Appendix 1.0-AA SRK, Tenas Project Dam Breach Analysis

TELKWA COAL
LIMITED

FINAL

Tenas Project Dam Breach Assessment Report

Tenas Project, Telkwa, BC, Canada

Telkwa Coal Limited

SRK Consulting (Canada) Inc. ▪ 1CT027.003 ▪ April 2021

FINAL

Tenas Project Dam Breach Assessment Report

Tenas Project, Telkwa, BC, Canada

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Cover Image(s):
Proposed North Management Pond area during drilling. Credit: Kyle Scale, February 17, 2021.

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Useful Definitions

This list contains definitions of symbols, units, abbreviations, and terminology that may be unfamiliar to the reader.

CDA	Canadian Dam Association
EA	Environmental Assessment
EMP	East Management Pond
GISTM	Global Industry Standard on Tailings Management
NAG	Non-acid generating
NMP	North Management Pond
PAG	Potentially acid generating
PMF	Probably maximum flood
Project	Tenas Project
Q200	1-in-200-year flood
SRK	SRK Consulting (Canada) Inc.
SRTM	Shuttle Radar Topography Mission
TCL	Telkwa Coal Limited
TCP	Tenas Control Pond
CPP	Coal Processing Plant
WMP	West Management Pond

Executive Summary

An inundation model was developed to simulate the effects of a dam breach event on areas downgradient of the Tenas Project's Management and Tenas Control Ponds, particularly the Village of Telkwa and the Maintenance Infrastructure Complex containing the Coal Processing Plant, Maintenance Facility and Mine Administration Building. A dam breach may also affect natural areas close to the site, including Tenas, Goathorn, and Four Creeks, and the Telkwa and Bulkley Rivers.

A cascade failure of the embankments corresponding to the West and North Management Ponds and the Tenas Control Pond was investigated, as well as the individual failure of the East Management Pond's dam. Incremental breach effects were assessed under fair-weather conditions (sunny-day), as well as under flood conditions (rainy-day). Flood depths, water velocities, and arrival times are provided, and the hazard for populations at risk is estimated.

Model inputs were developed based on the mine plan as of December 2020, topography, surface roughness estimates, regional hydrology, and methods from literature. There is much uncertainty surrounding inundation predictions, as the model does not account for sediment and debris transport, scouring, and hydraulic structures and infrastructure that may affect flow direction. Uncertainty and variability in predictions must be considered if using the results of the analysis for emergency response and action planning.

Results of the analysis estimate that up to 200 additional people may be put at risk due to the potential breach scenarios described, as compared to a no-breach scenario. The sunny-day breach scenarios have marginally higher incremental effects, as the total effects from a flood-induced scenario are largely driven by the flood itself. Effects on buildings, roadways, and bridges may be minor to moderate, and may result in temporary economic losses and reparation costs. Some damage to aquatic and terrestrial habitats will occur, but restoration is possible and this damage will be temporary in nature.

Based on the analysis, all four dams considered have been given a hazard classification of 'Very High', in accordance with Canadian Dam Association guidelines.

1 Introduction

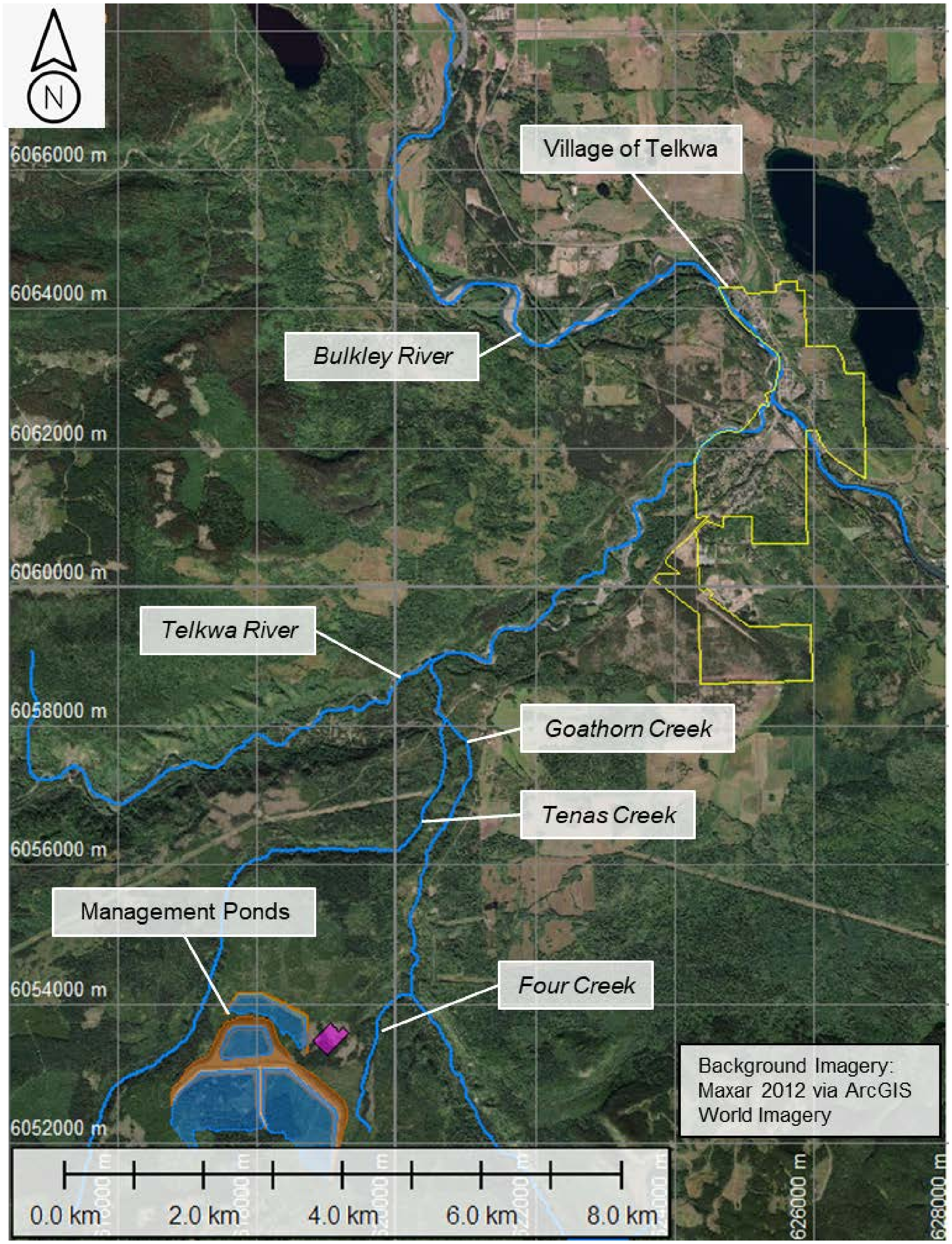
Telkwa Coal Limited (TCL) is proposing to develop the Tenas Project (the Project) in northwest British Columbia. The site is located approximately 25 kilometres (km) southwest of the town of Smithers within the Telkwa River watershed and will comprise of an open pit, backfill, external stockpiles, management ponds, control ponds, the Mine Infrastructure Complex and rail infrastructure pad. The Tenas Project's total mine life is approximately 25 years including construction, operations, decommissioning, and reclamation phases.

SRK Consulting (Canada) Inc. (SRK) has been retained to conduct a dam break assessment to evaluate the potential downstream flooding conditions resulting from failure of the dams associated with the management ponds. Results will support water management designs being completed for the Environmental Assessment Certificate (EAC) application, inform dam classification according to the Canadian Dam Association (CDA) guidelines, and will be incorporated into the Emergency Response Plan.

1.1 Site Description and Plan

The dam breach assessment extents encapsulate areas directly downgradient of the potential breach locations, areas along streams leading to the key receptors, and areas containing the key receptors. Figure 1-1 provides an aerial view of the project area, showing the site water management facilities, as well as the locations of the streams along which water released from the dams may travel. There are three creeks of interest, as well as the Telkwa River and Bulkley River. The nearby Village of Telkwa is located at the confluence of the Telkwa and Bulkley Rivers, approximately 11 km northeast of the Project's mine site.

Figure 1-1: Dam Breach Analysis Site Plan



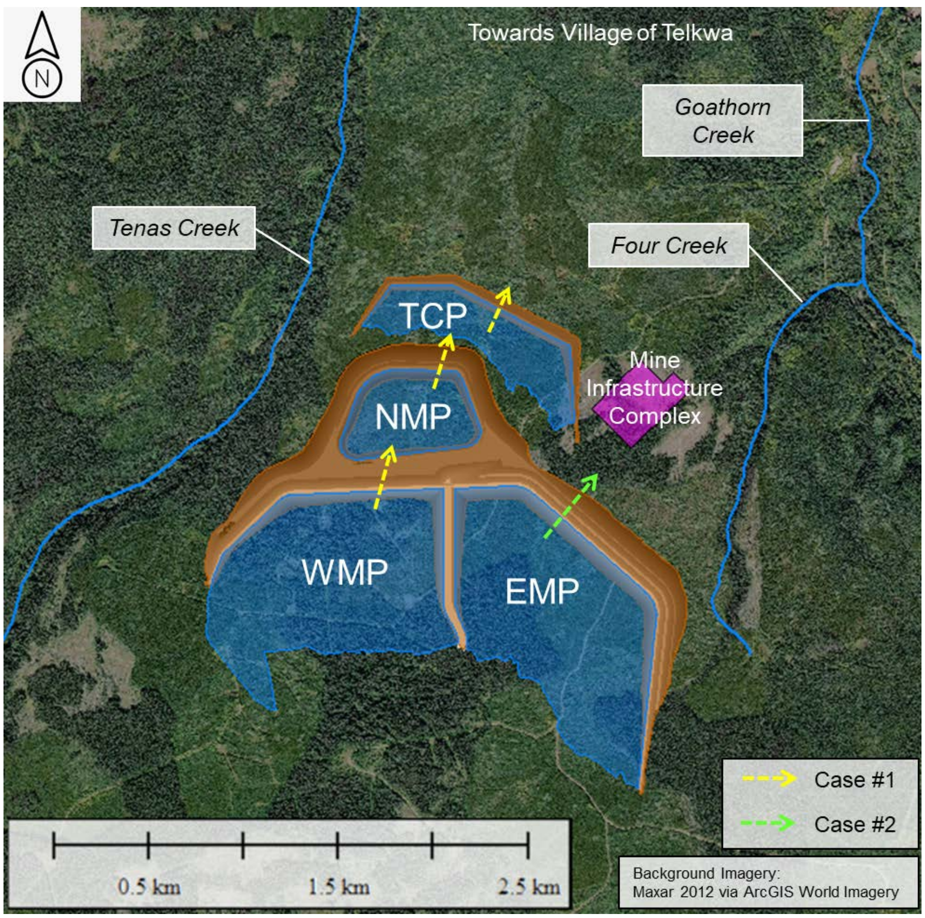
Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

There are four water management facilities of interest to the Dam Breach analysis as shown in Figure 1-2:

1. Tenas Control Pond (TCP)
2. North Management Pond (NMP)
3. East Management Pond (EMP)
4. West Management Pond (WMP)

The three management ponds serve as potentially acid generating (PAG) rock and processed rock storage facilities with approximately 2 metres (m) of water cover maintained during operations, decommissioning and reclamation and post closure phases of the Project. Non-acid generating (NAG) rock will be placed over the PAG rock as cover, followed by overburden material to an elevation above the proposed water level. The NMP is scheduled to be constructed, filled, and covered early in the life of mine, followed by the EMP, and then by the WMP. The TCP is located downstream of the management ponds and collects overflow from the ponds and surface runoff from upslope mine infrastructure.

Figure 1-2: Management and Control Pond Site Plan



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1.2 Scope of Work

The purpose of the dam breach assessment is to estimate the incremental consequences to key receptors downstream of the ponds resulting from embankment failure, the scope of which includes:

- identification of key risk receptors,
- assessment of credible failure modes,
- calculation of dam breach parameters and hydrographs,
- simulation of breach scenarios and production of inundation and hazard maps, and
- assessment of results to determine impacts of the potential dam breach.

The following two critical failure cases were assessed in the detailed dam breach study, and are shown previously by Figure 1-2:

1. Cascade failure of the West Dam, North Dam, and Tenas Dam, for which the key receptor is the Village of Telkwa and is shown by the yellow line on Figure 1-2.
2. Failure of the East Dam northeastward towards Four Creek, for which the key receptor is the Mine Infrastructure Complex, with some consideration given to the Village of Telkwa and is shown by green line on Figure 1-2.

The breach scenarios are determined by evaluating the mine plan for the worst-case conditions for failure during the life of mine.

In recent years, there have been a large number of long runout flow slides from Rocky Mountain coal mine waste dumps. The waste dumps are constructed as end-dumped fills with an angle of repose of 38°. Dump heights range between 100 and 400 m. The dumps are normally founded on mountain slopes that are covered with a thin veneer of granular colluvial and dense stony till materials (Dawson et al., 1998). Given the design heights of waste rock within the Management Ponds, the relatively flat ground beneath the ponds themselves, and the containment within an earthen dam, the liquefaction of neither the rock stored in the ponds nor the rock used in the dam fill is likely to occur.

The rock material stored in the ponds is therefore not expected to significantly affect inundation predictions. Additionally, the quantity of overburden from the dam that can mobilize during a breach event is considered insignificant compared to the quantity of water. Therefore, sediment transport modelling was not included in the inundation study, as the effects of a dam breach will be principally governed by the release of water, rather than eroded overburden from the embankments or stored rock material.

Water in the ponds may either be pore water that saturates the voids in the waste material, or free water which covers the mine rock. In the event of a breach, the pore water is expected to flow out relatively slowly compared to the free water and will therefore have a negligible effect on the peak flow from the breach and incremental flood effects. The breach parameters were therefore calculated based only on the free water present during the worst-case scenarios.

Sensitivity analyses were also completed to understand the effects of changes to breach and modelling parameters on inundation predictions.

2 Dam Breach Inputs

2.1 Dam Information and Geometry

The dams are to be constructed with coarse NAG waste rock and locally sourced overburden which comprises well-graded sands, silts, and gravels near the surface, with larger quantities of fine sands at greater depths. The embankment foundation consists of similar soils, and the North, East, and West dams will be supported by buttresses (SRK 2021a).

The embankment geometry for each dam at the critical failure scenario was compiled based on mine plan drawings and topographic data from the 2018 LiDAR survey of the Project area, and are summarized in Table 2-1. Storage volumes were estimated based on pond stage-storage relationships, developed using site topography and embankment surfaces provided by TCL. Summary elevation-storage tables are provided in Appendix A.

Table 2-1: Water management pond dam embankment geometry

Parameter	Unit	Critical Failure Case #1			Critical Failure Case #2
		West Dam	North Dam	Tenas Dam	East Dam
Crest length	m	1511	1173	1876	3225
Typical crest width	m	9	14.5	10	9
Overall upstream slope	-	2.5H:1V	2.5H:1V	2.5H:1V	2.5H:1V
Overall downstream slope	-	3.0H:1V	3.0H:1V	3.0H:1V	3.0H:1V
Maximum embankment height	m	37	27	18	40
Outlet elevation	masl	851	830	801	851
Crest elevation	masl	852	831	802	852
Rock fill elevation in worst-case scenario	masl	847	828	N/A	845
Total storage to outlet invert	m^3	35,151,000	3,800,800	1,936,600	16,379,300
Total storage to dam crest	m^3	36,211,900	4,119,000	2,292,100	17,514,600
Rock fill volume in worst-case scenario	m^3	31,108,800	3,239,600	N/A	10,120,000

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Telkwa_DamBreach_Inputs_1CT017-003_rev04_nf.xlsm

Note: Final mine plan designs have since reduced the dam crest elevations to 850 masl for the EMP and WMP and 800 masl for the TCP. Dam breach assessments continue to use higher dam crests, resulting in a more conservative dam breach hydrograph for the purpose of dam classification.

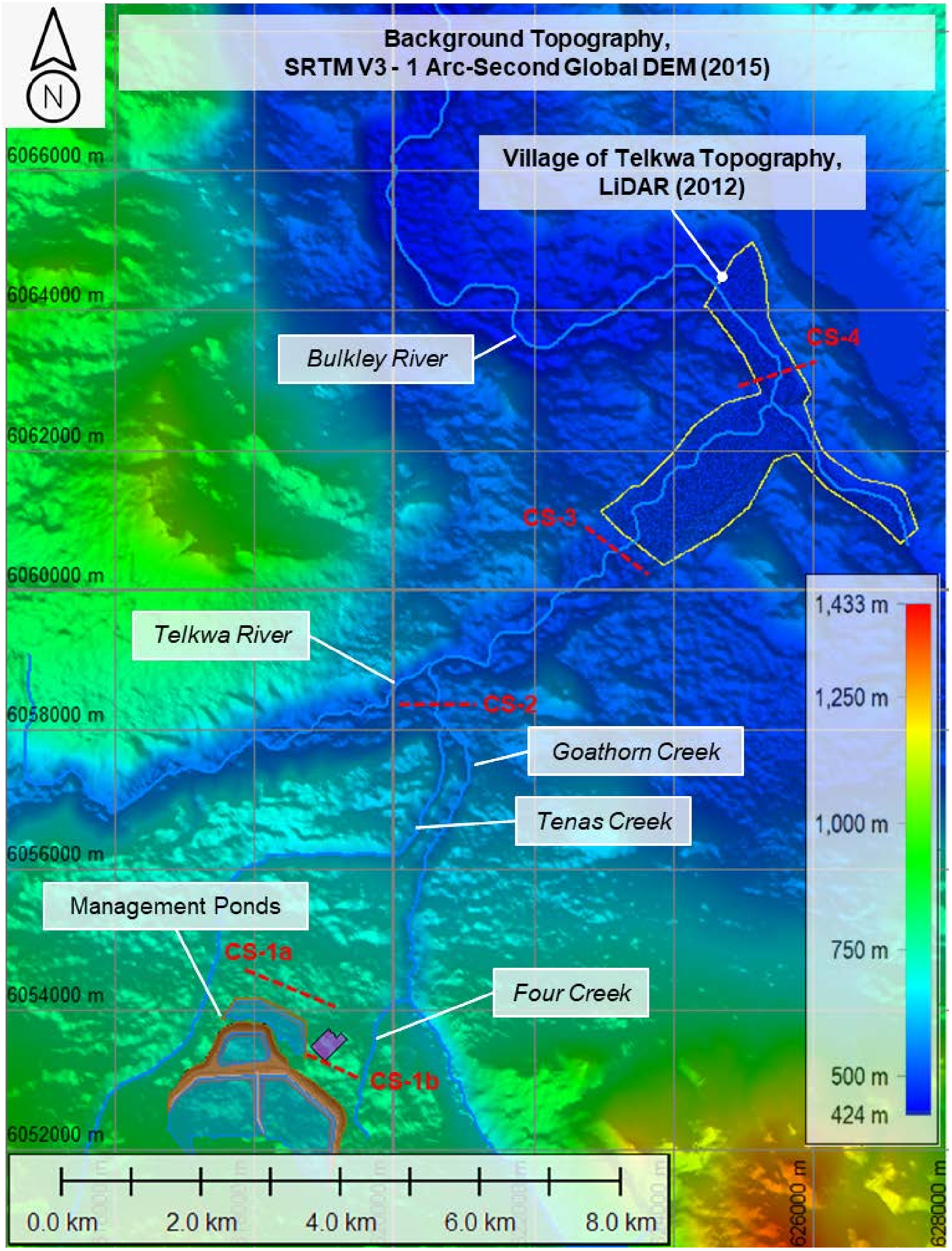
2.2 Topography

Detailed 2020 LiDAR topography for the site was provided by TCL, with a resolution of 1 m, which was used to develop pond storage-elevation curves and determine fill elevations in the facilities. To guarantee full coverage of the computational area, the SRTM (Shuttle Radar Topography Mission) 1 arc-second global digital elevation model (DEM) Version 3.0 was used for the majority of the study area, including areas immediately downgradient of the breach locations and along streams flowing towards the Village of Telkwa (USGS, 2020).

For added resolution within the Village of Telkwa, the SRTM surface was merged with 2012 topography data which was used in a flood inundation study completed on behalf of the village by Golder Associates Inc. (2019), which has a resolution of 1 m.

The SRTM and 2012 topography data (Village of Telkwa, 2020) were reasonably well-matched, but some minor feathering was required to smoothly transition between the two surfaces. No other erroneous topographical features that would adversely affect the modelling were perceived within the data. The grid cell size chosen for the model was 50 m by 50 m, in order to accommodate the resolution of the SRTM data.

Figure 2-1: SRTM and 2012 Digital Elevation Data Extents



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2.3 Hydrology

Peak stream flows are summarized in Table 2-2, and represent the reasonable worst-case natural flows in the five streams affected by the breaches. For streams that have tributaries that are also modelled in the list, the tributary flows are subtracted from the post-confluence total flow values, making the flows in Table 2-2 additive. This way, the streams may combine within the model without double-accounting for any flows.

Flows corresponding to the probable maximum flood (PMF) values are given for Four Creek, Goathorn Creek, and Tenas Creek, and were determined through rainfall-driven runoff modelling in HEC-HMS, consistent with methodologies outlined in the Tenas Project – Mine Site Water Management Design Technical Report (SRK 2021b) and Hydrometeorological Baseline Report (SRK 2021c). The 1-in-200 year flood events are used for the reasonable worst-case in the Telkwa and Bulkley Rivers in lieu of the PMF, and were determined with a frequency analysis of historical Water Survey of Canada records (SRK 2021c).

Table 2-2: Stream flow estimates for worst-case flood conditions

Return Period	Peak Flow (m^3/s)
Tenas Creek: PMF	168.0
Goathorn Creek: PMF	335.0
Four Creek: PMF	30.0
Telkwa River: 1-in-200 year	561.0
Bulkley River: 1-in-200 year	982.4

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Inflow Hydrographs\DamBreak_inflowHydrographs.xlsx

In addition to the in-stream flow conditions, the catchment areas and associated runoff contributions to the WMP and EMP were calculated based on inputs and assumptions consistent with SRK 2021b and 2021c, and added to the operating water cover to create the total stored water volume under worst-case conditions. Table 2-3 summarizes additional hydrological inputs applied to the breach configurations.

Table 2-3: Pond hydrological inputs

Parameter	Unit	Critical Failure Case #1 West Dam	Critical Failure Case #2 East Dam	Assumptions/Comments
1-in-100 wet year precipitation	mm	822		1-in-100 wet year precipitation
Worst-case contributing catchment area	km^2	2.4	4.2	Assumes upstream hydraulic structures have failed.
Conservative runoff coefficient	-	1	0.8	All pit runoff reports to the WMP. EMP receives majority of runoff from upstream natural catchments. Natural

Parameter	Unit	Critical Failure Case #1 West Dam	Critical Failure Case #2 East Dam	Assumptions/Comments
				runoff coefficient calculated to be 0.36 (SRK 2021c)
1-in-100 wet year inflow volume	m^3	1,600,000	2,900,000	Assumes volume from 1-in-100 wet year precipitation is added to total stored water in ponds.

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Telkwa_DamBreach_Inputs_1CT017-003_rev04_nf.xlsm

2.4 Key Downstream Receptors

Table 2-4 provides descriptions for specific downstream receptors of particular concern for the dam breach analysis, categorized according to CDA (2013) guidelines.

Table 2-4: Key receptors assessment

Category	Receptor	Critical Failure Case	Comments
Population	Residents of the Village of Telkwa and surrounding areas	1, 2	The Village of Telkwa is located approximately 11 km downstream of the water management ponds. It is the closest township to the site, and likely to be at risk due to inundation from a breach. The village is situated at the confluence of the Telkwa and Bulkley Rivers, with buildings located within the river floodplains.
	TCL Personnel	2	TCL personnel are anticipated to operate within the Mine Infrastructure Complex area at all times, and would be at risk should the East Dam fail in its northeastern section. Approximately 80 people are expected to occupy the area at the worse case during shift change.
Environmental	Trees/Habitat	1, 2	The undeveloped inundation area outside of the creek channels generally consists of forested terrain. Restoration of the habitat would be possible.
	Fish and Aquatic Habitat	1, 2	The creeks downslope of the mine site, as well as the Telkwa and Bulkley Rivers, provide a habitat for various fish and other aquatic species.
Cultural	Residents of the Village of Telkwa and surrounding areas	1, 2	Regional heritage sites and tourism in the Village of Telkwa may be affected by a breach event.
Infrastructure	Road bridge over Bulkley River (Telkwa Coalmine Rd to Riverside St crossing)	1, 2	A bridge crosses the Bulkley River and is located close to the junction of the Telkwa and Bulkley Rivers. It is the traversing location for vehicular traffic within the Village of Telkwa.

Category	Receptor	Critical Failure Case	Comments
	Railway bridge over Telkwa River	1, 2	A railway bridge crosses the Telkwa River close to the junction of the Telkwa and Bulkley Rivers. The railway serves both freight and public transport trains.
	Aveling/Telkwa Coalmine Rd	1, 2	Access road running alongside the Telkwa River to the Village of Telkwa.
	Highway 16	1, 2	Freeway alongside the Bulkley River, through the Village of Telkwa.
	Town roads	1, 2	Non-major roadways within the Village of Telkwa.
	Buildings and residential homes	1, 2	Encompasses the residential, commercial, and industrial edifices near and within the Village of Telkwa.

Sources: Compiled in text.

3 Dam Breach Model Development

The dam breach assessment was modelled using FLO-2D software (FLO-2D, 2019). The software applies the finite difference technique for overland flow routing by means of mass and momentum conservation. The outputs from the model can also be exported as shapefiles that can be viewed in GIS programs.

The development of the model comprised the following steps detailed in this section:

- Determination of the failure modes and breach locations for the critical cases
- Estimation of the volume released in the breach
- Valuation of the breach parameters and outflow hydrographs
- Routing of the downstream flood

3.1 Failure Modes and Breach Locations

In accordance with the CDA Guidelines (2013), the dam breaches and the associated discharge hydrographs are evaluated under two hydrologic conditions:

- **"Sunny-day" failure** – "a sudden dam failure that occurs during normal operations", which may be "caused by internal erosion, piping, earthquakes, mis-operation leading to overtopping, or another event".
- **Flood-induced or "rainy-day" failure** – "a dam failure resulting from a natural flood of a magnitude that is greater than what the dam can safely pass".

There are several credible failure modes for embankment dams, the most common of which are overtopping failures due to inadequate spillway capacities and/or large flood event, piping failures due to concentrated internal erosion of the dam, and foundation-related failures such as slippage or settlement. The failure modes have been assumed based on knowledge of the dam structures, construction schedules, and engineering judgement and previous dam failures that have occurred.

Along the lengths of the embankments, the breach locations were chosen to achieve the highest incremental effects for the key receptors. For the West, North, and Tenas Dams, the breach location must be in the north to north-east portions to simulate the cascade failure case that eventually reports to the Village of Telkwa. The breach location for the East Dam was chosen for the greatest impact to the MIC, which is the northeastern section of the dam.

3.1.1 Sunny-Day Breach

A sunny-day failure occurs during normal operations, with the most likely failure mode for the dams being piping failure. The likelihood of foundational failures in the management pond dams is further mitigated by the structural support from the buttresses, and the spillways are to be designed to prevent overtopping from flood events that are credibly expected to occur during operations.

The most likely failure location is typically near the dam crest, and/or where the embankment slopes are steepest, as these areas would have the maximum hydraulic gradient for free water retained in the facilities. The breach is not expected to extend significantly below the elevation of the rock fill in the ponds, therefore the maximum breach height is approximated by the depth of the free water in the pond.

The sunny day breach scenarios assume that mean annual flow conditions are occurring in the catchments with flow in the streams, whose flood extents are accounted for in the topography.

3.1.2 Rainy-Day Breach

The rainy-day breach occurs under conditions of exceptional flow due to large storm events. In the event of flows exceeding the spillway design criteria, the ponds would overtop the embankments resulting in overtopping failure. Piping failure is also a possibility, but the breach in either case would originate at or close to the dam crest.

In order to assess the incremental effects of a breach, two rainy day scenarios are modelled – both will have PMF or 1-in-200 year flows (summarized in Table 2-1). One model includes the breach while the other does not. Comparing the two sets of results allows separation of breach-related effects from storm event-related effects.

3.2 Breach Volumes

The critical failure conditions for each dam in the two main failure cases are summarized in this subsection, which includes cross-sectional diagrams of the dams with free water depths relative to the dam heights.

3.2.1 Critical Failure Case #1

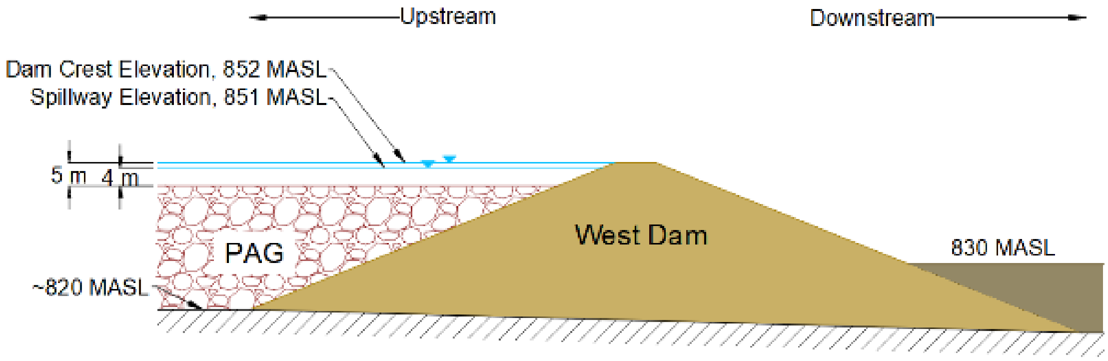
West Dam

Construction of the WMP is not expected to begin until later in the mine life, after which PAG filling and dam raising will occur incrementally until the dam is completed. According to the mine plan, the maximum volume of free water in the pond occurs after the dam has been raised to the maximum elevation.

Under typical operating conditions, the completed WMP (Figure 3-1) is not expected to have more than 2 m of water cover over the PAG waste rock, and lengthy periods of time without pump-controlled discharge from the pond is unlikely to occur. The maximum volume with the highest hydraulic gradient occurs when the stored water is at the spillway elevation. For the purpose of modelling critical conditions, an additional volume of water equal to the total runoff from upslope catchments during a 1-in-100 wet year was included in the facility addition to the 2 m typical water cover.

The total breach height in the West Dam with the additional 100-year wet runoff contributions (Table 2-3) is 4 m for the sunny day failure, corresponding to approximately 4.0 million cubic metres (Mm^3) of free water in the WMP. The breach height for the rainy-day overtopping failure is 5 m (5.1 Mm^3 stored), which occurs when the water level reaches and overtops the dam crest elevation during a large flood event.

Figure 3-1: West Dam cross-section in the critical case



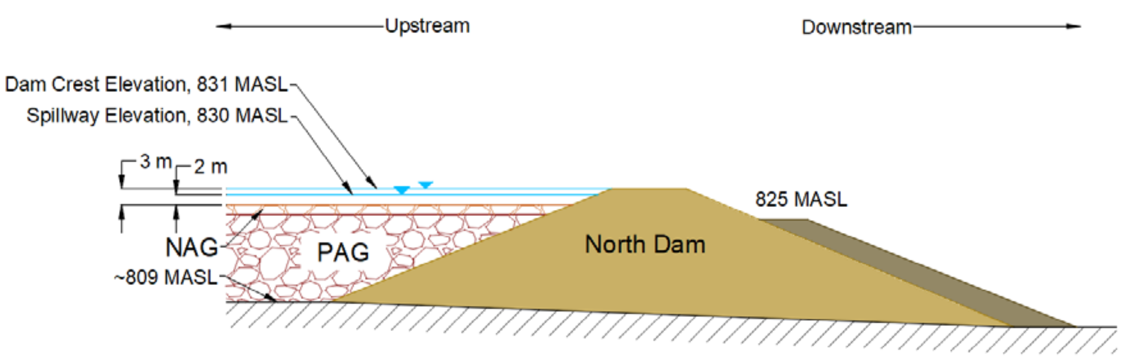
Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Dam Cross-Sections

North Dam

At the time of completion for the WMP, the filling of the NMP will have already been completed, including NAG rock cover over the PAG waste rock. For the failure case, it is assumed that the planned overburden cover will not have been placed in the facility, allowing a larger volume of water to be stored in the NMP and therefore released during the breach scenario.

The breach height for the sunny-day failure will comprise the water cover of 2 m (0.56 Mm^3), which will be 3 m (0.88 Mm^3) for the rainy-day failure.

Figure 3-2: North Dam cross-section in the critical case



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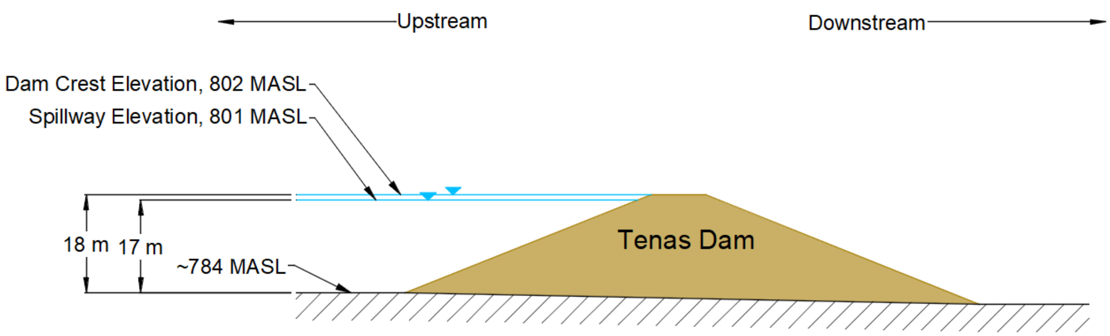
Tenas Control Pond Dam

It is assumed that the water level in the TCP is up to the spillway elevation at the start of a sunny day failure. Since TCP is a settling pond, there will be no rock storage resulting in maximum breach height equal to the entire height of the dam.

The sunny and rainy-day breach heights are therefore 17 m (1.9 Mm^3) and 18 m (2.3 Mm^3) respectively.

Figure 3-3: Tenas Dam cross-section in the critical case



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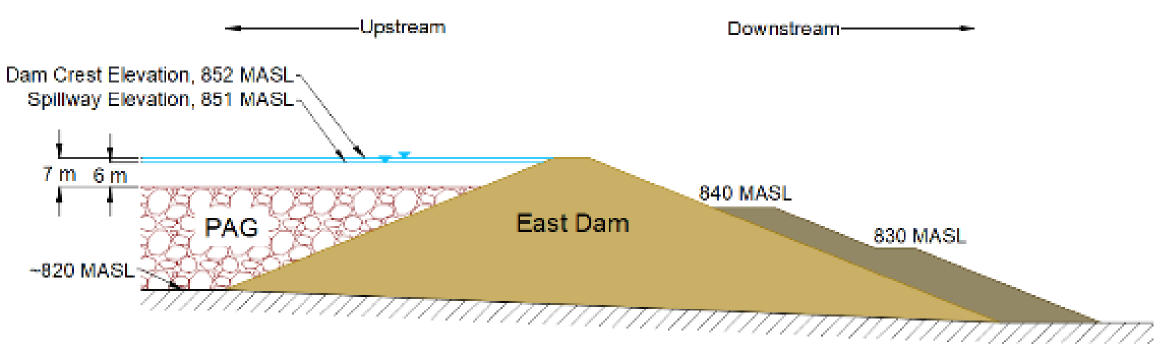
3.2.2 Critical Failure Case #2

East Dam

The second failure case assesses the failure of the East Dam towards the MIC. The approach to determining the critical failure conditions for the East Dam is the same as for the West Dam, where 2m of water cover and one year of 1-in-100 wet year runoff is stored at the time of breach (Table 2-3).

It then follows that the sunny and rainy-day breach heights are 6 m (6.3 Mm^3) and 7 m (7.4 Mm^3) respectively.

Figure 3-4: East Dam cross-section in the critical case



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Dam Cross-Sections

3.3 Dam Breach Hydrographs

The dam breach hydrographs are determined from parameters calculated using empirical equations that were developed through the assessment of case histories from past water-retaining embankment breaches. The equations from Froehlich (1995) and Froehlich (2008) were applied, and the resulting breach parameters for the sunny day breach are presented in Table 3-1, and the rainy day breach parameters are presented in Table 3-2.

The peak flows are relatively high due to the large volumes of water released. The formation times are slower (up to 2 hours) for breaches with relatively high volumes but relatively low breach heights, and faster for facilities with relatively low volumes with relatively high breach heights. The Tenas Dam can be expected to empty in as little as 12 to 30 minutes. The rainy-day peak flows are higher than the sunny-day flows, with a shorter breach formation time.

Table 3-1: Sunny day dam breach parameters

Parameter	Unit	Critical Failure Case #1			Critical Failure Case #2
		West Dam	North Dam	Tenas Dam	East Dam
Dam Type		Rock-filled	Rock-filled	Rock-filled	Rock-filled
Failure mode		Piping	Piping	Piping	Piping
Breach height	m	4	2	17	6
Free water volume	m^3	4,042,200	561,200	1,936,600	6,259,300
Individual dam breach peak flow	m^3/s	300	71	1500	570
Total breach case peak flow[1]	m^3/s	1871			570
Formation Time[2]	hr	1.8 (2.8)	1.1 (2.1)	0.2 (0.5)	1.5 (2.3)

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Telkwa_DamBreach_Inputs_1CT017-003_rev04_nf.xlsm

Notes:

[1] Peak flow for cascade failure assumed to equal peak flow from all contributing dams.

[2] Approximate value from fitting peak flow and volume to hydrograph is presented; calculated value from empirical equations in parenthesis.

Table 3-2: Rainy day dam breach parameters

Parameter	Unit	Critical Failure Case #1			Critical Failure Case #2
		West Dam	North Dam	Tenas Dam	East Dam
Dam Type		Rock-filled	Rock-filled	Rock-filled	Rock-filled
Failure mode		Overtopping	Overtopping	Overtopping	Overtopping
Breach height	m	5	3	18	7
Free water volume	m^3	5,103,100	879,400	2,292,100	7,394,600
Individual dam breach peak flow	m^3/s	430	130	1600	720

Parameter	Unit	Critical Failure Case #1			Critical Failure Case #2
		West Dam	North Dam	Tenas Dam	East Dam
Total breach case peak flow[1]	m^3/s		2160		720
Formation Time[2]	hr	1.6 (2.5)	0.9 (1.8)	0.2 (0.5)	1.4 (2.2)

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Telkwa_DamBreach_Inputs_1CT017-003_rev04_nf.xlsm

Notes:

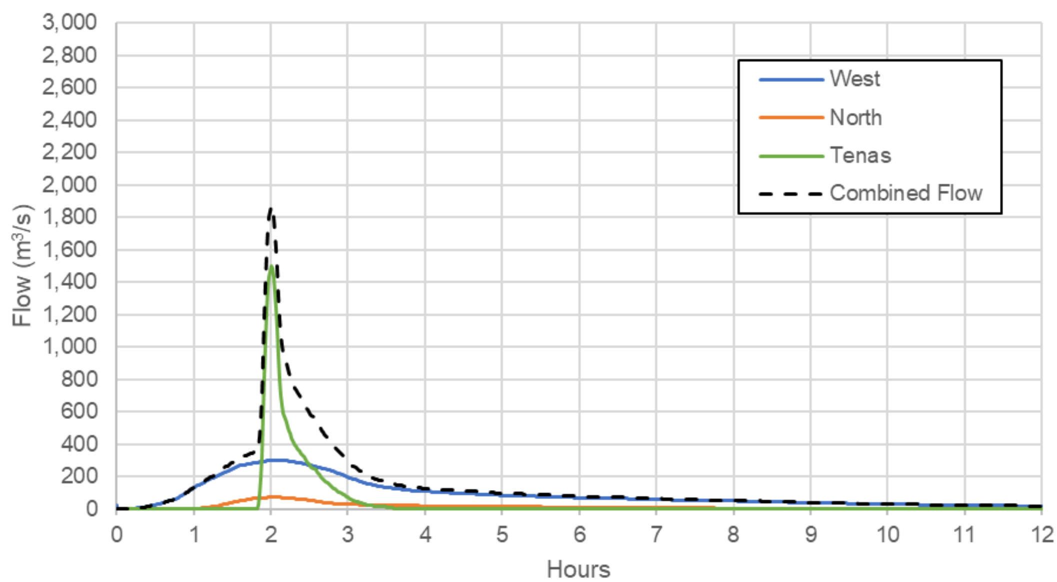
[1] Peak flow for cascade failure assumed to equal peak flow from all contributing dams.

[2] Approximate value from fitting peak flow and volume to hydrograph is presented, calculated value from empirical equations in parenthesis.

The breach hydrographs were prepared using an approximate log-normal distribution fitted to match the total volume released and calculated peak flow. The hydrographs representing the cascade failures were obtained by super-imposing the hydrographs from the contributing dams with the peaks aligned (Figure 3-5 for sunny-day; Figure 3-6 for rainy-day).

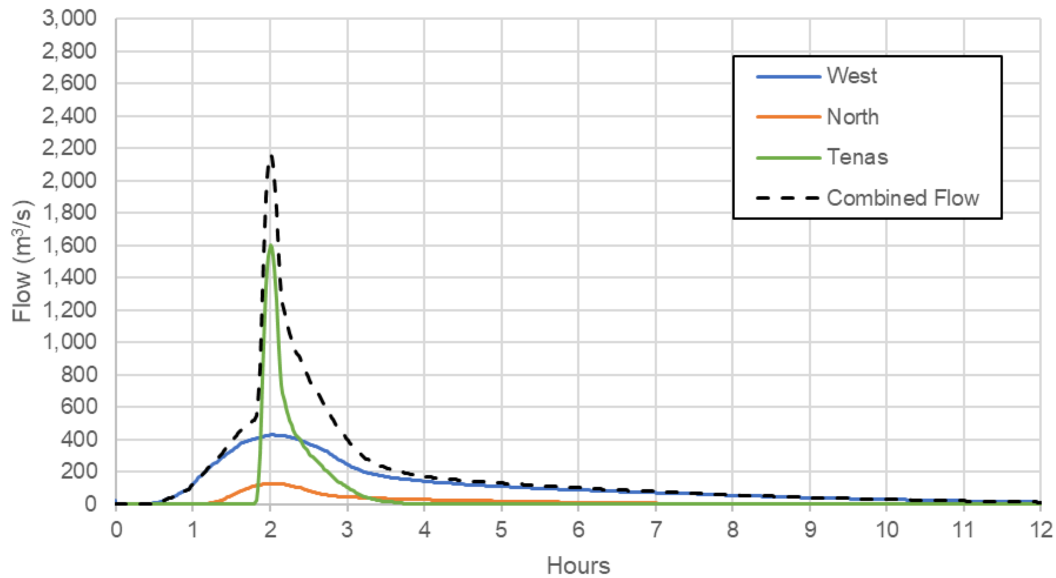
The hydrographs for the sunny and rainy-day failures for the East Dam are plotted in Figure 3-7.

Figure 3-5: Sunny day breach outflow hydrograph for Critical Failure Case #1



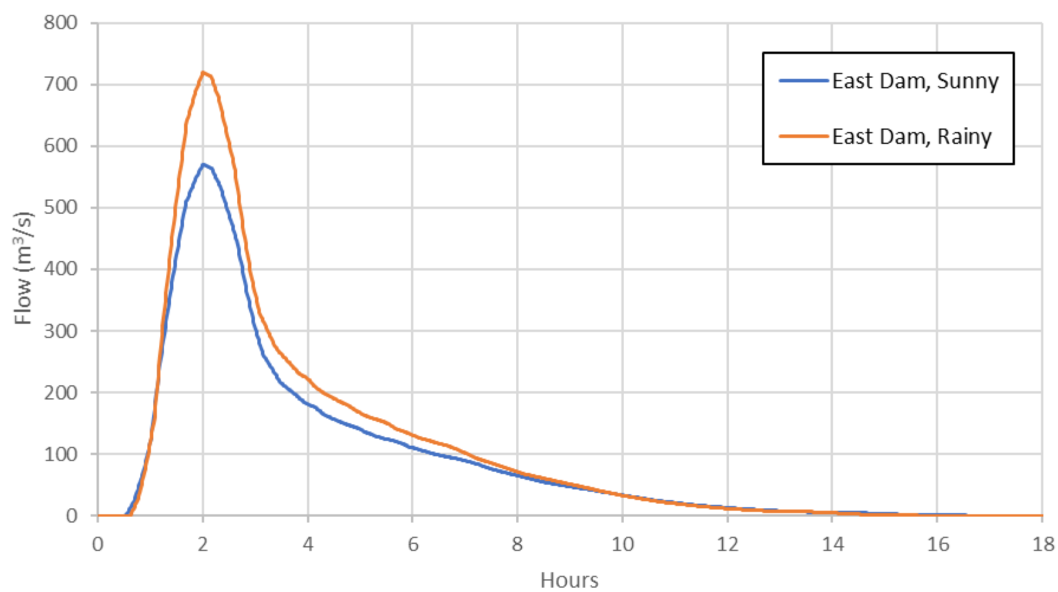
Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Breach Hydrographs\Base_Case\!Telkwa_BC_Breach_Spreadsheet_1CT027-003_rev04_nf.xlsx

Figure 3-6: Rainy day breach outflow hydrograph for Critical Failure Case #1



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Breach Hydrographs\Base_Case\!Telkwa_BC_Breach_Spreadsheet_1CT027-003_rev04_nf.xlsx

Figure 3-7: Sunny and rainy day breach outflow hydrographs for Critical Failure Case #2



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Breach Hydrographs\Base_Case\!Telkwa_BC_Breach_Spreadsheet_1CT027-003_rev04_nf.xlsx

3.4 Flood Route Modelling

3.4.1 Boundary Conditions

Preliminary simulations were run in order to estimate inundation limits, from which the size of the computational area could be adjusted. Overall, the model extents allow for the flood flows from the mine site to reach the Village of Telkwa, as well as provide buffer distance for the stream inflows to be applied. The inundation extents within the modeled area are generally determined by topography, with some effects from surface roughness. FLO-2D ‘Outflow elements’ are assigned to the downstream of the Bulkley River, past the Village of Telkwa.

3.4.2 Hydraulic structures

Hydraulic structures are not explicitly included in the analysis for the flood route modelling. The spillways are omitted in order to prescribe the breach locations along the dams. Bridges located in the Village of Telkwa are considered only when assessing breach effects on infrastructure.

3.4.3 Surface Roughness

The areas along the inundation pathway were classified into zones for surface roughness (Figure 3-8), quantified by Manning’s n values. The values were defined using recommendations from the FLO-2D PRO Reference Manual (2019) and are summarized in Table 3-3. The overland flow roughness coefficients are considerably higher than those used for open channel flow.

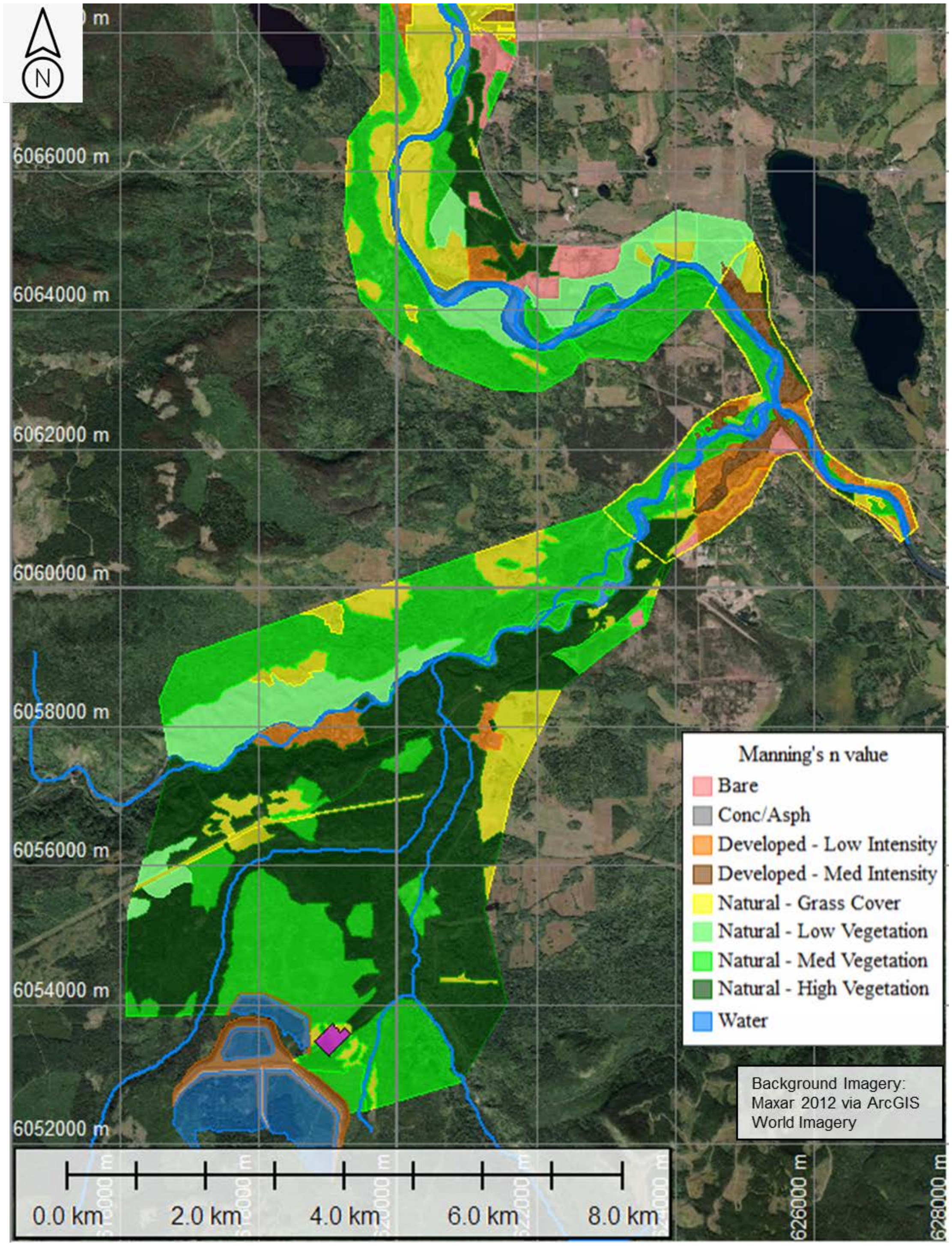
Sensitivity analyses were performed by varying the Manning’s n values by +/- 50% and showed that surface roughness has little impact on the results compared to other modeled factors. The results of the sensitivity analysis are not reported in this document for brevity.

Table 3-3: Manning’s n values used in the dam breach analysis

Zone Description	Manning’s n value
Open ground, no debris	0.04
Concrete/Asphalt	0.02
Developed - Low Intensity	0.30
Developed - Medium Intensity	0.35
Natural - Low Vegetation	0.20
Natural - Medium Vegetation	0.30
Natural - High Vegetation	0.35
Natural - Grass Cover	0.16
Water	0.04

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Inflow Hydrographs\DamBreak_inflowHydrographs.xlsx

Figure 3-8: Surface roughness zone assignment in computational area



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

3.4.4 Model Inflow Hydrographs

The combined breach hydrograph for the cascade failure (Figure 3-5 and Figure 3-6) were applied to the northern section of the Tenas Dam. The breach hydrographs for the East Dam failure (Figure 3-7) was applied to the northeastern section of the dam.

The stream peak inflow was applied as constant values for each creek or river, at locations upstream of any confluences.

3.4.5 Control Cross-Sections

Five cross-sections (dashed red lines in Figure 2-1) were created to assess the downstream effects of the flood wave. The cross-sections are detailed in Table 3-4 and are numbered upstream to downstream (south to north). CS-1a, CS-2, CS-3, and CS-4 are used for Critical Failure Case #1, and CS-1b is used for Critical Failure Case #2. Time series plots showing flow width and depth at each cross-section for each simulation scenario are provided in the appendices with the maximum flow depth contour plots. Time series for flow velocity and discharge rates are shown with the maximum flow velocity contour plots.

Table 3-4: Cross-section IDs and locations

Cross-Section ID	Location Description	Distance Downstream of Breach Location
CS-1a	Directly downgradient of Tenas Dam breach location	0 km
CS-1b[1]	Directly downgradient of East Dam breach location	0 km
CS-2	Tenas Creek, before confluence with Telkwa River	5.7 km
CS-3	Telkwa River, at south end of Village of Telkwa	9.5 km
CS-4	Bulkley River, after confluence with Telkwa River	13.1 km

Sources: Compiled in text.

Notes:

[1] Cross-section includes Four Creek inflow.

4 Results

The results from the following scenarios are discussed in this section:

1. Critical Failure Case #1
   a. Rainy day (PMF in creeks, 200-year flood in rivers) with no breach
   b. Sunny day with cascade breach at the northern embankment of Tenas Dam
   c. Rainy day with cascade breach at the northern embankment of Tenas Dam
2. Critical Failure Case #2
   a. Sunny day breach at the northeastern embankment of East Dam
   b. Rainy day breach at the northeastern embankment of East Dam

Inundation maps for each scenario are provided in Appendix A through E, which include the following:

- Maximum flow depth – relative to starting condition
- Maximum flow velocity
- Flood hazard maps
- Arrival time (sunny day scenarios) - relative to the start of the model, and not peak flow or breach formation.

The flood hazard maps were produced for the purpose of assessing risk to human life. The hazard levels were assigned based recommendations from the Professional Practice Guidelines for flood mapping provided by the Association of Professional Engineers and Geoscientists BC (APEGBC, 2017). The hazard ratings (HRs) are a function of the depth and velocity of flood waters (Equation 4-1), and the categories are summarized in Table 4-1. Additional risks posed by the inclusion of debris in the flood waters is uncertain but assumed to be negligible for this study. The presence of debris could result in a significant increase in hazard rating.

$$\boldsymbol{HR = d * (v + 0.5) + DF} \qquad \textbf{Equation 4-1}$$

Sources: Equation derived from HR Wallingford (2006), provided by APEGBC (2017).

Notes: *HR* = flood hazard rating
d = depth of flooding (m)
v = velocity of floodwaters (metres per second (m/s))
DF = debris factor (0, 0.5, or 1 depending on probability that debris will lead to significantly greater hazard – 0 used)

Table 4-1: Flood hazard level to people based on hazard rating

Hazard Rating (HR)	Hazard to People Classification
< 0.75	Very Low Hazard (Caution)
0.75 – 1.25	Danger for Some (includes children, the elderly, and the infirm)
1.25 – 2.00	Danger for Most (includes the general public)

Hazard Rating (HR)	Hazard to People Classification
> 2.00	Danger for All (includes emergency services)

Sources: Classification system developed by Surendran et al. (2008), provided by APEGBC (2017).

4.1 Critical Failure Case #1

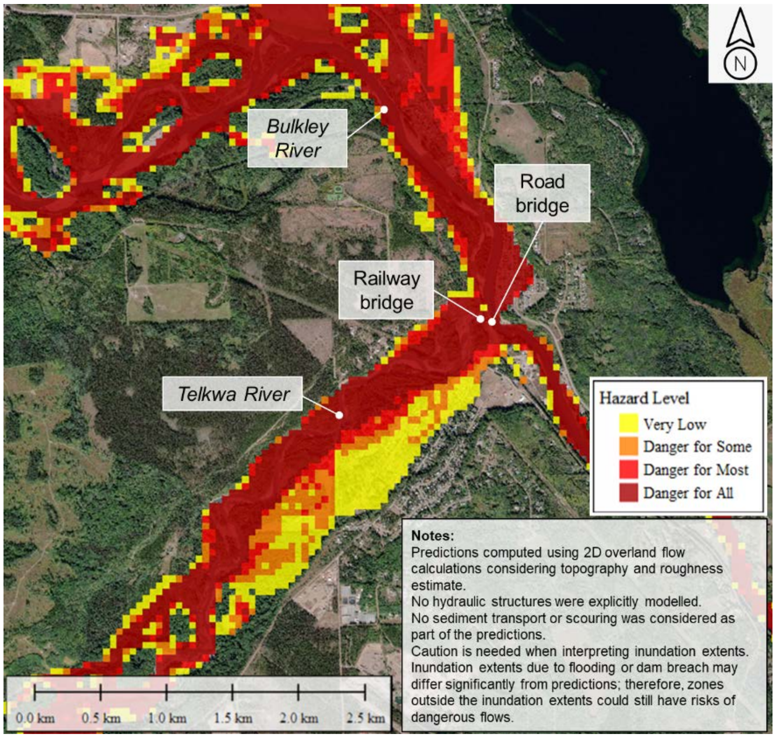
4.1.1 No Breach, Flood Event Scenario

Appendix A (Figures A.1 to A.3) provides inundation maps for maximum flow depths, maximum flow velocities, and flood hazard resulting from PMF conditions in the creeks and 200-year flood in the rivers (PMF/Q200). Maps for both the full study area and specifically the Village of Telkwa are shown. The CPP area is unaffected by stream flow during a rainy-day scenario with no breach.

According to the prediction as shown in Figure 4-1, the southern portion of the Village of Telkwa would be largely inundated during a PMF/Q200 event, but depth predictions do not generally exceed 1 m, nor do the predicted flows exceed 0.2 m/s, making the hazard mostly ‘Very Low’ or a ‘Danger for Some’ along the Telkwa River section. The risk to humans and infrastructure in the northern section of Telkwa is greater, where flows are predicted to be as high as 5 m, though velocities are relatively low at below 0.3 m/s in most areas.

Flows depths in the rivers near both the road bridge and railway bridge are predicted to exceed average depths by up to 9 m, with velocities close to 4 m/s. Therefore, bridge damage may occur during a PMF/Q200 event without a dam breach.

Figure 4-1: Rainy day, no breach maximum flood hazard in the Village of Telkwa



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

Notes: Background Imagery courtesy of Maxar 2012 via ArcGIS World Imagery

The inundation maps in Appendix A show that despite significantly higher flows in the streams, the flow is generally confined to within the existing creek or riverbanks in areas with less human development, such as towards the proposed mine site. There is some minor flooding in the clearing close to the confluence of Goathorn Creek with Tenas Creek, where there is some development and infrastructure

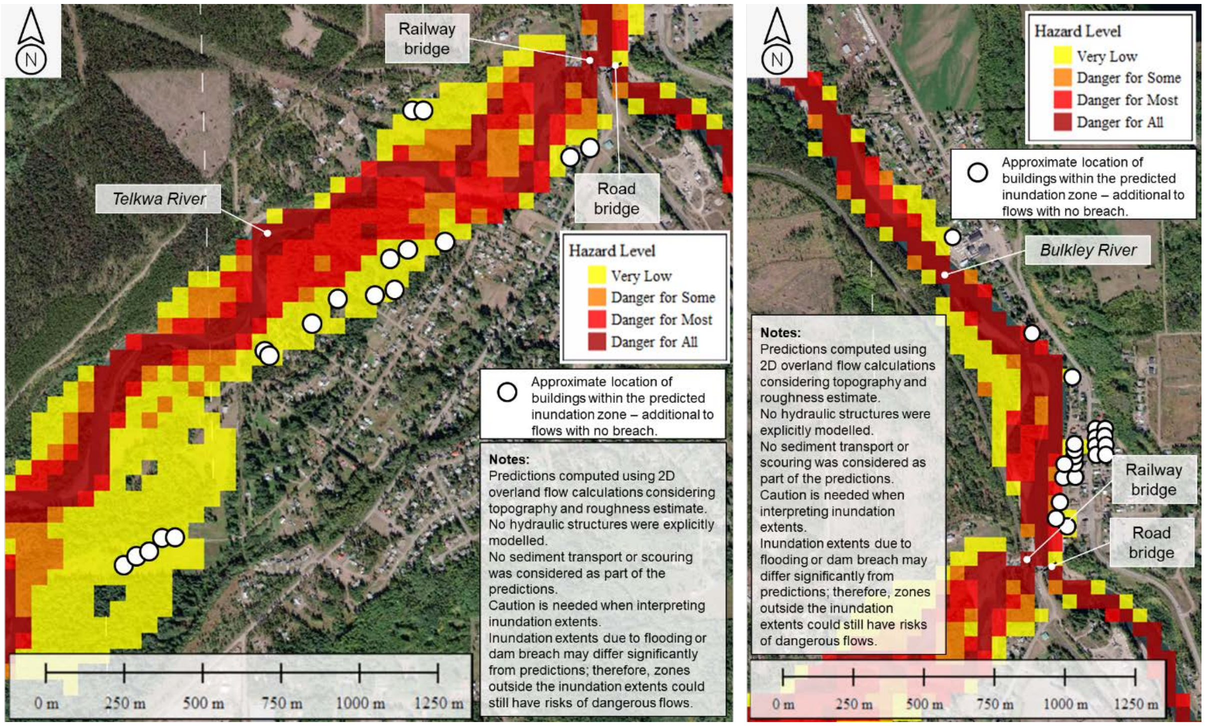
4.1.2 Sunny-Day Breach Scenario

Appendix B (Figures B.1 to B.4) provides inundation maps for maximum flow depths, maximum flow velocities, flood hazard, and arrival time for the sunny day cascade breach.

The predicted inundation area is not as extensive as that of the no breach rainy-day scenario, with most flows being confined to the existing riverbanks. There is some low hazard flooding (> 1 m depth, approximately 0.3 m/s velocity) of the predominantly uninhabited area at the southern tip the Village of Telkwa, as well as some contained inundation in the northern section (Figure 4-2). It is estimated that approximately 120 people would be affected during the sunny-day breach with the assumption of 3 persons per building, though the predicted flood hazard is considered is 'Very Low' for the vast majority of those at risk.

Bridge damage may occur, but the likelihood is much lower than those of the PMF/Q200 scenario as the predicted water depth at the bridges is greater than 3 m, with a velocity of greater than 2 m/s.

Figure 4-2: Sunny-day cascade breach flood hazard in Telkwa south (left) and north (right)



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

Notes: Background Imagery courtesy of Maxar 2012 via ArcGIS World Imagery.
Building count is an approximation used to estimate the population at risk.

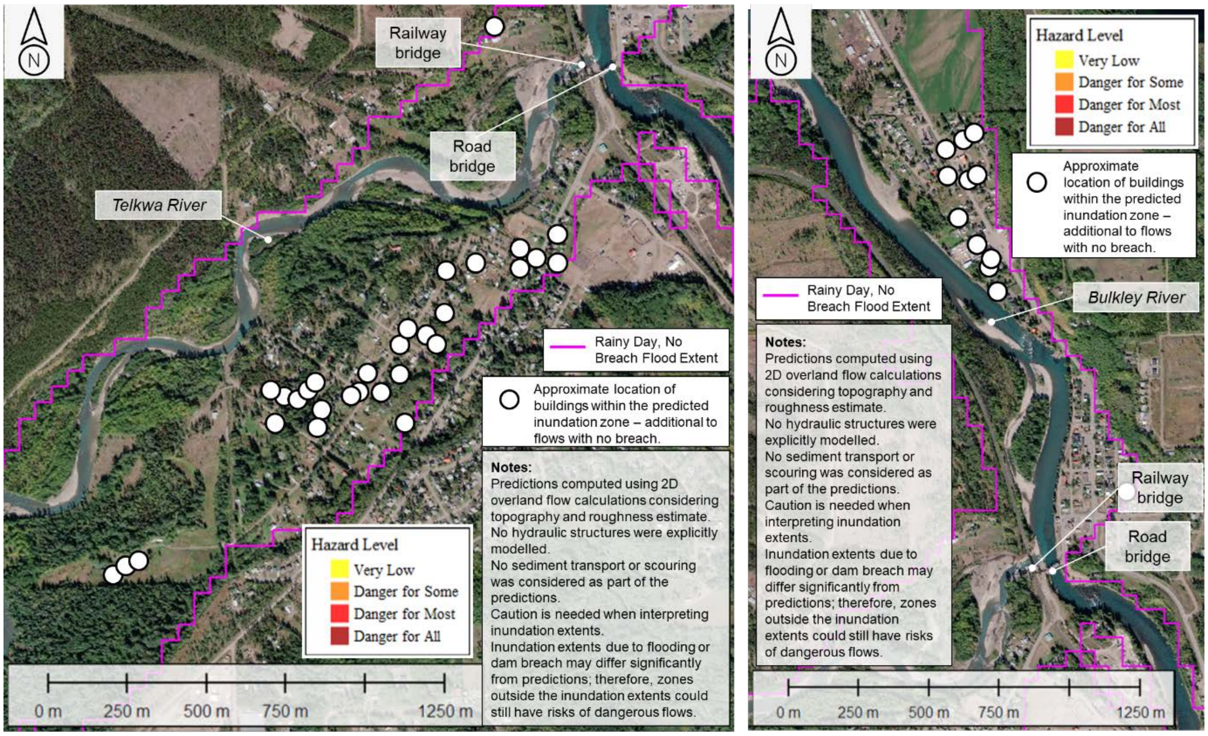
The greatest inundation effects of the sunny day breach occur in the natural area immediately north of the breach location, but there the risk to human life is lower since there is little to no permanent or temporary occupancy of that area.

4.1.3 Rainy Day Breach Scenario

Appendix C (Figures C.1 to C.3) provides inundation maps for maximum flow depths, maximum flow velocities, and flood hazard for the rainy-day cascade breach.

The inundation extents are very similar to the rainy-day with no breach scenario, and therefore the effects of the events are similar. Figure 4-3 shows locations of incremental hazard level resulting from the prediction of rainy-day breach as compared to the rainy-day, no breach scenario. The predictions suggest that approximately 150 people will be within an increased hazard level as compared to the rainy-day, no breach scenario.

Figure 4-3: Rainy-day cascade breach flood zones of increased hazard in Telkwa south (left) and north (right)



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

Notes: Background Imagery courtesy of Maxar 2012 via ArcGIS World Imagery.
Building count is an approximation used to estimate the population at risk.

The flooding is most extensive in the area directly downgradient of the breach location and is greater than of the sunny day breach. However, the population at risk directly downgradient of the breach is minimal compared to the town of Telkwa.

4.1.4 Discussion of Results

The incremental effects of the sunny-day breach are evaluated with respect to average flow conditions while the incremental effects of the rainy-day breach are compared to the rainy-day with no breach scenario. The resulting incremental population at risk is similar for both the sunny and rainy-day scenarios. The buildings that may be affected with a sunny day breach are predominantly located within the floodplains or near the banks of the river and are expected to experience flooding with a relatively low hazard level.

Though the incremental effects of the rainy-day scenarios introduce limited additional extent to the predicted inundation zone as compared to the rainy-day with no breach event, the hazard level in select areas increases to ‘Danger for Some’ and ‘Danger for Most’ from lower levels of hazard. The predicted incremental effects of the rainy-day breach (according to hazard rating) are more pronounced in locations further away from the river banks, where there are slight increases in flow depth (up to 1 m) and velocity (up to 0.1 m/s).

The arrival times for either case (Table 4-2) are driven in part by the stream flows that convey the water released from the breach towards the Village of Telkwa. The predicted flood wave from the rainy-day breach arrives, on average, three hours earlier than that of the sunny day breach due to the PMF and 200-year flows from contributing streams and rivers.

Table 4-2: Time of arrival of the flood wave to the Village of Telkwa in Critical Failure Case #1

Time of Arrival	Sunday Day Breach	Rainy Day Breach
	6 to 7 hours	3 to 4 hours

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Telkwa_DamBreach_Inputs_1CT017-003_rev04_nf.xlsm

Notes: Time of arrival corresponds to time since start of the model, and not necessarily time of formation for the breach. Peak flows from the dam breach are reached approximately 2 hours after model start time.

4.2 Critical Failure Case #2

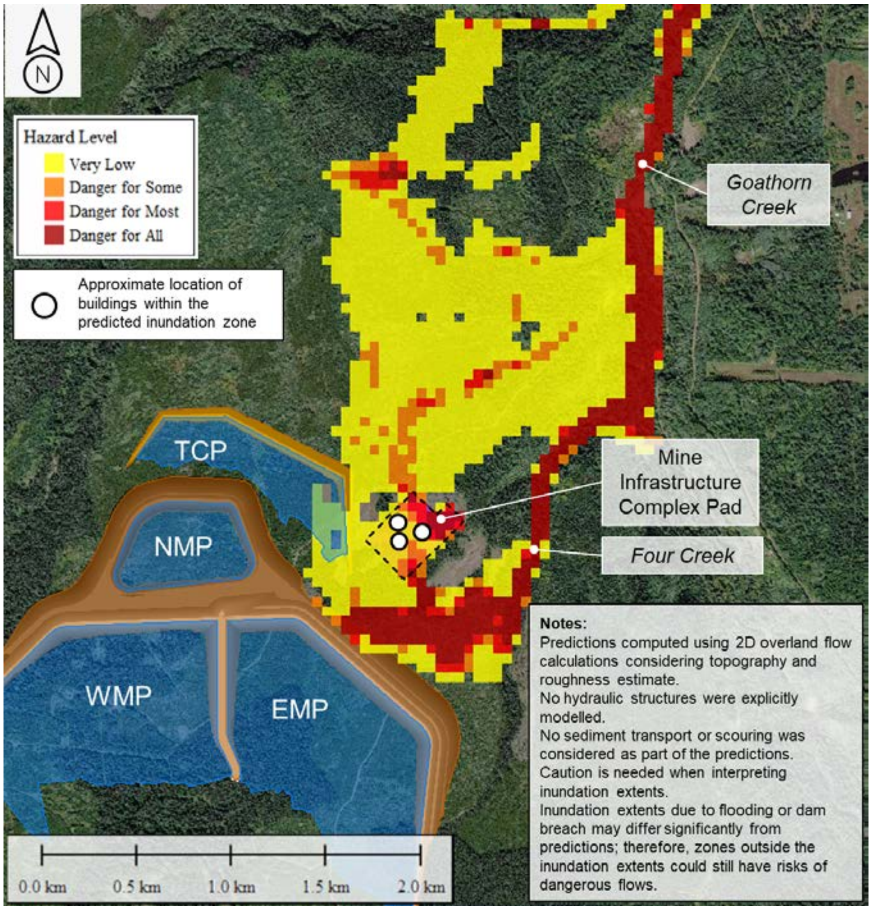
4.2.1 Sunny-Day Breach Scenario

Appendix D (Figures D.1 to D.4) provides inundation maps for maximum flow depths, maximum flow velocities, flood hazard, and time of arrival for the sunny day breach of the East Dam.

The sunny day breach of the East Dam affects firstly the TCL personnel working at the MIC, of which there are approximately 28 present for 24 hours a day and up to 80 personnel present at shift changes that occur twice a day for about 1 hour each. The predicted inundation hazard is ‘Very Low’ for the southwestern half of the MIC’s Pad, where two of the buildings will be located (Figure 4-4), and may be ‘Dangerous to Some’ towards the northeastern part of the MIC’s Pad, where there is another building. The CPP sedimentation pond is also located at the northeast portion of the MIC’s Pad. The inundation depth (Figure D.1 in Appendix D) is fairly uniform at 0.4 m throughout the Pad. The increased hazard in some areas of the MIC’s Pad are mainly due to slightly higher flows (Figure D.2 in Appendix D) driven by upgradient topography.

Aside from the MIC, the free water contained in the EMP is comparable to that released from the three ponds in the cascade failure, and the majority of the water bypasses the Pad and instead flows directly towards Four Creek and Goathorn Creek. As such, an East Dam sunny day breach affects the Village of Telkwa to a lesser but similar degree as the cascade sunny day breach. Furthermore, the clearing around the confluence of Goathorn Creek and the Telkwa River is also inundated.

Figure 4-4: Sunny-day East Dam breach flood hazard at the MIC Pad



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

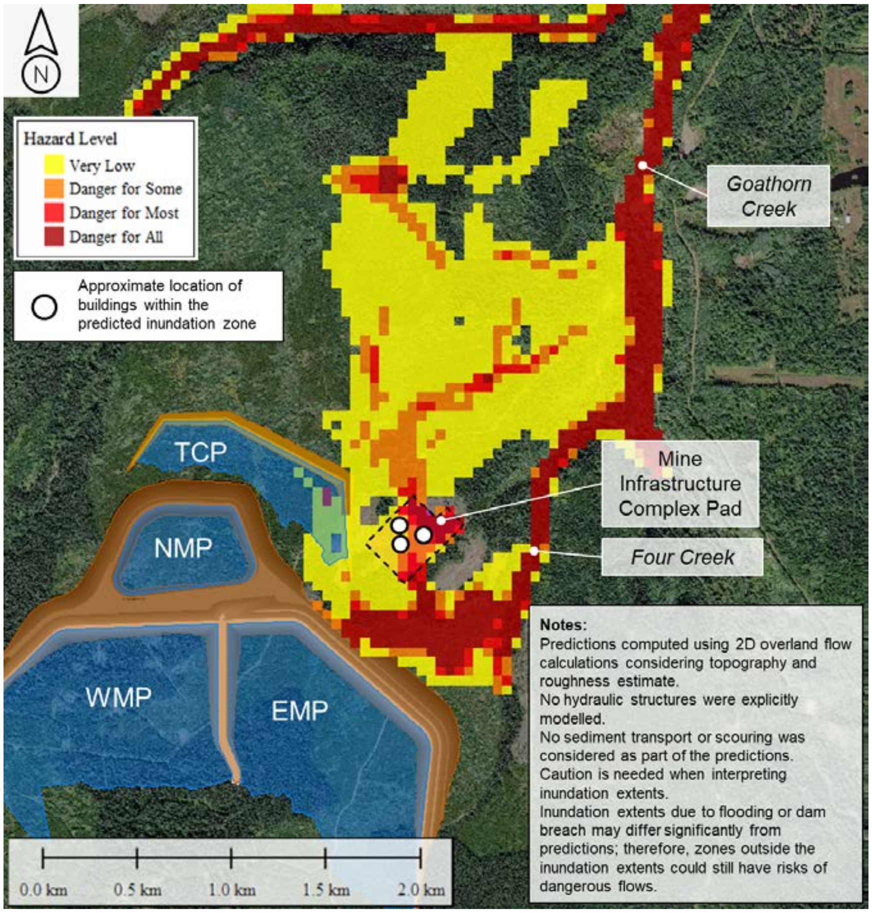
Notes: Background Imagery courtesy of Maxar 2012 via ArcGIS World Imagery.

4.2.2 Rainy-Day Breach Scenario

Appendix E (Figures E.1 to E.3) provides inundation maps for maximum flow depths, maximum flow velocities, and flood hazard for the rainy-day breach of the East Dam.

The rainy-day breach of the East Dam covers the same area of the CPP, but with an elevated hazard in the northeastern areas, including some locations with ‘Danger for Some’ or ‘Danger for Most’. Likewise, the effect at the Goathorn and Telkwa confluence and the effects in the Village of Telkwa are slightly less significant, but similar to the rainy-day cascade failure.

Figure 4-5: Rainy day East Dam breach flood hazard at the MIC Pad



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

Notes: Background Imagery courtesy of Maxar 2012 via ArcGIS World Imagery.

4.2.3 Discussion of Results

The sunny and rainy-day scenarios both inundate the CPP, with the difference being the hazard level, with the rainy-day scenario generating greater risk to personnel. The time of arrival (Table 4-3) of the flood wave to the MIC is approximately 1.5 hours for both scenarios, relative to model start time. It takes the flood wave about an hour longer to reach the Village of Telkwa in the sunny day East Dam breach than with the sunny day cascade breach, though the arrival time is similar during a rainy-day for both breach events. Based on the flooding extents, it is possible that greater than 200 additional people may be put at risk during a breach of the East Dam, compared with if there was no breach.

Table 4-3: Time of arrival of the flood wave in Critical Failure Case #2

Time of Arrival	Sunday Day Breach	Rainy Day Breach
To the MIC	<1.5 hours	<1.5 hours
To the Village of Telkwa	7 to 8 hours	3 to 4 hours

Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\800_Dam_Break\Inputs\Telkwa_DamBreach_Inputs_1CT017-003_rev04_nf.xlsm

Notes: Time of arrival corresponds to time since start of the model, and not necessarily time of formation for the breach. Peak flows from the dam breach are reached approximately 2 hours after model start time.

4.3 Sensitivity Analysis

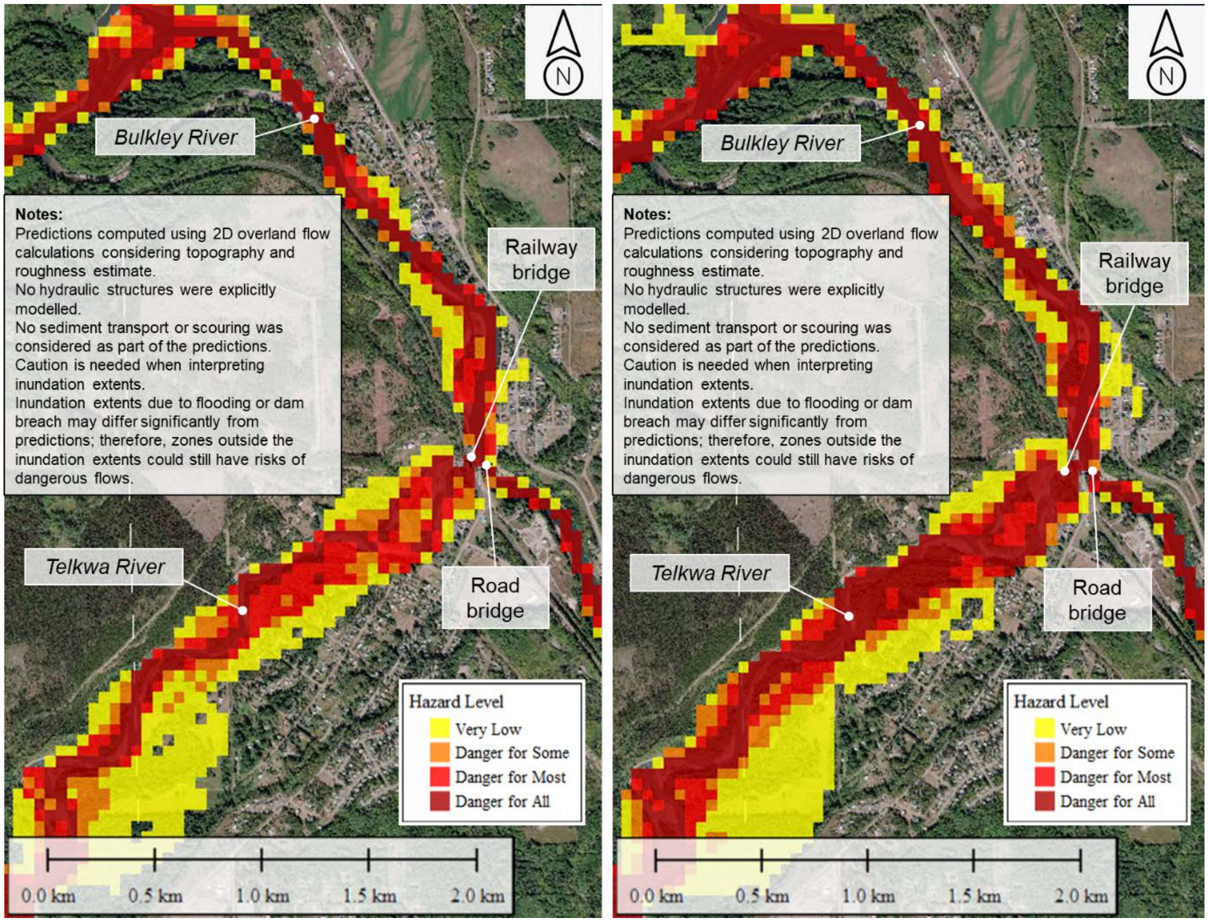
A sensitivity analysis was performed by simulating the sunny day cascade breach with 50% higher peak flows in the breach outflow hydrographs. The Telkwa River and post-confluence section of the Bulkley River show higher flows within the streams. The inundated area along the floodplains can extend up to approximately 100 m farther, nearly doubling the population at risk for the sunny day case.

The flow depths for the inundated areas of the Village of Telkwa are between 0.5 to 0.75 m greater, and the velocities are approximately 1 m/s faster. For the sunny day case, the depth and velocity increases are still unlikely to cause damage at the bridges. Some scouring and damage to the bridge is likely during the rainy-day event, regardless of whether a dam breach occurs since the majority of flow comes from precipitation rather than the reservoirs.

The flow hazards are compared in Figure 4-6 and show changes proportional to the according to the increasing depth and velocity. Hazard levels enter into the ‘Danger for Most’ and ‘Danger for All’ for those within the previous inundation area, and newer areas become assigned with a ‘Very Low’ or ‘Danger for Some’ rating.

Consideration should be given to uncertainties in model predictions if referring to them during emergency response planning. Variation in breach peak flows and volumes may cause underpredictions of inundation extent, which should be accounted for.

Figure 4-6: Telkwa hazards using original peak flows (left) and higher peak flows (right)



Sources: \\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\!080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

Notes: Background Imagery courtesy of Maxar 2012 via ArcGIS World Imagery.

5 Consequence Identification and Dam Classification

The dam consequence classifications are assessed according to CDA Guidelines (2013) and supported by the Global International Standards on Tailings Management (GISTM) (ICMM, 2020).

Table 5-1 is a reproduction of the CDA-recommended consequence classification criteria and Table 5-2 is a reproduction of the GISTM criteria. The classification systems are based on the incremental consequences of a dam failure, as opposed to total consequences. The incremental consequences of failure are defined as the total damage from an event with dam failure, less the damage that would have resulted from the same event (e.g. a large earthquake or a large flood event) had the dam not failed. During the dam classification process, each of the four hazard rating components in Table 5-1 are considered individually, and the overall dam hazard rating is defined by the component with the highest (i.e. most severe) rating. The GISTM descriptions are used as a supplemental reference as the incremental losses are defined in more detail, though the ponds are not tailings management facilities.

Table 5-1: CDA (2013) Dam Classifications

Dam Class	Population at Risk[1]	Incremental Losses		
		Loss of Life[2]	**Environmental and Cultural Values**	**Infrastructure and Economics**
Low	None	0	Minimal short-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No long-term loss	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	No significant loss or deterioration of fish or wildlife habitat	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very High	Permanent	100 or fewer	Loss of marginal habitat only	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Restoration or compensation in kind highly possible	Extreme losses affecting critical infrastructure or service (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Notes:

[1] Definitions for population at risk:

None: There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary: People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent: The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); Three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

[2] Implications for loss of life:

Unspecified: The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 5-2: GISTM (2020) Dam Classifications

Dam Class	Population at Risk	Incremental Losses			
		Loss of Life[1]	**Environment**	**Health, Social and Cultural**	**Infrastructure and Economics**
Low	None	None expected	Minimal short-term loss or deterioration of habitat or rare and endangered species.	Minimal effects and disruption of business and livelihoods. No measurable effect on human health. No disruption of heritage, recreation, community or cultural assets.	Low economic losses: area contains limited infrastructure or services. <US$1M.
Significant	1-10	Unspecified	No significant loss or deterioration of habitat. Potential contamination of livestock/fauna water supply with no health effects. Process water low potential toxicity. Tailings not potentially acid generating and have low neutral leaching potential. Restoration possible within 1 to 5 years.	Significant disruption of business, service or social dislocation. Low likelihood of loss of regional heritage, recreation, community, or cultural assets. Low likelihood of health effects.	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes. <US$10M.
High	10-100	Possible (1 - 10)	Significant loss or deterioration of critical habitat or rare and endangered species. Potential contamination of livestock/ fauna water supply with no health effects. Process water moderately toxic. Low potential for acid rock drainage or metal leaching effects of released tailings. Potential area of impact 10 km^2 – 20 km^2. Restoration possible but difficult and could take > 5 years.	500-1,000 people affected by disruption of business, services or social dislocation. Disruption of regional heritage, recreation, community or cultural assets. Potential for short term human health effects.	High economic losses affecting infrastructure, public transportation, and commercial facilities, or employment. Moderate relocation/compensation to communities. <US$100M.
Very High	100-1,000	Likely (10 - 100)	Major loss or deterioration of critical habitat or rare and endangered species. Process water highly toxic. High potential for acid rock drainage or metal leaching effects from released tailings. Potential area of impact > 20 km^2. Restoration or compensation possible but very difficult and requires a long time (5 years to 20 years).	1,000 people affected by disruption of business, services or social dislocation for more than one year. Significant loss of national heritage, community or cultural assets. Potential for significant long-term human health effects.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities, for dangerous substances), or employment. High relocation/ compensation to communities. < US$1B.
Extreme	> 1,000	Many (> 100)	Catastrophic loss of critical habitat or rare and endangered species. Process water highly toxic. Very high potential for acid rock drainage or metal leaching effects from released tailings. Potential area of impact > 20 km^2. Restoration or compensation in kind impossible or requires a very long time (> 20 years).	5,000 people affected by disruption of business, services or social dislocation for years. Significant National heritage or community facilities or cultural assets destroyed. Potential for severe and/or long- term human health effects.	Extreme economic losses affecting critical infrastructure or services, (e.g., hospital, major industrial complex, major storage facilities for dangerous substances) or employment. Very high relocation/compensation to communities and very high social readjustment costs. >US$1B.

Notes: [1] Implications for loss of life:

Unspecified: The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season

5.1 Population at Risk/Loss of Life

5.1.1 West, North, and Tenas Dams

The sunny and rainy-day failures both contribute to flood-related dangers to residents in the Village of Telkwa. There are many residencies located within the floodplains of a sunny day breach, or for which a rainy-day breach would increase risk. In the event of a cascade breach, approximately 150 people may be affected, possibly more to account for model uncertainty.

A 'Very High' consequence rating is recommended for all three dams.

5.1.2 East Dam

The breach of the East Dam may put all personnel at the CPP at risk, as well as those along at the junction of Goathorn Creek and the Telkwa River, and in the Vilage of Telkwa. Up to 200 people are predicted to be affected by the EMP failure.

A 'Very High' consequence rating is recommended for the East Dam.

5.2 Environmental and Cultural

5.2.1 West, North, and Tenas Dams

The greatest impact to the terrestrial environment is located in an area under 10 square kilometres (km^2) directly downslope of the Tenas Dam. The area is forested; habitat loss will be moderate and possible to restore after either the sunny or rainy-day event. Aquatic life in the streams will not experience significant effects from sediment deposition related to the breach in the long term, but the sudden high flows may temporarily damage fish habitat in the sunny-day breach. The effect of the rainy-day breach on aquatic habitat is low given the PMF/Q200 conditions already present.

PAG material and coal rejects are stored in the management ponds, and therefore there is potential for species from acid rock drainage (ARD) to be present in the free water released in a breach. As a mitigating factor, the NMP will have a NAG cover in the critical breach scenario, and the TCP does not contain waste material other than sediments accumulated during the operational period.

There are no known culturally significant artifacts in the area, though some sites significant to regional heritage sites are located within the Village of Telkwa.

A 'Very High' consequence rating is recommended for the West Dam as it is the primary source of water released in the breach and may also have poorer water quality. A 'High' consequence rating is recommended for the North and Tenas Dams.

5.2.2 East Dam

The primary impact to the terrestrial environment from the breach of the East Dam is also directly downslope of the breach. However, the majority of water released travels directly to Goathorn and Four Creeks, making the inundation of the forested area relatively low impact.

The impact to aquatic environment in the creeks may be moderate to significant due to the high addition of water, but the habitat can likely be restored. Similar to the WMP, there may be some impact from ARD.

A ‘High’ to ‘Very High’ consequence rating is recommended for the East Dam.

5.3 Infrastructure and Economics

5.3.1 West, North, and Tenas Dams

The road bridge and the railway bridge are both located at the junction of the Telkwa and Bulkley Rivers. The railway bridge is most at risk, as it is directly in the path of the flood wave. The road bridge is located over Bulkley River prior to the confluence but is likely to be affected due to backflow up the Bulkley River due to displacement caused by the flood wave. The rainy-day breach is unlikely to cause significantly more damage to the bridges than the PMF/Q200 flows due to similar predicted depths and velocities in the area, and the sunny day breach may cause minor or moderate damage.

Freeways, major access roads, and local roads may be temporarily unusable due to inundation or debris accumulation. Costs may be incurred from reparations for damage due to scouring, and debris removal.

Disruption to businesses and tourism such as those related to fishing would have an effect on local economy. Property damage requiring compensation to buildings located within the inundation area, but very high economic losses are not considered likely.

A ‘High’ consequence rating is recommended for all three dams.

5.3.2 East Dam

The impact of the East Dam breach on infrastructure and economics is similar to that of the cascade breach.

A ‘High’ consequence rating is recommended for the East Dam.

5.4 Recommended Dam Classification

Based on the consequence evaluations provided in the previous subsections, a consequence of ‘Very High’ for all four dams is recommended.

6 Conclusions and Recommendations

A dam breach assessment was completed to simulate flooding for two critical failure cases. The first critical case considers a cascade failure of the West Management Pond, North Management Pond, and Tenas Control Pond. The second critical case considers the failure of the East Management Pond. Sensitivity analyses were completed to check the variation due to changes in breach and modelling parameters.

Three scenarios were modelled to assist in evaluation of the potential effect of a dam breach on the downstream receptors for rainy-day and sunny-day conditions:

- The downstream creeks and rivers experiencing a large flood event with no dam breach (assuming 1 in 200-year flood for rivers and PMF for creeks)
- A Sunny-Day dam breach scenario (fair-weather scenario); and,
- A Rainy-Day dam breach scenario (flood-induced scenario).

The assessment suggests that the population at risk is up to approximately 200 for the sunny-day failure scenarios considered, with the majority of the buildings affected within the 'Very Low' to 'Danger for Some' hazard zones.

The assessment suggests there is significant risk to the majority of the population of the Village of Telkwa during a potential rainy-day event, but the danger is predominantly caused by the high flows due to the flood event rather than the dam breach. The predicted incremental population at risk is similar to the sunny-day breach scenario, but the resulting hazard is predominantly 'Danger for some' and 'Danger for Most'.

Terrestrial and aquatic habitats may be damaged during a breach event; however, clean up and restoration is possible.

Moderate damage to downstream infrastructure such as bridges, roadways, and some buildings may occur during a potential sunny-day breach, while the incremental effects of the rainy-day breach are generally less significant compared to the flood scenario with no breach.

Based on the dam breach assessment results, a 'Very High' consequence classification is recommended for the four embankments.

There are several sources of uncertainty that may impact model predictions. The inundation extents, depths, velocities, and arrival times from a breach event may vary significantly from that which is presented in this report. The overland flow calculations account for topography and estimates of surface roughness, but do not consider sediment transport or scouring. Hydraulic structures and infrastructure such as roadways and ditches were not explicitly modelled (though some larger features appar in the topography), therefore flow redirection unforeseen by the model presented in this report may occur.

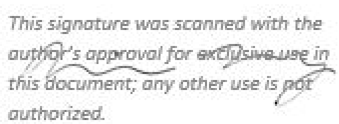
Caution is needed when interpreting inundation predictions for the development of emergency response and action plans. A thorough review of topography, geology, hydraulic structures, and emergency travel routes should be undertaken when developing emergency response plans.

At the time of the study, there was limited detailed information on the grain size of the stored rock, which is currently assumed to be coarse in nature. The potential impacts of the liquefaction of coal rejects and waste material should be considered in later stages of design.

Note - the dam crest elevations and spillway inverts on the West and East Management dams as well as the Tenas Control Pond have been reduced after completion of the dam breach assessment. Both the EMP and WMP dam crests have been lowered to 850 masl, with spillways at 848 masl, and the Tenas Control Pond dam crest has been lowered to 800 masl with spillway invert of 798 masl. Due to the shapes of the ponds and associated stage-storage relationships, lower elevation crests and inverts correspond to smaller incremental volumes of water for a given water cover thickness, which would be expected to reduce the volume of water released during a dam breach. For example, the final storage volume in the TCP at the dam crest was reduced from 2.3 Mm^3 to 1.6 Mm^3. As such, the results of this study were accepted as conservative for the purpose of dam classification and emergency response planning at this stage of the Project. An updated dam breach assessment is recommended for final design of all dams.

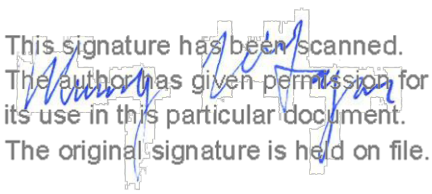
Closure

This report, Tenas Project Dam Breach Assessment Report, was prepared by

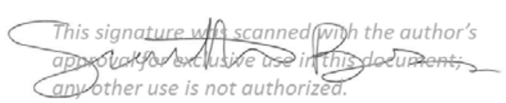


Nina Feng
Staff Consultant

and reviewed by



Murray McGregor
Senior Consultant



Samantha Barnes, P.Eng
Senior Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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Appendix A Pond Elevation-Storage Tables

Table A-1: Summary Elevations

Pond	Dam Crest (MASL)	Spillway Invert (MASL)
Tenas Dam	802	801
North Dam	831	830
East Dam	852	851
West Dam	852	851

Table A-2: Pond Elevation-Storage

Elevation (MASL)	TCP Capacity (m^3)	NMP Capacity (m^3)	WMP Capacity (m^3)	EMP Capacity (m^3)
752	-	-	0	-
752.5	-	-	0	-
753	-	-	0	-
753.5	-	-	120	-
754	-	-	820	-
754.5	-	-	2190	-
755	-	-	4210	-
755.5	-	-	6850	-
756	-	-	10210	-
756.5	-	-	14510	-
757	-	-	20040	-
757.5	-	-	26840	-
758	-	-	35430	-
758.5	-	-	46210	-
759	-	-	58790	-
759.5	-	-	72960	-
760	-	-	88660	-
760.5	-	-	105820	-
761	-	-	124250	-
761.5	-	-	144010	-

Elevation (MASL)	TCP Capacity (m^3)	NMP Capacity (m^3)	WMP Capacity (m^3)	EMP Capacity (m^3)
762	-	-	165080	-
762.5	-	-	187560	-
763	-	-	211480	-
763.5	-	-	236810	-
764	-	-	263540	-
764.5	-	-	291650	-
765	-	-	321140	-
765.5	-	-	351980	-
766	-	-	384160	-
766.5	-	-	417610	-
767	-	-	452220	-
767.5	-	-	487960	-
768	-	-	524810	-
768.5	-	-	562730	-
769	-	-	601750	-
769.5	-	-	641870	-
770	-	-	683050	-
770.5	-	-	725300	-
771	-	-	768590	-
771.5	-	-	812880	-
772	-	-	858170	-
772.5	-	-	904460	-
773	-	-	951750	-
773.5	-	-	1000050	-
774	-	-	1049390	-
774.5	-	-	1099780	-
775	-	-	1151240	-
775.5	-	-	1203790	-

Elevation (MASL)	TCP Capacity (m^3)	NMP Capacity (m^3)	WMP Capacity (m^3)	EMP Capacity (m^3)
776	-	-	1257480	-
776.5	-	-	1314720	-
777	-	-	1373180	-
777.5	-	-	1432730	-
778	-	-	1493350	-
778.5	-	-	1555000	-
779	-	-	1617700	-
779.5	-	-	1681430	-
780	-	-	1746210	-
780.5	-	-	1812020	-
781	-	-	1878850	-
781.5	-	-	1946720	-
782	-	-	2015620	-
782.5	-	-	2085550	-
783	-	-	2156520	-
783.5	-	-	2228590	-
784	0	-	2301860	-
784.5	-	-	2376500	-
785	0	-	2452530	-
785.5	-	-	2530030	-
786	230	-	2609060	-
786.5	-	-	2689720	-
787	1390	-	2772020	-
787.5	-	-	2855930	-
788	4610	-	2941440	-
788.5	-	-	3028550	-
789	15300	-	3117300	-
789.5	-	-	3207700	-

Elevation (MASL)	TCP Capacity (m^3)	NMP Capacity (m^3)	WMP Capacity (m^3)	EMP Capacity (m^3)
790	39250	-	3299860	-
790.5	-	-	3394020	-
791	79570	-	3490540	-
791.5	-	-	3589430	-
792	141540	-	3690700	-
792.5	-	-	3794530	-
793	226940	-	3901050	-
793.5	-	-	4009970	-
794	337760	-	4120670	-
794.5	-	-	4232960	-
795	475070	-	4346740	-
795.5	-	-	4461890	-
796	642340	-	4578070	-
796.5	-	-	4695150	-
797	839060	-	4813100	-
797.5	-	-	4931940	-
798	1064650	-	5051910	-
798.5	-	-	5173060	-
799	1323980	-	5295380	-
799.5	-	-	5418890	-
800	1615300	-	5543790	-
800.5	-	-	5678350	-
801	1936630	-	5814320	-
801.5	-	-	5951470	-
802	2292120	-	6089750	-
802.5	-	-	6229100	-
803	-	-	6369490	-
803.5	-	-	6510930	-

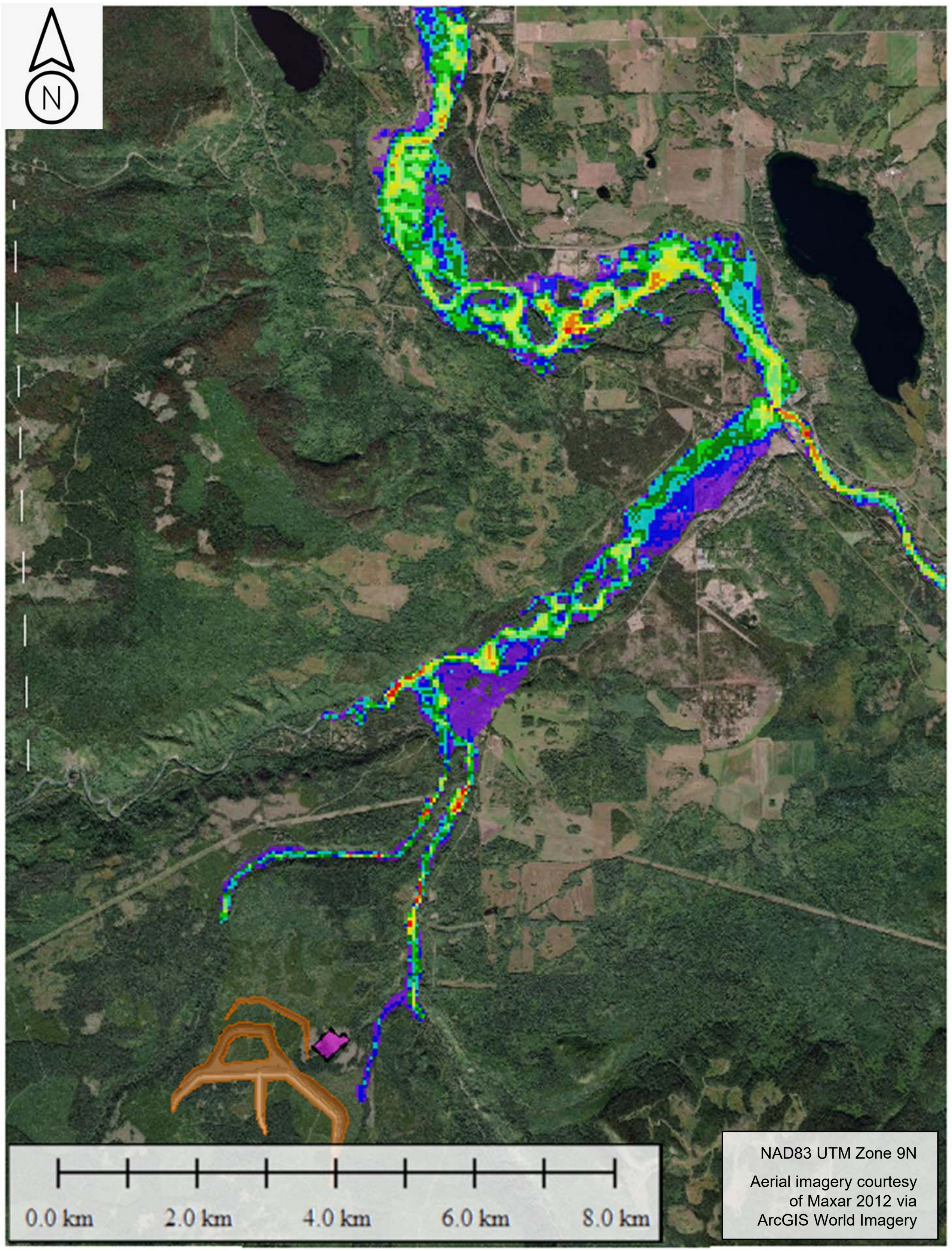
Elevation (MASL)	TCP Capacity (m^3)	NMP Capacity (m^3)	WMP Capacity (m^3)	EMP Capacity (m^3)
804	-	-	6653510	-
804.5	-	-	6797290	-
805	-	-	6942380	-
805.5	-	-	7088900	-
806	-	-	7236800	-
806.5	-	-	7386060	-
807	-	-	7536660	-
807.5	-	-	7688540	-
808	-	-	7841640	-
808.5	-	-	7995900	-
809	-	0	8151210	-
809.5	-	0	8307540	-
810	-	100	8464840	-
810.5	-	3350	8623050	-
811	-	9050	8782160	-
811.5	-	17320	8942140	-
812	-	28380	9103130	-
812.5	-	60090	9272160	-
813	-	97360	9442170	-
813.5	-	139980	9612990	-
814	-	187870	9784550	-
814.5	-	246300	9956810	-
815	-	308920	10129790	-
815.5	-	375800	10303530	-
816	-	446910	10478180	-
816.5	-	525550	10654290	-
817	-	607390	10831700	-
817.5	-	692780	11010460	-

Elevation (MASL)	**TCP Capacity (m^3)**	**NMP Capacity (m^3)**	**WMP Capacity (m^3)**	**EMP Capacity (m^3)**
818	-	782000	11190670	-
818.5	-	881020	11373620	-
819	-	983990	11558470	-
819.5	-	1090650	11745410	-
820	-	1200820	11934520	0
820.5	-	1316720	12127470	30
821	-	1435070	12323580	290
821.5	-	1555470	12523420	1000
822	-	1677560	12727910	2480
822.5	-	1800970	12940130	10530
823	-	1925590	13156820	22600
823.5	-	2051430	13378200	41410
824	-	2178490	13604830	68270
824.5	-	2306790	13859700	107850
825	-	2436310	14120330	154440
825.5	-	2567070	14386370	208130
826	-	2699070	14657870	269100
826.5	-	2832320	14937970	340900
827	-	2966830	15222750	419380
827.5	-	3102590	15512330	504360
828	-	3239610	15806980	595770
828.5	-	3377900	16110870	699130
829	-	3517480	16420000	809270
829.5	-	3658430	16734000	926100
830	-	3800820	17052600	1049630
830.5	-	3958230	17377830	1186010
831	-	4119020	17707750	1329520
831.5	-	-	18042250	1480120

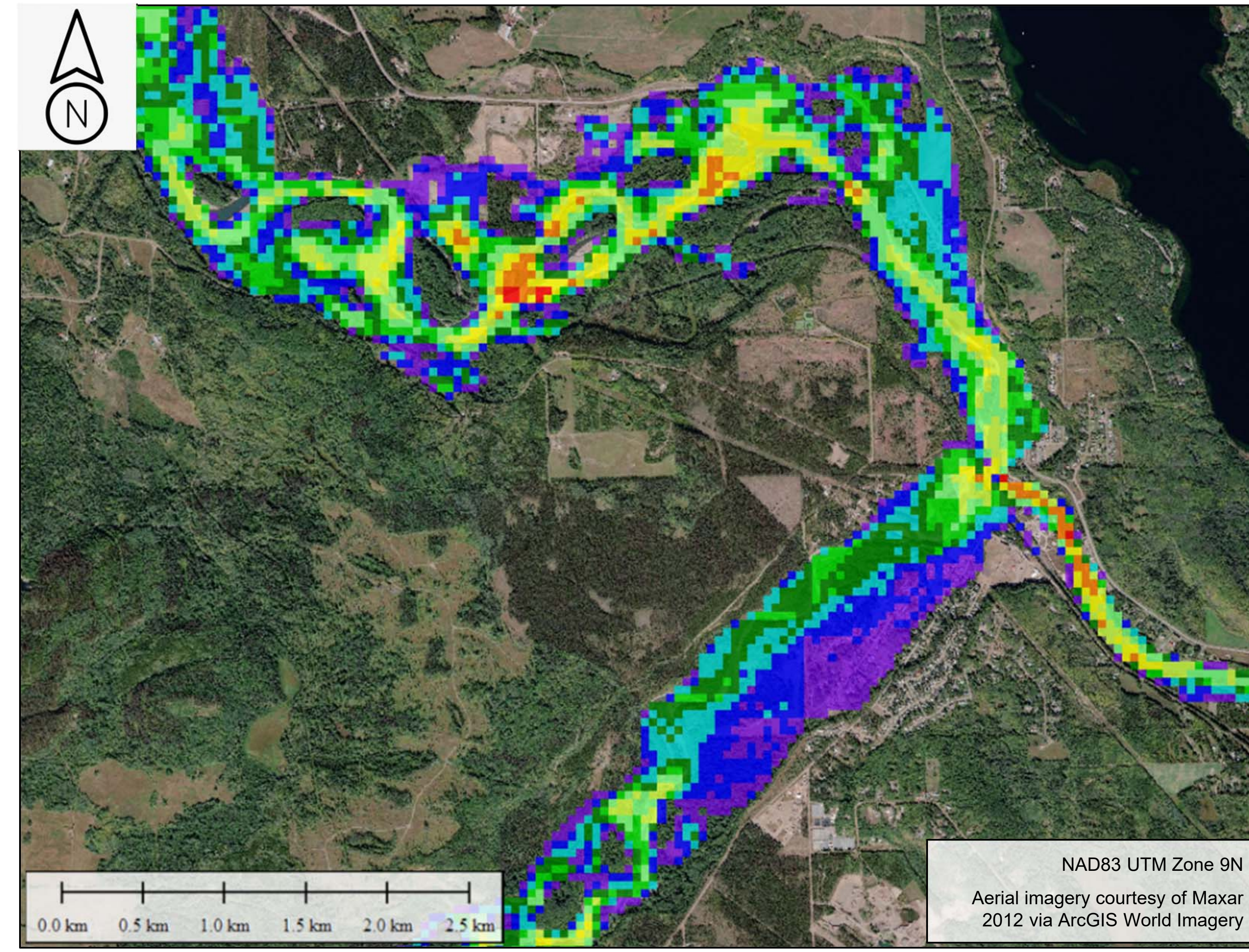
Elevation (MASL)	TCP Capacity (m^3)	NMP Capacity (m^3)	WMP Capacity (m^3)	EMP Capacity (m^3)
832	-	-	18381250	1637840
832.5	-	-	18725690	1814790
833	-	-	19074760	2000420
833.5	-	-	19428620	2195030
834	-	-	19787250	2399090
834.5	-	-	20152300	2624750
835	-	-	20522760	2860010
835.5	-	-	20898780	3105010
836	-	-	21280620	3360180
836.5	-	-	21680910	3638570
837	-	-	22088220	3924560
837.5	-	-	22501930	4218040
838	-	-	22921640	4519080
838.5	-	-	23350070	4842510
839	-	-	23782090	5173270
839.5	-	-	24217500	5511860
840	-	-	24656140	5858990
840.5	-	-	25098080	6235900
841	-	-	25543000	6620240
841.5	-	-	25990800	7012170
842	-	-	26441330	7412210
842.5	-	-	26895020	7838400
843	-	-	27351210	8273270
843.5	-	-	27809910	8717050
844	-	-	28271280	9170230
844.5	-	-	28735900	9642140
845	-	-	29203530	10120030
845.5	-	-	29674290	10603850

Elevation (MASL)	TCP Capacity (m^3)	NMP Capacity (m^3)	WMP Capacity (m^3)	EMP Capacity (m^3)
846	-	-	30148330	11093720
846.5	-	-	30626710	11592430
847	-	-	31108760	12097650
847.5	-	-	31594500	12609350
848	-	-	32084230	13127630
848.5	-	-	32584730	13653550
849	-	-	33089250	14185650
849.5	-	-	33597680	14723940
850	-	-	34110120	15268570
850.5	-	-	34628310	15820960
851	-	-	35151030	16379260
851.5	-	-	35678570	16943470
852	-	-	36211940	17514560

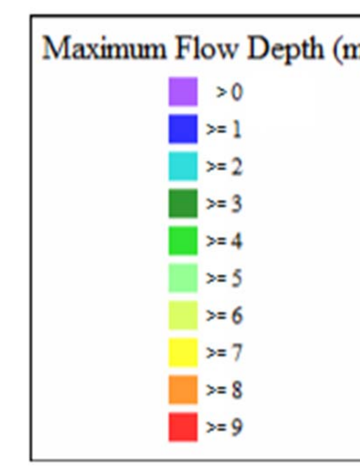
Appendix B No Breach, Rainy Day Scenario



a) Overall Site Plan



b) Village of Telkwa Area



Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

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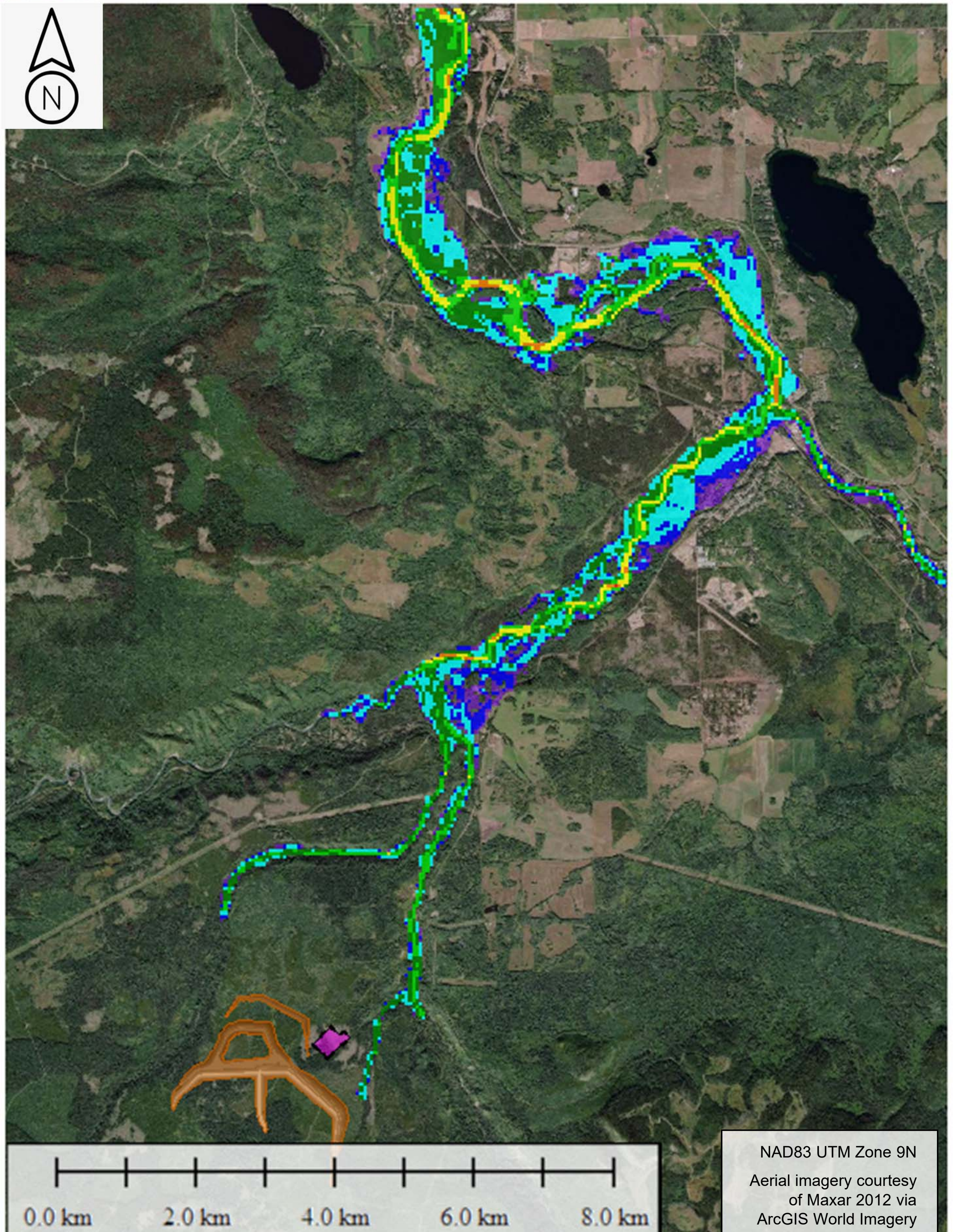
Dam Break Assessment

No Breach, Rainy Day (PMF/Q200) Maximum Flow Depth

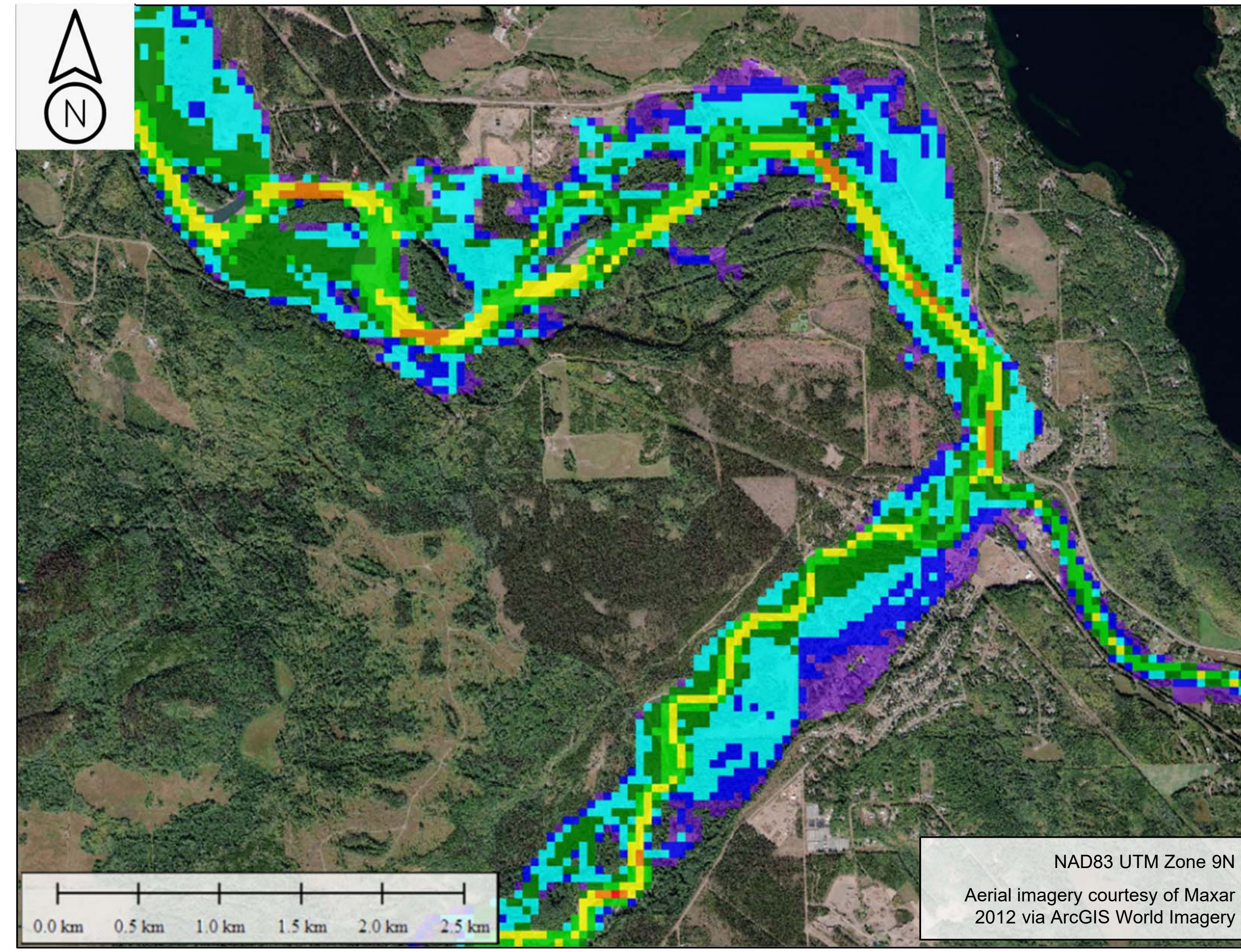
Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

Date: Jan. 2021
Prepared by: NF
Figure: **B.1**



a) Overall Site Plan



b) Village of Telkwa Area

Maximum Flow Velocity (m/s)
> 0
>= 0.1
>= 0.2
>= 0.5
>= 1
>= 2
>= 4
>= 6

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

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Dam Break Assessment

No Breach, Rainy Day Maximum Flow Velocity

Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

Date: Jan. 2021 | Prepared by: NF | Figure: **B.2**

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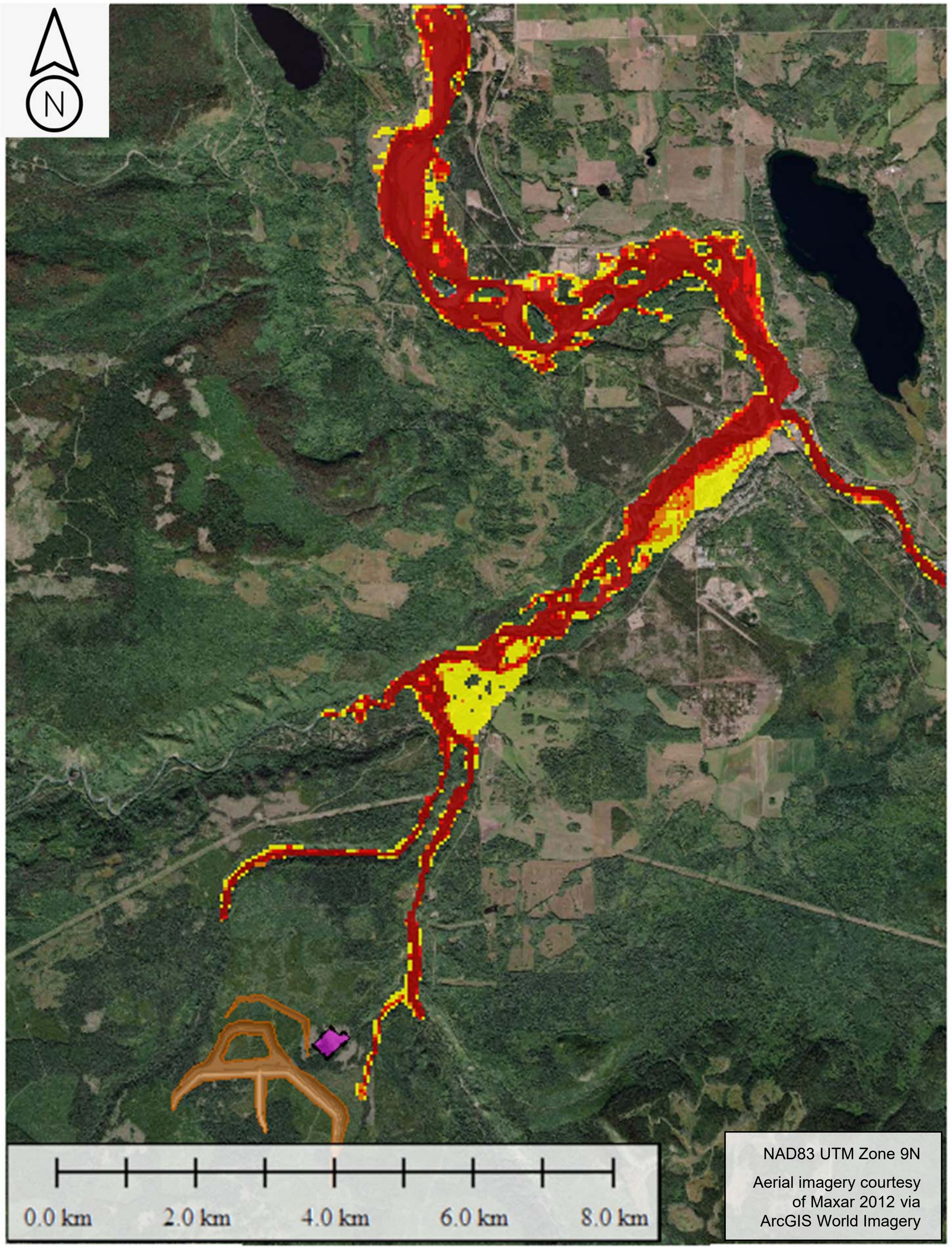
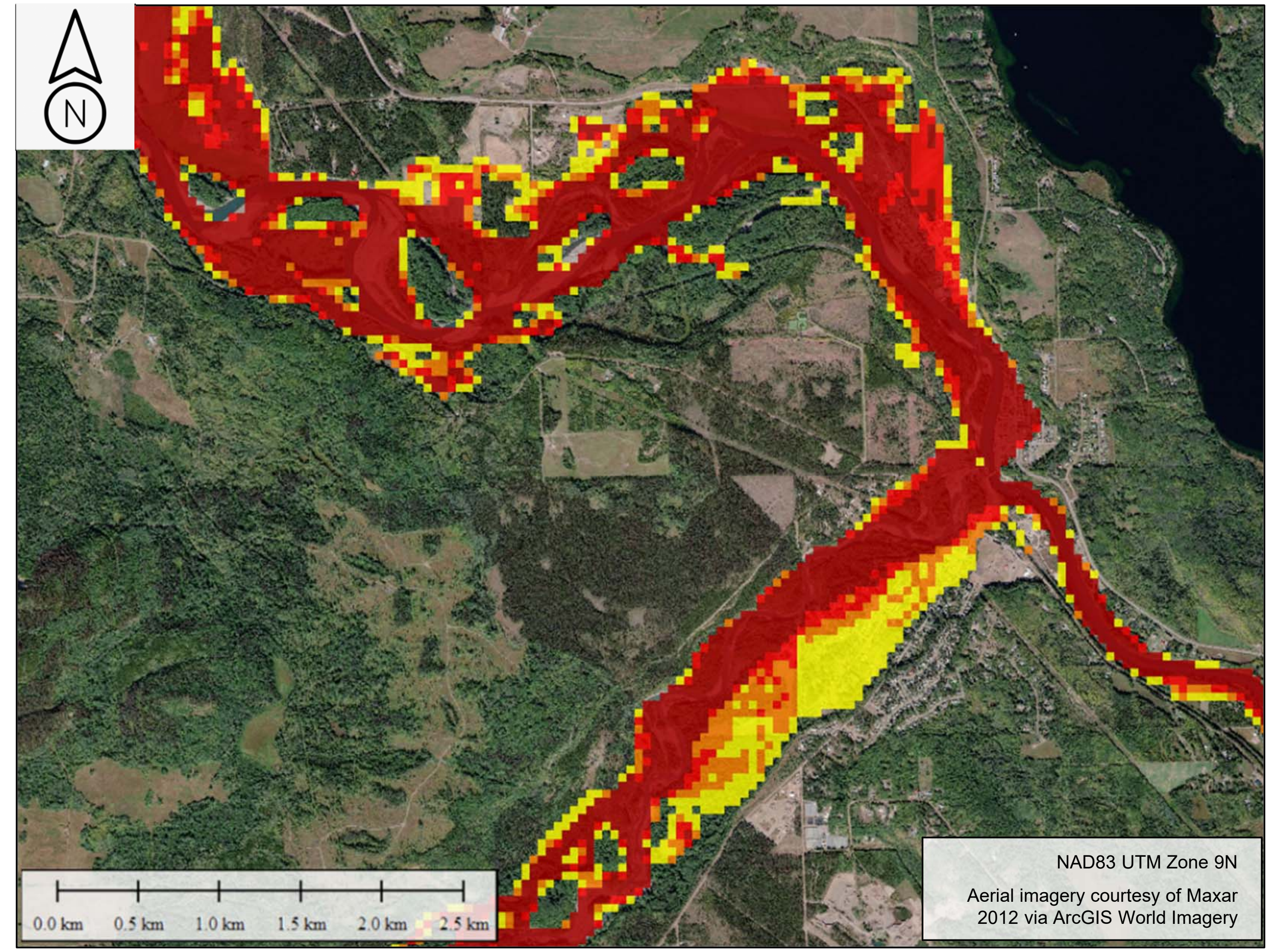


a) Overall Site Plan



b) Village of Telkwa Area

Hazard Rating	Risk to People
Very Low	Caution
Danger for Some	Includes children, the elderly, and the infirm
Danger for Most	Includes the general public
Danger for All	Includes emergency services

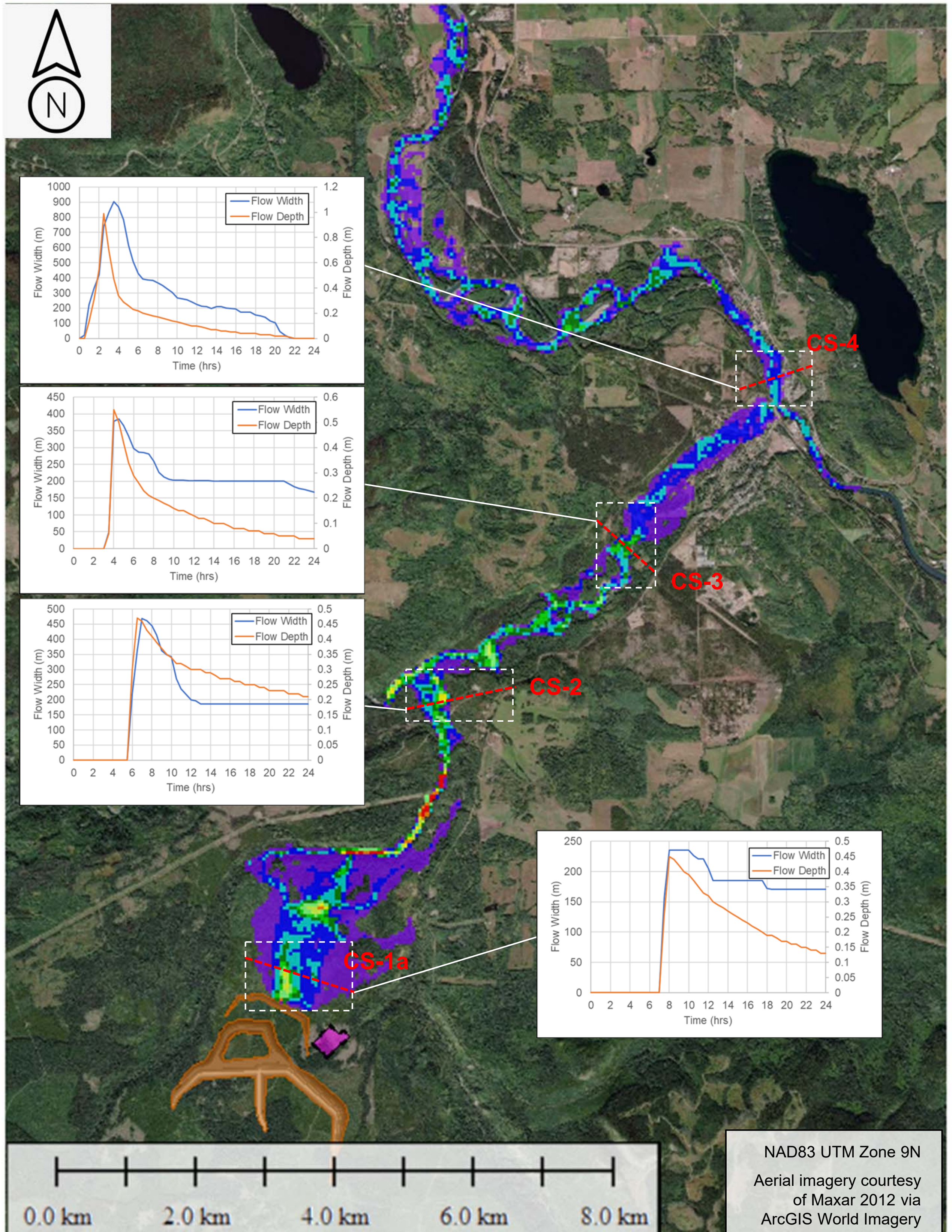
Hazard Level
- Very Low
- Danger for Some
- Danger for Most
- Danger for All

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

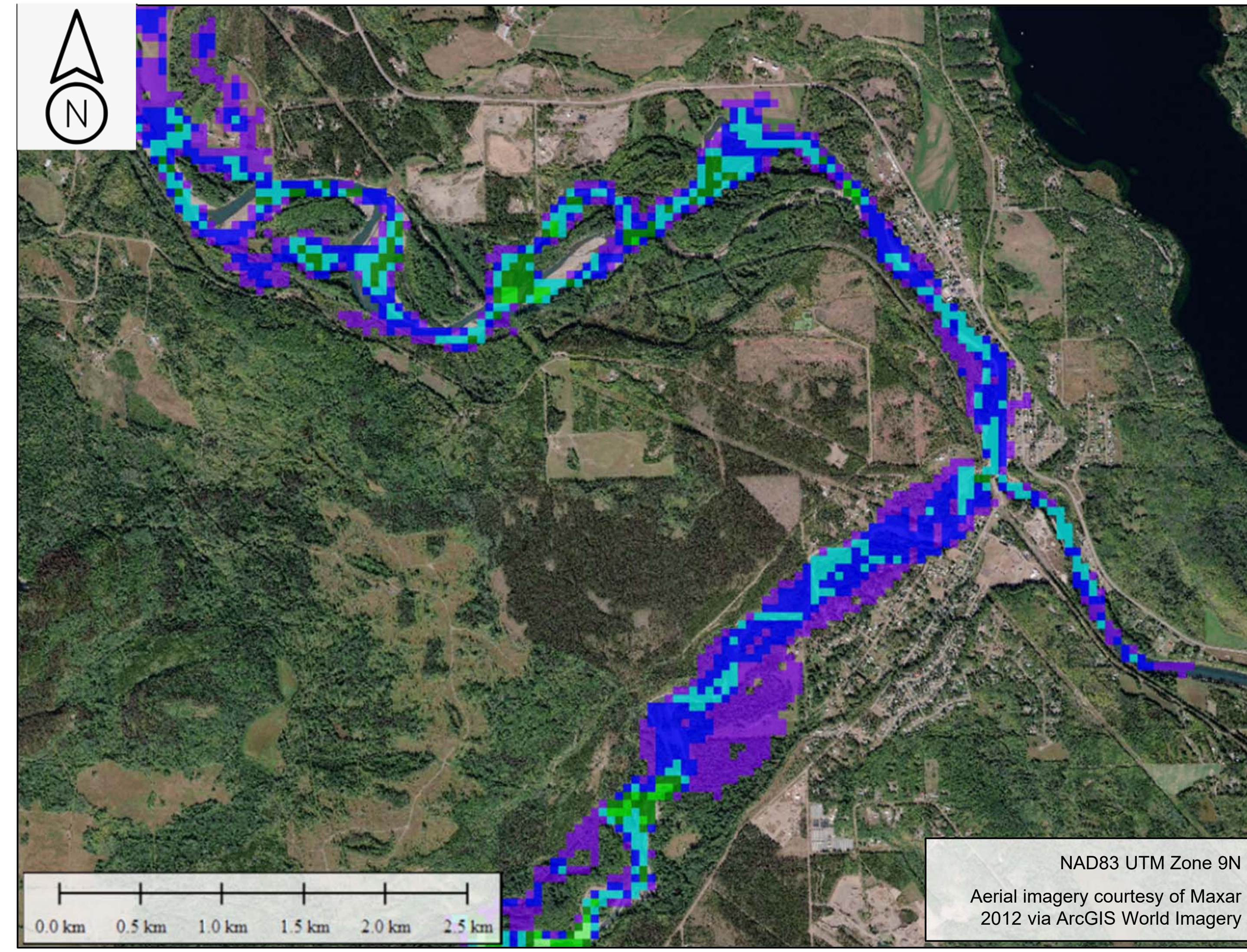
srk consulting	TELKWA COAL LIMITED	Dam Break Assessment **No Breach, Rainy Day Flood Hazard**
Job No: 1CT027.003 Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx	Tenas Project – EA Water Management	Date: Jan. 2021 / Prepared by: NF / Figure: **B.3**

\\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx

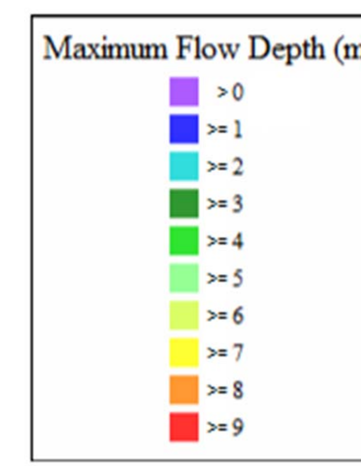
Appendix C West/North/Tenas Breach, Sunny Day Scenario



a) Overall Site Plan



b) Village of Telkwa Area



Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

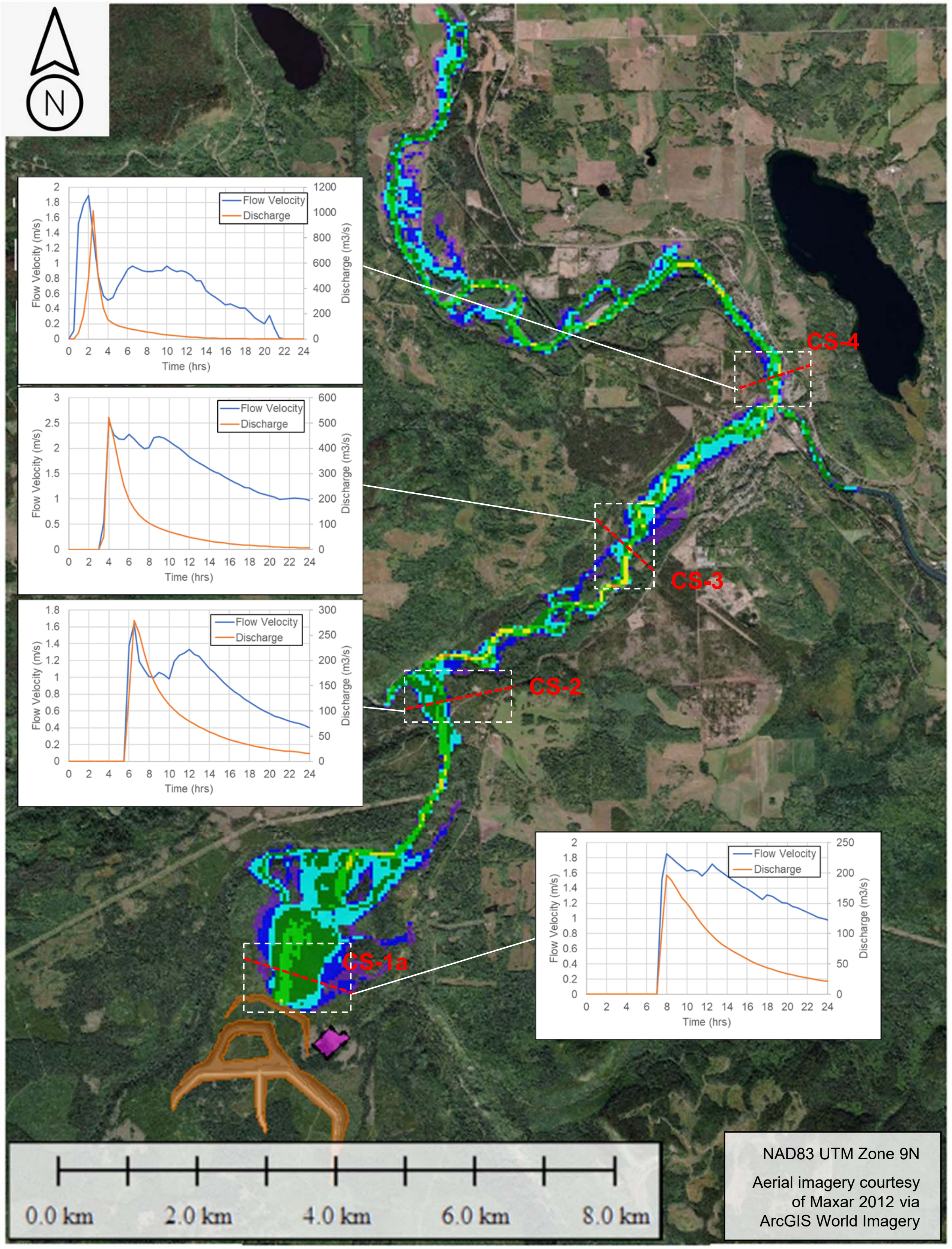
srk consulting

TELKWA COAL LIMITED

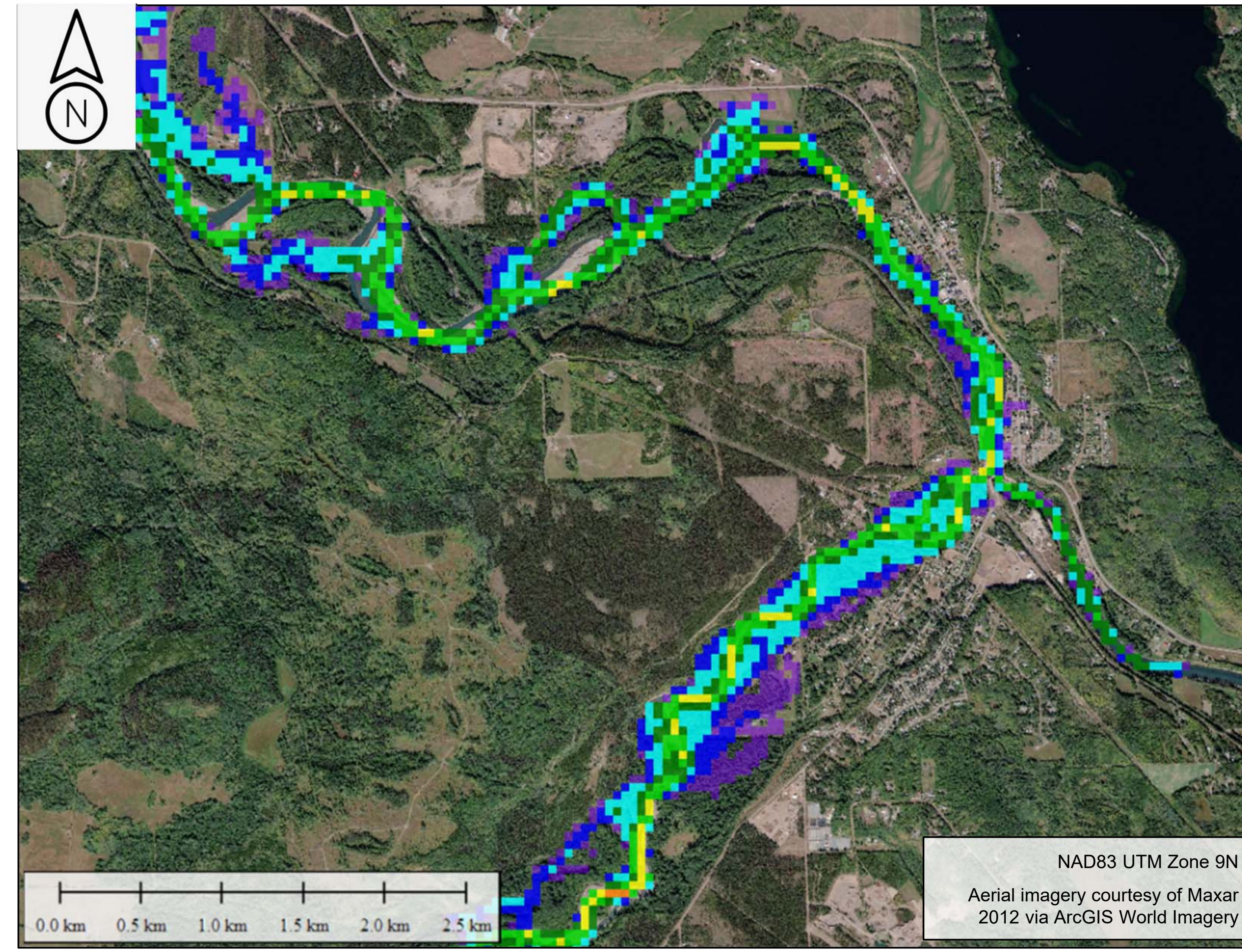
Dam Break Assessment

West/North/Tenas Breach, Sunny Day Maximum Flow Depth

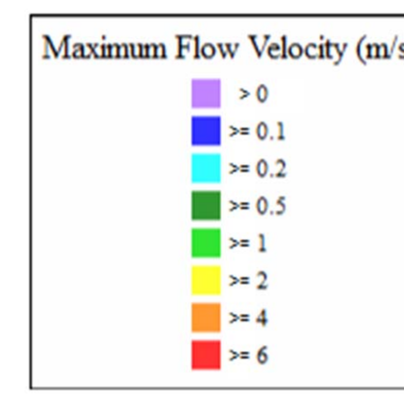
Job No: 1CT027.003	Tenas Project – EA Water Management	Date: Jan. 2021	Prepared by: NF	Figure: C.1
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx				



a) Overall Site Plan



b) Village of Telkwa Area



Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

srk consulting

TELKWA COAL LIMITED

Dam Break Assessment

West/North/Tenas Breach, Sunny Day Maximum Flow Velocity

Job No: 1CT027.003

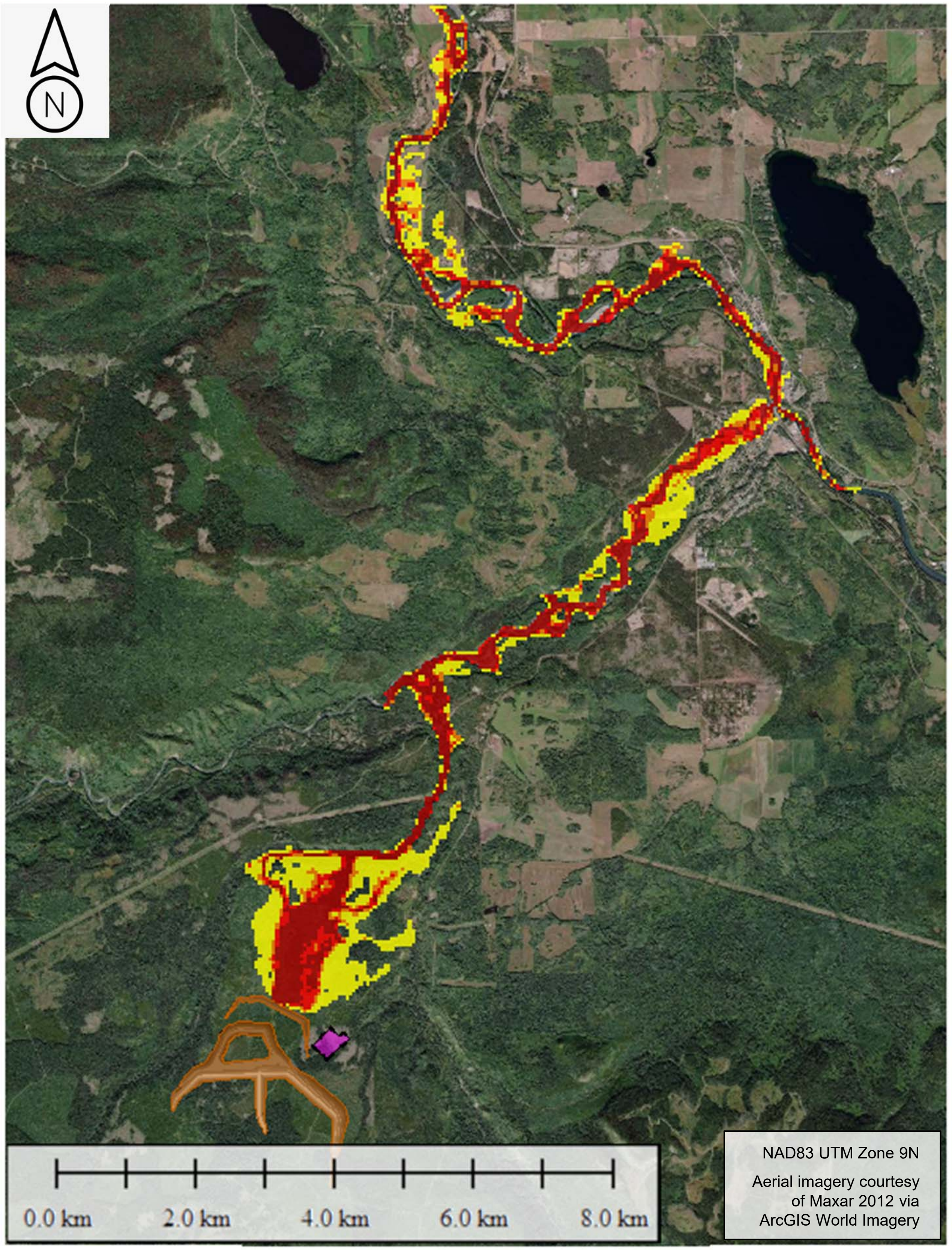
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

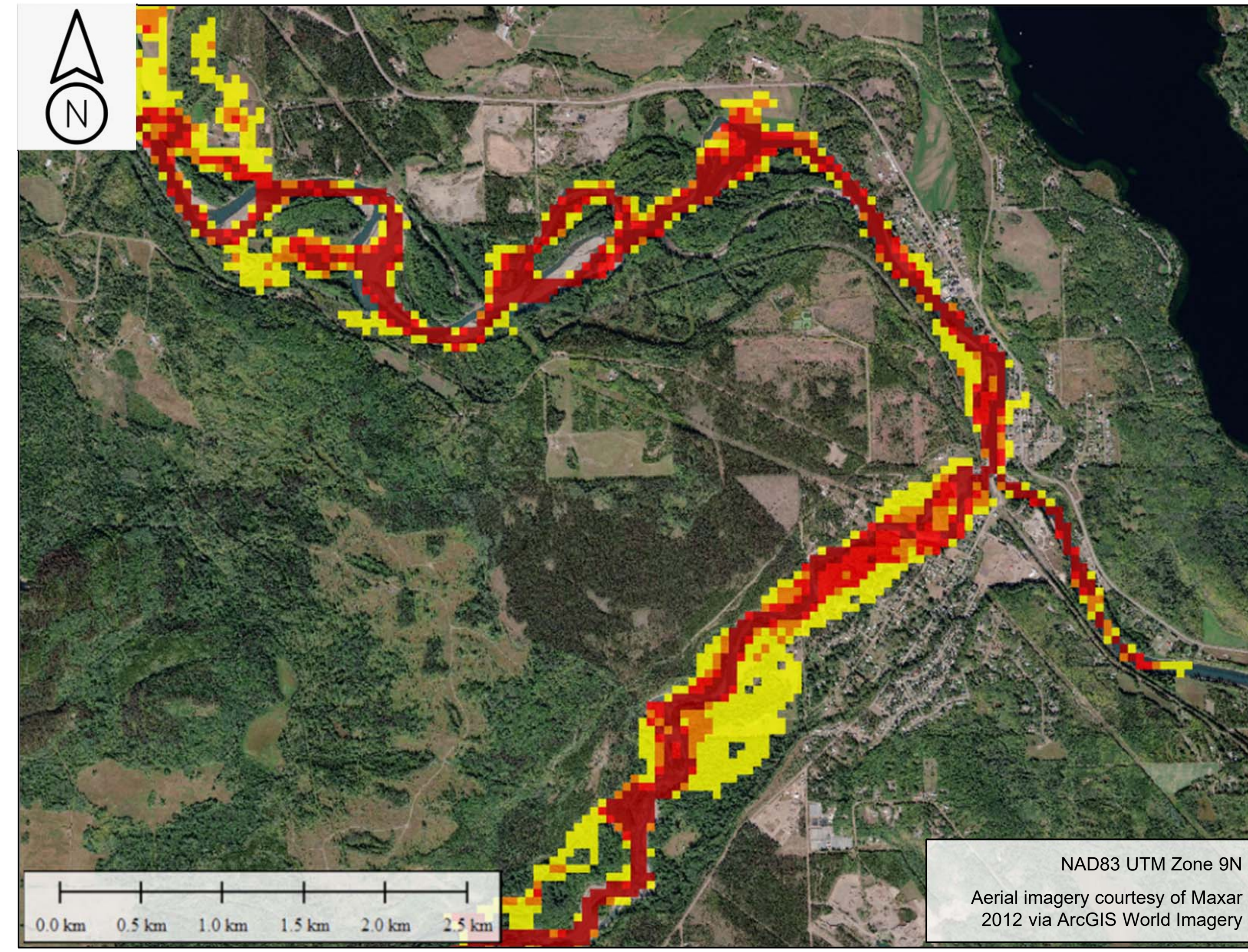
Date: Jan. 2021

Prepared by: NF

Figure: **C.2**



a) Overall Site Plan



b) Village of Telkwa Area

Hazard Rating	Risk to People
Very Low	Caution
Danger for Some	Includes children, the elderly, and the infirm
Danger for Most	Includes the general public
Danger for All	Includes emergency services

Hazard Level
- Very Low
- Danger for Some
- Danger for Most
- Danger for All

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
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srk consulting

TELKWA COAL LIMITED

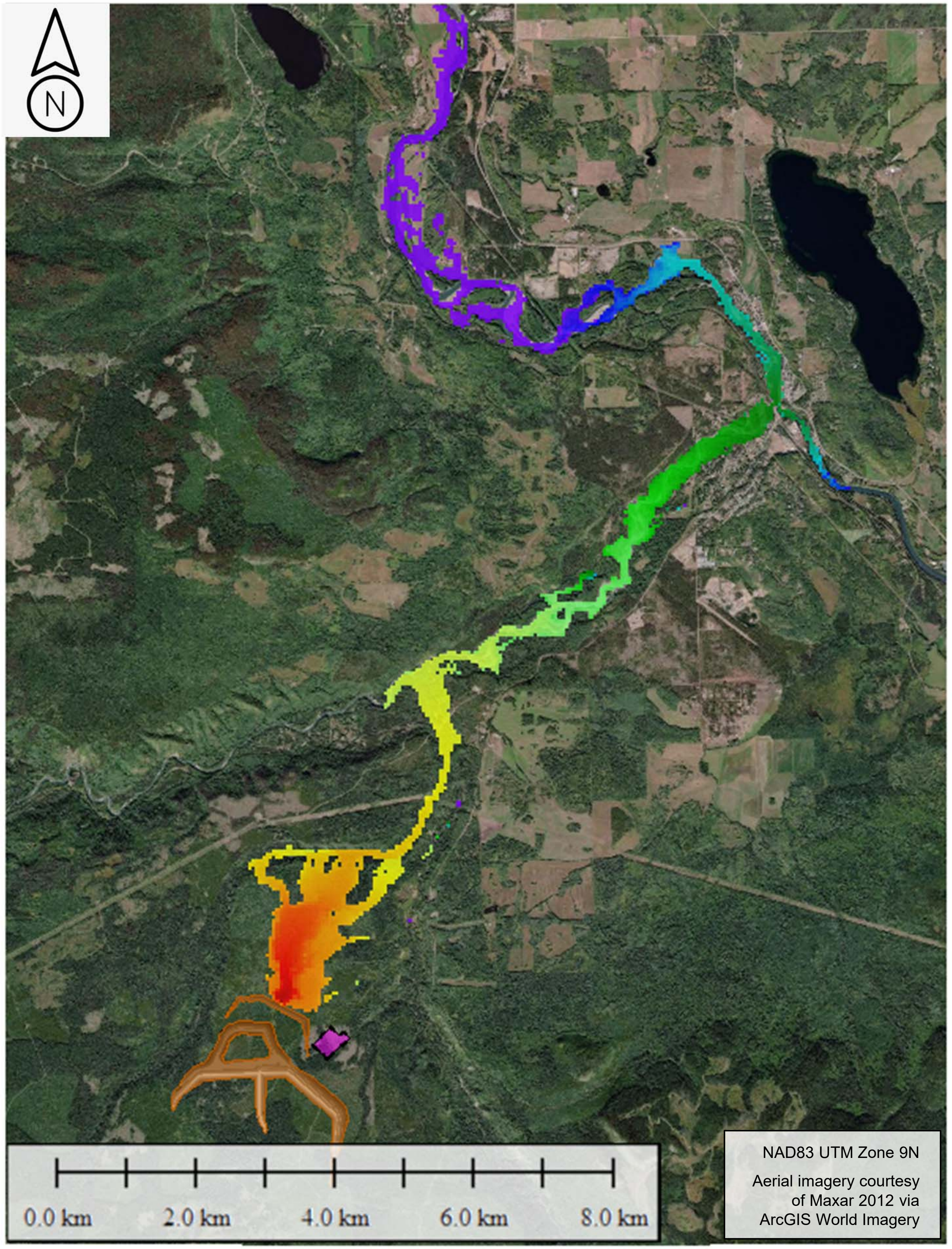
Dam Break Assessment

West/North/Tenas Breach, Sunny Day Flood Hazard

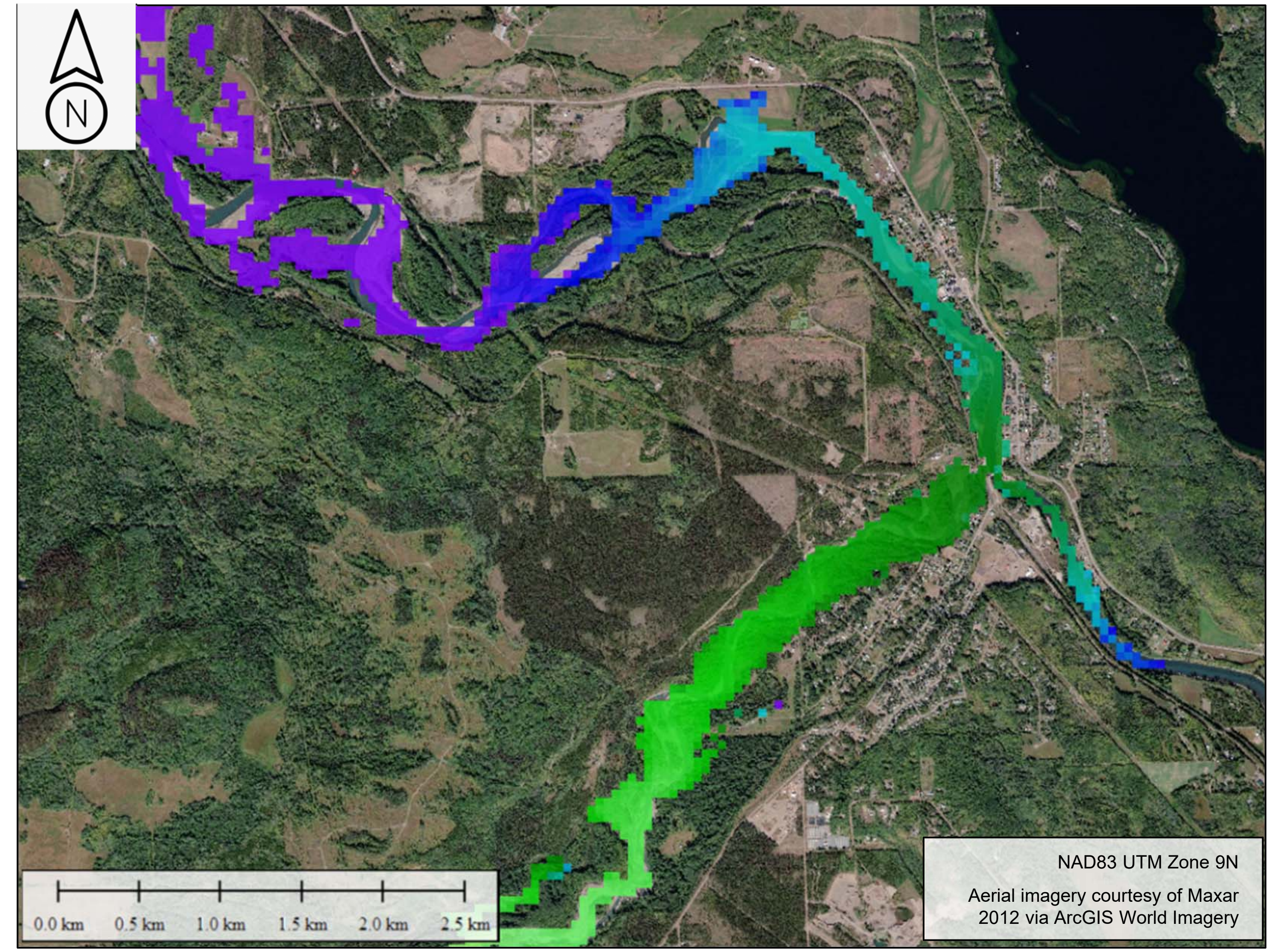
Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

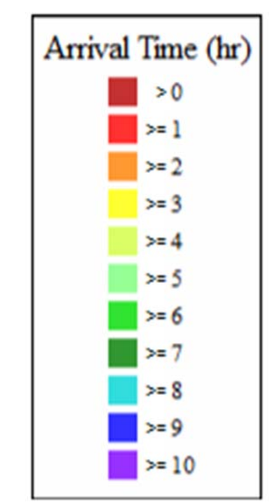
Date: Jan. 2021 | Prepared by: NF | Figure: C.3



a) Overall Site Plan



b) Village of Telkwa Area



Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

srk consulting

TELKWA COAL LIMITED

Dam Break Assessment

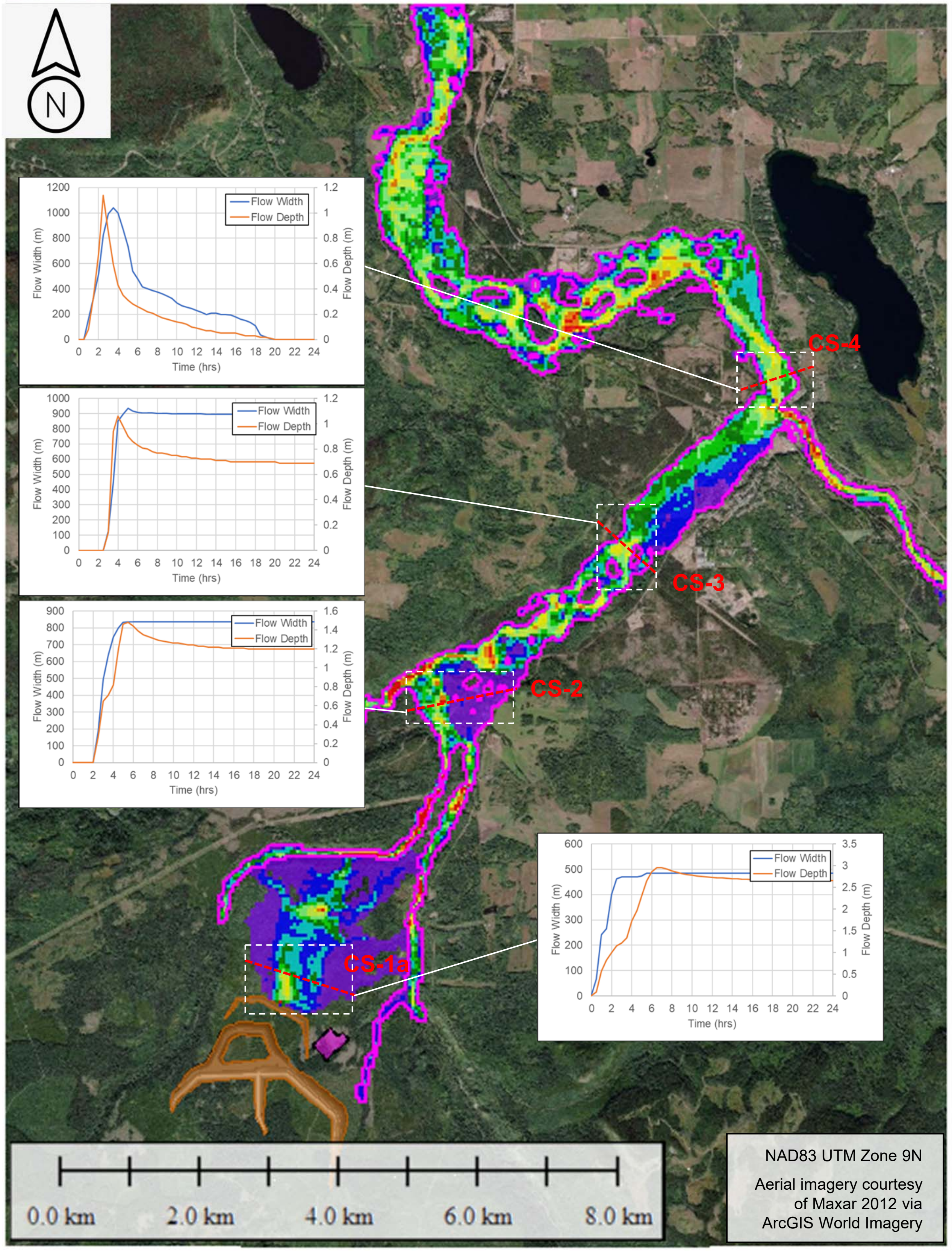
West/North/Tenas Breach, Sunny Day Arrival Time

Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

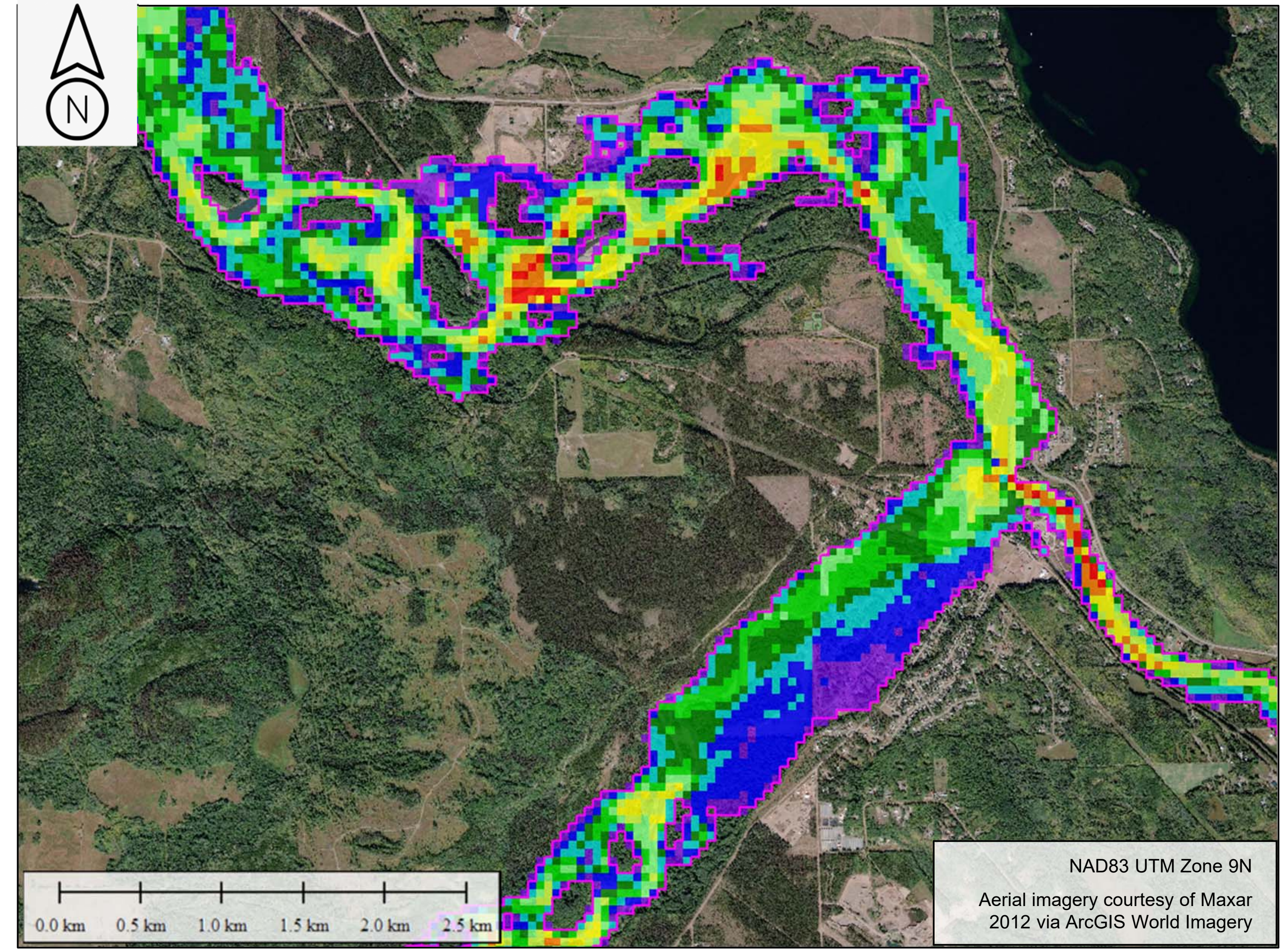
Tenas Project – EA Water Management

Date: Jan. 2021
Prepared by: NF
Figure: **C.4**

Appendix D West/North/Tenas Breach, Rainy Day Scenario



a) Overall Site Plan



b) Village of Telkwa Area

Maximum Flow Depth (m)
- > 0
- >= 1
- >= 2
- >= 3
- >= 4
- >= 5
- >= 6
- >= 7
- >= 8
- >= 9

Rainy Day, No Breach Flood Extent

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

srk consulting	TELKWA COAL LIMITED	Dam Break Assessment
		West/North/Tenas Breach, Rainy Day Maximum Flow Depth
Job No: 1CT027.003 Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx	Tenas Project – EA Water Management	Date: Jan. 2021 · Prepared by: NF · Figure: **D.1**

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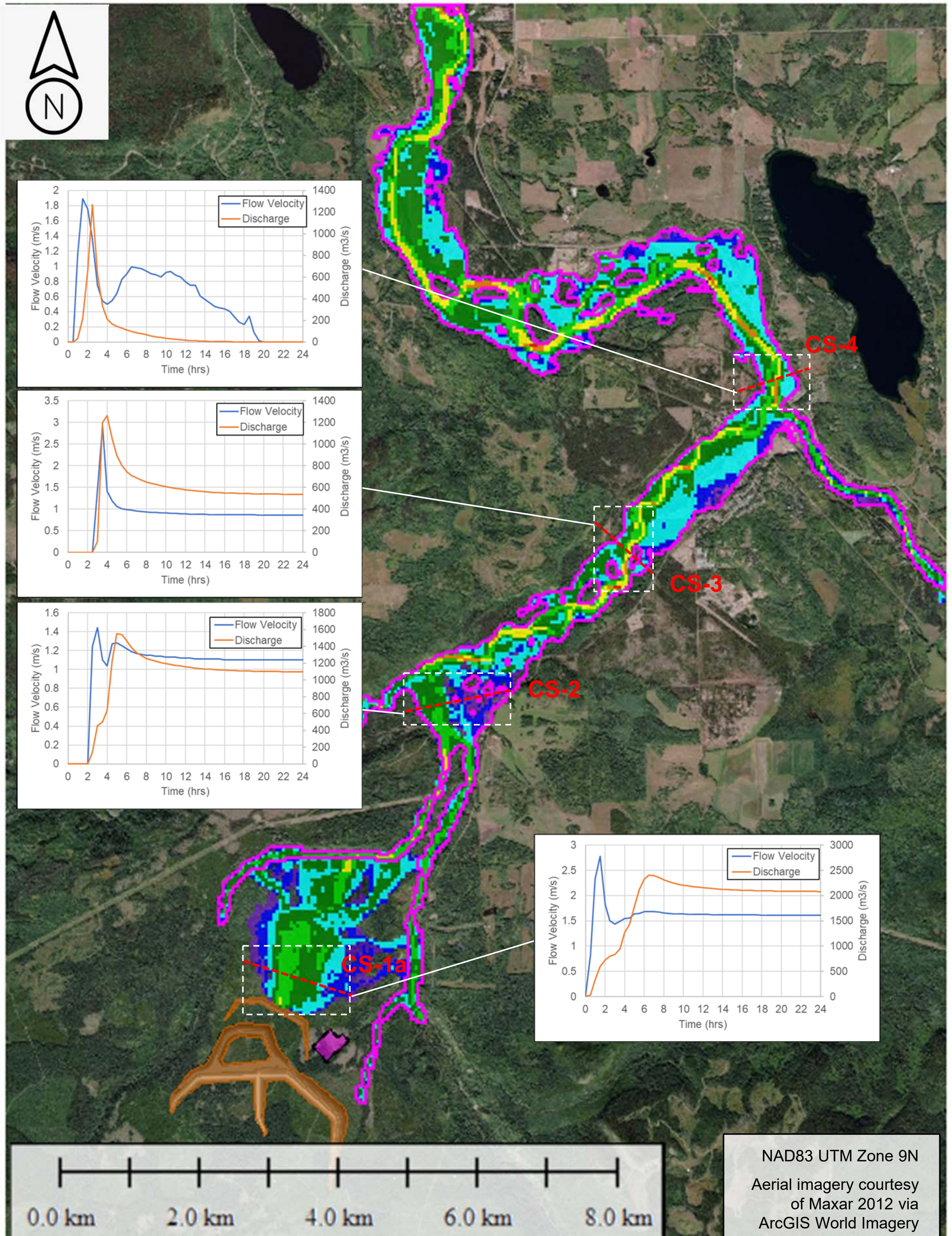
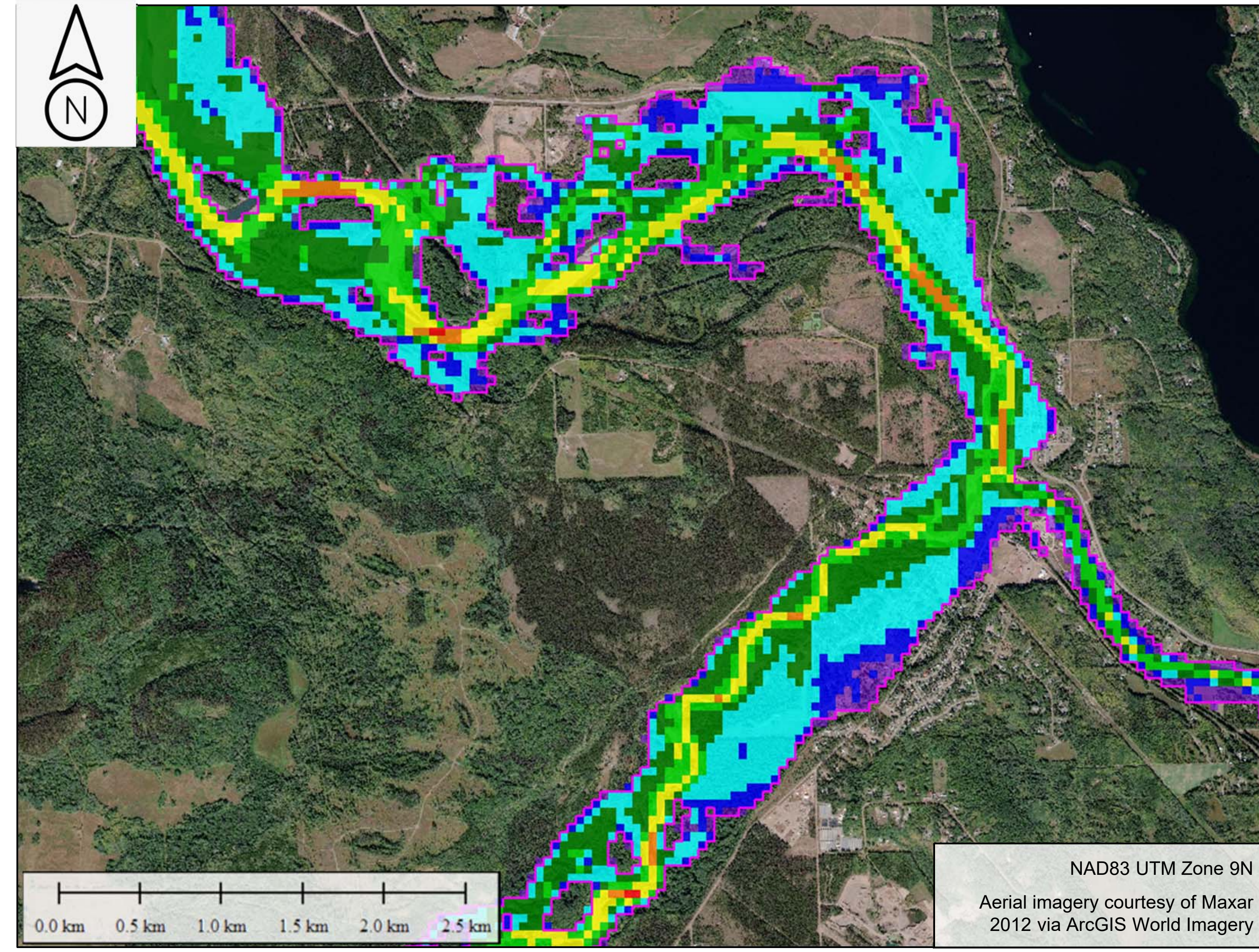


a) Overall Site Plan



b) Village of Telkwa Area

Maximum Flow Velocity (m/s)

- > 0
- >= 0.1
- >= 0.2
- >= 0.5
- >= 1
- >= 2
- >= 4
- >= 6

Rainy Day, No Breach Flood Extent

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

srk consulting

TELKWA COAL LIMITED

Dam Break Assessment

West/North/Tenas Breach, Rainy Day Maximum Flow Velocity

Job No: 1CT027.003

Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

Date: Jan. 2021

Prepared by: NF

Figure: **D.2**

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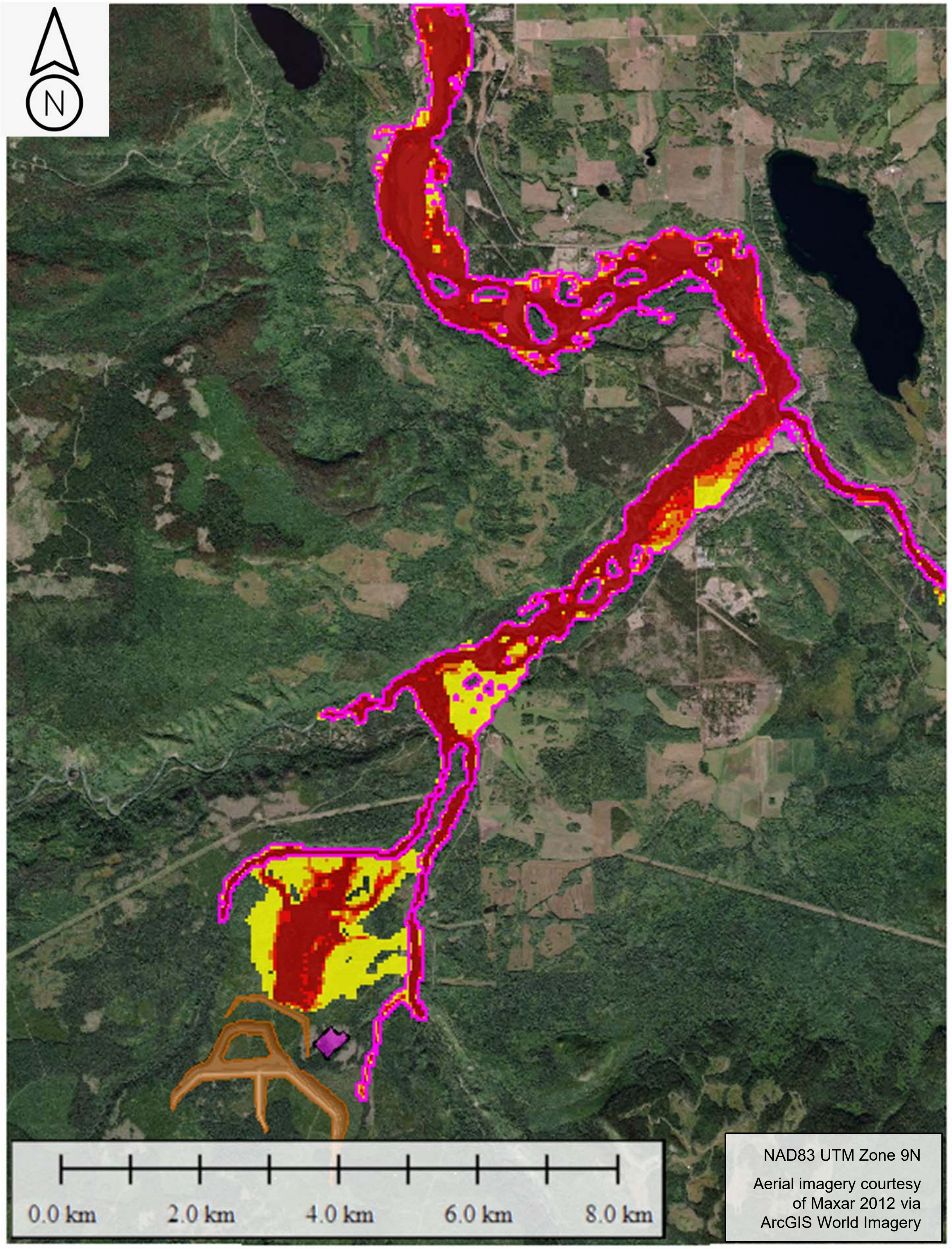
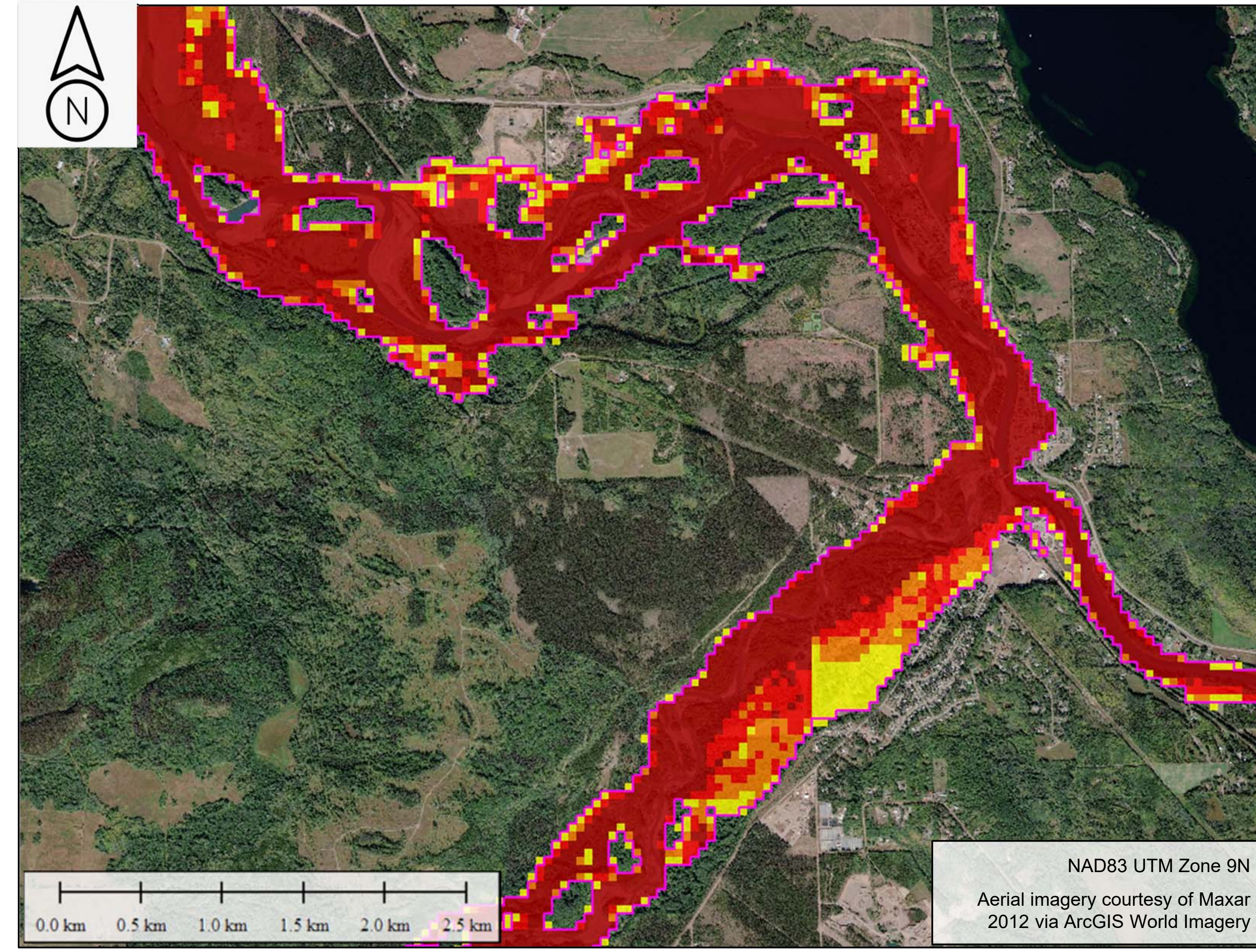


a) Overall Site Plan



b) Village of Telkwa Area

Hazard Rating	Risk to People
Very Low	Caution
Danger for Some	Includes children, the elderly, and the infirm
Danger for Most	Includes the general public
Danger for All	Includes emergency services

Rainy Day, No Breach Flood Extent

Hazard Level
- Very Low
- Danger for Some
- Danger for Most
- Danger for All

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
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Caution is needed when interpreting inundation extents.
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srk consulting	TELKWA COAL LIMITED	Dam Break Assessment
		West/North/Tenas Breach, Rainy Day Flood Hazard
Job No: 1CT027.003 Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx	Tenas Project – EA Water Management	Date: Jan. 2021 · Prepared by: NF · Figure: **D.3**

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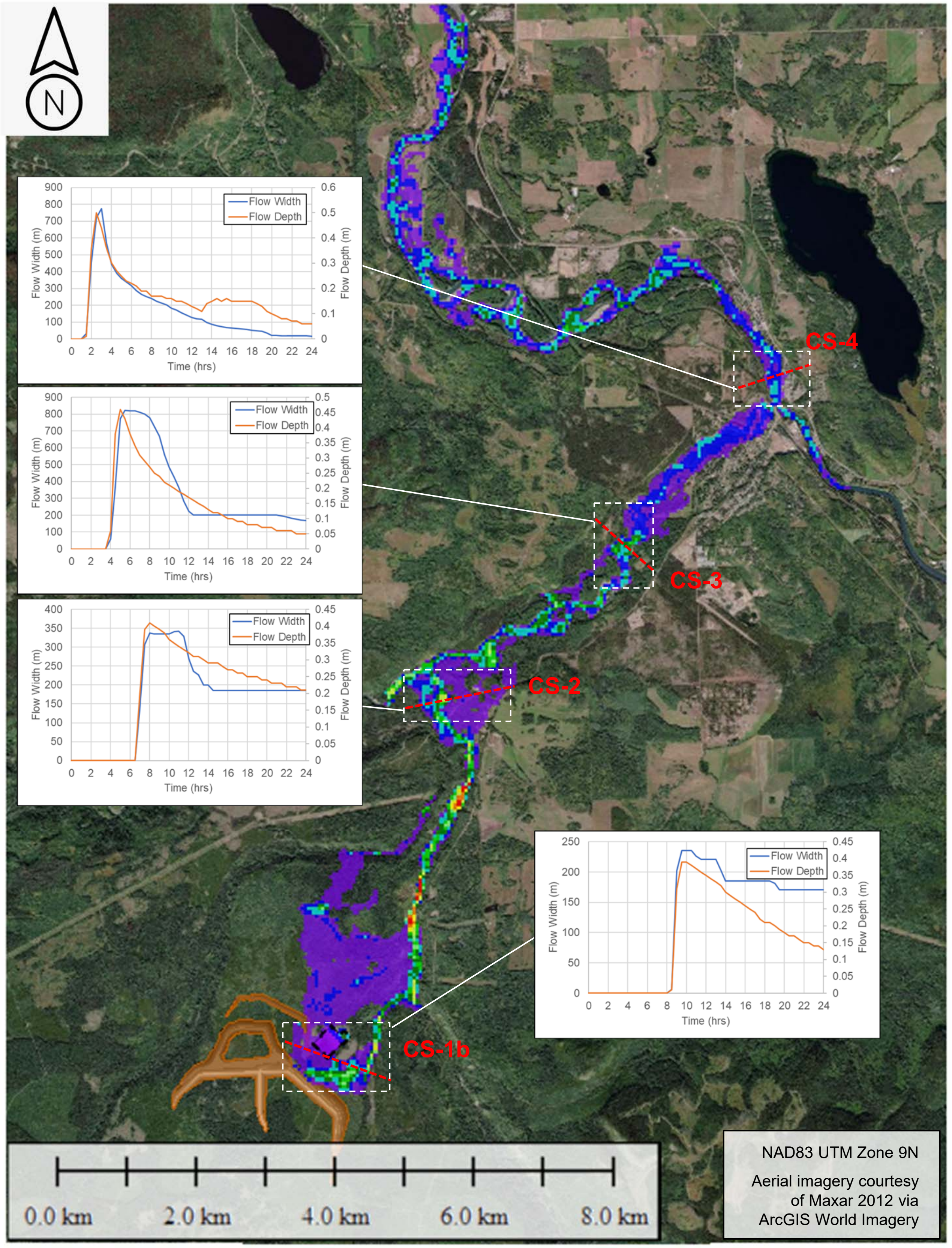
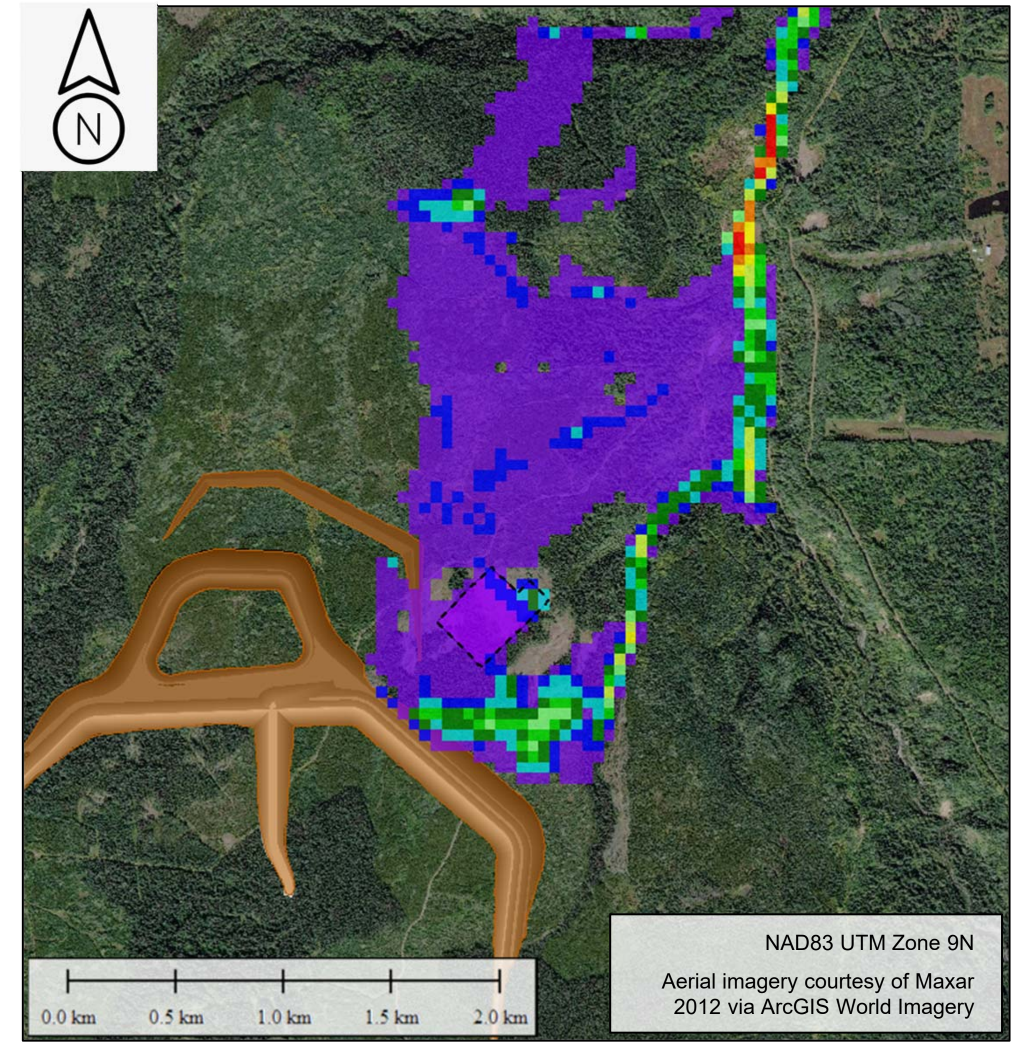
Appendix E East Dam Breach, Sunny Day Scenario



a) Overall Site Plan



b) Village of Telkwa Area

Maximum Flow Depth (m)
- > 0
- >= 1
- >= 2
- >= 3
- >= 4
- >= 5
- >= 6
- >= 7
- >= 8
- >= 9

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
No hydraulic structures were explicitly modelled.
No sediment transport or scouring was considered as part of the predictions.
Caution is needed when interpreting inundation extents.
Inundation extents due to flooding or dam breach may differ significantly from predictions; therefore, zones outside the inundation extents could still have risks of dangerous flows.

srk consulting | TELKWA COAL LIMITED | Dam Break Assessment

East Dam Breach, Sunny Day Maximum Flow Depth

Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

Date:	Prepared by:	Figure:
Jan. 2021	NF	E.1

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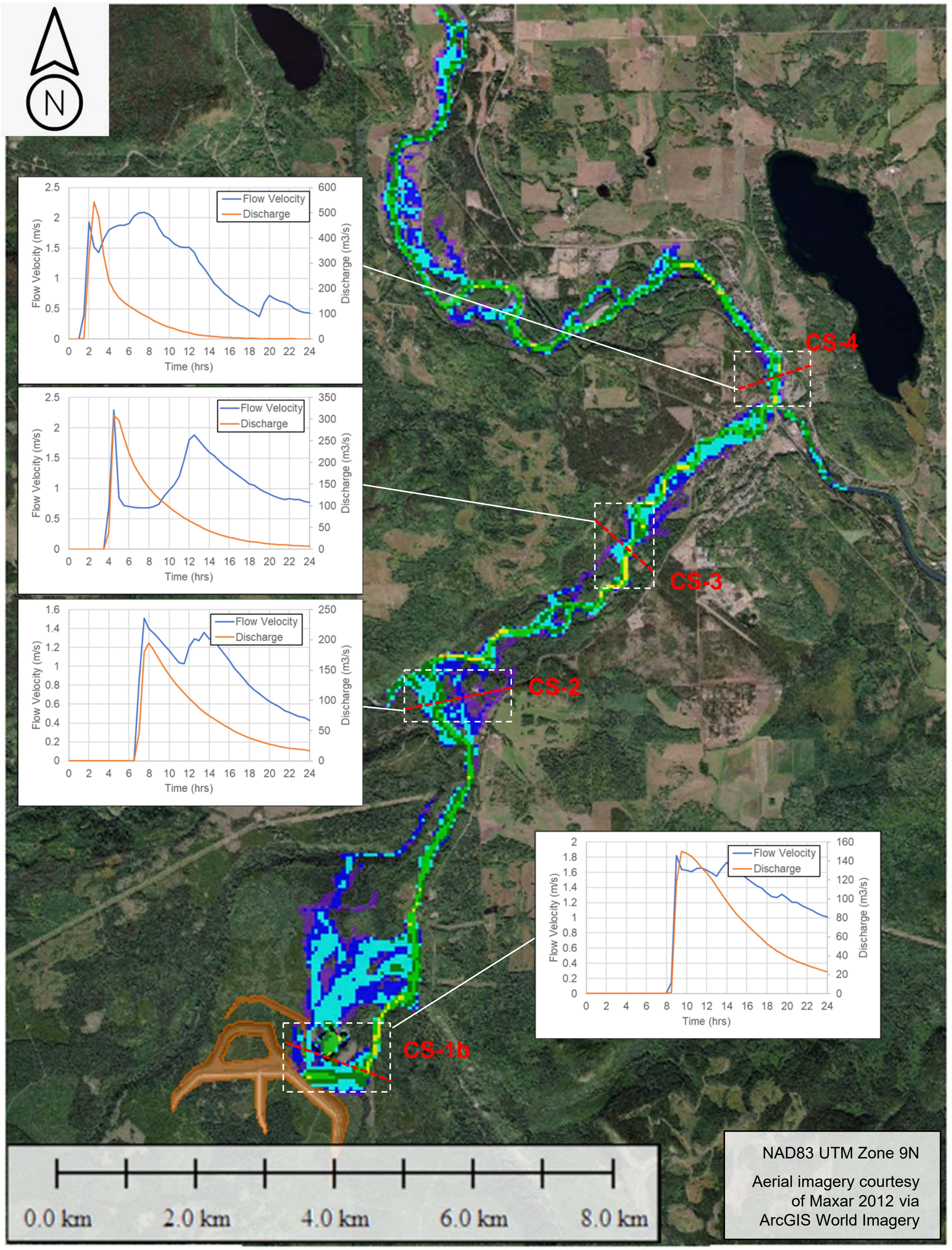
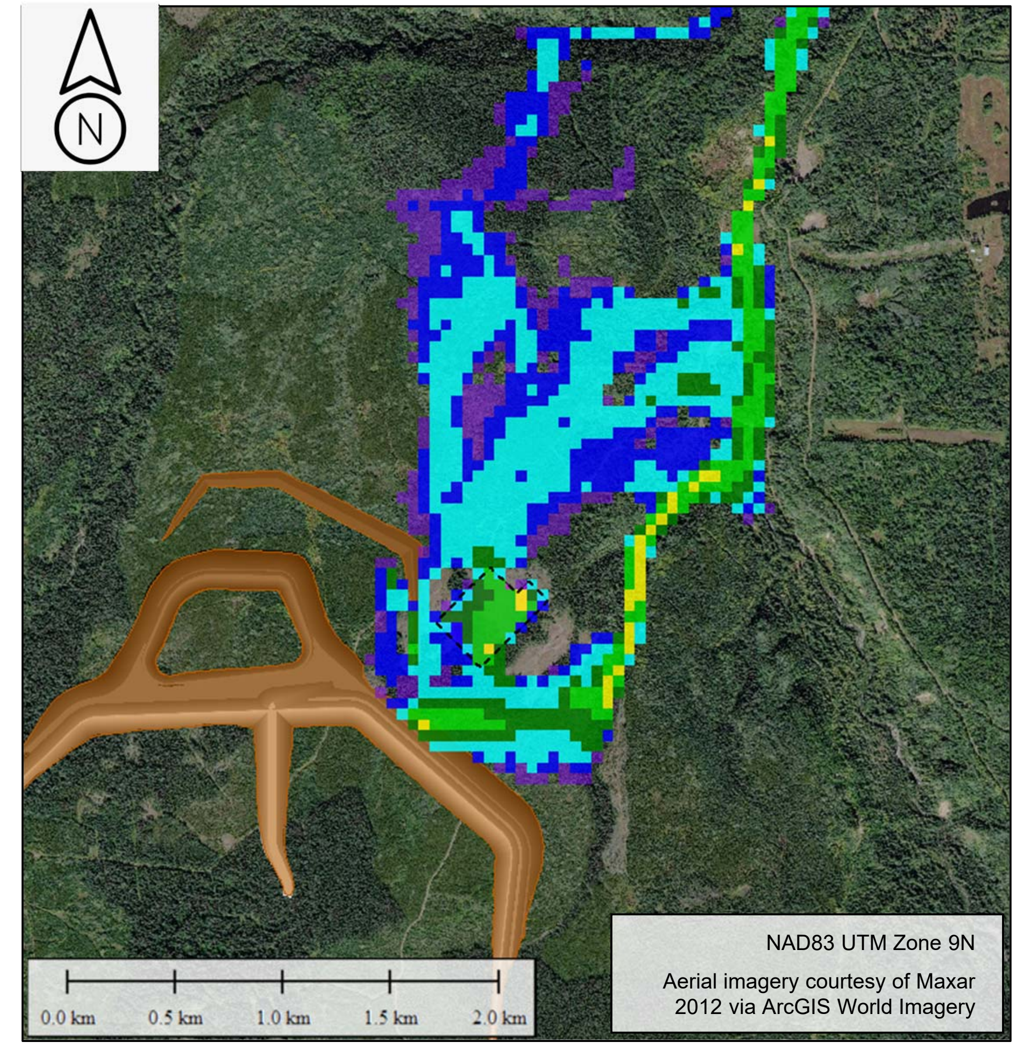
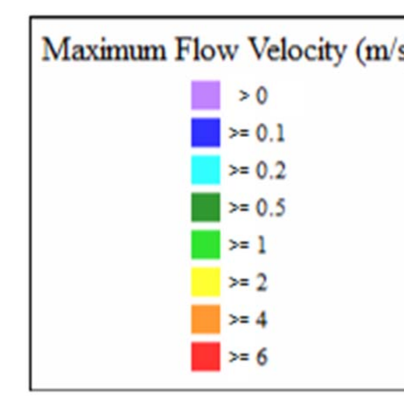


a) Overall Site Plan



b) Village of Telkwa Area



Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
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Caution is needed when interpreting inundation extents.
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srk consulting

TELKWA COAL LIMITED

Dam Break Assessment

East Dam Breach, Sunny Day Maximum Velocity

Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

Date: Jan. 2021 | Prepared by: NF | Figure: **E.2**

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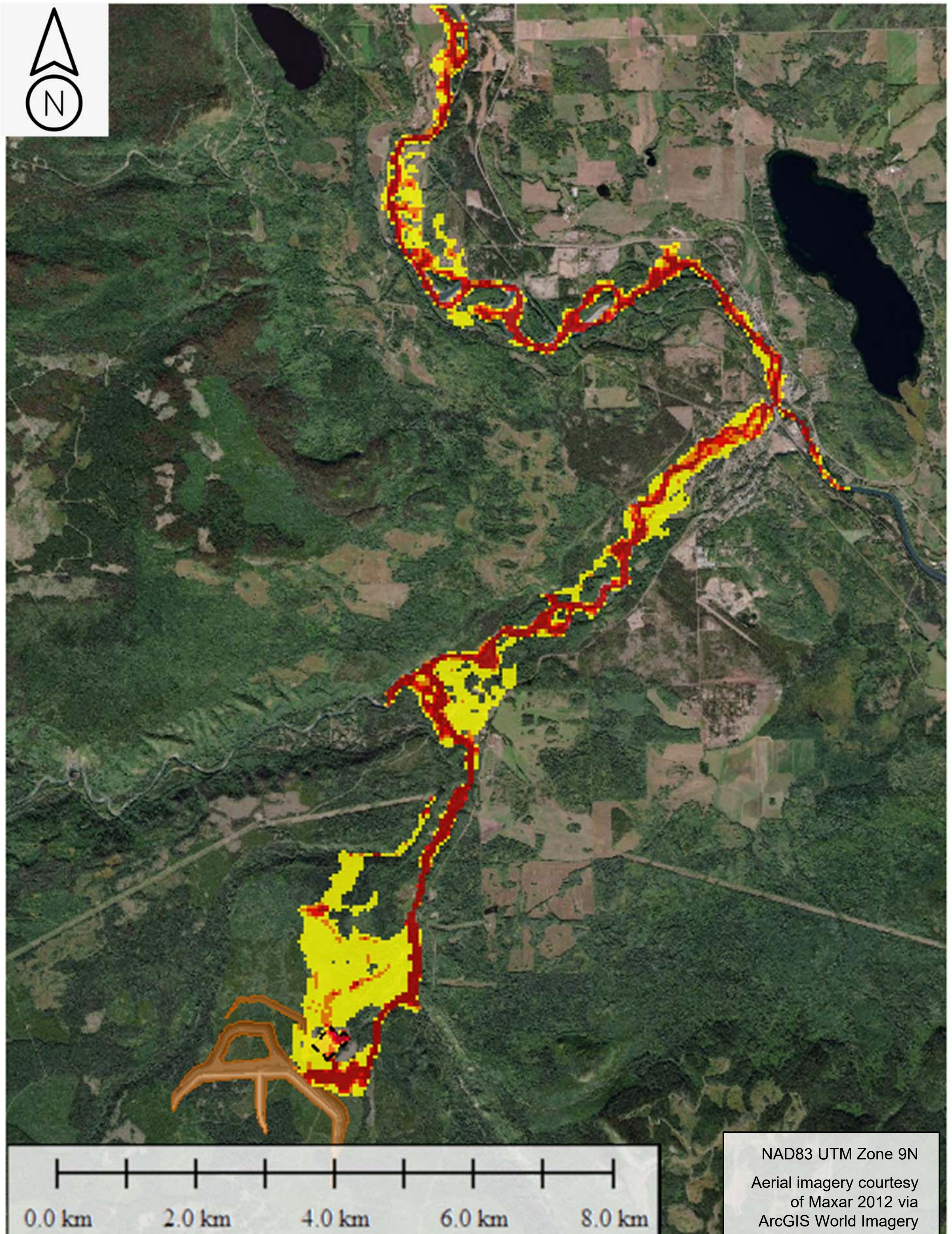
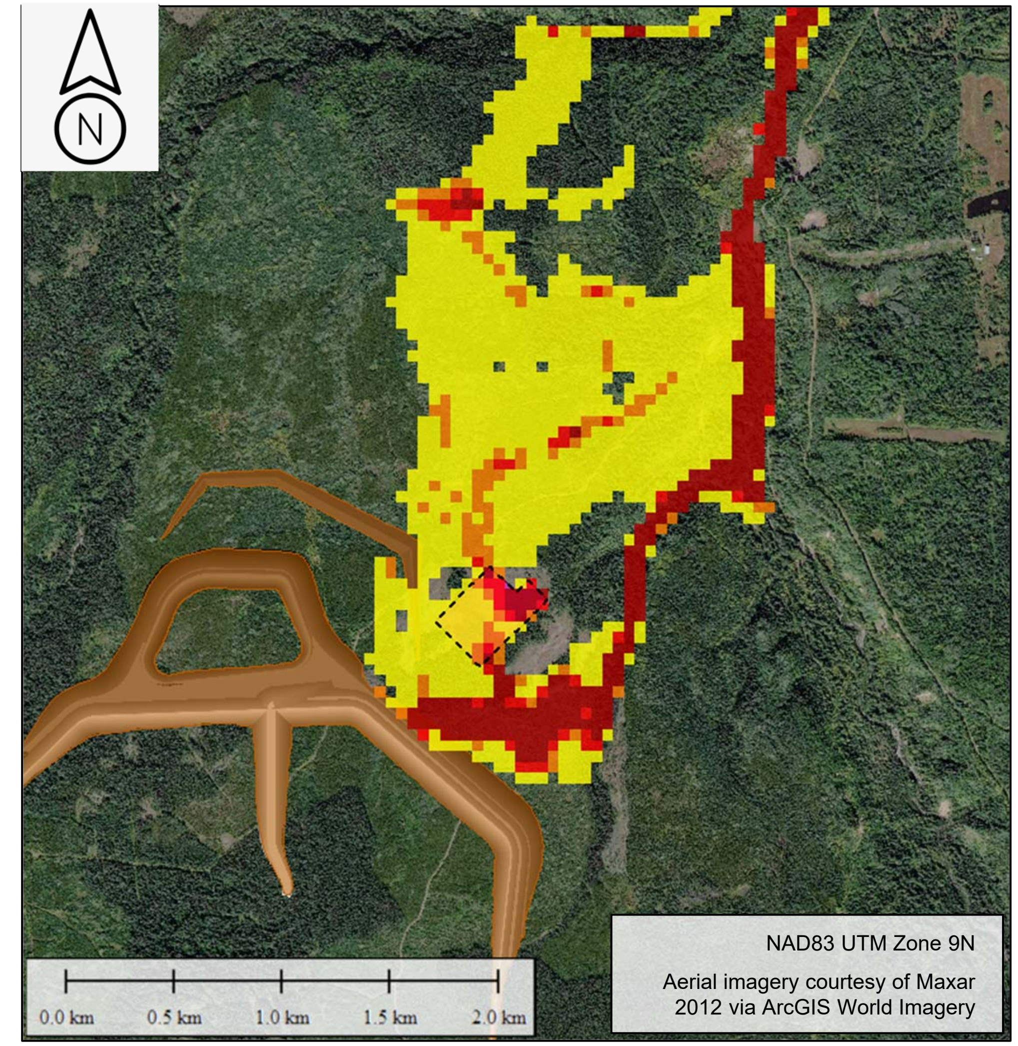


a) Overall Site Plan



b) Village of Telkwa Area

Hazard Rating	Risk to People
Very Low	Caution
Danger for Some	Includes children, the elderly, and the infirm
Danger for Most	Includes the general public
Danger for All	Includes emergency services

Hazard Level
- Very Low
- Danger for Some
- Danger for Most
- Danger for All

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
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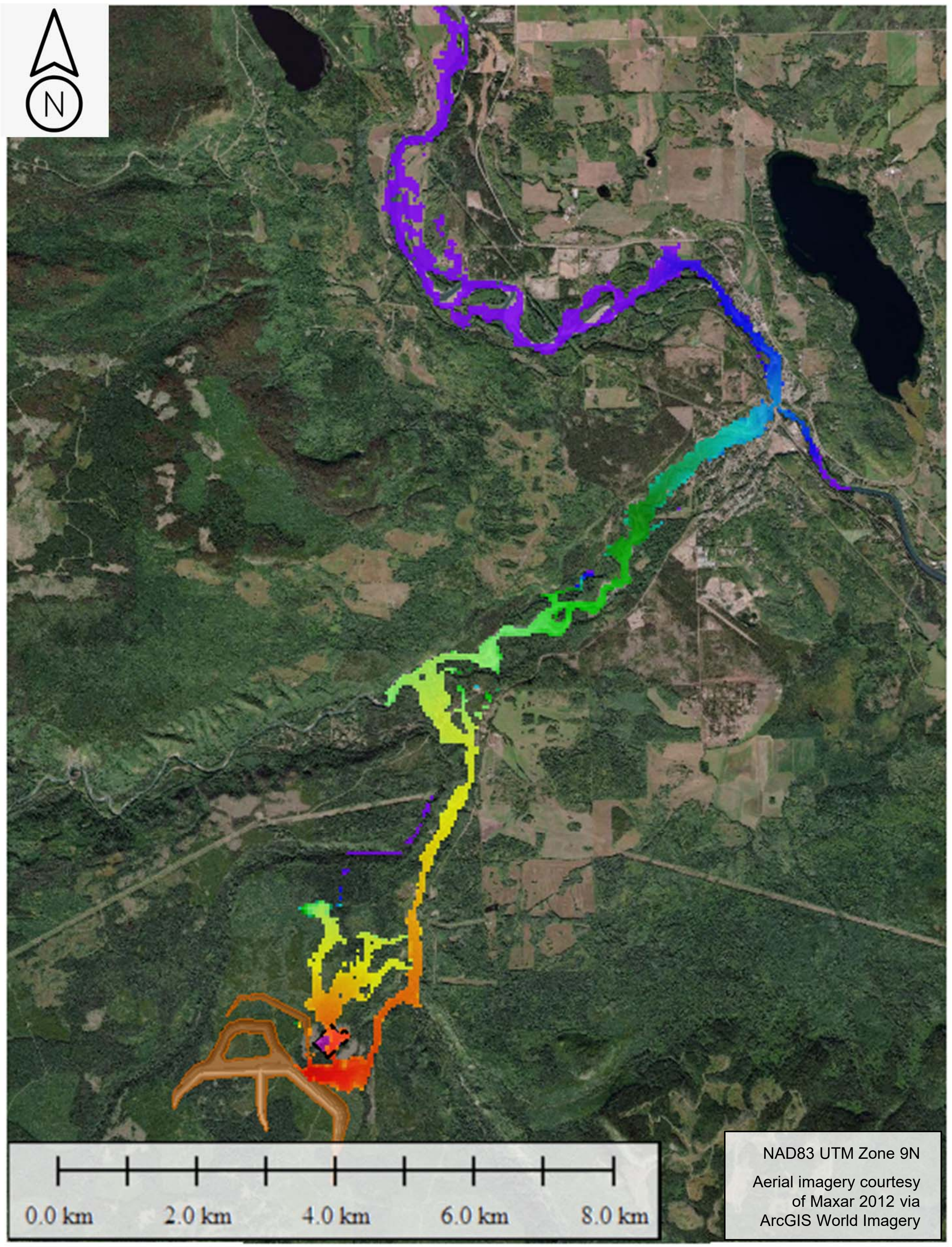
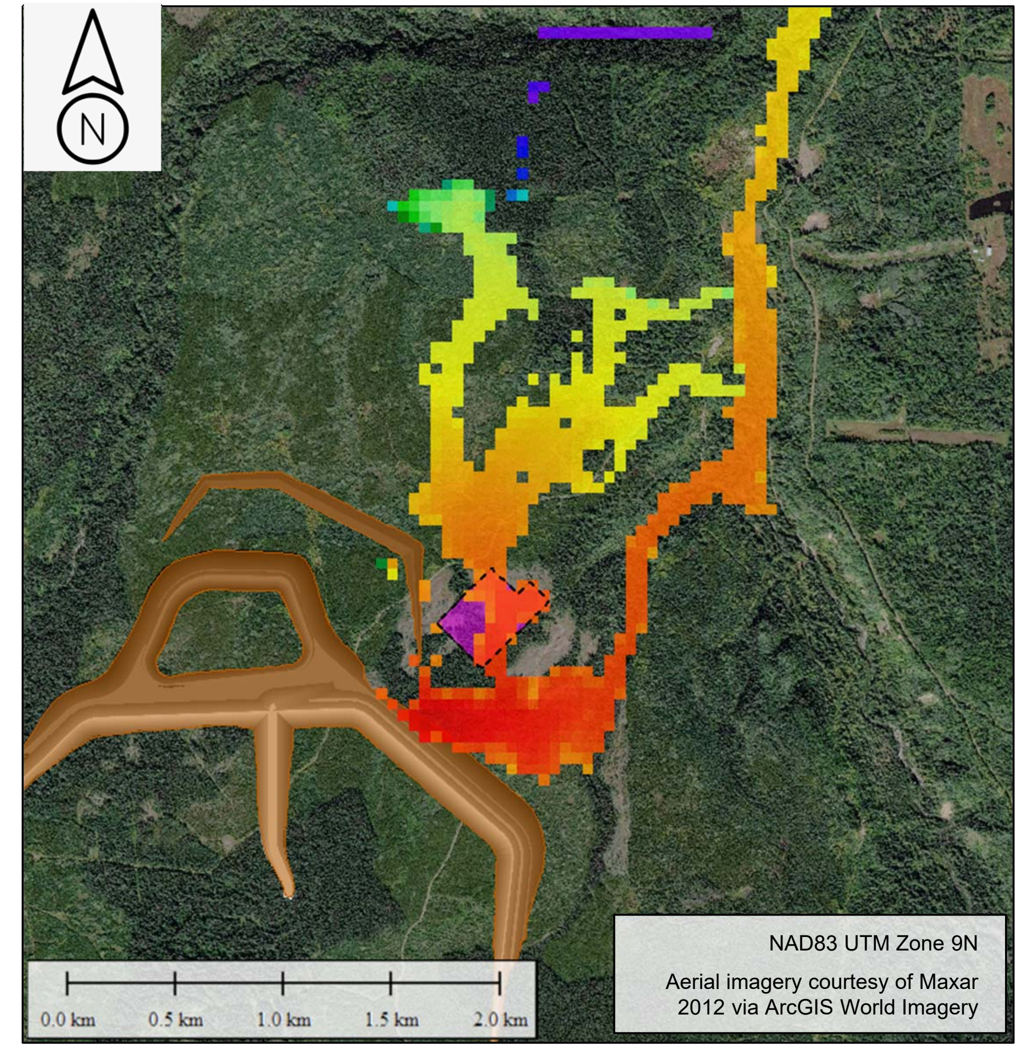
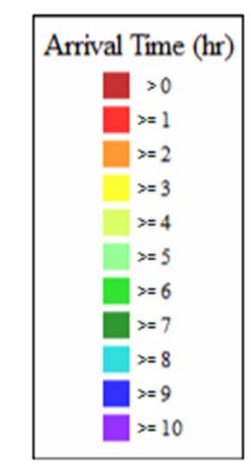
srk consulting	TELKWA COAL LIMITED	Dam Break Assessment
		East Dam Breach, Sunny Day Flood Hazard
Job No: 1CT027.003 Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx	Tenas Project – EA Water Management	Date: Jan. 2021 / Prepared by: NF / Figure: **E.3**



a) Overall Site Plan



b) Village of Telkwa Area



Notes:
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srk consulting

TELKWA COAL LIMITED

Dam Break Assessment

East Dam Breach, Sunny Day Arrival Time

Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

Tenas Project – EA Water Management

Date: Jan. 2021
Prepared by: NF
Figure: **E.4**

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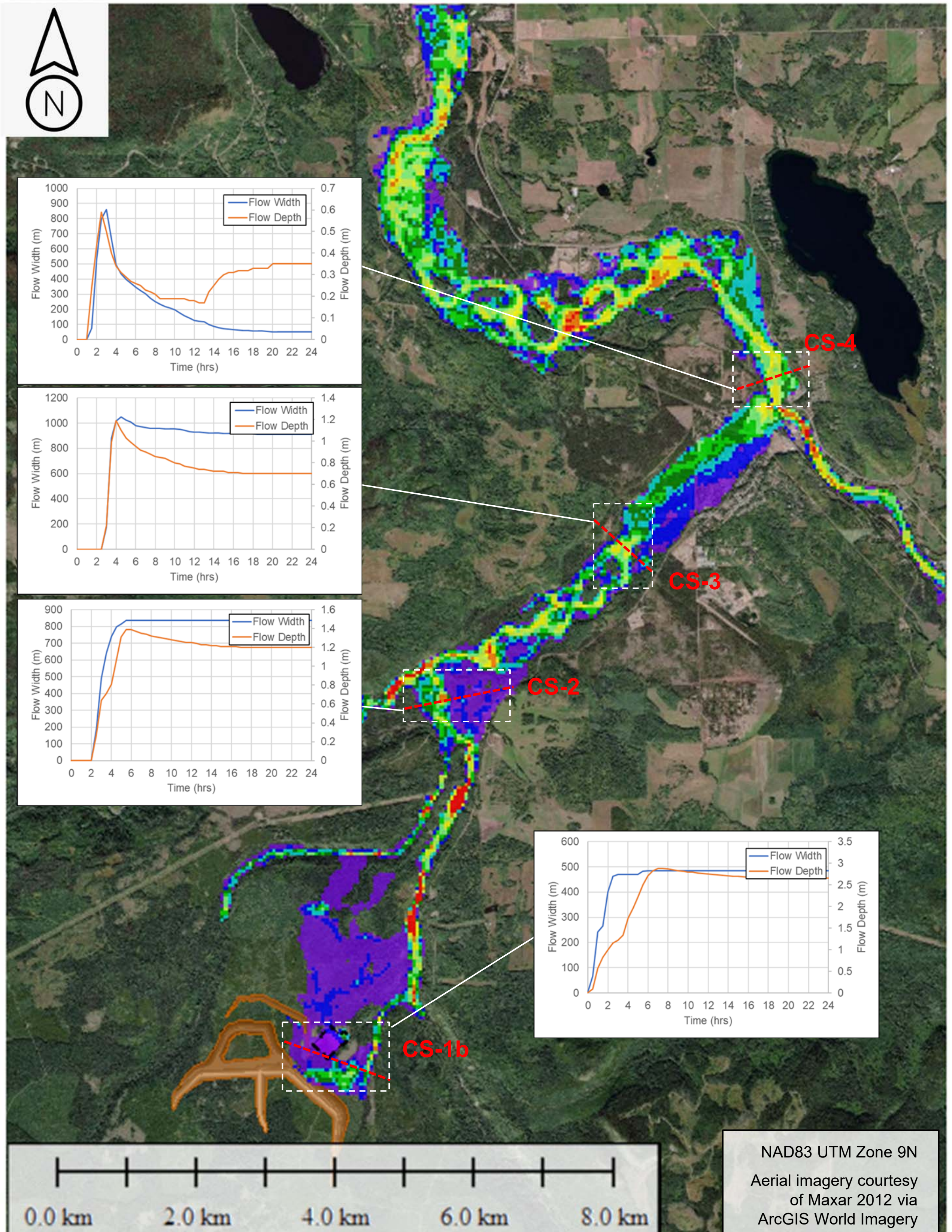
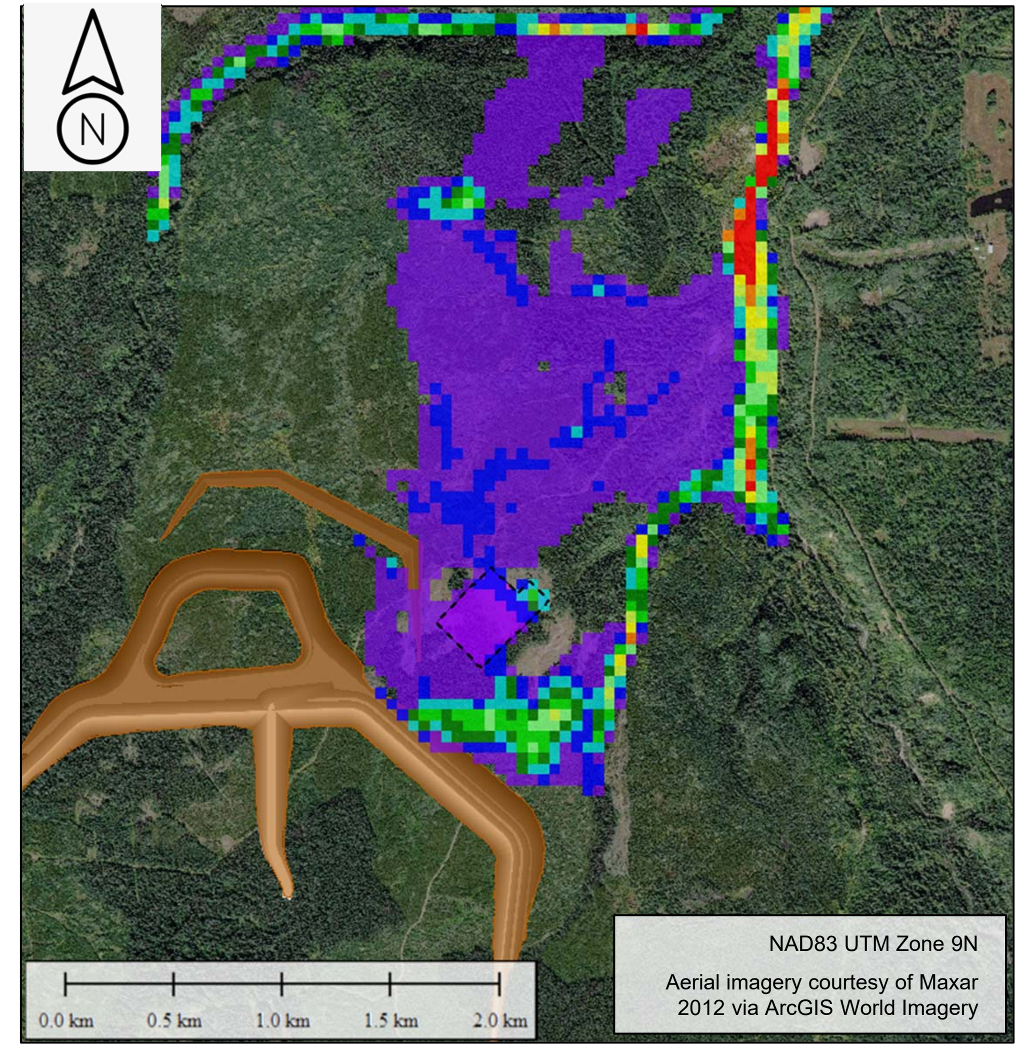
Appendix F East Dam Breach, Rainy Day Scenario



a) Overall Site Plan



b) Village of Telkwa Area

Maximum Flow Depth (m)

- > 0
- >= 1
- >= 2
- >= 3
- >= 4
- >= 5
- >= 6
- >= 7
- >= 8
- >= 9

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
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srk consulting

TELKWA COAL LIMITED

Dam Break Assessment

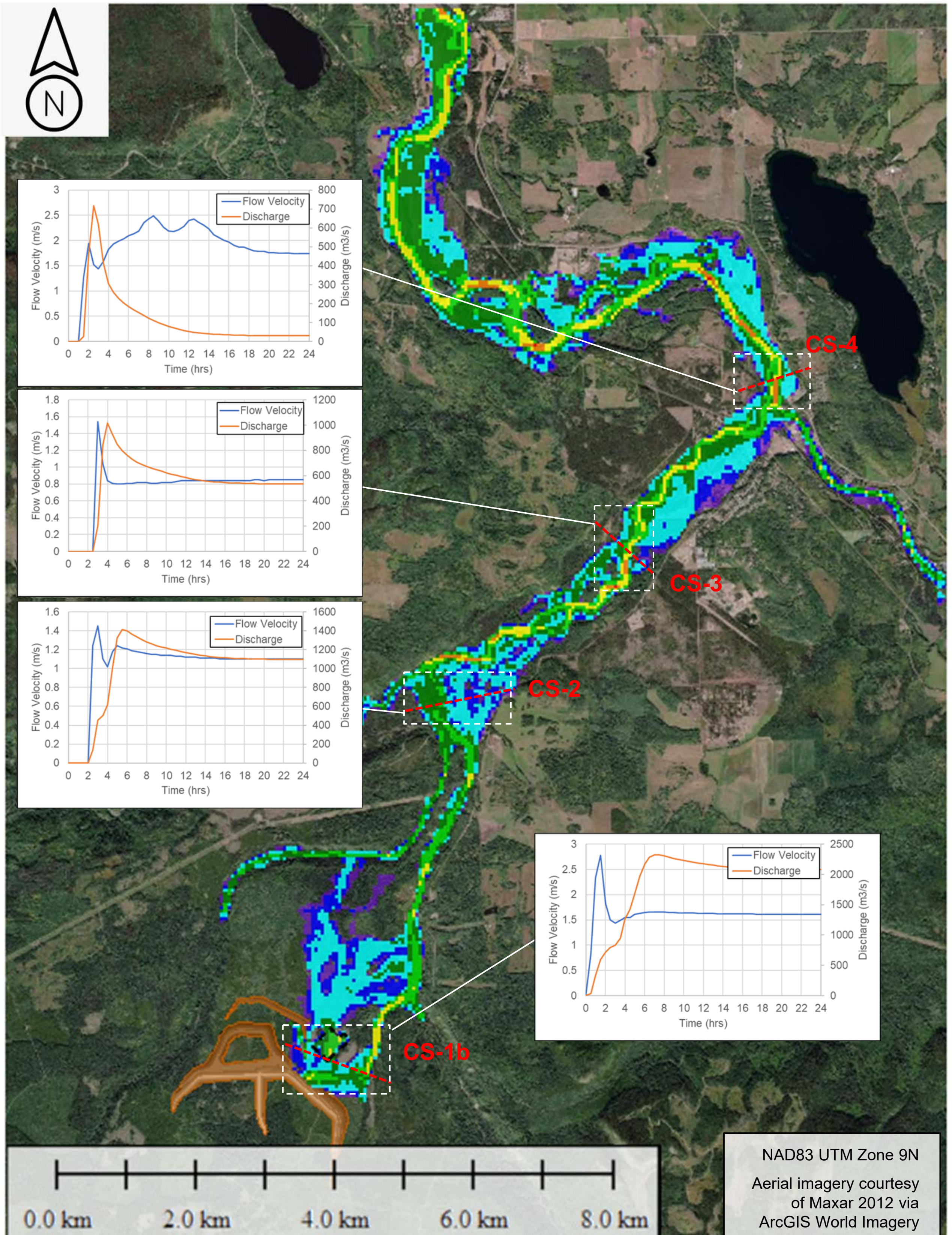
East Dam Breach, Rainy Day Maximum Flow Depth

Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

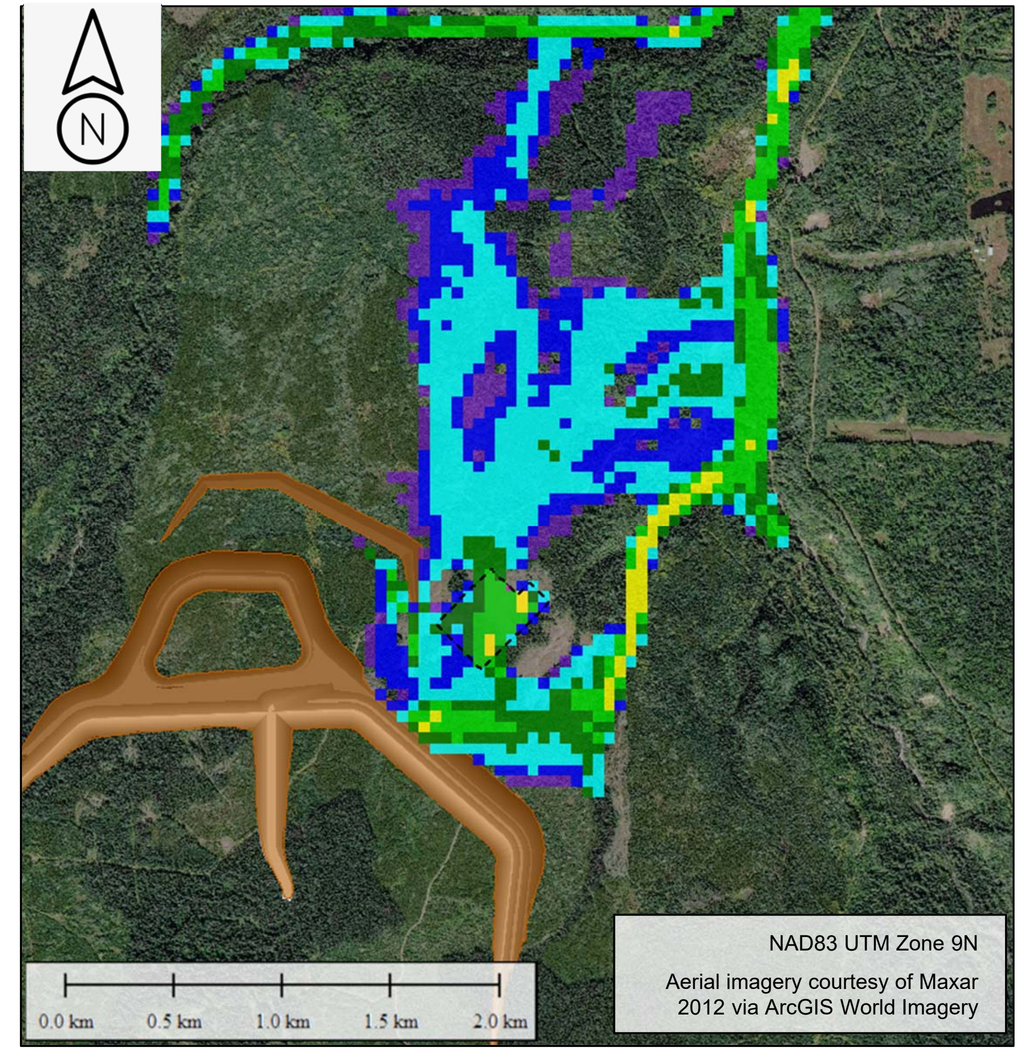
Tenas Project – EA Water Management

Date:	Prepared by:	Figure:
Jan. 2021	NF	F.1

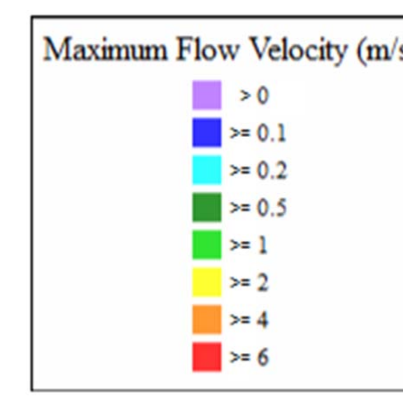
\\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx



a) Overall Site Plan



b) Village of Telkwa Area



Notes:
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srk consulting

TELKWA COAL LIMITED

Job No: 1CT027.003
Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx

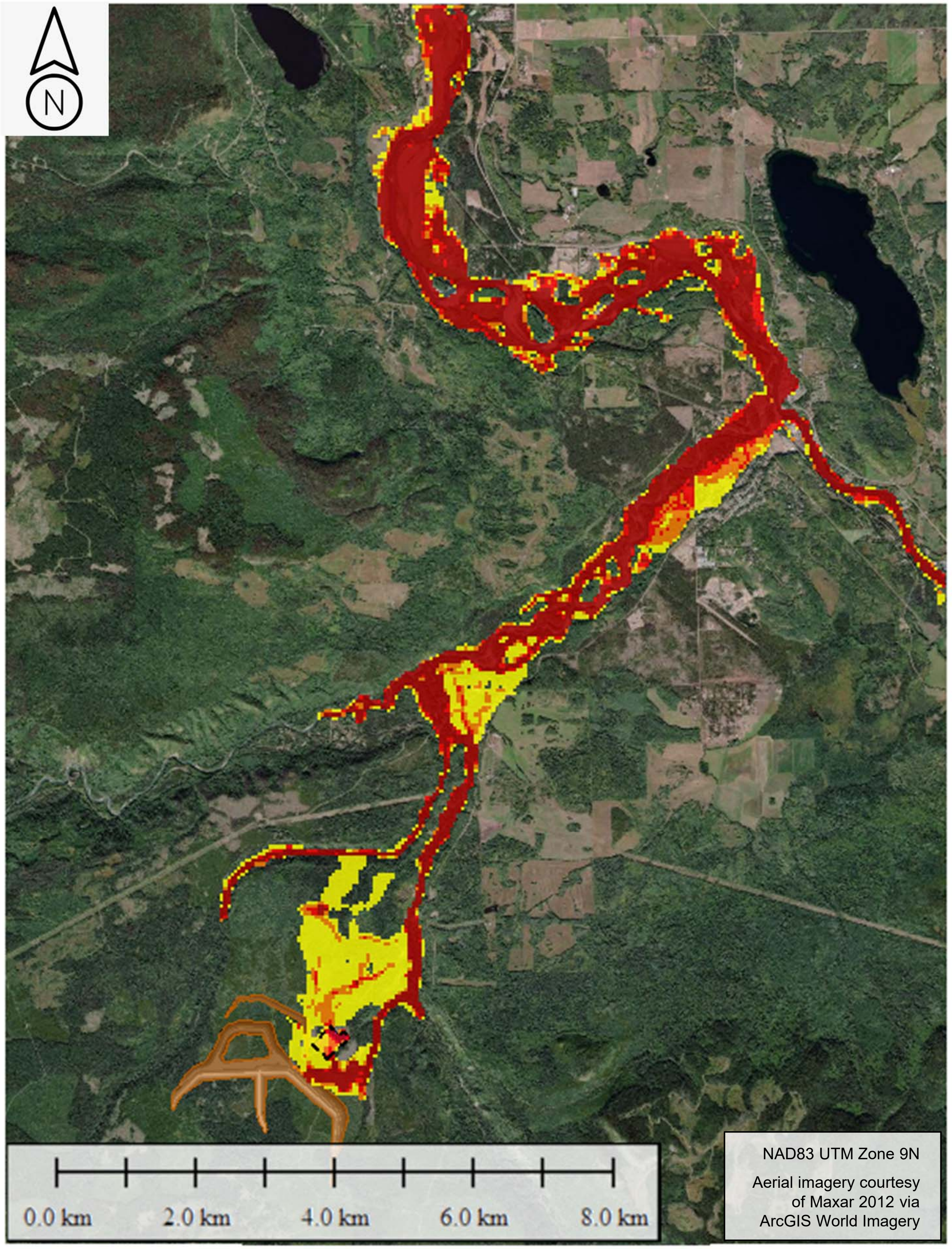
Tenas Project – EA Water Management

Dam Break Assessment

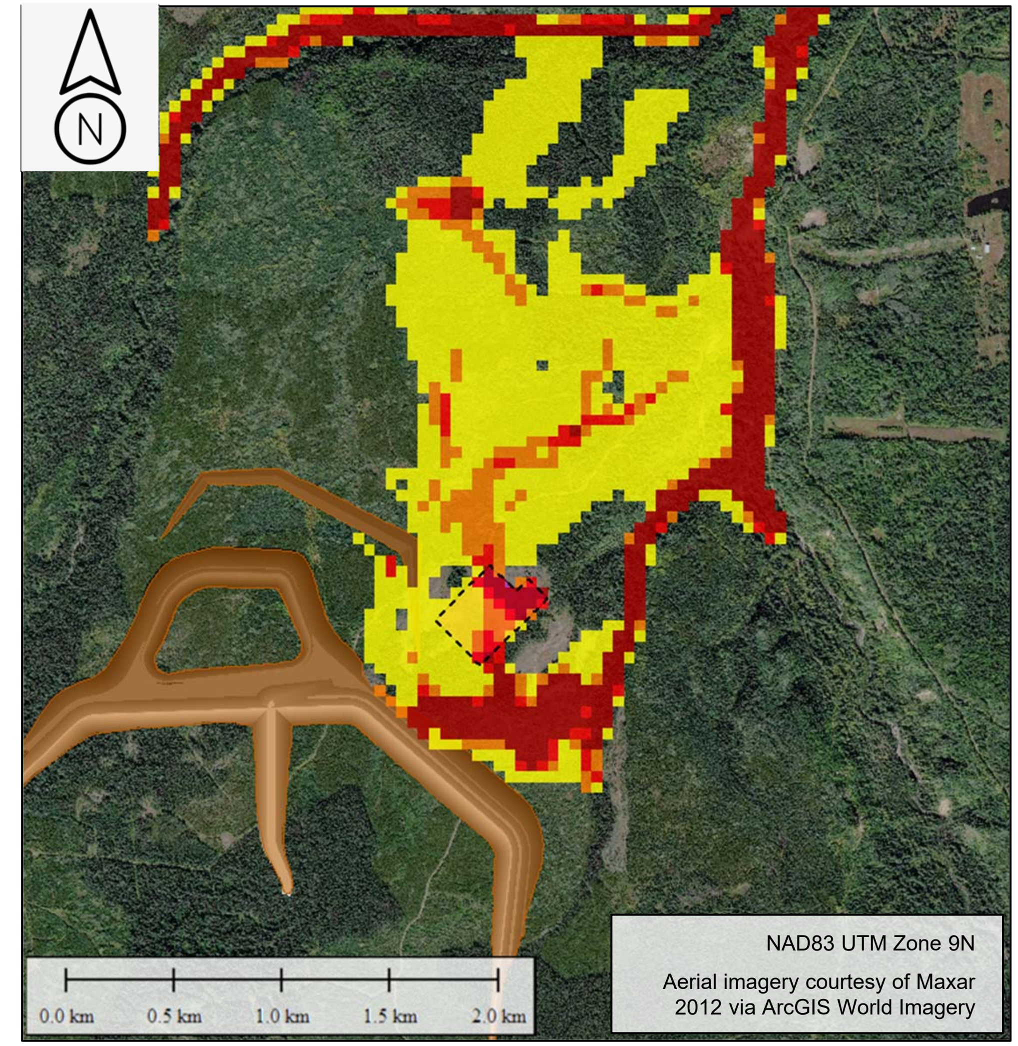
East Dam Breach, Rainy Day Maximum Flow Velocity

Date:	Prepared by:	Figure:
Jan. 2021	NF	F.2

\\srk.ad\dfs\na\van\Projects\01_SITES\Telkwa Coal\1CT027.003_2020 EA Water Management\080_Deliverables\Dam Breach Assessment Memo\040_Figures\Telkwa_DamBreak_Figs_1CT027-003_rev00_nf.pptx



a) Overall Site Plan



b) Village of Telkwa Area

Hazard Rating	Risk to People
Very Low	Caution
Danger for Some	Includes children, the elderly, and the infirm
Danger for Most	Includes the general public
Danger for All	Includes emergency services

Hazard Level
- Very Low
- Danger for Some
- Danger for Most
- Danger for All

Notes:
Predictions computed using 2D overland flow calculations considering topography and roughness estimate.
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srk consulting	TELKWA COAL LIMITED	Dam Break Assessment
		East Dam Breach, Rainy Day Flood Hazard
Job No: 1CT027.003 Filename: Telkwa_DamBreak_Appendices_1CT027-003.pptx	Tenas Project – EA Water Management	Date: Jan. 2021 / Prepared by: NF / Figure: **F.3**