Experience Using Interactive Highway Safety Design Model (IHSDM) To Evaluate 3R Project Alternatives

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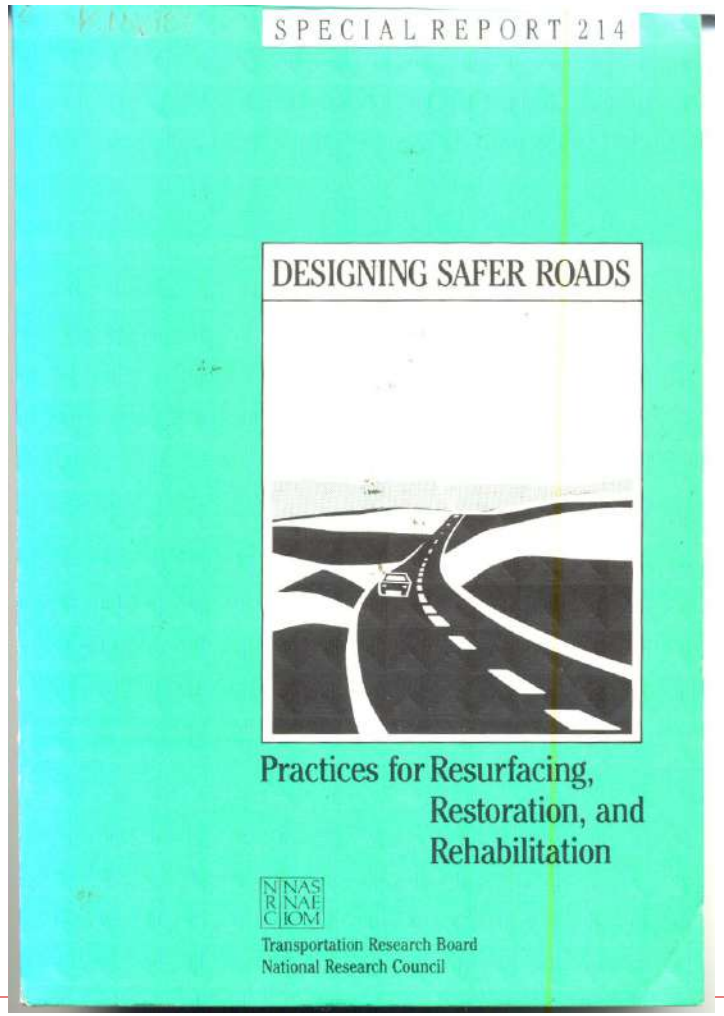
Presentation Overview

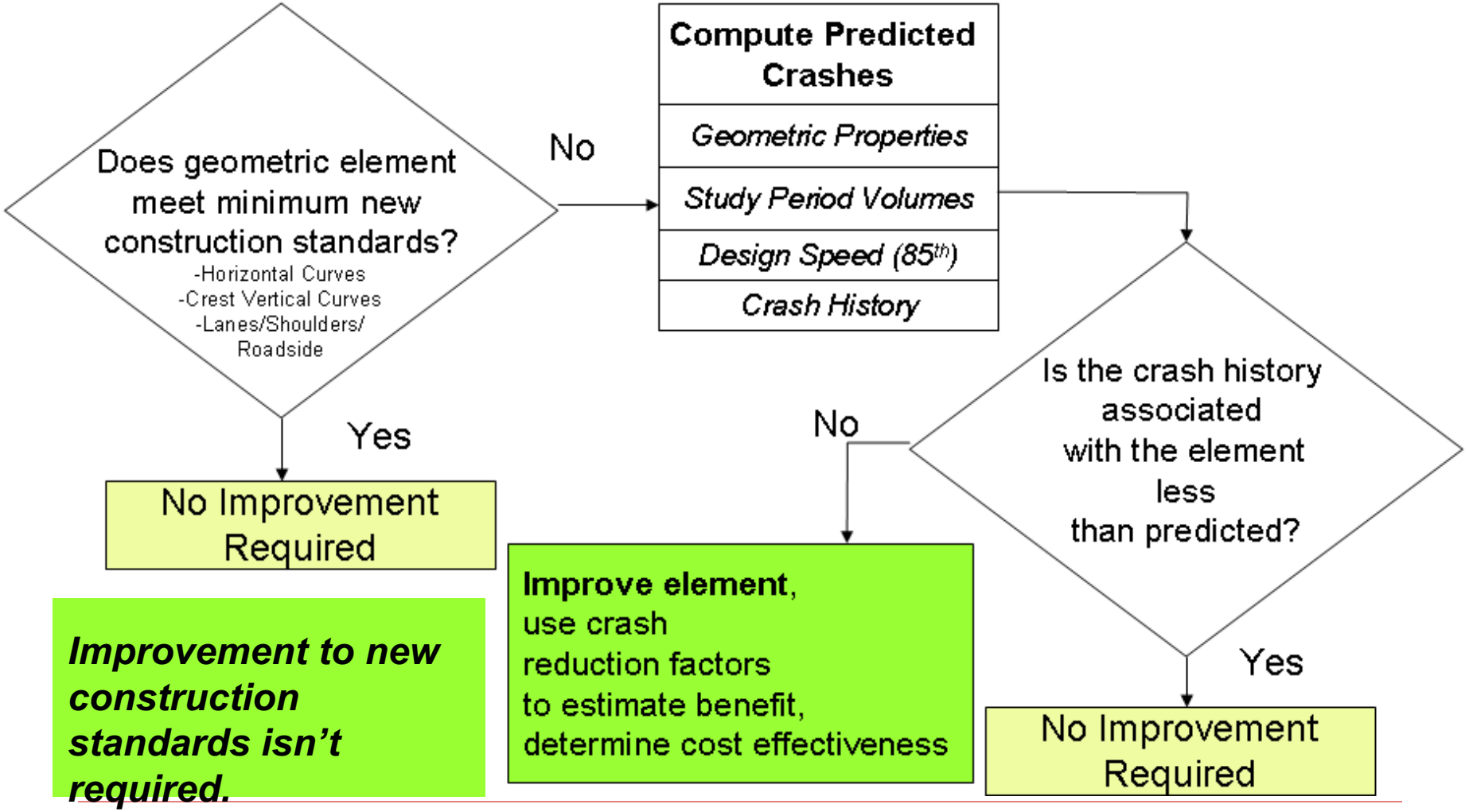
- 3R (Resurfacing, Restoration & Rehabilitation) Analysis Overview
- IHSDM Overview
- DeArmoun Road Project Example
  - IHSDM Application and Results
- Eagle River Road Project Example
  - IHSDM Application and Results
- Lessons Learned

Alaska 3R Projects

- Repave and extend the pavement structure's life.
- Allows cost-effective safety & capacity improvements.
- 3R safety procedures are in Alaska Preconstruction Manual Sec. 1160 uses the TRB Special Report 214 formulas



State of Alaska 3R Process



3R Procedure Doesn't Address-

- Grades- Other research indicates grades contribute to crashes.
- Sag Curves- Might be significant if night crashes are over represented .
- TRB 214 Analysis is meant for discrete elements and not overlapping geometric elements. In areas of overlaps, Combined Crash Reduction Factor may be computed as:

$$CR_t = 1 - (1-CR_1) \cdot (1-CR_2) \cdot \ldots \cdot (1-CR_m)$$

Interactive Highway Safety Design Model (IHSDM)

- IHSDM is software program that has been developed by FHWA as an evaluation tool for two-lane, rural highways.
- It consists of 5 modules:
  - Policy Review (PRM)- Evaluates compliance with AASHTO standards (nominal safety review).
  - Crash Prediction (CPM)- Evaluates substantive safety performance.
  - Design Consistency Module (DCM)- Evaluates speed along alternative alignments, identifies large differences between operating and design speeds, and tangent to curve 85th percentile speeds.

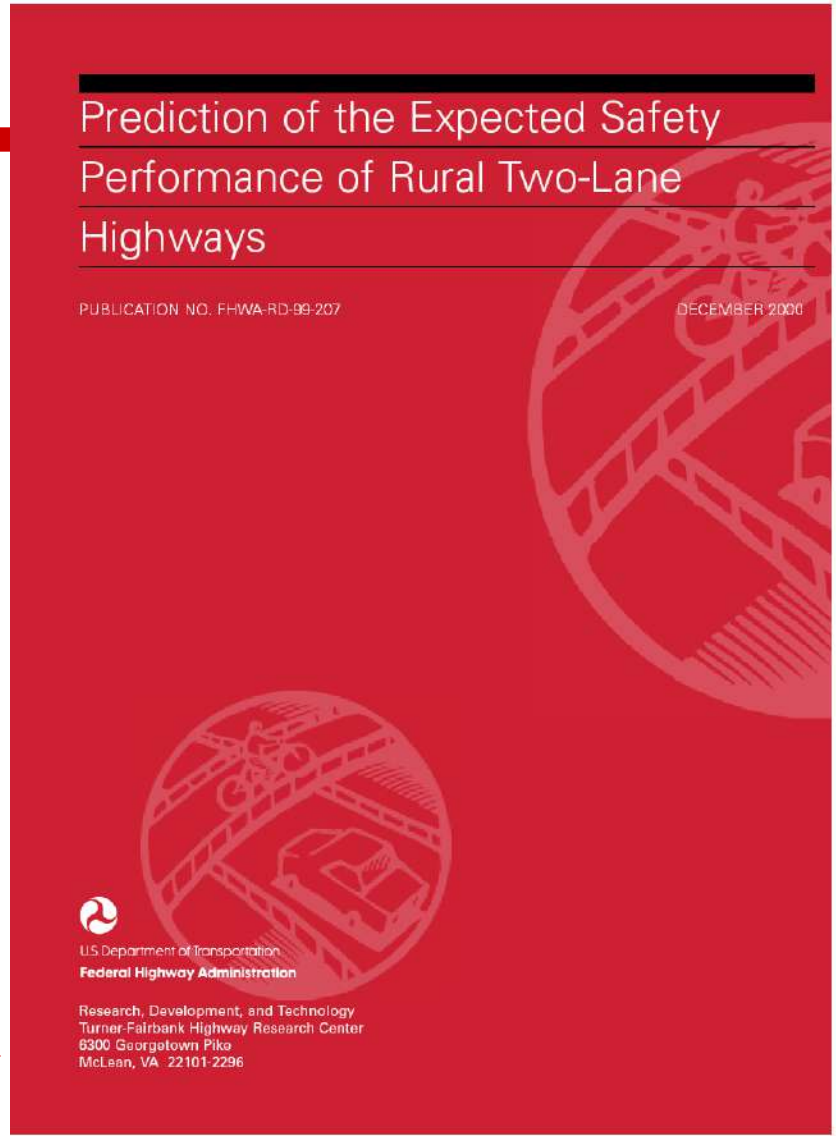
- Intersections (IRM)- Evaluates operational and safety for intersections
- Traffic Analysis (TAM)- Evaluates traffic flow and operations using TWOPASS (basis of the HCM2000 methodology).

- Download program and manuals from:

http://www.fhwa.dot.gov/ihsdm/index.htm

Crash Prediction Module of IHSDM

- An interactive tool that evaluates the highway as a system, rather than discrete geometric elements.
- Provides future safety performance measures…rates, frequency, etc.
- 2-Lane accident modification factors (AMF) based on Minnesota and Washington data



Crash Prediction Module of IHSDM

- Inputs used for analysis-
  - Lane Width
  - Shoulder Width
  - Shoulder Type
  - Horizontal Curves: length, radius, presence or absence of spiral transitions, and superelevation
  - Grades
  - Driveway Density
  - Two-Way-Left-Turn-Lanes
  - Passing or Climbing Lanes
  - Roadside Design

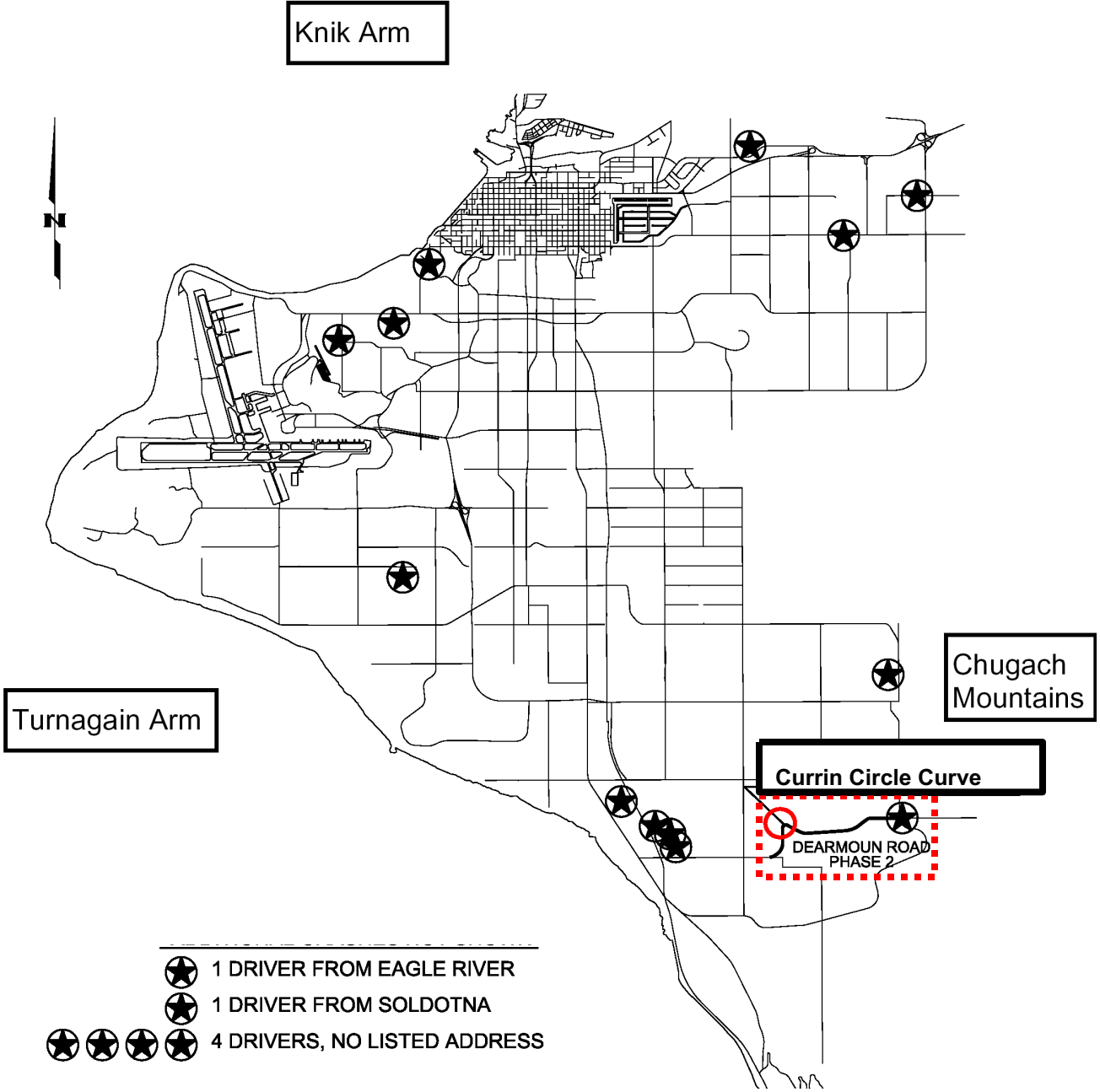
No Vertical Curvature AMF

Empirical Bayes Evaluation

- IHSDM will perform an Empirical Bayes (EB) Procedure crash prediction.
  - EB accounts for "regression to the mean"
  - Removes some degree of randomness that has little to do with conditions.
  - Applies historic crash profile to future traffic profile (volumes)
  - Will not apply historic crash profile to new alignment alternatives

DeArmoun Road Project

- Collector, rolling & mountainous terrain
- 11-foot lanes, 1-foot shoulders
- ≈50 mph 85th percentile speed (40 mph posted)
- 1,000 foot segment with deficient geometrics and a significant crash experience, **Currin Circle Curve**.
- Past 10-year average AADT in study area=1,600
- About 2,000 AADT now, and 2026 AADT is forecasted to be 3,100

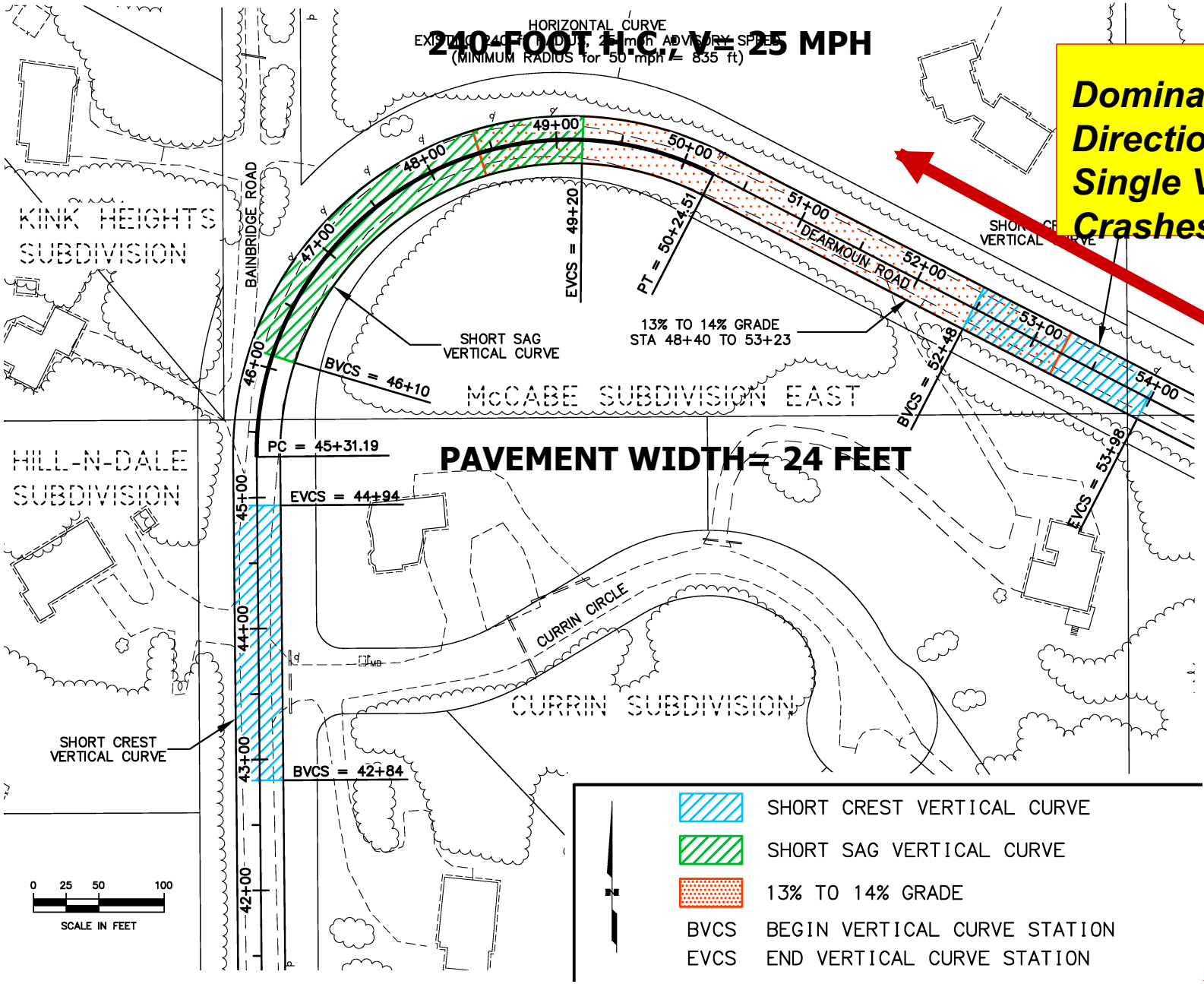

Knik Arm
N
Turnagain Arm
Chugach Mountains
Currin Circle Curve
DEARMOUN ROAD PHASE 2
1 DRIVER FROM EAGLE RIVER
1 DRIVER FROM SOLDOTNA
4 DRIVERS, NO LISTED ADDRESS

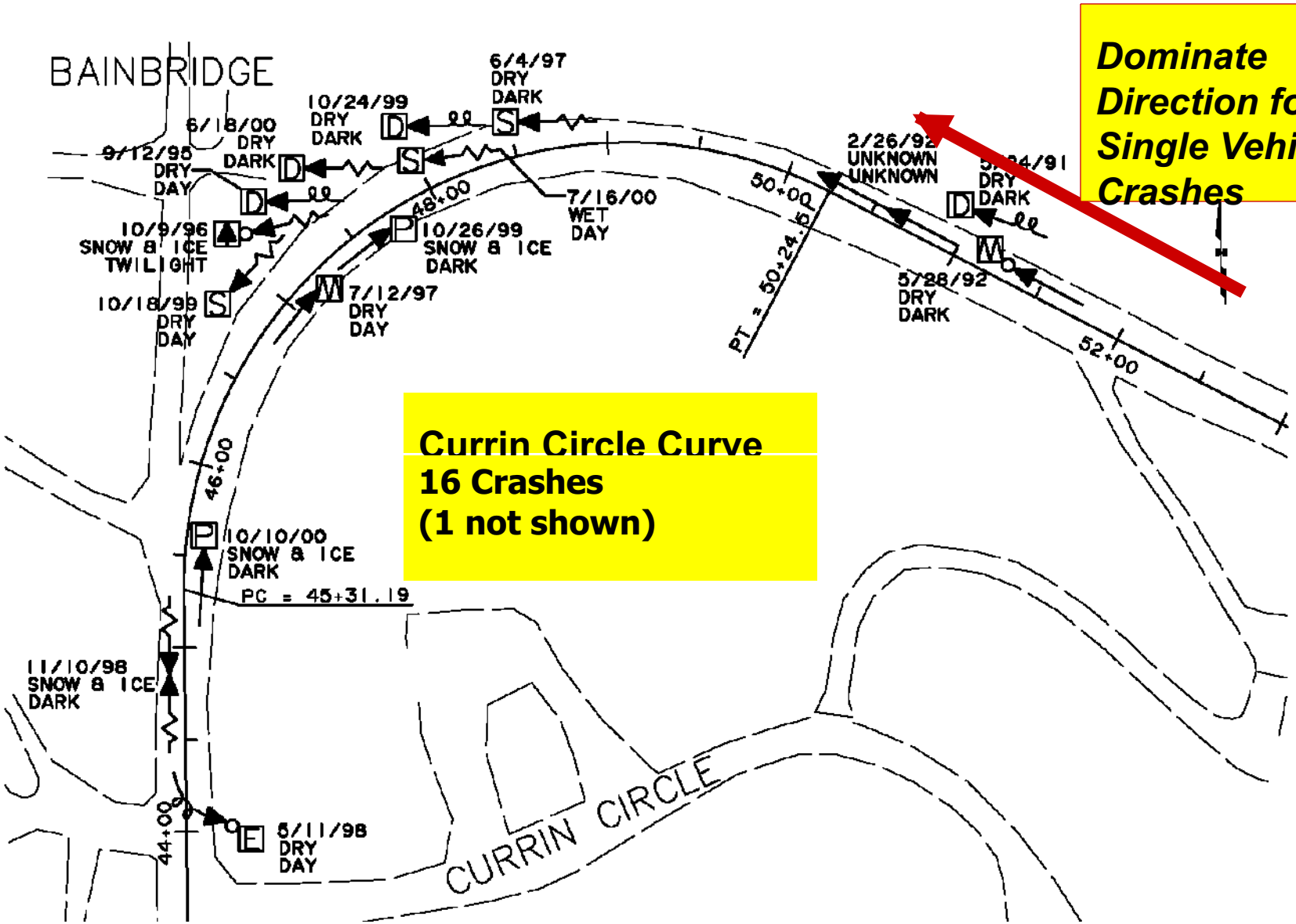
Currin Circle Crash Experience

- 16 reported crashes over 10 years. The majority of reported crashes were not on snow and ice.
- Majority are single vehicle types, involving drivers that don't live on the roadway.
- There is a higher percentage of night crashes here than the statewide averages.
- The above points to an driver expectancy problem. This 1,000-foot segment is highly inconsistent with remainder of road where 50 mph is the 85th percentile speed.

Currin Circle Crash Experience (cont'd)

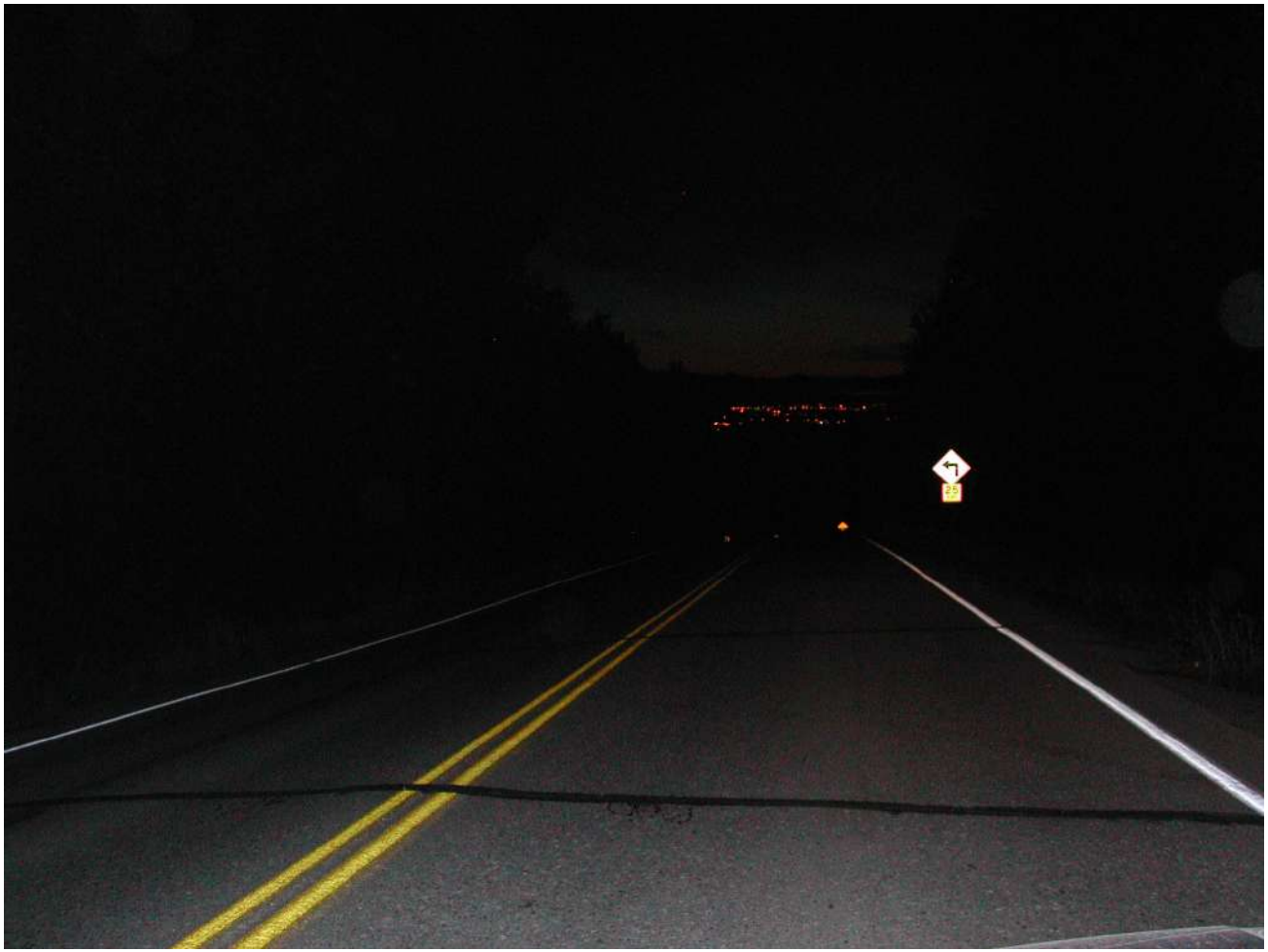
- Segment crash rate is about 13 crashes/million-vehicle-miles. Statistically significant when compared to statewide collector rate of 3.5 crashes/MVM


240-FOOT H.C.I.
V = 25 MPH
HORIZONTAL CURVE
(MINIMUM RADIUS for 50 mph = 835 ft)
Dominate Direction for Single Vehicle Crashes
KINK HEIGHTS SUBDIVISION
BAINBRIDGE ROAD
47+00
48+00
49+00
50+00
51+00
52+00
53+00
54+00
EVCS = 49+20
PT = 50+24.51
DEARMOUN ROAD
SHORT SAG VERTICAL CURVE
13% TO 14% GRADE
STA 48+40 TO 53+23
BVCS = 46+10
BVCS = 52+48
EVCS = 53+98
McCABE SUBDIVISION EAST
PAVEMENT WIDTH= 24 FEET
PC = 45+31.19
EVCS = 44+94
HILL-N-DALE SUBDIVISION
45+00
44+00
43+00
42+00
CURRIN CIRCLE
CURRIN SUBDIVISION
SHORT CREST VERTICAL CURVE
BVCS = 42+84
0 25 50 100
SCALE IN FEET
SHORT CREST VERTICAL CURVE
SHORT SAG VERTICAL CURVE
13% TO 14% GRADE
BVCS BEGIN VERTICAL CURVE STATION
EVCS END VERTICAL CURVE STATION


BAINBRIDGE
6/4/97
DRY
DARK
10/24/99
DRY
DARK
6/18/00
DRY
DARK
9/12/98
DRY
DAY
7/16/00
WET
DAY
10/9/96
SNOW & ICE
TWILIGHT
10/26/99
SNOW & ICE
DARK
10/18/99
DRY
DAY
7/12/97
DRY
DAY
48+00
50+00
PT = 50+24.67
2/26/92
UNKNOWN
UNKNOWN
DRY
DARK
5/28/92
DRY
DARK
52+00
46+00
10/10/00
SNOW & ICE
DARK
PC = 45+31.19
11/10/98
SNOW & ICE
DARK
44+00
5/11/98
DRY
DAY
CURRIN CIRCLE
Currin Circle Curve
16 Crashes
(1 not shown)
Dominate Direction for Single Vehicle Crashes

Vertical Curve and Grade Hides Horizontal Curve

Currin Circle Curve at Night (High-Beam)



3R Results- 3 Alternatives

- 240R: Existing radius, widen pavement to 36 feet vertical improvements
- 443R: 443-foot radius (V=35 mph), widen pavement to 36 feet , vertical improvements
- 835R: 835-foot radius (V=50 mph), widen pavement to 36 feet , vertical improvements

Alternative	Pavement Widening	Horizontal Curve	Vertical Curve Improvements	Combined CRF
240R	50%	0%	52%	76%
443R	50%	24%	52%	82%
835R	50%	52%	52%	89%

Because of the high and uncertain CRF, and significant impacts on private parties, it was decided to use IHSDM to evaluate the area.

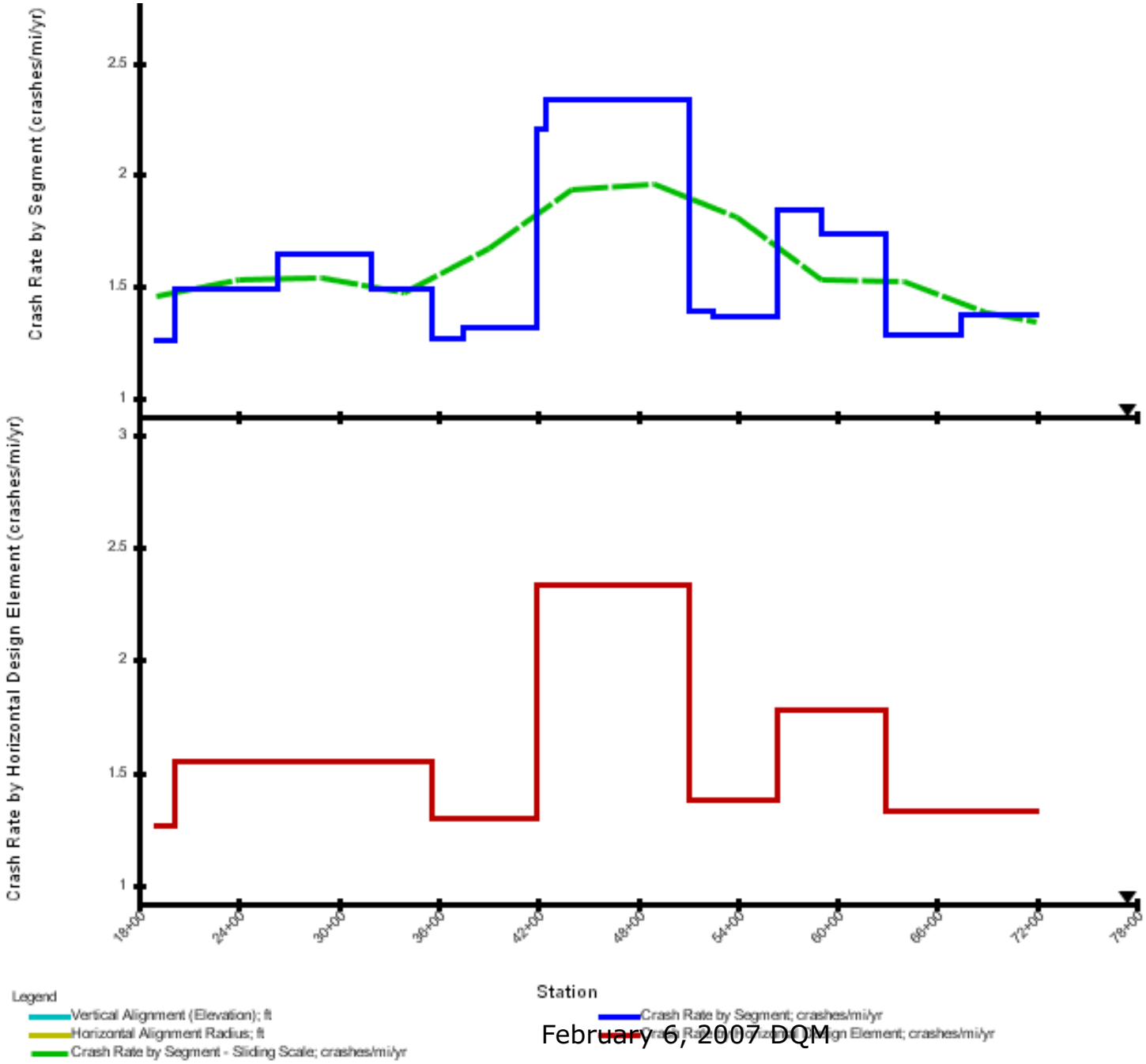
IHSDM Evaluations

Added Alternatives

- Used IHSDM to evaluate 20 years of crashes for:
  - Existing Conditions
  - Base: Existing Alignment, 36-foot pavement widening
  - 240R: 240’ radius Currin Cir. Curve, vertical realignment with 36 feet of pavement widening
  - 265R: 265’ radius curve, vertical realignment, with and without widening
  - 300R: 300’ radius curve, vertical realignment, with and without widening
  - 443R: 443’ radius (35 mph) curve, vertical realignment, with and without widening
  - 835R: 835’ radius (50 mph) curve, vertical realignment, with and without widening
- All alternatives shared a common start and ending point outside of critical geometric elements to avoid bias of altering length of geometric element.

Empirical Bayes (EB) Evaluation of Future Crashes on Existing Alignment

- Input past crash history, ADT, over study period
- IHSDM EB procedure forecasts 44 crashes within *existing* Currin Circle Curve area over the next 20 years, with AADT increasing from 2,000 now to 3,100 in 20 years
- However, remember that EB won't work on new alignments, therefore you must use a "relative" evaluation.


Crash Rate by Segment (crashes/mi/yr)
2.5
2
1.5
1
Crash Rate by Horizontal Design Element (crashes/mi/yr)
3
2.5
2
1.5
1
18+00
24+00
30+00
36+00
42+00
48+00
54+00
60+00
66+00
72+00
78+00
Station
Legend
Vertical Alignment (Elevation); ft
Horizontal Alignment Radius; ft
Crash Rate by Segment - Sliding Scale; crashes/mi/yr
Crash Rate by Segment; crashes/mi/yr

IHSDM Model Example Results (No EB adjustment)

	Existing	Base, Widening Only	240R Horz. & Vert., Realignment with Widening	265R Horz. & Vert., Realignment with Widening	300R Horz. & Vert. Realignment with Widening	443R Horz. & Vert. Realignment with Widening	835R Horz. & Vert. Realignment with Widening
IHSDM Predicted Crashes over 20 years	16.2	12.9	12.9	12.3	11.5	9	5.6
Relative Crash Reduction Factor (CRF) Using Exisiting as Baseline	0%	20%	20%	24%	29%	44%	65%

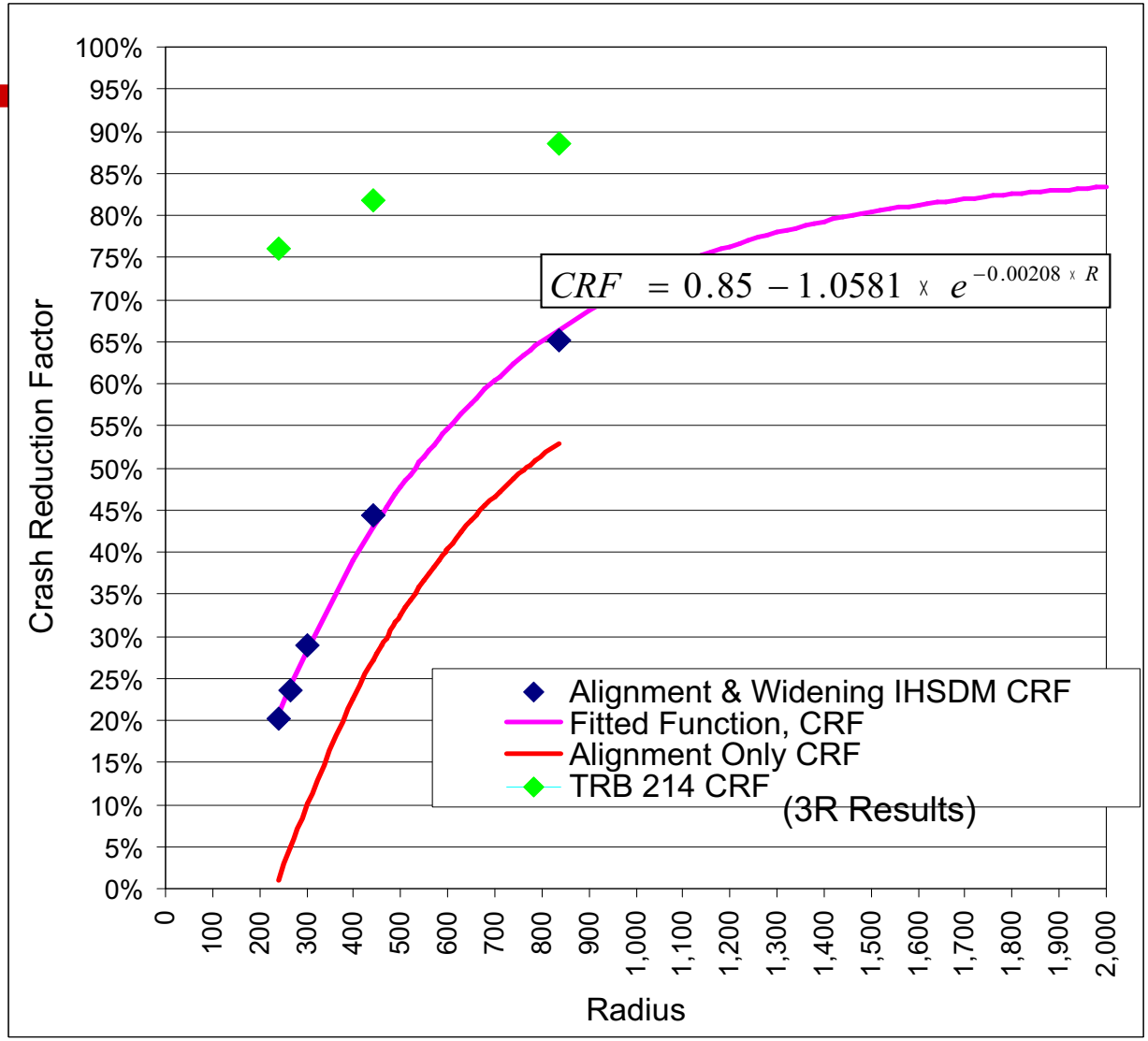
$$CRF = 100 \times \left[1 - \frac{N_{Alternative}}{N_{Existing}} \right]$$

CRF =Crash reduction factor, percent

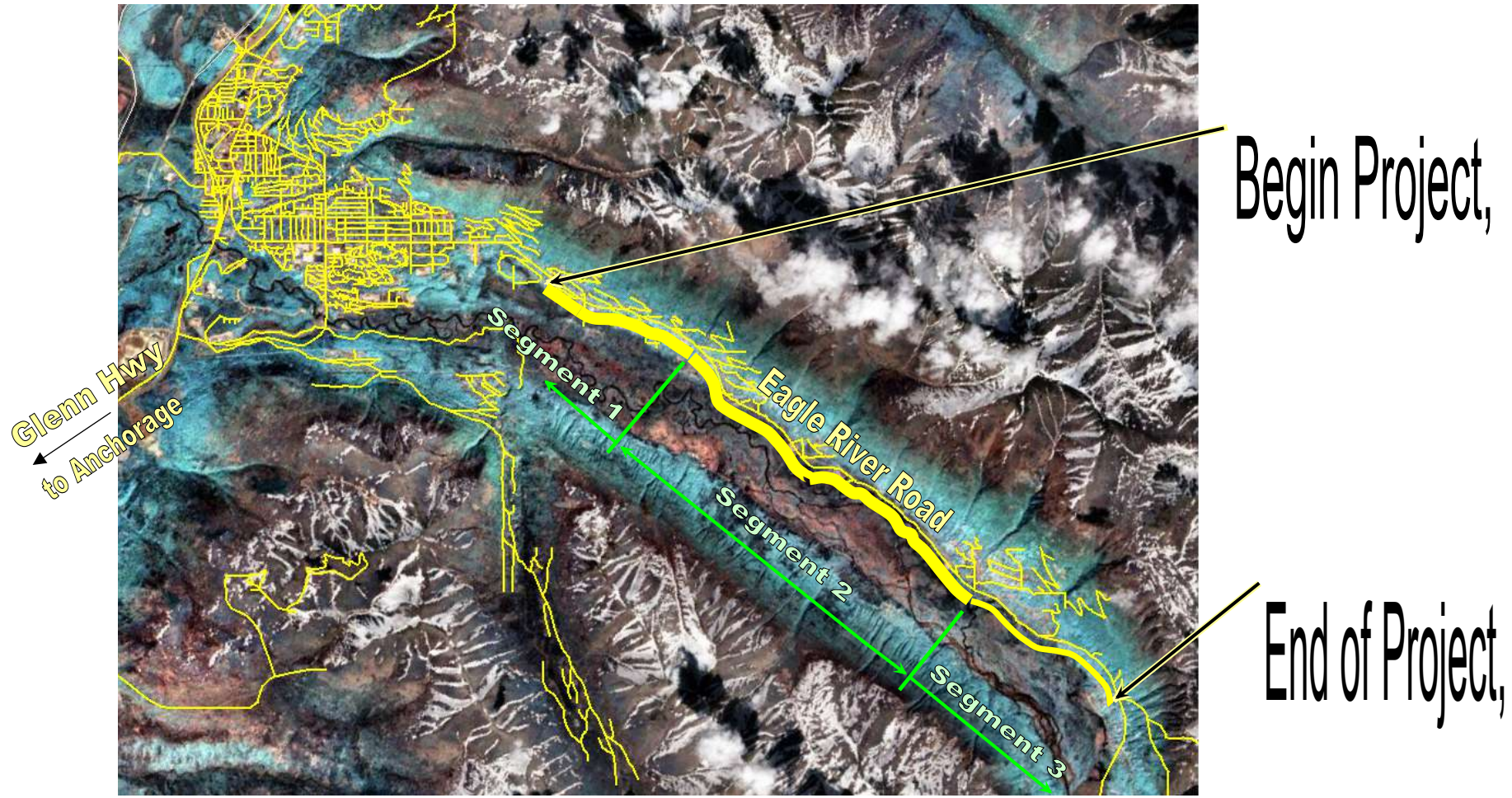
$N_{Alternative}$ =Number of accidents predicted by IHSDM Model for the alternative during design life 2006 to 2026

$N_{Existing}$ =Number of accidents predicted by IHSDM Model for the existing roadway during the design life 2006 to 2026

Relative Crash Reduction



Eagle River Road Rehabilitation Project



Eagle River Road Rehabilitation Project - Background

- Collector, rolling & mountainous terrain
- 12-foot lanes, 4-foot shoulders (Segment 1)
- 11-foot lanes, 1-foot shoulders (Segments 2 & 3)
- ≈60 mph 85th percentile speed (45 mph posted)
- Past 10-year average AADT in study area,

4,045 (seg.1) , 1,270 (seg.2) , 552 (seg.3)

- Crash History Past 10-years,

44 (seg.1) , 108 (seg.2) , 18 (seg.3)

- Forecasted 20-year average AADT,

6,804 (seg.1) , 2,652 (seg.2) , 988 (seg.3)

Eagle River Road Rehabilitation Project

Segment 2 Photo:

Looking South East to the End of Project

Eagle River Road Rehabilitation Project – 3R Recommendations

- 12’ Lanes & 4’ shoulders for Segments 2 & 3
- 17 of 37 Horizontal Curves do not meet AASHTO
  - Improve 11 Horizontal Curves based on accident rate
- 20 of 29 Crest Vertical Curves do not meet AASHTO
  - Improve 5 Crest Vertical Curves based on accident rate
- Intersection Crash Rates were not high, although 12 of 19 did not provide intersection sight distances.

Eagle River Road Rehabilitation Project – 3R Analysis Review

- Proposed 3R improvements will leave some existing Horizontal and Vertical curves in place
  - Do the resulting improvements produce a consistent design ?
  - Are there overlapping geometric elements that should be considered ?
  - Can IHSDM be used to improve the design ?

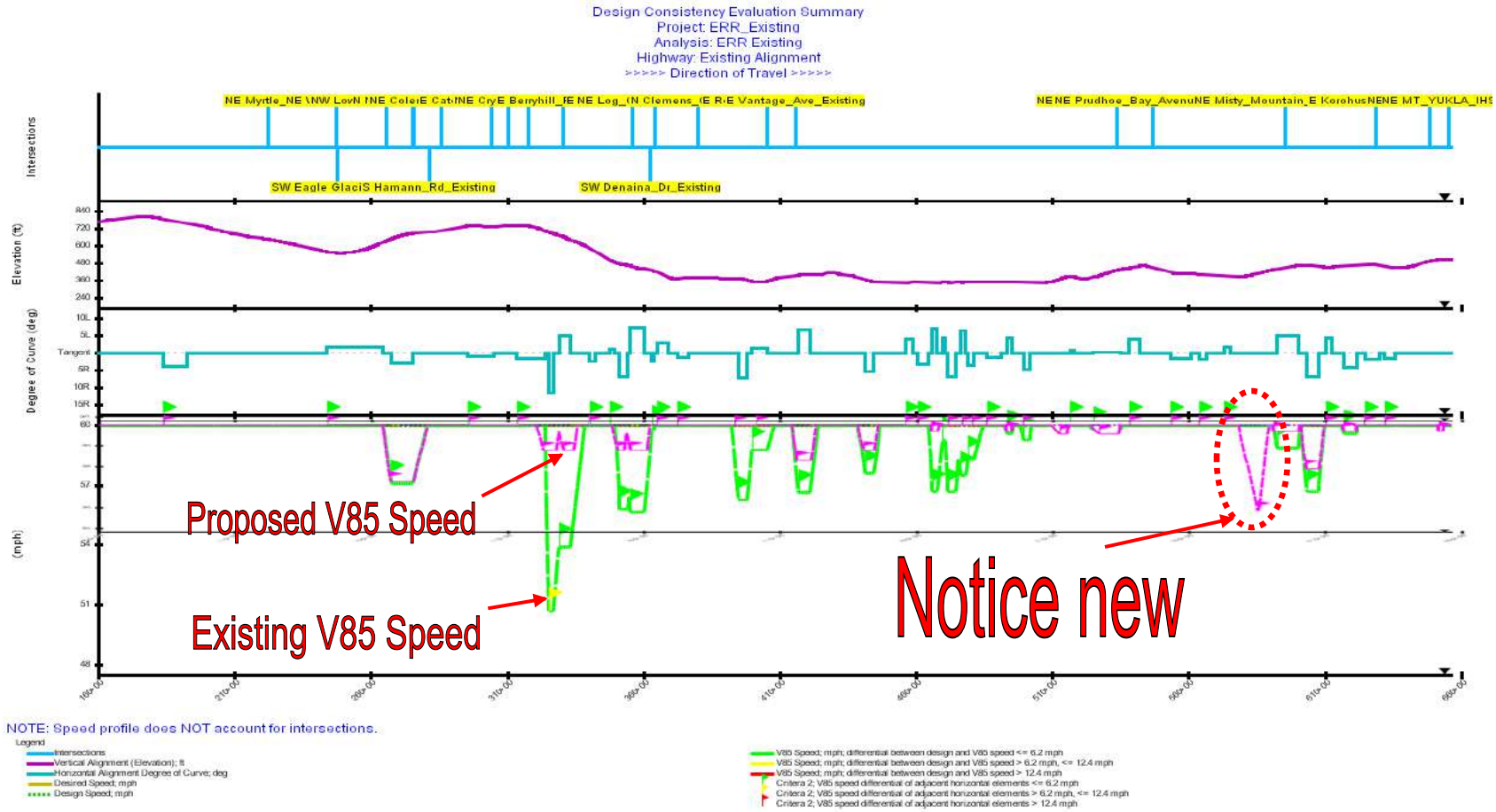
Eagle River Road Rehabilitation Project – IHSDM Sensitivity Analysis

Roadway Feature	Alternative Roadway Feature Combinations					
Horizontal Alignment	Existing	3R Local Review	Increased Curve Radii	3R Local Review	3R Local Review	3R Local Review
Shoulder Width	existing	4 ft.	4 ft.	4 ft.	4 ft.	6 ft.
Grades	existing	Local Review Grades	Local Review Grades	Local Review Grades	Level Grade	Local Review Grades
Roadside Hazard Rating	5	4	4	3	4	4
21-Year (2008-2028) EB Accident Forecast Total without Existing Accident Data Input	267	239	230	227	234	230
% Reduction in forecasted accidents vs. Existing Alignment	N/A	10.49%	13.86%	14.98%	12.36%	13.86%
% Reduction in forecasted accidents vs. Local Review Alignment	N/A	N/A	3.77%	5.02%	2.09%	3.77%

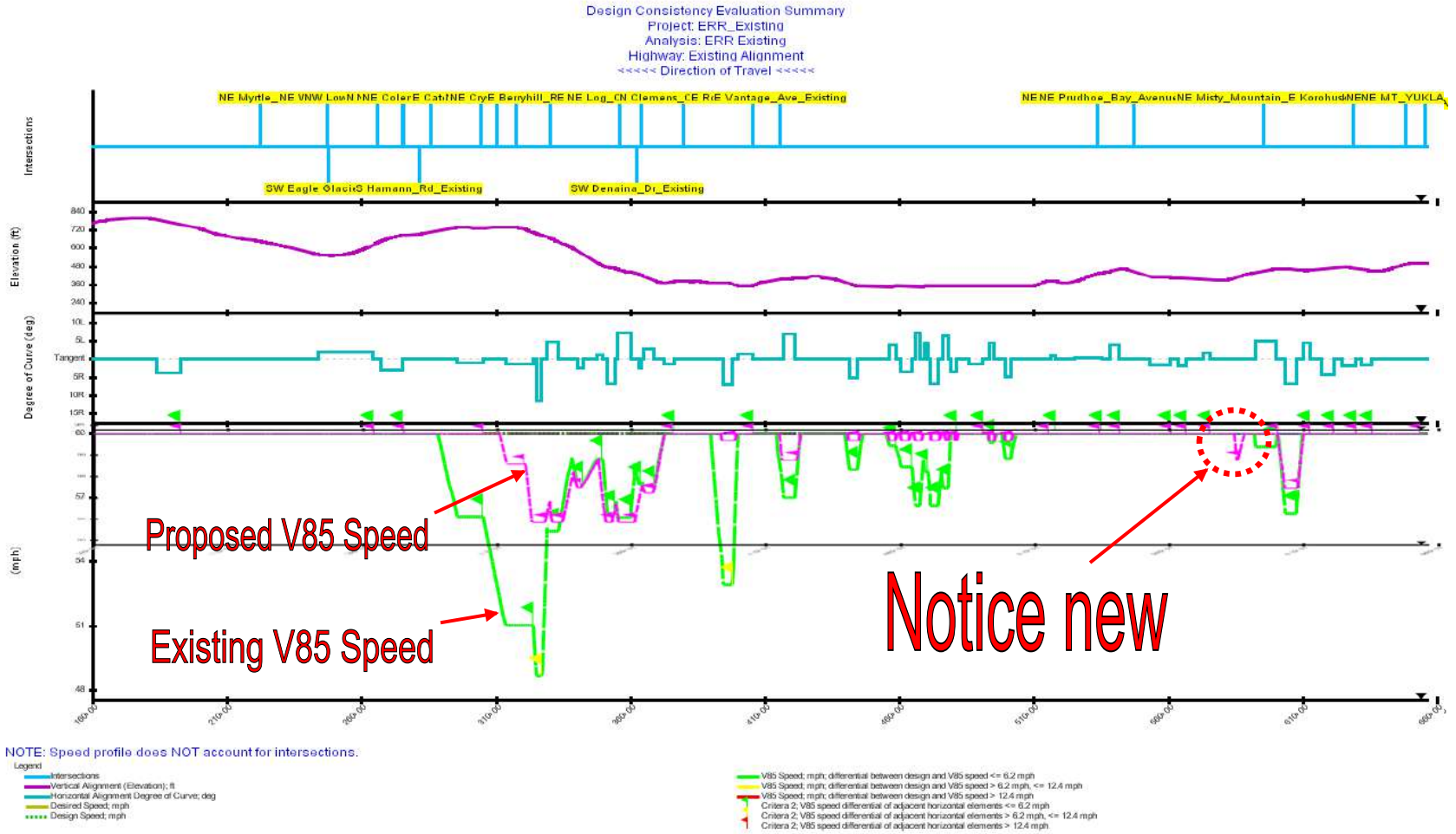
Eagle River Road Rehabilitation Project - Design Consistency Module

- Evaluates the geometry's conformance with diver expectations
- One expectation: operate uniformly at/near design speed.
- The measure of consistency for this check is the difference between the estimated 85th percentile speed (V_{85}) and the design speed (V_{design}) of the highway.

Eagle River Road Rehabilitation Project – Design Consistency RT Lane



Eagle River Road Rehabilitation Project – Design Consistency LT Lane



Lessons Learned

- IHSDM is a good tool for evaluating 2-lane alternatives.
- Applicable to new projects as well as 3R analysis (may be superior to current 3R methods when geometrics are overlapping)
- These models were un-calibrated; therefore only a relative performance measure can be used (CRF). There is significant benefit in calibrating models (calibration has become easier with recent IHSDM release).

Lessons Learned

- Analysis of individual geometric elements with IHSDM requires engineering judgment. In fact, it is best used for evaluating geometric systems. (May be biased when only evaluating discrete, individual elements!)
- Selection of Road Side Hazard Rating is the most sensitive element in accident forecast.
- IHSDM's Consistency Analysis is a good tool for refining proposed designs.