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Memo

To: Rafeal Odie, PL (Eng.), PMP
Senior Project Manager - Capital Projects

Company: Rocky View County

From: L.S. Hundal, P.Eng.

Date: 12 June 2018

CC: Cyril Mitchell

Ref: CT160213

Re: Response to PGL Review Memo Bragg Creek Flood Mitigation Project: Potential Pathways of Effect on Downstream Lands and Waters

1.0 INTRODUCTION

The Tsuut'ina Nation submitted a Statement of Concern (SoC) pursuant to the Water Act application 001-00397687 that was submitted by Rocky View County (RVC) to Alberta Environment & Parks (AEP) for the Bragg Creek Flood Mitigation Project. The support documentation for the SoC included a memo from PGL Environmental Consultants dated 16 April 2018 and titled *'Bragg Creek Flood Mitigation Project: Potential Pathways of Effect on Downstream Lands and Waters*'.

This memo from Wood Environment and Infrastructure Solutions (Wood) is intended to address the concerns contained in the PGL memo. This Wood memo is divided into the sections noted below, which generally follows the sequence of the PGL memo. Some of PGL's terminology for their headings have been revised for clarity and accuracy.

- Project Summary and Basics of River Behaviour and Shape and Flood Prediction
- Design Flood Estimate and Accounting for Climate Change
- Potential Impacts Under Typical Flood Conditions (1:2 year Return Period)
- Potential Impacts Under Moderately Large Flood Conditions (1:20 year Return Period)
- Potential Impacts Under Design Flood Conditions (1:100 year Return Period)
- Potential Impacts Under Extreme Flood Conditions (1,300 m^3/s)
- Groundwater Impacts
- Springbank Off-Stream Reservoir (SR1) Backwater Impacts

2.0 PROJECT SUMMARY AND BASICS OF RIVER BEHAVIOUR AND SHAPE AND FLOOD PREDICTION

Sections 1.1, 1.2 and 1.3 of the PGL memo are Project Summary and Basics of River Behaviour and Shape and Flood Prediction. These sections contain several unclear statements as noted in the Table below:

Table 2.1: Response to PGL Memo Sections 1.1, 1.2 and 1.3

PGL Statement	Response by Wood
The Project is composed of a discontinuous set of hard structures, most adjacent to or inland of the south bank of the Elbow River	The proposed structures are located on the east and west banks of the Elbow River
The upstream limit of the Project is at the confluence of Bragg Creek and the Elbow River	The upstream extent of the project extends to approximately 550 m upstream of the Bragg Creek confluence.
Bragg Creek is located in the narrowest portion of Elbow River	The channel width at the Hamlet of Bragg Creek is consistent with the channel width upstream of the Hamlet. However, the Elbow River flows through a narrow valley upstream of the Hamlet which then widens and the valley bottom consists of a wide gravel plain on which much of the Hamlet is located.
The Application Materials (Figure 6.4, Appendix B - Hydrology Model) identify a downstream channel incision during a 1:100-year flood that is consistent with the effects of increased flow and speed through an upstream training structure.	In river hydraulics, channel incision implies downcutting of the stream bed. The river consists of a series of gravel reaches separated by nick-points where bedrock is exposed in the channel. A bedrock outcrop is located 300 m downstream of the Hamlet/Tsuut'ina boundary. Channel incision will not occur due to the presence of the bedrock outcrops.
Floods are discussed in terms of "return periods" that reflect the likelihood of a flood of a certain size. A 1:100 flood is one that is only likely to occur once every hundred years	This statement is unclear since the implication is that a 100-year flood will likely only occur once every hundred years. A 100-year event is one that has a 1 percent chance of a flood of equal or greater magnitude occurring in any given year.

3.0 FLOOD CONDITIONS CONSIDERED

Section 1.4 of the PGL memo discussion of the flood conditions considered contains incorrect or unclear terminology that are discussed in the Table below. The flood conditions considered in this Wood memo are based on the corrected terms in the table below (i.e. those in the second column).

Table 3.2: Flood Conditions Considered

PGL Statement	Response by Wood
Low-flow conditions: these occur from the period following the end of snowmelt to the start of the following snowmelt. For the Bragg Creek area, these are the conditions prevailing from late summer, through	Low flow conditions would be those synonymous with those typically seen in non-flood conditions. These would occur during the late-summer/fall/winter period from August through to April. A good representation of this would be the

winter, to early spring. For reference. this is the flow associated with the 1-in-2-year flood, or 57m^3/s	Mean Monthly Discharge for these months, which is 5.2 m^3/s (based on Table 2.1 of Amec Design Report (June 2017). The structure has no impact on low flows, hence these conditions are not considered further in this memo.
"Normal" freshet (spring runoff) conditions: for the purpose of this memo, "normal" conditions are those in which flows do not exceed the 1-in-20-year flood, or 440m^3/s	Normal spring runoff conditions would be those typically occurring (i.e. those associated with neither a high or low peak flow). The 2-year flood estimate of 57 m^3/s is a good indicator of **typical flood conditions** because a flood of this magnitude or lower has a 50 percent chance of occurring in any given year. The 20-year flood of 440 m^3/s referenced by PGL is representative of a **moderately large sized flood** (there's a 5 percent chance flood of this magnitude or greater occurring in any given year). The 20-year flood is discussed in this Wood memo.
Design flood conditions: this is the 1-in-1 100-year flood volume and represents the maximum flow that the Project is designed to control. For reference, this now is 930 m^3/s.	The term volume is used incorrectly by PGL. Volume is the amount of space occupied, whereas flow rate is the volume per unit of time. The **Design flood** flow rate considered is 990 m^3/s.
Catastrophic floods: this is any flow volume over the 100-year flow. For reference, the measured flow during the 2013 flood was 1,170 m^3/s (Application Material, p.1, Footnote 5). This is greater than the design volume for the Bragg Creek project. The volume associated with the 2013 now is closer to that (1,197m^3/s) associated with an unadjusted-for-climate-variability 1 :200-year flood	In this Wood response memo, we have used a flow of 1,300 m^3/s to evaluate a breach scenario associated with a **catastrophic flood**. This has a return period greater than a 200-year return period flood event.

4.0 DESIGN FLOOD ESTIMATE AND ACCOUNTING FOR CLIMATE CHANGE

The proposed flood protection design accounts for climate change based on the following two factors:

1. The 100-year flow rate estimate[1] of 930 m^3/s was increased by 6.5 percent to 990 m^3/s; and
2. The design freeboard of 0.6 m is intended to apply for uncertainties including climate change. We note that a flood of 1300 m^3/s can be contained by the proposed structures, which is 40 percent greater than the 100-year flood estimate of 930 m^3/s.

Based on a combination of the above two factors, we believe the proposed design accounts adequately for climate change.

5.0 POTENTIAL IMPACTS UNDER TYPICAL FLOOD CONDITIONS (1:2 YEAR RETURN PERIOD)

The concerns identified in PGL's section 1.5.1 are addressed below. This is for potential impacts under typical flood conditions (1:2 year Return Period flow of 57 m^3/s). The attached **Figure 5.1**, which reflects the results of our hydraulic model, shows the flow patterns for the 2-year flood for both existing

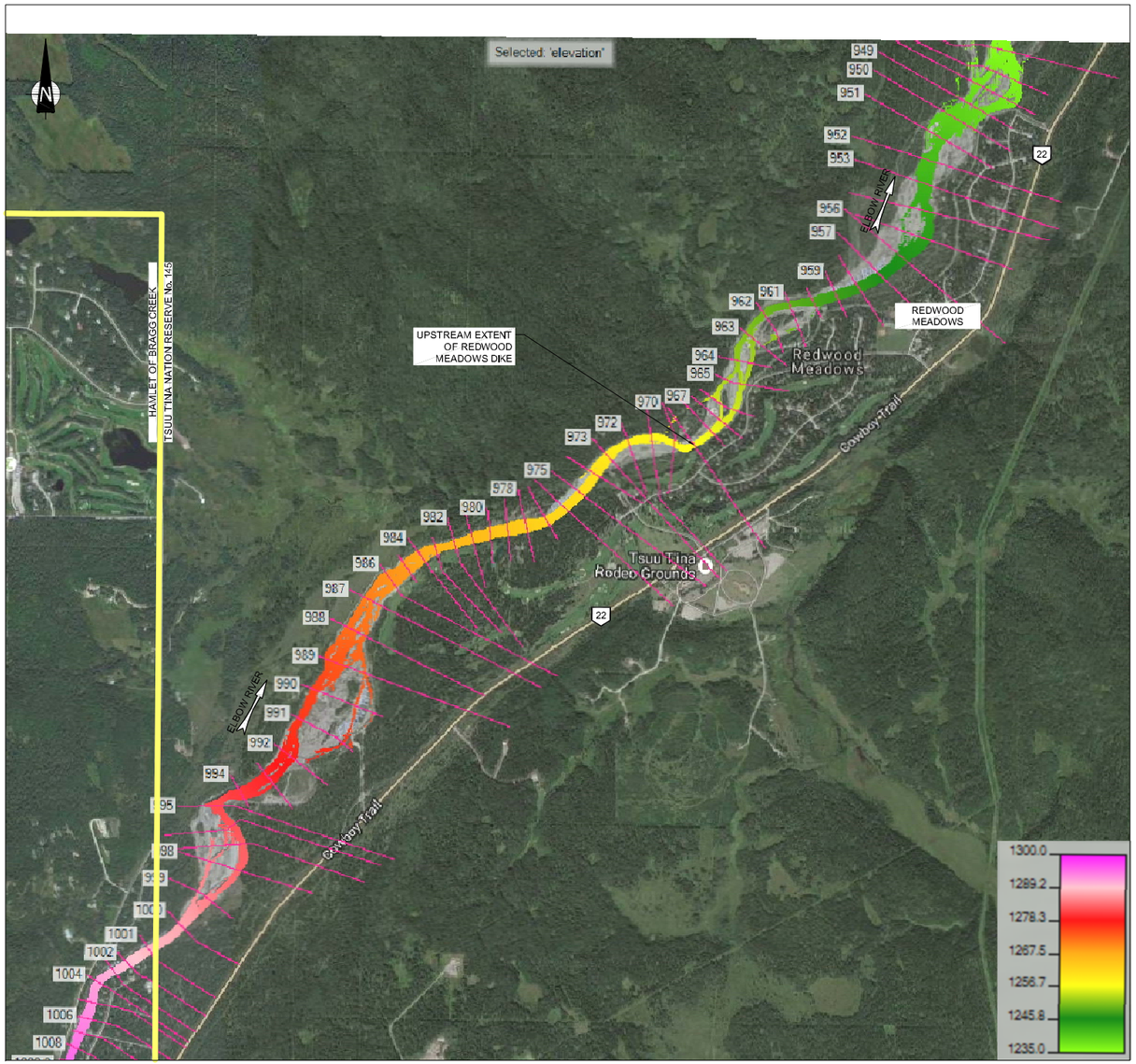
[1] Source: Southern Alberta Flood Recovery Task Force Flood Mitigation Measures for the Bow River, Elbow River and Oldman River Basins Volume 4 – Flood Mitigation Measures, June 2014.

conditions and flood protection conditions. As shown in the figure and in the discussion below, the proposed structure has no impact on the 2-year flood. Specific responses to PGL's statements are contained below.

Table 5.3: Response to PGL Memo Section 1.5.1

PGL Statement	Response by Wood
Water depth and speed will increase in the Elbow River in the reach of river bounded by Project infrastructure. The increase over base-conditions is predicted in the Application to be 0.31 m and 0.47m/s close to the boundary between Bragg Creek and IR145	The PGL statement is incorrect as the depth and velocity numbers quoted are with reference to the design flood of 990 m^3/s. Our hydraulic model indicates that there are no increases in depth or velocity on the reserve land at the Hamlet boundary or beyond, for **typical flood conditions**.
Water depth and speed will attenuate beyond the downstream infrastructure. According to the Application, depth and volume will be indistinguishable from pre-project conditions (0.01m and 0.01m/s) at the downstream end of the community of Redwood Meadows	Similar response to above, the numbers referenced are with respect to the design flood of 990 m^3/s. Our hydraulic model indicates that there are no differences in Redwood Meadows, for **typical flood conditions**.
Changes to river morphology (shape) may occur, but are expected to be minimal	On the basis of the above, no changes to river morphology would directly result from the Project, for **typical flood conditions**.
Increased water speed and volume may increase water turbidity (concentrations of suspended sediment), with corresponding potential effects on fish health and reproductive success	On the basis of the above, there will be no increase in water speed or volume. Hence, no increase in water turbidity (concentrations of suspended sediment), nor any potential effects on fish health and reproductive success

It should be noted that the proposed barrier surfaces are generally excavated into the existing river banks, or located above the 1:2 year flood water surface level, and for these reasons have no impact on water depth or speed upstream of the Tsuut'ina boundary in typical flood conditions.



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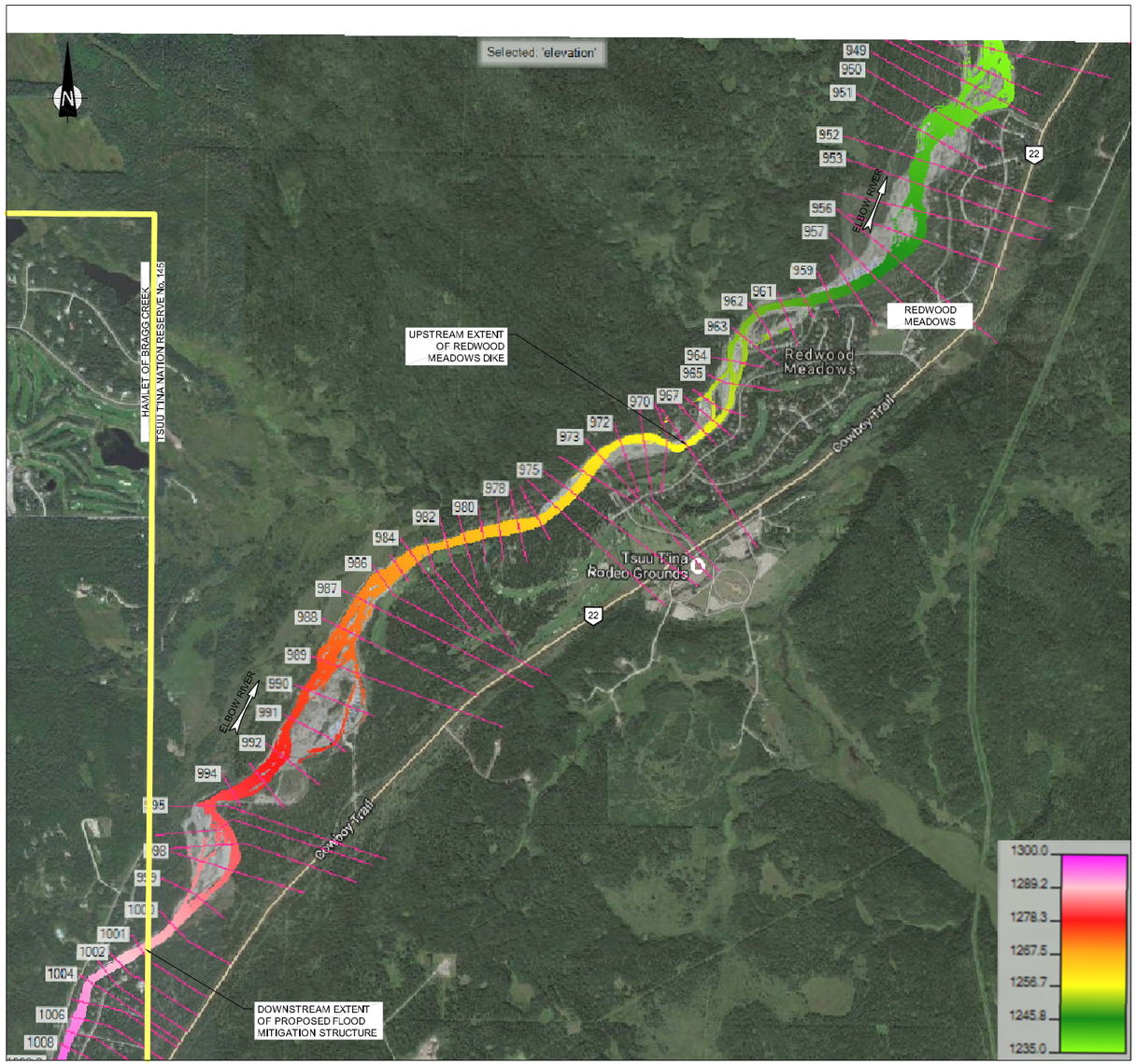

FLOOD MITIGATION STRUCTURE CONDITIONS

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NOTES:

1. NUMBERS ON FIGURE IDENTIFY MODEL CROSS SECTION NUMBERS.
2. COLOURS IN LEGEND DENOTE WATER SURFACE ELEVATIONS IN METRES, ABOVE SEA LEVEL.

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CLIENT: Rocky View County, Cultivating Communities

PROJECT NAME: BRAGG CREEK FLOOD MITIGATION

SHEET TITLE: 1:2 YEAR FLOOD INUNDATION EXTENTS AT TSUU T'INA RESERVE AND REDWOOD MEADOWS

PROJECT NUMBER: CT160213

FIGURE NUMBER: 5.1

ISSUE/REVISION: A

6.0 POTENTIAL IMPACTS UNDER MODERATELY LARGE FLOOD CONDITIONS (1:20 YEAR RETURN PERIOD)

The concerns identified in PGL's section 1.5.2 are addressed below. This is for potential impacts under moderately large flood conditions (1:20 year Return Period flow of 440 m^3/s). The attached **Figure 6.1** shows the flow patterns for the 20-year flood for both existing conditions and flood protection conditions. As shown in the figure and in the discussion below, the proposed structure has no impact on the 20-year flood. Specific responses to PGL's statements are contained below.

Table 6.1: Response to PGL Memo Section 1.5.2

PGL Statement	Response by Wood
As above. water depth and speed will increase in the Elbow River in the reach of river bounded by the Project infrastructure;	Our hydraulic model indicates that, at the boundary of the reserve with the Hamlet, there is no significant difference in depth or velocities for even moderately large flood conditions.
Additional water energy has the potential to move more or larger material downstream towards the community of Redwood Meadows	Our hydraulic model indicates that there is no additional water energy, hence no additional potential to move more or larger material downstream for even moderately large flood conditions.
Gradual deepening of the Elbow River downstream of the project structure is likely. The speed at which this will occur depends on the frequency of high volume flooding	There will be no deepening based on the above statements and as previously noted, the stream profile is controlled by bedrock outcrops including one outcrop that is located 300 m downstream of the Hamlet boundary. Bedrock weathering and scour is a very slow process not influenced by infrequent flooding.

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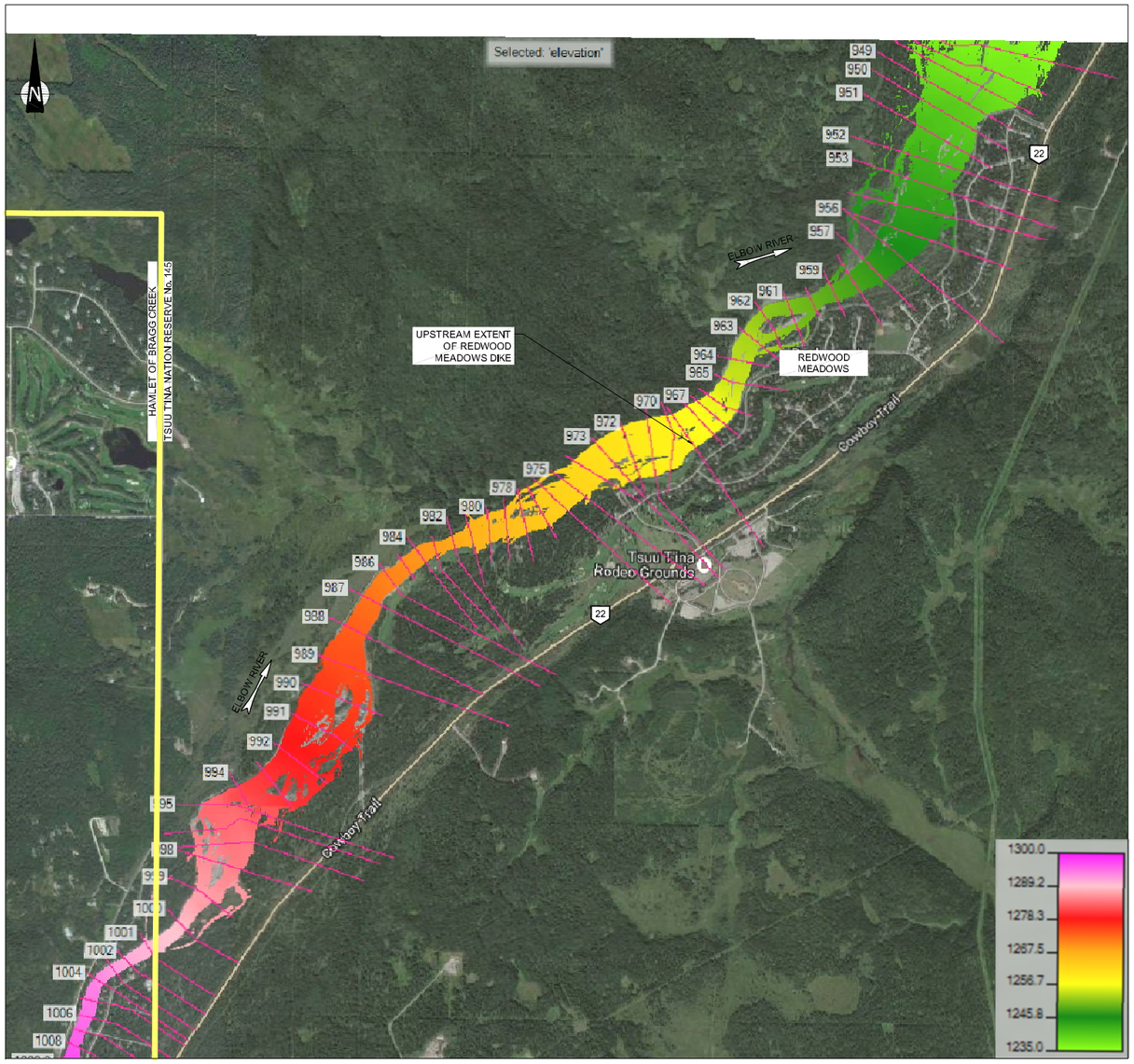

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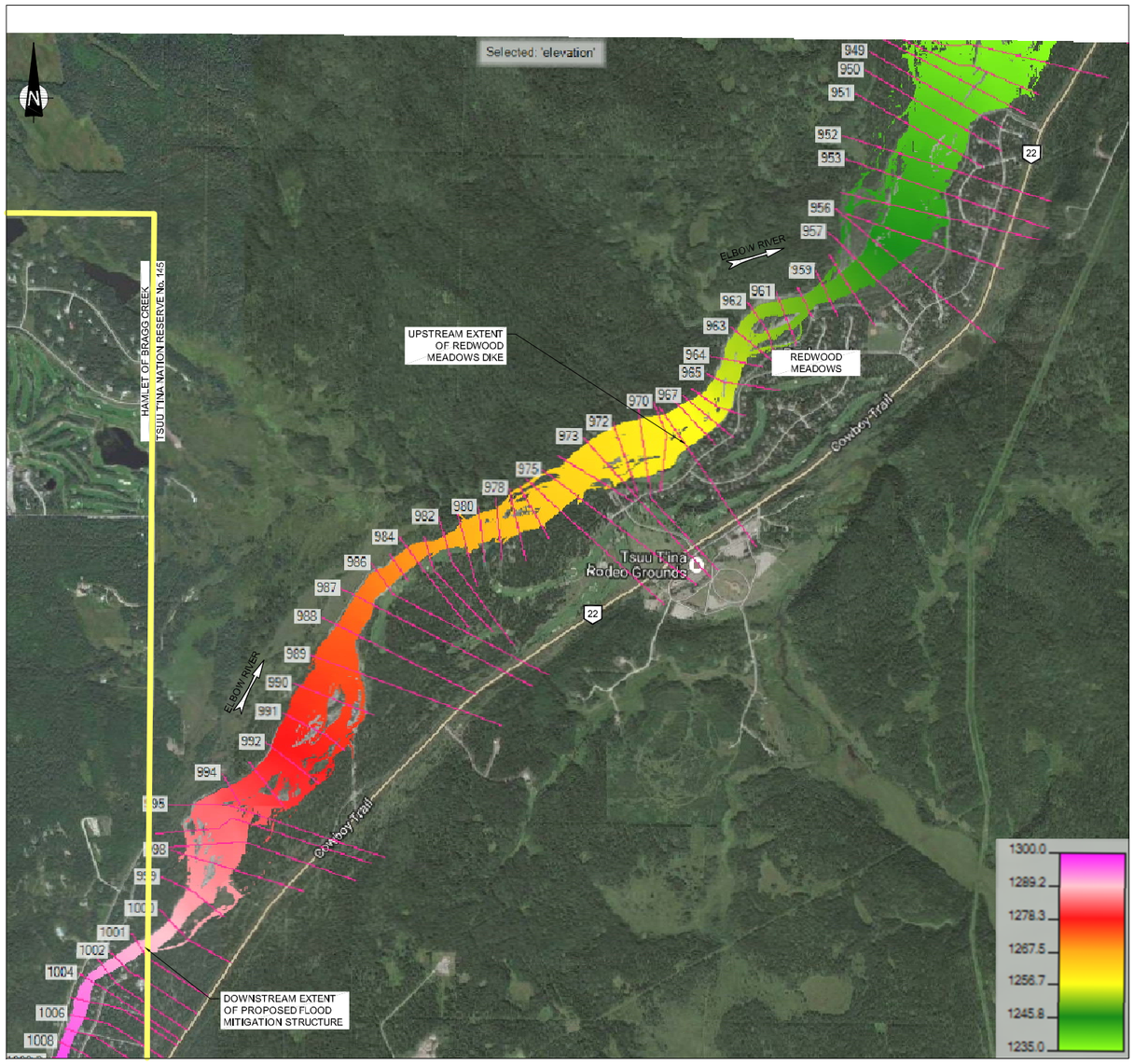

FLOOD MITIGATION STRUCTURE CONDITIONS

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CLIENT: Rocky View County, Cultivating Communities

PROJECT NAME: BRAGG CREEK FLOOD MITIGATION

SHEET TITLE: 1:20 YEAR FLOOD INUNDATION EXTENTS AT TSUU T'INA RESERVE AND REDWOOD MEADOWS

PROJECT NUMBER: CT160213

FIGURE NUMBER: 6.1

ISSUE/REVISION: A

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7.0 POTENTIAL IMPACTS UNDER DESIGN FLOOD CONDITIONS (1:100 YEAR RETURN PERIOD)

The concerns identified in PGL's section 1.5.3 are addressed below. This is for potential impacts under design flood conditions (1:100 year Return Period flow of 990 m^3/s). The two main issues identified in the PGL memo for this condition are: (1) Potential flood and erosion downstream of the Hamlet boundary: and (2) potential for additional large debris to be deposited on Tsuut'ina lands. These concerns are discussed below. It is emphasized that with only one-percent (1%) statistical probability of occurring in any given year, a 100-year flood is a very seldom occurring flood event.

7.1 Potential Flood and Erosion Downstream of Hamlet Boundary

The impacts on water levels and velocities for the design flood are summarized in **Table 7.1**.

Table 7.1: Comparison of Hydraulic Conditions for Design Flood

River Centreline Station (m)	Distance Downstream of Hamlet Boundary (m)	Existing Conditions		Flood Barrier Conditions		Percentage increase	
		Maximum Depth (m)	Velocity (m/s)	Maximum Depth (m)	Velocity (m/s)	Maximum Depth (%)	Velocity (%)
12994	174	2.76	4.73	2.95	5.11	7.0%	8.0%
13198	378	2.64	3.07	2.78	3.41	5.4%	10.8%
13385	565	3.40	2.21	3.54	2.35	4.0%	6.3%
14000	1180	2.29	4.00	2.36	4.13	3.0%	3.1%
16715	3895 (West / Upstream Boundary of Redwood Meadows)	2.01	4.01	2.03	4.05	0.9%	0.8%

Notes:
[1] Velocity taken at channel centreline
[2] River centreline stations correspond to Table 6.1 of the Engineering Design Report Appendix B

As shown above and indicated in the Appendix B of the Design Report the structure impacts are largely confined to a few hundred metres downstream of the Hamlet boundary. There is a general downward trend in the increase in depth and velocity of water. There is a negligible increase in depth and velocity at Redwood Meadows. It is important to note that the above impacts occur very rarely and only for a few days during large events such as the 2013 flood. As discussed in previous sections of this memo, typical floods (2-year return period) and moderately large flood (20-year return period) do not result in any increase in either velocity or water levels within Tsuut'ina lands.

For large floods (such as the design event), the increase in water levels and velocities that would occur in the few hundred meters downstream of the boundary is not expected to result in any measurable erosion over and above that which occurs naturally. The attached **Figure 7.1** shows the 2012 and current banklines superimposed on the 1924 airphoto. The 1924 channel was considerably wider and more

braided than the recent configuration. This previous (1924) configuration resulted from the large floods that occurred at the end of the 19th century and early 20th century (see Table 1.1 in the Engineering report). The channel became less braided with a narrower width due to relatively small floods that occurred after 1934, until the large 2013 flood. The channel became more braided and wider due to the 2013 flood, as shown by the comparison of the existing and 2012 banklines. It is within the context of the flood structure impacts being small (see **Table 7.1**), occurring very rarely (for only for a few days during large floods such as 2013) and the natural variability of the channel configurations (see **Figure 7.1**), that the statement is made that the proposed structures are expected to have limited impacts on the current channel morphology of this reach. It should be noted that the proposed barrier system has been set back as far from the main river as possible considering adjacent developments, often in floodplain areas well above normal river levels, and would be high and dry above all but the rare and extreme floods like 2013.

7.2 Potential Additional Large Debris Deposited on Tsuut'ina Lands

The PGL memo states "Given the increased water velocities predicted to result downstream as a result of the Project it is reasonable to expect that more and/or larger debris may be carried through the project reach to be deposited downstream of the project on Tsuut'ina or other lands. The distance this material may be carried has not been modelled."

Our response is that during extreme floods, the proposed works will result in considerably less deposition of debris and sediment on the Tsuut'ina land. The 2013 flood resulted in significant erosion of land within the Hamlet of Bragg Creek, which was conveyed downstream. Much of this sediment was deposited in the Tsuut'ina lands. An example from 2013 is provided below:

- One of the major overland flow paths occurring during the 2013 flood was the washout along White Avenue/Hwy 758, in the vicinity of the Trading Post. The volume of land lost at this one site was estimated to be approximately 20,000 m^3 (i.e. 2,000 dump truck loads), along a streambank length of 415 m. This estimate is based on the LiDAR Digital Elevation Model (DEM). This was just one site of many where erosion at the Hamlet occurred. This erosion and subsequent conveyance of material onto Tsuut'ina lands would not occur with the proposed structures in place.

Also, the barrier system prevents other man-made debris from within the community being swept into Tsuut'ina lands. An example if this follows:

- A house located near the Balsam Road bridge was washed out, conveyed by floodwaters and then deposited on the Tsuut'ina land. This suspension of structures and debris and subsequent deposition on Tsuut'ina lands would not occur with the proposed structures in place.

The proposed structures would prevent the above noted erosion and suspension of debris by floodwaters. This material would not be available for conveyance to Tsuut'ina, lands, which occurred in 2013.

Due to the very high velocities occurring during floods (in the order of 4 m/s or greater), the conveyance of sediment in the Elbow River is supply limited not transport limited. This means that the floodwaters will convey whatever sediment is available. Additional erosion would not occur on Tsuut'ina lands due to reduced erosion occurring in the Hamlet.

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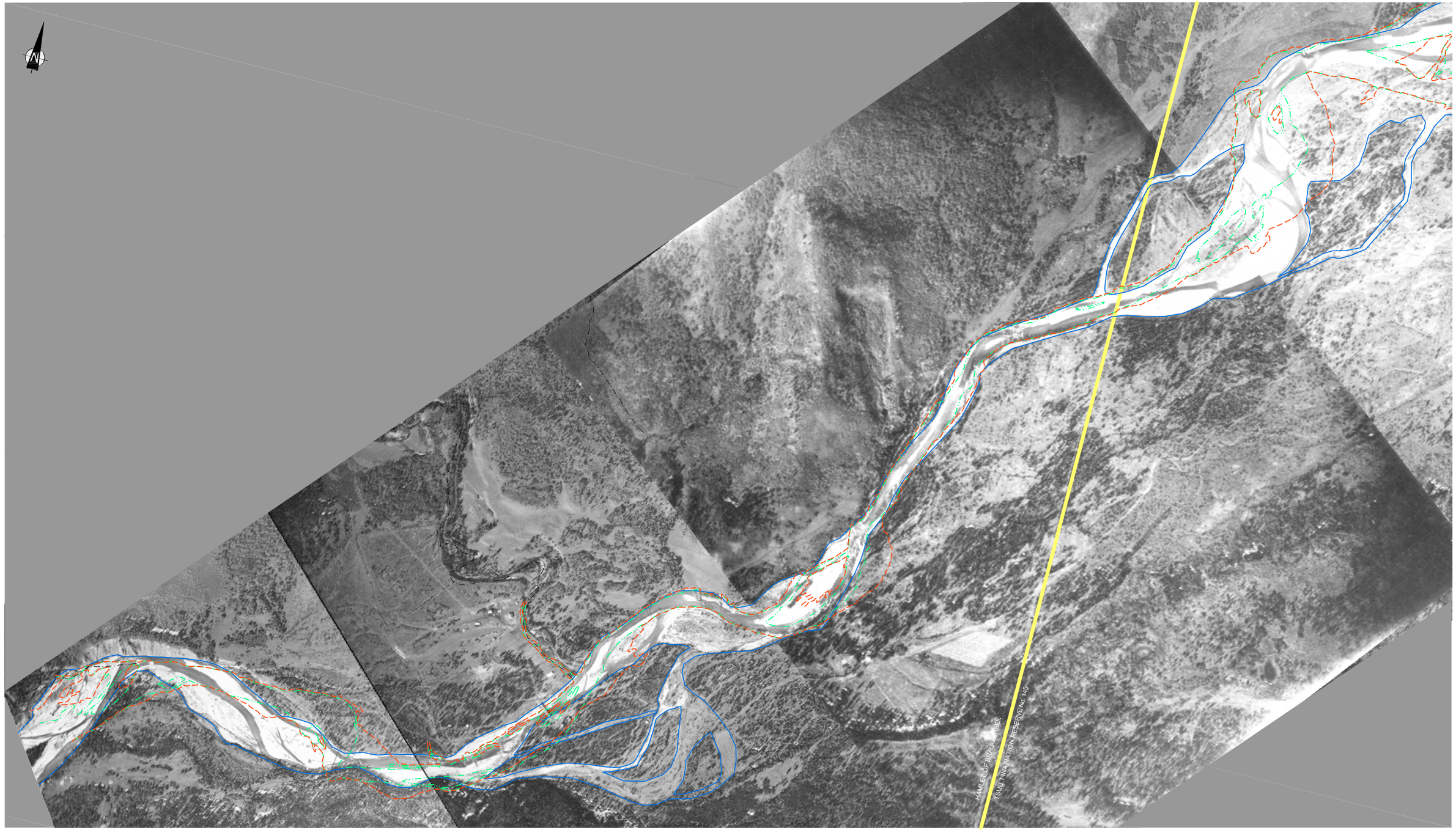

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LEGEND:
- 1924 BANK LINE
- 2012 BANK LINE
- 2013 POST-FLOOD BANK LINE

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CLIENT: ROCKY VIEW COUNTY Cultivating Communities

PROJECT NAME: BRAGG CREEK FLOOD MITIGATION

PROJECT NUMBER: CT160213

SHEET TITLE: 2012 AND EXISTING BANKLINE DELINEATION SUPERIMPOSED ON 1924 AIRPHOTO

FIGURE NUMBER: 7.1

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8.0 POTENTIAL IMPACTS OF STRUCTURE BREACH UNDER EXTREME FLOOD CONDITIONS (1,300 M^3/S)

The concerns identified in PGL's section 1.5.4 are addressed below. These refer to potential impacts resulting from a breach in the structure under catastrophic flood conditions. A flow rate of 1300 m^3/s, approximately 40 percent greater than the 930 m^3/s flow rate for a 100-year flood, has been used for this evaluation. The attached **Figure 8.1** shows the flow patterns for the catastrophic flood for both no breach of flood protection structure conditions and flood protection breach conditions. This scenario consists of an assumed 50 m long breach occurring at White Ave/Highway 758. This is at the upstream end of the east barrier between channel stationing 10+475 and 10+525, which was the location of major overland flow path during the 2013 flood. As shown in the figure and in the discussion below, the breach of the proposed structure has minimal impacts as compared to existing conditions.

- PGL states that 'spillout leads to widespread flooding'. As shown in **Figure 8.1**, this statement is incorrect as the flow patterns at the Tsuut'ina reserve are generally similar for existing and breach conditions. That is, the breach of the structure leads to overland flooding within the Hamlet which by the time it reaches the Tsuut'ina boundary is generally similar to no breach of flood protection structure conditions. For breach conditions, there is somewhat less overland flooding from the west (upstream) boundary of the Tsuut'ina reserve to the west (upstream) boundary of Redwood Meadows. The flooding extents are similar downstream of the west (upstream) boundary of Redwood Meadows.
- In the vicinity of the Tsuut'ina boundary, the peak flow rates for no breach and breach conditions are 1248.7 m^3/s and 1252.7 m^3/s, respectively. This shows there is no significant surge of water due to the breach (these flow rates vary slightly from the 1,300 m^3/s because this is an unsteady flow model).
- The channel velocities for both no breach and breach conditions are similar downstream of the Hamlet/Tsuut'ina boundary. Hence, the following statement from PGL is incorrect.
    - "Given the increased volume and velocity through the trained section of the river, the river will have greater power and carrying capacity, so will have the ability to move larger debris. In this situation, therefore, debris may reasonably be expected to move downstream and overtop banks as the floodwaters do."

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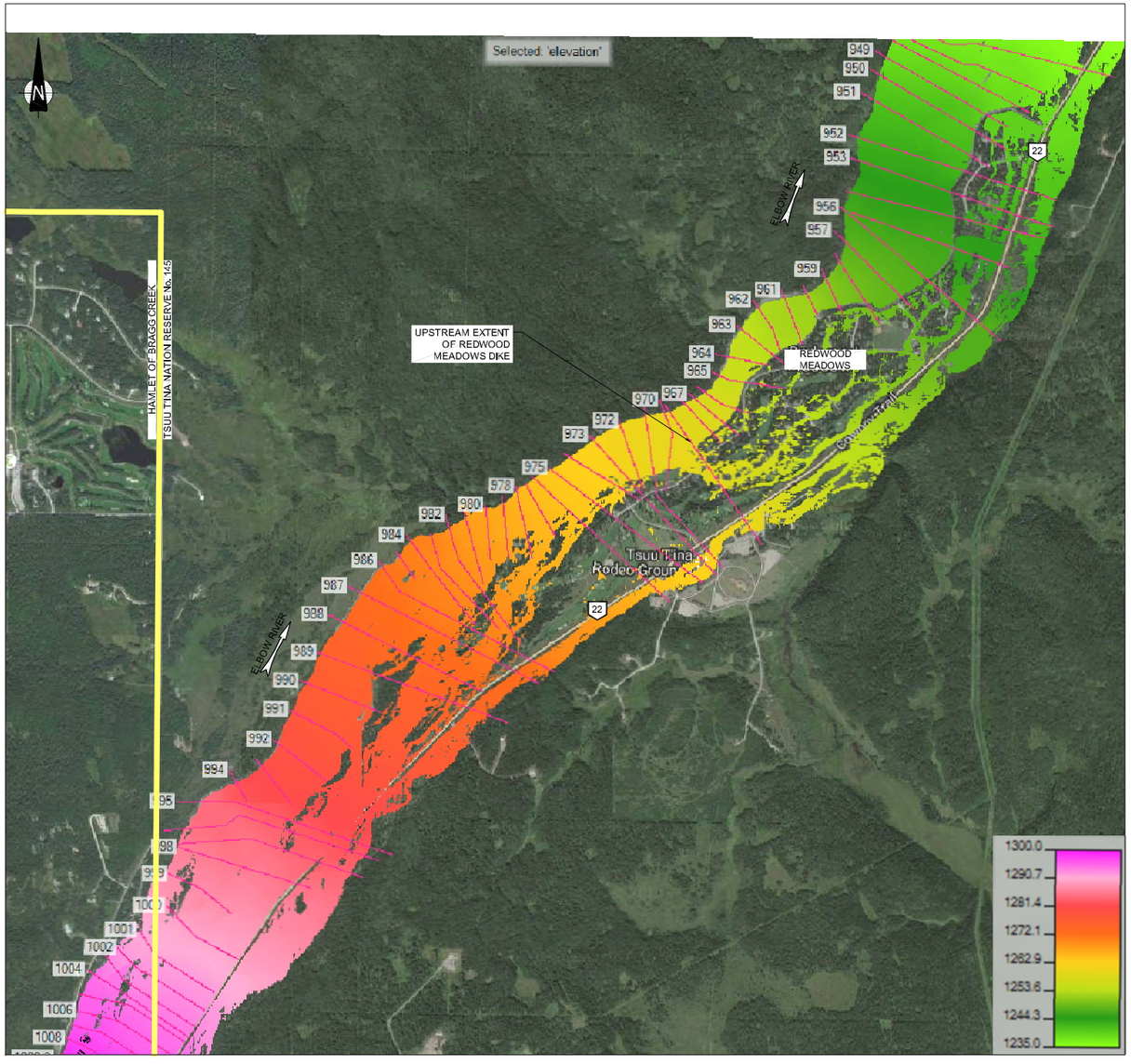

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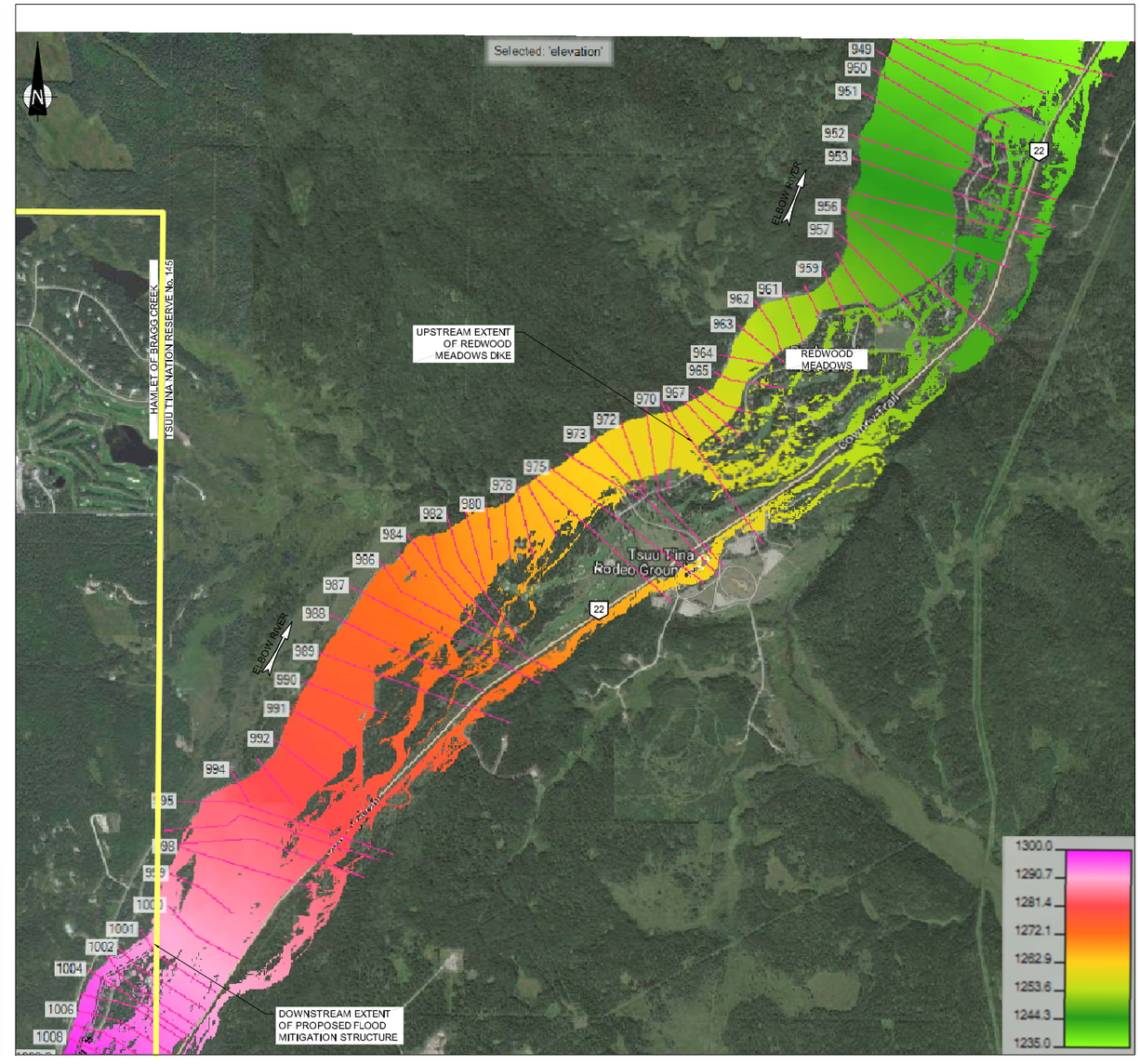

FLOOD MITIGATION STRUCTURE CONDITIONS

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CLIENT

ROCKY VIEW COUNTY
Cultivating Communities

PROJECT NAME
BRAGG CREEK FLOOD MITIGATION

SHEET TITLE
EXTREME FLOOD BREACH INUNDATION EXTENTS AT TSUU T'INA RESERVE AND REDWOOD MEADOWS

PROJECT NUMBER
CT160213

FIGURE NUMBER
8.1

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9.0 GROUNDWATER IMPACTS

The concerns identified in PGL's section 1.6.1 are addressed in this section. PGL states:

- "Over time, the faster flowing water through the project infrastructure may promote downstream changes. Specifically, the Project may foster a narrower, faster river downstream of the infrastructure, with consequent effects on the aquifer. Reduced aquifer recharge could in turn:
    - Reduce well-water production rates;
    - Affect water temperature, potentially increasing it during low flow periods when groundwater otherwise flowing into the river would cool temperatures;
    - Affect fish species dependent on groundwater recharge; and
    - Reduce soil moisture and agricultural capability."

Our response is that the Bragg Creek project will have negligible impact on the aquifer and the impacts noted above by PGL will not occur. As we have indicated in section 5 and 6 of this memo, the proposed barrier has no impacts for Typical Flood Conditions (1:2 year Return Period) nor for Moderately Large Flood Conditions (1:20 year Return Period). The impacts Under Design Flood Conditions (1:100 year Return Period) are small and occur very rarely (for only a few days during large floods such as 2013). Hence, the proposed structures will not foster a narrower, faster river downstream of the infrastructure and will not introduce noticeable change to aquifer recharge. Also, as previously noted, channel incision will not occur due to minor impacts of the proposed structure and the presence of the bedrock outcrops.

10.0 SPRINGBANK OFF-STREAM RESERVOIR (SR1) BACKWATER IMPACTS

The concerns identified in PGL's section 1.7 are addressed below.

PGL states that "there appears to be a meaningful difference between pre-project and project inundation patterns that extend well past Redwood Meadows" This is incorrect as shown by the information contained in the Engineering Report, Appendix B, page 19, 'the increase in water levels and velocities at the downstream end of the community of Redwood Meadows (STA 19+670) as a result of the proposed Bragg Creek project are 0.01 m and 0.01 m/s, respectively. These values represent a less than one percent increase, which is negligible.

PGL states the following:

- "As presently written, however, the Design Report does not consider how components of other projects, notably the backwatering required at the proposed diversion structure associated with the Springbank Off-stream Reservoir (SR1) project, may interact with the changes resulting from the Bragg Creek project. The absence of a cumulative effects assessment limits confidence in the conclusion made in the Bragg Creek Design Report that downstream effects are indeed 'relatively minor'."

Appendix A of this Wood response memo contains **Figure A1** obtained from Alberta Transportation (AT) that shows that the distance between the backwater extent of SR1 and the north Tsuut'ina boundary is 1,680 m (as measured along the channel, the distance is 1,130 m measured due south from the backwater to the Tsuut'ina boundary). There is no interaction between the two projects given that: (1) the impacts due to the Bragg Creek Flood Mitigation Project at Redwood Meadows are negligible; (2) the backwater extents of SR1 are 1,680 m downstream of the north Tsuut'ina boundary. Additionally, as can be seen in **Figure A2** of **Appendix A**, the difference in stream bed elevation (i.e. the vertical drop) between the backwater extent of SR1 and the Hamlet/Tsuut'ina boundary is 72.9 m and the horizontal (measured along the channel) distance is 9.5 km. Hence, there is no possible interaction between the water levels of the two projects.

11.0 JFK LAW CORPORATION STATEMENT OF CONCERN LETTER

The technical concerns contained in the JFK Law Corporation Statement of Concern letter dated 18 April 2018 are mostly the same as in the PGL memo and have been addressed above. However, there is an additional error in the JFK letter that is corrected herein. Section 5 A) of the JFK letter titled *Direct Alteration of Elbow River as it Flows within Tsuut'ina's Reserve Lands* states

> 'The Application confirms that the proposed flood mitigation structure will double the increased water levels and velocities for at least 565 m downstream of the project on Tsuut'ina's reserve lands from 0.07 m to 0.14 m/s'

The information presented in the Application has been misinterpreted in this statement. The information contained in the engineering report is that water levels increase 0.07 m and velocities increase 0.14 m/s, which are two distinct units of measure. As shown in **Table 7.1** of this memo, the increase in water level (depth) is 4.0 percent and velocity is 6.4 percent, which is considerably less than double. Also, as previously noted, these impacts only occur very rarely for large events, and even then, only during periods of extreme flow. As an example, during the 2013 flood, the Elbow River only exceeded its 20-year flood flow rate of 440 m^3/s for a period of less than 24 hours. As discussed in previous sections of this memo, typical floods (2-year floods) and moderately large flood (20-year floods) do not result in any increase in either velocity or water levels within Tsuut'ina lands.

12.0 CLOSURE

The concerns raised by PGL in their April 18, 2018 memo regarding the proposed Bragg Creek Flood Mitigation Project have each been addressed in this Wood memo. In summary:

- Impacts of the proposed structures on the morphology (shape) of the river and aquifer recharge are limited to only the most extreme of flood conditions, for example those with a statistical likelihood of occurrence of less than one-percent (1%) in any given year. Furthermore, the short duration of these rare events and the presence of bedrock outcrops within the riverbed, means that the proposed structures will not have a quantifiable impact on the morphology of the river, nor the rate of aquifer recharge. It has also been demonstrated that there are no potential interactions between the downstream affects of this project and the upstream affects of the proposed Springbank Off-Stream Reservoir (SR1).

- Since the proposed structures will improve riverbank integrity and stability throughout the Hamlet of Bragg Creek, this will reduce the amount of material available for the river carry downstream during a flood into the Tsuut'ina lands. Again, river velocity will only be marginally impacted by these proposed structures and even then, only during extreme flood events. In such an event the river velocity is already so great (in excess of 4 m/s) that the amount of riverbed sediment conveyed is limited by the amount available and not significantly affected by the incremental increase in velocity.

- The 100-year flow rate estimate of 930 m^3/s was increased by 6.5 percent to 990 m^3/s to account for climate change. Additionally, the proposed structures are designed to contain a flood with flow rates of up to 1,300 m^3/s, which is 40% greater than the provincial estimate of 930 m^3/s for a 100-year flood. Wood believes these factors afford the project a significant and appropriate factor of safety to account for climate change and other variabilities.

- In the above response, Wood demonstrated that a breach of the proposed structures during an extreme flood event would result in channel and overland flooding similar to what would occur if the structures are not built at all. This is the case for both the extents of overland flooding and the expected flood flows within the Tsuut'ina lands. A breach of the proposed structures, resulting from either the unlikely event of structural failure or flood rates in the order of 1,300 m^3/s, would not exacerbate the impacts of such an extreme flood.

If the reader should have any additional questions or concerns pertaining to the content of this memo, or the referenced project, they are asked to contact the undersigned.

Yours truly,

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

L.S. Hundal, M.Eng., P.Eng.
Snr. Associate Water Resources

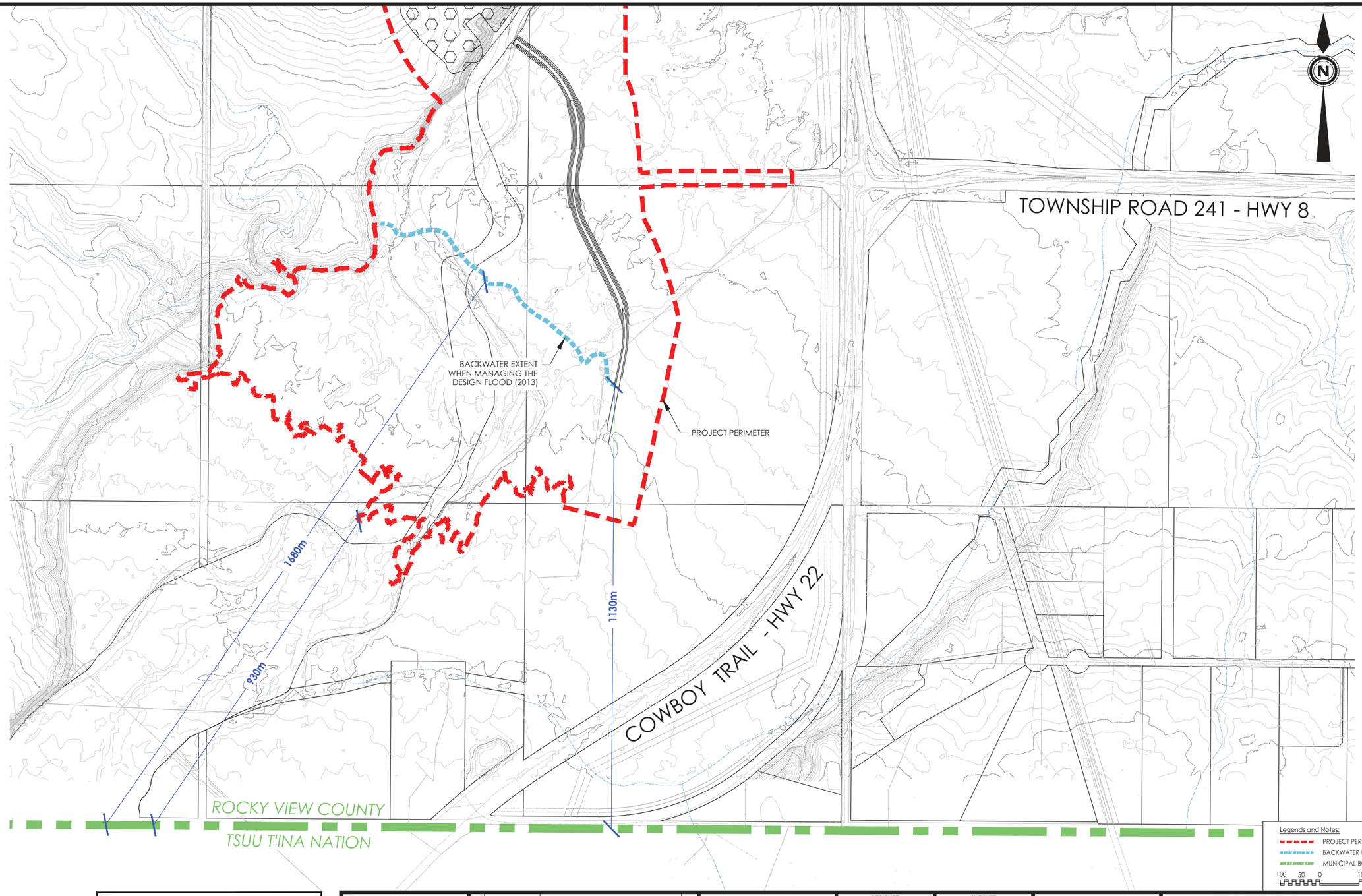
Reviewed by:

Ken Kress, P.Eng.
Principal Engineer

LSH/KGK/
Attach.
c: CM/MV/RO

Permit to Practice No. P-4546

APPENDIX A
Distance Between Backwater Extent and Tsuut'ina Nation Boundary



THIS DRAWING MAY HAVE BEEN REDUCED.
ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc) ARE BASED ON 22" X 34" FORMAT DRAWINGS

THINK SAFETY FIRST

DEPARTMENT BAR CODE

Stantec
Project No.: 110773396
200 - 325 25th Street SE
Calgary AB Canada T2A 7H8
Tel. 403.716.8000
www.stantec.com

REV	DATE	REVISIONS	BY
6			
5			
4			
3			
2			
1	2017-01-10	FOR INFORMATION	JW

DESIGNER N/A DATE

CHECKER N/A DATE

Alberta Transportation

SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) - UTILITY COORDINATION

DISTANCE BETWEEN BACKWATER EXTENT AND TSUU T'INA NATION BOUNDARY

DATE	ALBERTA ENVIRONMENT AND PARKS CAPITAL PROJECTS NUMBER	SITE	SHEET	CONSULTANT DRAWING	TRANSPORTATION DRAWING
2017-01-10		-	1 OF 1	FIG A1	?????-P

PlotDate: 2017.01.11 9:36 AM Login: Wick, Justin
AUTOCAD FILE No. U:\110773396\component_work\planning\05_design\02_community\SR1101_current\sr1_context_jan2017.dwg TENDER No. ?

RGE 5
RGE 4
RGE 3
RGE 2 W5
TWP 24
TWP 23
Calgary
Springbank Road
Springbank Road Project (SR1)
Dam
Diversion Channel
Diversion System
Elbow River
Redwood Meadows
Bragg Creek
Bragg Creek Flood Mitigation Project
1
2
3
4
22
8
758

Site #	Location	Design Flood Elevation (m)	Cumulative Flood Elevation Difference (m)	Cumulative Downstream Distance (km)
1	Hamlet / Tsuut'ina Boundary	1290.9	0	0
2	South Boundary Redwood Meadows	1261.5	29.4	3.9
3	North Boundary Redwood Meadows	1238.4	52.5	6.9
4	SR1 Backwater Extent Boundary	1218.0	72.9	9.5

1 0 1 2
Kilometres
1:75,000
N

Design Flood Elevation Location
SR1 Project Components
SR1 Design Flood Extent (2013)
Bragg Creek Provincial Park
Tsuut'ina Nation No. 145
Township Boundary
Highway
Road

ROCKY VIEW COUNTY
Cultivating Communities

Bragg Creek Flood Mitigation

Bragg Creek, Redwood Meadows and Springbank Road Project (SR1)

DATE: May 2018
ANALYST: TR
QA/QC: KW KK MV
PDF: BraggCreek_to_Springbank 18-05-29

Figure A2

wood.

S:\Gis\Projects\CT\160213_Bragg_Creek_Flood_Mitigation\ArcGIS\BraggCreek_to_Springbank.mxd