Analyzing historic drilling data to investigate gold distribution on lower Hunker Creek and Klondike River

Sydney van Loon
Yukon Geological Survey

van Loon, S., 2019. Analyzing historic drilling data to investigate gold distribution on lower Hunker Creek and Klondike River. *In:* Yukon Exploration and Geology 2018, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 111–126.

Abstract

The Yukon Consolidated Gold Corporation (YCGC) tested, mined, and documented placer gold resources in the Dawson region from 1923 to 1965. The company was established to acquire the holdings of other dredging operations and smaller companies in the Klondike, and during the time it was active in Yukon, YCGC produced a robust collection of maps and textual documents including drilling results, dredge reserves, thawing and stripping layouts, and dredging limits.

This paper uses historic YCGC data to summarize gold distribution characteristics in Hunker Creek and builds upon previously published summaries of YCGC data. Attributes of 1005 YCGC drill holes and shafts along lower Hunker Creek and a short section of the Klondike River were digitized, compiled, and analyzed in a Geographical Information System (GIS). A raster analysis of the digitized data allows for interpretation and examination of surficial material thicknesses and gold distribution in the project area and identifies potential prospects for further exploration.

* sydney.vanloon@gov.yk.ca

Introduction

Yukon Consolidated Gold Corporation (YCGC) operated in the Klondike for four decades (from 1923 to 1965) conducting mining operations and evaluating placer gold potential in many of the region's drainages. Technical staff at YCGC produced a robust collection of maps and textual documents including drilling results, dredging limits, dredge reserves, and thawing and stripping layouts during the time the company was active in Yukon. The exploration and mining data recorded by YCGC continues to assist modern mining activities in prominent gold-bearing drainages including Hunker, Bonanza, Quartz, Dominion and Sulphur creeks. Despite the vintage of these data, records from drilling conducted nearly one hundred years ago are thorough and a valuable tool for evaluating placer ground being mined today.

Bringing historic drill hole data and dredge limits into digital formats can assist the placer mining industry in unearthing new exploration targets. As shown in previous compilations (van Loon, 2016, 2017), translating paper records into a Geographical Information System (GIS) allows for a variety of spatial analyses that are difficult with paper maps and records. Placer potential can be identified through trends in gold distribution and surficial material thickness visible on raster maps that highlight tributary gold inputs, economic values in previously worked areas, and valley margins outside of dredge limits that may include unmined side pay and intermediate-level terraces.

Project Area

The project area (Fig. 1) is a 15 km-long stretch of valley bottom extending from the mouth of Colorado Creek, a left limit tributary of lower Hunker Creek, downstream to the mouth of Bear Creek in the Klondike River valley. Point and polygon data have been compiled from 31 historic YCGC maps dating from 1910 to 1958 (see references for YCGC file details); 1005 drill holes and shafts, and 25 km^2 of individual/isolated dredged area polygons have been digitized (Fig. 2). Of the 1005 drill holes and shafts, 83 are located on Dago and Paradise hills, which along with Australian Hill, are high-level White Channel benches perched above the modern Hunker Creek valley.

Hunker Creek has been a top producing placer creek since the discovery claim was first staked in 1897. Since then, the drainage has undergone extensive prospecting, drilling, dredging, cat mining and modern mining activities. More than 1.8 million crude ounces have been recovered from Hunker Creek and its respective tributaries since 1897. Dredge operations were active in the main stem of the drainage from 1908 to 1966 and produced more than 450,000 crude ounces.

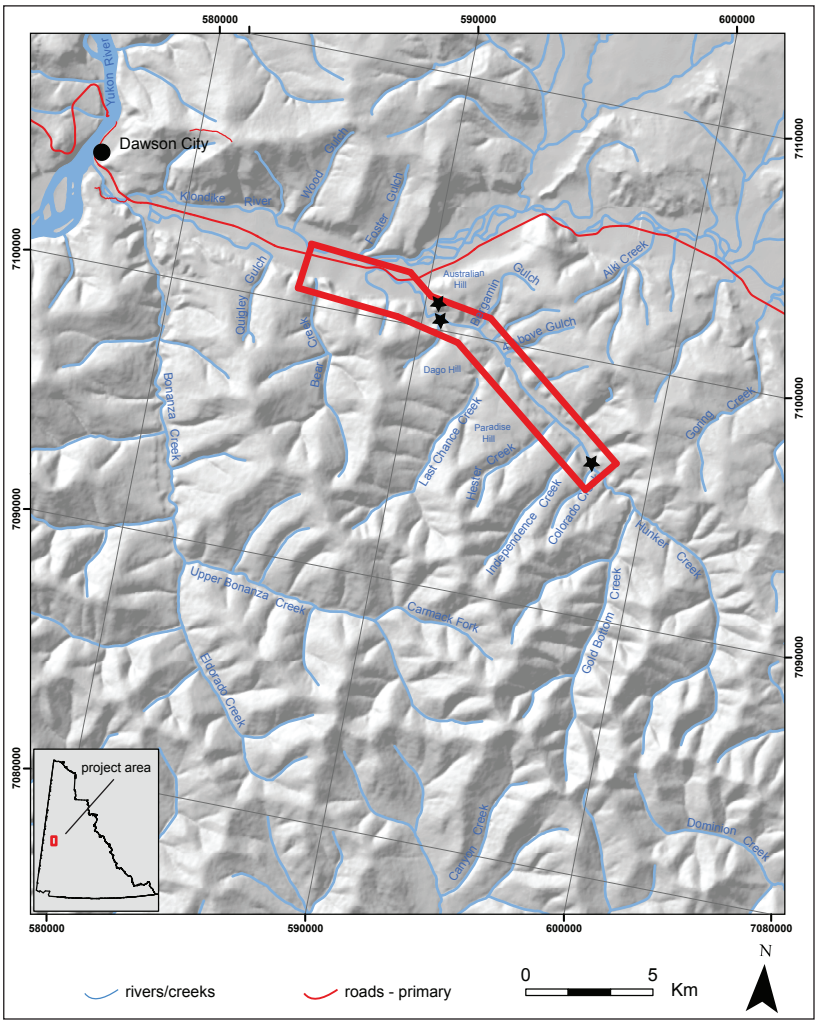

Figure 1. *Project area southeast of Dawson City on lower Hunker Creek and Klondike River valley; black stars indicate highest grades recovered from the YCGC drilling data set.*

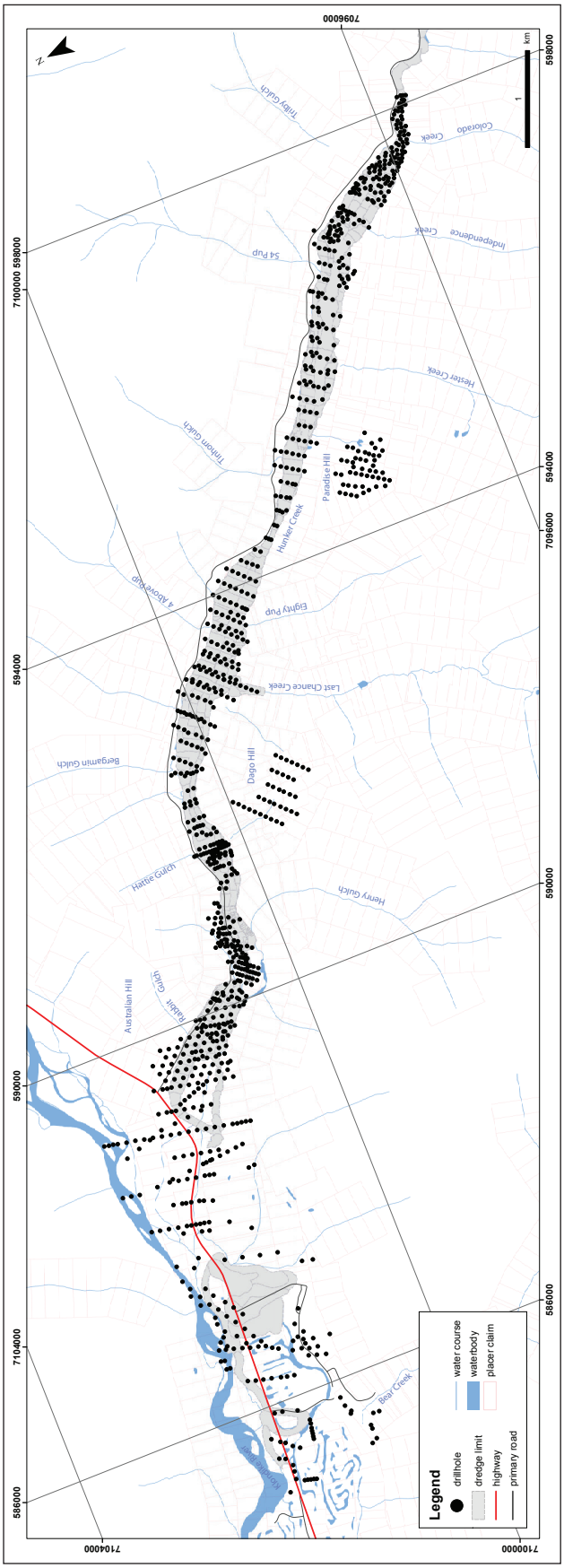

Figure 2. *Hunker Creek and Klondike River valley project area including YCGC drill holes and shafts (black dots) and dredge limits in grey.*

In 2018 a total of nine placer mines were sluicing in the project area, including operations in the modern valley, on intermediate-level terraces, in tributaries, and on high-level White Channel benches. The Hunker Creek drainage basin continues to be a significant gold producer in Yukon, with a total of 5,630 crude ounces reported in 2018 (as of December 12, 2018). The Klondike River has also undergone significant mining activities in the past, producing more than 275,000 crude ounces of gold since the 1930s (YGS, 2010).

Placer gold from Hunker Creek, and its principle tributaries Last Chance and Gold Bottom creeks, is variable in fineness and characteristics. Upper reaches of Hunker Creek range in fineness from 798 to 859, the middle reaches from 725 to 820, and the lower reaches from 701 to 726 (YGS, 2010). Benches in the lower reaches of the drainage also have variable fineness, with Australian Hill ranging from 850 to 860, Dago Hill from 798 to 859, and Paradise Hill from 735 to 802 (YGS, 2010). Gold characteristics in the drainage range from coarse to fine, with coarser components recovered from the major left limit tributaries of Hunker Creek.

Geologic Setting

The project area is primarily underlain by metamorphic rocks of the Yukon-Tanana terrane, largely Klondike schist, but also includes Finlayson assemblage metasedimentary rocks, Slide Mountain assemblage ultramafic rocks and Carmacks Group volcanic rocks (YGS, 2018). The Klondike schist is represented by quartzite, quartz-muscovite-chlorite schist, gneiss and amphibolite. The Finlayson assemblage consists of dark grey to black carbonaceous rocks including quartzite, graphitic quartzite and quartz-muscovite-chlorite schist. Slide Mountain assemblage structurally overlies the Klondike schist and comprises metamorphic igneous rocks which include dunite, peridotite and diabase. Volcanic rocks (andesite and porphyry) of the Carmacks Group are also present in outcrops along Last Chance Creek and on the right limit of Hunker Creek. The degree of bedrock weathering ranges from large blocky fragments to highly decomposed rock with pervasive clay alteration. Preserved mostly at high elevations in the Klondike, the White Channel gravel was deposited

at 2.6–3.3 Ma when a broad, meandering, gold-bearing paleo-Hunker River flowed up to 100 m above the modern Hunker Creek valley (Froese *et al.*, 2000; Westgate *et al.*, 2003).

A grey glacial outwash gravel known as the Klondike gravel occurs above, and is interbedded with the White Channel gravel in lower Bonanza, Hunker and Klondike valleys. Deposition of this gravel was *ca.* 2.6 Ma, when the most extensive advance of the Cordilleran Ice Sheet reached its maximum extent and initiated the establishment of the modern course of the Klondike and Yukon rivers (Hidy *et al.*, 2013). With the establishment of modern northward drainage, rapid incision occurred in Yukon River tributaries such as Bonanza and Hunker creeks (Lowey, 2004). The formerly broad and low-angled Hunker Creek drainage became increasingly incised into a narrow, bedrock entrenched valley, stranding high-level White Channel benches (Dago and Paradise hills) and establishing a number of intermediate-level benches above the modern valley floor.

Methods

Quality Assurance and Control (QA/QC)

As a large-scale enterprise scattered throughout the Klondike, YCGC collected vast amounts of geological information on a daily basis and there are many potential sources of error in these historic records. Transcription errors could have occurred from the field to the cartographer and resulted in incorrect values recorded on the original map. Additionally, the accuracy and reliability of location information is dependant on the accuracy of the data collector as well as the cartographer. When the historic data are brought into a modern GIS system, errors can be introduced both in geographical location information and raw data values that are manually entered into attribute tables. Once a series of drill holes and shafts have been digitized, QA/QC is required to identify any outlying locations or numbers that may represent errors in original documents or subsequent digitization. Outlying values and unrealistic calculations must be sensibly examined and should be removed from the data set to prevent skewing in raster analyses.

Conversions and Corrections

Calculations are required to convert this data set from imperial to metric, and to a modern grade that reflects the modern gold price. Overburden and dredge section thickness are converted from feet to metres, and modern grade is calculated based on today's average gold price of CDN$1,400. In addition to bulk unit conversions, other corrections and adjustments to the data set include:

- Gold distribution and surficial material thickness on high-level benches is calculated separately from the modern creek valley. Original YCGC records of drill holes and shafts located on high-level benches do not differentiate between overburden and dredge section thicknesses, therefore a 'total section thickness' is calculated for these records. As a result, data from the high-level benches are discussed separately from the modern valley.
- A drill hole with anomalously high gold values has been removed from the data set. Located at the mouth of Rabbit Gulch, on the right limit of Hunker Creek at the base of Australian Hill, the hole produced an historic grade of 3,360 cents/yd^3 (modern grade of $2,276/yd^3), which was 686% higher than the next highest value in the data set (490 cents/yd^3). As one of the richest holes drilled by YCGC, we consider its abnormally high value to be the result of the nugget effect.

Raster Analysis

A raster is a method used to display data where colours are used to represent information, such as gold grade. Raster surfaces are generated using a Spatial Analyst tool "Inverse Distance Weighting' (IDW) in ArcGIS. For this project area, two raster images were created from information associated with each drill hole; (1) grade raster and (2) surficial material thickness raster. High grades that form a continuous or semi-continuous linear feature are interpreted as pay channels representing the former thalweg of the stream. Using these linear features visible on the raster, pay channel characteristics, its location, and possibly gold contributors to the high-grade zones can be reconstructed.

Results

Modern gold grade calculated using the gold price of CDN$1,400/oz is displayed using raster data in Fig. 3, with red indicating areas of highest grade and green indicating lowest grade. The pay streak (in red) is disseminated and discontinuous throughout the modern valley bottom, and also occurs on the White Channel left limit benches. Increases in gold grade occur downstream of major tributaries including Hester, Independence and Last Chance creeks. The project area has been divided into three sections for ease of analyses: modern Hunker Creek valley, Klondike River valley, and left limit high-level benches on lower Hunker Creek.

Highest grades recovered from YCGC drill holes (indicated by black stars in Fig. 1) have been recovered at the mouth of Dago Gulch ($331/yd^3), the confluence of Colorado Creek and Hunker Creek ($322/yd^3), and the mouth of Rabbit Gulch on right limit Hunker Creek ($218/yd^3). Of the 1005 drill holes used in this study, 5% yielded grades greater than $50/yd^3. A significant number of drill holes (44%) resulted in grades ranging from $1 to $10/yd^3, and 10% of drill holes recovered grade between trace ($0.1) and less than $1/yd^3.

Modern Hunker Creek Valley

Concentration of the pay channel varies in the modern valley (Fig. 3), with high grades present at the mouth of most left limit tributaries. In the upper part of the study area, at the Colorado Creek confluence, the channel extends the width of the valley with a slight increase of grades on the left limit. Farther downstream, the broad pay streak narrows and remains in the centre of the valley bottom near the mouth of Independence Creek, and subsequently becomes disseminated and decreases in width as it remains pinned on the left limit of the valley. The pay channel remains intact on the high-level bench of Paradise Hill, approximately 85 m off the valley floor.

One of the areas of lowest grade in the project area is a 2.6 km-long section beginning 500 m downstream from the mouth of Hester Creek, to just upstream of the Last Chance Creek confluence, where grades range from $0 to $23/yd^3. Below Last Chance Creek the grades increase and the richest results were drilled at

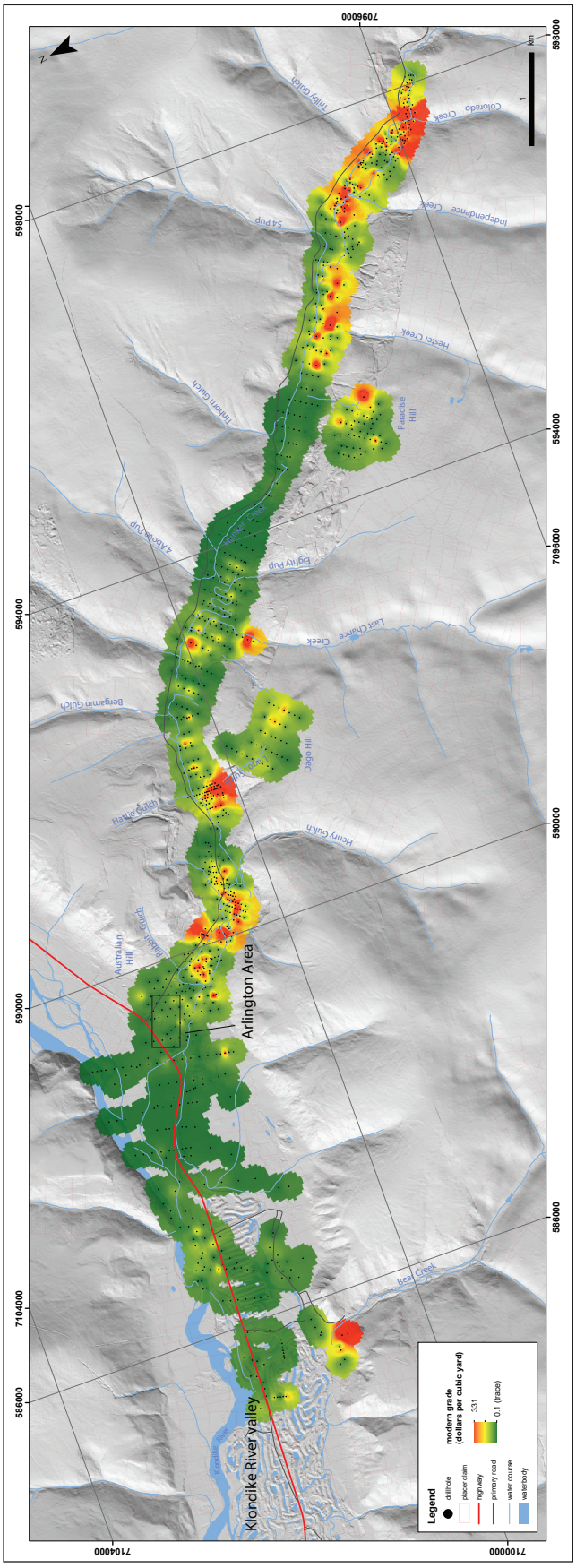

Figure 3. *Modern grade (calculated using the gold price at CDN$1,400/oz.); red colour indicates areas containing the highest gold value from drill hole results.*

the mouth of the left limit tributary, Dago Gulch. Farther downstream, the pay channel is well defined between Henry Gulch and Rabbit Gulch. The pay channel here appears to be up to 400 m in width, and to cross the valley in a diagonal direction from the left limit to the right limit.

No distinct pay channel is visible at the mouth of Hunker Creek where the drainage enters the broad Klondike River valley.

Klondike River Valley

Low gold grade values are present in the Klondike River valley (Fig. 4) where grades range from trace to $102/yd^3, with 86% of drill holes yielding between $0 and 10/yd^3. One hot spot is visible in lower Bear Creek, where values are as high as $102/yd^3. When grades were recalculated, assuming that most of the placer gold originated from a 1.8 m (6.0 ft) pay zone on the bedrock contact, areas of higher grade became apparent (Fig. 5). High-grade areas in this analysis include the mouth of Hunker Creek, on the north side of the Klondike River valley beside the modern river channel, and upstream from Bear Creek closer to the right limit of the Klondike River valley. Drill holes with no associated surficial material thickness were excluded from the recalculation (including the previous high visible at Bear Creek in Fig. 4).

High-Level Benches

Drilling occurred on the high-level benches on lower Hunker Creek in 1941 (Dago Hill) and 1916 (Paradise Hill). A total of 83 holes were analyzed, with drill hole

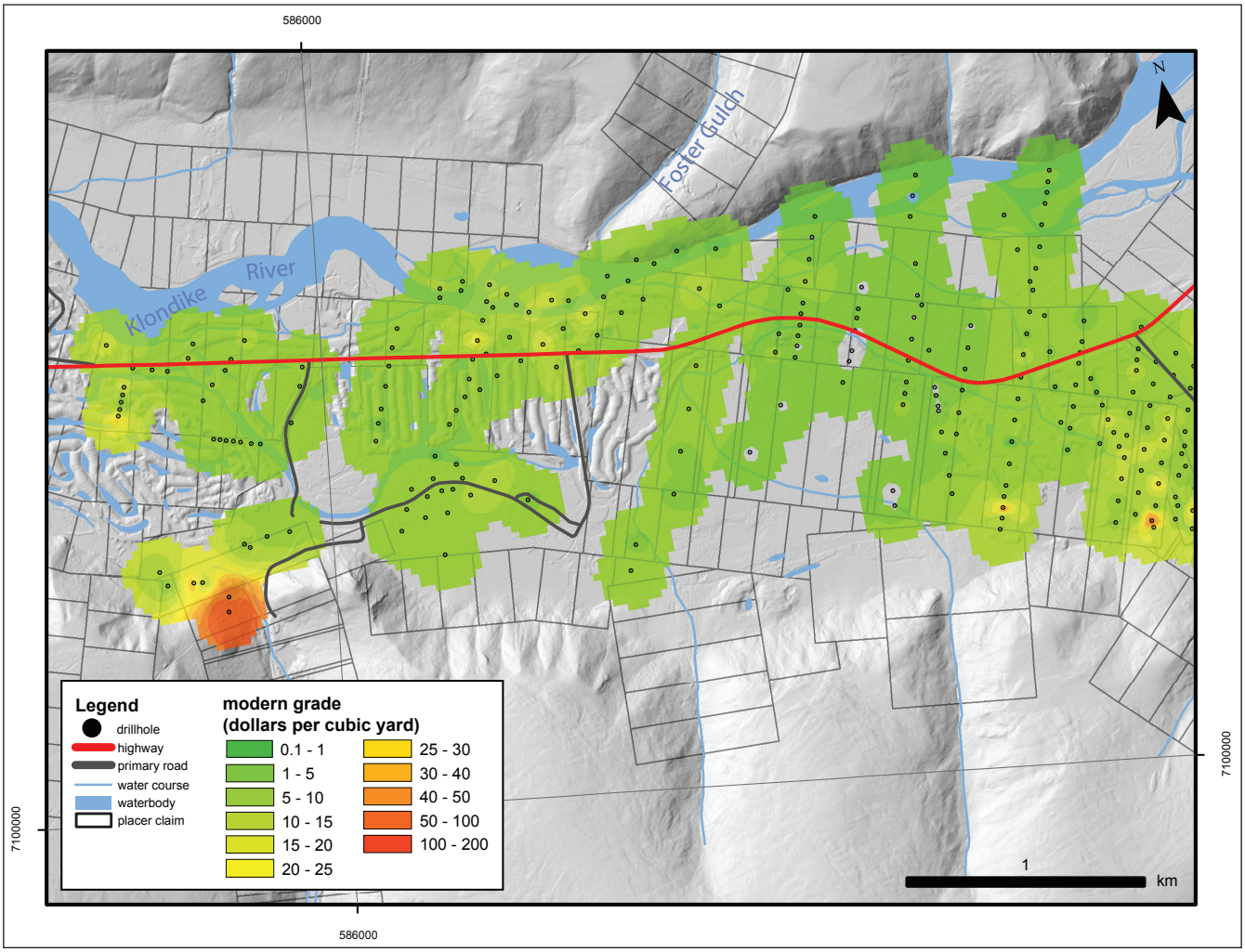

Figure 4. *Modern grade raster in the Klondike River valley; red colour indicates areas containing the highest gold value from drill hole results.*

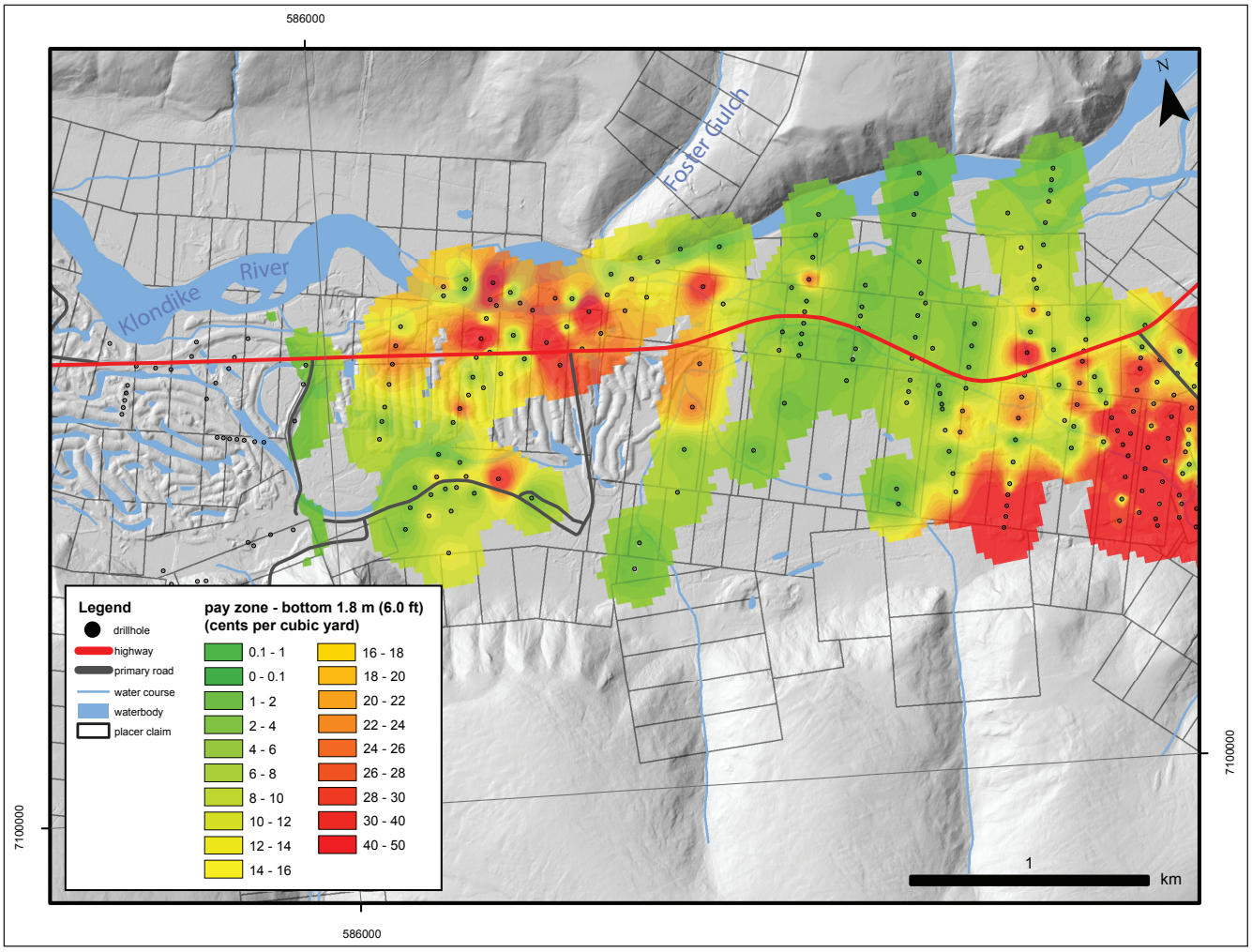

Figure 5. *Pay zone (bottom 1.8 m (6.0 ft) of dredge section) in the Klondike River valley illustrating the increase in gold grade values after accounting for the dilution factor.*

data consisting of total section thickness and grade. A total section thickness was derived from the benches because legends were not included on the maps and it was not possible to differentiate between the surficial material (overburden or gravel) values on the map. Total section thickness varies from 8–44 m (26–155 feet), with the thickness increasing laterally to the south, as you move from the rim toward the south margin of the valley (Fig. 6).

Similar to the Klondike River valley, grades on Dago and Paradise hills were recalculated to adjust for a concentrated (1.8 m-thick) pay zone located on the bedrock surface and to account for grade dilution if the total section thickness is used to calculate grade. Figure 7 displays the new "pay zone" grade for the high-level benches and interpreted margins of a reconstructed channel is represented by dashed lines. Derived from the GIS data, the maximum width of the channel is 400 m, and grades range from $50 to $165/yd^3 (Fig. 7). The Dago Hill paystreak was documented by McConnell (1907) to be 1128 m in length and range from 91 to 152 m in width; his calculations use the highest grade zone and did not include the medium-grade gravel bordering the pay channel.

Figure 6. *Satellite image of Dago Hill and Paradise Hill on lower left limit Hunker Creek, overlain by a raster image of total section thickness (gravel and overburden).*

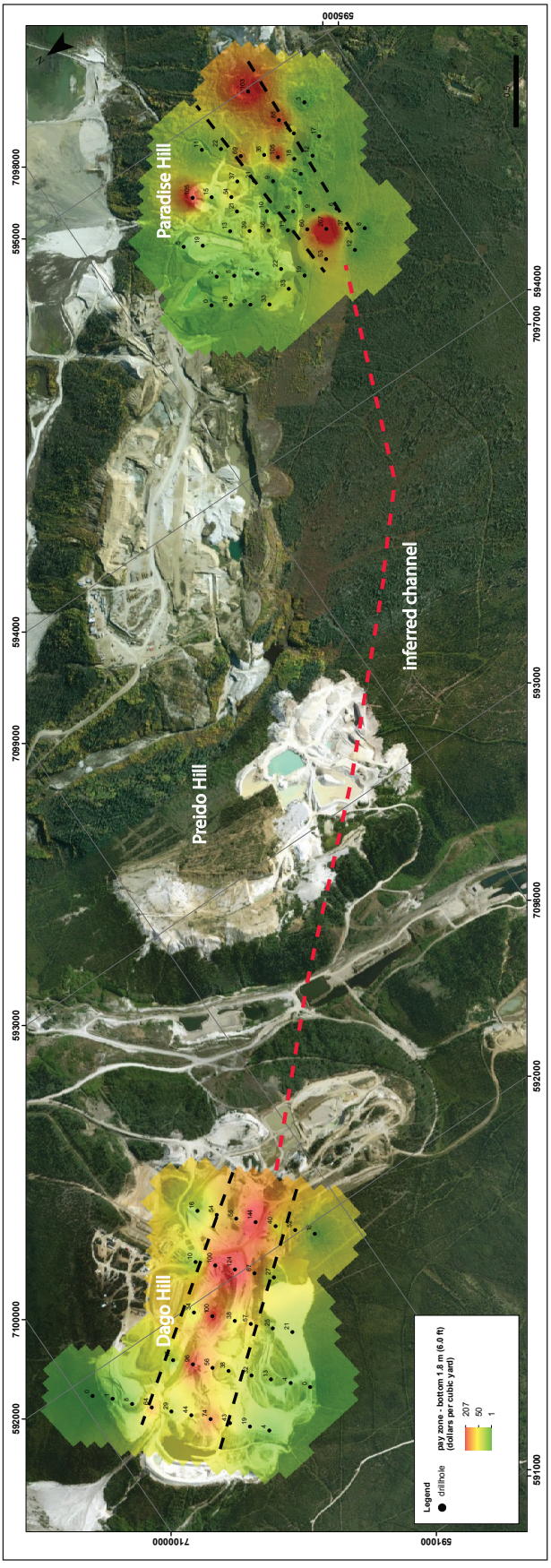

Figure 7. *Satellite image of Dago Hill and Paradise Hill on lower left limit Hunker Creek, overlain by pay zone raster. The reconstructed high-grade channel on the hills is represented by a black dashed line; red dashed line in the inferred pay channel that once connected both hills.*

Discussion

A pay streak in the upper reach of the project area is clearly visible from Colorado Creek to below Hester Creek (Fig. 3). This pay streak is interpreted to represent the concentrated equivalent of the former high-level pay streak that lowered vertically during base-level adjustment. Topography of the valley also influences the concentration of gold around Independence Creek due to the widening on the valley, which causes the stream hydraulics to decrease and enhance the deposition of gold. Vertical lowering of the pay channel is also visible in lower Hunker Creek, where the richest hot spot in the drainage is present at the mouth of the left limit tributary of Dago Gulch and directly across on the right limit, at the mouth of Rabbit Gulch. The accumulation of gold at the mouth of both gulches is contributed to the fluvial fan derived from their headwaters, which is reworking the paleo-Hunker Creek pay channel.

Low grades between Hester and Last Chance creeks are interpreted to be the result of the pay streak being "hung-up" on left limit high-level benches. These intact pay channels are visible on Dago and Paradise hills (Figs. 3 and 7) and are original channel deposits from the paleo-Hunker system. When the pay channel becomes constrained on high-level benches, grades in the modern valley become insignificant, highlighting the importance of reworked Pliocene gold within the modern channels. The inconsistent pattern of the pay streak within modern Hunker Creek is therefore directly attributed to variable reworking of the high-level pay streak. McConnell (1907) concluded that the richest sections of the modern valley are contributed to "the paystreak of the old valley [that] has been almost entirely destroyed and the gold contents washed down to the level of the present valley" (p. 24). Another large factor influencing gold distribution is the lithology and competency of the underlying bedrock, as noted by McConnell (1907). When he reported gold enrichment on the left limit hills of lower Hunker Creek, he attributed the enrichment to the decomposed nature of the bedrock, which contributed clay to the system and acted as a false-bedrock.

Where the high-level pay streak has been reworked by tributary streams, enrichment can be seen at the stream's confluence with Hunker Creek. The sharp spike in pay at the mouth of Hester Creek suggests Hester Creek eroded and reworked the heavy pay channel situated on the high-level benches, enriching the pay streak and transporting it into the Hunker Creek valley. A similar pattern is present at the mouth of Colorado Creek.

Farther downstream, where Hunker Creek valley enters the Klondike River valley, the prominent pay channel disappears. The White Channel deposit is traceable beyond Dago Hill and crosses the modern valley to Australian Hill. White Channel gravel is overlain by Klondike River gravel and extensive prospecting and sampling on the hill failed to produce a pay streak with similar grades and extent as preserved on Paradise and Dago hills (McConnell, 1907). Additional samples on the rim carried only minimal values, which could direct present day exploration to lower reconcentrated bench deposits some 10–50 m off the modern valley. The channel could be preserved on the lower right limit of Australian Hill, or on an intermediate-terrace on the left limit which has been concealed by glacial outwash and loess. Elimination of the channel could also be due to vigorous erosion by glacial fluvial action during glaciation. Evidence from McConnell's work in 1907 supports the reworking of the paystreak in the Klondike valley, as he believed the Hunker Creek high-level White Channel gravel extended for considerable distance into the Klondike River valley, but was destroyed during the deposition of the Klondike River and therefore scattered the gold throughout the valley.

Despite the absence of a continuous Hunker Creek pay streak in the Klondike valley, areas of enriched gold values are present (Fig. 5) and interpreted to be related to two possible sources of gold. Areas of enrichment are situated on the right limit of the broad valley, slightly downstream from the mouth of Foster Gulch, at the mouth of Bear Creek, and on the far left limit valley margin downstream from the Hunker Creek valley.

The first source is the paleo-Hunker channel that was once flowing on the far left limit of the drainage, and remains inconsistently preserved on high-level benches.

It is possible this pay streak extended into the Klondike valley where it has been reworked into modern Klondike valley gravel. The enriched paleo-Hunker pay streak may be visible in a series of small partially connected lenses in the Klondike valley rather than a continuous streak, and becomes destroyed farther downstream as it meanders its way to the Yukon River.

A second possible source for the enriched gold values is from bedrock sources in the Klondike River itself. Recent mining along the Klondike River has recovered small angular nuggets of gold, which suggests a local source.

The richest pay zone in the project area is situated in the uppermost 1.2 m (3.9 ft) of bedrock and within the lower 0.6 m (2.0 ft) of gravel on the bedrock surface (Daily, 1940). It is noted in the YCGC Report of Drilling Operations and Shaft work (1909) that the pay channel became richer in areas where "hard bedrock appears and forms a riffle." One of these riffles was present 100 m downstream from the mouth of Hester Creek, where a hot spot is present, and the miner reportedly recovered significant coarse gold (YCGC, 1909). The Hunker Creek pay channel was likely enriched by contributions from Hester Creek, and the trend was further enhanced by the riffle, which trapped the coarse gold derived from the main stem and the tributary.

Arlington – Predicted and Actual Dredge Recoveries

In the early 1930s the Arlington area at the confluence of Hunker Creek and the Klondike valley (Figs. 8 and 9) was divided into three blocks (A, B and C) and extensively drilled to determine the economics of the ground. This grade evaluation included the tailings from Yukon Gold Dredge No. 5, which was active in the Block C area in 1909. Favourable results were obtained by

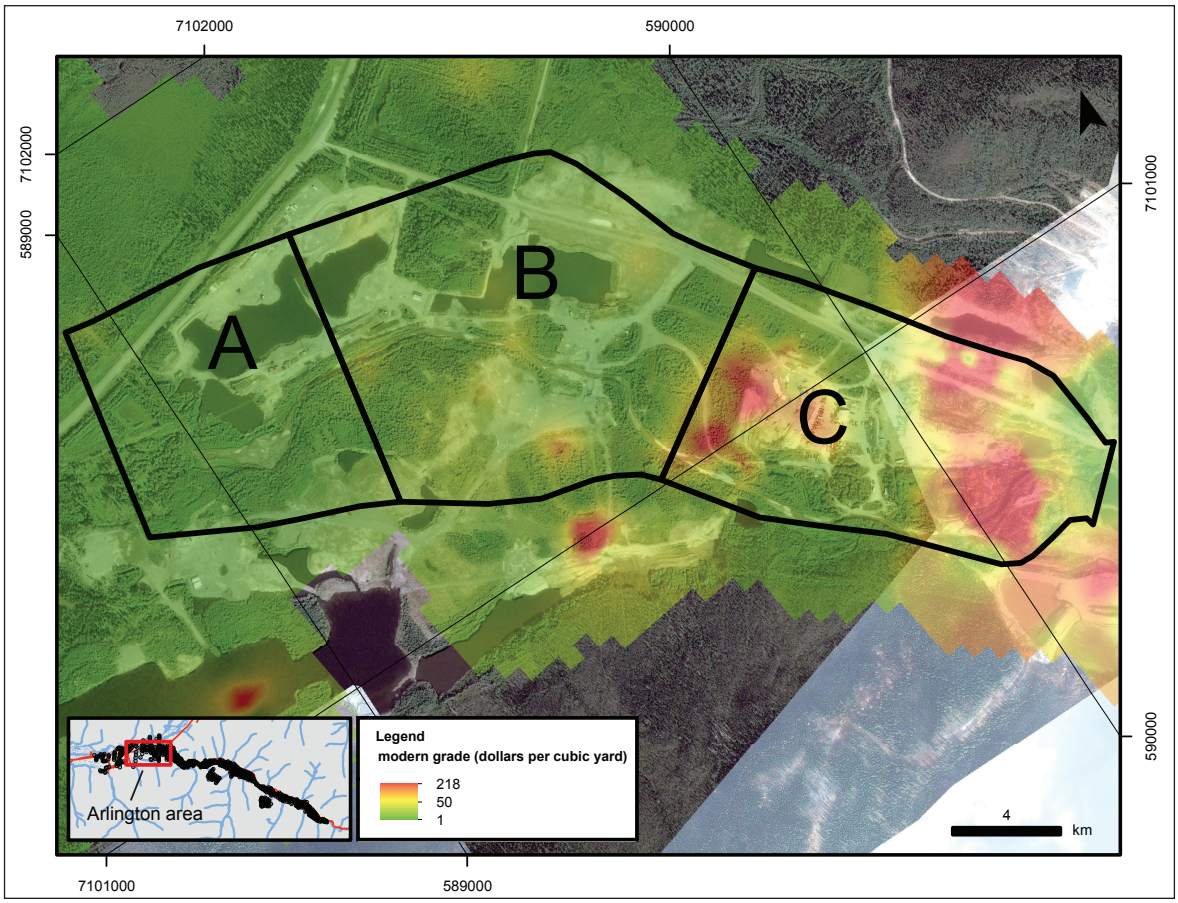

Figure 8. *Satellite image of the Arlington area at the mouth of Hunker Creek overlain by a raster image of recalculated pay zone (bottom 1.8 m) grade; black lines indicate the three blocks discussed in analyzing estimate verse actual production values.*

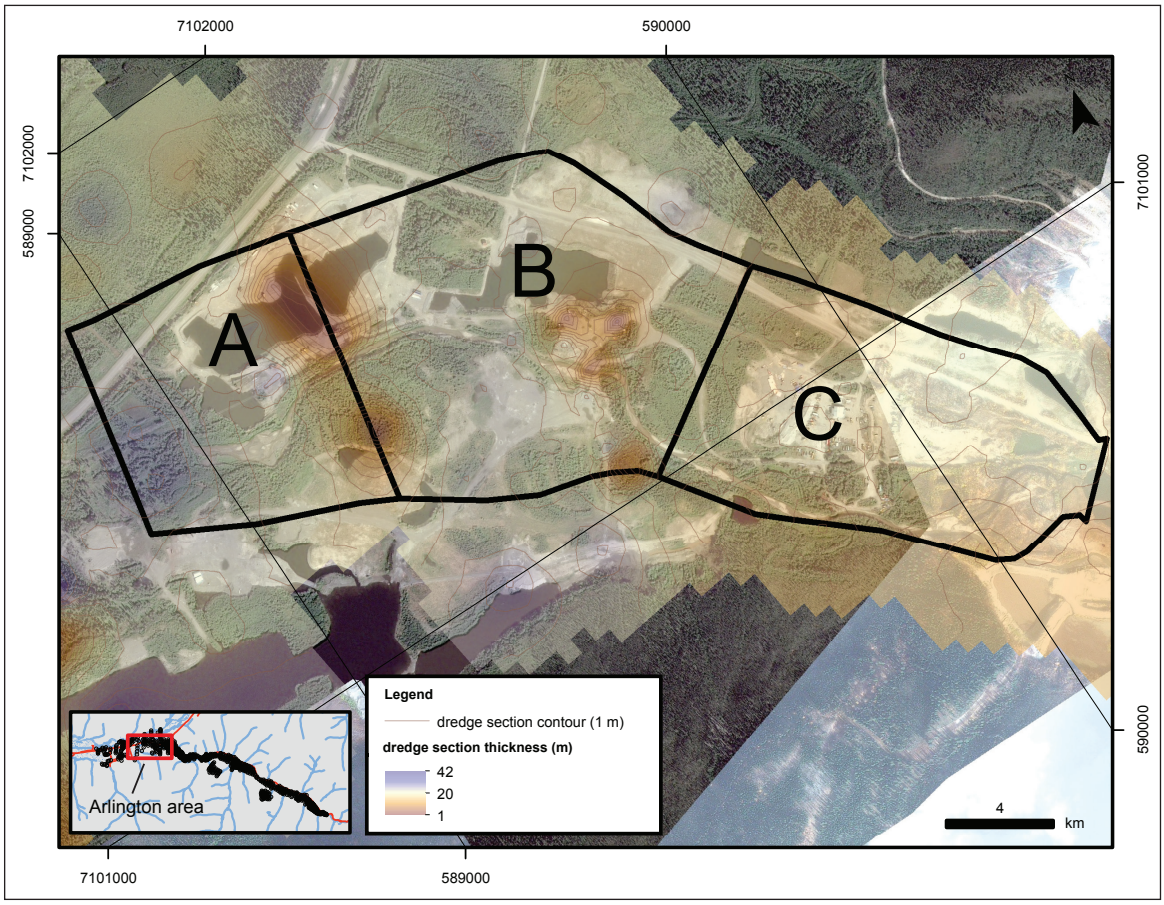

Figure 9. *Satellite image of the Arlington area at the mouth of Hunker Creek overlain by a raster image of dredge section thickness; black lines indicate the three blocks discussed in analyzing estimate verse actual production values.*

the drilling evaluation, and the company dredged the ground in 1940 with Dredge #4 (Daily, 1940). Table 1 compares estimates of volume, grade and depth based on drilling with actual recovered values during the dredging program.

Block A is the smallest of the blocks, contained the lowest average grade at 6.9 cents/yd^3, and had production values that were over-estimated by 23.3%. Block B is the largest block of the three, contained average grades of 19.5 cents/yd^3, and had production values that were over-estimated by 2.2%, and therefore contained the most reliable drilling data. Farthest upstream on lower Hunker Creek, Block C was the most productive area despite having already been dredged (Daily, 1940). Average recovered grades in Block C were 52.5 cents/yd^3 and the average production value was over-estimated by 22.6%.

Comparing the Arlington blocks estimate and actual values can help put drilling reliability into perspective. When the geology of a particular location and/or drainage is well understood, drilling data can more reliably predict the economics; whereas when pay channel characteristics are unknown or hypothesized, there is potential for a large discrepancy in production values. In van Loon (2016), the reliability of drilling accuracy was analyzed for mid-Dominion Creek, suggesting an average under-estimation of gold recovery by 8%. For the Arlington area the drilling accuracy shows a higher degree of discrepancy. This was determined by standardizing the depth in order to compare the grade predicted by the drilling to the actual grade derived from dredging results. In Table 1, the standardized depth results highlight that both block A and C over-estimated the drilling by ~20%, whereas

Table 1. *Comparison of estimate and actual data by Block A, B, and C of Arlington on lower Hunker Creek (Daily, 1940).*

	Block A		Block B		Block C	
	Estimate	*Actual*	Estimate	*Actual*	Estimate	*Actual*
Area (ft^2)	390,158	320,234	2,706,905	1,489,049	2,313,120	2,391,476
Average depth (ft)	33.5	39.8	32.0	37.2	26.1	29.1
yd^3 dredged	422,565	472,471	2,802,737	2,049,958	1,946,932	2,578,284
Recalculated yardage dredged (actual area x estimate depth = X; X/27)		397,327		1,764,799		2,311,760
Average dredge section value (cents/yd^3)	10.7	6.9	23.1	19.5	75.7	52.5
Recalculated average value of dredge section (standardized depth)		8.2		22.6		58.6
% difference between estimated value and recalculated value		23.3		2.2		22.6
Gross (dollars)	45,114	32,514	648,666	399,575	1,472,043	1,355,879

in Block B grade was over-estimated by 2.2% from the actual recovery. A summary of the dredging operation at Arlington by A.F. Daily (1940) concluded that:

- Block A was nearly all frozen except a strip on the left limit of the block. It was deemed difficult to thaw the Klondike River gravel in this block because it was a challenge to sink the hand-driven thawing points in such dense, coarse material. In order to reach the more profitable ground in Block B, dredging operations were limited to a narrow strip along the left limit edge of block A; enabling the company to reach higher grade ground quicker in the season. Coarse gravel that was difficult to thaw could be a significant factor in the 23% lower than expected gold recovery for Block A.
- Block B was also predominately frozen, with an excessive amount of sand encountered during dredging in the upper part of the block. Grades picked up as the dredge migrated towards Block C, where they started to process less Klondike River gravel. Drilling likely accurately predicted grades in this block due to the consistency of grade in Hunker Creek gravel, the pay zones tight association with the bedrock contact, and the frozen ground conditions that did not accentuate the grade when drilled.
- Block C had extensive drifts and a portion of its area on the left limit was worked by Dredge #5 in 1909. Gravel was largely frozen, but had thawed tailings that were determined economic to re-dredge. A significant contributor to the lower than expected grades recovered is the excess sand the dredge encountered, which was broadly distributed throughout the block. Massive sand in the project area is likely due to a technogenic source; historic dredge slickens, and/or fines, as a result from old-timer workings. The sand decreased the actual dredging rate, as well as hindered operations due to managing the fine-grained material that carried little to no values. Less gold was recovered from Block C than estimated, likely due to encountering the thick deposit of sand and the extensive old-timer workings that are hard to delineate (and account for) through drilling.

In contrast to the variability of the geological setting in Blocks A and B, Block C of the Arlington concession is characterized by a narrow, well-defined pay channel of very high grade (Fig. 8). Thinner surficial material thicknesses, and in particular, thinner muck thicknesses, contribute to more efficient and economical recoveries (Fig. 9).

Several variables can affect the reliability of drilling data. In the Klondike one of the most significant factors is the percentage of high-grade material that was excavated by old-timers (as in Block C), which is challenging to account for unless drill hole spacing was greatly reduced to several metres. Gravel characteristics can impact the ability to effectively thaw a column/section (as in Block A), and if blocks of frozen gravel are dredged, gold could remain inaccessible, still in section, and/or preserved, during the dredging process. The nugget effect could also contribute to inconsistent recovery, as likely occurred in the high-grade gravel of Block C.

Dredge recovery problems may also have contributed to the poor accuracy of the Arlington area estimates. Potential inefficiencies in dredging allow for remnants of *in situ* gravel to remain on the bedrock contact. The ability of dredges to recover gold can be affected by a few different factors:

1. thickness of surficial materials - if a gravel package was too thick, it presented a challenge for the dredge to reach the bedrock surface;
2. coarseness of surficial materials - if a gravel was too coarse and boulder enriched, it could impact the capacity on the bucket line; and
3. variability in bedrock lithology and topography; specifically its competency, degree of weathering, how it fractures and bedrock highs that make dredging challenging.

Exploration

A number of under-explored targets exist in the lower part of Hunker Creek and consist of hidden/buried channels and benches. As Hunker Creek incised below the original White Channel surface, gold is concentrated and vertically lowered to be preserved on intermediate-level terraces as well as the modern creek bottom. Because lateral movement of gold is difficult, there is potential for economic gravel deposits on the rim slopes, and at the base of the high-level terraces on intermediate and low-level terraces on the left limit. At the mouth of Dago Gulch, an intermediate-level terrace has been recently excavated and proven to contain economic grades ~10 m above the modern valley bottom. Enrichment in this location is likely attributed to reworking and re-concentrating of the heavy pay channel off the bench by Dago Gulch, and contributions from colluviation of Dago Hill rim material. Surface expression of these intermediate benches is limited due to their narrow width and thick packages of overburden (muck) concealing the landform. Drilling and geophysics are the most practical methods of locating these targets. Exploration for these narrow intermediate-level benches on the inside of the bends within the incised valley is recommended. For example, the northeasterly facing rim slope of Dago Hill is on an inside bend of Hunker Creek, and similarly, the slope between Hattie and Rabbit Gulch is an inside bend.

Using extrapolated grade information to direct bench exploration to areas with high grade, two areas of interest identified are (1) immediately downstream of Last Chance Creek on the left limit, and (2) a 1 km-long section between Henry Gulch and the next tributary downstream (unnamed left limit tributary). Formed during the deepening of the valley, these benches are likely to be small deposits with irregular distribution and could occur at various elevations from the valley floor to the high-level terrace (McConnell, 1904).

Another exploration target within the project area is side pay on the valley margins that is preserved beneath thick and often frozen overburden. Using grade data, and observing the absence of high grades both in the valley bottom and on the bench, we are able to determine locations where gold concentrations have the potential to be hung up on low-level terraces, or on the valley margins. An area that is identified as prospective due to high grades and potential for bench preservation is an 800 m-long section between Dago Gulch and Henry Gulch, on the left limit of Hunker Creek.

Potential also remains in secondary tributaries of Last Chance Creek and Hester Creek, as well as the headwaters of Hester and Colorado creeks, all of which appear to be contributing gold to the Hunker Creek valley. Lastly, continued exploration of the Hunker Creek pay channel and its disseminated nature in the Klondike River valley has potential to support large open pit mining operations that can target economic gravel on the bedrock contact. Additional exploration is warranted along the left limit of the Klondike River valley, both in the valley bottom and within a high-level terrace deposit.

Conclusion

Activity has occurred in the Hunker Creek and Klondike River valleys without pause for more than one hundred years. Initial activities of shafting, hand mining and hydraulic operations transformed into dredging operations, cat mining, and finally, modern day mechanized mining where operators process material more efficiently, operate within lower margins, and excavate thicker deposits.

Placer deposits in the modern valley were the initial target for miners exploring the Klondike, but with further exploration and drilling, additional targets including intermediate and high-level benches were discovered. Following a heavy pay steak that was continuous farther upstream and decreased to nearly absent downstream, the miners were able to adjust their focus and interpret the way the landscape may have looked before the last glacial influence. Using historic drilling data we are able to reconstruct gold distribution and confirm a pay channel trajectory on the high-level benches of the left limit of Hunker Creek, which can further enhance the knowledge of placer deposits for modern miners.

In summary, three prominent gold distribution patterns are present in the project area: (1) a heavy pay channel was present prior to the first glaciation, when the Hunker Creek channel was more than twice its current width, and after erosional down cutting the pay channel was variably reworked either into the modern channel, remained intact within the high-level deposits or was partially reworked; (2) reworking of the Pliocene pay streak into the modern channel appears to have left a disseminated or irregular gold distribution that may be caused by bedrock bed roughness; and (3) principal tributaries (Last Chance Creek) are contributing to the gold population, with secondary tributaries (Colorado Creek) also potential sources of input.

This compilation resulted in the identification of prospective targets in intermediate-level benches on the lower section of Hunker Creek where high grades in the valley margins can be extrapolated from drill data.

Three additional exploration ideas derived from the modeling exercise include (1) inefficient dredging due to frozen ground, particularly in coarse gravel where hand-drive points were unable to penetrate sufficiently; (2) areas where potential for a rich rim has been reworked into low-level terraces and/or the valley bottom (base of Australian Hill; base of upstream portion of Dago Hill); and (3) in secondary tributaries in the headwaters of Colorado, Hester, and Independence creeks are also encouraging areas to conduct future examinations.

Acknowledgments

Many thanks are owed to the Technical Services unit at YGS, especially to Brett Elliot for creating a web-based map to display and make the YCGC data searchable. Additional thanks are owed to our digitizing contractor Laura Grieve, to Karen MacFarlane, Kristen Kennedy and Jeff Bond for the contributions and edits to this project, and lastly to the placer industry for ground-truthing the value in this historic data set.

References

Daily, A.F., 1940. The Yukon Consolidated Gold Corporation, Limited Report on Arlington Area Operations 1935 to 1940. Energy, Mines and Resources Property File Collection; Archives Canada file MG 28 Series 111-43.

Froese, D.G., Barendregt, R.W., Enkin, R.J. and Baker, J., 2000. Paleomagnetic evidence for multiple Late Pliocene – Early Pleistocene glaciations in the Klondike area, Yukon Territory. Canadian Journal of Earth Science vol. 37, p. 863–877.

Green, L., 1977. The Gold Hustlers. Alaska Northwest Publishing Company, Anchorage, AK, 339 p.

Hidy, A.J., Gosse, J.C., Froese, D.G., Bond, J.D. and Rood, D.H., 2013. A latest Pliocene age for the earliest and most extensive Cordilleran Ice Sheet in northwestern Canada. Quaternary Science Reviews, vol. 61, p. 77–84.

Lowey, G.W., 2004. Placer geology of the Stewart River (115N&O) and part of the Dawson (116B&C) map areas, west-central Yukon, Canada. Yukon Geological Survey, Bulletin 14, 275 p.

McConnell, R.G., 1905. Report on the Klondike gold fields. Geological Survey of Canada, Annual Report, part B, vol. 14, p. 1–71.

McConnell, R.G., 1907. Report on gold values in the Klondike high level gravels. Geological Survey of Canada, Report No. 979, 34 p.

van Loon, S., 2016. Digitizing and spatially analyzing historic YCGC drill data from Dominion Creek: A pilot project. *In:* Yukon Exploration and Geology 2015, K.E. MacFarlane and M.G. Nordling (eds.), Yukon Geological Survey, p. 253–280, including appendices.

van Loon, S., 2017. Digital analysis of historic drilling data to reconstruct the placer gold distribution in Sulphur Creek and lower Dominion Creek, central Yukon. *In:* Yukon Exploration and Geology 2016, K.E. MacFarlane and L.H. Weston (eds.), Yukon Geological Survey, p. 225–242.

Westgate, J.A., Sandhu, A.S., Preece, S.J. and Froese, D.G., 2003. Age of the gold-bearing White Channel Gravel, Klondike district, Yukon. *In:* Yukon Exploration and Geology 2002, D.S. Emond and L.L. Lewis (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 241–250.

Yukon Consolidated Gold Corp. Mid Hunker drilling. Energy, Mines and Resources Property File Collection, YCGC26442.

Yukon Consolidated Gold Corp. Difference in elevation between X25 and Hunker Flat above Narrows. Energy, Mines and Resources Property File Collection, YCGC26434.

Yukon Consolidated Gold Corp. Plan of placer mining claims below discovery on Hunker Creek. Energy, Mines and Resources Property File Collection, YCGC25160.

Yukon Consolidated Gold Corp. Plan of Placer Mining Claims from No. 39 Below Discovery to No. 65 Below Discovery on Hunker Creek - Plan No. 5037. Energy, Mines and Resources Property File Collection, YCGC25100

Yukon Consolidated Gold Co., Report of drilling operations and shaft work for the examination of claims between #50 and #63 below Hunker Creek. Energy, Mines and Resources Property File Collection.

Yukon Consolidated Gold Co., 1909. Report of Hunker development company's properties. Energy, Mines and Resources Property File Collection.

Yukon Consolidated Gold Corp., 1910. Dredge No. 4 Workings. Energy, Mines and Resources Property File Collection, YCGC26287.

Yukon Consolidated Gold Corp., 1911. Sketch plan showing McDonnell and Barrett Lays, 1911, Plan no. 5036. Energy, Mines and Resources Property File Collection, YCGC26451.

Yukon Consolidated Gold Corp., 1913. Plan of portion of Klondike Valley ahead of dredges Canadian No. 2 and 4. Energy, Mines and Resources Property File Collection, YCGC25164.

Yukon Consolidated Gold Corp., 1915. Dredge No. 4 Workings. Energy, Mines and Resources Property File Collection, YCGC26288.

Yukon Consolidated Gold Corp., 1915. Map accompanying report for Yukon Gold Company. Energy, Mines and Resources Property File Collection, YCGC25158.

Yukon Consolidated Gold Corp., 1916. Blueprint: Examination of Paradise Hill, Shafts and Drill Holes. Energy, Mines and Resources Property File Collection, YCGC26566.

Yukon Consolidated Gold Corp., 1917. Plan of Klondike valley portion of Hydraulic Mining Lease No. 18. Energy, Mines and Resources Property File Collection, YCGC26528.

Yukon Consolidated Gold Corp., 1923. Plan showing Drilling results and area dredged in portion of Klondike valley, 1923, by Dredges Canadian 2 to 4 - Plan no. 289. Energy, Mines and Resources Property File Collection, YCGC26526.

Yukon Consolidated Gold Corp., 1933. Anderson Concession, Drilling and Plan. Energy, Mines and Resources Property File Collection, YCGC 26356.

Yukon Consolidated Gold Corp., 1933. Anderson Concession, Hunker Drilling. Energy, Mines and Resources Property File Collection, YCGC26435.

Yukon Consolidated Gold Corp., 1934. Arlington project - General map showing examination results and proposed method of working to accompany a report by R.E. Franklin. Energy, Mines and Resources Property File Collection, YCGC 25159.

Yukon Consolidated Gold Corp., 1934. Arlington Project General Map showing results and proposed method of working to accompany report by R.E. Franklin. Energy, Mines and Resources Property File Collection, YCGC 26468.

Yukon Consolidated Gold Corp., 1937. Dredge No. 4 Progress Map, Arlington Area - Plan No. 2. Energy, Mines and Resources Property File Collection, YCGC26358.

Yukon Consolidated Gold Corp., 1941. Dago Hill Examination. Energy, Mines and Resources Property File Collection, YCGC25180.

Yukon Consolidated Gold Corp., 1943. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26410.

Yukon Consolidated Gold Corp., 1946. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC26403.

Yukon Consolidated Gold Corp., 1947. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26397.

Yukon Consolidated Gold Corp., 1948. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26411.

Yukon Consolidated Gold Corp., 1949. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26399.

Yukon Consolidated Gold Corp., 1949. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26412.

Yukon Consolidated Gold Corp., 1951. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26400.

Yukon Consolidated Gold Corp., 1952. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26452.

Yukon Consolidated Gold Corp., 1953. No. 11 Stripping Layout. Energy, Mines and Resources Property File Collection, YCGC 26409.

Yukon Consolidated Gold Corp., 1957. Paradise Hill layout. Energy, Mines and Resources Property File Collection, YCGC25118.

Yukon Consolidated Gold Corp., 1958. Last Chance Drill Hole Layout. Energy, Mines and Resources Property File Collection, YCGC26534.

Yukon Consolidated Gold Corp., 1958. No. 11 Thaw Layout. Energy, Mines and Resources Property File Collection, YCGC 26454.

Yukon Consolidated Gold Corp., 1958. Paradise Hill hydraulic cut. Energy, Mines and Resources Property File Collection, YCGC25117.

Yukon Geological Survey, 2010. Yukon Placer Database – Geology and mining activity of placer occurrences. Yukon Geological Survey, CD-ROM.

Yukon Geological Survey, 2018. Yukon Digital Bedrock Geology. Yukon Geological Survey, http://www.geology.gov.yk.ca/update_yukon_bedrock_geology_map.html, [accessed December, 2018].