Table 8.19 Suggested Severity Indices for fill slopes

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Fill slope 1:infinity	0.0	A	F	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8
		B	F	0.3	0.4	0.4	0.5	0.6	0.8	1.0	1.1
		C	F	0.4	0.6	0.8	1.0	1.1	1.3	1.5	1.8
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4.0	4.5	5.1	5.7	6.3	7.0
Fill slope 1:10	0.15	A	F	0.2	0.3	0.5	0.6	0.7	0.9	1.1	1.2
		B	F	0.4	0.5	0.7	0.8	0.9	1.1	1.3	1.6
		C	F	0.7	0.9	1.1	1.3	1.4	1.6	1.9	2.2
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	> 0.30	A	F	0.4	0.5	0.7	0.8	1	1.2	1.4	1.5
		B	F	0.6	0.7	0.9	1	1.2	1.4	1.6	1.9
		C	F	0.9	1.1	1.3	1.5	1.7	1.9	2.2	2.5
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Fill slope 1:8	0.15	A	F	0.3	0.4	0.6	0.7	0.8	1	1.2	1.3
		B	F	0.5	0.6	0.8	0.9	1	1.2	1.4	1.7
		C	F	0.8	1	1.2	1.4	1.5	1.7	2	2.3
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	>0.30	A	F	0.4	0.6	0.8	1	1.2	1.4	1.6	1.9
		B	F	0.6	0.8	1	1.2	1.4	1.6	1.9	2.2
		C	F	0.9	1.2	1.4	1.7	1.9	2.1	2.5	2.9
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Fill slope 1:6	0.15	A	F	0.5	0.8	1	1.3	1.5	1.7	1.9	2
		B	F	0.7	1	1.2	1.5	1.7	1.9	2.1	2.2
		C	F	1.1	1.4	1.7	2	2.2	2.4	2.6	2.9
		D	F	2.9	3.4	3.9	4.4	4.9	5.5	5.9	6.3
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	6.9
	>0.30	A	F	0.5	0.8	1	1.3	1.6	1.9	2.1	2.2
		B	F	0.7	1	1.2	1.5	1.8	2.1	2.3	2.6
		C	F	1.1	1.4	1.7	2	2.3	2.6	2.9	3.2

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Fill slope 1:6	>0.30	D	F	3	3.8	4	4.5	5	5.6	6	6.4
		E	F	3.4	3.8	4.2	4.7	5.3	5.9	6.5	7
Fill slope 1:4	0.15	A	F	0.5	0.7	0.9	1.1	1.3	1.5	1.7	2
Fill slope 1:4	0.15	B	F	0.7	0.9	1.1	1.3	1.5	1.7	2	2.3
		C	F	1	1.3	1.5	1.8	2	2.2	2.6	3
		D	F	3	3.5	4	4.5	5	5.6	6	6.4
		E	F	3.4	3.8	4.2	4.7	5.3	5.9	6.5	7
	0.3	A	F	1.2	1.4	1.6	1.8	2	2.2	2.4	2.5
		B	F	1.4	1.6	1.8	2	2.2	2.4	2.6	2.9
		C	F	1.7	2	2.2	2.5	2.7	2.9	3.2	3.5
		D	F	3.2	3.6	4	4.5	5	5.6	6	6.4
		E	F	3.5	3.9	4.3	4.8	5.4	6	6.6	7.1
	>0.20	A	F	1.3	1.6	1.8	2.1	2.3	2.5	2.7	2.8
		B	F	1.5	1.8	2	2.3	2.5	2.7	2.9	3.2
		C	F	1.9	2.2	2.5	2.8	3	3.2	3.5	3.8
		D	F	3.2	3.6	4	4.5	5	5.6	6	6.4
		E	F	3.5	3.9	4.3	4.8	5.4	6	6.6	7.1
Fill slope 1:3	0.15	A	F	0.7	0.9	1.1	1.3	1.5	1.8	2	2.3
		B	F	0.9	1.1	1.3	1.5	1.7	2	2.3	2.6
		C	F	1.2	1.5	1.7	2	2.2	2.5	2.9	3.3
		D	F	3.2	3.6	4	4.5	5	5.6	6	6.4
		E	F	3.5	3.9	4.3	4.8	5.4	6	6.6	7.1
	0.3	A	F	1.6	1.8	2	2.2	2.4	2.6	2.8	2.9
		B	F	1.8	2	2.2	2.4	2.6	2.8	3	3.3
		C	F	2.1	2.4	2.6	2.9	3.1	3.3	3.6	3.9
		D	F	3.3	3.7	4.1	4.6	5.1	5.7	6.1	6.5
		E	F	3.6	4	4.4	4.9	5.5	6.1	6.7	7.2
	2	A	F	2	2.3	2.5	2.8	3	3.3	3.5	3.6
		B	F	2.2	2.5	2.7	3	3.2	3.5	3.7	4
		C	F	2.6	2.9	3.2	3.5	3.7	4	4.3	4.6
		D	F	3.4	3.8	4.2	4.7	5.2	5.8	6.2	6.6
		E	F	3.7	4.1	4.5	5	5.6	6.4	6.7	7.3
	4	A	F	2	2.3	2.6	2.9	3.1	3.4	3.6	3.9
		B	F	2.2	2.5	2.8	3.1	3.3	3.6	3.9	4.2
		C	F	2.5	2.8	3.2	3.6	3.8	4.1	4.5	4.9
		D	F	3.5	3.9	4.3	4.8	5.3	5.9	6.3	6.7
		E	F	3.8	4.2	4.6	5.1	5.7	6.3	6.9	7.4

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Fill slope 1:3	6	A	F	2	2.3	2.6	2.9	3.1	3.5	3.7	4
		B	F	2.2	2.5	2.8	3.1	3.3	3.7	4	4.3
		C	F	2.5	2.8	3.2	3.6	3.8	4.2	4.6	5
Fill slope 1:3	6	D	F	3.5	3.9	4.3	4.8	5.3	5.9	6.3	6.7
		E	F	3.8	4.2	4.6	5.1	5.7	6.3	6.9	7.4
	8	A	F	2	2.3	2.6	2.9	3.2	3.5	3.8	4.1
		B	F	2.2	2.5	2.8	3.1	3.4	3.7	4	4.3
		C	F	2.5	2.8	3.2	3.6	3.9	4.2	4.6	5
		D	F	3.5	3.9	4.3	4.8	5.3	5.9	6.3	6.7
		E	F	3.8	4.2	4.6	5.1	5.7	6.3	6.9	7.4
	> 10	A	F	2	2.3	2.6	2.9	3.2	3.5	3.9	4.3
		B	F	2.2	2.5	2.8	3.1	3.4	3.7	4.1	4.5
		C	F	2.5	2.8	3.2	3.6	3.96	4.3	4.7	5.1
		D	F	3.5	3.9	4.3	4.8	5.3	5.9	6.3	6.7
		E	F	3.8	4.2	4.3	5.1	5.7	6.3	6.9	7.4
Fill slope 1:2	0.15	A	F	0.9	1.2	1.5	1.8	2	2.3	2.6	2.9
		B	F	1.1	1.4	1.7	2	2.2	2.5	2.9	3.3
		C	F	1.4	1.7	2.1	2.5	2.7	3.1	3.5	3.9
		D	F	3.3	3.7	4.1	4.6	5.1	5.7	6.1	6.5
		E	F	3.6	4	4.4	4.9	5.5	6.1	6.7	7.2
	0.3	A	F	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.6
		B	F	2.3	2.5	2.7	2.9	3.1	3.3	3.6	3.9
		C	F	2.6	2.9	3.1	3.4	3.6	3.8	4.2	4.6
		D	F	3.4	3.8	4.2	4.7	5.2	5.8	6.2	6.6
		E	F	3.7	4.1	4.5	5	5.6	6.2	6.8	7.3
	2	A	F	2.9	3.2	3.5	3.8	4	4.3	4.5	4.8
		B	F	2.3	22.9	3.4	4	4.2	4.5	4.8	5.1
		C	F	2.6	3.2	3.9	4.5	4.7	5	5.4	5.8
		D	F	3.5	3.9	4.3	4.8	5.3	5.9	6.3	6.7
		E	F	3.8	4.2	4.6	5.1	5.7	6.3	6.9	7.4
	4	A	F	3.1	3.4	3.8	4.2	4.4	4.6	4.8	5.1
		B	F	2.5	3.1	3.8	4.4	4.6	4.8	5.1	5.4
		C	F	2.8	3.5	4.2	4.9	5.1	5.3	5.7	6.1
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	6	A	F	3.3	3.6	3.9	4.3	4.5	4.7	4.9	5.2
		B	F	3.2	3.6	4.1	4.5	4.7	4.9	5.2	5.5

8

8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
		C	F	2.9	4	4.5	4.9	5.2	5.4	6.1	6.2
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
Fill slope 1:2	8	A	F	3.6	3.9	4.1	4.4	4.6	4.8	5	5.3
		B	F	3.8	4.1	4.3	4.6	4.8	5	5.3	5.6
		C	F	4.1	4.4	4.7	5	5.2	5.4	5.8	6.2
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	10	A	F	4.1	4.3	4.5	4.7	4.9	5.2	5.4	5.5
		B	F	4.2	4.4	4.6	4.8	5	5.3	5.5	5.8
		C	F	4.4	4.7	4.9	5.2	5.4	5.7	6	6.3
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	14	A	F	4.5	4.7	4.9	5.1	5.3	5.5	5.7	6
		B	F	4.6	4.8	5	5.2	5.4	5.6	5.9	6.2
		C	F	4.7	5	5.2	5.5	5.7	5.9	6.3	6.7
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	18	A	F	4.8	5	5.2	5.4	5.6	5.8	6	6.3
		B	F	4.9	5.1	5.3	5.5	5.7	5.9	6.1	6.4
		C	F	4.9	5.2	5.4	5.7	5.9	6.1	6.4	6.7
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	22	A	F	4.9	5.1	5.3	5.5	5.7	5.9	6.1	6.4
		B	F	5	5.2	5.4	5.6	5.8	6	6.2	6.5
		C	F	5.1	5.3	5.5	5.7	5.9	6.2	6.5	6.8
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	26	A	F	4.8	5.1	5.3	5.6	5.8	6.1	6.3	6.4
		B	F	4.9	5.2	5.4	5.7	5.9	6.2	6.4	6.5
		C	F	5	5.3	5.5	5.8	6	6.3	6.6	6.9
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	30	A	F	4.8	5.1	5.3	5.6	5.9	6.2	6.4	6.5
		B	F	4.9	5.2	5.4	5.7	6	6.3	6.5	6.6
		C	F	5	5.3	5.5	5.8	6.1	6.4	6.6	6.9
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.4	6.8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	**Height (m)**	**#Surface Condition**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
	30	E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
	> 34	A	F	4.8	5.1	5.3	5.6	5.9	6.2	6.4	6.7
		B	F	4.9	5.3	5.4	5.7	6	6.3	6.5	6.8
Fill slope 1:2	> 34	C	F	5	5.3	5.5	5.8	6.1	6.4	6.6	6.9
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.6	7.3
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7	7.5
Fill slope 1:1.5	0.15	A	F	0.9	1.3	1.7	2.2	2.4	2.7	3	3.3
		B	F	1.1	1.5	1.9	2.4	2.6	2.9	3.3	3.7
		C	F	1.4	1.9	2.4	2.9	3.1	3.5	3.9	4.3
		D	F	3.3	3.8	4.3	4.8	5.3	5.9	6.3	6.7
		E	F	3.7	4.1	4.5	5	5.6	6.2	6.8	7.3
	0.3	A	F	2.4	2.6	2.8	3	3.2	3.5	3.7	4
		B	F	2.6	2.8	3	3.2	3.4	3.7	4	4.3
		C	F	2.9	3.2	2.4	3.7	3.9	4.2	4.6	5
		D	F	3.3	3.8	4.3	4.8	5.3	5.9	6.4	6.9
		E	F	3.7	4.1	4.5	5	5.6	6.2	6.9	7.6
	2	A	F	3.3	3.6	3.9	4.2	4.5	4.8	5	5.3
		B	F	3.2	3.5	3.7	4	4.4	4.8	5.2	5.6
		C	F	3.6	3.9	4.2	4.5	4.9	5.3	5.8	6.3
		D	F	3.4	3.9	4.4	4.9	5.4	6	6.5	7
		E	F	3.7	4.1	4.5	5	5.6	6.2	6.9	7.6
	4	A	F	3.8	4.1	4.4	4.7	4.9	5.2	5.4	5.7
		B	F	3.8	4.1	4.5	4.9	5.4	5.9	6.2	6.5
		C	F	4.8	5	5.2	5.4	5.8	6.3	6.8	7.3
		D	F	3.8	4.1	4.5	4.9	5.4	6	6.5	7
		E	F	3.8	4.2	4.6	4.1	5.7	6.3	7	7.7
	6	A	F	4.1	4.4	4.7	5	5.2	5.5	5.7	6
		B	F	4.7	4.4	4.7	5.5	5.9	6.3	6.6	7
		C	F	5.3	5.4	4.7	5.9	6.2	6.7	7.2	7.6
		D	F	3.9	4.2	4.6	5	5.5	6	6.6	7.2
		E	F	3.9	4.3	4.7	5.1	5.8	6.4	6.1	7.8
	8	A	F	4.3	4.6	4.9	5.2	5.4	5.7	5.9	6.2
		B	F	5.5	5.6	5.8	5.9	6.3	6.6	7	7.4
		C	F	5.7	5.9	6.1	6.3	6.6	7	7.5	8
		D	F	3.9	4.2	4.6	5	5.5	6	6.6	7.3
		E	F	3.9	4.3	4.7	5.2	5.8	6.4	7.1	7.8
	10	A	F	4.9	5.2	5.4	5.7	6	6.3	6.6	6.9

8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
		B	F	6.4	6.5	6.7	6.8	7.2	7.6	7.8	8.1
		C	F	6.8	6.9	7.1	7.2	7.6	8	8.2	8.5
		D	F	4	4.3	4.7	5.1	5.6	6.1	6.7	7.4
Fill slope 1:1.5	10	E	F	4	4.4	4.8	5.3	5.9	6.5	7.2	7.9
	14	A	F	5.4	5.7	5.9	6.2	6.6	6.9	7.2	7.5
		B	F	7.1	7.2	7.4	7.5	7.9	8.2	8.5	8.8
		C	F	7.5	7.6	7.8	7.9	8.2	8.5	8.8	9.1
		D	F	4	4.3	4.7	5.1	5.6	6.1	6.7	7.4
		E	F	4	4.4	4.8	5.3	5.9	6.5	7.2	7.9
	18	A	F	5.8	6.1	6.4	6.7	7.1	7.4	7.7	8
		B	F	7.6	7.7	7.9	8	8.4	8.7	9	9.3
		C	F	7.9	8	8.2	8.3	8.6	8.9	9.2	9.5
		D	F	4	4.3	4.7	5.1	5.6	6.1	6.7	7.4
		E	F	4	4.4	4.8	5.3	5.9	6.5	7.2	7.9
	22	A	F	6.2	6.5	6.8	7.1	7.4	7.7	8	8.3
		B	F	7.7	7.9	8.1	8.3	8.6	8.9	9.1	9.2
		C	F	8	8.2	8.4	8.6	8.8	9.1	9.3	9.4
		D	F	4	4.3	4.7	5.1	5.6	6.1	6.7	7.4
		E	F	4.2	4.5	4.9	5.3	5.9	6.5	7.2	7.9
	26	A	F	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4
		B	F	7.9	8.1	8.3	8.5	8.8	9.1	9.3	9.6
		C	F	8	8.3	8.5	8.8	9	9.2	9.4	9.7
		D	F	4.1	4.4	4.58	5.2	5.6	6.1	6.7	7.4
		E	F	4.2	4.5	4.9	5.3	5.9	6.5	7.2	7.9
	30	A	F	6.6	6.9	7.1	7.4	7.7	8	8.3	8.6
		B	F	7.8	8.1	8.3	8.6	8.8	9.1	9.4	9.7
		C	F	8	8.3	8.5	8.8	9	9.2	9.4	9.7
		D	F	4.1	4.4	4.8	5.2	5.5	6.1	6.7	7.4
		E	F	4.2	4.5	4.9	5.3	5.9	6.5	7.2	7.9
	34	A	F	6.8	7.1	7.3	7.6	7.8	8.1	8.4	8.7
		B	F	7.9	8.2	8.4	8.7	8.9	9.2	9.4	9.7
		C	F	8.1	8.4	8.6	8.9	9	9.2	9.4	9.7
		D	F	4.1	4.4	4.8	5.2	5.6	6.1	6.7	7.4
		E	F	4.2	4.5	4.9	5.3	5.9	6.5	7.2	7.9
	>38	A	F	6.9	7.2	7.4	7.7	7.9	8.2	8.5	8.8
		B	F	8	8.3	8.5	8.8	9	9.3	9.5	9.8
		C	F	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
		D	F	4.1	4.4	4.8	5.2	5.6	6.1	6.7	7.4
		E	F	4.2	4.5	4.9	5.3	5.9	6.5	7.2	7.9

* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F

#**Notes:**

A: Smooth and firm all seasons.

B: Smooth but subject to deep rutting by errant vehicles half of the year

C: Shallow gullies (100mm to 200mm deep), scattered small boulders (under 225mm projections), scattered small trees (diameters 75mm to 100mm), or structurally substantial woody brush. Features spaced so that nearly all encroaching vehicles will encounter them.

D: Medium gullies (approximately 250mm deep), boulders or riprap (projecting approximately 300mm), or medium trees (diameters 175mm to 225mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid, SI's for high, steep slopes may be considerably higher than values shown.

E: Deep gullies (over 0.5m deep), large boulders or heavy riprap (over 450mm projecting), large trees (diameters over 350mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid, SI's for high, steep slopes may be considerably higher than values shown.

8

Table 8.20 Suggested Severity Indices for fill slopes that are vertical, with and without water present

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	Water depth (m)	*Object Surface	50	60	70	80	90	100	110	120
Fill slope Vertical	0	0	F	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8
		1	F	2.6	2.7	2.9	3	3.2	3.4	3.6	3.7
		2	F	4.4	4.7	4.9	5.2	5.4	5.7	5.9	6.2
		4	F	6.2	6.4	6.6	6.8	7	7.2	7.4	7.7
		>6	F	7.9	8.1	8.3	8.5	8.7	8.8	9	9.1
	0.3	0	F	2.6	2.9	3.1	3.4	3.6	3.9	4.1	4.4
		1	F	3.2	3.4	3.6	3.8	4	4.2	4.4	4.7
		2	F	4.6	4.4	5.2	5.5	5.9	6.2	6.6	7
		4	F	6.3	6.6	6.9	7.2	7.4	7.7	7.9	8.2
		>6	F	8.2	8.3	8.5	8.6	8.8	9	9.2	9.3
	2	0	F	3.8	4.1	4.3	4.6	4.8	5.1	5.3	5.6
		1	F	4.4	4.6	4.8	5	5.2	5.4	5.6	5.7
		2	F	6.7	6.8	7	7.1	7.3	7.5	7.7	7.8
		4	F	7.6	7.7	7.9	8	8.2	8.4	8.6	8.7
		>6	F	8.4	8.5	8.7	8.8	9	9.2	9.4	9.5
	4	0	F	5.7	5.8	5.8	5.9	6.1	6.3	6.5	6.6
		1	F	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7
		2	F	7.4	7.5	7.7	7.8	8	8.2	8.4	8.5
		4	F	8	8.1	8.3	8.4	8.6	8.8	9	9.1
		>6	F	8.6	8.7	8.9	9	9.2	9.4	9.6	9.7
	6	0	F	6.6	6.7	6.8	6.9	7	7.2	7.4	7.5
		1	F	6.8	6.9	7.1	7.3	7.4	7.6	7.8	7.9
		2	F	7.8	7.9	8.1	8.2	8.4	8.6	8.8	8.9
		4	F	8.2	8.3	8.5	8.7	8.9	9.1	9.3	9.4
		>6	F	8.7	8.8	9	9.1	9.3	9.5	9.7	9.8
	8	0	F	7.4	7.5	7.7	7.8	7.9	8	8.2	8.3
		1	F	7.8	7.9	8.1	8.2	8.3	8.4	8.6	8.7
		2	F	8.1	8.2	8.4	8.5	8.7	8.9	9.1	9.2
		4	F	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.6
		>6	F	8.8	8.9	9.1	9.2	9.4	9.6	9.8	9.9
	10	0	F	8.6	8.8	9	9.2	9.2	9.2	9.3	9.3
		1	F	8.7	8.9	9.1	9.3	9.4	9.4	9.6	9.7
		2	F	9.2	9.3	9.3	9.4	9.5	9.6	9.8	9.9
		4	F	9.5	9.6	9.6	9.7	9.8	9.8	9.9	9.9

Object Type and Characteristics				**Severity Index for a design speed (km/h) of:**							
Slope (V:H)	**Height (m)**	**Water depth (m)**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
		>6	F	9	9.8	9.8	9.9	10	10	10	10
Fill slope Vertical	14	0	F	9.5	9.6	9.6	9.7	9.8	9.8	9.8	9.8
		1	F	9.6	9.7	9.7	9.8	9.8	9.8	9.9	9.9
		2	F	9.6	9.7	9.7	9.8	9.9	9.9	10	10
		4	F	9.8	9.9	9.9	10	10	10	10	10
		>6	F	10	10	10	10	10	10	10	10
	18	0	F	9.9	9.9	9.9	9.9	9.9	9.9	10	10
		1	F	10	10	10	10	10	10	10	10
		2	F	10	10	10	10	10	10	10	10
		4	F	10	10	10	10	10	10	10	10
		>6	F	10	10	10	10	10	10	10	10
	22	0	F	10	10	10	10	10	10	10	10
		1	F	10	10	10	10	10	10	10	10
		2	F	10	10	10	10	10	10	10	10
		4	F	10	10	10	10	10	10	10	10
		>6	F	10	10	10	10	10	10	10	10
* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F											

8

Table 8.21 Suggested Severity Indices for cut slopes

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Cut slope 1:10	0.15	A	F	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.7
		B	F	0.2	0.3	0.3	0.4	0.5	0.7	0.9	1
		C	F	0.6	0.7	0.9	1	1.1	1.3	1.5	1.8
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥3	A	F	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.6
		B	F	0.1	0.1	0.3	0.4	0.5	0.6	0.8	0.9
		C	F	0.6	0.7	0.9	1	1.1	1.3	1.5	1.8
		D	F	2.6	3.2	3.9	4.5	5.1	5.7	6.3	7
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Cut slope 1:8	0.15	A	F	0.1	0.1	0.2	0.3	0.4	0.4	0.6	0.7
		B	F	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1
		C	F	0.6	0.7	0.9	1	1.1	1.3	1.5	1.8
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥3	A	F	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.6
		B	F	0.1	0.2	0.2	0.3	0.4	0.6	0.8	0.9
		C	F	0.6	0.7	0.9	1	1.1	1.3	1.5	1.8
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Cut slope 1:6	0.15	A	F	0.1	0.1	0.3	0.4	0.5	0.5	1.7	0.8
		B	F	0.3	0.4	0.4	0.5	0.6	0.8	1	1.1
		C	F	0.6	0.7	0.9	1	1.1	1.3	1.5	1.8
		D	F	2.8	3.6	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥0.5	A	F	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.6
		B	F	0.1	0.2	0.4	0.5	0.5	0.6	0.8	0.9
		C	F	0.6	0.7	0.9	1	1.1	1.3	1.5	1.8
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Cut slope 1:4	0.15	A	F	0.1	0.1	0.3	0.4	0.5	0.6	0.8	0.9
		B	F	0.4	0.5	0.5	0.6	0.7	0.9	1.1	1.2
		C	F	0.7	0.8	1	1.1	1.3	1.4	1.6	1.7
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Cut slope 1:3	0.15	A	F	0.2	0.3	0.5	0.6	0.7	0.7	0.9	1

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Cut slope 1:3	0.15	B	F	0.4	0.5	0.7	0.8	0.9	1.1	1.3	1.4
		C	F	0.8	0.9	1.1	1.2	1.4	1.6	1.8	1.9
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥1	A	F	0.3	0.4	0.6	0.7	0.9	1.2	1.3	1.4
		B	F	0.7	0.8	0.1	1.1	1.3	1.5	1.7	1.8
		C	F	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.4
		D	F	2.9	3.4	3.9	4.4	4.9	5.5	6	6.5
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Cut slope 1:2	0.15	A	F	0.4	0.5	0.7	0.8	1	1.2	1.4	1.7
		B	F	0.7	0.8	1	1.1	1.3	1.5	1.7	2
		C	F	1	1.1	1.3	1.4	1.6	1.9	2.2	2.5
		D	F	2.9	3.4	3.9	4.4	4.9	5.5	6	6.5
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	F	0.5	0.6	0.8	0.9	1.1	1.3	1.6	1.9
		B	F	0.9	1	1.2	1.3	1.4	1.6	1.9	2.2
		C	F	1.4	1.5	1.7	1.8	1.9	2.1	2.3	2.6
		D	F	3	3.5	4	4.5	5	5.6	6.1	6.6
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	7.1
	0.6	A	F	0.7	0.8	1	1.1	1.3	1.5	1.8	2.1
		B	F	1.1	1.2	1.4	1.5	1.7	1.9	2.1	2.4
		C	F	1.9	2	2.2	2.3	2.4	2.6	2.8	3.1
		D	F	3	3.5	4	4.5	5	5.6	6.1	6.6
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	7.1
	≥1.2	A	F	0.8	0.9	1.1	1.2	1.5	1.8	2.1	2.4
		B	F	1.2	1.3	1.5	1.6	1.8	2.1	2.3	2.6
		C	F	2	2.1	2.3	2.4	2.5	2.7	2.9	3.2
		D	F	3	3.5	4	4.5	5	5.6	6.1	6.6
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	7.1
Cut slope 1:1.5	0.15	A	F	0.3	0.6	0.8	1.1	1.4	1.8	2.2	2.6
		B	F	0.6	0.9	1.1	1.4	1.7	2.1	2.5	2.9
		C	F	0.9	1.2	1.4	1.7	2.1	2.5	3	3.5
		D	F	2.9	3.4	3.9	4.4	4.9	5.5	6	6.5
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥0.3	A	F	0.5	0.8	1	1.3	1.6	2	2.6	3.1
		B	F	0.9	1.2	1.4	1.7	1.9	2.3	2.9	3.4
		C	F	1.4	1.7	1.9	2.2	2.4	2.8	3.3	3.8

8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	**Height (m)**	**#Surface Condition**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Cut slope 1:1.5	≥0.3	D	F	3	3.5	4	4.5	5	5.6	6.1	6.6
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	7.1
	0.6	A	F	0.9	1.1	1.3	1.5	1.8	2.2	2.7	3.2
		B	F	1.3	1.5	1.7	1.9	2.2	2.6	3.1	3.6
		C	F	2.1	2.3	2.5	2.7	2.9	3.2	3.8	4.3
		D	F	3	3.5	4	4.5	5	5.6	6.1	6.6
		E	F	3.3	3.7	4.1	4.5	5.2	5.8	6.4	7.1
	≥1.2	A	F	1	1.2	1.4	1.6	2	2.4	2.8	3.2
		B	F	1.4	1.6	1.4	2	2.3	2.7	3.2	3.7
		C	F	2.2	2.4	2.6	2.8	3	3.4	3.9	4.4
		D	F	3.1	3.6	4.1	4.6	5.1	5.7	6.2	6.7
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	7.1
Cut slope 1:1	0.15	A	F	0.4	0.7	1	1.3	1.7	2.2	2.8	3.3
		B	F	0.7	1	1.3	1.6	2	2.5	3.1	3.6
		C	F	1	1.3	1.6	1.9	2.4	2.9	3.5	4.2
		D	F	2.9	3.4	3.9	4.4	4.9	5.5	6	6.5
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	F	0.7	1	1.3	1.6	2	2.4	3.1	3.8
		B	F	1.1	1.4	1.7	2	2.3	2.7	3.4	4.1
		C	F	1.6	1.9	2.2	2.5	2.8	3.2	3.8	4.5
		D	F	3	3.5	4	4.5	5	5.6	6.1	6.6
		E	F	3.3	3.7	4.1	4	5.1	5.8	6.4	7.1
	0.6	A	F	1	1.3	1.5	1.8	2.2	2.6	3.3	4
		B	F	1.4	1.7	1.9	2.2	2.6	3	3.6	4.1
		C	F	2.2	2.5	2.7	3	3.2	3.6	4.2	4.9
		D	F	3	3.5	4	4.5	5	5.6	3.1	6.6
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	7.1
	≥1.2	A	F	1.1	1.4	1.6	1.9	2.3	2.8	3.4	3.9
		B	F	1.5	1.8	2	2.3	2.7	3.1	3.7	4.2
		C	F	2.3	2.6	2.8	3.1	3.4	3.8	4.4	4.9
		D	F	3.1	3.6	4.1	1.6	5.1	5.7	6.2	6.7
		E	F	3.3	3.7	4.1	4.6	5.2	5.8	6.4	7.1
Cut slope Vertical	0.15	A	F	0.5	0.8	1.1	1.4	1.9	2.4	3	3.7
		B	F	0.8	1.1	1.4	1.7	2.2	2.7	3.3	4
		C	F	1.1	1.4	1.7	2	2.5	3.1	3.8	4.5
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Cut slope Vertical	0.3	A	F	0.7	1	1.3	1.6	2	2.5	3.2	3.9
		B	F	1.1	1.4	1.7	2	2.4	2.8	3.5	4.2
		C	F	1.6	1.9	2.2	2.5	2.9	3.3	3.9	4.6
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	F	0.7	1	1.3	1.6	2	2.4	3	3.7
		B	F	1.1	1.4	1.7	2	2.3	2.7	3.3	4
		C	F	1.6	1.9	2.2	2.5	2.8	3.2	3.8	4.3
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥1	A	F	0.6	0.9	1.2	1.5	1.9	2.3	2.9	3.6
		B	F	1	1.3	1.6	1.9	2.2	2.6	3.2	3.9
		C	F	1.5	1.8	2.1	2.4	2.7	3.1	3.7	4.2
		D	F	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	F	3.2	3.6	4	4.5	5.1	5.7	6.3	7

* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F

#**Notes:**

A: Smooth and firm all seasons.

B: Smooth but subject to deep rutting by errant vehicles half of the year

C: Shallow gullies (100mm to 200mm deep), scattered small boulders (under 225mm projections), scattered small trees (diameters 75mm to 100mm), or structurally substantial woody brush. Features spaced so that nearly all encroaching vehicles will encounter them.

D: Medium gullies (approximately 250mm deep), boulders or riprap (projecting approximately 300mm), or medium trees (diameters 175mm to 225mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid, SI's for high, steep slopes may be considerably higher than values shown.

E: Deep gullies (over 0.5m deep), large boulders or heavy riprap (over 450mm projecting), large trees (diameters over 350mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid, SI's for high, steep slopes may be considerably higher than values shown.

8

8

Table 8.22 Suggested Severity Indices for parallel ditches

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Verge slope (V:H)	Backslope (m)	Depth (m)	*Object Surface	50	60	70	80	90	100	110	120
1:2 Slope	1:2 Slope	0.15	F	1.2	1.5	1.7	2	2.4	2.8	3.4	3.9
		0.3	F	1.7	1.8	2	2.1	2.5	2.9	3.5	4
		0.6	F	1.9	2	2.2	2.3	2.7	3.1	3.6	4.1
		1	F	2	2.1	2.3	2.4	2.7	3.1	3.6	4.1
		1.2	F	2.1	2.2	2.4	2.5	2.8	3.2	3.7	4.2
	1:3 Slope	0.15	F	1.1	1.4	1.6	1.9	2.2	2.6	3.1	3.6
		0.3	F	1.5	1.7	1.9	2.1	2.4	2.8	3.2	3.6
		0.6	F	1.8	1.9	2.1	2.2	2.5	2.9	3.4	3.9
		1	F	1.9	2	2.2	2.3	2.5	2.9	3.5	4
		1.2	F	2	2.1	2.3	2.4	2.6	3	3.6	4.1
1:3 Slope	1:2 Slope	0.15	F	1.2	1.5	1.7	2	2.4	2.8	3.4	3.9
		0.3	F	1.6	1.7	1.9	2	2.4	2.8	3.4	3.9
		0.6	F	1.9	2	2	2.1	2.5	2.9	3.4	3.9
		1	F	2	2.1	2.1	2.2	2.5	2.9	3.4	3.9
		1.2	F	2.1	2.2	2.2	2.3	2.6	3	3.4	3.8
	1:3 Slope	0.15	F	1.1	1.4	1.6	1.9	2.2	2.6	3.1	3.6
		0.3	F	1.4	1.6	1.8	2	2.3	2.7	3.1	3.5
		0.6	F	1.7	1.8	2	2.1	2.3	2.7	3.1	3.5
		1	F	1.8	1.9	2.1	2.2	2.4	2.7	3.1	3.5
		1.2	F	2	2.1	2.1	2.2	2.4	2.8	3.2	3.6
	1:4 Slope	0.15	F	1.1	1.3	1.5	1.7	1.9	2.3	2.7	3.1
		0.3	F	1.3	1.5	1.7	1.9	2.1	2.4	2.8	3.2
		0.6	F	1.6	1.7	1.9	2	2.2	2.4	2.8	3.2
		1	F	1.9	2	2	2.1	2.2	2.5	2.9	3.3
		1.2	F	1.8	1.9	2.1	2.2	2.3	2.5	2.9	3.3
1:4 Slope	1:2 Slope	0.15	F	1.1	1.4	1.6	1.9	2.3	2.7	3.2	3.7
		0.3	F	1.1	1.4	1.6	1.9	2.3	2.7	3.2	3.7
		0.6	F	1.2	1.5	1.7	2	2.3	2.7	3.2	3.7
		1	F	1.2	1.5	1.7	2	2.3	2.7	3.1	3.5
		1.2	F	1.2	1.5	1	2	2.3	2.7	3.1	3.5
	1:3 Slope	0.15	F	1	1.2	1.4	1.6	1.9	2.3	2.7	3.1
		0.3	F	1.1	1.3	1.5	1.7	1.9	2.3	2.7	3.1
		0.6	F	1	1.3	1.5	1.8	2	2.3	2.7	3.1
		1	F	1.1	1.4	1.6	1.9	2.1	2.3	2.7	3.1
		1.2	F	1.1	1.4	1.7	2	2.1	2.3	2.7	3.1
	1:4 Slope	0.15	F	0.9	1.1	1.3	1.5	1.7	2	2.3	2.6

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Verge slope (V:H)	Backslope (m)	Depth (m)	*Object Surface	50	60	70	80	90	100	110	120
1:4 Slope	1:4 Slope	0.3	F	1	1.2	1.4	1.6	1.8	2.1	2.3	2.6
		0.6	F	1.1	1.3	1.5	1.7	1.9	2.2	2.4	2.5
		1	F	1	1.3	1.5	1.8	2	2.2	2.4	2.7
1:6 Slope	1:2 Slope	0.15	F	0.8	1.1	1.3	1.6	2	2.4	2.9	3.4
		0.3	F	0.8	1.1	1.3	1.6	2	2.4	2.9	3.4
		0.6	F	0.8	1.1	1.3	1.6	2	2.4	2.9	3.4
		1	F	0.7	1	1.2	1.5	1.9	2.3	2.7	3.1
		1.2	F	0.6	0.9	1.1	1.4	1.8	2.2	2.5	2.8
	1:3 Slope	0.15	F	0.7	0.9	1.1	1.3	1.6	1.9	2.2	2.5
		0.3	F	0.7	0.9	1.1	1.3	1.6	1.9	2.2	2.5
		0.6	F	0.7	0.9	1.1	1.3	1.6	1.9	2.2	2.5
		1	F	0.5	0.8	1	1.3	1.6	1.9	2.1	2.4
		1.2	F	0.5	0.8	1	1.3	1.6	1.9	2.1	2.4
	1:4 Slope	0.15	F	0.5	0.7	0.9	1.1	1.3	1.6	1.9	2.2
		0.3	F	0.4	0.7	0.9	1.2	1.4	1.7	1.9	2.2
		0.6	F	0.6	0.8	1	1.2	1.4	1.7	1.9	2.2
		1	F	0.6	0.8	1	1.2	1.5	1.8	2	2.1
		1.2	F	0.6	0.8	1	1.2	1.5	1.8	2	2.1
	1:6 Slope	0.15	F	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.6
		0.3	F	0.4	0.6	0.8	1	1.2	1.4	1.6	1.7
		0.6	F	0.6	0.7	0.9	1	1.2	1.5	1.7	2
		1	F	0.5	0.7	0.9	1.1	1.3	1.6	1.8	2.1
		1.2	F	0.4	0.7	0.9	1.2	1.4	1.6	1.9	2.2
* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F											

Table 8.23 Suggested Severity Indices for negative (i.e. down) intersecting slopes

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (negative) 1:10	0.3	A	S	0.7	0.8	1	1.1	1.4	1.7	2	2.3
		B	S	0.9	1	1.2	1.3	1.4	1.6	2.2	2.9
		C	S	1.2	1.4	1.6	1.8	1.9	2.1	2.8	3.5
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	>1.0	A	S	0.6	0.8	1	1.2	1.5	1.9	2.3	2.7
		B	S	0.8	1	1.2	1.4	0.7	2.1	2.6	3.1
		C	S	1.1	1.4	1.6	1.9	2.2	2.6	3.2	3.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (negative) 1:8	0.3	A	S	1.3	1.4	1.6	1.7	1.9	2.1	2.4	2.7
		B	S	1.5	1.6	1.8	1.9	2.1	2.3	2.7	3.1
		C	S	1.8	2	2.2	2.3	2.6	2.9	3.3	3.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	1.4	1.6	1.8	2	2.2	2.5	3	3.5
		B	S	1.6	1.8	2	2.2	2.4	2.7	3.3	3.8
		C	S	1.9	2.2	2.4	2.7	2.9	3.2	3.8	4.5
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	2	A	S	1.4	1.6	1.8	2	2.3	2.7	3.2	3.7
		B	S	1.6	1.8	2	2.2	2.5	2.9	3.5	4
		C	S	1.9	2.2	2.4	2.7	3	3.4	4	4.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥4	A	S	1.4	1.6	1.8	2	2.3	2.7	3.3	3.8
		B	S	1.6	1.8	2	2.2	2.5	2.9	3.5	4.2
		C	S	1.9	2.2	2.4	2.7	3	3.4	4.1	4.8
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (negative) 1:6	0.3	A	S	1.7.	1.8	2	2.1	2.3	2.5	2.7	3
		B	S	1.9	2	2.2	2.3	2.5	2.7	3	3.3
		C	S	2.2	2.4	2.6	2.8	3	3.2	3.6	4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	2.1	2.3	2.5	2.7	2.9	3.3	3.7	4.1

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (negative) 1:6	1	B	S	2.3	2.5	2.7	2.9	3.1	3.5	4	4.5
		C	S	2.6	2.9	3.1	3.4	3.6	4	4.6	2.1
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	2	A	S	2.3	2.6	2.9	3.2	3.5	3.9	4.4	4.9
		B	S	2.5	2.8	3.1	3.4	3.7	4.1	4.7	5.2
		C	S	2.8	3.1	3.5	3.9	4.2	4.6	5.2	5.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	4	A	S	2.2	2.5	2.9	3.3	3.7	4.2	4.8	5.3
		B	S	2.4	2.7	3.1	3.5	3.9	4.4	5	5.5
		C	S	2.7	3.1	3.5	4	4.4	4.9	5.5	6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	6	A	S	2.2	2.5	2.9	3.3	3.7	4.2	4.9	5.5
		B	S	2.4	2.7	3.1	3.5	3.9	4.4	5	5.6
		C	S	2.7	3.1	3.5	4	4.4	4.9	5.5	6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥8	A	S	2.2	2.5	2.9	3.3	3.7	4.2	4.9	5.6
		B	S	2.4	2.7	3.1	3.5	3.9	4.4	5	5.7
		C	S	2.7	3.1	3.5	4	4.4	4.9	5.5	6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (negative) 1:4	0.3	A	S	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
		B	S	2.1	2.2	2.4	2.5	2.7	2.9	3.2	3.5
		C	S	2.4	2.6	2.8	3	3.2	3.4	3.8	4.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	2.6	2.8	3	3.2	3.4	3.6	4	4.4
		B	S	2.8	3	3.2	3.4	3.6	3.9	4.3	4.7
		C	S	3.1	3.4	3.6	3.9	4.1	4.4	4.9	5.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	2	A	S	3.5	3.7	3.9	4.1	4.3	4.6	5	5.4
		B	S	3.6	3.8	4	4.2	4.5	4.8	5.2	5.6
		C	S	3.8	4.1	4.3	4.6	5	5.3	5.7	6.1

8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (negative) 1:4	2	D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	4	A	S	3.7	4.1	4.5	5	5.2	5.5	5.9	6.3
		B	S	3.8	4.2	4.6	5.1	5.4	5.7	6.1	6.5
		C	S	4	4.5	5	5.5	5.8	6.2	6.6	7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	6	A	S	3.7	4.2	4.7	5.2	5.6	6	6.4	6.8
		B	S	3.8	4.3	4.8	5.3	5.8	6.2	6.6	7
		C	S	3.9	4.5	5.1	5.7	6.1	6.6	7	7.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	8	A	S	3.7	4.3	4.8	5.4	5.9	6.4	6.8	7.2
		B	S	3.8	4.4	4.9	5.5	6.1	6.6	7	7.4
		C	S	3.9	4.5	5.2	5.8	6.4	7	7.4	7.8
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	10	A	S	3.7	4.3	4.8	5.4	6	6.6	7.2	7.7
		B	S	3.8	4.4	4.9	5.5	6.2	6.8	7.3	7.8
		C	S	3.9	4.5	5.2	5.8	6.5	7.1	7.5	7.9
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥14	A	S	3.7	4.3	4.8	5.4	6	6.6	7.2	7.9
		B	S	3.8	4.4	4.9	5.5	6.2	6.8	7.4	4.9
		C	S	3.9	4.5	5.2	5.8	6.5	7.1	7.5	7.9
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (negative) 1:3	0.3	A	S	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
		B	S	2.1	2.2	2.4	2.5	2.7	2.9	3.2	3.5
		C	S	2.4	2.6	2.8	3	3.2	3.4	3.8	4.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	2.7	2.9	3.1	3.3	3.5	3.7	4	4.3
		B	S	2.7	3	3.2	3.5	3.6	3.9	4.3	4.7
		C	S	3.1	3.4	3.6	3.9	4.1	4.4	4.9	5.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (negative) 1:3	2	A	S	3.8	4	4.2	4.4	4.6	4.8	5.1	5.4
		B	S	3.9	4.1	4.3	4.5	4.7	5	5.3	5.6
		C	S	4.2	4.4	4.6	4.8	5	5.3	5.6	5.9
		D	S	2.8	3.3	3.8	4.3	4.5	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	4	A	S	4.8	5	5.2	5.4	5.7	6	6.2	6.5
		B	S	4.9	5.1	5.3	5.5	5.9	6.2	6.4	6.7
		C	S	5.1	5.3	5.5	5.7	6.1	6.4	6.9	7.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	6	A	S	4.9	5.3	5.7	6.1	6.4	6.7	6.9.	7.2
		B	S	5	5.4	5.8	6.2	6.6	6.98	7.1	7.4
		C	S	5.2	5.6	5.9	6.3	6.7	7	7.3	7.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	6.4
	8	A	S	5	5.6	6.1	6.7	7	7.3	7.5	7.8
		B	S	5.1	5.7	6.2	6.8	7.2	7.5	7.7	8
		C	S	5.2	5.8	6.3	6.9	7.3	7.6	7.8	8.1
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	10	A	S	4.9	5.6	6.3	7	7.4	7.8	8.2	8.6
		B	S	5	5.7	6.4	7.1	7.5	7.9	8.3	8.7
		C	S	5.1	5.8	6.5	7.2	7.6	8	8.4	8.8
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	14	A	S	4.9	5.6	6.3	7	7.5	7.9	8.3	8.7
		B	S	5	5.7	6.4	7.1	7.5	7.9	8.3	8.7
		C	S	5.1	5.8	6.5	7.2	7.6	8	8.4	8.8
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥18	A	S	4.9	5.6	6.3	7	7.5	8	8.4	8.8
		B	S	5	5.7	6.4	7.1	7.6	8	8.4	8.8
		C	S	5.1	5.8	6.5	7.2	7.6	8	8.4	8.8
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (negative) 1:2	0.3	A	S	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
		B	S	2.1	2.2	2.4	2.5	2.7	2.9	3.2	3.5

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (negative) 1:2	0.3	C	S	2.4	2.6	2.8	3	3.2	3.4	3.8	4.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	2.9	3	3.2	3.3	3.5	3.7	4	4.3
		B	S	2.9	3.1	3.3	3.5	3.6	3.9	4.3	4.7
		C	S	3.3	3.5	3.7	3.9	4.1	4.4	4.9	5.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	2	A	S	4.1	4.2	4.4	4.5	4.7	4.9	5.1	5.4
		B	S	4.1	4.2	4.4	4.5	4.7	5	5.3	5.6
		C	S	4.2	4.4	4.6	4.8	5	5.3	5.6	5.9
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	4	A	S	5.5	5.6	5.6	5.7	5.9	6.2	6.4	6.5
		B	S	5.5	5.6	5.6	5.7	6	6.3	6.5	6.6
		C	S	5.6	5.7	5.7	5.8	6.1	6.4	6.6	6.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	6	A	S	6	6.2	6.4	6.6	6.8	7.1	7.3	7.4
		B	S	6	6.2	6.4	6.6	6.9	7.2	7.4	7.5
		C	S	6.1	6.3	6.5	6.7	7	7.3	7.5	7.6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	8	A	S	6.5	6.8	7.1	7.4	7.6	7.9.	8.1	8.2
		B	S	6.5	6.8	7.1	7.4	7.7	8	8.2	8.3
		C	S	6.6	6.9	7.2	7.5	7.8	8.1	8.3	8.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	10	A	S	7	7.4	7.8	8.3	8.5	8.7	8.9	9
		B	S	7	7.4	7.8	8.3	8.5	8.8	9	9.1
		C	S	7.1	7.5	7.9	8.4	8.6	8.9	9.1	9.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	14	A	S	7.2	7.6	8	8.5	8.7	9	9.2	9.3
		B	S	7.2	7.6	8	8.5	8.7	9	9.2	9.3
		C	S	7.2	7.6	8	8.5	8.7	9	9.2	9.3
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	**Height (m)**	**#Surface Condition**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Intersecting Slopes (negative) 1:2	14	E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	18	A	S	7.3	7.7	8.1	8.6	8.9	9.1	9.3	9.4
		B	S	7.3	7.7	8.1	8.6	8.9	9.1	9.3	9.4
		C	S	7.3	7.7	8.1	8.6	8.9	9.1	9.3	9.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	22	A	S	7.2	7.7	8.2	8.7	8.9	9.1	9.3	9.4
		B	S	7.2	7.7	8.2	8.7	8.9	9.1	9.3	9.4
		C	S	7.2	7.7	8.2	8.7	8.9	9.1	9.3	9.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (negative) 1:1.5	0.3	A	S	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
		B	S	2.1	2.2	2.4	2.5	2.7	2.9	3.2	3.5
		C	S	2.4	2.6	2.8	3	3.2	3.4	3.8	4.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	2.9	3	3.2	3.3	3.5	3.7	4	4.3
		B	S	2.9	3.1	3.3	3.5	3.6	3.9	4.3	4.7
		C	S	3.3	3.5	3.7	3.9	4.1	4.4	4.9	5.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	2	A	S	4.1	4.2	4.4	4.5	4.7	4.9	5.1	5.4
		B	S	4.1	4.2	4.4	4.5	4.7	5	5.3	5.6
		C	S	4.2	4.4	4.6	4.8	5	5.3	5.6	5.9
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	4	A	S	5.6	5.7	5.7	5.8	6	6.2	6.4	6.5
		B	S	5.6	5.7	5.7	5.8	6	6.3	6.5	6.6
		C	S	5.5	5.6	5.8	5.9	6.1	6.4	6.6	6.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	6	A	S	6.3	6.5	6.6	6.7	6.9	7.1	7.4	7.7
		B	S	6.3	6.5	6.6	6.7	6.9	7.2	7.4	7.5
		C	S	6.3	6.5	6.6	6.7	6.9	7.2	7.4	7.5
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	6	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	8	A	S	7	7.2	7.4	7.6	7.8	8	8.2	8.3

8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (negative) 1:1.5	8	B	S	7	7.2	7.4	7.6	7.8	8	8.2	8.3
		C	S	7	7.2	7.4	7.6	7.8	8	8.2	8.3
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	10	A	S	7.9	8.2	8.5	8.8	8.9	8.9	9.1	9.2
		B	S	7.9	8.2	8.5	8.8	8.9	8.9	9.1	9.2
		C	S	7.9	8.2	8.5	8.8	8.9	8.9	9.1	9.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	14	A	S	8.3	8.6	8.8	9.1	9.2	9.3	9.5	9.6
		B	S	8.3	8.6	8.8	9.1	9.2	9.3	9.5	9.6
		C	S	8.3	8.6	8.8	9.1	9.2	9.3	9.5	9.6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	18	A	S	8.5	8.8	9	9.3	9.4	9.5	9.5	9.5
		B	S	8.5	8.8	9	9.3	9.4	9.5	9.6	9.6
		C	S	8.5	8.8	9	9.3	9.4	9.5	9.6	9.6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	≥22	A	S	8.6	8.9	9.1	9.4	9.5	9.5	9.6	9.6
		B	S	8.6	8.9	9.1	9.4	9.5	9.5	9.6	9.6
		C	S	8.6	8.9	9.1	9.4	9.5	9.5	9.6	9.6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7

* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F

#**Notes:**

A: Smooth and firm all seasons.

B: Smooth but subject to deep rutting by errant vehicles half of the year

C: Shallow gullies (100mm to 200mm deep), scattered small boulders (under 225mm projections), scattered small trees (diameters 75mm to 100mm), or structurally substantial woody brush. Features spaced so that nearly all encroaching vehicles will encounter them.

D: Medium gullies (approximately 250mm deep), boulders or riprap (projecting approximately 300mm), or medium trees (diameters 175mm to 225mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid, SI's for high, steep slopes may be considerably higher than values shown.

E: Deep gullies (over 0.5m deep), large boulders or heavy riprap (over 450mm projecting), large trees (diameters over 350mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid,

Object Type and Characteristics				**Severity Index for a design speed (km/h) of:**							
Slope (V:H)	**Height (m)**	**#Surface Condition**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
SI's for high, steep slopes may be considerably higher than values shown.											

Table 8.24 Suggested Severity Indices for intersecting slopes with a vertical drop, with and without water present

Object Type and Characteristics				**Severity Index for a design speed (km/h) of:**							
Slope (V:H)	**Height (m)**	**Water depth (m)**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Intersecting Slopes Vertical Drop	0	0	S	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8
		1	S	2.2	2.4	2.6	2.8	3	3.2	3.4	3.7
		2	S	4.3	4.6	4.8	5.1	5.3	5.6	5.8	6.1
		4	S	6	6.2	6.4	6.6	6.8	7	7.2	7.5
		> 6	S	7.5	7.7	7.9	8.1	8.3	8.4	8.6	8.7
	0.3	0	S	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
		1	S	2.6	2.9	3.1	3.4	3.6	3.9	4.1	4.4
		2	S	4.3	4.6	4.9	5.2	5.6	5.9	6.3	6.7
		4	S	6	6.3	6.6	6.9	7.1	7.4	7.6	7.9
		>6	S	7.9	8	8.2	8.3	8.5	8.7	8.9	9
	1	0	S	2.9	3	3.2	3.3	3.5	3.7	4	4.3
		1	S	3.2	3.4	3.6	3.8	4	4.2	4.5	4.8
		2	S	5.4	5.6	5.8	6	6.3	6.6	6.8	7.1
		4	S	6.5	6.8	7	7.3	7.5	7.7	7.9	8.2
		>6	S	8	8.1	8.3	8.4	8.6	8.8	9	9.1
	2	0	S	4.1	4.2	4.4	4.5	4.7	4.9	5.1	5.4
		1	S	4.2	4.4	4.6	4.8	5	5.2	5.4	5.7
		2	S	6.5	6.6	6.8	6.9	7.1	7.3	7.5	7.6
		4	S	7.3	7.4	7.6	7.7	7.9	8.1	8.3	8.4
		>6	S	8.1	8.2	8.4	8.5	8.7	8.9	9.1	9.2
	4	0	S	5.7	5.8	5.8	5.9	6	6.2	6.4	6.5
		1	S	5.7	5.8	6	6.1	6.2	6.4	6.7	7
		2	S	7.2	7.3	7.5	7.6	7.8	8	8.2	8.3
		4	S	7.8	7.9	8.1	8.2	8.4	8.6	8.8	8.9
		>6	S	8.4	8.5	8.7	8.8	9	9.2	9.4	9.5
	Any depth	>8	S	Use Values from Foreslopes - Vertical							
* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F											

8

Table 8.25 Suggested Severity Indices for positive (i.e. up) intersecting slopes

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (positive) 1:10	0.15	A	S	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6
		B	S	0.5	0.6	0.8	0.9	1.1	1.3	1.2	1.8
		C	S	0.9	1	1.2	1.3	1.5	1.7	2	2.3
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	0.4	0.5	0.7	0.8	1.2	1.5	1.9	2.3
		B	S	0.6	0.7	0.9	1	1.4	1.7	2.1	2.5
		C	S	0.8	1	1.2	1.4	1.8	2.1	2.5	2.9
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	0.4	0.5	0.7	0.8	1.2	1.6	2	2.4
		B	S	0.6	0.7	0.9	1	1.4	1.8	2.2	2.9
		C	S	0.8	1	1.2	1.4	1.8	2.2	2.6	3
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (positive) 1:8	0.15	A	S	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6
		B	S	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.8
		C	S	0.9	1	1.2	1.3	1.5	1.7	2	2.3
		D	S	2.8	3.3	3.8	4.3	4.4	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	0.4	0.6	0.8	1	1.5	2	2.2	2.5
		B	S	0.6	0.8	1	1.2	1.7	2.1	2.4	2.7
		C	S	0.8	1.1	1.3	1.6	2.1	2.5	2.8	3.1
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	0.3	0.6	0.9	1.2	1.7	2.1	2.3	2.4
		B	S	0.5	0.8	1	1.3	1.8	2.2	2.4	2.7
		C	S	0.8	1.1	1.4	1.7	2.2	2.6	2.8	3.1
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	0.3	0.6	0.9	1.2	1.7	2.1	2.3	2.6
		B	S	0.5	0.8	1.1	1.4	1.8	2.2	2.5	2.8
		C	S	0.7	1	1.4	1.8	2.2	2.6	2.9	3.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes	0.15	A	S	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
(positive) 1:6	0.15	B	S	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.8
		C	S	0.7	0.9	1.1	1.3	1.5	1.8	2	2.3
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	0.5	0.8	1.2	1.6	2	2.3	2.6	2.9
		B	S	0.7	1	1.4	1.8	2.1	2.4	2.8	3.2
		C	S	1	1.3	1.7	2.1	2.4	2.7	3.1	3.5
		D	S	23	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	0.5	0.9	1.3	1.8	2.1	2.4	2.7	3
		B	S	0.8	1.1	1.5	1.9	2.2	2.5	2.9	3.3
		C	S	1	1.4	1.8	2.3	2.5	2.8	3.2	3.6
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	0.7	6.3	7
	1	A	S	0.4	0.9	1.4	1.9	2.2	2.5	2.8	3.1
		B	S	0.7	1.1	1.5	2	2.3	2.6	3	3.4
		C	S	0.9	1.4	1.9	2.4	2.6	2.9	3.3	3.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (positive) 1:4	0.15	A	S	0.2	0.4	0.6	0.8	1	1.2	1.4	1.7
		B	S	0.4	0.6	0.8	1	1.2	1.4	1.6	1.9
		C	S	0.6	0.9	1.1	1.4	1.6	1.8	2.1	2.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	1.3	1.6	1.9	2.2	2.6	3	3.3	3.6
		B	S	1.5	1.8	2	2.3	2.7	3.1	3.5	3.9
		C	S	1.8	2.1	2.3	2.6	3	3.4	3.8	4.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	1.6	1.9	2.1	2.4	2.8	3.2	3.5	3.8
		B	S	1.7	2	2.2	2.5	2.9	3.3	3.6	3.9
		C	S	2.2	2.4	2.6	2.8	3.2	3.6	3.9	4.2
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	1.6	1.9	2.1	2.4	2.8	3.2	3.6	4
		B	S	1.7	2	2.2	2.5	2.9	3.3	3.7	4.1
		C	S	2.2	2.4	2.6	2.8	3.2	3.6	4	4.4

8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	**Height (m)**	**#Surface Condition**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Intersecting Slopes (positive) 1:4	1	D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	537	6.3	7
Intersecting Slopes (positive) 1:3	0.15	A	S	0.2	0.4	0.6	0.8	1	1.2	1.4	1.7
		B	S	0.4	0.6	0.8	1	1.2	1.4	1.6	1.9
		C	S	0.6	0.9	1.1	1.4	1.6	18	2.1	2.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	1.8	2.1	2.4	2.7	3.1	3.5	3.9	4.3
		B	S	1.9	2.2	2.5	2.8	3.2	3.6	4	4.4
		C	S	2.2	2.5	2.8	3.2	3.5	3.9	4.2	4.5
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	1.8	2.1	2.5	2.9	3.3	3.7	4.1	4.5
		B	S	1.9	2.2	2.6	3	3.4	3.8	4.2	4.6
		C	S	2.2	2.5	2.9	3.3	3.7	4	4.4	4.8
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	1.9	2.2	2.6	3	3.4	3.8	4.2	4.6
		B	S	2	2.3	2.7	3.1	3.5	3.9	4.3	4.7
		C	S	2.1	2.5	2.9	3.4	3.8	4.1	4.5	4.9
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (positive) 1:2	0.15	A	S	0.4	0.5	0.7	0.8	1	1.2	1.4	1.9
		B	S	0.6	0.7	0.9	1	1.2	1.4	1.6	1.9
		C	S	0.8	1	1.2	1.4	1.6	1.8	2.1	2.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	2.1	2.5	2.9	3.4	3.9	4.4	4.8	5.2
		B	S	2.2	2.6	3	3.5	4	4.5	4.9	5.3
		C	S	2.3	2.8	3.3	3.8	4.2	4.7	5.1	5.5
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	2.5	2.8	3.2	3.6	4.1	4.6	5	5.4
		B	S	2.6	2.9	3.3	3.7	4.2	4.7	5.1	5.5
		C	S	2.8	3.1	3.5	3.9	4.4	4.9	5.3	5.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.4	5.7	6.3	7

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (positive) 1:2	1	A	S	2.6	2.9	3.3	3.7	4.2	4.7	5.1	5.5
		B	S	2.7	3	3.4	3.8	4.3	4.8	5.2	5.6
		C	S	2.9	3.2	3.6	4	4.5	4.9	5.3	5.7
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (positive) 1:1.5	0.15	A	S	0.4	0.5	0.7	0.8	1	1.3	1.5	1.8
		B	S	0.6	0.7	0.9	1	1.2	1.5	1.7	2
		C	S	0.8	1	1.2	1.4	1.6	1.9	2.1	2.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	2.4	2.9	3.4	3.9	4.3	4.8	5.3	5.8
		B	S	2.5	3	3.5	4	4.4	4.9	5.4	5.9
		C	S	2.7	3.2	3.7	4.2	4.6	5.1	5.5	5.9
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	2.6	3.1	3.6	4.1	4.6	5.2	5.6	6
		B	S	2.7	3.2	3.7	4.2	4.7	5.3	5.7	6.1
		C	S	2.9	3.4	3.9	4.4	4.9	5.4	5.8	6.2
		D	S	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	1	A	S	2.7	3.2	3.7	4.2	4.7	5.3	5.7	6.1
		B	S	2.8	3.3	3.8	4.3	4.8	5.4	5.8	6.2
		C	S	3	3.5	4	4.5	5	5.5	5.9	6.3
		D	S	3	3.5	4	4.5	5	5.5	5.9	6.3
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
Intersecting Slopes (positive) 1:1	0.15	A	S	0.4	0.5	0.7	0.8	1	1.3	1.5	1.8
		B	S	0.6	0.7	0.9	1	1.2	1.5	1.7	2
		C	S	0.8	1	1.2	1.4	1.6	1.9	2.1	2.4
		D	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.3	A	S	2.9	3.3	3.7	4.2	4.7	5.3	5.8	6.3
		B	S	3	3.4	3.8	4.3	4.8	5.4	5.8	6.2
		C	S	3.2	3.6	4	4.5	5	5.5	5.9	6.3
		D	S	3.2	3.6	4	4.5	5	5.5	5.9	6.4
		E	S	3.2	3.6	4	4.5	5.1	5.7	6.3	7
	0.6	A	S	3	3.5	4	4.5	5	5.6	6.2	6.7
		B	S	3.1	3.6	4.1	4.6	5.1	5.6	6.2	6.7

8

Object Type and Characteristics				Severity Index for a design speed (km/h) of:							
Slope (V:H)	Height (m)	#Surface Condition	*Object Surface	50	60	70	80	90	100	110	120
Intersecting Slopes (positive) 1:1	0.6	C	S	3.3	3.8	4.3	4.8	5.2	5.7	6.3	6.8
		D	S	3.3	3.8	4.3	4.8	5.2	5.7	6.3	6.8
		E	S	3.3	3.8	4.3	4.8	5.2	5.7	6.3	7
	1	A	S	3.1	3.6	4.1	4.6	5.1	5.7	6.3	6.8
		B	S	3.2	3.7	4.2	4.7	5.2	5.7	6.3	6.8
		C	S	3.4	3.9	4.4	4.9	5.3	5.8	6.4	6.9
		D	S	3.4	3.9	4.4	4.9	5.3	5.8	6.4	6.9
		E	S	3.4	3.9	4.4	4.9	5.3	5.8	6.4	6.9

* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F

** The condition addressed in this table is a relatively simple one where the vehicle encounters an intersecting upward slope that connects to a relatively level and wide surface at its upper limit. Transitions between foreslope or backslope and intersecting slopes are not addressed, nor is the condition where a vehicle might vault a dike or a narrow intersecting roadway. Developing SIs for the conditions not addressed will require special analysis and engineering judgement.

#Notes:

A: Smooth and firm all seasons.

B: Smooth but subject to deep rutting by errant vehicles half of the year

C: Shallow gullies (100mm to 200mm deep), scattered small boulders (under 225mm projections), scattered small trees (diameters 75mm to 100mm), or structurally substantial woody brush. Features spaced so that nearly all encroaching vehicles will encounter them.

D: Medium gullies (approximately 250mm deep), boulders or riprap (projecting approximately 300mm), or medium trees (diameters 175mm to 225mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid, SI's for high, steep slopes may be considerably higher than values shown.

E: Deep gullies (over 0.5m deep), large boulders or heavy riprap (over 450mm projecting), large trees (diameters over 350mm). Features spaced so that all encroaching vehicles will encounter them. It is assumed that density of features will preclude deep penetration of roadside. If this assumption is not valid, SI's for high, steep slopes may be considerably higher than values shown.

8

Table 8.26 Suggested Severity Indices for traffic barriers

Object Type and Characteristics			Severity Index for a design speed (km/h) of:							
Application	**Description**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Longitudinal Traffic Barriers - Uniform Section	W-Beam Thrie Beam Wire Rope Basic SI for all currently accepted barriers, guardrails, bridgerails, median barriers, apply the basic SI to that percentage of impacts estimated to be contained by the barrier. For that percentage of impacts estimated to penetrate and SI appropriate for the shielded hazard should be used to adjust the effective barrier SI.	F	1.9	2	2.2	2.3	2.5	2.7	3	3.3
	Concrete Barrier (F-Type and single slope)	F	3.61	3.8	4.18	4.37	4.75	5.13	5.7	6.27
Guardrail to Parapet Transitions	Treat the same as currently acceptable longitudinal barriers if transition meets crash test acceptable requirements and adjust for estimated penetrations	F	1.9	2	2.2	2.3	2.5	2.7	3	3.3
	For substandard transitions consider a section of the face of the approach guardrail as having the severity of a fixed object. This section of barrier would nominally be part of a continuous barrier face, thus the corner and side SIs would be zero.									
Examples of guardrail to parapet transitions	Standard, strong-post, w-beam guardrail, blocked out with two spaces at .95m and full-strength attachment to parapet	F	0.1m @ 1.8	0.1m @ 2	0.3m @ 2.2	0.4m @ 2.4	0.7m @ 2.6	1.1m @ 2.9	1.6 m @ 3.2	2m @ 3.5

8

Object Type and Characteristics			Severity Index for a design speed (km/h) of:							
Application	**Description**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Examples of guardrail to parapet transitions	Standard, strong-post, w-beam guardrail, blocked out with 1.9m post spacing and no connection to parapet	F	0.4 m @ 2	0.7m @ 2.3	1.1m @ 2.5	1.5m @ 2.8	2.1m @ 3.2	2.7m @ 3.5	3.5m @ 3.9	4.2m @ 4.3
	Three cable guardrail, 4.88m post spacing, attached to parapet end	F	2.4m @ 3	2.8m @ 3.4	3.3m @ 3.8	3.8m @ 4.3	4.5m @ 4.8	5.5m @ 5.4	6.9m @ 6	8.4m @ 6.5
Terminals (approach end except where noted)	BCT without diaphragms (properly installed with recommended flare)	C&S	3	3.3	3.6	3.9	4.1	4.3	4.5	4.8
		F	1.8m @ 2.1	1.8m @ 2.3	1.8m @ 2.5	1.8m @ 2.7	1.8m @ 2.9	1.8m @ 3.2	1.8m @ 3.5	1.8m @ 3.8
	Three cable, wood post guardrail terminal with cables anchored to end post and end post restrained by rod attached to a deadman. Approach end.	C&S	3	3.3	3.5	3.8	4.2	4.6	5	5.4
	Exit end (treat as fixed objects) (Departure End)	C&S	2.7	3.1	3.5	4	4.5	5	5.5	6
	BCT with diaphragm (properly installed with recommended flare)	C&S	2.9	3.1	3.3	3.5	3.7	3.9	4.1	4.4
		F	2m @ 2.1	2m @ 2.3	2m @ 2.5	2m @ 2.7	2m @ 2.9	2m @ 3.2	2m @ 3.5	2m @ 3.8
	ET 2000, Brakemaster, MELT, SKT, FLEAT, QuadTrend350, Thrie Beam Bullnose	C&S	2	2.2	2.4	2.6	2.9	3.2	3.5	3.8
		F	2m @ 2.1	2m @ 2.3	2m @ 2.5	2m @ 2.7	2m @ 2.9	2m @ 3.2	2m @ 3.5	2m @ 3.8

Object Type and Characteristics			Severity Index for a design speed (km/h) of:							
Application	**Description**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Crash Cushions	Redirecting - Brakemaster Quadguard Quadguard Wide Quadeguard Elite React 350 TRACC TAUII Design meets recommended performance requirements	C&S	2.1	2.2	2.4	2.5	2.7	3	3.3	3.6
		F	1.9	2	2.2	2.3	2.5	2.8	3.1	3.4
Crash Cushions	Non-Redirecting - Energite and Fitch sand barrels Design meets recommended performance requirements, sand barrels have recommended .75-m shadow offset at rear of array - treat a section of the face at the rear of the array as having higher SI than that assigned to the remainder of the crash cushion. Consider section as part of a continuous barrier face. Thus the corner and side SIs of the section equal zero.	C&S	1.9	2	2.2	2.3	2.5	2.8	3.1	3.4
		F	0.2m @ 3.3	0.3m @ 3.6	0.5m @ 3.9	1m @ 4.2	1.5m @ 4.6	2.3m @ 5.1	2.7m @ 5.6	3.3m @ 6.1
* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F										

8

Table 8.27 Suggested Severity Indices for fixed objects

Object Type and Characteristics			Severity Index for a design speed (km/h) of:							
Type	**For:**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Round	Diameter equal to 0.5m	S	3	3.4	3.8	4.3	4.8	5.4	6	6.5
		C	3.4	3.8	4.2	4.7	5.2	5.8	6.5	7.2
		F	2.6	3	3.4	3.9	4.4	4.9	5.3	5.7
	Diameter equal to 1m	S	2.8	3.3	3.8	4.3	4.8	5.3	5.9	6.4
		C	3.3	3.7	4.1	4.6	5.1	5.7	6.4	7.1
		F	2.5	2.9	3.3	3.8	4.3	4.7	5	5.3
	Diameter equal to or great than 2m	S	2.7	3.2	3.7	4.2	4.7	5.3	5.9	6.4
		C	3.2	3.6	4	4.5	5	5.6	6.3	7
		F	2.6	2.9	3.3	3.7	4.2	4.7	5.2	5.7
Rectangular: Width of approach side equal to .5 m Face parallel to roadway, sides are perpendicular	Height = 0.15m	S	0.2	0.3	0.5	0.6	0.7	0.8	0.9	0.9
		C	0.2	0.3	0.5	0.6	0.7	0.8	0.9	0.9
		F	0.4	0.5	0.7	0.8	1	1.2	1.4	1.5
	Height = 0.3m	S	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		C	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
	Height = 0.5m	S	3.2	3.6	4	4.5	5.1	5.7	6.3	6.8
		C	3.2	3.6	4	4.5	5.1	5.7	6.3	6.8
		F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
	Height = 0.6m	S	3.4	3.8	4.2	4.7	5.2	5.8	6.5	7.2
		C	3.4	3.8	4.2	4.7	5.2	5.8	6.5	7.2
		F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
	Height > 1.0m	S	3.4	3.9	4.4	4.9	5.4	6	6.7	7.4
		C	3.4	3.9	4.4	4.9	5.4	6	6.7	7.4
		F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
Rectangular: Width of approach side is 1.25m. Face is parallel to roadway, sides are perpendicular	Height = 0.15 m	S	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.8
		C	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.8
		F	0.4	0.5	0.7	0.8	1	1.2	1.4	0.5
	Height = 0.3m	S	2.6	3.2	3.7	4.3	4.8	5.3	5.8	6.3
		C	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
	Height = 0.5m	S	3	3.5	4	4.5	5	5.6	6.2	6.7
		C	3.2	3.6	4	4.5	5.1	5.7	6.3	6.8
		F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
	Height = 0.6m	S	3.1	3.6	4.1	4.6	5.1	5.7	6.4	7.1
		C	3.4	3.8	4.2	4.7	5.2	5.8	6.5	7.2

Object Type and Characteristics			Severity Index for a design speed (km/h) of:							
Type	**For:**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Rectangular: Width of approach side is 1.25m. Face is parallel to roadway, sides are perpendicular	Height = 0.6m	F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
	Height > 1.0m	S	3.3	3.8	4.3	4.8	5.3	5.9	6.6	7.3
		C	3.4	3.9	4.4	4.9	5.4	6	6.7	7.4
Rectangular: Width of approach side is 1.25m. Face is parallel to roadway, sides are perpendicular	Height > 1.0m	F	1.9	2	2.2	2.3	2.5	2.7	2.9	3.2
Rectangular: Width of approach side is 2m or greater. Face is parallel to traffic and sides are perpendicular	Height = 0.15 m	S	0.5	0.7	0.9	1.1	1.3	1.6	1.9	2.2
		C	0.5	0.7	0.9	1.1	1.3	1.6	1.9	2.2
		F	0.4	0.5	0.7	0.8	1	1.2	1.4	1.5
	Height = 0.3m	S	2.5	3.1	3.6	4.2	4.7	5.3	5.8	6.3
		C	2.8	3.3	3.8	4.3	4.8	5.4	5.9	6.4
		F	1.9	2	2.2	2.3	2.5	2.7	3	3.3
	Height = 0.5m	S	2.9	3.4	3.9	4.4	4.9	5.5	6.1	6.6
		C	3.2	3.6	4	4.5	5.1	5.7	6.3	6.8
		F	1.9	2	2.2	2.3	2.5	2.7	3	3.3
	Height = 0.6m	S	2.8	3.4	4.1	4.7	5.1	5.6	6.3	7
		C	3.5	3.8	4.2	4.6	5.2	5.8	6.5	7.2
		F	1.9	2	2.2	2.3	2.5	2.7	3	3.3
	Height > 1.0m	S	3.2	3.7	4.2	4.7	5.2	5.8	6.5	7.2
		C	3.4	3.9	4.4	4.9	5.4	6	6.7	7.4
		F	1.9	2	2.2	2.3	2.5	2.7	3	3.3
Trees	Diameter = 50mm	A	0.2	0.3	0.3	0.4	0.5	0.5	0.7	0.8
	Diameter = 100mm	A	1	1.1	1.1	1.2	1.3	1.5	1.7	2
	Diameter = 150mm	A	2.5	2.6	2.6	2.7	2.9	3	3.2	3.3
	Diameter = 200mm	A	3.2	3.5	3.7	4	4.3	4.6	5	5.4
	Diameter = 250mm	A	3.2	3.6	4	4.5	5	5.6	6.2	6.7
	Diameter = 300mm	A	3.3	3.7	4.1	4.6	5.1	5.7	6.4	7.1
	Diameter > 300mm	A	3.4	3.8	4.2	4.7	5.2	5.8	6.5	7.2
Utility Poles (Wooden)	Diameter = 200mm	A	3.1	3.4	3.6	3.9	4.2	4.5	4.9	5.3
	Diameter = 250mm	A	3.1	3.5	3.9	4.4	4.9	5.5	6.1	6.6
	Diameter = 300mm	A	3.3	3.7	4.1	4.6	5.1	5.6	6.3	7

8

Object Type and Characteristics			**Severity Index for a design speed (km/h) of:**							
Type	**For:**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Utility Poles (Wooden)	Diameter > 300mm	A	3.4	3.8	4.2	4.7	5.2	5.8	6.5	7.2
Breakaway Supports with 35 km/h crash	Test velocity change of 1.5 m/s	A	0.9	1	1.2	1.3	1.4	1.6	1.8	1.9
	Test velocity change of 3 m/s	A	1.4	1.5	1.7	1.8	1.9	2.1	2.3	2.6
	Test velocity change of 4.5m/s	A	1.8	2	2.2	2.4	2.5	2.7	2.9	3.2
	Test velocity change of 6.1 m/s	A	3.2	2.5	2.7	2.9	3.1	3.3	3.5	3.8
	Test velocity change of 7.6 m/s	A	2.9	3.1	3.3	3.5	3.7	3.9	4.1	4.4
* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F										

Table 8.28 Suggested Severity Indices for culverts

Object Type and Characteristics			Severity Index for a design speed (km/h) of:							
Type	**Height (m)**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Culvert Ends: Culvert Axis Transverse to traffic Culvert End Type A	0.3m	S	0.4	0.5	0.7	0.8	0.9	1.1	1.3	1.4
		C	1.4	1.7	2	2.3	2.7	3.1	3.4	3.7
		F	2.3	2.6	2.9	3.2	3.4	3.7	4	4.3
	0.5m	S	0.6	0.7	0.9	1	1.2	1.4	1.6	1.7
		C	1.7	2.1	2.5	3	3.4	3.8	4.3	4.8
		F	2.1	2.4	2.8	3.2	3.4	3.6	4	4.4
	0.6m	S	1.5	1.8	2.2	2.6	2.9	3.2	3.6	4
		C	1.9	2.5	3.2	3.8	4.3	4.8	5.3	5.8
		F	2.2	2.5	2.8	3.1	3.3	3.6	4	4.4
	1 m	S	2.1	2.5	2.9	3.4	3.8	4.2	4.7	5.2
		C	2	2.6	3.1	3.7	4.3	4.9	5.5	6
		F	2.2	2.5	2.8	3.1	3.5	3.8	4.1	4.4
	1.2m	S	2.6	3	3.4	3.9	4.3	4.8	5.4	5.9
		C	1.6	2.2	2.9	3.5	4.2	4.8	5.4	6.1
		F	2.1	2.5	2.9	3.4	3.8	4.1	4.3	4.6
	1.8m	S	2.9	3.3	3.7	4.2	4.7	5.2	5.8	6.5
		C	1.1	1.8	2.5	3.2	3.9	4.5	5.1	5.8
		F	1.6	2.1	2.6	3.1	3.4	3.8	4.2	4.6
	2.4m	S	3	3.5	4	4.5	5	5.6	6.2	6.7
		C	0.2	1	1.9	2.7	3.4	4.1	4.7	5.4
		F	1.5	1.9	2.4	2.8	3.3	3.7	4.1	4.5
Culvert Ends: Culvert Axis Transverse to traffic Culvert End Type B	0.3m	A	0.2	0.3	0.5	0.6	0.8	1	1.3	1.6
	0.5m	A	0.4	0.5	0.7	0.8	1.2	1.6	2	2.4
	0.6m	A	0.3	0.6	0.9	1.2	1.7	2.1	2.3	2.6
	1m	A	0.5	1	1.5	2	2.3	2.6	3	3.4
	1.2m	A	1.5	1.8	2.1	2.4	2.8	3.2	3.6	4
	1.8m	A	1.9	2.3	2.7	3.2	3.7	4.1	4.5	4.9
	2.4m	A	2.5	2.9	3.3	3.8	4.3	4.8	5.3	5.8
Culvert Ends: Culvert Axis Transverse to Traffic Culvert End Type C	0.3m	C, S	2.4	2.7	3	3.3	3.6	3.9	4.3	4.7
		F	2.1	2.4	2.7	3	3.3	3.6	3.8	4.1
	0.5m	C, S	3	3.3	3.5	3.8	4.1	4.4	4.6	4.9
		F	2.6	2.9	3.1	3.4	3.6	3.9	4.1	4.4
	0.6m	C, S	3.2	3.5	3.8	4.1	4.4	4.7	5	5.3
		F	2.8	3.1	3.3	3.6	3.8	4.1	4.3	4.6
	1m	C, S	3.9	4.2	4.5	4.8	5	5.3	5.5	5.8

8

Object Type and Characteristics			Severity Index for a design speed (km/h) of:							
Type	**Height (m)**	***Object Surface**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Culvert Ends: Culvert Axis Transverse to Traffic Culvert End Type C	1m	F	3	3.3	3.6	3.9	4.1	4.4	4.6	4.9
	1.2m	C, S	4.3	4.5	4.7	4.9	5.2	5.5	5.8	6.1
		F	3.5	3.7	3.9	4.1	4.3	4.6	4.8	5.1
	1.8m	C, S	4.8	5	5.2	5.4	5.7	6	6.3	6.6
		F	4	4.2	4.4	4.6	4.8	5.1	5.3	5.6
	2.4m	C, S	53	5.4	5.6	5.8	6	6.3	6.6	6.9
		F	4.6	4.7	4.9	5	5.2	5.5	5.7	6
Culvert Ends: Culvert Axis Transverse to Traffic Culvert End Type D	.3m	A	1.2	1.4	1.6	1.8	2	2.3	2.4	2.9
	0.5m	A	1.5	1.7	1.9	2.1	2.4	2.8	3.5	4.2
	0.6m	A	1.6	1.9	2.1	2.4	2.8	3.1	3.3	3.6
	1m	A	1.7	2.1	2.5	3	3.2	3.5	3.8	4.1
	1.2 m	A	2.4	2.7	3	3.3	3.6	3.9	4.2	4.5
	1.8m	A	3	3.3	3.6	3.9	4.3	4.6	4.9	5.2
	2.4m	A	3.3	3.6	4	4.4	4.8	5.1	5.5	5.9
Culvert Ends: Culvert Axis Transverse to Traffic Culvert End Type E	0.3m	S	1.8	2.1	2.3	2.6	2.9	3.1	3.3	3.4
		C	2.2	2.5	2.8	3.1	3.4	3.7	3.9	4.2
		F	1.8	2	2.2	2.4	2.3	3	3.2	3.3
	0.5m	S	2.5	2.7	2.9	3.1	3.2	3.4	3.7	4
		C	3	3.2	3.4	3.6	3.8	4.1	4.3	4.6
		F	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.8
	0.6m	S	2.6	2.8	3	3.2	3.4	3.7	4	4.3
		C	3	3.3	3.5	3.8	4	4.3	4.6	4.9
		F	2.3	2.6	2.8	3.1	3.3	3.5	3.8	4.1
	1m	S	2.7	3	3.4	3.8	4	4.2	4.4	4.5
		C	3.3	3.6	4	4.4	4.6	4.8	5	5.3
		F	2.7	3	3.3	3.6	3.8	4	4.2	4.3
	1.2m	S	3.3	3.5	3.7	3.9	4.1	4.3	4.6	4.9
		C	3.9	4.1	4.3	4.5	4.7	5	5.3	5.6
		F	3.1	3.3	3.5	3.7	3.9	4.1	4.4	4.7
	1.8m	S	3.9	4	4.2	4.3	4.5	4.8	5.1	5.4
		C	4.4	4.6	4.8	5	5.2	5.5	5.8	6.1
		F	3.7	3.8	4	4.1	4.3	4.6	4.9	5.2
	2.4m	S	4.3	4.4	4.6	4.7	4.9	5.1	5.2	5.2
		C	5	5.1	5.3	5.4	5.6	5.8	6	6.1
		F	4.1	4.2	4.4	4.5	4.7	4.9	5	5

* S = Approach Side, C = Corner, F = Traffic Face, A = S, C, and F

Appendix 8B: User guide for the roadside incident severity calculator (RISC)

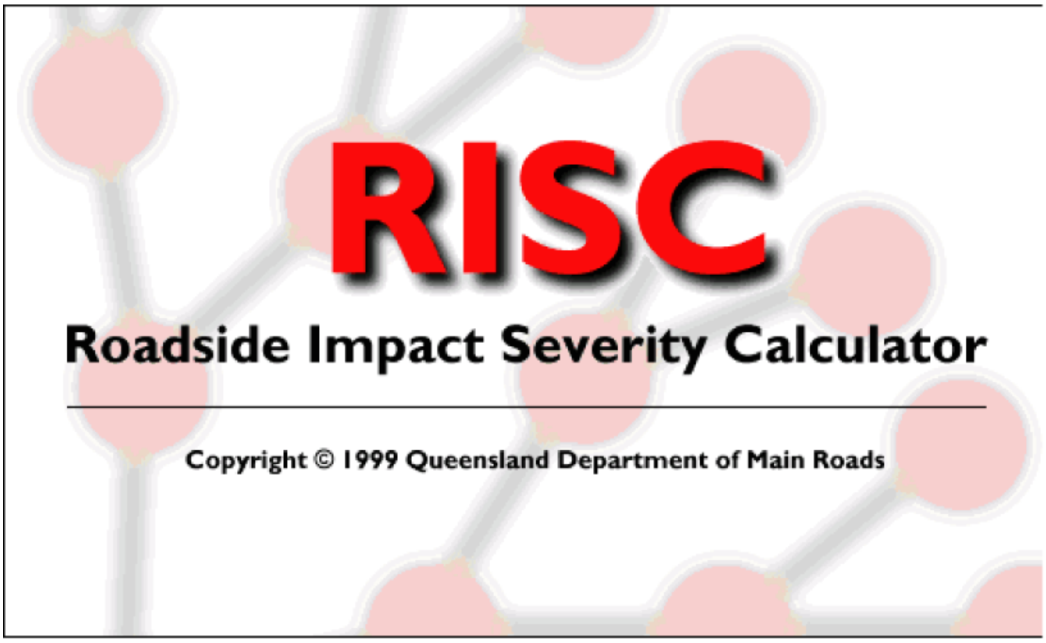


Figure 8.70 Roadside Impact Severity Calculator (RISC)

The Roadside Impact Severity Calculator (RISC) is a program developed by Main Roads to perform quantitative evaluation of hazardous roadside objects (Figure 8.70). It is intended to be used in conjunction with the Main Roads publication Roadside Barrier Guidelines.

<u>*Beginning RISC*</u>

The program begins by briefly displaying a splash screen, which clears to reveal the main window.

MAIN WINDOW

The main window (Figure 8.71) is divided into two sections. The left half is an object tree display of the roads, objects and treatments in the current *.ris file. The right half lists the properties of all the objects and treatments.

The button headings on the right-hand side of the window are used to sort the objects into order. Right-clicking on any of the items in the main window brings up a context menu at the mouse cursor location.

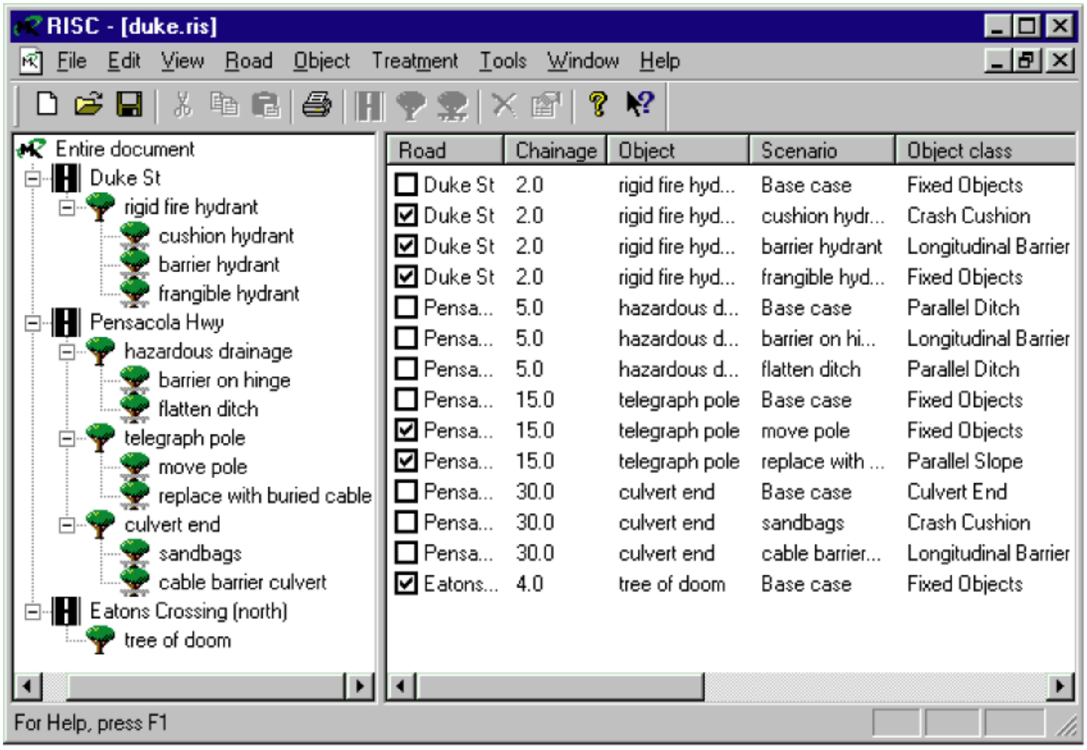


Figure 8.71 Example of main RISC window

MENUS

File Menu:

- New - create a new document.
- Open - open a previously created document.
- Close - close the current document.
- Save - save the current document.
- Save As - save the current document at a different location and/or filename.
- Print - print the selected objects.
- Print Preview - see what the printed document will look like.
- Print Setup - adjust the printer settings.
- (Recent Documents) - lists the last four documents to have been opened.
- Exit - exit RISC.

Edit Menu:

- Select All - selects all objects and treatments in the display.
- Deselect All - deselects all objects and treatments in the display.

View Menu:

- Toolbar - toggles the display of the toolbar.
- Status - toggles the display of the status bar.
- Split - adjust the position of the split bar.

Road Menu:

- New - create a new road section.
- Delete - delete the selected road section.
- Properties - edit the properties of the selected road section.

Object Menu:

- New - create a new object.
- Delete - delete the selected object.
- Properties - edit the properties of the current object.

Treatment Menu:

- New - create a new object treatment.
- Delete - delete the selected object treatment.
- Properties - edit the properties of the current object treatment.
- Combine - combine the selected treatment with compatible treatments for the same object (refer to Object Treatments).
- Uncombine - reverse the previous combine operation.

Tools Menu:

Options - edit the program parameters.

Window Menu:

- New Window, Cascade, Tile; and Arrange Icons - organise the display

Help Menu:

- Help Topics - help with aspects of the program
- About RISC - information about the Roadside Impact Severity Calculator.

TOOLBAR

The toolbar (Figure 8.72) displays the most commonly used menu items in an accessible format. Note that the Delete and Properties buttons are sensitive to which type of object is currently selected (road, object or treatment option), as are the Combine and Uncombine buttons.

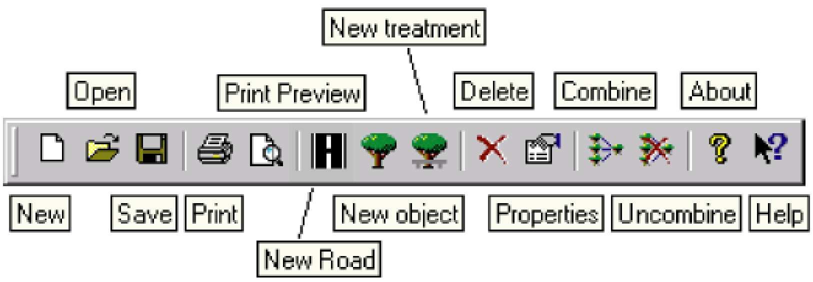


Figure 8.72 RISC toolbar

Using RISC

RISC requires the user to model roadside objects and potential treatments for these objects using an array of numerical parameters. Once this is done the relative benefits and costs for different treatments are automatically calculated using an algorithm based on the AASHTO Roadside Design Guide. The most cost-effective treatment for each hazard can be determined, and the decision-making process can continue to the next step.

The first step in using RISC is to create a new road section. Click the New Road button on the toolbar, or select New from the Road menu.

In RISC, each roadside object is associated with a road section. Any number of road sections can be specified. The properties of the road sections can be used to help identify the actual location. Fill in an appropriate Name and Description (Figure 8.73). The Start and End points define the limits of object chainage.

Figure 8.73 RISC road property dialogue box

OBJECT PROPERTIES

The next step is to create a new roadside object. Click on the New Object button, or select New from the Object menu. The button is only enabled while a road is selected.

The Object Properties (Figure 8.74) form requires information about the road environment, the type of object and its associated severity index, the position and dimensions of the object and scenario costs (installation, maintenance and repair). Fill in the form to describe the object being analysed. Refer to the descriptions below for assistance.

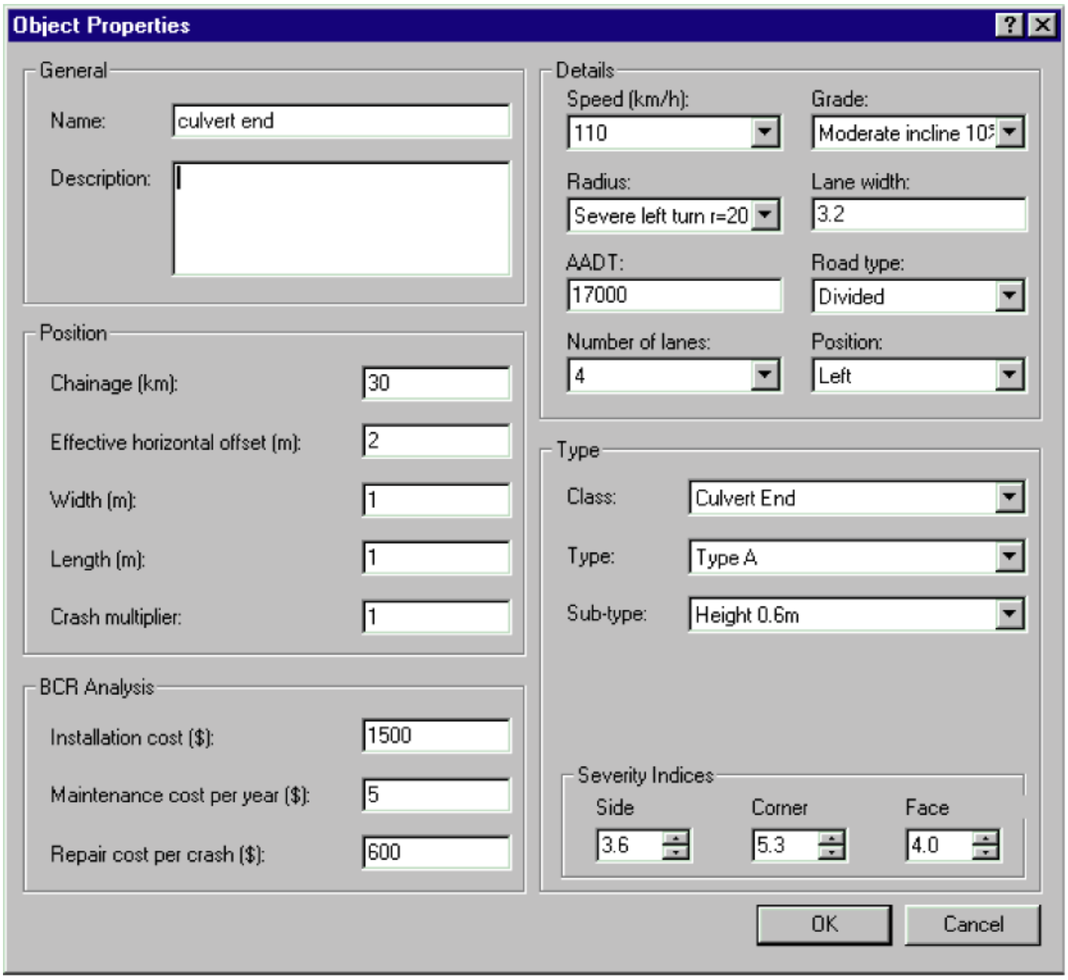


Figure 8.74 RISC object properties dialogue box.

General:

- General - object name and description.

Details:

- Speed - 85th percentile traffic speed at the object location. If this information is unavailable, the posted speed limit may be used instead.
- Grade - grade of road at object location. Positive grades denote an incline in the direction of travel; negative grades denote a decline.
- Radius - approximate radius of curvature at object location.
- Lane Width - average lane width at object location (width of road divided by the number of lanes)
- AADT - annual average daily traffic, in units of vehicles per day.
- Road Type - undivided, divided or one-way.
- Number of Lanes - total number of lanes (both directions included - Figure 8.75).

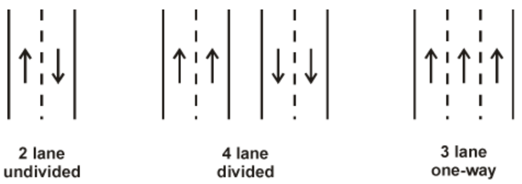


Figure 8.75 Number of lanes used in RISC

- Position - the side of the road on which the object is located (left, centre or right). For divided roads, the object may be located on the median strip (centre).

Position:

- Horizontal offset - the distance from the closest edge line to the object. RISC automatically calculates the increased offset for traffic crossing one or more lanes (e.g. opposing traffic encroaching onto the left hand side of an undivided road).
- Width - width of the object.
- Length - length of the object.
- Crash multiplier - adjusts the encroachment rate in recognition of increased likelihood of encroachment (eg. fatigue zones).

Type:

Class, Type and Sub-type - select the closest match to the object under consideration.

Note: when modelling a Fixed Object, confusion may arise with the apparent conflict of Width and Length settings (in the Position box) with Diameter settings (for trees, utility poles etc). Engineering judgement is required in these situations, along with the recognition that the Width and Length parameters are used to calculate the crash frequency for the object, while the Diameter determines the severity index for a single object of that type. This allows the modelling of either a single tree or a clump of trees, for example.

BCR Analysis:

- Installation Cost - installation cost for the object or treatment option. (For base case usually set all costs to $1). If comparing a new, non-barrier installation with the installation of a barrier, enter the actual costs of the non-barrier base case as well as the costs for the barrier case.
- Maintenance cost per year - general maintenance cost per year for the object

or treatment option (excludes repair maintenance). (Usually 10% of the installed cost).

- Repair cost per crash - cost of repairing the object as a result of a crash.

Severity Indices:

- Severity Indices - the recommended severity index for the object (determined as a result of object type characteristics). This number can be adjusted for non-typical situations.

OBJECT TREATMENT

Each object may have any number of treatment options associated with it. To create a new treatment, click on the New Treatment button while the desired object is selected.

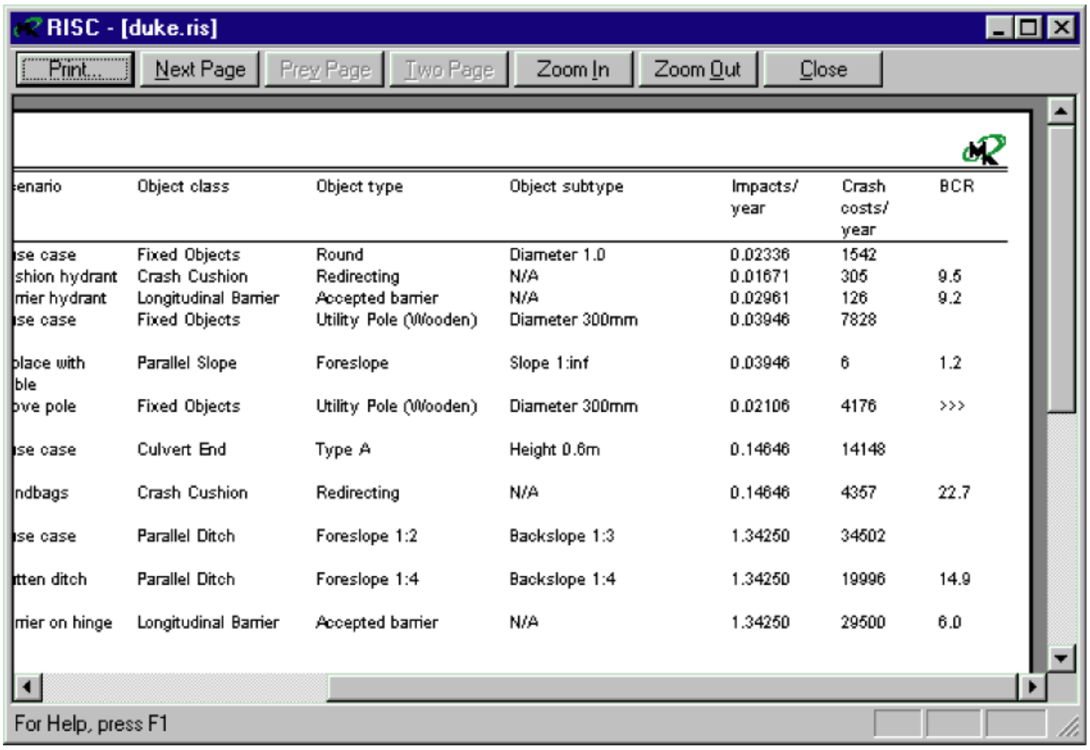
Object treatments are modelled similarly to objects, using the same Object Properties form. In most cases there will be significant differences from the object to the treatment in all sections apart from the roadside environment.

Barrier lengths and terminals are the only treatments that can be combined. This allows for an overall BCR to be calculated for the entire barrier assembly. To combine two or more treatments for the same object, select one of the treatments and click on the Combine button, and then select the other desired treatments from the pop-up window. The BCR will now read the same for all of those objects, and all of the combined treatments will be highlighted when one is selected. To undo a Combine operation, select one of the combined treatments and click on the Uncombine button.

Results

The right half of the main window (Figure 8.76) lists each of the objects and object treatments contained in the *.ris file with a summary of properties. The first six headings are descriptions of the objects/treatments with enough detail to distinguish each one. The last three headings contain the results of the program calculations:

- Impacts/year - the estimated number of impacts per year, based on road geometry and size of object.
- Crash costs/year - the estimated social cost as a result of the number of crashes per year. This figure is simply the impact frequency multiplied by the crash cost for the object's severity index.
- BCR - this value is the Benefit Cost Ratio of each treatment option. To be economically viable, a project must have a ratio greater than 1. The greater the ratio, the greater the benefit the project is relative to the cost. The BCR calculation sometimes results in values approaching ± infinity, represented in the program output by >>> for positive infinity and <<< for negative infinity. This is because the program is attempting to divide a positive or negative benefit by a zero cost. Check that the BCR information entered in for the treatment is different to that for the hazardous object, since the relative cost is the difference between the object costs and the treatment costs.



enario	Object class	Object type	Object subtype	Impacts/ year	Crash costs/ year	BCR
se case	Fixed Objects	Round	Diameter 1.0	0.02336	1542	
shion hydrant	Crash Cushion	Redirecting	N/A	0.01671	305	9.5
rier hydrant	Longitudinal Barrier	Accepted barrier	N/A	0.02961	126	9.2
se case	Fixed Objects	Utility Pole (Wooden)	Diameter 300mm	0.03946	7828	
place with ble	Parallel Slope	Foreslope	Slope 1:inf	0.03946	6	1.2
ove pole	Fixed Objects	Utility Pole (Wooden)	Diameter 300mm	0.02106	4176	>>>
se case	Culvert End	Type A	Height 0.6m	0.14646	14148	
ndbags	Crash Cushion	Redirecting	N/A	0.14646	4357	22.7
se case	Parallel Ditch	Foreslope 1:2	Backslope 1:3	1.34250	34502	
tten ditch	Parallel Ditch	Foreslope 1:4	Backslope 1:4	1.34250	19996	14.9
rier on hinge	Longitudinal Barrier	Accepted barrier	N/A	1.34250	29500	6.0

Figure 8.76 Example of RISC results dialogue box

Printing

The check boxes to the right of the split bar on the main window are used to select which objects will be printed. Select which objects you want to print, and then click the Print button from the Toolbar, or Print from the File menu.

Print Setup is used to adjust the properties of the selected printer.

To view what the printed document will look like before you print, select Print Preview from the File menu.

Adjusting RISC parameters

The calculations performed in RISC are dependant on a number of parameters. The default values that RISC uses are based on the best current practice at the time of release. To adjust the default values select Options from the Tools menu.

Note that adjusted values apply only the current document. New documents automatically use the default values. To use the same values for more than one document, there are two methods available:

1. Save the document containing the desired values under a new name using the Save As command, then delete the old road sections.

2. Manually enter the adjusted values each time a new document is created.

OPTIONS

General:

- Vehicle Swath Width - average width of vehicle in direction of encroachment angle. Default = 3·6m

- Discount Rate - discounting gives a measure of the present value of a future expenditure, excluding the effects of

8

8

inflation. A 6% discount rate means that receiving $100 now is equivalent to receiving $106 in a year's time or $112.36 in two year's time. Default = 6·0%.

- Growth Rate - annual traffic growth rate. Default = 2·0%.
- Project Life - expected life duration of project. Default = 20 years.
- Coefficient of Friction - braking and cornering friction between tyres and road. Default = 0·4.
- Base Encroachment Rate - The encroachment rate for specific situations is based on this figure, adjusted for roadside geometry and environment. It is primarily based on work performed in the United States by the American Association of State Highway Traffic Officials (AASHTO). Default = 0·0003 enc/km/year/vpd.

Crash cost:

- Crash Cost - RISC employs a social cost model to estimate crash costs. Five different categories of cost contribution are recognised (with 2001 costs as base case default values): Property $5,808, Minor Injury $10,000, Moderate Injury $13,776, Hospitalisation $407,990 and Fatal $1,652,994. More recent values derived from the Australian Bureau of Statistics may be used, if desired.

Encroachment Angle:

- Encroachment Angle - expected angle at which an encroaching vehicle leaves the road, measured between the axis of the road and the direction in which the vehicle is moving. Default values are adopted from research performed by the American Association of State Highway Traffic Officials (AASHTO).

Capacity:

- Capacity - carriageway capacity in vehicles per day. Encroachment frequency becomes constant above this capacity.

Appendix 8C: Practical applications and lessons from past practice

Introduction

This Appendix serves to gather into one place the information about the application of safety barriers to real-world situations that may not be covered by Main Roads Standard Drawings, conventional documentation or ready-to-use guidelines, all of which may assume a more ideal reality in the road environment than practitioners will encounter. It is also the intent of this Appendix to show installations that are not optimal and provide advice on what could have been done better. A barrier is, in itself, a hazard and is more hazardous if not installed correctly.

End treatments

End treatments are the most misunderstood and consistently badly implemented portion of safety barrier systems. This section attempts to redress some of the myths and misconceptions regarding them.

Illustrations in this Appendix show examples of actual installations. Commentary with each one provides guidance on which aspects are inappropriate or appropriate.

Figure 8.77 Wire rope end treatment showing below ground anchorage

The failure mechanism for end-on approach crashes is that the posts collapse progressively until the energy of the errant vehicle is dissipated. The anchor block detail is such that the swaged ends are designed to pull out for departure end crashes; thus preventing pocketing.

As an aside, concrete between the anchor blocks and a sealed (or asphalt surfaced) pavement between the shoulder and the installation to manage vegetation growth should produce a more maintenance friendly installation.

8

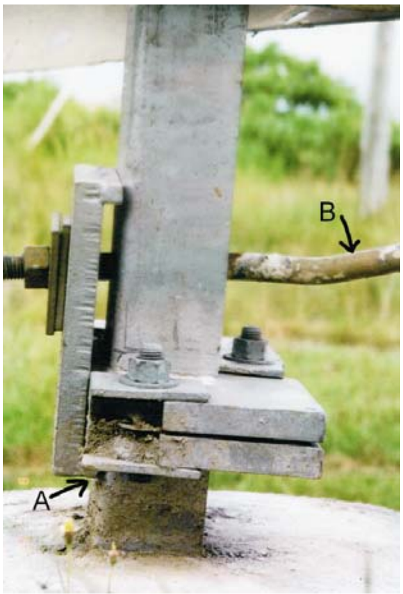


Figure 8.78 Illustrating general but sub-optimal arrangement for w-beam slip base assembly

Note rod (B) instead of cable and unnecessary second spacer (A) on lower portion of bearing plate. Either could cause non-optimal operation and result in spearing of errant vehicle.

In Figure 8.79, the end treatment is sub-optimal. The cable anchor assembly is missing, a splayed or "fish-tail" end is present on the approach side and there are no frangible elements present in the first posts.

Figure 8.79 Sub-optimal end treatment installation showing missing cable anchor assembly, "fish-tail" end and lack of frangible elements in approach end posts

Figure 8.80 Spearing hazard created by welding a bar (A) to the back of an end treatment in an attempt to make the posts more friendly to pedestrians and cyclists

Refer to Figure 8.125 for one suggested solution to this problem.

Figure 8.81 Another attempt to make the posts friendly to pedestrians and cyclists

This is a spearing hazard created because of lack of appreciation of the design failure mechanism of this end treatment. Refer to Figure 8.125 for one suggested solution to this problem.

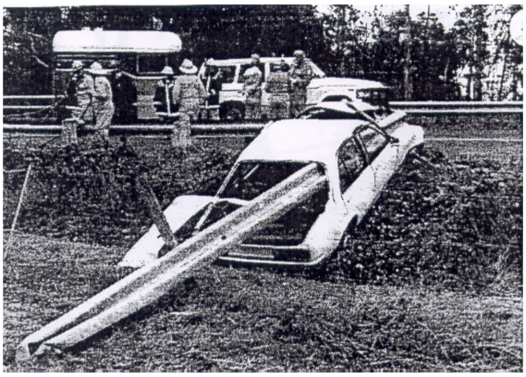


Figure 8.82 This is the reason for moving to the MELT system as given in the current Main Roads Standard Drawings for guardrail

Figure 8.83 Small and medium sized vehicles are now more common and a larger proportion of the vehicle fleet than they were when Breakaway Cable Terminals (BCTs), commonly known as bull nose ends, were developed in the 1950s

This fatality resulted from a failure of the BCT to operate (refer to Figure 8.84).

Figure 8.84 The failure of the end treatment to operate when hit in the fatality shown in Figure 8.83 can be seen here

Note that the bull nose end has not collapsed, the first posts have not broken and the first rail(s) have not buckled. The mass of the vehicle is less than those used when this end treatment was developed in the 1950s and was not sufficient to make the end treatment collapse as designed

Figure 8.85 Ideal MELT end treatment

Note the correct flare and adequate hazard free runout area.

8

Figure 8.86 MELT- - midspan impact

Note that the system will effectively redirect an errant vehicle from the 3rd post onwards.

Figure 8.87 Rubber crash cushion and 22,000kg articulated vehicle

Note that the system is designed for Test Level-2 crash, and although it was destroyed, effective attenuation was still achieved. (Test Level 2 is for a 2000kg vehicle.)

Figure 8.88 Thrie-beam bullnose – gore area, after initial impact

Note that this installation predated Standard Drawing Number 1488, and performance was less than desirable, however the outcome was tolerable.

Figure 8.89 Thrie-beam bullnose – gore area, after second Impact

Note that the installation still predated Standard Drawing Number 1488, and included several erroneous elements. However, it still performed extremely well.

Figure 8.90 Thrie-beam bullnose – gore area, after third impact

By correcting the installation to comply with Standard Drawing No. 1488 and Standard Drawing No. 1489, nuisance impacts may be reduced.

At the time of printing, this installation has been impacted at least six times, which suggests the need for a more re-useable system, unless the crash causes can be addressed.

Figure 8.91 Length of need – Picture 1 of 1

This demonstrates the importance of adequate length of need, and why gating end treatments are not suitable for high embankments.

The need for an end treatment could be avoided by continuing the w-beam barrier into the cutting, and anchoring. Refer Standard Drawing 1484.

Figure 8.92 Length of need – Picture 2 of 2

The vehicle glanced the BCT as shown above in Figure 8.91, and fortunately was retained by the chain wire fence prior to the 10m embankment.

Post-installation changes

Operational staff should be alert to alterations to barrier installations that render the barrier installation inoperative.

Figure 8.93 Poor installation practice

Note the washer under the cup-head bolt, which jeopardises the post/rail separation.

The washer is NOT to be installed, to allow the bolt to pull through the slot, enabling the rail height to be maintained, whilst the

8

post rotates away from the impacting vehicle.

Figure 8.94, Figure 8.95, Figure 8.96, Figure 8.97, Figure 8.98 and Figure 8.99 all show how, after correct installation, end treatments can be rendered inoperative by other factors.

Figure 8.94 Slip base mechanism, probably installed correctly, which has been rendered inoperative by the addition of decorative concrete overlay

Whilst pleasing to the visual senses, the textured concrete treatment of this island has turned a crash-sympathetic end treatment into a spearing and/or rigid hazard

Figure 8.95 Another view of slip base mechanism in Figure 8.94

It is unlikely that this will operate as designed in a crash

Figure 8.96 The traffic signals post will prevent this end treatment from operating in the desired manner

Figure 8.97 This installation was sub-optimal when installed from new

The slip mechanisms are installed in constricting voids in the concrete verge and will not operate as intended.

Figure 8.98 Close-up of slip base arrangement from Figure 8.97

The insufficiently sized void in the concrete verge and the concrete spilt over the slip base posts will inhibit correct operation.

Figure 8.99 This barrier has been incorrectly installed on the side leg of a T-junction

Turning traffic will not be hitting the barrier on the right of the photo at significant speed and it poses no spearing threat to right to left turning traffic so the need for slip base posts on that portion of the installation needs to be reviewed

Figure 8.100 Another view of the installation shown in Figure 8.99 looking along the top of the T-junction

Given the proximity of the two unconnected barrier ends it unlikely that the barrier in the foreground would operate as designed in a crash. A more optimal solution would have been the curved rail treatment shown in Figure 8.31.

Figure 8.101 Incorrect installation – no hazard fee zone

AS 3845 requires a hazard-free runout area that is 22.5m long and 6m wide behind this end treatment. The decorative rock feature of this installation is not an approved element under this Australian Standard.

Figure 8.102 Ramped ends

Ramped ends such as this will cause errant vehicles to lose stability and, in moderate to high speed crashes, will cause errant vehicles to become airborne

Severe or fatal injuries are a probable outcome in these cases. A crash cushion that meets AS3845 should be used instead (e.g**.** Figure 8.108, Figure 8.110, Figure 8.111, Figure 8.112, Figure 8.113, Figure 8.114 and Figure 8.115)**.**

8

Figure 8.103 This installation did not comply when built – incorrect offset

A 1200mm offset at the start of the end treatment was the requirement when this installation was undertaken. It is now obsolete because the lower mass of cars in the modern vehicle fleet is not capable of operating this end treatment in a safe manner.

Figure 8.104 Comments made for Figure 8.103 also apply to this example

Figure 8.105 Dead straight end rails, no offset, no flare, no curve; a spearing hazard regardless of the mass of the impacting vehicle.

<u>Back-to-back w-beam end treatment</u>

A directive was issued by Main Roads in January 2000 banning the double (w-beam) bull nose end treatment for back-to-back guardrail end treatment as shown on the superseded Main Roads Standard Drawing Number 1341.

The previous Main Roads standard w-beam end treatment was the BCT. This end treatment was detailed in the Standard Drawings as having a flare and parabolic end rail to ensure moment was initiated in a crash so that the end rail was moved away from the impact area and thus reduced the likelihood of spearing. The new MELT accentuates this detail.

When the median barrier end treatment was developed, the design did not include provision for the energy of the crash to rotate the barrier away from the vehicle. Before the advent of the small car and its increasing proportion of the vehicle fleet, this lack of moment in a crash did not feature prominently in crash analyses. The reasons for this was that larger mass passenger vehicles tended not to be as affected by crashes into this type of feature as smaller cars have been.

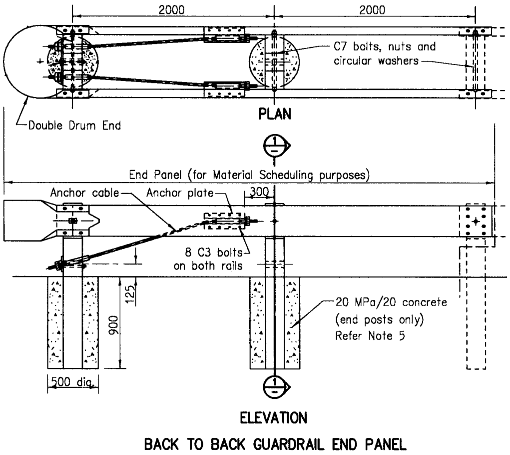


Figure 8.106 BANNED end treatment previously used for back-to-back guardrail installations

Figure 8.107 Showing a back-to-back w-beam end treatment after crash

Note no rotation of the end in the horizontal plane so any energy dissipation results in moment in the vertical plane forcing the end panel through the windscreen into the passenger cell.

When off-ramp barrier installations are needed to shield errant vehicles from hazards the designer's options are reduced because of space restrictions in gore areas. Similar restrictions are also evident when choosing median barrier end treatments. In narrow spaces, the crash cushion is the only option but this can be expensive (e.g. indicative pricing for a Quadguard is $20,000) for example. Where more space can be made available as a trade-off against cost of proprietary cushion systems, the public domain MELT or the Thrie-beam Bull nose can be used if the area in question can meet the required set out details.

Remedial treatment is clearly necessary; however AS3845 cautions:

"With respect to current installations, the wide variation in type, age and general condition of … barrier [systems] should be noted. The intention of this Standard is not to create a demand to remove all examples of superseded practice from the roadside. It is anticipated that equipping the road network with [satisfactory] barrier systems … will take many years to achieve. It is essential that due thrift be exercised in meeting the large number of competing demands for scarce resources. Instead, a rational analysis of the hazards and the risks should be used to identify sites with the highest need and ensure that these sites are addressed first."

Once identified, back-to-back w-beam end treatments should be prioritised in severity order (using traffic volume and speed environment as metrics) with a view to orderly removal and replacement with best practice end treatment systems.

Figure 8.108 Best practice example – the Crash Attenuating Terminal (C-A-T)

Suitable for back-to-back w-beam end treatment or for rigid concrete barrier crash cushion termination

Figure 8.109 Best practice example – the Crash Attenuating Terminal (C-A-T)

Suitable for back-to-back w-beam end treatment or for rigid concrete barrier crash cushion termination

Figure 8.110 Best practice end treatments, Quadguard Elite

Suitable for back-to-back w-beam end treatment or for rigid concrete barrier crash cushion termination

Figure 8.111 Best practice end treatments, Thrie-beam bullnose

Suitable for median applications.

Figure 8.112 Best practice end treatments, Thrie-beam bullnose

Suitable for gore area applications.

Figure 8.113 Best practice end treatments, Brakemaster

Suitable for back-to-back w-beam end treatment or for rigid concrete barrier crash cushion termination

Figure 8.114 Best practice end treatments, Quadguard and Quadguard CZ

These are suitable for back-to-back w-beam end treatment or for rigid concrete barrier *crash cushion termination. CZ designation stands for construction zone working.*

Figure 8.115 Best practice end treatments, Fitch and Energite sand filled barrels

These are suitable for temporary works or for shielding permanent hazards

Longitudinal barrier

Figure 8.116 It appears that the barrier is there to shield the pole but will not perform adequately in a crash

If an errant vehicle hits this barrier, it will encounter the power pole and the barrier will not be effective in reducing the impact forces to the occupants of the errant vehicle. It appears that the barrier is there to shield the pole but will not perform adequately in a crash.

Wire rope barrier

In cases where there is very little room to install a barrier system but there is a definite need to do so, such as mountain roads where it is desired to preserve the scenic character; wire rope barriers may be the appropriate solution (Figure 8.117) These may be installed using appropriate concrete beam sections as shown below and as developed by Peninsula District.

Figure 8.117 An innovative approach to installing wire rope barriers at a difficult site whilst preserving the scenic character

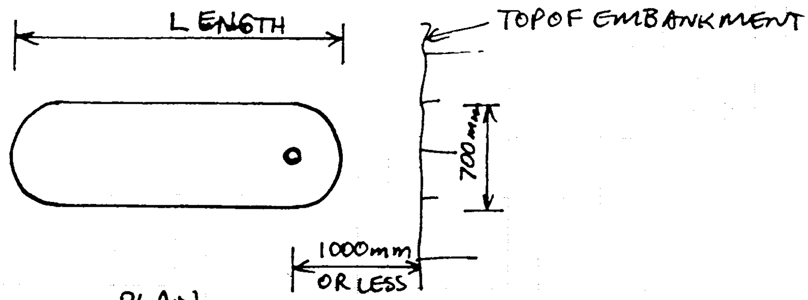
Figure 8.118 Wire rope barrier

One of several proprietary wire rope systems, complying with AS3845.

Note the off-set and location of the barrier, and although the vegetation behind the barrier is marginally within the dynamic deflection zone, it is considered frangible.

8

1) POST WITHIN 1m OF EDGE OF EMBANKMENT



PLAN

WIDE (mm)	DEPTH (mm)	LENGTH (mm)
700	600	1200
700	700	1000
700	800	900

NOTE

REINF WITH 4-Y12 BARS TOP + BTM (75 COVER)
COGG ENDS 300 mm.

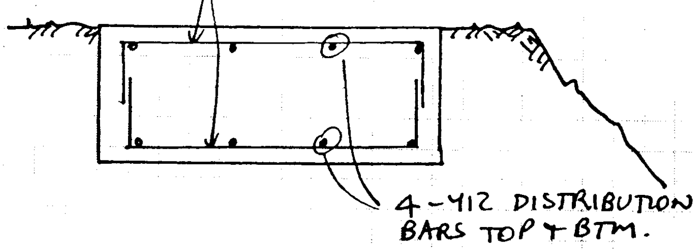


Figure 8.119 Footing assembly for culvert crossings Sheet 1 of 4 (refer also to Figure 8.117)

8

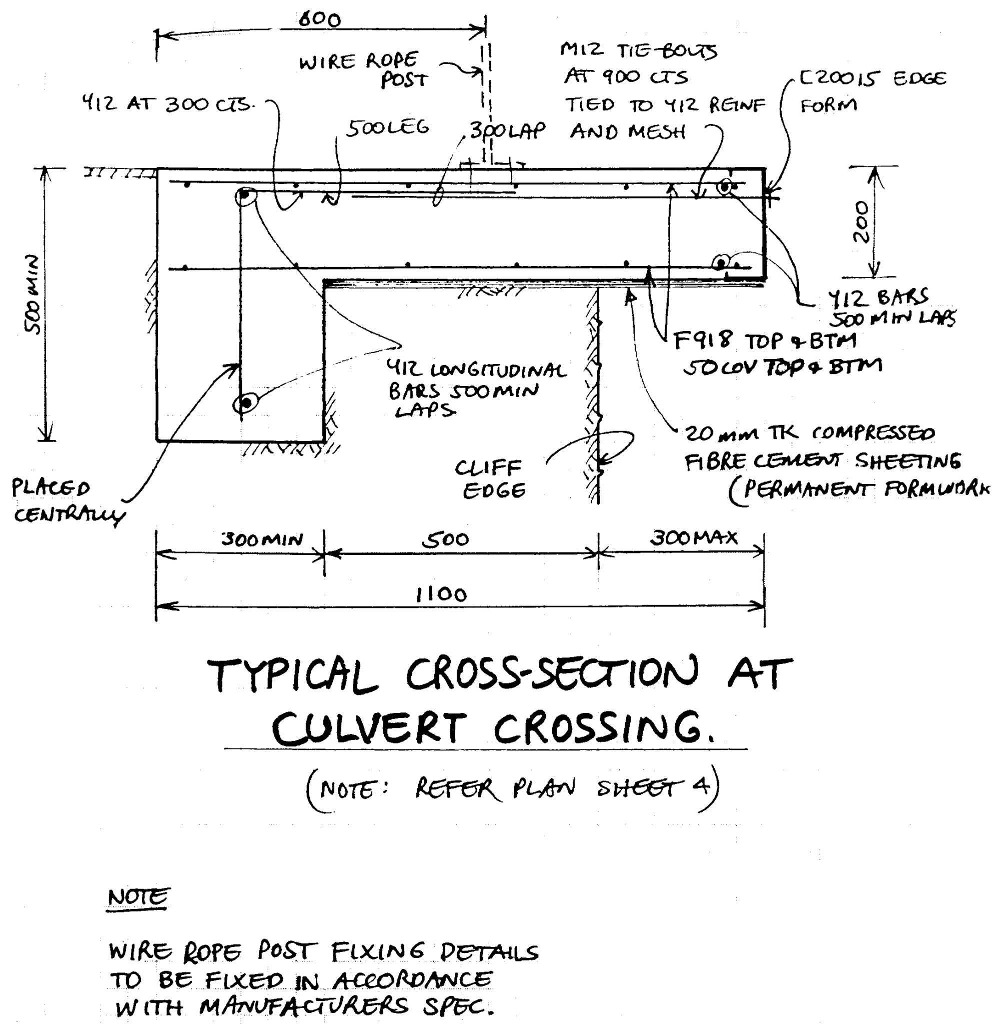


Figure 8.120 Footing assembly for culvert crossings Sheet 2 of 4 (refer also to Figure 8.117)

8

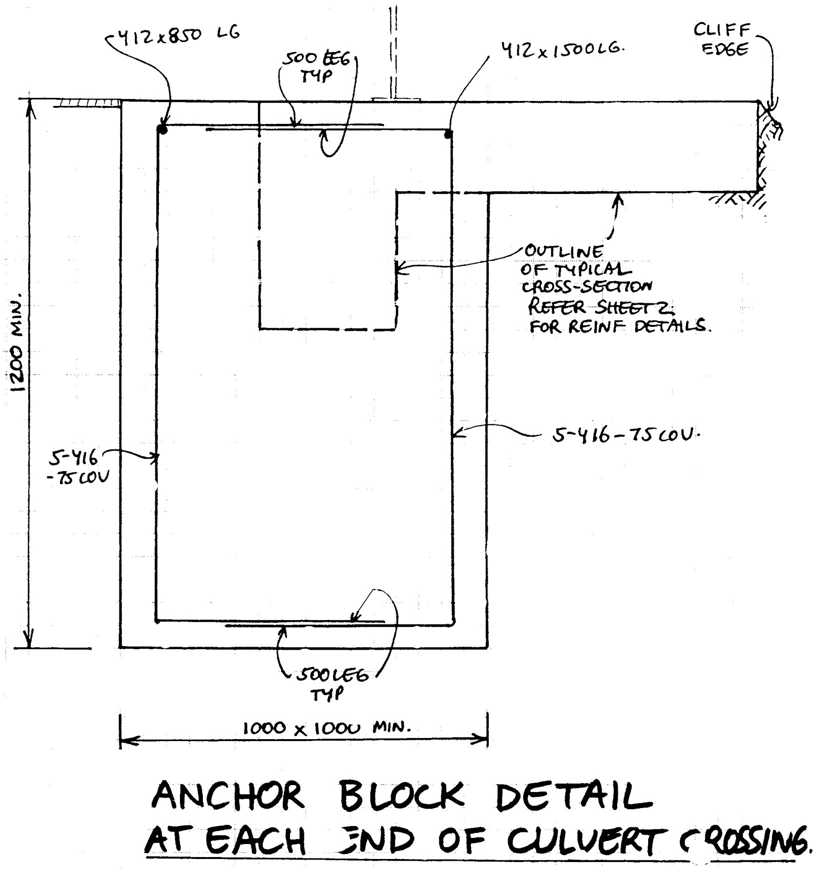


Figure 8.121 Footing assembly for culvert crossings Sheet 3 of 4 (refer also to Figure 8.117)

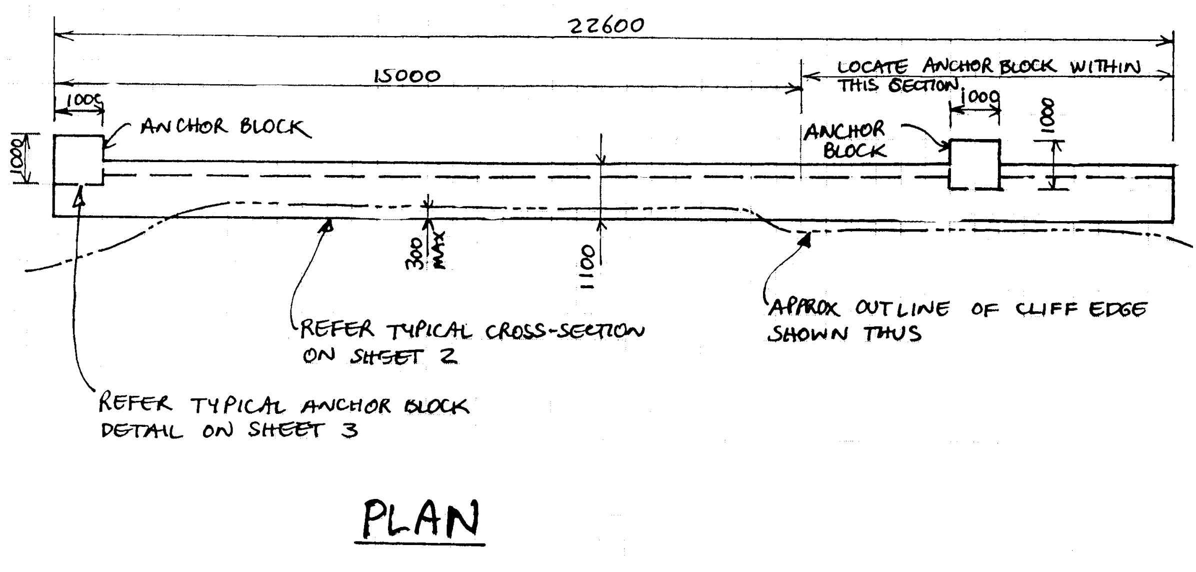


Figure 8.122 Footing assembly for culvert crossings Sheet 4 of 4 (refer also to Figure 8.117)

W-beam/thrie beam barrier

Short sections of unanchored guardrail do not redirect errant vehicles. The AASHTO tests conducted in the 1950s and 1960s proved that in excess of 20m of anchored (e.g. anchor assembly using wire rope part number FC01 from Main Roads Standard Drawing Number 1479) guardrail was required to develop sufficient tensional strength to redirect errant vehicles. The installation shown in Figure 8.123 is more hazardous than a bare light pole as it presents a spearing hazard and will not shield the pole.

Figure 8.123 This short section does not have anchored ends and is too short

Both of these faults result in insufficient strength to shield the pole from errant vehicles

Figure 8.124 Short sections

Short, unconnected w-beam will provide no shielding or redirection. This would pull out due to the lack of tensile strength. It also has the potential to be a spearing hazard, due to the fishtail and negligible flare.

Sometimes w-beam barriers are installed in high pedestrian or cycle traffic areas. This can lead to complaints of cuts and abrasions resulting from the barrier support posts. A 1.6mm pressed section of galvanised steel sheet (e.g. Zincalume brand) covering the posts, lightly anchored with pop rivets and of sufficient short lengths so as not to present a spearing hazard (e.g. 4m), as developed by Peninsula District, can be used without interfering with the guardrail operation and is shown in Figure 8.125.

Figure 8.125 Light steel sheeting covering the pedestrian/cycle side of w-beam guardrail installation

8

*Note: **A better solution is to install a 1.2m weldmesh fence between the barrier and the path used by cyclists. This is because it both protects cyclists from the barrier and mitigates the possibility of cyclists toppling over the barrier, perhaps into the path of traffic.** Note also the incorrect fishtail end on approach (far right) (The light sheet metal helps blend the feature into the surrounding environment by the use of matching paint.)*

<u>*Rigid (concrete) barrier*</u>

Figure 8.126 Single slope rigid barrier system used as a median barrier

<u>*Temporary barrier*</u>

Figure 8.127 This is not adequate as a barrier system; neither the plastic blocks nor their arrangement comply with the requirements for re-directive barriers or end treatments under AS3845

Figure 8.128 Another view of the arrangement in Figure 8.127

Note also that the temporary concrete barriers are not anchored together and, even if anchored together as per the Standard Drawings, are in a configuration that is too short to be effective as a re-directive system (refer to Section 8.2.4.1)

Figure 8.129 The temporary plastic blocks will not redirect errant vehicles

Note also that the concrete barriers in the foreground are not anchored together.

Figure 8.130 This drop (of about 12m) is the reason the temporary plastic blocks were installed (Figure 8.129)

Testing has shown that these blocks do not redirect errant vehicles, even when full of water and errant vehicles are moving at low speed.

Transitions

Figure 8.131 Transition between w-beam bridge approach and wire rope barrier

8

Appendix 8D: Worked example – RISC

Details of hazard

A bridge over a river with permanent water. The roadway is a two-lane undivided facility with an 85th percentile speed of 100km/h and a shoulder of 1m.

Figure 8.132 shows the dialogue box that must be completed.

ROAD ENVIRONMENT VARIABLES

Road type:	two-way
Number of lanes:	two
Width of lane	3.5m
Shoulder width	1m
85th percentile speed:	100km/h

TRAFFIC VOLUMES

AADT:	10,000

HORIZONTAL AND VERTICAL CURVATURE FACTORS

Curvature:	straight
Grade in direction of traffic:	flat

IDENTIFY ROADSIDE OBJECT ATTRIBUTES

Object: water hazard, 2m of water depth, 4m of embankment

Object length: Not applicable

Object width: 9m (i.e. set $L_c = L_a$) from Figure 8.4 and Section 8.2.4.1.

Horizontal offset: 1.0m from the travelled way.

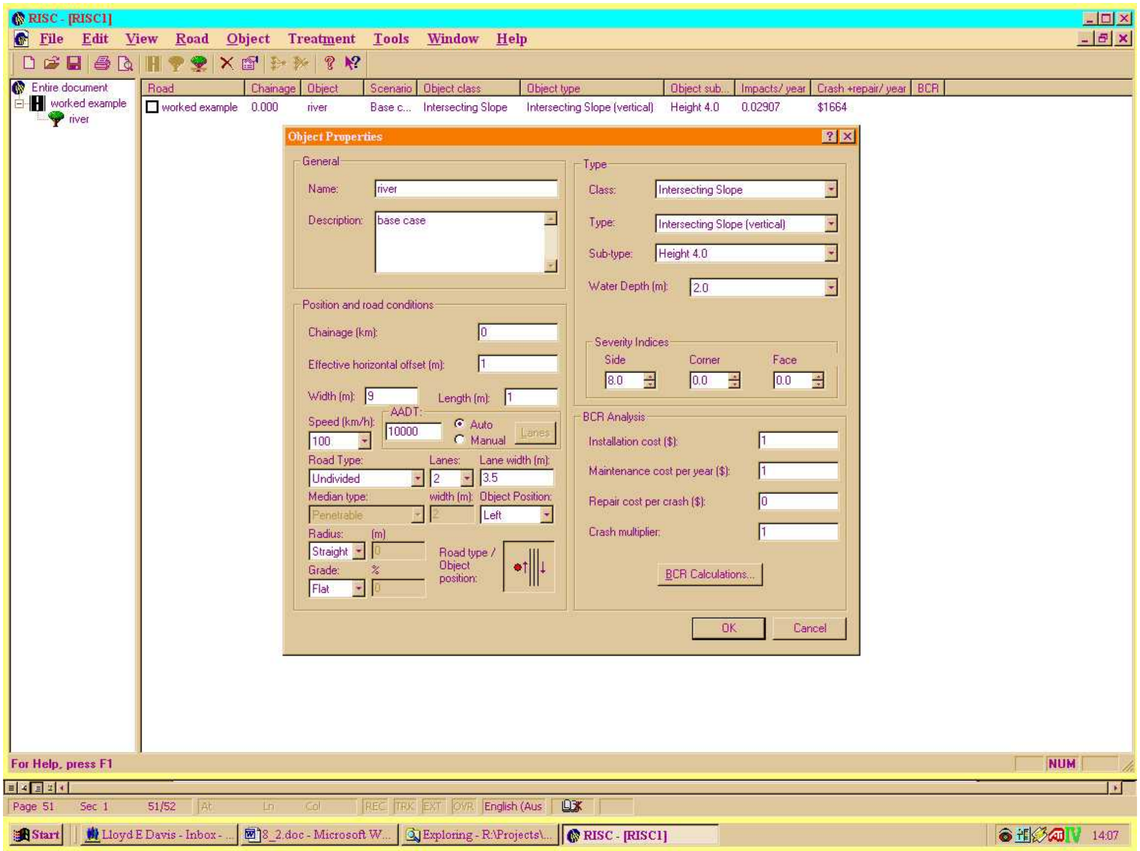


Figure 8.132 Worked RISC example – object properties for base case

Step 1 - Determine the lateral distance of the barrier from the edge of the road

In this case, set barrier back as far as possible, 1m less the minimum distance to hinge point, 0.6m. Therefore the distance is 0.4m.

Step 2 - Determine the barrier length of need

L_R, the runout length = 130m.

L_A, the lateral extent of the area of concern, = 9m

X (from Figure 8.21) is the required length of barrier upstream from the "Area of Concern".

The barrier length of need is determined using the chord line from L_R to the rear corner of the hazard, or to the clear zone if a non-traversable feature is being shielded.

From a preliminary sketch (Figure 8.133) the length of need is determined as 125m.

Step 3 - Check that the length of need can be justified using the BCR

Refer to Section 8.1.5 and determine whether the value of the BCR for the design is above the given thresholds. This example uses the default crash costs in the RISC program ().

Using $250/m installed for w-beam, insert the appropriate values into the treatment options box in RISC (Figure 8.134).

Clicking on the OK button yields the BCR of 3.3 for this length of need. The installation would need to consider current funding implications to justify this length compared to the required minimum length of 28m including the MELT.

Step 4 - Select an appropriate end treatment

The MELT would be the default end treatment chosen in this design, however any other end treatment meeting the requirements of AS3845 would be suitable. Some end treatments are:

- MELT – Requires appropriate flare and embankment, including hazard free zone.
- FLEAT - Requires appropriate flare (760mm – 1200mm) and embankment, including hazard free zone.
- SKT - Requires no flare, (but up to 300mm recommended), and requires a hazard free zone.
- ET-2000 Plus – Requires little or no flare, but requires a hazard free zone.

Step 5 - Determine the flare rate

The flare rate for the MELT is given in the Standard Drawings.

For design details of all proprietary products, the manufacturer must be consulted.

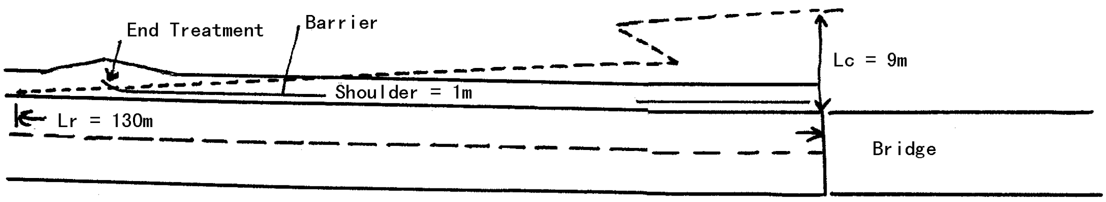


Figure 8.133 Preliminary sketch for Appendix 8D RISC example (not to scale and truncated for economy of space).

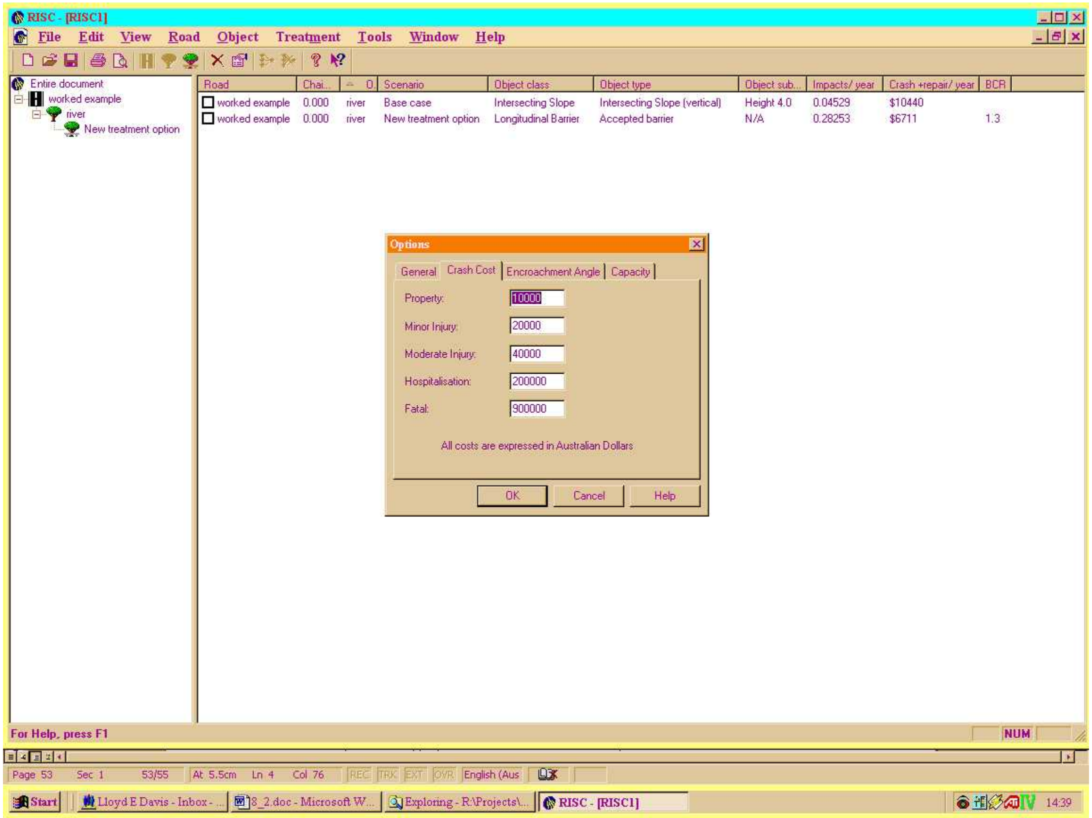


Figure 8.134 Worked RISC example – crash costs

8

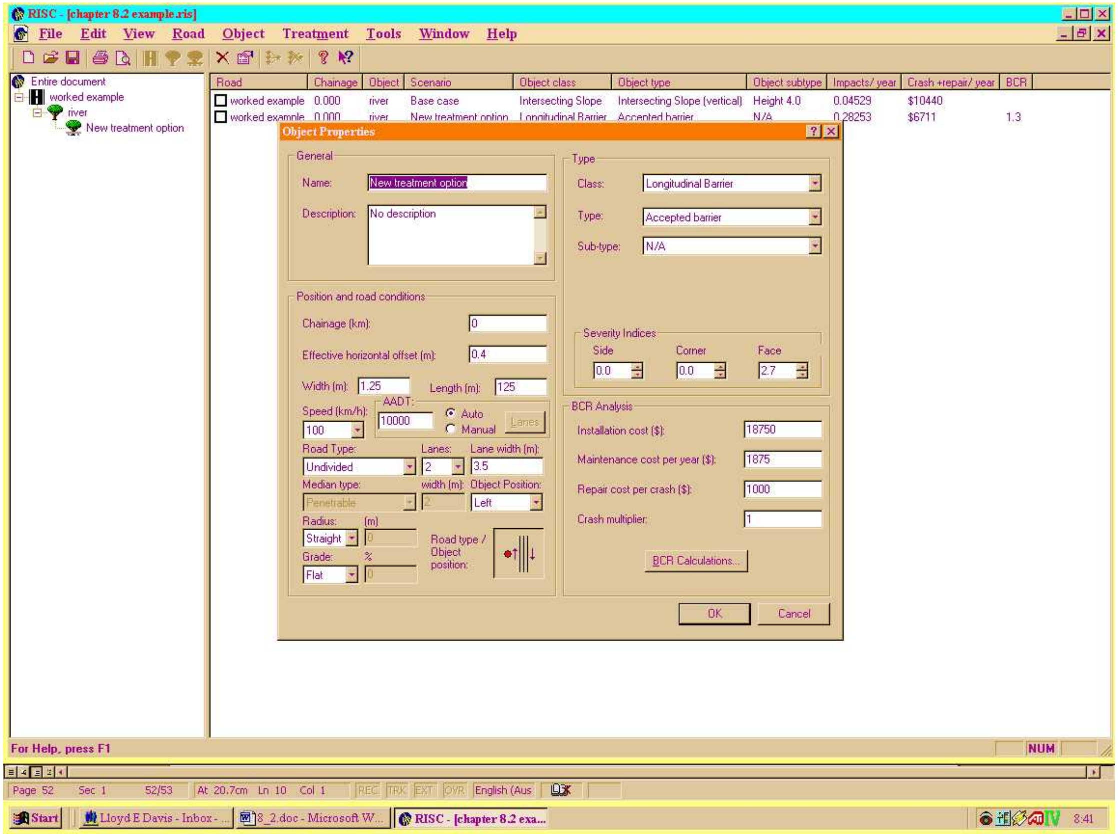


Figure 8.135 Worked RISC example – object properties for treatment option