Appendix B.9

Final – Seloam Brook Realignment Hydraulic Analysis, Downstream Environment Technical Memo, Golder Associates

GOLDER

TECHNICAL MEMORANDUM

DATE October 15, 2020 **Project No.** 1895674-Rev1

TO Jim Millard
Atlantic Mining NS Corp

CC Meghan Milloy, McCallum Environmental

FROM Shannon Percival; Steve Kaufman **EMAIL** Shannon_Percival@golder.com

SELOAM BROOK REALIGNMENT
HYDRAULIC ANALYSIS – DOWNSTREAM ENVIRONMENT
FIFTEEN MILE STREAM PROJECT

Introduction

Golder Associates Ltd. (Golder) was retained by Atlantic Mining NS Corp (AMNS), a wholly owned subsidiary of St. Barbara Ltd., to complete hydraulic modelling to support the on-going Environmental Impact Statement (EIS) for the Fifteen Mile Stream Gold Project (the Project). The Project is located 115 km east of Halifax, in Halifax county, in the province of Nova Scotia. The hydraulic modelling, as described herein, is specific to the planned Seloam Brook Realignment and the downstream receiving waterways that drain to Fifteen Mile Stream, and was completed in order to further investigate the conceptual placement of features downstream of the constructed channel that could reduce stream energy (velocity) and provide potential additional aquatic habitat.

Background

The Seloam Brook watershed consists of drainage from the following three main inflows:

- Seloam Brook from the outlet of Seloam Reservoir.
- Trafalgar Creek from the northern unregulated reaches of the watershed.
- An un-named waterway (termed WC-12 in accompanying EIS documentation) that drains the eastern reaches of the watershed.

These inflows discharge to a wetland complex that in turn drains west to Fifteen Mile Stream (Figure 1).

Project infrastructure will require the diversion of the main Seloam Brook tributary and the inflows from WC12 to the north of its existing path around the planned Open Pit (Figure 2). Therefore, a feasibility-level design of the Seloam Brook Realignment was completed by Knight Piésold (KP; 2020) and is referred to as “the Realignment” herein. Through further project development analysis and discussion, there was recognition that the Realignment as designed by KP had the potential to provide additional opportunity for habitat and fisheries offsetting. Wood Environment and Infrastructure Solutions, a Division of Wood Canada Limited (Wood; 2020), provided a revised and conceptual plan for the Realignment that incorporated these types of features and a more meandering low-flow stream alignment than the design proposed by KP (2020).

The net effect of the Realignment will be to route the main channel of Seloam Book and inflows from WC-12 to alternate receiving waterways within the Seloam Brook watershed. The purpose of the hydraulic modelling described in this memorandum is, therefore, to simulate the discharge pathways and water velocity for the receiving waterways downstream of the Realignment and to provide conceptual options for stream energy dissipation in the downstream environment.

Site Setting – Downstream Environment

At the outlet of the Realignment, flow diverges via a “North Channel” and a “South Channel”. The North Channel flows west before its confluence with the main Seloam Brook reach, while the South Channel flows south to join with the main Seloam Brook reach (Figure 2).

Based on aerial imagery and field data provided by McCallum Environmental Limited (MEL), the North Channel is characterized as having a channel width ranging from 2.0 to 4.0 m, with floodplains dominated by grasses and alders. The South Channel is characterized as having a channel width ranging from approximately 2.0 m up to approximately 15.0 m with beaver activity noted within this area. Similar to the North Channel, the flood plains of the South Channel were noted to be dominated by grasses and alders. These characteristics indicate that the North Channel and South Channel are both low-gradient and low-energy components of the overall Seloam Brook watershed.

Methods and Model Inputs

A site-specific Hydraulic Engineering Centre River Analysis System (HEC-RAS) model was developed for the Realignment and downstream environment to the discharge of Seloam Brook to Fifteen Mile Stream. The model incorporated:

1) High-level design details from KP (2020), such as slope, dimensions, and outlet energy dissipation pad.

2) Estimated downstream (North Channel, South Channel, and Seloam Brook) stream and flood plain dimensions and stream bed roughness.

The Realignment design, as revised by Wood, was not modelled, rather, the range of stream velocity estimated through the revised design (Wood 2020) was compared from those modelled using the KP (2020) design for applicability to this downstream hydraulic assessment.

Modelling Conditions

In order to assess the North Channel and South Channel, the hydraulic model was simulated with the following conditions:

1) Baseline Conditions: An estimated existing discharge through the North Channel and South Channel.

1) Operations Conditions: An estimated future discharge through the North Channel and South Channel and downstream Seloam Brook, with the Realignment and several conceptual downstream energy dissipation features incorporated.

Seloam Brook Realignment Design

A feasibility-level design of the channel for the Realignment was completed by KP (2020). The dimensions of the channel, as proposed by KP (2020), were used in the model and are provided in Table 1.

Table 1: Seloam Brook Realignment Channel Key Dimensions

Location	Channel Slope (%)	Minimum Channel Depth (m)	Channel Base Width (m)	Channel Side Slope (H:V)
Seloam Brook Realignment	0.5	1.5	1.0	2:1

Natural Channels

Estimated stream gradient profiles for the North Channel and South Channel are summarized in Figure 3 and Figure 4. While stream and floodplain dimensions and grades were estimated based on the available topographic data and input from MEL, further characterization of these streams is ongoing in 2020 that can refine these estimates. The model input data used for the natural channels are summarized in Table 2.

Table 2: Natural Channel Parameters

Parameter	North Channel	South Channel
Channel Width Range	2.0 m to 4.0 m	2.0 m to 15.0 m
Maximum Channel Slope	2.6%	0.7%
Average Channel Slope	0.5%	0.3%

Stream Discharge

For consistency with EIS hydrology documentation, the hydraulic model was simulated for the average annual and the 95th percentile stream discharge conditions. Hydrological modelling completed for the EIS simulated flows at the outlet of Fifteen Mile Stream and, so, these flows were pro-rated by contributing upstream watershed size as inputs to the North Channel and South Channel from the Realignment. For the Operations Conditions scenario, the Realignment, and associated changes to watersheds as a result of infrastructure were accounted for.

Results

Stream Velocity

Baseline Conditions

While discharge provides an estimate of the total water moving through the system, it is the velocity of the water that drives the energy potential that leads to changes in stream morphology (sediment transport and deposition). Therefore, the focus of these results is on velocity in the receiving waterways.

Under mean discharge rates, simulated baseline water velocities through the North Channel ranged from 0.7 m/s to less than 0.1 m/s, with an average of approximately 0.2 m/s. Through the South Channel, simulated baseline stream velocity ranged from 0.6 m/s to less than 0.1 m/s, with an average of 0.2 m/s under mean discharge rates (Table 3).

For the 95th percentile discharge rate, simulated baseline stream velocity in the North Channel ranged from 0.8 m/s to less than 0.1 m/s, with an average of 0.3 m/s. For the South Channel simulated baseline stream velocity ranged from 0.7 m/s to less than 0.1 m/s, with an average of 0.3 m/s (Table 3).

Table 3: Baseline Conditions Stream Velocity

	Baseline Conditions					
	Mean Discharge			95th Percentile Discharge		
	Maximum – Velocity (m/s)	Average – Velocity (m/s)	Minimum – Velocity (m/s)	Maximum – Velocity (m/s)	Average – Velocity (m/s)	Minimum – Velocity (m/s)
North Channel	0.7	0.2	<0.1	0.8	0.3	<0.1
South Channel	0.6	0.2	<0.1	0.7	0.3	<0.1

Operations Conditions

Through an iterative process, energy dissipation features were added to the model domain that were intended to reduce stream velocity in the North Channel and South Channel. These features were conceptually considered to be check berms that would span the channel and floodplain. The optimization of the size, composition, and shape of these features will require additional study and collaboration with aquatic habitat disciplines. Conceptual placement of these structures is provided on Figure 5.

For the mean discharge scenario, simulated stream velocity through the North Channel ranged from 0.7 m/s to less than 0.1 m/s, with an average of approximately 0.2 m/s (Table 4). Through the South Channel, simulated stream velocity ranged from 0.3 m/s to less than 0.1 m/s, with an average of 0.1 m/s (Table 4).

For the 95th percentile discharge rate, simulated stream velocity in the North Channel ranged from 0.8 m/s to less than 1 m/s, with an average of 0.3 m/s (Table 4). In the South Channel, simulated stream velocity ranged from 0.5 m/s to less than 0.1 m/s, with an average of 0.2 m/s (Table 4).

Table 4: Operations Conditions Stream Velocity

	Operations Conditions					
	Mean Discharge			95th Percentile Discharge		
	Maximum – Velocity (m/s)	Average – Velocity (m/s)	Minimum – Velocity (m/s)	Maximum – Velocity (m/s)	Average – Velocity (m/s)	Minimum – Velocity (m/s)
North Channel	0.7	0.3	0.1	0.8	0.3	<0.1
South Channel	0.3	0.1	<0.1	0.5	0.2	<0.1

The range in simulated velocity along the channel lengths in Baseline Conditions and Operations Conditions are summarized in Figure 6 through Figure 9. Stream velocity simulated along the North Channel and South Channel in the Operation Conditions were similar to those simulated in the Baseline Conditions.

Stream velocity estimated for within the revised realignment plan (Wood 2020) are in the same order of magnitude of the analysis completed herein. These Wood (2020) estimates were for within the channel and not reflective of the plunge pool/dissipation basin incorporated in KP (2020). Therefore, it is likely that the conceptual placement and applicability of these downstream features remain consistent with this hydraulic modelling.

Flooding Extent

Under the Operation Conditions, the flood extent was also simulated with the addition of the structures. The resulting simulated flood extents for the mean average discharge rates and the 95th percentile of discharge rates are displayed on Figure 10 and Figure 11, respectively. In both scenarios, the flood extent was simulated with depths ranging from 1.8 m within the channel to a maximum depth of approximately 0.4 m in the floodplain.

Sediment Mobility

Simulated stream velocity was equal to or above 0.1 m/s for the North Channel and South Channel under Baseline and Operational Conditions. Typically, water velocity above 0.1 m/s have sufficient energy to mobilize finer particles such as silts and clays. With geomorphic analysis underway on these water features, additional detail will become available on the composition and potential mobility of sediments and the stability of the existing stream system. In turn, this work can inform the appropriate design of the Realignment and the downstream energy dissipation features.

Conclusions

The South Channel and North Channel of the Seloam Brook watershed were simulated within a hydraulic model. The model was simulated for under Baseline Conditions and Operations Conditions and for a mean discharge scenario, and a 95th percentile discharge scenario.

An increase in discharge (and stream velocity), as a result of the Realignment through tributaries of Seloam Brook, were simulated to be mitigated by the placement of energy dissipation features in the North Channel and South Channel. These conceptual features decrease overall simulated stream velocity (energy and sediment transport capability) to those simulated under Baseline Conditions. As a trade off, the flooded extent of the channels may occur. Therefore, additional studies will need to be completed that consider the optimization of the size, placement, and design of these features and associated additional potential aquatic habitat.

References

Knight Piésold Consulting (KP), 2020. Seloam Brook Diversion Channel Design. File No. VA101-00708/04-A.01.

Wood Environment and Infrastructure Solutions, a Division of Wood Canada Limited (Wood), 2020. Seloam Brook Realignment Section Model Results.

Closure

We trust that this memorandum meets your current requirements. Should you have questions regarding this memorandum please contact the undersigned.

Golder Associates Ltd.

<Original signed by>

<Original signed by>

Shannon Percival, B.Eng., EIT *Water Resource Specialist*

Steve Kaufman, M.Sc., EP
Associate, Hydrologist

SP/SK/sm

Attachments: Figures 1 to 11

https://golderassociates.sharepoint.com/sites/23819g/deliverables/1895674-xx realignment memo/rev 1 - october 2020/1895674-tm-rev1-atlantic gold hydraulic modelling 15oct_2020.docx

LEGEND

- Surface Water Flow Direction
- Watercourse
- Waterbody

0 400 800

1:20,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. MCCALLUM ENVIRONMENTAL LTD. EIS PROJECT AREA, (VER.190313, RECEIVED 2019-03-18).
2. MCCALLUM ENVIRONMENTAL LTD. PROPOSED INFRASTRUCTURE, (VER.190620, RECEIVED 2019-06-28).

PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 20 VERTICAL DATUM: CGVD28

CLIENT
ATLANTIC MINING NS CORP

Atlantic Gold

PROJECT
FIFTEEN MILE STREAM GOLD PROJECT

TITLE
EXISTING FLOW PATHS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-10-15
DESIGNED	---
PREPARED	RRD
REVIEWED	SP
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
1895674	0032	1	1

LEGEND

- Surface Water Flow Direction
- Watercourse
- Waterbody
- Infrastructure

0 400 800
1:20,000 METRES

NOTE(S)
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REFERENCE(S)
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PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 20 VERTICAL DATUM: CGVD28

CLIENT
ATLANTIC MINING NS CORP

Atlantic Gold

PROJECT
FIFTEEN MILE STREAM GOLD PROJECT

TITLE
OPERATIONAL FLOW PATHS

CONSULTANT

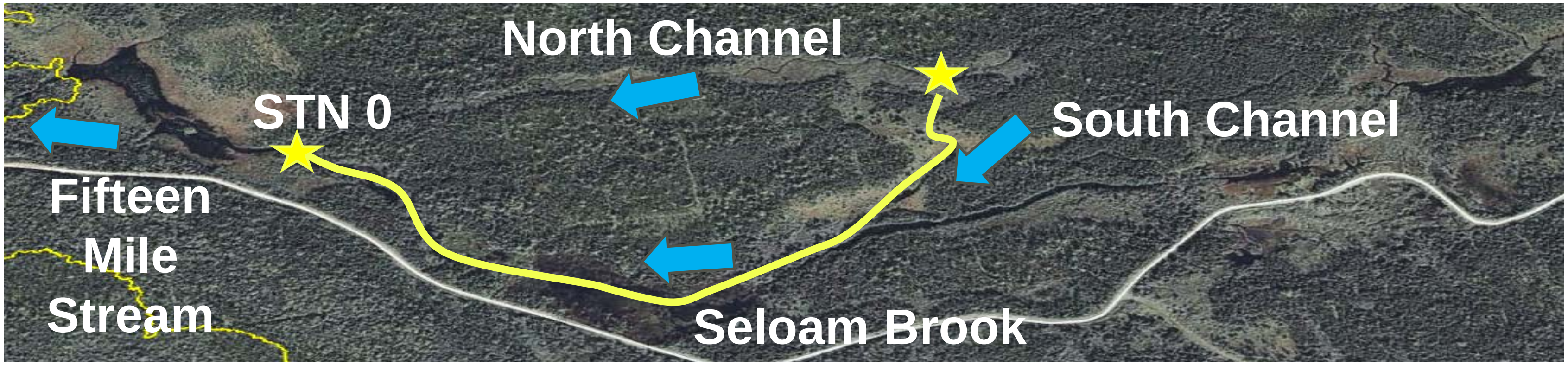
GOLDER

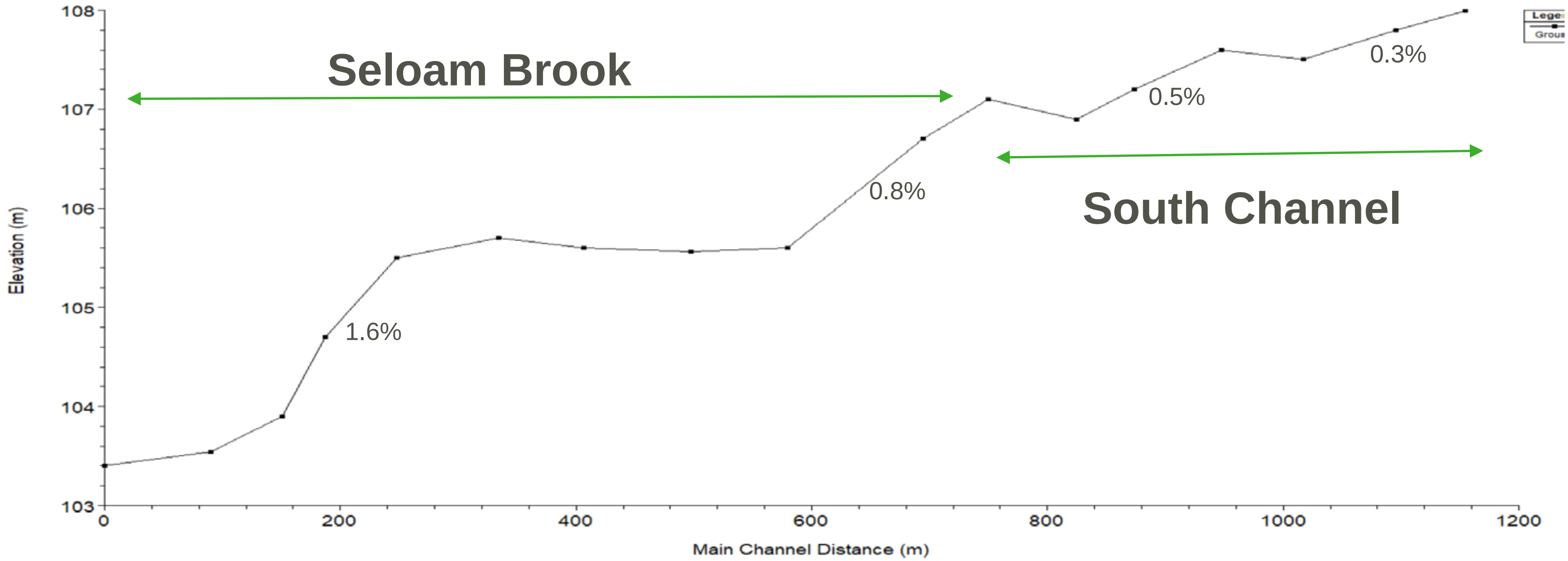
YYYY-MM-DD	2020-10-15
DESIGNED	---
PREPARED	RRD
REVIEWED	SP
APPROVED	SK

PROJECT NO.	CONTROL	0	FIGURE
1895674	0032	1	2

Atlantic Mining NS Corp
Seloam Brook Realignment – Hydraulic Analysis
South Channel and Seloam Brook Profile

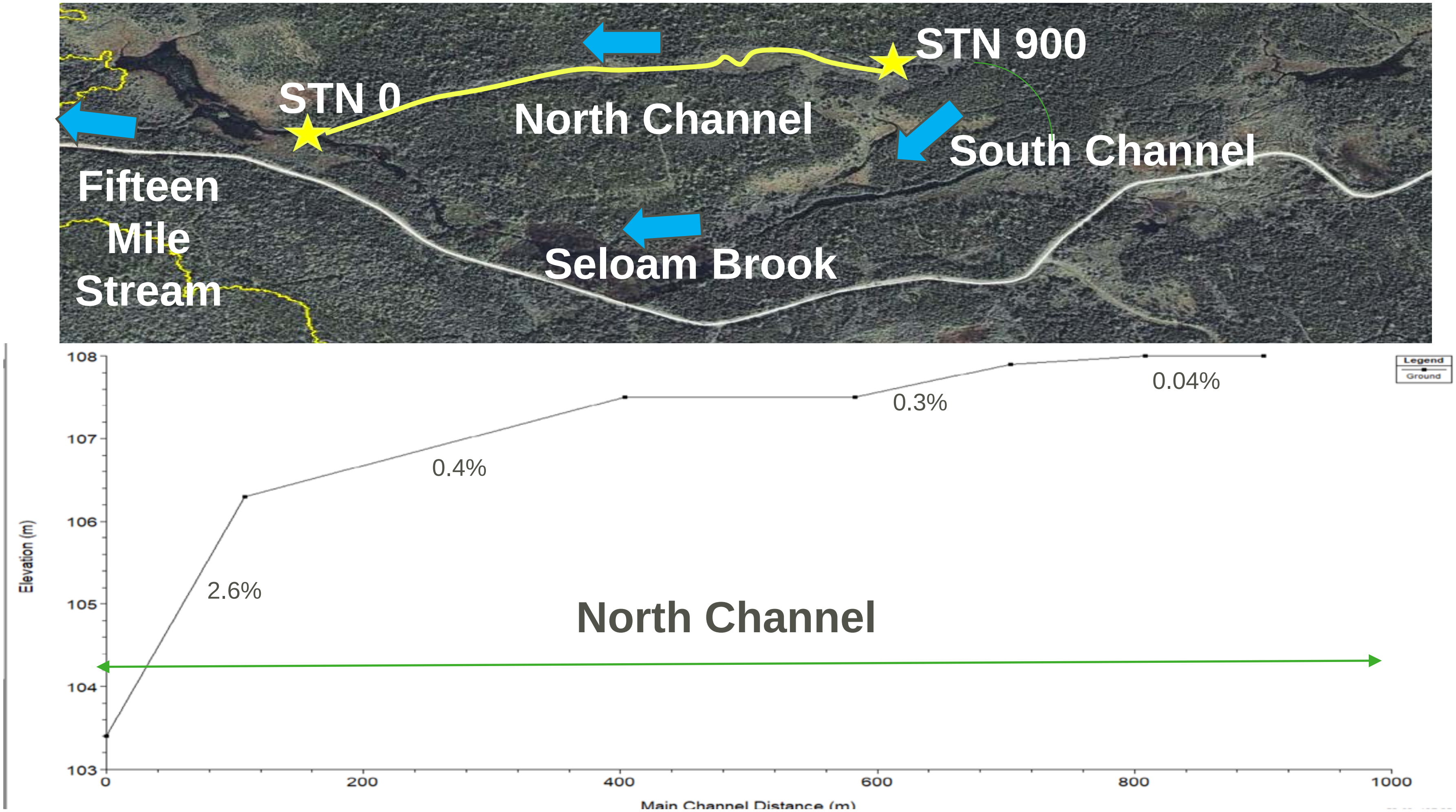
FIGURE 3





Atlantic Mining NS Corp
Seloam Brook Realignment – Hydraulic Analysis
North Channel Profile

FIGURE 4



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Project: 1895674

Drawn By: SF
Checked By: SK

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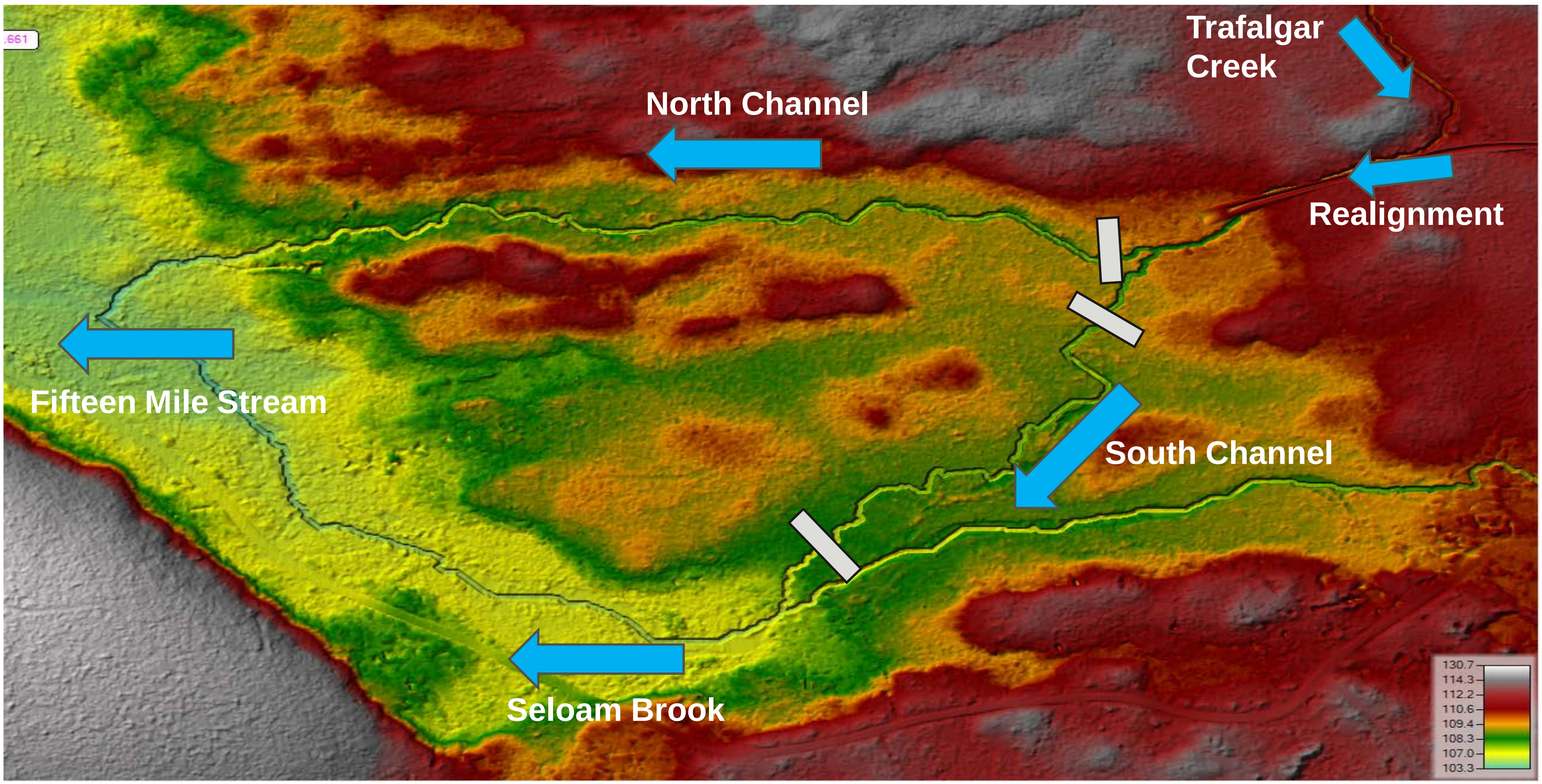
Seloam Brook Realignment – Hydraulic Analysis
Operations Conditions – Conceptual Downstream Structure Placement

FIGURE 5



Energy Dissipation Feature

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Checked By: SK

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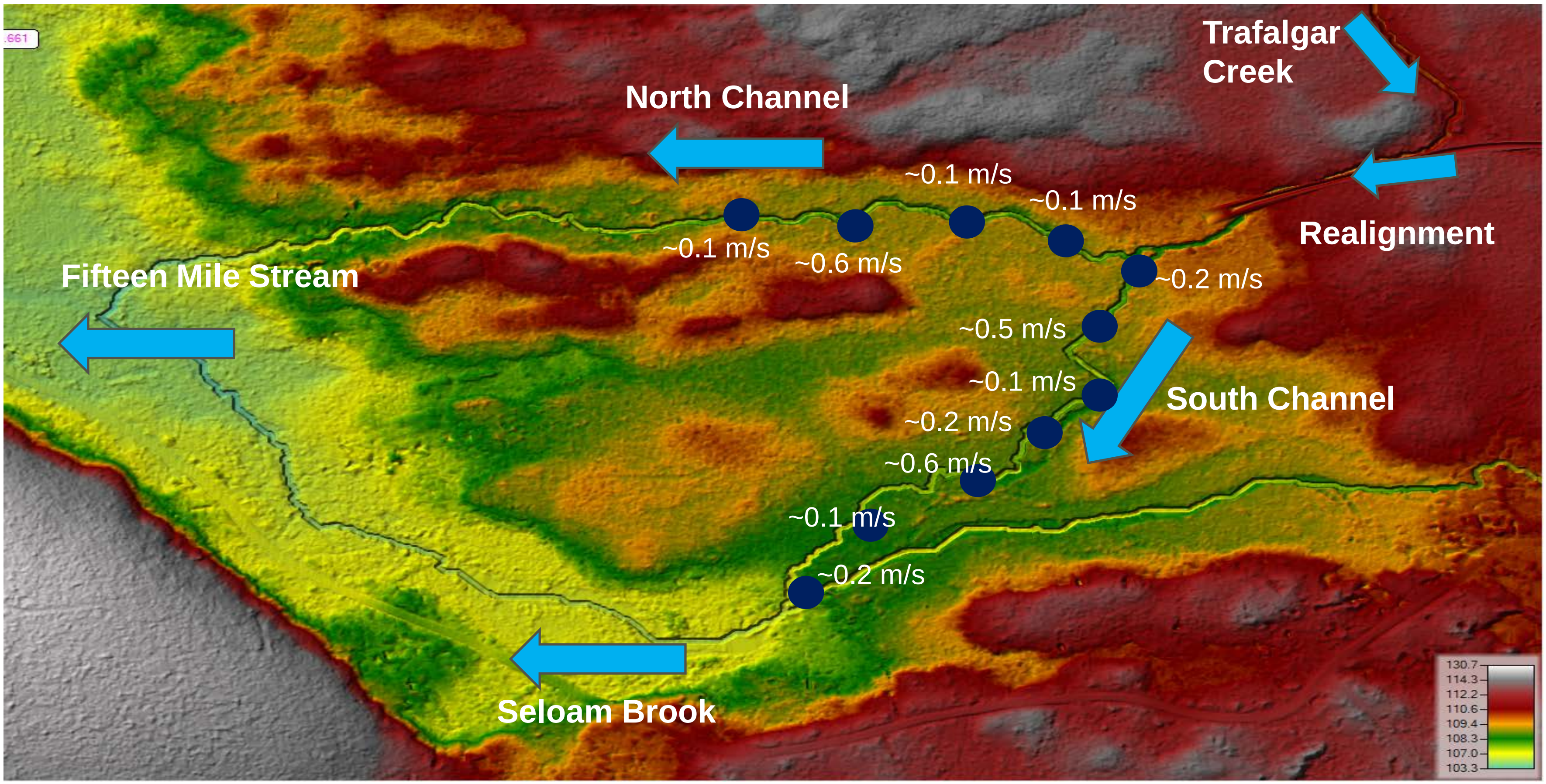
Seloam Brook Realignment – Hydraulic Analysis
Baseline Conditions – Mean Discharge Rate
North Channel and South Channel Stream Velocity

FIGURE 6



Velocity simulation location

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Date: October 2020
Project: 1895674

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Checked By: SK

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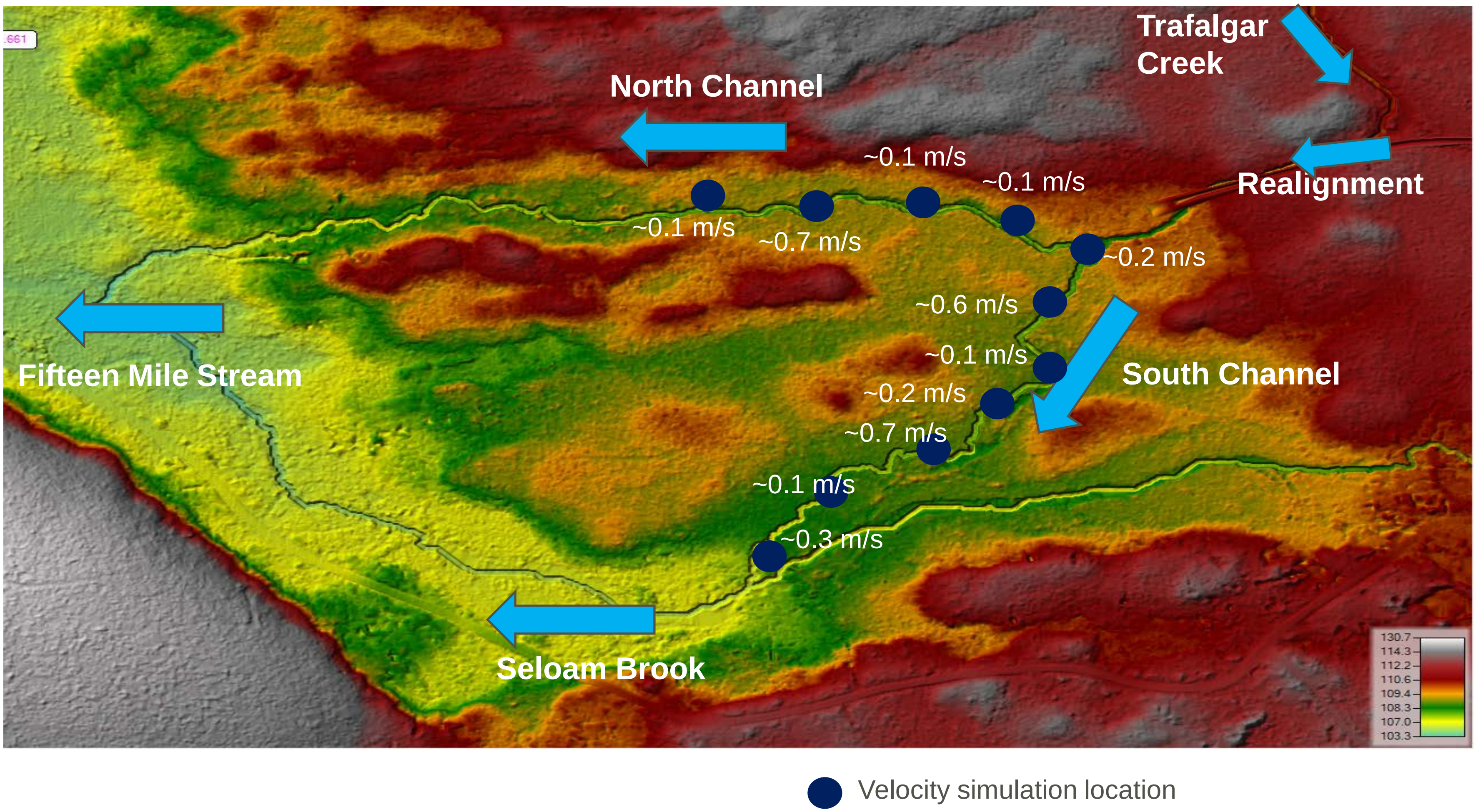
Seloam Brook Realignment – Hydraulic Analysis
Baseline Conditions – 95th Percentile Discharge Rate
North Channel and South Channel Stream Velocity

FIGURE 7



GOLDER

Date: October 2020
Project: 1895674

Drawn By: SF
Checked By: SK

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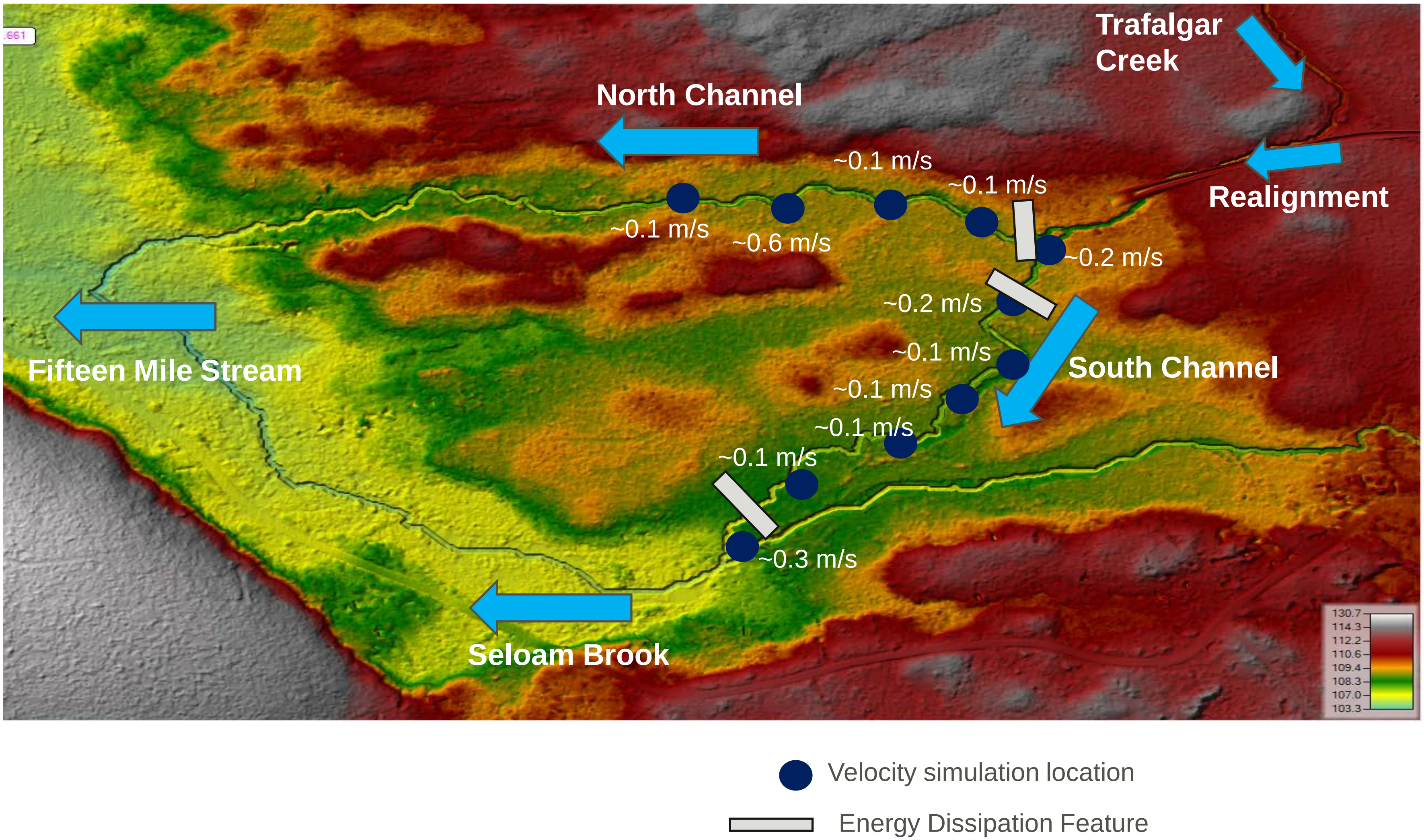
Seloam Brook Realignment – Hydraulic Analysis
Operations Conditions – Mean Discharge Rate
North Channel and South Channel Stream Velocity

FIGURE 8



GOLDER

Date: October 2020
Project: 1895674

Drawn By: SF
Checked By: SK

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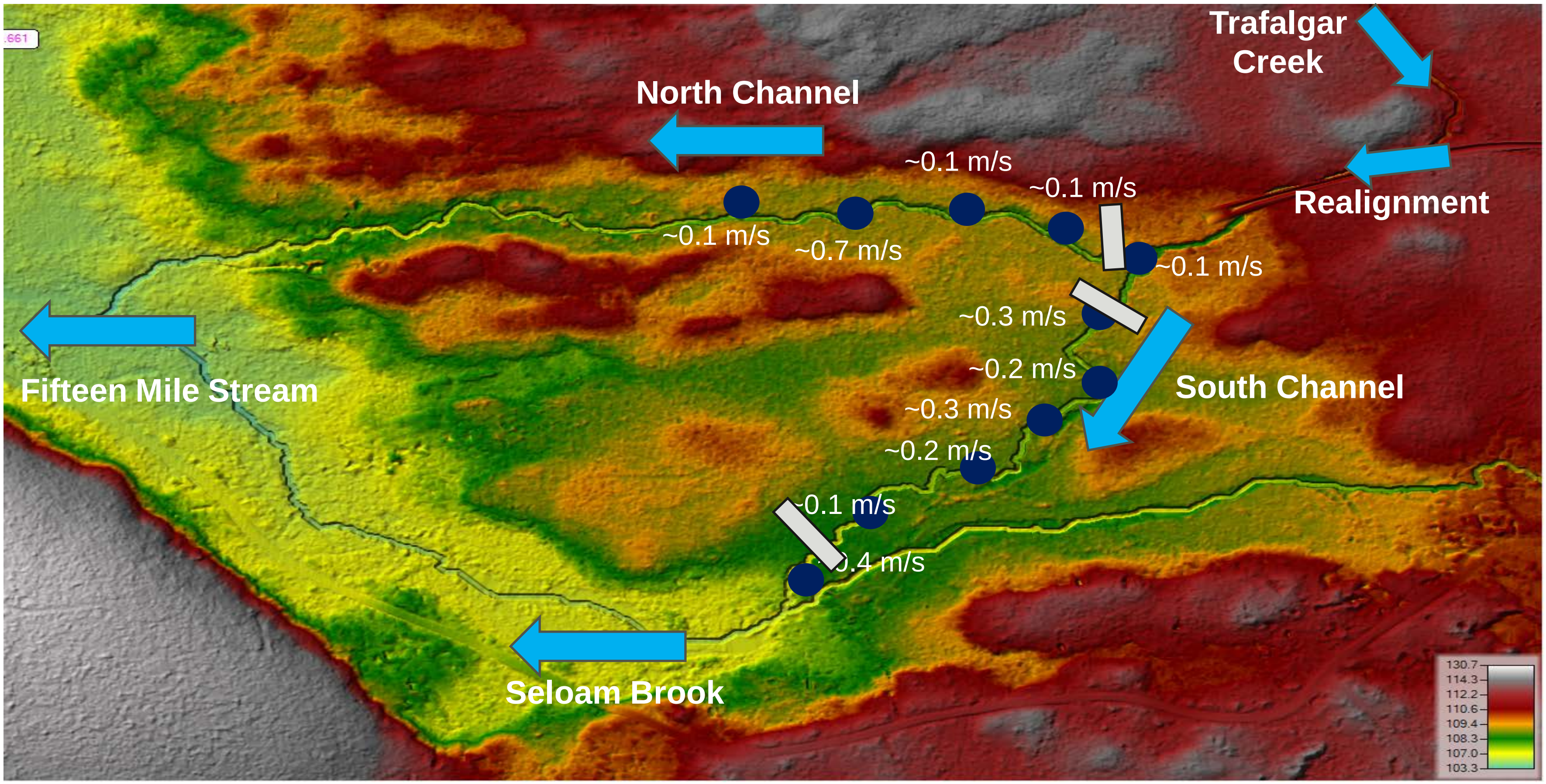
Seloam Brook Realignment – Hydraulic Analysis
Operations Conditions – 95th Percentile Discharge Rate
North Channel and South Channel Stream Velocity

FIGURE 9



Velocity simulation location

Energy Dissipation Feature

GOLDER

Date: October 2020
Project: 1895674

Drawn By: SF
Checked By: SK

LEGEND

simulated Flooded Extent

0 80 160
1:4,000 METRES

NOTE(S)
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REFERENCE(S)
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CLIENT
ATLANTIC MINING NS CORP

Atlantic Gold

PROJECT
FIFTEEN MILE STREAM GOLD PROJECT

TITLE
FLOODED EXTENT - AVERAGE ANNUAL DISCHARGE

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-15
DESIGNED	---
PREPARED	RRD
REVIEWED	SP
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
1895674	0032	1	10

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
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LEGEND

Simulated Flooded Extent

0 80 160

1:4,000 METRES

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PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83

COORDINATE SYSTEM: UTM ZONE 20 VERTICAL DATUM: CGVD28

CLIENT

ATLANTIC MINING NS CORP

Atlantic Gold

PROJECT

FIFTEEN MILE STREAM GOLD PROJECT

TITLE

FLOODED EXTENT -95TH PERCENTILE DISCHARGE

CONSULTANT

GOLDER

YYYY-MM-DD	2020-10-15
DESIGNED	---
PREPARED	RRD
REVIEWED	SP
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
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