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Safety Evaluation of Cable Barrier Installations on BC Highways

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CARSP 2018 June 10-13 Victoria, BC

Background

A High Tension Cable Barrier is a barrier that consists of 3 or 4-strand high tension cables that is designed to contain and redirect vehicles that leave the road.

- Cross-median and off-road collisions result in serious injuries and death
- Off-road and crossover head-on collisions ≈ 42% of all serious collisions. i.e. injury + fatal on provincial highways

Median Cable Barrier: *Reported Benefits*

- Texas - prevented 98% cross-over crashes
- Wyoming - reduced fatal (44%) and serious (12%) collisions
- Washington - reduced fatal and serious collisions by 72%
- Florida - contained light trucks (79.9%) and heavy trucks (64.3%) collisions

- Severity ↓, Overall collisions ↑ (24%) for MCB (HSM)

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Highway 1 – Median Installation

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Highway 1 – Median Installation

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Cable Barrier After a Collision

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Rockwell Drive – Roadside Installation

Study Overview

- Researched safety benefits and existing studies
- Gathered collision history for cable barrier locations

Methodology

- Data Collection
  - Treatment Sites: 3 Median Cable Barrier and 2 Roadside Cable Barrier sites
  - Reference Sites: RAU4, RFD4
  - Before and after collision and traffic volume data (6 years)
- Analysis
  - Simple before and after
  - Empirical Bayes

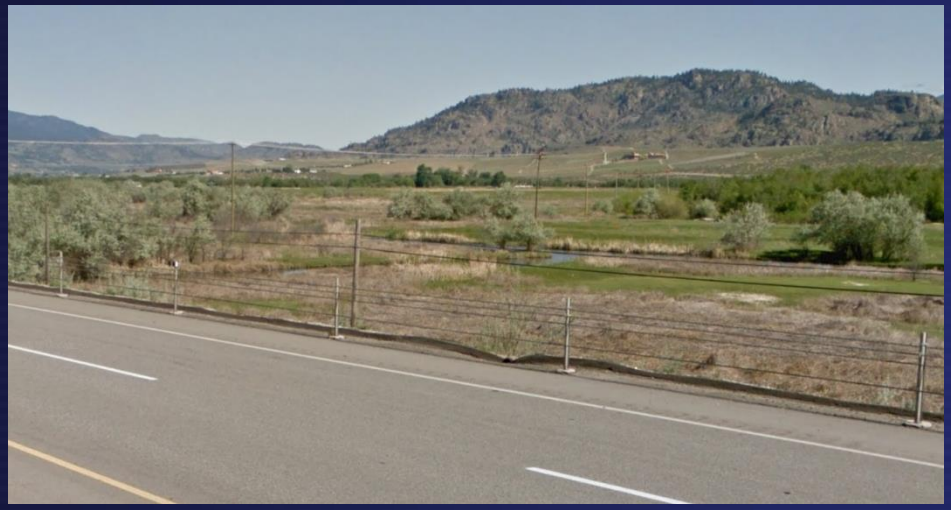
Median Cable Barrier Sites

Highway 99 South of Richmond

Highway 99 South of White Rock

Highway 1 East of Chilliwack

Roadside Cable Barrier Sites



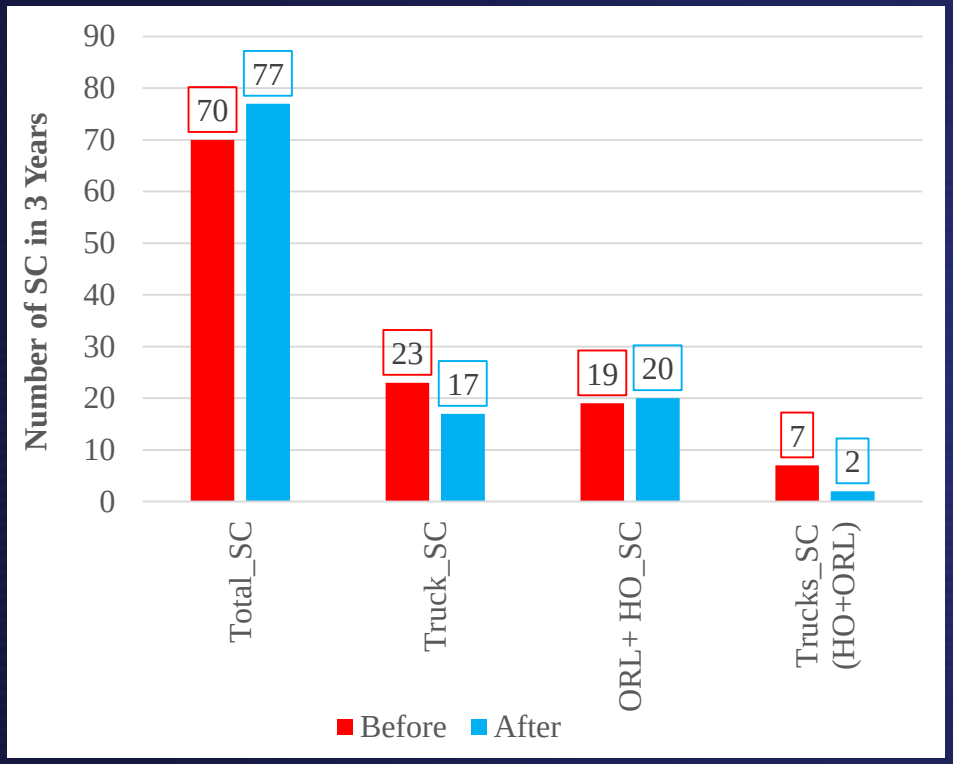
Highway 97 North of Osoyoos Lake

Highway 97 South of Penticton

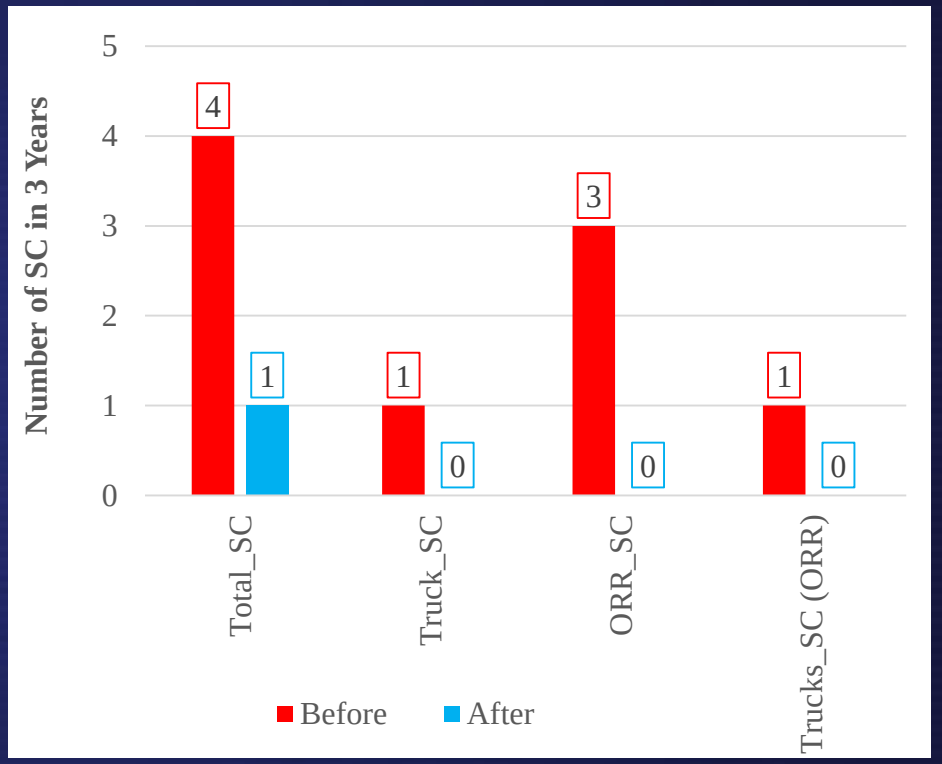
Evaluation Sites

Section ID	Evaluation Group	Road Class	Hwy #	L (km)	Barrier Type	Installation Date	Before Period Start	ADT (Before)	After Period Start	ADT (After)
1	1	RFD4	1	2.9	MB	2007-07-11	2004-01-01	15720	2008-01-01	14129
2				2.9				15378		11847
3	2		99	8.0		2011-04-07	2008-01-01	23622	2012-01-01	27571
4				5.7				37637		48033
5				5.0				37637		48033
6				3.8				23481		25035
7				3.6				24177		26222
8				5.0				24481		26239
9				6.1				35030		44369
10				7.7				22532		26208
11				0.8				4844		8343
12				0.8				3170		5767
13	3	RAU4	97	2.5	RB	2010-12-08	2007-01-01	7370	2011-01-01	7358
14				2.1		2013-10-31	2010-01-01	9211	2014-01-01	10278

Simple Before and After



Median Cable Barrier Sections



Roadside Cable Barrier Sections

Simple Before and After

Barrier Type	SC		Truck SC		ORL+ HO SC		ORR	
	CF*	CR**	CF	CR	CF	CR	CF	CR
MCB	10.0%	-6.4%	-26.1%	-37.1%	5.3%	-10.5%		
RCB	-75.0%	-76.4%	-100.0%	-100.0%			-100.0%	-100.0%

** CF = Collision Frequency*

*** CR = Collision Rate*

Empirical Bayes Method

$$O.R. = \frac{D}{\hat{B}}$$

$$E(O.R.) = \frac{O.R.}{(1 + \frac{Var\hat{B}}{\hat{B}^2})}$$

Where:

$\hat{B}$ = EB safety estimate of collisions in the treatment group had no treatment taken place during post improvement period,

D = Observed number of collisions in the treatment group during post improvement period.

Empirical Bayes Method

$$EB_i = \gamma_i \cdot \mu_i + (1 - \gamma_i) \cdot y_i$$

$$Var(EB_i) = \gamma_i \cdot (1 - \gamma_i) \cdot \mu_i + (1 - \gamma_i)^2 \cdot y_i$$

$$\gamma_i = \frac{1}{1 + \frac{\mu_i}{k}}$$

Where:

y_i = Observed collisions in the before period for location *i*

γ_i = Weight assigned to the predicted value for location *I*

k = Dispersion parameter of the negative binomial model

μ_i = Expected annual mean collision frequency (Collisions/ year) on location *i*

Empirical Bayes Method

$$\widehat{B} = (EB_i)_a = (EB_i)_b \times \frac{(\mu_i)_a}{(\mu_i)_b}$$

$$Var\widehat{B} = Var(EB_i)_a = Var(EB_i)_b \times \left[\frac{(\mu_i)_a}{(\mu_i)_b}\right]^2$$

Where:

$(EBi)_a$ = EB safety estimate of treated site *i* in the "after" period had no treatment taken place.

$(EBi)_b$ = EB safety estimate of treated site *i* in the "before" period.

$(\mu_i)_a$ = Expected mean collision frequency given by the SPF for a treated site

Safety Performance Functions (SPFs) Development

- Mathematical models
- 3 Evaluation groups (2 MCB + 1 RCB)
- 3 Collisions types
  - All serious collisions
  - Truck serious collisions
  - Off road serious collisions

- **9 Safety Performance Functions**

Safety Performance Functions (SPF) Development

A general functional form is:

$$\mu_i = a_0 \cdot AADT^{a_1} \cdot L^{a_2}$$

Where:

y : Expected Collision Frequency per n years

AADT : Annual Average Daily Traffic

L : Section Length

Safety Evaluation Summary

- Median Cable Barrier
  - Reduction of 21.7% in all Serious Collisions
  - Reduction of 53.8% in Truck Serious Collisions
  - Reduction of 34.8% in ORL+HO Serious Collisions

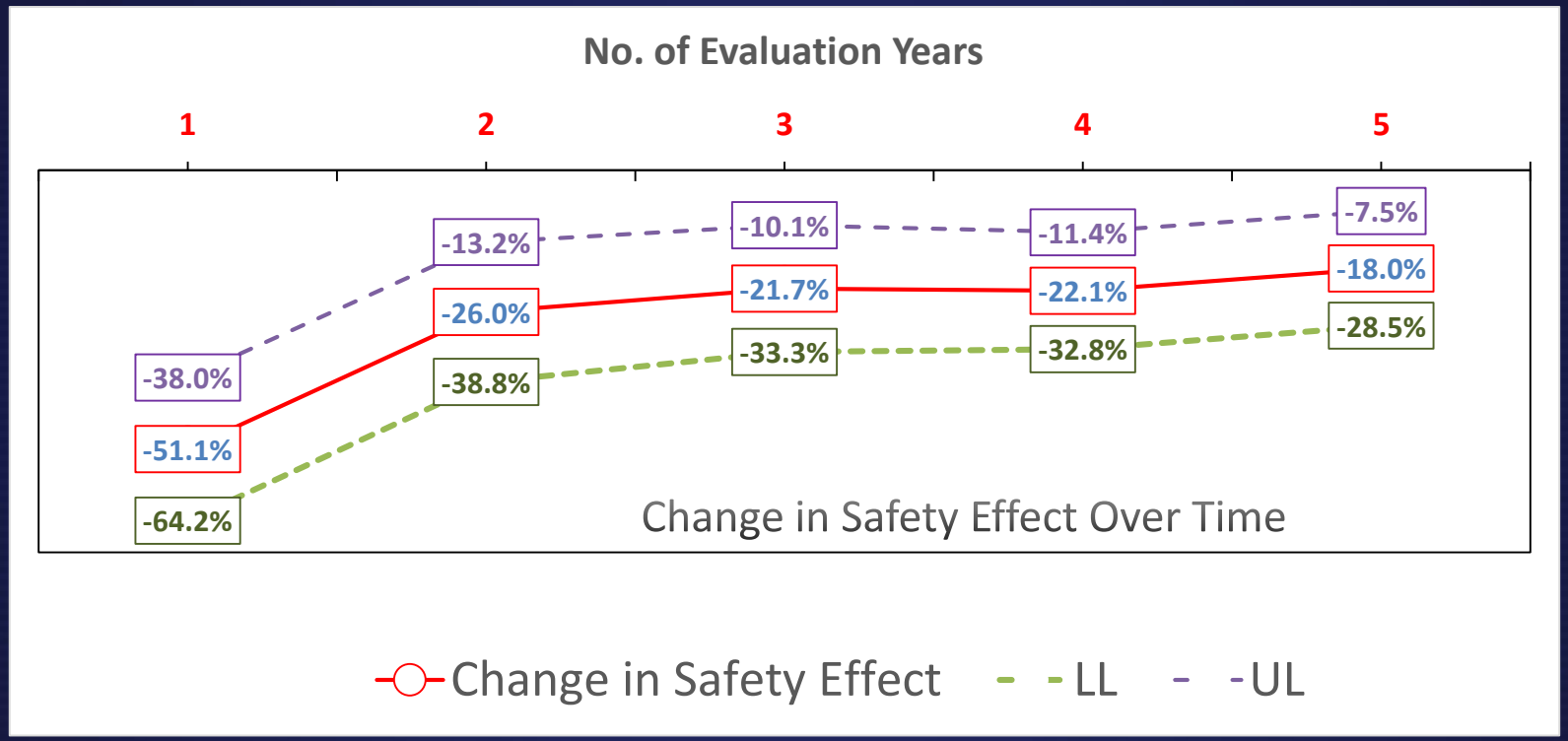
Safety Evaluation Summary

- Roadside Cable Barrier
  - Reduction of 74.7% in all Serious Collisions
  - Reduction of 100% in Truck Serious Collisions
  - Reduction of 100% in ORR Serious Collisions

Safety Evaluation Summary

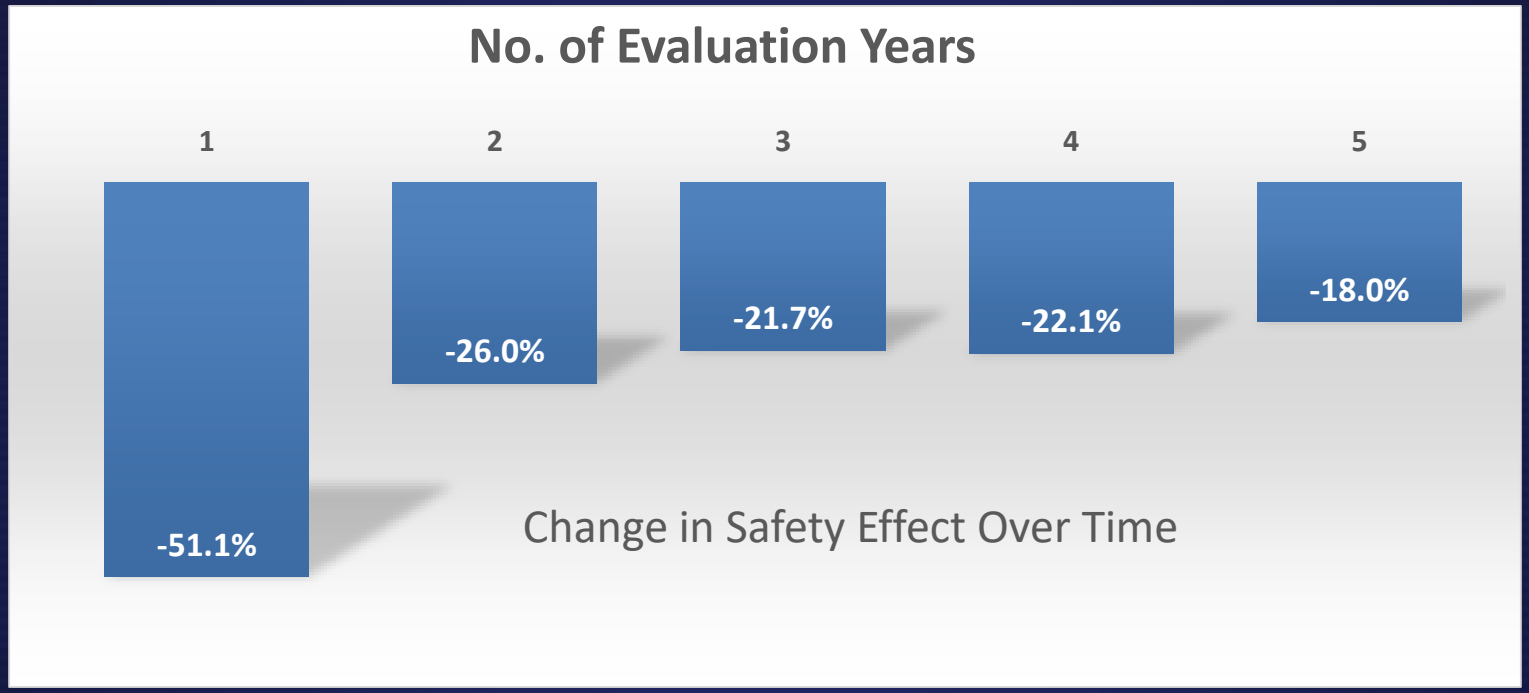
Group ID	Hwy #	Barrier Type	Length (km)	Serious Collisions		Truck SC		ORL+ HO SC	
				Change (%)	*p-value*	Change (%)	*p-value*	Change (%)	*p-value*
1	1	MCB	5.8	**-21.7% ± 11.6%**	0.06	**-53.8% ± 13.2%**	0.00	**-34.8% ± 16.7%**	0.04
2	99	MCB	46.5						
3	97	RCB	2.5	**-74.7% ± 28.0%**	0.01	**-100% ± 0.0%**	0.00	**-100% ± 0.0%**	0.00
4	97	RCB	2.1						

Impact of After-Implementation Period



*All Serious Collisions – Median Cable Barrier

Impact of After-Implementation Period



*All Serious Collisions – Median Cable Barrier

Proposed Collision Modification Factors

CMF Recommended Values for MCB

Collision Type	Severity Type	CMF
Median, Cross-median	Fatal, and All Injuries	0.72
Head On, Cross-median	All	0.52
All	Fatal, and All Injuries	0.76
Trucks	Fatal, and All Injuries	0.46

Summary & Conclusions

- Cable barriers have performed successfully in BC
- Placement of the system is key to maximizing the performance
- The safety effect stabilized after the first implementation year with some fluctuations over 2-5 years
- The findings of this study were compared to other Collision Modification Factors (CMFs) in the literature
- A recommendation was given on the best values to be used

Questions???!

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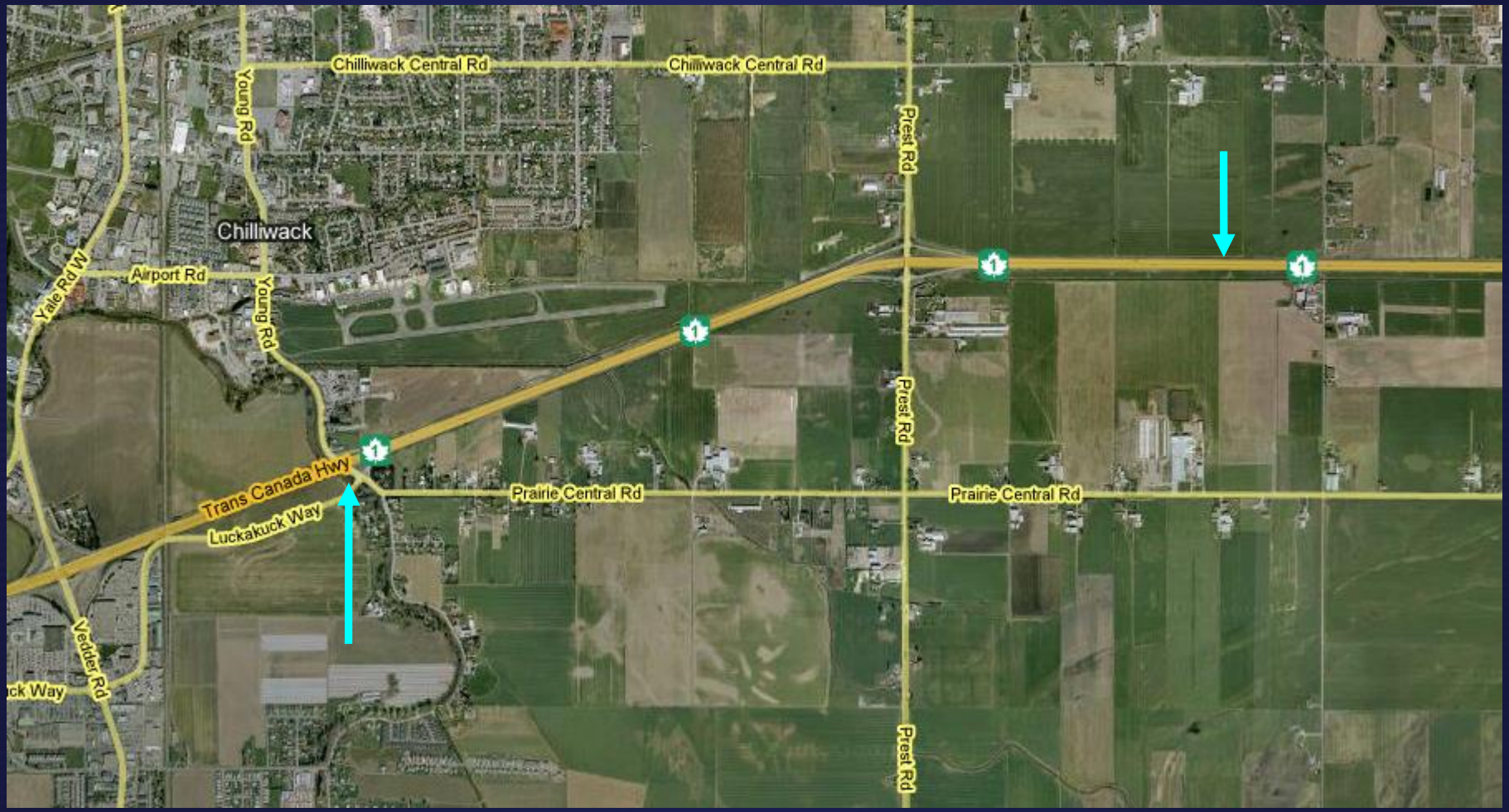
Highway 1 – Median Installation



Cable Barriers: *Cost*

- Cost of installation is comparable to other barrier types
- Cost is dependent on installation length & site conditions
- Median installation cost for Highway 1 near Chilliwack was $116/linear meter (3 km installation length)

Cable Barrier After a Collision

Cable Barrier After a Collision

Highway 1 – Chilliwack