Coffee Gold Mine

YESAB Project Proposal

Appendix 11-B Surficial Geology, Terrain, and Soils Valued Component Assessment Report

VOLUME II

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File: 1658-003.01

Ver. 1.0

March 2017

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
BC	British Columbia
ELC	Ecological Land Classification
EMR	Department of Energy, Mines, and Resources
HLF	Heap Leach Facility
ICMC	International Cyanide Management Code
ISO	International Organization for Standardization
LAA	Local Assessment Area
NaCN	Sodium Cyanide
NAR	Northern Access Route
NOAA	National Oceanic and Atmospheric Administration
Project	Coffee Gold Mine Project
QML	Quartz Mining License
RAA	Regional Assessment Area
RIC	Resources Inventory Committee
ROM	Run-of-mine
ROW	Right-Of-Way
TK	Traditional Knowledge
VC	Valued Environmental Component or Valued Socio-economic Component
WL	Water License
WRSF	Waste Rock Storage Facility
YBIS	Yukon Biophysical Inventory System
YESAB	Yukon Environmental and Socio-economic Assessment Board
YWB	Yukon Water Board

1.0 INTRODUCTION

Describing the Surficial Geology, Terrain, and Soils in the areas encompassed by the proposed Coffee Gold Mine (Project) and their responses to anthropogenic influences, is fundamental to the planning and placement of mine and access infrastructure, as well as for directing mine reclamation. Surficial geology and terrain are two of several factors (such as climate, vegetation, time) that interact to form soils. For clarity, the following definitions from Howes and Kenk (1997) and Resources Inventory Committee (RIC) (1996) are used:

- **Surficial geology (materials)** – relatively young, non-lithified, unconsolidated sediments produced by weathering, sediment deposition, biological accumulation, human, and volcanic activity; surficial materials constitute the parent material of most soils.
- **Terrain** – tract of landscape being studied with respect to its natural features; terrain features are often represented on maps as units with varying surficial materials, material textures, surface expressions, geomorphological processes, and subsurface information.
- **Soils** – Natural medium for growth of land plants; the result of the combined effects of physical, chemical, and biological processes.

The purpose of this assessment is to describe the potential effects of the Project on Surficial Geology, Terrain, and Soils and to identify mitigation measures that, when applied, would mitigate (e.g., eliminate or avoid, reduce, or control) predicted adverse effects.

1.1 ISSUES SCOPING

Surficial Geology, Terrain, and Soils contribute to the supporting structure of landscapes and ecosystems which in turn support various functions and values that range from biological to cultural. Because Project activities have the potential to directly disturb this valued component (VC), it is included as part of the environmental assessment. Disturbance of this VC can also result in the extension of effects to ecosystems and vegetation, wildlife and fish habitat, and water resources. The location of the Project within the zone of extensive discontinuous permafrost adds a level of complexity that is addressed from both a terrain and soils perspective.

The assessment of effects to terrain is discussed in terms of a potential change in terrain stability as a result of Project activities, such as road construction or general site disturbance. The discussion includes potential stability-related effects resulting from disturbances to permafrost within the Mine Site area and along the Northern Access Route (NAR). Potential stability issues will not be discussed for engineered structures (e.g., open pits, pit walls, waste rock dumps, general infrastructure), as these aspects are covered by mine design (JDS Energy & Mining Inc. 2016).

The assessment of effects to soils focuses on a potential decrease in soil quality within the Mine Site area for both soils that are left in situ as well as those that will be salvaged and stockpiled. Soils here refer to materials within 0.5 metres (m) of the surface and includes frozen soils. Materials at depths below 0.5 m are classified as overburden.

For the purposes of this assessment, the potential effects to surficial geology relate to overburden materials (i.e., at depths below 0.5 m of the surface) but have been included as part of the assessment of soils due to the inherent influence surficial geology has on soil development and the premise that surficial geology could be affected in a manner similar to that described for soils.

The scope of the assessment for potential effects to Surficial Geology, Terrain, and Soils relies on information compiled from both past and new studies commissioned as part of the Project baseline characterization program as well as from the review of other existing and proposed quartz mining projects in the Yukon and other parts of northern Canada. Although surficial geology and soil are not specifically mentioned in the Traditional Knowledge (TK) data collected to date for the Project, the importance of these features in maintaining the integrity of other components (e.g., plants, ecosystems, wildlife habitat) is inferred through views that expressed traditional ways of life being tied to “healthy and intact ecosystems” (Bates, et al. 2014) and being “key to the overall health of the land” (Tr'ondëk Hwëch'in 2012). The importance of terrain in terms of TK has been identified with respect to the avoidance of natural hazards and the use of landscape features as lookouts as well as for travel corridors and the establishment of hunting and camping sites (Dobrowolsky 2014; Tr'ondëk Hwëch'in 2012).

1.2 Selection of Surficial Geology, Terrain, and Soils

Selection of Surficial Geology, Terrain, and Soils as a VC followed the VC selection process presented in **Section 5.1.1 Selecting Intermediate Components and Valued Components** of the Project Proposal. Surficial Geology, Terrain, and Soils are present within the proposed Project area and have the potential to interact with Project activities.

1.2.1 Candidate VCs

Surficial Geology, Terrain, and Soils was selected as a candidate VC as it was clear from the review of past submissions to the Yukon Environmental and Socio-economic Assessment Board (YESAB) (e.g., Casino Project 2014; Eagle Gold Project 2011) and other regulatory agencies (e.g., British Columbia Environmental Assessment Office, Mackenzie Valley Environmental Impact Review Board) that Surficial Geology, Terrain, and Soils are sufficiently important to government agencies, potentially affected First Nations, affected local communities, the public, and other interested parties, as well as to other biophysical components of the environment to warrant full consideration in the effects assessment (**Table 1.2-1**).

Table 1.2-1 Candidate Valued Components for Surficial Geology, Terrain, and Soils – Evaluation Summary

Candidate VC	Project Interaction			Third Party Input		Supports the Assessment of Which Other VC?	Selected as a VC?	Decision Rationale
	Interaction?	Project Phase / Project Component / Activity	Nature of Interaction	Source	Input			
Surficial geology, terrain, and soil	Yes – potential to interact with other VCs such as surface water quality, fish and fish habitat, vegetation.	All phases	Land clearing and other activities resulting in site disturbance have the potential to disturb surficial geology, terrain, and soils	Past Project Proposal submissions to YESAB Past EA submissions in other jurisdictions including northern Canada	Based on precedent	Vegetation and Ecosystems Wildlife and Wildlife Habitat Fish and Fish Habitat	Yes – Surficial Geology, Terrain, and Soils (combined into single VC)	Potential for effects from land clearing and other activities resulting in site disturbance Also informs closure and reclamation planning

1.2.2 SELECTED VC

Surficial Geology, Terrain, and Soils have the potential to interact directly with Project-related activities and may in turn affect other biophysical components (e.g., plants, ecosystems, wildlife and fish habitat) when disturbed, such as losing suitable substrate for plant establishment and increasing sedimentation into streams via soil erosion. This makes them suitable for consideration as VCs; due to their interconnected nature however, these three components are considered collectively as a single VC.

1.2.3 VC SUBCOMPONENTS

To simplify and focus the assessment, three subcomponents are identified for the Surficial Geology, Terrain, and Soils VC: terrain stability, unique landforms, and soil quality. Terrain stability contributes to the safe and effective planning of mine infrastructure. Unique landforms represent features on the landscape (in this instance, tors and pingos) that are distinctive and may be included in the types of landscape features mentioned in TK that were used as lookouts (Tr'ondëk Hwëch'in 2012). They may also provide particular habitat qualities for plants and/or wildlife. Soil quality is integral to the maintenance of overall ecological health and for reclamation planning (**Table 1.2-2**).

Table 1.2-2 Subcomponents for Surficial Geology, Terrain, and Soils

Subcomponent	Rationale for Selection
Terrain Stability	Terrain stability is fundamental to the planning and placement of mine and access infrastructure. Identifying areas of potential instability can improve engineering design and decision-making and helps to avoid exacerbating prospective high risk (e.g., mass movement) events.
Unique Landforms	Several unique landforms (specifically tors and pingos) have been identified within or adjacent to the Project footprint and may have served as navigational aids to First Nations and/or provide particular habitat qualities for plants and/or wildlife.
Soil Quality	Soil quality is central to the maintenance of ecosystem integrity (for soils left in-situ) and reclamation planning (for soils that will be salvaged and stockpiled).

1.2.4 INDICATORS

Several indicators for the terrain and soils (including permafrost) subcomponents were selected to focus the assessment of Project effects on the overarching VC (**Table 1.2-3**). Terrain stability indicators are characterized as the following:

- Change in terrain stability class due to Project activities such as site clearing
- Change in terrain stability due to permafrost disturbance associated with Project activities.

The unique landform indicator is characterized as the following:

- Disturbance of unique landforms.

Soil quality indicators are characterized as the following:

- Soil disturbance (for in situ soils) calculated as the amount of surface area disturbed (in hectares)
- Soil degradation (for in situ soils) characterized qualitatively by the potential for compaction and/or contamination
- Soil salvage and handling (for salvaged and stockpiled soils) characterized qualitatively by the potential to change the properties of soils that will be salvaged and stockpiled for later use in reclamation.

Table 1.2-3 Indicators for Surficial Geology, Terrain, and Soils and Associated VC Subcomponents

VC	Subcomponent	Indicator
Surficial Geology, Terrain, and Soils	Terrain Stability	Change in terrain stability class Change in terrain stability as a result of permafrost disturbance
	Unique Landforms	Disturbance of unique landforms
	Soil Quality	Soil disturbance (for in situ soils) Soil degradation (for in situ soils) Soil salvage and handling (for salvaged and stockpiled soils)

1.3 ESTABLISHMENT OF ASSESSMENT BOUNDARIES

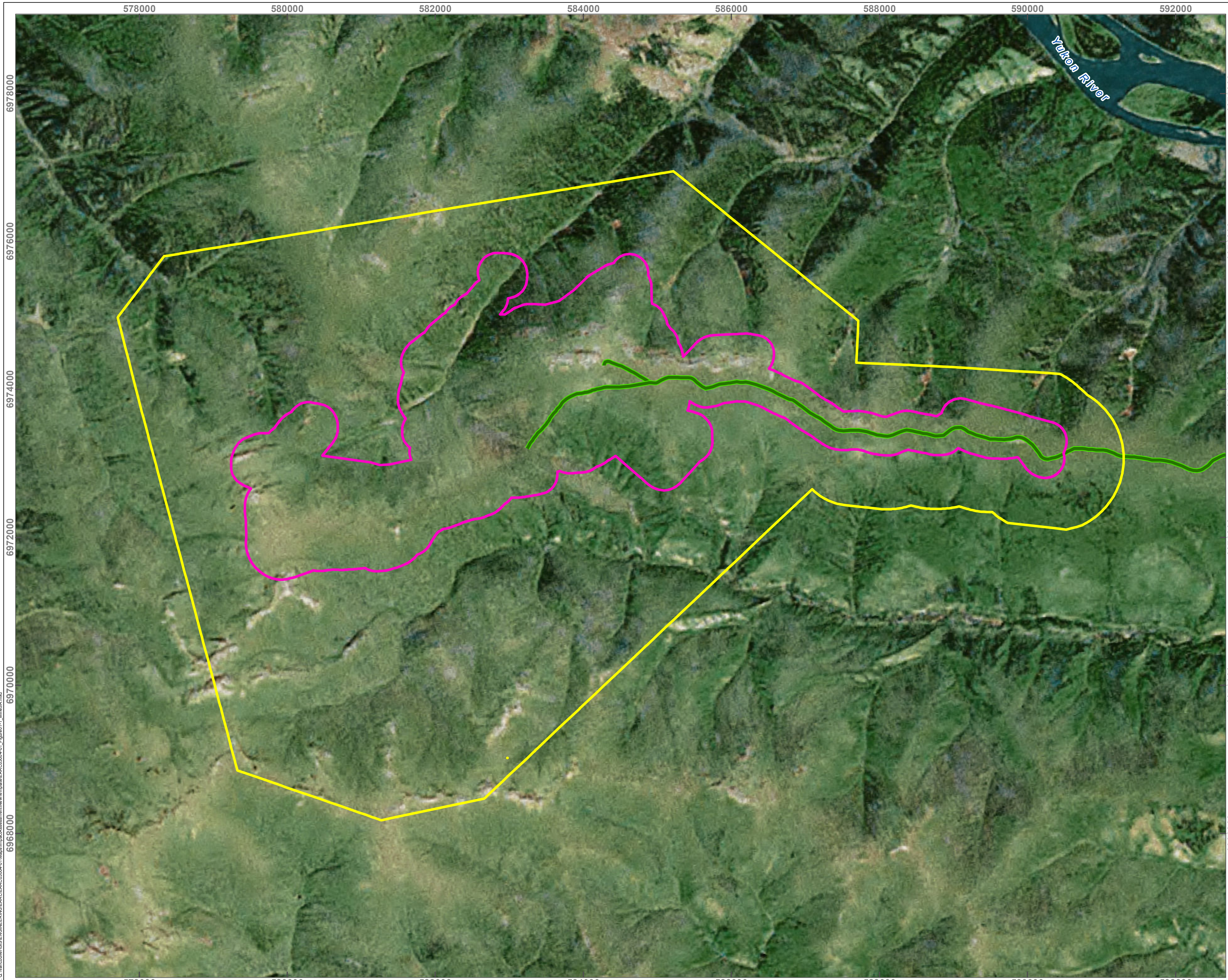
The establishment of the spatial boundaries for the Surficial Geology, Terrain, and Soils VC took into consideration the various related baseline studies conducted at the Project site (described in more detail in **Section 3.2.3**), each of which examined different overall extents. The local assessment areas (LAA) and regional assessment areas (RAA) developed for the assessment of potential Project effects on Surficial Geology, Terrain, and Soils represent the intersection of these various study areas and serves to identify where effects to the VC are most likely to occur within a localized and broader context.

Local and regional assessment area boundaries to address potential changes in terrain stability and soil quality are defined for two main components of the Project: the Mine Site area, which will support primary mine infrastructure and associated activities, and the NAR, which will serve as the main land-based access to the site (**Figure 1.3-1** and **Figure 1.3-2**, respectively). This division was made so that the discussion of potential Project effects could focus on each component area due to the differences between the effects and mitigation measures associated with mine infrastructure and activities versus those associated with linear corridors such as roads. This is also suitable given that the NAR will follow an existing road network for the majority of its length (which totals 214 km). Upgrades and some realignments will be necessary for some portions of the existing route and 37 km of new construction will be required. Existing conditions and potential effects along the NAR are not discussed in terms of the ice road or barge routes, largely because these components are unlikely to interact with Surficial Geology, Terrain, and Soils. Further descriptions of the assessment area boundaries are presented below in **Table 1.3-1**.

1.3.1 SPATIAL BOUNDARIES

Local assessment areas (LAA) to assess potential changes in terrain stability and soil quality are defined for the Mine Site area and NAR. The LAA within the Mine Site area was derived by buffering the edge of mine infrastructure by 250 m and applying a 500 m buffer around the centreline of the access road that leads to the proposed airstrip facility (**Figure 1.3-1**). The LAA associated with the NAR was derived by buffering the proposed NAR centreline by 500 m (**Figure 1.3-2**). Both LAAs were designed to encompass the direct physical effects of Project activities. The total Mine Site LAA is approximately 1,837 ha, while the LAA for the NAR is approximately 19,773 ha.

The regional assessment area (RAA) defined for the Mine Site area to assess potential changes in terrain stability and soil quality include the footprints of proposed mine infrastructure plus a 1 km buffer in order to capture upslope instabilities or hazards and to accommodate minor adjustments in infrastructure site selection (**Figure 1.3-1**). The RAA for the NAR comprises a 1 km buffer extending from the road centreline (for a 2 km wide band overall), with some areas extending up to 5 km wide to capture heights of land where upslope processes could potentially affect infrastructure (**Figure 1.3-2**). The RAA for the Mine Site area is approximately 6,689 ha in size, while the NAR RAA is approximately 45,897 ha. Both regional boundaries place the potential effects of the Project into a broader context and will also be used to address potential cumulative effects.



COFFEE GOLD MINE

Local and Regional Assessment Areas for Surficial Geology, Terrain, and Soils within the Mine Site Area

Legend

- Mine Site Access Road
- Local Assessment Area
- Regional Assessment Area

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2.Imagery from ESRI; Earthstar Geographics (1999)

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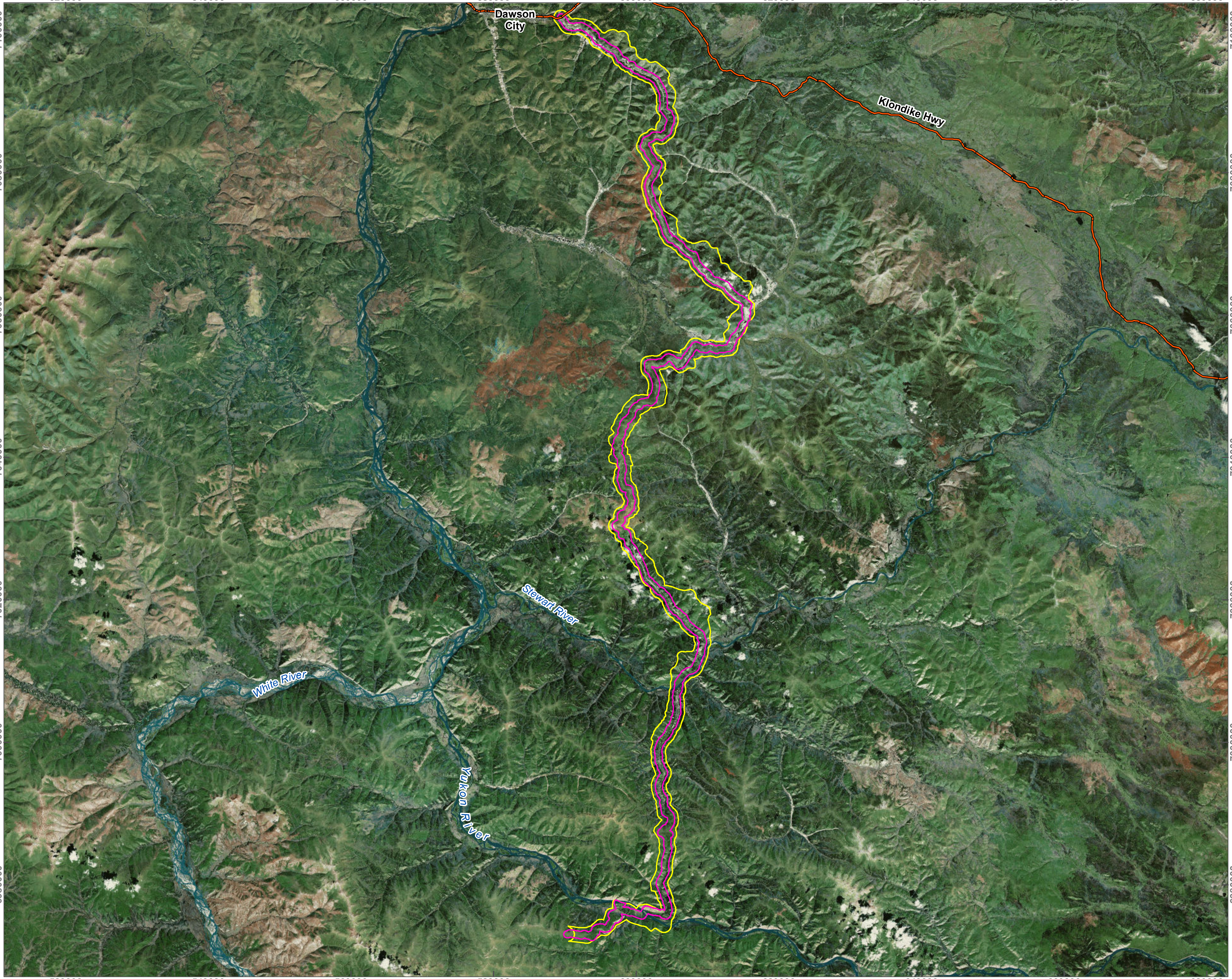
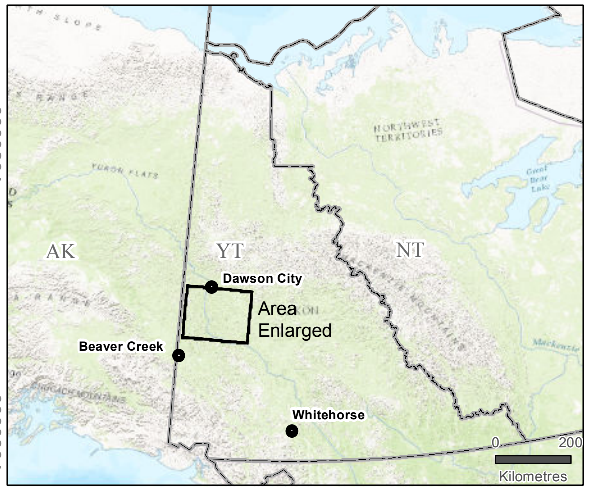
Figure 1.3-1	Date: Mar 16, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Local and Regional Assessment Areas for Surficial Geology, Terrain, and Soils along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Klondike Highway

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2.Imagery from ESRI; Earthstar Geographics (1999)

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Figure 1.3-2	Date: Jan 11, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

Table 1.3-1 Spatial Boundary Definitions for Surficial Geology, Terrain, and Soils

Spatial Boundary	Description of Assessment Area
Terrain Stability	
Local Assessment Area	• Within the Mine Site area, consists of a 250 m buffer around mine infrastructure and a 500 m buffer around the centreline of the access route to airstrip facilities (**1,837 ha**) • For the NAR, consists of a 500 m buffer around the route centreline (**19,773 ha**)
Regional Assessment Area	• Full extent of terrain hazard mapping for the Mine Site area and mine access route to the airstrip facilities (**6,689 ha**) • Full extent of terrain hazard mapping for the NAR (which includes a minimum 1 km buffer around the route centreline) (**45,897 ha**)
Cumulative Effects Assessment Area	• Same as RAAs within the Mine Site area and along the NAR
Unique Landforms	
Local Assessment Area	• Same as LAA for terrain stability within the Mine Site area and along the NAR
Regional Assessment Area	• Same as RAA for terrain stability within the Mine Site area and along the NAR
Cumulative Effects Assessment Area	• Same as RAA within the Mine Site area and along the NAR
Soil Quality	
Local Assessment Area	• Same as LAA for terrain stability within the Mine Site area and along the NAR
Regional Assessment Area	• Same as RAA for terrain stability within the Mine Site area and along the NAR
Cumulative Effects Assessment Area	• Same as RAA within the Mine Site area and along the NAR

1.3.2 TEMPORAL BOUNDARIES

The temporal boundaries of the Project consist of Construction, Operation, Reclamation and Closure, and Post-closure Phases, which are described in **Section 2.0 Project Description** of the Project Proposal. These temporal boundaries apply to the assessment of potential Project effects on Surficial Geology, Terrain, and Soils.

1.3.3 ADMINISTRATIVE BOUNDARIES

No administrative boundaries were identified for the assessment of potential Project effects on Surficial Geology, Terrain, and Soils.

1.3.4 TECHNICAL BOUNDARIES

Data compiled to support the Surficial Geology, Terrain, and Soils VC consisted of a combination of field surveys, mapping (terrain, terrain hazards, permafrost, soils, and ecological land classification – ELC), and the review of other existing information. These various data sources come with inherent technical limitations which form the basis of the technical boundaries for this VC. Examples of such limitations include completing field surveys in areas that are safely accessible, identifying a minimum survey intensity level for field plots (e.g., 1 plot per 100 hectares), focussing surveys in areas where Project disturbance is anticipated (all of which result in areas being unassessed in the field), and mapping polygons to a certain level of detail based on the resolution of available imagery or the overall objectives of the map (e.g., identifying only two map units within a polygon instead of three).

The quantitative estimates (in hectares) presented to determine the distribution of features (e.g., terrain stability classes, permafrost, soil types) within each study area are considered conservative as they generally relied on mapped attributes that were assigned to polygons in their entirety (e.g., a single terrain stability class or permafrost type used to characterize a complete polygon). The resulting calculations likely over or underestimate, to an extent, the particular features being summarized, however the overall trends identified can still be considered representative of site conditions.

For the purposes of the effects assessment, the anticipated extent of Project disturbance has been overestimated through the application of a 50 m buffer around the outer boundaries of Project infrastructure. This provides some flexibility with respect to infrastructure placement and presents a more conservative approach in terms of overall disturbance areas.

Development of the soils map was restricted to the Mine Site area, as this is where the greatest extent of disturbance to soils is expected to occur and where the majority of reclamation efforts will take place. The identification of soil map units provides a level of detail necessary to support the assessment of effects as well as reclamation planning. Descriptions of soils along the NAR are provided in terms of soil parent materials present within the study areas defined. Soil mapping was not conducted specifically along the NAR as the parent material attribute provides an appropriate level of detail, particularly given that the majority of the NAR is aligned with existing roadways and major disturbances to soils have already occurred.

These limitations are common to effects assessments that rely on these types of data and do not impede the ability to assess potential Project effects. They can be offset through the use of a conservative approach to the identification of potential Project effects. For the Coffee Gold Mine, the conservative approach involved the establishment of a 50 m buffer around proposed infrastructure which will provide an over-estimation of potential Project effects. Additionally, soils and reclamation studies are ongoing at the Project site, the results of which will be used to further inform Project activities and applicable management plans.

2.0 ASSESSMENT METHODS

The assessment of effects to Surficial Geology, Terrain, and Soils was conducted in accordance with the methods identified in **Section 5.0 Assessment Methodology** of the Project Proposal.

Input to the assessment included data collected from field survey programs, terrain mapping, terrain stability mapping, permafrost mapping, ELC mapping, soils mapping (including soil salvage and reclamation suitability), results from the air quality model (for dustfall in particular), and consultation and engagement with government agencies, potentially affected First Nations, and the public. Map products were developed at a scale of 1:20,000. The potential effects to soils as a result of possible alterations to groundwater (e.g., as presented by localized increases or decreases in relative soil moisture) from Project activities were also considered. The groundwater model revealed that the water table is sufficiently deep as to limit the interaction with soil (defined here as the top 0.5 m of material). As such, this potential linkage is not considered further in the assessment.

The methods used to compile information from consultation activities, develop maps, collect field information, and conduct the air quality and groundwater modelling are presented below as well as in the following sections of the Project Proposal and corresponding appendices:

- **Section 3.0 Consultation**
- **Section 9.0 Air Quality and Greenhouse Gas Emissions**
- **Appendix 11-A Surficial Geology, Permafrost, and Terrain Stability Baseline Report**

Changes in terrain stability were determined quantitatively and qualitatively using GIS to overlay the Project footprint onto the various maps produced. Areas that were considered as being particularly sensitive to disturbance were then identified and included areas that:

- Are currently considered to be relatively unstable from a terrain stability perspective
- Could become unstable with the addition of Project infrastructure
- Are underlain by ice-rich permafrost or
- Support unique landforms.

Changes in soil quality were also determined quantitatively and qualitatively using a similar approach to that described for changes in terrain stability class. The Project footprint was overlain onto the soils map (which includes the identification of areas suitable for reclamation) to identify likely disturbance areas.

3.0 EXISTING CONDITIONS

A summary of the existing baseline conditions for Surficial Geology, Terrain, and Soils is presented for the LAA and RAA defined for the Project. This information provides the context for the assessment of effects on this VC.

3.1 REGULATORY CONTEXT

The regulation and management of Surficial Geology, Terrain, and Soils is largely through the reclamation policies and guidelines developed for hard rock (quartz) mines in the Yukon (e.g., EMR 2006; YWB and EMR 2013). Mining projects are likely to require a Quartz Mining License (QML), which is regulated by the *Quartz Mining Act* (SY 2003, c.14) and issued by the Department of Energy, Mines, and Resources (EMR), and a Water License (WL), which is regulated by the *Waters Act* (SY 2003, c.19), and issued by the Yukon Water Board (YWB). Both licenses have reclamation and closure requirements; however, the expectations for reclamation and closure present themselves much earlier in the initial approval stages of a project (e.g., at the Project Proposal stage). These expectations have guided the assessment of potential effects, as well as the mitigation measures, for the Surficial Geology, Terrain, and Soils VC.

3.2 BACKGROUND INFORMATION AND STUDIES

3.2.1 TRADITIONAL KNOWLEDGE

The description of existing conditions for Surficial Geology, Terrain, and Soils relies on information compiled from both past and new studies commissioned as part of the Project baseline characterization program as well as through the review of other existing and proposed quartz mining projects in the Yukon and other parts of northern Canada. Although Surficial Geology and Soil are not specifically mentioned in the TK data collected to date for the Project (**Section 3.0 Consultation**), the importance of these features in maintaining the integrity of other components (e.g., plants, ecosystems, wildlife habitat) is inferred through views that expressed traditional ways of life being tied to “healthy and intact ecosystems” (Bates, et al. 2014) and being “key to the overall health of the land” (Tr'ondëk Hwëch'in 2012). The importance of terrain in terms of TK has been identified with respect to the avoidance of natural hazards and the use of landscape features as lookouts as well as for travel corridors and the establishment of hunting and camping sites (Dobrowolsky 2014; Tr'ondëk Hwëch'in 2012). There is no specific mention that tors and/or pingos constitute the landscape features used as lookouts in the TK data collected for the Project.

3.2.2 SCIENTIFIC AND OTHER INFORMATION

Data and results from other sources of information were compiled during a desktop review study for the Project. Projects, particularly those in the vicinity of the Coffee Gold Mine, that are either undergoing or have completed the assessment process (e.g., Casino Mine Project and Eagle Gold Mine, respectively) provided valuable insight into the scope and level of detail presented. Scientific literature such as journal publications and white papers were also reviewed and referenced to help characterize existing conditions and identify potential effects and mitigation measures.

3.2.3 BASELINE STUDIES CONDUCTED DURING THE PROJECT'S FEASIBILITY PROGRAM

Baseline data to support the Surficial Geology, Terrain, and Soils VC were collected and compiled from the vegetation and ecosystem mapping study (**Appendix 15-A**), surficial geology, permafrost, and terrain stability study (**Appendix 11-A**), and terrain stability and hazard mapping study (**Appendix 11-A**), as presented in **Table 3.2-1**. Data collection and compilation were guided by methods and standards developed specifically for Yukon as well as British Columbia (BC) (listed in **Table 3.2-1**). Further details of the methods and results of these studies are provided as appendices to this VC report as well as appendices to the VC report for vegetation (**Appendix 15**). The study area boundaries established for each of these baseline studies differ from one another and were taken into consideration when establishing the LAA and RAA used to assess the Surficial Geology, Terrain, and Soils VC.

Table 3.2-1 Summary of Desktop and Field Studies Related to Surficial Geology, Terrain, and Soils

Study Name	Study Purpose, Duration and Spatial Boundaries	Methods and Standards Used
Coffee Gold Project Environmental Baseline Report, Mine Area: Surficial Geology, Permafrost, and Terrain Stability (**Appendix 11-A**).	Evaluation of surficial geology, permafrost, and terrain stability for the Mine Site area. Involved the preparation of maps and compilation of data from various field investigations conducted from 2011 to 2016 ranging from soils, hydrogeology, permafrost, and geotechnical, which included the installation of instruments in boreholes, testpitting, ground investigations, and helicopter flyovers.	Surficial geology mapping: • Yukon Digital Surficial Geology Compilation and Terrain Classification System (Yukon Government 2016)
Soils Map (**Appendix 11-A)**	Soils mapping conducted in 2016 within the Mine Site area. Utilized field and spatial data from permafrost, terrain stability, and ecosystem mapping components.	Soil mapping: • Canadian System of Soil Classification (Soil Classification Working Group 1998) • Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC 1998) • Terrain Classification System for British Columbia (Howes and Kenk 1997) • Field Manual for Describing Terrestrial Ecosystems (BC Ministry of Forests and Range and BC Ministry of Environment 2010)
Terrain Stability and Hazard Mapping for the Coffee Gold Project (**Appendix 11-A**)	Detailed terrain stability and hazard mapping with supporting field studies conducted in 2015-2016 to characterize the types and distribution of terrain hazards in the vicinity of proposed Project infrastructure. Mine study area encompasses the proposed footprints of mine infrastructure plus a minimum 1 km buffer. Road study area consists of an average 2 km wide access road corridor beginning at KP 700 of the North Klondike Highway and extending south to the proposed Mine Site.	Field investigations for terrain stability: • Field Manual for Describing Terrestrial Ecosystems (BC Ministry of Forests and Range and BC Ministry of Environment 2010) • Canadian System of Soil Classification (Soil Classification Working Group 1998) • Terrain stability mapping: • Geohazards and Risk: A Proponent's Guide to Linear Infrastructure (Guthrie and Cuervo 2015) • Yukon Government's adaptation of the Terrain Classification System for British Columbia (Howes and Kenk 1997) • Mapping and Assessing Terrain Stability Guidebook (BC Ministry of Forests 1999) • A User's Guide to Terrain Stability Mapping in British Columbia (J.M Ryder and Associates 2002) • Guide for Management of Landslide-Prone Terrain in the Pacific Northwest (BC Ministry of Forests 1994)

Study Name	Study Purpose, Duration and Spatial Boundaries	Methods and Standards Used
Coffee Gold Project: Vegetation Baseline Report (**Appendix 15-A**)	Detailed ecosystem mapping and supporting field studies conducted from 2014-2016 to characterize the types and distribution of ecosystems in the vicinity of proposed Project infrastructure. Ecosystem descriptions include soil characteristics. Soil samples were also collected and analyzed for trace metals. Local Study Area in the Mine Site area was delineated in part based on height of land while including a minimum buffer of 1 km around the proposed footprint. Studies along the proposed access route occurred within a 2 km corridor.	ELC mapping and field investigations: • Yukon Ecological and Landscape Classification Guidelines, Version 1.0. (Environment Yukon. Draft 2015a) • Field Manual for Describing Terrestrial Ecosystems (BC Ministry of Forests and Range and BC Ministry of Environment 2010) • Ecoregions of the Yukon Territory: Biophysical Properties of Yukon Landscapes (Yukon Ecoregions Working Group 2004) • Flora of the Yukon Territory (Cody 2000) • Yukon Biophysical Inventory System (YBIS) • Field Manual for Describing Yukon Ecosystems, Draft document. Provided by the ELC Coordinator for Environment Yukon • A Field Guide to the Ecosite Identification for the Boreal Low Subzone of Yukon (Environment Yukon. 2015b) • Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC 1998).

As part of the terrain stability assessment, the terrain stability mapping conducted for the Project considered landscape conditions, previous disturbances and site history, and the location of the Project within the zone of discontinuous permafrost when determining which terrain stability class to assign to each mapped polygon. Definitions of the terrain stability classes defined for the Project are provided in **Appendix 11-A**. Mapped polygons were assigned an 'existing terrain stability' class, which is representative of current conditions, and a 'disturbed terrain stability' class, which identifies what stability conditions could end up being following conventional construction of mine infrastructure and roads without mitigation for conditions such as steep slopes and permafrost with excess ice (**Appendix 11-A**). The disturbed terrain stability class was used to identify potential Project effects on terrain stability and is discussed further in **Section 4.0**.

Hazards associated with mass movements (slope failure) and thermokarst (the process by which characteristic landforms result from the thawing of ice-rich permafrost; as per Harris et al. 1988) were also assessed by reviewing the geomorphological process codes of mapped polygons, on-site symbols (which are either points or linear features), and terrain characteristics (**Appendix 11-A**). Polygons were assigned a dominant hazard potential so that the nature of the hazard influencing the terrain stability class of each polygon could be conveyed. Three categories of dominant hazard potential were identified as follows: slope failure potential is dominant, thermokarst potential is dominant, or slope failure and thermokarst potential are co-dominant (**Appendix 11-A**). Use of such hazard potential designations, however, does not indicate that polygons exhibit any evidence of such hazards or that thermokarst or slope failures are imminent; that purpose is achieved through the use of codes or on-site symbols during map development that identify geomorphological processes.

The Project is located within the zone of extensive discontinuous permafrost, where 50% to 90% of the area is expected to be perennially frozen (Heginbottom et al. 1995). Within the Mine Site area and along the NAR, permafrost was described in terms of relative ice content, based on field observations and past studies conducted in the area. The studies of permafrost conducted by Tetra Tech EBA (2016; **Appendix 11-A**) and PECG (2016; **Appendix 11-A**) were largely consistent in the description of permafrost. Where localized differences in the interpretation of permafrost distribution and ice content occurred, however, the differences were reviewed and were considered generally minor (PECG 2016; **Appendix 11-A**). The permafrost classes used to describe baseline conditions and potential effects generally follow Tetra Tech EBA (2016; **Appendix 11-A**) as follows:

- Frozen, no visible ice, generally ice-poor (Fn)
- Frozen, visible ice, generally considered ice-moderate to ice-rich (Fv)
- Frozen, ice-rich, and may include large accumulations of ground ice such as ice wedges and other massive ice bodies (Fi).

Areas not assigned a permafrost type were considered to be largely permafrost-free, however, these areas may contain patches of permafrost in locations that are conducive to permafrost formation.

Soil types within the Mine Site area were characterized by the development of a soil map. Soil map units were derived by incorporating information from various data sources such as the field studies conducted at site (e.g., vegetation, permafrost, surficial geology, and geotechnical investigations), the ELC map, permafrost map, surficial geology map, and soil trace metals data. Data included field observations as well as spatial information. Mapped polygons were characterized, on occasion, by a single soil map unit, however, in most cases, polygons were characterized by a dominant soil map unit and minor occurrences of other soil types. Data summaries present information for the dominant soil map unit only. The soil map was developed for the Mine Site area specifically as this is where the greatest disturbances to soils are anticipated to occur and will also be the primary location for closure and reclamation activities. The soil map also provides information on soil reclamation suitability and the spatial distribution of likely salvage areas. Reclamation suitability was generally determined by slope class (with more gentle slopes being more suitable) and ice-content (with soils having a lower ice content being more suitable). The soil map and associated units developed for the Mine Site area are presented in **Figure 3.3-5.**

Soils along the NAR are characterized in terms of the soil parent materials present, which were compiled as part of the terrain stability assessment (**Appendix 11-A**). This approach was taken for the NAR as much of the route is aligned with existing roadways and major disturbances to soils have already occurred.

3.3 DESCRIPTION OF EXISTING CONDITIONS

The existing conditions for Surficial Geology, Terrain, and Soils are presented for the LAAs and RAAs defined using data compiled from the studies listed in **Table 3.2-1**. Surficial geology information is presented as part of the soils component given its influence on soil formation. Terrain conditions are expressed in terms of terrain stability and landforms characteristic of the area. Permafrost is presented from both a terrain stability and soils perspective.

Within the Mine Site area and along the NAR, previous disturbances, both natural and anthropogenic, are evident to varying extents. Wildfires occur relatively frequently in Yukon (**Appendix 15-A**) and Yukon's fire history was taken into consideration when mapping terrain stability, permafrost distribution, and soil types. Fire can lead to permafrost degradation by altering the ground thermal regime through the removal of insulating surface organic material. This can further result in ground instability such as the development of thermokarst or active layer detachments (**Appendix 11-A**). Along the NAR, anthropogenic disturbances, particularly from placer mining, are common within many of the valleys (**Appendix 11-A**).

3.3.1 TERRAIN STABILITY

3.3.1.1 Terrain Stability Class

The majority of the Mine Site area (85% of the LAA and 79% of the RAA) is considered to be relatively stable (terrain stability classes 0-II) (**Figure 3.3-1**; **Table 3.3-1**); when combined with areas that are considered to be 'generally stable with minor potential for instability' (class III), this increases to approximately 97% and 93% of the LAA and RAA, respectively. These conditions are reflective of the gentle to moderate slopes that predominate on lower valley sides and in uplands (**Appendix 11-A**). Areas that are considered relatively unstable (terrain stability classes IV and V) within the Mine Site area are minor, with 3% of the LAA and 7% of the RAA falling within these terrain stability classes (**Table 3.3-1**). Geohazards identified within the Mine Site area include rockfall, debris slides, rock creep, gullying, solifluction, thermokarst, and slopewash.

Along the NAR (including areas requiring new construction), 80% of the LAA and 79% of the RAA are considered to be relatively stable and are mapped as stability classes 0-II (**Table 3.3-1**; **Figure 3.3-2**). When terrain stability class III ('generally stable with minor potential for instability') is included, the proportion increases to 93% for the LAA and 92% for the RAA. Approximately 7% of the LAA and 8% of the RAA have been classified as relatively unstable (classes IV and V), owing primarily to steep, gullied slopes and areas underlain by permafrost displaying thermokarst activity (**Appendix 11-A**). Approximately 14% and 8% of the NAR LAA and RAA, respectively, have no terrain stability rating assigned (class 0) and are associated with anthropogenic disturbances (**Table 3.3-1**), largely from placer mining activity along the valleys of larger tributaries.

3.3.1.2 Permafrost

Within the Mine Site area, approximately 65% of the LAA and 56% of the RAA are likely underlain by permafrost (**Table 3.3-2; Figure 3.3-3**). Permafrost distribution within the Mine Site area appears to be influenced by aspect and vegetation cover (**Appendix 11-A**). Shallow permafrost is typically present on northeast-facing slopes that support sparse, stunted black spruce and a thick moss layer, while southwest-facing slopes with virtually pure stands of trembling aspen (which require warmer air temperatures and deeper root penetration), are generally free of permafrost.

Along the NAR (including areas requiring new construction), it is estimated that approximately 56% of the LAA and 59% of the RAA is influenced by permafrost (**Table 3.3-2**). The distribution of permafrost is presented spatially in **Figure 3.3-4**.

Table 3.3-1 Distribution of Terrain Stability Classes within the Local and Regional Assessment Areas of the Mine Site Area and Northern Access Route

		Mine Site Area				Northern Access Route			
Existing Terrain Stability Class[1]	Terrain Stability Class Description	LAA (ha)	LAA (%)	RAA (ha)	RAA (%)	LAA (ha)	LAA (%)	RAA (ha)	RAA (%)
0	N/A, Anthropogenic	-	-	-	-	2,823	14	3,765	8
I	Stable	-	-	-	-	509	3	1,182	3
II	Generally Stable	1,561	85	5,267	79	12,422	63	31,356	68
III	Generally Stable with Minor Potential for Instability	214	12	967	14	2,621	13	6,105	13
IV	Potentially Unstable	18	1	81	1	199	1	498	1
V	Unstable	44	2	374	6	1,199	6	2,992	7
Total		**1,837**	**100**	**6,689**	**100**	**19,773**	**100**	**45,897**	**100**

Source: Appendix 11-A; Classes: 0 – N/A, anthropogenic, I – stable, II – generally stable, III – generally stable with minor potential for instability, IV – potentially unstable, and V – unstable. Shaded cells represent no change between existing and disturbed classes.

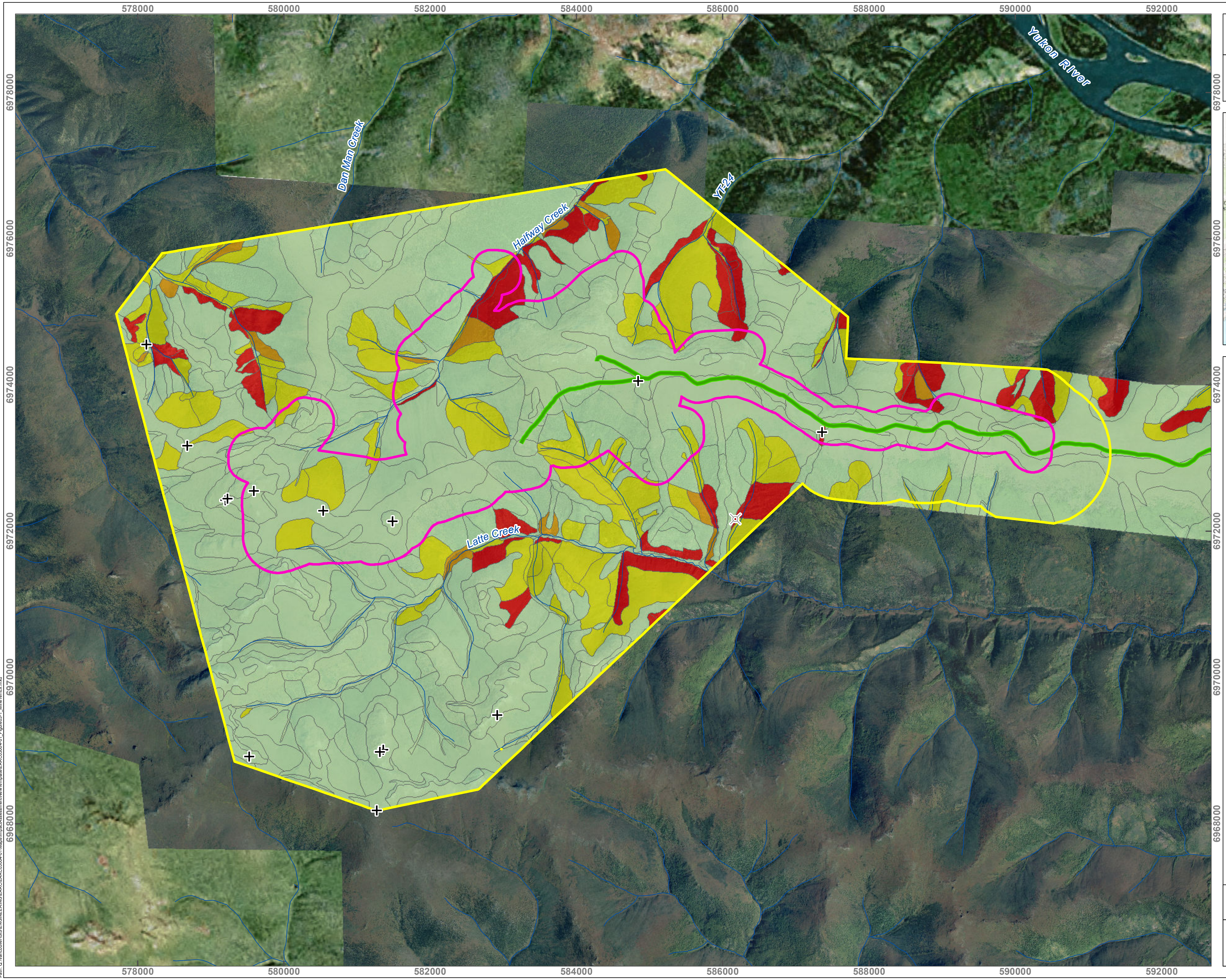
Table 3.3-2 Distribution of Permafrost within the Local and Regional Assessment Areas of the Mine Site Area and Northern Access Route

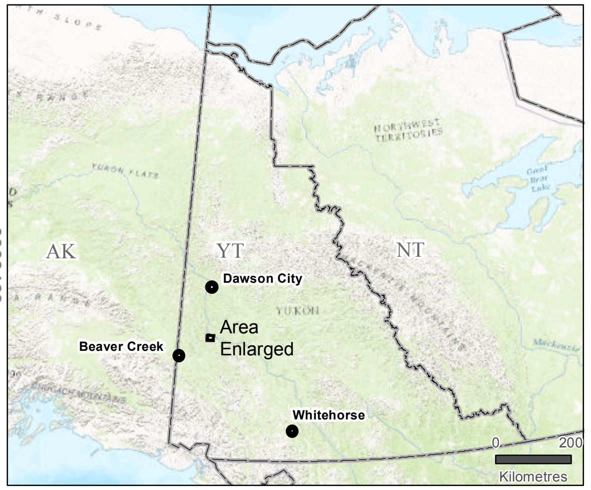
	Mine Site Area				Northern Access Route			
Permafrost Type[1]	LAA (ha)	LAA (%)	RAA (ha)	RAA (%)	LAA (ha)	LAA (%)	RAA (ha)	RAA (%)
Frozen, no visible ice (Fn)	828	45	2,153	32	5,646	29	15,326	33
Frozen, visible ice (Fv)	366	20	1,585	24	3,146	16	7,495	16
Frozen, ice-rich (Fi)	-	-	25	<1	2,350	12	4,104	9
Unfrozen	644	35	2,925	44	8,630	44	18,972	41
Total	**1,837**	**100**	**6,689**	**100**	**19,773**	**100**	**45,897**	**100**

Source: [1]Permafrost types and distributions are compiled from studies conducted by Tetra Tech EBA (2016; **Appendix 11-A**) and PECG (2016; **Appendix 11-A**).

COFFEE GOLD MINE

Existing Terrain Stability Conditions within the Mine Site Area





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Existing Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
- IV - Potentially Unstable
- V - Unstable

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3. Terrain data provided by Palmer Environmental Consulting Group (March 3, 2016)

N

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0 1 2 3

Kilometres

NAD 1983 UTM Zone 7N

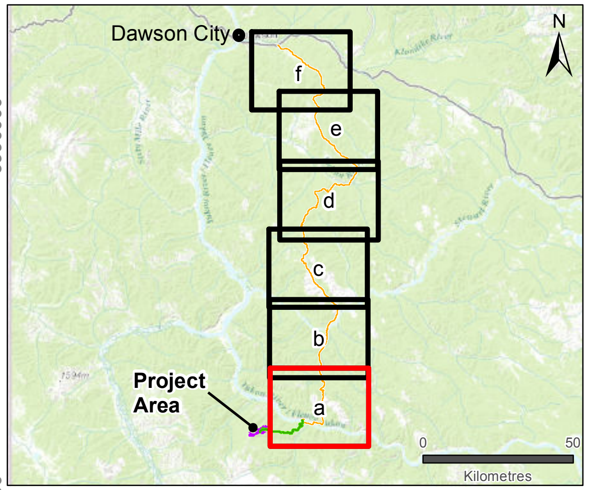
Page Size: 11" x 17"

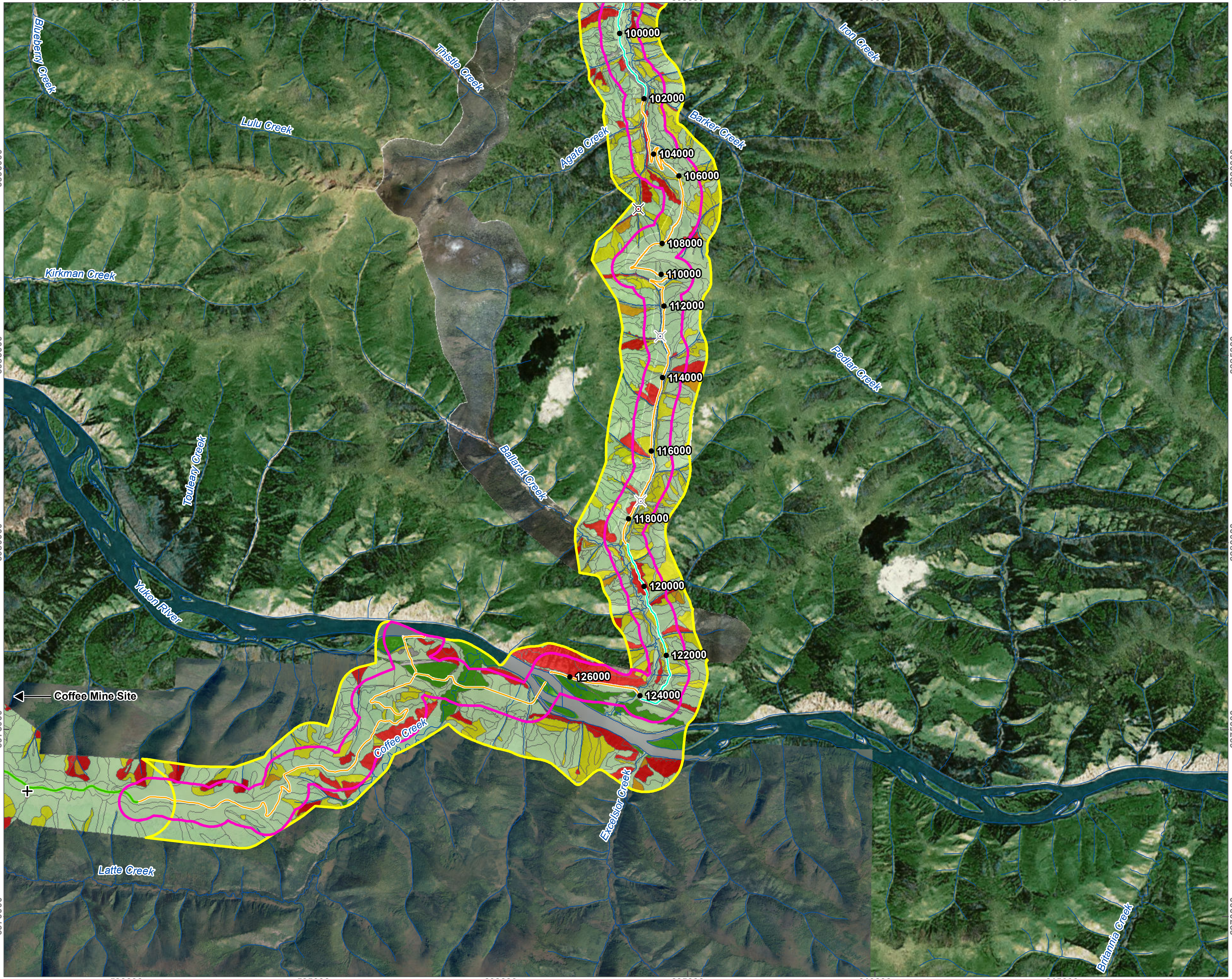
Figure 3.3-1	Date: Mar 16, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

COFFEE GOLD MINE

Existing Terrain Stability Conditions along the Northern Access Route





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo
- Pingo (collapsed)
- Tor
- Watercourse

Existing Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
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- V - Unstable

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3. Terrain data provided by Palmer Environmental Consulting Group (March 3, 2016)

N

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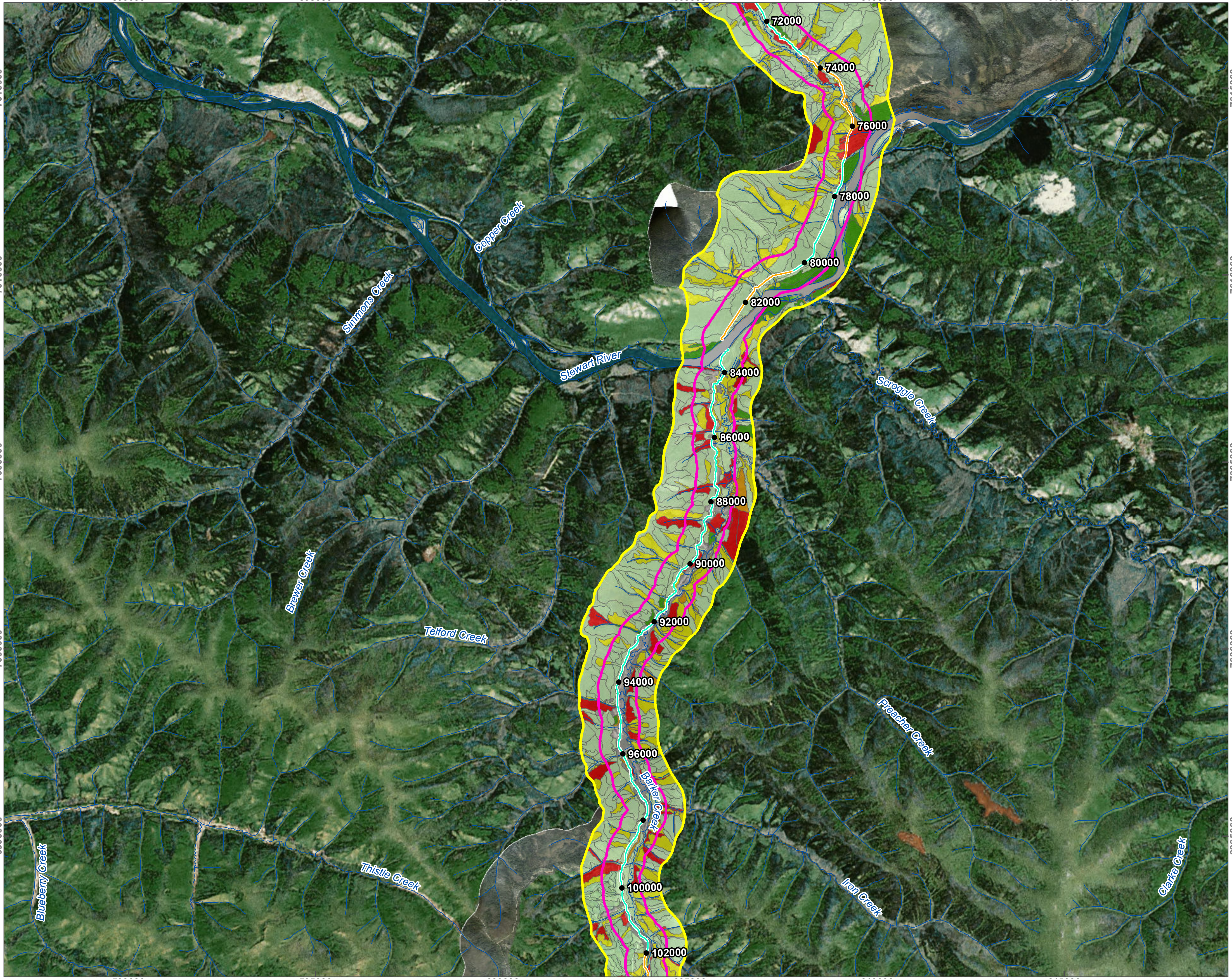
Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

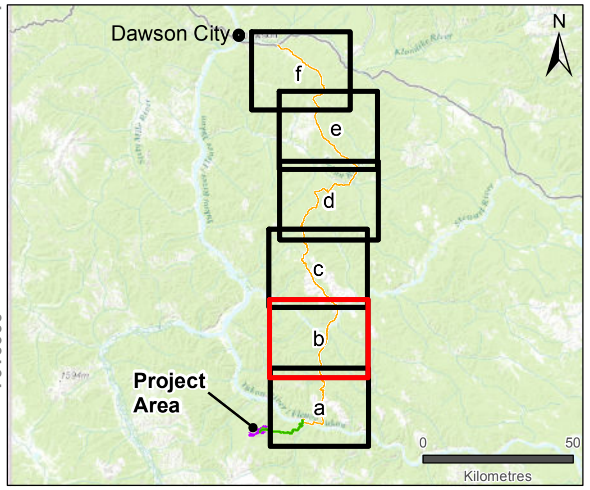
Figure 3.3-2a	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Existing Terrain Stability Conditions along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Existing Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
- IV - Potentially Unstable
- V - Unstable

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3.Terrain data provided by Palmer Environmental Consulting Group (March 3, 2016)

N

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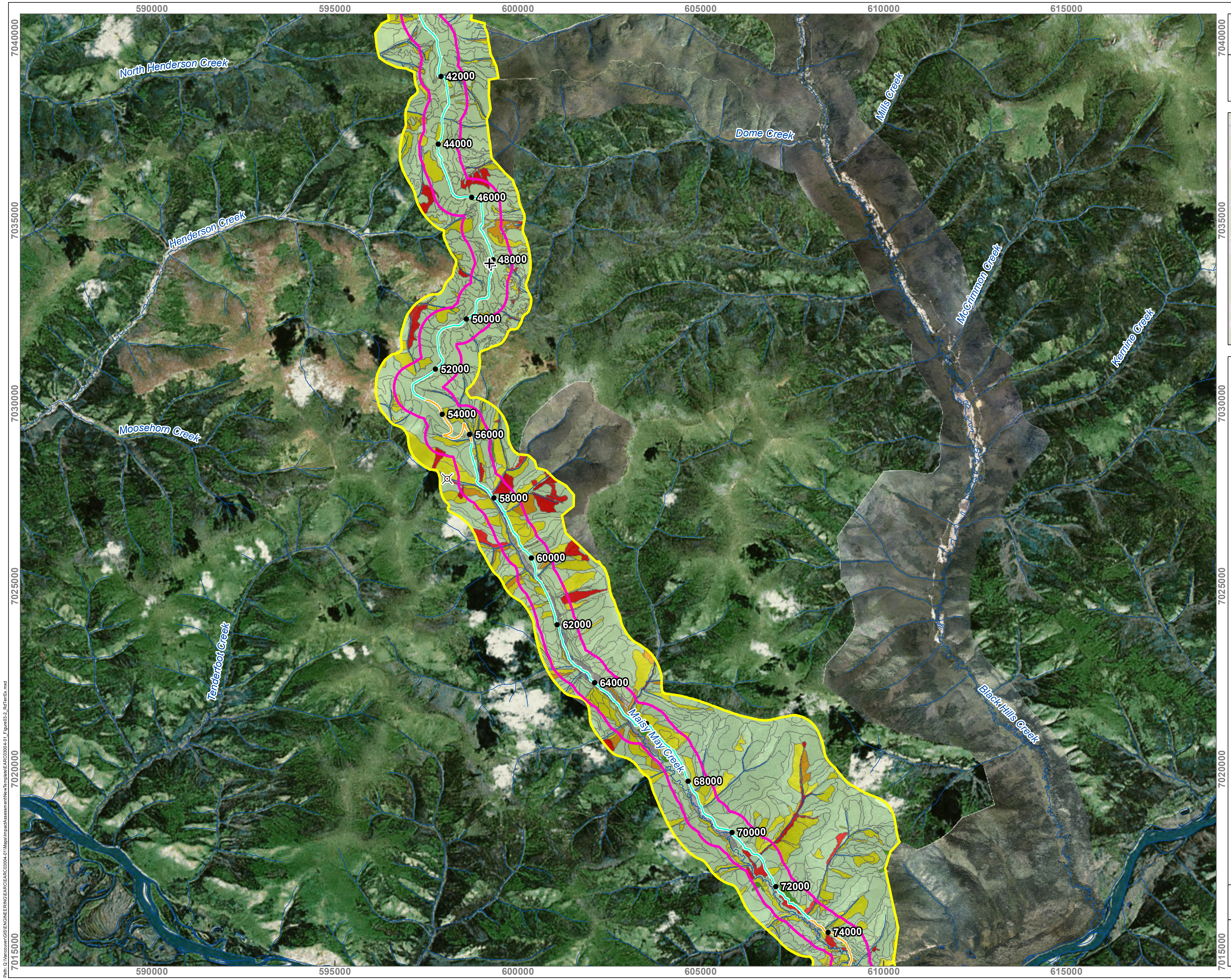
Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

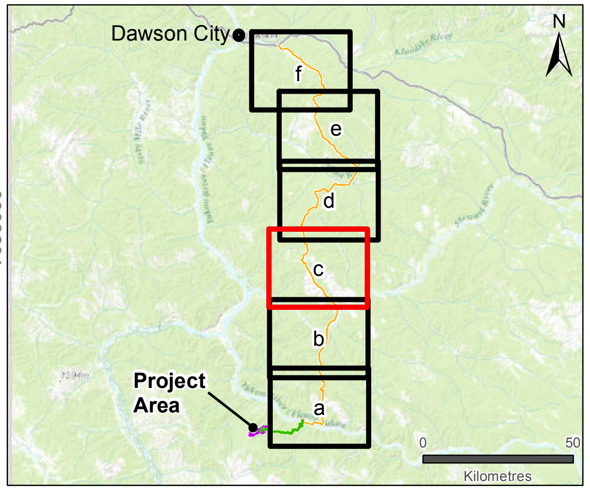
Figure 3.3-2b	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Existing Terrain Stability Conditions along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo
- Tor
- Watercourse

Existing Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
- IV - Potentially Unstable
- V - Unstable

Notes

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3. Terrain data provided by Palmer Environmental Consulting Group (March 3, 2016)

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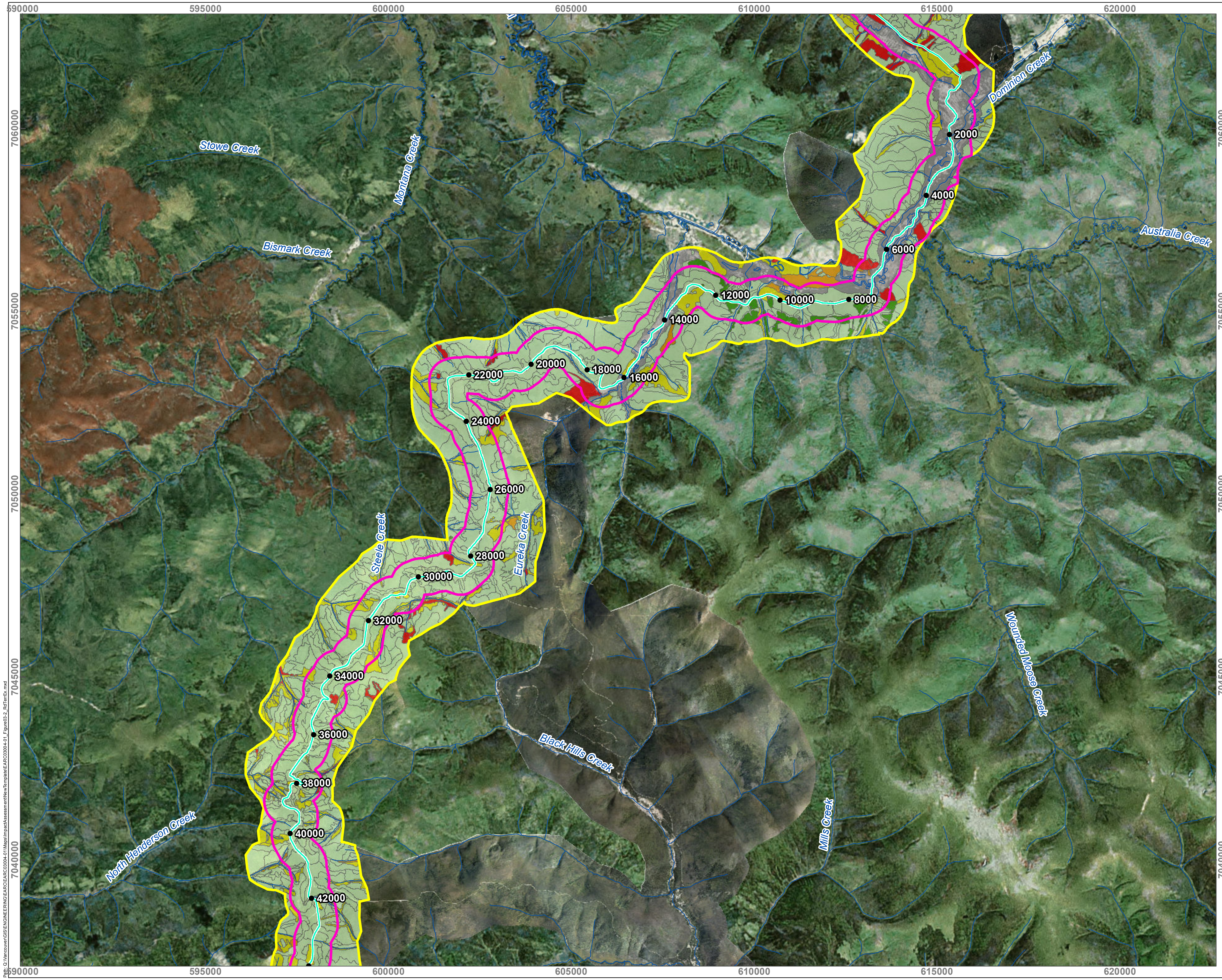
Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

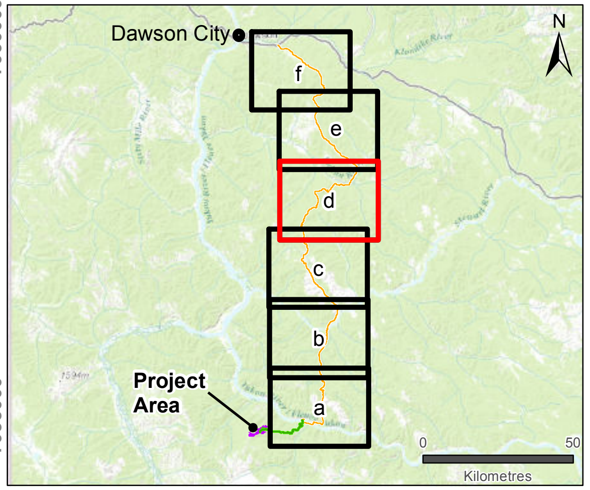
Figure 3.3-2c	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Existing Terrain Stability Conditions along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Existing Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
- IV - Potentially Unstable
- V - Unstable

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3. Terrain data provided by Palmer Environmental Consulting Group (March 3, 2016)

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Kilometres

NAD 1983 UTM Zone 7N

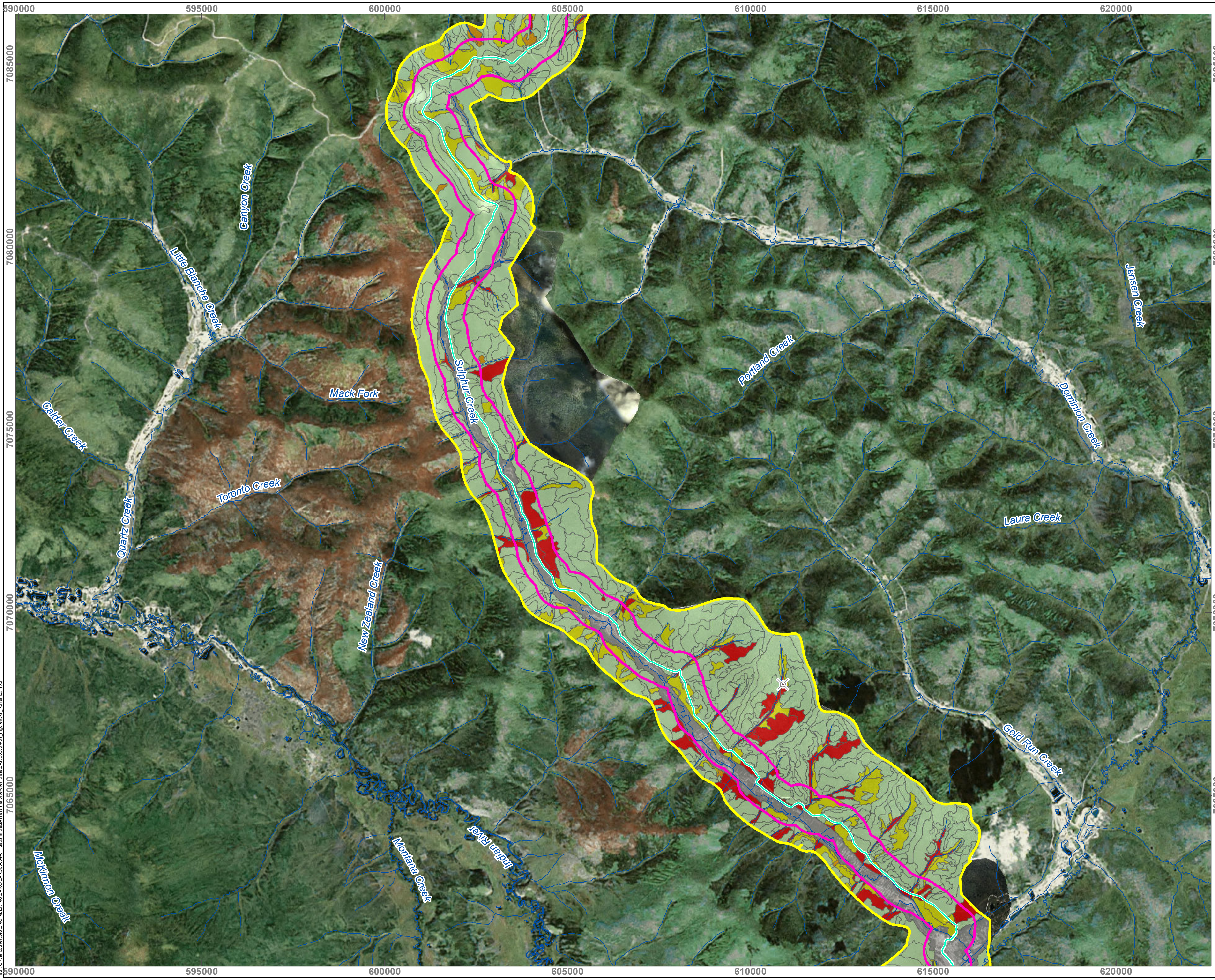
Page Size: 11" x 17"

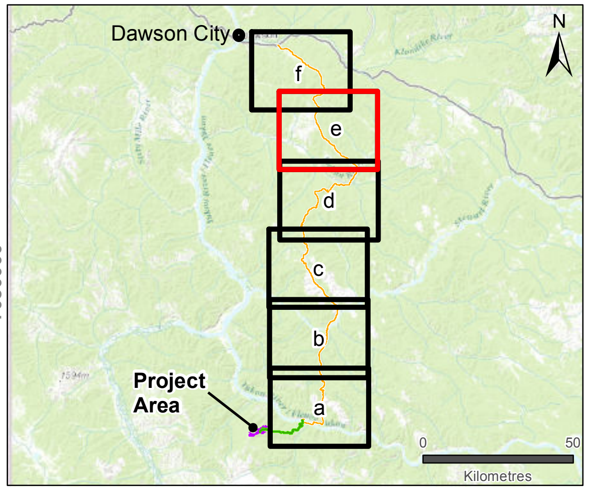
Figure 3.3-2d	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

COFFEE GOLD MINE

Existing Terrain Stability Conditions along the Northern Access Route





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo (collapsed)
- Watercourse

Existing Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
- IV - Potentially Unstable
- V - Unstable

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3.Terrain data provided by Palmer Environmental Consulting Group (March 3, 2016)

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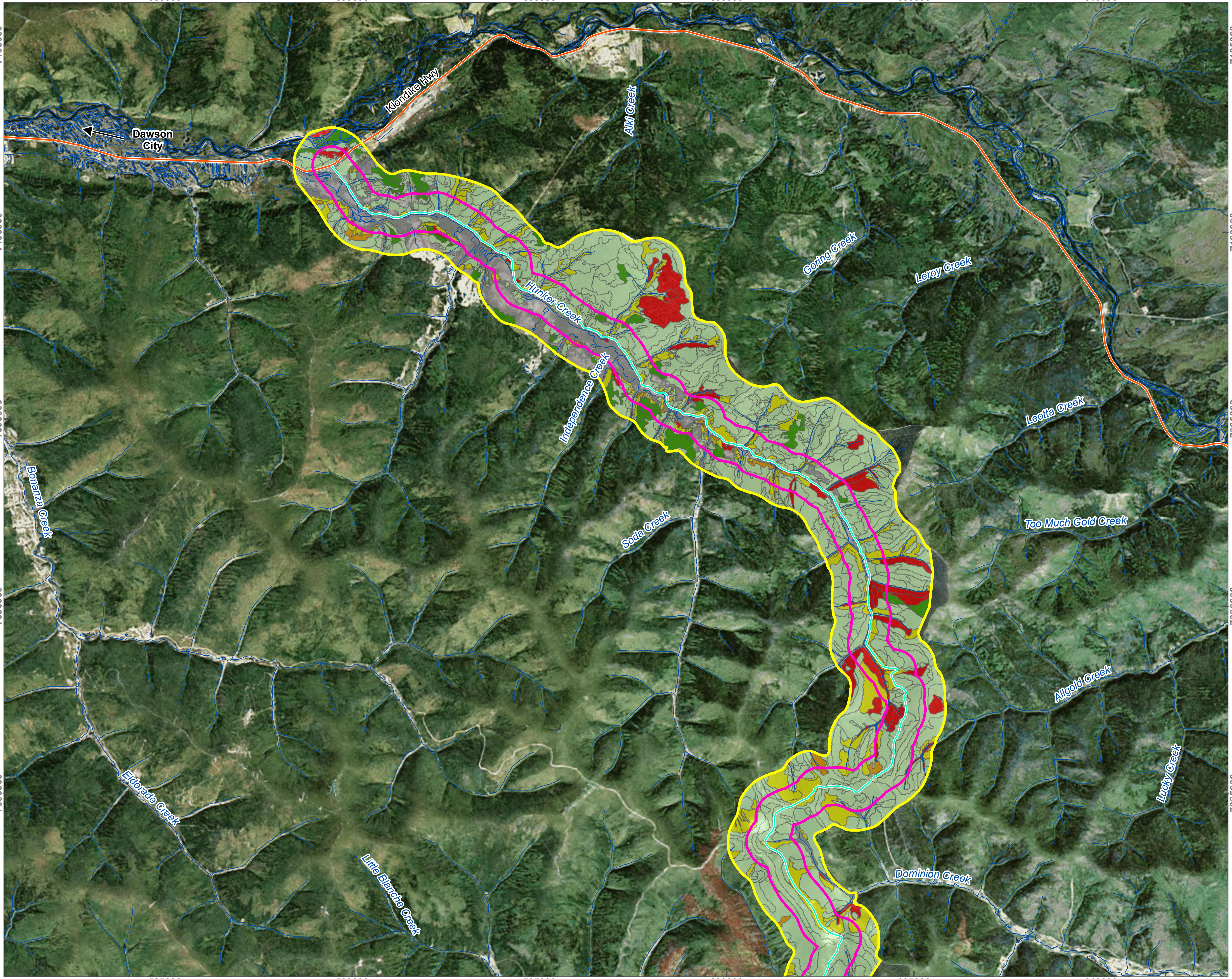
Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

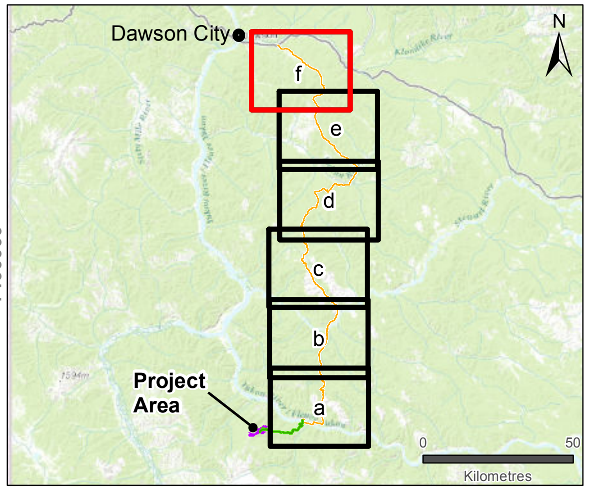
Figure 3.3-2e	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Existing Terrain Stability Conditions along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Existing Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
- IV - Potentially Unstable
- V - Unstable

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3.Terrain data provided by Palmer Environmental Consulting Group (March 3, 2016)

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Kilometres

NAD 1983 UTM Zone 7N

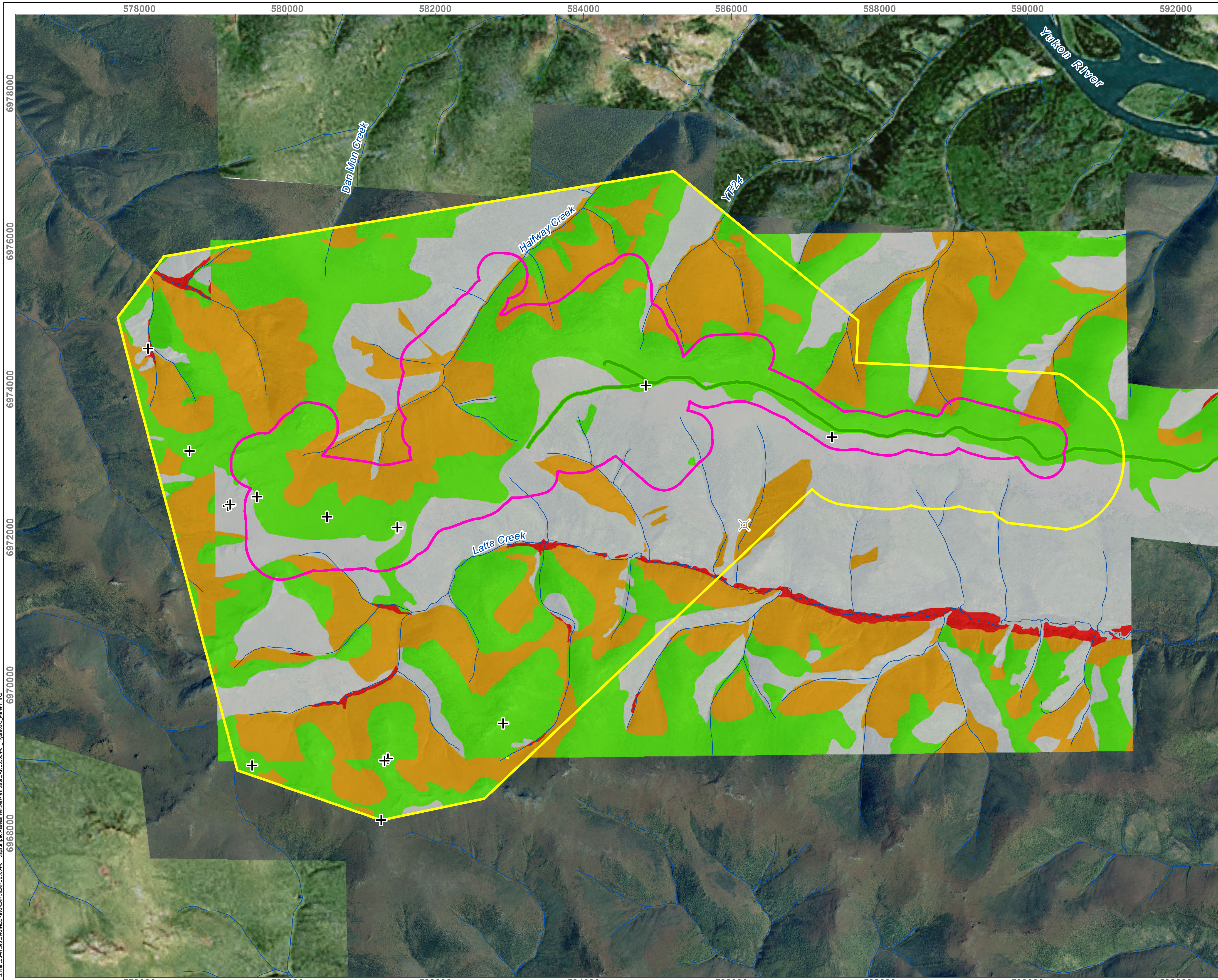
Page Size: 11" x 17"

Figure 3.3-2f	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

COFFEE GOLD MINE

Existing Permafrost Conditions within the Mine Site Area



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3. Permafrost data from Tetra Tech EBA (April 2016) and Palmer Environmental Consulting Group (March 2016)

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Kilometres

NAD 1983 UTM Zone 7N

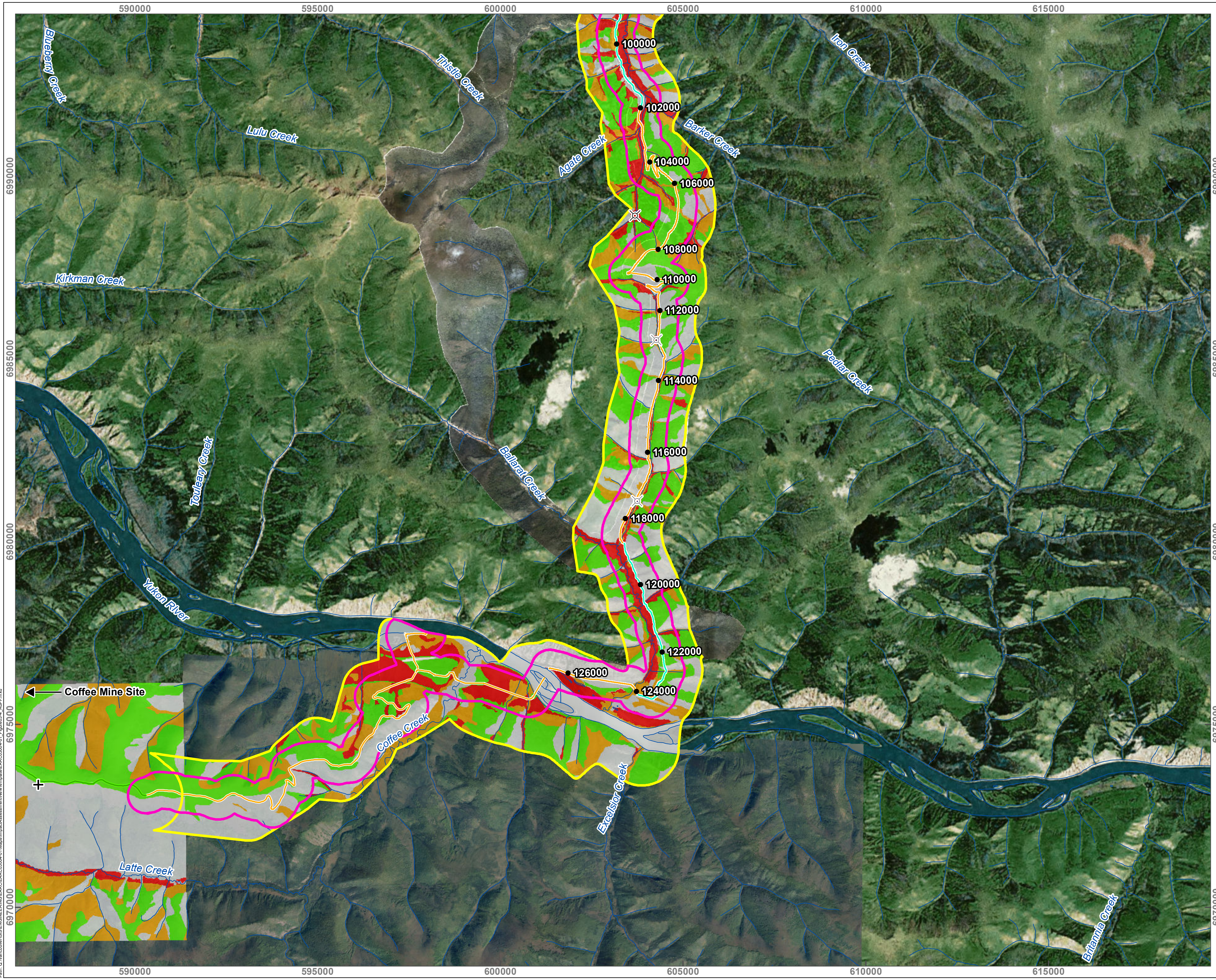
Page Size: 11" x 17"

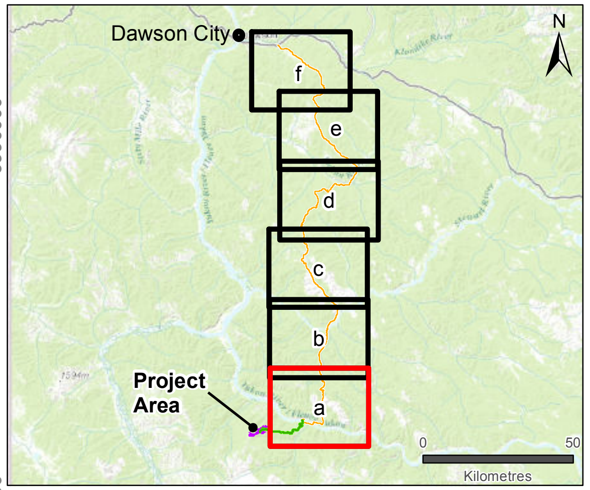
Figure 3.3-3	Date: Mar 16, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

COFFEE GOLD MINE

Existing Permafrost Conditions along the Northern Access Route





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo
- Pingo (collapsed)
- Tor
- Watercourse
- Base_YT.DBO.Places_1M

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3.Permafrost data for the access route provided by Palmer Environmental Consulting Group (March, 2016)

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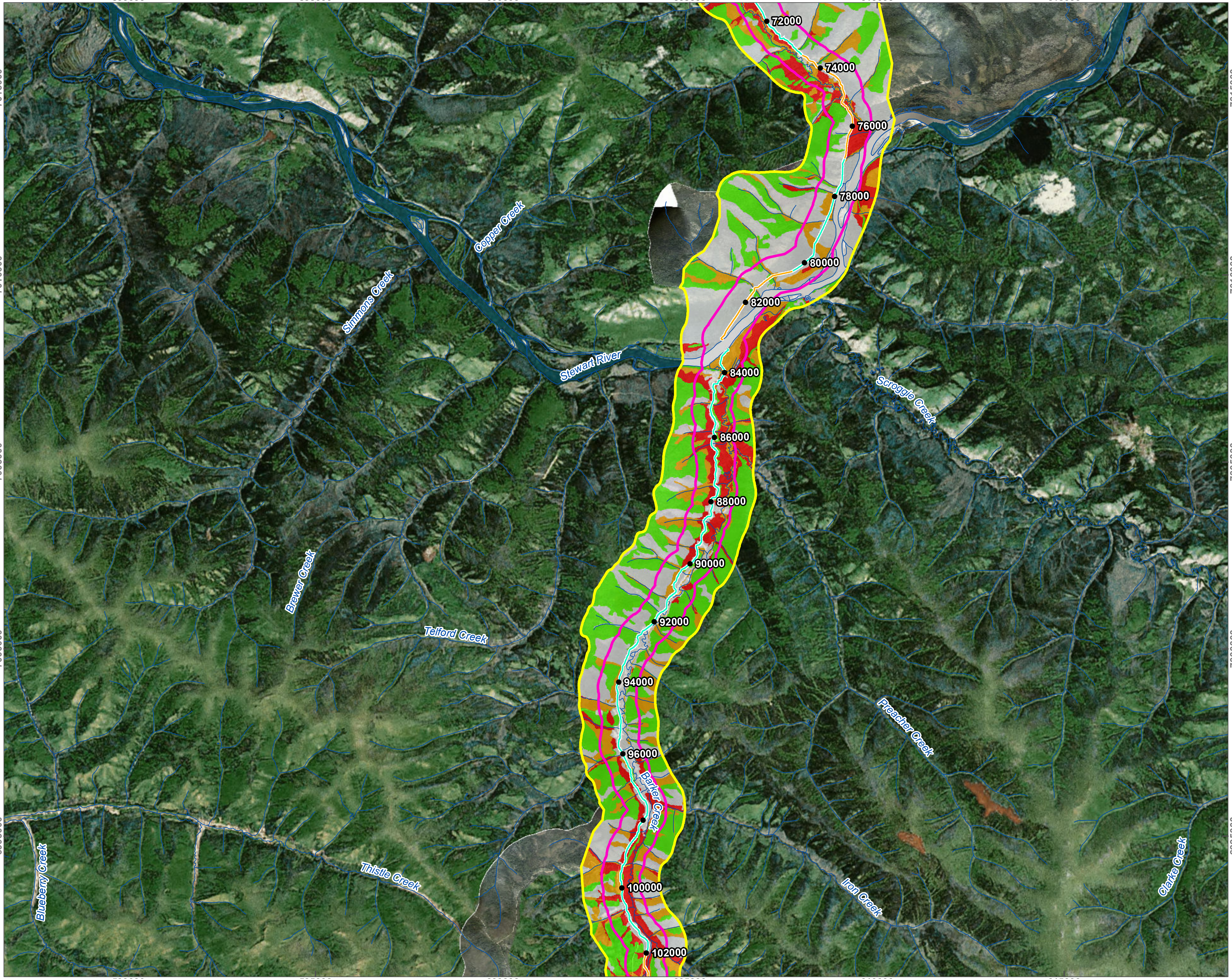
Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

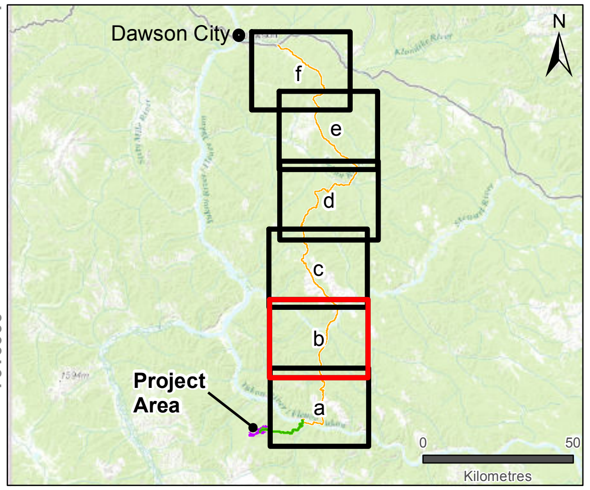
Figure 3.3-4a	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Existing Permafrost Conditions along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse
- Base_YT.DBO.Places_1M

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3.Permafrost data for the access route provided by Palmer Environmental Consulting Group (March, 2016)

N

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0 1 2 3

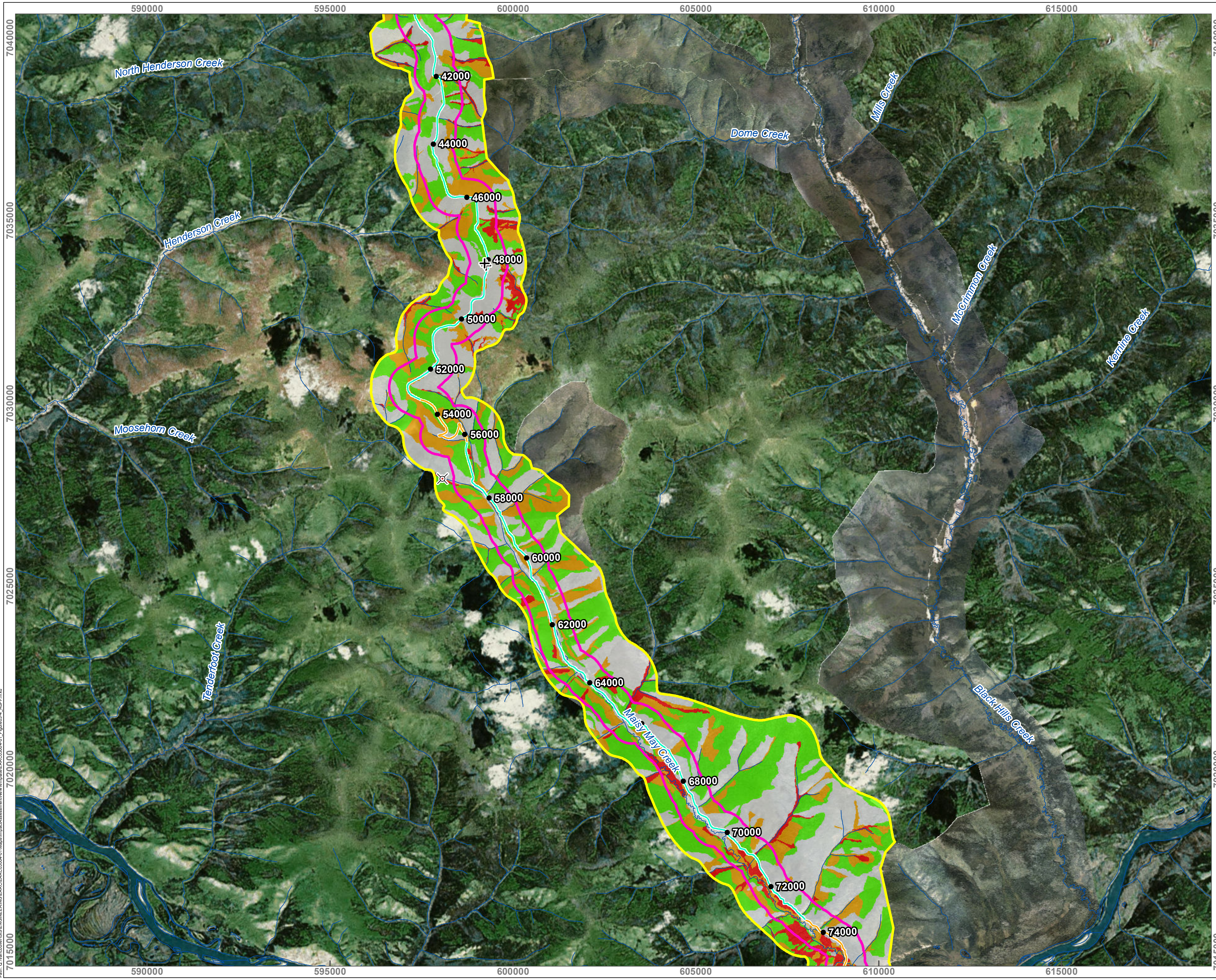
Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

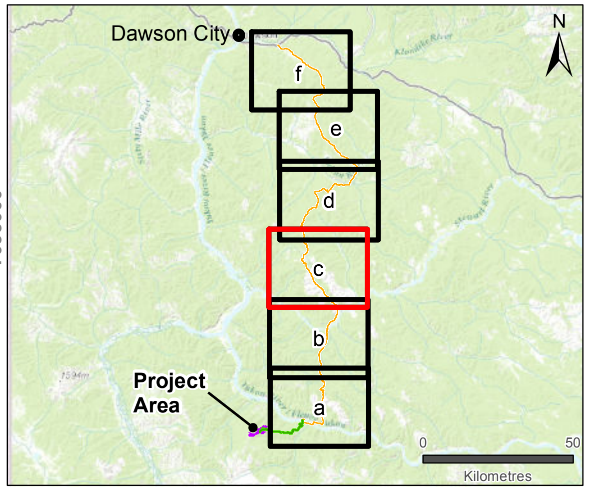
Figure 3.3-4b	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Existing Permafrost Conditions along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo
- Tor
- Watercourse
- Base_YT.DBO.Places_1M

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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3. Permafrost data for the access route provided by Palmer Environmental Consulting Group (March, 2016)

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Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 3.3-4c	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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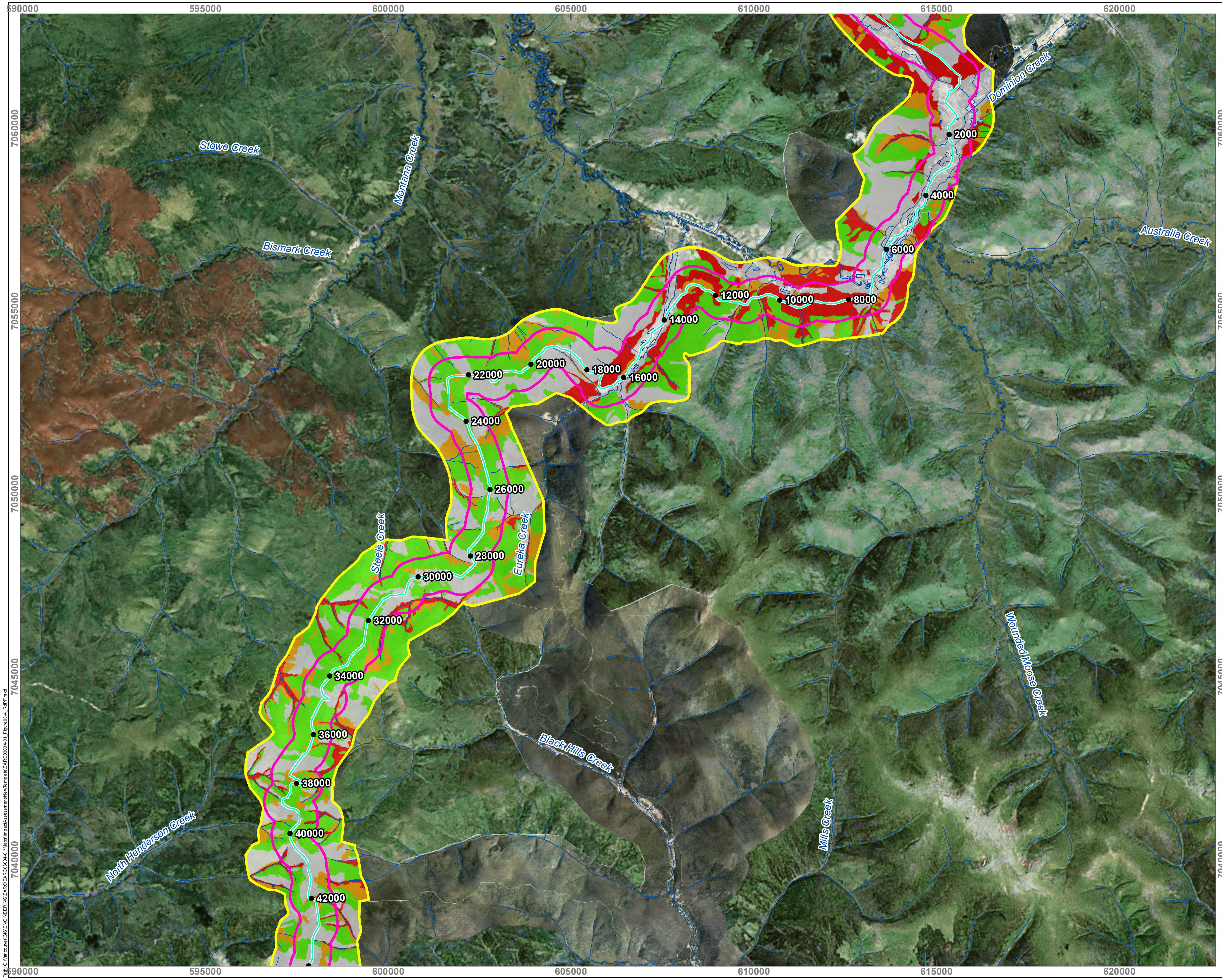
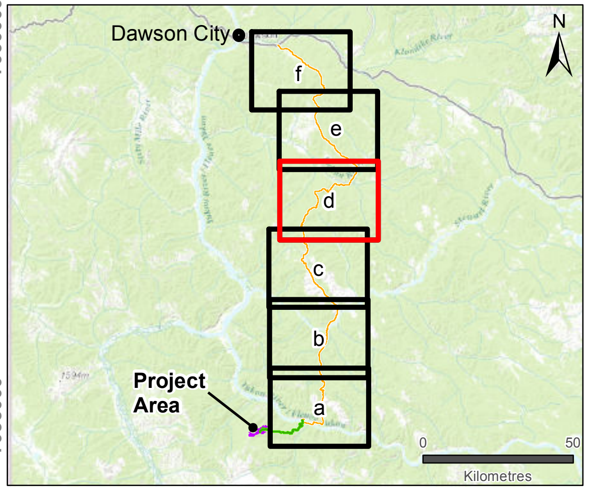


COFFEE GOLD MINE

Existing Permafrost Conditions along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse
- Base_YT.DBO.Places_1M

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3.Permafrost data for the access route provided by Palmer Environmental Consulting Group (March, 2016)

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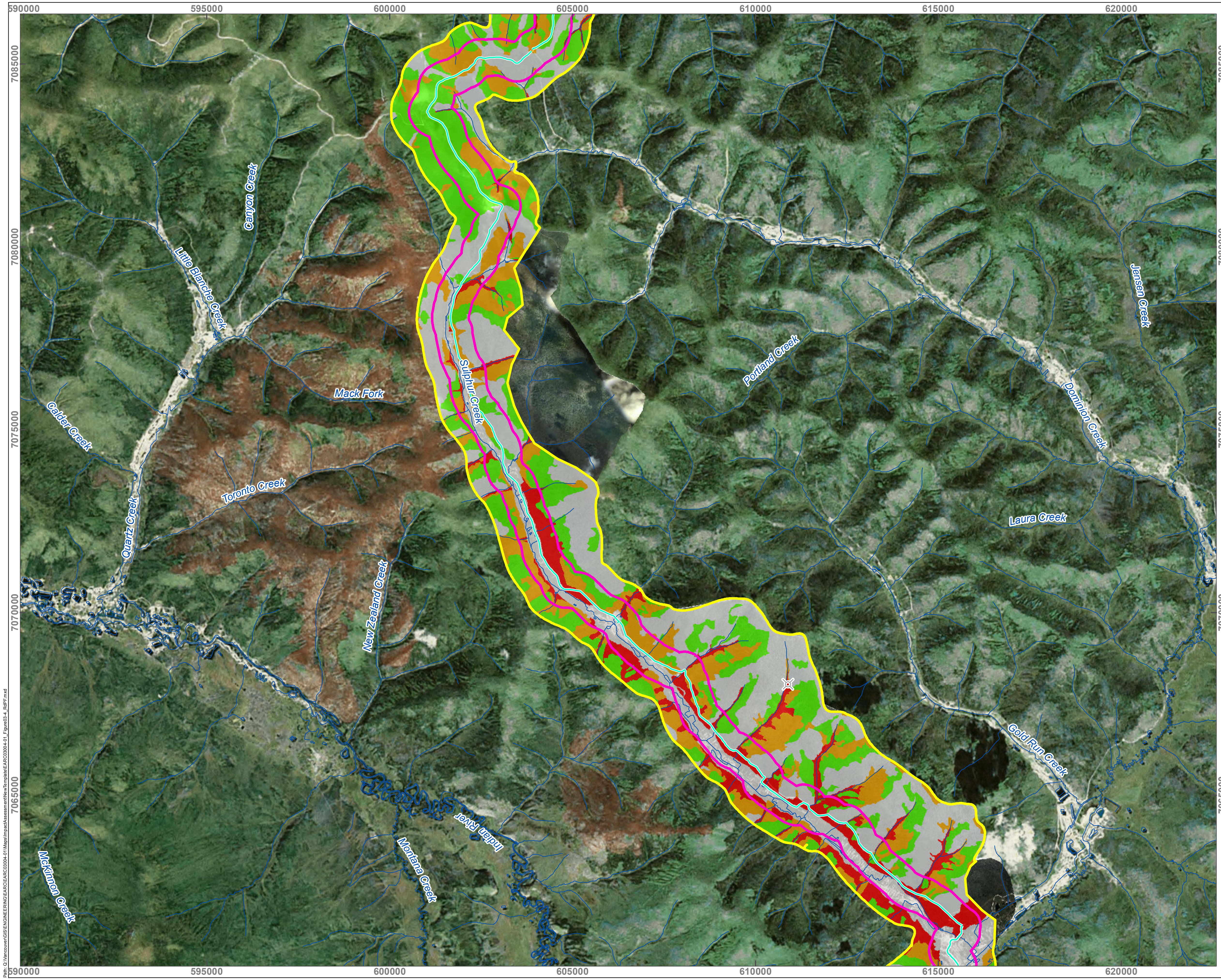
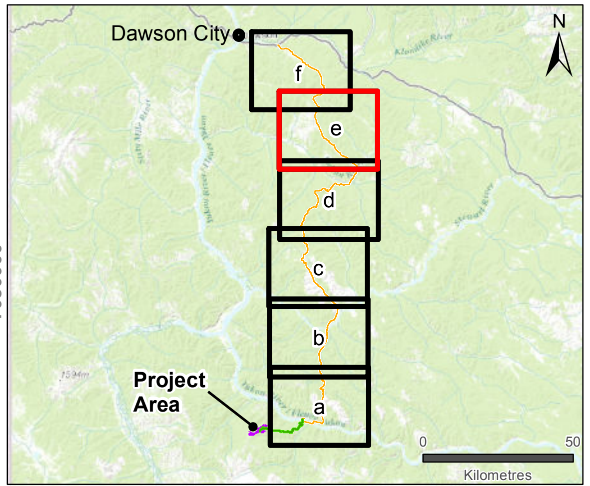
Figure 3.3-4d	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

COFFEE GOLD MINE

Existing Permafrost Conditions along the Northern Access Route





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo (collapsed)
- Watercourse
- Base_YT.DBO.Places_1M

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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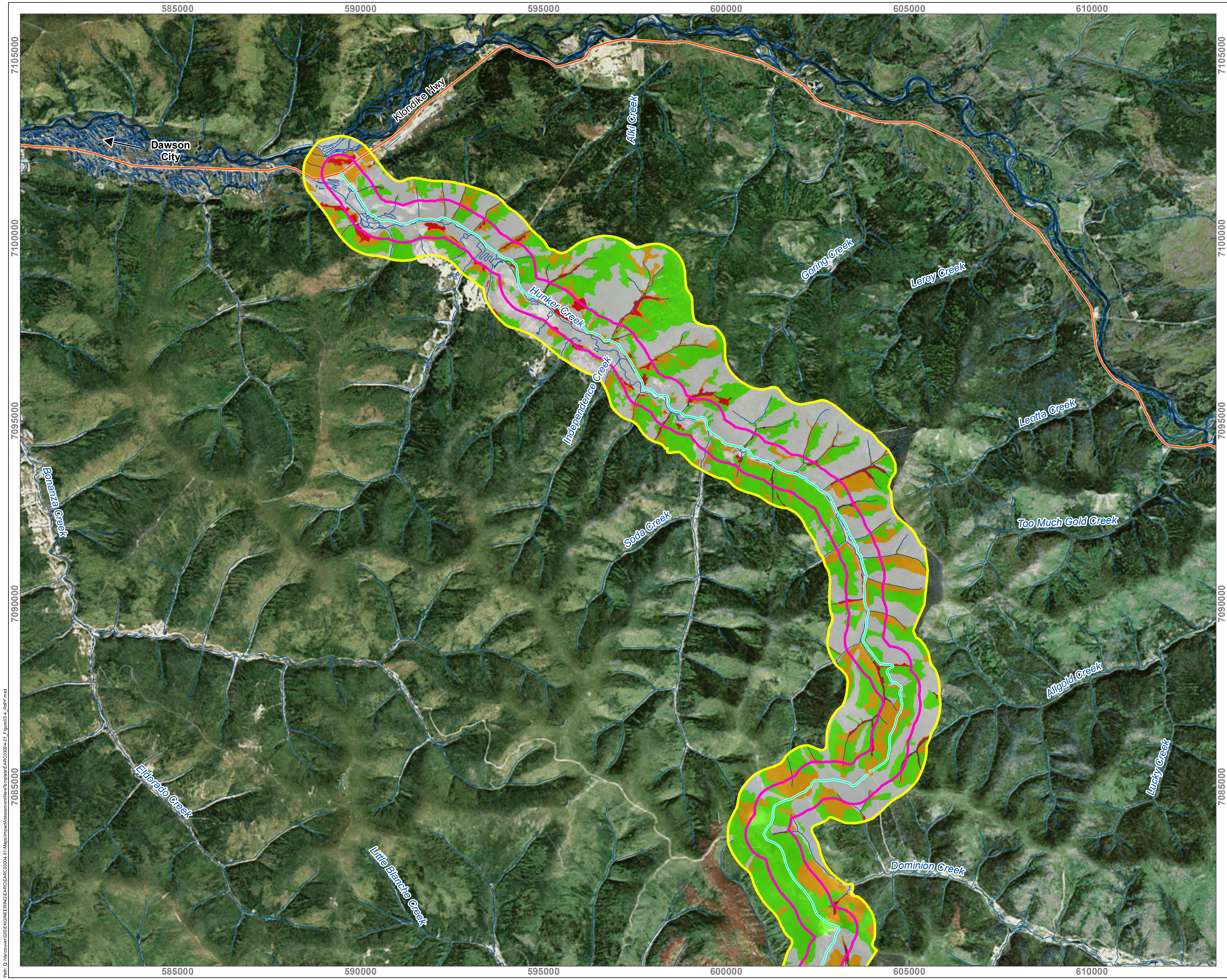
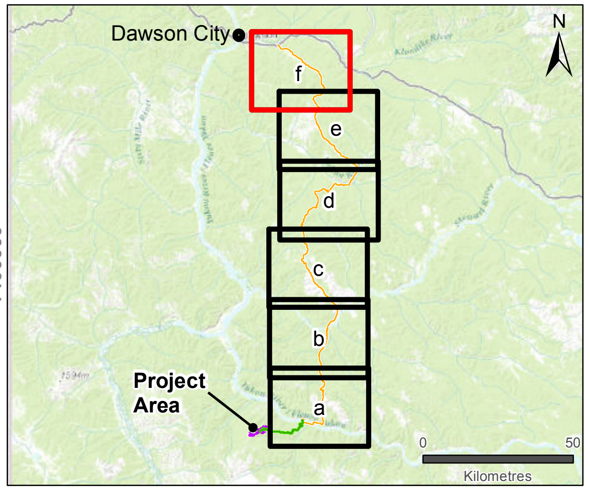
Figure 3.3-4e	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

COFFEE GOLD MINE

Existing Permafrost Conditions along the Northern Access Route





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse
- Base_YT.DBO.Places_1M

Permafrost Classification

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Figure 3.3-4f	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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3.3.2 UNIQUE LANDFORMS

Landforms that are relatively unique in the area include tors and collapsed and intact open-system pingos (**Figure 3.3-1** and **Figure 3.3-2**). Tors are erosional remnants of a higher plateau level and are located along ridge tops primarily in the central and western parts of the Mine Site area and along the NAR north of the Stewart River (**Appendix 11-A**). The tors form towers above otherwise smooth, rounded ridges underlain by granitic bedrock and are surrounded by either thick colluvium or weathered bedrock.

Pingos are perennial frost mounds that consist of a core of massive ice and are covered by soil and vegetation (Harris et al. 1988). Open-system pingos result when the water forming the dome of frozen ground is supplied by groundwater moving downslope. Collapsed pingos are indicative of the former presence of massive ground ice and ice-rich permafrost which has since thawed, leaving behind a low, circular ridge of material as a result of the sides of the pingo slumping, and a depression, which in this case is filled with water (**Appendix 11-A**). A total of six pingos (two collapsed and four intact) were identified; one collapsed pingo is located within the Mine Site area with the remaining pingos located along the NAR (see figures throughout this VC Report for more specific locations).

3.3.3 SOIL QUALITY

3.3.3.1 Surficial Geology

The Mine Site area falls within the portion of Yukon that remained unglaciated during the Pliocene to early Pleistocene (3 million to 1.8 million years ago), however, glaciers were present within the Stewart River valley to the north as well as to the west and east of the Mine Site area (Duk-Rodkin 1999). This lack of glaciation has resulted in an extensive period of weathering with surficial deposits composed primarily of weathered bedrock, colluvium derived from weathered bedrock and loess, and fluvial materials (**Appendix 11-A**). At high elevations and along valley slopes, colluvium is anticipated to be coarse grained, whereas ice-rich resedimented loess and peat form colluvial aprons on lower slopes, and fluvial deposits are found in valley bottoms. These deposits may be subject to gullying, cryoturbation, solifluction, permafrost processes, periglacial processes, landslides, and snow avalanches (**Appendix 11-A**).

3.3.3.2 Soils

The distribution of soils (both unfrozen and frozen) is presented in **Table 3.3-3** and **Figure 3.3-5** for the Mine Site area. The extent of the soil map units listed represent the dominant soil type in a polygon; minor inclusions of other soil types are not accounted for. Soils are predominantly Cryosols (frozen soils) and represent 63% of the LAA and 67% of the RAA. Unfrozen soils are represented primarily by Brunisols. Parent materials are largely colluvium, which cover 97% of the LAA and 95% of the RAA.

Table 3.3-3 Distribution of Soil Types within the Local and Regional Assessment Areas of the Mine Site Area

Parent Material	Soil Map Unit	Description	LAA (ha)	LAA (%)	RAA (ha)	RAA (%)
Colluvium	C1*	Orthic Dystric (Eutirc) Brunisol/Eluviated Dystric (Eutric) Brunisol//Orthic Regosol	614	33	2,067	31
	C2*	Gleyed Brunisols/Rego Gleysol	6	<1	119	2
	C3	Brunisolic Dystric (Eutric) Static Cryosol// Regosol Static Cryosol	646	35	1,865	28
	C4	Gleysolic Static Cryosol/ Histic Dystric (Eutric) Static Cryosol /Fibric Organic Cryosol//Brunisolic Dystric (Eutric)Static Cryosol	183	10	623	9
	C5	Brunisolic Dystric (Eutric) Static Cryosol// Regosol Static Cryosol	37	2	405	6
	C6	Gleysolic Static Cryosol/Histic Dystric (Eutric) Static Cryosol//Organic Cryosol (Fibirc and Mesic)	290	16	1,293	19
Weathered Bedrock	D1*	Orthic Dystric (Eutric) Brunisol/Eluviated Dystric (Eutric) Brunisol//Orthic Regosol	1	<1	23	<1
	D3	Brunisolic Dystric Static Cryosol//Regosolic Cryosol	54	3	168	3
	D4	Gleysolic Static Cryosol/ Brunisolic Dystric (Eutric) Static Cryosol//Regosolic Cryosol	-	-	4	<1
	D5	Brunisolic Dystric (Eutric) Static Cryosol//Regosol Static Cryosol	-	-	19	<1
Fluvial	F1*	Orthic Dystric (Eutric) Brunisol//Orthic Regosol	-	-	1	<1
	F2*	Gleyed Brunisols/Rego Gleysol	-	-	6	<1
	F4	Gleysolic Static Cryosol/ Histic Dystric (Eutric) Static Cryosol /Fibric Organic Cryosol//Brunisolic Dystric (Eutric)Static Cryosol	-	-	2	<1
	F5	Brunisolic Dystric (Eutric) Static Cryosol//Regosol Static Cryosol	-	-	1	<1
	F6	Gleysolic Static Cryosol/Histic Dystric (Eutric) Static Cryosol/Organic Cryosol//Regosolic Static Cryosol	8	<1	86	1
Bedrock	R3	Rock//Regosol Static Cryosol	-	-	7	<1
Total			**1,837**	**100**	**6,689**	**100**

Note: * denotes unfrozen soils; Soil descriptions follow the Canadian Soil Classification System (Soil Classification Working Group 1998)

The dominant soil parent material along the NAR (which includes portions that require new construction) is colluvium, which covers 67% to 74% of the LAA and RAA, respectively (**Table 3.3-4**; **Figure 3.3-6**). Anthropogenic materials, where the original geological materials have been heavily modified by human activities, are also fairly widespread in the LAA in particular and are primarily the result of placer mining, which is widespread along some of the larger river valleys (**Appendix 11-A**).

Table 3.3-4 Distribution of Soil Parent Materials within the Local and Regional Assessment Areas Along the Northern Access Route

Parent Material	LAA (ha)	LAA (%)	RAA (ha)	RAA (%)
Colluvium	13,288	67	33,895	74
Anthropogenic	2,823	14	3,765	8
Fluvial	1,537	8	3,021	7
Weathered Bedrock	1,508	8	4,258	9
Organic	368	2	588	1
Bedrock	150	1	255	1
Glaciofluvial	100	<1	115	<1
Total	**19,773**	**100**	**45,897**	**100**

The distribution of soils according to their potential reclamation suitability is presented in **Table 3.3-5** and **Figure 3.3-7**. Approximately 42% of the soils within the LAA are considered suitable for reclamation compared to 30% within the RAA. The dominance of colluvium is likely a factor limiting the quality of soils available for reclamation.

Estimated topsoil (which is characterized as the organic L, F, H, and A horizons of (upland) mineral soils, and the O layer of (wetland) organic soils, as per BC Ministry of Forests and Range and BC Ministry of Environment 2010) depths range from a minimum of 10 cm in frozen fluvial soils (F5) to a maximum of 32 cm in frozen fluvial (F6) and frozen colluvial (C6) soil types (**Table 3.3-5**). Depth estimates were derived from the review of field data as well as surficial materials and vegetation cover during development of the soil map.

Soil (both unfrozen and frozen) identified as being suitable for use in reclamation will be salvaged from the foundation areas of most Project facilities, where feasible. Salvaged material will include topsoil (defined above) and subsoil (characterized as the B and upper C horizons of mineral soil) to a minimum depth of 0.5 m below the topsoil, where practical. Deeper overburden that is not considered suitable for reclamation that will still be removed from infrastructure foundations as part of site preparation will be stockpiled away from suitable materials to avoid admixing (where suitable material is inadvertently mixed with unsuitable subsoil, spoil, or waste material, thus reducing the quality of the suitable material). Deeper overburden material may still be used in reclamation activities if sufficient suitable material is not available for salvage.

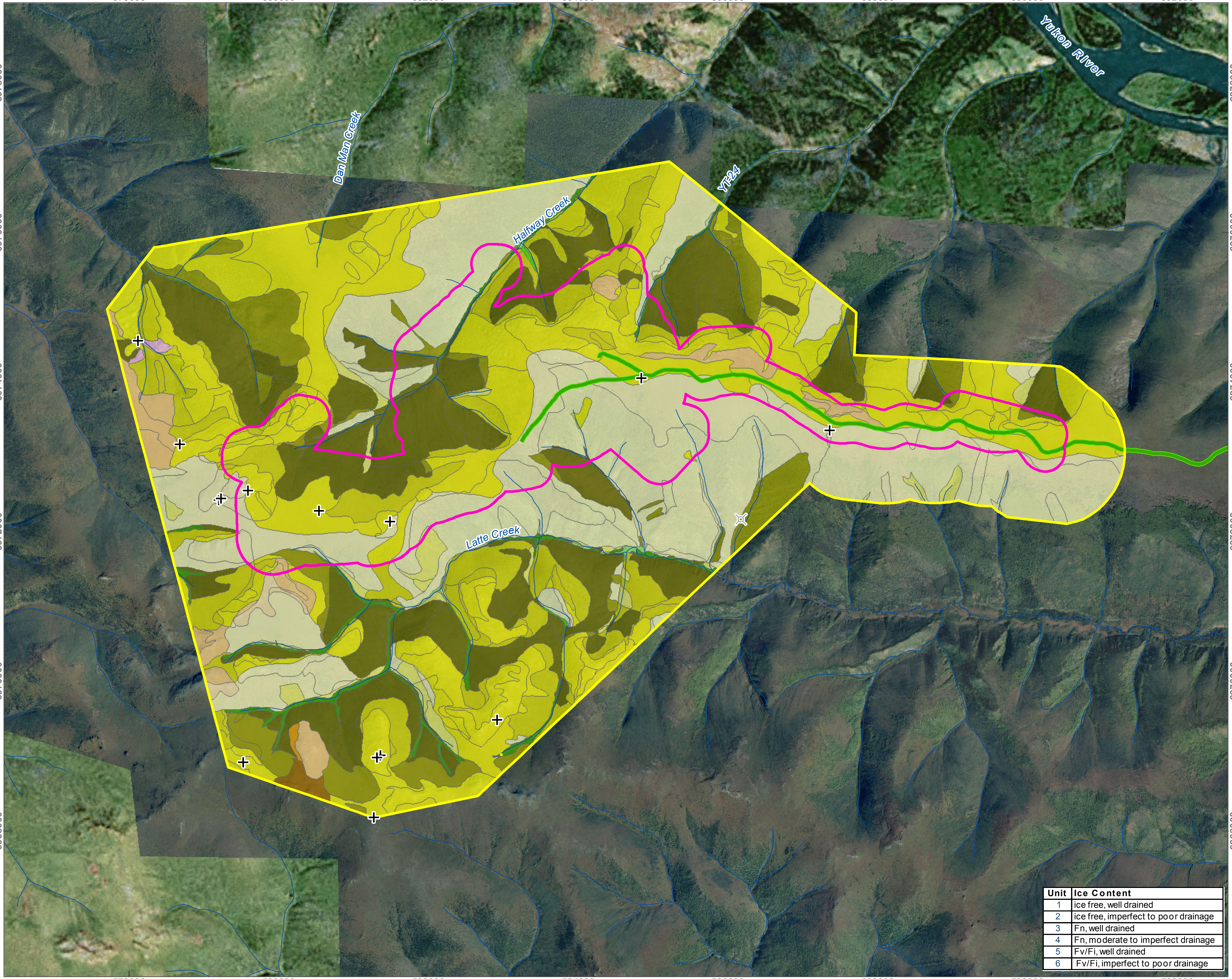
Table 3.3-5 Distribution of Soil Reclamation Suitability in the Mine Site Area

Parent Material	Soil Map Unit	Estimated Topsoil Depth (cm)	Study Area Total (ha)	Suitable (ha)	Suitable % of Study Area	Unsuitable (ha)	Unsuitable % of Study Area
Local Assessment Area							
Colluvium	C1*	15	614	254	14	359	20
	C2*	14	6	-	-	6	<1
	C3	12	646	389	21	257	14
	C4	24	183	104	6	78	4
	C5	13	37	-	-	37	2
	C6	32	290	-	-	290	16
Weathered Bedrock	D1*	22	1	<1	<1	1	<1
	D3	11	54	36	2	18	1
Fluvial	F6	32	8	-	-	8	<1
Total			**1,837**	**784**	**43**	**1,053**	**57**
Regional Assessment Area							
Colluvium	C1*	15	2,067	569	9	1,498	22
	C2*	14	119	51	1	68	1
	C3	12	1,865	981	15	884	13
	C4	24	623	289	4	335	5
	C5	13	405	-	-	405	6
	C6	32	1,293	-	-	1,293	19
Weathered Bedrock	D1*	22	23	19	<1	4	<1
	D3	11	168	79	1	89	1
	D4	24	4	-	-	4	<1
	D5	13	19	-	-	19	<1
Fluvial	F1*	15	1	<1	<1	1	<1
	F2*	14	6	4	<1	2	<1
	F4	24	2	<1	<1	2	<1
	F5	10	1	-	-	1	<1
	F6	32	86	-	-	86	1
Bedrock	R3	21	7	-	-	7	<1
Total			**6,689**	**1,991**	**30**	**4,698**	**70**

Note: * denotes unfrozen soil types

COFFEE GOLD MINE

Soil Map of the Mine Site Area



Unit	Ice Content
1	ice free, well drained
2	ice free, imperfect to poor drainage
3	Fn, well drained
4	Fn, moderate to imperfect drainage
5	Fv/Fi, well drained
6	Fv/Fi, imperfect to poor drainage

Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Dominant Soil Parent Material (Permafrost Category)

Colluvial

- C1
- C2
- C3 (Fn)
- C4 (Fn)
- C5 (Fv/Fi)
- C6 (Fv/Fi)

Fluvial

- F1
- F2
- F4 (Fn)
- F5 (Fv/Fi)
- F6 (Fv/Fi)

Bedrock

- R3 (Fn)

Weathered Bedrock

- D1
- D3 (Fn)
- D4 (Fv/Fi)
- D5 (Fv/Fi)

Permafrost Category

Fn = Ice-poor
Fi = Ice-rich
Fv = Very Ice-rich

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Page Size: 11" x 17"

Figure 3.3-5	Date: Mar 16, 2017	Drawn by: MEZ	Reviewed: TP

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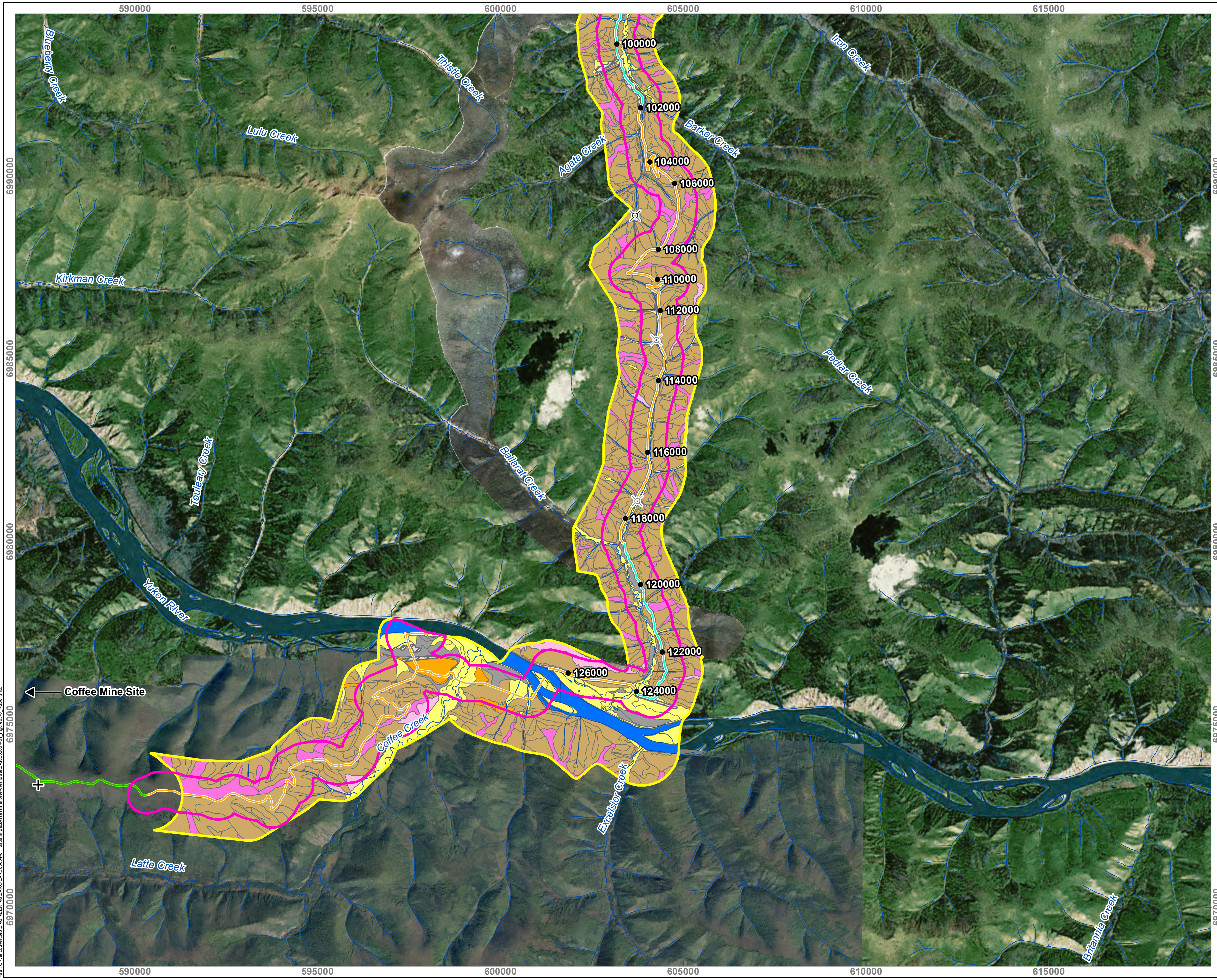
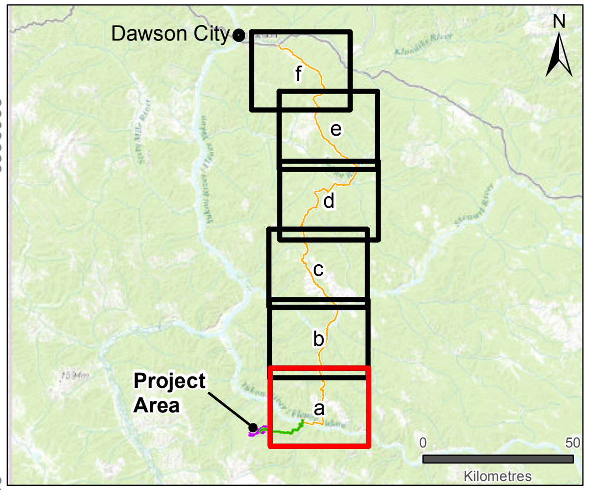


COFFEE GOLD MINE

Soil Parent Materials along the Northern Access Route



Legend

- Local Assessment Area
- Regional Assessment Area
- Pingo
- Pingo (collapsed)
- Tor
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Dominant Soil Parent Material

- Colluvium
- Fluvial
- Glaciofluvial
- Bedrock
- Weathered Bedrock
- Organic
- Anthropogenic
- Water

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Figure 3.3-6	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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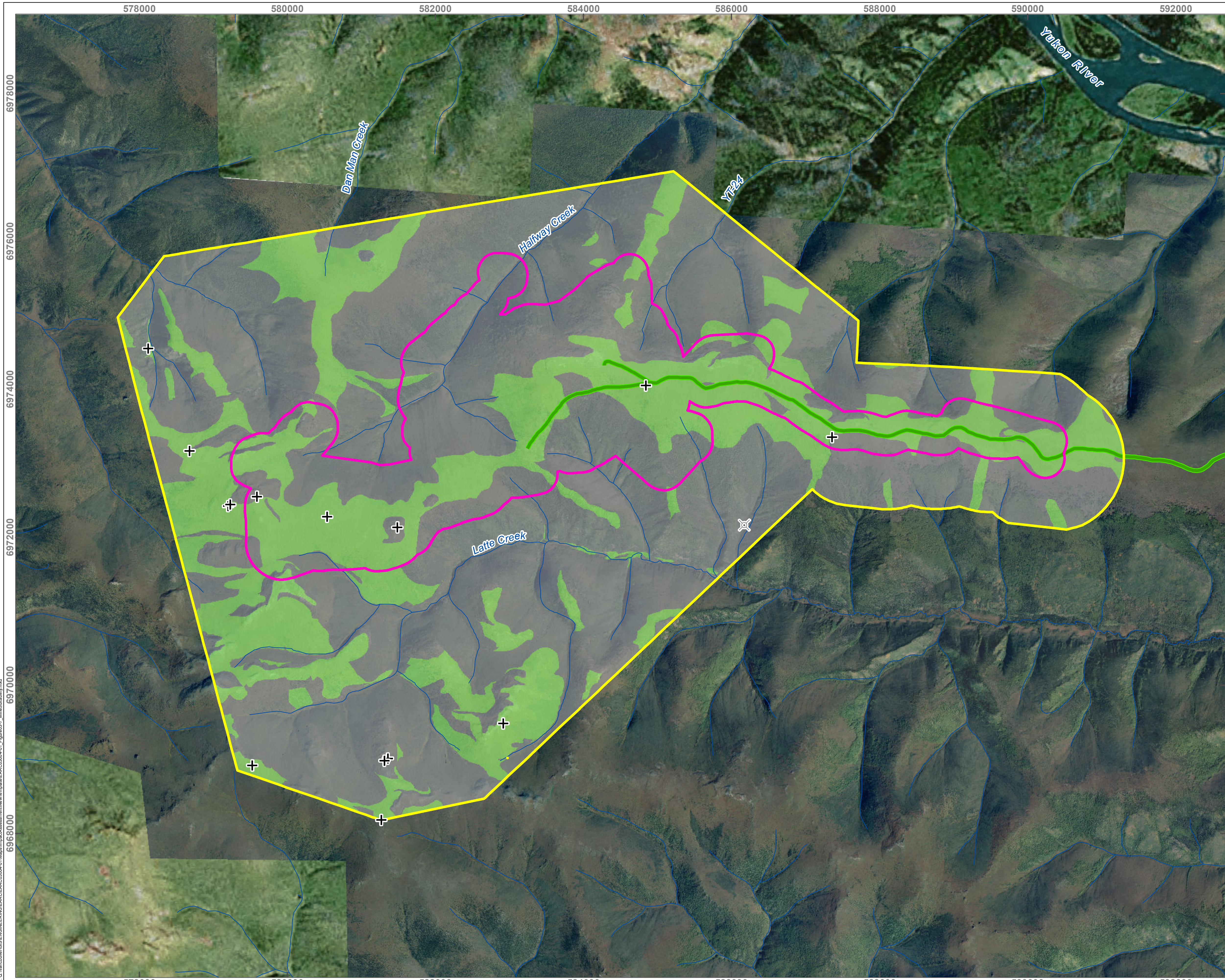
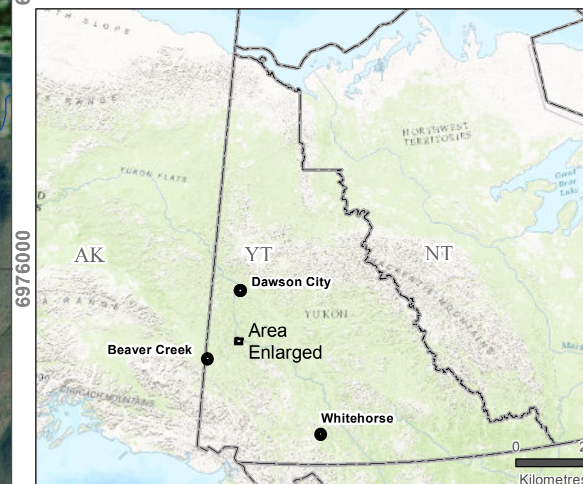
COFFEE GOLD MINE

Soil Reclamation Suitability Potential within the Mine Site Area





Legend

- Local Assessment
- Regional Assessment
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Reclamation Suitability

- Suitable
- Unsuitable

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Figure 3.3-7	Date: Mar 16, 2017	Drawn by: MEZ	Reviewed: TP

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4.0 ASSESSMENT OF PROJECT-RELATED EFFECTS

Potential Project-related interactions with Surficial Geology, Terrain, and Soils are presented in **Table 4.1-1** using the terms defined in **Section 5.0 Assessment Methodology** of the Project Proposal. Potential Project-related effects and mitigation measures are provided along with an assessment of residual effects and a significance determination.

4.1 POTENTIAL PROJECT-RELATED INTERACTIONS WITH SURFICIAL GEOLOGY, TERRAIN, AND SOILS

Certain Project activities have the potential to interact with Surficial Geology, Terrain, and Soils. Each interaction is ranked as follows: No Interaction, Negligible Interaction, or Potential Interaction. Definitions of these terms are provided in **Section 5.0 Assessment Methodology** of the Project Proposal.

Project activities that are not anticipated to interact with the Surficial Geology, Terrain, and Soils VC are primarily those associated with water conveyance in and around the site, air traffic, barge traffic on the Stewart and Yukon rivers, activities associated with ice roads, and operation of the process plant (**Table 4.1-1**).

Activities anticipated to have a negligible interaction with the VC range from those that will generate dust to those that could result in localized soil compaction and/or contamination. These interactions however are unlikely to have a substantive influence on the long-term integrity of the VC and can be readily mitigated through the provisions identified in the various management plans developed for the Project (see **Section 31.0 Environmental and Socio-economic Management Program** of the Project Proposal).

Project activities that will potentially interact with Surficial Geology, Terrain, and Soils are those that are likely to result in some form of physical site disturbance. The potential effects of these interactions have been carried forward for further consideration in the effects assessment (**Section 4.2**).

Table 4.1-1 Identification of Potential Project Interactions with Surficial Geology, Terrain, and Soils

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Construction Phase (Year -2 through Year -1)								
Overall Construction Phase								
Overall Mine Site	C-0	Confirmatory geotechnical drilling in select areas at the Mine Site, as necessary	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-1	Mobilization of mobile equipment and construction materials	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	C-2	Clearing, grubbing, and grading of areas to be developed within the Mine Site	Potential Interaction	Changes to terrain stability.	Potential Interaction	Disturbance of unique landforms	Potential Interaction	Soil disturbance and degradation
	C-3	Material handling	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
Open Pits	C-4	Development of Latte pit and Double Double pit	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-5	Dewatering of pits (as required)	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
Waste Rock Storage Facilities	C-6	Development and use of Alpha WRSF	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
Stockpiles	C-7	Development and use of temporary organics stockpile for vegetation and topsoil	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-8	Development and use of frozen soils storage area	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-9	Development and use of run-of-mine (ROM) stockpile for temporary storage of ROM ore	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Crusher System	C-10	Construction and operation of crushing circuit	Negligible Interaction	Changes to terrain stability	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-11	Construction and operation of crushed ore stockpile	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
Heap Leach Facility	C-12	Staged heap leach facility (HLF) construction, including associated event ponds, rainwater pond, piping, and water management infrastructure	Potential Interaction	Changes to terrain stability	Potential Interaction	Disturbance of unique landforms	Potential Interaction	Soil disturbance and degradation
	C-13	Heap leach pad loading	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
Plant Site	C-14	Construction and operation of process plant	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-15	Construction and operation of reagent storage area and on-site use of processing reagents	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-16	Construction and operation of laboratory, truck shop, and warehouse building	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-17	Construction and operation of power plant	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-18	Construction and operation of bulk fuel/LNG storage and on-site use of diesel fuel or LNG	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Camp Site	C-19	Construction and operation of dormitories and kitchen, dining, and recreation complex buildings; mine dry and office complex; emergency response and training building; fresh (potable) water and fire water systems; and sewage treatment plant	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	C-20	Construction and operation of waste management building and waste management area	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
Bulk Explosive Storage Area	C-21	Construction of storage facilities for explosives components and on-site use of explosives	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
Mine Site and Haul Roads	C-22	Upgrade, construction, and maintenance of Mine Site service roads and haul roads	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
Site Water Management Infrastructure	C-23	Development and use of sedimentation ponds and conveyance structures	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-24	Initial supply of HLF process water	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	C-25	Ongoing use of site contact water (i.e., precipitation, stored rainwater) as HLF process water	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Ancillary Components	C-26	Upgrade of existing road sections for Northern Access Route (NAR), including installation of culverts and bridges	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	C-27	Construction of new road sections for NAR, including installation of culverts and bridges	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-28	Development, operation, and maintenance of temporary work camps along road route	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-29	Vehicle traffic, including mobilization and re-supply of freight and consumables	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	C-30	Development, operation, and maintenance of barge landing sites on Yukon River and Stewart River	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-31	Barge traffic on Stewart River and Yukon River, including barge mobilization of equipment for NAR construction	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	C-32	Annual construction, operation, maintenance, and removal of Stewart River and Yukon River ice roads	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	C-33	Annual construction and operation of winter road on the south side of the Yukon River	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Soil disturbance and degradation.

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
	C-34	Construction, operation, and maintenance of permanent bridge over Coffee Creek	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	C-35	Construction and maintenance of gravel airstrips	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	C-36	Air traffic	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	C-37	Use of all laydown areas	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	C-38	Use of Coffee Exploration Camp	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
Operation Phase (Year 1 through Year 9)								
Overall Operation Phase								
Overall Mine Site	O-1	Material handling	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	O-2	Excavation of contaminated soils followed by on-site treatment or temporary storage and off-site disposal	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	O-3	Progressive reclamation of disturbed areas within Mine Site footprint	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Open Pits	O-4	Development of Kona pit and Supremo pit and continued development of Double Double pit and Latte pit	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
	O-5	Cessation of mining at Double Double pit, Latte pit, Kona pit, and Supremo pit	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-6	Partial backfill of Latte pit and Supremo pit	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition
	O-7	Backfill of Double Double pit and Kona pit	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition
	O-8	Dewatering of pits (as required)	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
Waste Rock Storage Facilities	O-9	Continued development and use of Alpha WRSF	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
	O-10	Development and use of Beta WRSF	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
Stockpiles	O-11	Continued use of temporary organics stockpile for vegetation and topsoil	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Water and wind erosion and soil compaction.
	O-12	Continued use of frozen soils storage area	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Water and wind erosion and soil compaction.
	O-13	Continued use of ROM stockpile for temporary storage of ROM ore	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
Crusher System	O-14	Crusher operation	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
	O-15	Continued use of crushed ore stockpile	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Heap Leach Facility	O-16	Continued staged HLF construction, including related water management structures and year-round operation	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation.
	O-17	Progressive closure and reclamation of HLF	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Plant Site	O-18	Process plant operation	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-19	Continued on-site use of processing reagents	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Localized soil contamination.
	O-20	Continued on-site use of diesel fuel or LNG	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Localized soil contamination.
Camp Site	O-21	Continued use of facilities	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
Bulk Explosive Storage Area	O-22	Continued on-site use of explosives	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Localized soil contamination.
Mine Site and Haul Roads	O-23	Use and maintenance of Mine Site service roads and haul roads	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
Site Water Management Infrastructure	O-24	Continued use of sedimentation ponds conveyance structures	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-25	Ongoing use of site contact water (i.e., precipitation, stored rainwater) as HLF process water	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-26	Installation and operation of water treatment facility for HLF rinse water	Potential Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Ancillary Components	O-27	NAR road maintenance (e.g., aggregate re-surfacing, sanding, snow removal)	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	O-28	NAR vehicle traffic, including mobilization and re-supply of freight and consumables	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	O-29	Operation and maintenance of barge landing sites on Stewart River and Yukon River	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Soil compaction.
	O-30	Barge traffic on Stewart River and Yukon River	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-31	Annual construction, operation, maintenance, and removal of Stewart River and Yukon River ice roads	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-32	Annual construction and operation of winter road on the south side of the Yukon River	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-33	Operation and maintenance of gravel air strips	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Soil compaction.
	O-34	Air traffic	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	O-35	Use of all laydown areas	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	O-36	Use of Coffee Exploration Camp	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Reclamation and Closure Phase (Year 10 through Year 20)								
Overall Reclamation and Closure Phase								
Overall Mine Site	R-1	Reclamation of disturbed areas within Mine Site footprint	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
	R-2	Excavation of contaminated soils followed by on-site treatment or temporary storage and off-site disposal	Negligible Interaction	Changes to terrain stability.	No Interaction	Interactions are not anticipated.	Potential Interaction	Soil disturbance and degradation
Open Pits	R-3	Reclamation of Double Double pit, Latte pit, Kona pit, and Supremo pit	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Waste Rock Storage Facilities	R-4	Reclamation of Alpha WRSF	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
	R-5	Reclamation of Beta WRSF	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Stockpiles	R-6	Reclamation of temporary organics stockpile, frozen soils storage area, and ROM stockpile	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Crusher System	R-7	Dismantling and removal of crusher facility and stockpile	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Heap Leach Facility	R-8	Closure of HLF and related water management structures	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Plant Site	R-9	Dismantling and removal of process plant, reagent storage area, laboratory, truck shop and warehouse building, power plant, and bulk fuel storage	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
Camp Site	R-10	Dismantling and removal or dormitories and kitchen, dining, and recreation complex buildings, mine dry and office complex, emergency response and training building, fresh (potable) water and fire water systems, sewage treatment plant, and waste management building	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Bulk Explosive Storage Area	R-11	Dismantling and removal of explosives storage facility	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Mine Site and Haul Roads	R-12	Decommissioning and reclamation of Mine Site service roads and haul roads	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Site Water Management Infrastructure	R-13	Decommissioning and reclamation of selected water management infrastructure, construction of long term water management infrastructure	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
	R-14	Operation and maintenance of HLF water treatment facility	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	R-15	Decommissioning and removal of HLF water treatment plant	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
Ancillary Components	R-16	NAR road maintenance (e.g., aggregate re-surfacing, sanding, snow removal)	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.

Project Component	Project Activities		Terrain Stability		Unique Landforms		Soil Quality	
	#	Description	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect	Interaction Rating	Nature of Interaction and Potential Effect
	R-17	NAR vehicle traffic	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition and soil compaction.
	R-18	Operation and maintenance of barge landing sites on Stewart River and Yukon River	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Soil compaction.
	R-19	Annual resupply of consumables and materials for active closure via barge on the Yukon River	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	R-20	Annual construction, maintenance, and decommissioning of Stewart River and Yukon River ice roads	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	R-21	Decommissioning of new road portions	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
	R-22	Air traffic	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
	R-23	Decommissioning and reclamation of airstrip	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	Negligible Interaction	Fugitive dust deposition.
	R-24	Re-opening and operation of pre-existing Yukon River exploration camp and airstrip to support post-closure monitoring activities	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.
Post-closure Phase (Year 21 onwards)								
Overall Post-closure Phase								
Overall Mine Site	P-1	Long-term monitoring	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.	No Interaction	Interactions are not anticipated.

4.2 POTENTIAL PROJECT-RELATED EFFECTS

Potential adverse Project-related effects to terrain stability and soil quality arising from potential interactions, as identified in **Table 4.1-1**, are discussed in more detail below. Anticipated adverse effects to both terrain stability and soil quality are based on the dimensions of the Project footprint as presented in **Table 4.2-1**. The dimensions represent the full extent of Project disturbance, irrespective of when during the mine life the disturbance occurs. The spatial extent of the Project footprint within the Mine Site area is shown in **Figure 4.2-1.** The outer extent of Project infrastructure was buffered by 50 m to allow for possible future adjustments in infrastructure placement, thus producing a conservative estimate of the overall disturbance. The main source of infrastructure-related disturbance within the Mine Site area is associated with the pits, which cover approximately 19% of the total footprint area (**Table 4.2-1**).

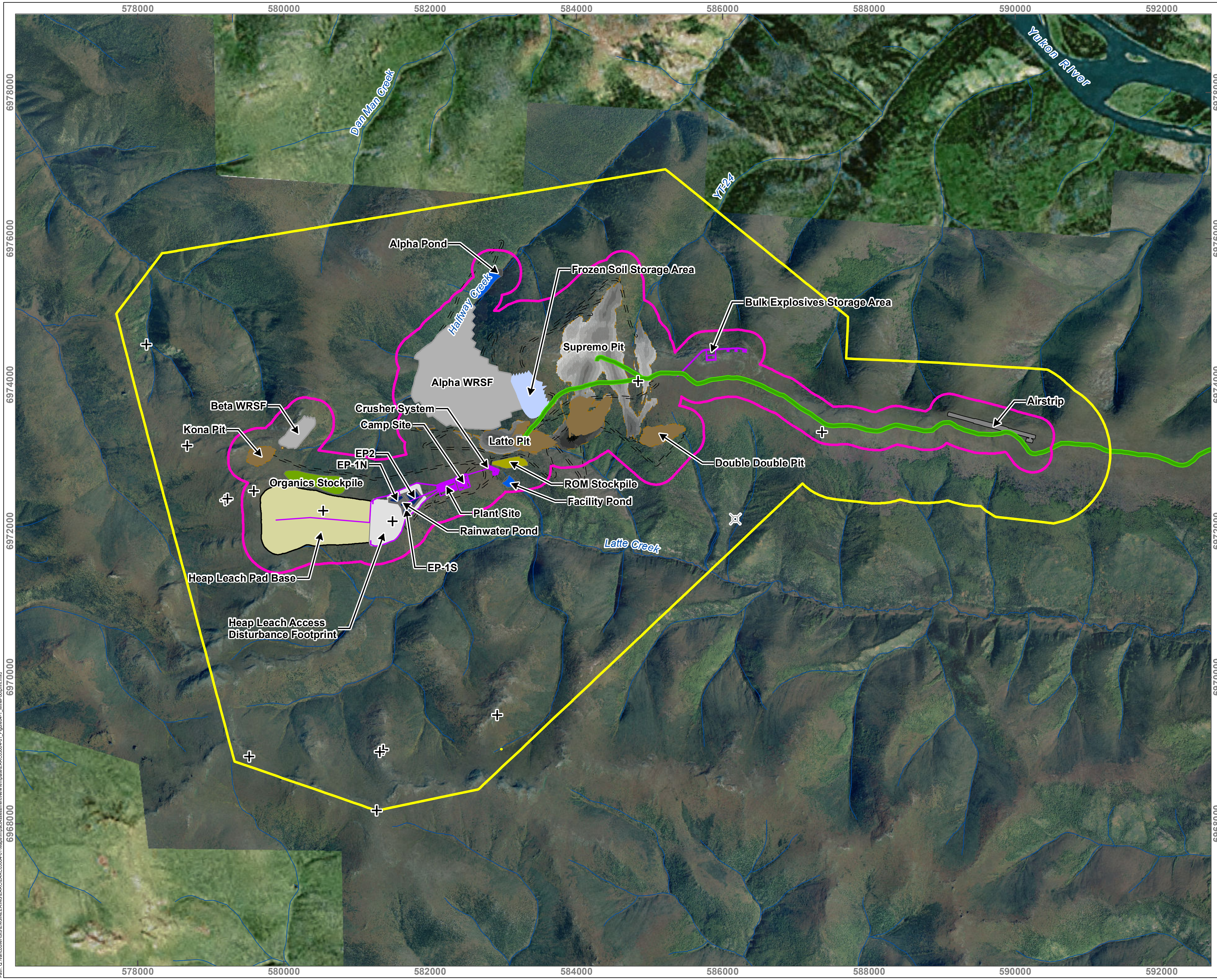
The NAR also represents an extensive footprint, however, this is largely a function of its 214 km length rather than the average width of disturbance (e.g., 50 m) in any particular location (**Figure 4.2-2**). Approximately 37 km (365 ha) of the NAR will require new construction; the remaining portions may be subject to upgrades and realignment to make it suitable for year-round access and to meet design criteria.

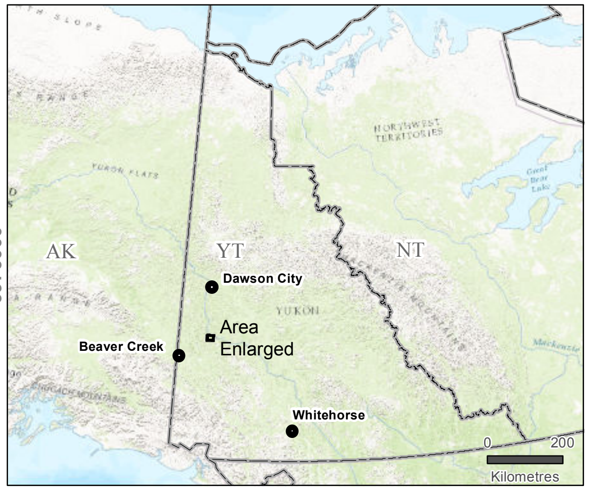
Table 4.2-1 Coffee Gold Mine Footprint Disturbance Areas

Project Footprint Component	Study Area (ha)	Proportion of Footprint (%)
Mine Site Area		
Interior Fragmented Areas	231	21
50 m Buffer – Outer Extent	219	20
Pits	215	19
Waste Rock Storage Facilities	159	14
Heap Leach and Base	122	11
Roads	69	6
Miscellaneous Infrastructure	39	4
Event Pond	29	3
Organic Soil Stockpile	16	1
Ore Stockpiles (ROM and Crushed)	10	1
Total	1,109	100
Northern Access Route		
Upgraded Sections	1,549	81
New Sections	365	19
Total	1,914	100

COFFEE GOLD MINE

Project Footprint within the Mine Site Area





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Proposed Footprint

- Airstrip
- Total Pit Outline
- Backfill
- Pit Lake
- WRSF
- Organics Stockpile
- ROM Stockpile
- Event Pond Slope
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure
- Haul Road
- Settling Pond
- Settling Pond Dam

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3. Footprint data from Hemmera (March 17, 2017)
4. Pingo and Tor locations from Palmer Environmental Consulting Group

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Figure 4.2-1	Date: Mar 27, 2017	Drawn by: MEZ	Reviewed: TP

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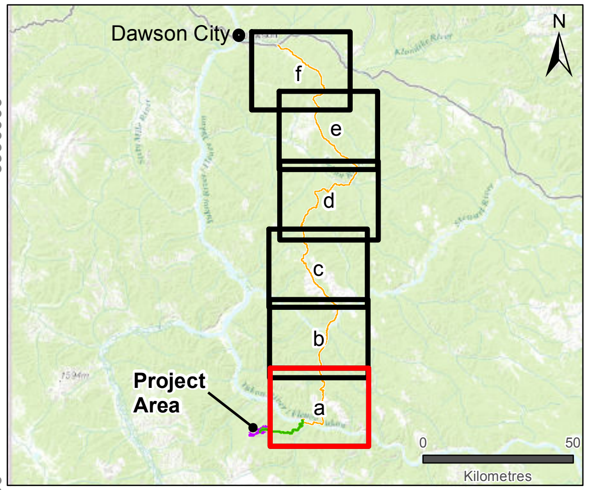
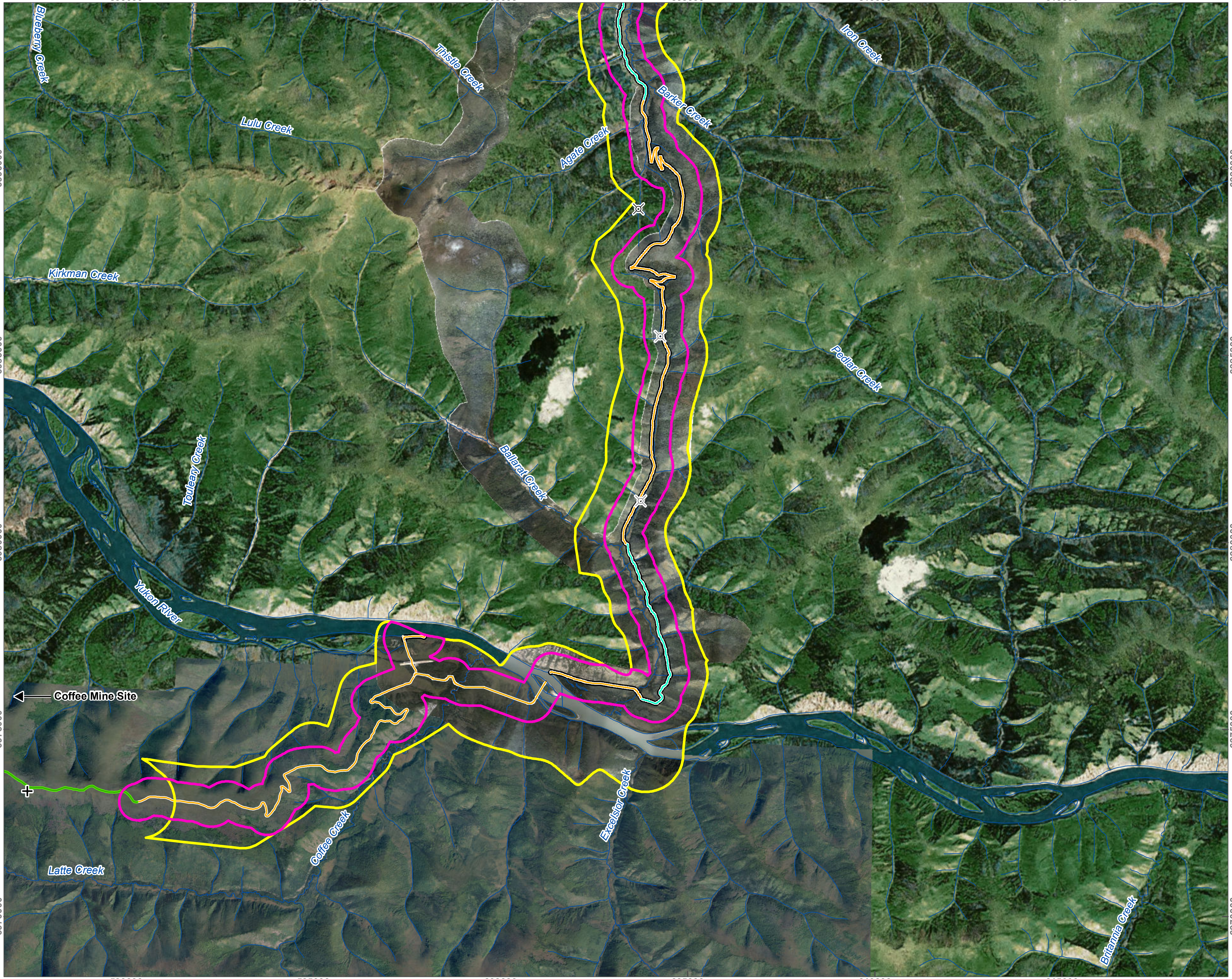
COFFEE GOLD MINE

Project Footprint along the Northern Access Route





Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo
- Pingo (collapsed)
- Tor
- Watercourse

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3. Footprint data modified from Hemmera (April 2016)
4. Pingo and Tor locations from Palmer Environmental Consulting Group

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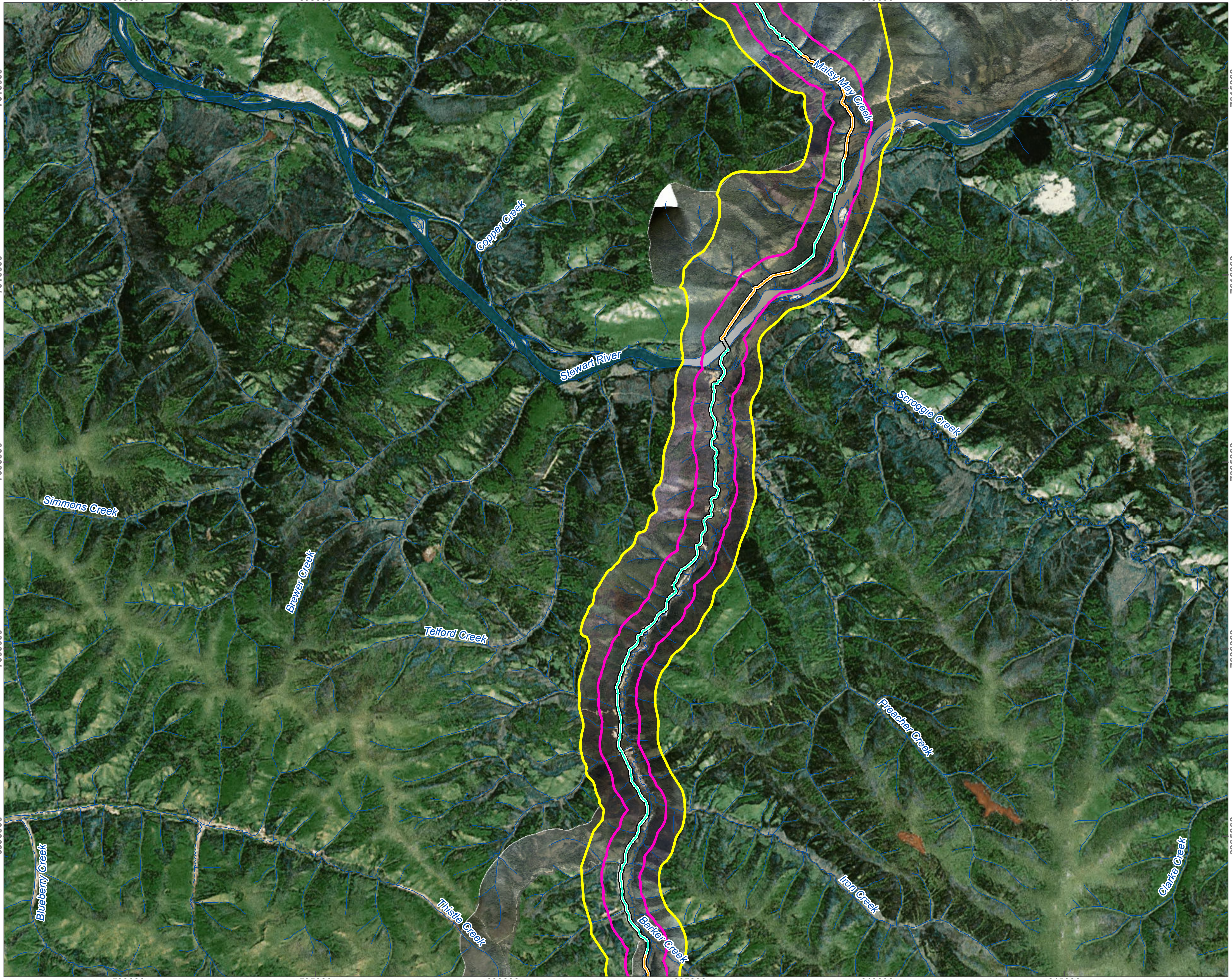
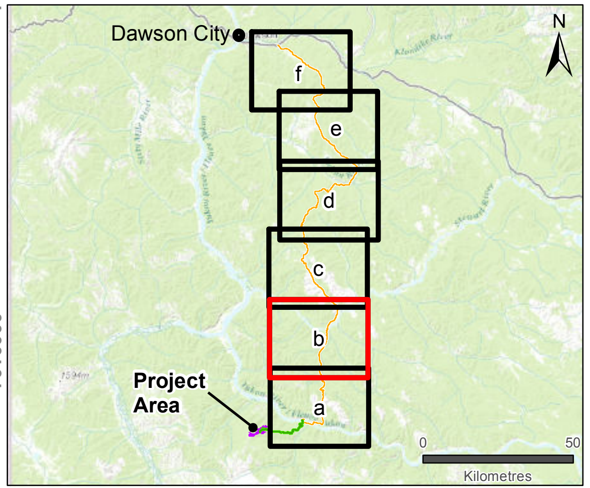


COFFEE GOLD MINE

Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
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- Watercourse

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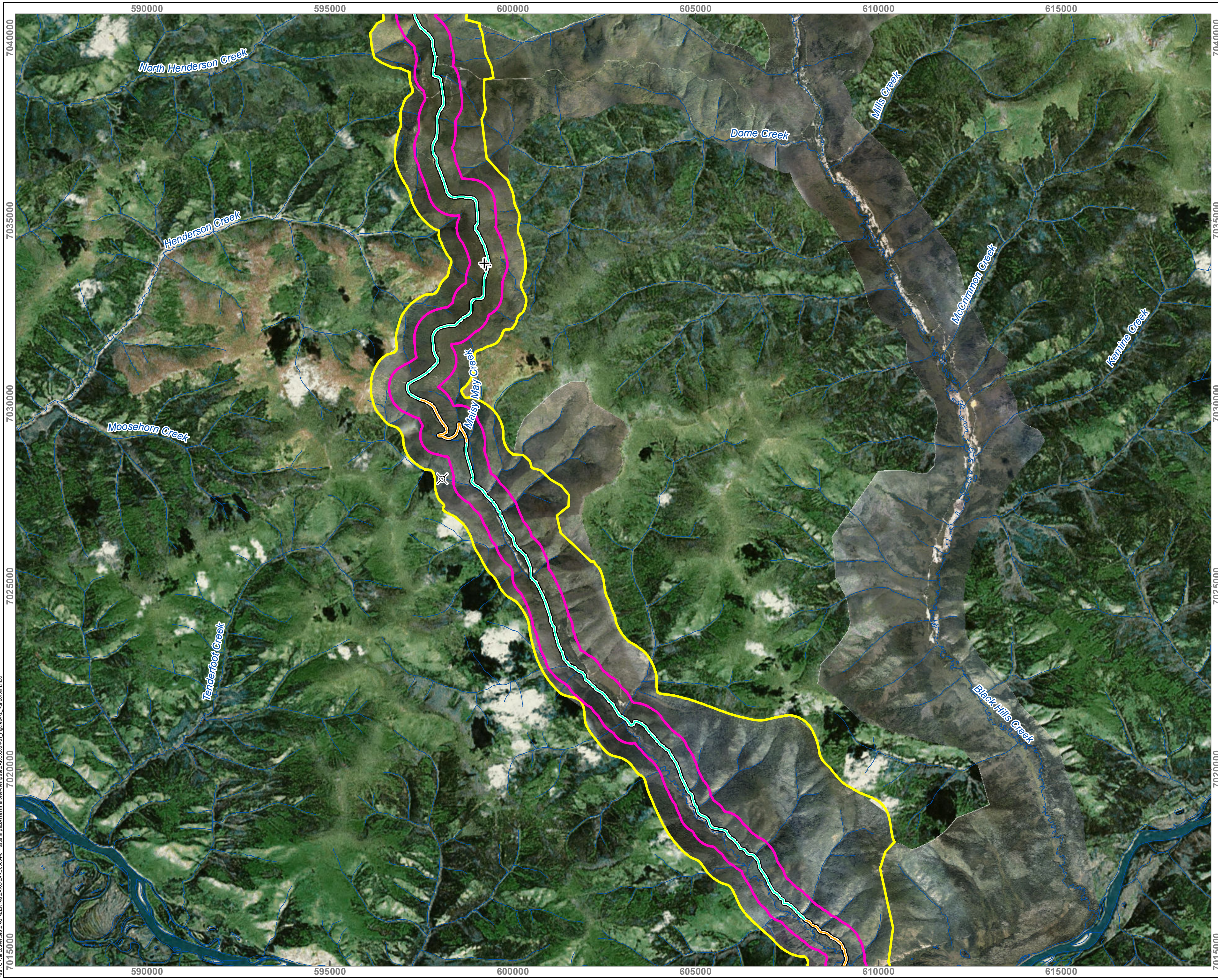
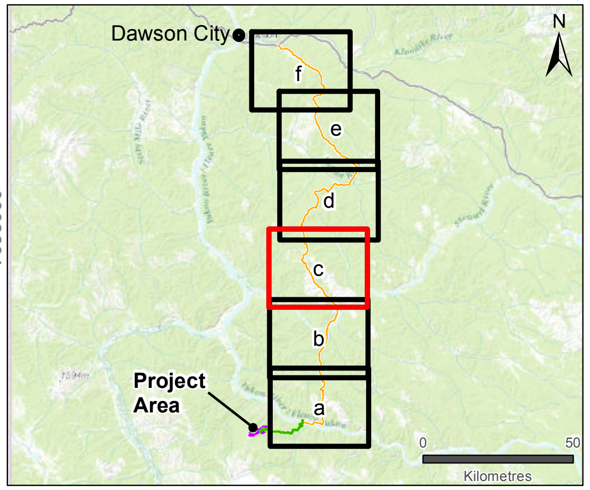


COFFEE GOLD MINE

Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo
- Tor
- Watercourse

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3. Footprint data modified from Hemmera (April 2016)
4. Pingo and Tor locations from Palmer Environmental Consulting Group

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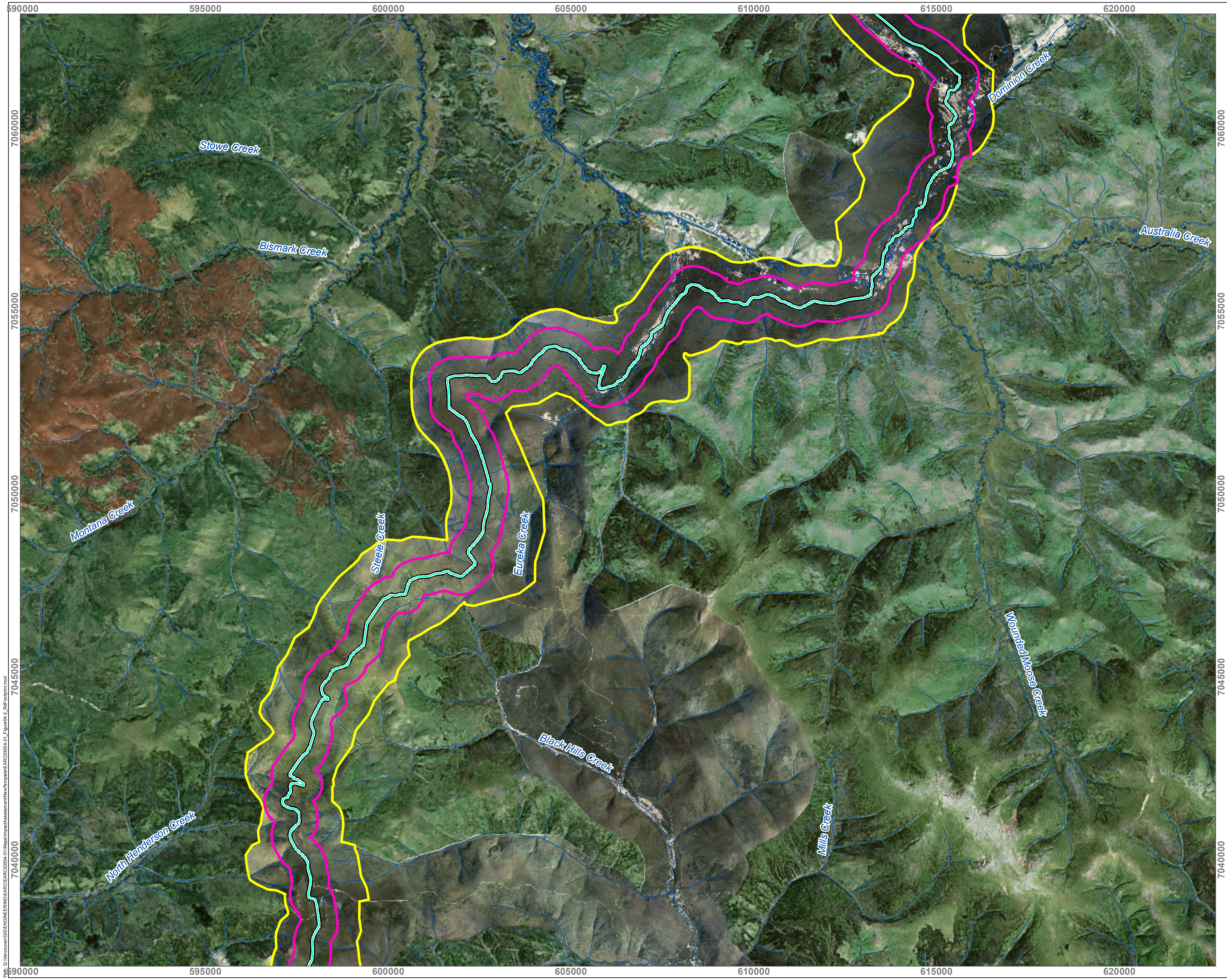
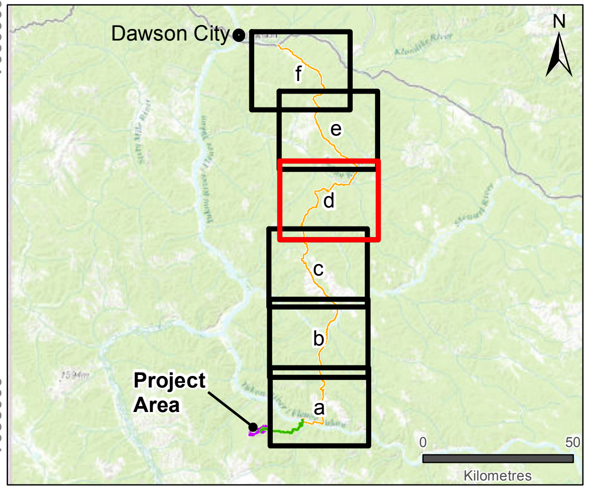


COFFEE GOLD MINE

Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
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- Watercourse

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4. Pingo and Tor locations from Palmer Environmental Consulting Group

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Figure 4.2-2d	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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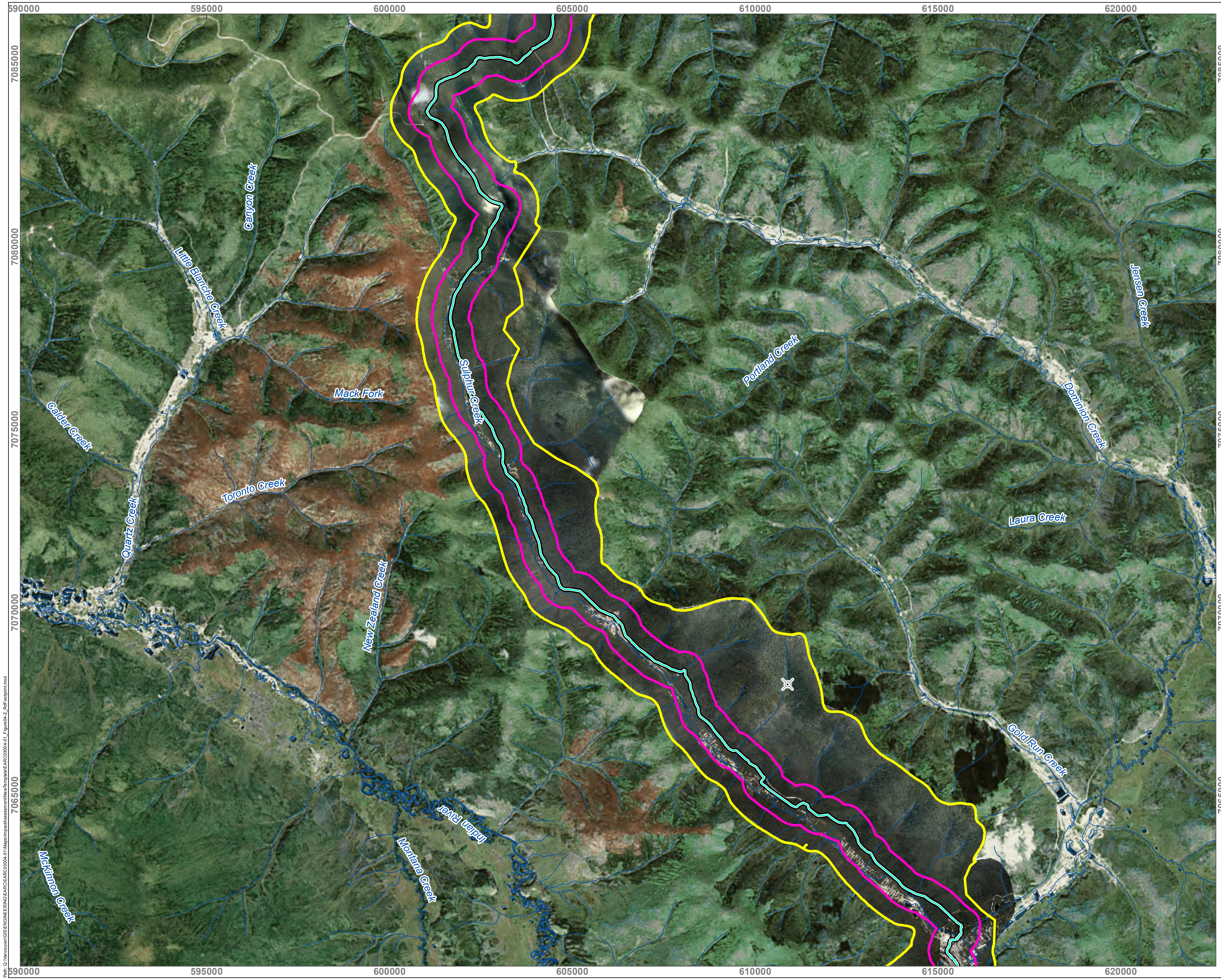
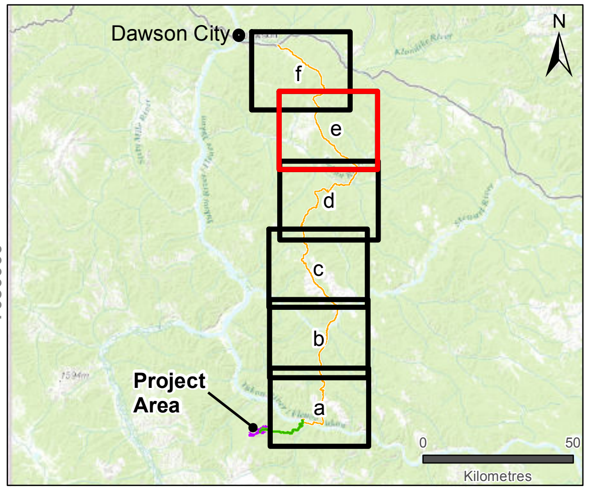
COFFEE GOLD MINE

Project Footprint along the Northern Access Route





Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Pingo (collapsed)
- Watercourse

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3. Footprint data modified from Hemmera (April 2016)
4. Pingo and Tor locations from Palmer Environmental Consulting Group

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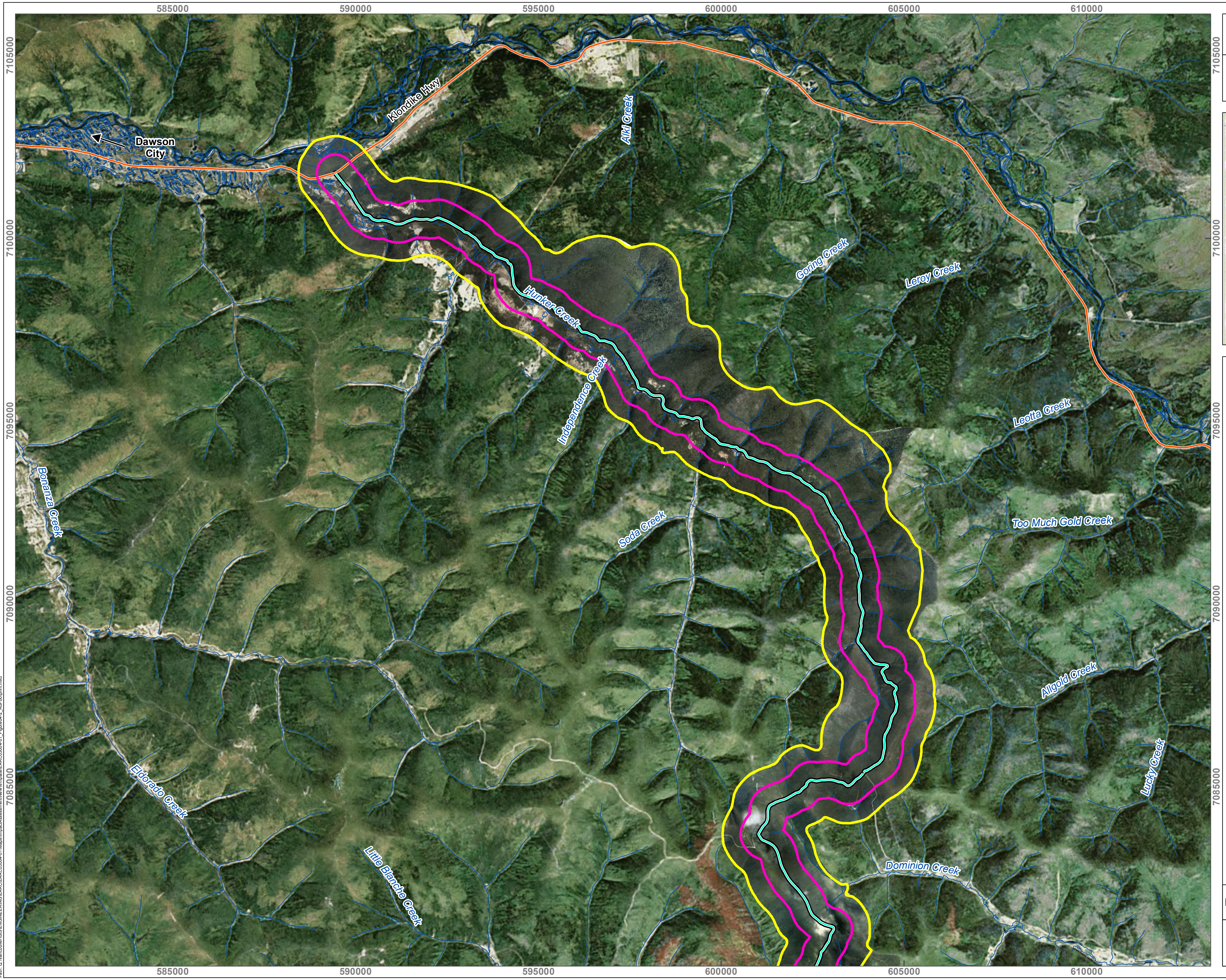
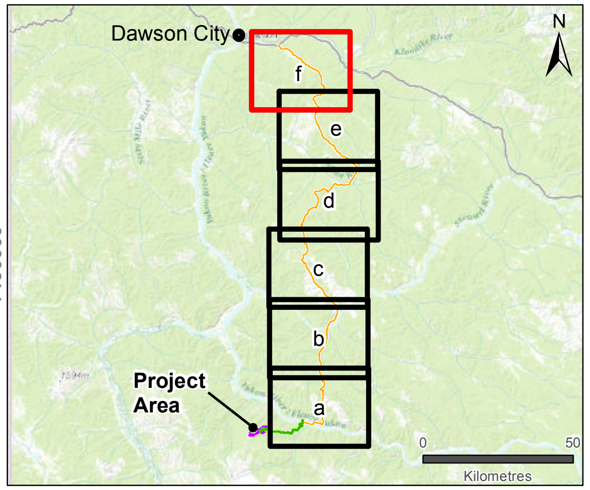


COFFEE GOLD MINE

Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
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- Mine Site Access Road
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3. Footprint data modified from Hemmera (April 2016)
4. Pingo and Tor locations from Palmer Environmental Consulting Group

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Figure 4.2-2f	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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4.2.1 TERRAIN STABILITY

As presented in **Section 2.0**, potential changes in terrain stability class were determined by identifying areas considered as being particularly sensitive to disturbance (e.g., areas that will support infrastructure that are considered to be relatively unstable from a terrain stability perspective, could become unstable with the addition of infrastructure, or are underlain by ice-rich permafrost). Potential effects are presented for the Mine Site area as well as the NAR.

4.2.1.1 Change in Terrain Stability Class to IV or V

The inclusion of the Project footprint in the Mine Site area has the potential to change the terrain stability classification of certain areas. Using the disturbed terrain stability classes identified in **Table 4.2-2** and **Appendix 11-A**, which present a conservative base case of typical construction techniques with no mitigation measures to offset potential instability on steep slopes or from disturbance to frozen, ice-rich (Fv or Fi) permafrost, approximately 243 ha (22%) of areas mapped as being relatively stable (terrain stability classes 0-III) within the Mine Site area footprint may become potentially unstable (classes IV and V) with the addition of Project infrastructure (**Table 4.2-2**, **Figure 4.2-3**). A further 15 ha of area currently mapped as being potentially unstable (terrain stability class IV) may become unstable (class V) with Project development. This is particularly evident in areas proposed to support the Alpha WRSF. Areas currently mapped as unstable (class V) are anticipated to remain as such.

Along the NAR, the Project footprint also has the potential to change the terrain stability classification of approximately 458 ha (24% of areas mapped within the Project footprint) from relatively stable (classes 0-III) to relatively unstable (classes IV and V), assuming no mitigation for slope instability or permafrost conditions, and typical cut and fill construction techniques (**Table 4.2-2**; **Figure 4.2-4**). This includes areas of new construction as well as areas along the existing roadway that require upgrading.

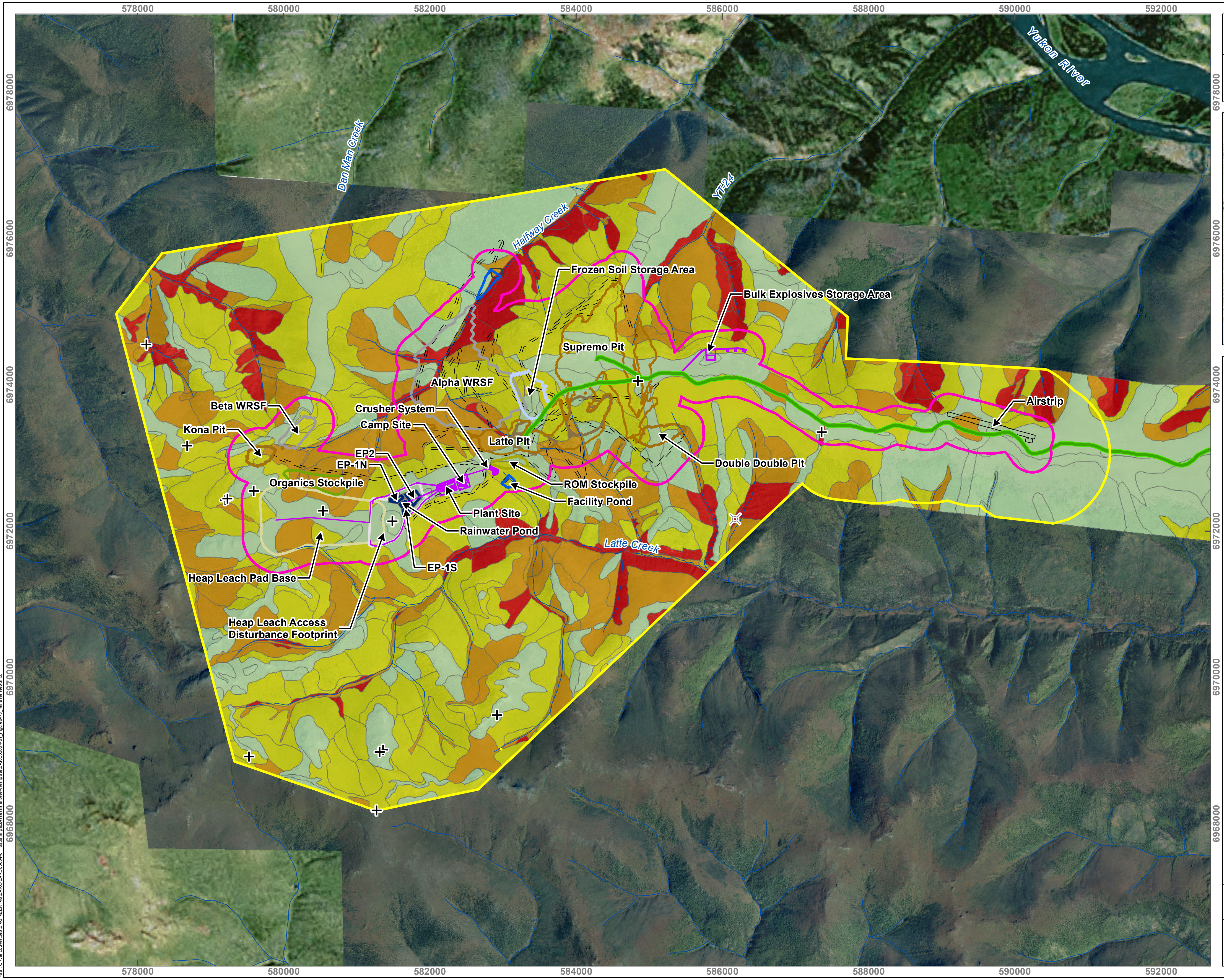
Table 4.2-2 Change in Terrain Stability Class Resulting from the Project Footprint within the Mine Site Area and along the Northern Access Route

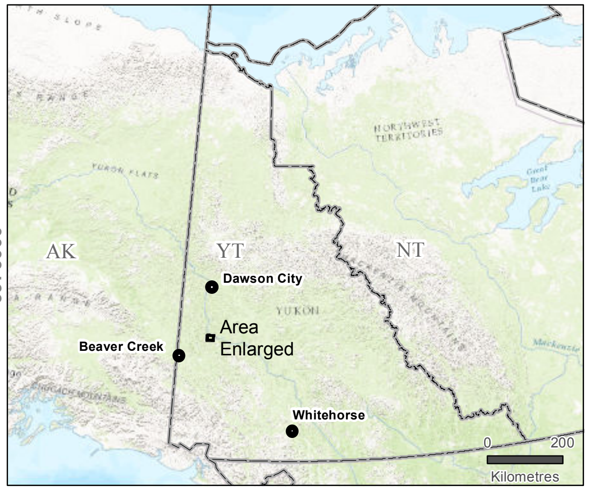
Existing Terrain Stability Class	Total Area (ha)	Disturbed Terrain Stability Class					
		0 (ha)	I (ha)	II (ha)	III (ha)	IV (ha)	V (ha)
Mine Site Area							
0	-	-	-	-	-	-	-
I	-	-	-	-	-	-	-
II	933	-	-	404	439	80	10
III	152	-	-	-	-	148	4
IV	15	-	-	-	-	-	15
V	8	-	-	-	-	-	8
Total	**1,109**	**-**	**-**	**404**	**439**	**228**	**37**
Northern Access Route							
0	478	478					
I	21		11	10		<1	
II	1,086			510	293	198	84
III	236				70	97	69
IV	12					2	10
V	81						81
Total	**1,914**	**478**	**11**	**520**	**363**	**297**	**244**

Source: **Appendix 11-A**; Classes: 0 – N/A, anthropogenic, I – stable, II – generally stable, III – generally stable with minor potential for instability, IV – potentially unstable, and V – unstable. Shaded cells represent no change between existing and disturbed classes.

COFFEE GOLD MINE

Terrain Stability Conditions with Inclusion of the Project Footprint within the Mine Site Area





Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Disturbed Terrain Stability Class

- 0 - N/A, Anthropogenic
- I - Stable
- II - Generally Stable
- III - Generally Stable with Minor Potential for Instability
- IV - Potentially Unstable
- V - Unstable

Proposed Footprint

- Airstrip
- Total Pit Outline
- Backfill
- Pit Lake
- WRSF
- Organics Stockpile
- ROM Stockpile
- Event Pond Slope
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure
- Haul Road
- Settling Pond
- Settling Pond Dam

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3. Footprint data from Hemmera (March 17, 2017)
4. Terrain data provided by Palmer Environmental Consulting Group (March

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Figure 4.2-3	Date: Mar 27, 2017	Drawn by: MEZ	Reviewed: TP

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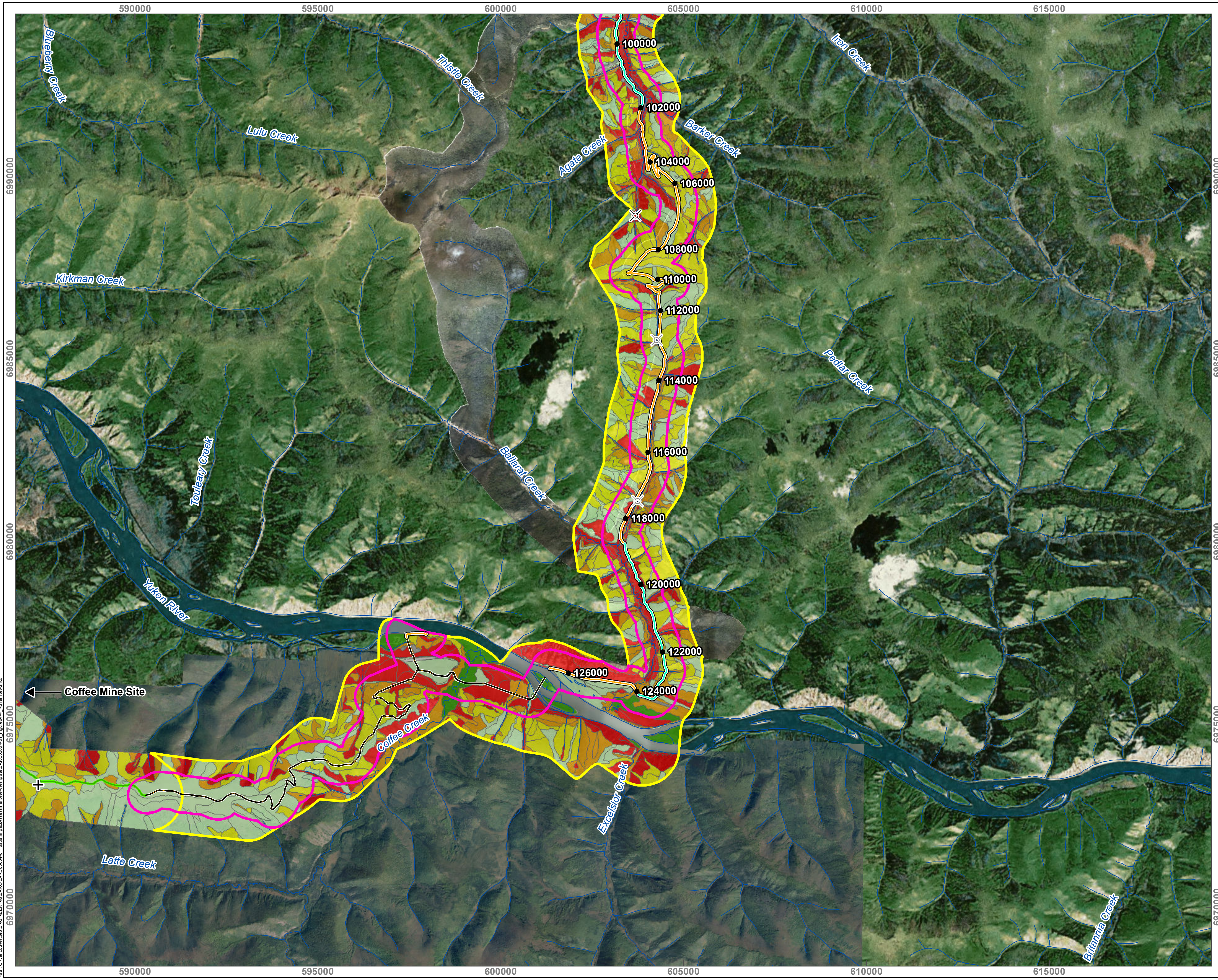
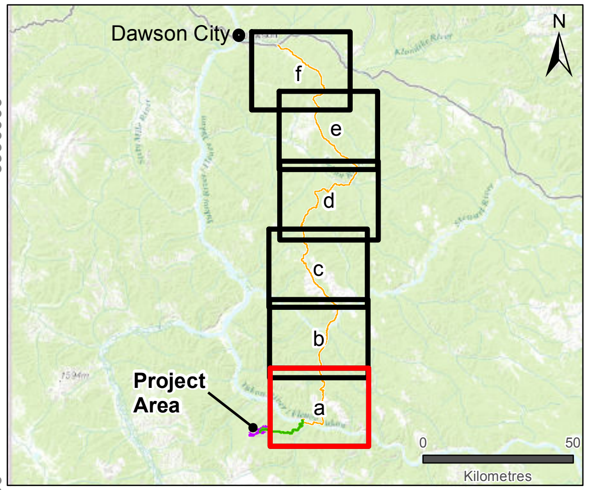


COFFEE GOLD MINE

Terrain Stability Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Pingo
- Pingo (collapsed)
- Tor
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Disturbed Terrain Stability Class

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Page Size: 11" x 17"

Figure 4.2-4a	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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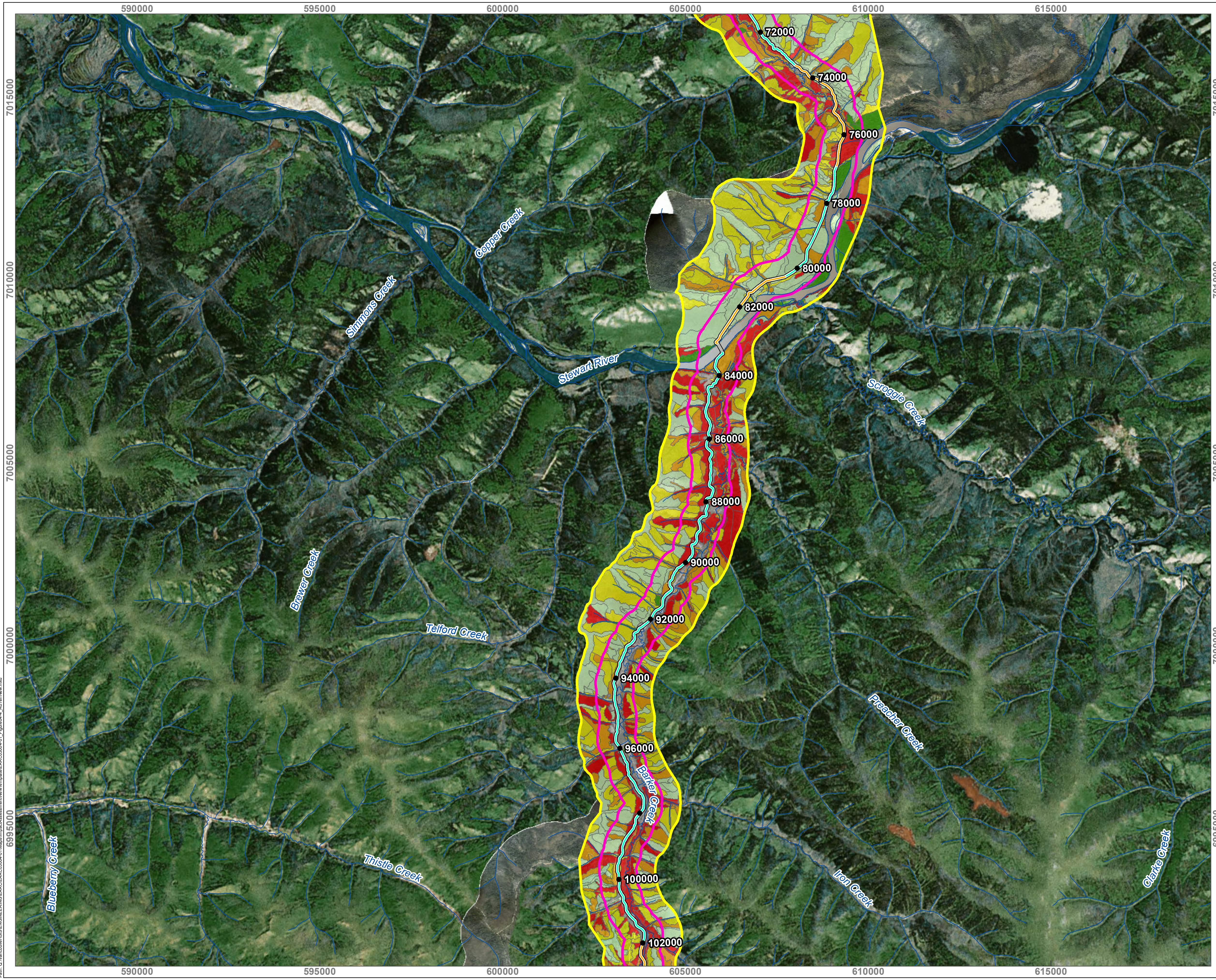
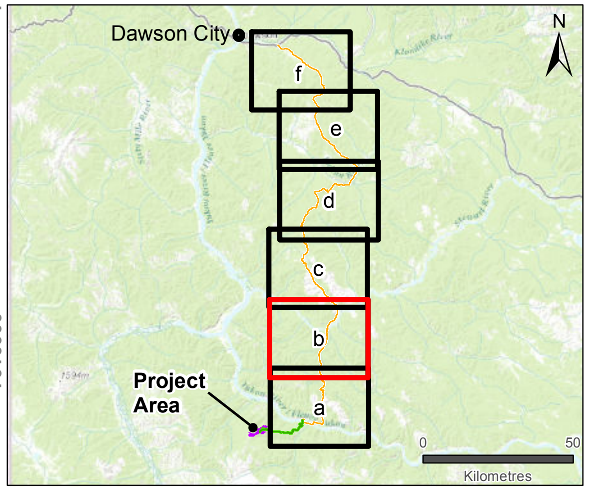


COFFEE GOLD MINE

Terrain Stability Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Disturbed Terrain Stability Class

- 0 - N/A, Anthropogenic
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Figure 4.2-4b	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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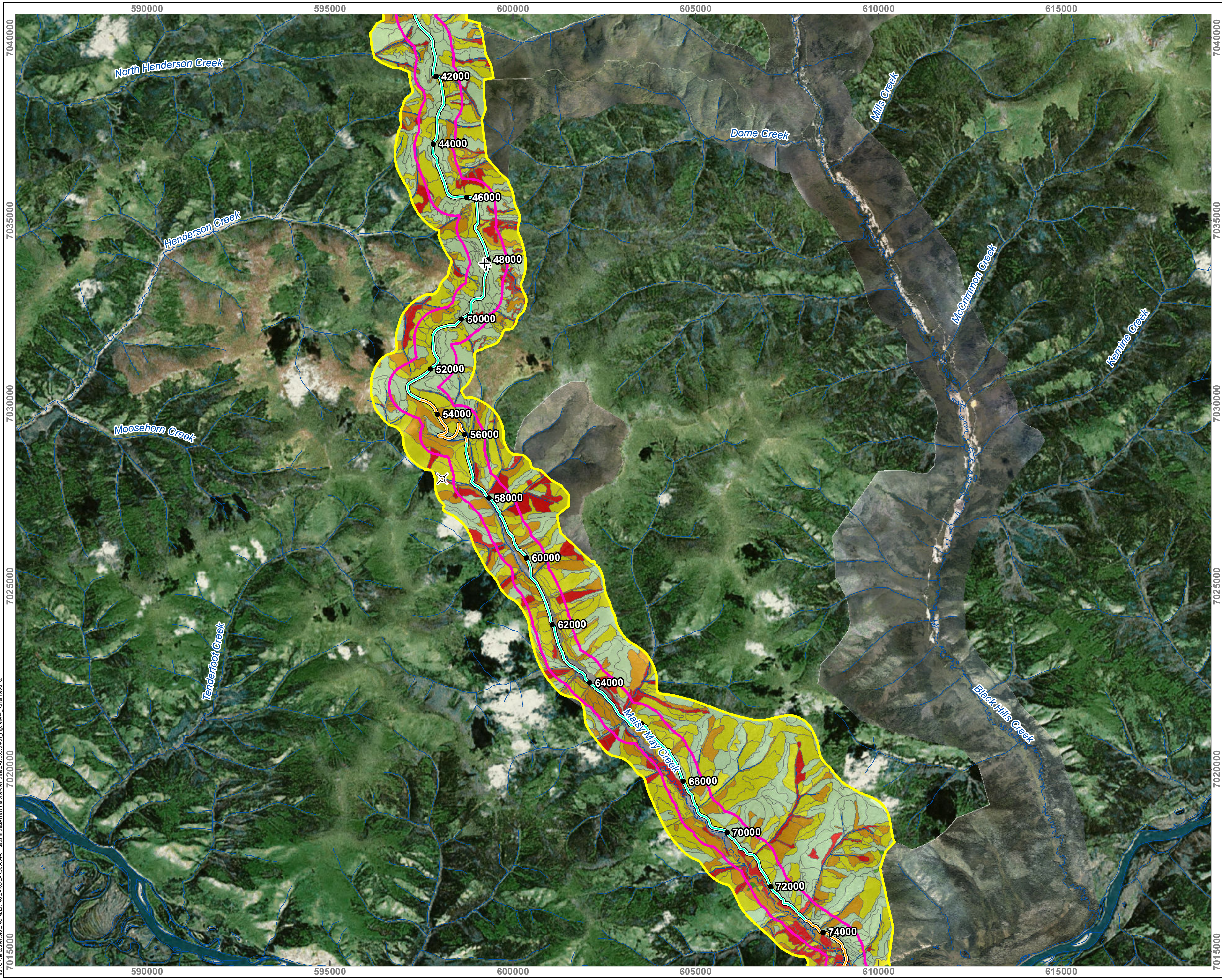
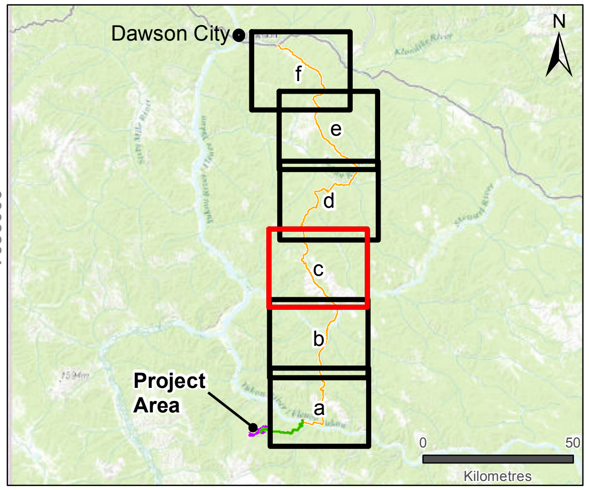


COFFEE GOLD MINE

Terrain Stability Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Pingo
- Tor
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Disturbed Terrain Stability Class

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Figure 4.2-4c	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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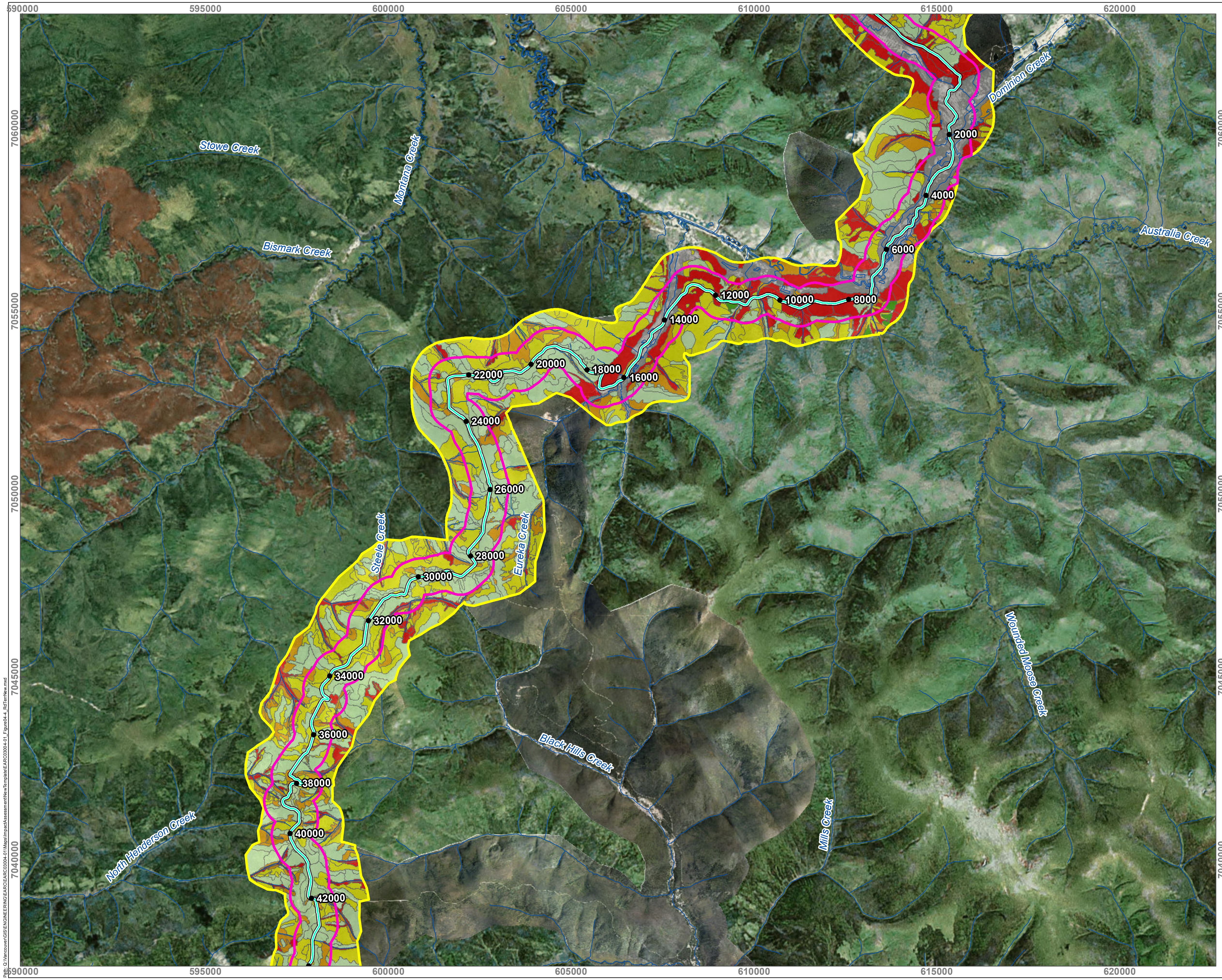
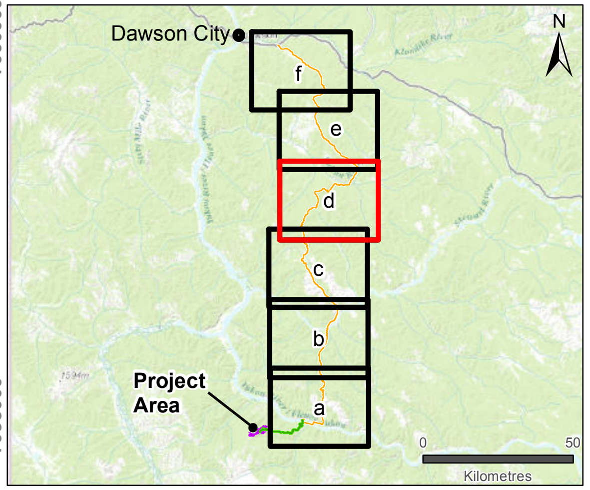


COFFEE GOLD MINE

Terrain Stability Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Disturbed Terrain Stability Class

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Figure 4.2-4d	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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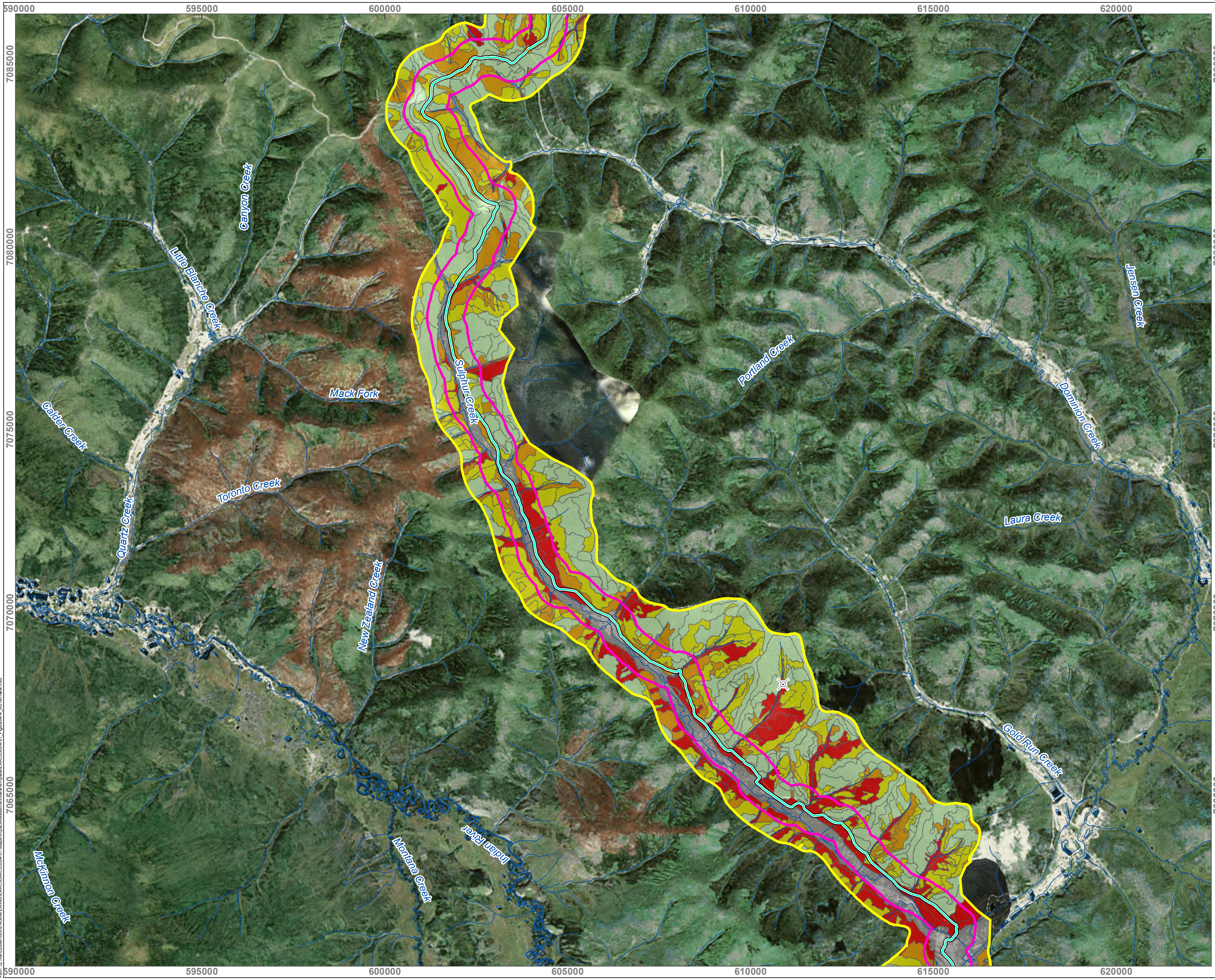
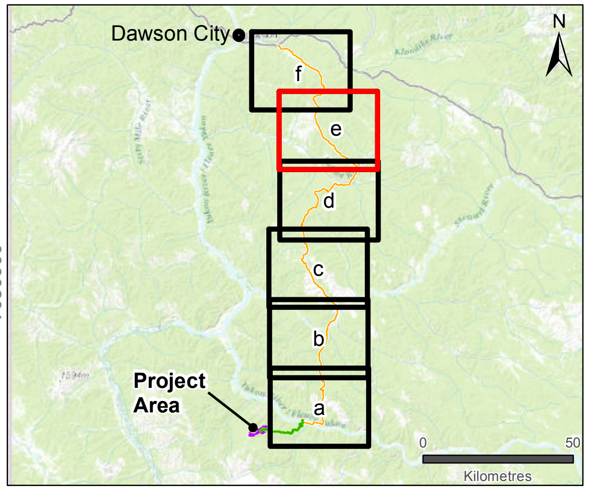


COFFEE GOLD MINE

Terrain Stability Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Pingo (collapsed)
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Disturbed Terrain Stability Class

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Figure 4.2-4e	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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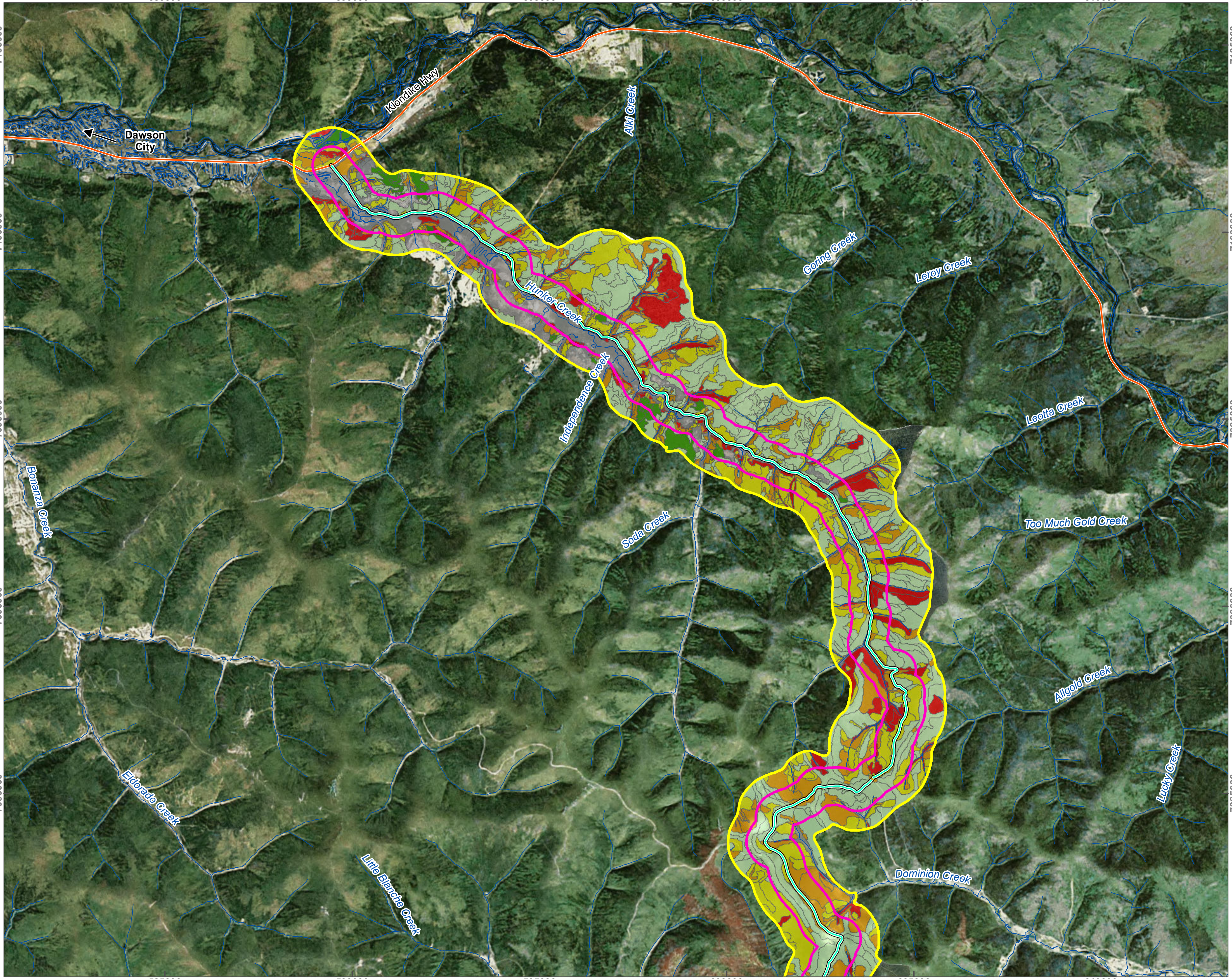
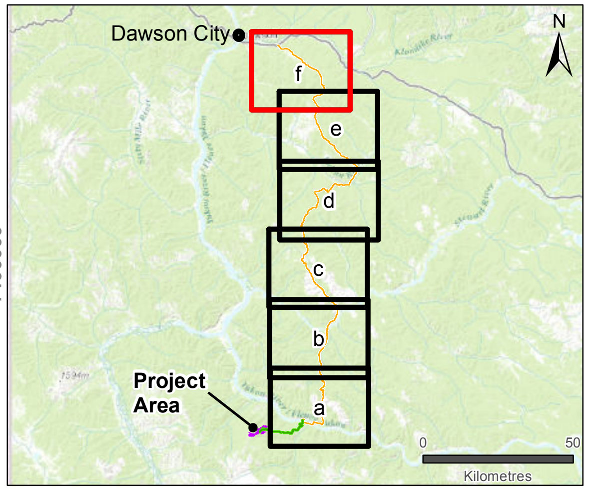


COFFEE GOLD MINE

Terrain Stability Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Disturbed Terrain Stability Class

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- IV - Potentially Unstable
- V - Unstable

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NAD 1983 UTM Zone 7N

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Figure 4.2-4f	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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4.2.1.2 Change in Terrain Stability Due to Permafrost Disturbance

Within the Mine Site area, approximately 757 ha (69%) of the Project footprint is underlain by permafrost, 21% of which is considered to be frozen with visible ice (Fv) (**Table 4.2-3**; **Figure 4.2-5**). Temperatures collected within the Mine Site area using thermistor cables and temperature sensors on vibrating wire piezometers ranged between -0.6°C to -2°C; these temperatures indicate the permafrost is relatively "warm" and therefore particularly sensitive to disturbance (**Appendix 11-A**). Thermokarst is one of the permafrost-related geohazards that could result from disturbance to permafrost with development. Development-induced thermokarst can also be accompanied by thermal erosion, subsidence, and mass wasting as organic and ice-rich, fine-grained soils thaw, which can lead to stability concerns for infrastructure (**Appendix 11-A**). Facilities to be located at least partially within areas classified as being underlain by permafrost with visible ice (Fv) include the Alpha WRSF and organic soil stockpile along with various mine roads. Particular attention will be required during detailed design, construction, and operation of any facilities underlain by permafrost in order to maintain infrastructure stability and functionality.

Table 4.2-3 Extent of Disturbance to Permafrost in the Mine Site Area

Permafrost Type[1]	Baseline		Disturbance Extent			
	LAA (ha)	RAA (ha)	Footprint Area (ha)	Footprint (%)	LAA (%)	RAA (%)
Frozen, no visible ice (Fn)	828	2,153	527	48	64	24
Frozen, visible ice (Fv)	366	1,585	230	21	63	15
Frozen, ice-rich (Fi)	-	25	-	-	-	-
Unfrozen	644	2,925	351	32	55	12
Total	**1,837**	**6,689**	**1,109**	**100**	**60**	**17**

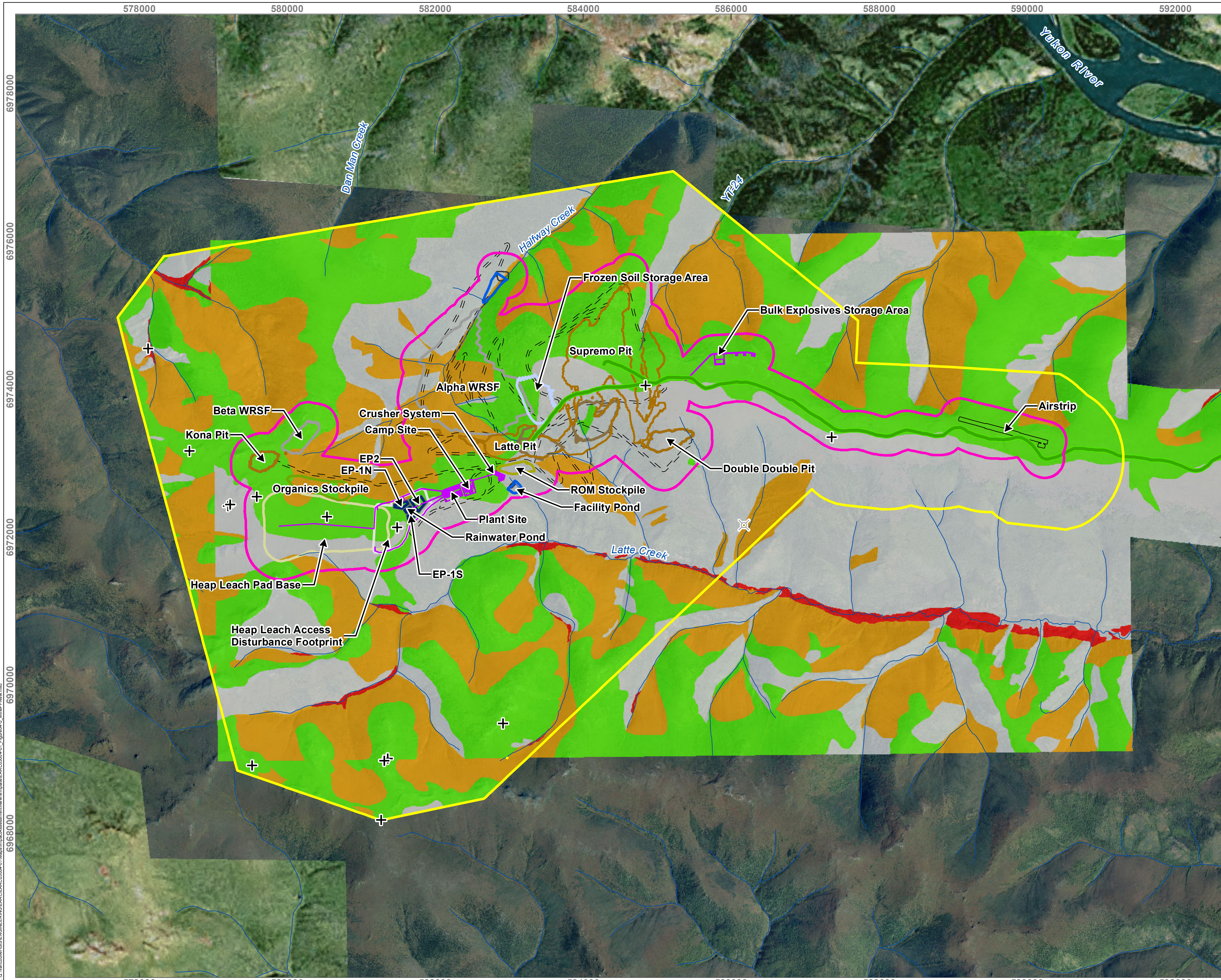
[1]Permafrost types and distributions are compiled from studies conducted by Tetra Tech EBA (2016; **Appendix 11-A**) and PECG (2016; **Appendix 11-A**).

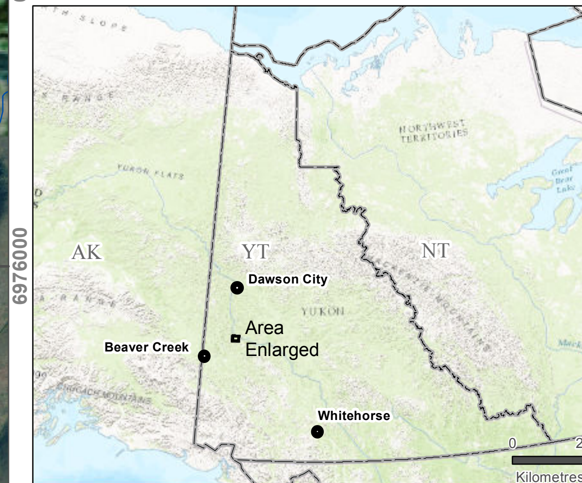
Along the NAR, just over half (52%) of the footprint corridor (which includes areas requiring new construction) will be located in unfrozen ground (**Table 4.2-4**). The remaining 48% of the footprint corridor is underlain by permafrost, 14% and 11% of which are classified as being frozen with visible ice (Fv) and frozen and ice-rich (Fi), respectively (**Table 4.2-4** and **Figure 4.2-6**). Without specific consideration of permafrost conditions, road construction and operation can alter the heat exchange at the ground surface and a change in the existing thermal regime of the ground (**Appendix 11-A**). This may lead to the gradual melting of ground ice beneath the road which can result in differential settlement, displayed as sharp dips in the road surface, progressively widening cracks, and less commonly, sinkholes.

Table 4.2-4 Extent of Disturbance to Permafrost Along the Northern Access Route

Permafrost Type[1]	Baseline		Disturbance Extent			
	LAA (ha)	RAA (ha)	Footprint Area (ha)	Footprint (%)	LAA (%)	RAA (%)
Frozen, no visible ice (Fn)	5,646	15,326	449	23	8	3
Frozen, visible ice (Fv)	3,146	7,495	273	14	9	4
Frozen, ice-rich (Fi)	2,350	4,104	205	11	9	5
Unfrozen	8,630	18,972	986	52	11	5
Total	**19,773**	**45,897**	**1,914**	**100**	**10**	**4**

1 Permafrost types and distributions are compiled from studies conducted by Tetra Tech EBA (2016; Appendix 11-A) and PECG (2016; Appendix 11-A).





COFFEE GOLD MINE

Permafrost Conditions with Inclusion of the Project Footprint within the Mine Site Area

Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Proposed Footprint

- Airstrip
- Total Pit Outline
- Backfill
- Pit Lake
- WRSF
- Organics Stockpile
- ROM Stockpile
- Event Pond Slope
- Event Pond
- Heap Leach Access Disturbance Footprint
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- Haul Road
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Notes

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3. Footprint data from Hemmera (March 17, 2017)
4. Permafrost and associated data from Tetra Tech EBA (April 2016) and

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Page Size: 11" x 17"

Figure 4.2-5	Date: Mar 27, 2017	Drawn by: MEZ	Reviewed: TP

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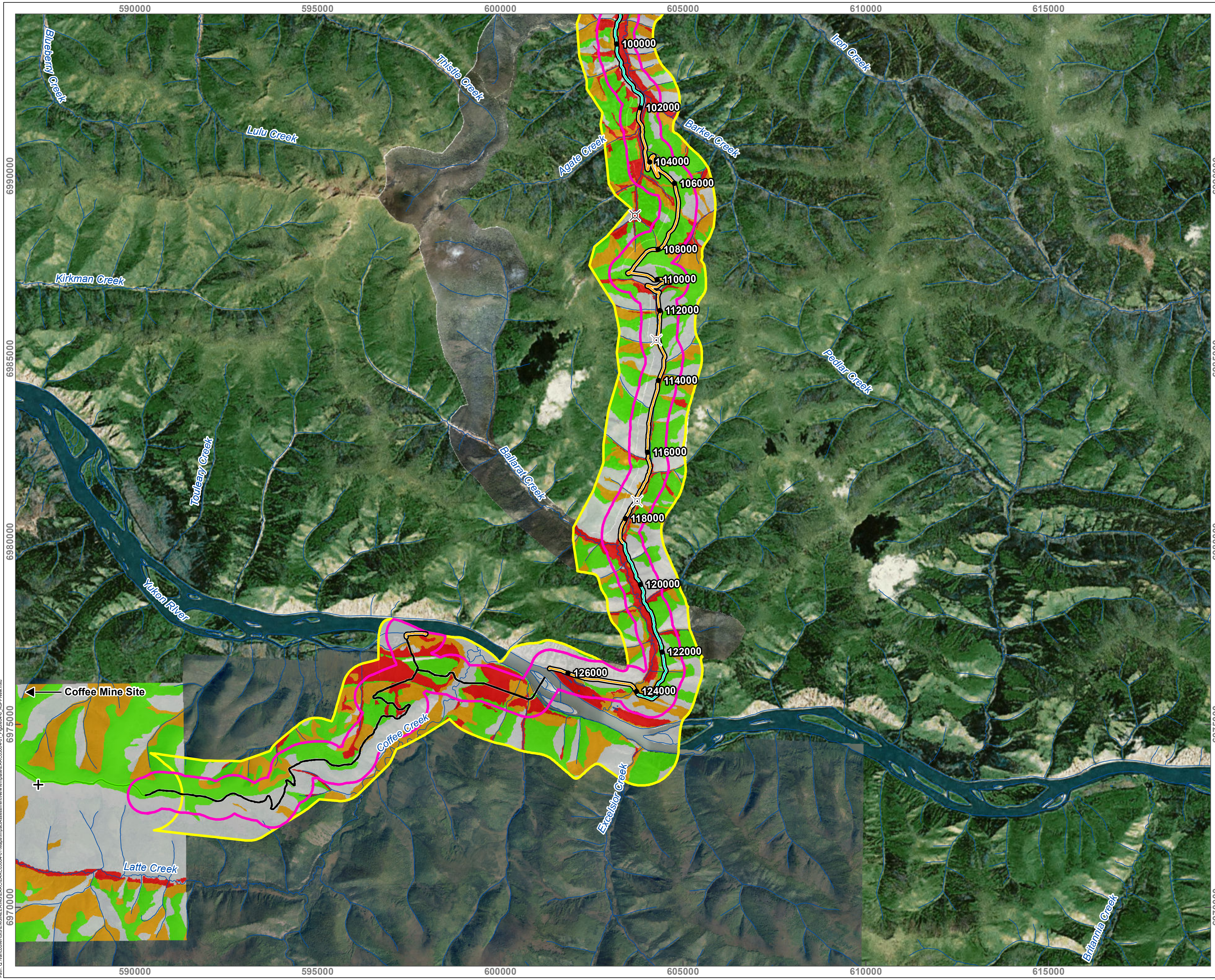
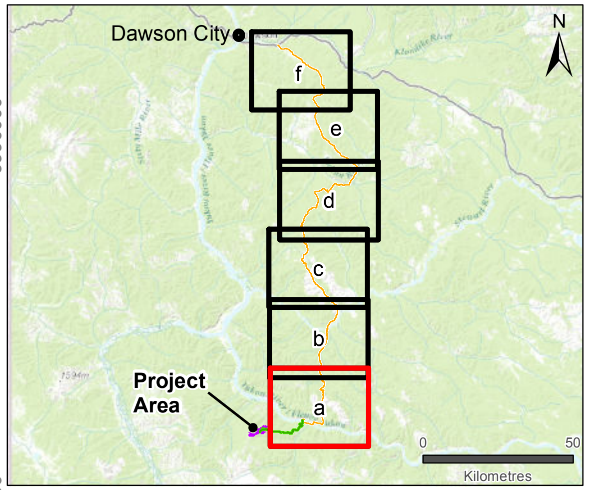
Permafrost Conditions with Inclusion of the Project Footprint along the Northern Access Route





Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Pingo
- Pingo (collapsed)
- Tor
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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Page Size: 11" x 17"

Figure 4.2-6a	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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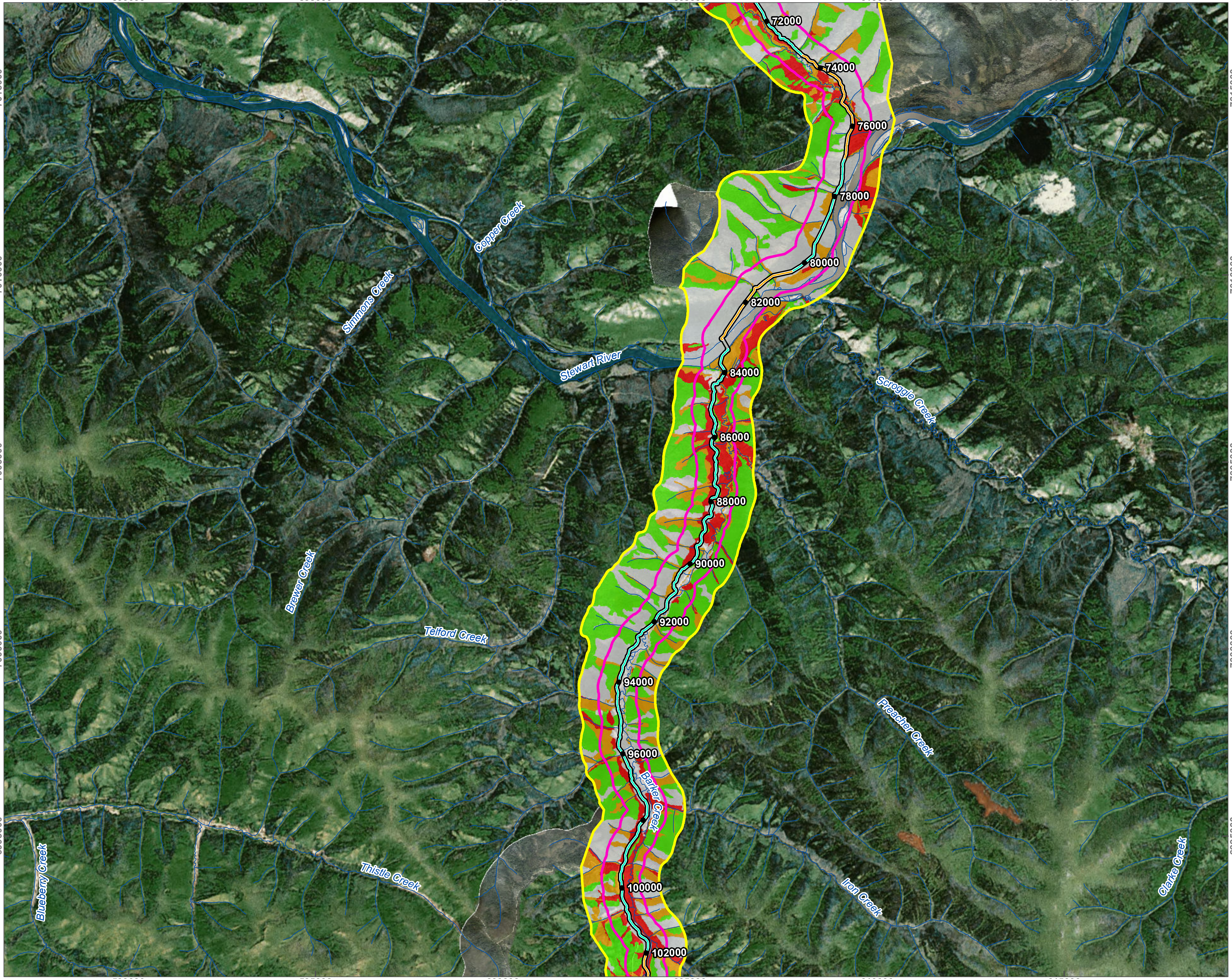
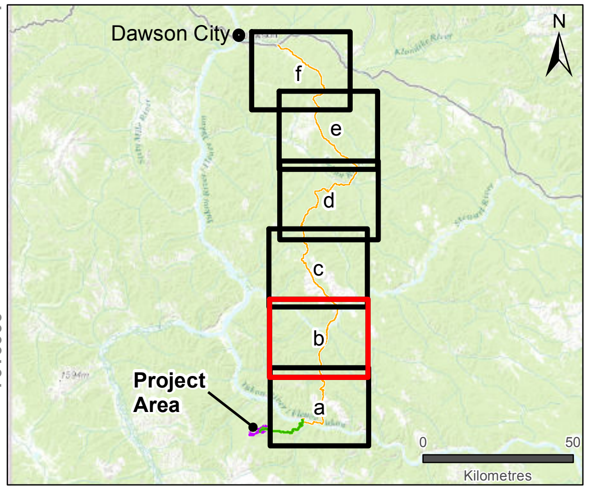
COFFEE GOLD MINE

Permafrost Conditions with Inclusion of the Project Footprint along the Northern Access Route





Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway

Permafrost Classification

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- Frozen, no visible ice (Fn)
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Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 4.2-6b	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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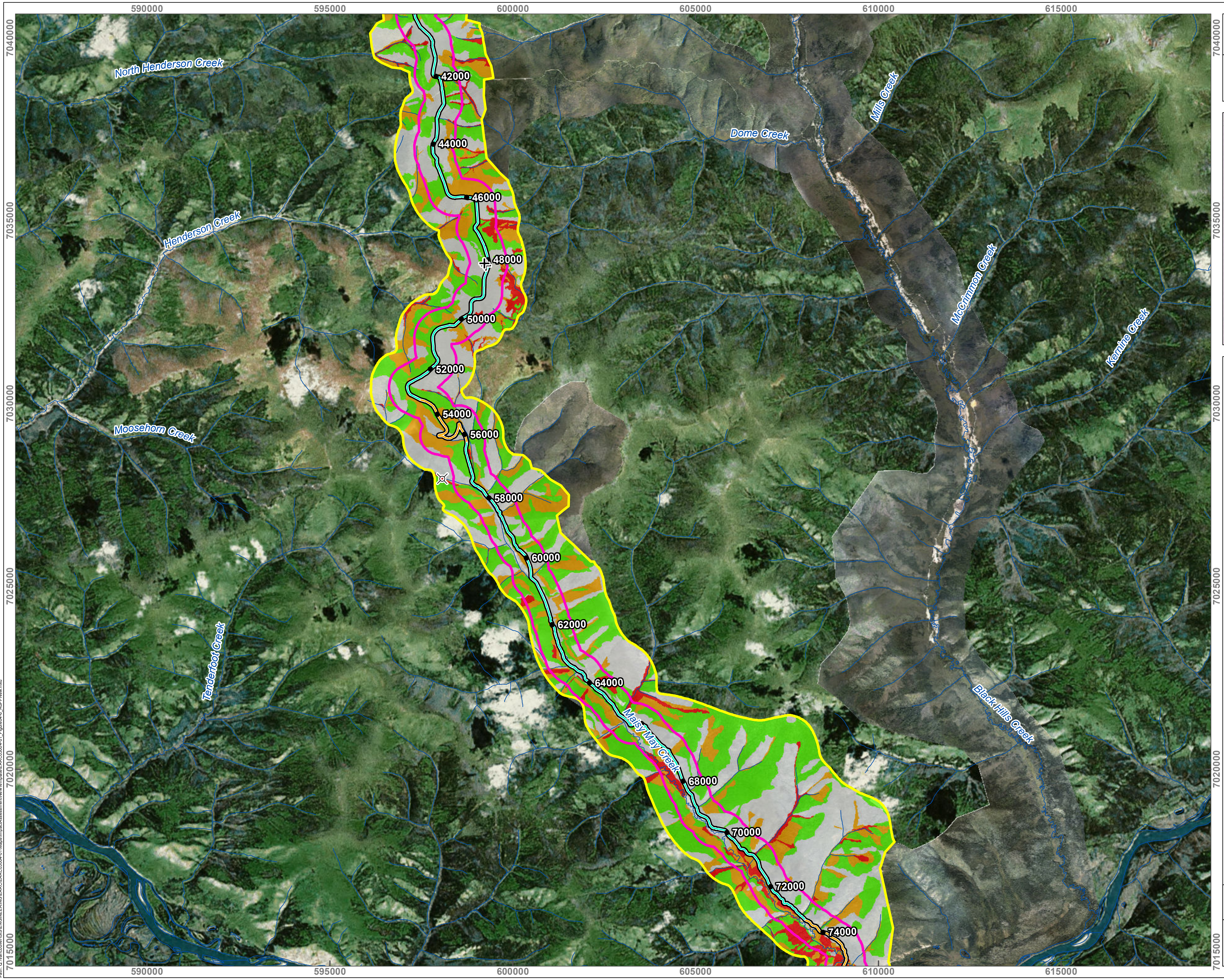
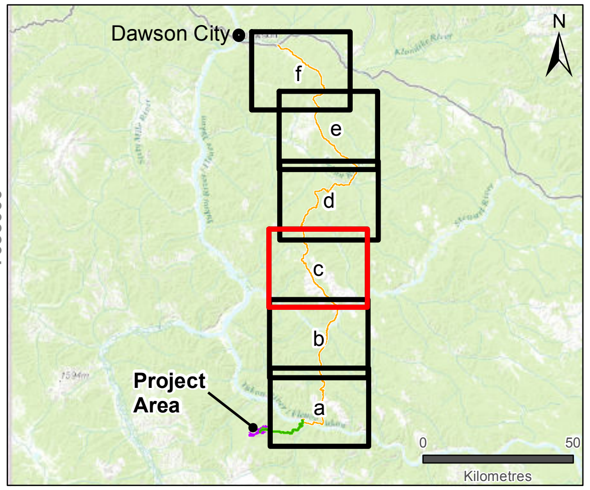


COFFEE GOLD MINE

Permafrost Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
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- Pingo
- Tor
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- Northern Access Route (new section)
- Northern Access Route (upgrade section)
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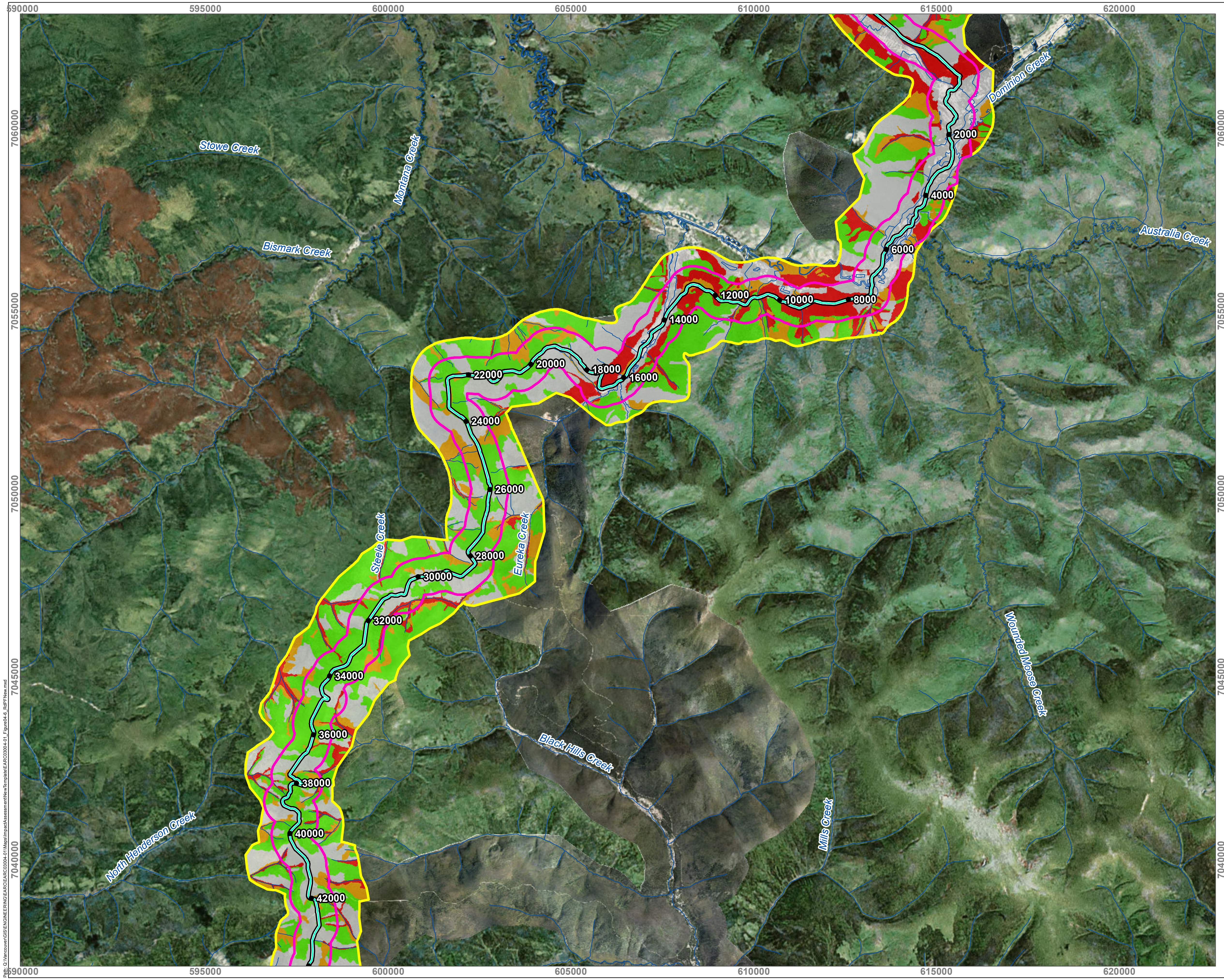
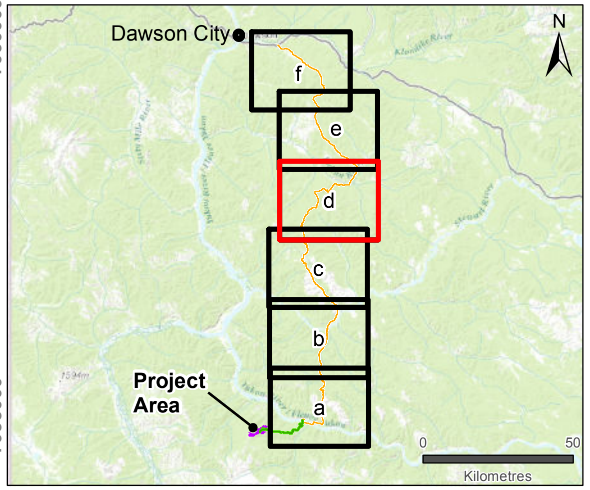
Figure 4.2-6c	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP



COFFEE GOLD MINE

Permafrost Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway

Permafrost Classification

- Unfrozen
- Frozen, no visible ice (Fn)
- Frozen, visible ice (Fv)
- Frozen, ice-rich (Fi)

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3. Permafrost and associated data for the access route provided by Palmer Environmental Consulting Group (March, 2016)

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Kilometres

NAD 1983 UTM Zone 7N

Page Size: 11" x 17"

Figure 4.2-6d	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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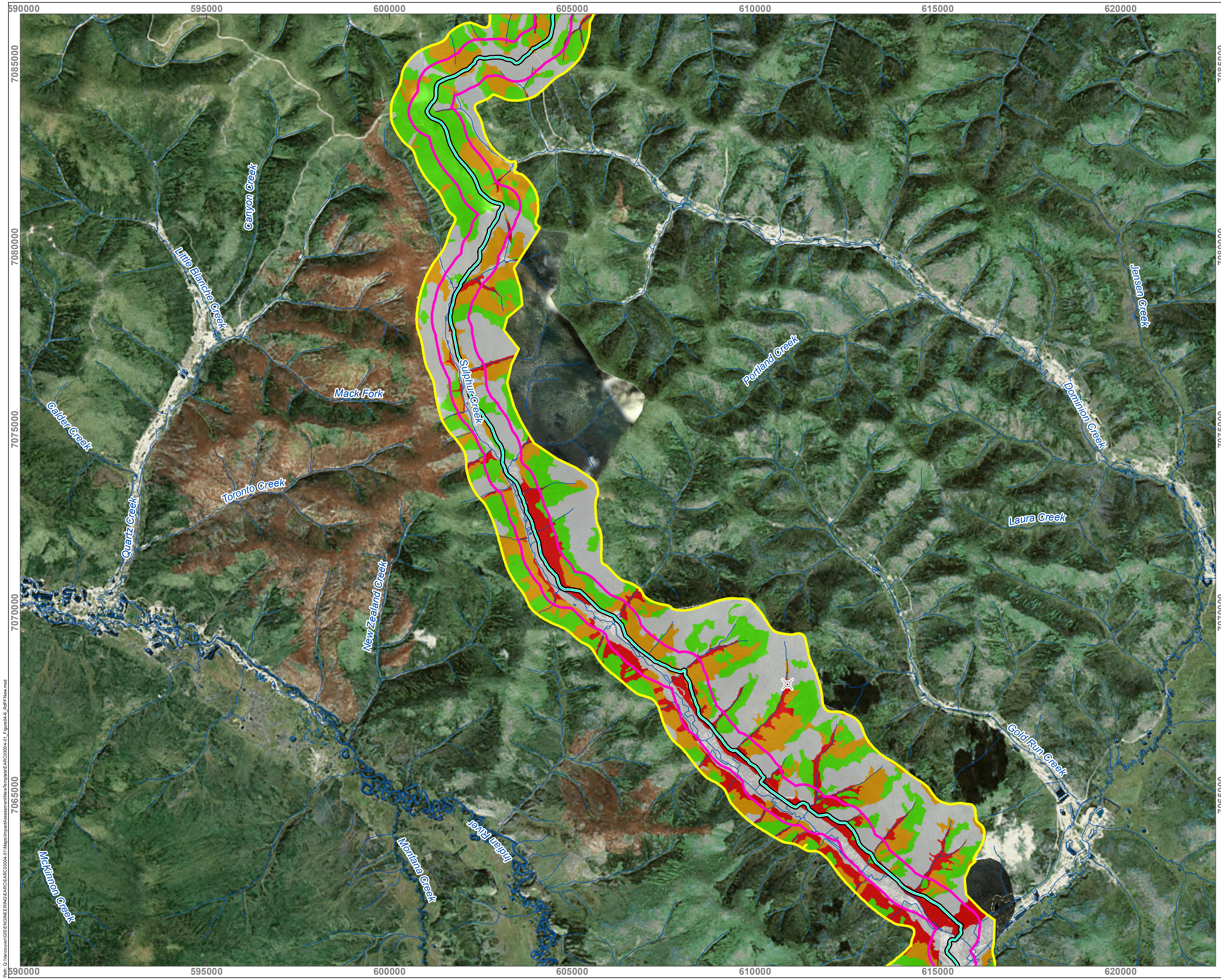
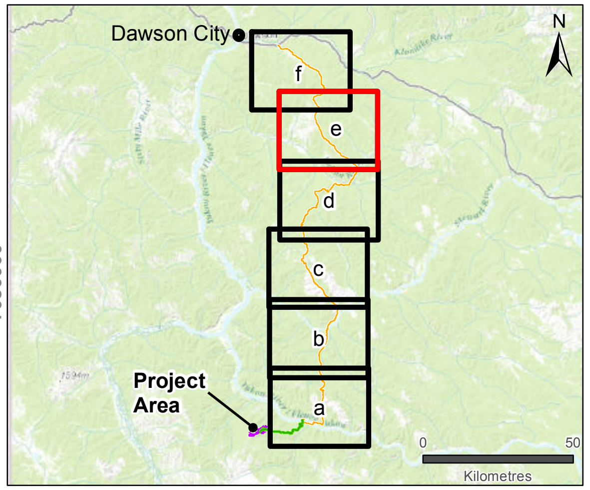
COFFEE GOLD MINE

Permafrost Conditions with Inclusion of the Project Footprint along the Northern Access Route





Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Pingo (collapsed)
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway

Permafrost Classification

- Unfrozen
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Kilometres

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Page Size: 11" x 17"

Figure 4.2-6e	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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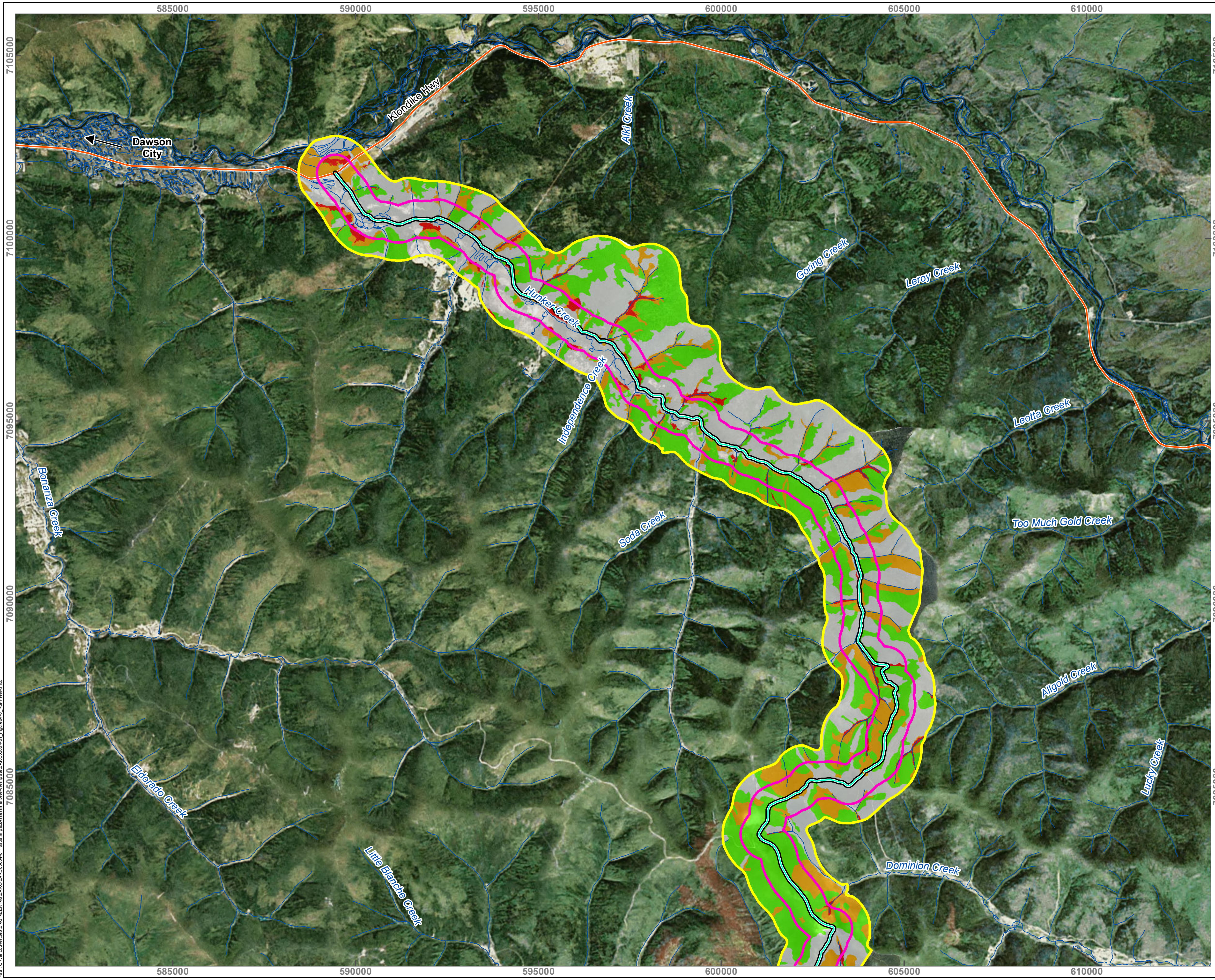
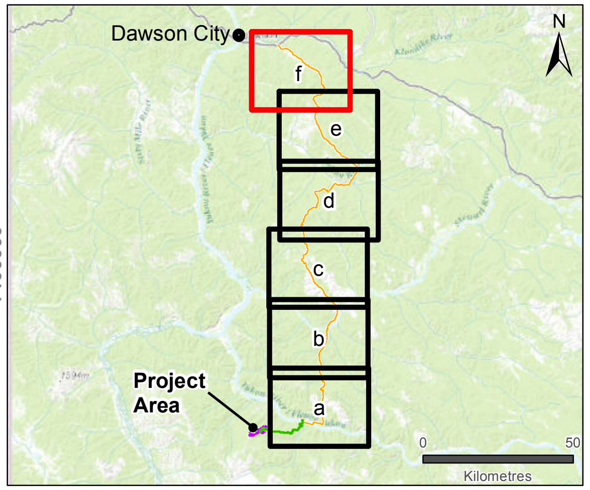


COFFEE GOLD MINE

Permafrost Conditions with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway

Permafrost Classification

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Kilometres

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Figure 4.2-6f	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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4.2.2 Unique Landforms

Of the unique landform features identified, several tors occur within the Project footprint of the Mine Site area (**Figure 4.2-1**). Two tors will likely be removed as part of the construction of the heap leach facility. A third tor, located just beyond the heap leach facility footprint to the northwest may also be disturbed depending on how the heap leach facility is constructed and the requirements for access to the construction site to ensure safety of operators and crews undertaking construction activities.

The pingos identified within the Mine Site area (**Figure 4.2-1**) and in the vicinity of the NAR (**Figure 4.2-2**) are outside the Project footprint and should not be affected by Project activities.

4.2.3 Soil Quality

Potential changes in soil quality were determined by identifying areas where in-situ soils are likely to be disturbed by Project activities and to what possible extent (e.g., through direct activities such as site preparation or more indirectly via activities that generate dust). Soils that will be salvaged and stockpiled for future reclamation purposes are also included in the assessment, as the properties of stockpiled soils can change depending on handling and storage methods.

4.2.3.1 Soil Disturbance

The construction of Project infrastructure will disturb soils largely through land clearing and site preparation activities. Within the Mine Site area, the Project footprint will disturb approximately 60% of the LAA and 17% of the RAA (**Table 4.2-5, Figure 4.2-7**). Of the soils that fall within the Project footprint specifically, 98% have colluvium as the parent material and 67% of these are Cryosols (**Table 4.2-5**).

Soil disturbance may also occur in the form of erosion, particularly if in-situ soils remain exposed for longer periods of time following vegetation removal and are subject to high winds (e.g., on ridgetops) or heavier rainfall or snow melt events. Erosion can result in the loss of soil material and can potentially affect the receiving environment (aquatic and terrestrial) if material is deposited into local streams and rivers or on downslope vegetation.

Table 4.2-5 Extent of Disturbance to Soil Types within the Mine Site Area

Parent Material	Soil Map Unit	Baseline			Disturbance Extent		
		LAA (ha)	RAA (ha)	Footprint Area (ha)	Footprint (%)	LAA (%)	RAA (%)
Colluvium	C1*	614	2,067	334	30	54	16
	C2*	6	119	3	<1	54	3
	C3	646	1,865	437	39	68	23
	C4	183	623	116	10	64	19
	C5	37	405	18	2	48	4
	C6	290	1,293	174	16	60	13
Weathered Bedrock	D1*	1	23	<1	-	1	<1
	D3	54	168	21	2	40	13
	D4	-	4	-	-	-	-
	D5	-	19	-	-	-	-
Fluvial	F1*	-	1	-	-	-	-
	F2*	-	6	-	-	-	-
	F4	-	2	-	-	-	-
	F5	-	1	-	-	-	-
	F6	8	86	5	<1	73	6
Bedrock	R3	-	7	-	-	-	-
Total		**1,837**	**6,689**	**1,109**	**100**	**60**	**17**

Note: * denotes unfrozen soil types

Approximately 46% of the soils within the Project footprint overall are considered suitable for reclamation (**Table 4.2-6**, **Figure 4.2-8**) and should be targeted for salvage during Construction. Certain soil map units (e.g., C3, C4, and D3), all of which are Cryosols, are considered particularly suitable for use in reclamation due to their gentle slopes and generally lower ice content.

Table 4.2-6 Soil Reclamation Suitability within the Mine Site Area Project Footprint

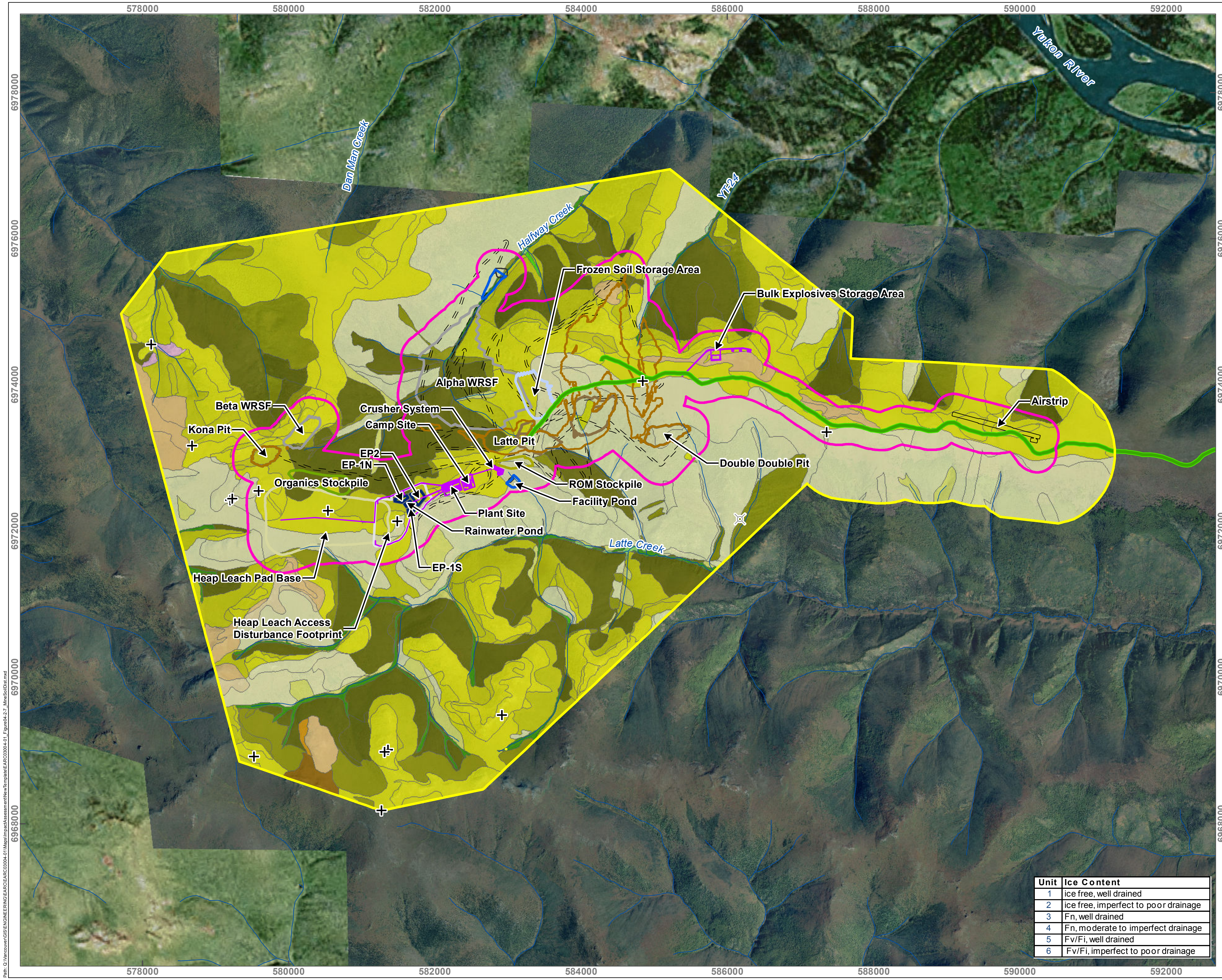
Parent Material	Soil Map Unit	Project Footprint Total (ha)	Suitable (ha)	Suitable % of Project Footprint	Unsuitable (ha)	Unsuitable % of Project Footprint
Colluvium	C1*	334	157	14	177	16
	C2*	3	-	-	3	<1
	C3	437	262	24	175	16
	C4	116	82	7	34	3
	C5	18	-	-	18	2
	C6	174	-	-	174	16
Weathered Bedrock	D1*	<1	-	-	<1	<1
	D3	21	12	1	9	1
Fluvial	F6	5	-	-	5	<1
Total		**1,109**	**514**	**46**	**595**	**54**

Note: * denotes unfrozen soil types

The majority (57%) of the NAR footprint will be located in colluvium, which is the dominant soil parent material present within both the LAA and RAA (**Table 4.2-7**, **Figure 4.2-9**). Anthropogenic materials comprise another 25% of the footprint area. Colluvium and fluvial materials are characteristic of the portions of the NAR requiring new construction.

Table 4.2-7 Extent of Disturbance to Soil Parent Materials along the Northern Access Route

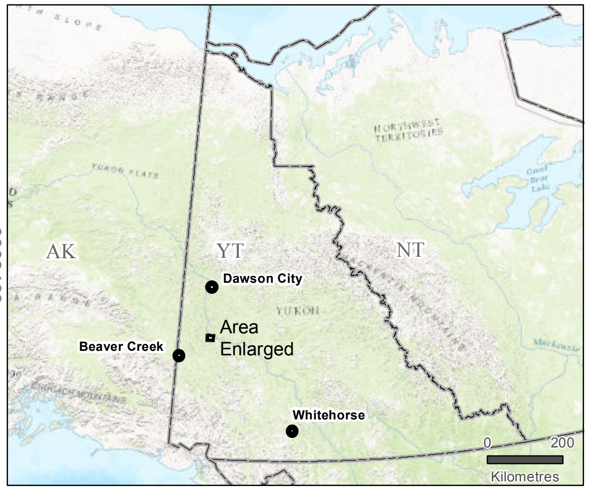
Soil Parent Material	Baseline			Disturbance Extent		
	LAA (ha)	RAA (ha)	Footprint Area (ha)	Footprint (%)	LAA (%)	RAA (%)
Colluvium	13,288	33,895	1,085	57	8	3
Anthropogenic	2,823	3,765	478	25	17	13
Fluvial	1,537	3,021	117	6	8	4
Weathered Bedrock	1,508	4,258	195	10	13	5
Organic	368	588	26	1	7	4
Bedrock	150	255	9	<1	6	4
Glaciofluvial	100	115	4	<1	4	3
Total	**19,773**	**45,897**	**1,914**	**100**	**10**	**4**



Unit	Ice Content
1	ice free, well drained
2	ice free, imperfect to poor drainage
3	Fn, well drained
4	Fn, moderate to imperfect drainage
5	Fv/Fi, well drained
6	Fv/Fi, imperfect to poor drainage

COFFEE GOLD MINE

Potential Soil Disturbance within the Project Footprint of the Mine Site Area



Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Dominant Soil Parent Material (Permafrost Category)

Colluvial
- C1
- C2
- C3 (Fn)
- C4 (Fn)
- C5 (Fv/Fi)
- C6 (Fv/Fi)

Fluvial
- F1
- F2
- F4 (Fn)
- F5 (Fv/Fi)
- F6 (Fv/Fi)

Bedrock
- R3 (Fn)

Weathered Bedrock
- D1
- D3 (Fn)
- D4 (Fv/Fi)
- D5 (Fv/Fi)

Proposed Footprint
- Airstrip
- Total Pit Outline
- Backfill
- Pit Lake
- WRSF
- Organics Stockpile
- ROM Stockpile
- Event Pond Slope
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure
- Haul Road
- Settling Pond
- Settling Pond Dam

Permafrost Category
Fn = Ice-poor
Fi = Ice-rich
Fv = Very Ice-rich

Notes

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2. Imagery from Kaminak. Additional imagery from ESRI; Earthstar Geographics (1999)
3. Footprint data from Hemmera (March 17, 2017)
4. Permafrost and associated data from Tetra Tech EBA (April 2016) and

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Figure 4.2-7	Date: Mar 28, 2017	Drawn by: MEZ	Reviewed: TP

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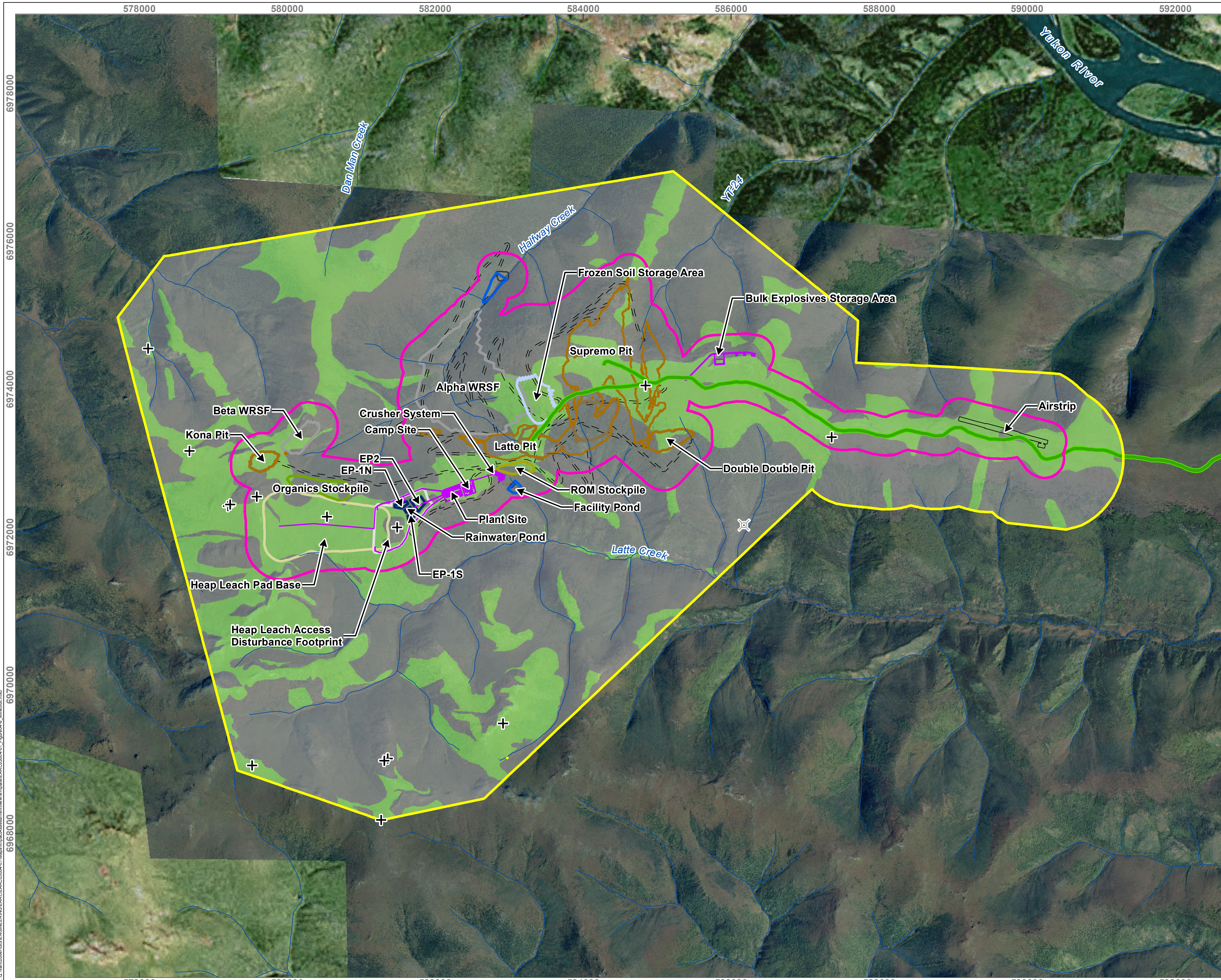

COFFEE GOLD MINE

Soil Reclamation Suitability Potential within the Project Footprint of the Mine Site Area

Legend

- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Pingo (collapsed)
- Tor
- Watercourse

Reclamation Suitability

- Suitable
- Unsuitable

Proposed Footprint

- Airstrip
- Total Pit Outline
- Backfill
- Pit Lake
- WRSF
- Organics Stockpile
- ROM Stockpile
- Event Pond Slope
- Event Pond
- Heap Leach Access Disturbance Footprint
- Heap Leach Pad Base
- Support Infrastructure
- Haul Road
- Settling Pond
- Settling Pond Dam

Notes

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4. Soils data from Tetra Tech EBA (May 2016)

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Figure 4.2-8	Date: Mar 27, 2017	Drawn by: MEZ	Reviewed: TP

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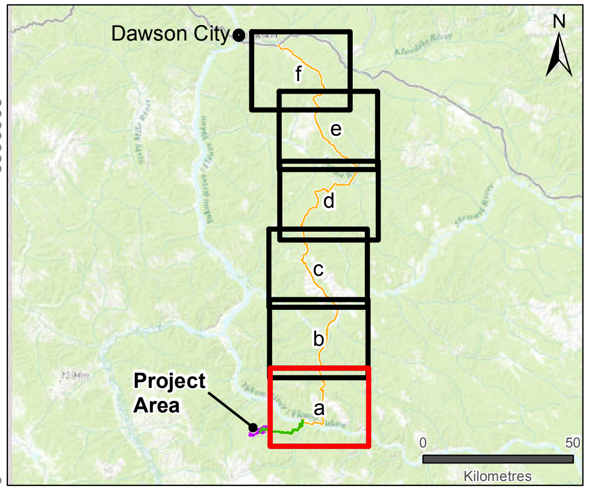
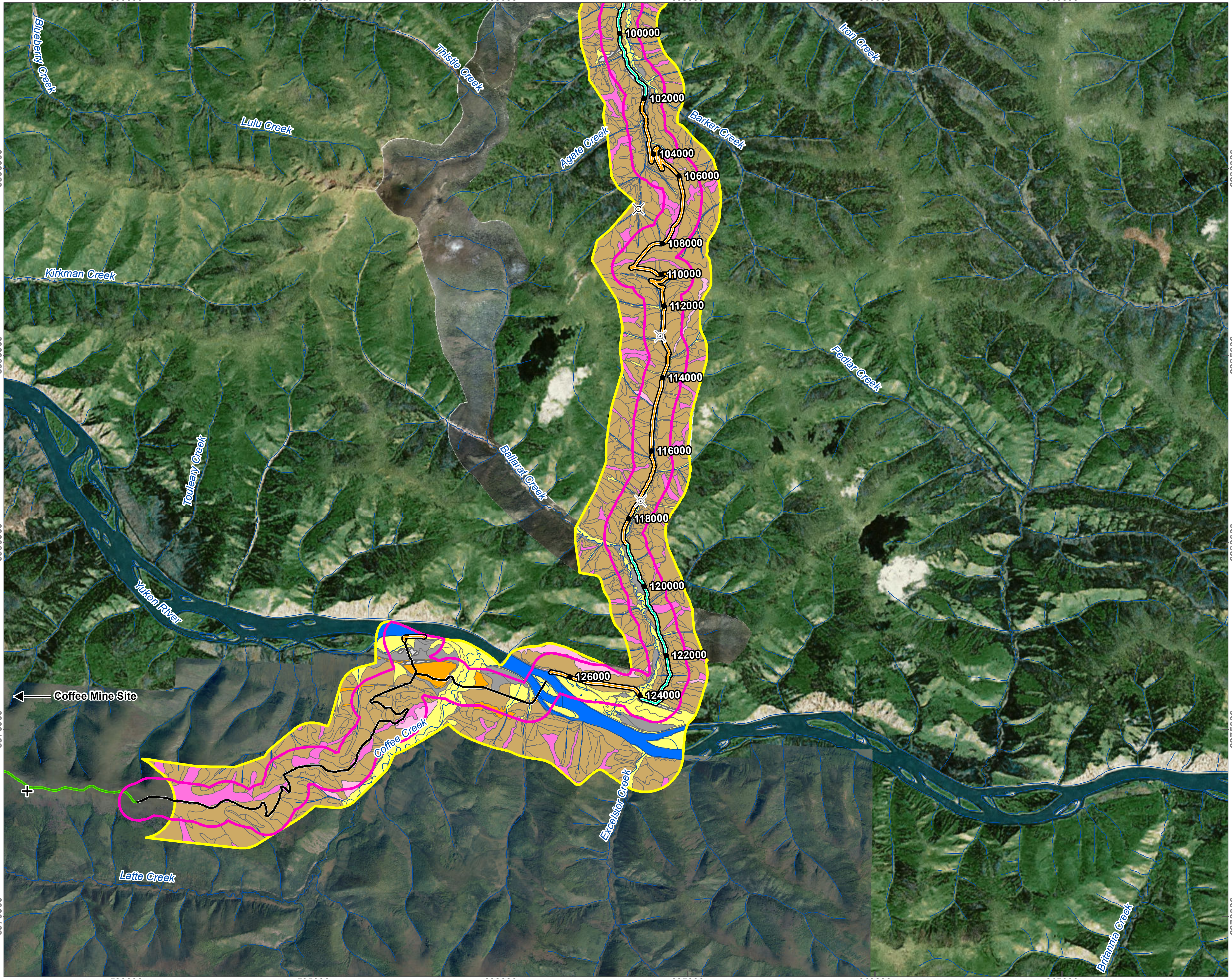
COFFEE GOLD MINE

Potential Disturbance to Soil Parent Materials with Inclusion of the Project Footprint along the Northern Access Route





Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Pingo
- Pingo (collapsed)
- Tor
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Dominant Soil Parent Material

- Colluvium
- Fluvial
- Glaciofluvial
- Bedrock
- Weathered Bedrock
- Organic
- Anthropogenic
- Water

Notes

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Figure 4.2-9a	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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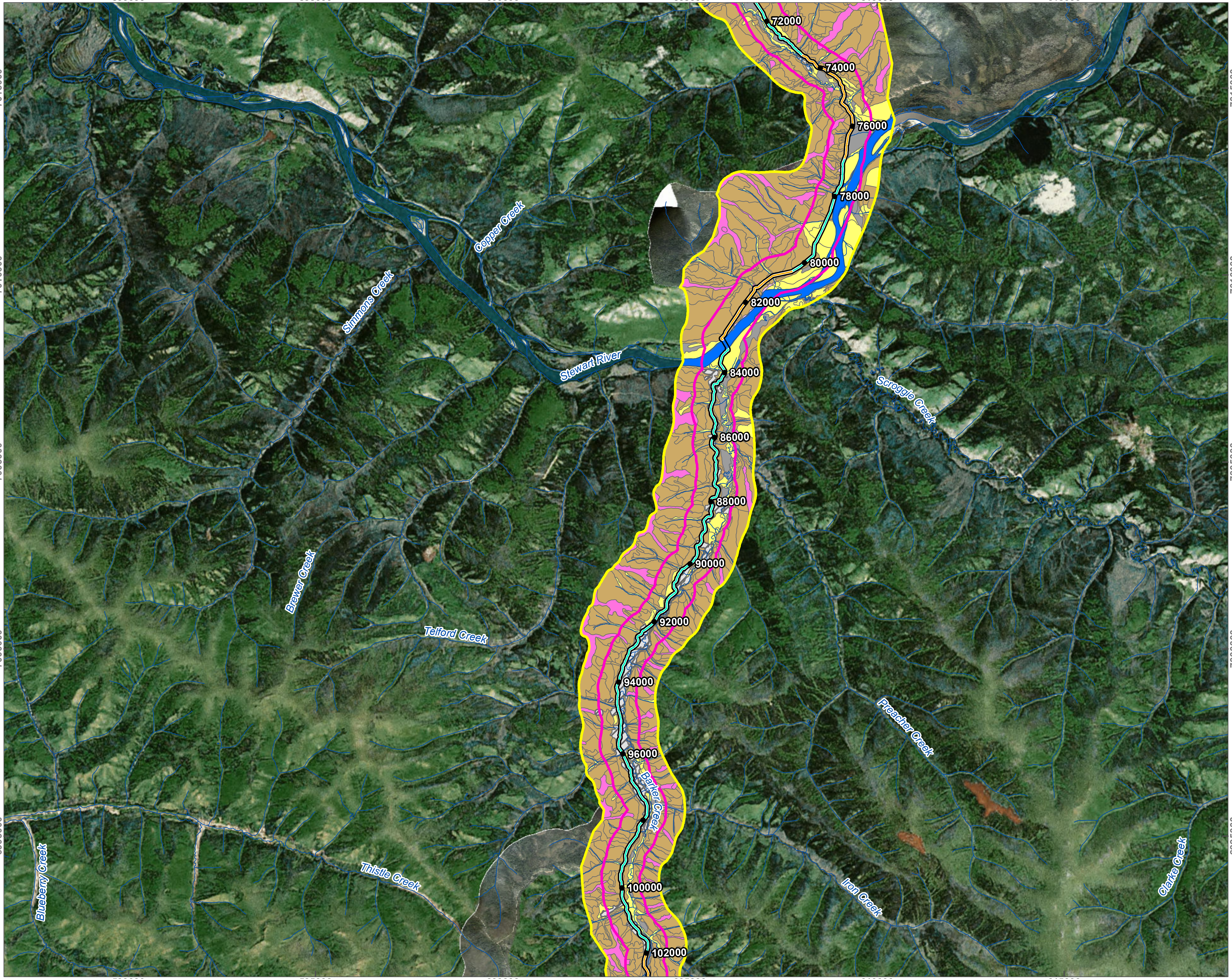
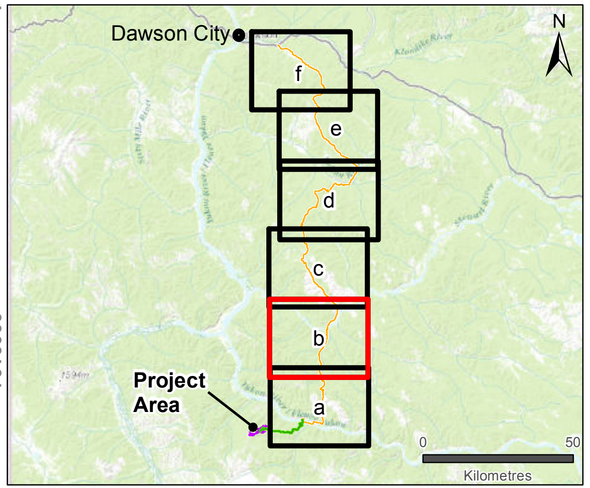


COFFEE GOLD MINE

Potential Disturbance to Soil Parent Materials with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Dominant Soil Parent Material

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Kilometres

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Figure 4.2-9b	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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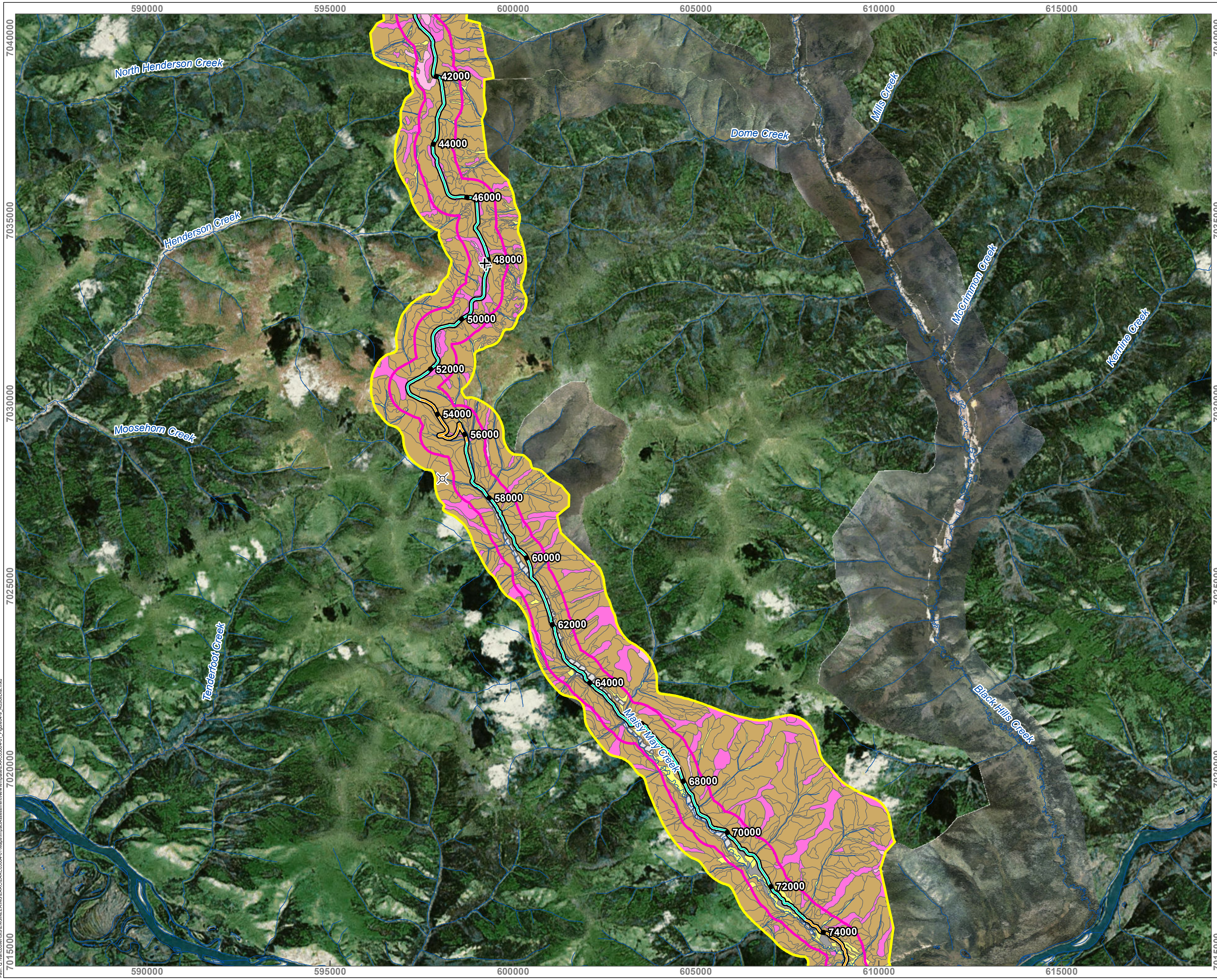
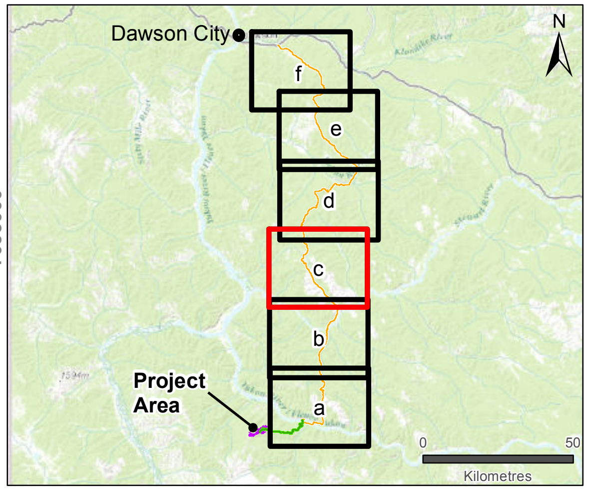
COFFEE GOLD MINE

Potential Disturbance to Soil Parent Materials with Inclusion of the Project Footprint along the Northern Access Route





Legend

- Northern Access Route Footprint
- Local Assessment Area
- Regional Assessment Area
- Pingo
- Tor
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Watercourse

Dominant Soil Parent Material

- Colluvium
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Figure 4.2-9c	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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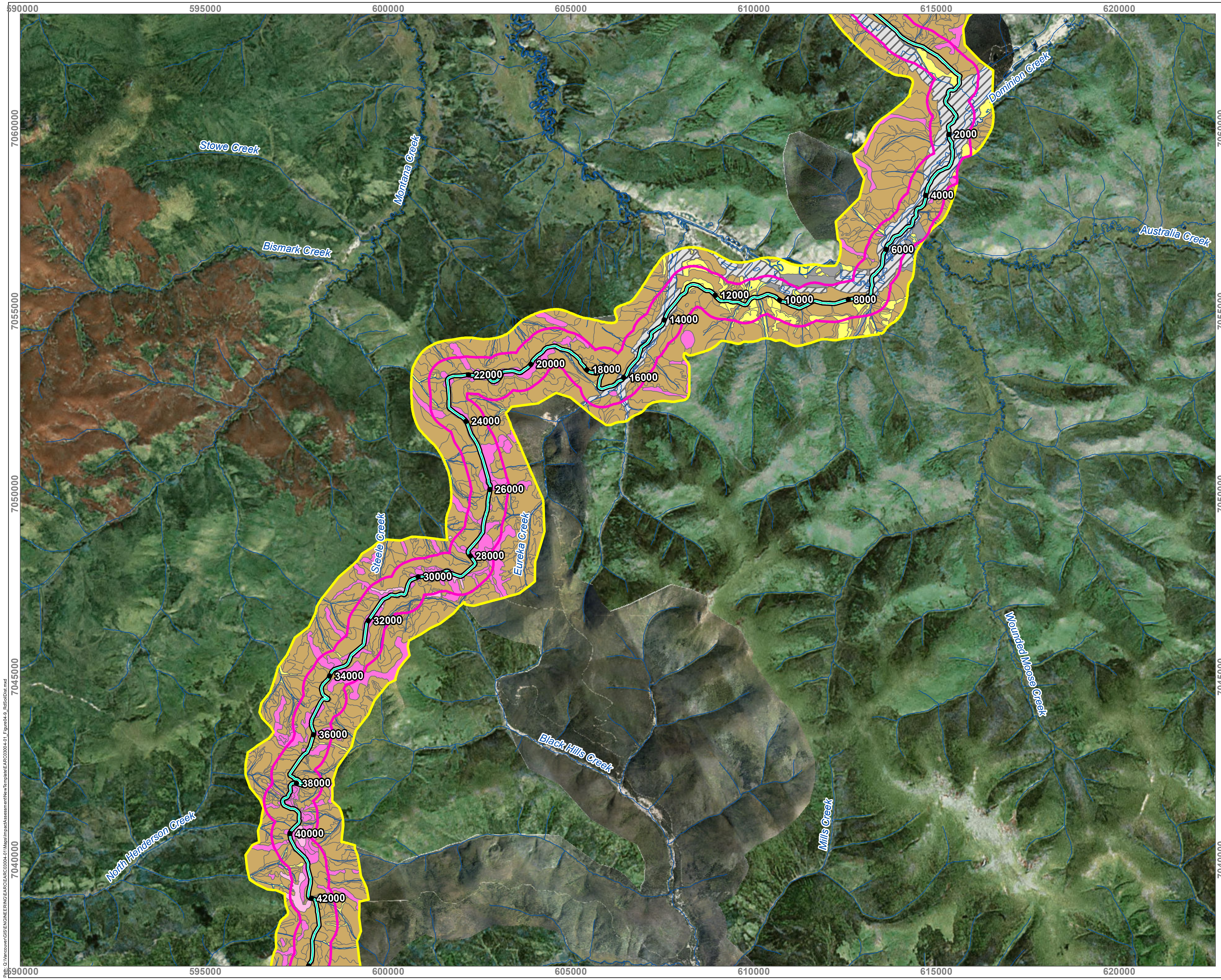
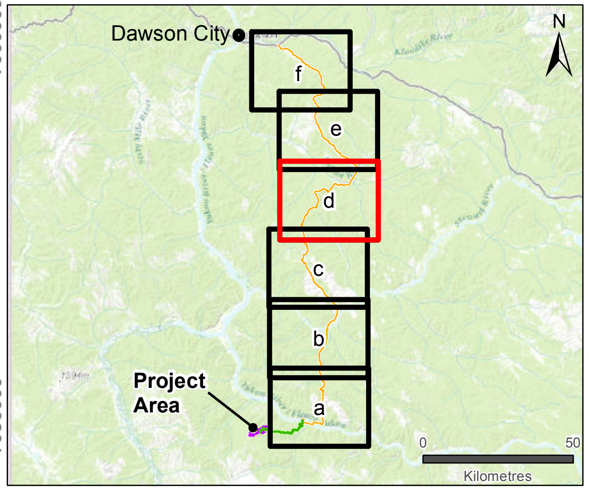


COFFEE GOLD MINE

Potential Disturbance to Soil Parent Materials with Inclusion of the Project Footprint along the Northern Access Route



Legend

- Northern Access Route Footprint
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- Regional Assessment Area
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Dominant Soil Parent Material

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Figure 4.2-9d	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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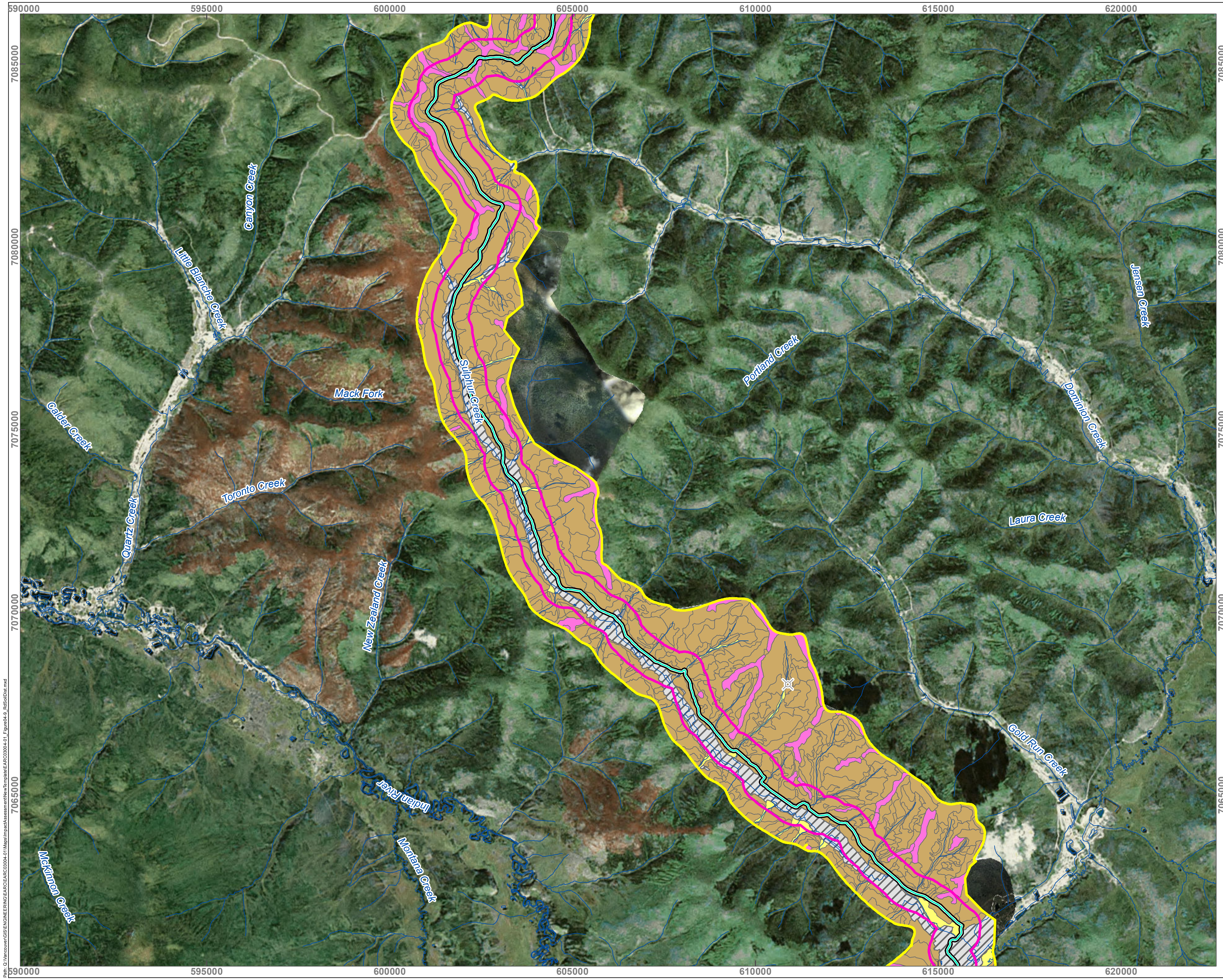
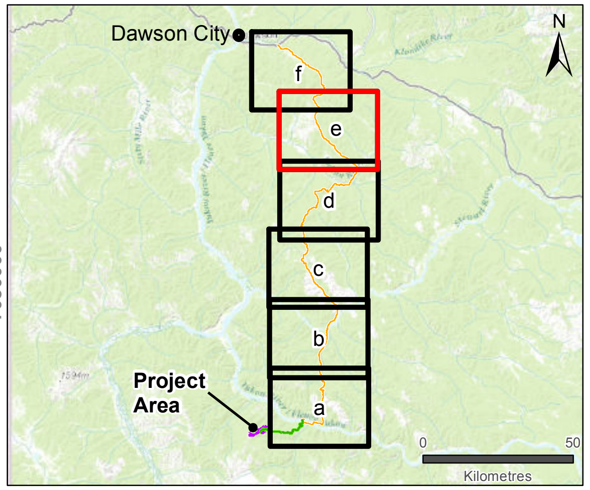


COFFEE GOLD MINE

Potential Disturbance to Soil Parent Materials with Inclusion of the Project Footprint along the Northern Access Route



Legend

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Figure 4.2-9e	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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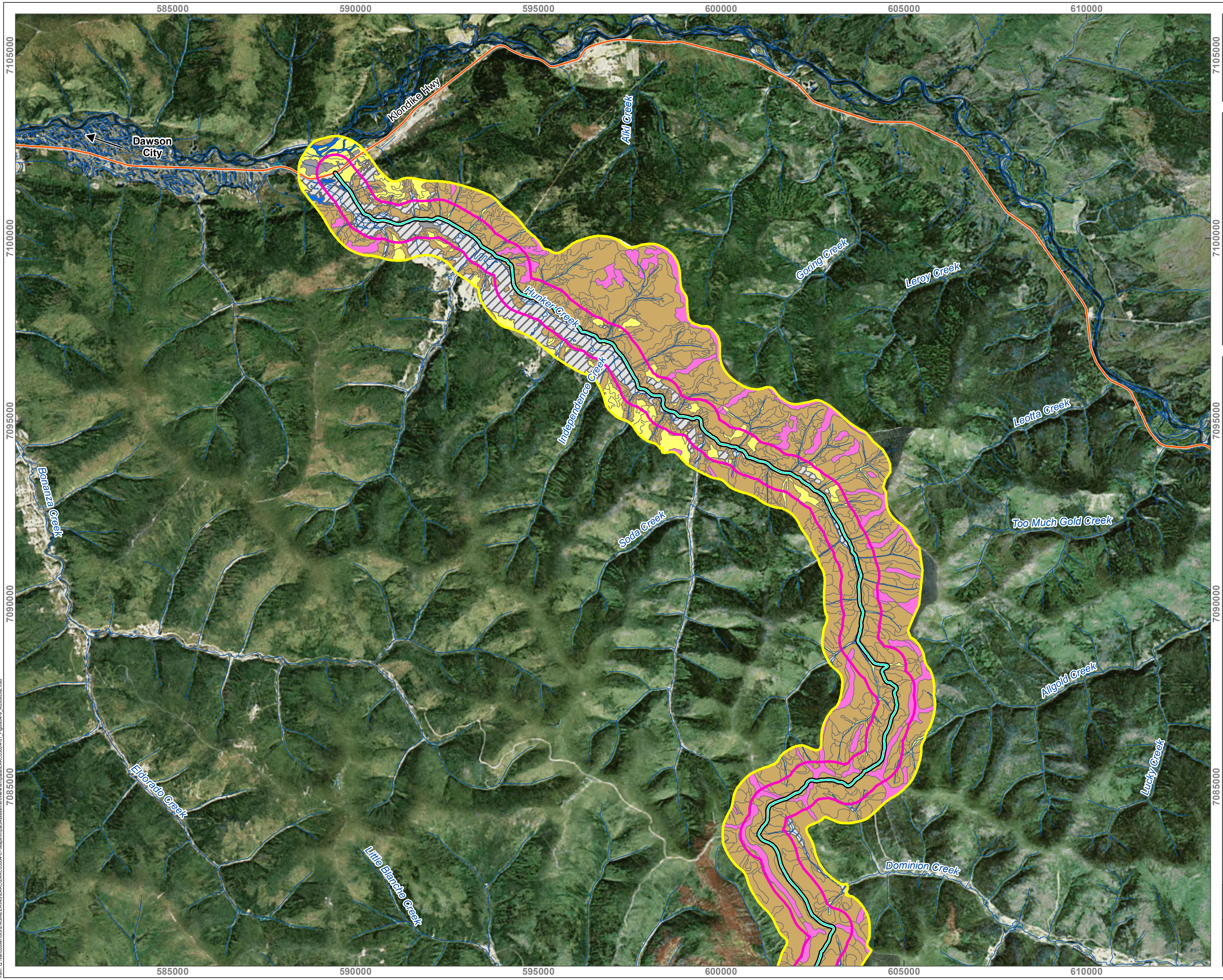
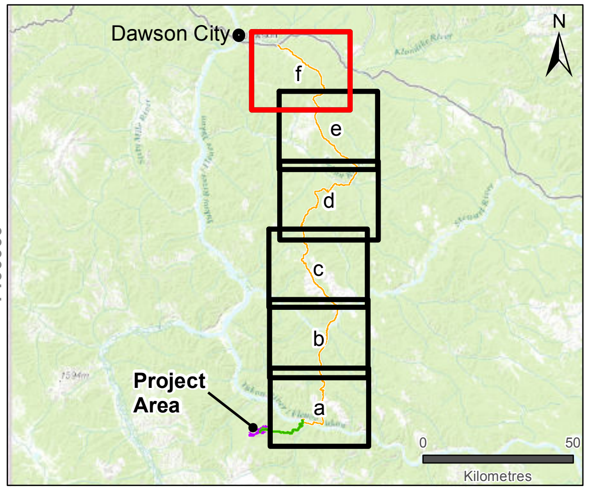
COFFEE GOLD MINE

Potential Disturbance to Soil Parent Materials with Inclusion of the Project Footprint along the Northern Access Route





Legend

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Figure 4.2-9f	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

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4.2.3.2 Soil Degradation

Soils left in-situ (i.e., not salvaged for reclamation purposes or stripped as part of construction site preparation) may be subject to degradation as a result of localized contamination from accidental spills of materials such as fuels or lubricants, localized compaction resulting from heavy equipment use or repeated traffic, or from dust deposition primarily from traffic on adjacent roadways. Effects are anticipated to be largely confined to the Project footprint.

Soil contamination resulting from spills of fuels or lubricants can compromise soil quality, particularly in areas that would require revegetation, due primarily to the presence of contaminants such as hydrocarbons. Compaction can adversely affect water infiltration and can alter the physical structure of soils by reducing pore spaces. Dust deposition has the potential to alter the chemical properties of soils, however, physical changes are generally not expected to occur.

4.2.3.3 Soil Salvage and Handling

Soil quality can be reduced if the recommended measures for salvage and handling are not followed. During Construction, admixing (where salvaged soil is inadvertently mixed with subsoil, spoil, or waste material) can occur which can reduce soil quality by altering the texture, structure, and/or organic matter content (Powter 2002). Soil loss can also occur during Construction by various means such as inaccurate stripping, lax transfer and/or handling, or burial. Soils that will be stockpiled for later use in reclamation activities may be subject to erosion by water or wind if they are not quickly or adequately covered, may be subject to localized contamination primarily from dust deposition, and may undergo changes in soil fertility if stockpiled over the long-term (e.g., for the life of the Project).

Along the NAR, soils that will be stripped in preparation for road construction or upgrading may be stockpiled in windrows close to the excavation site. If not used immediately after road construction, stockpiled material will be stored for later use as part of the reclamation activities planned for the road.

4.3 MITIGATION MEASURES

Measures to avoid, eliminate, reduce, or control adverse environmental effects to Surficial Geology, Terrain, and Soils are presented below. These include measures that have been integrated into the Project design as well as those that target specific potential effects. The mitigation measures presented for terrain stability, including those related to permafrost disturbance, are primarily engineered solutions.

4.3.1 PROJECT DESIGN

Elements that have already been incorporated into Project design that will help reduce the potential effects to Surficial Geology, Terrain, and Soils include the phased development of the mine, which will reduce pre-stripping requirements in the early years of the Project. This minimizes the extent of soil disturbance and simplifies soil erosion control measures. Progressive reclamation will also be initiated after Year 2 which with further stabilize disturbed areas. All non-Kona external pit waste has been concentrated to the Alpha WRSF to minimize the total area of disturbance. Additionally, the design of the Alpha WRSF has been engineered to abut the opposite valley wall in order to improve stability. With respect to the NAR, the Proponent has tried to use the existing road network as much as practical, such that only 37 km of the 214 km route requires new construction.

Project design has also included, where feasible, avoiding the placement of infrastructure in areas prone to mass movement, slope erosion, or fluvial processes as well as areas underlain by permafrost (**Appendix 11-A**). With the Project being located within the zone of extensive discontinuous permafrost, avoiding permafrost altogether is unrealistic, however, site selection and engineering practices (as described in more detail below) continue to be incorporated into Project design in order to mitigate potential effects that may result from permafrost disturbance.

With respect to mitigating terrain hazards in permafrost areas, the following measures have been incorporated into Project design:

- Sediment ponds located in ice-rich permafrost will have frozen material excavated down to bedrock below the bases of the structures.
- To avoid permafrost-related stability and erosion issues in surface water diversions, berms will be used rather than ditches wherever practical. The alternative would be to over-excavate frozen material and replace it with thaw-stable granular material in the ditch bottoms and alongside slopes.
- All permafrost material will be removed from below the heap leach facility.

4.3.2 TERRAIN HAZARD AVOIDANCE

As Project design progresses, efforts will continue to be made to avoid crossing or exposing infrastructure to upslope or downslope areas classified as having an existing terrain stability class of V (unstable) due to past or possible future slope failure. Site preparation may also help avoid hazards by eliminating or altering the conditions responsible for the hazard (e.g., excavating ice-rich surficial material prior to construction).

4.3.3 TERRAIN HAZARD MITIGATION

In the event that hazard avoidance is not possible, site-specific hazard mitigation measures will be developed and applied as appropriate. General strategies to mitigate the primary hazards identified within the Mine Site area and along the NAR are presented below; further details are provided in **Appendix 11-A**.

4.3.3.1 Slope Failure

Mitigation measures for potential slope failures primarily involve the management of surface runoff as well as surface and groundwater drainage patterns to avoid pooling and oversaturation of surficial materials. These measures are of particular importance in areas underlain by permafrost. Additionally, modifying the slope geometry to reduce geohazard initiation potential and introducing active or passive external forces to increase shear strength are further design and maintenance options that help minimize the potential for slope failure.

4.3.3.2 Icing

Certain streams and seepage areas along the NAR are prone to icing (which can result in springtime flooding and increase road maintenance requirements) and require particular attention during the design of crossing structures. Mitigation measures include locally enlarged entrances to culverts and local drainage diversions as a means of accommodating potential ice accumulation and springtime flooding.

4.3.3.3 Permafrost Considerations

The primary mitigation measure for construction in permafrost areas is avoidance of thaw-sensitive perennially frozen ice-rich soils. Where avoidance is not feasible, the mitigation measures below are proposed for mine infrastructure and roads.

Within the Mine Site area, the following permafrost mitigation measures will be applied:

- The vegetative mat will be left in place within the WRSF footprint to preserve permafrost conditions, except where foundation soils will require removal to bedrock, near the toes.
- In areas where thaw-unstable permafrost is identified and no suitable alternate location for infrastructure is available, engineering design will either seek to protect permafrost from degradation through insulation (seasonal placement of rock in lifts with a thickness of material with a thermal insulation capacity greater than that of the active layer) or through the design of infrastructure foundations that thermally protect the underlying permafrost or are founded on underlying bedrock. Alternatively, removal of the thaw-unstable material prior to infrastructure development will be carried out where practical.
- The Alpha WRSF will be constructed using a bottom up approach to improve stability over the short and long term.

The design of roads in permafrost areas generally follows one of two approaches (as per **Appendix 11-A**):

1. Passive approach – provide full thermal protection to maintain permafrost in its frozen condition
2. Active approach – provide for limited thaw penetration into the underlying subgrade where preservation of permafrost is not possible or practical and the consequences of thaw are incorporated into the design.

The passive approach is recommended along sections of road that cross areas underlain by ice-rich permafrost. Along the NAR in areas requiring new construction and upgrading, the following geotechnical considerations are presented as mitigation measures and will be applied as appropriate:

- Cuts and ditches are avoided wherever possible (i.e., use a fill-only approach)
- Movement of equipment used for clearing the right-of-way (ROW) should be controlled to keep the terrain disturbance to a minimum and to preserve the organic mat
- During winter operations, snow cover should be carefully removed before construction of the embankment to reduce settlement of the fill during the thaw period
- The embankment should be constructed by the end dumping method so that the vegetation cover will not be damaged by hauling equipment
- High fills and sideslope alignments are avoided wherever possible
- Embankment thickness should be a minimum of 1.5 m (ideally 2 m), with material placed on woven geotextile to protect the subgrade from thawing; one (1) m of fill should be adequate within sections of the road embankment underlain by ice-poor permafrost
- Where practical, maintain flat horizontal and vertical curves and gradients not exceeding 10%
- Drainage should be controlled to prevent water ponding along the toe of the embankment. This will allow the thermal regime of the frozen subgrade to be maintained. If runoff water must be collected and channelized, it should be done at a reasonable distance from the embankment (>10 m)
- Minimize snow accumulation on the lee side of higher sections of the road embankment to maintain the thermal regime of the frozen subgrade.

Additionally, adherence to the management plans presented in **Section 31.0 Environmental and Socio-economic Management Program** of the Project Proposal will also help reduce potential effects on terrain stability.

4.3.4 MITIGATION FOR UNIQUE LANDFORMS

The primary mitigation measure for the potential disturbance to tors located within the Project footprint is avoidance, which would effectively eliminate the effect. In the case of the tors located within the heap leach facility footprint, avoidance is likely not an option, and it is assumed they will be disturbed as part of Project construction. Along the NAR, the alignment was adjusted to avoid pingos.

4.3.5 MITIGATION FOR SOIL QUALITY

The primary mitigation measures to reduce potential Project effects on soils include limiting the amount of overall site disturbance and salvaging soils for use in reclamation. Reducing the size of the overall Project footprint will, by extension, reduce the amount of soil disturbed.

Soil handling measures are presented in the Waste Rock and Overburden Management Plan (**Appendix 31-D**), which describe the conditions under which soils will be salvaged. The variability of the soils present on site, however, may not present ideal salvage opportunities. Efforts will be made to salvage suitable soil material from areas that will be disturbed by the Project footprint. Measures for handling soils during the reclamation phase are also presented in the Conceptual Reclamation and Closure Plan (**Appendix 31-C**).

To further offset potential effects to soils (amongst other VCs), the Proponent has initiated several reclamation research initiatives at site to develop treatments that are tailored to the local conditions in order to increase the likelihood for reclamation success. Part of these initiatives include:

- Development of a Revegetation Reclamation Research Program whereby reclamation protocols are being developed and tested on-site; the most successful treatments will ultimately be applied more broadly during the reclamation phase.
- The Yukon Research Centre established revegetation and soil amendment trials in 2015 to test various reclamation techniques in the different ecotypes (local ecosystems) present onsite. The results of these initial trials are being incorporated further into the reclamation research being conducted at site (see the **Conceptual Reclamation and Closure Plan**, **Appendix 31-C**).
- The Proponent plans to fund research projects conducted by university graduate students whereby site-specific materials for restoration are developed, including the examination of the effects of stockpiling local peat soil amendment and the interactions of the peat amendment with above and belowground plant-soil systems.

Adherence to the management plans presented in **Section 31.0 Environmental and Socio-economic Management Program** of the Project Proposal will further mitigate potential effects to soils, including effects resulting from localized soil contamination from fuel drips and small spills, soil compaction, dust deposition, and soil erosion.

4.3.6 SUMMARY OF MITIGATION MEASURES

The primary mitigation measure to address potential changes in terrain stability that could result from either natural hazards or permafrost disturbance involves the avoidance of problematic areas. Where this is not possible or practical, mitigation measures focus on engineered solutions. The combination of avoidance and engineered solutions should be sufficient to reduce potential effects to the point that no residual effects remain; however, a conservative approach was taken to offset the possibility that mitigation measures are not applied as prescribed during Project Construction or Operation. As such, residual effects to terrain stability have been identified for further analysis.

The primary mitigation measure for the potential disturbance to tors located within the Project footprint is avoidance, which would effectively eliminate the effect. In the case of the tors located within the heap leach facility footprint, avoidance is likely not an option, and it is assumed they will be disturbed as part of Project construction. Along the NAR, the alignment was adjusted to avoid pingos.

The most effective mitigation measures to address potential changes in soil quality include minimizing the overall extent of Project disturbance and salvaging soils from the Project footprint and stockpiling them for later use in reclamation activities. The potential effects to soil quality in the form of soil disturbance may not be fully mitigated, however, and are therefore assessed further.

The effects relating to the potential for soil degradation and the potential for effects resulting from soil salvage and handling can be satisfactorily addressed through the implementation of the mitigation measures and management plans identified for the Project. Residual effects that may remain are likely to be negligible.

A summary of mitigation measures for each potential effect is presented in **Table 4.3-1**.

Table 4.3-1 Summary of Potential Effects and Mitigation Measures for Surficial Geology, Terrain, and Soils

Summary of Potential Effect	Project Phase	Contributing Project Activities	Proposed Mitigation Measure	Detectable / Measurable Residual Effect (Yes / No)
Change in Terrain Stability Class to IV or V	Construction, Operation, and Reclamation and Closure – Mine Site Area	Activities associated with ground disturbance	Project Design Terrain Hazard Avoidance Terrain Hazard Mitigation for Slope Failures	Yes
	Construction and Reclamation and Closure – NAR	Activities associated with ground disturbance	Project Design Terrain Hazard Avoidance Terrain Hazard Mitigation for Slope Failures, Meander Migration, and Icing	Yes
Change in Terrain Stability Due to Permafrost Disturbance	Construction, Operation, and Reclamation and Closure – Mine Site Area	Activities associated with ground disturbance	Project Design Terrain Hazard Avoidance Terrain Hazard Mitigation for Permafrost Considerations	Yes
	Construction and Reclamation and Closure – NAR	Activities associated with ground disturbance	Project Design Terrain Hazard Avoidance Terrain Hazard Mitigation for Permafrost Considerations	Yes
Disturbance of Unique Landforms	Construction – Mine Site Area	Activities associated with ground disturbance	Avoidance of Unique Landforms.	Yes
Soil Disturbance	Construction, Operation, Reclamation and Closure	Activities associated with ground disturbance	Limit size of overall footprint area Salvage soils for use in reclamation	Yes
Soil Degradation	Construction, Operation, Reclamation and Closure	Activities associated with ground disturbance, traffic (both in terms of compaction and dust production), equipment maintenance (e.g., primarily as it relates to localized soil contamination)	Implement Soil Quality Mitigation Measures including adherence to various management and monitoring plans	No
Soil Salvage and Handling	Construction, Operation, Reclamation and Closure	Activities associated with soil salvage and handling	Salvage soils for use in reclamation Implement Soil Quality Mitigation Measures including adherence to various management and monitoring plans	No

4.4 RESIDUAL EFFECTS AND SIGNIFICANCE OF RESIDUAL EFFECTS

The effects to terrain stability (including those resulting from the disturbance of permafrost), unique landforms, and soil quality that could potentially remain following the application of mitigation measures are presented below for the Mine Site area and NAR. A determination of the significance of the residual effects, the likelihood of the residual effects occurring, and the level of confidence associated with the overall assessment are also discussed. All residual effects are expected to originate during Project Construction, the effects of which may persist through to Reclamation and Closure.

There are no residual effects anticipated for soil quality as a result of soil degradation or soil salvage and handling as the mitigation measures and management plans that will be in place are expected to be effective once implemented and followed.

Determining the significance of the potential residual effects on terrain stability, unique landforms, and soil quality is based on the consideration of residual effects characteristics and the environmental context within which the effect could potentially occur.

4.4.1 RESIDUAL EFFECTS CHARACTERISTICS AND SIGNIFICANCE DEFINITIONS

4.4.1.1 Residual Effects Characteristics

The characteristics used to determine the significance of residual effects to terrain stability, including those resulting from permafrost disturbance and disturbance to unique landforms, are presented in **Table 4.4-1**. Additionally, the characterization of residual effects is based on a combination of (where available) published literature, applicable guidelines and standards (including those from other, relevant geographic areas), TK, and professional judgement. Past disturbances from events such as wildfires or placer mining have been taken into consideration when determining the significance of residual effects.

Table 4.4-1 Effect Characteristics Considered When Determining the Significance of Residual Effects to Terrain Stability (Including Permafrost Disturbance)[1]

Residual Effect Characteristic	Definition	Rating
Direction	Identifies whether the residual effect will be adverse or positive.	• **Adverse** – decline in terrain stability relative to baseline • **Neutral** – no change in terrain stability relative to baseline • **Positive** – increase in terrain stability relative to baseline
Magnitude	Size or severity of the residual effect measured relative to baseline conditions.	• **Low** – no change in terrain stability class or terrain stability class is no greater than II (generally stable); no change to permafrost-related geohazards • **Moderate** – terrain stability class changes to III (generally stable with minor potential for instability); disturbance to ice-poor (Fn) permafrost • **High** – terrain stability class changes to IV or V (potentially unstable or unstable); disturbance to ice-rich (Fv, Fi) permafrost
Geographic Extent	Spatial scale over which the residual effect is expected to occur.	• **Project Footprint** – residual effect confined to areas within the Project footprint • **Local** – residual effect is limited to LAA • **Regional** – residual effect is limited to RAA
Timing	Occurrence of the residual effect with respect a temporal attribute important to the VC.	• N/A (effect is likely to occur irrespective of timing)
Frequency	How often the residual effect is expected to occur.	• **Once** – residual effect occurs once • **Infrequent** – residual effect occurs more than once but at unpredictable intervals • **Frequent** – residual effect occurs repeatedly at regular intervals • **Continuous** – residual effect occurs continuously
Duration	Length of time over which the residual effect is expected to persist.	• **Short-term** – residual effect limited to <1 year • **Medium term** – residual effect lasts for >1 year but not beyond duration of Project life (i.e., does not last beyond closure phase) • **Long-term** – residual effect lasts beyond the life of the Project (i.e., extends beyond closure phase) • **Permanent** – residual effect is permanent
Reversibility	Whether or not the residual effect can be reversed once the activity causing the residual effect ceases. Irreversible effects are considered to be permanent.	• **Fully reversible** – recovery to baseline condition is possible over time • **Partially reversible** – recovery to near baseline condition is possible over time • **Irreversible** – recovery is not possible
Probability of Occurrence	Likelihood that the predicted residual effect will occur.	• **Likely** – residual effect is likely to occur • **Unlikely** – residual effect is unlikely to occur

Residual Effect Characteristic	Definition	Rating
Context	Extent to which terrain stability and permafrost have been affected by past and present environmental processes and conditions, their potential sensitivity to Project-related residual effects, and their ability to recover from that effect	• **Low** – little to no exposure to past or present disturbance; ability to recover from disturbance is low or involves a lengthy timeframe (e.g., in the 100's of years) • **Moderate** – some exposure to past or present disturbance; moderate ability to recover from disturbance (e.g., in the 10's of years) • **High** – extensive exposure to past or present disturbance; rapid recovery in light of disturbance (e.g., <10 years)

[1]Terrain stability classes are as described in **Appendix 11-A**

The characteristics used to determine the significance of residual effects to unique landforms, are presented in **Table 4.4-2**.

Table 4.4-2 Effect Characteristics Considered When Determining the Significance of Residual Effects to Unique Landforms

Residual Effect Characteristic	Definition	Rating
Direction	Identifies whether the residual effect will be adverse or positive.	• **Adverse** – disturbance of unique landforms • **Neutral** – no disturbance of unique landforms • **Positive** – no disturbance of unique landforms
Magnitude	Size or severity of the residual effect measured relative to baseline conditions.	• **Low** – no disturbance to unique landforms • **Moderate** – partial disturbance of unique landforms • **High** – unique landforms are removed from the landscape
Geographic Extent	Spatial scale over which the residual effect is expected to occur.	• **Project Footprint** – residual effect confined to areas within the Project footprint • **Local** – residual effect is limited to LAA • **Regional** – residual effect is limited to RAA
Timing	Occurrence of the residual effect with respect a temporal attribute important to the VC.	• N/A (effect is likely to occur irrespective of timing)
Frequency	How often the residual effect is expected to occur.	• **Once** – residual effect occurs once • **Infrequent** – residual effect occurs more than once but at unpredictable intervals • **Frequent** – residual effect occurs repeatedly at regular intervals • **Continuous** – residual effect occurs continuously
Duration	Length of time over which the residual effect is expected to persist.	• **Short-term** – residual effect limited to <1 year • **Medium term** – residual effect lasts for >1 year but not beyond duration of Project life (i.e., does not last beyond closure phase) • **Long-term** – residual effect lasts beyond the life of the Project (i.e., extends beyond closure phase) • **Permanent** – residual effect is permanent

Residual Effect Characteristic	Definition	Rating
Reversibility	Whether or not the residual effect can be reversed once the activity causing the residual effect ceases. Irreversible effects are considered to be permanent.	• **Fully reversible** – recovery to baseline condition is possible over time • **Partially reversible** – recovery to near baseline condition is possible over time • **Irreversible** – recovery is not possible
Probability of Occurrence	Likelihood that the predicted residual effect will occur.	• **Likely** – residual effect is likely to occur • **Unlikely** – residual effect is unlikely to occur
Context	Extent to which unique landforms have been affected by past and present environmental processes and conditions, their potential sensitivity to Project-related residual effects, and their ability to recover from that effect	• **Low** – little to no exposure to past or present disturbance; ability to recover from disturbance is low or involves a lengthy timeframe (e.g., in the 100's of years) • **Moderate** – some exposure to past or present disturbance; moderate ability to recover from disturbance (e.g., in the 10's of years) • **High** – extensive exposure to past or present disturbance; rapid recovery in light of disturbance (e.g., <10 years)

The characteristics used to determine the significance of residual effects to soil quality are presented in **Table 4.4-3**. Past disturbances from events such as wildfires or placer mining have been taken into consideration when determining the significance of residual effects.

Table 4.4-3 Effect Characteristics Considered When Determining the Significance of Residual Effects to Soil Quality

Residual Effect Characteristic	Definition	Rating
Direction	Identifies whether the residual effect will be adverse or positive.	• **Adverse** – decline in soil quality relative to baseline • **Neutral** – no change in soil quality relative to baseline • **Positive** – increase in soil quality relative to baseline
Magnitude	Size or severity of the residual effect measured relative to baseline conditions.	• **Low** – residual effect is within the range of baseline conditions • **Moderate** – residual effect is at or slightly exceeds baseline conditions • **High** – residual effect will result in a notable change beyond baseline conditions
Geographic Extent	Spatial scale over which the residual effect is expected to occur. Note that, while all effects occur within the LAA, the LAA for some VCs extends out as far as the RAA or beyond.	• **Project Footprint** – residual effect confined to areas within the Project footprint • **Local** – residual effect is limited to LAA • **Regional** – residual effect is limited to RAA
Timing	Occurrence of the residual effect with respect a temporal attribute important to the VC.	• N/A (effect is likely to occur irrespective of timing)

Residual Effect Characteristic	Definition	Rating
Frequency	How often the residual effect is expected to occur.	• **Once** – residual effect occurs once • **Infrequent** – residual effect occurs more than once but at unpredictable intervals • **Frequent** – residual effect occurs repeatedly at regular intervals • **Continuous** – residual effect occurs continuously
Duration	Length of time over which the residual effect is expected to persist.	• **Short-term** – residual effect limited to <1 year • **Medium term** – residual effect lasts for >1 year but not beyond duration of Project life (i.e., does not last beyond closure phase) • **Long-term** – residual effect lasts beyond the life of the Project (i.e., extends beyond closure phase) • **Permanent** – residual effect is permanent
Reversibility	Whether or not the residual effect can be reversed once the activity causing the residual effect ceases. Irreversible effects are considered to be permanent.	• **Fully reversible** – recovery to baseline condition is possible over time • **Partially reversible** – recovery to near baseline condition is possible over time • **Irreversible** – recovery is not possible
Probability of occurrence	Likelihood that the predicted residual effect will occur.	• **Likely** – residual effect is likely to occur • **Unlikely** – residual effect is unlikely to occur
Context	Extent to which soils have been affected by past and present environmental processes and conditions, their potential sensitivity to Project-related residual effects, and their ability to recover from that effect	• **Low** – little to no exposure to past or present disturbance; ability to recover from disturbance is low or involves a lengthy timeframe (e.g., in the 100's of years) • **Moderate** – some exposure to past or present disturbance; moderate ability to recover from disturbance (e.g., in the 10's of years) • **High** – extensive exposure to past or present disturbance; rapid recovery in light of disturbance (e.g., <10 years)

4.4.1.2 Significance Definition

Criteria or thresholds, which when surpassed would signal the likely presence of a significant residual effect, have not been defined for terrain stability. A qualitative approach was adopted based on the residual effects characteristics presented in **Table 4.4-1** as well as professional judgement. Emphasis is placed on the magnitude, geographic extent, duration, reversibility, and probability of occurrence criteria when assigning a significance rating as these provide suitable context of the potential implications of the residual effect. Significant residual effects to terrain stability would be characterized as high magnitude, of regional extent, permanent, irreversible, and likely to occur.

Criteria or thresholds, which when surpassed would signal the likely presence of a significant residual effect, have not been defined for unique landforms. A qualitative approach was adopted based on the residual effects characteristics presented in **Table 4.4-2** as well as professional judgement. Emphasis is placed on the magnitude, geographic extent, duration, reversibility, and probability of occurrence criteria when assigning a significance rating as these provide suitable context of the potential implications of the residual effect. Significant residual effects to unique landforms would be characterized as high magnitude, of regional extent, permanent, irreversible, and likely to occur.

As with terrain stability and unique landforms, criteria or thresholds, which when surpassed would signal the likely presence of a significant residual effect, have not been defined for soil quality. A qualitative approach was adopted based on the residual effects characteristics presented in **Table 4.4-3** as well as professional judgement. Emphasis is placed on the magnitude, geographic extent, duration, reversibility, and probability of occurrence criteria when assigning a significance rating as these provide suitable context of the potential implications of the residual effect. Significant residual effects to soil quality would be characterized as high magnitude, of regional extent, permanent, irreversible, and likely to occur.

A confidence level has also been assigned to each significance determination. Confidence levels include low, moderate, or high, and are based upon a combination of the amount of data available (either collected directly for the Project or from similar projects), published or available literature, professional judgement, and the anticipated effectiveness of mitigation measures.

4.4.2 Terrain Stability

4.4.2.1 Change in Terrain Stability Class to IV or V

Residual effects of the Project on terrain stability are adverse, of high magnitude, and are restricted to the Project footprint both within the Mine Site area and along the NAR (**Table 4.4-4**). The residual effect occurs once as part of construction activities but is anticipated to persist into the long-term (potentially beyond the closure phase). Residual effects are partially reversible in that original terrain stability levels may not be replicated but similar, stable terrain conditions will be reproduced as part of the closure and reclamation phase. The residual effect is considered unlikely to occur as infrastructure that may be located in unstable terrain (either existing or induced through construction activities) will be designed, constructed, and operated in a manner that is safe and appropriate for the conditions. Additionally, the mitigation measures presented in **Section 4.3.3** that are engineered solutions are tailored specifically to terrain stability and are effective when implemented correctly. Because the residual effects are restricted to the Project footprint, are not permanent, are partially reversible, and are unlikely to occur, they are anticipated to be not significant. This assessment has a moderate level of confidence, partly because terrain stability in this context (e.g., a change in terrain stability class due to the addition of a disturbance) is not well documented thus limiting the opportunity for comparison to other similar circumstances.

Table 4.4-4 Summary of Effect Characteristics Ratings for Change in Terrain Stability Class to IV or V

Residual Effect Characteristic	Definition	Rationale Rating
Direction	*Adverse*	*Decline in terrain stability relative to baseline*
Magnitude	*High*	*Terrain stability class changes to IV or V (potentially unstable or unstable)*
Geographic Extent	*Project Footprint*	*Residual effect is restricted to the extent of the Project footprint*
Timing	*N/A*	*N/A*
Frequency	*Once*	*Residual effect occurs during construction*
Duration	*Long-term*	*Areas are stabilized for operations and as part of closure measures but should be monitored over the long-term to verify stability is not decreasing*
Reversibility	*Partially reversible*	*Areas are stabilized for operations and as part of closure measures*
Probability of Occurrence	*Unlikely*	*Residual effect is unlikely to occur as infrastructure will be designed to suit the conditions and potential for instability*

4.4.2.2 Change in Terrain Stability Due to Permafrost Disturbance

Residual effects of the Project on terrain stability resulting from disturbance to permafrost are adverse, of high magnitude, and are restricted to the Project footprint within the Mine Site area and along the NAR (**Table 4.4-5**). The residual effect occurs once as part of construction activities but is anticipated to persist into the long-term (potentially beyond the closure phase). Residual effects are partially reversible in that permafrost aggradation may occur under certain conditions, however, the length of time under which this process would occur is likely considerable. The residual effect is considered unlikely to occur as infrastructure that may be located in areas underlain by ice-rich (Fv, Fi) permafrost will be designed, constructed, and operated in a manner that has successfully incorporated the mitigation measures presented in **Section 4.3.3.4**. These measures are engineered solutions tailored specifically to construction and operation in permafrost conditions and are effective when implemented correctly. Because the residual effects are restricted to the Project footprint, are not permanent, are partially reversible, and are unlikely to occur, they are anticipated to be not significant. This assessment has a moderate level of confidence partly because of the possibility that the implementation of the mitigation measures proposed could be reliant on a third party (e.g., a construction contractor) not fully versed in the intricacies of building on permafrost.

Table 4.4-5 Summary of Effect Characteristics Ratings for Potential Change in Terrain Stability Due to Permafrost Disturbance

Residual Effect Characteristic	Definition	Rationale Rating
Direction	*Adverse*	*Decline in terrain stability relative to baseline*
Magnitude	*High*	*Disturbance to ice-rich (Fv, Fi) permafrost*
Geographic Extent	*Project footprint*	*Residual effect is restricted to the extent of the Project footprint*
Timing	*N/A*	*N/A*
Frequency	*Once*	*Residual effect occurs during construction*
Duration	*Long-term*	*Areas are stabilized for operations and as part of closure measures but should be monitored over the long-term to verify stability is not decreasing*
Reversibility	*Partially reversible*	*Areas are stabilized for operations and as part of closure measures. Permafrost aggradation may be encouraged in areas, where feasible.*
Probability of Occurrence	*Unlikely*	*Residual effect is unlikely to occur as infrastructure will be designed to suit the conditions and presence of ice-rich permafrost in particular*

4.4.3 UNIQUE LANDFORMS

Residual effects of the Project as disturbance to unique landforms are adverse, of high magnitude, and are restricted to the Project footprint within the Mine Site area (**Table 4.4-6**). The residual effect occurs once as part of construction activities and is considered to be permanent and irreversible. The residual effect is considered likely to occur as there is little opportunity to move infrastructure to a more suitable location in an effort to avoid these landform features. The potential effects to unique landforms are considered to be not significant despite the effects being of high magnitude, permanent, irreversible, and likely to occur. The residual effects are restricted to the Project footprint and do not represent the elimination of unique landforms from the regional area. There are other unique landforms in the LAA and RAA that will remain undisturbed by Project activities, and this is primarily why the effects are thought to be not significant. This assessment has a high level of confidence.

Table 4.4-6 Summary of Effect Characteristics Ratings for Disturbance of Unique Landforms

Residual Effect Characteristic	Definition	Rationale Rating
Direction	*Adverse*	*Disturbance of unique landforms*
Magnitude	*High*	*Unique landforms will be removed*
Geographic Extent	*Project footprint*	*Residual effect is restricted to the extent of the Project footprint*
Timing	*N/A*	*N/A*
Frequency	*Once*	*Residual effect occurs during construction*
Duration	*Permanent*	*Residual effect is permanent*
Reversibility	*Irreversible*	*Recovery is not possible*
Probability of Occurrence	*Likely*	*Residual effect is likely to occur as there are few suitable alternate locations for infrastructure*

4.4.4 Soil Quality

4.4.4.1 Soil Disturbance

Residual effects of the Project on soil quality as soil disturbance are adverse, of moderate magnitude, and are restricted to the Project footprint both within the Mine Site area and along the NAR (**Table 4.4-7**). The residual effect occurs once as part of construction activities but may persist into the long-term (potentially beyond the closure phase). Residual effects are partially reversible in that soil replacement may not replicate pre-disturbance conditions, but the re-establishment of productive areas is included as part of the closure and reclamation phase. The residual effect is likely to occur as soil disturbance is unavoidable with Project construction. The mitigation measures presented in **Section 4.3.5** are likely to be effective if implemented accordingly. Because the residual effects are of moderate magnitude, are restricted to the Project footprint, are not permanent, and are partially reversible, they are anticipated to be not significant. This assessment has a high level of confidence.

Table 4.4-7 Summary of Effect Characteristics Ratings for Soil Disturbance

Residual Effect Characteristic	Definition	Rationale Rating
Direction	*Adverse*	*Decline in soil quality relative to baseline*
Magnitude	*Moderate*	*Disturbance to soils may exceed baseline conditions*
Geographic Extent	*Project footprint*	*Residual effect is restricted to the extent of the Project footprint*
Timing	*N/A*	*N/A*
Frequency	*Once*	*Residual effect occurs during construction*
Duration	*Long-term*	*Reclaimed areas may require post-closure follow-up monitoring to verify treatments are effective*
Reversibility	*Partially reversible*	*Productive areas may be re-established with reclamation treatments*
Probability of Occurrence	*Likely*	*Residual effect is likely to occur as site disturbance is required for Project construction*

4.4.5 SUMMARY OF PROJECT–RELATED RESIDUAL ADVERSE EFFECTS AND SIGNIFICANCE

Residual effects of the Project are summarized in **Table 4.4-8** to **Table 4.4-10** for terrain stability, unique landforms, and soil quality, respectively. Potential residual effects to Surficial Geology, Terrain, and Soils were determined to be not significant. For potential effects to the terrain stability subcomponent, this is largely due to the unlikely nature of the residual effects occurring and that mine design and all phases of Project activities will incorporate engineering techniques and regular monitoring that are specifically tailored to potential areas of instability, including those that might result from disturbance to permafrost.

The potential effects to unique landforms were also determined to be not significant despite the effects being permanent, irreversible, and likely to occur. The rationale for this significance determination is that there is no indication, as determined through consultation, the collection of TK information, or baseline studies, that these specific landforms serve a particular purpose, and that if lost, would result in an adverse effect. As examples, these landforms have not been identified as being directional markers, or providing limiting habitat for wildlife (such as cliff-nesting raptors) or rare plants (see **Appendix 17-A** and **Appendix 15-A**, for wildlife and vegetation, respectively). Additionally, the landforms that fall within the Project footprint are not the only ones present in the area. There are other tors and pingos within the Mine Site area LAA and RAA as well as within the NAR LAA and RAA that will not be disturbed as a result of Project activities, and these will remain as examples of the unique landforms that are present within the broader area.

For potential effects to soil quality (as soil disturbance), the determination that residual effects are likely to be not significant is due primarily to the localized extent of the effect and the mitigation measures and planned reclamation activities that would offset potential effects.

All residual effects have been carried forward into the cumulative effects assessment described in **Section 5.0.**

Table 4.4-8 Summary of Potential Residual Adverse Effects for Terrain Stability (Including Permafrost Disturbance)

Potential Residual Adverse Effects to Terrain Stability	Contributing Project Activities	Proposed Mitigation Measures	Residual Effects Characterization (see Notes for details)									
			Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Context	Significance	Level of Confidence
Construction Phase	Activities associated with ground disturbance	Project Design Terrain Hazard Avoidance Terrain Hazard Mitigation	A	HM	PF	LT	O	PR	U	L	NS	M
Operation Phase	Activities associated with ground disturbance	Project Design Terrain Hazard Avoidance Terrain Hazard Mitigation	A	HM	PF	LT	O	PR	U	L	NS	M
Closure and Reclamation Phase	Activities associated with ground disturbance	Closure Design Terrain Hazard Avoidance Terrain Hazard Mitigation	A	HM	PF	LT	O	PR	U	L	NS	M

Notes: *Definitions are as follows:*

Direction Positive (P), N = Neutral, Adverse (A).
Magnitude: NM = Negligible, LM = Low magnitude, MM = Moderate magnitude, HM = High magnitude
Geographic Extent: PF = Project footprint, LAA = local, RAA = regional, T = territorial
Timing: N/A
Duration: LT = Long-term, MT = Medium-term, ST = Short-term, TT = Transient term, P = Permanent
Frequency: CF = Continuous, FF = Frequent, IF = Infrequent, O = Once
Reversibility: FR = Fully reversible, PR = Partially reversible, IR = Irreversible,
Context: L=Low, M=Moderate, H=High
Likelihood: L=Likely, U=Unlikely
Significance: NS = Not-Significant, S = Significant
Level of Confidence: L = Low, M = Moderate, H = High

Table 4.4-9 Summary of Potential Residual Adverse Effects for Unique Landforms

Potential Residual Adverse Effects to Terrain Stability	Contributing Project Activities	Proposed Mitigation Measures	Residual Effects Characterization (see Notes for details)									
			Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Context	Significance	Level of Confidence
Construction Phase	Activities associated with ground disturbance	Project Design Unique Landform Avoidance	A	HM	PF	P	O	I	L	L	NS	H
Operation Phase	Activities associated with ground disturbance	Project Design Unique Landform Avoidance	A	HM	PF	P	O	I	L	L	NS	H
Closure and Reclamation Phase	Activities associated with ground disturbance	Closure Design Unique Landform Avoidance	A	HM	PF	P	O	I	L	L	NS	H

Notes: *Definitions are as follows:*

Direction Positive (P), N = Neutral, Adverse (A).
Magnitude: NM = Negligible, LM = Low magnitude, MM = Moderate magnitude, HM = High magnitude
Geographic Extent: PF = Project footprint, LAA = local, RAA = regional, T = territorial
Timing: N/A
Duration: LT = Long-term, MT = Medium-term, ST = Short-term, TT = Transient term, P = Permanent
Frequency: CF = Continuous, FF = Frequent, IF = Infrequent, O = Once
Reversibility: FR = Fully reversible, PR = Partially reversible, IR = Irreversible,
Context: L=Low, M=Moderate, H=High
Likelihood: L=Likely, U=Unlikely
Significance: NS = Not-Significant, S = Significant
Level of Confidence: L = Low, M = Moderate, H = High

Table 4.4-10 Summary of Potential Residual Adverse Effects for Soil Quality

Potential Residual Adverse Effects to Soil Quality	Contributing Project Activities	Proposed Mitigation Measures	Residual Effects Characterization (see Notes for details)									
			Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Context	Significance	Level of Confidence
Construction Phase	Activities associated with ground disturbance, traffic (both in terms of compaction and dust production), equipment maintenance (e.g., primarily as it relates to localized soil contamination)	Limit Amount of Site Disturbance Soil Salvage and Replacement Adherence to Applicable Management Plans	A	HM	PF	LT	O	PR	U	M	NS	M
Operation Phase	Activities associated with ground disturbance, traffic (both in terms of compaction and dust production), equipment maintenance (e.g., primarily as it relates to localized soil contamination)	Soil Salvage and Replacement Adherence to Applicable Management Plans	A	HM	PF	LT	O	PR	U	M	NS	M
Closure and Reclamation Phase	Activities associated with ground disturbance, traffic (both in terms of compaction and dust production), equipment maintenance (e.g., primarily as it relates to localized soil contamination)	Soil Replacement Adherence to Closure and Reclamation Plan	A	HM	PF	LT	O	PR	U	M	NS	M

Notes: *Definitions are as follows:*

Direction	Positive (P), N = Neutral, Adverse (A).
Magnitude:	NM = Negligible, LM = Low magnitude, MM = Moderate magnitude, HM = High magnitude
Geographic Extent:	PF = Project footprint, LAA = local, RAA = regional, T = territorial
Timing:	N/A
Duration:	LT = Long-term, MT = Medium-term, ST = Short-term, TT = Transient term, P = Permanent
Frequency:	CF = Continuous, FF = Frequent, IF = Infrequent, O = Once
Reversibility:	FR = Fully reversible, PR = Partially reversible, IR = Irreversible,
Context:	L=Low, M=Moderate, H=High
Likelihood:	L=Likely, U=Unlikely
Significance:	NS = Not-Significant, S = Significant
Level of Confidence:	L = Low, M = Moderate, H = High

5.0 CUMULATIVE EFFECTS ASSESSMENT

An assessment of the potential cumulative effects to Surficial Geology, Terrain, and Soils is presented below. Cumulative effects result from interactions between Project-related residual effects and the incremental effects on Surficial Geology, Terrain, and Soils from other past, present, and reasonably foreseeable projects and activities. The projects and activities listed in **Section 5.0** of the Project Proposal were used to determine the potential cumulative effects on Surficial Geology, Terrain, and Soils. There are no projects that overlap with the Mine Site area RAA, therefore the cumulative effects assessment focuses on the NAR only.

5.1 PROJECT-RELATED RESIDUAL EFFECTS

Residual effects that were carried forward into the cumulative effects assessment include potential effects to terrain stability from Project activities (including disturbance to permafrost) and potential for soil disturbance along the NAR (**Table 5.1-1**).

Table 5.1-1 Project-related Residual Effects Considered in the Cumulative Effects Assessment

Project-related Residual Effect	Included in Cumulative Effects Assessment	Rationale
Terrain Stability		
Change in Terrain Stability Class to IV or V	Yes	Potential for cumulative effects along the NAR
Change in Terrain Stability Due to Permafrost Disturbance	Yes	Potential for cumulative effects along the NAR
Soil Quality		
Soil Disturbance	Yes	Potential for cumulative effects along the NAR

5.1.1 CUMULATIVE EFFECTS BASELINE INFORMATION

The scope of the assessment for potential effects to Surficial Geology, Terrain, and Soils relies on information compiled from both past and new studies commissioned as part of the Project baseline characterization program as well as from the review of other existing and proposed quartz mining projects in the Yukon and other parts of northern Canada. Although surficial geology and soils are not specifically mentioned in the TK data collected to date for the Project, the importance of these features in maintaining the integrity of other components (e.g., plants, ecosystems, wildlife habitat) is inferred through views that expressed traditional ways of life being tied to "healthy and intact ecosystems" (Bates, et al. 2014) and being "key to the overall health of the land" (Tr'ondëk Hwëch'in 2012). The importance of terrain in terms of TK has been identified with respect to the avoidance of natural hazards and the use of landscape features as lookouts as well as for travel corridors and the establishment of hunting and camping sites (Dobrowolsky 2014; Tr'ondëk Hwëch'in 2012). This information was incorporated into the cumulative effects assessment as well. Further details are provided in **Section 1.0 Introduction** and **Section 3.0 Existing Conditions**.

5.1.2 Spatial and Temporal Scope of the Cumulative Effects Assessment

The spatial boundary defined for the cumulative effects assessment is identical to the RAA presented for the NAR (the Mine Site area is not being included as part of the cumulative effects assessment for the reasons presented in **Section 5.0** above). The RAA includes a 1 km buffer around the route centreline, which is the full extent of terrain stability mapping completed for the NAR, and is approximately 45,897 ha in size.

The temporal boundaries for the cumulative effects assessment cover the life of the Project, including the post-closure phase. Additional details are provided in **Section 1.1.3.2** above.

5.1.3 Other Projects and Activities

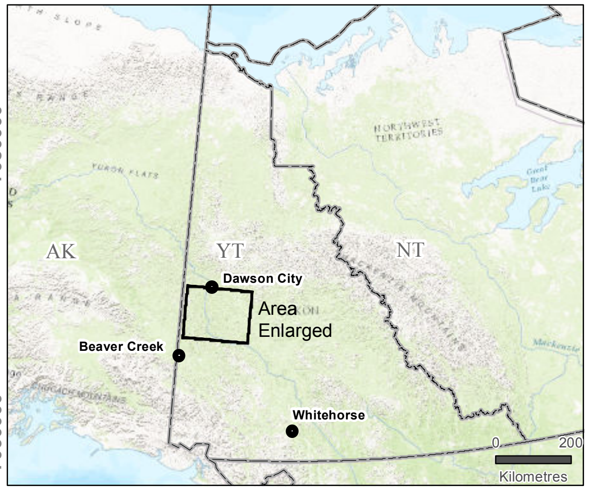
Relevant projects and activities included in the assessment of cumulative effects include not only those that overlap with the RAA for Surficial Geology, Terrain, and Soils along the NAR, but those that intersect the same terrain stability polygons as the Project footprint (see **Figure 5.1-1** for an example of this scoping exercise). This distinction is made based on how the assessment of a change in terrain stability was carried out in **Section 4.0**. Adverse effects to terrain stability are those in which the disturbed terrain stability class (as described in **Appendix 11-A**) of a polygon changed to either class IV (potentially unstable) or class V (unstable) after the inclusion of Project infrastructure. The consideration of additional development from other projects in these class IV or V polygons could exacerbate this, leading to further instability. Projects that simply fall within the RAA alone are less likely to interact in a cumulative manner with Project infrastructure and activities and as such have not been considered further in the assessment.

With respect to soil disturbance, projects and activities in addition to those associated with the Coffee Gold Mine that overlap spatially with the areas that require new construction along the NAR are included in the cumulative effects assessment. The reason for this distinction is that the majority of the disturbance to soils has already occurred along the NAR, and upgrades to the existing road that are in the vicinity of existing or proposed projects are unlikely to result in disturbances that will interact in a cumulative manner. Projects and activities that are located in areas of new construction, however, may interact cumulatively with the Project footprint, and as such have been considered for assessment.

A total of 24 projects (23 existing and one planned for future) overlap with the same terrain stability polygons as the NAR alignment, and fall within sections of the existing alignment. No projects fall within the portions of the NAR that require new construction. The majority (21) of these projects are associated with placer mining. The remaining three projects include one quartz exploration project and two settlement projects, all of which are existing. The likely interactions between these projects and the Coffee Gold Mine arise from the possibility of the projects collectively changing the terrain stability in the area as part of project activities. Summaries are presented in **Table 5.1-2**.

COFFEE GOLD MINE

Example of Project Overlap with Coffee Gold Mine Activities to Trigger Potential Cumulative Effects



Legend

- Project within Regional Assessment Area
- Regional Assessment Area
- Mine Site Access Road
- Northern Access Route (new section)
- Northern Access Route (upgrade section)
- Klondike Highway
- Terrain Polygon

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
2. Imagery from ESRI; Earthstar Geographics (1999)
3. Terrain data from Palmer Environmental Consulting Group (March 2016)
4. CEA project locations from Hemmera (April 2016)

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Figure 5.1-1	Date: Jan 30, 2017	Drawn by: MEZ	Reviewed: TP

GOLDCORP

Table 5.1-2 Potential Residual Adverse Effects of Other Project and Activities on Surficial Geology, Terrain, and Soils

Other Project / Activity Category	Description	Potential Residual Effects	
		Terrain Stability (Including Disturbance to Permafrost)	Soil Quality (Soil Disturbance)
Quartz projects	Hard rock mining of ore bodies; activities include quartz exploration and quartz mining	*Yes. Potential for disturbances to decrease terrain stability, particularly in areas classified as being unstable*	*Yes. Potential for additional disturbance to soils from project activities*
Placer projects	Mining of alluvial deposits for minerals; activities include placer exploration, and placer mining	*Yes. Potential for disturbances to decrease terrain stability, particularly in areas classified as being unstable*	*Yes. Potential for additional disturbance to soils from project activities*
Transportation	Access roads construction and upgrades, bridges, and culverts	*No projects overlap the same terrain stability polygons as the NAR within RAA.*	*No projects overlap the same terrain stability polygons as the NAR within RAA.*
Utilities	Water supply wells, wastewater treatment, and on-site sewage disposal systems	*No projects overlap the same terrain stability polygons as the NAR within RAA.*	*No projects overlap the same terrain stability polygons as the NAR within RAA.*
Energy	Air emissions permits and electric power transmission lines	*No projects overlap the same terrain stability polygons as the NAR within RAA.*	*No projects overlap the same terrain stability polygons as the NAR within RAA.*
Forestry	Timber harvesting activities for commercial purposes or clearing of forest resources incidental to other activities	*No projects overlap the same terrain stability polygons as the NAR within RAA.*	*No projects overlap the same terrain stability polygons as the NAR within RAA.*
Agriculture	Soil-based agricultural land applications and livestock grazing land applications	*No projects overlap the same terrain stability polygons as the NAR within RAA.*	*No projects overlap the same terrain stability polygons as the NAR within RAA.*
Settlements	Residential and commercial land use, community infrastructure, and historic sites	*Yes. Potential for disturbances to decrease terrain stability, particularly in areas classified as being unstable*	*Yes. Potential for additional disturbance to soils from project activities*
Industrial	Installation and upgrade of oil and solid fuel burning appliances and fuel oil storage tanks	*No projects overlap the same terrain stability polygons as the NAR within RAA.*	*No projects overlap the same terrain stability polygons as the NAR within RAA.*
Wildlife	Registered trapping concession areas and guide outfitter concession areas	*No projects overlap the same terrain stability polygons as the NAR within RAA.*	*No projects overlap the same terrain stability polygons as the NAR within RAA.*

5.1.4 POTENTIAL CUMULATIVE EFFECTS

Of the projects presented in **Table 5.1-2**, only three placer projects (all currently in operation) fall within the same terrain stability polygons as the NAR alignment and have the potential to change the terrain stability classification from an existing class of III (generally stable with minor potential for instability) to a disturbed terrain stability class of either IV (potentially unstable) or V (unstable). As the disturbed terrain stability class represents conditions that could result following ground disturbance from road construction without mitigation, these placer operations, which are currently in operation and would have been visible during development of the terrain stability map, would have been taken into consideration when assigning a disturbed terrain stability class (**Appendix 11-A**). The potential decrease in terrain stability therefore is largely attributed to the inclusion of the NAR and associated upgrading activities (given that the overlap occurs along existing portions of the alignment).

There are no potential interactions between the NAR and the projects listed in **Table 5.1-2** that would adversely affect soil quality, as the projects fall within existing portions of the alignment, which is already largely disturbed. **Table 5.1-3** presents a summary of the potential cumulative effects on Surficial Geology, Terrain, and Soils.

Table 5.1-3 Potential Cumulative Effects on Surficial Geology, Terrain, and Soils due to Interactions between the Project and Other Project and Activities

Other Project / Activity	Potential Residual Adverse Effect	Potential for Interaction Resulting in Cumulative Effect (see Note) and Rationale
Placer operations (3 current) within polygons with an existing terrain stability class of III1 or lower	Change in terrain stability class to IV or V	No. Placer projects are currently in operation and would have been taken into consideration when assigning a disturbed terrain stability class as part of development of the terrain stability map. The potential decreases to terrain stability noted are largely from Project construction and upgrades along the NAR.
Placer operations (18), settlement projects (2), quartz projects (1) with an existing terrain stability class of III or lower	Change in terrain stability class to IV or V	No. These projects (both current and future) do not fall within terrain stability polygons that could become unstable following inclusion of the NAR. All fall within a disturbed terrain stability class of III or lower.
Placer projects (21), settlement projects (2), quartz projects (1)	Soil disturbance	No. Projects do not overlap with areas requiring new construction along the NAR, therefore no cumulative disturbance to soil is anticipated.

Note: [1]**Appendix 11-A**; Terrain Stability Classes: 0 – N/A, anthropogenic, I – stable, II – generally stable, III – generally stable with minor potential for instability, IV – potentially unstable, and V – unstable.
No: no interaction or not likely to interact cumulatively; **Yes**: potential for cumulative effect.

5.1.4.1 Change in Terrain Stability Class to IV or V

The projects that have the potential to interact cumulatively with the Project's NAR to the extent they may change the terrain stability classes of certain areas to IV (potentially unstable) to V (unstable) were taken into consideration as part of the terrain stability assessment. As such, no potential cumulative effects are anticipated or would not be detectable beyond the effects already described for the Project.

5.1.4.2 Soil Disturbance

No projects fall within sections of the NAR requiring new construction. As such, there is no interaction with Project activities that may result in further disturbance to soils and no potential for cumulative effects.

5.1.5 MITIGATION MEASURES FOR CUMULATIVE EFFECTS

The Project design changes, mitigation measures, and management plans presented in **Section 4.3** are relevant to the mitigation of potential cumulative effects to terrain stability and soil disturbance.

5.1.6 RESIDUAL CUMULATIVE EFFECTS AND SIGNIFICANCE OF RESIDUAL CUMULATIVE EFFECTS

Following the application of mitigation measures and the implementation of the management plans developed for the Project, there are no residual cumulative effects anticipated for Surficial Geology, Terrain, and Soils. As such, an assessment of residual cumulative effects and subsequent determination of significance have not been conducted as they are not required.

6.0 SUMMARY OF EFFECTS ASSESSMENT ON SURFICIAL GEOLOGY, TERRAIN, AND SOILS

The primary residual effects to Surficial Geology, Terrain, and Soils that are anticipated to result from the Project are associated with terrain stability and soil quality (as soil disturbance). For terrain stability, the residual effects were determined to be not significant, largely because of the unlikely nature of the residual effect occurring and that mine design and the various phases of Project activities will incorporate engineering techniques and regular monitoring that are specifically tailored to potential areas of instability, including those that might result from disturbance to permafrost.

For potential effects to soil quality (and soil disturbance specifically), residual effects are also considered to be not significant primarily due to the localized extent of the effect and the mitigation measures and planned reclamation activities that would offset potential effects.

No residual cumulative effects are anticipated for Surficial Geology, Terrain, and Soils largely because the potential terrain stability issues that could result from existing projects have been taken into consideration in the determination of potentially unstable areas. There is also no overlap with these projects and areas of new construction required along the NAR that could result in further soil disturbance.

7.0 EFFECTS MONITORING AND ADAPTIVE MANAGEMENT

Monitoring programs and adaptive management will be implemented for both terrain stability and soil quality. Monitoring will focus on clarifying uncertainty, the effectiveness of proposed mitigation measures, and the identification of unanticipated environmental issues. The information collected from these monitoring programs will feed back into the management plans developed for the Project in order to refine mitigation measures and enable continuous improvement.

7.1 TERRAIN STABILITY

The majority of the mitigation measures developed to offset potential effects to terrain stability (including those involving disturbance to permafrost) rely largely on engineered solutions. Additional geotechnical investigations are proposed for the summer of 2016 and more may be required as part of the permitting stage in order to further characterize permafrost areas that may support Project infrastructure. The results of these investigations will feed into detailed mine design and will refine the mitigation measures proposed.

Additional monitoring programs are proposed as part of the plans developed for the Project, described further in **Section 31.0 Environmental and Socio-economic Management Program** of the Project Proposal (for efficiency, the specific measures have not been repeated):

- Waste Rock and Overburden Management Plan (**Appendix 31-D**)
- Access Route Construction Management Plan (**Appendix 31-A**)

For site preparation and construction activities that will occur in permafrost areas, personnel qualified in the evaluation of permafrost conditions will be on-site so that design-based mitigation measures are applied correctly and in-field recommendations can be made correctly and expeditiously.

7.2 UNIQUE LANDFORMS

No follow-up or monitoring programs are proposed for unique landforms, as the potential effects described will be a one-time occurrence which will result in removal of the feature from the landscape.

7.3 SOIL QUALITY

Several follow-up and monitoring programs are proposed for soil quality, in addition to general construction monitoring that will be carried out to avoid soil loss through processes like erosion. The Proponent has already initiated various revegetation and soil amendment trials at site in an effort to develop site-specific treatments that can then be implemented as part of the reclamation plan. The Proponent has also approached several academic institutions and other experts to assist with the development of projects that will further research on soil and soil amendments that could be used in reclamation. These projects include:

- characterizing the soil of northern native plants that are potential candidates for revegetation
- developing site-specific materials for use in restoration including the effects of stockpiling on a local peat soil amendment and the interactions of the peat amendment with above and below-ground plan-soil systems.

Further details on the soil research to be carried out as part of the Project are presented in the Conceptual Reclamation and Closure Plan (**Appendix 31-C**).

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