TETRA TECH EBA

OQM | Organizational Quality Management Program

Hazard Abatement Order Report

PRESENTED TO

Village of Cumberland
Comox Valley Regional District
TimberWest Forest Corporation

SEPTEMBER 2015
ISSUED FOR USE
FILE: 704-V13103549-01

CONSULTING ENGINEERS & SCIENTISTS · www.eba.ca

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TABLE OF CONTENTS

APPENDIX SECTIONS

TABLES

FIGURES

APPENDICES

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of The Village of Cumberland, Comox Valley Regional District, and TimberWest Forest Corporation and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than The Village of Cumberland, Comox Valley Regional District, and TimberWest Forest Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) have been retained by The Village of Cumberland (the Village), Comox Valley Regional District (CVRD) and TimberWest Forest Corporation (TimberWest) to prepare this report in response to the Hazard Abatement or Prevention Orders, dated August 7, 2015, received from the Medical Health Officer, Dr. Charmaine Enns, MD., MHSc., FRCPC. Copies of these orders are attached as Appendix B.

The work was authorized by the Village of Cumberland on behalf of the three parties via a Tetra Tech EBA Service Agreement, signed on August 25, 2015. The scope of services, as well as Tetra Tech EBA's General Conditions, were provided in our proposal letter dated August 25, 2015.

2.0 OBJECTIVE AND SCOPE OF WORK

The objective of this study is to provide a report which:

- Identifies feasible options, estimated costs, and the likely effectiveness of means to control, minimize or prevent bank collapse and otherwise mitigate introduction of sediment into Perseverance Creek; and
- Identifies feasible options, estimated costs, and the likely effectiveness of means to control, minimize and manage the effects of overflow from Cumberland Creek No. 2 Dam spillway into Perseverance Creek.

The scope of services agreed to was limited to:

- A site visit with the Village of Cumberland staff on August 17, 2015 to observe current conditions along the creek;
- Discussions with Village of Cumberland staff;
- Meeting on August 27, 2015 with the three parties to review the scope of work and resources available;
- A field visit on August 27, 2015 to Cumberland No. 2 Dam, Cumberland No. 1 Dam, Cumberland Creek between these two dams and the lower reaches of Perseverance Creek with Village, CVRD and TimberWest representatives;
- Developing options for reducing the erosion in the spillway channel;
- Developing options for minimizing or eliminating the outflow from Cumberland Creek No. 2 Dam to the overflow spillway channel;
- Estimating the cost of the various options;
- Comparing the options;
- Preparation of a report presenting the results of the study;
- Discussions regarding the options and comparison with the Village of Cumberland, TimberWest Forest Corporation and Comox Valley Regional District; and
- Finalizing the report.

3.0 BACKGROUND

Cumberland Creek No. 2 Dam, refer to Figure 1, was initially constructed sometime between the late 1890's and early 1930's as a timber crib structure. It was part of a hydroelectric project and also a source of potable water for the Village of Cumberland. A low level conduit, located near the right abutment, discharges flow to Cumberland Creek. An air photograph from 1931 indicates that there was also discharge to the southeast, down an un-named channel, herein called the 'spillway channel'. Some minor erosion along this channel was evident in the 1931 photograph.

At some point prior to 1972, the timber crib was covered with fill and the dam raised. A concrete weir with three, 1.2 m diameter corrugated steel culverts was constructed at the southeast end of the lake likely during this work. This weir structure acted as the spillway, discharging flow down the 'spillway channel', to Perseverance Creek.

Evidence from air photographs indicate activity around the lake in 1964 and, although not conclusive, an apparent increase in the rate of erosion after the early 1960's.

This suggests the raising of No. 2 Dam may have occurred in the late 1950's or early 1960's.

On December 19, 1972, a rain-on-snow event was experienced. It is postulated that the three culverts were at least partially plugged prior to, or by, this event, resulting in a rise of the lake level.

This rise in lake level increased the head differential across the dam, resulting in severe piping and an 11 m wide breach. Reports from that time indicated the piping may have been due to rotting timbers. This breach resulted in damage to Cumberland No. 1 Dam as well as overtopping and a breach at Henderson Lake Dam.

During the subsequent repairs to the No. 2 Dam, fill was removed adjacent to the concrete weir and a cofferdam built across the lake to divert flow to the spillway channel. The flow eroded the base of the channel near the weir to approximately 1.5 m below the invert of the culverts.

When the repairs to No. 2 Dam were complete, the cofferdam was breached, however the opening at the concrete weir was left at the eroded elevation.

Historic air photographs show clearcut logging was carried out over much of the Cumberland Creek watershed, including riparian areas, between 1931 and 1950. However, over the past 20+ years, logging has been limited to small cutblocks, with water management used to minimize erosion and replanting, based on Equivalent Cutblock Area management principles.

There has been concern regarding the diversion of the majority of the Cumberland Creek flow down the spillway channel since the erosion was observed in 2002. It is understood the concerns were for three reasons:

- Water was being diverted between watersheds;
- Loss of land; and
- The ongoing erosion of the spillway channel delivering sediment to Perseverance Creek.

It is understood that there was an issue with erosion in this channel during a high flow event in 2003.

In early December 2014, extreme rainfall caused in an increase in turbidity in Comox Lake resulting in a boil water advisory. Observations and testing at that time revealed that Perseverance Creek was a source of some portion of the turbidity.

4.0 INFORMATION AVAILABLE

The following information was available for review during this study:

Date	Title	Author
December 1972	Diary of field trip to inspect Cumberland Water Supply after reported failure	Water Rights Branch
January 1973	Cumberland Water Supply Dams	Golder Brawner Associates Ltd.
February 1973	Dam Inspection Report	Provincial Dam Safety Authorities
March 1973	Dam Inspection Report – Cumberland Dams	Provincial Dam Safety Authorities
April 1973	Diary of Field Trip to Cumberland Area	Provincial Dam Safety Authorities
January 1974	Report on the Adequacy of the Cumberland Water Supply System for Present and Future Needs	Willis Cunliffe Tait & Company Ltd.
January 2003	Water licenses and dam safety on Cumberland and Perseverance Creeks	Dam Safety Auditor
February 2003	Perseverance Creek #2 Reservoir Overflow Channel Surface Area Changes 1931 to 2002	TimberWest
June 2003	Rough order of Magnitude Cost Estimates Cumberland Creek Dams	EBA Engineering Ltd.
December 2003	Dam Safety Review Cumberland Creek Dams	EBA Engineering Ltd.
July 2006	2006 Annual Inspection Allen Lake and Cumberland Creek Dams	EBA Engineering Ltd.
January 2010	Dam Stability Assessment Cumberland Creek Dams	Levelton Consultants Ltd.
August 2014	Cumberland Dam Breach Study	Tetra Tech EBA Inc.
February 6, 2015	Field Review: Perseverance Creek Gorge; Puntledge Perseverance Community Watershed	Contour Geoscience Ltd.

Also available was:

- Historic Aerial Photographs from the Crown Registry and Geographic Base Branch-Geo BC;
- Photographs taken of Comox Lake in December 2014; and
- Photographs of Perseverance Creek during the December 2014 event.

5.0 PROCEDURE

5.1 Identifying Options

In order to identify the feasible options, we have reviewed previous studies regarding the Cumberland Creek Dams, met with representatives of the Village of Cumberland, Comox Valley Regional District and TimberWest Forest Corporation, and convened an internal meeting of Tetra tech EBA staff familiar with the Cumberland area.

5.2 Comparison

For each option, a series of factors have been assessed to allow for a comparison of the various concepts.

Cost: A screening level cost estimate will be made of each option with an accuracy range of +/- 50%. These estimates are for comparison purposes only and should not be utilized for preparing budgets. The estimated cost is for the initial works and does not attempt to incorporate life cycle costs.

Schedule: Depending on the amount of design and regulator approvals required, as well as construction time, an estimate of the likely completion date of each option will be predicted.

Regulatory Approval Process: The complexity, and therefore the cost and time required, for approvals will be estimated using qualitative rankings of High, Medium, Low and None.

Land Ownership: Some of the solutions being considered are on land owned by the Village of Cumberland, TimberWest Forest Corporation, and Hancock Timber.

Environmental Impacts: A qualitative assessment (High, Medium, Low or None) of the impacts, as well as an estimate of the duration of the impact (Short, Medium or Long Term), will be made.

Public and Worker Safety: A qualitative assessment (High, Medium, Low or None) will be made regarding long term public safety and worker safety during construction.

Lifespan: An assessment of whether the solution is short, medium or long term will be made. For the purpose of this study, short term will be 10 years, medium term 10 to 20 years, and long term greater than 20 years.

Effectiveness: For each option, the likely impact on the amount of sediment produced by the spillway channel during an extreme event will be predicted. It must be noted these are based on judgement and should be used for comparison only.

Local Knowledge/Skills: This will be an indication of whether local contractors using locally available materials can undertake any construction required.

Risk: This would be an identification of the residual risks for each option.

6.0 CUMBERLAND CREEK

Currently, Cumberland No. 2 Dam diverts the majority of the flow during flood events down the spillway channel. The options described below are designed to reduce or eliminate that diversion.

6.1 CC-1 Remove Cumberland No. 2 Dam

If this dam were removed, flow would continue down Cumberland Creek to Henderson Lake and on to Perseverance Creek. Flow into the spillway channel would only occur during very extreme events.

The removal would involve:

- Re-establishing the cofferdam across the lake to temporarily divert all flow down the spillway channel.
- Dewatering the lake and re-locating any fish.
- Removing the fill timbers comprising No. 2 Dam.
- Removing Cumberland No. 1 Dam.
- Reconstructing the spillway and/or creating a new spillway at Henderson Lake Dam.

- Replacing the resource road crossing of Cumberland Creek downstream of Henderson Lake.
- Breaching of the cofferdam.
- Habitat restoration in the dewatered lake.

6.2 CC-2 Remove Cumberland No. 2 Dam and Construct a Small Dam Across the Spillway Channel

This option is similar to the one above, except it would include the construction of an earthfill embankment across the spillway channel to reduce the potential for flow during very extreme events. This may not be necessary if hydrologic modelling results, based on accurate topographic information, indicate this structure is not required.

All the tasks described for CC-1 would be necessary.

6.3 CC-3 Divert Cumberland Creek to an Unnamed Creek to the North

Approximately 0.6 km downstream of Hamilton Lake, there is a low area (saddle) on the left (north) bank between Cumberland Creek and an unnamed creek which discharges into Perseverance Creek near the Community Forest. The creek bank in this area decreases in height from 10 m or more to less than 5 m.

Just downstream of this low area, Cumberland Creek flows through a narrow, rock lined section.

Option CC-3 would involve creating a channel through this low area to allow diversion of the Cumberland Creek flow to the unnamed creek. To facilitate this diversion, a concrete weir would be constructed across Cumberland Creek at the rock section.

The weir would incorporate a means to discharge flow to No. 2 Lake and on to Henderson Lake, but divert any flood flows to the unnamed creek.

This construction would involve pumping the creek flow around the construction site and so would be best carried out in the dry period of the year (July/August).

6.4 CC-4 Reconstruct Cumberland No. 2 Dam with a Spillway

Cumberland No. 2 Dam requires upgrading. This construction could incorporate a larger low level conduit with valves to allow more refined operation, as well as a spillway to carry flood flows.

The tasks involved would be similar to those outlined in CC-1, with the addition of the reconstruction of the embankment, the addition of a spillway, and the construction of a new spillway at Henderson Lake.

A control structure would be necessary on the spillway channel. It would be possible to use this to pass some flow during extreme events, thus reducing the size of the new spillway and that at Henderson Lake.

6.5 CC-5 Refined Operation of Cumberland No. 2 Dam

This would involve adapting the operating procedures to lower the lake level prior to flood events by discharging as much flow as possible through the low level conduit. Due to the limited storage capacity of Cumberland No. 2 Dam, this option would only be effective for events of modest proportion. However, the occurrence of flow in the spillway channel may be for a shorter time due to the buffering effect of the lake storage.

7.0 SPILLWAY CHANNEL

The spillway channel has two reaches, the upstream portion is approximately 950 m long and the downstream 750 m long.

The upstream portion is typically contained in steep, till banks up to 6 m in height. The channel base varies up to 10 m in width and comprises till or rock, covered in places by alluvium and/or woody debris.

The downstream portion has a steeper gradient, higher banks (to 15 m) and is wider (to 15 m). The base of the channel is bedrock controlled. The left bank, which is oversteepened, comprises dense till. Erosion has resulted in overhanging portions. There is an area near the downstream end of this channel where recent slope instability has deposited disturbed till in the channel and erosion of this material is evident.

It is noted that some options, such as a new spillway channel and shotcreting the exposed till, have been judged to be not feasible and are not discussed further.

7.1 SC-1 Create a Channel and Rip Rap Berm (Figure 2)

This would involve creating access to the base of the downstream portion of the spillway channel to allow tracked equipment access.

A channel would be constructed into the rock invert by blasting and the blast rock used to form a berm along the base of the till slope. The procedure for undertaking this work would include:

- Constructing a road along the crest of the till slope to allow an excavator to access this area to pull back the overhanging/oversteepened portion of the upper slope.
- Form a cofferdam across the spillway channel near the old concrete weir to reduce the potential for flow down the channel.
- Create access to the base in several locations.
- Drill and blast a channel in the rock invert.
- Construct an approximately 3 m by 3 m berm against the base of the till slope. A bedding layer would be needed under the rock to lessen the potential for ongoing erosion of the till.
- Remove the cofferdam.

This concept would allow the till slope to ravel, with the colluvial material being retained on the berm, allowing vegetation to generate.

Some additional work to remove woody debris from the upstream portion of the channel would also be included.

7.2 SC-2 Construct a Concrete Deflection Wall (Figure 3)

This would involve the construction of a reinforced concrete wall near the base of the till slope and involve the same preparatory work as SC-1, however would require better access to allow the delivery of precast concrete panels. These panels would be placed on a prepared footing with dowels into the rock. Some drilling and blasting would be necessary in establishing a base for the wall. A fillet of grout would be needed at the base of the wall.

The area behind the wall would act as a catchment for the colluvium from the till slope.

7.3 SC-3 Convey the Flow in a Pipe (Figure 4)

In order to isolate the flows from the eroding bank, a large (e.g., 3 m diameter or multiple smaller diameter) pipe could be placed to carry the water.

This would involve the same preparatory works at SC-1 including some drilling and blasting to form a base and create backfill. It would also include:

- Constructing a headwall to direct water into the pipe;
- Constructing a discharge structure; and
- Mobilizing cranes to lower the pipe into the channel.

8.0 PERSEVERANCE CREEK

There is a section of Perseverance Creek before it enters the culvert under Comox Lake Road were the gradient lessens. This portion of the creek flows through the Community Forest.

A few options have been developed which would take advantage of this lower gradient to increase retention time and encourage sediment from the flow.

8.1 PC-1 Construct Berms in the Community Forest

The 2014 event overflowed the banks of the channel through this forested area. There is evidence of deposition of sand and fine grained material on the forest floor.

By constructing some granular berms in this area, this phenomenon could be enhanced.

8.2 PC-2 Route Flood Flows through the Wetland

There is a pre-existing wetland to the north of Perseverance Creek in this low gradient area.

By constructing a flow control structure on the creek, flood water could be diverted to the wetland. A series of berms in the wetland would increase retention time and deposition.

8.3 Silt Curtain in Comox Lake

A silt curtain which extends around the outlet of Perseverance Creek could serve to reduce the disbursement of sediment into the lake. This silt curtain would be deployed when extreme weather events are predicted.

9.0 COMPARISON

The attached Table 1 provides a comparison of the various options. It is noted that other options could be developed by combining those identified herein, as discussed in the next section.

10.0 DISCUSSION

It must be acknowledged that the options identified by this study are intended to reduce the sediment, originating from the spillway channel delivered to Comox Lake by Perseverance Creek during extreme flood events. This study does not address the effectiveness of these solutions on the water quality in Comox Lake as many other factors exist.

As there is no information regarding the size of event that results in harmful sediment delivery or the amount of sediment that causes issued with water quality, it is difficult to set a target for the effectiveness. Should such a target be established, it would be possible to combine some of the options described in order to achieve the desired decrease in sediment.

The “Do Nothing” option has not been included as this does not meet the objective of the study. However, it is possible a new, deep water intake in Comox Lake and a treatment plant may be constructed. If so, the options discussed herein may become redundant.

11.0 RECOMMENDATIONS

For each of the options listed (except for CC-5) the next step would be preliminary design. This would involve collecting additional topographic, hydrogeologic, geotechnical, land ownership, regulatory and other data.

Once the design has been advanced to the preliminary stage, it is recommended that stakeholders, (e.g., landowners, regulatory bodies, environmental groups) be consulted.

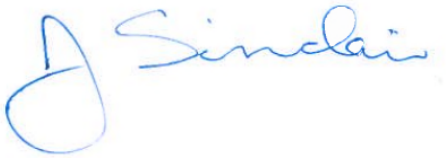
The design can be further refined at that point and a more accurate cost estimate prepared.

12.0 CLOSURE

Tetra Tech EBA trusts the information in this report is suitable for your purposes at this time. Please refer to the attached General Conditions, included in Appendix A, which are considered part of this report.

Should you require clarification of any aspect of this report, please contact Mr. Bob Patrick at 250.756.2256 or bob.patrick@tetratech.com.

Respectfully submitted,
Tetra Tech EBA Inc.



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/dr

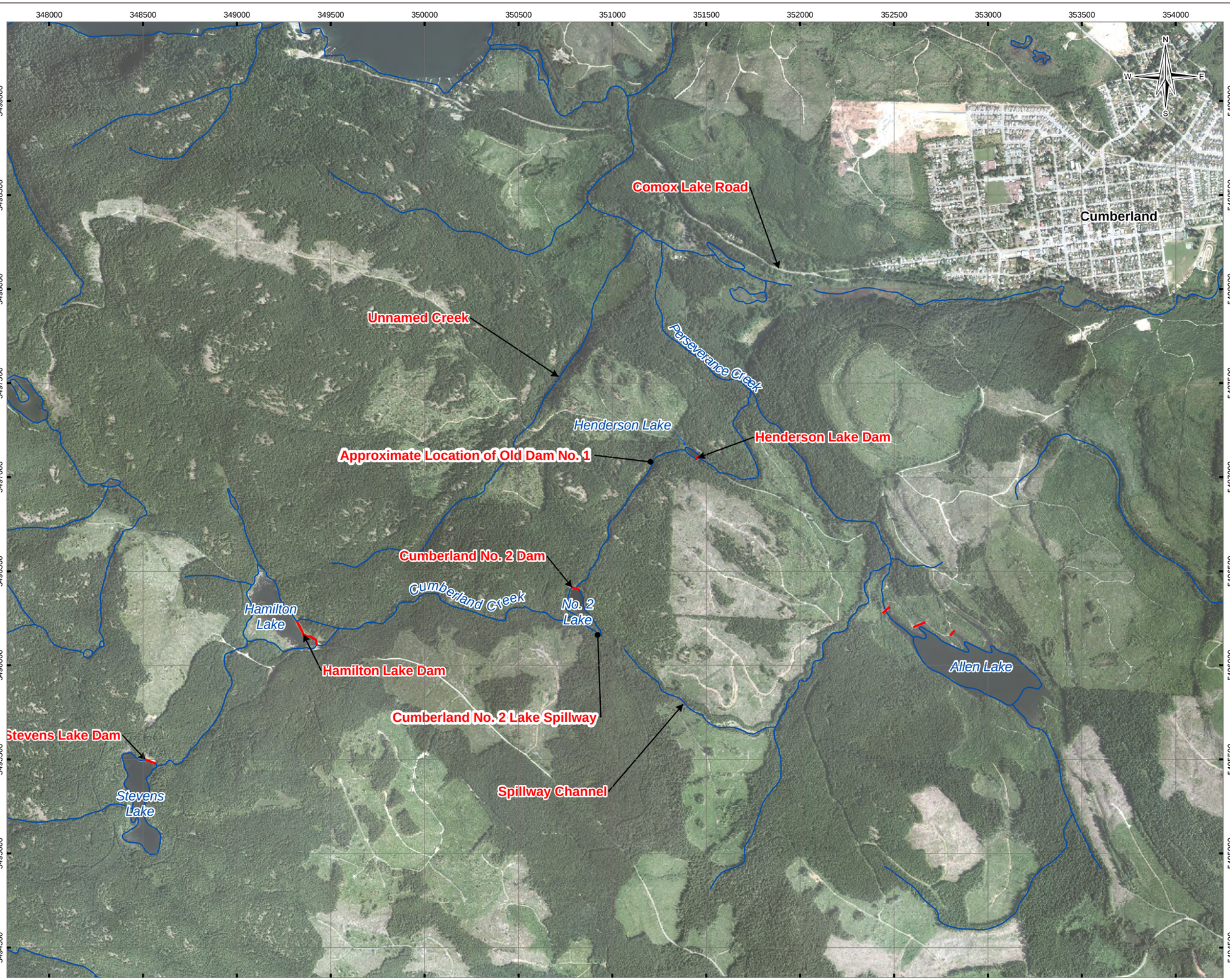
TABLE

Table 1 – Comparison of the Various Options

Option	Estimated Cost (+/-50%)	Schedule (Estimated Completion Date)	Complexity of Regulatory Approvals	Land Ownership and Use	Environmental Impacts		Public Safety	Worker Safety	Lifespan	Effectiveness of Sediment Reduction	Local Content	Risk
					Extent	Duration						
CC-1 Remove No. 2 Dam	$1.75 million	Autumn 2017	Medium	Village Land	**High** (Loss of habitat, Flush of debris)	Medium	Medium	Low	Long	75%	All work and materials	▪ Extreme events cause flow in Spillway Channel ▪ Flow from local watershed causes erosion in Spillway Channel ▪ Debris in Henderson Lake ▪ Loss of water storage for Village of Cumberland ▪ Potential impact on Village of Cumberland water quality ▪ Potential impact on VHA treatment deferral
CC-2 Remove No. 2 Dam Construct Dam at Spillway Channel	$2.0 million	Autumn 2017	Medium	Village Land	**High** (Loss of habitat, Flush of debris)	Medium	Medium	Low	Long	90%	All work and materials	▪ Flow from local watershed causes erosion in Spillway Channel ▪ Debris in Henderson Lake ▪ Loss of water storage for Village of Cumberland ▪ Potential impact on Village of Cumberland water quality ▪ Potential impact on VHA treatment deferral
CC-3 Divert Cumberland Creek to Unnamed Creek	$2.1 million	Autumn 2018	High	Village Land and Hancock	**High** (Diverting water to another watershed)	Long	Medium	Low	Long	60%	Most work and materials	▪ Extreme events may cause flow in Spillway Channel ▪ Flow from local watershed causes erosion in Spillway Channel ▪ Erosion in unnamed creek
CC-4 Reconstruct No. 2 Dam with a Spillway	$3.2 million	Autumn 2018	Medium-High	Village Land	Medium	Short	Low - Medium	Low	Long	50%	Most work and materials Import pipe, gates and controls	▪ Erosion during extreme events ▪ Flow from local watershed causes erosion in Spillway Channel ▪ Debris in Henderson Lake ▪ Potential impact on Village of Cumberland water quality ▪ Potential impact on VHA treatment deferral
CC-5 Refine Operation of No. 2 Dam	$25,000	Autumn 2015	Low	Village Land	Low – None	Short	Low	None – Low	Long	<20%	Village Staff	▪ Limited to no impact during extreme events
SC-1 Create Channel and Berm	$5.3 million	Autumn 2017	High	TimberWest	Medium – High	Short	Low	Medium	Medium	60%	Local Contractors	▪ Extreme events could cause erosion ▪ Large failures could deposit debris in Channel
SC-2 Conduit Deflection Berm	$7.1 million	Autumn 2017	Medium-High	TimberWest	Medium	Short	Low	Medium – High	Medium	60%	Imported material and skills	▪ Stability of wall ▪ Large failures could damage wall or deposit debris in Channel ▪ Flow from local watershed causes erosion in spillway channel

Option	Estimated Cost (+/-50%)	Schedule (Estimated Completion Date)	Complexity of Regulatory Approvals	Land Ownership and Use	Environmental Impacts		Public Safety	Worker Safety	Lifespan	Effectiveness of Sediment Reduction	Local Content	Risk
					Extent	Duration						
SC-3 Convey Flow in Pipe	$8.2 million	Autumn 2018	Medium	TimberWest	Medium	Short	Low – Medium	Medium – High	Medium	70%	Imported material and equipment	▪ Flow from watershed cause erosion outside pipe ▪ Pipe plugs ▪ Flow from local watershed causes erosion in spillway channel
PC-1 Berms in Community Forest	$400,000	Autumn 2016	High	Covenant on Land	Medium	Long	Low	Low	Low – Medium	>20%	All work and materials	▪ Berms could fail in large storm ▪ Difficult to get approvals
PC-2 Route Flow through Wet lands	$3.0 million	Autumn 2017	High	Covenant on Land	**High**	Long	Low	Low	Short – Medium	>20%	All work and materials	▪ Berms could fail in extreme event ▪ Difficult to get approvals
PC-3 Silt Curtain	$750,000	Autumn 2016	Medium	Comox Lake Land Corporation	Medium	Short - Medium	Medium	Medium	Short	30%	Import materials	▪ Has to be installed prior to storm event ▪ Subject to damage from debris ▪ Limited lifespan

FIGURES



LEGEND

- Dam Location
- Watercourse/Waterbody

NOTES
Base data source:
Imagery provided by the client

STATUS
FOR INFORMATION ONLY

HAZARD ABATEMENT AND PREVENTION ORDER CUMBERLAND, BC

Cumberland Water Supply

PROJECTION UTM Zone 10		**DATUM** NAD83				**CLIENT** VILLAGE OF CUMBERLAND
Scale: 1:20,000 — 400 200 0 400 — Metres						TETRA TECH EBA
FILE NO. V13203549-01_Figure1.mxd						
PROJECT NO. V13203549-01	**DWN** CC/IK	**CKD** BP	**APVD**	**REV** 0		**Figure 1**
OFFICE Tt EBA-NAN	**DATE** September 9, 2015					

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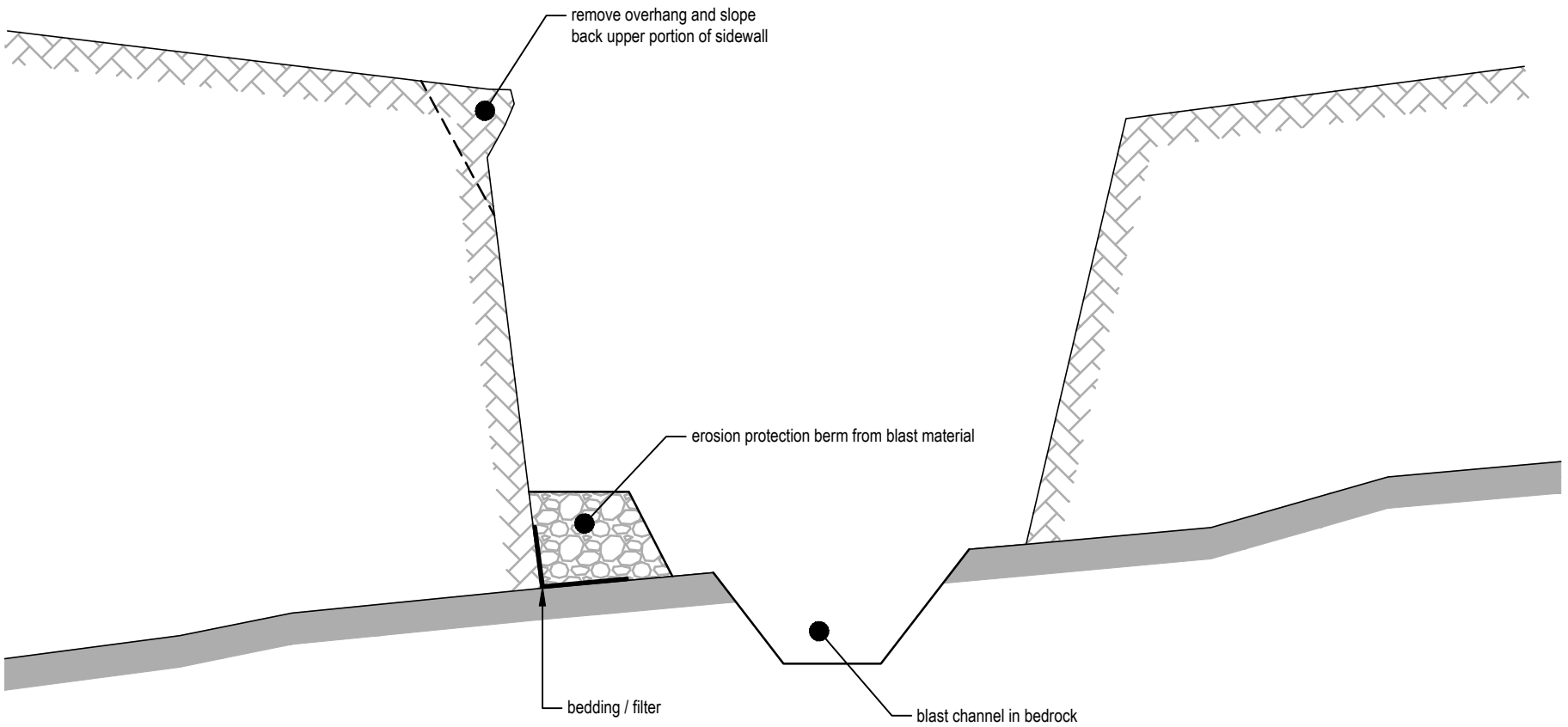

FOR INFORMATION ONLY

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CLIENT

The Corporation of the Viilage of Cumberland

HAZARD ABATEMENT AND PREVENTION ORDER CUMBERLAND, BC

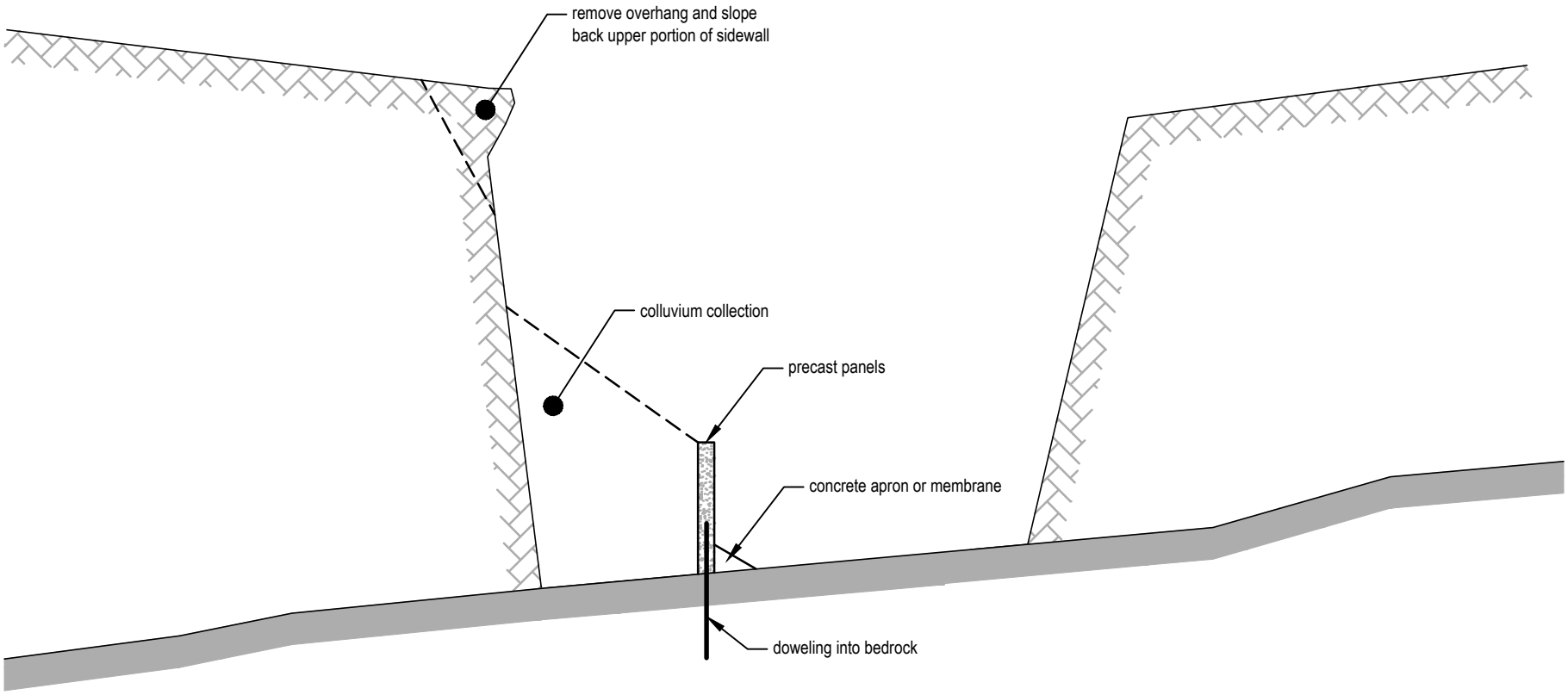
Option SC-1 - Blasted Channel

TETRA TECH EBA

PROJECT NO.	DWN	CKD	REV
V13103549-01	IK	BP	0

OFFICE	DATE
Nanaimo	September 8, 2015

Figure 2



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CLIENT

The Corporation of the
Viilage of Cumberland

TETRA TECH EBA

HAZARD ABATEMENT AND PREVENTION ORDER
CUMBERLAND, BC

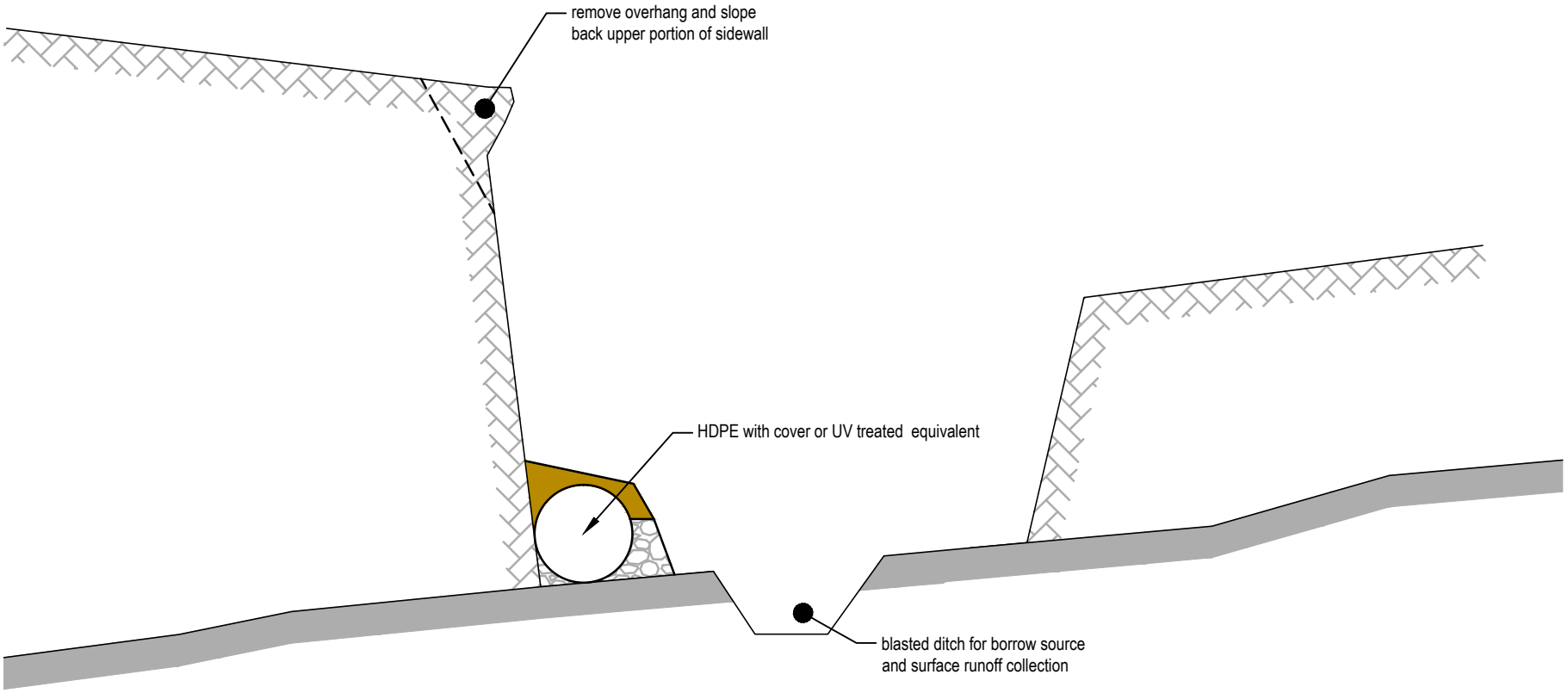
Option SC-2 - Retaining Wall

PROJECT NO.	DWN	CKD	REV
V13103549-01	IK	BP	0

OFFICE	DATE
Nanaimo	September 8, 2015

Figure 3

C:\Users\isaac.kitchingman\Desktop\v13103549.dwg [FIGURE 4] September 09, 2015 - 8:25:19 am (BY: KITCHINGMAN, ISAAC)



FOR INFORMATION ONLY

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CLIENT

The Corporation of the Viilage of Cumberland

HAZARD ABATEMENT AND PREVENTION ORDER CUMBERLAND, BC

Option - SC3 - Piped Diversion

TETRA TECH EBA

PROJECT NO.	DWN	CKD	REV
V13103549-01	IK	BP	0

OFFICE: Nanaimo

DATE: September 8, 2015

Figure 4

APPENDIX A
TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. Tetra Tech EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of testholes and/or soil/rock exposures. Stratigraphy is known only at the locations of the testhole or exposure. Actual geology and stratigraphy between testholes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. Tetra Tech EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

Tetra Tech EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

COPIES OF HAZARD ABATEMENT OR PREVENTION ORDERS

August 7, 2015

The Corporation of the Village of Cumberland
2673 Dunsmuir Avenue
Box 340
Cumberland BC V0R 1S0
Attn: Sundance Topham

Dear Village of Cumberland:

Re: Hazard Abatement or Prevention Order

This letter constitutes an Order under section 25 of the *Drinking Water Protection Act* (the "Act"). For your ease of reference, I have provided the link to access a copy of the Act, http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_01009_01.

I am also hereby advising you that I am issuing a similar and related Order to the TimberWest Forest Corp (copy attached) and the Comox Valley Regional District (copy attached), given the interrelatedness of the spillway overflow and Perseverance Creek erosion. I encourage you to consider cooperating with TimberWest Forest Corp and the Comox Valley Regional District to complete the actions set out below. I believe that would be a constructive approach and could help minimize costs, but in any case that decision is yours and your obligations are as set out in the Order below.

I also wish to note that I may, upon consideration of the report(s) described below, be required to issue further orders respecting drinking water health hazard abatement. I will also be in further discussions with you and other interested parties regarding longer term drinking water safety, assessment and planning matters. Nothing in this order is intended to limit any such exercise of powers, and nothing in it determines your responsibility (if any) in respect of any future potential orders, assessments or planning exercises.

Action Required

The action that I am ordering you to take is as follows:

Obtain and provide to me a report from an independent engineering firm to:

(a) Identify the feasible options, costs, and likely effectiveness of means to control, minimize or prevent bank collapse and otherwise mitigate introduction of sediment into Perseverance Creek. These options may include but are not limited to streamflow diversion, storage of storm water, or stream bank stabilization (all having regard to the bank collapse of December 2014).

(b) Identify feasible options, costs, and likely effectiveness of means to control, minimize and manage the effects of overflow from Lake No.2 spillway into Perseverance Creek, all having regard to the bank collapse that occurred in Perseverance Creek in Dec 2014, the related boil water notification and the present state of banks in Perseverance Creek downstream of the spillway overflow.

This is to be completed by September 16, 2015.

Reasons for this Order

I am issuing this Order because I have reason to believe that there is a significant risk of an imminent drinking water health hazard. I have formed this belief in the circumstances of this case for reasons that are summarized as follows:

- Lake No. 2 spillway overflowed and bank collapse/erosion of Perseverance Creek occurred in December 2014.
- In my view, based on information available to me and my own visits to the area, I believe the bank collapse materially contributed to elevated turbidity in Perseverance Creek. I believe this in turn materially increased the turbidity levels in Comox Lake.
- While I accept there were likely also other sources contributing *some* degree of sedimentation, no sources other than the bank collapse have been identified to explain such a substantial turbidity increase during late 2014/early 2015, and I note that turbidity levels during that period were elevated (above 1 ntu) and remained sustained substantially longer than previously experienced during rain events that were not associated with a known material bank collapse.
- Given high turbidity levels, a Boil Water Notice was issued to the Comox Valley Regional District (CVRD) drinking water supply system from December 11, 2014 to January 27, 2015. This water supply system draws water that is sourced from Comox Lake and has only one form of disinfection (chlorination), with no filtration.
- The CVRD supplies water to approximately 41,000 residents.
- I believe there is a significant and imminent risk of further bank collapse in the near future (and related turbidity risks), particularly (but not only) in the event of significant rainfall, as some banks are now undercut and overhanging and there still remains a related risk of overflow from Lake No.2 spillway under significant rainfall events.

I note that I have provided each of Timberwest, the Village of Cumberland and the Comox Valley Regional District an opportunity to review and comment on a draft order and I have considered comments received before issuing orders to these parties. I am aware of the fact that the Village of Cumberland notes that the spillway and related infrastructure was approved by provincial officials. I am also aware that that Timberwest has expressed concerns about the Village of Cumberland infrastructure and alteration of historic drainage patterns. But in my view none of this obviates the need for an order under section 25 of the DWPA at this time and as outlined herein.

I have also considered comments from the CVRD and the Village of Cumberland expressing concerns about the time frame for completion of the report. I am of the view that the present timeframe is reasonable in all circumstances, particularly in light of the approaching Fall/Winter season.

Authority to issue this Order

I have issued this Order under my authority as a Drinking Water Officer under sections 3 and 25 of the Act.

Authority to enter on or into property

I (pursuant to section 25(5) of the Act) hereby authorizing Village of Cumberland and the engineer they retain to enter on lands adjacent to Perseverance Creek owned by Comox Timber Ltd and on lands adjacent to Perseverance Creek owned by TimberWest Forest Corp, for the purposes of complying with this order. By copy of this letter I am providing notice to this to you, Timberwest, Comox Valley Regional District and Comox Timber Ltd. I encourage all parties to familiarize themselves with section 25(6) of the Act.

Duration of this Order

This Order remains in effect unless and until you are notified in writing by me or another Drinking Water Officer that the Order is satisfied, amended or rescinded.

Right of review or reconsideration

You may request that I reconsider this decision if you believe that there is sufficient new evidence for this purpose. You may also request that this decision be reviewed by the Provincial Health Officer or a Medical Health Officer nominated by him.

If you wish to make a request for reconsideration or review, please review section 39.1 of the *Drinking Water Protection Act*. I can also provide you with forms if you wish, but there is no requirement to use a specific form.

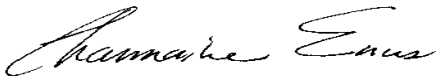
Please note however that a request for reconsideration or review does not put the Order into abeyance while any such request is considered. If you believe that the Order should be deferred while a review or reconsideration is requested, please advise me accordingly and I will consider whether to amend the Order accordingly. Unless I do so, the Order remains in force during any period of review or reconsideration.

Consequences of failure to comply

It is an offence under the *Drinking Water Protection Act* to fail to comply with an Order under section 25. Penalties upon conviction for an offence may be up to $200,000 per day and up to 12 months imprisonment. In addition, if you fail to comply with the Order, a Drinking Water Officer may take or authorize actions to be taken as necessary, at your expense (see sections 27 and 28).

Please do not hesitate to contact me if you have any questions respecting this Order.

Yours truly,



Charmaine Enns, , MD, MHSc, FRCPC
Medical Health Officer

Enclosure

cc: Chris Cole, TimberWest Forest Corporation
Domenico Iannidinardo, TimberWest Forest Corporation
Rob Crisfield, Village of Cumberland
Marc Rutten, Comox Valley Regional District
Ian DeLisle, Comox Timber Ltd.
Bob Wells, City of Courtenay
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Lynne Magee, Provincial Drinking Water Officer
Ann Thomas, Island Health
Charlene MacKinnon, Island Health
Dave Cherry, Island Health
Gary Anderson, Island Health
Don McRae, MLA

August 7, 2015

Comox Valley Regional District
600 Comox Road
Courtenay BC V9N 3P6
Attn: Marc Rutten

Dear Comox Valley Regional District:

Re: Hazard Abatement or Prevention Order

This letter constitutes an Order under section 25 of the *Drinking Water Protection Act* (the "Act"). For your ease of reference, I have provided the link to access a copy of the Act, http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_01009_01.

I am also hereby advising you that I am issuing a similar and related Order to the TimberWest Forest Corp (copy attached) and the Village of Cumberland (copy attached), given the interrelatedness of the spillway overflow and Perseverance Creek erosion. I encourage you to consider cooperating with TimberWest Forest Corp and the Village of Cumberland to complete the actions set out below. I believe that would be a constructive approach and could help minimize costs, but in any case that decision is yours and your obligations are as set out in the Order below.

I also wish to note that I may, upon consideration of the report(s) described below, be required to issue further orders respecting drinking water health hazard abatement. I will also be in further discussions with you and other interested parties regarding longer term drinking water safety, assessment and planning matters. Nothing in this order is intended to limit any such exercise of powers, and nothing in it determines your responsibility (if any) in respect of any future potential orders, assessments or planning exercises.

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The action that I am ordering you to take is as follows:

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(b) Identify feasible options, costs, and likely effectiveness of means to control, minimize and manage the effects of overflow from Lake No.2 spillway into Perseverance Creek, all having regard to the bank collapse that occurred in Perseverance Creek in Dec 2014, the related boil water notification and the present state of banks in Perseverance Creek downstream of the spillway overflow.

This is to be completed by September 16, 2015.

Reasons for this Order

I am issuing this Order because I have reason to believe that there is a significant risk of an imminent drinking water health hazard. I have formed this belief in the circumstances of this case for reasons that are summarized as follows:

- Lake No. 2 spillway overflowed and bank collapse/erosion of Perseverance Creek occurred in December 2014.
- In my view, based on information available to me and my own visits to the area, I believe the bank collapse materially contributed to elevated turbidity in Perseverance Creek. I believe this in turn materially increased the turbidity levels in Comox Lake.
- While I accept there were likely also other sources contributing *some* degree of sedimentation, no sources other than the bank collapse have been identified to explain such a substantial turbidity increase during late 2014/early 2015, and I note that turbidity levels during that period were elevated (above 1 ntu) and remained sustained substantially longer than previously experienced during rain events that were not associated with a known material bank collapse.
- Given high turbidity levels, a Boil Water Notice was issued to the Comox Valley Regional District (CVRD) drinking water supply system from December 11, 2014 to January 27, 2015. This water supply system draws water that is sourced from Comox Lake and has only one form of disinfection (chlorination), with no filtration.
- The CVRD supplies water to approximately 41,000 residents.
- I believe there is a significant and imminent risk of further bank collapse in the near future (and related turbidity risks), particularly (but not only) in the event of significant rainfall, as some banks are now undercut and overhanging and there still remains a related risk of overflow from Lake No.2 spillway under significant rainfall events.

I note that I have provided each of Timberwest, the Village of Cumberland and the Comox Valley Regional District an opportunity to review and comment on a draft order and I have considered comments received before issuing orders to these parties. I am aware of the fact that the Village of Cumberland notes that the spillway and related infrastructure was approved by provincial officials. I am also aware that that Timberwest has expressed concerns about the Village of Cumberland infrastructure and alteration of historic drainage patterns. But in my view none of this obviates the need for an order under section 25 of the DWPA at this time and as outlined herein.

I have also considered comments from the CVRD and the Village of Cumberland expressing concerns about the time frame for completion of the report. I am of the view that the present timeframe is reasonable in all circumstances, particularly in light of the approaching Fall/Winter season.

Authority to issue this Order

I have issued this Order under my authority as a Drinking Water Officer under sections 3 and 25 of the Act.

Authority to enter on or into property

I (pursuant to section 25(5) of the Act) hereby authorizing Comox Valley Regional District and the engineer they retain to enter on Village of Cumberland property in the area of the Lake No. 2 spillway, on lands adjacent to Perseverance Creek owned by the Comox Timber Ltd, and on lands adjacent to Perseverance Creek owned by TimberWest Forest Corp, for the purposes of complying with this order. By copy of this letter I am providing notice to this to you, Timberwest, the Village of Cumberland and Comox Timber Ltd. I encourage all parties to familiarize themselves with section 25(6) of the Act.

Duration of this Order

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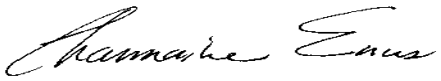

Charmaine Enns, , MD, MHSc, FRCPC
Medical Health Officer

Enclosure

cc: Sundance Topham, CAO, Village of Cumberland
Chris Cole, TimberWest Forest Corporation
Domenico Iannidinardo, TimberWest Forest Corporation
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Ann Thomas, Island Health
Charlene MacKinnon, Island Health
Dave Cherry, Island Health
Gary Anderson, Island Health
Don McRae, MLA

August 7, 2015

TimberWest Forest Corporation
#201 - 648 Terminal Ave.
Nanaimo BC V9R 5E2
Attn: Chris Cole, RPF, PEng

Dear TimberWest Forest Corporation:

Re: Hazard Abatement or Prevention Order

This letter constitutes an Order under section 25 of the *Drinking Water Protection Act* (the "Act"). For your ease of reference, I have provided the link to access a copy of the Act, http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_01009_01.

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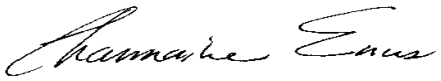
Yours truly,



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