Appendix D: Improvement Options

Needs and Objectives

The needs for the corridor were developed based on the assessment of existing and future conditions along the corridor. The needs describe the general areas of concern reported by the public, stakeholders, and resource/other agency staff and the problems identified in the existing and future conditions analysis.

Two main needs were identified – "Improve Roadway Safety" and "Improve Roadway Surface Conditions". Within each of the needs, the following objectives were defined:

I. Improve Roadway Safety

To the extent practicable, improve:

A. Overall geometry[1]
B. Public intersections
C. Consistency of roadway width
D. Roadside clear zone

II. Improve Roadway Surface Conditions

To the extent practicable:

A. Allow for all-weather travel
B. Reduce roadway maintenance costs
C. Improve emergency response times

The needs and objectives were used in the development of preliminary improvement options.

[1] Overall geometry includes geometric features such as stopping sight distance, passing sight distance, horizontal alignment, and vertical alignment.

Issue Locations

Improvement options were developed for locations along the corridor where there was an issue. Two criteria were used in making this determination:

- A problem was identified through the existing and future conditions analysis or it was reported as an area of concern; and
- A reasonable level of justification for an improvement could be established.

For example, if determined that for a particular location one of MDT's standards was not met, but did not pose a significant safety or operational problem, the location was dropped from further consideration. If both criteria were met, improvement options were developed for the location.

To facilitate the identification of issue locations, a table was developed listing all of the areas along the corridor where a problem was identified through the existing and future conditions analysis or reported as an area of concern (Table D-1). A description of the problem/concern was provided for each location, together with the source of information and, if it was a reported problem/concern, how many times it had been mentioned by the public, stakeholders, and/or resource/other agency staff. The factors considered in determining whether there was an issue at a location were included under the column labeled "Basis of Problem/Concern". A need category was assigned for locations where it was determined there was an issue. Locations where no issue was identified were shown with an "N/A" under the "Need Category" column.

The first portion of the table describes general problems/concerns reported for the entire corridor or long segments of the corridor. The problems/concerns for individual locations are shown following this.

Table D-1
Issue Locations

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category
			Description	Source	Comment Frequency*		
1	Town of Winifred	23.4-24.1	Truck route outside of town should be converted to main route due to safety concerns along existing main route.	Stakeholder interviews	1	Further study required.	N/A
2	Corridor-long	23.5-74.0	Sharp vertical and horizontal curves at multiple locations, including 90-degree curves.	- Stakeholder interviews - Informational Meetings - Agency staff - DKS analysis	12	Sharp curves can limit sight distance and result in loss of vehicle control.	Improve Safety – I.A
3	Corridor-long	23.5-74.0	Conflicts between agricultural and recreational traffic.	Informational Meetings	1	Conflicts are a potential safety problem.	Improve Safety – I.A, I.B, I.C
4	Corridor-Long	23.5-74.0	Roadway surface - road needs to be paved.	Stakeholder interviews	1	Paved road would improve all-weather travel, reduce roadway maintenance costs, and improve emergency response times.	Improve Surface Conditions – II.A, II.B., II.C
5	Corridor-Long	23.5-74.0	Roadway width too narrow in sections.	- Stakeholder interviews - Informational Meetings	4	Restricted roadway width creates potentially unsafe driving conditions between opposing vehicles and reduces drivers' margin of error.	Improve Safety – I.C
6	Corridor-Long	23.5-74.0	Emergency response times too slow.	Stakeholder interviews	3	Response times are increased by poor geometrics and road surface conditions.	Improve Safety – I.A, I.B., I.C Improve Roadway Surface – II.A, II.C
7	Corridor-Long	23.5-74.0	Road is not adequate for the amount of traffic on it.	Stakeholder interviews	1	No volume-related improvements recommended – volumes are low.	N/A
8	Corridor-Long	23.5-74.0	Roadway surface - road base causes poor surface conditions.	- Informational Meetings - Stakeholder interviews	5	Poor roadway surface conditions can cause loss of vehicle control, higher maintenance costs, and increased emergency vehicle response times.	Improve Roadway Surface – II.A., II.B., II.C
9	Corridor-Long	23.5-74.0	Lack of guide signs and warning signs for hills and sharp curves.	Stakeholder interviews	4	Guide signs can reduce driver confusion. Warning signs may reduce potential safety problems by increasing driver awareness of problem locations.	Improve Safety
10	Corridor-Long	23.5-74.0	Steep side slopes	Informational Meetings	2	Steep side slopes reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D
11	Corridor-Long	23.5-74.0	Passing lanes needed on steep hills.	Informational Meetings	1	No improvement recommended – passing lanes are used to improve level-of-service but this is not a need.	N/A
12	Corridor-Long	23.5-74.0	Dust from roadway can limit drivers' visibility.	Stakeholder interviews	1	No improvement recommended – potential safety problems associated with this issue are likely not serious because of low volumes.	N/A
13	Corridor-Long	23.5-74.0	Chuckholes	Stakeholder interviews	2	Chuckholes and other road base failures may cause loss of vehicle control at higher speeds.	Improve Surface Conditions – II.A., II.C

Table D-1 (cont.)
Issue Locations

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category
			Description	Source	Comment Frequency*		
14	Corridor-Long	23.5-74.0	Roadside hazards	Stakeholder interviews	1	Utility poles, steep slopes and embankments, trees, and other roadside hazards reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D
15	Corridor-Long	23.5-74.0	Excessive speeds	Informational Meetings	1	No improvement recommended – excessive speeds are an enforcement issue.	N/A
16	Corridor-Long	23.5-74.0	Roadway too wide in places	Stakeholder interviews	2	No improvement recommended – wider-than-needed roadway is not a safety issue.	N/A
17	Corridor-Long	23.5-74.0	Hunters stop in blind spots caused by vertical curves.	Informational Meetings	1	No improvement recommended – this is driver behavior issue.	N/A
18	Winifred to Missouri River	23.5-40.3	Vertical curves	Stakeholder interviews	1	Vertical curves limit stopping sight distance.	Improve Safety – I.A
19	Winifred to Missouri River	23.5-40.3	Roadway width	Stakeholder interviews	1	Restricted roadway width creates potentially unsafe driving conditions between opposing vehicles and reduces drivers' margin of error.	Improve Safety – I.C
20	Winifred to Missouri River	23.5-40.3	Horizontal curves	Stakeholder interviews	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A
21	Winifred to Missouri River	23.5-40.3	Steep side slopes	Stakeholder interviews	1	Steep side slopes reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D
22	Winifred to Missouri River	23.5-40.3	Excessive road maintenance	Stakeholder interviews	1	Road is costly to maintain and reduces resources for other roads.	Improve Surface Conditions – II.B
23	Winifred to Missouri River	23.5-40.3	Snow drifts across roadway	Stakeholder interviews	1	Drifting snow can result in maintenance and access problems and hazardous driving.	Improve Surface Conditions – II.A, II.B, II.C
24	Bear Springs Rd. (south intersection)	24.2	Skewed intersection	DKS analysis	0	No improvement recommended – alternate access to S-236 exists.	N/A
25	Bear Springs Rd. (north intersection)	24.2	Skewed intersection	DKS analysis	0	No improvement recommended – alternate access to road exists.	N/A
26	N. of Winifred	24.2-24.3	Horizontal curve	- Agency staff - DKS analysis	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A
27	N. of Winifred	24.2-24.8	Vertical curve	- Agency staff - DKS analysis	1	Vertical curve limits stopping sight distance and intersection sight distance – access points at top and bottom of hill.	Improve Safety – I.A
28	N. of Winifred	25.1-25.5	Vertical curve	DKS analysis	0	No improvement recommended unless part of larger improvement project - small curve.	N/A
29	Yapps Corner	26.7	- Vertical curve - Horizontal curve	- Agency staff - DKS analysis	3	Vertical curve hides 90-degree horizontal curve from driver, creating stopping sight distance problem.	Improve Safety - IA
30	W. of Kucera Ln.	27.5-27.9	Vertical curve	DKS analysis	0	No improvement recommended unless a part of larger improvement project - small depression.	N/A

Table D-1 (cont.)
Issue Locations

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category
			Description	Source	Comment Frequency*		
31	W. of Tobin Ln.	28.8	Vertical curve	- Informational Meetings - DKS analysis	2	Vertical curve limits sight distance.	Improve Safety - IA
32	W. of Tobin Ln.	29.3-29.5	Vertical curve	DKS analysis	0	No improvement recommended unless a part of larger improvement project - small depression.	N/A
33	W. of Murphy Ln.	29.9-30.1	Vertical curve	DKS analysis	0	No improvement recommended unless a part of larger improvement project - small depression.	N/A
34	S. of Heggem Ln.	30.2-30.9	- Vertical curve - Horizontal curve	DKS analysis	0	Combination of vertical/horizontal curves restricts sight distance through the curve.	Improve Safety - IA
35	S. of Stulc Ln.	30.6	- Roadway width - Vertical curves - Horizontal curves - Roadside hazard	- Agency staff - DKS analysis	5	This section is narrow (21') and has two vertical curves that block sight distance, a steep side slope, and four sharp horizontal curves, including a 90-degree curve.	Improve Safety - I.A, I.C, 1.D
36	W. of Murphy Ln.	31.3-32.1	Roadside hazard	DKS analysis	0	Two cut slopes and large vegetation exist within clear zone, resulting in limited recovery area for vehicles leaving road. Road narrows at culvert location.	Improve Safety – I.D
37	S. of Heggem Ln.	31.4-31.9	- Vertical curves - Roadside obstruction	DKS analysis	0	Combination of crest vertical curve, sag vertical curve, and hill to west restricts stopping sight distance.	Improve Safety – I.A, I.D
38	S. of Stulc Ln.	31.7-32.2	Snow drifts across roadway	Agency staff	1	Drifting snow can result in maintenance and access problems and hazardous driving.	Improve Surface Conditions – II.A, II.B, II.C
39	S. of Heggem Ln.	31.9-32.8	Vertical curves	DKS analysis	0	Stopping sight distance restricted by series of crest and sag vertical curves that create "roller coaster" effect.	Improve Safety – I.A
40	W. of Murphy Ln.	32.1-32.2	Roadside hazard	DKS analysis	0	Utility poles and hill cut within clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D
41	Stulc Ln.	32.5	- Vertical curve - Intersection sight distance	- Agency staff - Informational Meetings - DKS analysis	4	Vertical curve and vegetation near intersection restrict intersection sight distance in both directions. Vertical curve also limits stopping sight distance.	Improve Safety – I.A, I.B, I.D
42	East of Badd's Place	33.6	- Horizontal curve - Vertical curve - Roadway surface - Roadside hazard	- Agency staff - Informational Meetings - DKS analysis	2	Vertical curve and hill on roadside restrict sight distance around 90-degree curve. Vehicles can slide off road at low speeds in muddy conditions.	Improve Safety – I. A, I.B, I.D Improve Surface Conditions – II.A, II.C
43	East of Badd's Place	33.6	- Horizontal curve - Vertical curve	- Informational Meetings - DKS analysis	1	Stopping sight distance is limited by the combination of horizontal and vertical curves.	Improve Safety – I.A
44	Near Heggem Ln.	33.7-34.9	Roadside hazard	DKS analysis	0	Steep side slope near culvert reduces likelihood of recovery for errant vehicles.	Improve Safety – I.D

Table D-1 (cont.)
Issue Locations

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category
			Description	Source	Comment Frequency*		
45	Near Heggem Ln.	33.9-34.0	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance.	Improve Safety – I.A
46	Near Heggem Ln.	34.1-34.2	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance.	Improve Safety – I.A
47	Near Heggem Ln.	34.3-34.5	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance and partially hides adjacent horizontal curve.	Improve Safety – I.A
48	Near Heggem Ln.	34.5-35.63	Horizontal curve	DKS analysis	0	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A
49	W. of Heggem Ln.	34.7-35.1	Roadway width	DKS analysis	0	Roadway width is restricted by steep side slopes, creating potentially unsafe driving conditions between opposing vehicles and reducing drivers' margin of error.	Improve Safety – I.D
50	Badd's Place	34.9-39.9	- Vertical curves - Horizontal curves - Roadside hazards	- Informational Meetings Agency staff - DKS analysis	18	There are many horizontal and vertical curves in this area that restrict stopping sight distance. There are also steep side slopes and other roadside hazards that reduce likelihood of recovery for errant vehicles.	Improve Safety – I.A, I.C, I.D
51	Badd's Place	34.9	- Vertical curve - Horizontal curves	- Informational Meetings - DKS analysis	5	Combination of vertical curve and adjacent horizontal curves limit stopping sight distance.	Improve Safety - I.A
52	W. of Heggem Ln.	34.9-35	Roadside hazards	DKS analysis	0	Trees in clear zone and steep side slopes reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D
53	Badd's Place	35.0-35.6	- Roadway width - Roadside hazards	DKS analysis	0	Narrow roadway width (21'), trees in clear zone, and steep side slopes create potentially unsafe driving conditions between opposing vehicles and reduce drivers' margin of error.	Improve Safety – I.A, I.D
54	Badd's Place	35.6-35.9	Roadside hazards	DKS analysis	0	Several steep side slopes and cuts in clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D
55	Badd's Place	35.9-39	Roadside hazards	DKS analysis	0	Trees in the clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D
56	Badd's Place	37.3-37.5	- Vertical curve - Horizontal curve	DKS analysis	0	Vertical and horizontal curves restrict stopping sight distance.	Improve Safety – I.A
57	Badd's Place	37.6-37.8	Horizontal curve	DKS analysis	0	Horizontal curve is hidden from driver by crest vertical curve, with steep side slope on outside of curve.	Improve Safety – I.A
58	Badd's Place	37.7-38.0	Vertical curve	DKS analysis	0	Vertical curve limits sight distance.	Improve Safety – I.A
59	Badd's Place	38.1-38.7	- Vertical curve - Roadside obstruction	DKS analysis	0	Embankment on east side of road restricts sight distance through horizontal curve.	Improve Safety – I.A
60	Badd's Place	39.1-39.3	- Horizontal curves - Roadside obstruction	- Informational Meetings - DKS analysis	4	Sharp curves can limit stopping sight distance and cause loss of vehicle control. Stopping sight distance restricted by roadside embankment.	Improve Safety - IA

Table D-1 (cont.)
Issue Locations

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category
			Description	Source	Comment Frequency*		
61	Badd's Place	39.5-39.7	- Vertical curve - Horizontal curve - Roadside hazard	DKS analysis	0	Combination of horizontal and vertical curves restricts sight distance. Steep side slope reduces likelihood of recovery for errant vehicles.	Improve Safety - I.A, I.D
62	S. of Claggett Hill	40.3	- Vertical curve - Horizontal curve	- Informational Meetings - Agency staff - DKS analysis	7	Horizontal curve is hidden from driver by crest vertical curve.	Improve Safety – I.A
63	S. of Claggett Hill	41.3	Horizontal curve	- Informational Meetings - DKS analysis	4	Sharp curve could cause loss of vehicle control.	Improve Safety - IA
64	N. of Old S-236 Alignment	41.5-41.6	Horizontal curve	DKS analysis	0	Sharp curve could cause loss of vehicle control.	Improve Safety - IA
65	Claggett Hill	45.0-47.0	Road surface	- Informational Meetings - Agency staff - Stakeholder interviews	5	Icy road surface causes hazardous driving conditions.	Improve Surface Condition – II.A
66	N. of Missouri River	48.0-74.0	Road surface	Stakeholder interviews	6	Poor surface conditions can cause loss of vehicle control at higher speeds - sections of road deteriorate faster than county can maintain.	Improve Surface Conditions – II.A, II.B, II.C
67	N. of Missouri River	48.0-48.2	Horizontal curve	DKS analysis	0	Sharp curve could cause loss of vehicle control.	Improve Safety – I.A
68	N. of Missouri River	49.6-50.4	Roadway width	DKS analysis	0	Restricted roadway width (21') creates potentially unsafe driving conditions between opposing vehicles and reduces drivers' margin of error.	Improve Safety – I.C.
69	Near Chip Creek	51.0-53	Road surface	Informational Meetings	4	Poor surface conditions in bad weather - can cause loss of vehicle control.	Improve Surface Conditions – II.A, II.C
70	N. of Missouri River	51.0-51.4	Vertical curve	DKS analysis	0	Vertical curve limits sight distance.	Improve Safety – I.A
71	N. of Missouri River	51.9-52.7	Vertical curves	DKS analysis	0	Several smaller vertical curves and one long curve limit sight distance.	Improve Safety – I.A
72	N. of Missouri River	52.8-53.3	Vertical curve	DKS analysis	0	Vertical curve limits sight distance.	Improve Safety – I.A
73	Near Chip Creek	53.2	- Vertical curve - Horizontal curves - Lack of signage - Roadside obstruction	- Informational Meetings - Agency staff - DKS analysis	6	Vertical curve limits sight distance through "S" curves. Berm on side of road also restricts sight distance through curves. Seven known accidents (only one reported) at this location, including three rollovers.	Improve Safety – I.A
74	N. of Jappe Trail	54.9	Road surface - wash boarding	Informational Meetings	2	Wash boarding has adverse affects driving safety, riding comfort, and vehicle condition.	Improve Surface Conditions – II.A, II.B., II.C
75	N. of Jappe Trail	55.1	Horizontal curve	- Agency staff - DKS analysis	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A

Table D-1 (cont.)
Issue Locations

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category
			Description	Source	Comment Frequency*		
76	S. of Adamec Rd.	57.2	Horizontal curve	Agency staff	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A
77	N. of Missouri River	57.7-57.8	Vertical curve	DKS analysis	0	Vertical curve restricts sight distance through horizontal curve.	Improve Safety – I.A
78	Adamec Rd.	58.5	Skewed intersection	DKS analysis	0	Skewed intersections can cause vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.
79	Eight-Mile Bench Rd.	59.4	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.
80	Iliad Loop (south)	59.6	Intersection – inadequate turn radius	DKS analysis	0	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B.
81	S. of Eskay Rd.	61.5-61.6	Vertical curve	DKS analysis	0	No improvement recommended - vertical curve is slight and does not restrict sight distance.	N/A
82	Eskay Rd. to Beg. of Pavement	61.8-74.0	Roadway surface	- Stakeholder interviews - Agency staff - Informational Meetings	5	Road is difficult and costly to maintain, and reduces speeds and emergency response times. Too much gravel in wider sections.	Improve Surface Conditions – II.A, II.B, II.C
83	Iliad Loop (north)	63.5	Intersection – turn radius	DKS analysis	0	Turn radius too tight for large vehicles.	Improve Safety – I.B
84	Five Corner Rd.	63.9	Intersection – inadequate turn radius	DKS analysis	0	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B.
85	N. of Unnamed County Rd.	67.0-67.6	Vertical curve	DKS analysis	0	No improvement recommended unless part of larger improvement project – gradual curve.	N/A
86	Eagleton Rd.	67.8-70.0	Road surface	Agency staff	4	Relatively high truck volumes from Eagleton Rd. combined with steep grade in northbound direction result in poor surface conditions (binding problem) and higher maintenance costs.	Improve Surface Conditions – II.A, II.B
87	S. of Big Sandy	74.0.0-80.0	Roadway width	Stakeholder interviews	1	No improvement recommended – roadway width meets standard.	N/A
88	Tuttle Rd.	79.0	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.
89	Zeock Rd.	80.7	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.

Table D-1 (cont.)
Issue Locations

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category
			Description	Source	Comment Frequency*		
90	Lone Tree Trail (north)	82.8	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.
91	Lone Tree Trail	82.9	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.

* Comment frequency refers to the number of comments received the public, stakeholders, and/or agency staff regarding the same issue.

Preliminary Improvement Options

Improvement options were defined so the roadway would meet MDT's design standards as determined practicable. A range of options was developed to ensure that all feasible improvement options could be considered. Factors considered were:

- Input received from the public, stakeholders, and resource/other agency staff
- Consistency with MDT standards and policies
- Existing and future roadway geometrics
- Feasibility of implementation

The feasibility of an improvement option was based on the magnitude of the cost, physical and/or environmental constraints, and potential impacts.

Engineering judgment and practical design were also used in the development of each option.

The preliminary improvement options were summarized in a revised version of the issue location table (Table D-2). In this table, the locations with no issue were deleted. Closely clustered issue locations were aggregated into a single location (outlined in bold). The corridor-long issues were separated from the specific issue locations because the corridor-long issues were addressed in more generic way. These are summarized below:

- Sharp vertical and horizontal curves at multiple locations, including 90-degree curves.
- Conflicts between agricultural and recreational traffic.
- Roadway surface problems, including poor road base, chuck holes, wash boarding, and excessive maintenance requirements.
- Inconsistent roadway width, with some sections that are too narrow and others that are too wide.
- Slow emergency response times caused by poor road surface conditions and substandard geometrics.

- Lack of guide signs and warning signs in advance of hills and sharp curves.
- Roadside hazards, including steep side slopes and embankments, trees, and utility poles.
- Snow drifts across the roadway.

Table D-2
Preliminary Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Preliminary Improvement Options
			Description	Source	Comment Frequency*			
1	**N. of Winifred**	**24.2-24.8**						
		24.2-24.8	Vertical curve	- Agency staff - DKS analysis	1	Vertical curve limits stopping sight distance and intersection sight distance – access points at top and bottom of hill.	Improve Safety – I.A	Flatten vertical curve
		24.2-24.3	Horizontal curve	- Agency staff - DKS analysis	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase horizontal curve radius
2	Yapps Corner	26.7	- Vertical curve - Horizontal curve	- Agency staff - DKS analysis	3	Vertical curve hides 90-degree horizontal curve from driver, creating stopping sight distance problem.	Improve Safety - IA	Flatten vertical curve and increase horizontal curve radius.
3	W. of Tobin Ln.	28.8	Vertical curve	- Informational Meetings - DKS analysis	2	Vertical curve limits sight distance.	Improve Safety - IA	Flatten vertical curve
4	**W. of Murphy Ln.**	**30.2-30.9**						
		30.2-30.9	- Vertical curve - Horizontal curve	DKS analysis	0	Combination of vertical/horizontal curves restricts sight distance through the curve.	Improve Safety - IA	Increase horizontal curve radius and flatten vertical curve.
		30.6	- Roadway width - Vertical curves - Horizontal curves - Roadside hazard	- Agency staff - DKS analysis	5	This section is narrow (21') and has two vertical curves that block sight distance, a steep side slope, and four sharp horizontal curves, including a 90-degree curve.	Improve Safety - I.A, I.C, 1.D	Increase radius of 90-degree curve, combine smaller horizontal curves into single long curve, and flatten vertical curves.
5	**S. of Stulc Ln.**	**31.3 – 32.8**						
		31.3-32.1	Roadside hazard	DKS analysis	0	Two cut slopes and large vegetation exist within clear zone, resulting in limited recovery area for vehicles leaving road. Road narrows at culvert location.	Improve Safety – I.D	- Remove portion of embankment within clear zone. - Remove vegetation - Widen road and extend culvert
		31.4-31.9	- Vertical curves - Roadside obstruction	DKS analysis	0	Combination of crest vertical curve, sag vertical curve, and hill to west restricts stopping sight distance.	Improve Safety – I.A, I.D	Flatten vertical curves and remove portion of hill
		31.7-32.2	Snow drifts across roadway	Agency staff	1	Drifting snow can result in maintenance and access problems and hazardous driving.	Improve Surface Conditions – II.A, II.B, II.C	Work with landowners to develop a mitigation plan.
		31.9-32.8	Vertical curves	DKS analysis	0	Stopping sight distance restricted by series of crest and sag vertical curves that create "roller coaster" effect.	Improve Safety – I.A	Flatten and combine vertical curves into single curve.

Table D-2 (cont.)
Preliminary Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Preliminary Improvement Options
			Description	Source	Comment Frequency*			
		32.1-32.2	Roadside hazard	DKS analysis	0	Utility poles and hill cut within clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Relocate poles and remove portion of hill within clear zone.
6	Stulc Ln.	32.5	- Vertical curve - Intersection sight distance	- Agency staff - Informational Meetings - DKS analysis	4	Vertical curve and vegetation near intersection restrict intersection sight distance in both directions. Vertical curve also limits stopping sight distance.	Improve Safety – I.A, I.B, I.D	Remove vegetation and flatten vertical curve.
7	Heggem Ln.	33.6	- Horizontal curve - Vertical curve - Roadway surface - Roadside hazard	- Agency staff - Informational Meetings - DKS analysis	3	Vertical curve and hill on roadside restrict sight distance around 90-degree curve. Vehicles can slide off road at low speeds in muddy conditions.	Improve Safety – I. A, I.B, I.D Improve Surface Conditions – II.A, II.C	- Increase horizontal curve radius, flatten vertical curve, and realign Heggem Ln. to "T" into S-236. - Remove and replace existing road base and surface with alternative material.
8	**W. of Heggem Ln.**	**33.7-34.9**						
		33.7-34.9	Roadside hazard	DKS analysis	0	Steep side slope near culvert reduces likelihood of recovery for errant vehicles.	Improve Safety – I.D	- Reduce steepness of side slope - Install guardrail
		33.9-34.0	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance.	Improve Safety – I.A	Flatten curve
		34.1-34.2	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance.	Improve Safety – I.A	Flatten curve
		34.3-34.5	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance and partially hides adjacent horizontal curve.	Improve Safety – I.A	Flatten curve
9	**Badd's Place**	**34.5-35.6**						
		34.5-35.6	Horizontal curve	DKS analysis	0	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
		34.7-35.1	Roadway width	DKS analysis	0	Roadway width is restricted by steep side slopes, creating potentially unsafe driving conditions between opposing vehicles and reducing drivers' margin of error.	Improve Safety – I.D	- Widen roadway to minimum of 24'. - Reduce steepness of side slopes - Install guardrails

Table D-2 (cont.)
Preliminary Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Preliminary Improvement Options
			Description	Source	Comment Frequency*			
		34.9-35	Roadside hazards	DKS analysis	0	Trees in clear zone and steep side slopes reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	- Remove roadside hazards - Install guardrail
		34.9	- Vertical curve - Horizontal curves	- Informational Meetings - DKS analysis	5	Combination of vertical curve and adjacent horizontal curves limit stopping sight distance.	Improve Safety - I.A	Flatten vertical curve
		35.0-35.6	- Roadway width - Roadside hazards	DKS analysis	0	Narrow roadway width (21'), trees in clear zone, and steep side slopes create potentially unsafe driving conditions between opposing vehicles and reduce drivers' margin of error.	Improve Safety – I.A, I.D	- Widen roadway to minimum of 24'. - Remove roadside hazards - Install guardrail
10	**Badd's Place**	**35.6-39.0**						
		35.6-35.9	Roadside hazards	DKS analysis	0	Several steep side slopes and cuts in clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Install guardrail
		35.9-39.0	Roadside hazards	DKS analysis	0	Trees in the clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	- Remove trees - Install guardrail
		37.3-37.5	- Vertical curve - Horizontal curve	DKS analysis	0	Vertical and horizontal curves restrict stopping sight distance.	Improve Safety – I.A	Increase radius of horizontal curve and relocate crest of vertical curve beyond horizontal curve.
		37.6-37.8	Vertical curve	DKS analysis	0	Horizontal curve is hidden from driver by crest vertical curve, with steep side slope on outside of curve.	Improve Safety – I.A	Flatten vertical curve
		37.7-38.0	Vertical curve	DKS analysis	0	Vertical curve limits sight distance.	Improve Safety – I.A	Flatten vertical curve.
		38.1-38.7	- Vertical curve - Roadside obstruction	DKS analysis	0	Embankment on east side of road restricts sight distance through horizontal curve.	Improve Safety – I.A	Flatten vertical curve and remove portion of embankment to increase sight distance.

Table D-2 (cont.)
Preliminary Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Preliminary Improvement Options
			Description	Source	Comment Frequency*			
11	Badd's Place	39.1-39.3	- Horizontal curves - Roadside obstruction	- Informational Meetings - DKS analysis	4	Sharp curves can limit stopping sight distance and cause loss of vehicle control. Stopping sight distance restricted by roadside embankment.	Improve Safety - IA	Combine "S" curves and remove portion of embankment.
12	Badd's Place	39.5-39.7	- Vertical curve - Horizontal curve - Roadside hazard	DKS analysis	0	Combination of horizontal and vertical curves restricts sight distance. Steep side slope reduces likelihood of recovery for errant vehicles.	Improve Safety - I.A, I.D	- Flatten vertical curve and increase radius of horizontal curve. - Install guardrail
13	S. of Old Sec. 236 Alignment	40.3	- Vertical curve - Horizontal curve	- Informational Meetings - Agency staff - DKS analysis	7	Horizontal curve is hidden from driver by crest vertical curve.	Improve Safety – I.A	Flatten vertical curve and increase radius of horizontal curve.
14	S. of Old Sec. 236 Alignment	41.3	Horizontal curve	- Informational Meetings - DKS analysis	4	Sharp curve could cause loss of vehicle control.	Improve Safety - IA	Increase radius of horizontal curve and include transition into adjacent curve.
15	S. of Old Sec. 236 Alignment	41.5-41.6	Horizontal curve	DKS analysis	0	Sharp curve could cause loss of vehicle control.	Improve Safety - IA	Increase radius of horizontal curve and include transition into adjacent curve.
16	Claggett Hill	45.0-47.0	Road surface	- Informational Meetings - Agency staff - Stakeholder interviews	5	Icy road surface causes hazardous driving conditions.	Improve Surface Condition – II.A	Construct chain-up area on either side of hill.
17	N. of Missouri River	48.0-48.2	Horizontal curve	DKS analysis	0	Sharp curve could cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
18	N. of Missouri River	49.6-50.4	Roadway width	DKS analysis	0	Restricted roadway width (21') creates potentially unsafe driving conditions between opposing vehicles and reduces drivers' margin of error.	Improve Safety – I.C.	Increase roadway width to minimum of 24'.
19	**Near Chip Creek**	**51.0 – 53.3**						
		51.0-53	Road surface	Informational Meetings	4	Poor surface conditions in bad weather - can cause loss of vehicle control.	Improve Surface Conditions – II.A, II.C	Remove and replace existing road surface with alternative material.
		51.0-51.4	Vertical curve	DKS analysis	0	Vertical curve limits sight distance.	Improve Safety – I.A	Flatten curve

Table D-2 (cont.)
Preliminary Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Preliminary Improvement Options
			Description	Source	Comment Frequency*			
		51.9-52.7	Vertical curves	DKS analysis	0	Several smaller vertical curves and one long curve limit sight distance.	Improve Safety – I.A	Flatten curves to create single, lower curve.
		52.8-53.3	Vertical curves	DKS analysis	0	Vertical curves limit sight distance.	Improve Safety – I.A	Flatten curve
		53.2	- Vertical curve - Horizontal curves - Lack of signage - Roadside obstruction	- Informational Meetings - Agency staff - DKS analysis	6	Vertical curve limits sight distance through "S" curves. Berm on side of road also restricts sight distance through curves. Seven known accidents (only one reported) at this location, including three rollovers.	Improve Safety – I.A	- Increase radius of horizontal curves. - Install advance warning signs.
20	N. of Jappe Trail	54.9	Road surface - wash boarding	Informational Meetings	2	Wash boarding has adverse affects driving safety, riding comfort, and vehicle condition.	Improve Surface Conditions – II.A, II.B., II.C	- Remove and replace existing road surface with alternative material. - Improve roadway drainage - Use well-graded materials for surface and base. - Use synthetic binders
21	N. Jappe Trail	55.1	Horizontal curve	- Agency staff - DKS analysis	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
22	S. of Adamec Rd.	57.2	Horizontal curve	Agency staff	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
23	S. of Adamec Rd.	57.7-57.8	Vertical curve	DKS analysis	0	Vertical curve restricts sight distance through horizontal curve.	Improve Safety – I.A	Flatten curve
24	Adamec Rd.	58.5	Skewed intersection	DKS analysis	0	Skewed intersections can cause vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved access/egress for large vehicles.
25	Eight-Mile Bench Rd.	59.4	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved large vehicle access/egress.

Table D-2 (cont.)
Preliminary Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Preliminary Improvement Options
			Description	Source	Comment Frequency*			
26	Iliad Loop (S.)	59.6	Intersection – inadequate turn radius	DKS analysis	0	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved large vehicle access/egress.
27	Eskay Rd. to Beg. of Pavement	61.8-74.0	Roadway surface	- Stakeholder interviews - Agency staff - Informational Meetings	5	Road is difficult and costly to maintain, and reduces speeds and emergency response times. Too much gravel in wider sections.	Improve Surface Conditions – II.A, II.B, II.C	- Remove and replace existing road base and surface with alternative material. - Improve drainage
28	Iliad Loop (N.)	63.5	Intersection – turn radius	DKS analysis	0	Turn radius too tight for large vehicles.	Improve Safety – I.B	Widen Iliad Loop leg to provide improved access/egress for large vehicles.
29	Five Corner Rd.	63.9	Intersection – inadequate turn radius	DKS analysis	0	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved large vehicle access/egress.
30	Eagleton Rd.	67.8-70.0	Road surface	Agency staff	4	Relatively high truck volumes from Eagleton Rd. combined with steep grade in northbound direction result in poor surface conditions (binding problem) and higher maintenance costs.	Improve Surface Conditions – II.A, II.B	- Remove and replace existing road surface with alternative material. - Use synthetic binders
31	Tuttle Rd.	79.0	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved large vehicle access/egress.

Table D-2 (cont.)
Preliminary Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Preliminary Improvement Options
			Description	Source	Comment Frequency*			
32	Zeock Rd.	80.7	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved large vehicle access/egress.
33	**Lone Tree Trail**	**82.8-82.9**						
	Lone Tree Trail (N.)	82.8	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved large vehicle access/egress.
	Lone Tree Trail (S.)	82.9	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. - Widen minor road approaches to provide improved large vehicle access/egress.

* Comment frequency refers to the number of comments received the public, stakeholders, and/or agency staff regarding the same issue.

Evaluation of Preliminary Improvement Options

For locations along the corridor where more than one preliminary improvement option was available, it was necessary to have an evaluation method to determine the recommended option. Therefore, an evaluation procedure was developed based on a set of eight screening criteria and weights.

The improvement options were evaluated by developing scores for the screening criteria. For each option, point scores of between zero and ten were assigned to all of the criteria except cost. The point scores reflect the assessment, based on professional judgment, of the degree to which the improvement option satisfies the criteria. The cost criterion was scored based on planning level cost estimates for the improvement, expressed in current (2010) dollars.

The score for each criterion was multiplied by the associated weight, which reflects the relative importance of the criterion. The weighted scores were normalized to standard units and summed to produce a total weighted score for each option. The option with the highest score was identified as the draft recommended option.

The criteria and their relative weights are summarized in Table D-3 below, followed by a description of each criterion and the corresponding weight.

Table D-3
Improvement Option Screening Criteria

Criteria	Scoring Unit	Weight
1. Cost	$'s	-19
2. Constructability	0 - 10 points	11
3. Minimization of environmental impacts	0 - 10 points	17
4. Addresses concern	0 - 10 points	21
5. Implementation time frame	0 - 10 points	3
6. Potential for project companioning	0 - 10 points	7

Table D-3 (cont.)
Improvement Option Screening Criteria

Criteria	Scoring Unit	Weight
7. Additional benefits	0 - 10 points	7
8. Consistency with ultimate corridor configuration	0 - 10 points	9

1. Cost - Reflects the planning level cost of the improvement option. The weight (-19) has a negative value, because the cost is a negative factor of the improvement options. Therefore, the cost criterion has the effect of lowering the total score for the improvement option.

2. Constructability – Reflects the estimated feasibility of construction. For example, an improvement option on level terrain within the existing right-of-way that could be quickly constructed by county or MDT staff would receive a high score. An option in difficult/steep terrain requiring specialized expertise and equipment would rate much lower. This criterion has a higher weight (11) because constructability is an important determinant of project feasibility.

3. Minimization of Environmental Impacts – Accounts for the estimated amount of environmental impacts associated with an improvement option, including encroachment on private property. Options with no environmental impacts would receive a high score. Options that would encroach into potentially environmentally sensitive areas or require additional right-of-way would receive a lower score. This criterion has a high weight (17) because potential environmental impacts have a strong influence on project feasibility.

4. Addresses Concern - Measures how well an improvement option would address the identified concern for a given location. An option that

completely addresses the concern would receive a higher score than an option that only partially addresses the concern. This criterion has the highest weight (21) because the primary reason for an improvement is to address the concern.

5. Implementation Time Frame - Reflects the amount of time that is anticipated for project programming and environmental documentation. An improvement option that could be immediately undertaken by county or MDT maintenance staff would receive a high score. An option that would require significant time for planning, programming, and environmental studies would receive a lower score. A short implementation time frame is a desirable but relatively minor consideration, so this criterion was assigned the lowest (positive) weight (3).

6. Potential for Project Companioning – Accounts for the value of combining an improvement with a similar, nearby improvement to minimize mobilization and start-up costs. Improvement options that could be easily combined with adjacent improvements would score higher than isolated improvements. This criterion reflects the efficiency of project implementation, which was considered lower in importance than project feasibility and effectiveness (Criteria 2 – 4). Therefore, it was assigned a lower weight (7).

7. Additional Benefits – In certain cases, there may be additional benefits from constructing an improvement, other than addressing the original issue. An example would be a vertical curve near a private driveway that is improved to address a stopping sight distance problem along the road. An additional benefit of this improvement option may be increased intersection sight distance from the private driveway. This criterion was considered lower in

importance than project feasibility and effectiveness (Criteria 2 – 4) and so was assigned a lower weight (7).

8. Consistency with Ultimate Corridor Configuration – Reflects the degree to which an improvement option would match the features of a fully-developed corridor. An improvement option that meets MDT standards would receive a high score while an option that provides a temporary fix would be scored lower. This criterion reflects an important, though not essential, project feature and therefore was assigned a medium weight (9).

The draft recommended improvement options are listed in the far right-hand column of Table D-4. The total score for each preliminary improvement option is shown for locations where the screening criteria were applied, with the draft recommended options highlighted in red.

Table D-4
Draft Recommended Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Draft Recommended Improvement Options
			Description	Source	Comment Frequency*			
1	**N. of Winifred**	**24.2-24.8**						
		24.2-24.8	Vertical curve	- Agency staff - DKS analysis	1	Vertical curve limits stopping sight distance and intersection sight distance – access points at top and bottom of hill.	Improve Safety – I.A	Flatten vertical curve
		24.2-24.3	Horizontal curve	- Agency staff - DKS analysis	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase horizontal curve radius
2	Yapps Corner	25.7	- Vertical curve - Horizontal curve	- Agency staff - DKS analysis	3	Vertical curve hides 90-degree horizontal curve from driver, creating stopping sight distance problem.	Improve Safety - IA	Flatten vertical curve and increase horizontal curve radius.
3	W. of Tobin Ln.	28.8	Vertical curve	- Informational Meetings - DKS analysis	2	Vertical curve limits sight distance.	Improve Safety - IA	Flatten vertical curve
4	**W. of Murphy Ln.**	**30.2-30.9**						
		30.2-30.9	- Vertical curve - Horizontal curve	DKS analysis	0	Combination of vertical/horizontal curves restricts sight distance through the curve.	Improve Safety - IA	Increase horizontal curve radius and flatten vertical curve.
		30.6	- Roadway width - Vertical curves - Horizontal curves - Roadside hazard	- Agency staff - DKS analysis	5	Road narrows to 21’ at culvert location and has two vertical curves that block sight distance, a steep side slope, and four sharp horizontal curves, including a 90-degree curve.	Improve Safety - I.A, I.C, 1.D	Widen road and extend culvert, increase radius of 90-degree curve, combine smaller horizontal curves into single long curve, and flatten vertical curves.
5	**S. of Stulc Ln.**	**31.3 – 32.8**						
		31.3-32.1	Roadside hazard	DKS analysis	0	Two cut slopes and large vegetation exist within clear zone, resulting in limited recovery area for vehicles leaving road.	Improve Safety – I.D	Remove portion of embankment within clear zone and remove vegetation.
		31.4-31.9	- Vertical curves - Roadside obstruction	DKS analysis	0	Combination of crest vertical curve, sag vertical curve, and hill to west restricts stopping sight distance.	Improve Safety – I.A, I.D	Flatten vertical curves and remove portion of hill.
		31.7-32.2	Snow drifts across roadway	Agency staff	1	Drifting snow can result in maintenance and access problems and hazardous driving.	Improve Surface Conditions – II.A, II.B, II.C	Work with landowners to develop a mitigation plan.

Table D-4 (cont.)
Draft Recommended Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Draft Recommended Improvement Options
			Description	Source	Comment Frequency*			
		31.9-32.8	Vertical curves	DKS analysis	0	Stopping sight distance restricted by series of crest and sag vertical curves that create "roller coaster" effect.	Improve Safety – I.A	Flatten and combine vertical curves into single curve.
		32.1-32.2	Roadside hazard	DKS analysis	0	Utility poles and hill cut within clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Relocate poles and remove portion of hill within clear zone.
6	Stulc Ln.	32.5	- Vertical curve - Intersection sight distance	- Agency staff - Informational Meetings - DKS analysis	4	Vertical curve and vegetation near intersection restrict intersection sight distance in both directions. Vertical curve also limits stopping sight distance.	Improve Safety – I.A, I.B, I.D	Remove vegetation and flatten vertical curve.
7	Heggem Ln.	33.6	- Horizontal curve - Vertical curve - Roadway surface - Roadside hazard	- Agency staff - Informational Meetings - DKS analysis	3	Vertical curve and hill on roadside restrict sight distance around 90-degree curve. Vehicles can slide off road at low speeds in muddy conditions.	Improve Safety – I. A, I.B, I.D Improve Surface Conditions – II.A, II.C	- **Increase horizontal curve radius, flatten vertical curve, and realign Heggem Ln. to "T" into S-236. (Total Score = 51)** - Remove and replace existing road base and surface with alternative material. (Total Score = 47)
8	**W. of Heggem Ln.**	**33.7-34.9**						
		33.7-34.9	Roadside hazard	DKS analysis	0	Steep side slope near culvert reduces likelihood of recovery for errant vehicles.	Improve Safety – I.D	- **Reduce steepness of side slope. (Total Score = 45)** - Install guardrail (Total Score = 35)
		33.9-34.0	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance.	Improve Safety – I.A	Flatten curve
		34.1-34.2	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance.	Improve Safety – I.A	Flatten curve
		34.3-34.5	Vertical curve	DKS analysis	0	Vertical curve restricts stopping sight distance and partially hides adjacent horizontal curve.	Improve Safety – I.A	Flatten curve

Table D-4 (cont.)
Draft Recommended Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Draft Recommended Improvement Options
			Description	Source	Comment Frequency*			
9	**Badd's Place**	**34.5-35.6**						
		34.5-35.6	Horizontal curve	DKS analysis	0	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
		34.9-35	Roadside hazards	DKS analysis	0	Trees in clear zone and steep side slopes reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	- **Remove roadside hazards (Total Score = 66)** - Install guardrail (Total Score = 58)
		34.9	- Vertical curve - Horizontal curves	- Informational Meetings - DKS analysis	5	Combination of vertical curve and adjacent horizontal curves limit stopping sight distance.	Improve Safety - I.A	Flatten vertical curve
		35.0-35.1	- Roadway width - Roadside hazards	DKS analysis	0	Narrow roadway width (21'), trees in clear zone, and steep side slopes create potentially unsafe driving conditions between opposing vehicles and reduce drivers' margin of error.	Improve Safety – I.A, I.D	- **Widen roadway to minimum of 24'. (Total Score = 58)** - Remove roadside hazards (Total Score = 36) - Install guardrail (Total Score = 53)
		35.1-35.6	Roadway hazard	DKS analysis	0	Steep side slopes reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	- Reduce steepness of side slopes. (Total Score = 18) - **Install guardrails (Total Score = 80)**
10	**Badd's Place**	**35.6-39.0**						
		35.6-35.9	Roadside hazards	DKS analysis	0	Several steep side slopes and cuts in clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Install guardrail
		35.9-39.0	Roadside hazards	DKS analysis	0	Trees in the clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	- **Remove trees (Total Score = 73)** - Install guardrail (Total Score = 7)
		37.3-37.5	- Vertical curve - Horizontal curve	DKS analysis	0	Vertical and horizontal curves restrict stopping sight distance.	Improve Safety – I.A	Increase radius of horizontal curve and relocate crest of vertical curve beyond horizontal curve.
		37.6-37.8	Vertical curve	DKS analysis	0	Horizontal curve is hidden from driver by crest vertical curve, with steep side slope on outside of curve.	Improve Safety – I.A	Flatten vertical curve

Table D-4 (cont.)
Draft Recommended Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Draft Recommended Improvement Options
			Description	Source	Comment Frequency*			
		37.7-38.0	Vertical curve	DKS analysis	0	Vertical curve limits sight distance.	Improve Safety – I.A	Flatten vertical curve.
		38.1-38.7	- Vertical curve - Roadside obstruction	DKS analysis	0	Embankment on east side of road restricts sight distance through horizontal curve.	Improve Safety – I.A	Flatten vertical curve and remove portion of embankment to increase sight distance.
11	Badd's Place	39.1-39.3	- Horizontal curves - Roadside obstruction	- Informational Meetings - DKS analysis	4	Sharp curves can limit stopping sight distance and cause loss of vehicle control. Stopping sight distance restricted by roadside embankment.	Improve Safety - IA	Combine "S" curves and remove portion of embankment.
12	Badd's Place	39.5-39.7	- Vertical curve - Horizontal curve - Roadside hazard	DKS analysis	0	Combination of horizontal and vertical curves restricts sight distance. Steep side slope reduces likelihood of recovery for errant vehicles.	Improve Safety - I.A, I.D	Flatten vertical curve and increase radius of horizontal curve and install guardrail.
13	S. of Old Sec. 236 Alignment	40.3	- Vertical curve - Horizontal curve	- Informational Meetings - Agency staff - DKS analysis	7	Horizontal curve is hidden from driver by crest vertical curve.	Improve Safety – I.A	Flatten vertical curve and increase radius of horizontal curve.
14	S. of Old Sec. 236 Alignment	41.3	Horizontal curve	- Informational Meetings - DKS analysis	4	Sharp curve could cause loss of vehicle control.	Improve Safety - IA	Increase radius of horizontal curve and include transition into adjacent curve.
15	S. of Old Sec. 236 Alignment	41.5-41.6	Horizontal curve	DKS analysis	0	Sharp curve could cause loss of vehicle control.	Improve Safety - IA	Increase radius of horizontal curve and include transition into adjacent curve.
16	Claggett Hill	45.0-47.0	Road surface	- Informational Meetings - Agency staff - Stakeholder interviews	5	Icy road surface causes hazardous driving conditions.	Improve Surface Condition – II.A	Construct chain-up area on either side of hill.
17	N. of Missouri River	48.0-48.2	Horizontal curve	DKS analysis	0	Sharp curve could cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
18	N. of Missouri River	49.6-50.4	Roadway width	DKS analysis	0	Restricted roadway width (21') creates potentially unsafe driving conditions between opposing vehicles and reduces drivers' margin of error.	Improve Safety – I.C.	Increase roadway width to minimum of 24'.

Table D-4 (cont.)
Draft Recommended Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Draft Recommended Improvement Options
			Description	Source	Comment Frequency*			
19	**Near Chip Creek**	**51.0 – 53.3**						
		51.0-53	Road surface	Informational Meetings	4	Poor surface conditions in bad weather - can cause loss of vehicle control.	Improve Surface Conditions – II.A, II.C	Remove and replace existing road surface with alternative material.
		51.0-51.4	Vertical curve	DKS analysis	0	Vertical curve limits sight distance.	Improve Safety – I.A	Flatten curve
		51.9-52.7	Vertical curves	DKS analysis	0	Several smaller vertical curves and one long curve limit sight distance.	Improve Safety – I.A	Flatten curves to create single, lower curve.
		52.8 – 53.3	- Vertical curve - Horizontal curves - Lack of signage - Roadside obstruction	- Informational Meetings - Agency staff - DKS analysis	6	Vertical curve limits sight distance through "S" curves. Berm on side of road also restricts sight distance through curves. Seven known accidents (only one reported) at this location, including three rollovers.	Improve Safety – I.A	- Increase radius of horizontal curves and flatten vertical curves. (Total Score = 44) - **Install advance warning signs. (Total Score = 54)**
20	**N. of Jappe Trail/Jappe Trail**	**54.7 – 55.1**						
		54.7 – 55.1	Road surface - wash boarding	Informational Meetings	2	Wash boarding has adverse affects driving safety, riding comfort, and vehicle condition.	Improve Surface Conditions – II.A, II.B., II.C	- Remove and replace existing road surface with alternative material. (Total Score = 53) - Improve roadway drainage (Total Score = 59) - **Use well-graded materials for surface and base. (Total Score = 85)**
		55.1	Horizontal curve	- Agency staff - DKS analysis	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
22	S. of Adamec Rd.	57.2	Horizontal curve	Agency staff	1	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of curve
23	S. of Adamec Rd.	57.7-57.8	Vertical curve	DKS analysis	0	Vertical curve restricts sight distance through horizontal curve.	Improve Safety – I.A	Flatten curve
24	Adamec Rd.	58.5	Skewed intersection	DKS analysis	0	Skewed intersections can cause vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. (Total Score = 47) - **Widen minor road approaches to provide improved access/egress for large vehicles. (Total Score = 51)**

Table D-4 (cont.)
Draft Recommended Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Draft Recommended Improvement Options
			Description	Source	Comment Frequency*			
25	Eight-Mile Bench Rd.	59.4	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- **Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. (Total Score = 44)** - Widen minor road approaches to provide improved large vehicle access/egress. (Total Score = 40)
26	Iliad Loop (S.)	59.6	Intersection – inadequate turn radius	DKS analysis	0	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. (Total Score = 32) - **Widen minor road approaches to provide improved large vehicle access/egress. (Total Score = 52)**
27	Eskay Rd. to Beg. of Pavement	61.8-74.0	Roadway surface	- Stakeholder interviews - Agency staff - Informational Meetings	5	Road is difficult and costly to maintain, and reduces speeds and emergency response times. Too much gravel in wider sections.	Improve Surface Conditions – II.A, II.B, II.C	- **Remove and replace existing road base and surface with alternative material. (Total Score = 55)** - Improve drainage (Total Score = 43)
28	Iliad Loop (N.)	63.5	Intersection – turn radius	DKS analysis	0	Turn radius too tight for large vehicles.	Improve Safety – I.B	Widen Iliad Loop leg to provide improved access/egress for large vehicles.
29	Five Corner Rd.	63.9	Intersection – inadequate turn radius	DKS analysis	0	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. (Total Score = 32) - **Widen minor road approaches to provide improved large vehicle access/egress. (Total Score = 52)**
30	Eagleton Rd.	67.8-70.0	Road surface	Agency staff	4	Relatively high truck volumes from Eagleton Rd. combined with steep grade in northbound direction result in poor surface conditions (binding problem) and higher maintenance costs.	Improve Surface Conditions – II.A, II.B	Remove and replace existing road surface with alternative material.

Table D-4 (cont.)
Draft Recommended Improvement Options

No.	Location	Reference Post(s)	Problem/Concern			Basis of Issue	Need Category	Draft Recommended Improvement Options
			Description	Source	Comment Frequency*			
31	Tuttle Rd.	79.0	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- **Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. (Total Score = 43)** - Widen minor road approaches to provide improved large vehicle access/egress. (Total Score = 41)
32	Zeock Rd.	80.7	Skewed intersection	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- Realign intersection so that minor road legs are at ~ 90-degree angle to S-236. (Total Score = 38) - **Widen minor road approaches to provide improved large vehicle access/egress. (Total Score = 46)**
33	Lone Tree Trail (N. and S.)	82.8-82.9	Skewed intersections	DKS analysis	0	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approach.	Improve Safety – I.B.	- **Combine existing intersections into one "T" intersection with S-236. (Total Score = 45)** - Widen minor road approaches to provide improved large vehicle access/egress. (Total Score = 39)

* Comment frequency refers to the number of comments received the public, stakeholders, and/or agency staff regarding the same issue.

Estimation of Improvement Costs

The methodology for calculating the improvement cost estimates shown was based on unit cost data and the quantities of material that would be required to construct the improvements.

Unit Cost Data

Two sets of data were provided by MDT for the purpose of estimating construction costs. The first data set consisted of average unit costs for materials purchased by MDT in 2010. Table D-5 contains the 13 relevant unit costs used for estimating the construction costs of the spot improvements.

Table D-5
Unit Material Costs

Material	Description	Unit Measure*	Unit Cost
Excavation street	Removal of material from within the roadway	CUYD	$15.70
Embankment-in-place	Removal of embankment material outside of roadway	CUYD	$8.50
Crushed aggregate course	Base material for roadway construction	CUYD	$15.73
Shoulder gravel	Roadway shoulder material	CUYD	$10.53
Traffic gravel	Material for top course of roadway	CUYD	$15.58
Special backfill	Fill material for low sections of roadway	CUYD	$12.70
Commercial mix-PG 70-28	Hot-mix asphalt mix	TON	$84.66
W8X28 culvert stiffener	Reinforcement material for culverts	LNFT	$93.00
Culvert-liner concrete	Material for the repair of culverts	LNFT	$195.36
Guardrail stiffened	Guardrail	LNFT	$45.72
Guardrail- optional term sect	Guardrail end treatment	EACH	$2,592.31
Remove and reset exist pole	Move existing utility pole to new location	LS	$3,000.00

Table D-5 (cont.)
Unit Material Costs

Material	Description	Unit Measure*	Unit Cost
Geogrid-bi-axial	Composite material for stabilizing retaining walls, slopes, and road base	SQYD	$2.31

* CUYD = cubic yard
LNFT = linear foot
LS = lump sum

The second data set contained the approximate costs for roadway reconstruction and rehabilitation activities. Two of the 10 possible activities included in the data set were applicable S-236 corridor. The cost estimates for these activities were valid for finished roadway surface widths ranging between 24 to 40 feet. For this corridor, a 26-foot wide finished surface is assumed. Table D-6 shows the cost per mile for the two roadway reconstruction activities.

Table D-6
Construction Cost per Mile

Improvement Type	Cost per Mile*
Reconstruct to Gravel	$404,213
Reconstruct to Pavement	$808,427

* This cost assumes a 26-foot wide cross-section.

Quantity Calculations

The quantities of material are the second component of the construction cost estimation equation. The primary data sources for the quantity calculations were the same as those used for the existing and future conditions analysis. Table D-7 identifies the data sources used for each improvement type.

Table D-7
Data Sources for Quantity Calculations

Improvement Type	Data Source
Horizontal curve	MDT GIS shape files, Google Earth Pro
Vertical curve	MDT video log database (GPS Data)
Roadway width	MDT roadway inventory data
Roadside hazard	MDT video log

Horizontal Curve, Vertical Curve, and Road Width Improvements

For the horizontal curve, vertical curve, and roadway width improvement types, three values were required to calculate the volume of material that would need to be removed or added to the project site: depth, width and length.

Figure D-8: Steep vertical curve (R.P. 35.7)

Depth

The required depth for vertical curve improvements was estimated based on in-roadway elevation data collected by MDT using a GPS-enabled video log vehicle. This data, together with the K-values for vertical curves described in the Section 3.1, were used to estimate the depth of earth removal or fill needed to bring a vertical curve up to MDT's standard. The K-value is defined as the horizontal distance needed to produce a one percent change in gradient.[2] Table D-8 shows the K-value formulas for crest and sag vertical curves for various speeds and the minimum K-values required to meet MDT's stopping sight distance standards.

[2] Montana Department of Transportation, *Road Design Manual*, Helena, MT, August 2008.

Table D-8
Stopping Sight Distance and K-Value Requirements

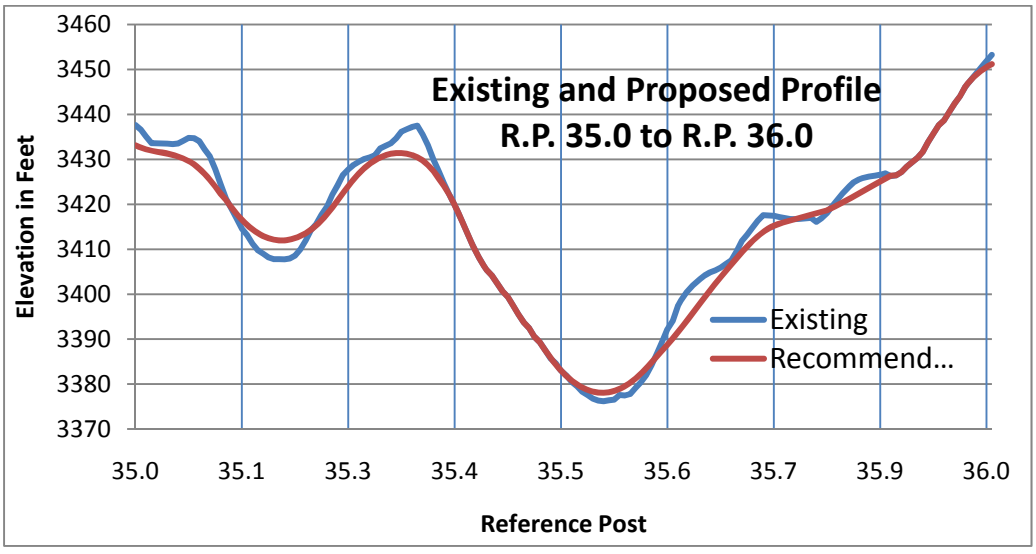
Criteria	Formula	Design Speed		
		45 mph	50 mph	60 mph
Stopping sight distance		360’	425’	570’
Crest vertical curve	$K = \frac{S^2}{2158}$	61	84	151
Sag Vertical Curve	$K = \frac{S^2}{400 + 3.5 * S}$	79	96	136

Note: S = Stopping Sight Distance

The depth calculations were performed as follows:

- The existing roadway profile was determined using MDT’s GPS data.
- The minimum required K-values were calculated for all of the hills and valleys (crest and sag vertical curves) along the corridor.
- New (proposed) vertical curves are calculated for the locations that did not meet the standard.
- The difference between the existing elevation and the proposed elevation was the depth of cut or fill required.

Figure D-1: Existing and Proposed Road Profile



A similar process is used to calculate the depth of construction for the realignment of horizontal curves. There were slight differences, since the realignment of horizontal curves involves construction outside of the existing roadway centerline, where detailed elevation data is not available. Therefore, the depths calculated using this technique served as starting points that were refined based on the specific requirements of each horizontal curve. Approximations for the cut or fill material needed were based on field visits and the MDT video log photos.

Width

The width of earth that must be removed or filled-in is directly related to the depth of the cut or fill required by the proposed improvement. Without the assistance of retaining walls, cuts or fills in soil need to be sloped at a minimum angle away from the road to maintain material stability. Because of this, it is important to account for the additional material represented by having a slope instead of a cliff.

The side slope design criterion for this roadway is described in MDT's Geometric Design Table.[3] The design side slopes used for this analysis were 5:1 for cut sections and 4:1 for fill sections. The difference in the allowable side slope for cut versus fill slopes stems from the material properties of the soils. Typically, less is known about the material properties of cut sections than fill sections. Because of this, it is assumed that cut slopes cannot support as steep of a slope as fill slopes.

In addition to the material properties of the native soils, there are several other factors such as driver safety, design standards, and construction cost that play a role in determining the width of the cut or fill needed for an improved section of road.

[3] Montana Department of Transportation, *Road Design Manual*, Helena, MT, August 2008.

Length

Once the required depth of a cut or fill for a vertical curve improvement has been determined, the length of the improvement is can be estimated from the locations where the differences between the existing and proposed vertical curves become zero. These are the locations where the new alignment ties in with the existing roadway profile. The length of the roadway will decrease slightly with improvements to the vertical alignment. For the purpose of cost estimation, the length is calculated along the existing profile between these two points.

The length of a horizontal curve improvement is calculated as the product of the radius and deflection angle of the roadway. The length is measured along the new (proposed) centerline of the curve between the existing tangent sections of the roadway.

Roadside Hazards

Direct measurements of roadside hazards along the corridor, such as the elevation of hills or valleys, were not available. Therefore, the quantities for the roadside hazard improvements (e.g., the length of guardrail or volume of cuts and fills) were estimated using the MDT video log, in-field observations, and GIS data. This was done by identifying the start and end locations of the hazard in the MDT video log and then correlating these locations with the roadway using GIS data. Once the locations were identified, the length of the required improvement was measured along the roadway centerline between the two points.

Cost Calculation

Cost calculations for the project bundles were performed for each implementation scenario. For the Spot Improvements implementation scenario, calculation of the improvement cost estimates was a simple exercise in multiplying the unit cost of each of the required materials by the estimated material quantity, then summing the individual cost components:

$$Cost = \sum Unit\ Cost * Material\ Quantity$$

Cost estimates for the project bundles under the Reconstruct-to-Gravel and Reconstruct/ Rehabilitate-to-Pavement scenarios were calculated as the sum of spot improvement costs and the cost of reconstruction-to-gravel or the cost of reconstruction/rehabilitation-to-pavement for the overall segment.

The reconstruction/rehabilitation cost for the overall segment was estimated by multiplying the cost per mile for reconstruction/rehabilitation by the segment length. However, because the reconstruction/rehabilitation cost was included as a part of spot improvement cost estimates, the total length of the spot improvements within each bundle was subtracted from the total segment length to avoid double-counting of the reconstruction/rehabilitation cost for the spot improvements. Thus, the total cost of the project bundles was estimated as:

$$Total\ Cost = \sum Spot\ Improvement\ Cost + Cost\ per\ Mile * (Project\ Bundle\ Length - \sum Spot\ Improvement\ Length)$$

The difference between reconstruct-to-pavement and rehabilitate-to-pavement scenarios is the level of effort required to construct the final roadway. Under a reconstruction scenario, it is assumed that the entire roadway will need to be replaced. With rehabilitation, it is assumed that most of the roadway base is ready to accept pavement. Therefore, rehabilitation would be less costly than reconstruction.

Project Bundles

Projects that are similar and have close proximity are more efficient to implement as a group or bundle. The proposed project bundles are only preliminary groupings of the improvement options. The bundles may also serve as a starting point for future project development. How the improvement options would be implemented will depend on the amount and timing of future funding and the implementation strategy decided upon by the counties, in coordination with MDT.

Two examples of how the proposed project bundles may be modified are provided below:

- Example 1: In addition to constructing the spot improvement options, the segment of road within the bundle will be paved at the same time. If available funding is $2 million and the estimated cost of the improvements, including the paving, is $2.5 million, an adjustment could be made to shorten the length of original segment to fit the available funding.
- Example 2: If instead of improving the corridor segment-by-segment, it is more important to address high priorities throughout the corridor, the bundles could be broken into smaller project subgroups comprising the high priorities.

The proposed project bundles and improvement options included in each are shown in Table D-9 and Figure D-2. There is no bundle for the northernmost portion of the corridor between RP 83.5 and RP 90 because no improvements were identified for this area. Following this, an overview of the general improvement types included in the project bundles is provided.

Table D-9
Project Bundles

Project Bundle	Implementation Scenario	Improvement No.	Location	Reference Posts	Issues	Basis of Issue	Need Category	Improvements	Estimated Cost
1 – North of Winifred				**24.0-29.5**					
	1 - Spot Improvements								**$2,240,000**
		1	N. of Winifred	24.2-24.8	Vertical curve	Vertical curve limits stopping sight distance and intersection sight distance. Access points at top and bottom of hill.	Improve Safety – I.A	Flatten vertical curve.	$670,000
				24.2-24.3	Horizontal curve	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase horizontal curve radius.	
		2	Yapp's Corner	25.7	- Vertical curve - Horizontal curve	Vertical curve hides 90-degree horizontal curve from driver, creating stopping sight distance problem.	Improve Safety - I.A	1. Flatten vertical curve. 2. Increase radius of horizontal curve.	$870,000
		3	W. of Tobin Ln.	28.8	Vertical curve	Vertical curve limits stopping sight distance.	Improve Safety - I.A	Flatten vertical curve.	$720,000
	2 - Reconstruct-to-Gravel (incl. Spot Improvements)			24.0-29.5				1. Construct Spot Improvements 1 – 3. 2. Reconstruct roadway to gravel surface.	$4,470,000
	3 - Reconstruct-to-Pavement (incl. Spot Improvements)			24.0-29.5				1. Construct Spot Improvements 1 – 3. 2. Reconstruct roadway to paved surface.	$6,690,000
2 - Murphy Lane - Heggem Lane				**29.5-34.5**					
	1 – Spot Improvements								**$3,400,000**
		4	W. of Murphy Ln.	30.2-30.9	- Vertical curve - Horizontal curve	Combination of vertical and horizontal curves restricts stopping sight distance through curve.	Improve Safety – I.A	1. Flatten vertical curve. 2. Increase radius of horizontal curve.	$730,000
				30.6	- Roadway width - Vertical curves - Horizontal curves - Roadside hazard	Road narrows to 21' at culvert location. Also two vertical curves that block sight distance, a steep side slope, and four sharp horizontal curves, including a 90-degree curve.	Improve Safety – I.A, I.C, 1.D	1. Widen road to accommodate minimum of 26' paved surface and extend culvert. 2. Flatten vertical curves. 3. Increase radius of 90-degree curve. 4. Combine smaller horizontal curves into single long curve.	

Table D-9 (cont.)
Project Bundles

Project Bundle	Implementation Scenario	Improvement No.	Location	Reference Posts	Issues	Basis of Issue	Need Category	Improvements	Estimated Cost
		5	S. of Stulc Ln.	31.3-32.1	Roadside hazard	Two cut slopes and large vegetation exist within clear zone, resulting in limited recovery area for vehicles leaving road.	Improve Safety – I.D	Remove portion of embankment within clear zone and remove vegetation.	$670,000
				31.4-31.9	- Vertical curves - Roadside obstruction	Combination of crest vertical curve, sag vertical curve, and hill to west restricts stopping sight distance.	Improve Safety – I.A, I.D	1. Flatten vertical curves. 2. Remove portion of hill.	
				31.7-32.2	Snow drifts across roadway	Drifting snow can result in maintenance and access problems and hazardous driving.	Improve Surface Conditions – II.A, II.B, II.C	Work with landowners to develop mitigation plan.	
				31.9-32.8	Vertical curves	Stopping sight distance restricted by series of crest and sag vertical curves that create “roller coaster” effect.	Improve Safety – I.A	Flatten and combine vertical curves into single curve.	
				32.1-32.2	Roadside hazard	Utility poles and hill cut within clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Relocate poles and remove portion of hill within clear zone.	
		6	Stulc Ln.	32.5	- Vertical curve - Intersection sight distance	Vertical curve and vegetation near intersection restrict intersection sight distance in both directions. Vertical curve also limits stopping sight distance.	Improve Safety – I.A, I.B, I.D	1. Flatten vertical curve. 2. Remove vegetation.	$1,110,000
		7	Heggem Ln.	33.6	- Horizontal curve - Vertical curve - Roadway surface - Roadside hazard	Vertical curve and hill on roadside restrict stopping sight distance around 90-degree curve. Vehicles can slide off road at low speeds in muddy conditions.	Improve Safety – I. A, I.B, I.D Improve Surface Conditions – II.A, II.C	1. Flatten vertical curve. 2. Increase radius of horizontal curve. 3. Realign Heggem Ln. to “T” into S-236.	$610,000
		8	W. of Heggem Ln.	33.7-34.9	Roadside hazard	Steep side slope near culvert reduces likelihood of recovery for errant vehicles.	Improve Safety – I.D	Reduce steepness of side slope.	$290,000
				33.9-34.0	Vertical curve	Vertical curve restricts stopping sight distance.	Improve Safety – I.A	Flatten vertical curve.	
				34.1-34.2	Vertical curve	Vertical curve restricts stopping sight distance.	Improve Safety – I.A	Flatten vertical curve.	
				34.3-34.5	Vertical curve	Vertical curve restricts stopping sight distance and partially hides adjacent horizontal curve.	Improve Safety – I.A	Flatten vertical curve.	

Table D-9 (cont.)
Project Bundles

Project Bundle	Implementation Scenario	Improvement No.	Location	Reference Posts	Issues	Basis of Issue	Need Category	Improvements	Estimated Cost
	2 - Reconstruct-to-Gravel (incl. Spot Improvements)			29.5-34.5				1. Construct Spot Improvements 4 – 8. 2. Reconstruct roadway to gravel surface.	$5,430,000
	3 - Reconstruct-to-Pavement (incl. Spot Improvements)			29.5-34.5				1. Construct Spot Improvements 4 – 8. 2. Reconstruct roadway to paved surface.	$7,450,000
3 – Badd's Place				**34.5-41.8**					
	1 – Spot Improvements								**$5,710,000**
		9	Badd's Place	34.5-35.6	Horizontal curve	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of horizontal curve.	$970,000
				34.9-35	Roadside hazards	Trees in clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Remove trees.	
				34.9	- Vertical curve - Horizontal curves	Combination of vertical curve and adjacent horizontal curves limit stopping sight distance.	Improve Safety – I.A	Flatten vertical curve.	
				35.0-35.1	- Roadway width - Roadside hazards	Narrow roadway width (21'), trees in clear zone, and steep side slopes create potentially unsafe driving conditions between opposing vehicles and reduce drivers' margin of error.	Improve Safety – I.A, I.D	Widen roadway to accommodate minimum of 26' paved surface.	
				35.1-35.6	Roadway hazard	Steep side slopes reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Install guardrail.	
		10	Badd's Place	35.6-35.9	Roadside hazards	Several steep side slopes and cuts in clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Install guardrail.	$3,240,000
				36.3-36.9	- Vertical curve - Horizontal curve	Vertical and horizontal curves restrict stopping sight distance.	Improve Safety – I.A	1. Increase radius of horizontal curve. 2. Flatten vertical curve.	
				37.3-37.5	- Vertical curve - Horizontal curve	Vertical and horizontal curves restrict stopping sight distance.	Improve Safety – I.A	1. Increase radius of horizontal curve. 2. Relocate crest of vertical curve beyond horizontal curve.	
				35.9-39.0	Roadside hazards	Trees in the clear zone reduce likelihood of recovery for errant vehicles.	Improve Safety – I.D	Remove trees.	

Table D-9 (cont.)
Project Bundles

Project Bundle	Implementation Scenario	Improvement No.	Location	Reference Posts	Issues	Basis of Issue	Need Category	Improvements	Estimated Cost
				37.6-37.8	Vertical curve	Crest vertical curve hides horizontal curve from driver. Steep side slope on outside of curve.	Improve Safety – I.A	Flatten vertical curve.	
				37.7-38.0	Vertical curve	Vertical curve limits stopping sight distance.	Improve Safety – I.A	Flatten vertical curve.	
				38.1-38.7	- Vertical curve - Roadside obstruction	Vertical curve and embankment on east side of road restricts stopping sight distance through horizontal curve.	Improve Safety – I.A	1. Flatten vertical curve. 2. Remove portion of embankment.	
		11	Badd's Place	39.1-39.3	- Horizontal curves - Roadside obstruction	Sharp curves can limit stopping sight distance and cause loss of vehicle control. Stopping sight distance also restricted by roadside embankment.	Improve Safety – I.A	1. Combine "S" curves. 2. Remove portion of embankment.	$370,000
		12	Badd's Place	39.5-39.7	- Vertical curve - Horizontal curve - Roadside hazard	Combination of horizontal and vertical curves restricts stopping sight distance. Steep side slope reduces likelihood of recovery for errant vehicles.	Improve Safety – I.A, I.D	1. Flatten vertical curve. 2. Increase radius of horizontal curve. 3. Install guardrail.	$180,000
		13	S. of Old Sec. 236 Alignment	40.3	- Vertical curve - Horizontal curve	Horizontal curve is hidden from driver by crest vertical curve.	Improve Safety – I.A	1. Flatten vertical curve. 2. Increase radius of horizontal curve.	$320,000
		14	S. of Old Sec. 236 Alignment	41.3	Horizontal curve	Sharp curve could cause loss of vehicle control.	Improve Safety – I.A	Increase radius of horizontal curve and include transition into adjacent curve.	$310,000
		15	S. of Old Sec. 236 Alignment	41.5-41.6	Horizontal curve	Sharp curve could cause loss of vehicle control.	Improve Safety – I.A	Increase radius of horizontal curve and include transition into adjacent curve.	$340,000
	2 - Reconstruct-to-Gravel (incl. Spot Improvements)			34.5-41.8				1. Construct Spot Improvements 9 – 15. 2. Reconstruct roadway to gravel surface.	$8,670,000
	3 - Reconstruct-to-Pavement (incl. Spot Improvements)			34.5-41.8				1. Construct Spot Improvements 9 – 15. 2. Reconstruct roadway to paved surface.	$11,620,000
4 – Claggett Hill				**41.8-48.0**					
	1, 2 – Spot Improvements								**$60,000**
		16	Claggett Hill	45.3-47.0	Road surface	Icy road surface causes hazardous driving conditions.	Improve Surface Condition – II.A	Construct chain-up area on either side of hill.	$60,000

Table D-9 (cont.)
Project Bundles

Project Bundle	Implementation Scenario	Improvement No.	Location	Reference Posts	Issues	Basis of Issue	Need Category	Improvements	Estimated Cost
	3 - Rehabilitate-to-Pavement (incl. Spot Improvements)			41.8-45.3 47.0-47.9				1. Construct Spot Improvement 16. 2. Rehabilitate roadway to paved surface.	$4,660,000
5 – North of Missouri River				**48.0-53.5**					
	1 – Spot Improvements								**$2,170,000**
		17	N. of Missouri River	48.0-48.2	Horizontal curve	Sharp curves can cause loss of vehicle control.	Improve Safety – I.A	Increase radius of horizontal curve.	$270,000
		18	N. of Missouri River	49.6-50.4	Roadway width	Restricted roadway width (21') creates potentially unsafe driving conditions between opposing vehicles and reduces drivers' margin of error.	Improve Safety – I.C	Widen roadway to accommodate minimum of 26' paved surface.	$240,000
		19	Near Chip Creek	51.0-53.0	Road surface	Poor surface conditions in bad weather can cause loss of vehicle control.	Improve Surface Conditions – II.A, II.C	Remove and replace existing road surface with alternative material.	$1,680,000
				51.0-51.4	Vertical curve	Vertical curve limits stopping sight distance.	Improve Safety – I.A	Flatten vertical curve.	
				51.9-52.7	Vertical curves	Several smaller vertical curves and one long curve limit stopping sight distance.	Improve Safety – I.A	Flatten curves to create single, lower curve.	
				52.8 – 53.3	- Vertical curve - Horizontal curves - Lack of signage - Roadside obstruction	Vertical curve limits stopping sight distance through "S" curves. Berm on side of road also restricts sight distance through curves. Seven known accidents (only one reported) at this location, including three rollovers.	Improve Safety – I.A	Install advance warning signs.	
	2 - Reconstruct-to-Gravel (incl. Spot Improvements)			48.0-53.5				1. Construct Spot Improvements 17 – 19. 2. Reconstruct roadway to gravel surface.	$4,400,000
	3 - Reconstruct-to-Pavement (incl. Spot Improvements)			48.0-53.5				1. Construct Spot Improvements 17 – 19. 2. Reconstruct roadway to paved surface.	$6,620,000

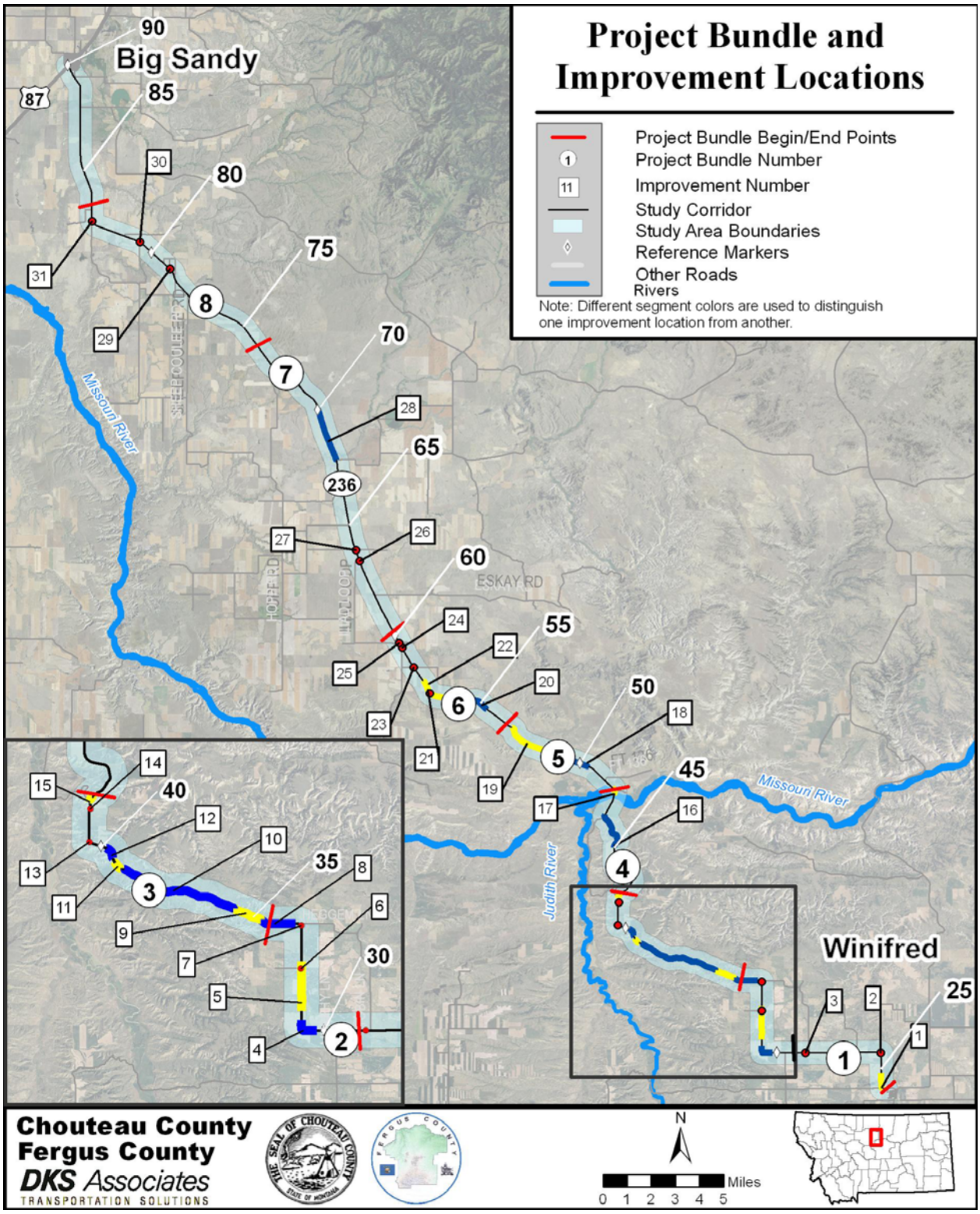
Table D-9 (cont.)
Project Bundles

Project Bundle	Implementation Scenario	Improvement No.	Location	Reference Posts	Issues	Basis of Issue	Need Category	Improvements	Estimated Cost
6 - Near Jappe Trail				**53.5 – 60.0**					
	1 – Spot Improvements								**$950,000**
		20	N. of Jappe Trail/Jappe Trail	54.7 – 55.1	Road surface - wash boarding	Wash boarding has adverse effects on driving safety, riding comfort, and vehicle condition.	Improve Surface Conditions – II.A, II.B, II.C	Use well-graded materials for surface and base.	$440,000
				55.1	Horizontal curve	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of horizontal curve.	
		21	S. of Adamec Rd.	57.2	Horizontal curve	Sharp curves can limit stopping sight distance and cause loss of vehicle control.	Improve Safety – I.A	Increase radius of horizontal curve.	$170,000
		22	S. of Adamec Rd.	57.7-57.8	Vertical curve	Vertical curve restricts stopping sight distance through horizontal curve.	Improve Safety – I.A	Flatten vertical curve.	$140,000
		23	Adamec Rd.	58.5	Skewed intersection	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane.	Improve Safety – I.B	Widen minor road approaches to provide improved access/egress for large vehicles.	$20,000
		24	Eight-Mile Bench Rd.	59.4	Skewed intersection	Skewed intersections can limit intersection sight distance, cause large vehicles to/from minor road to turn into opposing travel lane, and reduce visibility of vehicles on minor road approaches.	Improve Safety – I.B	Realign intersection so that minor road legs are at roughly 90-degree angle to S-236.	$60,000
		25	Iliad Loop (S.)	59.6	Intersection – turn radius	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B	Widen minor road approaches to provide improved access/egress for large vehicles.	$20,000
	2 - Reconstruct-to-Gravel (incl. Spot Improvements)			53.5 – 60.0				1. Construct Spot Improvements 20 – 25. 2. Reconstruct roadway to gravel surface.	$3,580,000
	3 - Reconstruct-to-Pavement (incl. Spot Improvements)			53.5 – 60.0				1. Construct Spot Improvements 20 – 25. 2. Reconstruct roadway to paved surface.	$6,210,000

Table D-9 (cont.)
Project Bundles

Project Bundle	Implementation Scenario	Improvement No.	Location	Reference Posts	Issues	Basis of Issue	Need Category	Improvements	Estimated Cost
7 - The "Wide Spot"				**60.0-74.0**					
	1 – Spot Improvements								**$2,280,000**
		26	Iliad Loop (N.)	63.5	Intersection – turn radius	Turn radius too tight for large vehicles.	Improve Safety – I.B	Widen minor road approach to provide improved access/egress for large vehicles.	$20,000
		27	Five Corner Rd.	63.9	Intersection – turn radius	Intersection is slightly skewed, restricting turning radius for large vehicles.	Improve Safety – I.B	Widen minor road approaches to provide improved access/egress for large vehicles.	$30,000
		28	Eagleton Rd.	67.8-70.0	Road surface	Relatively high truck volumes from Eagleton Rd. combined with steep grade in northbound direction result in poor surface conditions (binding problem) and higher maintenance costs.	Improve Surface Conditions – II.A, II.B	Remove and replace existing road surface with alternative material.	$2,230,000
	2, 3 - Rehabilitate-to-Pavement (incl. Spot Improvements)			60.0-74.0				1. Construct Spot Improvements 26 – 28. 2. Rehabilitate roadway to paved surface.	$9,920,000
8 – Hopp Rd. – Lone Tree Trail				**74.0-83.5**					
	1,2, 3 – Spot Improvements								**$140,000**
		29	Tuttle Rd.	79.0	Skewed intersection	Skewed intersections cause large vehicles to/from minor road to turn into opposing travel lane, and reduce visibility of vehicles on minor road approaches.	Improve Safety – I.B	Realign intersection so that minor road legs are at roughly 90-degree angle to S-236.	$40,000
		30	Zeock Rd.	80.7	Skewed intersection	Skewed intersections can cause large vehicles to/from minor road to turn into opposing travel lane and reduce visibility of vehicles on minor road approaches.	Improve Safety – I.B	Widen minor road approaches to provide improved access/egress for large vehicles.	$30,000
		31	Lone Tree Trail (N. and S.)	82.8-82.9	Skewed intersections	Skewed intersections can limit intersection sight distance, cause large vehicles to/from minor road to turn into opposing travel lane, and reduce visibility of vehicles on minor road approaches.	Improve Safety – I.B	Combine existing intersections into one "T" intersection with S-236.	$70,000

Figure D-2


Project Bundle and Improvement Locations
Project Bundle Begin/End Points
Project Bundle Number
Improvement Number
Study Corridor
Study Area Boundaries
Reference Markers
Other Roads
Rivers
Note: Different segment colors are used to distinguish one improvement location from another.
Big Sandy
Winifred
Missouri River
Judith River
ESKAY RD
HOPPER RD
Chouteau County
Fergus County
DKS Associates
TRANSPORTATION SOLUTIONS
N
Miles
0 1 2 3 4 5

Horizontal Curve Improvements

Three issue locations were determined within Project Bundle 1 to the north of Winifred, including a 90-degree horizontal curve located at Yapp's Corner (R.P. 25.7). Horizontal curves that are too sharp can result in limited sight distance as well as the potential loss of vehicle control. There are two general approaches for addressing horizontal curve problems. The lower-cost approach is to install advance warning signs. The higher-cost approach is to realign the curve. It was determined that for this location, the only reasonable improvement option would be realignment. This was based on the following factors:

Figure D-3: 90-degree curve at Yapp's Corner (R.P. 25.7)

- The curve is already signed in the southbound direction.
- A vertical curve at the same location limits the sight distance for drivers heading north around the curve.
- A second vertical curve to the west (R.P. 25.8) restricts the sight distance to the curve for drivers heading south.
- The land is relatively flat, other than a coulee that the road crosses to the south of Yapp's Corner.
- A realigned horizontal curve would be more consistent with future improvements to the alignment within the overall segment.

Figure D-4: Vertical curve west of Yapp's Corner (R.P. 25.8)

Therefore, the recommended improvement option for this location would be to increase the radius of the horizontal curve and flatten

the adjacent vertical curves to provide adequate sight distance.

Vertical Curve Improvements

Within Project Bundle 3, improvements are recommended at seven vertical curves. An example of one of these curves is shown in the inset below.

Vertical curves restrict the driver's ability to see along the road (sight distance). Two general methods for improving vertical curves are to decrease the sight distance requirements by reducing speeds or flatten the curve. The lower-cost option is to reduce speeds by lowering the speed limit and installing warning signs. Within Project Bundle 3, however, it was determined that flattening of the curves would be the only practical and long-term solution. The reasons for this were:

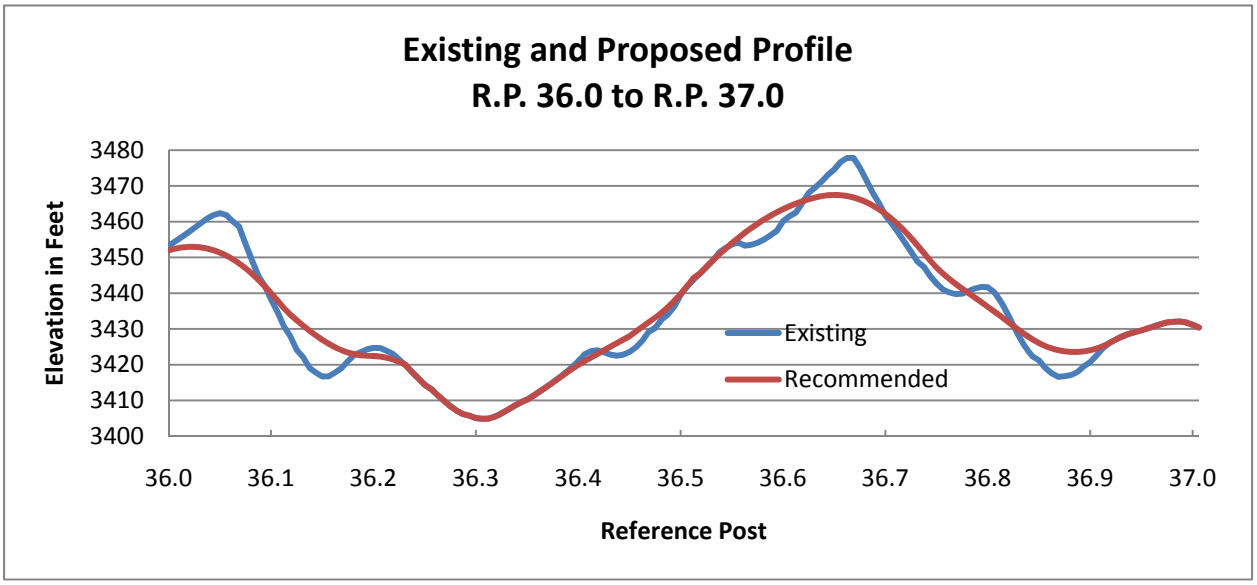
- The Installation of warning signs does not address the key issue of limited sight distance; flattening the curves, on the other hand, would increase the ability of the driver to see objects in the roadway in time to avoid collisions.
- Placing warning signs and reduced speed limits at multiple curves may create driver confusion and lead to disregard for the signs.

Figure D-5: Vertical and horizontal curves at R.P. 36.6

- Flattening the curves could be coupled with improvements to the horizontal curve at the same locations.
- The flattening of one vertical hill often facilitates the flattening of adjacent vertical curves. Figure D-6 illustrates the smoother, more uniform road that results from the flattening of adjacent vertical curves. The locations where the recommended profile is above the existing profile indicate a proposed filling of a sag vertical curve, while the

places where the existing profile is above the proposed profile indicate the cutting of a crest vertical curve.

Figure D-6: Existing and Proposed Roadway Profile



Roadside Hazard Improvements

Figure D-7: Combined horizontal/vertical curve and roadside obstruction south of Stulc Ln. (R.P. 31.5)

Roadside hazards reduce the ability of the driver to make a safe recovery if the vehicle leaves the road. There are five locations within the area covered by Project Bundle 2 where improvements to roadside hazards have been identified. These include steep slopes and fixed objects. Some of the improvements coincide with the locations of recommended vertical and horizontal curve improvements. There are three approaches for improving roadside hazards: delineation, removal, and protection. In the example shown to the right, the hazard is combined with a horizontal and vertical curve. At this

location, the removal of a portion of the embankment is recommended for several reasons, including:

- The embankment and vertical curve restrict sight distance along the road and to a private driveway approximately 300 feet north of the hill; removal of the embankment would also improve sight distance.
- There is a slight curve in the road to accommodate the embankment. The road could the straightened once the embankment is removed.
- Delineation or protection from the hill with guardrail would not minimize the roadside hazard in this case.

Intersection Improvements

Improvements are recommended for three of the county road intersections within the area covered by Project Bundle 7. Improvements are generally recommended when the intersection skew angle is 60-degrees or less and/or the available turn radius is restricted. The intersection shown to the right is skewed, which can limit sight distance for stopped vehicles and cause vehicles to turn into the opposing travel lane when leaving or entering the minor road. Improvement options available at these locations are to widen the minor road leg or realign the minor road to form an intersection angle that is closer to 90-degrees. For this intersection, the recommended improvement is to realign the minor road for the following reasons:

Figure D-8: Skewed intersection with tight turning radius at Eight Mile Bench Rd. (R.P. 59.4)

- It is one of the most skewed intersections along the corridor. Because of this, widening the minor road leg would only minimally improve the intersection.

- The cost of the improvement would be lower than average because it is a T-intersection. Therefore, only one minor road leg would have to be realigned.

Prioritization of Project Bundles

MDT's Secondary Roads Capital Construction Priority Process is used to establish the implementation priority of improvement projects for MDT's secondary road system. The ranking criteria for the process are presented in Table D-10.

Table D-10
MDT Ranking Criteria for Secondary Road Improvement Projects

Criteria	Maximum Score
Safety	100
Scope	90
Geometrics	80
Traffic	70
Maintenance	60

Safety - The score for the safety criterion is calculated based on a formula that incorporates segment - specific and statewide average safety data developed by MDT:

$$Score = \text{DSF} * \left(\frac{SR}{State\ SR} * 4 + \frac{CR}{State\ \text{CR}} * 4 + \frac{SI}{State\ SI} + \frac{ACC\ per\ mile}{State\ ACC\ per\ mile}\right)$$

Where:

- *District Safety Factor (DSF)* is a boosting factor that adds weight to the safety score. The value of this factor agreed upon by the MDT districts is 2.5.
- *Crash Rate (CR)* is the number of crashes per million vehicle-miles traveled.
- *Crash Severity Index (SI)* is the ratio of the number of fatal and incapacitating injury crashes times 8 plus the number of other injury crashes times 3 plus the number of property damage crashes to the total number of crashes.

- *Crash Severity Rate (SR)* is the crash rate multiplied by the severity index.
- *Total Accidents (ACC)* is the total number of accidents recorded for the analysis time period. The time period used for this study was 2004 - 2008.

Scope - The score for the scope criterion is based on the proposed project type, defined according to the categories below:

- *Reconstruct-to-Gravel (90 points)* - Assumes that the existing road surface and roadbed will need to be replaced along the entire length of the segment. Several geometric improvements are also assumed, including the improvement of horizontal and vertical curves as well as the approaches of adjoining public intersections and private driveways.
- *Rehabilitate-to-Pavement (60 points)* - Assumes that most of the existing roadway is in good condition. With the exception of a few spot improvements, the road would need only minor work to prepare it for a pavement surface treatment.
- *Reconstruct-to-Pavement (30 points)* – Assumes that the existing road surface and roadbed will need to be replaced along the entire length of the segment. Several geometric improvements are also assumed, including the improvement of horizontal and vertical curves as well as the approaches of adjoining public intersections and private driveways. These improvements would be necessary to prepare the roadway for a pavement surface treatment.
- *Safety Project (90 points)* - Assumes a project of limited scope that may include improvements to geometric features, such as horizontal or vertical curvature, or improvements to a public intersection. Essentially, this improvement category covers all improvements not included in one of the other categories.

The point differences for each project type are the result of an agreement reached between all Montana counties and MDT during the development of the Secondary Roads Capital Construction Program.

The differences between the points for the Reconstruct-to-Gravel category and the Rehabilitate/Reconstruct-to-Pavement categories are intended to reflect the greater efficiency with which counties can maintain gravel roads compared to paved roads. If a road remains gravel, then counties can continue to maintain it. If road becomes paved, however, MDT usually must become responsible for maintenance, which is less efficient for both MDT and the counties. Therefore, projects in the Reconstruct-to-Gravel category receive more points than projects in the Rehabilitate/Reconstruct-to-Pavement categories.

The scoring system also recognizes the cost differences between reconstruction and rehabilitation activities. Since rehabilitation-to-pavement projects are less costly than reconstruction-to-pavement projects, these are given a higher score.

Safety projects receive a higher score, equivalent to the score for reconstruction-to-gravel projects, reflecting the intrinsic value of these projects.

Geometrics - The score for the geometrics criterion is based on the number of geometric features that would be improved within the segment as a result of the proposed project. The geometric features include horizontal curves, vertical curves, and intersections. More points are awarded to projects that improve multiple locations because, in general, costs can be reduced by constructing improvements simultaneously rather than over time. The points are awarded in the following manner:

- 0 locations (0 Points)
- 1-2 locations (25 Points)
- 3-5 locations (55 Points)
- >5 locations (80 Points)

Traffic - The score for the traffic criterion is calculated based on the segment AADT and the 85th percentile AADT for all MDT secondary roads within the applicable district:

$$Score = \left(\frac{\text{AADT}}{85\text{AADT}}\right) * \frac{1}{70}$$

Where:

- *Annual Average Daily Traffic (AADT)* is the average daily number of vehicles that travel along a roadway.
- *85th percentile AADT (85AADT)* is the 85th percentile AADT for all MDT secondary roads within the applicable district.

With this criterion, roadway segments with higher traffic volumes receive more points than segments with lower volumes.

Maintenance - The score for the maintenance criterion is related to the cost of on-going maintenance once a project has been constructed. The maintenance cost of a roadway varies by surface type. In general, it is less expensive to maintain a roadway with a gravel surface than a paved surface. Therefore, projects that do not convert a roadway surface from gravel to pavement receive a higher score than projects that result in a paved surface. For the S-236 corridor, the following project types were applicable:

- Gravel-to-gravel (60 points)
- Pavement overlay (40 points)
- Gravel-to-paved (20 points)

The point differences for each project type are the result of an agreement reached between all Montana counties and MDT during the development of the Secondary Roads Capital Construction Program.

The scoring also recognizes the lower project cost of maintaining an existing paved segment (pavement overlay) compared to creating a new paved segment (gravel-to-paved).

The scores and rankings for the proposed project bundles are shown by implementation scenario in Tables D-11 through D-13 below.

Table D-11
Implementation Scenario 1 – Spot Improvements Only
Proposed Project Bundle Rankings

Project Bundle	County	From RP	To R.P	Scope	Estimated Cost	Score	Rank
1	Fergus	24.0	29.5	Spot Improvements	$2,240,000	228.1	4
2	Fergus	29.5	34.5	Spot Improvements	$3,400,000	254.7	1
3	Fergus	34.5	41.8	Spot Improvements	$5,710,000	250.1	2
4	Fergus	41.8	48.0	Spot Improvements	$60,000	159.4	8
5	Chouteau	48.0	53.5	Spot Improvements	$2,170,000	223.0	5
6	Chouteau	53.5	60.0	Spot Improvements	$950,000	216.6	6
7	Chouteau	60.0	74.0	Spot Improvements	$2,280,000	199.4	7
8	Chouteau	74.0	83.5	Spot Improvements	$140,000	230.2	3
Total Estimated Cost					$16,950,000		

Table D-12
Implementation Scenario 2 – Reconstruct/Rehabilitate to Gravel
Proposed Project Bundle Rankings

Project Bundle	County	From RP	To R.P	Scope	Estimated Cost	Score	Rank
1	Fergus	24.0	29.5	Reconst. to Gravel	$4,470,000	228.1	3
2	Fergus	29.5	34.5	Reconst. to Gravel	$5,430,000	254.7	1
3	Fergus	34.5	41.8	Reconst. to Gravel	$8,670,000	250.1	2
4	Fergus	41.8	48.0	Spot Improvements	$60,000	N/A	N/A
5	Chouteau	48.0	53.5	Reconst. to Gravel	$4,400,000	223.0	4
6	Chouteau	53.5	60.0	Reconst. to Gravel	$3,580,000	216.6	5
7	Chouteau	60.0	74.0	Rehab. to Gravel	$3,080,000	199.4	6
8	Chouteau	74.0	83.5	Spot Improvements	$140,000	N/A	N/A
Total Estimated Cost					$29,830,000		

Table D-13
Implementation Scenario 3 – Reconstruct/Rehabilitate to Pavement
Proposed Project Bundle Rankings

Project Bundle	County	From RP	To R.P	Scope	Estimated Cost	Score	Rank
1	Fergus	24.0	29.5	Reconst. to Pvmt.	$6,690,000	128.1	4
2	Fergus	29.5	34.5	Reconst. to Pvmt.	$7,450,000	154.7	1
3	Fergus	34.5	41.8	Reconst. to Pvmt.	$11,620,000	150.1	2
4	Fergus	41.8	48.0	Rehab. to Pvmt.	$4,660,000	89.4	7
5	Chouteau	48.0	53.5	Reconst. to Pvmt.	$6,620,000	123.0	5
6	Chouteau	53.5	60.0	Reconst. to Pvmt.	$6,210,000	116.6	6
7	Chouteau	60.0	74.0	Rehab. to Pvmt.	$9,920,000	129.4	3
8	Chouteau	74.0	83.5	Spot Improvements	$140,000	N/A	N/A
Total Estimated Cost					$53,310,000		

Table D-14 shows the planning level cost estimate for the corridor for each implementation scenario.

Table D-14
Cost Estimates

Implementation Scenario	Corridor Cost	Cost per Mile
Spot Improvements Only	$16.95 million	N/A
Reconstruct/Rehabilitate to Gravel Including Spot Improvements	$29.83 million	$404,000 per mile*
Reconstruct/Rehabilitate to Pavement Including Spot Improvements	$53.31 million	$808,000 per mile*

* Cost per mile for reconstruction only. Does not include cost of spot improvements.