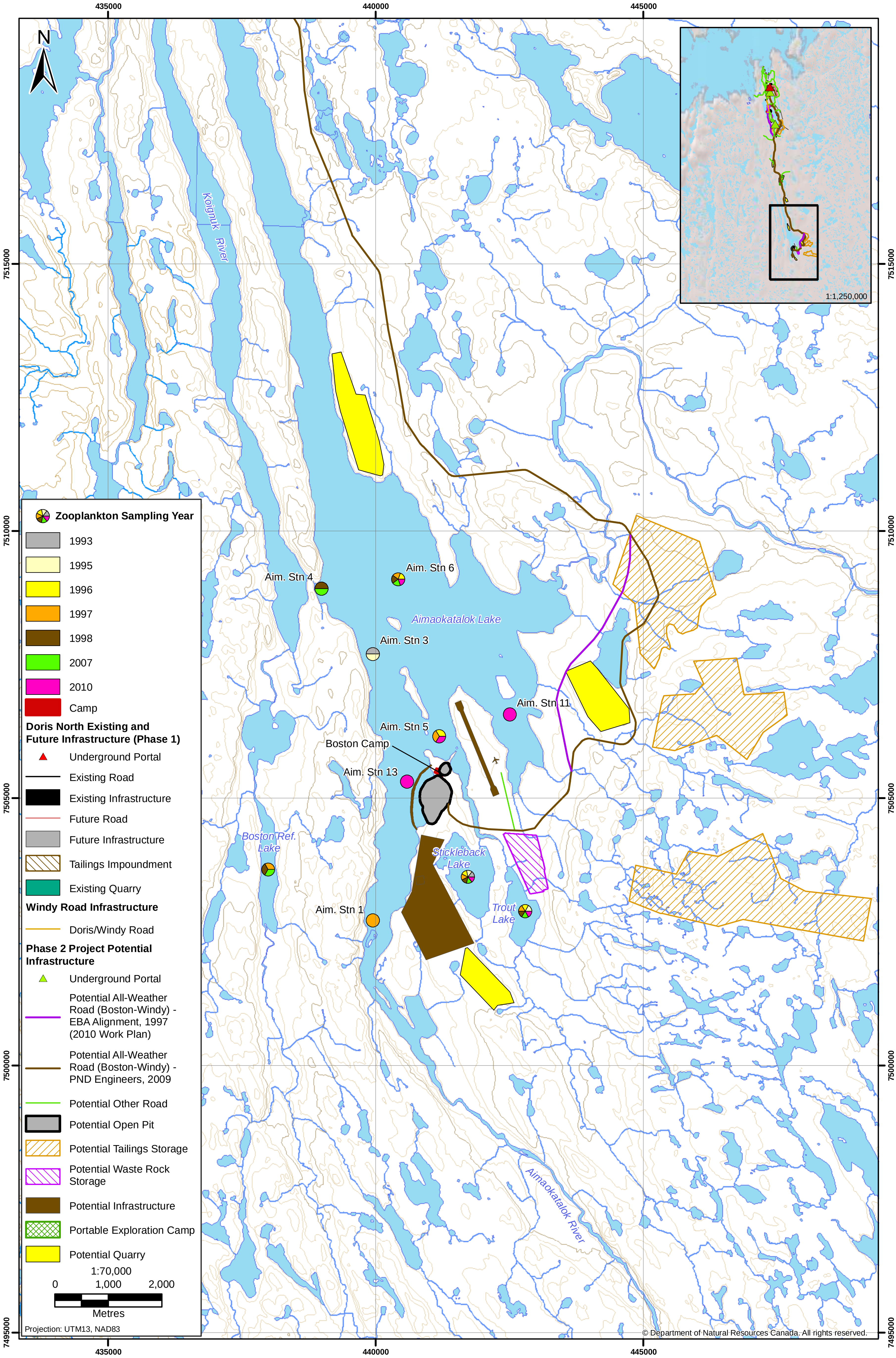

Figure 2.14-4b

Historical Zooplankton Sampling Locations, Hope Bay Belt Project, South End of the Belt

NEWMONT NORTH AMERICA

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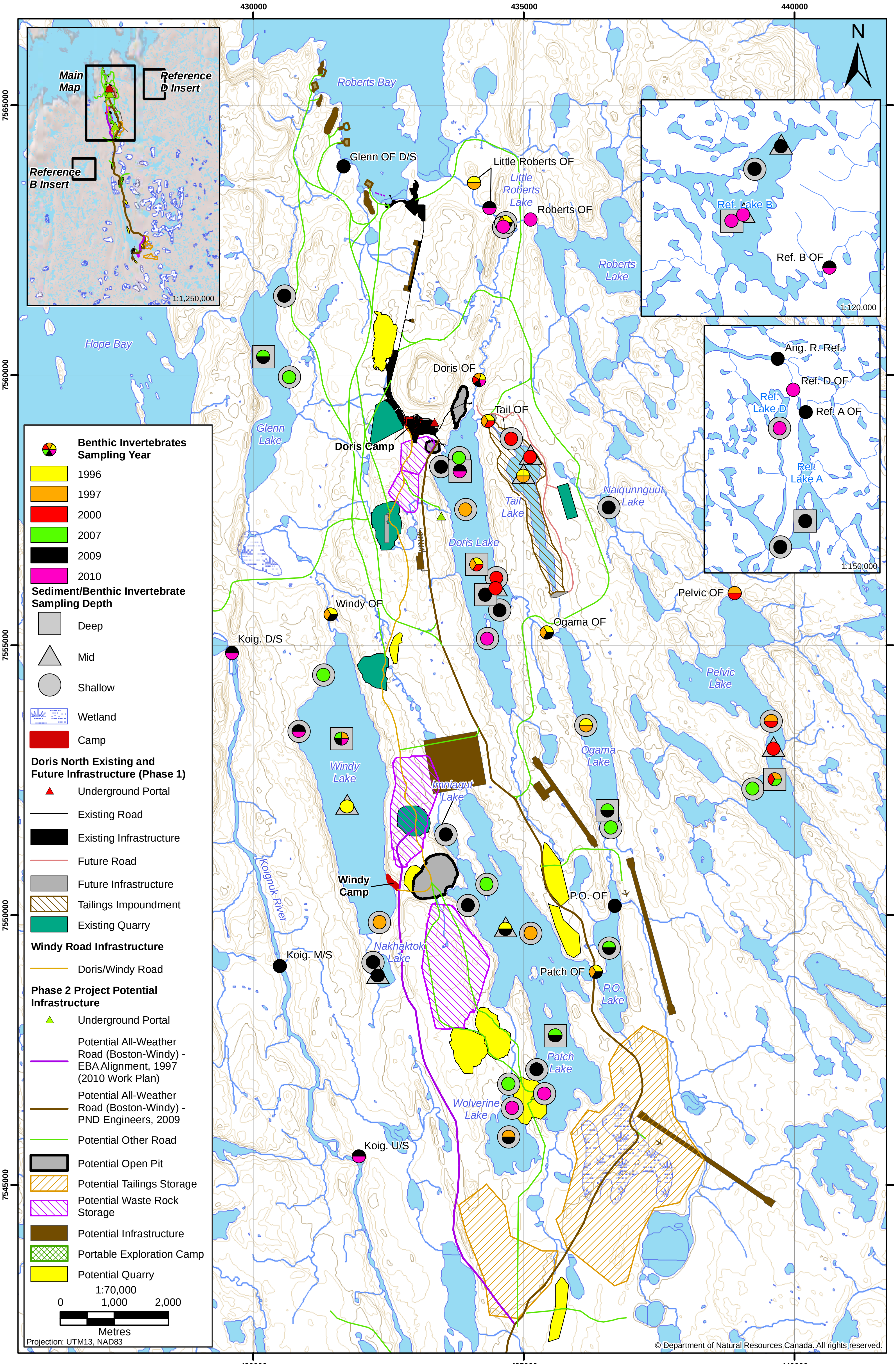

Figure 2.14-5a

Historical Benthic Invertebrate Sampling Locations, Hope Bay Belt Project, North End of the Belt

NEWMONT NORTH AMERICA

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Figure 2.14-5a

PROJECT #1009-002-05 GIS # HB-01-036b December 7, 2010

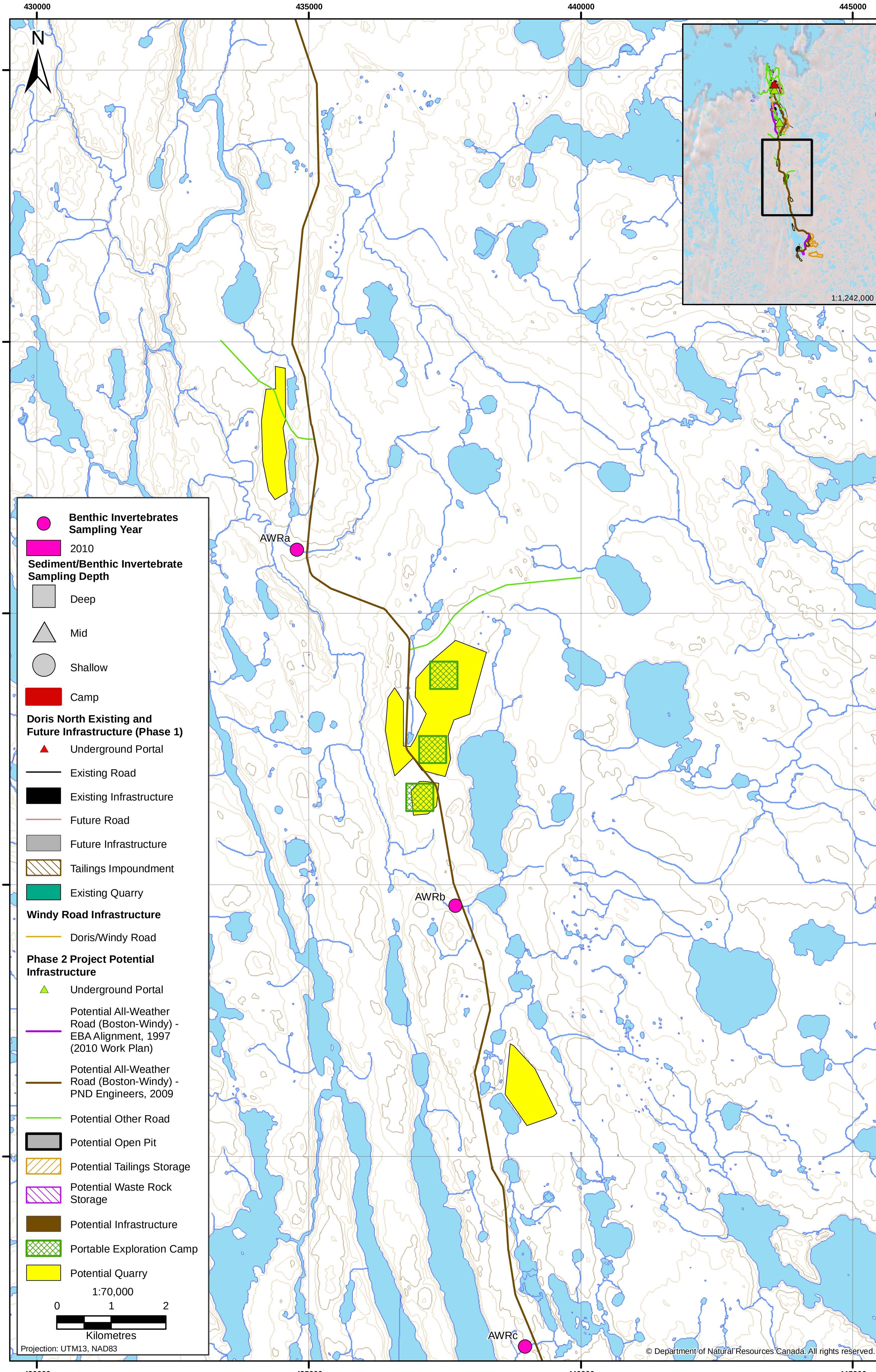

Figure 2.14-5b

Historical Benthic Invertebrate Sampling Locations, Hope Bay Belt Project, Central Area of the Belt

NEWMONT NORTH AMERICA

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Figure 2.14-5b

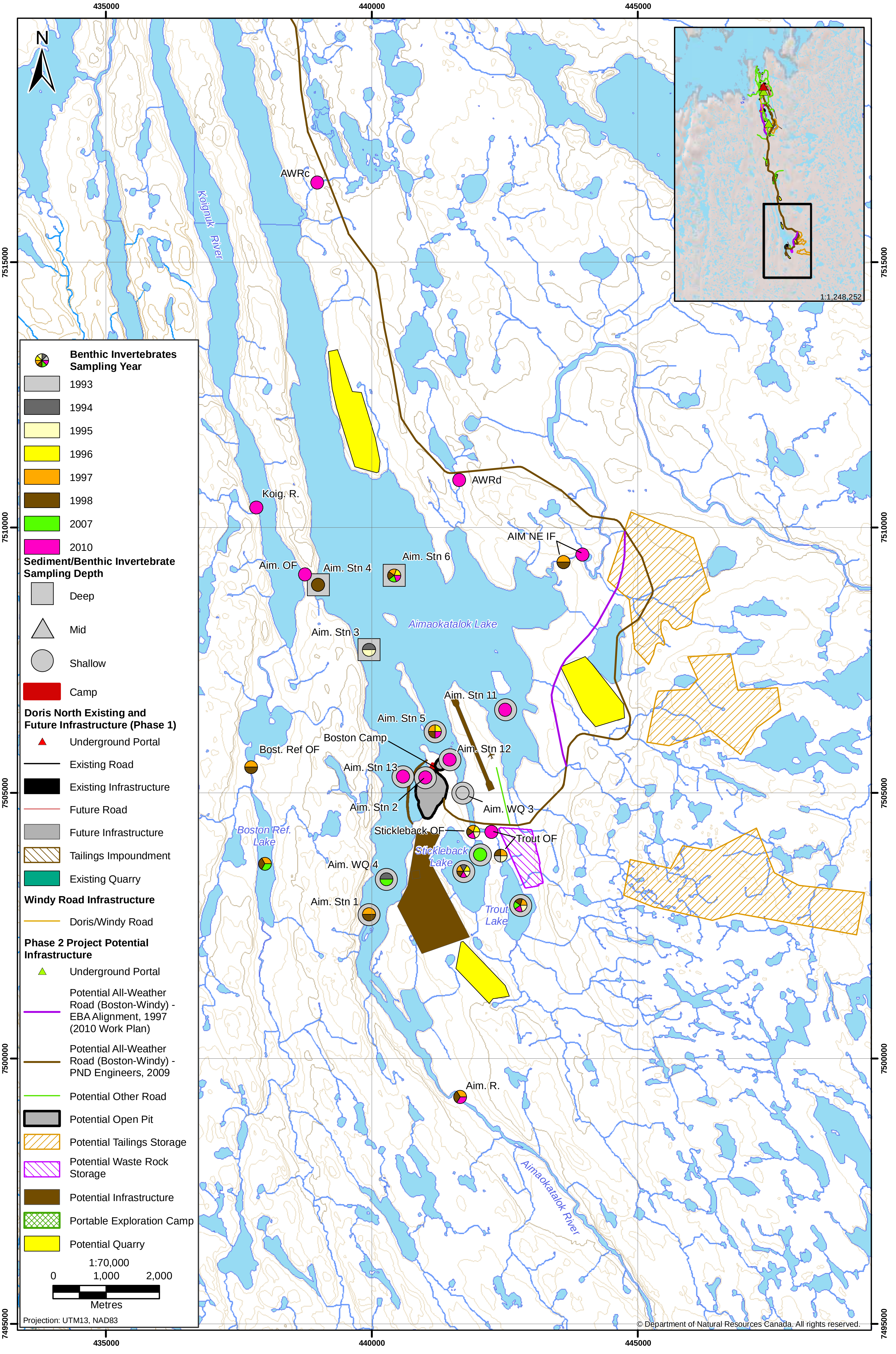

Figure 2.14-5c

NEWMONT NORTH AMERICA

Historical Benthic Invertebrate Sampling Locations, Hope Bay Belt Project, South End of the Belt

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3. Results and Discussion

3. Results and Discussion

3.1 BATHYMETRY AND PHYSICAL LIMNOLOGY

3.1.1 Bathymetry

Bathymetric surveys of Stickleback Lake, Trout Lake, Imniagut Lake, Reference Lake B, and Reference Lake D were conducted in August 2010. Bathymetric maps produced for each of these lakes, including details on lake surface area, volume, and maximum and mean depths are presented in Figures 2.1-4 to 2.1-13. Benchmark locations (to which water levels at the time of each survey were measured) and photographs are presented in Appendix 2.1-1.

3.1.2 Physical Limnology

3.1.2.1 Winter Lake Physical Limnology

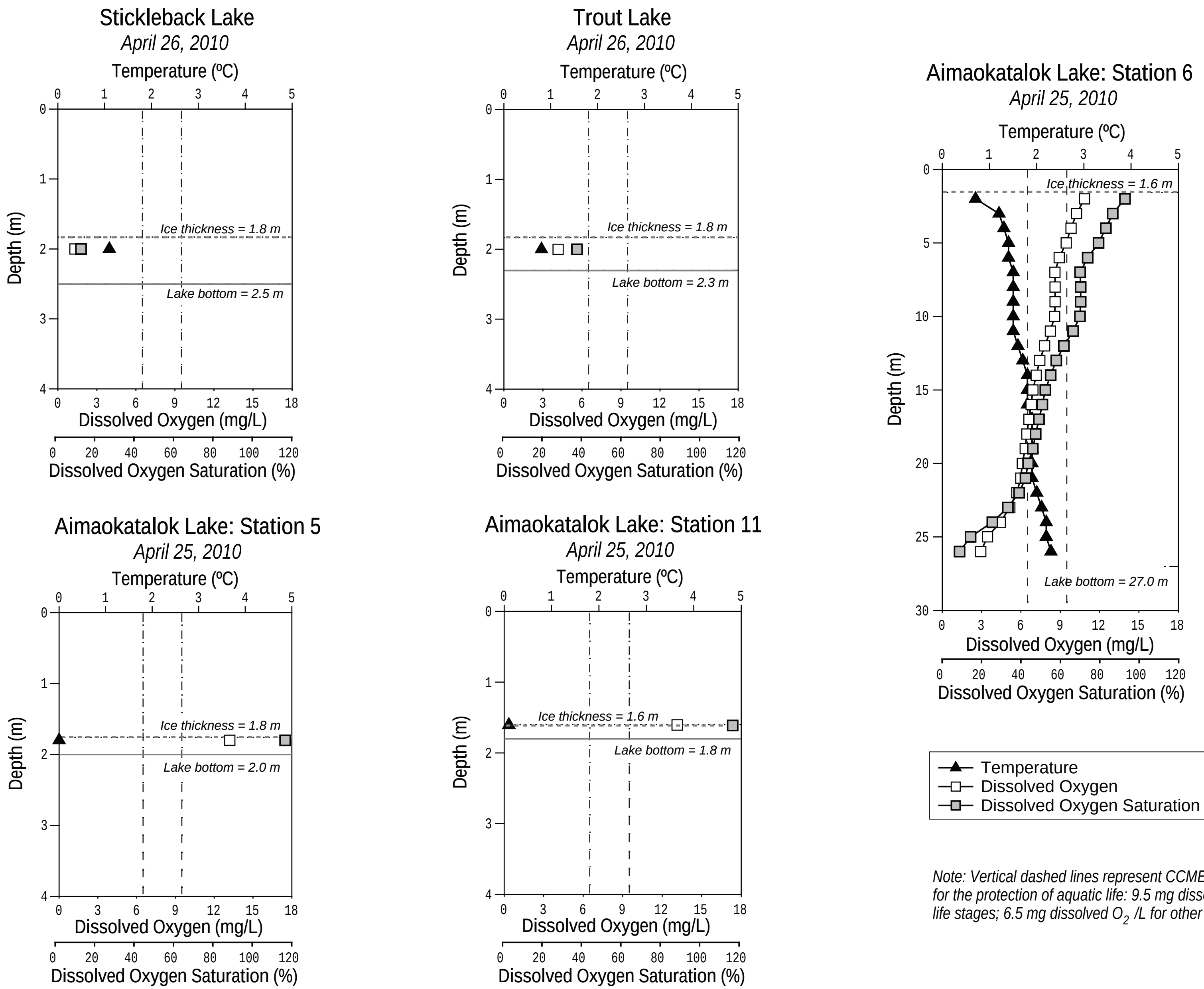
The ice cover was approximately 2 m thick on all lakes in April. Overall, the winter water column structure was typical of ice-covered lakes as water temperatures were coldest just below the ice, ranging from 0.0 to 1.1°C, and warmed slightly with depth in deeper lakes, reaching 2.2. to 2.3°C at the sediment-water interface (Figures 3.1-1a to 3.1-1b; raw data in Appendix 3.1-1). Although there were slight temperature gradients in the water columns of the deepest lakes, Aim. Stn 6 and Windy, the thermocline was not well-defined and temperatures generally changed gradually with depth.

Winter dissolved oxygen concentrations were highest near the water-ice interface, generally ranging between 10.8 and 13.2 mg/L. These levels were nearly saturated (97%) or supersaturated (117%), indicating that algae were actively photosynthesizing during this time. In two of the shallowest lakes, Stickleback and Trout, the ice cover extended nearly to the lake bottom and dissolved oxygen levels in the thin layer of water overlying the sediment were relatively low (Stickleback Lake: 1.3 mg/L, 11.9% saturation; Trout Lake: 4.2 mg/L, 37.4% saturation). In deeper lakes, dissolved oxygen concentrations and saturation levels gradually declined with depth to 2.9 to 3.8 mg/L and 27 to 35% at the water-sediment interface (Figure 3.1-1a to 3.1-1b and Table 3.1-1).

The CCME guideline for the lowest acceptable dissolved oxygen concentration for the protection of (cold-water) aquatic life is 9.5 mg/L for early life stages and 6.5 mg/L for other life stages (CCME 2007). During winter, dissolved oxygen concentrations in most lakes were above these guidelines in the upper portions of the water column (Figure 3.1-1a to 3.1-1b). However, bottom water dissolved oxygen concentrations were below guideline levels in the deeper lakes (Aim.Lake Stn 6 and Windy Lake). In the shallow Stickleback and Trout lakes, oxygen levels were also below 6.5 mg/L near the water-sediment interface. The low winter levels of dissolved oxygen in the deep waters of the sampled lakes are a common phenomenon in Arctic lakes, and are a result of oxygen depletion from respiration and a lack of exchange with atmospheric oxygen. This trend was also seen in Hope Bay area lakes during the winter of 2009 (Rescan 2010a).

3.1.2.2 Summer Lake Physical Limnology

Open-water limnological characteristics were measured in August 2010 (Figures 3.1-2a to 3.1-2c; Appendix 3.1-1). Most sites were well mixed during the summer. The exception was the deepest site, Aim. Stn 6, which had a pronounced thermal gradient at approximately 19 m depth. Overall, lake water temperatures ranged from 11.2°C to 14.8°C in August.



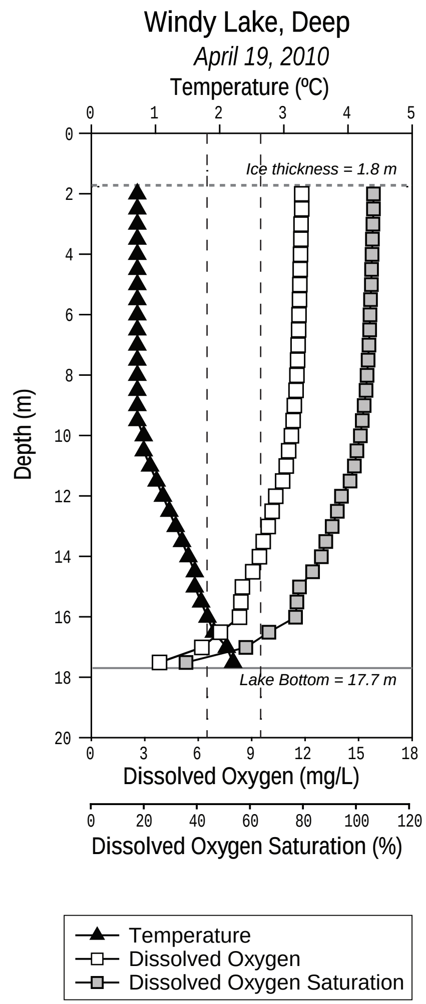
Note: Vertical dashed lines represent CCME guidelines for the protection of aquatic life: 9.5 mg dissolved O_2 /L for early life stages; 6.5 mg dissolved O_2 /L for other life stages.

Figure 3.1-1a

NEWMONT NORTH AMERICA

Winter Dissolved Oxygen and Temperature Profiles in Lakes, Hope Bay Belt Project, April 2010

Rescan Engineers & Scientists



Note: Vertical dashed lines represent CCME guidelines for the protection of aquatic life: 9.5 mg dissolved O_2 /L for early life stages; 6.5 mg dissolved O_2 /L for other life stages.

NEWMONT NORTH AMERICA

Winter Dissolved Oxygen and Temperature Profiles in Lakes, Hope Bay Belt Project, April 2010

Figure 3.1-1b

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Table 3.1-1. Lake Dissolved Oxygen Concentrations and Percent Saturation, Winter and Summer 2010

	Winter					Summer				
	Bottom Depth	Dissolved Oxygen Concentration (mg/L)		Dissolved Oxygen Saturation (%)		Bottom Depth	Dissolved Oxygen Concentration (mg/L)		Dissolved Oxygen Saturation (%)	
Lake	(m)	min.	max.	min.	max.	(m)	min.	max.	min.	max.
Stickleback	2.5	**1.3**	**1.3**	11.9	11.9	2.6	**9.4**	**9.4**	100.0	100.7
Trout	2.3	**4.2**	**4.2**	37.4	37.4	2.4	**8.8**	**8.8**	96.7	97.0
Aim.Stn 13			NC			3.7	10.1	10.2	97.9	98.4
Aim. Stn 2			NC			2.5	**8.4**	**8.5**	91.3	91.7
Aim. Stn 12			NC			0.3	10.4	10.4	117.2	117.2
Aim. Stn 5	2.0	13.2	13.3	116.6	116.6	2.5	10.0	10.0	98.3	98.7
Aim. Stn 11	1.8	13.2	13.2	116.0	116.0	2.6	**9.2**	**9.2**	100.2	100.5
Aim. Stn 6	27.0	**2.9**	10.8	27.2	97.4	28.5	**8.8**	10.1	81.5	97.7
Windy Deep	17.7	**3.8**	11.8	35.1	105.6	17.7	10.2	10.3	93.1	95.5

CCME guideline for dissolved oxygen is 9.5 mg/L for early life stages, 6.5 mg/L for other life stages.
Bold values indicate concentrations that are below at least one CCME guideline level.
NC - not collected

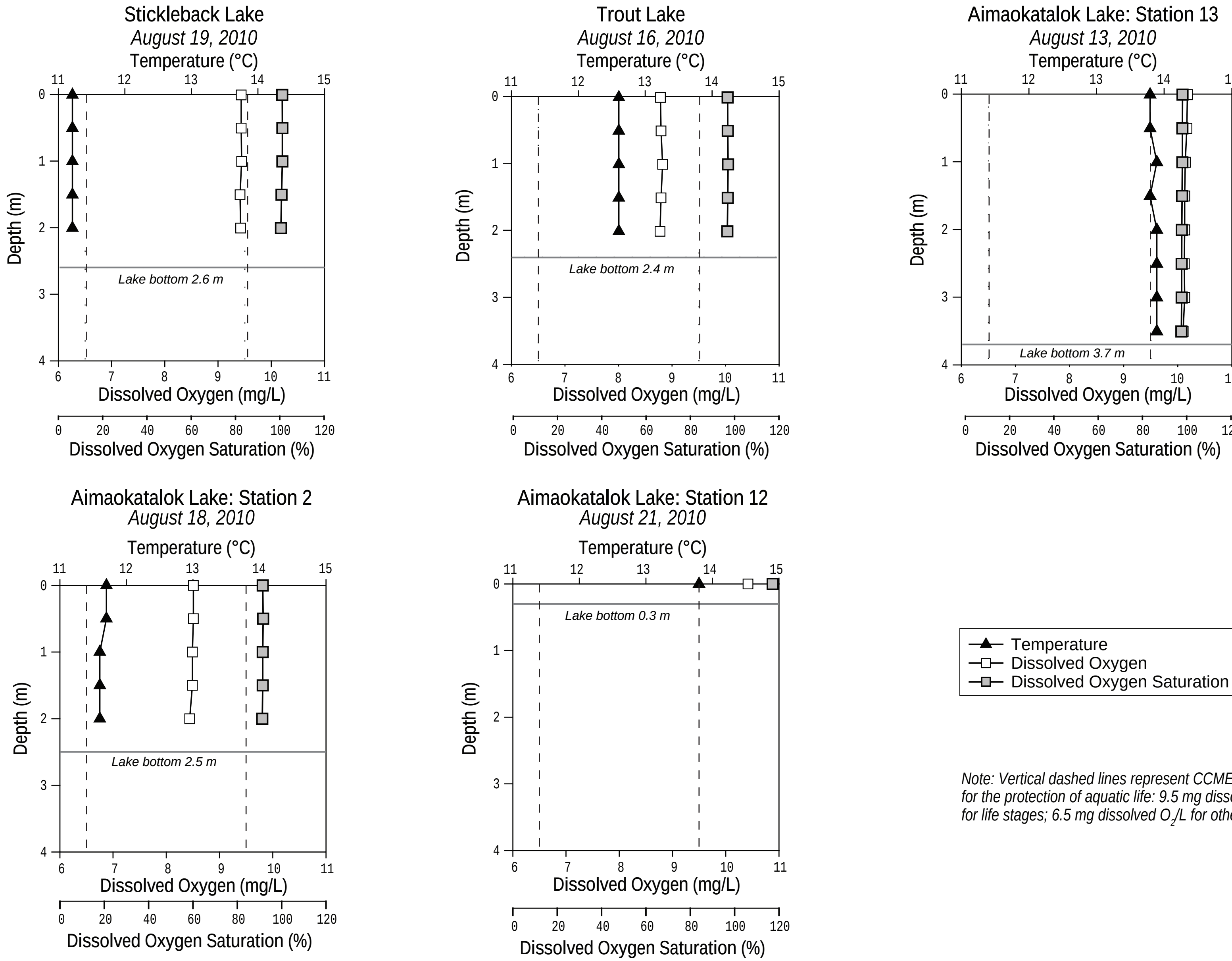
Summer dissolved oxygen concentrations changed little throughout the water columns of all lakes, mirroring patterns observed in water temperature. Slight declines in oxygen concentrations occurred near the lake bottom at Aim. Stn 6, likely due to respiratory oxygen consumption. Overall, lakes were well-oxygenated, with water column oxygen concentrations ranging from 8.4 mg/L (Aim. Stn 2 at 2.0 m depth) to 10.4 mg/L (Aim. Stn 12 at the surface). Dissolved oxygen saturation levels ranged from 81.5% in the bottom waters of Aim. Stn 6 to 117% at the surface of the shallow site Aim. Stn 12 (Figures 3.1-2a to 3.1-2c; Table 3.1-1).

Secchi depths and calculated euphotic zone depths for all lakes sampled during the open-water season are presented in Table 3.1-2. Secchi depth, a measure of water clarity, was shallow and ranged from 1.4 m (Trout) to 3.5 m (Windy). Water clarity was generally greatest in deepest lake sites, Windy (17.7 m) than in the other shallow lake sites.

The euphotic zone depth, which defines the area of the water column where there is enough light to support photosynthesis, ranged from 5.7 to 14.2 m (calculated from Secchi depth). The euphotic zone extended throughout the entire water column in all shallow lake sampling sites, allowing benthic primary production in these lakes (Table 3.1-2).

Table 3.1-2. Lake Secchi and Euphotic Zone Depths, August 2010

Watershed	Lake/Station	Lake Depth (m)	Secchi Depth D_s (m)	Euphotic Zone Depth EZD (m)
Aimaokatalok	Stickleback	2.6	bottom	10.6
	Trout	2.4	1.4	5.7
	Aim. Stn 13	3.7	2.7	11.0
	Aim. Stn 2	2.5	2.4	9.7
	Aim. Stn 5	2.5	2.0	8.1
	Aim. Stn 11	2.6	2.2	8.9
	Aim. Stn 6	28.5	2.7	11.0
Windy	Windy	17.7	3.5	14.2



Note: Vertical dashed lines represent CCME guidelines for the protection of aquatic life: 9.5 mg dissolved O_2/L for life stages; 6.5 mg dissolved O_2/L for other life stages.

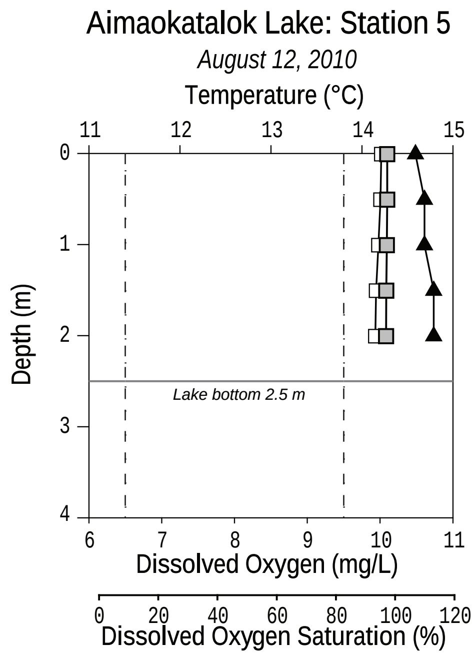
Figure 3.1-2a

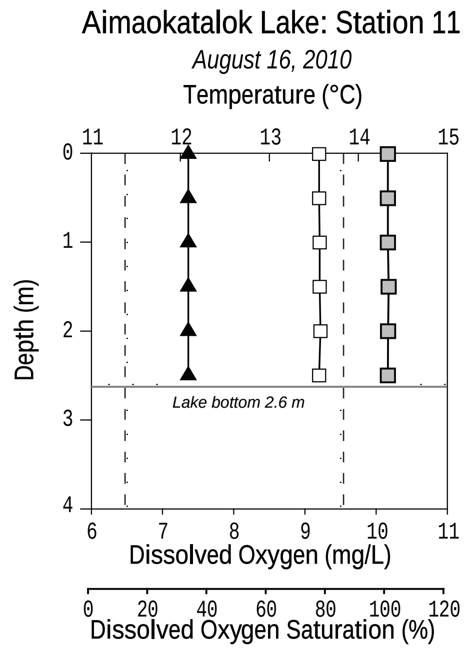
NEWMONT NORTH AMERICA

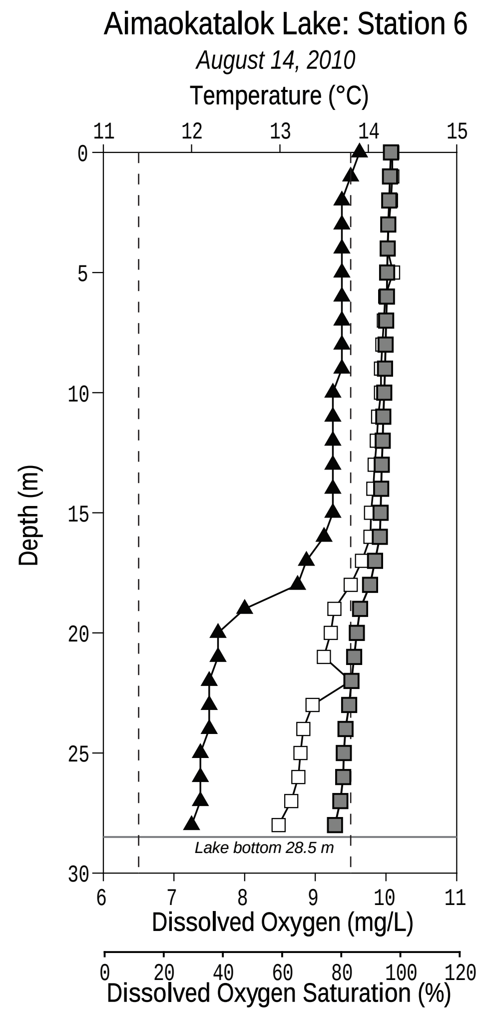
Summer Dissolved Oxygen and Temperature Profiles in Lakes, Hope Bay Belt Project, August 2010

Figure 3.1-2a

Rescan™ Engineers & Scientists







Temperature
Dissolved Oxygen
Dissolved Oxygen Saturation

Note: Vertical dashed lines represent CCME guidelines for the protection of aquatic life: 9.5 mg dissolved O_2 /L for early life stages; 6.5 mg dissolved O_2 /L for other life stages.

Figure 3.1-2b

NEWMONT NORTH AMERICA

Summer Dissolved Oxygen and Temperature Profiles in Lakes, Hope Bay Belt Project, August 2010

Figure 3.1-2b

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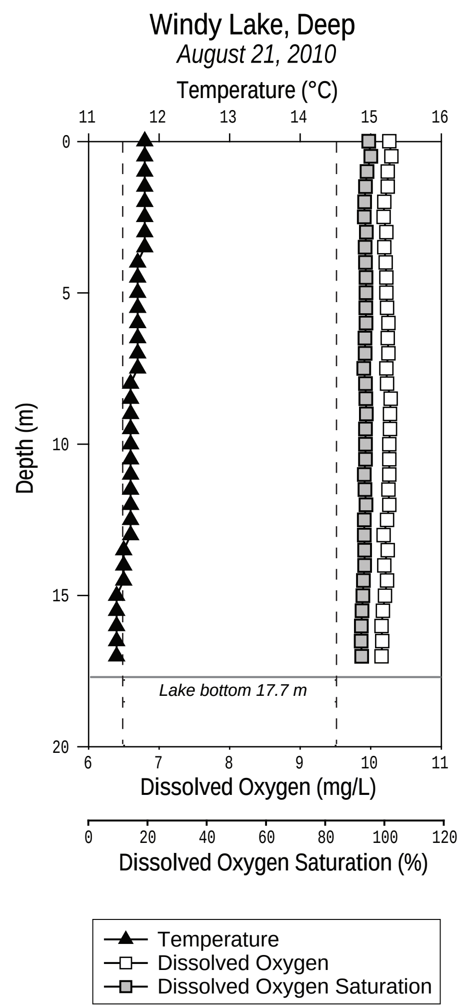

Note: Vertical dashed lines represent CCME guidelines for the protection of aquatic life: 9.5 mg dissolved O_2 /L for early life stages; 6.5 mg dissolved O_2 /L for other life stages.

Figure 3.1-2c

NEWMONT NORTH AMERICA

Summer Dissolved Oxygen and Temperature Profiles in Lakes, Hope Bay Belt Project, August 2010

Figure 3.1-2c

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3.1.2.3 Winter Stream and River Physical Limnology

Winter temperature and dissolved oxygen profiles were collected at Koig. R. and Koig. U/S on the Koignuk River in April 2010 (Table 3.1-3 and Appendix 3.1-2). Ice thickness on the Koignuk River ranged from 1.5 to 1.8 m. Because of the ice thickness, under-ice river water was assumed to be limited to isolated pools separated by frozen sections of river. The following observations supported this assumption:

- four attempts to reach under-ice river water in the downstream Koignuk were unsuccessful as ice extended to the river bottom. This site was successfully sampled in 2009 (Rescan 2010a);
- stream flow measurements from 2009 found that the Koignuk River does not flow year-round, and flow ceases during some winter months (Rescan 2009);
- there was no evidence of freshwater input at the confluence with Hope Bay (no decrease in ocean salinity; Rescan 2010b); and
- no section of the Koignuk River was observed to be free of ice.

Table 3.1-3. River Dissolved Oxygen and Temperature Profiles, Winter 2010

Site	Date Sampled	Ice Thickness (m)	Bottom Depth (m)	Sampling Depth (m)	Temp (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)
Koig. R.	25-April-10	1.81	4.3	2.0	0.5	10.72	95.6
				2.5	0.8	9.74	87.4
				3.0	1.0	**9.29**	83.5
				3.5	1.0	**8.25**	74.5
				4.0	1.1	**8.03**	72.6
Koig. U/S	18-April-10	1.46	2.0	1.5	0.0	**9.46**	83.2
				2.0	0.0	9.51	83.8

CCME guideline for dissolved oxygen is 9.5 mg/L for early life stages, 6.5 mg/L for other life stages.
Bold values indicate concentrations that are below at least one CCME guideline level.

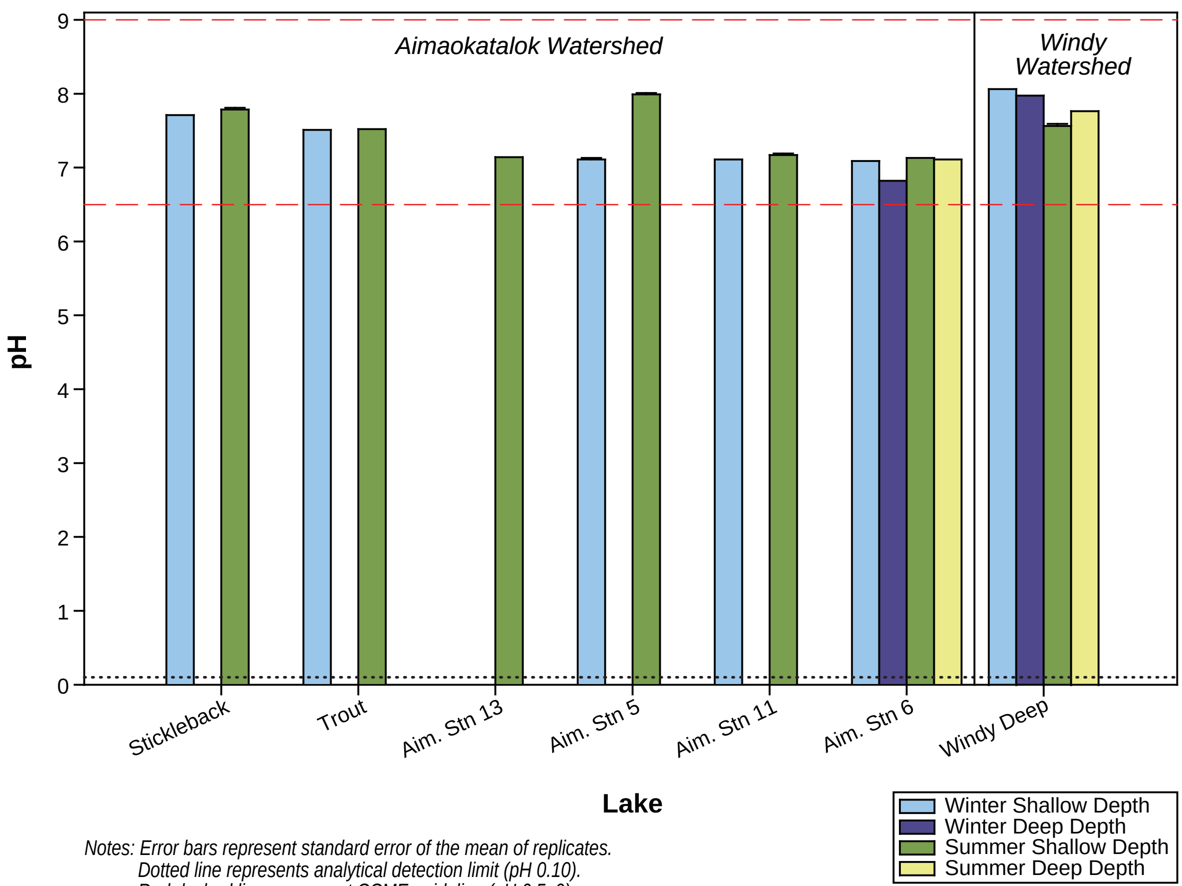
As expected, the water temperatures in the Koignuk River were near freezing, ranging from 0.0 to 1.1°C. Oxygen concentrations were similar at both Koignuk River sampling sites, averaging 9.3 mg/L and 83% saturation. Temperatures increased and dissolved oxygen decreased with depth at the deeper Koig. R. sampling site.

3.2 LAKE WATER QUALITY

Lake water quality samples were collected in both the under-ice (April) and open-water season (August) in 2010. Historical data are also available for some lakes in the study area (Figures 2.14-1a to 2.14-1c; Table 2.14-1). Raw 2010 water quality data for lakes are presented in Appendix 3.2-1, and QA/QC data are presented in Appendix 3.2-2. All water quality data were compared to CCME guidelines for the protection of freshwater aquatic life (CCME 2007).

3.2.1 Depth Variation

Lake water quality data collected in 2010 are presented graphically in Figures 3.2-1a to 3.2-1y. Within the two deep lake sampling stations, Aim. Stn 6 and Windy, there were few differences in water quality between surface samples and samples collected from 2 m above the sediment. This is not surprising, as lakes tended to be well-mixed to weakly stratified in both April and August 2010.



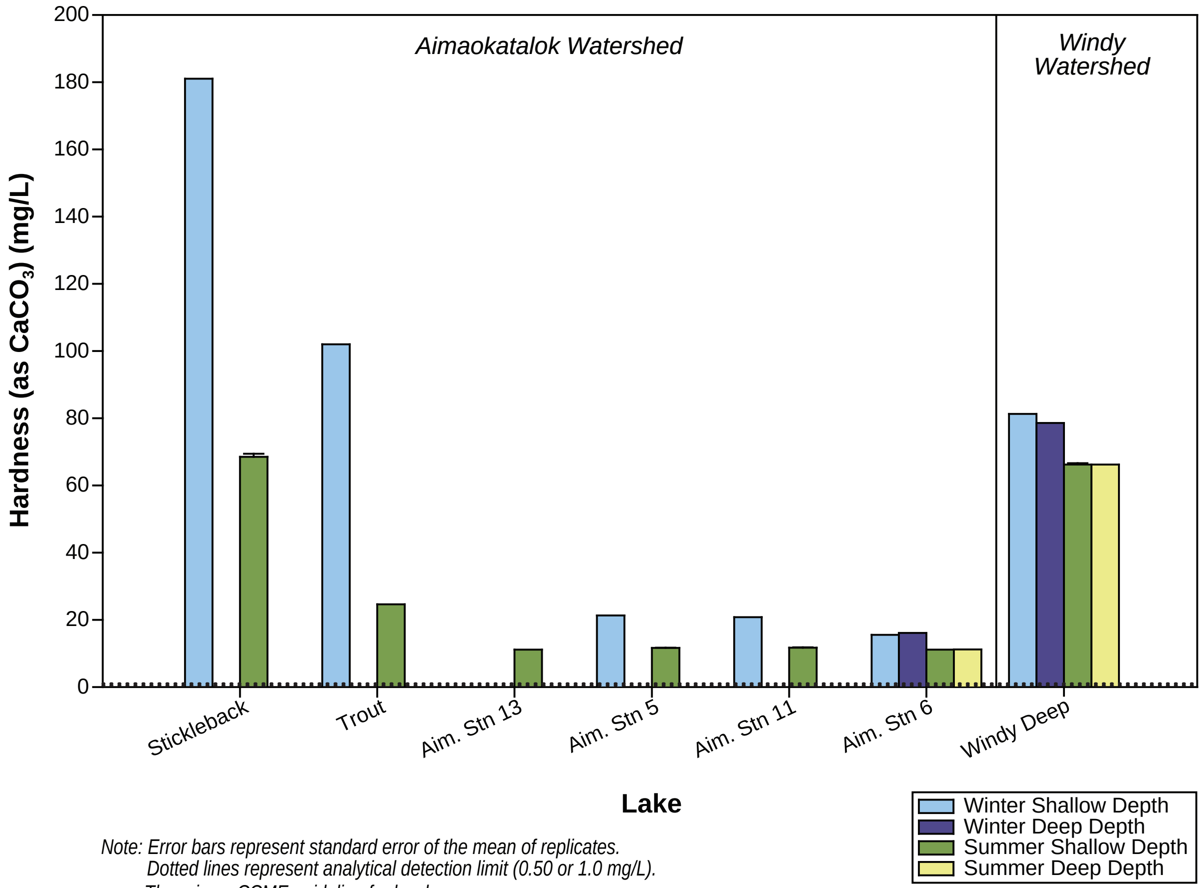
Notes: Error bars represent standard error of the mean of replicates.
Dotted line represents analytical detection limit (pH 0.10).
Red dashed lines represent CCME guideline (pH 6.5–9).

Figure 3.2-1a

NEWMONT NORTH AMERICA

pH in Lakes,
Hope Bay Belt Project, 2010

Rescan Engineers & Scientists



Note: Error bars represent standard error of the mean of replicates.
Dotted lines represent analytical detection limit (0.50 or 1.0 mg/L).
There is no CCME guideline for hardness.

Figure 3.2-1b

Hardness in Lakes,
Hope Bay Belt Project, 2010

NEWMONT NORTH AMERICA

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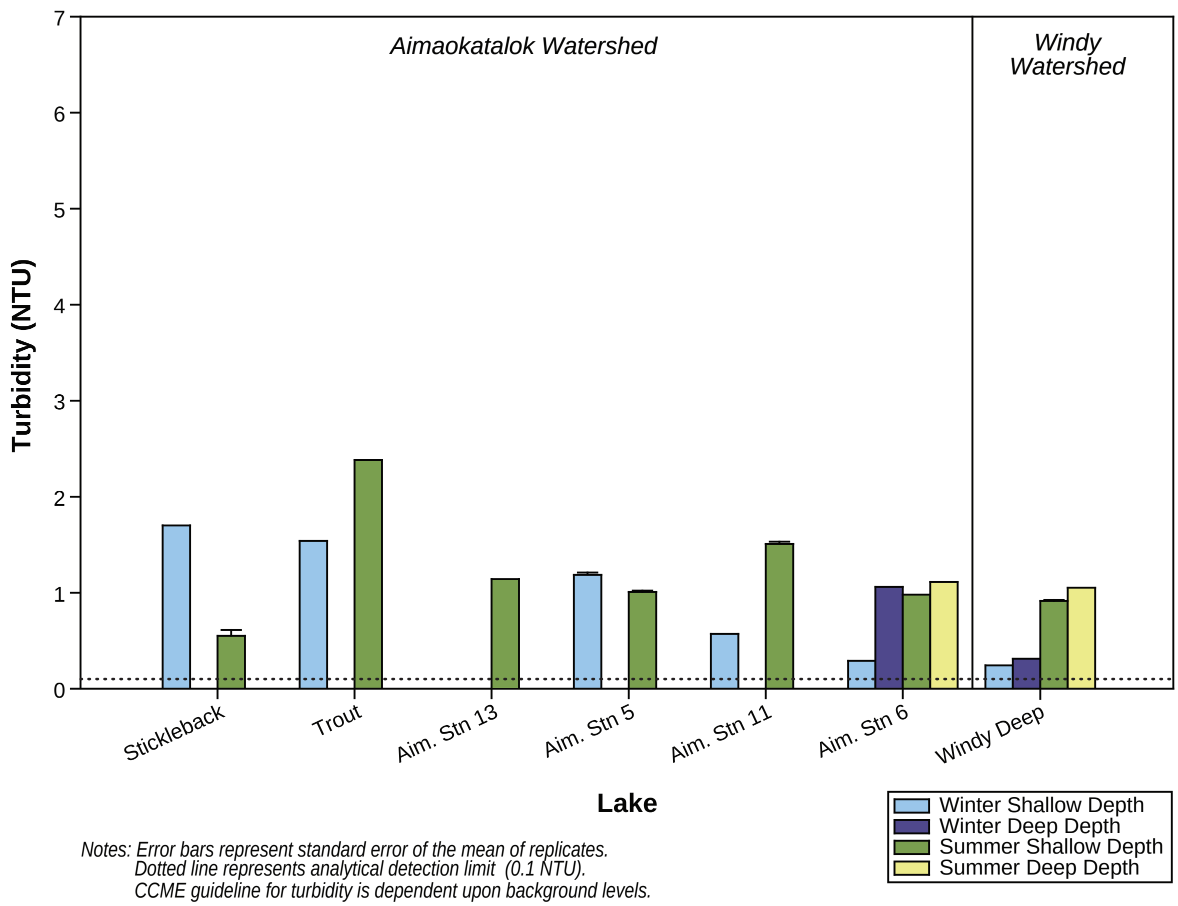

Notes: Error bars represent standard error of the mean of replicates.
Dotted line represents analytical detection limit (0.1 NTU).
CCME guideline for turbidity is dependent upon background levels.

NEWMONT NORTH AMERICA

Turbidity in Lakes,
Hope Bay Belt Project, 2010

Figure 3.2-1c

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