Appendix F6

Aquatic Effects Monitoring Program – Addendum to the 2008 Fish-Out of the Northwest Arm of Second Portage Lake:
Habitat Mapping of the Northwest Arm of Second Portage Lake 2009, Meadowbank Gold Project, April 2010

Final

Aquatic Effects Monitoring Program – Addendum to the 2008 Fish-Out of the Northwest Arm of Second Portage Lake: Habitat Mapping of the Northwest Arm of Second Portage Lake 2009

Meadowbank Gold Project

Prepared for

Agnico-Eagle Mines Ltd.
Meadowbank Division
P.O. Box 540
Baker Lake, Nunavut X0C 0A0

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AZIMUTH

Azimuth Consulting Group Inc.
218-2902 West Broadway
Vancouver, BC
V6K 2G8

Project No. AE-09-01.3

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- Randy Baker (Azimuth) – Randy has been responsible for overall design and implementation of this project. He conducted the 2009 ground survey and authored the 2006 and 2010 reports.
- Laura Nendick (Azimuth) – Laura provided support throughout the data analysis and reporting process, including preparation of the figure series comparing mapping techniques (**Appendix F**).
- Gary Mann (Azimuth) **–** Gary was project manager, provided technical advice on project implementation and was reviewer of the 2010 document.
- Coastal and Ocean Resources Sidney BC conducted the original aerial photograph interpretation and the 2009 interpretation. Mr. Kalen Morrow is acknowledged for polygon mapping and interpretation and integration of air photo and ground survey data.
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- Natalia Waldner (North/South) and Robert Tookoome provided field assistance.

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ACRONYMS

AEM – Agnico-Eagle Mines
AEMP – Aquatic Effects Monitoring Program
asl – Above sea level
BFHAR – Baseline Fish Habitat Assessment Report
CPUE – Catch per Unit Effort
CREMP – Core Receiving Environment Monitoring Program
DFO – Department of Fisheries and Oceans
DQO – Data Quality Objective
EAS – Effects Assessment Strategy
EEM – Environmental Effects Monitoring
EIA – Environmental Impact Assessment
GIS – Geographic Information System
GPS – Global Positioning System
ha – hectares
HADD – Harmful Alteration Disturbance and Destruction
HCF – Habitat Compensation Feature
HSI – Habitat Suitability Index
HU – Habitat Unit
MMER – Metal Mining Effluent Regulations
NAD – North American Datum
NNLP – No Net Loss of Habitat Plan
QA/QC – Quality Assurance / Quality Control
SOP – Standard Operating Procedure
SQG – Sediment Quality Guidelines
SP – Second Portage Lake
UTM – Universal Transverse Mercator

EXECUTIVE SUMMARY

Background and Objectives

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 (hereafter referred to as the "Authorization"). The East Dike was the first dike constructed in the project during the open water season of 2008 and divided Second Portage Lake more or less in half, separating the northwest arm of Second Portage Lake (SP) from the rest of the lake. Prior to draining the northwest arm as part of mine development, and as stipulated by the Authorization, fish were removed from the entire area during the summer of 2008. The fish-out program was specifically designed (Azimuth, 2008) and implemented (Azimuth, 2009) to obtain a broad range of scientific information to improve our overall understanding of the ecology of northern lakes.

Another requirement of the fish-out program (Azimuth, 2008), which was founded on DFO's draft "General Fish-Out Protocol for Lakes to be Lost due to Mining Developments", was the mapping of fisheries habitat exposed after dewatering. The original habitat mapping was conducted in support of the No-Net-Loss Plan (NNLP; Azimuth, 2006), which was based primarily on aerial photographs taken through the water. This report addresses the above requirement, through completion of the following objectives:

1. Conduct an on-the-ground survey and an aerial survey of the dewatered impoundment to describe and quantify habitat features.
2. Compare the results of the basic mapping techniques (i.e., 2006 "through water" air photo, 2009 "through air" photo and 2009 ground survey) to better understand the advantages and limitations of each method.
3. Develop an integrated map based on both 2009 methods.
4. Relate habitat value and habitat units (HUs) to fish biomass as determined from the fish-out program in 2008 (Azimuth, 2009).

As an additional objective, DFO requested photographs (from the air) of the footprint of the Stormwater Dike in advance of its construction to document the underlying habitat (i.e., construction was planned to start in advance of the aerial survey).

To facilitate method comparisons, the 2009 habitat mapping was conducted using the same methods as those used for the NNLP. GIS was used to describe, rank, quantify and map 627 unique polygons according to depth, ice scour, substrate size, slope, and complexity. Scores were used to rank habitat as low, moderate and high value with respect to critical life history functions (e.g., spawning, rearing, foraging) of fish.

By July 2009 the impoundment was partially drained, exposing all moderate and high-value rocky habitat along shore and on shoals. In August 2009 the impoundment was photographed using a remote controlled aircraft. We conducted a ground survey where 33 transects were walked, and surveyed using differential GSP to acquire precise locations and elevations of changes in habitat features. Habitat segments were described, photographed and scored according to the above classification scheme.

Comparison of Mapping Results

Results of the 2006 through water, 2009 through air (i.e., unbiased) and 2009 ground surveys were compared with respect to their ability to accurately and precisely map and quantify important fish habitat features. The 33 ground survey transects were overlain over the 2006 and 2009 air photo generated habitat maps.

- In 2006, 21 polygons were delineated, with the majority of habitat ranked as moderate with no distinction of apron habitat at the terminus of each transect. Large areas near the sill separating the north and middle basins were ranked as high, as was the submerged shoal at T30 in the southwest corner. Through water mapping was unable to distinguish subtle changes in substrate and slope and rankings appeared to be less conservative, assuming a greater proportion of high value habitat especially in some areas (e.g., T30).
- The 2009 aerial survey delineated 52 polygons. Depth and slope were difficult to distinguish, even in "through air" photos, conservatively resulting in less area rated as high value at transects T9 and T11. Fewer assumptions about slope and depth of ice cover were made in 2009, resulting in less habitat being classified as high value than in 2006 as less subjectivity was required. However, the quantity of moderate and low habitats were similar for both aerial photo interpretation methods, suggesting that better air photos may not be better at distinguishing moderate and low habitats, and may underestimate the amount of high value habitat present.
- The ground survey identified high value habitat within apron habitat, running like a ribbon around the lake in the steep transition zone towards low value sediment basin habitat that was not detected in the aerial surveys. High value habitat was characterized by moderate to complex boulder/cobble substrate below the ice scour zone and a steep slope that resists sedimentation. The ground survey identified more high value habitat than from the 2009 air photos but less than from 2006 photos, which was more liberal in its assignment of high value.

Both air survey methods suffered from being subjective because of inability to confidently distinguish slope, depth change and subtle changes in substrate composition and complexity. The ground survey was much more effective at detecting these changes and allowed better discrimination of habitat types.

Integration of Mapping Results

Recognizing the complementary features of both methods, the 2009 ground survey results were used with the 2009 air photos to create an 'integrated' map of the dewatered impoundment having 78 polygons. The integrated map is the best basin-wide measure of habitat value because habitat polygons were easily inferred and connected between ground transects. Integrating ground transect attributes across the 2009 air photos provided for more detailed mapping and verified the steep, narrow apron habitat along a large portion of shoreline that was not easily distinguishable in the unbiased 2009 air photos alone.

Key Findings and Recommendations for Mapping

- The hectares of low value, and to a slightly lesser extent moderate value, habitat was similar among all methods because of the ease in delineating low value habitat.
- Distinguishing between 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.
- Scoring of habitat attributes should be changed. Platform reduced to 2 from 4; apron from 2 to 4 and shoal maintained at 4. This reflects the greater importance of apron habitat above platform habitat (i.e., greater slope and substrate diversity) that was not appreciated until dewatering and results of the ground survey.
- Air photograph acquisition using a remotely controlled aircraft was highly successful and much cheaper than traditional methods.
- In future, habitat suitability indices (HSIs) could be altered to reflect the relatively greater proportion of burbot and smaller proportion of lake trout and round whitefish; however, fish composition may be different in another impoundment than in Second Portage Lake.
- While the 2006 mapping exercise was too liberal, overestimating the amount of high value habitat, the 2009 exercise was too conservative, unable to distinguish key features (e.g., slope, depth) that distinguish high from moderate value habitat. Ground survey results were key to properly measuring basin-wide habitat value.
- In general (i.e., for application at other sites too), habitat mapping based on through-water imagery would benefit from combined use of underwater video and detailed bathymetry conducted in an analogous manner to the ground surveys reported herein.
- We found differences among methods in total HU predictions for the northwest relative to the 2006 NNLP (555 HUs). Based on the 2006 air photos, there were fewer HUs (522.5) because the as-built orientation and size of the East Dike is

slightly different than was assumed in 2006. From the 2009 air photo mapping, we estimated 467 HUs, primarily because of the lack of high value habitat discerned. The 2009 integrated map provided the best estimate of habitat distribution yielding 472.8 HUs, 82 less than predicted in 2006.

Relationship between Habitat and Fish Biomass

The impoundment behind the East Dike was fished out in 2008. Total catch during the catch-per-unit-effort (CPUE) and final removal phase was 3078 fish weighing 1123 kg. Assuming that the 2009 integrated map is the best approximation of habitat value, the number of kg of fish broken down by surface area, water volume and HU is as follows:

- Assuming a volume of 14.6 Mm^3 of water in the impoundment, this is 0.0077 kg of fish / 1000 m^3
- Assuming an impoundment surface area of 1.4 km^2, this is 0.86 kg fish per hectare
- Assuming 472 HUs from the integrated map of the impoundment, this is 2.3 kg of fish per HU.

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 (hereafter referred to as the "Authorization"). The East Dike was the first dike constructed in the project during the open water season of 2008 and divided Second Portage Lake more or less in half, separating the northwest arm of Second Portage Lake (SP) from the rest of the lake (**Figure 1-1**). Prior to draining the northwest arm as part of mine development, and as stipulated by the Authorization, fish were removed from the entire area during the summer of 2008. The fish-out program was specifically designed (Azimuth, 2008) and implemented (Azimuth, 2009) to obtain a broad range of scientific information to improve our overall understanding of the ecology of northern lakes.

Another requirement of the fish-out program (Azimuth, 2008), which was founded on DFO's draft "General Fish-Out Protocol for Lakes to be Lost due to Mining Developments", was the mapping of fisheries habitat exposed after dewatering. This report addresses this requirement.

1.2. Setting

The Meadowbank project lakes are headwater, ultra-oligotrophic (nutrient poor and unproductive) lakes that are situated on the watershed boundary that separates the Arctic and Hudson Bay drainages Nunavut. The landscape consists of rolling hills and low relief with low-growing vegetative cover and poor soil development. As is common of headwater lakes, all of the Meadowbank project lakes have small drainage areas relative to the surface area of the lakes themselves. Local inflow from surrounding terrain is the predominant influence on water movement within the system. Small, boulder-strewn channels connect the project area lakes, although there is little flow between lakes with the vast majority of flow between lakes occurring at ice-off and freshet in late-June to mid-July. Freeze up occurs in early to mid-October.

Second Portage Lake has a total surface area of 4.8 km^2 and a total volume of 29.7 million cubic meters (Mm^3). Surface area of the northwest arm impounded by the East Dike is 1.30 km^2 with a total estimated volume of 14.6 Mm^3 divided among three basins separated by shallow sills **(Figure 1-1).** Immediately adjacent to the dike and moving northwest is the southeast basin (1.84 Mm^3, maximum depth 17 m), a deep middle basin (10.8 Mm^3, maximum depth 40 m) and a northwest basin (2.0 Mm^3, maximum depth 11 m).

1.3. Approach

Understanding the relative abundance and spatial distribution of physical features and structure of habitat in lakes is important to determine the quality of habitat, which is reflected ultimately in the abundance (i.e., biomass), productivity, and diversity of fish. Physical features include the type, size, shape, distribution, and slope of bottom sediment, ranging in size from fine (clay, silt, and sand) to coarse material (gravel, cobble, and boulder), water depth, exposure to wind forces, currents, ice scour, morphology, and vertical and horizontal complexity of the substrate. Each of these parameters alone, and in combination, can affect the quality of habitat with respect to its suitability as spawning, nursery, rearing, and foraging habitat, and ultimately, utilization by fish. For example, the project lakes are ice-bound for much of the year (October through June), with ice depth reaching two meters, which has a strong influence on habitat quality in shallow, nearshore areas.

Achieving a good understanding of the physical makeup, quality and distribution of physical habitat in the project lakes is challenging because these features are under water and not easily quantitatively defined. Furthermore, there was no prescriptive, established means to describe and map habitat in Arctic lakes. Thus, as part of the Environmental Impact Assessment (EIA) process and the development of the No-Net-Loss Plan (NNLP; Azimuth, 2006), the features, quality and quantity of fish habitat were classified throughout the project lakes. Using a Geographic Information System (GIS); ortho-rectified, stereoscopic, high-resolution, aerial photographic images; bathymetry; direct substrate sampling; and underwater video to ground truth representative habitat types and features; more than 600 unique polygons were identified. Details regarding methods and procedures were described in the NNLP (Azimuth, 2006).

The approach followed in 2009 repeated the aerial photographic survey from 2006, except that survey flights were made after the northwest basin had been sufficiently dewatered to expose all of the shallow (i.e., <8 m) rocky nearshore and shoal substrate to allow much higher image resolution. This was supplemented by an on-the-ground survey of 33 transects around the lake to document the exposed habitat. The ground survey was considered the "gold standard" against which the accuracy and precision of the other two methods could be compared; ultimately, the 2009 ground survey and aerial photo interpretation methods were integrated to develop a more accurate map of the entire dewatered basin.

1.4. Objectives

Requirements for habitat mapping of the northwest arm were detailed in the *Technical Memorandum – Fish-Out Program for the Meadowbank Gold Project* (Azimuth, 2008). Specifically, "low level photogrammetric aerial photographs will be taken to document the habitat. The aerial photos will enable us to confirm earlier estimates of habitat quality in the impounded area, and will allow derivation of a relationship between habitat area and fish biomass[1]. These relationships could be extrapolated to provide information about the expected value of reconstructed fish habitat features in terms of fish biomass production[1]".

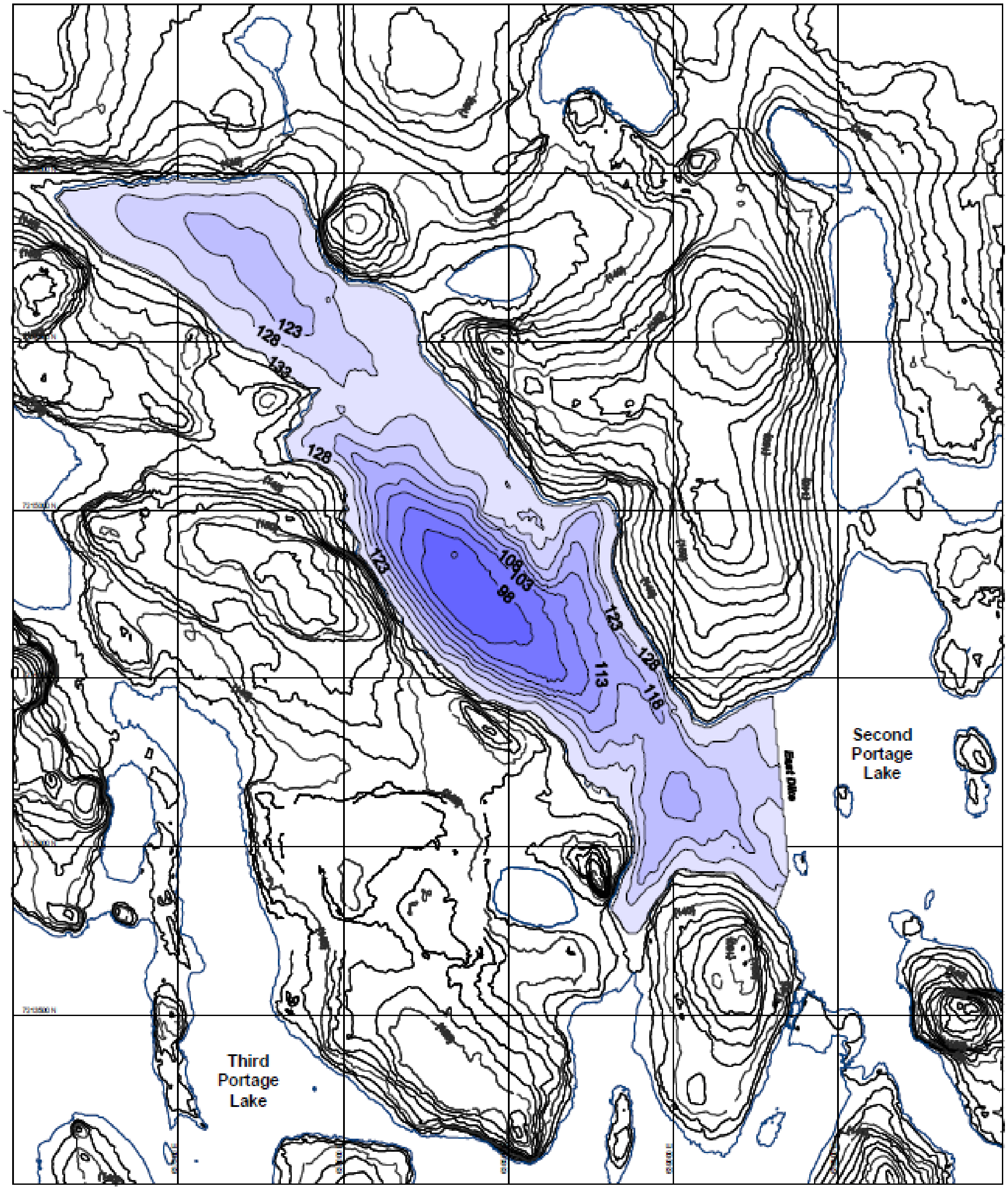
Based on the above, the objectives of the 2009 habitat mapping studies were to:

5. Conduct an on-the-ground survey and an aerial survey of the dewatered impoundment to describe and quantify habitat features.
6. Compare the results of the basic mapping techniques (i.e., 2006 "through water" air photo, 2009 "through air" photo and 2009 ground survey) to better understand the advantages and limitations of each method.
7. Develop an integrated map based on both 2009 methods.
8. Relate habitat value and habitat units (HUs) to fish biomass as determined from the fish-out program in 2008 (Azimuth, 2009).

As an additional objective, DFO requested photographs (from the air) of the footprint of the Stormwater Dike in advance of its construction to document the underlying habitat (i.e., construction was planned to start in advance of the aerial survey).

[1] The intent of these statements was meant to infer that such a relationship could be developed after other similar programs had been conducted. With a single study, the best that can be done is to relate habitat estimators to fish biomass.

Figure 1-1. Bathymetric map of NW arm of Second Portage Lake behind East Dike.



2. 2006 AIR PHOTO INTERPRETATION AND MAPPING

A detailed description of habitat mapping methods is described in detail in the NNLP (Azimuth, 2006). This section briefly describes the methodology used to describe and map physical habitat features in the project lakes and to quantify habitat units (HUs) using GIS. Similar methods were used to interpret the 2009 aerial photographs, with the only difference being that bottom features were viewed through air and not through water as they were in 2006. Details of the 2009 aerial survey are described in **Section 3.0**.

2.1. Habitat Mapping Methods

Two sets of aerial photos were used in the assessment: 1998 aerial photography (5,544 ft survey altitude) collected by Eagle Mapping Services Ltd.; and 2002 aerial photography (5,657 ft survey altitude), collected by Geographic Air Survey Ltd. Although air photos were acquired as early as 1998, detailed interpretation was not undertaken until 2003. We refer to this process as the 2006 air photo interpretation exercise because this interpretation is most closely associated with the 2006 NNLP report (Azimuth, 2006).

First, a base map was created by scanning aerial photographs and transferring the data to GIS for analysis. Using a stereoscopic imager, visible substrate features were inferred from various colour signatures visible in the aerial photos and used to delineate identifiable polygons. The following physical attributes were used to delineate polygon boundaries and to describe visible features of each polygon:

- *Substrate* – an estimate of the substrate composition (gravel, cobble, boulder).
- *Morphology* – the general form of the polygon feature.
- *Depth* – an estimate of depth based on colour, position, and limited empirical bathymetry data.
- *Complexity* – a qualitative estimate about the composition and spatial heterogeneity of the habitat.

Slope and ice scour depth could not be inferred from the air photos and had to be accounted for post-processing. Following aerial photograph interpretation, underwater video was also used in 2003 to acquire imagery of representative habitat areas, focusing on lake areas contained within the proposed dike locations. Underwater imagery was combined with coarse bathymetry data (10-m contours) to augment interpretation and classification of habitat features to better define polygon attributes. Then, polygons were digitized in ArcView and assigned attributes using information from the scanned digital images, original aerial photographs, bathymetry, and underwater video.

The following sections summarize how each major physical descriptor was used to describe, rank and quantify habitat quality from the air photographs and groundtruthed from the underwater video.

2.1.1. Substrate

Lakebed substrate is a key habitat attribute that dictates the function (e.g., spawning, feeding) and extent to which fish utilize particular habitats, and is a major factor in assessing habitat value. In general, coarser, heterogeneous sediment mixtures have a greater value because of higher diversity and structure, which is better suited as spawning habitat. Sediment composed of an even mixture of fine substrates with little or no complexity is very common and provides feeding habitat only. It is therefore considered to have lesser overall value than heterogeneous substrates.

Substrate of each habitat polygon was classified according to one of four categories: boulder dominated substrate (B); boulder/cobble (BC); sediment dominated with cobble/boulder (CB); and fine sediment dominated (S). Some of the clues used to classify substrate from aerial photographs included: appearance of the immediate shoreline edge (rough or smooth; presence of boulder veneer at shoreline edge); sharpness of platform/shoal's edge (definite or fuzzy boundaries, gradation of colour); complexity of coloration; and visible boulders in the photo.

A description of the four substrates categories is as follows:

- *Boulder* – defined as consisting predominantly of large and small boulder and large cobble substrates. These may be ice-scoured in very shallow platforms and have light to heavy periphyton coverage. These locations ranged from fractured boulder-rubble to rounded boulder-cobble-pebble.
- *Boulder/Cobble* – a heterogeneous mixture of boulder-cobble substrate, sometimes interspersed with small gravel patches. This substrate type is most common in water depths of 1-4 m.
- *Sediment with Boulder/Cobble* – a heterogeneous mixture of sediment dominated by gravelly sand with occasional boulder-cobble or fine sediment coverage. Boulders and cobble may have a light veneer of fines draped over the surface. This substrate occurs primarily on the aprons, in the transition zone between shallow boulder cover and deeper fine sediments, in depths of 4-6 m.
- *Sediment Fines (Silt/Clay)* – predominantly silt/clay sediment (90%) with some sand (<5%) and occasional patchy boulder/cobble (<5%). Low diversity of sediment grain size.

2.1.2. Morphology

Morphology of habitat is a term used to describe large, discrete units of substrate features (i.e., polygons) that can be delineated and quantified using GIS, and are distinct from adjacent units. The four categories of habitat morphology are:

- *Platform* – A continuous, low-slope polygon adjacent to and connected to the shoreline. Generally, consists of coarse, boulder substrate, but occasionally may include a discontinuous veneer of boulder cobble over bedrock.

- *Apron* – Occurs lakeward of platforms, and generally has a steep slope. Substrate is assumed to be finer than at platforms or shoals, and represents transitional habitat between shallow littoral areas and deep (>6 m) zones of the lake with fine to intermediate (sand or silt/clay) sediments.

- *Shoal* – May or may not be associated with platforms or connected by aprons. Shoals are most commonly not attached to land and are found at depths of 2-4 m and deeper. Substrate consists of a mixture of coarse material (boulder, cobble), but may have a veneer of fine sediment draped over the surface.

- *Sediment Basin* – Represented by large, low-slope continuous polygons, offshore of aprons, shoals, and platforms, generally in deep depths (>8 m), with predominantly fine substrates (silt/clay).

Ground survey results have altered our descriptions of the typical features of morphology units and in future, would be scored differently to recognize differences in habitat quality. For example, apron habitat tended to be much less 'transitional' and had steep slope that resisted sedimentation and generally had a higher value than was assumed from what could be distinguished from air photos taken through water. This aspect is discussed in more detail in **Section 4.0**.

2.1.3. Depth

Depth (m) was estimated from features that could be distinguished from the air photos and ground truthed from actual depths measured in the field using underwater video photography. However, at the time of the survey bathymetric information was quite coarse and was not very useful in assisting in depth classifications. Furthermore, it was difficult to determine depth and slope accurately from the air photo's so this feature was scored with less confidence than other features.

Classifying depth is important in ranking habitat quality because of the influence of ice, wind driven currents, and wave action on nearshore and shoal habitat features. Lack of ice is important for incubation of eggs and nursery areas for hatched fish. Wave action and exposure determines sediment grain size and sedimentation rate in shallower waters.

Depth was classified into four categories:.

- *Shallow* – <2 m depth, typically adjacent to shorelines and associated with platforms and sometimes shoals.

- *Moderate* – From 2-4 m depth and optimum for spawning because of favourable substrate size and distribution and lack of ice. Shoals and aprons typically have moderate depth. Recent studies at Diavik and Snap Lake have determined that this depth is preferentially used by lake trout for spawning.

- *Deep* – From 4-6 m depth, generally lakeward of apron habitat. The 6 m contour corresponds to the outer edge of platforms/aprons and is the transition to fine sediment bottom.

- *Very Deep* – >6 m depth where bottom substrate features could not be easily distinguished from the air photos and was assumed to consist of almost exclusively of fine (clay/silt) sediment, based on video and sediment grabs.

2.1.4. Complexity

Complexity of substrate was a subjective attribute that describes relative diversity, roughness, and heterogeneity of bottom substrate visible from air photos and from underwater video. There is assumed to be a positive correlation between substrate complexity and habitat quality. Habitat complexity was described as follows:

- *Complex* – mapping unit shows considerable surface roughness (e.g., boulder veneer on bedrock) and a diversity of microhabitats is likely within the polygon most frequently observed at shallow to moderate depths (0-4 m) associated with platform and shoal habitats.

- *Moderately Complex* – mapping unit shows some (25% to 50% of total polygon area) surface roughness that contributes to diversity of microhabitats. Typically found at depths > 3-4 m, and associated with shoal and apron habitat.

- *Uniform* – mapping unit shows little or no surface roughness, low diversity of microhabitats (e.g., flat rock platform, fine sediment) and typically found in deeper (>8 m) depths with fine substrate or in shallow depth with bedrock platforms.

2.1.5. Slope and Ice Scour

Habitats that appeared to drop steeply into the water column were deemed to have higher value because steep slope areas resist deposition of fine sediments and are associated with spawning/rearing and foraging areas. However, it was difficult to distinguish or quantify slope from the air photos and this feature was relatively subjective and was most often associated with apron morphology.

For platform polygons that are attached to shore and obviously situated in shallow water, it was assumed that given that an ice depth forms to 2 m this would negate these areas as spawning/rearing habitat. Thus, shallow, nearshore platform habitat was applied with a penalty score and automatically ranked lower because ice cover and risk of freezing would prevent egg survival. That is, shallow habitats, whether attached to shore or on shoals, would not be considered high value.

2.2. Habitat Value and Habitat Units (HUs)

The general approach to defining and mapping habitat at Meadowbank was similar in principal to mapping exercises carried out by mine companies at other northern developments such as Diavik Diamond mines (Golder, 1998), Snap Lake diamond mine (Golder, 2002), Doris North Gold project (RL&L and Golder, 2003), Tahera Diamond (2004), and by Fisheries and Oceans Canada (FOC) for Newfoundland and Labrador (Bradbury et al, 2001) and in general by Minns (1995).

2.2.1. Determining Habitat Value

Habitat value was calculated based on the cumulative assigned scores of morphology, substrate, depth, complexity, ice scour and slope for each polygon. The suitability of discrete habitat types (and polygons) to support life history functions was determined based on the scoring system described in detail in the NNLP (Azimuth, 2006) and summarized here. Essentially, polygons that scored higher for each habitat attribute (e.g., slope, depth, substrate) contributed in a weight-of-evidence manner towards its relative value, measured through its presumed capability of providing for spawning/nursery, rearing, foraging and overwintering.

Thus, cumulative habitat feature score was used to judge whether individual habitat polygons were ranked as having high, moderate or low value. The rationale for weighting and scoring of habitat attributes was based on our understanding of fish habitat requirements and local conditions, professional judgment and experience, and the scientific literature (Azimuth, 2006). The scoring system used to score and rank each individual polygon is presented in **Table 2-1** with raw data provided in **Appendix A** for the 21 distinguishable polygons within the NW basin of Second Portage Lake in 2006. This same system was used to score the 2006 aerial photographs and the 2009 aerial photographs of the partially dewatered impoundment.

Based on this scoring system, the highest possible score is 24. Habitat scores were categorized as follows: 18 to 24 were assigned a value of “high,” 12 to 17 were “moderate,” and 6 to 11 were “low.” The defining features of high, moderate, and low value habitat polygons are as follows:

- *High Value* – High value habitat polygons are characterized by complex, heterogeneous boulder or boulder/cobble substrate with few fines situated in moderate depth (2-4 m) below the ice scour zone, but above the transition zone to fine silt/clay. High value polygons were usually associated with shoals or aprons with good exposure and discernable slope. These polygons combined many of the habitat features sought by fish and are best suited for multiple life history requirements, including spawning/nursery, rearing, shelter, and feeding.
- *Moderate Value* – Moderate value habitat polygons are typically found within two depth ranges; 0-2 m and 4-8 m. Moderate value polygons in shallow (<2 m) water are characterized by large boulder or, less frequently, boulder/cobble habitat with no fines, shallow slope and are usually attached to shorelines (platforms). Substrate is usually ice-scoured and unavailable for spawning, but does provide excellent rearing and foraging habitat. Overwintering habitat value is nil in water depth less than 2 m. At mid-range depths (>4 m), moderate value polygons consist of a mixture of coarse substrates on shoals or aprons in transition areas. This habitat offers good protection for all fish species, especially juveniles, and is less important for spawning/nursery, but is very important as rearing and feeding habitat. Overwintering is also important in this depth / substrate zone. HSI values reflect this diversity of habitat, stratified by depth.
- *Low Value* – Low value habitat polygons consist primarily of uniform fine substrate or bedrock slope, of low complexity in very shallow or deep water (>8 m) providing feeding and overwintering habitat. The importance of this habitat varies according to species. Juveniles and round whitefish of all ages forage for chironomid larvae near transition zones where there is adequate shelter. Arctic char, especially adults, forage in mid-water feeding on zooplankton, and are commonly found above this habitat type in the pelagic environment (Jansen et al, 2001, Saksgard and Hesthagen 2004).

2.2.2. Determining Habitat Units (HUs)

The procedure for determining HUs is derived from area-weighted sums in hectares (ha) of habitat type multiplied by a HSI. The HSI is a derived metric of the relative importance of a habitat type to different life history stages of fish. A detailed discussion of the background and derivation of HSI units for this project is provided in the NNLP (Azimuth, 2006). The product of low, moderate and high habitat areas and their relative importance or suitability (HSI) is represented as HUs that are used to calculate losses and gains to achieve no net loss of habitat. Given that different habitat types (e.g., substrate, depth, complexity etc.) have different relative contributions to different life history stages and species (e.g., Arctic char, burbot, sculpin) application of an HSI recognizes specific requirements related to life history stage and fish species, as well as relative numerical abundance/biomass of each species. For example, because lake trout are relatively quite abundant, both in terms of absolute number and biomass, certain habitat features that are relatively more important (i.e., have greater 'suitability') to lake trout were given greater weight in the suitability index than for low biomass, relatively rare species like ninespine stickleback (Azimuth, 2006).

HSI values were derived for each species for each of four major life history stages: spawning/nursery; rearing; foraging and overwintering of all fish species present (**Table 2-2**). The ranking or scoring system of HSI used by Azimuth (2006) was similar to what has been used at other northern mines.

Species weighting scores were multiplied by the HSI score and then summed to derive a species weighted score for project lakes for high, moderate and low value polygons. Thus, HUs incorporate habitat suitability of uncommon and forage species in overall assessment of no net loss for all species, but is weighted to more prevalent species (e.g., lake trout).

HUs are the product of the appropriate HSI multiplied by the spatial area (ha) of high, medium and low value polygons (e.g., HSI of 8.9 x 10 ha [high value] = 89 HUs of high value habitat. HUs derived in this manner were used to develop the habitat "balance sheet" in the NNLP by determining habitat losses (i.e., HADD) and gains (through compensation) during various phases of the project.

2.3. 2006 Air Photo Interpretation and Mapping

The results of the air photo interpretation and habitat scoring exercises were ultimately used to create a habitat map for the project lakes. The portion pertaining to the northwest arm, which is the focus of this report, is shown in **Figure 2-1** (details for each polygon shown in **Appendix A**). Note the following colouring scheme for habitat value, which is used throughout this report: high (red), moderate (orange), and low (yellow).

Twenty-one polygons covering a total of 132.1 ha were identified within the northwest arm from the 2006 aerial photograph interpretation. The most abundant habitat type was low value habitat (85.48 ha; 4 polygons) because of the deep basins that exist within the lake, surrounded by steep sided banks, especially in the middle basin (42 m depth). Moderate (32.8 ha; 12 polygons) and high value habitat (13.86 ha; 5 polygons) constituted about 35% of the available habitat. The majority of high value habitat is situated across the shallow sill that separates the northern and middle basins and along the east side of the lake south of this sill.

Table 2-1. System used to score and rank habitat polygons

Habitat Attribute	Weighting[1]	Class	Rank[2]	Feature Score[3]
Substrate	2	Boulder	3	6
	2	Boulder/Cobble	4	8
	2	Boulder/Cobble/Fines	2	4
	2	>90% Fines	1	2
Complexity	2	Uniform	1	2
	2	Moderate	2	4
	2	Complex	3	6
Ice Scour	1	Ice Scoured	- 2	- 2
Slope	1	Flat slope	1	0
	1	Steep slope	2	2
Morphology	1	Apron	2	2
	1	Shoal	3	3
	1	Platform	4	4
	1	Sediment Basin	1	1
Depth	1	Shallow (0 to 2 m)	1	1
	1	Moderate (2 to 4 m)	4	4
	1	Deep (4 to 6 m)	3	3
	1	Very Deep (>6m)	2	2

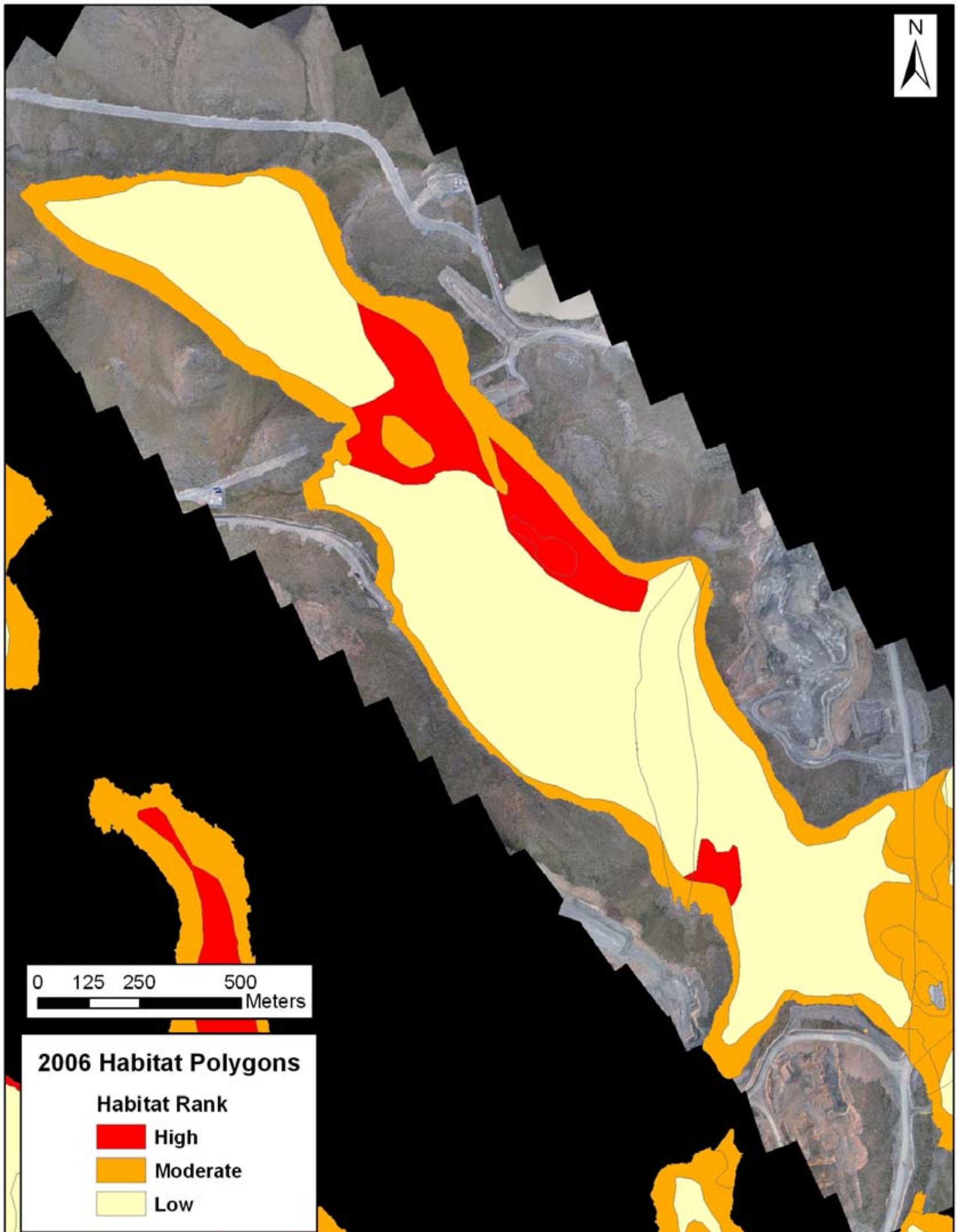
Notes:

[1] Weighting indicates the relative importance of each habitat attribute as a determinant of habitat value.
[2] Ranking indicates relative importance of features within habitat attributes.
[3] Feature score is the product of Weight x Rank (except ice scour), and indicates the relative importance of habitat attributes as they contribute to overall habitat value (Azimuth, 2006)

Table 2-2. Weighted mean habitat suitability indices (HSIs)

Polygon Value	Species	HS I	Species Abundance Weighting	Final HS I
High	Lake trout	9.25	0.75	6.94
	Round whitefish	7.5	0.15	1.13
	Arctic char	8.5	0.09	0.77
	Burbot	7	0.005	0.04
	Slimy sculpin	6.25	0.0025	0.02
	Ninespine stickleback	7	0.0025	0.02
			SUM	**8.90**
Moderate	Lake trout	6	0.75	4.50
	Round whitefish	7	0.15	1.05
	Arctic char	5	0.09	0.45
	Burbot	5.75	0.005	0.03
	Slimy sculpin	5.75	0.0025	0.01
	Ninespine stickleback	6	0.0025	0.02
			SUM	**6.06**
Low	Lake trout	2.25	0.75	1.69
	Round whitefish	2.5	0.15	0.38
	Arctic char	2.75	0.09	0.25
	Burbot	4.5	0.005	0.02
	Slimy sculpin	3.5	0.0025	0.01
	Ninespine stickleback	0.5	0.0025	0.00
			SUM	**2.34**

Figure 2-1. Habitat values of NW arm derived from 2006 aerial photographic interpretation through water.



3. 2009 AIR PHOTO INTERPRETATION AND MAPPING

3.1. Aerial Photographic Survey

On August 7, 2009, a small (2.5 m wingspan) remote controlled aircraft was used to take aerial photographs of the impoundment area and shorelines along a pre-programmed flight path. At the time of the flight, the impoundment had been drawn down by approximately 8 m, which was sufficient to reveal all rocky habitat features and the transition to low-value habitat (i.e., silt/clay bottom).

The aircraft is owned and operated by Greg Lewis of "On Demand Imagery Solutions Inc" (ODIS), Brandon Manitoba. The aircraft was equipped with a GPS unit that was also tied to a local mine site signal to improve geo-referencing capability. The aircraft was flown at approximately 1,200 m elevation during the survey. Using a 10 megapixel digital camera mounted to the bottom of the aircraft, this allowed for a ground-level resolution of 17 cm. After the route was flown the digital images were downloaded to a computer, "stitched" together to make a single mosaic and orthorectified using known coordinates for prominent features (**Figure 3-1**).

The stitched, geo-referenced image and individual images were delivered to Coastal and Ocean Resources (C&O), Sidney BC for delineation of habitat polygons and detailed interpretation. C&O is the same company that conducted the original air photo interpretation and similar methods and procedures were followed as for the original mapping and habitat quantification exercise (Azimuth, 2006).

3.2. Air Photograph Interpretation

The 2009 interpretation is referred to as the 'unbiased' polygon mapping exercise. Although C&O had the benefit of the results of the ground survey and was aware of the subtleties in habitat features, interpretation was conducted based on what could be actually seen in the air photos and inferred from bathymetry (e.g., the 2-m contour to define the ice scour zone). The goal was to accurately reflect the capabilities of the technology as if it were being used as a stand-alone mapping technique.

Although the photos were taken through air, interpretation of aerial photographs still posed some challenges. It was difficult to estimate depth from a two-dimensional air photograph and even though a two meter bathymetry contour was used it was too imprecise, particularly in nearshore areas that likely did not have much coverage in the bathymetric surveys, to be of much use. This made distinction of depth, ice and slope categories difficult and required some subjectivity, which was an even greater challenge in 2006 when photos were interpreted through water (and lower resolution bathymetry was used).

For example, the steep habitat band that was easily observed on the ground was very difficult to identify in the air photographs. Although there are detectable changes in substrate characteristics, it was not possible to definitively associate this with a change in slope or in morphology. Thus, changes in substrate characteristics were not sufficiently different to allow for apron habitat to be distinguished from nearshore platform habitat and the two habitat types were often lumped together.

Fifty-two unique polygons totaling 131.5 ha were identified and scored (**Appendix B**)[2]. Low-value habitat (89.9 ha; 8 polygons) was the most abundant habitat type, followed by moderate value (39.7 ha; 40 polygons) and a small amount of high-value habitat (1.8 ha; 4 polygons). The spatial distribution of high, moderate and low-value habitats is depicted in **Figure 3-2**. The biggest difference between the 2006 interpretation (**Figure 2-1**) and the 2009 unbiased map is the lack of high value habitat identified along the shallow, exposed shelf in the middle of the northwest arm on the east side, and across the shoal habitat along the sill that separates the north from the middle basin (**Figure 1-1**). The paucity of high-value habitat was due to the difficulty in identifying apron habitat, slope and depth, which would have added habitat score to apron habitats with high slope and depth greater than 2 m. Consequently, the majority of these polygons were identified as having moderate value. Despite this, the distribution and quantity of low value habitat was very similar among years (85.5 ha in 2006 and 89.9 ha in 2009) due to the ease of distinction of this habitat type, even through water.

[2] Habitat underlying the constructed portions of Stormwater Dike were inferred from interpolation of the air photos and from the series of photos taken of the area in advance of dike construction on 22 July 2009 (see **Appendix C**).

Figure 3-1. Composite image of 2009 air photos of partially de-watered NW arm, Second Portage Lake.

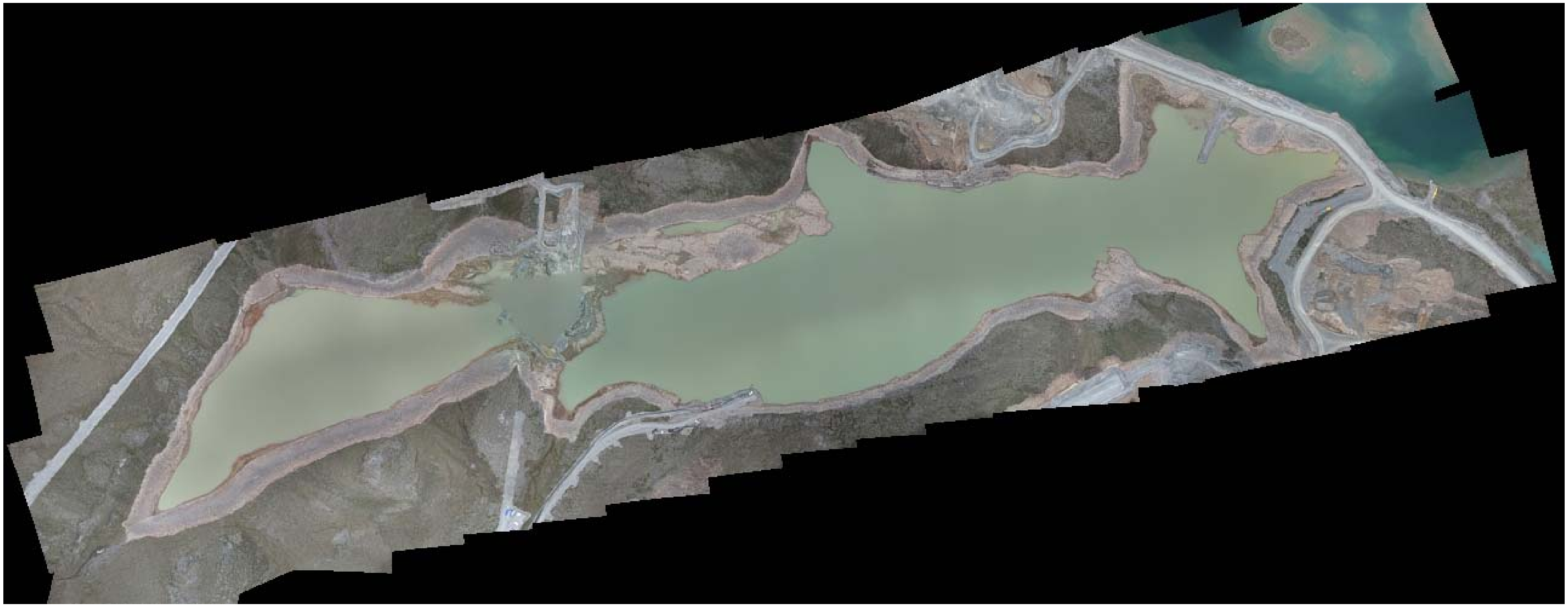
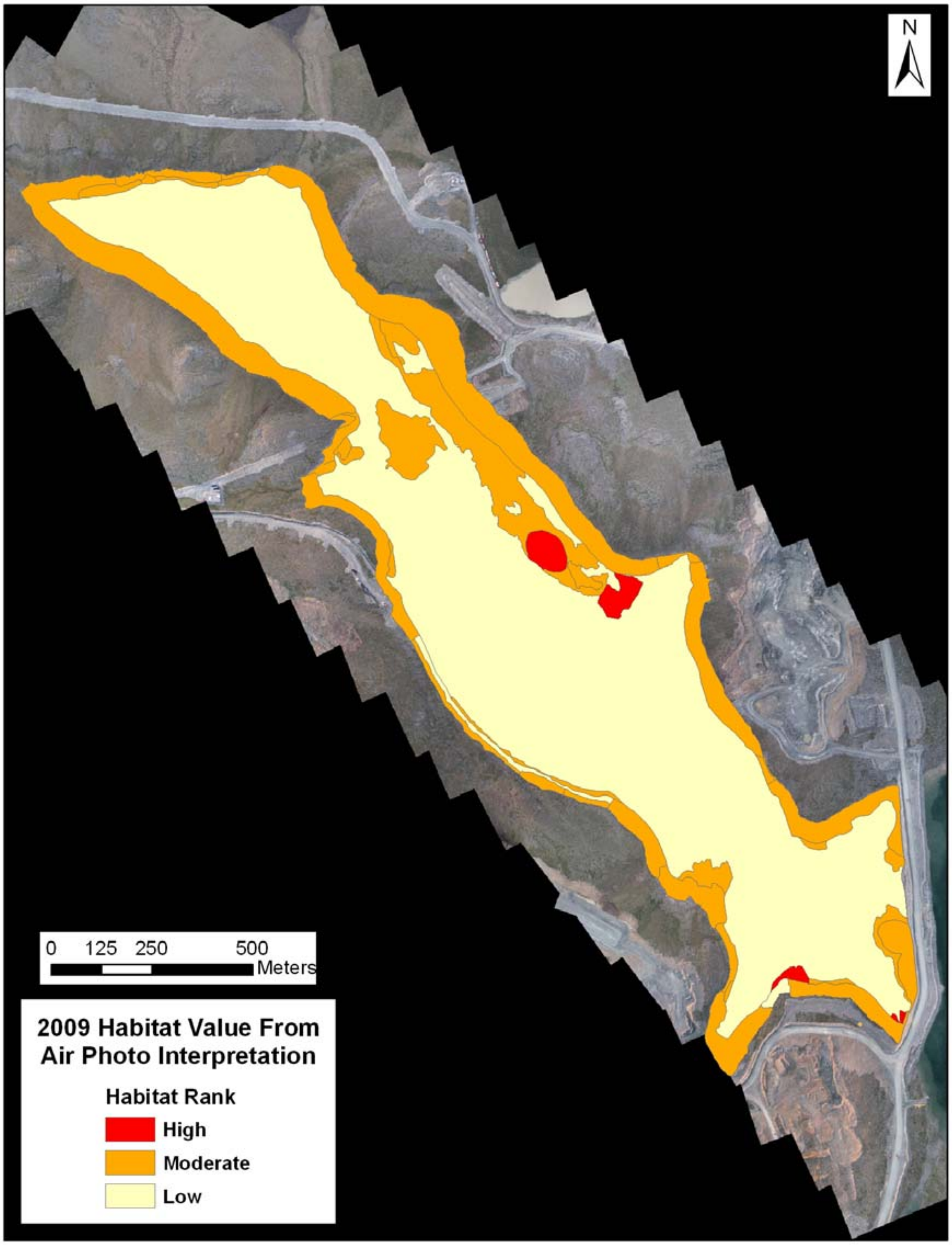


Figure 3-2. Map depicting habitat values of unbiased interpretation of 2009 aerial photographs.



4. 2009 GROUND SURVEY AND INTERPRETATION

4.1. Methods

Dewatering of the northwest arm of Second Portage Lake prior to mid-July 2008 was sufficient to expose all rocky habitats within the lake, either along shorelines or submerged shoals. Previous investigations indicated that there was a rapid transition from rocky substrate to silt/clay sediment at depths between 4 and 6 m, depending on aspect and slope within the project lakes. Thus the dewatering depth was sufficient to allow foot access to most of these areas for mapping purposes in 2009.

Substrate features of the partially dewatered portion of the northwest arm of Second Portage Lake were quantitatively described and mapped between July 12 and July 16, 2009. Thirty-three transects were surveyed around the lake (**Figure 4-1**). All transects started at the boundary where spring high water level met un-eroded shoreline and extended perpendicular to shore into the lake and terminated at the transition to low-value silt/clay substrate. A wooden stake was driven into the substrate at the starting transect (e.g., T1) at the shoreline, marked as T1-A, and a UTM location acquired using a hand held Garmin 76Cx GPS to record easting and northing (NAD 83). The exposed habitat was walked towards the lake and evaluated according to changes in depth and slope, evidence of ice scour, substrate type and composition and overall complexity (vertical, lateral and horizontal material composition). Where significant or obvious changes in substrate type, morphology and/or slope occurred a new stake was driven into the substrate and designated as T1-B. A GPS position was acquired and depth (elevation) was visually estimated. Photographs were taken looking up slope, down slope and across slope in both directions. This process was repeated until the transect ended at the interface between rocky substrate and silt/clay substrate (i.e., the transition zone to low value habitat), which was always abrupt (e.g., T1-C or T1-X as appropriate). A metered tape measure was run from the start to the finish of each transect to acquire the total length of each transect and segment lengths (i.e., between A and B, B and C and so on) to calculate slope (rise / run).

Subsequent to the mapping exercise by Azimuth staff, transect stakes were surveyed by AEM to acquire precise UTM locations (<0.1 m) and elevation above sea level (m asl) data.

4.2. Ground Survey Findings

The ground survey provided a unique opportunity to closely view nearshore platform and shoal habitat that only a few months earlier was either under water or ice, allowing a detailed inspection of substrate, periphyton coverage, ice scour and other habitat features. This inspection was especially useful to contrast and (literally) ground truth interpretations of habitat features from the 2006 and 2009 aerial surveys. All of the information collected from the ground survey transects, including elevation data from detailed survey information from each transect segment was used to determine slope and ice scour depth in order to determine habitat value. This information is summarized in **Appendix D** and is considered the best overall assessment of habitat classification and ranking because features that are difficult to observe from aerial photographs are much more easily discerned on the ground. A selection of photographs for each transect segment is provided for review in **Appendix E**. In addition, a description of each transect segment was also recorded and transcribed from field notes into **Table 4-1**.

Across the 33 transects, there was a discernable pattern that emerged in the distribution and composition of habitat around the northwest arm (see **Figure 4-2** for example). Nearshore platform habitat up to about 2 m depth was very uniform around the lake with respect to substrate composition with few exceptions. Substrate of platform areas around the lake tended to be large boulder dominated, shallow sloping (<10%), periphyton covered, ice scoured and moderately complex with a low diversity of rock types and vertical/horizontal diversity. In most cases there was a very distinct change in both substrate type and elevation easily distinguishing the transition between platform and apron habitat. Typically there was a large slope change (>10%) where elevation changed by 2-4 m or more within a distance of 5-10 m, usually with a change in substrate composition, becoming more mixed with patches of gravel/cobble and small boulder near the toe, above the transition to fines. This steeply sloped apron habitat distinctly separated platform habitat from sediment basin habitat, was deeper than 2 m, non-ice scoured, resistant to sedimentation, and was vertically and laterally complex, which typified high value habitat. That is, this habitat type satisfied requirements for spawning/nursery areas by fish as well as other life history functions. The relatively small spatial strip of this habitat that existed adjacent to platform habitat was not easily distinguishable from air photos, especially through water. This is discussed in greater detail in the following section.

At most transects there was a distinct transition to silt/clay low-value habitat at the toe of the steeply sloped apron habitat that extended into the lake, consisting of uniform soft silt/clay substrate with no rocky material. This demarked the termination of most ground transect surveys. The exception to this pattern was where there were exposed shoal habitats along the sill separating the north and middle basins and along the eastern margin of the impoundment south of the sill. Here there were small strips of low or moderate value habitats that separated shoals which sometimes were ranked as high value, as in the 2006 air photographic interpretation which tended to be less conservative. This habitat was ranked as such in the 2009 aerial photograph interpretation because slope and elevation were not easily distinguished.

Following is a summary of differences to the general pattern described above as observed along the ground survey transects of the impoundment area (**Figure 4-1**).

- Along steep sided slopes on the southern side of the impoundment opposite the deep middle basin (e.g., T27, T28, T29) slope was steeper and transect distances were shorter.
- There was a shoal presumed to be visible at T30 in the 2006 mapping exercise that extended for 170 m offshore that was ranked as high value habitat. However, this shoal was not observed the 2009 aerial (90 m) and ground surveys (94 m) and substrate complexity was ranked much lower from the ground than what was assumed when viewed from the air. Thus this area was ranked as moderate value habitat, which was the largest discrepancy between the two major surveys.
- Although all transects ended abruptly at the transition from coarse rocky (boulder, cobble) substrate to silt/clay at a distinct elevation, which varied among some transects. Transition elevation varied between one and two meters, depending on orientation to the predominant wind direction, aspect and embayment. Along shorelines with high wind exposure the transition elevation (or depth below 133 m) occurred deeper, between 5 and 6 m. In sheltered areas in embayments or leeward of the predominant wind direction (e.g., T7, T1, T4), transition elevation was shallower (3-4 m)
- At the southwest corner of the impoundment, nearshore substrate of several transects (i.e., T24, T25, T26A-B) consisted of sloping bedrock shelves that sloped steeply down and contributed very little to habitat value (and were ranked as low value).
- Near the sill separating the middle and north basins, depth was shallower and there was a much higher proportion of moderate and high value habitat because of shoals and greater vertical and horizontal diversity in morphology and substrate complexity.

Table 4-1. Location (UTM), transect distance by segment, habitat classification and description of 2009 ground survey transects of the NW Arm of Second Portage Lake.

		UTM at segment start								
Tansect	Segment	Easting	Northing	Depth at End (m)	Segment Length (m)	Substrate	Slope	Complex	Photo Number	Notes
T1	A - B	639227	7214434	1.43	30.4	B	F	MC	1	Large moderately complex cobble field of boulder, bedrock pieces and loose rock. V. good peri coverage. Ice scour, especially at upper end which is very shallow - cobble at toe/top of slope.
T1	B - C	639248	7214412	3.16	5.8	B	S	C	2	Short steep boulder slope into the mud. Complex habitat. But shallow in lee of point behind wind direction and deposition area
T1	C	639016	7214405							
T2	A - B	639043	7214422	1.84	26.4	B	F	MC	3	Shallow sloping boulder field with M-H complexity. Good periphyton growth but shallow and probably ice covered. Fairly uniform composition but with a few large blouders
T2	B - C	639022	7214406	5.0	8.0	BS	S	M	4	From top of slope to toe very steep boose cobble and boulder with 50-60% gravelly sand some fines. Wind exposed, rock resists sedimentation
T3	A - B	638949	7214583	2.06	25.6	B	F	MC	5,6	Shallow sloping mod complex boulder field - mostly L to VL boulders with some cobble underneath, good peri coverage, extends with uniform slope (periphyton cover here, with good sun exposure) to ledge of very steep wall/cliff
T3	B - C	638930	7214567	5.0	7.3	B	S	M	-	Steep drop (45%) slope of v. loose boulder to toe of slope intersecting mud ~6 m down., no fines here- wind exposed slope. Peri cover extends down to base of rock wall - good sun exposure direct
T3	C	638924	7214562							
T4	A - B	639140	7214380	1.62	45.3	B	F	MC	7	Shallow boulder slope with cobble patches. Moderate periphyton cover, low vertical diversity, ice flattened and scoured in lee of wind area
T4	B - C	639158	7214338	3.09	5.0	B	F	C	8	Similar to transect A-B; short shallow boulder slope to mud immediately at toe, appears to be deopositional area ~3 m elevation
T4	B - C	639152	7214380							
T5	A-B	638898	7214656	-	36.9	B	F	C	9	Moderate sloping boulder field with cobble patches and good vertical heterogeneity, lots of space between boulders; Good periphyton coverage. Ice covered in winter. Good rearing and foraging habitat
T5	B-C	638863	7214628	-	7.2	B	S	C	10	Very steep boulder pitch with good peri cover- ideal sun exposure, no fines, potential spawning habitat. Cobble at bottom of steep slope at mud level, same water level on July 16
T6	A - B	638815	7214843	1.5	33.2	B	F	C	11	A-B long flat boulder. Cobble shelf. Mostly large boulder. Some cobble pattern. Good peri coverage. Lots of interstitial space. Medium vertical diversity. Ice scoured/covered in winter. Extends to top of slope, shallow.
T6	B - C	638776	7214832	4.0	6.9	B	S	C	12	short steep boulder slope below ice level. Good peri cover- poss. spawn habitat- large wind exposure. Cobble at intersection with mud substrate
T6	C	638776	7214832							
T7	A - B	638685	7215025	1.0	14.8	BS	F	C	13,14	Primary cobble compact with large intersperced boulders below shore, 15 m in before transition to boulder dominated substrate. Moderate peri growth good vertical complexity, compact cobble/gravel.
T7	B - C	638692	7215012	2.0	12	B	F	C	15	Transition to boulder slope, complex mixture of rock and some cobble. High peri growth - wind sheltered extendes to lip of slope
T7	C - D	638699	7215002	4.0	4.9	BS	S	C	16	Steep slope with bouder cobble at top. Rapidly turns into mud slope with cobble gravel with good complexity possible spawning habitat at toe
T7	D	638700	7215000							
T8	A - B	638650	7215020	1.43	32	BS	F	C	17,18	Shallow flat sloping cobble gravel shelf with large interspersed boulders. Good complexity with heterogeneity, substrate complex vertical profile. Good periphyton coverage
T8	B - C	638647	7214988	2.68	7.2	B	S	C	19	Short steep boulder slope to mud strip separating shoal from platform
T8	C	638645	7214981							
T9	A - B	638640	7214969	3.75	37.7	BS	F	M	20	Similar to other shoal habitat; Mostly gravel cobble/sand with few boulders on low profile shoal with moderate peri cover. Wind exposed few fines on surface, compact sand
T9	B - C	638639	7214931	6.1	32.6	SB	F	M	21	Similar substate, moderate slope. Moderate peri cover. Firm bottom- not much cover. Poor/nil sp. Habitat.
T9	C	638643	7214899							
T10	A - B	638548	7215110	1.74	44	BS	F	M	22	Shallow sloping boulder field with cobble gravel patches at surface; Extends to sharp dip at toe. Good periphyton coverage.
T10	B - C	638514	7215082	4.32	4.5	BS	S	C	23	Steep boulder slope with no fines. Below ice cover, some peri cover. V. steep with large cobble boulder. Good interstitial spaces.
T10	C	638511	7215079							
T11	A - B	638499	7215069	3.20	23.0	SB	F	M	24	From bottom of toe area of T10, mix of small bldr/cobble gravel substrate in trench between platform and adjacent shoal leeding up to B at foot of shoal
T11	B - C	638480	7215057	1.91	4.2	B	S	C	25	Short steep boulder wall to top of shoal. Periphyton coverage on boulders; nice transition to submerged shoal
T11	C - D	638477	7215054	2.73	73.0	B	F	C	26	Large shoal consisting of broken and fractured rock. Few large cobble patches. Good peri coverage over the shoal. Ice scour at top of rocks suggest that most of the base of the shoal is ice free. Possible spawning habitat. The knoll of the shoal is frozen in winter.
T11	D - E	638425	7215004	5.50	9.0	BS	S	M	27	Relatively stable but steep slope to mud at toe. Moderately complex but not much interstital space, sparce peri growth. At top of slope good boulder cover and spawning habitat.
T11	E	638507	7215080							
T12	A - B	638462	7215249	2.22	46.4	B	F	M	28	Shallow sloping boulder field consisting of medium size boulders, a few large and some small. Few cobble patches. Heavy peri cover; broken rock jumbled leading towards lip of ledge at B, 46 m away. Substrate gets more cobbley at end.
T12	B - C	638429	7215217	3.01	2.0	B	S	M	29	Very short slope (~1m) of boulder intersecting directly with mud probably no deeper than 2 m. possible ice cover? This is a depositional cover between the shoal and platform where there is a pinch as shoal connects to platform just north at of transect
T12	C	638427	7215215							
T13	A - B	638404	7215186	63.47	22.3	SB	F	C	30	Heterogeneous mix of few boulders, smothered cobble and gravel/sand with good peri coverage. Moderage slope up to top of shoal.
T13	B - C	638383	7215176	2.52	72.2	SB	F	C	31,32	Scattered rocks few boulders and cobble gravel sand mix. Large shoal N and S of transect extending 150 m from shore into lake. Top of shoal may be frozen in late winter.
T13	C - D	638333	7215125	5.20	8.5	SB	S	M	33	Steep sloping shelf to lake with gradual transition from coarse to fine materials with gravel sand at toe to mud no peri growth , wind exposed fetch
T13	D	638327	7215121							
T14	A - B	638342	7215368	43.46	59.20	BS	F	M	34,35	Periphyton covered heterogeneous mixture of large, medium boulder, angular rock, rounded, fractured ice covered. Few patches of large cobble interspersed 1m squared boulders. Slope is v gradual. Ends abruptly with 0.5 m drop to B-C
T14	B - C	638302	7215325	2.49	44.50	SB	F	C	36	Below small 0.5 m drop, all flat v heterogeneous mix of large boulder to 45% fines and patchy. Some peri on larger rocks; sandy patches in depressions. Very heterogeneous mix to edge of C where slope changes with transition to fines.
T14	C - D	638269	7215295	4.18	17.00	S	S	M		Short moderate slope to 100% fines at edge of slope before sharp turn to fines. Water ~2m below D, uniform fines beyond D. Some periphyton on top of boulders.
T14	D	638254	7215286							

Table 4-1. Location (UTM), transect distance by segment, habitat classification and description of 2009 ground survey transects of the NW Arm of Second Portage Lake.

T15	A - B	638263	7215442	40.87	71.0	B	F	MC	37	Very similar to T14; heterogeneous boulder large cobble mix. Few cobble patches here and there inercepted by large boulders. Few discrete patches of cobble ~30% cover. Flat medium complex, good peri cover
T15	B - C	638205	7215401	3.72	26.6	BS	F	MC	38	As T14, transition from boulder to small boulder moderately complex cobble mix, with fines interspersed across shallow moderate slope - at C slope ends and flattens across to D
T15	C - D	638185	7215383	3.57	52.0	S	F	U	39	Muddy shallow bottom with few small boulders, cobble patches connecting platform to shoal.
T15	D - E	638145	7215347	2.91	23.2	S	F	U	40	Transition to patchy cobble ground to start of shoal.
T15	E - F	638128	7215332	2.42	87.5	BS	F	C		Shoal habitat; Mostly submerged - ice cover in top of taller boulder and central bedrock platform; peri growth; heterogeneous, complex mix of substrate 2/3 across lake adjacent to shoal at boulder shelf; steep 1 m decline to mostly fines with few gravel patches, rapid transition down to mud and water.
T15	F	638066	7215270							
T16	A - B	638017	7215682	1.90	34.8	B	F	M	41	Very large uniform angular boulder field, broken rock very jumbled and mixed- preiphyton cover good; fine sediment (dried) on everything in this area
T16	B - C	637998	7215652	2.2	17.00	BS	F	C	42	~2m below transition to heterogeneous mix of gravelly boulder cobble of very mixed size and composition; patchy, flat ice compressed and probably ice covered except in interstitial spaces
T16	C - D	637986	7215641	4.02	4.3	BS	S	C	43	Short steep boulder wall with sharp drop to mud bottom at foot of boulder wall- no transition to anything except fines
T16	D	637983	7215638							
T17	A - B	637874	7215937	2.52	46.2	B	F	MC	44	Large boulder slightly rounded with cobbly patches of moderate complexity; good peri cover flat, shallow slope, ice to bottom
T17	B - C	637836	7215910	3.77	4.3	B	S	M	45	short steep boulder slope to edge of very deep shelf soft silt clay mud at C
T17	C	637833	7215907							
T18	A - B	637505	7215989	1.75	21.5	B	F	M	46	Large boulder field short reach, peri on rocks, less sediment on surface; transition from very large to large boulders, some very large cobble at lip of ledge at 13. Ice to upper lip of slope
T18	B - C	637501	7215968	4.33	5.2	BS	S	C	47	Very steep slope ~35 degree of boulder and cobble with course gravel eroded; no periphyton; Top of slope is flattened. Probably ice limited. Below at base of slope is immediate transition to gravel (1m) and thick deep mud.
T18	C	637501	7215964							
T19	A - B	637286	7215978	1.71	37.4	BS	F	C	48	Heterogeneous mix of large boulder, cobble with cobble/sand mounds and patches. Few very large boulders and mounded terrain although slope to shore is flat.
T19	B - C	637285	7215941	2.12	51	BS	F	C	49	Transition from boulders to patchy boulder and cobble gravel sand patches and mounds at 1.6-1.8 m elevation (depth)- probably still ice covered at maximum ice thickness; good periphyton cover. Surface sedimentation
T19	C - D	637287	7215926	4.28	4.7	BS	S	C	50	Very steep unstable slope of boulder, cobble, gravel to mud at base of slope
T19	D	637287	7215922							
T20	A - B	637305	7215752	1.62	37.6	B	F	M	51,52	Ice scoured boulder medium size, some cobble patches. Partly rounded stone, flat surface profile, peri and silt cover on rock. Uniform slope from shore to ~2m depth where no substrate transition - but change in ice
T20	B - C	637315	7215789	3.2	23.2	BS	F	C	53	Large boulder dominant but with more cobble patches. Heterogeneousdistribution of material, substrate becomes finer down the transect below ice level. Reasonable peri cover transition to rock and large cobble at end of C
T20	C - D	637321	7215811	4.06	4.7	BS	S	C	54	Short steep boulder slope to sharp transition to fines, soft and deep right at water edge. Beneith boulder is fine material at edge.
T20	D	637322	7215814							
T21	A - B	637582	7215586	1.98	35	B	F	MC	55	Very similar to T20. Wind perpendicular to shore. Large mod complex boulder with small patches of large cobble here and there. Angular rock, peri covered. Ice flattened rock ~ darker colour because less peri cover than below ice level and main reason for change between B&C, although there is also a change in substrate composition.
T21	B - C	637606	7215613	2.72	18	BS	F	M	56	Reduction in substrate size, smaller boulder, more cobble, some small gravel patches. Slope very shallow and uniform from shoreline to top of C at transition.
T21	C - D	637617	7215627	4.33	5.1	B	S	M	57	Sharp steep slope of small boulder/rock, peri cover - still looks ice compacted.
T21	D	637620	7215630							
T22	A - B	637831	7215407	1.96	47.2	B	F	MC	58	Very similar to T21. Large boulder field gradual sloping into lake. Moderate complexity; larger cobble in interstitial space. Good peri cover, sediment. Ice scour at lower end of transect. Which ends near the 2 m depth zone and near ice bottom level.
T22	B - C	637855	7215448	2.08	12.8	B	F	M	59	Flat slope of boulder cobble mix. Some patches of small cobble/gravel, possible ice compacted. Heterogeneous mix of materials. Peri cover.
T22	C - D	637860	7215459	3.2	5.9	B	S	C	60	Short steep unstable slope of small boulder cobble. Soft bottom in ~1/3 m below water level.
T23	A - B	637916	7215349	8.18	9.3	S	F	U	61	Steep bedrock shelf. Slope to 2 m and near bottom of ice level, beginning shallow sloping boulder
T23	B - C	637919	7215341	2.43	18.2	B	F	C	62	Heterogeneous mix of boulder, cobble, broken rocks few gravel/sandy materials and complexity- leading to boulder shelf/slope
T23	C - D	637929	7215327	3.2	4.2	B	S	C	63	short steep (1m) boulder wall to fine sediment.
T23	D	637932	7215323							Shoal. Thin layer of fines with cobble boulder mix (30%). 1 to 1.5 m elevation below current elevation. About 40 m away to good shoal.
T24	A - B	637870	7215257	2.71	22.2	S	F	U	64	Steep sloping large fractured rock slabs extending from shoal to ~ 3m depth. Some bedrock face, boulder very very large boulder extending to foot of slope. Peri moderate.
T24	B - C	637881	7215239	4.01	7.8	BS	S	C	65	At foot of B, transition to heterogeneous mix of cobble rock and small boulder. Appears to be good species spawning habitat wrt depth, slope , cover, interstitial spacing. At foot of C, rapid transition to clay.
T24	C	637884	7215232							
T25	A - B	637907	7215144	1.88	5.1	S	S	U	67	Very short, very steep slope ~3m to floor consisting of fractured bedrock and boulder, rubble field to below ice scour zone.
T25	B - C	637909	7215148	2.25	18.4	BS	F	C	69	Long flat base of heterogeneous mix of boulder and cobble, large and small. Lots of good spawning habitat, some peri. Beneath rubble is sand. Toe of table grain size diminshes to cobble boulder mix to toe of slope at C
T25	C - D	637915	7215166	4.04	5.4	B	S	C	70	Steep short loose small boulder, large cobble field. 4-5 m depth to intersection with fines. Very oxidized surface, reddish colour vs grey elsewhere
T25	D	637917	7215170							

Table 4-1. Location (UTM), transect distance by segment, habitat classification and description of 2009 ground survey transects of the NW Arm of Second Portage Lake.

T26	A - B	638007	7215019	2.4	31	B	F	C	71	Initially, a drop of 1 m to 10 m away, flattening. Substrate is fractured rock and cobble, relatively small size interspersed with small boulders. Excellent peri cover, nice flat shelf brobably good for foragingm rearing. Probably ice covered to end of slope before steep drop.
T26	B - C	638036	7215029	4.5	5.2	B	S	C	72	Short steep boulder wall falling quickly to mud. Bottom a few m away. Over 2 m elevation
T26	C	638041	7215031							
T27	A - B	638133	7214742	1.7	9.1	S	S	M	73,74	Short steep slope of bedrock, fractured bedrock and boulder. A bit of ice scour and poor peri coverage. Heterogeneous mix of boulder, cobble, broken rocks at toe of slope.
T27	B - C	638140	7214746	2.19	6.9	BS	S	M	75,76	Transition to flat slope ~1.5m depth with v heterogeneous mix of substrates including gravel and sand. Excellent peri growth. Probably ice covered late winter. Very good complexity with different materials and sizes.
T27	C - D	638147	7214750	5.5	8.1	BS	S	C		Very steep and deep unstable boulder/cobble/gravel substrate. Ending sharply at mud ~2-3.5m down 35 degree slope.
T27	D	638152	7214755							
T28	A - B	638381	7214473	1.57	13.2	B	F	M	77	Moderate sloping boulder field (bedrock at top) with large cobble intermixed; gently sloping to base where transtion to smaller boulder cobble and small cobble/gravel patches. Good peri coverage excet at top (ice)
T28	B - C	638387	7214485	1.79	8.4	B	S	C	78	Flat bench of boulder/cobble/gravel below initial slope ~3m wide, ice flattened and stable. V good compexity of material. Rearing/feeding habitat. Extends all long this part of the lake.
T28	C - D	638391	7214492	5.88	8.6	B	S	C	79	Very steep, very unstable skree slope of boulder cobble, large gravel. Extending to toe of slope where it appears to flatten and become muddy silt/clay.
T28	D	638394	7214500							
T29	A - B	638639	7214341	1.6	31.5	SB	F	M	80	Very large booulder field running down shallow slope with many large (2m squared) flat rock slabs. Lots of s.a. for peri growth, especially below .5m elevation. Probably ice covered in winter.
T29	B - C	638660	7214364	5.5	9.2	SB	S	M	81	Very steep unstable slope of large boulder. Some cobble. At top of slope few ridges of small cobble, large gravel. At toe of slope, transition to mud.
T29	C	638662	7214376							
T30	A - B	638789	7214181	2.61	39.3	B	F	M	82	Moderate sloping boulder field of broken rock, angular slab descending down with even pitch. Moderate peri growth. Toe of slope ~2m or at ice level and transitions to short slope down to foot of rocky shoal.
T30	B - C	638809	7214214	4.65	17.4	SB	S	M	83	Transition zone from boulder across heterogeneous mix of materials to foot of shoal. Some fines, gravel, small cobble and sand.
T30	C - D	638821	7214227	3.8	11.1	SB	F	M	84	Increase in elevation to rocky shoal of compacted gravel/cobble. Mostly flat surface. Not much vertical diversity. Moderate periphyton coverage
T30	D - E	638828	7214235	6.42	26.3	SB	S	M	85	Same as above, but less slope to mud in lake.
T30	E	638844	7214256							
T31	A - B	638881	7213991	1.84	7.4	B	S	C	86	Steep slope, boulder and some cobble. Heterogeneous mix of substrate with good vertical diversity to ~2m depth with ice level good peri growth with some ice scouring.
T31	B - C	638887	7213990	2.66	3.9	B	S	C		Along some slope. Similar to substrate but below 2m and ice zone. Toe of C starts very steep. Drop to fine substrate.
T31	C - D	638891	7213989	5.11	5.4	S	S	U	87	From C-D quiet transition from boulder to sandy gravel with some scattered boulders, cobble. Toe of D is mud.
T31	D	638896	7213988							
T32	A - B	638962	7213860	2.0	31.4	B	F	U	88	Gently sloping to large boulder field with mix of boulder size large/very large to 5 pin bowling size. Lots of interstitial space, periphyton. To toe of slope, consistent distribtion of materials ~ smaller grain size at toe
T32	B - C	638940	7213883	4.7	7.1	B	S	U	89	Large boulders 1.5-2m squared like a wall to fines. Wind blows straight onto slope. No fines on boulders or in spaces. Good spawning habitat?
T32	C	638937	7213888							
T33	A - B	639170	7213928	1.65	31.4	B	F	MC	90	Long even slope of large to very large boulder with few cobble patches near shore. Very good peri cover. Moderate to good complexity. Good vertical ~1m height - lots of cover. Foraging, rearing habitat.
T33	B - C	639172	7213959	4.5	9.8	SB	S	U	91	Steep slope to lake basin; Transition from large boulder on top to compact cobble gravel, sand at toe. Possible spawning habitat at toe. Moderate peri growth
T33	C - D	639171	7213968	5.66	8.1	S	S	U	92,93	Relatively flat transition from gravelly sand to sandy/silt.
T33	D	639169	7213976							

Figure 4-1. Map showing location of 2009 ground survey transects of NW arm of Second Portage Lake.

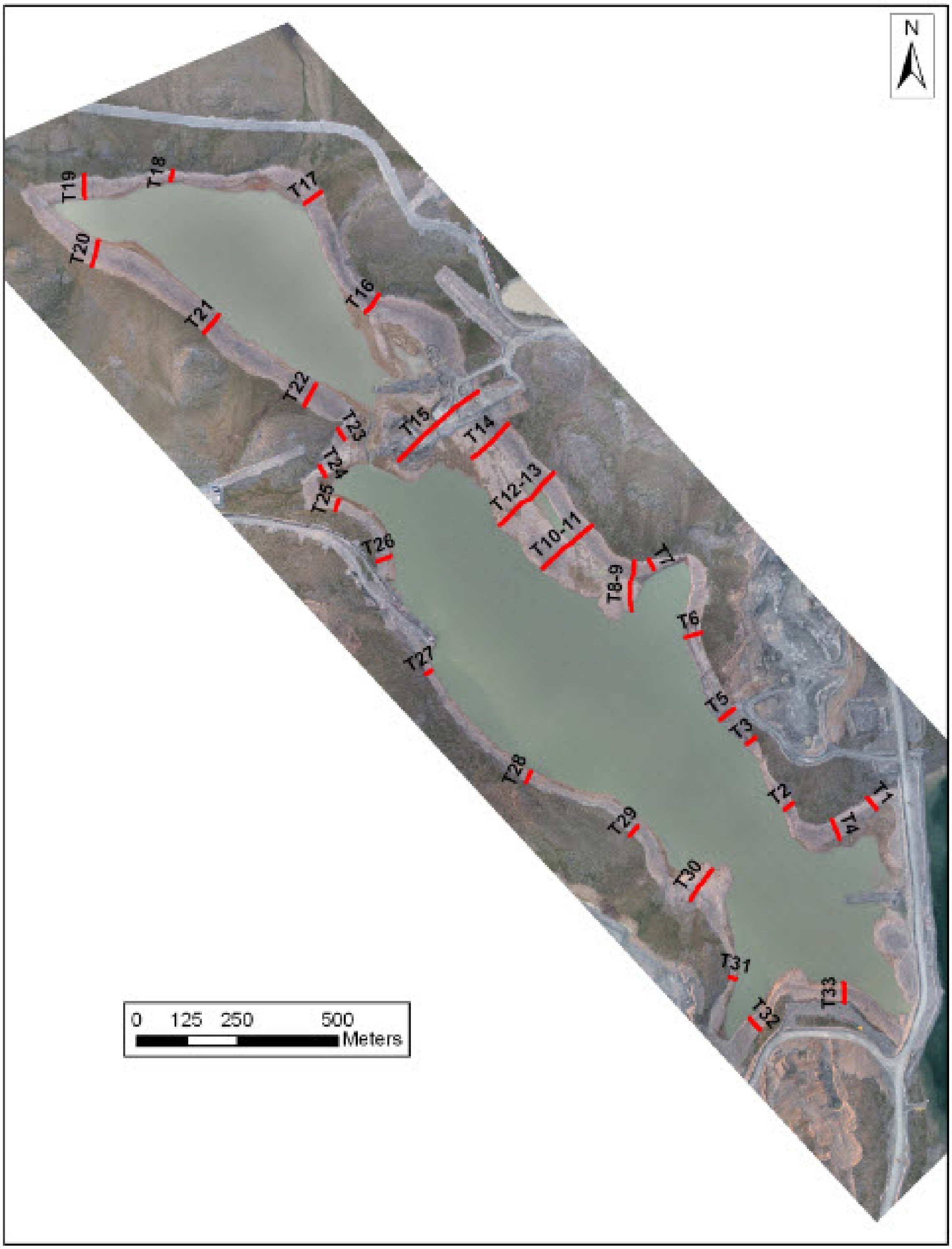


Figure 4-2. Photo of sill area (taken on 22 July 2009) looking east towards the central basin of the northwest arm.

Note: The foreground (lower right portion away from the sill) shows typical habitat zonation found in the northwest arm.

5. COMPARISON OF MAPPING RESULTS

This section compares results of the three independent mapping techniques:

- The 2006 air photos (through water) (**Section 2**)
- The 2009 air photos (through air) (**Section 3**)
- The 2009 ground survey (**Section 4**)

The objective of this exercise was to comparatively assess the accuracy and precision of each method to map important fish habitat features. The 33 ground transect lines from 2009 were considered the 'gold standard' against which to quantitatively compare the two different mapping results

5.1. Methods

Given that the 2009 ground survey covered the 33 transects only, these lines were used as the basis for comparing the three mapping techniques. Note that some transects (T8-T9, T10-T11 and T12-T13) were dealt with as single transects because they were essentially contiguous, usually separated by small sections of low-value sediment basin habitat. These lines were overlain onto each of the air photo maps (i.e., **Figure 2-1** or **Figure 3-2**) and "clipped" according to the underlying habitat boundaries. This means that each transect was represented by one to three line segments, depending on how many habitat polygons the transect crosses.

5.2. Results

The clipped transect results (segment lengths, habitat attributes and habitat value score) for the 2006 and 2009 air photo based maps are provided in **Appendix F-1 and F-2**, respectively. documents the total length (m) of each 2009 transect or segment clipped to the original 2006 habitat polygons and describes the attribute and score of the assigned habitat beneath the transect. Profiles of each of the three methods for each transect are provided in **Appendix F**. Depth was not included as part of the profile information for the 2006 and 2009 clipped transects, so the focus of comparisons is how accurately key breakpoints in the transects match the ground survey results.

The single most obvious difference between the air surveys and the ground survey was the ability of the latter to distinguish the steep transition zone that occurred at the end of most transects. This resulted in more habitat segments and more high-value ratings in the ground survey transects than either of the aerial survey methods, which most frequently only identified one segment (i.e., A-B). The other difference is total length of many transects. Because we measured distance between the shoreline and the transition to low value sediment basin habitat using a tape measure, this is considered most accurate. Air photo interpretation in 2009 from the dewatered impoundment was frequently very close to the ground survey results, seldom differing by a few meters. However, the 2006 survey distance was more frequently shorter in distance than equal or greater distance than the ground or 2009 surveys. This is because it was more difficult to distinguish the transition zone between rocky and silt/clay habitat through the water because of the depth of this transition (6 – 8 m).

The biggest difference between 2006 and 2009 aerial survey methods was in the distribution and amount of high habitat polygons. The ability to “see” the underlying habitat in the 2009 photos meant that fewer assumptions were made regarding the underlying features. Interestingly, this resulted in fewer polygons being rated as high-value habitat (this is discussed more in **Section 6**).

The 2009 (through air) air photos provide greater resolution than the 2006 (through water) interpretation. Where only 21 habitat polygons were identified from the 2006 survey, 52 polygons were identified from the 2009 imagery of the partially drained impoundment (**Appendices A and B**, respectively). However, both methods were open to some subjectivity and/or bias because of the lack of ability to confidently distinguish slope, depth change and subtle, but important changes in substrate composition and complexity. The ground survey was much more effective at detecting these changes and allowing better discrimination of habitat types (**Appendix C**).

6. INTEGRATION OF MAPPING RESULTS

The logical extension of the previous comparisons was to integrate the 2009 ground survey results into interpretation process using the 2009 aerial photographs. This not only allowed the specific results of each transect to be considered in the interpretation, but also allowed interpolation of features between transects (i.e., to link common habitat types around the lake).

Ultimately, better discrimination of polygons and habitat attributes could be achieved by overlaying findings of the 2009 ground survey along the transect lines while combining bathymetry, transect depths and slope from the ground survey findings. Having access to the transect habitat scores and depths allowed for higher resolution and more accurate air photo interpretation. It became obvious that there was indeed a steep habitat band along a large portion of shoreline that was not easily distinguishable in the initial "unbiased" 2009 habitat interpretation (**Figure 3-2**). Using the survey depths also allowed for better depth classifications and ice scour ratings of the polygons. As a result of this exercise, 78 unique polygons were delineated and described (**Appendix H**).

As a matter of note, when some transects were laid on top of the map it was apparent that there was some locational error in either georeferencing of the map sheet due to slight warping in certain areas or in small GPS survey errors in control points, or both. In the end it was assumed that the airphoto was generally in the right location and certain transect points were slightly misplaced (GPS error or warping) by a few meters. This assumption was backed up by the location of the 2006 habitat polygons which generally fit the 2009 air photograph. The origins of transects T10, T11, T12, T13, T14, T25, T26 and T31 where slightly shifted on the order of 3 – 5 m.

The 78 polygons were assigned a habitat value of low, moderate or high and are mapped in **Figure 6-1**. This "2009 Integrated" map clearly shows the narrow band of high value habitat that extends much of the way around the lake that is associated with apron habitat. In addition there are areas of high value on the shoal that lies across the sill separating the north and middle basins, along the shoal extending south from the sill along the eastern shore and at two small areas on the south east corner of the lake.

Figures 6-2 and **6-3** illustrate the southern and northern halves of the impoundment, respectively, with the transect lines overlaid. The clear demarcations between high, moderate and low habitat on each transect allowed for interpolation of polygons between transects.

Finally, **Table 6-1** presents the number of habitat polygons and hectares of high, moderate and low value habitat from each of the three mapping techniques (i.e., 2006 and 2009 air photo interpretations and the 2009 "Integrated"). The number of hectares of low value, and to a slightly lesser extent moderate value, habitat were similar among all three methods because it was relatively easy to distinguish low value deep water sediment basin habitat. The major difference was in the hectares of high value habitat. Relative to the 2009 “Integrated” map, the 2006 mapping exercise was too liberal, overestimating the amount of high value habitat, while the 2009 exercise was too conservative and was not able to distinguish the certain features (e.g., slope, depth) that are important for high value habitat.

With respect to estimates of overall habitat units, we compared predicted total HUs for the entire northwest arm (i.e., everything northwest of the East Dike) for each method to the NNLP (Azimuth, 2006) predictions (**Table 6-2**). The NNLP estimated that 555 HUs would be affected, based on the 2006 aerial habitat mapping exercise. This differs slightly from our re-examination of the 2006 data (522.5 HUs) because orientation and size of the East Dike were slightly different than was assumed in 2006. The 2009 aerial photographic interpretation, with lower high value habitat estimated that 467 HUs would be affected. The 2009 integrated map provides the best estimate of habitat value and accounts in a loss of 472.8 HUs, which is less than the estimate of 522.5 HUs from the 2006 aerial photographic interpretation accounting for the actual orientation and size of the East Dike as constructed.

Table 6-1. Number and area (ha) of low, moderate and high value polygons from the 2006 aerial, 2009 unbiased aerial and 2009 integrated habitat surveys.

Survey Method	Number Habitat Polygons	Total Area (ha)	Number Low Value Polygons	Area Low Value Polygons	Number Moderate Value Polygons	Area Moderate Value Polygons	Number High Value Polygons	Area High Value Polygons
2006 Aerial Through Water	21	132.2	4	85.5	12	32.8	5	13.9
2009 Aerial Unbiased Through Air	52	131.4	8	89.9	40	39.7	4	1.8
2009 Integrated Ground and Air	78	131.4	15	93.9	41	28.4	22	9.1

Table 6-2. Comparison of Habitat Units (HUs) from 2006 NNLP, 2006 and 2009 air photo interpretation and 2009 ground survey.

Survey Method	Habitat Type	Area (ha)	HIS	Habitat Units
2006 No Net Loss Plan	High	14.0	8.90	124.6
	Moderate	38.0	6.06	230.3
	Low	85.5	2.34	200.1
	Total			**555.0**
2006 Aerial Photograph	High	13.9	8.90	123.7
	Moderate	32.8	6.06	198.8
	Low	85.5	2.34	200.1
	Total			**522.5**
2009 Aerial Photograph	High	1.8	8.90	16.0
	Moderate	39.7	6.06	240.6
	Low	89.9	2.34	210.4
	Total			**467.0**
2009 Integrated	High	9.1	8.90	81.0
	Moderate	28.4	6.06	172.1
	Low	93.9	2.34	219.7
	Total			**472.8**

Figure 6-1. Map showing habitat values of 2009 integrated map of ground survey and air photo information.

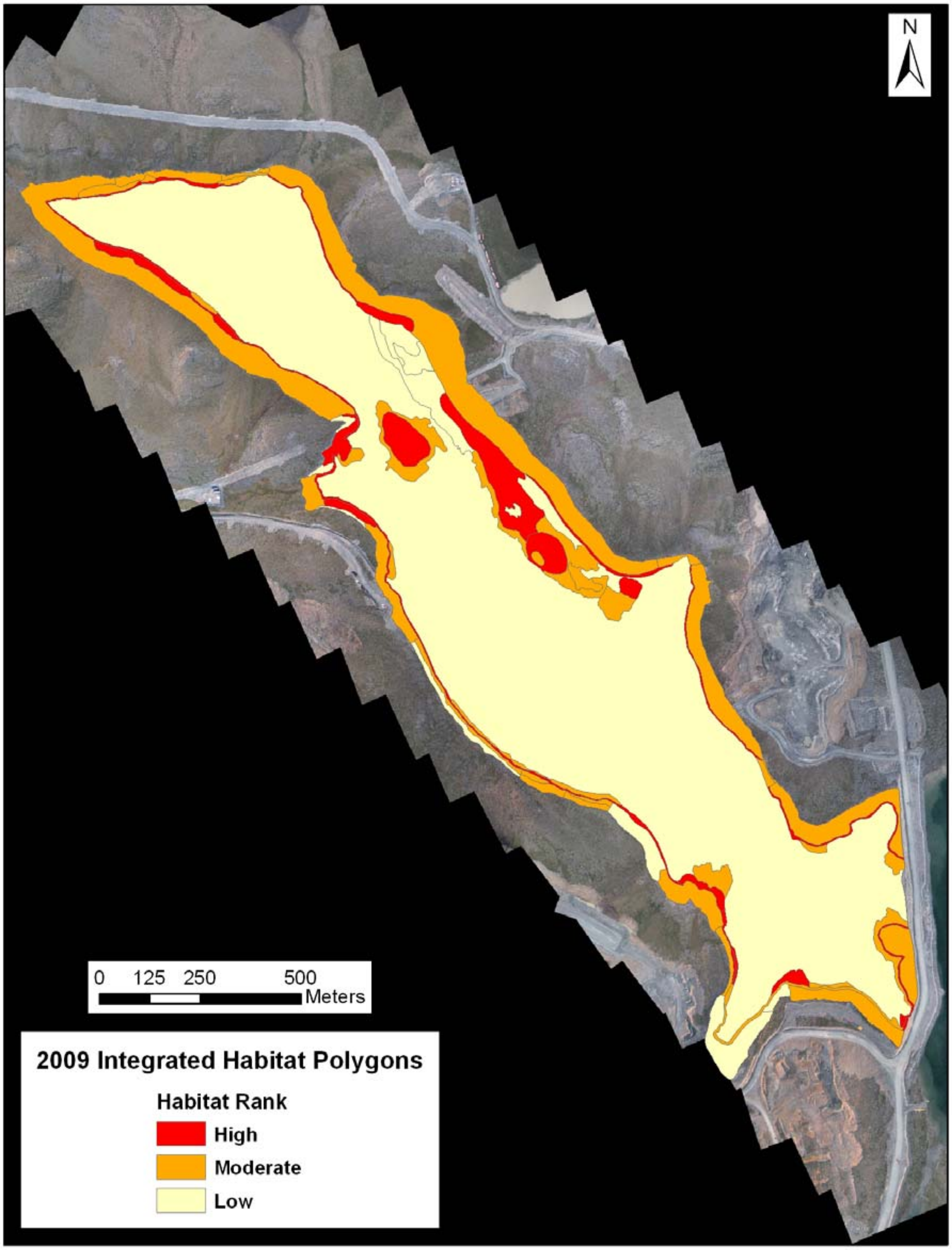


Figure 6-2. Map showing transect location and habitat value of 2009 ground transects transposed on integrated map, south NW arm.

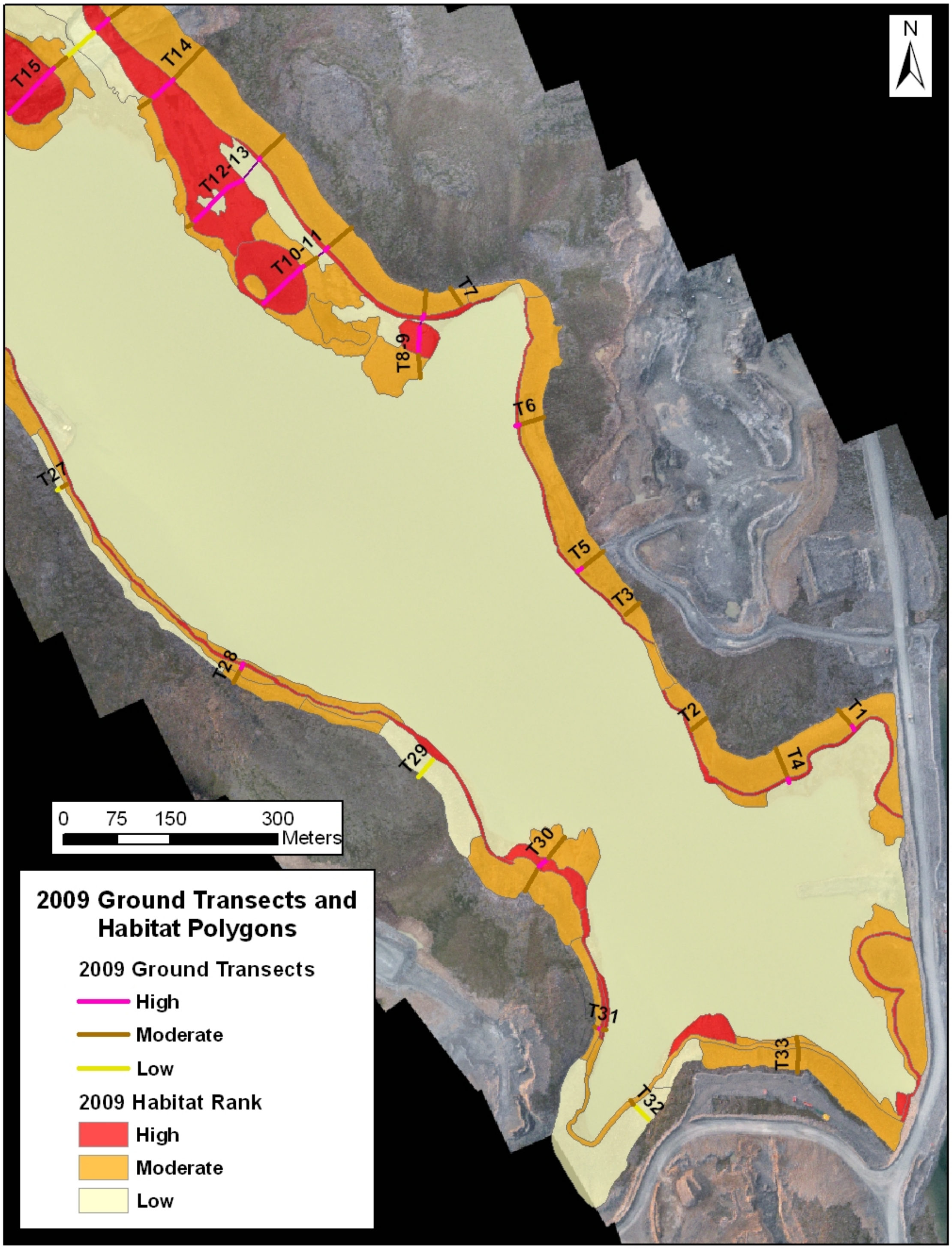
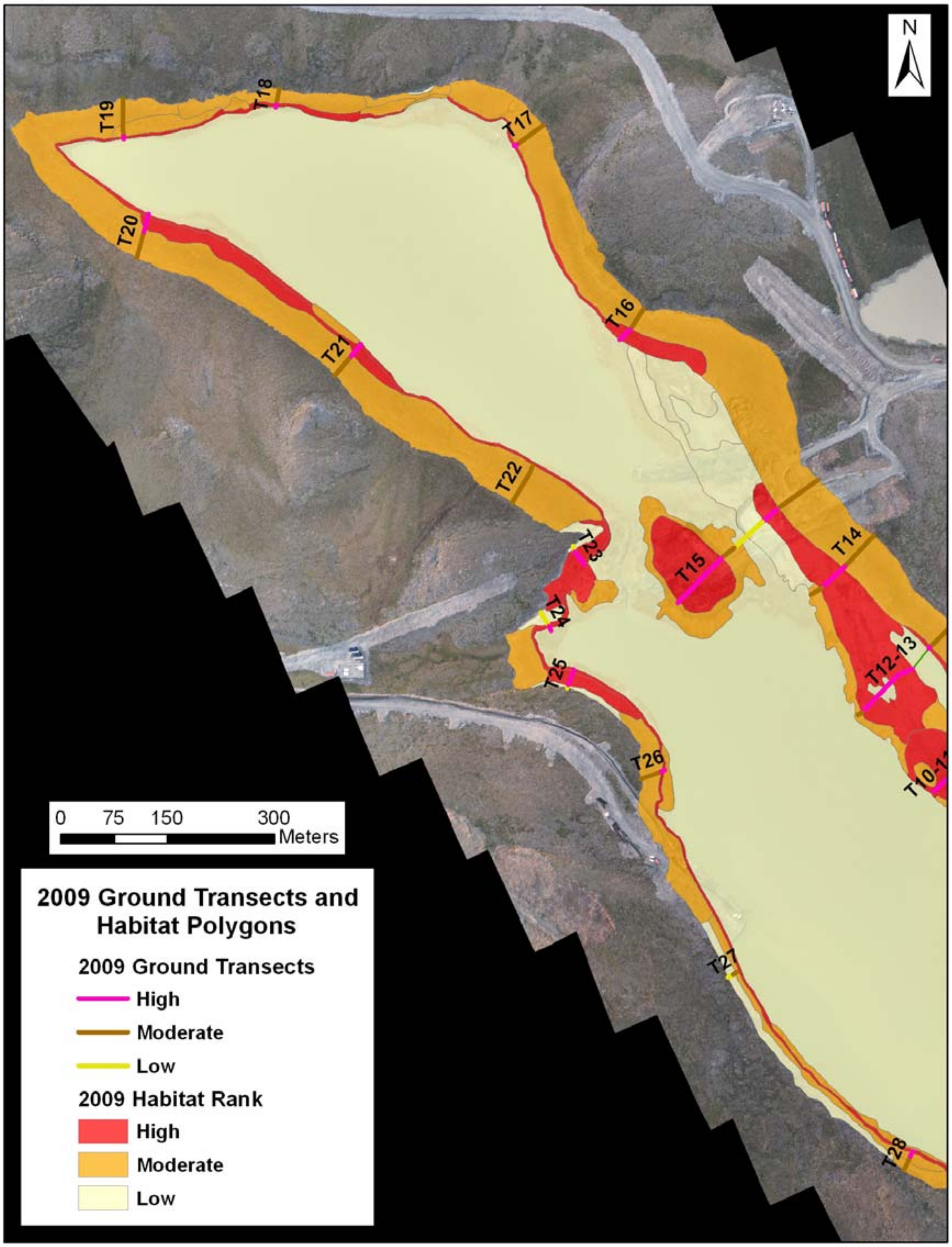


Figure 6-3. Map showing transect location and habitat value of 2009 ground transects transposed on integrated map, north NW arm.



7. RELATIONSHIPS BETWEEN HABITAT AND FISH BIOMASS

Construction of the East Dike isolated the northwest arm of Second Portage Lake from the rest of the lake. Prior to draining the northwest arm for various aspects of mine development, a fish-out program was implemented during the open water season of 2008 (Azimuth, 2009), as required by the Authorization.

The fish-out report included a detailed assessment of a range of published models used to estimate fish biomass from limnology and productivity data (Azimuth, 2009). The advantage of these models is that they can be parameterized fairly easily and give reasonable estimates of biomass. Their main drawback, however, is that they fail to incorporate site-specific information such as habitat quality and quantity.

Given the wealth of information available from the fish-out program and habitat mapping, it would be useful in the long term to “harvest” this information to better understand the importance of habitat to overall productivity, particularly for lakes that might be nutrient limited. Ultimately, after such programs were completed at a range of northern lakes, and the underlying relationships determined across these sites, this could lead to more accurate quantification of habitat losses and more efficient design of compensatory habitat. In the interim, however, the northwest arm data represents only a single sample, so there is great uncertainty in directly using these data to infer relationships elsewhere.

During the 2008 fish-out program, a total of 3078 fish weighing 1123 kg were removed from the northwest arm (see Azimuth, 2009 for a much more detailed discussion regarding population estimates, etc.) (**Table 7-1**).

The impoundment has a total surface area of 1.30 km^2 with a total estimated volume of 14.6 Mm^3 divided among three basins (**Figure 1-1**). As presented in **Table 6-2**, there were 473 habitat units in the northwest arm based on the 2009 “Integrated” habitat map (i.e., our best estimate).

Focusing on biomass only, estimates relating to surface area, water volume and habitat units are as follows:

- Assuming a volume of 14.6 Mm^3 of water, this equates to 0.0077 kg of fish / 1000 m^3
- Assuming a surface are of 1.4 km^2, this equates to 0.86 kg fish per hectare
- Assuming the impoundment contains 472 HUs, this equates to 2.3 kg of fish per habitat unit in the northwest arm of Second Portage Lake.

Table 7-1. Biomass and catch for the northwest arm of Second Portage Lake after the final removal phase of the fish-out program in 2008.

Species	Catch (number)	Catch (biomass in kg)
Lake trout	2018	721
Arctic char	485	298
Round whitefish	295	74
Burbot	280	30
Totals:	3078	1123

8. CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations for this study were as follows:

- The number of hectares of low value, and to a slightly lesser extent, moderate value habitat was similar among all methods because of the ease in delineating low value habitat.
- Distinguishing between 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.
- Scoring of habitat attributes should be changed. Platform score reduced to 2 from 4; apron score from 2 to 4 and shoal maintained at 4. This change would reflect the greater importance of apron habitat over platform habitat because of the greater slope and substrate diversity possessed by apron morphology that was not appreciated until dewatering and results of the ground survey.
- Air photograph acquisition using a remotely controlled aircraft was highly successful, being rapid, inexpensive, and providing good quality images.
- In future, changes to HSI indices could be altered to reflect the relatively greater proportion of burbot and smaller proportion of lake trout and round whitefish; however, fish composition may be different in another impoundment than in Second Portage Lake.
- While the 2006 mapping exercise was too liberal, overestimating the amount of high value habitat, the 2009 exercise was too conservative, unable to distinguish key features (e.g., slope, depth) that distinguish high from moderate value habitat. Ground survey results were key to properly measuring basin-wide habitat value.
- In general (i.e., for application at other sites too), habitat mapping based on through-water imagery would benefit from combined use of underwater video and detailed bathymetry conducted in an analogous manner to the ground surveys reported herein.
- We found differences among methods in total HU estimates for the northwest arm relative to the 2006 NNLP estimates (555 HUs). Based on the 2006 air photos, there were fewer HUs (522.5) because the as-built orientation and size of the East Dike is slightly different than was assumed in 2006. From the 2009 air photo mapping, we estimated 467 HUs, primarily because of the lack of high value habitat discerned. The 2009 integrated map provided the best estimate of habitat distribution yielding 472.8 HUs, 82 less than predicted in 2006.

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APPENDICES

APPENDIX A

HABITAT ATTRIBUTES, SCORES AND VALUE OF 2006 AERIAL PHOTGRAPH POLYGON INTERPRETATION.

Appendix A: Habitat attributes, scores and value of 2006 aerial photgraph polygon interpretaion.

	Habitat Attribute						Habitat Attribute Score								
Polygon	Substrate	Morphology	Depth	Complexity	Slope	Ice Cover	Substrate Score	Morphology Score	Depth Score	Complexity Score	Slope Score	Ice Cover Score	Total	**Habitat Value**	**Polygon Area (ha)**
1	S	A	M	U	S	N	2	2	4	2	2	0	12	High*	0.03
2	S	A	M	U	S	N	2	2	4	2	2	0	12	High*	1.13
3	B	P	S	C	F	N	6	4	1	6	0	0	17	Moderate	0.34
4	S	PS	VD	U	M	N	2	1	2	2	0	0	7	Low	21.90
5	BS	S	M	C	M	N	8	3	4	6	0	0	21	High	0.99
6	BS	S	S	C	F	Y	8	3	1	6	0	-2	16	Moderate	1.06
7	SB	S	M	M	M	N	7	3	4	4	1	0	19	High	7.25
8	SB	S	M	M	M	N	7	3	4	4	1	0	19	High	4.46
9	S	S	M	M	M	N	2	3	4	4	1	0	14	Moderate	0.02
10	S	S	M	M	M	N	2	3	4	4	1	0	14	Moderate	2.22
11	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	0.81
12	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	0.65
13	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	0.19
14	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	0.45
15	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	0.00
16	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	19.89
17	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	4.37
18	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	2.80
19	S	PS	VD	U	M	N	2	1	2	2	0	0	7	Low	7.75
20	S	PS	VD	U	M	N	2	1	2	2	0	0	7	Low	33.85
21	S	PS	VD	U	M	N	2	1	2	2	0	0	7	Low	21.98

* Note that these two polygons were subsequently ranked as high based on high slope, although underwater features were poorly distinguishable.

APPENDIX B

HABITAT ATTRIBUTE, SCORE AND VALUE OF 'UNBIASED' POLYGONS FROM 2009 AERIAL PHOTOGRAPH INTERPRETATION

Appendix B. Habitat attribute, score and value of 'unbiasted' polygons from 2009 aerial photograph interpretation.

	Habitat Attribute						Habitat Attribute Score								
Polygon	Substrate	Morphology	Depth	Complexity	Slope	Ice Cover	Substrate Score	Morphology Score	Depth Score	Complexity Score	Slope Score	Ice Cover Score	Total	**Habitat Value**	**Polygon Area (ha)**
1	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	87.68
2	SB	P	M	M	F	N	4	4	4	4	0	0	16	Moderate	0.14
3	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	6.55
4	SB	A	M	M	F	N	4	2	4	4	0	0	14	Moderate	0.33
5	S	P	M	U	F	N	2	4	4	2	0	0	12	Moderate	0.06
6	SB	A	M	M	S	N	4	2	4	4	2	0	16	Moderate	0.16
7	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.50
8	S	P	M	U	F	N	2	4	4	2	0	0	12	Moderate	0.12
9	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.14
10	S	P	S	U	S	Y	2	4	1	2	2	-2	9	Low	0.01
11	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.11
12	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.13
13	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.34
14	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.10
15	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.13
16	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.19
17	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	2.13
18	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.10
19	SB	P	M	M	F	Y	4	4	4	4	0	-2	14	Moderate	0.10
20	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.02
21	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	1.94
22	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.17
23	SB	A	M	M	F	N	4	2	4	4	0	0	14	Moderate	0.43
24	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	1.02
25	BS	P	M	M	F	N	8	4	4	4	0	0	20	High	0.06
26	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.10
27	BS	A	M	M	F	N	8	2	4	4	0	0	18	High	0.23
28	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	1.21
29	SB	P	S	M	F	Y	4	4	1	4	0	-2	11	Low	0.22
30	SB	A	M	M	S	N	4	2	4	4	2	0	16	Moderate	0.05
31	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	1.46
32	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.37
33	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.59
34	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.31
35	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	1.07
36	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.88
37	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.15
38	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.26
39	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.47
40	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	1.70
41	BS	S	M	M	F	N	8	3	4	4	0	0	19	High	0.71
42	SB	SB	VD	M	F	N	4	1	2	4	0	0	11	Low	0.24
43	SB	SB	D	M	F	N	4	1	3	4	0	0	12	Moderate	0.26
44	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	5.00
45	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	0.58
46	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	0.41
47	SB	SB	D	M	F	N	4	1	3	4	0	0	12	Moderate	0.54
48	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	8.45
49	BS	S	M	M	S	N	8	3	4	4	2	0	21	High	0.80
50	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	0.08
51	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	1.94
52	SB	P	S	M	F	Y	4	4	1	4	0	-2	11	Low	0.70

APPENDIX C

ELEVATION, UTM, SLOPE, ATTRIBUTE, FEATURE SCORE AND HABITAT VALUE OF 2009 GROUND TRANSECT SURVEY LOCATIONS

Appendix C: Aerial photographs of the stormwater dike prior to construction.

Photo 1: View of stormwater dike area looking north

Photo 2: View of stormwater dike area looking south

APPENDIX D

PHOTOS OF TRANSECTS FROM 2009 GROUND SURVEY OF NW ARM

Appendix D. Elevation, UTM, slope, attribute, feature score and habitat value of 2009 ground transect survey locations.

	UTM							2009 Attributes						2009 Feature Score							
Transect Segment	Easting	Northing	Elevation (m) at Start	Depth at End (m)	Transect Length (m)	Segment Length (m)	Slope	Depth	Slope	Ice scour	Substrate	Morphology	Complexity	Depth	Slope	Ice Scour	Substrate	Morphology	Complexity	TOTAL SCORE	Habitat Value
T1A - B	639227	7214434	133.1	1.43	36	30.4	0.047	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T1B - C	639248	7214412	131.6	3.16	36	5.8	0.298	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T1C	639016	7214405	129.9																		
T2A - B	639043	7214422	132.7	1.84	34.4	26.4	0.070	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T2B - C	639022	7214406	130.9	5.0	34.4	8.0	0.395	D	S	N	BS	A	M	3	2	0	8	3	4	20	H
T2C																					
T3A - B	638949	7214583	132.6	2.06	32.9	25.6	0.080	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T3B - C	638930	7214567	130.6	5.0	32.9	7.3	0.403	M	S	N	B	A	M	4	2	0	6	3	4	19	H
T3C	638924	7214562																			
T4A - B	639140	7214380	132.9	1.62	50.3	45.3	0.036	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T4B - C	639158	7214338	131.3	3.09	50.3	5.0	0.294	M	F	N	B	A	C	4	2	0	6	3	6	21	H
T4B - C	639152	7214380																			
T5A - B	638898	7214656	-	Not	44.1	36.9	-	S	F	Y	B	P	C	1	0	-2	6	2	6	13	M
T5B - C			-	surveyed	44.1	7.2	-	D	S	N	B	A	C	3	2	0	6	3	6	20	H
T5C	638863	7214628																			
T6A - B	638815	7214843	132.9	1.5	40.3	33.2	0.045	S	F	Y	B	P	C	1	0	-2	6	2	6	13	M
T6B - C	638776	7214832	128.9	4.0	40.3	6.9	0.362	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T6C	638776	7214832																			
T7A - B	638685	7215025	132.9	1.0	31.7	14.8	0.068	S	F	Y	BS	P	C	1	0	-2	8	2	6	15	M
T7B - C	638692	7215012	131.9	2.0	31.7	12	0.167	S	F	Y	B	P	C	1	0	-2	6	2	6	13	M
T7C - D	638699	7215002	130.9	4.0	31.7	4.9	0.408	M	S	N	BS	A	C	4	2	0	8	3	6	23	H
T7D	638700	7215000																			
T8A - B	638650	7215020	132.9	1.43	39.2	32	0.045	S	F	Y	BS	P	C	1	0	-2	8	2	6	15	M
T8B - C	638647	7214988	131.5	2.68	39.2	7.2	0.174	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T8C	638645	7214981	130.2																		
T9A - B	638640	7214969	129.8	3.75	70.3	37.7	0.099	M	F	N	BS	S	M	4	0	0	8	4	4	20	H
T9B - C	638639	7214931	129.2	6.1	70.3	32.6	0.072	D	F	N	SB	S	M	3	0	0	4	4	4	15	M
T9C	638643	7214899	126.9																		
T10A - B	638548	7215110	132.7	1.74	48.5	44	0.040	S	F	Y	BS	P	M	1	0	-2	8	2	4	13	M
T10B - C	638514	7215082	131.0	4.32	48.5	4.5	0.573	M	S	N	BS	A	C	4	2	0	8	3	6	23	H
T10C	638511	7215079	128.4																		
T11A - B	638499	7215069	128.3	3.20	109.2	23.0	0.139	M	S	N	SB	S	M	4	2	0	4	4	4	18	M
T11B - C	638480	7215057	129.5	1.91	109.2	4.2	-0.307	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T11C - D	638477	7215054	130.8	2.73	109.2	73.0	0.011	M	F	N	B	S	C	4	0	0	6	4	6	20	H
T11D - E	638425	7215004	130.0	5.50	109.2	9.0	0.308	D	S	N	BS	A	M	3	2	0	8	3	4	20	H
T11E	638507	7215080	-																		
T12A - B	638462	7215249	132.8	2.22	48.4	46.4	0.048	S	F	Y	B	P	M	1	0	-2	7	2	4	12	M
T12B - C	638429	7215217	130.6	3.01	48.4	2.0	0.395	M	S	N	B	A	M	4	2	0	6	3	4	19	H
T12C	638427	7215215	129.8																		
T13A - B	638404	7215186	128.7	4.10	103.0	22.3	0.049	M	F	N	BS	S	C	4	0	0	7	4	6	21	H
T13B - C	638383	7215176	130.1	2.52	103.0	72.2	-0.022	M	F	N	BS	S	C	4	0	0	7	4	6	21	H
T13C - D	638333	7215125	130.3	5.20	103.0	8.5	0.315	D	S	N	SB	A	M	3	2	0	4	3	4	16	M
T13D	638327	7215121	127.6																		
T14A - B	638342	7215368	132.8	2.12	120.7	59.2	0.036	S	F	Y	BS	P	M	1	0	-2	8	2	4	13	M
T14B - C	638302	7215325	130.7	2.49	120.7	44.5	0.008	M	F	N	BS	P	C	4	0	0	7	2	6	19	H
T14C - D	638269	7215295	130.3	4.20	120.7	17.0	0.101	M	S	N	S	A	M	4	2	0	2	3	4	15	M
T14D	638254	7215286	128.6																		
T15A - B	638263	7215442	132.9	2.03	208.30	71.0	-0.031	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T15B - C	638205	7215401	130.8	3.72	208.30	26.6	0.064	M	F	N	BS	P	MC	4	0	0	8	2	5	19	H
T15C - D	638185	7215383	129.2	3.57	208.30	52.0	-0.003	M	F	N	S	S	U	4	0	0	2	4	2	12	M
T15D - E	638145	7215347	129.3	2.91	208.30	23.2	-0.028	M	F	N	SB	S	U	4	0	0	4	4	2	14	M
T15E - F	638128	7215332	130.0	2.42	208.30	87.5	-0.006	M	F	N	BS	S	C	4	0	0	8	4	6	22	H
T15F	638066	7215270	130.5																		

Appendix D. Elevation, UTM, slope, attribute, feature score and habitat value of 2009 ground transect survey locations.

	UTM							2009 Attributes						2009 Feature Score							
Transect Segment	Easting	Northing	Elevation (m) at Start	Depth at End (m)	Transect Length (m)	Segment Length (m)	Slope	Depth	Slope	Ice scour	Substrate	Morphology	Complexity	Depth	Slope	Ice Scour	Substrate	Morphology	Complexity	TOTAL SCORE	Habitat Value
T16A - B	638017	7215682	133.2	1.90	56.1	34.8	0.055	S	F	Y	B	P	M	1	0	-2	7	2	4	12	M
T16B - C	637998	7215652	131.3	2.2	56.1	17.0	0.018	M	F	N	BS	P	C	4	0	0	8	2	6	20	H
T16C - D	637986	7215641	131.0	4.02	56.1	4.3	0.423	M	S	N	BS	A	C	4	2	0	8	3	6	23	H
T16D	637983	7215638	129.1																		
T17A - B	637874	7215937	132.7	2.52	50.5	46.2	0.055	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T17B - C	637836	7215910	130.2	3.77	50.5	4.3	0.291	M	S	N	B	A	M	4	2	0	6	3	4	19	H
T17C	637833	7215907	128.9																		
T18A - B	637505	7215989	133.0	1.75	26.7	21.5	0.081	S	F	Y	B	P	M	1	0	-2	7	2	4	12	M
T18B - C	637501	7215968	131.3	4.33	26.7	5.2	0.496	M	S	N	BS	A	C	4	2	0	8	3	6	23	H
T18C	637501	7215964	128.7																	0	
T19A - B	637286	7215978	132.8	1.71	93.1	37.4	0.046	S	F	Y	BS	P	C	1	0	-2	7	2	6	14	M
T19B - C	637285	7215941	131.1	2.12	93.1	51	0.008	S	F	Y	BS	P	C	1	0	-2	8	2	6	15	M
T19C - D	637287	7215926	130.7	4.28	93.1	4.7	0.460	M	S	N	BS	A	C	4	2	0	8	3	6	23	H
T19D	637287	7215922	128.5																		
T20A - B	637305	7215752	132.7	1.62	65.5	37.6	0.043	S	F	Y	B	P	M	1	0	-2	7	2	4	12	M
T20B - C	637315	7215789	131.1	3.2	65.5	23.2	0.068	M	F	N	BS	P	C	4	0	0	8	2	6	20	H
T20C - D	637321	7215811	129.5	4.06	65.5	4.7	0.183	M	S	N	BS	A	C	4	2	0	8	3	6	23	H
T20D	637322	7215814	128.6																		
T21A - B	637582	7215586	133.1	1.98	58.1	35	0.057	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T21B - C	637606	7215613	131.1	2.72	58.1	18	0.041	M	F	N	BS	P	M	4	0	0	8	2	5	19	H
T21C - D	637617	7215627	130.3	4.33	58.1	5.1	0.316	M	S	N	B	A	M	4	2	0	6	3	4	19	H
T21D	637620	7215630	128.7																		
T22A - B	637831	7215407	132.9	1.96	65.9	47.2	0.042	S	F	Y	B	P	MC	1	0	-2	6	2	5	12	M
T22B - C	637855	7215448	130.9	2.08	65.9	12.8	0.009	S	F	Y	B	P	M	1	0	-1	6	2	4	12	M
T22C - D	637860	7215459	130.8	3.2	65.9	5.9	0.190	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T22D	637859	7215462	-																		
T23A - B	637916	7215349	133.4	2.37	31.7	9.3	0.255	S	S	Y	S	P	U	1	2	-2	2	2	2	7	L
T23B - C	637919	7215341	131.0	2.43	31.7	18.2	0.003	M	F	N	B	P	C	4	0	0	6	2	7	19	H
T23C - D	637929	7215327	131.0	3.2	31.7	4.2	0.183	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T23D	637932	7215323	130.2																		
T24A - B	637870	7215257	133.1	2.71	28.0	22.2	0.122	S	S	Y	S	P	U	1	2	-2	2	2	2	7	L
T24B - C	637881	7215239	130.4	4.01	28.0	7.8	0.167	M	S	N	BS	A	C	4	2	0	8	3	6	23	H
T24C	637884	7215232	129.1																		
T25A - B	637907	7215144	133.1	1.88	28.9	5.1	0.369	S	S	Y	S	P	U	1	2	-2	2	2	2	7	L
T25B - C	637909	7215148	131.2	2.25	28.9	18.4	0.020	M	F	N	BS	P	C	4	0	0	8	2	6	20	H
T25C - D	637915	7215166	130.9	4.04	28.9	5.4	0.331	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T25D	637917	7215170	129.1																		
T26A - B	638007	7215019	133.4	2.4	36.2	31	0.077	S	F	Y	B	P	C	1	0	-2	6	2	6	13	M
T26B - C	638036	7215029	131.0	4.5	36.2	5.2	0.404	M	S	N	B	A	C	4	2	0	6	3	6	21	H
T26C	638041	7215031	128.9																		
T27A - B	638133	7214742	133.0	1.7	24.1	9.1	0.187	S	S	Y	S	P	M	1	2	-2	2	2	4	9	L
T27B - C	638140	7214746	131.3	2.19	24.1	6.9	0.071	S	F	Y	BS	P	M	1	0	-2	8	2	4	13	M
T27C - D	638147	7214750	130.8	5.5	24.1	8.1	0.409	D	S	N	BS	A	C	3	2	0	8	3	6	22	H
T27D	638152	7214755	-																		
T28A - B	638381	7214473	132.9	1.57	30.2	13.2	0.119	S	F	Y	B	P	M	1	2	-2	6	2	4	13	M
T28B - C	638387	7214485	131.4	1.79	30.2	8.4	0.026	S	F	Y	B	P	C	1	0	-2	6	2	6	13	M
T28C - D	638391	7214492	131.1	5.88	30.2	8.6	0.476	D	S	N	B	A	C	3	2	0	6	3	6	20	H
T28D	638394	7214500	127.1																		
T29A - B	638639	7214341	132.8	1.6	40.7	31.5	0.051	S	F	Y	SB	P	M	1	0	-2	4	2	4	9	L
T29B - C	638660	7214364	131.2	5.5	40.7	9.2	0.424	D	S	N	SB	A	M	3	2	0	4	3	4	16	M
T29C	638662	7214376	-																		

Appendix D. Elevation, UTM, slope, attribute, feature score and habitat value of 2009 ground transect survey locations.

	UTM							2009 Attributes						2009 Feature Score							
Transect Segment	Easting	Northing	Elevation (m) at Start	Depth at End (m)	Transect Length (m)	Segment Length (m)	Slope	Depth	Slope	Ice scour	Substrate	Morphology	Complexity	Depth	Slope	Ice Scour	Substrate	Morphology	Complexity	**TOTAL SCORE**	**Habitat Value**
T30A - B	638789	7214181	133.1	2.61	84.1	39.3	0.066	S	F	Y	B	P	M	1	0	-2	7	2	4	12	M
T30B - C	638809	7214214	130.5	4.65	84.1	17.4	0.117	M	S	N	BS	P	C	4	2	0	8	2	6	22	H
T30C - D	638821	7214227	128.5	3.8	84.1	11.1	-0.077	M	F	N	SB	S	M	4	0	0	4	4	4	16	M
T30D - E	638828	7214235	129.4	6.42	84.1	26.3	0.100	D	S	N	SB	S	M	3	2	0	4	4	4	17	M
T30E	638844	7214256	126.8																		
T31A - B	638881	7213991	132.9	1.81	16.7	7.4	0.245	S	S	Y	B	P	C	1	2	-2	6	2	6	15	M
T31B - C	638887	7213990	131.1	2.66	16.7	3.9	0.218	M	S	N	B	P	C	4	2	0	6	2	6	20	H
T31C - D	638891	7213989	130.3	5.11	16.7	5.4	0.454	M	S	N	S	S	U	4	2	0	3	4	2	15	M
T31D	638896	7213988	127.8																		
T32A - B	638962	7213860	133.0	2.0	38.5	31.4	0.064	S	F	Y	B	P	U	1	0	-2	6	2	2	9	L
T32B - C	638940	7213883	131.0	4.7	38.5	7.1	0.380	M	S	N	B	A	U	4	2	0	6	3	2	17	M
T32C	638937	7213888	128.2																		
T33A - B	639170	7213928	132.6	1.65	49.3	31.4	0.053	S	F	Y	B	P	MC	1	0	-2	7	2	5	13	M
T33B - C	639172	7213959	131.0	4.5	49.3	9.8	0.291	M	S	N	SB	P	U	4	2	0	4	2	3	15	M
T33C - D	639171	7213968	128.1	5.66	49.3	8.1	0.143	M	S	N	S	A	U	4	2	0	3	3	2	14	M
T33D	639169	7213976	127.0																		

APPENDIX E

2009 TRANSECTS CLIPPED TO HABITAT POLYGON MAPS

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 1: T1A-B

Photo 2: T1B-C

Photo 3: T2A-B

Photo 4: T2B-C

Photo 5: T3A-B

Photo 6: T3A-B

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 7: T4A-B

Photo 8: T4B-C

Photo 9: T5A-B

Photo 10: T5B-C

Photo 11: T6A-B

Photo 12: T6B-C

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 13: T7A-B

Photo 14: T7A-B

Photo 15: T7B-C

Photo 16: T7C-D

Photo 17: T8A-B

Photo 18: T8A-B

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 19: T8B-C

Photo 20 T9A-B

Photo 21: T9B-C

Photo 22 T10A-B

Photo 23: T10B-C

Photo 24 T11A-B

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 25: T11B-C

Photo 26 T11C-D

Photo 27: T11D-E

Photo 28 T12A-B

Photo 29: T12B-C

Photo30: T13A-B

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 31: T13B-C

Photo 32: T13B-C

Photo 33: T13C-D

Photo 34: T14A-B

Photo 35: T14A-B

Photo 36: T14B-C

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 37: T15A-B

Photo 38: T15B-C

Photo 39: T15C-D

Photo 40: T15D-E

Photo 41: T16A-B

Photo 42: T16B-C

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 43: T16C-D

Photo 44: T17A-B

Photo 45: T17B-C

Photo 46: T18A-B

Photo 47: T18B-C

Photo 48: T19A-B

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 49: T19B-C

Photo 50: T19C-D

Photo 51: T20A-B

Photo 52: T20A-B

Photo 53: T20B-C

Photo 54: T20C-D

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 55: T21A-B

Photo 56: T21B-C

Photo 57: T21C-D

Photo 58: T22A-B

Photo 59: T22B-C

Photo 60: T22C-D

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 61: T23A-B

Photo 62: T23B-C

Photo 63: T23C-D

Photo 64: T24A-B

Photo 65: T24B-C

Photo 66: T24 Sediment Basin

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 67: T25A-B

Photo 68: T25A-C

Photo 69: T25B-C

Photo 70: T25C-D

Photo 71: T26A-B

Photo 72: T26B-C

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 73: T27A-B

Photo 74: T27A-B

Photo 75: T27B-C

Photo 76: T27B-C

Photo 77: T28A-B

Photo 78: T28B-C

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 79: T28C-D

Photo 80: T29A-B

Photo 81: T29B-C

Photo 82: T30A-B

Photo 83: T30B-C

Photo 84: T30C-D

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 85: T30D-E

Photo 86: T31A-B

Photo 87: T31C-D

Photo 88: T32A-B

Photo 89: T32B-C

Photo 90: T33A-B

Appendix E. Photos of transects from 2009 ground survey of NW arm.

Photo 91: T33B-C

Photo 92: T33C-D

Photo 93: T33C-D

APPENDIX F

2009 GROUND AND 2006 AND 2009 AIR SURVEYS: TRANSECT LENGTH, ELEVATION AND ATTRIBUTES

Appendix F-1. 2009 Transects clipped to 2006 habitat polygon map.

		2006 Attribute						2006 Scores								
2009 Transect	Segment	Substrate	Ice	Slope	Morphology	Depth	Complexity	Substrate	Ice	Slope	Morphology	Depth	Complexity	Total Score	2006 Habitat Value	Transect Length (m)
T1		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	28.4
T2		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	41.7
T4		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	45.0
T3		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	30.2
T5		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	46.1
T6		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	27.9
T7		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	36.1
T8-9	B-C	SB	N	M	S	M	M	7	0	1	3	4	4	19	High	83.9
T8-9	A-B	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	37.4
T10-11	C-D	BS	N	M	S	M	C	8	0	1	3	4	6	22	High	77.9
T10-11	B-C	SB	N	M	S	M	M	7	0	1	3	4	4	19	High	53.5
T10-11	A-B	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	39.5
T12-13	C-D	BS	N	M	S	M	C	8	0	1	3	4	6	22	High	17.4
T12-13	B-C	SB	N	M	S	M	M	7	0	1	3	4	4	19	High	112.3
T12-13	A-B	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	49.4
T14	C-D	SB	N	M	S	M	M	7	0	1	3	4	4	19	High	69.8
T14	B-C	SB	N	M	S	M	M	7	0	1	3	4	4	19	High	12.3
T14	A-B	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	95.1
T15	C-D	BS	Y	F	S	S	C	8	-2	0	3	1	6	16	Moderate	81.5
T15	B-C	SB	N	M	S	M	M	7	0	1	3	4	4	19	High	116.1
T15	A-B	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	63.6
T16	A-B	SB	Y	M	S	M	M	7	0	1	3	4	4	19	High	33.5
T16	B-C	BS	N	F	P	S	C	8	-2	0	4	1	6	17	Moderate	43.6
T17		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	52.9
T18		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	24.2
T19		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	58.1
T20		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	53.7
T21		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	47.5
T22		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	58.7
T23		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	29.9
T24		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	29.8
T25		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	13.1
T26	A-B	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	41.8
T27		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	24.6
T28		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	17.0
T29		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	54.7
T30	A-B	S	N	S	A	M	U	2	0	2	2	4	2	12	High*	113.0
T30	B-C	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	57.1
T31	A-B	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	15.2
T32		BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	32.4
T33		B	N	F	P	S	C	6	0	0	4	1	6	17	Moderate	22.5
T33	B-C	BS	Y	F	P	S	C	8	-2	0	4	1	6	17	Moderate	4.8

* This polygon at T3 was mapped as high value habitat in 2006, despite the low score as a shoal was inferred from the air photo; this features was absent from the 2009 survey

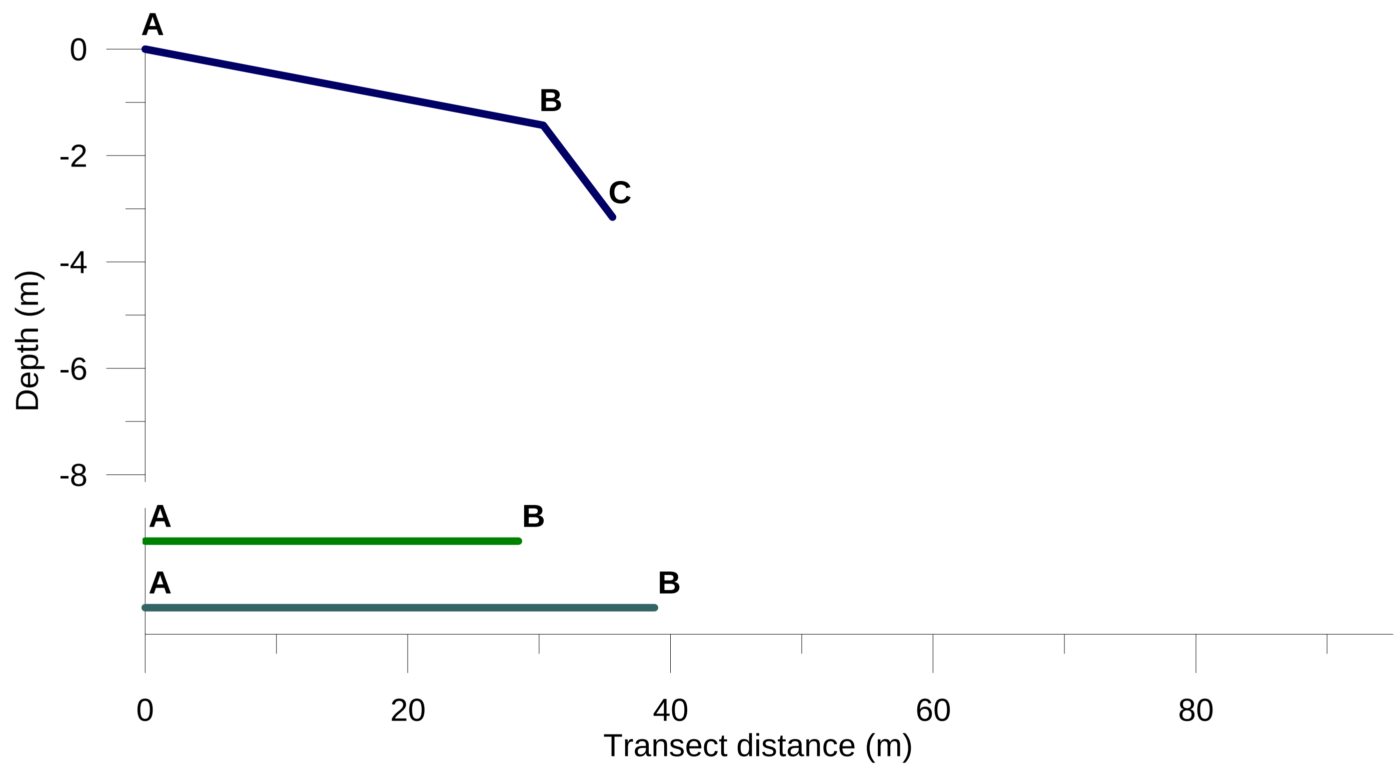
Appendix F-2. 2009 Transects clipped to 2009 unbiased habitat polygon map.

		2009 Attribute						2009 Score								
Transect	Segment	Substrate	Ice	Slope	Morphology	Depth	Complexity	Substrate	Ice	Slope	Morphology	Depth	Complexity	Total Score	2009 Habitat Value	Transect Length (m)
T1		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	38.8
T2		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	34.2
T4		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	50.7
T3		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	31.6
T5		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	39.4
T6		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	48.5
T7		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	37.5
T8-9	B-C	S	N	F	SB	VD	U	2	0	0	1	2	2	7	Low	2.6
T8-9	C-D	BS	N	F	S	M	M	8	0	0	3	4	4	19	High	74.6
T8-9	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	40.9
T10-11	C-D	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	25.1
T10-11	B-C	S	N	F	SB	VD	U	2	0	0	1	2	2	7	Low	14.0
T10-11	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	50.9
T10-11	D-E	BS	N	S	S	M	M	8	0	2	3	4	4	21	High	77.7
T12-13	C-D	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	78.7
T12-13	B-C	S	N	F	SB	VD	U	2	0	0	1	2	2	7	Low	33.6
T12-13	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	49.7
T12-13	D-E	S	N	F	SB	VD	U	2	0	0	1	2	2	7	Low	30.1
T14	B-C	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	58.3
T14	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	64.8
T15	C-D	S	N	F	SB	VD	U	2	0	0	1	2	2	7	Low	12.3
T15	B-C	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	63.3
T15	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	63.8
T15	D-E	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	145.4
T16		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	55.5
T17		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	51.7
T18	B-C	SB	N	S	A	M	M	4	0	2	2	4	4	16	Moderate	7.5
T18	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	18.3
T19	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	33.8
T19	B-C	SB	N	F	A	M	M	4	0	0	2	4	4	14	Moderate	22.0
T20		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	64.2
T21		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	59.8
T22		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	64.3
T23	B-C	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	27.1
T23	A-B	B	Y	S	P	S	C	6	-2	2	4	1	6	17	Moderate	3.1
T24		B	Y	S	P	S	C	6	-2	2	4	1	6	17	Moderate	24.8
T25		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	30.0
T26	B-C	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	6.6
T26	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	35.9
T27	A-B	B	Y	S	P	S	C	6	-2	2	4	1	6	17	Moderate	12.3
T27	B-C	SB	Y	F	P	S	M	4	-2	0	4	1	4	11	Low	9.7
T28	C-D	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	3.0
T28	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	22.1
T28	B-C	SB	Y	F	P	S	M	4	-2	0	4	1	4	11	Low	9.8
T29		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	42.3
T30	B-C	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	57.2
T30	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	33.1
T31		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	16.0
T32		B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	41.3
T33	B-C	SB	N	F	S	M	M	4	0	0	3	4	4	15	Moderate	10.9
T33	A-B	B	Y	F	P	S	C	6	-2	0	4	1	6	15	Moderate	36.5

APPENDIX G

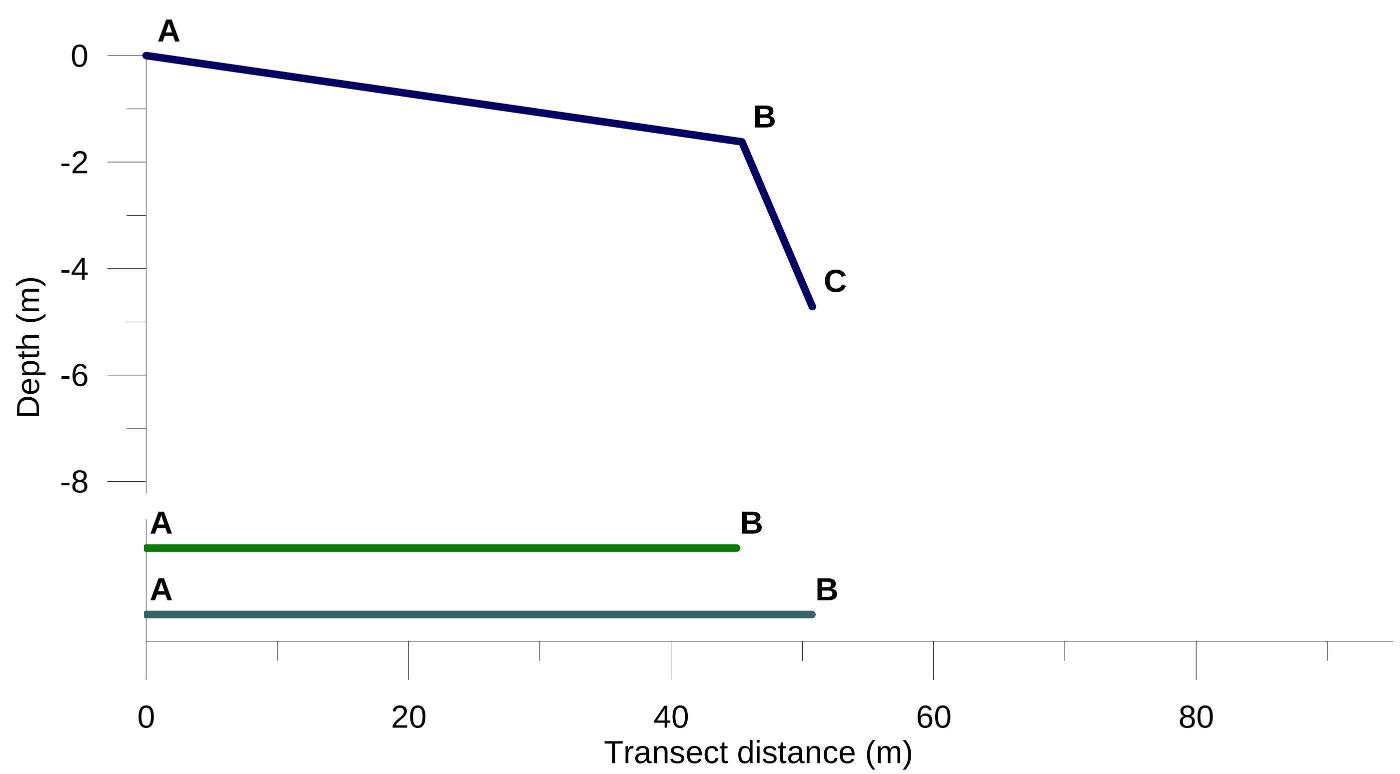
COMPARISON OF MAPPING METHODS

T1



T1	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	S	N	B	P	C
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T4



T4	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	S	F	N	B	P	C
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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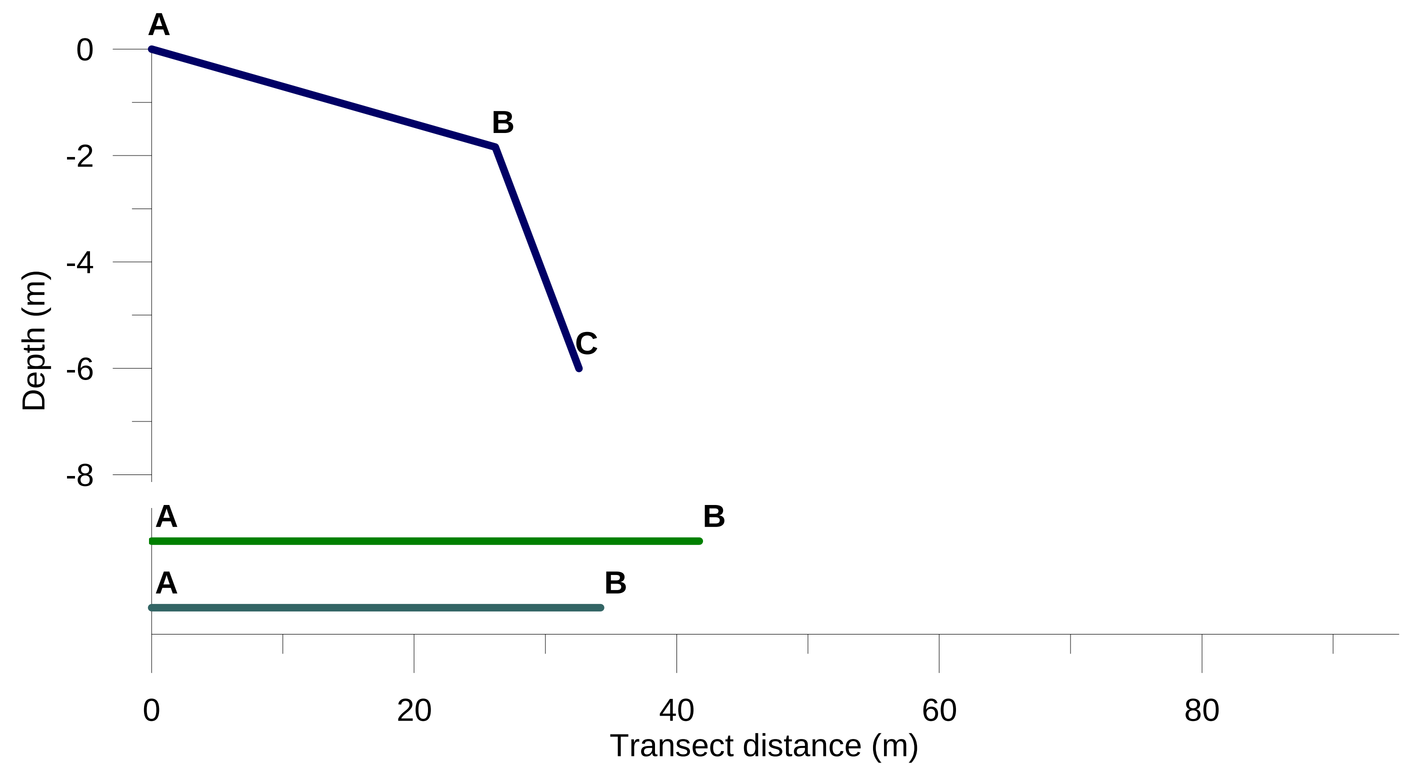
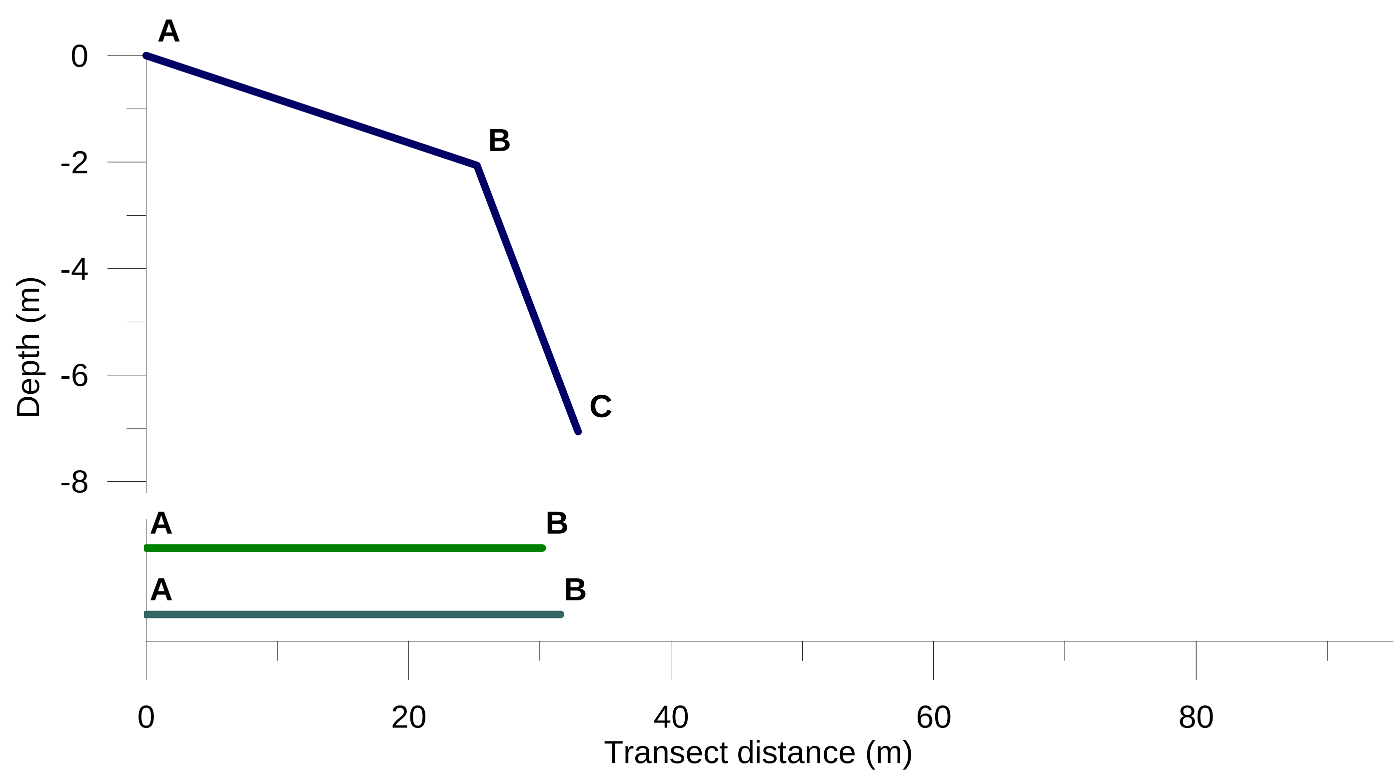
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T1 & T4.

T2



T2	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	U
	B-C	H	M	S	N	BS	P	M
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T3



T3	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	S	N	B	P	M
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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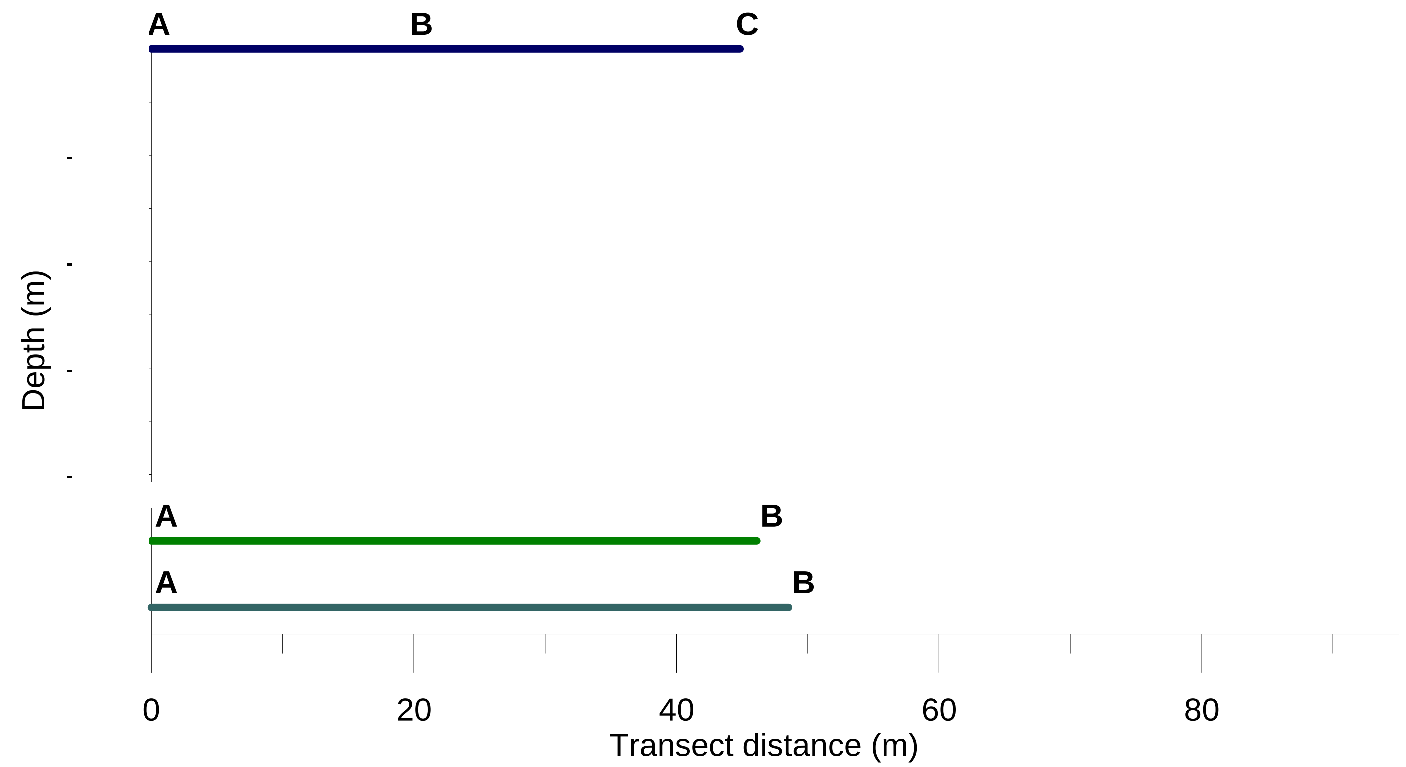
NW ARM HABITAT MAPPING

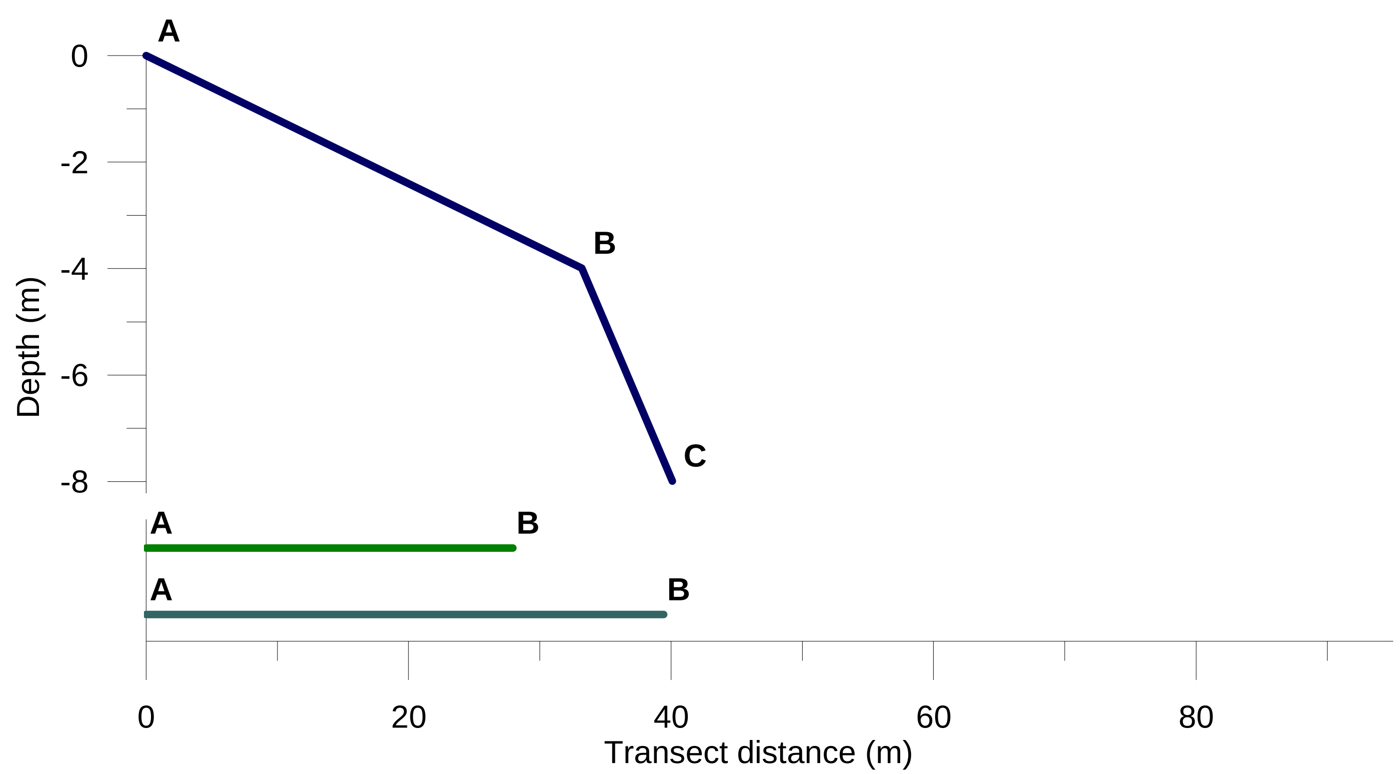
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T2 & T3.

T5*



T5	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	C
	B-C	H	D	S	N	B	A	C
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T6



T6	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	C
	B-C	H	M	S	N	B	P	C
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

* No depth information collected.

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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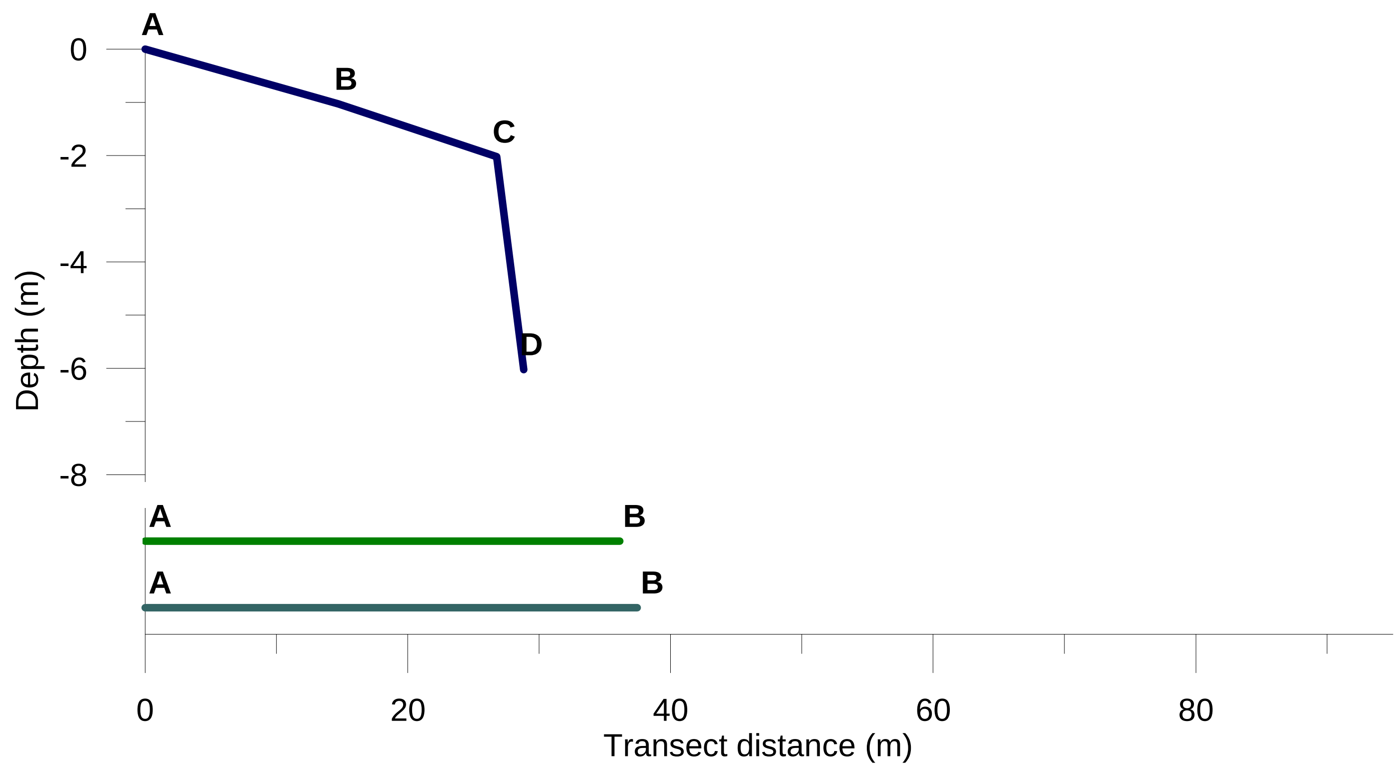
2009 GROUND AND 2006 & 2009 AIR SURVEYS
FOR TRANSECT T5 & T6.

T7



T7	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	BS	P	C
	B-C	M	S	F	Y	B	P	C
	C-D	H	M	S	N	BS	A	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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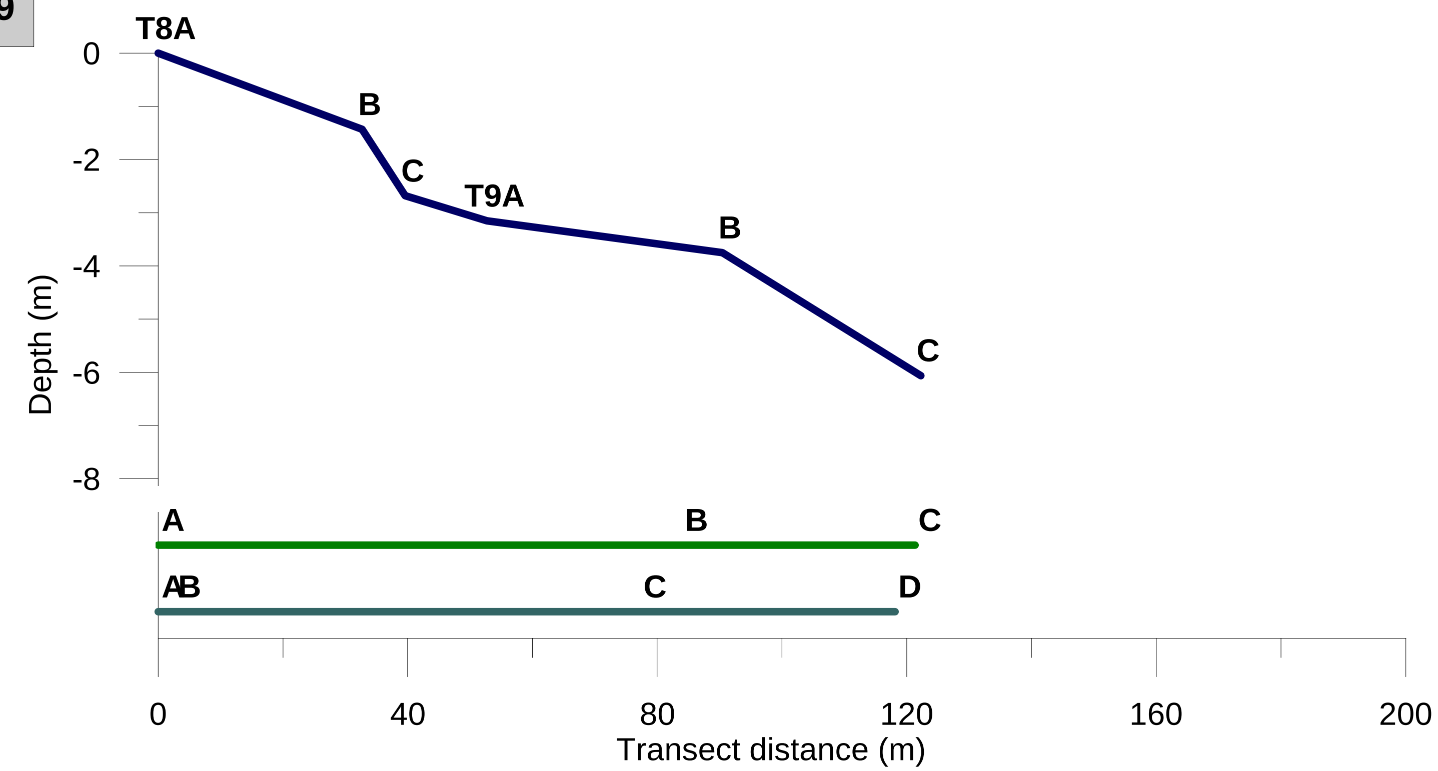
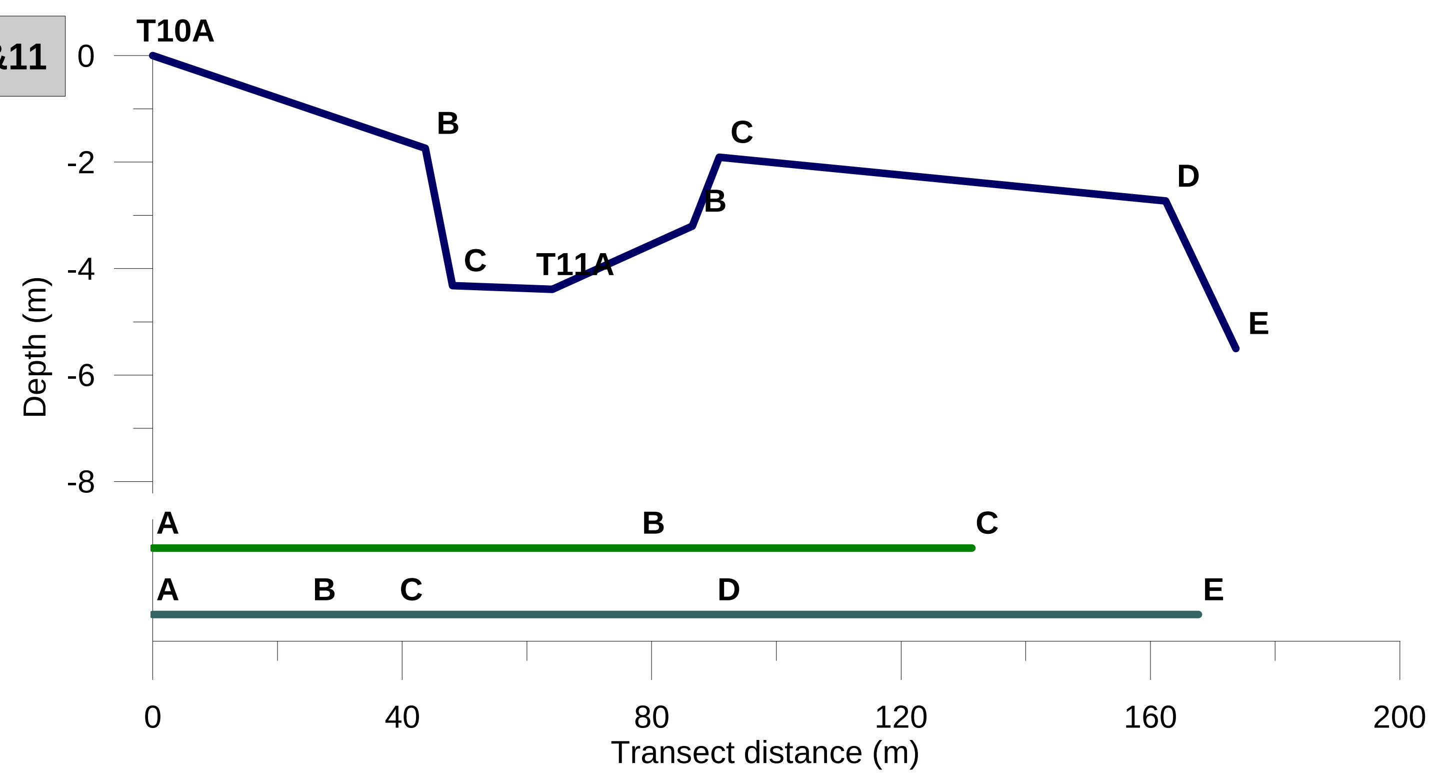
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T7

T8&9



T8 & 9	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	H	S	F	Y	BS	P	C
	B-C	H	M	S	Y	B	A	C
	A-B	L	M	S	N	SB	SB	U
	B-C	H	M	F	N	BS	S	M
	C-D	M	M	F	N	SB	S	M
2006 Air	A-B	H	M	M	N	SB	S	M
	B-C	M	S	F	Y	BS	P	C
	C-D	-	-	-	-	-	-	-
2009 Air	A-B	L	VD	F	N	F	SB	U
	B-C	H	M	F	N	BS	S	M
	C-D	M	S	F	Y	B	P	C
	D-E	-	-	-	-	-	-	-

T10&11



T10 & 11	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	BS	P	M
	B-C	H	M	S	N	BS	P	C
	A-B	L	M	F	N	SB	SB	U
	B-C	M	M	S	N	SB	S	M
	C-D	H	M	S	N	B	S	C
	D-E	H	M	F	N	B	S	C
	E-F	H	M	S	N	BS	S	M
2006 Air	A-B	H	M	M	N	BS	S	C
	B-C	H	M	M	N	SB	S	M
	C-D	M	S	F	Y	BS	P	C
2009 Air	A-B	M	M	F	N	SB	P	M
	B-C	L	D	F	N	F	SB	U
	C-D	M	S	F	Y	B	P	C
	D-E	H	M	S	N	BS	S	M

Legend

2009 Ground Survey
2006 Air Survey
2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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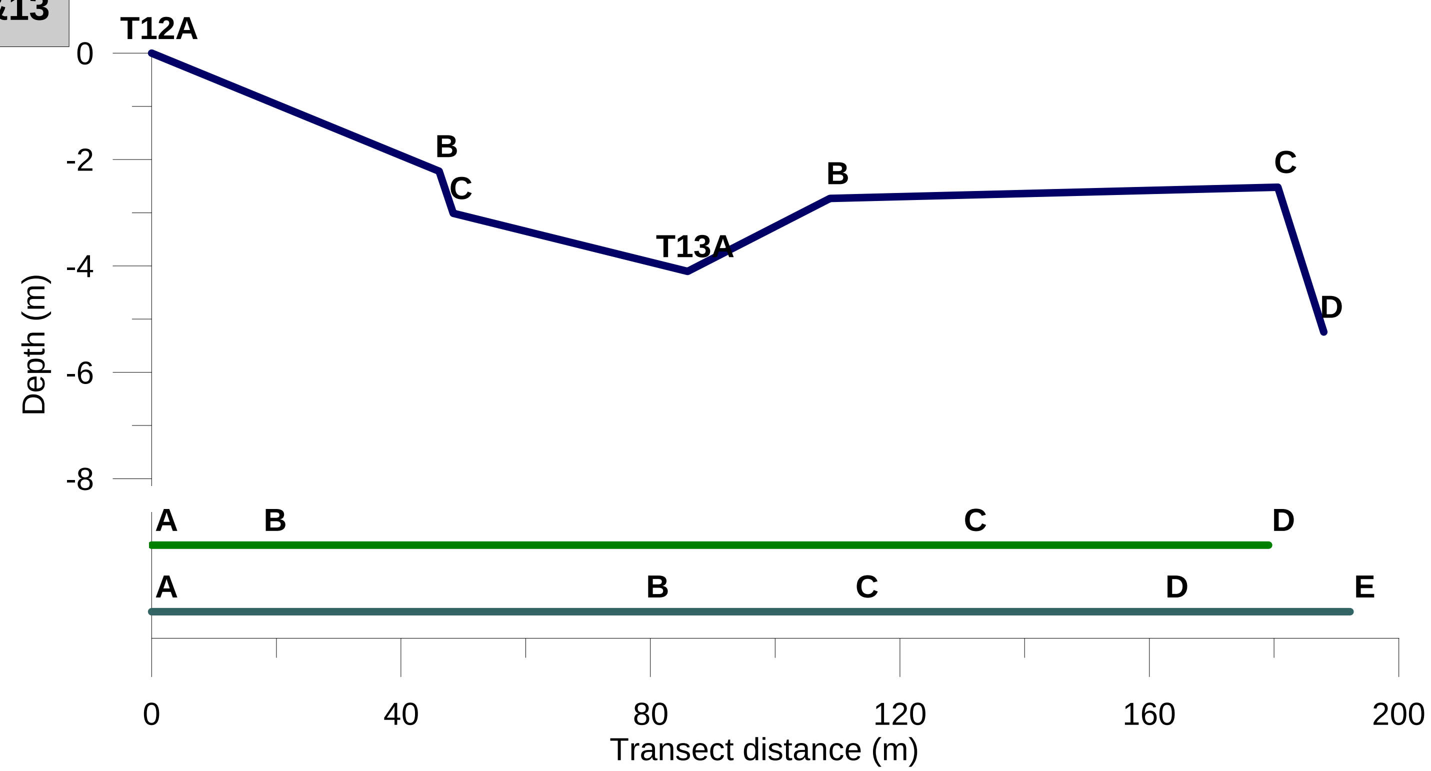
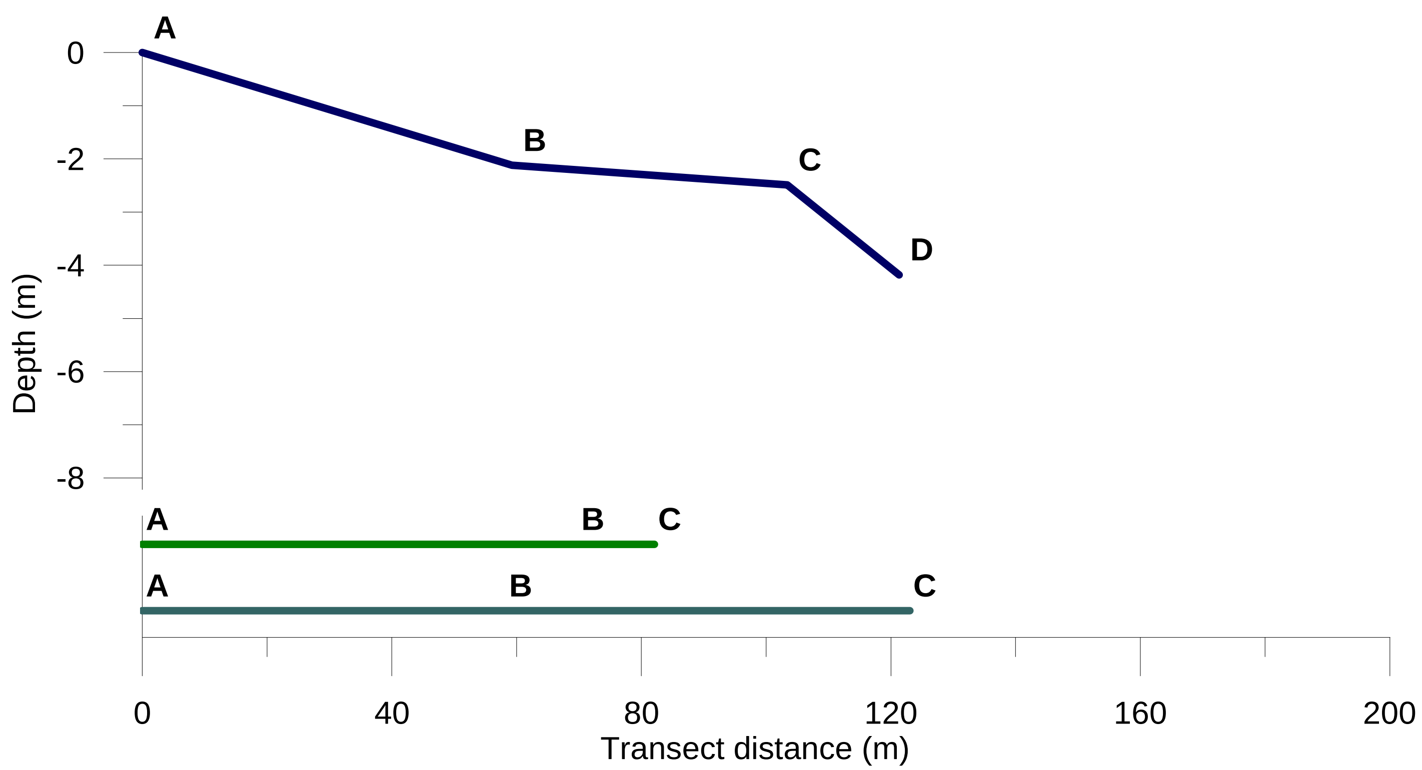
FOR TRANSECT T8&9 & T10&11.

T12&13



T12 & 13	Section	Hab Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	S	N	B	P	M
	C-D	L	M	F	N	SB	SB	U
	D-E	H	M	F	N	SB	S	C
	E-F	H	M	F	N	SB	S	C
	F-G	M	M	S	N	SB	S	M
2006 Air	A-B	H	M	M	N	BS	S	C
	B-C	H	M	M	N	SB	S	M
	C-D	M	S	F	Y	BS	P	C
2009 Air	A-B	M	M	F	N	SB	P	M
	B-C	L	D	F	N	F	SB	U
	C-D	M	S	F	Y	B	P	C
	D-E	L	D	F	N	F	SB	U

T14



T14	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	BS	P	M
	B-C	H	M	F	N	SB	P	C
	C-D	M	M	S	N	S	P	M
	D-E							
	E-F							
2006 Air	A-B	H	M	M	N	SB	S	M
	B-C	H	M	M	N	SB	S	M
	C-D	M	S	F	Y	BS	P	C
2009 Air	A-B	M	M	F	N	SB	P	M
	B-C	M	S	F	Y	B	P	C
	C-D	-	-	-	-	-	-	-
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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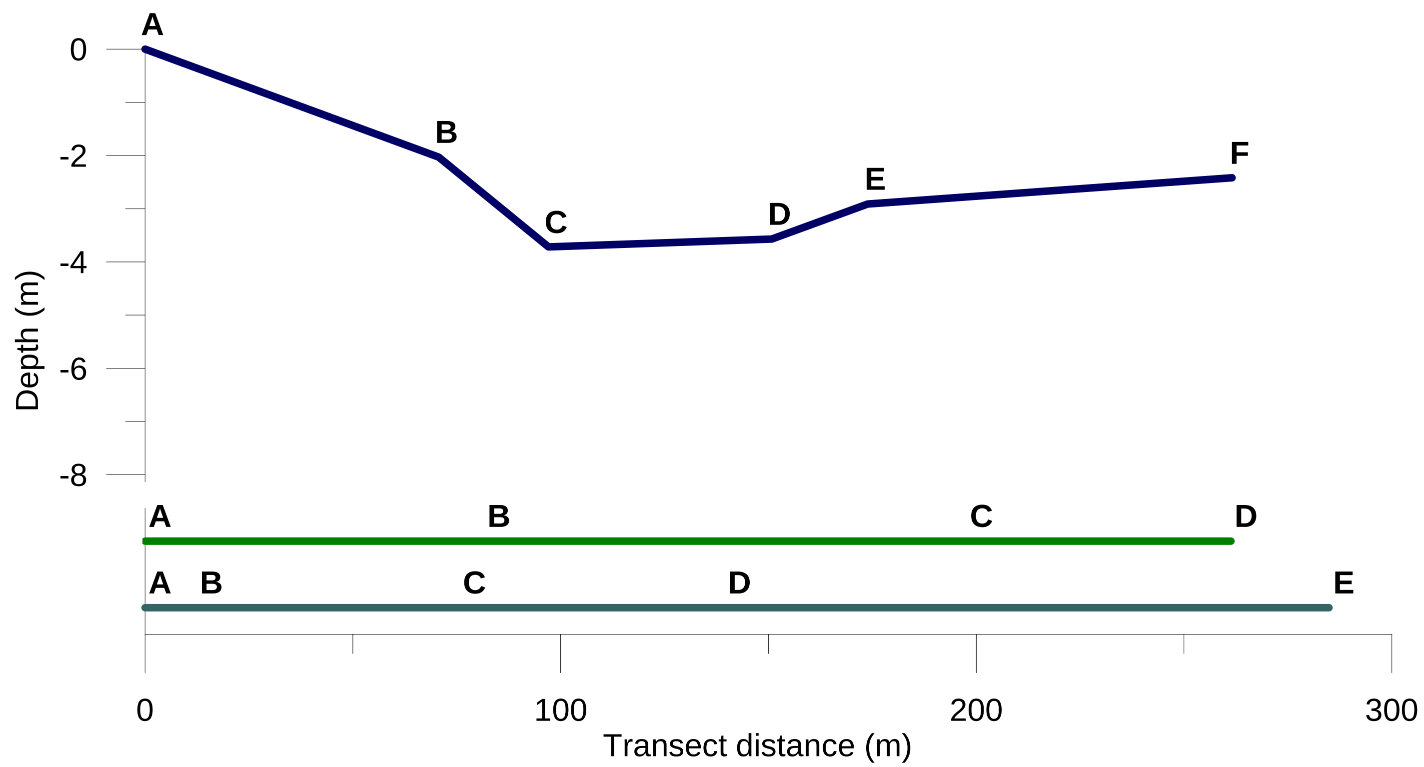
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T12&13 & T14.

T15



T15	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	F	N	BS	P	M
	C-D	M	M	F	N	S	S	U
	D-E	M	M	F	N	SB	S	U
	E-F	H	M	F	N	BS	S	C
2006 Air	A-B	M	S	F	Y	BS	S	C
	B-C	H	M	M	N	SB	S	M
	C-D	M	S	F	Y	BS	P	C
2009 Air	A-B	L	VD	F	N	F	SB	U
	B-C	M	M	F	N	SB	P	M
	C-D	M	S	F	Y	B	P	C
	D-E	M	M	F	N	SB	S	M

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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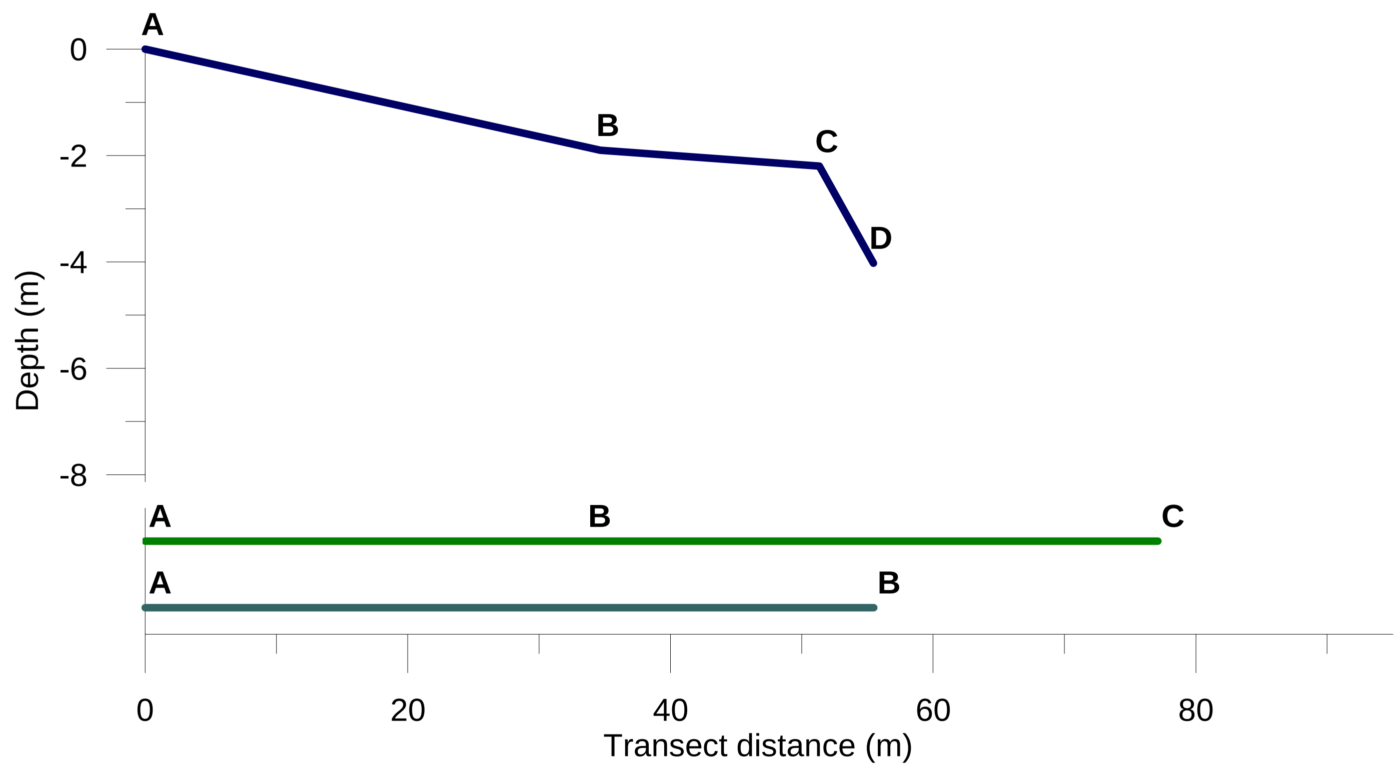
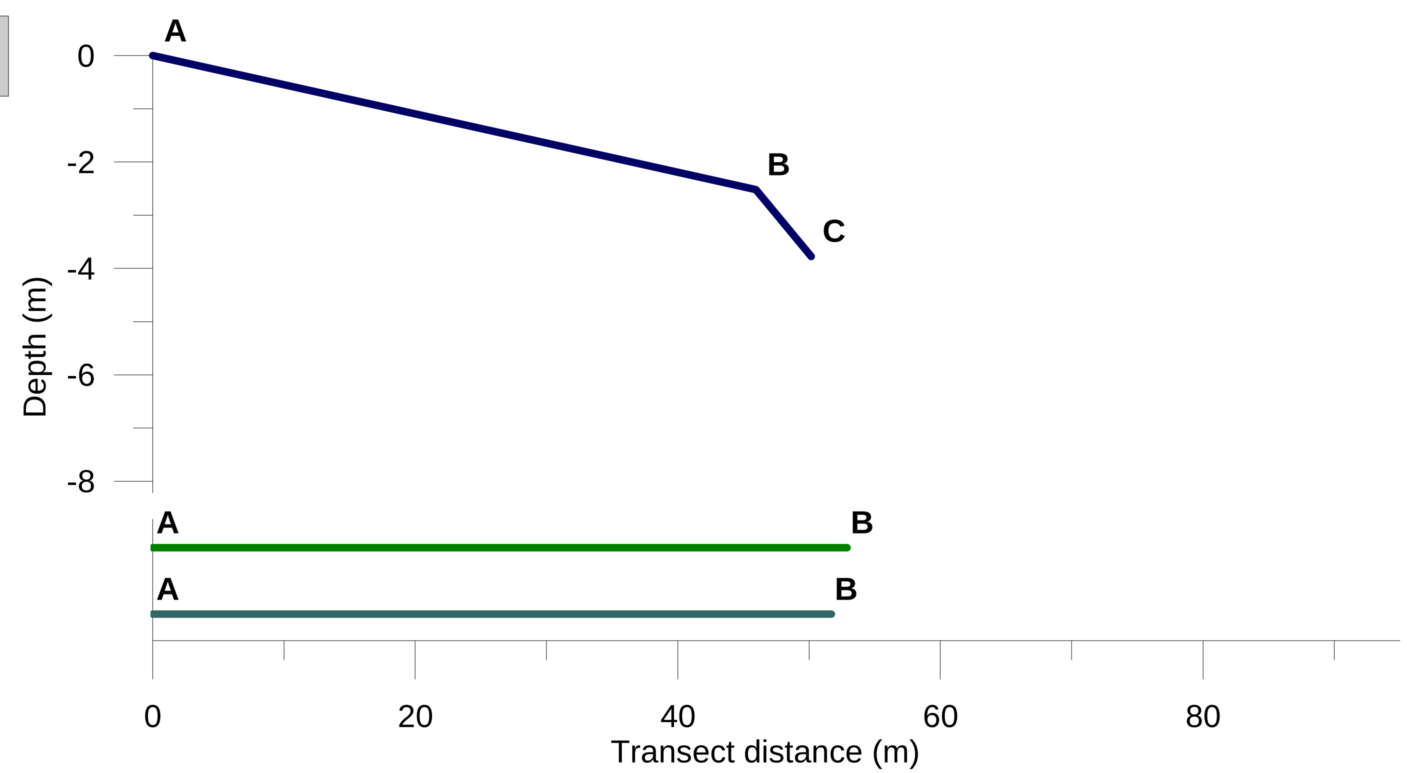
2009 GROUND AND 2006 & 2009 AIR SURVEYS
FOR TRANSECT T15

T16



T16	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	F	N	BS	P	C
	C-D	H	M	S	N	BS	P	C
	D-E							
	E-F							
2006 Air	A-B	H	M	M	N	SB	S	M
	B-C	M	S	F	Y	BS	P	C
	C-D	-	-	-	-	-	-	-
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T17



T17	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	S	N	B	P	M
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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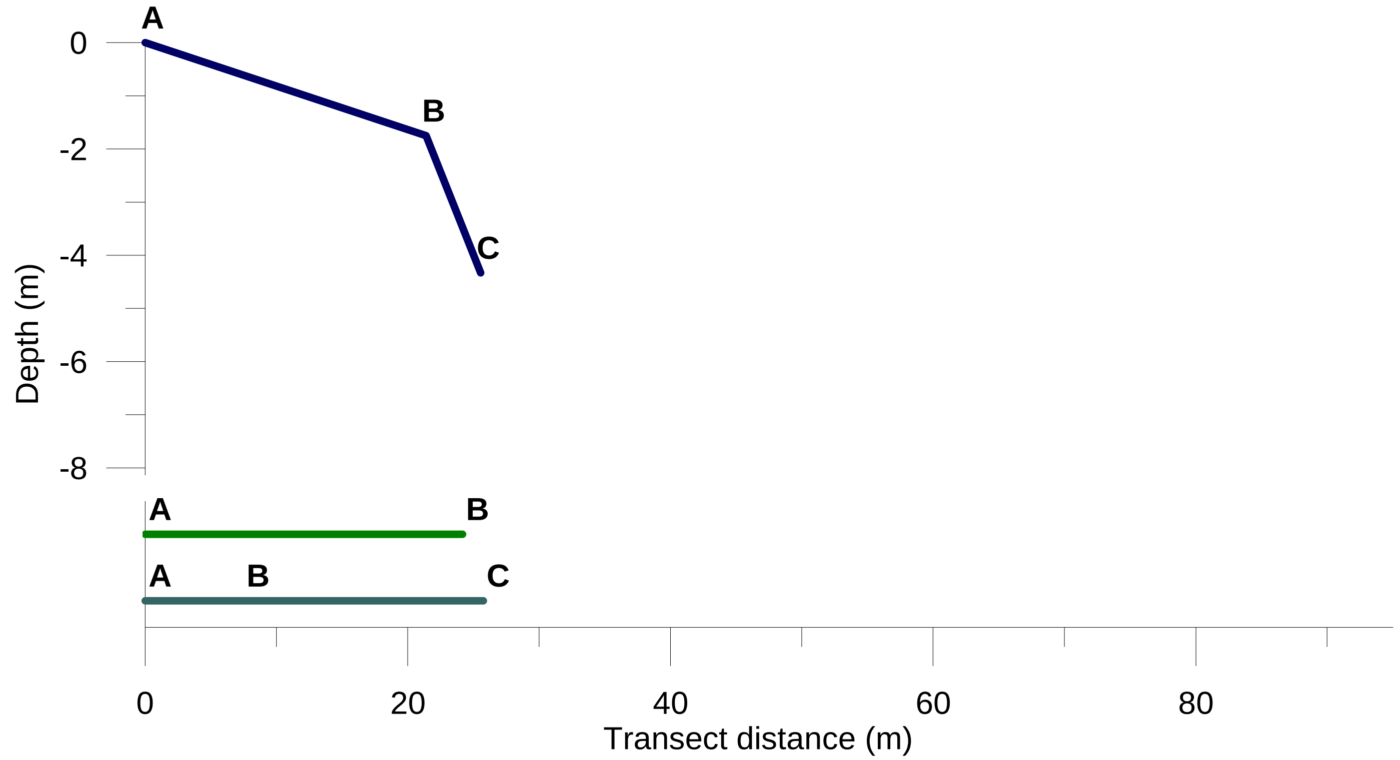
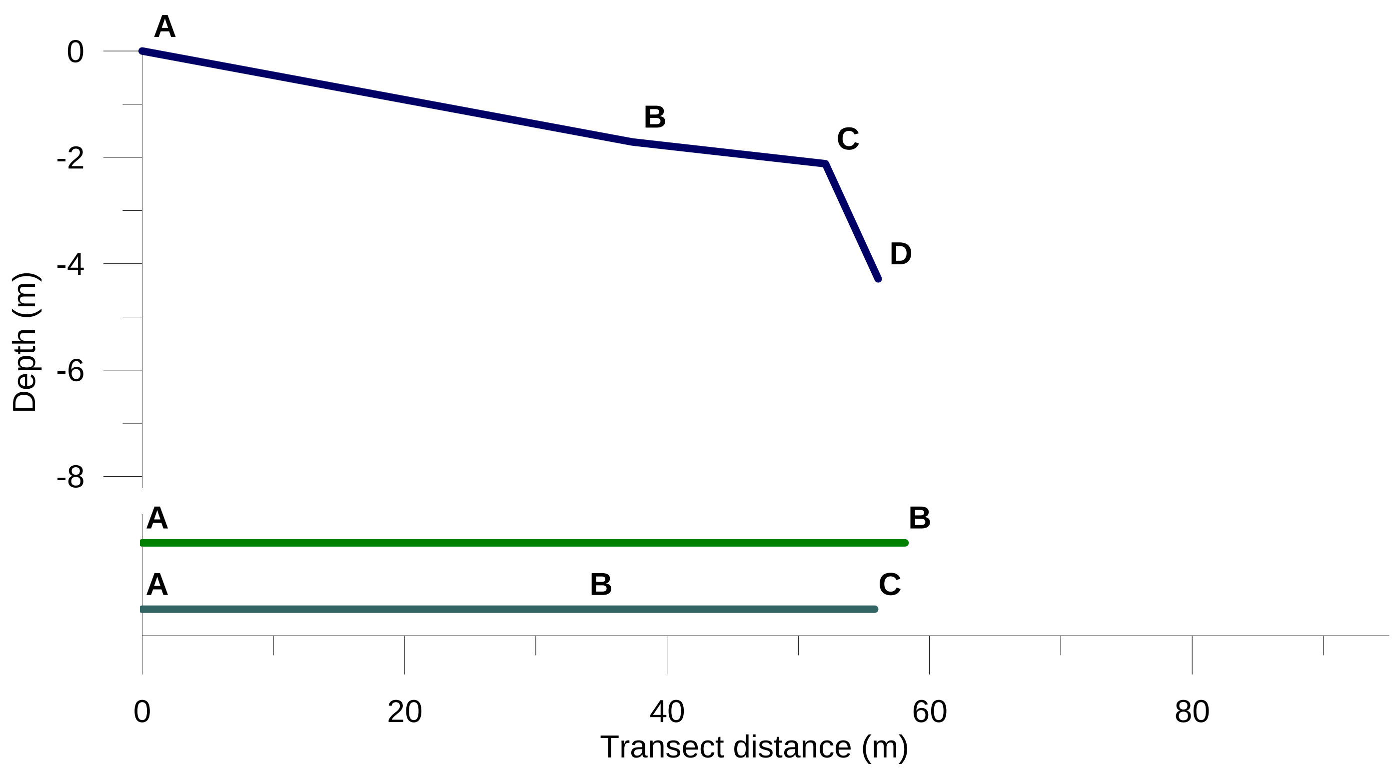
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T16 & T17.

T18



T18	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	S	N	BS	P	C
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	M	F	N	SB	P	M
	B-C	M	S	F	Y	B	P	C
	C-D	-	-	-	-	-	-	-
	D-E							

T19



T19	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	BS	P	C
	B-C	M	S	F	Y	BS	P	C
	C-D	H	M	S	N	BS	P	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	M	M	F	N	SB	P	M
	C-D	-	-	-	-	-	-	-
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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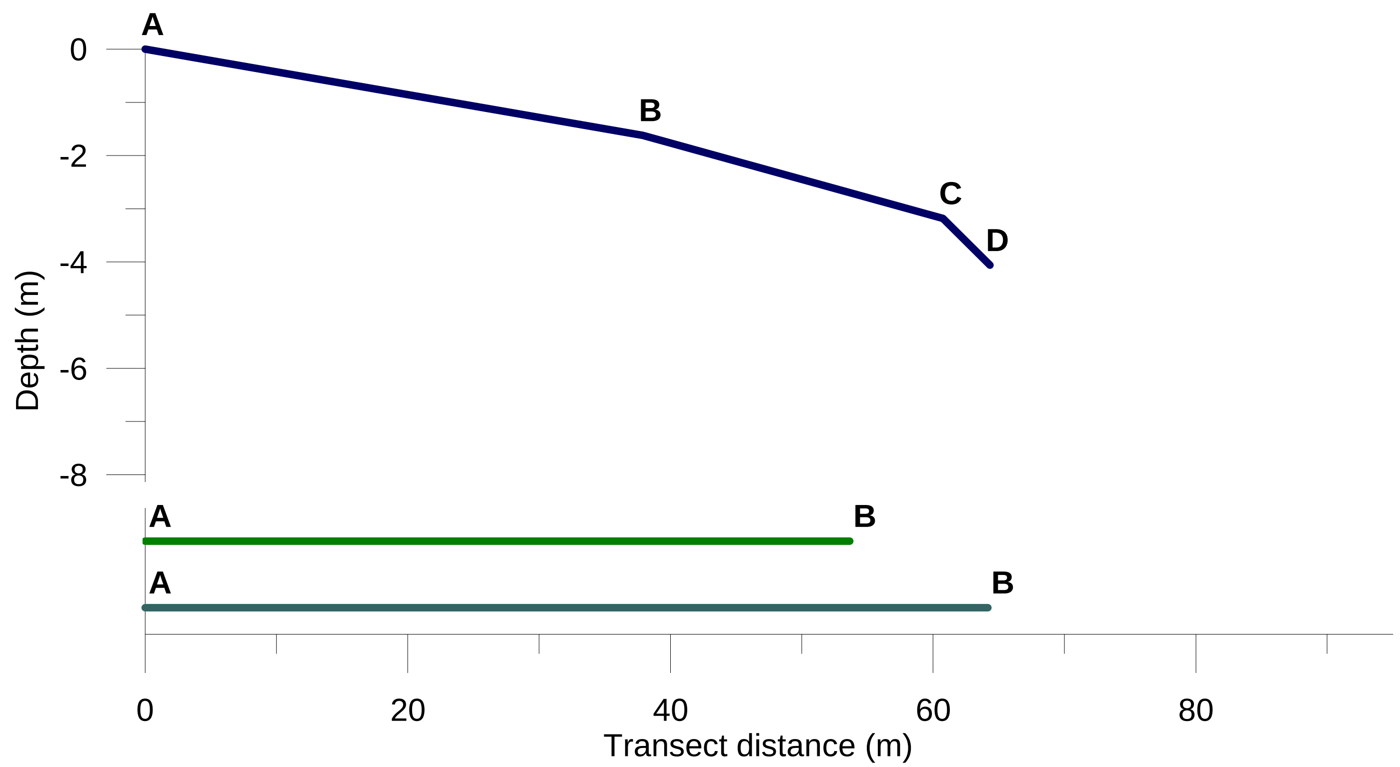
NW ARM HABITAT MAPPING

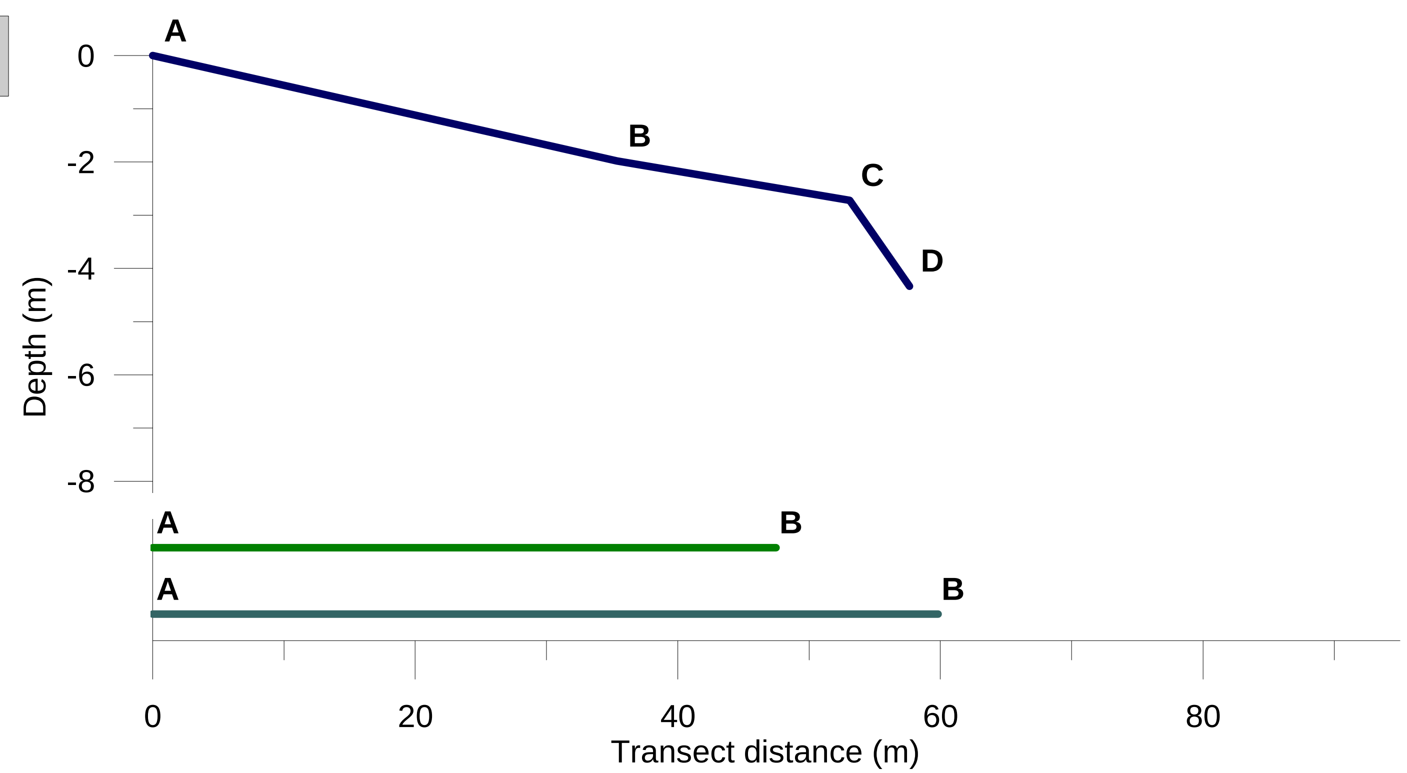
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T18 & T19.

T20



T20	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	F	N	BS	P	C
	C-D	H	M	S	N	BS	P	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T21



T21	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	F	N	BS	P	M
	C-D	H	M	S	N	B	P	M
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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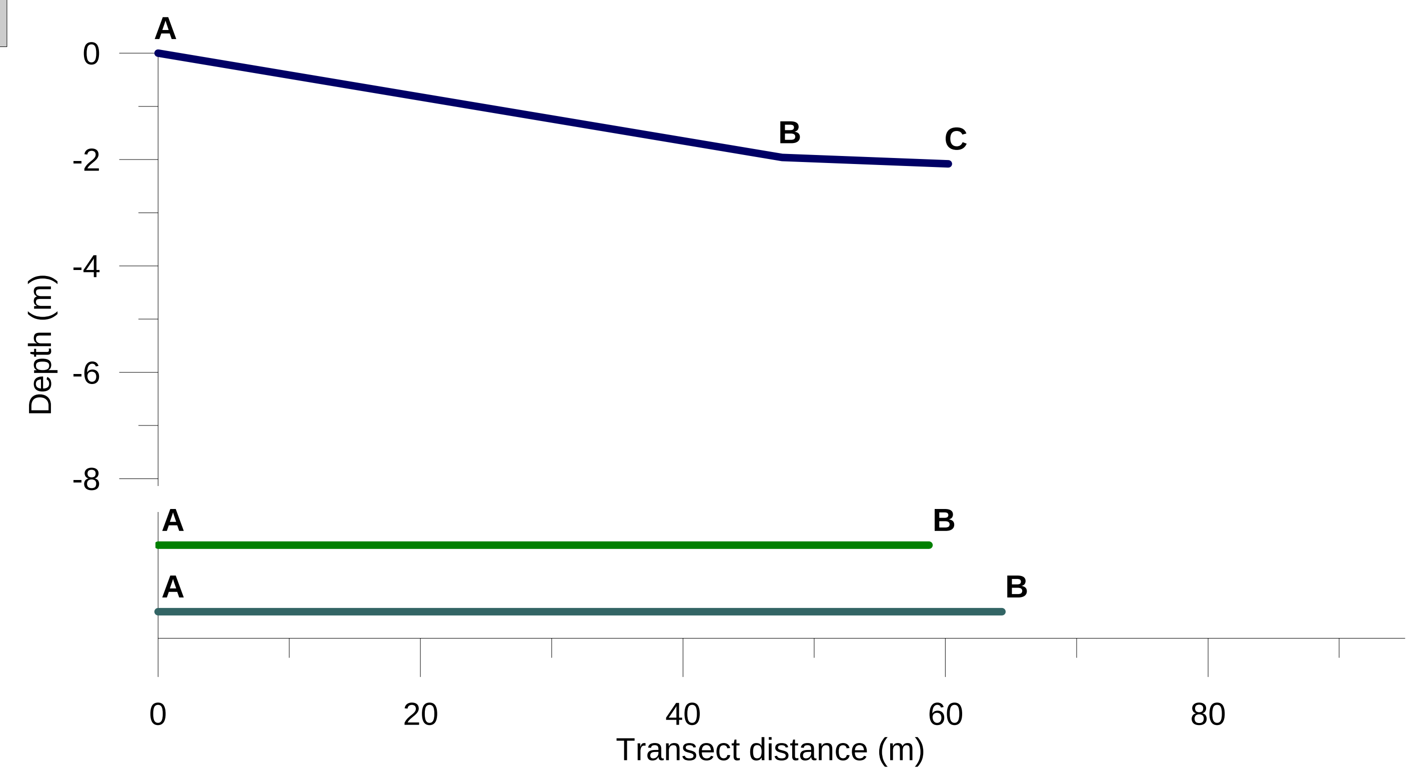
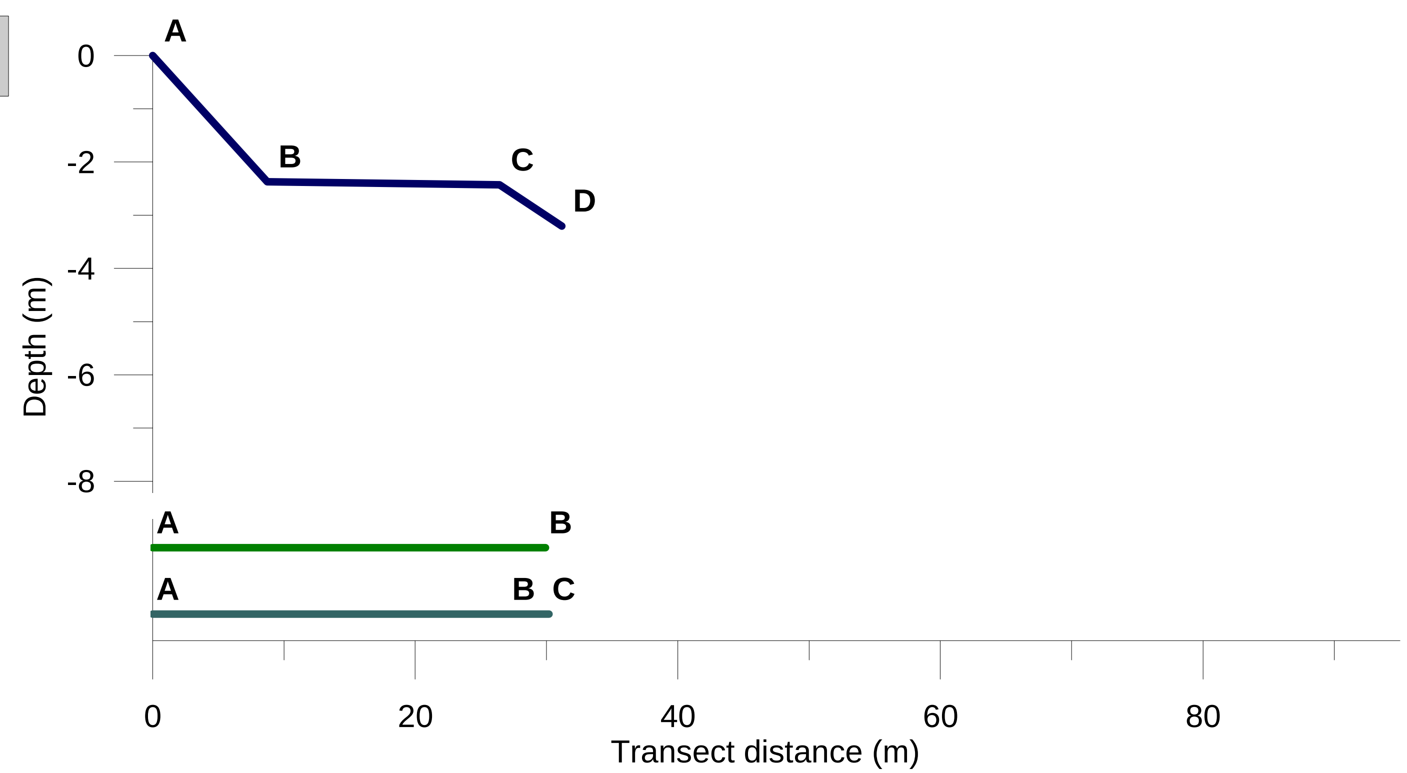
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T20 & T21.

T22



T22	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	M	S	F	Y	B	P	M
	C-D	H	M	S	N	B	P	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T23



T23	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	L	S	S	Y	S	P	U
	B-C	H	M	F	N	B	P	C
	C-D	H	M	S	N	B	P	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	M	S	S	Y	B	P	C
	C-D	-	-	-	-	-	-	-
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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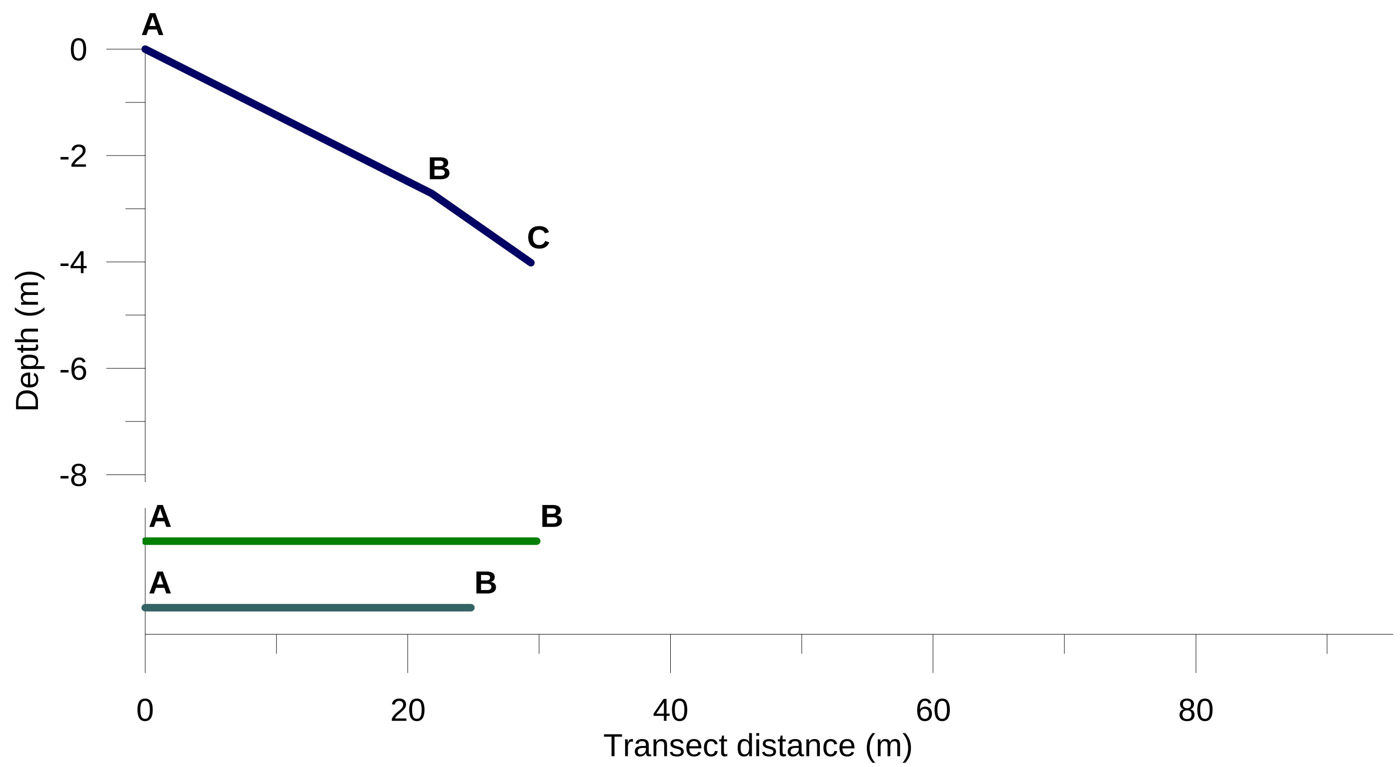
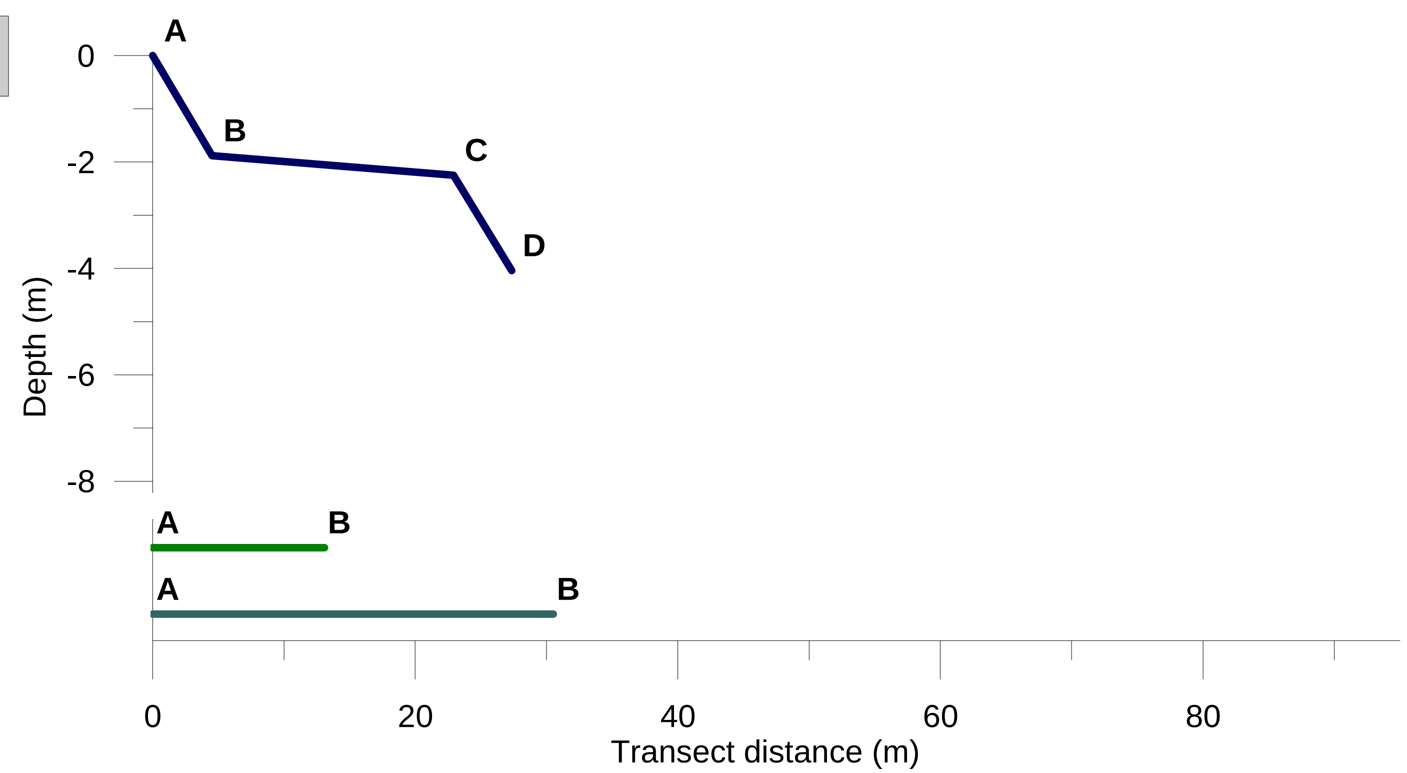
2009 GROUND AND 2006 & 2009 AIR SURVEYS
FOR TRANSECT T22 & T23.

T24



T24	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	L	S	S	Y	S	SB	U
	B-C	H	M	S	N	BS	P	C
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	S	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T25



T25	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	L	S	S	Y	S	SB	U
	B-C	H	M	F	N	BS	P	C
	C-D	H	M	S	N	B	P	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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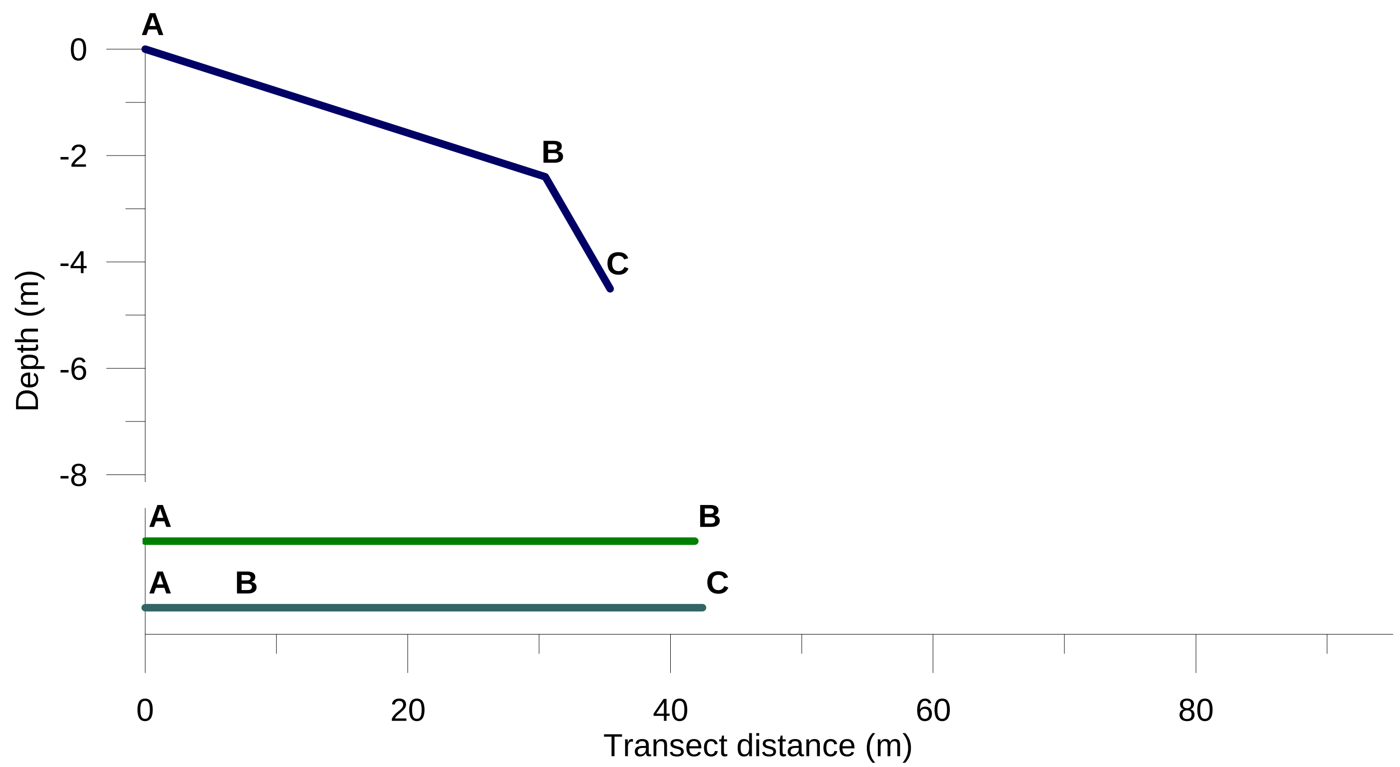
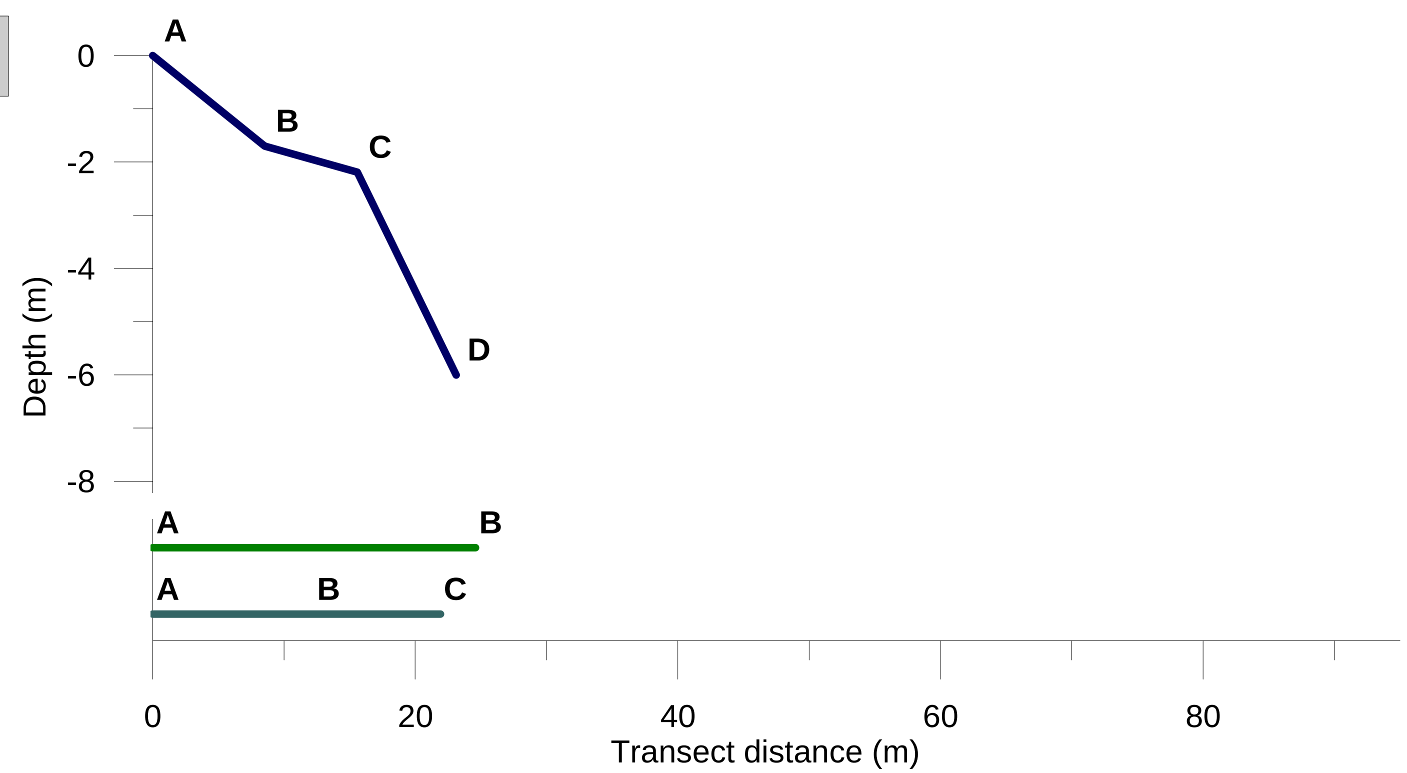
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T24 & T25.

T26



T26	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	C
	B-C	H	M	S	N	B	P	C
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	M	F	N	SB	A	M
	B-C	M	S	F	Y	B	P	C
	C-D	-	-	-	-	-	-	-
	D-E							

T27



T27	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	L	S	S	Y	S	SB	M
	B-C	M	S	F	Y	BS	P	M
	C-D	H	M	S	N	BS	P	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	S	Y	B	P	C
	B-C	L	S	F	Y	SB	P	M
	C-D	-	-	-	-	-	-	-
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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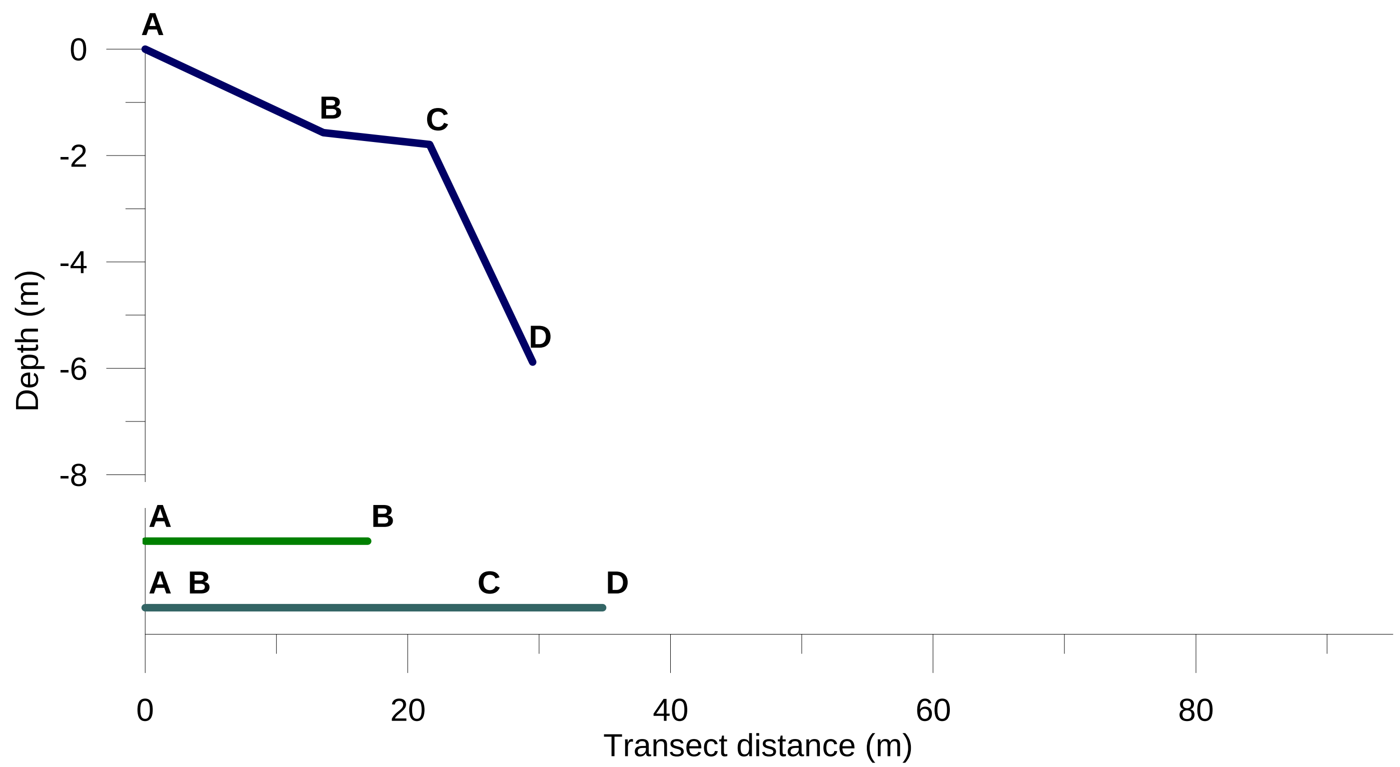
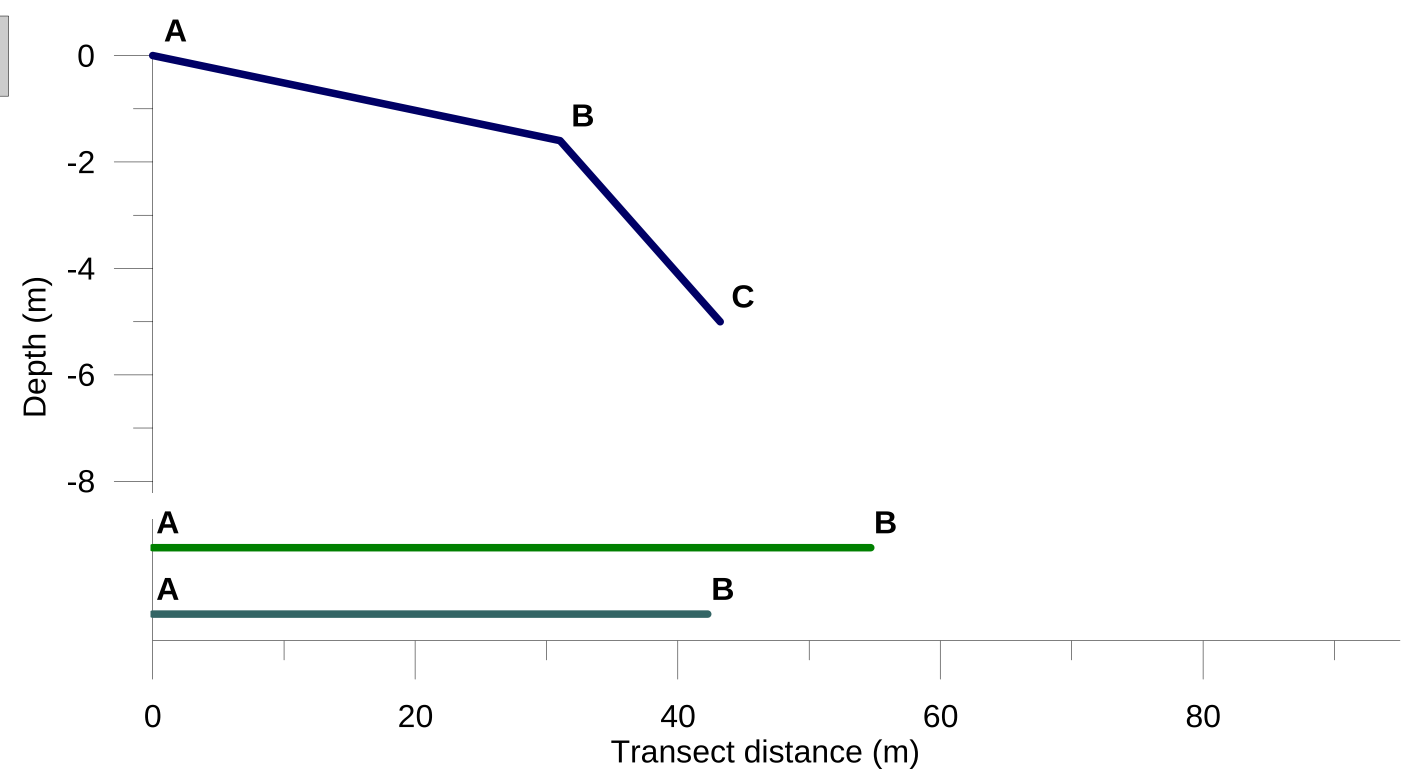
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T26 & T27.

T28



T28	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	M	S	F	Y	B	P	C
	C-D	H	M	S	N	B	P	C
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	M	F	N	SB	A	M
	B-C	M	S	F	Y	B	P	C
	C-D	L	S	F	Y	SB	P	M
	D-E	-	-	-	-	-	-	-

T29



T29	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	SB	P	M
	B-C	H	M	S	N	SB	P	M
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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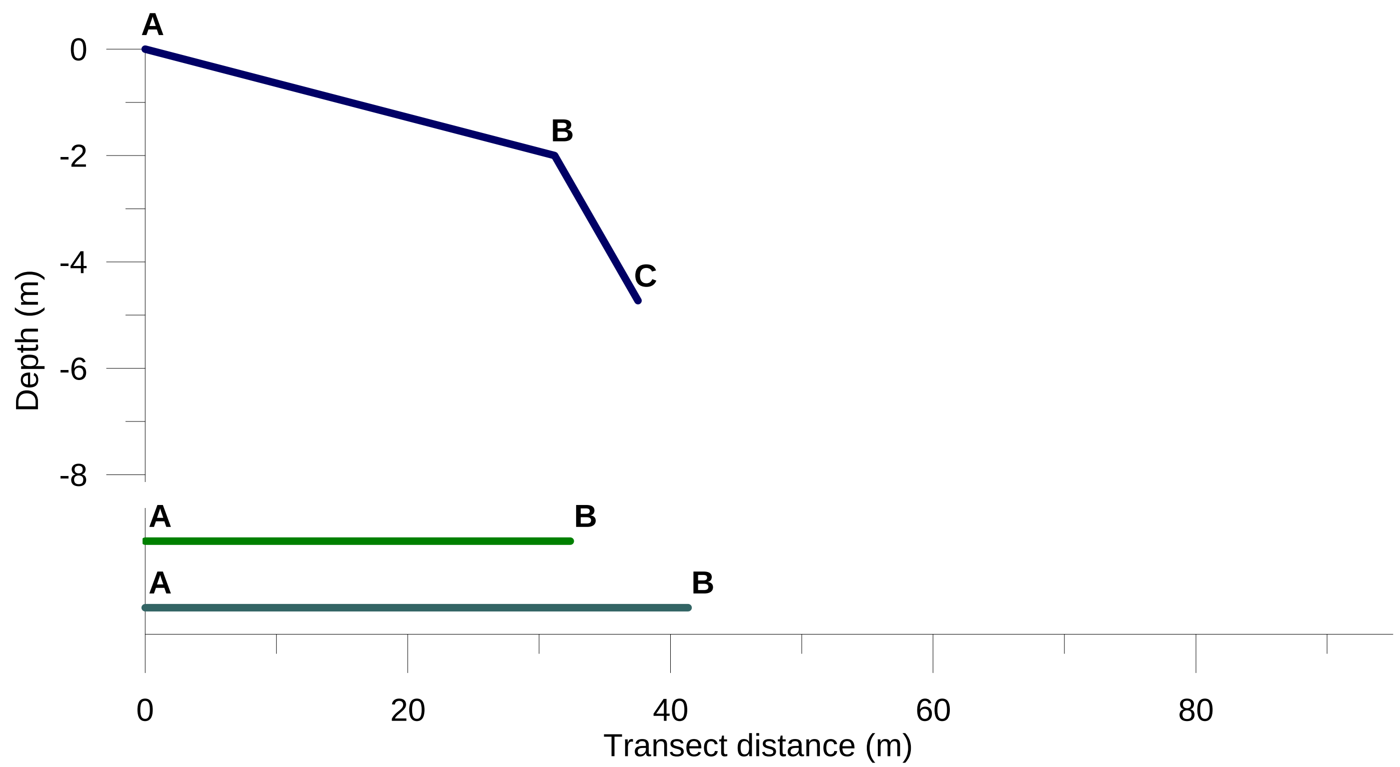
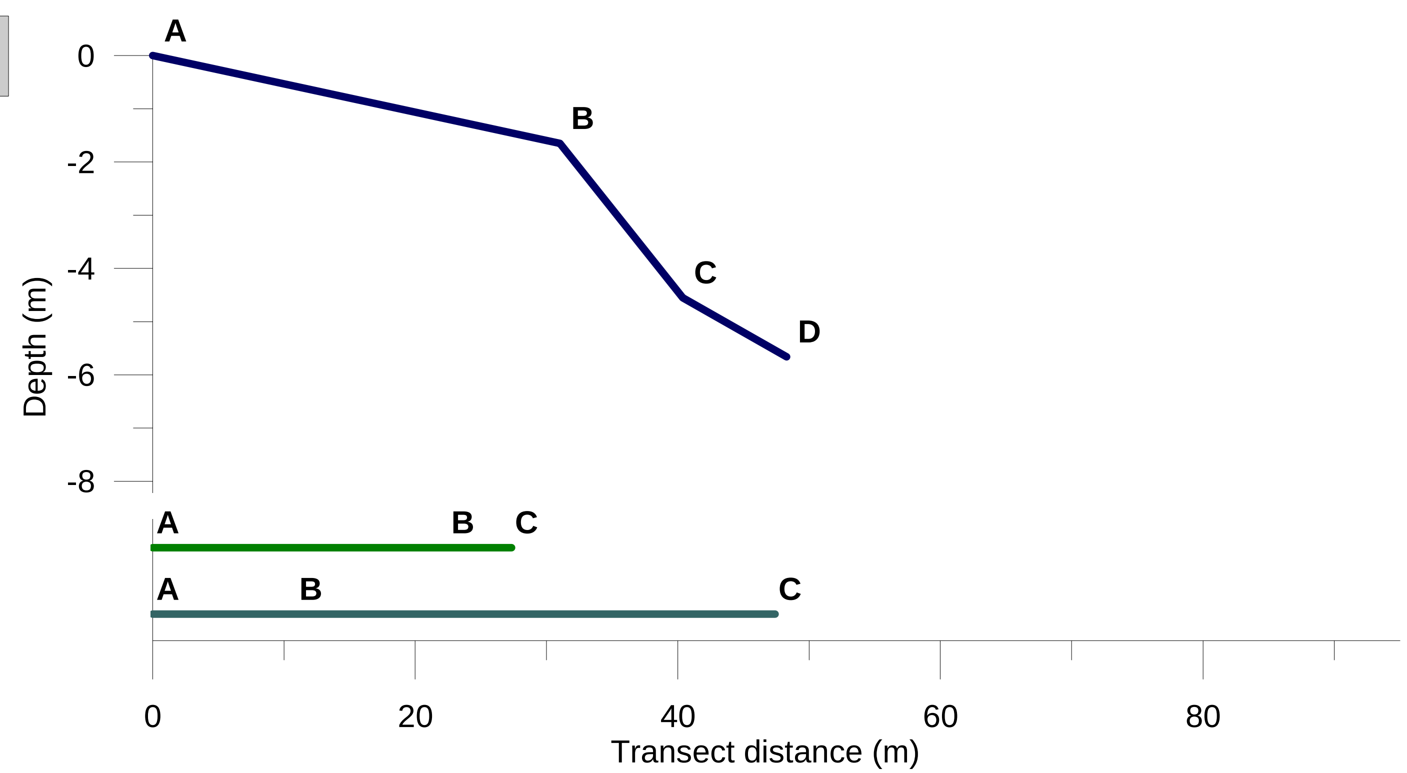
T32



T32	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	U
	B-C	H	M	S	N	B	P	U
	C-D							
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

T33



T33	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	M	M	S	N	SB	P	U
	C-D	M	M	S	N	S	P	U
	D-E							
	E-F							
2006 Air	A-B	M	S	F	N	B	P	C
	B-C	M	S	F	Y	BS	P	C
	C-D	0	0	0	0	0	0	0
2009 Air	A-B	M	M	F	N	SB	P	M
	B-C	M	S	F	Y	B	P	C
	C-D	0	0	0	0	0	0	0
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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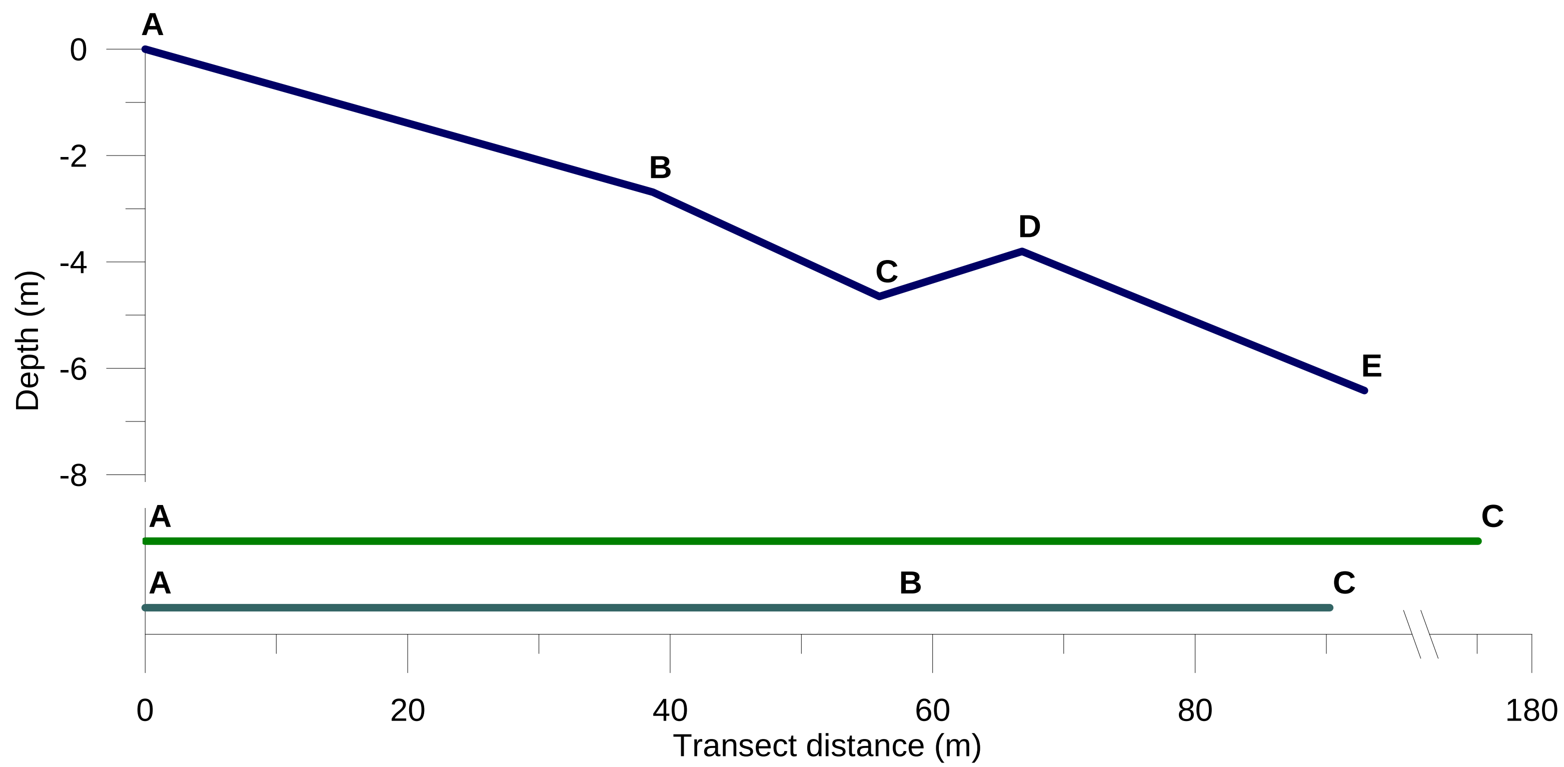
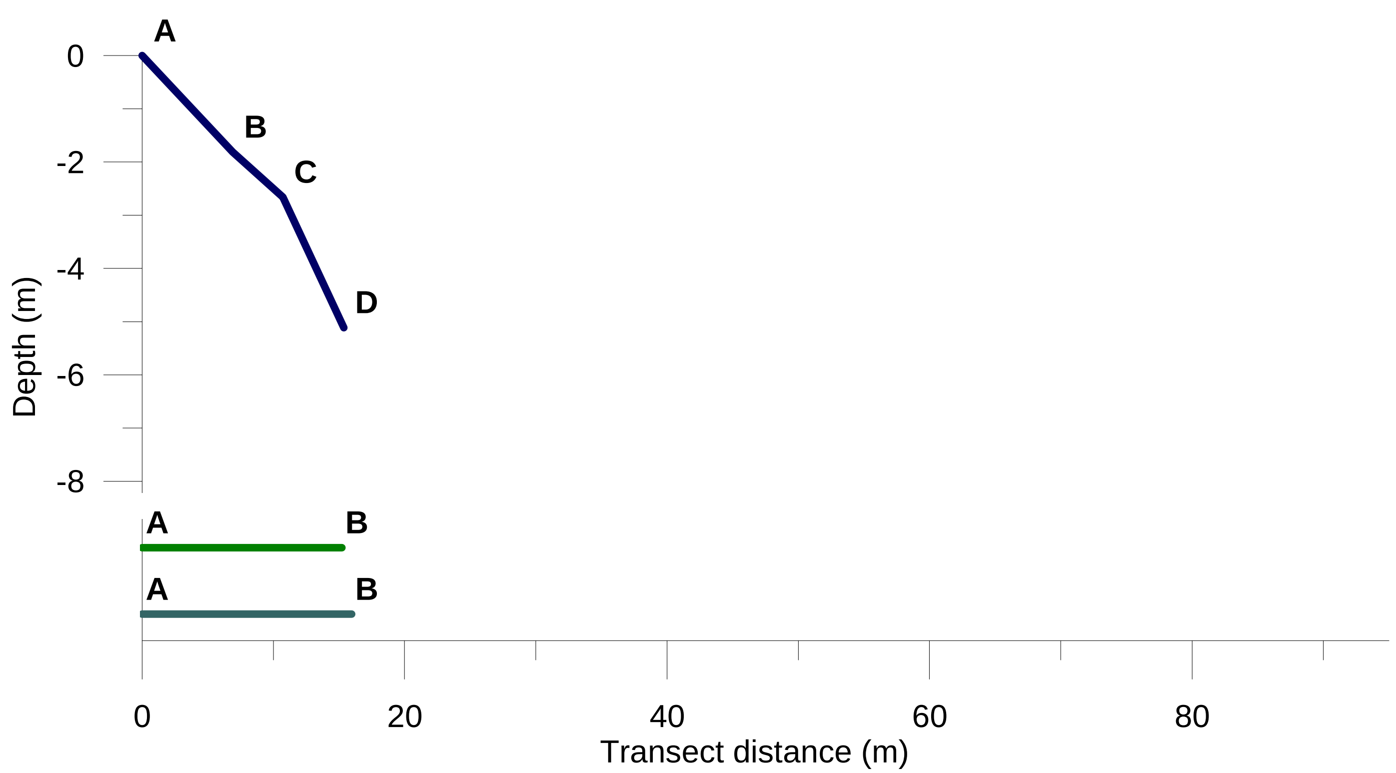
2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T32 & T33.

T30



T30	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	F	Y	B	P	M
	B-C	H	M	S	N	BS	P	C
	C-D	M	M	F	N	SB	S	M
	D-E	M	D	S	N	SB	S	M
	E-F							
2006 Air	A-B	H	M	S	N	S	A	U
	B-C	M	S	F	Y	BS	P	C
	C-D	-	-	-	-	-	-	-
2009 Air	A-B	M	M	F	N	SB	P	M
	B-C	M	S	F	Y	B	P	C
	C-D	-	-	-	-	-	-	-
	D-E							

T31



T31	Section	Habitat Value	Depth	Slope	Ice Scour	Substrate	Morphology	Complex
2009 Ground	A-B	M	S	S	Y	B	P	C
	B-C	H	M	S	N	B	P	C
	C-D	M	M	S	N	S	S	U
	D-E							
	E-F							
2006 Air	A-B	M	S	F	Y	BS	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
2009 Air	A-B	M	S	F	Y	B	P	C
	B-C	-	-	-	-	-	-	-
	C-D							
	D-E							

Legend

- 2009 Ground Survey
- 2006 Air Survey
- 2009 Air Survey

Attributes

Habitat Value: L = low, M = Moderate, H = High
Depth: S = Shallow, M = Moderate
Slope: F = Flat, S = Steep
Ice Scour: Y = Yes, N = No
Substrate: B = Boulder, S = Sediment, BS = Boulder with sediment, SB = Sediment with boulder
Morphology: A = Apron, S = Shoal, P = Platform
Complexity: U = Uniform, M = Moderate, C = Complex

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2009 GROUND AND 2006 & 2009 AIR SURVEYS FOR TRANSECT T30 & T31.

APPENDIX H

2009 INTEGRATED MAPPING: HABITAT ATTRIBUTE, SCORE AND VALUE RESULTS

Appendix H. Habitat attribute, score and value of 2009 integrated polygons.

2009 Integrated Habitat Attribute							2009 Integrated Habitat Attribute Score								
Polygon	Substrate	Morphology	Depth	Complexity	Slope	Ice Cover	Substrate Score	Morphology Score	Depth Score	Complexity Score	Slope Score	Ice Cover Score	Total	**Habitat Value**	**Polygon Area (ha)**
1	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	87.70
2	BS	A	M	C	S	N	8	2	4	6	2	0	22	High	0.28
3	SB	P	M	M	F	N	4	4	4	4	0	0	16	Moderate	0.14
4	SB	A	M	M	S	N	4	2	4	4	2	0	16	Moderate	0.09
5	B	A	M	M	S	N	6	2	4	4	2	0	18	High	0.21
6	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	5.40
7	BS	P	S	C	F	Y	8	4	1	6	0	-2	17	Moderate	0.26
8	BS	A	M	C	S	N	8	2	4	6	2	0	22	High	0.18
9	S	P	M	U	F	N	2	4	4	2	0	0	12	Moderate	0.04
10	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	0.53
11	S	P	M	U	F	N	2	4	4	2	0	0	12	Moderate	0.09
12	SB	A	M	M	S	N	4	2	4	4	2	0	16	Moderate	0.03
13	B	P	S	M	S	Y	6	4	1	4	2	-2	15	Moderate	0.12
14	S	P	S	U	S	Y	2	4	1	2	2	-2	9	Low	0.01
15	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.11
16	B	P	M	C	S	N	6	4	4	6	2	0	22	High	0.43
17	S	P	S	U	S	Y	2	4	1	2	2	-2	9	Low	0.10
18	S	P	S	U	F	Y	2	4	1	2	0	-2	7	Low	0.09
19	B	P	S	M	S	Y	6	4	1	4	2	-2	15	Moderate	0.17
20	B	A	M	M	S	N	6	2	4	4	2	0	18	High	0.21
21	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	1.92
22	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.10
23	B	A	M	C	S	N	6	2	4	6	2	0	20	High	0.30
24	SB	P	M	M	F	Y	4	4	4	4	0	-2	14	Moderate	0.10
25	B	P	S	M	S	Y	6	4	1	4	2	-2	15	Moderate	0.02
26	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	1.64
27	BS	A	M	C	S	N	8	2	4	6	2	0	22	High	0.18
28	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.17
29	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.43
30	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	0.86
31	BS	P	M	M	F	N	8	4	4	4	0	0	20	High	0.04
32	B	A	M	U	S	N	6	2	4	2	2	0	16	Moderate	0.43
33	S	S	M	M	F	N	2	3	4	4	0	0	13	Moderate	0.09
34	BS	S	M	M	F	N	8	3	4	4	0	0	19	High	0.23
35	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	1.01
36	SB	P	S	M	F	Y	4	4	1	4	0	-2	11	Low	0.17
37	SB	A	M	M	S	N	4	2	4	4	2	0	16	Moderate	0.05
38	B	P	S	U	F	Y	6	4	1	2	0	-2	11	Low	1.30
39	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.37
40	SB	S	D	M	S	N	4	3	3	4	2	0	16	Moderate	0.46
41	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.20
42	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	0.88

Appendix H. Habitat attribute, score and value of 2009 integrated polygons.

2009 Integrated Habitat Attribute							2009 Integrated Habitat Attribute Score								
Polygon	Substrate	Morphology	Depth	Complexity	Slope	Ice Cover	Substrate Score	Morphology Score	Depth Score	Complexity Score	Slope Score	Ice Cover Score	Total	**Habitat Value**	**Polygon Area (ha)**
43	SB	P	S	M	F	Y	4	4	1	4	0	-2	11	Low	0.74
44	SB	P	M	M	F	N	4	4	4	4	0	0	16	Moderate	0.09
45	B	P	S	M	S	Y	6	4	1	4	2	-2	15	Moderate	0.15
46	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	0.22
47	BS	P	S	M	S	Y	8	4	1	4	2	-2	17	Moderate	0.30
48	S	P	S	M	S	Y	2	4	1	4	2	-2	11	Low	0.47
49	BS	S	M	M	F	N	8	3	4	4	0	0	19	High	0.22
50	SB	SB	VD	M	F	N	4	1	2	4	0	0	11	Low	0.27
51	SB	SB	D	M	F	N	4	1	3	4	0	0	12	Moderate	0.26
52	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	0.58
53	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	0.41
54	SB	SB	D	U	F	N	4	1	3	2	0	0	10	Low	0.54
55	B	P	S	M	F	Y	6	4	1	4	0	-2	13	Moderate	7.63
56	B	S	M	C	F	N	6	3	4	6	0	0	19	High	0.73
57	S	SB	VD	U	F	N	2	1	2	2	0	0	7	Low	0.08
58	B	S	S	M	F	Y	6	3	1	4	0	-2	12	Moderate	0.07
59	SB	S	D	M	F	N	4	3	3	4	0	0	14	Moderate	0.46
60	SB	S	M	M	F	N	4	3	4	4	0	0	15	Moderate	0.98
61	BS	S	M	C	F	N	8	3	4	6	0	0	21	High	2.21
62	S	A	M	M	S	N	2	2	4	4	2	0	14	Moderate	0.42
63	S	S	M	U	F	N	2	3	4	2	0	0	11	Low	1.40
64	BS	A	M	C	S	N	8	2	4	6	2	0	22	High	0.30
65	BS	A	M	C	S	N	8	2	4	6	2	0	22	High	0.35
66	B	A	M	M	S	N	6	2	4	4	2	0	18	High	0.18
67	BS	P	M	M	S	N	8	4	4	4	2	0	22	High	0.67
68	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.82
69	B	P	S	C	F	Y	6	4	1	6	0	-2	15	Moderate	0.33
70	BS	P	M	C	F	N	8	4	4	6	0	0	22	High	0.24
71	S	P	S	U	S	Y	2	4	1	2	2	-2	9	Low	0.08
72	B	P	S	C	S	Y	6	4	1	6	2	-2	17	Moderate	0.08
73	B	A	D	C	S	N	6	2	3	6	2	0	19	High	0.72
74	BS	P	M	C	S	N	8	4	4	6	2	0	24	High	0.25
75	S	P	M	C	S	N	2	4	4	6	2	0	18	High	0.11
76	BS	S	M	C	F	N	8	3	4	6	0	0	21	High	1.00
77	SB	S	M	U	F	N	4	3	4	2	0	0	13	Moderate	0.94
78	B	P	M	C	S	N	6	4	4	6	2	0	22	High	0.04