Appendix G10

Report: *Fisheries Habitat Mapping of Bay-Goose Basin: Pre-mine-operations versus post-dewatering analysis*

TECHNICAL MEMORANDUM

Agnico Eagle Mines Ltd: Meadowbank Division
Baker Lake NU.

Subject: Fisheries Habitat Mapping of Bay-Goose Basin: Pre-mine-operations versus post-dewatering analysis

Date: March 25, 2013

From: Ryan VanEngen (Environment Biologist) and Dougan and Associates- Ecological Consulting and Design.

Executive Summary

In 2009 AEM completed a post-dewatering evaluation of fish habitat in the northwest arm of Second Portage Lake. This assessment was conducted in compliance with the DFO Fisheries Authorization issued in 2008, and the AEM/draft DFO the fishout protocol. In 2012, dewatering was complete in the Bay-Goose basin of Third Portage Lake, and a similar evaluation was completed for this area. The objective of the 2012 evaluation was to delineate habitat types in a portion of the de-watered basin, and compare these results with predictions made prior to dewatering. Methods were generally the same as in 2009, however changes in the use of GIS technology and the incorporation of statistical approaches have allowed for an improved analysis, specifically with regards to the classification of habitat types and estimates of habitat type areas by habitat type. The evaluation consisted of aerial photo interpretation and field transects, detailed surveying (+/- 0.25m accuracy) and GIS interpretation within a sub-basin of Bay-Goose basin that was not disturbed by mine operations. The overall goal of the 2012 evaluation was to help quantify habitat type classification error in order to assist in informing future HEP methods and identifing uncertainties specific to habitat area calculations.

In summary, the evaluation found that substrate was misclassified 8% of the time and depth was misclassified 38% of the time. Overall, the observed classification error was 42% for the model used to predict habitat types (which integrates both depth and substrate) prior to dewatering Bay-Goose basin. As may be expected, shallow coarse-grained areas and deep fine-grained areas tended to be classified correctly, whereas mid-depth, mixed-substrate areas were more often mis-classified. Advances in GIS data collection and high resolution CMS laser scanning are expected to be the primary reasons for habitat type classification errors.The choice of a shallow sub-basin for this study that was difficult to map pre-dewatering likely enhanced the observed error rate compared to the 2009 study in Second Portage Lake.

Nonetheless, the 2012 evaluation results indicate areas for which methods can be improved for classifying habitat types. This evaluation will ultimately assist in refining calculations for habitat compensation projects and follow-up monitoring programs.

1 Introduction

1.1 Background

Agnico-Eagle Mines Ltd. (AEM) officially began construction of the Meadowbank Gold Project, north of Baker Lake, Nunavut, in July 2008 under Fisheries and Oceans Canada (DFO) authorization for works or undertakings affecting fish habitat (NU-03-0191). To obtain this authorization, a No Net Loss Plan (NNLP; Cumberland, 2006) was developed for the minesite to quantify baseline fish habitat and describe compensation for losses to habitat that would occur as a result of mine development. In 2008, the East Dike was constructed during the open water season, separating the northwest arm of Second Portage Lake from the rest of the lake. The Bay-Goose dike was constructed in 2009-2010, and isolated the Bay-Goose Basin from the rest of Third Portage Lake. Prior to de-watering the northwest arm and Bay-Goose Basin for mine development, and as stipulated by the Authorization, fish were removed from each area during the summers of 2008 and 2010, respectively. The fish-out programs were specifically designed to meet the *DFO Draft Fishout Protocol* which addresses a broad range of concerns, to prevent wasting of fish and improve the overall understanding of the ecology of northern lakes. After the dewatering of the northwest arm, an evaluation of the accuracy of initial habitat mapping in the 2006 NNLP was conducted (Azimuth, 2010), as summarized here in Section 1.2. In 2012, an updated NNLP was created for the entire site (AEM, 2012) using a new method of habitat classification that was developed in consultation with Golder Associates and DFO. This technical memorandum presents a similar evaluation of the new method, by comparing habitat classification in the Bay-Goose basin with measurements taken in that area post-dewatering.

1.2 Summary of 2009 Second Portage Lake Habitat Mapping Evaluation

1.2.1 2006 Habitat Evaluation Procedure

As part of the FEIS, Cumberland (2006) provided a No Net Loss Plan for the Meadowbank Gold Project, in support of application for a DFO Fisheries Authorization. The Cumberland (2006) habitat evaluation procedure (HEP) involved the classification of all project area lakes by six attributes:

- Morphology (classes = apron, shoal, platform, sediment basin),
- Substrate (classes = boulder, boulder /cobble, boulder/cobble/fines, >90% fines),
- Depth (classes = 0-2m, 2-4m, 4-6m, >6m),

- Complexity (classes = uniform, moderate, complex), Ice-scour (classes = ice scoured (<2m) or not), and
- Slope (classes = flat slope, steep slope).

The spatial extent of each attribute class was delineated and mapped to generate polygons based on the cumulative contribution of morphology, substrate, depth, complexity, ice scour and slope for each polygon (See Cumberland 2005, Section 3.4). The structures were ranked and summed to derive a score that is a reflection of a generic habitat value (high, medium or low).

As is typical with all HEP methods, a habitat suitability index (HSI) for was identified for each life function stages (spawning, foraging, nursery and overwintering) of each project lake fish species. The HSIs were weighted according to the species assemblages of each lake during baseline data collection, and were multiplied by the habitat type area (high, medium or low) in hectares, to provide a unitless measurement incorporating both quantity and quality of habitat ("habitat units").Ultimately, total habitat units lost and conceptual habitat unit gains were determined.

The 2009 habitat mapping re-evaluation compared the results of the pre-construction habitat calculations for the northwest arm of Second Portage Lake in Cumberland (2006) with a post-dewatering evaluation using aerial photography and field transects.

1.2.2 2009 Re-mapping Results and Conclusions

Results of the 33 ground survey transects were overlain over the 2006 and 2009 air-photo-generated habitat maps. Overall, the 2006 mapping exercise overestimated the amount of high value habitat. Quantity of low value, and to a slightly lesser extent, moderate value habitat was similar between the 2006 and 2009 methods, because of the ease in delineating low value habitat (generally deep water, soft sediment basins). The delineation of high and moderate value habitat was best achieved from the ground survey, as transition from platform to apron habitat, slope and depth were more easily detected. Overall, total baseline HUs predicted for the northwest arm in the 2006 NNLP were 555 HUs. Incorporating changes to as-built East Dike configuration, this value would have been 522.5 HUs, using 2006 mapping. The 2009 mapping using air photos and field transects indicated actual habitat units were 472.8 HUs; or 49.7 less than predicted using 2006 mapping. As discussed above, the 15% difference was primarily explained by a reduced footprint, but also by the model being overly conservative.

1.3 Summary of the 2012 Revised No Net Loss Plan

In 2012, AEM presented a new Meadowbank site No Net Loss Plan based on a refined HEP model that was considered to provide an effective, simple, transparent and transferable method for quantifying habitat units. The NNL HEP method was developed in collaboration with DFO and the revision of the NNL plan provided an opportunity to update calculations based on the most up-to-date life of mine footprints, mine operations and corrected discrepancies in the original DFO authorization. In brief, this model classifies the physical habitat by three depth intervals and three substrate categories for a total of nine unique habitat classification identifiers. See Table 1 for identification of these categories.

Table 1: AEM (2012) habitat classifications

Classification ID	Depth (m)	Substrate Type
1	<2	Fines
2	<2	Mixed
3	<2	Coarse (Boulder/cobble)
4	2-4	Fines
5	2-4	Mixed
6	2-4	Coarse
7	>4	Fines
8	>4	Mixed
9	>4	Coarse

As in Cumberland (2005), HSI values were developed for project lake fish species for four life functional stages (spawning, foraging, nursery and overwintering) and the HSI was weighted by species according to the species assemblages during baseline data collection. Furthermore, as recommended by DFO, a fish value was used to weight species according to fisheries value (i.e. traditional, sport and commercial use).

This method will be used at other projects in the North and will provide an opportunity for consistent compensation approaches for Agnico-Eagle Mines and other proponents with evaluating options for compensation at other projects. The analysis herein will assist in identifying uncertainties in this method.

1.4 2012 Objectives

Similar to the evaluation completed in 2009, the objective of the 2012 evaluation was to make a comparison of the pre-operations method of evaluating habitat (which used data collected from 2005 bathymetry mapping, aerial surveys and underwater cameras) to a post-dewatering habitat evaluation. In 2012 the methods were generally the same as in 2009, however changes in the use of GIS technology and the incorporation of statistical approaches allowed for a more detailed analysis. The evaluation consisted of aerial photo interpretation and field transects, detailed surveying (+/- 0.25m accuracy) and GIS interpretation within a sub-basin of Bay-Goose basin that was not disturbed by mine operations (see Figure 1-1). The overall goal of the 2012 evaluation was to help quantify habitat type classification error in order to assist in informing future HEP methods and identifing uncertainties specific to habitat area calculations.

2 Methodology

2.1 Aerial photography

Aerial photos of the entire Bay-Goose Basin were taken from helicopter using a standard SLR camera on June 6th, 2012 and on August 7th, 2013. For the purposes of the assessment, only high resolution photos gathered on August 7th were used.

2.2 Ground Survey

Mining activity began in the Bay-Goose basin in the last quarter of 2011. As a result, a portion of the basin was selected within Bay-Goose basin that had minimal disturbance from mining activity. A CMS laser scan (+/- 0.25m resolution) was completed by AEM surveyors in August 2012. Ground transects were completed along 3 x 30m transects with a focus on the undisturbed area in the northwest sub-basin along areas that had a variety of substrates types according to the classification system. This, along with the aerial photography, assisted in defining the substrate types for the GIS evaluation.

2.3 GIS Evaluation

2.3.1 Pre-Construction Mapping

For the updated NNLP completed in October 2012, all delineation of baseline habitat types (1 – 9) used data files for substrate and bathymetry that were generated prior to de-watering. These maps showing baseline (or pre-construction) habitat types were generated by Dougan and Associates using bathymetry and substrate files provided by AEM.

2.3.2 Dewatered Bay Goose Substrate Zones

After dewatering, substrate zones (fine, mixed coarse) in the Bay Goose basinwere digitized from an aerial photograph of the dewatered basin taken on August 7th, 2012. The aerial photograph was georeferenced using the study lakes boundary and bathymetry from the transects, aerial photography and contours generated from the dewatered Bay Goose sub-basin CMS mass point data.

2.3.3 Dewatered Bay Goose Basin Depth Zones

After dewatering, depth zones (< 2 m, 2 – 4 m, > 4 m) were delineated using contour lines generated from mass point data. The high water line was assumed to be at an elevation of 134 m to be consistent with the high water line and study lake boundary used in the original mapping. The mass point data was used to generate a triangulated irregular network (TIN), using the 3D Analyst Create Tin Tool. Contours were generated from the TIN (after conversion to raster format) using the Spatial Analyst Contour Tool with a contour interval of 0.5 m. This approach was used to create a smoother contour line than is created directly from the TIN. Manual contour correction was performed for the southwest corner of the study area due to a lack of mass point data.

2.3.4 Dewatered Bay Goose Basin Habitat Types

Habitat types were created following the methods in AEM (2012). Each habitat type represents a unique combination of substrate and depth zones. The data layers were joined using the Union tool.

2.3.5 Analysis

All GIS analysis and mapping was completed using ESRI ArcGIS 10/10.1 with Spatial Analyst and 3D Analyst Extensions.

The pre-construction and dewatered Bay Goose data was converted to raster format for analysis. Substrate and depth zones were assigned relative numerical rankings. The pre-construction and dewatered Bay Goose data was compared using the Cell Statistics and Combine Tools from the Spatial Analysis Local Toolset. Variety was the overlay statistic option chosen in the Cell Statistics Tool. The statistics for classification error were generated using Cell Counts from the raster output of the Cell Statistics and Combine tools. The classification error is consistent with classification error from the Error Matrix.

2.4 Statistical Analysis- Model Validation

A measure of inter-rater reliability known as Cohen's kappa (Kappa; Cohen 1960) was used to evaluate the degree of classification error associated with habitat type predictions for the Bay Goose Basin study area (Table 1 shows the habitat types that were assessed). Kappa provides a quantification of agreement between model predictions and ground-truthed observations (Equation 2.1) and is commonly used to assess the validity of species-specific habitat models (e.g. Segurado and Araujo, 2004). The measure varies between -1 and +1; -1 indicating complete misclassification, and +1 indicating perfect classification. Additionally, Kappa values close to zero indicate a classification that is close to that generated by chance.

Table 2 shows the typical approach to setting up a table (also known as a confusion matrix or error matrix) that documents model prediction categories as rows and ground-truthed observations as columns; each table cell represents that sum of pixels (or cells) from a raster that represent accurate classification of habitat types (table cells along the table diagonal), and misclassified habitat types (any table cells not along the table diagonal).

Table 2. Confusion matrix showing model and ground-truthed habitat classification. Kappa = 0.45, SE = 0.002, N = 65824, Z_K = 180.6, p < 0.001

Habitat Type Prior to Dewatering	Habitat Type After Dewatering: 1	3	4	5	6	7	8	9	14	Row Total	Habitat Classification Accuracy (%)
1	0	0	139	0	12	0	0	0	0	151	0
3	0	10667	77	0	458	0	0	0	293	11495	92.8
4	0	70	6035	611	712	915	0	0	0	8343	72.3
5	0	0	0	0	0	0	0	0	0	0	0
6	0	8509	861	587	5014	2	0	1	0	14974	33.5
7	0	0	11309	1727	206	16284	312	2	0	29840	54.6
8	0	0	0	0	0	0	0	0	0	0	0
9	0	194	289	118	420	0	0	0	0	1021	0
14	0	0	0	0	0	0	0	0	0	0	0
Column Total	0	19440	18710	3043	6822	17201	312	3	293	65824	

Estimates of Kappa can be evaluated to determine if model classification was likely due to chance alone. This is accomplished by dividing Kappa by its standard error (Equation 2.2). The result is a standard normal deviate than can be compared to a distribution of Z-scores. Qualitative interpretations of Kappa are shown in Table 3 (Landis and Koch, 1977).

$$K = \frac{p(agreement) - p(chance\ agreement)}{1 - p(chance\ agreement)} \qquad [2.1]$$

$$SE_K = \sqrt{\frac{p(agreement)(1 - p(agreement))}{n(1 - p(chance\ agreement)^2}} \qquad [2.2]$$

Kappa was calculated using pixel counts for each of the various tables cells shown in Table 2. Pixels were calculated based on the area estimate for each of the model and ground-truthed habitat type combinations, weighted by the total number of cells determined for a raster covering the study area at a resolution of 2m (total = 65824 cells). Data analysis was conducted using Microsoft Excel and the package [psych] (Revelle 2012) in R (R Development Core Team, 2011).

Table 3. Interpretation of Kappa values

Value of Kappa	Classification Agreement
< 0.2	Poor
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81 – 1.00	Very Good

3 Results and Discussion

3.1 Habitat Classification Model Evaluation

A comparison was made between the baseline habitat type classifications and classifications after dewatering. Classification errors are summarized in Table 3 and illustrated in Figure 3.1 for substrate, Figure 3.2 for depth and Figure 3.3 for the overall classification. In summary, substrate was misclassified 8% of the time and depth was misclassified 38% of the time. Overall, the model used to predict habitat types (which integrates both depth and substrate) prior to dewatering Bay-Goose basin classified 58% of the study area was correctly. Despite this relatively low rate of correct classification, the overall model used to predict habitat types at Bay-Goose was significantly better than chance ($K = 0.45$, Z¬K = 180.6, $p < 0.001$).

More specifically, complete misclassifications were associated with habitats representing fine substrate in shallow (< 2m) areas, mixed substrate in moderately deep (2-4m) areas, fine substrate in deep (> 4m) areas, mixed substrate in deep areas, and a small amount of area that was determined to be above the lake's high water mark. Classification rates were moderately accurate for coarse substrate in moderately deep areas (33.5% correct), and fine substrate in deep areas (54.6% correct). Classification rates were highest for coarse substrate in shallow areas (92.8%) and fine substrate in moderately deep areas (72.3%). These errors make sense as it is quite easy to distinguish coarse material in shallow and fines by aerial photography, whereas the mixed substrates in moderately deep areas were quantified in the field using underwater cameras, where it is impossible to effectively cover all of the lake.

Classification errors likely occurred for a number of reasons. Firstly, the quality and resolution in the original 2005 bathymetric data (used to determine depth) was inferior to 2012 data. In

2009 bathymetry data was collected at 1m resolution and in-filled to 0.5 meter intervals. In comparison, the 2012 method in the de-watered basin used a CMS laser scanning method that provided 0.25m intervals which allowed the mapping to be infilled to 0.5m with improved resolution. Since this basin has a maximum depth of 12 m, the resolution in mapping depth is likely the main contributor to the classification error. Although the northwest sub-basin studied has representative substrate types, it has shallow extensions off of an island that made boat navigation difficult in baseline bathymetric surveys. Along with wave action and changes in water level during bathymetric data collection due to the wind, this may have caused errors in initial bathymetric data collection. Although substrate classification was relatively accurate, it should be noted that the lake may have undergone changes during dewatering, such as sediment sloughing and boulder sliding that may have altered pre-existing depths and substrate classifications. Lastly, the CSM scan conducted in 2012 cannot scan through water, sodata in areas where ponded water had to be manually adjusted or inferred from the baseline bathymetry.

Table 3- Habitat classification areas pre-construction and post-dewatering.

a) Substrate

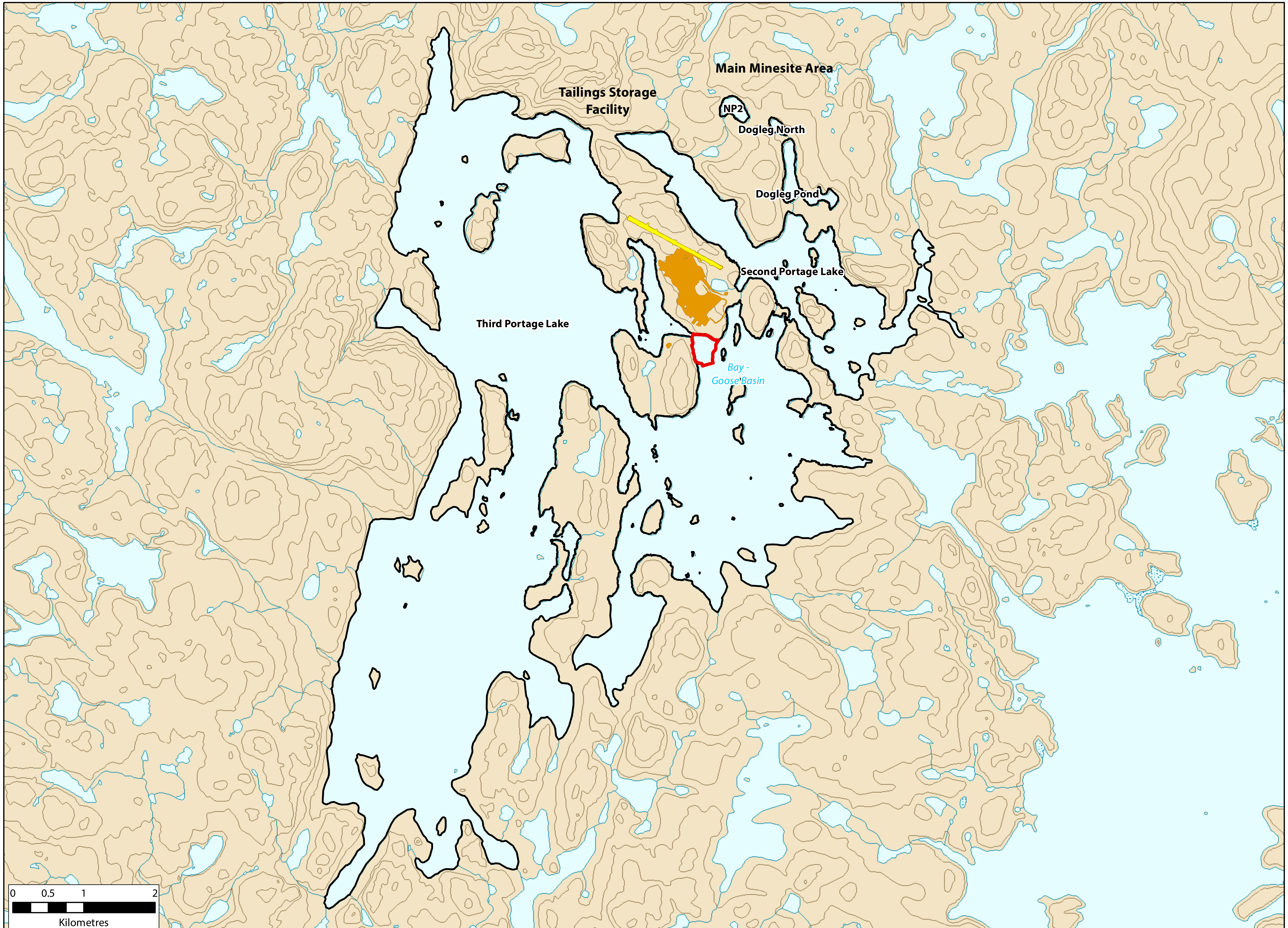
Substrate	Pre-Construction (ha)	Post-Dewatering (ha)	Difference (ha)	Classification Accuracy
Fines	6.80	4.77	-2.03	92%
Mixed		6.36	6.36	0%
Coarse	4.94	0.60	-4.34	92%
Total	**11.74**	**11.74**		

b) Depth

Depth Zone	Pre-Construction (ha)	Post-Dewatering (ha)	Difference (ha)	Classification Accuracy
< 2 m	2.09	3.49	1.40	92%
2-4 m	5.54	3.15	-2.39	59%
> 4 m	4.10	5.05	0.95	54%
Land		0.05	0.05	0%
Total	**11.73**	**11.74**		

c) Habitat Type

Habitat Type	Pre-Construction (ha)	Post-Dewatering (ha)	Difference (ha)	Classification Accuracy
1	0.03		-0.03	0.0%
2	~	~	~	~
3	2.06	3.49	1.43	92.8%
4	1.41	3.27	1.86	72.3%
5		0.55	0.55	0.0%
6	2.69	1.23	-1.46	33.5%
7	5.36	3.09	-2.27	54.6%
8		0.06	0.06	0.0%
9	0.18		-0.18	0.0%
14		0.05	0.05	0.0%
Total	**11.73**	**11.74**		

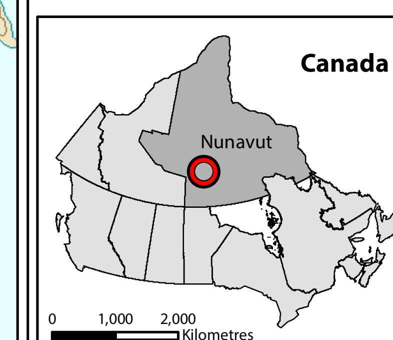


Legend

- Dewatered Bay Goose Basin
- Study Lakes
- Contour

Meadowbank Mine

- Facility
- Airstrip



Dewatered Bay Goose Basin
Location

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PROJECT: DA11-062-03

CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.

N W E S
UTM Zone 14 NAD83

DATE: MARCH 2013

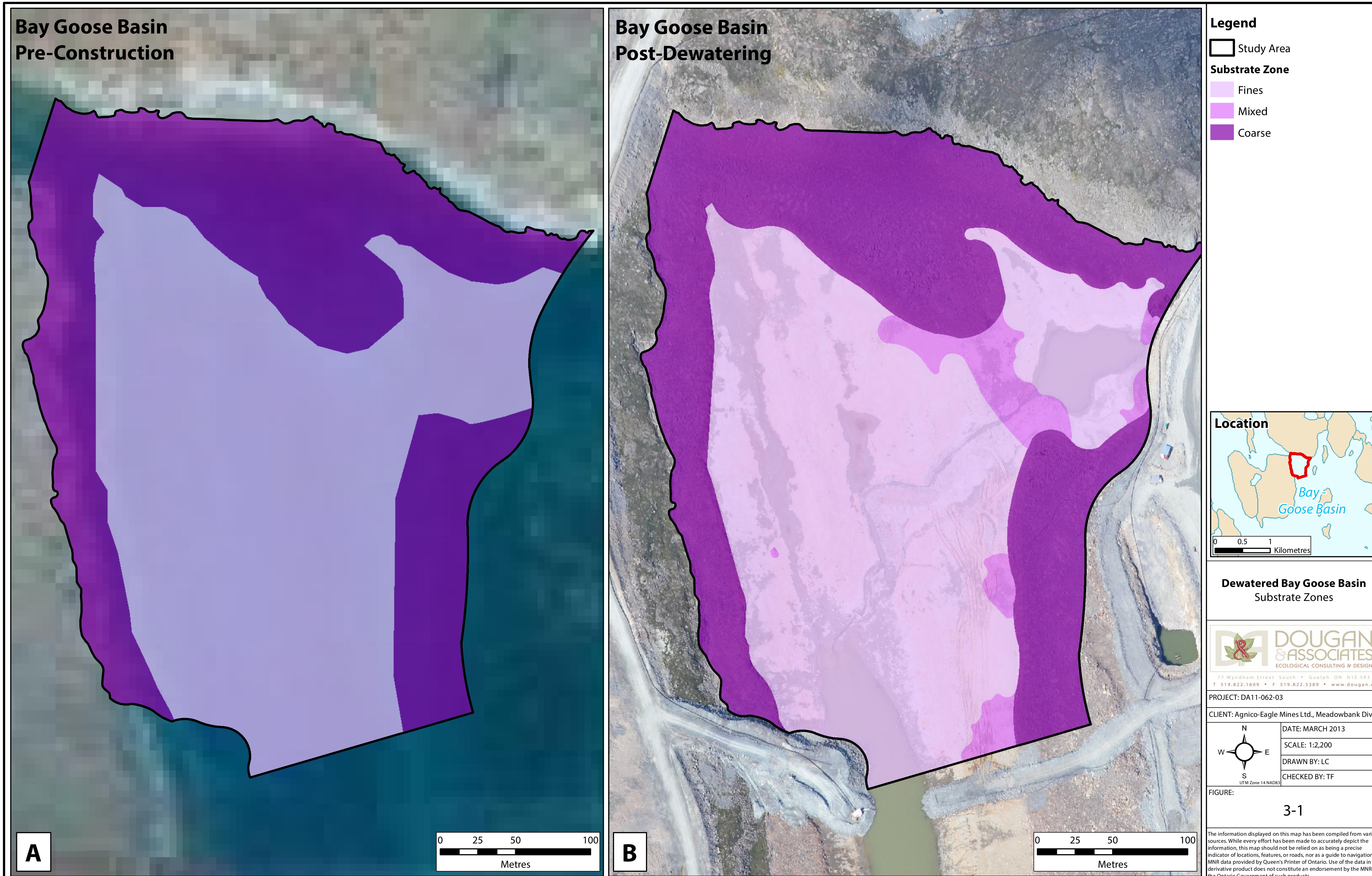
SCALE: 1:50,000

DRAWN BY: LC

CHECKED BY: TF

FIGURE:

1-1



Bay Goose Basin
Pre-Construction
A
0 25 50 100
Metres
Bay Goose Basin
Post-Dewatering
B
0 25 50 100
Metres
Legend
Study Area
Substrate Zone
Fines
Mixed
Coarse
Location
Bay Goose Basin
0 0.5 1
Kilometres
Dewatered Bay Goose Basin
Substrate Zones
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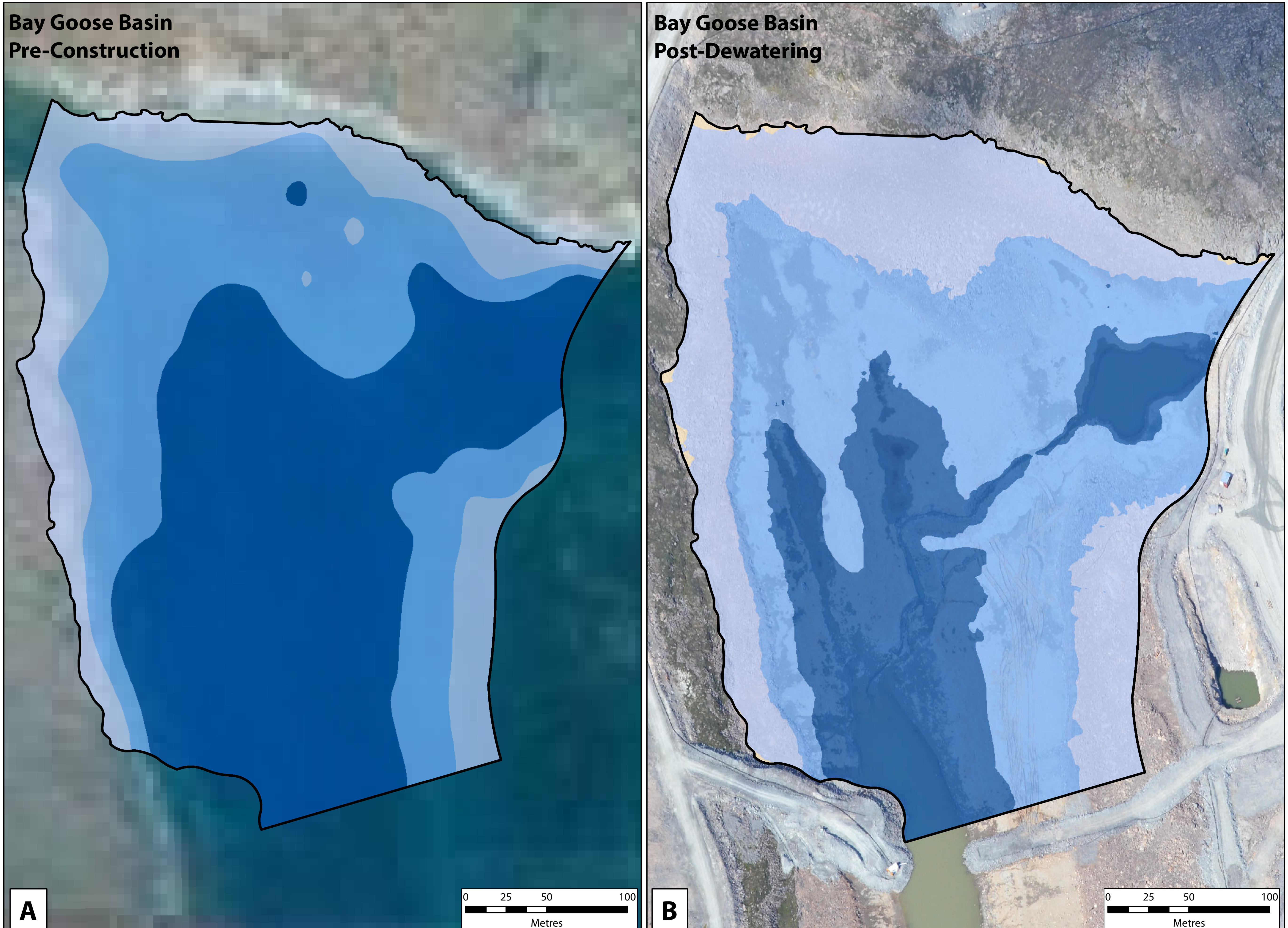
PROJECT: DA11-062-03
CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.
N
W
E
S
UTM Zone 14 NAD83
DATE: MARCH 2013
SCALE: 1:2,200
DRAWN BY: LC
CHECKED BY: TF
FIGURE:
3-1
The information displayed on this map has been compiled from various sources. While every effort has been made to accurately depict the information, this map should not be relied on as being a precise indicator of locations, features, or roads, nor as a guide to navigation. MNR data provided by Queen's Printer of Ontario. Use of the data in any derivative product does not constitute an endorsement by the MNR or the Ontario Government of such products.

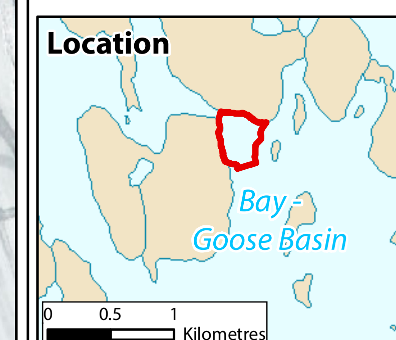


Legend

Study Area

Depth Zone

- Land
- <2m
- 2-4m
- 4-10m
- >10m



Dewatered Bay Goose Basin
Depth Zones

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N W E S
UTM Zone 14 NAD83

DATE: MARCH 2013

SCALE: 1:2,200

DRAWN BY: LC

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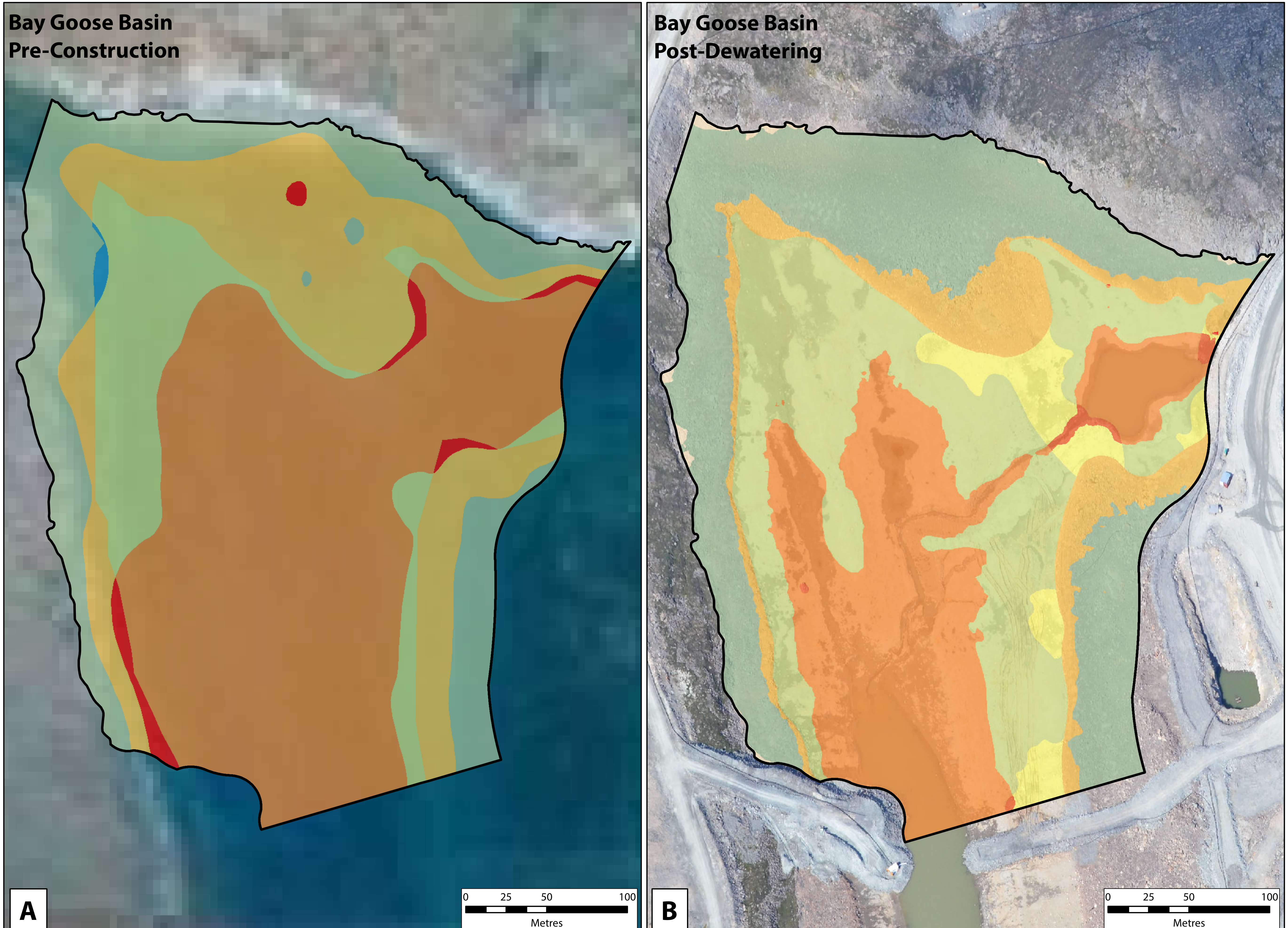
FIGURE:

3-2



Legend

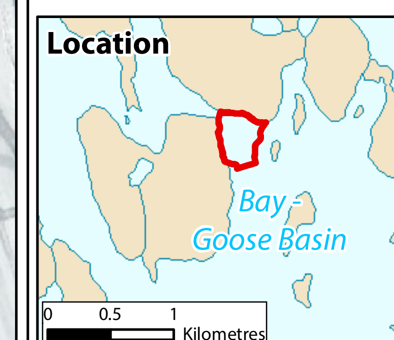
Study Area

Habitat Type

1, 2, 3, 4, 5, 6, 7, 8, 9, 14

Habitat Type	Criteria: Depth Zone	Criteria: Subsrate
1	<2 m	Fines
2	<2 m	Mixed
3	<2 m	Coarse
4	2-4 m	Fines
5	2-4 m	Mixed
6	2-4 m	Coarse
7	>4 m	Fines
8	>4 m	Mixed
9	>4 m	Coarse
14	Land	Coarse

Location



Dewatered Bay Goose Basin
Habitat Types

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CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.

N, S, E, W
UTM Zone 14 NAD83

DATE: MARCH 2013

SCALE: 1:2,200

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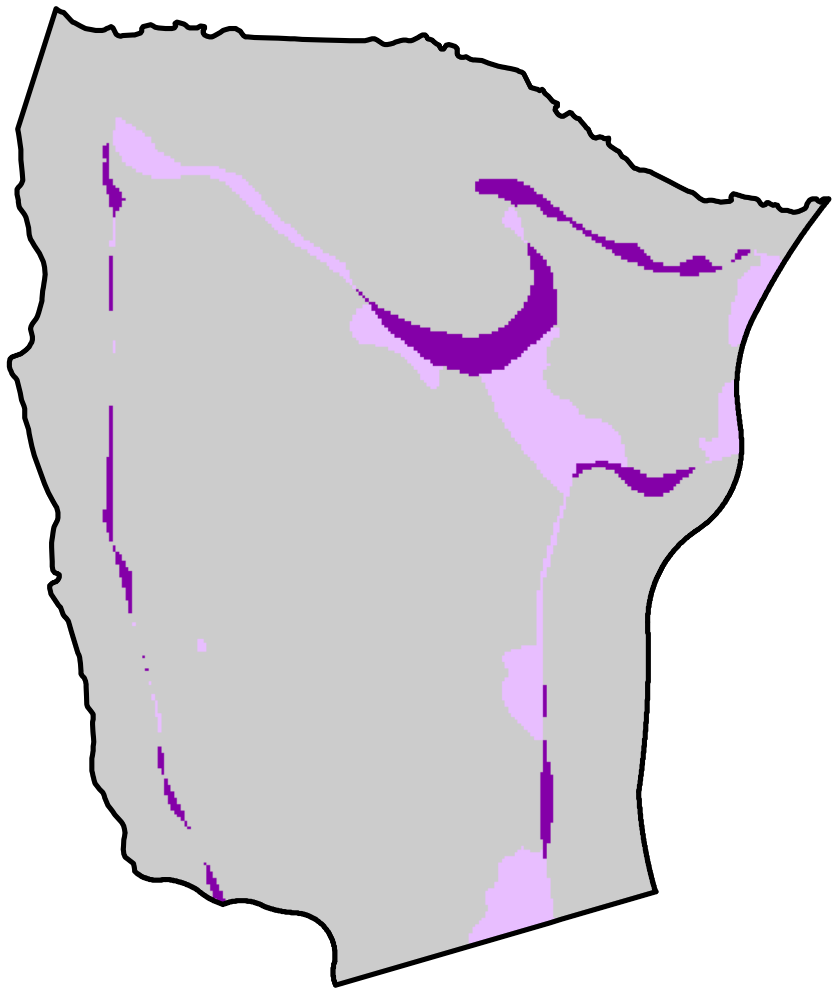
FIGURE:

3-3

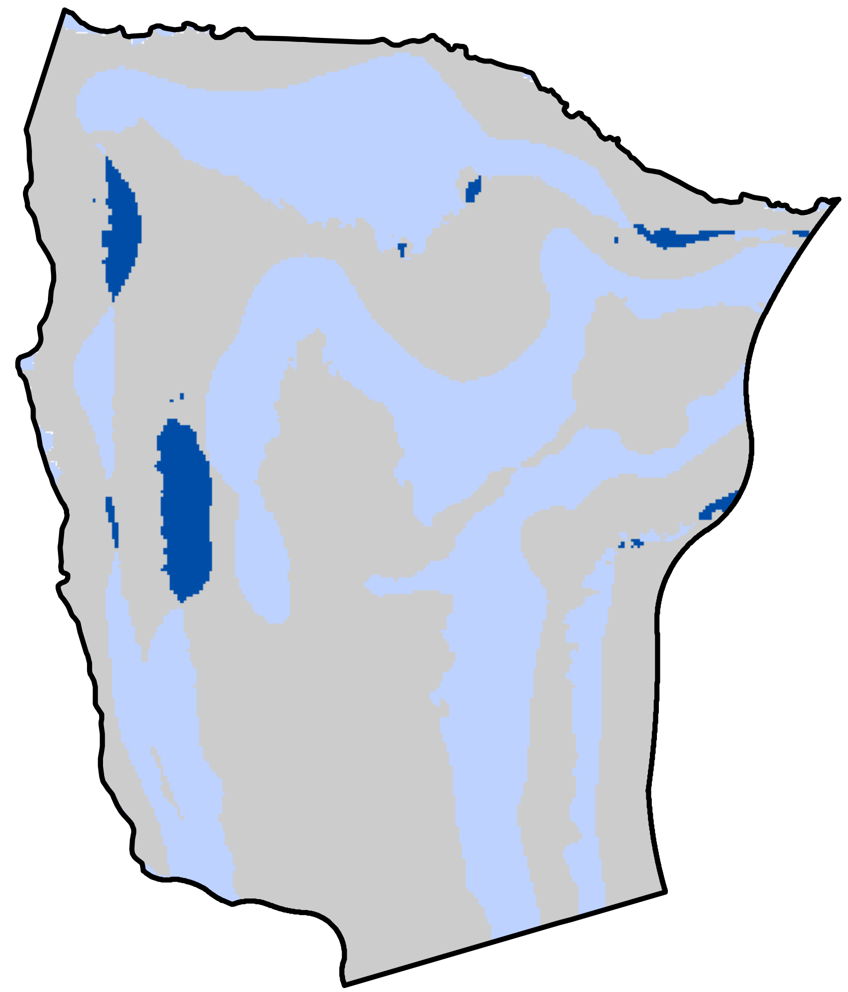
Substrate



Classification Error: 8%

- 3% Coarser than estimated
- 5% Finer than estimated
- 92% Consistant with estimation

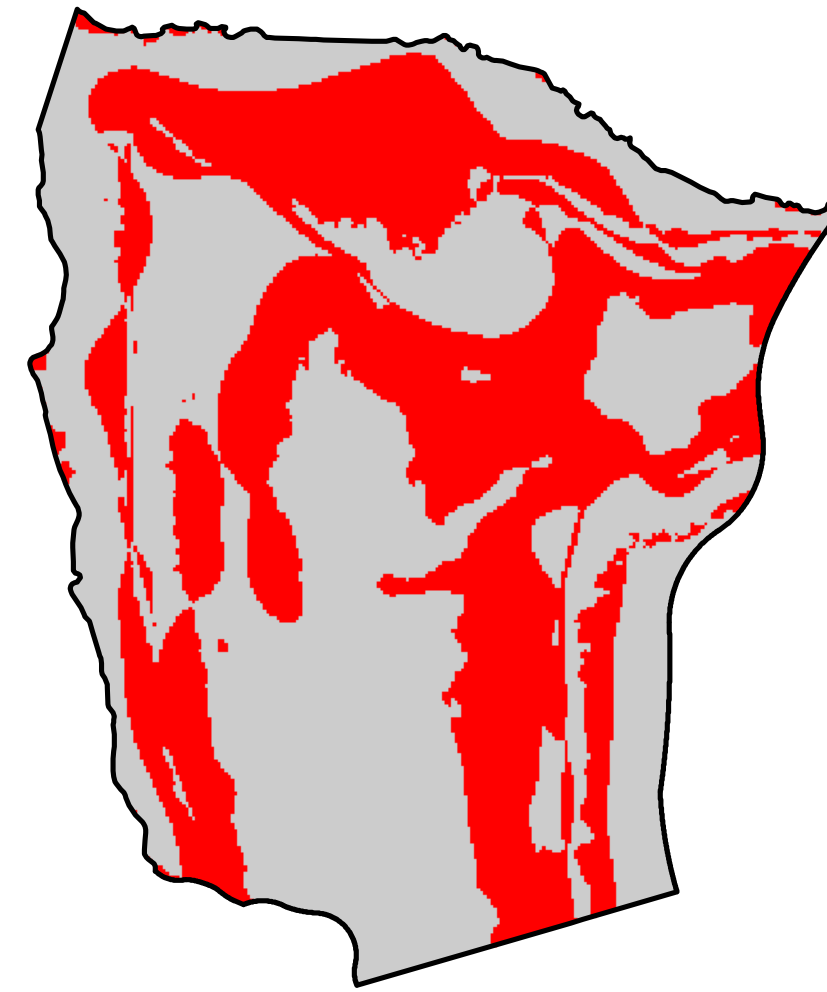
Water Depth



Classification Error: 38%

- 36% Shallower than estimated
- 2% Deeper than estimated
- 62% Consistant with estimation

Habitat Type



Classification Error: 42%

- 42% Misclassified
- 58% Accurately Classified

Note:Statistics were generated in ArcGIS10.1 using cell counts from the Pre-Construction & Dewatered Bay Goose data shown in Figures 3-1 to 3-3

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Dewatered Bay Goose Basin Analysis

Dewatered Bay Goose Basin vs. Pre-Construction Estimates

0 125 250 500
Metres

PROJECT: DA11-062-03

CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.

N W E S
UTM Zone 14 NAD83

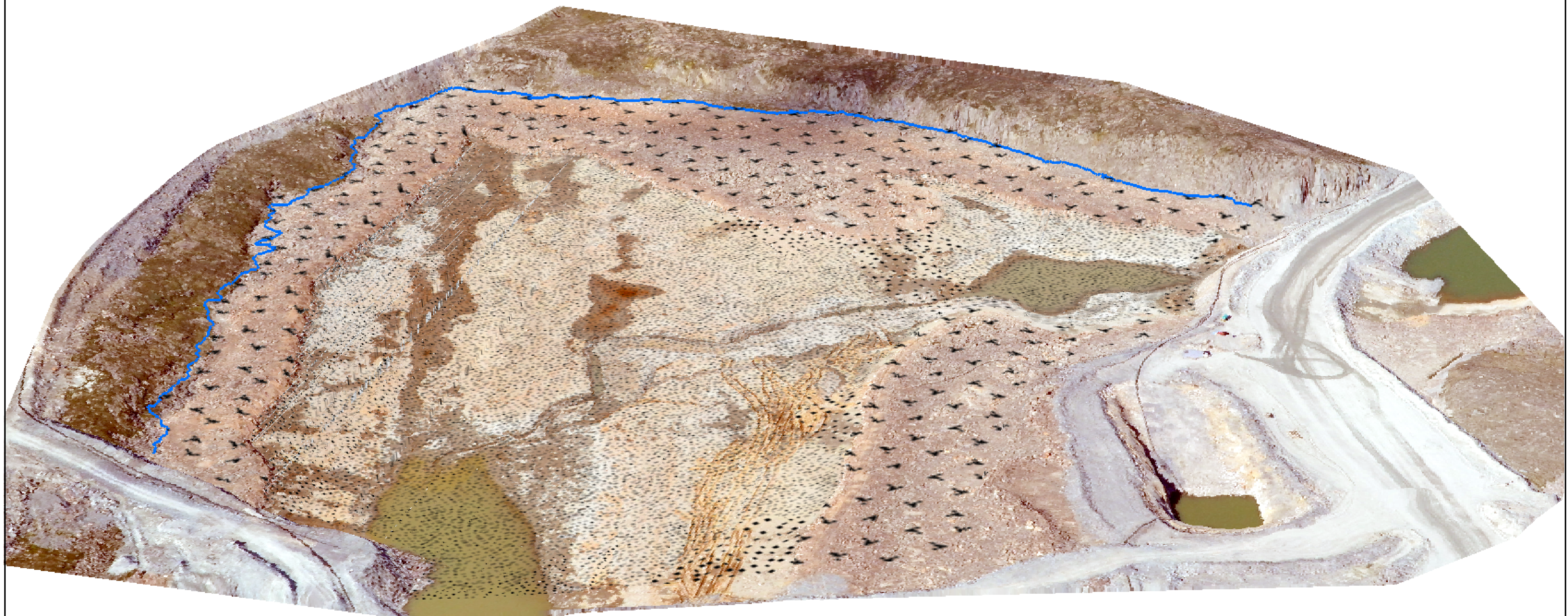
DATE: MARCH 2013

SCALE: 1:3,500

DRAWN BY: LC

CHECKED BY: TF

FIGURE: 3-4

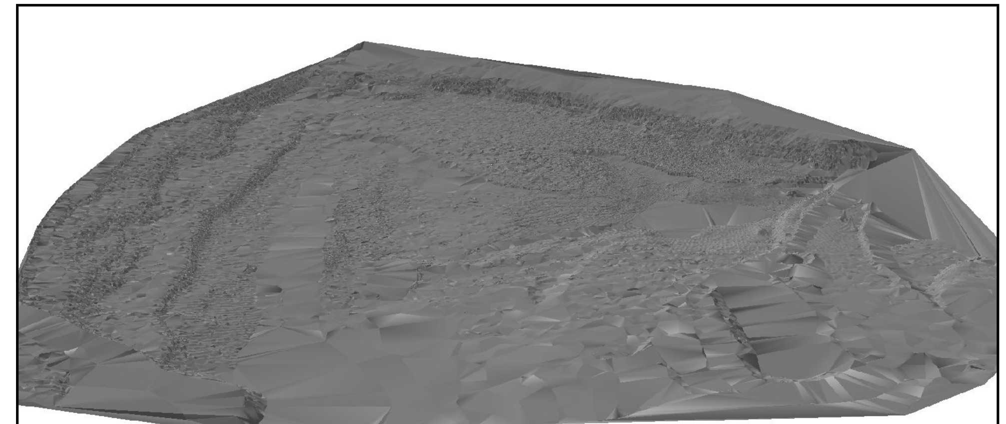


Legend

High Waterline

Substrate Zone

- Coarse
- Mixed
- Fines



Triangulated Irregular Network

(3D surface representation created from mass point elevation data)

Aerial Photo: August 7, 2012.

Dewatered Bay Goose Basin

3D Representation

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PROJECT:DA11-062-03

CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.

N / W / E / S (Approx.)	DATE: MARCH 2013
	DRAWN BY: LC
	CHECKED BY: TF
	SCALE: Not To Scale

Figure:

3-5

3.2 Future Application of these findings to the Habitat Evaluation Procedure

As a condition of an authorization from DFO to permit habitat alteration, disruption or destruction (HADD), the proponent must ensure there is no net loss of productive capacity of fish habitat. Since it is normally not possible to directly measure production of fish populations (i.e. kg/yr) because of time and expense, alternative metrics such as habitat area and suitability are commonly measured instead (Randall and Minns 2002). The concept of HUs as a surrogate measure for productive capacity of fish communities was first developed by the US Fish and Wildlife Service in the 1980s and has since been adopted by habitat managers in northern Canada. A system to provide managers with repeatable habitat suitability indices based on measurable physical properties, such as the scientifically defensible Habitat Suitability Matrix model for fishes of the Great Lakes region (Minns, Moore et al. 2001), is not currently available for arctic development projects. With the exception of arctic grayling (Hubert, Helzner et al. 1985; Jones and Tonn 2004), no habitat models are available for arctic species, to our knowledge. Furthermore, while general life history characteristics have been published for arctic fishes, it is recognized that major gaps even exist in current understanding of northern fish preferences (Richardson, Reist et al. 2001), let alone productivity relationships.

A further consideration is that even if standardized habitat suitability models were to be developed from observational data, it has been argued that correlative studies of habitat selectivity are not necessarily representative of actual habitat requirements, and these models are rarely validated with experimental evidence (Rosenfeld 2003). According to Rosenfeld (2003), the removal or conversion of an apparently "preferred" habitat may not actually affect productivity of the population, if alternate habitats provide adequate life-functions.

As a result of this lack of information, habitat suitabilities for northern fish species are extrapolated from southern-developed models, with an unknown degree of certainty. It has been suggested that the accuracy of predictions made using HSIs may not transfer well between watersheds (De Kerckhove, Smokorowski et al. 2008), let alone ecozones. Furthermore, it is known that the way fish adapt to habitat change is dependent on many factors, including location, temperature, season, maturity, population diversity and the availability of habitat (Smokorowski and Pratt 2006). While uncertainty factors (associated with habitat suitability determinations) can be included in compensation ratio calculations (Minns 2006) by increasing required compensation amounts, it may be difficult for northern project proponents to find feasible opportunities for compensation that have historically been demonstrated as cost-effective and successful. Thus plans which optimize the required ratio will likely have a greater chance at achieving NNL. An even greater consideration in this situation may be that compensation options in the north typically involve further alterations of pristine habitat, which arguably are not desirable.

Since no reference models are available for most northern species, and no standardized NNLP approach is available, proponents have developed slightly different HEP methods. Usually, these methods are determined by professional judgement, and/or modifications from previously developed NNLPs at other northern mines with little consideration for the certainty or uncertainty of the estimates. This is valid, as the assessment of the habitat units uses the same methods to conceptually estimate the habitat losses as it does for the gains. Thus the goal of the model is not to predict the offset of absolute losses versus absolute gains, rather it is to have consistent and transferable method to ensure compensation is being met.

Given the high economic cost associated with habitat offsetting and the related uncertainties in the models that estimate habitat use and ultimately productivity, it is of interest to determine the accuracy of all of the components of the HEP to assist in improving the methods. As a result the most obvious starting point is to validate the ability to delineate physical habitat. This was the goal of the 2012 evaluation which found that overall, there is a high level of incorrect classification of habitat types for areas that are moderately deep and have a mixture of substrates. This trend was also observed in a previous evaluation in a larger, deeper area (northwest arm of Second Portage Lake; Azimuth, 2010), indicating a potential focus for improving habitat classification techniques.

4 Conclusions and Recommendations

This evaluation will assist in the development of a consistent and more robust HEP method in the north, by increasing the ability to accurately delineate fish habitat. Furthermore, this improved understanding of error potential in habitat classification will assist in refining methods of collecting data to avoid mis-classifications of habitat types that have the greatest potential for error. Improved accuracy in habitat type mapping will ultimately help refine habitat loss and gain calculations, thereby enhancing success rates of habitat offsets. A requirement of all DFO authorizations is that the proponent is to demonstrate the success of compensation projects. Currently only the physical construction must be shown successful, because changes in productive capacity are assumed to be related to habitat quantity and quality. Unfortunately, in the north, there is little or no research to relate the habitat suitability (or biological components) to these physical features and professional judgement along with a limited amount of academic literature are used to inform decisions. The information gathered in this evaluation will assist AEM and perhaps academic researchers in design monitoring studies and fish removal studies to validate HEP methods.

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