III-14.01 Safety Review Process

Safety Reviews are items for the project development process for Minor Rehabilitation, Structural Improvement, and Major Rehabilitation projects. The Safety Review project development process is outlined in detail within the flow chart shown in Chapter 2 Section 2 Appendix A "Milestone Flow Charts" (Section II-02A) of the Design Manual

III-14.02 Safety Review Investment Strategy & Scope of Work

There are 3 different types of Safety Reviews, which are dependent on the project investment strategy contained within the *DESIGN GUIDELINES,* Chapter 1 Section 6 (Section I-06) of the Design Manual:

- Minor Rehabilitation Safety Review (SRMIR)
- Structural Improvement Safety Review (SRSIM)
- Major Rehabilitation Safety Review (SRMAR)

The above listed Safety Reviews have different scopes of work as a result of the investment strategy for the project. The guidance contained within following sections of this document may not apply to the scope of the specific Safety Review being completed for the particular project. Therefore, not all of the guidance within the following sections may be proposed with the particular Safety Review if not within the scope.

Safety Review templates and information regarding what is contained within the scopes of work for the various types of Safety Reviews shown above are available on the Design Manual "Reference and Forms" webpage at:
http://www.dot.nd.gov/manuals/design/designmanual/reference-forms.htm

III-14.03 Clear Zone

Clear zone is defined as the total roadside area, beyond the edge of the through traveled way, which is traversable and free of obstructions. The clear zone value used for the design and recommendations within the Safety Review vary with the investment strategy as shown in the *DESIGN GUIDELINES,* Chapter 1 Section 6 (Section I-06) of the Design Manual. All references to clear zone hereinafter within this document and within the particular Safety Review shall be the clear zone as designated by the *DESIGN GUIDELINES* for the particular project:

- Minor Rehabilitation clear zone = Use existing
- Structural Improvement clear zone = 20' NDDOT clear zone*
- Major Rehabilitation (ADT < 2000) clear zone = 20' NDDOT clear zone*
- Major Rehabilitation (ADT > 2000) clear zone = AASHTO clear zone, see Chapter 3 Section 14 Appendix B of the Design Manual (Section III-14B)

**If circumstances result in the AASHTO clear zone value less than the NDDOT 20' clear zone such as in urban/low speed areas, the AASHTO clear zone value may be used instead.*

III-14.04 Field Survey

The field surveys are made to determine the location and size of all obstructions along the roadway. Refer to Chapter 18 of the Survey Manual for an explanation of the data collection process.

III-14.05 Safety Enhancements

All obstructions within the clear zone should have one of six safety enhancements performed. In order of preference, these are:

1. Remove the obstruction.
2. Make the obstruction traversable.
3. Relocate the obstruction beyond the clear zone.
4. Reduce impact severity by using an appropriate breakaway system.
5. Shield the obstruction with a longitudinal barrier or crash cushion (only if obstruction cannot be removed, relocated, or redesigned.)
6. Delineate the obstruction (only if all above options are not appropriate.)

Attenuation devices, guardrail, and breakaway systems to be installed should be of a type that has been crash tested successfully in accordance with "Recommended Procedure for the Safety Performance Evaluation of Highway Features" (NCHRP) Report 350.

The basic concept of the breakaway support is to provide a structure that will resist wind and ice loads, yet fail in a safe and predictable manner when struck by a vehicle. The term "breakaway support" refers to all types of sign, luminaire, and traffic signal supports that are designed to yield when struck by a vehicle. The release mechanism may be a slip base, base-bending, fracture elements, or a combination of these.

III-14.06 Obstructions

An obstruction is anything that would hinder the recovery/movement of a vehicle that has left the traveled way. Obstructions include, but are not limited to: a rigid object with a height greater than 4 inches, non-yielding/non-breakaway signs, light standards, and utility poles, signal

standards, culvert (or end section) openings over 36 inches, multiple openings greater than 30 inches, box culverts, bridge rail ends, bridge piers, trees having a mature diameter of 4" or larger, large rocks, water over 2 feet deep, and foreslopes that are steeper than 3:1. The *Roadside Design Guide*, published by AASHTO, contains the guidelines used to determine what constitutes an obstruction and how the obstruction should be dealt with. The following sections describe some of the more common obstructions found alongside the roadway.

III-14.06.01 Roadside Signs

Roadside signs can be divided into three main categories: overhead signs, large roadside signs, and small roadside signs. The hardware and corresponding safety treatment of sign supports varies with the sign category.

1. Overhead signs: Where possible, overhead signs should be installed on overpasses or other structures. Overhead signs generally require massive support systems which cannot be made breakaway. All overhead sign structures located within the clear zone should be shielded with crashworthy barriers.

2. Large Roadside Signs: Large roadside signs may be defined as those greater than 50 ft^2 in area. They typically have two or more steel pipe or W-shape support posts which are breakaway. The following criteria should be satisfied if the support is to perform adequately as a breakaway support:

    - The hinge should be a minimum of 7ft above the ground surface.

    - A single post, or multiple posts with a post spacing greater than 7ft, should have a weight less than 45 lb/ft with a total weight of the support between the hinge and the breakaway base not to exceed 600 lb. For two or more posts with a post spacing less than 7ft, the post should not have a weight less than 18 lb/ft.

    - No supplemental sign should be attached below the hinges. The sign may interfere with the performance of the breakaway support and/or it may enter the windshield if the sign is struck.

    - The base plate of the anchoring unit shall not protrude above the ground more than 4" (see Figure 1 in Appendix III-14 A.)

3. Small Roadside Signs: Small roadside signs can be identified as signs having a sign surface area less than 50 ft^2 and they may be supported on one or more posts. A single support post is generally made of steel pipe or perforated tube and multiple supports are generally made of perforated tubes.

- Sign supports that are made from 2 1/4" 12 gauge steel or smaller square perforated tube (and do not have a reinforcing sleeve) are considered to be base-bending and do not require a breakaway base.

- U-channel posts, when used as single posts, are also considered base-bending and do not require a breakaway base. The U-channel post should not be spliced unless it has been crash tested.

- Sign supports that are made of wood, buried a minimum of 3ft in the ground, and 4"x 4" or smaller will yield when struck by a vehicle. Posts made of wood that are larger than 4"x 4" need to be weakened by having two holes drilled perpendicular to the roadway into the base of the sign support (see Figure 2 in Appendix III-14 A.)

- Supports made with steel pipe are not considered to be base-bending and are required to have a breakaway base.

- Diagonal bracing, also known as "A-frame", sign supports should not be used.

- The base plate of the anchoring unit shall not protrude above the ground more than 4" (see Figure 1 in Appendix III-14 A.)

III-14.06.02 Steep Foreslopes

Foreslopes parallel to the roadway can be categorized as recoverable, non-recoverable (traversable), or critical. A vehicle entering a critical foreslope is likely to overturn. A critical foreslopes is classified as a slope that has a rate steeper than 3:1.

When the foreslope is considered critical, the fill height and ADT of the roadway is examined. The depth of the fill is measured from the toe of the critical slope at the tie in with the ditch bottom to the top of the slope.

- If the fill height is 10' or less or if the forecast ADT is 750 or less, it is not considered cost effective to improve the slope.

- If the fill height is greater than 10' and the forecast ADT is greater than 750, foreslope flattening or guardrail protection should be considered.

It may be more cost effective to flatten foreslopes even though the initial cost may be greater than guardrail. The Safety Review shall determine if flattening foreslopes or guardrail is more cost effective. The cost effectiveness is based on crash costs and the cost to install the fill material. The flattening of foreslopes should be proposed for the project if cost effective. If guardrail is

determined more cost effective, an executive decision item within the environmental document shall added to determine if guardrail should be used, or if the foreslopes should be flattened.

There may be circumstance where flattening foreslopes is more cost effective, but cannot be done because of right of way impacts, environmental factors, or other special circumstances.

Many times drainage structures are located within steep slope areas. These structures may need to be extended when the slope is flattened. The cost for the extensions should be included in the cost to flatten the slopes. Use Chapter 3 Section 15 (Section III-15) of the Design Manual to determine how the foreslope should be flattened.

III-14.06.03 Cross Slopes (Transverse Slopes)

Common obstacles on the roadside are embankment slopes created by median crossings, driveways, intersecting side roads, and ditch blocks. These slopes are more critical to errant vehicles than foreslopes and backslopes because they are struck by the vehicle directly. Cross slopes of 6:1 or flatter are acceptable, but median crossings and ditch block embankment cross slopes of 10:1 are desirable.

- All ditch block cross slopes steeper than 6:1 should be flattened.
  - On Interstate highways, they should be flattened to 10:1.
  - On all other roadways, they should be flattened to 8:1.

- The cross slopes of median crossings on the Interstate highways that are steeper than 6:1 should be flattened to 10:1 (see Figure 3 in Appendix III-14 A).

- Cross slopes of median crossings and side road approaches (all roadways except the Interstate) that are steeper than 6:1 should be flattened to 8:1. The following criteria should be used when flattening the cross slopes:
  - Flatten all 4:1 or steeper cross slopes where the forecast ADT is less than 500
  - Flatten all cross slopes between 4:1 and 6:1 where the forecast ADT is less than 500 and it is cost effective
  - Flatten all cross slopes steeper than 6:1 where the forecast ADT is greater than 500
  - Culverts located with the cross slopes may need to be extended when the slope is flattened.

III-14.06.04 Cross-Drainage Structures

Cross-drainage structures are used to move water under the roadway. They may consist of reinforced concrete pipes, corrugated metal pipes, structural plate pipes, or concrete box culverts. These structures can also be used by pedestrians, vehicles, or animals.

Cross-drainage structures with openings within the clear zone should be made traversable, extended beyond the clear zone, or shielded with guardrail. Single structures with openings 36" or less and multiple structures with openings 30" or less are considered to be traversable and do not need to be improved. The openings for centerline pipes are measured at the opening of the flared end section if present, otherwise are measured at the pipe opening if no end sections are present. For example, a single 36" centerline pipe with a flared end section would not be considered traversable because the opening of the flared end section is greater than 36". If a single 36" centerline pipe exists with no end section, it may be considered traversable as the pipe opening is only 36".

Grates can be installed to make the openings of the cross-drainage structures traversable (see Figure 4 in Appendix III-14 A.) Smaller diameter (15" to 36") reinforced concrete pipes can be made traversable by removing the flared end section and installing a traversable end section. See Standard Drawings for traversable end sections.

- A cost effective analysis should be performed on all structures with openings within the clear zone on roadways with a forecast ADT greater than 750. If it is determined that it is not cost effective to improve the structure, object markers should be installed.

- It is not considered cost effective to improve structures with openings within the clear zone on roadways with a forecast ADT of 750 or less. Therefore, these structures should have object markers installed.

III-14.06.05 Parallel Drainage Structures

Parallel drainage structures are those which parallel the mainline flow of traffic. These features can present a significant safety obstruction because they can be struck head-on by errant vehicles. Safety treatment options are similar to those for cross drainage structures:

- Eliminate the structure
- Use a traversable design
- Move the structure laterally to a less vulnerable location
- Shield the structure

Eliminating the structure may be difficult, but on field entrances and very low volume driveways, an overflow section may be constructed.

Traversable designs are to provide grates constructed of pipes set on 24 inch centers to reduce wheel snagging. Generally, pipes of 24 inch diameter or less may not require a grate. However, when a multiple pipe installation is encountered, grating smaller pipes may be appropriate.

Relocating the structure is the most desirable. This allows the opportunity to flatten the cross slope within the clear zone distance of the roadway. If the new culvert is located beyond the clear zone of the roadway, and will also be beyond the clear zone for the approach roadway, then relocation of the drainage structure should be considered. When a structure is relocated, it should be moved to at least 60 feet from the centerline of the roadway.

In cases where the cross slope cannot be made traversable, and the structure cannot be relocated or is too large to be safety treated effectively, it may be necessary to shield the obstacle with a traffic barrier.

III-14.06.06 Water

Streams or bodies of water with a depth of more than 2 feet within the clear zone should be moved beyond the clear zone or shielded. A cost effective analysis should be performed to determine what action should be taken. The water should be present for long periods of time (one year or longer.)

III-14.06.07 Riprap

Riprap that is within the clear zone and extends above the surrounding ground surface more than 4” should be removed to the clear zone or shielded. A cost effective analysis should be performed to determine what action should be taken.

If erosion control is necessary, an erosion control blanket should be installed after the riprap is removed. The cost for the erosion control blanket should be included in the cost for removing the riprap when the cost analysis is performed.

III-14.06.08 Light Standards, Signal Standards, Utility Poles, Trees, and Similar Roadside Features

Roadside features that are within the clear zone and protrude above the surrounding surface more than 4” should be removed, made breakaway, relocated beyond the clear zone, or shielded.

Features, such as signal standards (with mast arms), utility poles, and railroad signals, cannot be made breakaway and should be relocated beyond the clear zone or shielded. Sometimes, features such as these need to be close to the roadway and cannot be relocated. In these instances, consideration should be given to installing a crash cushion to shield the supports.

Light standards and signal standards (without mast arms) should be made breakaway or relocated beyond the clear zone.

Trees with a mature size greater than 4" in diameter should be removed. If they cannot be removed they should be shielded.

III-14.06.09 Bridge Rail

The bridge railing should be of a type that is crashworthy. The bridge rails that the department uses and has accepted are: Jersey Barrier and Double Box Beam Rail Retrofit. Other types of bridge rail, such as the Sloped E-Rail, should be modified to a Double Box Beam Rail Retrofit.

III-14.06.10 Guardrail

For Minor Rehabilitation and Structural Improvement investment strategies, guardrail that has not been successfully crash tested in accordance with the guidelines of NCHRP Report 230 should be replaced with guardrail that has been successfully crash tested in accordance with the guidelines as set forth in NCHRP Report 350. Guardrail should be checked to ensure that it meets the requirements based on the existing ADT and posted speed less 10 mph of the roadway, and the variation for height of rail cannot be more than ±3 inches of the design dimension when originally installed. See *DESIGN GUIDELINES*, Chapter 1 Section 6 (Section I-06) of the Design Manual.

For Major Rehabilitation investment strategies, guardrail shall meet guidelines as set forth in NCHRP Report 350. See *DESIGN GUIDELINES*, Chapter 1 Section 6 (Section I-06) of the Design Manual. Guardrail should be checked to ensure that it meets the requirements based on the forecast ADT and design speed of the roadway.

If one or more of the following deficiencies is present, the guardrail should be replaced with guardrail that meets current design practices:

- Guardrail that is attached to a safety shape transition (only if there is another deficiency or the approach slab is being replaced.)
- Guardrail tapers away from the roadway at a greater rate than what is required.
- There is insufficient space between guardrail and obstruction for proper deflection.
- The distance from the top of the guardrail to the ground surface is less than 27" or greater than 29" (after roadway improvement.)
- The guardrail is not long enough to shield the obstruction from an errant vehicle (see Length of Need in Section III-13 Guardrail.)

III-14.06.11 T-Intersection

Whenever a county, state, or US highway has an intersection or dead end with another state or US highway, there should be an approach or escape road provided for errant vehicles. If it is not feasible, other protective devices such as warning signs, rumble strips, or barricades should be provided (see Design Manual Section III-03.05.03 "Recovery Approaches").

III-14.07 Cost Effective Analysis

Collisions involving vehicles with roadside objects are a probable occurrence with any existing highway facility. The purpose of cost effective analysis is to provide a technique for comparing alternate solutions to problem locations. Present value of the total cost of each alternative is computed over a given period of time, taking into consideration initial cost, maintenance cost, and accident cost. The costs for each alternative are compared to the cost of the accidents that would occur if no safety enhancements were performed. The option with the least total cost would normally be chosen.

The Road Safety Analysis Program (RSAP) Software was developed under National Cooperative Highway Research Program (NCHRP) Project 22-9 and represents one approach to using the procedures described in Appendix A of the 2002 AASHTO *Roadside Design Guide*. The research for NCHRP Project 22-9 can be found in NCHRP Report 492, *Roadside Safety Analysis Program (RSAP)—Engineer's Manual*. The RSAP program is intended as a tool for economic analysis and should not supersede the guidelines presented in the *Roadside Design Guide* or sound engineering judgment.

The cost of making the improvements to enhance the safety of the roadside should be used to determine if the improvements are cost effective. The initial cost to make the improvements should be estimated to the nearest 100 dollars.

The maintenance costs to maintain the improvements should be on an annual basis. When guardrail is the improvement, the price for removal of snow should be included in the maintenance costs. Generally, a value of $10 per linear foot is used for snow removal maintenance costs for W-beam guardrail. No snow removal maintenance costs for 3-cable guardrail is typically used.

The salvage value for the improvements at the end of the project life is typically considered zero, but may be used for W-beam guardrail. Note: If using the Road Safety Analysis Program (RSAP) software, it is not possible to input a salvage value.

The project life of a roadway design is an input value selected by the user. The discount rate is also a basic input value in the economic analysis. Generally, a value of 10% is used for the discount rate.

Once the information is obtained, the total present worth and annualized costs are computed. The Road Safety Analysis Program (RSAP) software has been prepared to make a direct comparison between several proposed safety treatments.