CryoGeographic Consulting

In association with

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Mapping and classifying wetlands in the Indian River valley, Yukon

Final Report

Prepared for

Government of Yukon

January 21, 2018

CryoGeographic Consulting

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January 21, 2018

Briar Young
Energy, Mines and Resources
and
Bruce McLean
Yukon Environment

Dear Messrs. Young and McLean,

Re: Mapping and classifying wetlands in the Indian River valley, Yukon

CryoGeographic Consulting, in association with Palmer Environmental Consulting Group Inc., is pleased to provide Yukon Energy, Mines and Resources and Yukon Environment with the results of the mapping and classification of wetlands and adjacent upland habitat in the Indian River valley and its major tributaries. This report and its accompanying map set have been updated to reflect study area expansion and additional field reconnaissance completed in the summer of 2017.

Five classes of wetlands are distinguished – bogs, fens, swamps, marshes and shallow water – based on field investigations and interpretation of high-resolution aerial photography and satellite imagery.

Should you have any questions, please do not hesitate to contact Karen McKenna at 867-335-0191 or kmckenna@northwestel.net.

We appreciate the opportunity to work on this interesting and important project.

Yours truly,

CryoGeographic Consulting

Karen McKenna

Distribution List

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0	Yes	Yukon Energy, Mines and Resources
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Revision Log

Revision #	Reviewed By	Date	Issue / Revision Description
1	K. McKenna/R. McKillop	January 21, 2018	Updated to reflect expanded study area

Signatures

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Palmer Environmental Consulting Group Inc.

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1 Introduction

This report accompanies and explains the mapping of wetlands and adjacent upland habitat in the Indian River valley. The principal objective of the Indian River wetland mapping is to delineate, classify and describe existing wetland areas (and adjacent upland habitat) within the Indian River valley and its major tributaries (Figure 1). The description of the wetlands includes their distribution within the map area, associated landforms, soils, permafrost conditions, vegetation and (where possible) hydrological conditions. This mapping will provide technical support for decision bodies, regulators, project proponents, industry, environmental assessors and First Nations. The mapping will also assist with assessment of cumulative effects.

The mapping establishes the distribution of different classes of wetlands within undisturbed parts of the Indian River valley study area. The mapped wetlands consist of bogs, fens, swamps, marshes and shallow water[1]. There are also wetlands in the disturbed and mined areas – mostly swamps, marshes and shallow water – which were not mapped. Wetlands are also common in the unmapped areas and adjacent valleys throughout the region. Although similar wetlands are found throughout the Klondike Plateau, the Indian River valley is broader than many other valleys and thus contains more extensive wetlands. The initial mapping study area outlined in pink focused on the mainstem of the upper Indian River valley, but the mapping area was expanded in 2017 to include more tributary valleys and the lower Indian River valley, shown in green (Figure 1).

1.1 Geological Setting

The Indian River is a meandering river in a broad valley within the unglaciated Klondike Plateau. Old fluvial and glaciofluvial terraces, more widespread on the south side of the valley, mark the channels of former Pleistocene and/or Pliocene rivers draining glaciers from the east (Froese and Jackson 2005). The active river channel follows the right (northeast) margin of the valley, commonly cutting into the Klondike muscovite-chlorite-quartz-feldspar schist, quartzite, gneiss or amphibolite bedrock (Gordey and Ryan 2005). The fluvial and glaciofluvial sands and gravels are overlain in most places by extensive reworked and resedimented loess (wind-blown silt and fine sand) known by placer miners as “muck”, and a surface organic layer of variable thickness.

Permafrost is discontinuous but extensive throughout most of the study area (Bonnaventure and Lewkowicz 2012) except beneath and immediately adjacent to the active river channel, which maintains a localized ‘talik’ of unfrozen ground. Permafrost, at least near-surface, has disappeared from some of the areas most severely altered by anthropogenic activities. It is found close to the surface, within 1.2 metres, in most wetlands and many of the uplands investigated as part of this project. At several locations on the old fluvial terraces, thermokarst has outlined ice-wedge polygons visible in high-resolution imagery. It is expected that the distribution of these ice wedges extends throughout most of the fine textured loess overlying the old floodplain and glaciofluvial terraces, which are slightly higher than the active river and creek floodplains.

[1] The simpler term ‘shallow water’ is used throughout this report, in accordance with nomenclature in *Boreal Low Zone of Yukon: A Field Guide to Ecosite Identification* (Environment Yukon, in press), but it is synonymous with the original term ‘shallow open water’, established in *The Canadian Wetland Classification System* by the National Wetlands Working Group (1997).

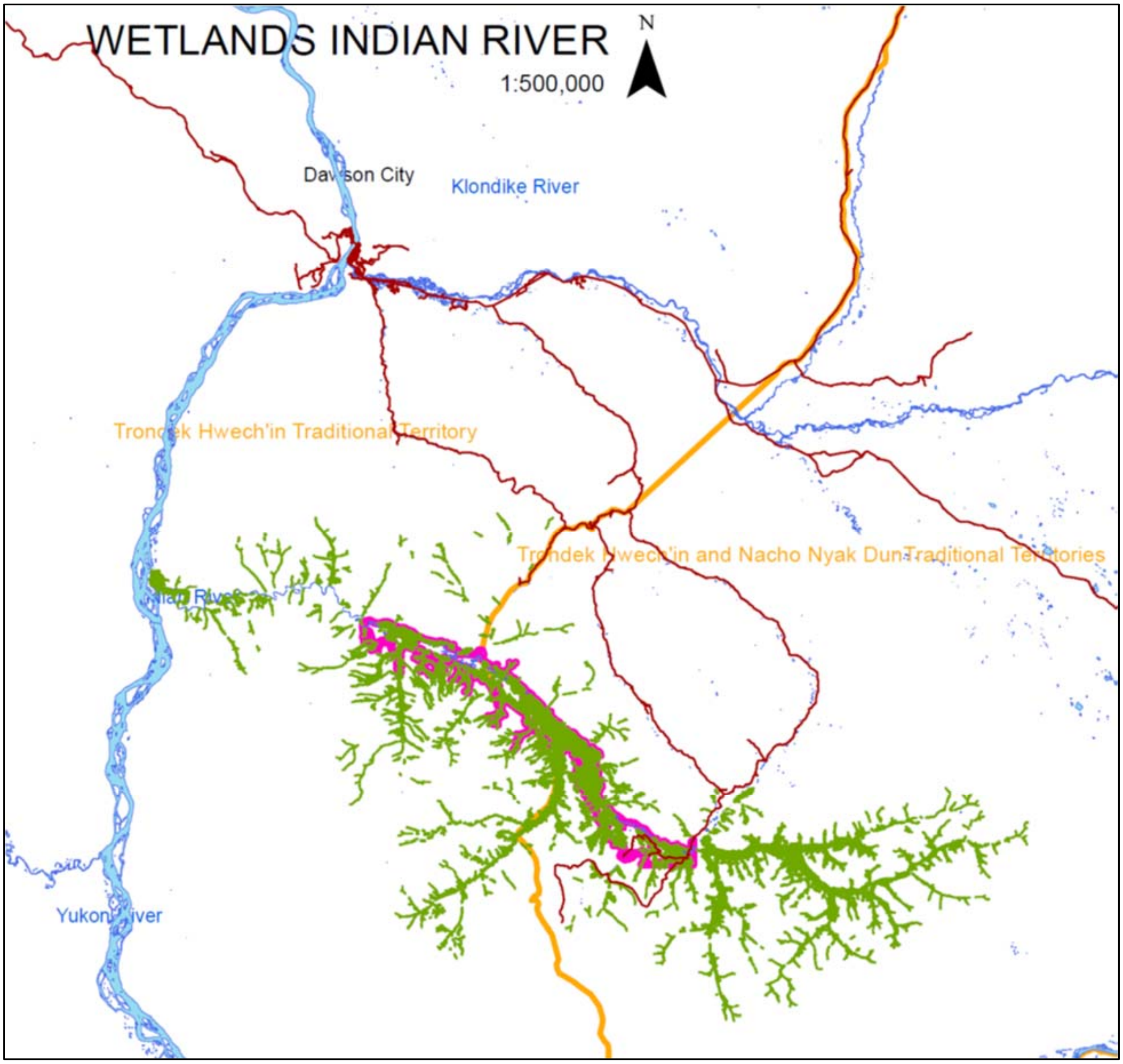


Figure 1. Original (pink) and Expanded (green) Mapping Study Areas within the Indian River Valley

1.2 Wetlands Overview

Wetlands are lands that are saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity that are adapted to a wet environment (Canadian Wetland Working Group 1998).

Wetlands, fens, swamps, bogs, marshes and shallow water are common throughout much of the undisturbed portions of the Indian River valley. These wetlands are the focus of this mapping project. Shallow water, marsh and swamp wetlands found in the disturbed and mined portions of the valley (Chevreux and Clarkson 2015) have not been mapped as part of this project.

Wetlands are found on the fluvial and glaciofluvial terraces above the river, as well as in the drainages and fans that drain the surrounding uplands. They are also found on the current floodplain of the Indian River, which is incised into older fluvial and glaciofluvial sediments. Based on the distribution of old meander scars and abandoned oxbows, the modern river channel appears to be gradually migrating towards the north side of the valley (Bond, pers. com.) leaving broad areas of fen, swamp and bog wetlands south of the current river. There are also wetlands found on the north side through the central part of the map area. Peat ranges from about 0.2 to more than 1.3 meters deep, based on representative, hand-dug soil pits or hand-auger holes excavated in association with this project. The deepest peat appears to be located on the old floodplain south of the Indian River. Where the peat fills old oxbows, the peat is likely even deeper. Wetlands extend along most of the tributary valleys draining the uplands south and east of the main Indian River valley.

The most common mapped wetland classes are fens and swamps. Wetlands are dynamic ecosystems, however, and natural transitions from one wetland class to another, from wetlands to non-wetlands and non-wetlands to wetlands commonly occur over decades to centuries. Disturbances, both natural (fire, succession, flooding, changes in hydrology, climate change) and human-generated (trenching, regrading, drainage alteration, vegetation disturbance, vehicle travel), can alter natural conditions, and the succession within and adjacent to the disturbance. Permafrost, widely distributed in the wetlands mapped, is particularly sensitive to any change.

2 Methods

2.1 Desktop Methods

The wetland mapping project began by compiling and reviewing the available data including surficial geology mapping, preliminary draft wetland mapping by Jeff Bond (Yukon Geological Survey (YGS)), permafrost probability mapping (Bonnaventure and Lewkowicz 2012), and geological reports. Mapping commenced once the available data, imagery and digital aerial photography were acquired.

High- (2009, 2010) and medium-resolution (2013, 2016) colour satellite imagery available from Geomatics Yukon covered the whole area with good correlation to the base map data (list of consulted imagery data sources included in Appendix A). This imagery was used in ArcMap to interpret, delineate and classify wetland polygons and adjacent upland habitats. The 2016 SPOT imagery, first available in February 2017, was used to interpret the additional map areas completed after that date and to delineate the extent of the highly disturbed mined areas throughout the whole study area. Aerial photograph stereo-imagery (1989, 1995) was reviewed, mainly in association with QA/QC checks of the draft mapping, but poor georeferencing of the photos (±25 m) relative to the satellite imagery and base mapping data precluded its direct use in polygon delineation. Interpretations were completed at a view scale larger than 1:10,000 (e.g., up to 1:5,000) to allow map production at a scale of 1:10,000.

2.1.1 Polygon Classification

A flow chart outlining the stepwise procedure used to interpret and map wetlands and adjacent upland habitat is provided in Figure 2. Polygons were classified according to cover type class according to the Yukon Vegetation Inventory Manual (Energy, Mines and Resources, 2014). If polygons represented disturbed anthropogenic landforms where major landform alteration had occurred, no further classification was completed.

The undisturbed portion of the landscape was further classified. Wetland polygons were distinguished by wetland class throughout the whole Indian River watershed excluding the watershed of the historically mined Sulphur, Dominion and Gold Run Creeks. Upland areas under placer claim within the original study area were classified according to the tree species present or, in the case of non-forested polygons, by physiognomic class (Yukon Vegetation Inventory 2014). Figure 2 illustrates the general work flow and, when viewed in conjunction with the information presented below, codifies the mapping procedure.

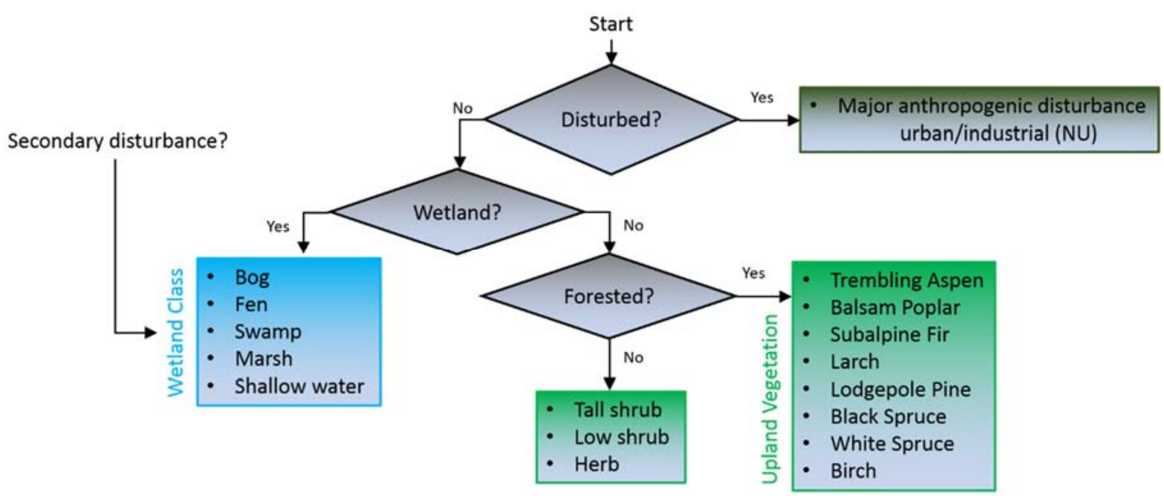


Figure 2. Systematic Procedure for Mapping and Classifying Wetlands and Adjacent Upland Habitat in the Indian River Valley

The following fields are characterized for each polygon, where applicable:

Cover type – The cover type class was interpreted for each polygon (Energy Mines and Resources 2014). The classes mapped include:

Code	Cover type class	Description
NU	industrial/urban	Anthropogenic landform. Developed land such as municipalities, mines and gravel pits
NW	water	Lakes and rivers. Includes wider portions of Indian River; no lakes were present within the study area.
VF	vegetated forested	Polygons with greater than or equal to 10% tree cover
VN	vegetated non-forested	Polygons with less than 10% tree cover
BR	bedrock	Steep bedrock exposures

Wetland Class – Each polygon was also classified as a wetland or upland (National Wetlands Working Group 1997). The wetlands were classified as 1 of 5 classes, or in some cases as a complex of 2 or 3 wetland classes where they could not be differentiated due to the scale of mapping. If more than one class is indicated, the proportion of each class (decile) is also indicated:

Code	Wetland class
B	bog
F	fen
S	swamp
M	marsh
W	shallow water (<2 m deep)

Upland Vegetation – Uplands were classified by tree cover and the relative proportion (decile) of each species within a polygon, or by the non-forested class for non-forested polygons (codes are from Energy Mines and Resources 2014):

Code	Upland vegetation (tree species/non-forested class)
Sw	White spruce [1]
Sb	Black spruce [1]
A	Aspen
B	Balsam poplar
W	Alaska birch
TS	Tall shrub
LS	Low shrub
HE	Herbaceous

[1] Many areas on the floodplain of the Indian River and some lower slopes appear to consist of a mixed tree cover of black and white spruce and hybrids (similarly noted from other parts of central Yukon, Bennett, pers.com.). The tree cover in these locations has been noted as **SwSb** or **SbSw** with no corresponding % cover indicator.

Disturbance – Two degrees of disturbance are represented in the mapping. Highly disturbed polygons, where major land alteration has occurred, include features such as mined pits, overburden piles, tailings ponds, and recontoured landscapes. Such highly disturbed areas have been assigned a cover type class of NU, in addition to being identified as Disturbed (D) in the digital database. Disturbances also includes areas of more subtle changes such as clearing, extensive vehicle tracks, and changes to natural drainage patterns, which have resulted in changes to the wetland polygon. Such modestly disturbed areas are identified solely by a D in the Disturbed Field.

Code	Disturbed?
D	Minor disturbance by anthropogenic activities to vegetation and/or soils at surface, but with limited to no alteration to the underlying materials/landforms such as is the case for polygons classified as NU
	Polygon is largely undisturbed (no code assigned)

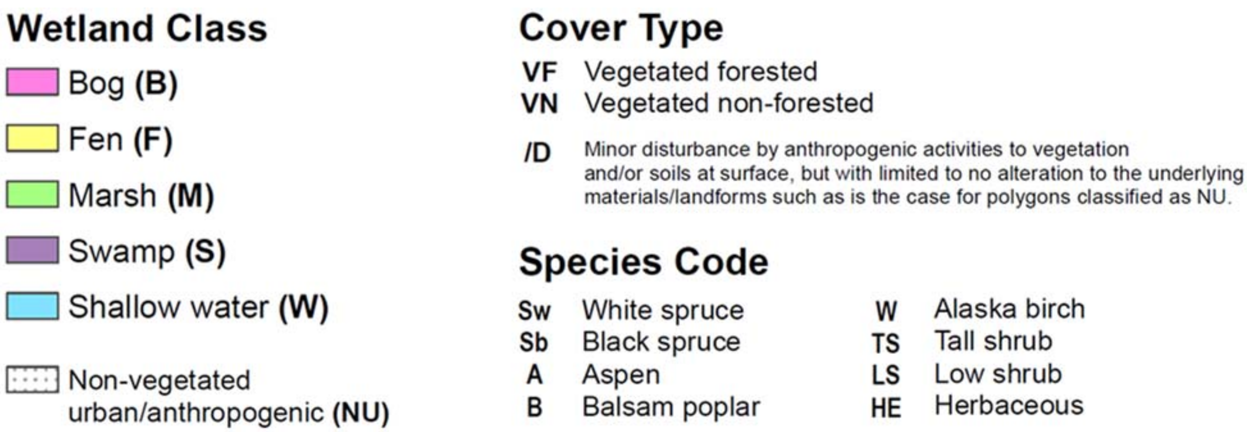
Table 1 summarizes the key factors that distinguish different wetland classes.

Table 1. Key Factors Distinguishing Different Wetland Classes

Wetland Class	Site/Terrain	Moisture	Soils	Overstory Vegetation	Groundcover Vegetation
BOGS	Low terraces along river, surrounded by fen	SMR 6-7; may appear dry on surface	Poorly decomposed peat; permafrost; Fibric Organic Cryosols	Open to sparse stunted black spruce; low shrub cover of Labrador tea, shrub birch	Sphagnum moss and Cladina/Cladonia lichen
	Steep north facing slopes at edge of valley	SMR 6; may appear dry at surface	40-60 cm poorly decomposed peat; permafrost; Terric Fibric Organic Cryosols	Open to sparse stunted black spruce; low shrub cover of Labrador tea, shrub birch	Sphagnum moss and Cladina/Cladonia lichen
FENS	Gently sloping terraces along river and drainages	SMR 6-8	Variable depth of peat from 20 cm to greater than 1 metre	Extensive shrub cover willow, shrub birch, Chamaedaphne, Labrador tea; sparse black or white spruce	Sedge tussocks (*Eriophorum vaginatum* and *Carex lugens*)
	Old meander scars or channels along old trails	SMR 6-8; water table often at surface	Greater than 40 cm poorly decomposed peat; deep active layer often greater than 1 metre	Few trees or shrubs	Sedges dominated by *Carex aquatilis*, *C. utriculata*
SWAMPS	Adjacent to river or oxbows	SMR 6-7; signs of fluctuating water table within about 30 cm of surface	Mineral soils; Gleyed Regosol or Gleysol soils	Dominated by willow and alder and some balsam poplar	Horsetails, groundcover may be sparse
	Adjacent to river or oxbows	SMR 6-7; signs of fluctuating water table within about 30 cm of surface	Mineral soils, permafrost usually present; moderately well decomposed peaty surface horizon may be present	Decadent white and/or black spruce; willow, Labrador tea understory may be present	Moss, horsetails
	Gently sloping terraces often between fens and uplands	SMR 6-7; signs of fluctuating water table within about 30 cm of surface	Mineral soils, permafrost usually present; moderately well decomposed peaty surface horizon may be present	White or black spruce with willow, Labrador tea understory	Mixed groundcover of moss, ground shrubs, lichen, sparse tussocks, *Tomenhypnum nitens*, Sphagnum moss
MARSHES	In oxbows near rivers	SMR 7-8; frequently flooded	Mineral soils; Gleysols	Trees and tall shrub cover less than about 10%	Dominated by sedges, horsetails, wetland plants
SHALLOW WATER	In old oxbows or old test pits; may also be found adjacent to placer mining disturbance	SMR 9	Stable water regimes usually have limnic peat or limnic peat interspersed with mineral sediments	-	Emergent and submergent aquatic plants

2.2 Map Legend

Map symbolization was designed to highlight the distribution and classification of wetlands. Each of the five wetland classes was represented by a standardized colour. Non-vegetated urban/anthropogenic disturbance areas were shaded lightly (transparent white) and denoted using a stippled pattern; other uplands are only shaded lightly. Labels were used to differentiate cover types and distinguish different species by codes. Complexes are indicated by the proportion of each component (decile). The final depiction of wetlands, cover types and species codes is included below.



2.3 Field Work

Ground truthing (field checking) of the preliminary desktop interpretations was undertaken within the original mapping area along the mainstem Indian River from Dominion to Ophir Creek in September 2016. The mapping area was expanded in 2017 to the lower Indian River, as well as southern tributaries including Ruby, McKinnon, Montana, Eureka, Wounded Moose and Australia Creeks. The additional map area was field checked in July 2017. The historically mined northern tributaries - Sulphur, Dominion and Gold Run Creeks - were not mapped.

Early fall is a good time of year to study soils in permafrost regions, to determine the depth of the peat and active layer, and to examine as much of the soil as possible with a hand auger at the time of maximum thaw. The vegetation is slightly more challenging to identify in September as many plants have gone to seed at this time of year. However, because the focus of the project was to map wetland class and not to identify rare species occurrences or to provide detailed vegetation lists, September field work is appropriate and was undertaken in 2016. Field work in 2017 was undertaken in July, which is a better time to identify plants, though not optimal for sampling the maximum depth of the active layer in permafrost areas.

Thanks to Schmidt Mining, the field crew consisting of Karen McKenna (project lead and wetland mapper) and Dirk Janas (vegetation ecologist) had excellent accommodation and food at the Schmidt placer mining camp on Quartz Creek in 2016. The camp provided easy access to the Indian River valley. Most areas were accessed by truck along placer mining roads and foot traverses. In 2016, seven days were spent checking as many polygons and wetlands as possible in the accessible mined areas along the main stem of the Indian River. In 2017, the same field crew of Karen McKenna and Dirk Janas completed additional field checks by truck of wetlands and upland habitats accessible from mining roads in the main valley and tributaries. The crew also paddled the lower Indian River from near the mouth of Ruby Creek to the Yukon River, which allowed access to numerous wetland sites along the lower reaches of the river.

In 2016, YGS' Jeff Bond and Syd Van Loon provided the opportunity for a helicopter overview flight to access parts of the valley inaccessible by road, take photographs of the valley from oblique aerial perspectives, identify limits of the most recent placer development (since acquisition of the 2013 satellite imagery) and check wetland delineations from the air. A helicopter overview flight with Trans North was undertaken in July 2017 with Dirk Janas to check map designations and complete ground checks in remote reaches of the tributaries. Even with a helicopter, however, it is difficult to access wetlands in the Klondike region. Metre-high shrubs and 2-5 m-high spruce are widespread throughout most of the wetlands and uplands of the Indian River watershed, which makes safe landing sites a rarity.

Most of the field data were compiled on Yukon Environment's site visit and vegetation forms, including GPS location, terrain factors, important soil characteristics, wetland class and detailed vegetation lists and cover (sample form in Appendix B). It was decided that the forms provided a good summary of the data required to distinguish different wetland classes and assist with understanding and describing the wetland classes. Data collected included tree, shrub and graminoid cover, depth of peat, depth to water table and depth to permafrost. pH was also measured at numerous locations to help classify the wetlands. The forms also provided a good way to standardize the data collection. Notes, photographs and quick checks were made at additional sites, recorded by waypoint locations. The site visit plot data was entered to Environment Yukon's Yukon Biophysical Information System (YBIS) to be stored and where it can be used for Environment Yukon's future ecosite and wetland classification of the Klondike Region.

Numerous stakeholders were interested in accompanying the field crew to gain an introduction to the wetlands and the methods used for the mapping. Interested parties were invited to visit the wetlands on two separate days in 2016 following the originally planned field work. Randy Clarkson (KPMA), Adam Thom (THFN), Jeff Schuyler, Johnny Nunan, Tyson Bourgard (Compliance Monitoring and Inspections EMR, Dawson City), Bruce McLean, John Ryder, (Environment Yukon - Whitehorse), Mike Suitor (Environment Yukon - Dawson City) and Katie Fraser (YESAB - Dawson City) all spent a day assisting with additional data collection and becoming more familiar with the wetlands in the Indian River valley and the mapping process.

A sincere thank you is extended to all the placer miners who provided access to their claims.

2.4 Final Mapping

During the winter of 2016-2017, the main Indian River valley was reinterpreted based on the 2016 field work. Preliminary mapping was extended to the lower Indian River and southern tributaries. Following the 2017 field work, the mapped polygons were reinterpreted and refined based on the data and knowledge gained from the two seasons of field work. The mapping includes wetlands throughout all the tributary valleys of the valleys. Polygons were extended where possible to the boundaries of the placer claims along each creek throughout the complete area.

2.4.1 Limitations of the Mapping

The wetland map of the Indian River valley reflects the best interpretation possible based on the available imagery and aerial photographs, and the experience of the interpreter. The mapping does not include the part of the Indian River watershed upstream of the confluence of Sulphur and Dominion Creeks.

Even at a mapping scale of 1:10,000, inclusions of non-wetland may be included in a wetland polygon and vice versa due to inherent landscape heterogeneity at that scale. Inclusions of different wetland classes may also be found within polygons mapped as another class. Some small and/or narrow wetlands may not be mapped. In addition, some areas may be misinterpreted or mismapped due to the complex interaction between different site factors that are visible on the available imagery and differences between different images. Some wetlands may actually be larger or smaller than they appear on the map.

Mapping is dependent on how the vegetation cover is reflected in the imagery. The imagery coverage available is excellent. The 2016 SPOT imagery covering the whole area is very good for identifying wetlands. In some cases, however, the older, higher-resolution GeoEye imagery from 2009 and 2010 is better for distinguishing classes of wetlands and wetlands from uplands. Interpretation is more difficult in burned areas. Areas that were burned in a 2004 forest fire show significant shrub cover in wetlands and in uplands, complicating the distinction between wetlands and uplands. Distinguishing some swamps from moist upland polygons can be difficult even with the good quality available imagery. Field visits may be required to confirm site-specific classifications.

The mapping represents a snap-shot in time of wetland type and distribution in the valley, in this case in 2016 with refinements based on 2016 and 2017 field observations and a review of available 2016 imagery coverage.

3 Description of Wetland Classes

The definitions of wetland classes in the following paragraphs are simplified from those provided in *The Canadian Wetland Classification System* (National Wetlands Working Group, 1997). The descriptions and discussion of the distribution of each class of wetland are based on CryoGeographic's field work in September 2016 and July 2017.

3.1 Bogs

Bogs are peat landforms characterized by a surface raised above the surrounding terrain, receiving water from precipitation but virtually unaffected by any groundwater flow. The pH of the soil and soil water is low, usually less than pH 4.8. The surface of the bogs is usually fairly dry (usually providing much easier walking than other wetland classes).

Bogs are sparsely mapped in the study area. Typically, Yukon bog soils are frozen close to the surface, though the bogs investigated in September 2016 were generally found to be unfrozen to 60 to 100 cm. Many of the bogs investigated had wetter parts within them. Bogs in the Indian River valley are usually characterized by stunted black spruce vegetation, *Sphagnum fuscum* moss and, on the driest undisturbed sites, a high *Cladina* lichen cover. Other species such as Labrador tea, bog cranberry, cloudberry, low bush cranberry and crowberry are also typical. Pocket depressions within the drier bog may consist of Sphagnum capillifolium, S. girgensohnii, brown mosses and various sedges.

Bogs are found in two different landscape positions in the Indian River valley. They are associated with deep peats on old river deposits, usually surrounded by fens. They are also found on very steep, northerly aspects on the valley sides, where the cooler temperatures are associated with permafrost, slow decomposition of organic material and accumulation of peat under Sphagnum moss. The peat on these slopes is usually more than 30 cm thick but generally thinner than in the bogs on the valley floor. The black spruce lichen and Sphagnum community with Labrador tea, cloudberry and bog cranberry is similar to the vegetation on level bogs of the valley floor. Some input of more nutrient-rich groundwater appears to occur along the permafrost table where the base of the active layer peat has a higher pH than typical of bogs.

3.2 Fens

Fens are peatlands influenced by minerotrophic groundwater, rich in dissolved minerals, and thus have a higher pH and are more productive than bogs. Slow groundwater and sometimes surface water flow are characteristic. The water table is usually at or just below the surface, and peat is composed of moderately decomposed sedge or brown moss peat. Fens can range from rich fens, dominated by herbaceous vegetation, to poor fens, with lower pH and nutrients and with many species in common with bogs.

Fens are very common in the Indian River valley. The depth of peat in fens within the study area varies from about 20 cm to more than 2 m. The pH is typically in the range of 5.5 to 7. The ground vegetation of fens is typically dominated by sedge and moss communities. In the Indian River valley, the most extensive fens are characterized by sedge tussocks, which may be of two different species: Tussock cottongrass (*Eriophorum vaginatum*) and muskeg sedge (*Carex lugens*). There tends to be a transition between the driest fens, which may have black, white and hybrid spruce trees (Bennett pers. com.); to shrub fens with shrub birch, leatherleaf (*Chamaedaphne calyculata*), willow (Salix spp.) and sedge tussocks; to wetter fens dominated by sedge tussocks and fewer shrubs. The wettest fens occur in channels with more water flow and are usually dominated by *Carex utriculata*. The deeper peat (depth is difficult to assess where the soils are frozen) appears to be found on the old floodplain of the Indian River in old meander scars.

3.3 Swamps

A swamp is a tall shrub or tree dominated wetland (usually >25% cover of woody species) that is influenced by minerotrophic groundwater. Swamps are characterized by well decomposed woody peat and can be either peatlands or non-peatlands. They typically have a fluctuating water table.

Swamps are one of the most common wetland classes in the study area. On the Indian River floodplain, there are willow and alder shrub swamps adjacent to the river that are frequently inundated by flood water.

There are also coniferous treed swamps affected by a shallow water table and a shallow depth to permafrost. These may also be subject to flooding. The swamps are interspersed with white and black spruce riparian forest. The spruce trees in the swamps are usually slightly smaller and leaning ("drunken"), or with numerous dead branches, and the ground cover includes species indicating a shallow water table. Similar but narrow bands of coniferous treed floodplain forest and shrub swamps are also found along smaller tributary creeks.

Another type of swamp is found along the margins of the fens on the higher terraces where the black spruce coniferous swamps transition to adjacent uplands. These swamps generally have taller trees and a denser tree canopy than the tussock fens, however growth is severely limited by excess water and underlying permafrost. These swamps are also slightly drier than fens, with more shrubs and lichen, but still show some cover of sedge tussocks.

3.4 Marshes

A marsh is a minerotrophic wetland with a near-surface water table that fluctuates daily, seasonally, or annually. Water levels may vary from year to year. Marshes are characterized by herbaceous sedge, grass or forb vegetation.

Marshes are not widespread in the study area but are common in recently abandoned meander channels of the Indian River. Grasses dominated by *Calamagrostis canadensis*, diverse sedges including *Carex utriculata, C. aquatilis*, and *Scirpus* sp., *Juncus* sp., and *Equisetum fluviatile* are typical dominant species in these marshes with occasional small willow shrubs.

3.5 Shallow Water

Shallow water wetlands have standing or flowing water less than 2 m deep in mid-summer. Shallow water wetlands are transitional between seasonally wet (i.e. bog, fen, marsh or swamp) and permanent, deep water bodies. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts, low flows or intertidal periods. Shallow waters are subject to aquatic processes typical of upper limnetic or infralittoral lake zones, such as nutrient and gaseous exchange, oxidation and decomposition.

The shallow water wetland class excludes artificial water bodies (reservoirs, impoundments and dugouts), where water regimes have been manipulated. As such, *active* tailings ponds, with controlled inputs and outputs, have not been mapped as shallow water wetlands. *Abandoned* tailings ponds that appear to be less than 2 m deep and are subject to natural aquatic processes typical of upper limnetic or infralittoral lake zones have been included.

Shallow waters are variously called ponds, pools, shallow lakes, oxbows, sloughs, reaches or channels. They may occupy portions of larger wetlands or bays and margins of profundal lakes. In the Indian River valley, these wetlands may be surrounded by fens, marshes, swamps and/or riparian forest. Aquatic submergents, such as pondweeds and bladderworts, and emergent, including sedges, cattails and rushes (*Juncaceae*), usually characterize the vegetation.

4 References

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Appendix A

Imagery Data Sources Consulted

HIGH RESOLUTION SATELLITES:

Acquisition Date: 14-Jul-2009
File Name: GeoEye_Klondike_88_1_0-4_50cm_14July2009_NAD_1983_UTM_Zone_7N
Sensor: GeoEye-1
Project Area: Klondike Region
Pixel Resolution (m): 0.5
Cloud Cover (%): 40
Horizontal Accuracy (m): 1.5
Licensee: Yukon government

Acquisition Date: 25-Jul-2009
File Name: GeoEye_Klondike_88_0_1-6_50cm_25July2009_NAD_1983_UTM_Zone_7N
Sensor: GeoEye-1
Project Area: Klondike Region
Pixel Resolution (m): 0.5
Cloud Cover (%): 35
Horizontal Accuracy (m): 1.5
Licensee: Yukon government

Acquisition Date: 03-Aug-2010
File Name: GeoEye_Klondike_97_0_0-3_50cm_03Aug2010_NAD_1983_UTM_Zone_7N
Sensor: GeoEye-1
Project Area: Klondike Region
Pixel Resolution (m): 0.5
Cloud Cover (%): 55
Horizontal Accuracy (m): 1.5
Licensee: Yukon government

MEDIUM/LOW RESOLUTION SATELLITES:

Acquisition Date: 07-Oct-2016
File Name: SPOT6_IndianR_RGB_150cm_07Oct2016_NAD_1983_UTM_7N
Sensor: SPOT-6
Project Area: Indian River Disturbance Updates (2016)
Pixel Resolution (m): 1.5
Cloud Cover (%): 0
Horizontal Accuracy (m): 3
Licensee: Yukon government

Acquisition Date: 07-Oct-2016
File Name: SPOT6_IndianR_rgba_150cm_07Oct2016_NAD_1983_UTM_7x
Sensor: SPOT-6
Project Area: Indian River Disturbance Updates (2016)
Pixel Resolution (m): 1.5
Cloud Cover (%): 0
Horizontal Accuracy (m): 3
Licensee: Yukon government

Acquisition Date: 08-Oct-2016
File Name: SPOT6_IndianR_RGB_150cm_08Sep2016_NAD_1983_UTM_7N
Sensor: SPOT-6
Project Area: Indian River Disturbance Updates (2016)
Pixel Resolution (m): 1.5
Cloud Cover (%): 0
Horizontal Accuracy (m): 3
Licensee: Yukon government

Acquisition Date: 09-Oct-2016
File Name: SPOT6_IndianRiver_RGB_150cm_09Oct2016_NAD_1983_UTM_Zone_7N
Sensor: SPOT-6
Project Area: Indian River Disturbance Updates (2016)
Pixel Resolution (m): 1.5
Cloud Cover (%): 0
Horizontal Accuracy (m): 3
Licensee: Yukon government

Acquisition Date: 13-Jul-2013
File Name: SPOT6_Klondike_13July2013_utm7
Sensor: SPOT-6
Project Area: Klondike Region
Pixel Resolution (m): 1.5
Cloud Cover (%): 0
Horizontal Accuracy (m): 1
Licensee: Yukon Government

Acquisition Date: 16-Aug-2007
File Name: SPOT5_GY_KlondikeRiverValley_16Aug2007_pan_UTM7
Sensor: IRS
Project Area: Klondike River Valley
Pixel Resolution (m): 5
Cloud Cover (%): 0
Horizontal Accuracy (m): 1
Licensee: Yukon Government

Acquisition Date: 10-Sep-2000
File Name: IRS_IndianRiver_Klondike_pan_20000910_albers
Sensor: IRS
Project Area: Indian River
Pixel Resolution (m): 5
Cloud Cover (%): 0
Horizontal Accuracy (m): 5
Licensee: Yukon Government

AERIAL PHOTOGRAPHS:

Acquisition Date: 01-Jul-1989
Name: ocPan_ortho_115O11_1989_albers
Sensor: Unknown
Project: Yukon - Central Region
LowPS: 1.5
Cloud Cover (%): 0
Horizontal Accuracy (m): 3
Licensee: Public

Appendix B

Field Form Sample

Yukon Environment

SITE VISIT FORM

Project | Plot No. | Plot Level: ☐G ☐V

Date: YYYY-MM-DD | Plot Type: ☐ Standard ☐ Noveg ☐ Irreg | Field No. | Observer(s)

NTS map | Location

Northing | Easting | UTM Zone | YBEC

Lat N | Long W | Accur (m) WGS84 ☐ ____ | Polygon No.

Site Features | Elev (m) | Aspect (°) | Slope % | Surface Shape ☐ CV ☐ CX ☐ ST ☐ UN

☐ Crest ☐ Upper ☐ Mid ☐ Lower ☐ Toe ☐ Level ☐ Dep. ☐ Gully | Flood plain? ☐ | SMR | SNR

Site Disturb. ☐ None ☐ Veg. Removal ☐ Soil Dist. ☐ Plant Gather ☐ Fire ☐ Biotic ☐ Terrain ☐ Water ☐ Other ____

Expose. Type ☐ None ☐ Insolation ☐ Wind ☐ Snow ☐ Water Spray ☐ Frost ☐ Cold Air ☐ Aufeis ☐ Rain Shadow ☐ Other ____

Stand Attributes Stand Age ____ ☐ Est. ☐ Mea. | Canopy Composition
Stand Ht. ____ ☐ Est. ☐ Mea.
Structure ☐1 ☐2a ☐2b ☐2c ☐2d ☐3a ☐3b ☐4 ☐5 ☐6 ☐7a ☐7b ☐8

Plot Representing

Wetland Class | Veg Assoc.

Ecosite | Map Label

Terrain	Texture	Surficial Material	Surface Expression	Geo. Process	Rock Types
1.					1.
2.					2.

Rooting Zone

Drainage ☐ VR ☐ R ☐ W ☐ MW ☐ I ☐ P ☐ VP

Humus/Organic Form ☐ Mor ☐ Moder ☐ Mull ☐ Fibric ☐ Mesic ☐ Humic

Humus thickness ____ cm | ☐ Ah? ☐ Ae? ____ cm | Est. soil depth ____ cm

Depth to: (cm) | Min Soil | Wat. table | Seepage | Mottle/gley | Restrict. | ☐ None

Rest. Type ☐ Cement ☐ Pan ☐ Kompact ☐ Water ☐ Lithic ☐ CaCO3 ☐ Frost

R.Z. Soil Texture | R.Z. Coarse Fragment % | Estimated Rooting Depth ____ cm

Comments

YG(6329E)F2 06/2016