

Section 3-04
Cross Sectional Elements

TABLE OF CONTENTS

INTRODUCTION3
 General.....3
 Exhibit 1-Cross-Sectional Elements3

CROSS-SECTIONAL ELEMENTS3
 Traveled Way3
 Shoulder3
 Surfacing Taper3
 Grading Slope3
 Foreslope.....3
 Backslope (Cut Slope)4
 Embankment Slope (Fill Slope).....4
 Clear Zone.....4
 Barn Roof Slope.....4

FORESLOPES4
 Recoverable Slope4
 Non-Recoverable Slope4
 Critical Slope4

TRAVELED LANE WIDTH4

SHOULDER WIDTH.....5

SURFACING TAPER5
 General.....5
 Exhibit 2-Taper Width and Effective Slope Calculation6
 Exhibit 3-Effective 1:5 Surfacing Taper Slopes6
 Exhibit 4-Effective 1:6 Surfacing Taper Slopes7

CLEAR ZONE DESIGN CRITERIA.....7
 General.....7
 Exhibit 5-Directional Clear Zones8
 Hazards Within the Clear Zone.....8
 Clear Zone Distance.....8
 Exhibit 6-Non-Recoverable Slope Within Clear Zone9

FACTORS THAT AFFECT CLEAR ZONE DISTANCE10
 Design Speed10
 Embankment Slope10
 Traffic Volume.....10

EMBANKMENT SLOPE DESIGN CRITERIA.....10
 Barn Roof Slope Design10
 Exhibit 7-Minimum Clear Zone Distance Table11

EXCAVATION SLOPE DESIGN CRITERIA12
 Ditch Section.....12
 Backslope.....12

SLOPE SELECTION AND CLEAR ZONE DESIGN13
 Exhibit 8-Fill Slope and Clear Zone Example14
 Exhibit 9-Cut Slope and Clear Zone Example.....15
 Exhibit 10-1V:4H Foreslope with Ditch Bottom in Clear Zone.....16

APPROACH DESIGN CRITERIA16

SNOW DRIFTING CONSIDERATIONS17

CURBS17

INTERSTATE MEDIAN DESIGN CRITERIA17
 Width 84 ft or Less17
 Median Width 84 ft to126 ft17
 Median Width 126 ft or Greater.....17
 Median Inlets18
 Median Barrier18
 Median Crossover and Drainage Dikes18
 Crossover Approach Widening.....18
 Exhibit 11-Crossover Approach Shoulder Widening18

SLOPE DESIGN FOR GUARDRAIL INSTALLATIONS19
 General19
 Exhibit 12-Guardrail Without Slope Modification19
 Exhibit 13-Guardrail With 1V:10H Slope Modification20

CABLE MEDIAN BARRIER20
 Exhibit 14-Cable Median Barrier Restricted Zone21

RIGHT OF WAY21

INTRODUCTION

General: A cross section is a vertical “cut” of the ground and roadway at right angles to the centerline of the roadway and includes all elements of the road from right-of-way to right-of-way. The names and locations of the cross-sectional elements found on a typical roadway section are shown in EXHIBIT 1.

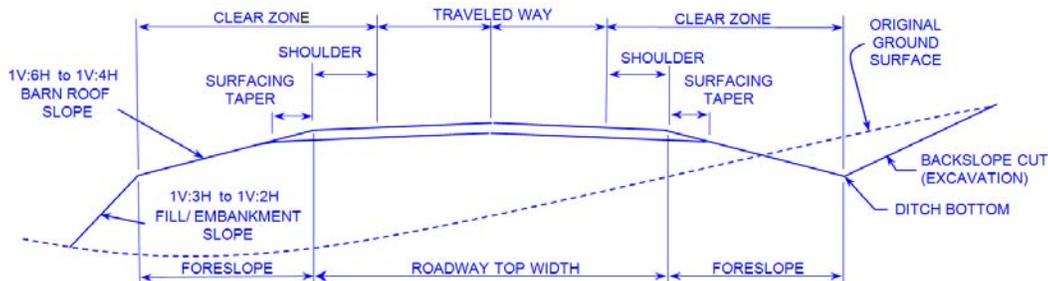


EXHIBIT 1
CROSS-SECTIONAL ELEMENTS

CROSS-SECTIONAL ELEMENTS

Traveled Way: The portion of the roadway for the movement of vehicles, exclusive of shoulders. See section on TRAVELED LANE WIDTH.

Shoulder: The top surface of roadway beyond the traveled way that provides for emergency parking and functions as part of the recovery area for errant vehicles. See section on SHOULDER WIDTH.

Surfacing Taper: The area outside the shoulder where the thickness of the surfacing materials (including pavement and base) transitions from full depth to zero. Surfacing taper slopes are relative to the pavement slope and are included as part of the foreslope. See section on SURFACING TAPER.

Grading Slope: Designation of fill (embankment) and cut (excavation) slopes are true to the vertical and horizontal axis and should be delineated as 1V:6H, 1V:5H, etc.

Foreslope: An embankment slope or the portion of a cut section sloping down and away from the roadway toward the toe of slope or ditch bottom. The foreslope in a fill section begins at the top outside edge of the surfaced shoulder and includes the combination of surfacing taper and barn roof slope to the clear zone or existing terrain. The foreslope in a cut section also begins at the top outside edge of the surfaced shoulder and includes the combination of surfacing taper and cut slope to the ditch bottom.

Backslope (Cut Slope): The portion of a cut (excavation) slope extending from the ditch bottom outward and upward until it intersects the existing terrain.

Embankment Slope (Fill Slope): The fill (embankment) slope beyond the surfacing taper, or clear zone hinge point for barn roof design, that extends outward and down until it intersects the existing terrain.

Clear Zone: The area free of hazardous objects and slopes on each side of the traveled way for each direction of travel. It is intended to improve the chances of errant vehicles that leave the traveled way to be able to stop or safely return to the roadway.

Barn Roof Slope: A 1V:6H to 1V:4H fixed fill slope within the clear zone that is normally followed by a 1V:3H to 1V:2H fill slope to existing terrain.

FORESLOPES

Recoverable Slope: A slope on which a vehicle can either stop or safely return to the roadway. Recoverable slopes are 1V:4H or flatter and can be included as part of the specified clear zone distance.

Non-Recoverable Slope: A slope that a vehicle can traverse, but it is generally too steep to allow the vehicle to stop or return to the roadway. Traversable non-recoverable slopes are between 1V:4H and 1V:3H and are NOT included in the specified clear zone distance.

Critical Slope: A slope that is considered severe enough to possibly cause a vehicle to overturn. It is steeper than 1V:3H. Critical slopes must be located beyond the required clear zone or must be shielded by guardrail.

TRAVELED LANE WIDTH

The traveled lane width and shoulder width are determined in accordance with AASHTO standards on the basis of the highway's functional classification, design speed, traffic volumes, level of service desired, and make-up of the traffic. Typically, 12 ft or 11 ft lane widths are used. Designers should refer to the latest edition of the *WYDOT Design Guides* for lane and shoulder width options based on project type.

SHOULDER WIDTH

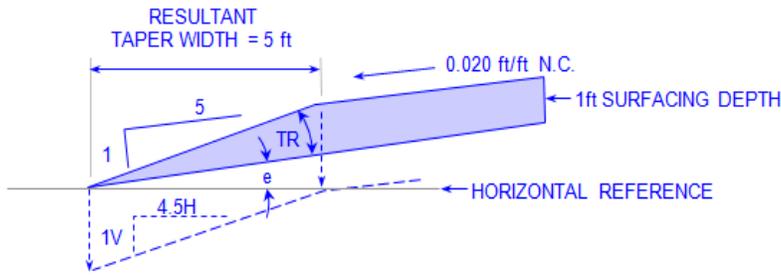
On rural highways with a surfacing taper section, the shoulder width is measured from the outside edge of the traveled way to where the surfacing taper begins. On urban streets with curb and gutter, the shoulder width is measured from the outside edge of the traveled way to the vertical face of the curb. The minimum shoulder width from face of curb is 2 ft. The gutter section is never considered part of the travel way, but it is considered part of the usable shoulder width. Consider bicycle usage when determining shoulder width. Designers should refer to the latest edition of the *WYDOT Design Guides* for lane and shoulder width options based on project type.

SURFACING TAPER

General: The surfacing taper extends from the outside edge of the surfaced shoulder out and away from the roadway until the depth of surfacing materials have been transitioned to zero, which is typically the hinge point for the earthgrade template. The surfacing taper is set at a fixed distance from the shoulder and is free to rotate with the surfacing template when rotated into normal crown and superelevation. The width of the surfacing taper is calculated based on an assumption of a defined slope for the taper applied on a flat template (no crown) and multiplied by the depth of surfacing materials.

The basic surfacing taper slope when considered as part of the surfacing template is designated as 1:5 or 1:6 (not 1V:5H or 1V:6H) because they are relative slopes that rotate with the crown and superelevation of the surfacing template. When considered as part of the foreslope, the surfacing taper slope is then expressed in terms of the rotated effective slope. Slopes designated as 1V:6H or 1V:4H, for the foreslope or embankment slope, are true to the vertical and horizontal axis and do not rotate.

EXHIBIT 2 shows the effective slope calculations for a typical 1:5 surfacing taper at a normal crown of 0.02 ft/ft. EXHIBITS 3 and 4 show the basic and effective surfacing taper slopes for the 1:5 and 1:6 surfacing tapers as the template is rotated into normal crown and superelevation. Red slope text indicates a non-recoverable slope.



HORIZONTAL COMPONENT OF THE EFFECTIVE SLOPE CAN BE CALCULATED AS:
 $b = 1 / (TR + e)$ = The horizontal component of the effective slope (e.g. 1V:bH)
 TR = The taper rate expressed as a decimal (e.g. 1V:5H or 1/5 = 0.20)
 e = Superelevation rate expressed as a decimal (+ or -)

RESULTANT TAPER WIDTH = SURFACING DEPTH X 1:5 TAPER SLOPE = 1ft X 5 = 5 ft.

TAPER WIDTHS ARE FIXED AND DO NOT CHANGE WITH SUPERELEVATION ROTATION

TAPER SLOPES ARE RELATIVE TO THE PAVEMENT TOP AND ROTATE WITH SUPERELEVATION.

EXHIBIT 2
 TAPER WIDTH AND EFFECTIVE SLOPE CALCULATION

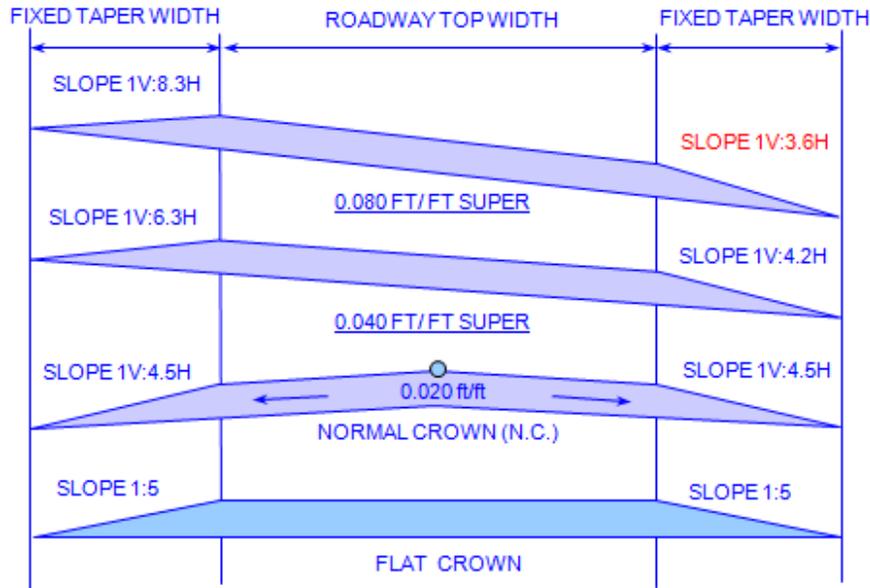


EXHIBIT 3
 EFFECTIVE 1:5 SURFACING TAPER SLOPES

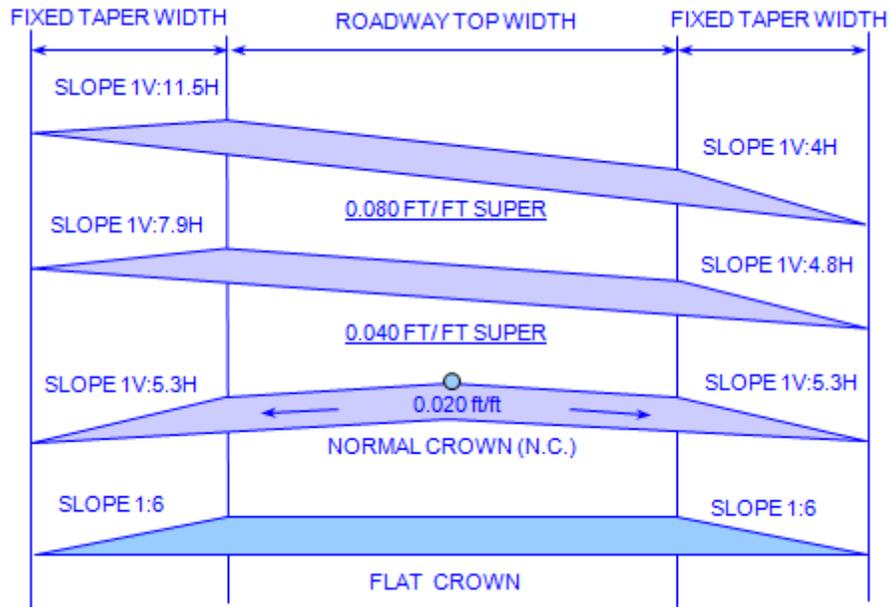


EXHIBIT 4
EFFECTIVE 1:6 SURFACING TAPER SLOPES

Designers should keep in mind that most guardrail installations require flatter slopes than typical surfacing taper slopes leading into the face of the guardrail, so slope modifications are necessary. See section SLOPE DESIGN FOR GUARDRAIL INSTALLATIONS.

CLEAR ZONE DESIGN CRITERIA

General: Clear zones are required to be free of fixed object hazards and have 1V:6H to 1V:4H slopes to reduce the likelihood of a rollover and allow a vehicle to come to a controlled stop. Objects that are located within the clear zone are required to be crashworthy to minimize the chance of serious injury or death. The clear zone is the specified distance as measured from the traveled way and includes the shoulder and surfacing taper. See the *AASHTO Roadside Design Guide* for detailed clear zone discussion and design criteria. The clear zone also applies to the left edge of the traveled way for a given direction of travel. See EXHIBIT 5.

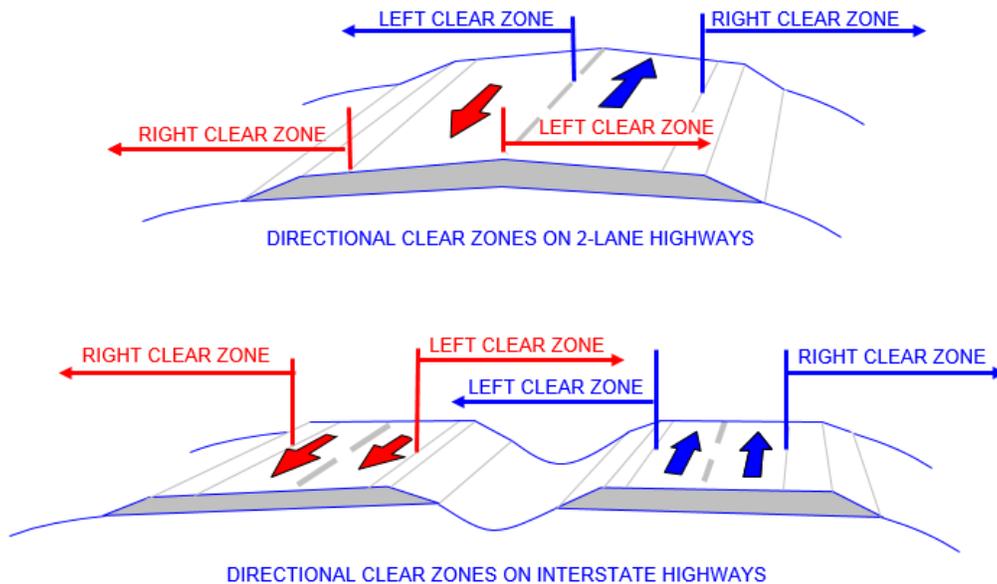


EXHIBIT 5
DIRECTIONAL CLEAR ZONES

Hazards Within the Clear Zone: Clear zones are to be free of fixed object hazards and critical slopes. To mitigate or shield hazards within the clear zone, consider the following options, which are listed in **order of priority**:

1. Remove the hazard or make safely traversable
2. Relocate the hazard
3. Make the hazard breakaway
4. Shield the hazard with an approved roadside barrier

A roadside barrier is a hazard in itself and should be used only as the last alternative. Before installing a roadside barrier, make sure the hazard cannot be mitigated by one of the higher priority options. Sometimes it becomes necessary to use guardrail for shielding hazardous slopes, which are often used to avoid the acquisition of additional right of way, to avoid impacts to sensitive areas (i.e. wetlands), etc.

Clear Zone Distance: Clear zone distances shown in EXHIBIT 7 represent the minimum values for the design speed selected in accordance with the current design guides and for the slopes given in the table. The barn roof design with a 1V:6H, 1V:5H or 1V:4H foreslope to the clear zone distance normally followed by a 1V:3H to 1V:2H embankment slope to ground is required for all rural reconstruction projects.

If the surfacing taper slope becomes steeper than 1V:4H because of super elevation rotation, it is not considered recoverable and cannot be included in the clear zone distance, therefore, the clear zone distance will need to extend out an additional amount equal to the surfacing taper width to obtain the full length of recoverable slope. See EXHIBIT 6.

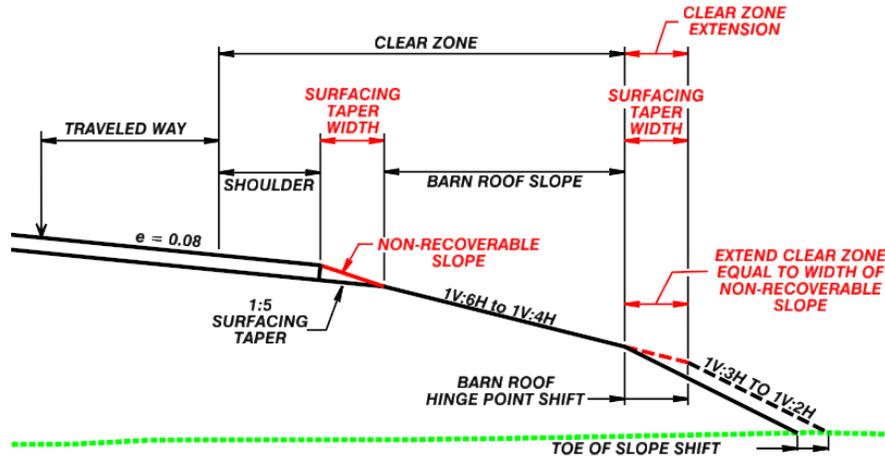


EXHIBIT 6

NON-RECOVERABLE SLOPE WITHIN CLEAR ZONE

The clear zone distance may be increased on curves or tangents where the crash history indicates a need or a specific site investigation shows a definitive crash potential that could be significantly lessened by increasing the clear zone distance and the additional cost can be justified. The designer should evaluate all options that might better reduce or eliminate crash potential. The use of curve correction factors as outlined in the *AASHTO Roadside Design Guide* is a good option that could be considered if warranted.

Interstate interchange ramp clear zone distance is usually less than the interstate mainline and should be based on the individual ramp design speed and traffic volume.

Clear zone distance adjacent to a passing or climbing lane on 2-lane roadways is measured from the outside edge of traveled way because WYDOT signs these areas “Keep right except to pass”, allowing high speed traffic in the passing or climbing lane.

For urban roadway design, the clear distance required is referred to as “lateral offset”. The required offset distance is usually a minimum of 1.5 feet measured from the face of curb and is needed to avoid conflicts with sign poles, trees, etc.

FACTORS THAT AFFECT CLEAR ZONE DISTANCE

Design Speed: As vehicles travel at higher speeds, their lateral encroachment distance increases.

Embankment Slope: On steep slopes, errant vehicles travel farther and therefore require larger distances to recover safely. A 1V:4H foreslope requires a wider clear zone distance than a 1V:5H foreslope, which also requires a wider clear zone distance than a 1V:6H foreslope. Clear zone distance can have an effect on the amount of adjacent impact area and amount of embankment grading.

Traffic Volume: On roadways with low traffic volumes, fewer vehicles leave the traveled way, thus justifying the use of a narrower clear zone.

These factors and their relationship to clear zone distance are illustrated in EXHIBIT 7, WYDOT Minimum Clear Zone Distance Table. The table is derived from Table 3-1 in the *AASHTO Roadside Design Guide*. The 1V:6H values are the minimum given for the 1V:6H or flatter category. The 1V:5H values are the minimum given for the 1V:5H to 1V:4H category. The 1V:4H values are the maximum given for the 1V:5H to 1V:4H category.

EMBANKMENT SLOPE DESIGN CRITERIA

The **barn roof slope design** is required for all rural reconstruction and rehabilitation projects and consists of a fixed 1V:6H to 1V:4H foreslope extending from the outside edge of the surfacing taper to the outside edge of the clear zone followed by a fixed embankment (fill) slope of 1V:3H to 1V:2H. If long term slope stability or revegetation, is anticipated to be problematic, then the use of a fill slope of 1V:3H is desirable. The cost related to the additional amount of excavation required for the flatter fill slopes will need to be compared to the risk of future slope maintenance problems.

If fairly long sections of high 1V:2H embankment slopes are used or there are severe hazards at the bottom of the slope, consider widening the barn roof or placing guardrail. Evaluate factors such as costs, traffic volumes, roadway geometry, grades, prevalent snow conditions, etc., to determine if guardrail is justified.

Special fill slope design modifications are required for interstate median slopes and guardrail installations. See INTERSTATE MEDIAN DESIGN CRITERIA and SLOPE DESIGN FOR GUARDRAIL INSTALLATIONS sections.

WYDOT MINIMUM CLEAR ZONE DISTANCE TABLE

| CLEAR ZONE REQUIREMENTS - RURAL ROADWAYS | | | | | | |
|--|-----------------------------------|---|-------------------------------|-------------------------------|-------------------------------|-----------------------------------|
| ROADWAY DESIGN SPEED mph | PROJECTED DESIGN ADT VEHICLES/DAY | MINIMUM CLEAR ZONE DISTANCE - ft. | | | | LOCAL ROADS AND STREETS |
| | | INTERSTATE HIGHWAYS | | NON-INTERSTATE | | |
| | | NON-NHS STATE HIGHWAYS (ARTERIALS & COLLECTORS) | 1V:5H FORESLOPE TO CLEAR ZONE | 1V:4H FORESLOPE TO CLEAR ZONE | 1V:4H FORESLOPE TO CLEAR ZONE | |
| 40 OR LESS | UNDER 750 | 7 | 7 | 10 | 10 | FOR ALL DESIGN SPEEDS AND VOLUMES |
| | 750 - 1500 | 10 | 12 | 14 | 14 | |
| | 1500 - 6000 | 12 | 14 | 16 | 16 | |
| | OVER 6000 | 14 | 16 | 18 | 18 | |
| 45-50 | UNDER 750 | 10 | 12 | 14 | 14 | |
| | 750 - 1500 | 14 | 16 | 20 | 20 | |
| | 1500 - 6000 | 16 | 20 | 26 | 26 | |
| | OVER 6000 | 20 | 24 | 28 | 28 | |
| 55 | UNDER 750 | 12 | 14 | 18 | 18 | |
| | 750 - 1500 | 16 | 20 | 24 | 24 | |
| | 1500 - 6000 | 20 | 24 | 30 | 30 | |
| | OVER 6000 | 22 | 26 | 32 | 32 | |
| 60 | UNDER 750 | 16 | 20 | 24 | 24 | |
| | 750 - 1500 | 20 | 26 | 32 | 32 | |
| | 1500 - 6000 | 26 | 32 | 40 | 40 | |
| | OVER 6000 | 30 | 36 | 44 | 44 | |
| 65 OR GREATER | UNDER 750 | 18 | 20 | 26 | 26 | |
| | 750 - 1500 | 24 | 28 | 36 | 36 | |
| | 1500 - 6000 | 28 | 34 | 42 | 42 | |
| | OVER 6000 | 30 | 38 | 46 | 46 | |

EXHIBIT 7
MINIMUM CLEAR ZONE DISTANCE

EXCAVATION SLOPE DESIGN CRITERIA

Ditch Section: Appropriate combinations of a foreslope, ditch bottom, and backslope that are traversable and can be located within the clear zone are given in the *AASHTO Roadside Design Guide*. For example: a V-ditch section within the clear zone (foreslope/backslope combination) where the foreslope is 1V:6H, the backslope should be no steeper than a 1V:4H. Ditch channels not having the preferred backslope for the given foreslope, should be located at or beyond the recommended clear zone distance. The use of trapezoidal or flat bottom ditch sections can also be used for hydraulic performance, snow storage, or to acquire excavation material to balance an earthwork. See the *AASHTO Roadside Design Guide* for further information concerning preferred ditch cross sections.

Rural Two Lane: The foreslope should be a 1V:6H to 1V:4H slope. Ditch sections normally range in depths from 1 ft to 3 ft with deeper ditches usually being used on roadways with higher functional classifications and traffic volumes or in heavy snow areas or when needed to facilitate drainage. If the ditch section is located within the clear zone, the foreslope/backslope combination should meet the requirements given in the *AASHTO Roadside Design Guide*. In choosing the type and depth of ditch section for use on a project, consider factors such as safety, good drainage, amount of excavation, right-of-way availability, snow depths, and other factors, as applicable.

Interstate: Ditches should have a 1V:6H to 1V:4H foreslope, with the ditch bottom preferably located at or beyond the clear zone limit. The use of trapezoidal or flat bottom ditch sections may be preferred along high speed roadways. It is also preferable along high speed interstate medians and ramp gore areas to have each slope at 1V:6H or flatter if the median or gore ditch bottom is within the clear zone.

Backslope: The backslope that produces the least amount of excavation and the least amount of impact distance away from the roadway will typically be the 1V:2H slope. If slope stability or revegetation, is anticipated to be problematic, then the use of a backslope of 1V:3H is desirable. The cost related to the additional amount of excavation developed from the flatter backslopes will need to be compared to the risk of future slope maintenance problems. Flatter backslopes are acceptable to obtain material if needed to balance the project earthwork. A fixed catch distance from the ditch bottom, with variable backslopes, provides a more aesthetically pleasing design and is typically used for cut sections. See EXHIBITS 9 and 10 for typical excavation slope examples.

SLOPE SELECTION AND CLEAR ZONE DESIGN

Slope selection and clear zone design necessary to meet the requirements outlined in the current WYDOT Design Guides is iterative in nature. The basic intent of the new design guides is to produce economical surfacing taper and overall road designs with the least amount of adjacent impacts, without compromising safety.

Consider the length of curved sections and the magnitude of superelevation on the project, if the project has numerous high superelevated curves ($e > 5\%$), then the 1:6 surfacing taper should be used to provide a safe slope design in the curve areas. If the project has only a few sharp curves, the 1:5 surfacing taper could probably be used throughout, saving surfacing materials.

If the 1:5 option is chosen, the surfacing taper slopes in the curve areas must be evaluated on the cross sections for non-recoverable slopes and if present, extend the clear zone distance the same length as the non-recoverable slope. See EXHIBIT 6.

The 1V:4H barn roof slope option could be considered in low fill height areas to reduce grading requirements. The 1V:5H and 1V:6H barn roof slopes require less clear zone distance so may provide less grading in higher fills with less impacts compared to the longer 1V:4H clear zone distance. Refer to the Minimum Clear Zone Distance Table shown in EXHIBIT 7 for slope and clear zone distance options.

The resulting slope catch line for the clear zone distance selected for the chosen barn roof slope needs to be evaluated in critical areas to see if unwanted impacts are likely. It may be necessary to run select cross sections and plot the limits of construction for evaluation in these areas. The reduction in clear zone distance required for the flatter foreslope may help to avoid the impacted areas. Evaluate the steeper slopes vs. the shorter clear zone distance to determine which combination has the most economical earthwork requirements. Consider maintaining the same design criteria through a critical area to provide a fairly consistent road section.

The designer should keep in mind that the basic intent is to produce a grading design combination that provides the least amount of impacts AND with the most economical overall road design. See EXHIBIT 8 for a typical barn roof fill slope example. It appears in this situation the end area for the 1V:6H slope and clear zone option would probably produce less grading volumes and smaller disturbed area.

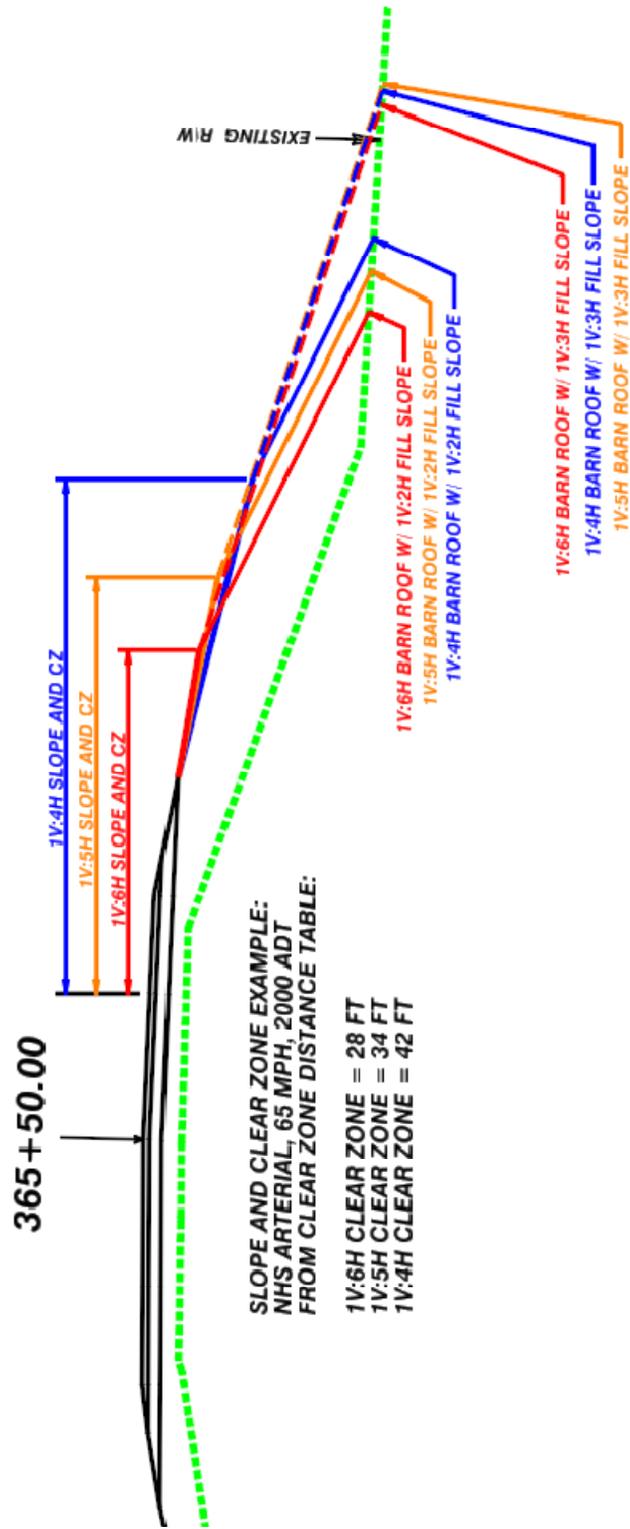


EXHIBIT 8
 FILL SLOPE AND CLEAR ZONE EXAMPLE

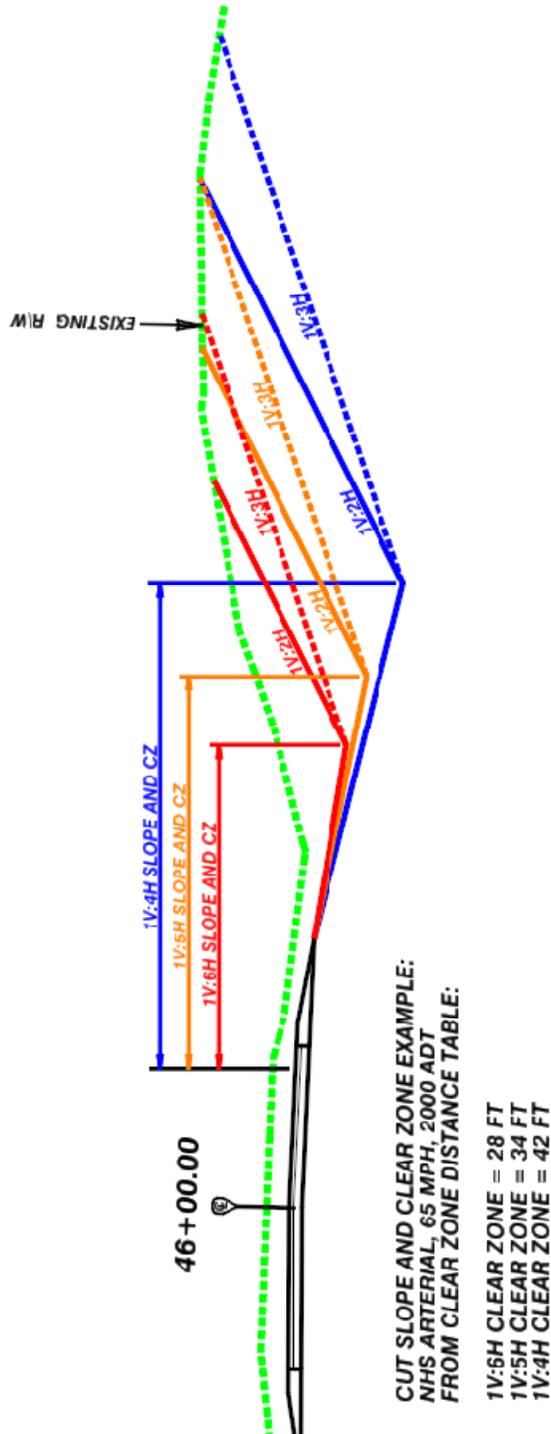


EXHIBIT 9

CUT SLOPE AND CLEAR ZONE EXAMPLE

For cut ditch sections, evaluate the foreslope/backslope combinations to ensure a safe design within the clear zone. Changes made to the foreslope, clear zone distance, and ditch bottom location may negatively affect the roadside drainage patterns. Remember that after every design iteration, re-evaluation of the project pipe culvert design and pipe placement will be required. Observe the significant change in ditch bottom elevation for each slope option shown in EXHIBIT 9.

EXHIBIT 10 illustrates a 1V:4H foreslope ditch bottom and required backslope located within the clear zone compared to flatter foreslope options. For this example, it appears the end area for the 1V:6H slope and clear zone option would probably produce less grading volumes and smaller disturbed area. However, other clear zone and backslope options may be used to obtain additional excavation material to balance the earthwork.

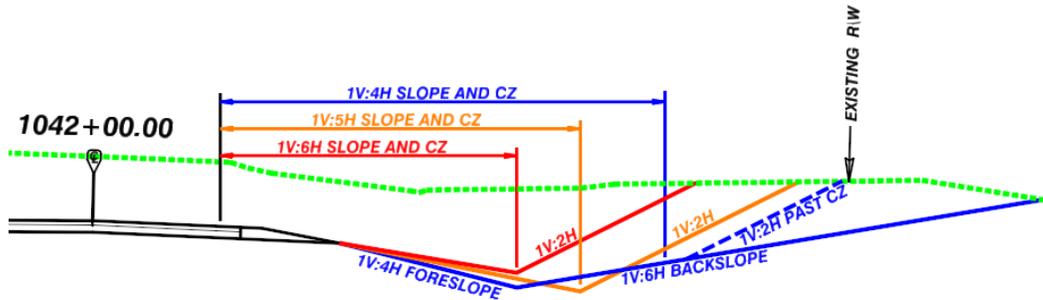


EXHIBIT 10
1V:4H FORESLOPE WITH DITCH BOTTOM IN CLEAR ZONE

Surfacing tapers for pavement overlays on typical preservation type projects with no safety grading can probably be 1:4 throughout the project with no need to evaluate for non-recoverable slopes, as described in the WYDOT Design Guides. Flatter taper slopes can be used for pavement overlays if they don't cause additional grading requirements and can be justified.

APPROACH DESIGN CRITERIA

Approaches are to have embankment slopes of 1V:8H or flatter for that portion of the approach which is located within the clear zone.

SNOW DRIFTING CONSIDERATIONS

Based on input from the District Maintenance and Blowing Snow Team, analyze the cross-section design to ensure its adequacy under snow drifting situations. Detailed discussion, design considerations and guidance can be found in the EARTHWORK DESIGN CHAPTER.

CURBS

Curbs are frequently used on low-speed urban roadways (design speed of 45 mph or less) to control drainage and to provide separation between traffic and pedestrians. The standard curb and gutter section used is a Type A Curb, which is 6 in high with a nearly vertical face (see WYDOT Standard Plans). The use of curbs along high speed roadways (design speeds greater than 45 mph) is strongly discouraged due to a vehicle's propensity to lose control when impacting and traversing curbs at high speeds. Vehicles that encounter sliding during slick conditions or other loss of control can be "tripped" when impacting a curb, potentially causing a rollover. If it is determined a curb is necessary to control drainage or access on a high speed roadway, the curb should be no higher than 4 in and have a sloping face of approximately 1V:2H, i.e Type C Curb found in the WYDOT Standard Plans. A double gutter may be considered as a safer option for drainage since there is no curb "face".

Use care when placing a roadside barrier on roadways where curbs are present. The barrier face of a metal beam guardrail should be flush with or in front of the curb face. Curbs can be used on high speed roadways when they are fully shielded by a roadside barrier (for example, located far enough behind the guardrail to accommodate full deflection). However, it is important that rigid pavement not be placed directly around guardrail posts; "pavement leave-outs" should be provided to allow guardrail posts to rotate normally under impact and to facilitate replacement (see WYDOT Standard Plans).

INTERSTATE MEDIAN DESIGN CRITERIA

Width 84 ft or Less: 1V:6H or flatter median slopes are required.

Median Width 84 ft to 126 ft: Use the applicable clear zone and fill slope criteria, preferably with no slope steeper than 1V:4H.

Median Width 126 ft or Greater: Use the applicable clear zone and fill slope criteria.

Median Inlets: On median widths of 84 ft or less, or where the pipe culvert ends are within the clear zone, use M-1 inlets or safety grates on all exposed pipe culvert ends.

Median Barrier: The purpose of the median barrier is to reduce cross-median crashes on high speed roadways. Median barrier placement is usually limited to narrow (40 ft or less) medians but can be justified for other locations based on accident history or District recommendations. Median barrier types can be box beam, cable, MGS, or concrete, installation details can be found in the WYDOT Standard Plans. Also refer to the AASHTO Roadside Design Guide for detailed discussion on the types and use of median barriers.

Median Crossover and Drainage Dikes: Crossovers and drainage dikes are hazardous features that should be used only where necessary. The crossover and drainage dike slopes are perpendicular to the roadway and can cause severe vaulting of errant vehicles, even with relatively flat slopes. Any perpendicular embankment slopes should be 1V:10H or flatter. The location of median crossovers should be carefully considered to best accommodate snow removal operations without degrading highway safety. District personnel should provide recommendations that justify and document the location of crossovers or drainage dikes. Avoid placing crossovers in narrow medians where the width is not sufficient enough to prevent snow plows (typically 40 ft long) from encroaching into travel lanes while stopped in the median waiting for opposing traffic to clear.

Crossover Approach Widening: Shoulder widening should be provided at median crossovers where feasible to accommodate left turning vehicles. See EXHIBIT 11 for a typical shoulder widening for median turn lane layout.

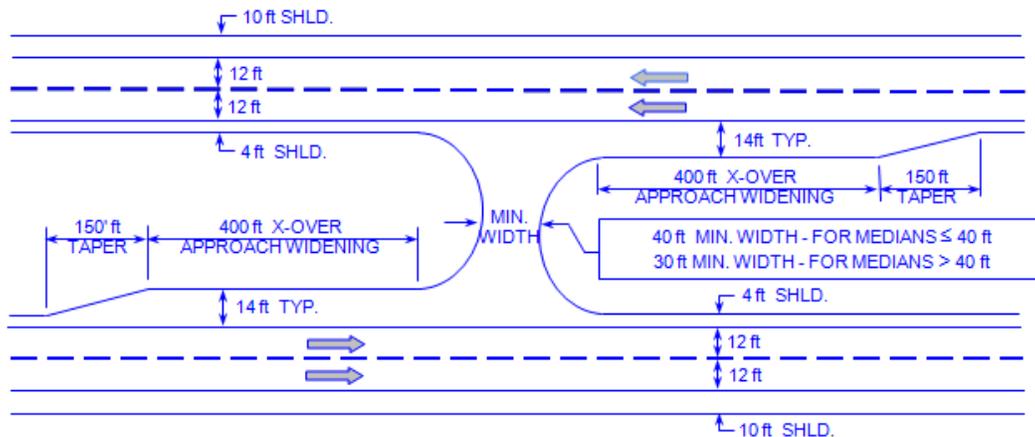


EXHIBIT 11
CROSSOVER APPROACH SHOULDER WIDENING

SLOPE DESIGN FOR GUARDRAIL INSTALLATIONS

General: The performance of guardrail on slopes steeper than 1V:10H or where the slope breakover angle is abrupt can be unpredictable and should be avoided. Guardrail design requires the proper slope grading from the shoulder break line of the roadway to beyond the back of the guardrail posts.

Vehicles depart the roadway at various angles. Depending on the encroachment angle, a vehicle crossing a slope break line (change in slope) may become airborne or have its suspension compressed. To ensure that errant vehicles contact guardrail installations at the correct height, it is important to provide flat slopes and small breakover angles at slope break points. At locations where guardrail is to be installed, the standard roadway slope design should be modified to provide a 1V:10H or flatter slope extending from the shoulder break line to a minimum of 2 ft behind the guardrail posts. See EXHIBITS 12 and 13. The slope modification should begin a sufficient distance in advance of the guardrail and extend out far enough to provide a 1V:10H slope platform for errant vehicles approaching the guardrail terminal end.

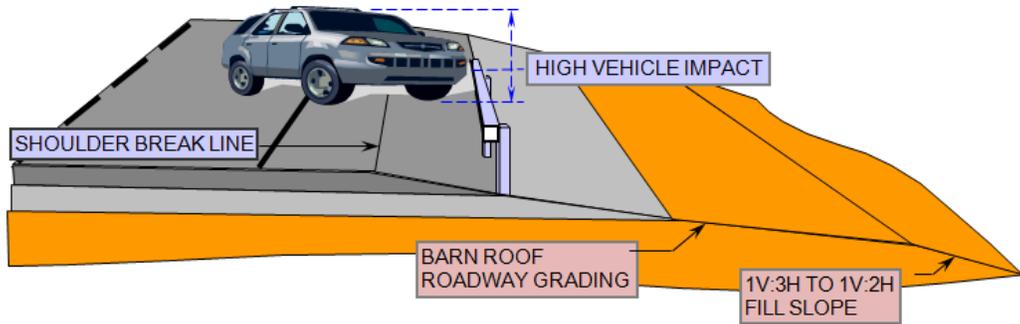


EXHIBIT 12
GUARDRAIL WITHOUT SLOPE MODIFICATION

EXHIBIT 12 illustrates how a vehicle crossing a steep breakover angle is likely to contact the guardrail too high, potentially causing it to vault over the guardrail.

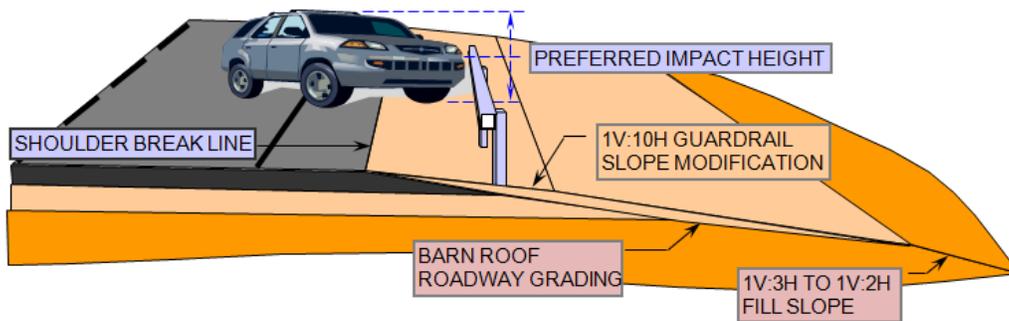


EXHIBIT 13

GUARDRAIL WITH 1V:10H SLOPE MODIFICATION

EXHIBIT 13 illustrates how 1V:10H guardrail slope modification reduces the break over angle to keep the vehicle and guardrail height compatible, therefore providing a preferred impact height and safe redirection of the vehicle. Refer to WYDOT Standard Plans for guardrail layout requirements and installation details.

Median ditches tend to have high breakover angles, even with fairly flat embankment slopes. Do not install guardrail across median ditches unless the ditch section is made very flat. Slopes as flat as 1V:20H are recommended on each side of the ditch in areas where the guardrail must cross the median or where a guardrail terminal is located at or near the ditch line. The high side of superelevated sections also have high breakover slope angles that merit special consideration. Locate guardrail (when needed) close to the roadway on these sections to reduce high side grading requirements.

CABLE MEDIAN BARRIER

Slope criteria for cable guardrail is more flexible than for other barrier systems. The cable barrier system has been shown to perform adequately on slopes as steep as 1V:6H; however, it will deflect more than other systems and proper placement in narrow medians is critical to ensure proper performance. The typical cable barrier system used in Wyoming has a lateral deflection distance up to about 9 ft when impacted.

The optimum placement of cable median barrier is 8 ft or more from the median ditch to prevent vehicles from deflecting into or through the ditch bottom, causing the vehicle to submerge, under-ride, and penetrate the bottom cable, thus allowing penetration of the barrier. Because cable barriers deflect much more than conventional barriers, it is desirable to keep vehicles from deflecting into the median ditch bottom. This is particularly true when the median slopes are steeper than 1V:8H.

In narrow medians (40 ft wide or less) where the median slopes are steeper than 1V:10H, it is acceptable to place the cable median barrier within 1 ft from the median ditch bottom. Cable median barrier should be placed at 1 ft or less, or farther than 8 ft from the median ditch bottom, but avoid placing cable median barrier in between 1 ft and 8 ft from the median ditch bottom. See EXHIBIT 14.

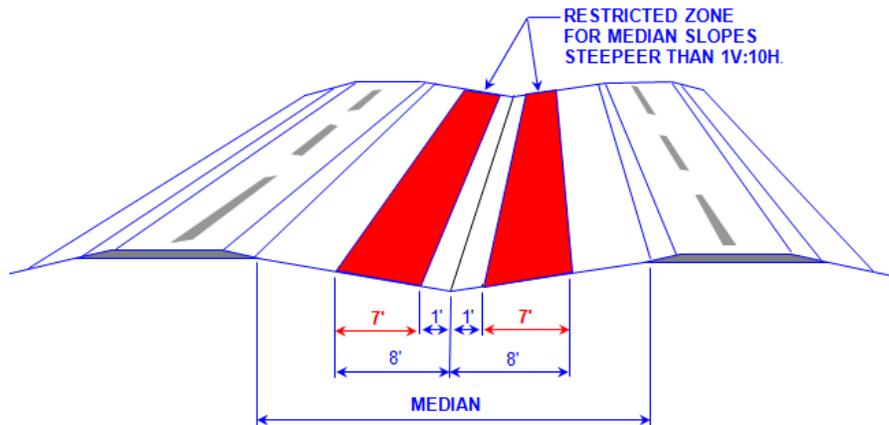


EXHIBIT 14
CABLE MEDIAN BARRIER RESTRICTED ZONE

It is also important to place the cable barrier so that it will not deflect into oncoming traffic, and, if possible, provide additional lateral distance to reduce the likelihood of dangerous avoidance maneuvers by oncoming traffic. Where cable median barrier must cross the median bottom, the slopes should be 1V:10H or flatter.

RIGHT-OF-WAY

Right-of-way is the area of land including the roadway, owned by deed or easement, by WYDOT. This strip of land generally includes any improvements owned and maintained by WYDOT and is wide enough to include the roadway, clear zone, and cut and fill slopes.

Factors that need to be considered for setting the proposed right-of-way width are:

- Width of entire roadway plus clear zone
- Placement of cut and fill slopes, slope rounding, and fencing
- Adjacent land use and ownership
- Maintenance access to appurtenances (e.g., culvert ends, signs, etc.)
- Terrain and environmental restrictions