REVIEW OF STATE DOT GUARDRAIL CONSTRUCTION PRACTICES AND POLICIES

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1 INTRODUCTION

1.1 Background

The Federal Highway Administration (FHWA), U.S. Department of Transportation (USDOT), provides guidance for the construction of roads and bridges on Federal Highway projects which fall under its direct administration. This guidance has been published in the document entitled, *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, Report No. FP-03 [1].

Recently, the Federal Lands Highway Division (FLHD) began a review of the policies and practices pertaining to the installation, removal, and/or repair of guardrail on construction projects adjacent to an open lane of vehicular traffic. During this review, it was found that only limited guidance was provided in *Section 617 – Guardrail* in terms of the methods of installation. In addition, *Section 156 – Public Traffic, 156.06 – Limitations on Construction Operations* only briefly addressed the hazard of partially installed guardrail, as shown below.

> <u>156.06 Limitations on Construction Operations</u>
>
> (j) Maintain existing guardrails, barriers, and bridge railings until removal is necessary for construction. Use temporary barrier or appropriate channelizing devices while guardrails and bridge rails are absent. Install permanent barriers, guardrails, and bridge rails as soon as possible to minimize risk to the public.

As such, FLHD personnel deemed it necessary to modify current guidance to better address barrier construction and maintenance adjacent to open lanes of vehicular traffic as well as provide improved safety guidance for the work zone operations, including provisions for traffic control, speed reduction, delineation, etc. Based on this fact, the FLHD deemed it necessary to review existing guidelines from various State Departments of Transportation (DOTs) in order to assist with the modification the FLHD guidelines.

1.2 Research Objective

The FLHD funded a Technical Services Agreement with the Midwest Roadside Safety Facility (MwRSF) in order to conduct a limited research review of State DOT specifications, policies, and practices in the areas noted above. This review of State DOT guidance was performed in order to gather and summarize information that would assist with the preparation of future revisions to the FLHD *Standard Specifications* [1].

1.3 Research Plan

The project consisted of MwRSF researchers reviewing the relevant practices, policies, and procedures for the State of New York as well as for the ten (10) member states of the Midwest States Pooled Fund Program, which included Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, South Dakota, Wisconsin, and Wyoming. This review was specifically directed toward determining what level of barrier construction must be completed before adjacent vehicular traffic is allowed on the nearby roadways for both new construction projects as well as for 3R/4R projects. In addition, all segments of the barrier system were considered, including the bridge rail, buttress/bridge anchor section, guardrail, and end terminal.

In addition, the research team reviewed State DOT guidance specifically corresponding to the need to provide traffic control, reduce vehicle speeds, and utilize delineated work zones when barrier construction is active. The research team also inquired as to whether the State DOT guidance denoted the need to follow guidelines found in the *Manual on Uniform Traffic Control Devices* (MUTCD) [2].

Personnel from all eleven State DOTs noted above were contacted in order to obtain confirmation that the appropriate materials were obtained and reviewed as well as to receive information on non-documented, in-house practices, if used.

2 STATE DOT LITERATURE REVIEW

2.1 Nebraska Department of Roads (NDOR)

The 1998 Version, 2002 Update of the *Construction Manual* [3] provides general guidance for speed limits in maintenance work areas as well as for bridge approach guardrails within *Division 400 – Lighting, Signs, and Traffic Signs and Traffic Control*. More specifically and as shown below, Section 404.15 addresses speed limits in work zones, Section 404.16 pertains to bridge approach rails, and Section 903.03 corresponds to construction methods. Further, Section 422 of NDOR's *Standard Specifications for Highway Construction* states that traffic control devices shall be located according to and follow MUTCD guidelines [4]. Finally, a Standard Plan for bridge and culvert guardrail removal on two-lane, two-way roads is shown in Appendix A. The relevant NDOR guidance is provided below for convenience.

404.15 WORK AREA SPEED ZONE

Speed Limits in Maintenance Work Areas

For the purpose of establishing speed limits through a maintenance work area, an urban area is defined as the portion of the State Highway System within the corporate limits of a city or village, and a rural area is defined as the portion of the State Highway System outside the corporate limits of a city or village.

Never drop speed more than 20 mph at one point. If 20 mph or greater reduction is needed, phase the drop so that no phase exceeds 20 mph.

When it is deemed necessary to implement a speed limit through a maintenance work area, the following guidelines should be used in determining the value of the speed limit:

<u>Rural Areas</u>

Work activity is being performed in the driving lanes.

Freeways - Normally 50	40 mph
Other State Highways -	35 mph

Work activity is being performed on the shoulder and the work does not encroach onto the driving lane.

Freeways - Normally 50	45 mph
Other State Highways -	40 mph

Work activity is being performed off the shoulder.
No change from statutory limit.

Urban Areas

Freeways
The guideline for determining the value of the speed limit in a rural area for freeways should be used.

Other State Highways
35 mph if the posted speed limit is 50 mph or higher.
25 mph if the posted speed limit is 45 mph or lower.

Special conditions or work activities may occur where speed limits higher or lower than those described above may be appropriate; however, in no situation can a speed limit of less than 35 mph in a rural area, or 25 mph in an urban area, be implemented.

Many maintenance work activities are of short duration (approximately 1/2 day) take place off the roadway or shoulder, or are fast-moving operations. In many cases, the additional exposure to traffic while setting up signing to mark the work area creates a greater hazard than the actual work activity. Work activities of this type may not require work area speed limit signing and are exempted from the provisions of the guideline regarding speed limits and double fines. In all instances, however, the safety of the worker and the traveling public must be the determining factor. If, in the opinion of the supervisor, a work area speed zone is appropriate, the provisions of the guideline should be followed.

The following activities may not require speed zone signing:

- Survey crew (See existing policy)
- Litter pickup (Adopt-a-Highway)
- Bridge deck inspection (non-snooper) if under 1 hour (snooper)
- Pavement condition and inspection survey
- Deflection testing
- Coring operations
- Traffic counting
- Minor milling (Activity Code 2003)
- Hauling and mixing materials for cold mix (Activity Code 2020)
- Spot patching (Activity Code 2026)
- Grade shoulders (Activity Code 2031)
- Blading unpaved roads (Activity Code 2035)
- Major restoration unpaved roads (Activity Code 2036)
- Maintenance of access and frontage roads (Activity Code 2040)
- Unspecified roadway and shoulder maintenance (Activity Code 2050)
- Drainage structure maintenance (Activity Code 2101)
- Maintaining miscellaneous structures (Activity Code 2102)
- Reshaping ditches and filling washouts (Activity Code 2111)

- Channel cleaning and reshaping (Activity Code 2114)
- Machine mowing (Activity Code 2301)
- Hand mowing (Activity Code 2302)
- Chemical control of insects and roadside trees and shrubs (Activity Code 2303)
- Care and replacement of desirable roadside trees and shrubs (Activity Code 2304)
- Litter pickup (Activity Code 2311)
- Rest area and wayside area operations (Activity Code 2313)
- Seeding and sodding (Activity Code 2315)
- Survey and investigation of junkyard sites (Activity Code 2321)
- Outdoor Advertising Control (Activity Code 2323)
- Fence repair (Activity Code 2332)
- Other roadside maintenance (Activity Code 2350)
- Sign repair or replacement (Activity Code 2401)
- Centerline and edgeline striping (Activity Code 2408)
- Contract striping (Activity Code 2409)
- Signal Repair (Activity Code 2415)
- Highway lighting maintenance (Activity Code 2416)
- Erecting and removing snow fence (Activity Code 2501)
- Brush cutting (Activity Code 2505)
- Snow plowing and spreading of winter chemicals and sand (Activity Code 2511)
- Loading and hauling of snow (Activity Code 2514)
- Stockpiling chemical and sand (Activity Code 2521)
- Correct vandalism or roadside features (Activity Code 2603)

Speed Limits in Construction Work Areas

The maximum speed limit through any construction and maintenance work area shall be 35 mph in rural areas and 25 mph in urban areas, provided signs are in place to give notice of the speed limit.

The Director may raise the 35-mph speed limit in rural areas and the 25-mph speed limit in urban areas, or may delegate the authority to raise the speed limits to Department of Roads' employees in a supervisory capacity. The speed limits shall be raised in 5-mph increments, and cannot exceed the statutory speed limits.

Speed limits above 35 mph in a rural area and 25 mph in an urban area will be effective when the Director, or any officer to whom authority has been delegated, gives a written order for the increase and signs identifying the speed limit are displayed.

Speed limit signs may be mounted on a fixed or movable stand. For a moving-type operation, speed limit signs may be mounted upon moving Department of Roads' vehicles.

Authorization

In order to raise the work area speed limit from 35 mph in rural areas and 25 mph in urban areas, the authorized supervisory employee shall complete a Speed Zone

Authorization form identifying the speed limit, highway number, location, and starting and ending times that the speed limit will be in effect. The original Speed Zone Authorization form should be kept in the file of the individual signing the authorization. A copy of the Speed Zone Authorization should be forwarded to the individual in charge of the work crew.

The establishment of speed limits through construction work areas will be determined in the Lincoln office, and will be included in the contract provisions so that a contractor will be aware of a construction speed limit while preparing his/her bid.

If a situation arises where a construction speed limit is needed during the course of a construction project and no provision was made for the speed limit in the contract provisions, or if a speed zone established through the contract provisions needs to be raised or lowered, individuals designated by the Director may establish or alter speed limits in accordance with these guidelines.

Signing (SSHC Section 422)

All signing shall conform to the requirements of the Manual on Uniform Traffic Control Devices.

Speed limit signs are intended to supplement normal work area signing. They are not intended to replace any of the signs that are now being used, except under certain situations where advisory speed plates are used.

In order to make the “Double Fines” enforceable, the “FINES FOR SPEEDING DOUBLED IN WORK ZONES” sign must be posted at the beginning of each work zone. On all speed limit signs, the “FINES DOUBLED” sign needs to be installed, except for 35 mph in rural areas and 25 mph in urban areas, must be set by utilizing the authorization form. If, for example, within the limits of an interstate construction project, there are two sections under work which require a reduced speed of 55 mph and the balance of the project maintains a 75 mph speed limit, an authorization form must be completed raising the speed limit on the two sections from 35 mph to 55 mph and the balance to 75 mph.

All existing speed limit signs that conflict with the work area speed limit should be removed or covered during the period of time that the work area speed limit is in effect, except that advisory speed limits that are lower than the work area speed limit being implemented should be left in place. The minimum length of a work area speed zone should be 1/2 mile.

A "Work Area - Speed Zone Ahead" sign should be placed approximately 250 m (800 feet) in advance of the first work area speed limit sign. If the work area is on a steep downhill grade, the 250 m (800 foot) distance should be extended to allow a motorist sufficient distance to decelerate from the statutory speed limit to the work area speed limit. In urban areas where lower speed limits exist, the 250 m (800 foot) distance should

be decreased to from 100 m (300 foot) to 200 m (450 foot), depending on the reduction in speed limit that is being implemented through a work area.

The first speed limit sign should be placed approximately 200 m (450 m) in advance of the start of the work area. In urban areas where lower speed limits exist, the 200 m (450 m) distance should be decreased to from 30 m (100 feet) to 100 m (300 feet), depending on the reduction in the speed limit that is being implemented.

The maximum length of a work area speed zone should be one-half mile, with the exception of work operations that are being performed simultaneously at the beginning, through, and at the end of a work area that is longer than one-half mile in length.

A "FINES FOR SPEEDING DOUBLED IN WORK ZONES" signs should be placed 500 to 1000 feet following the first work zone signs with the appropriate speed limit sign with the "FINES DOUBLE" plate 500 to 1000 feet beyond that.

For reduced speed areas, a "REDUCED SPEED AHEAD" sign should be placed approximately 800 feet in advance of the first work area speed limit signs. If the work area is on a steep downhill grade, the 800-foot distance should be extended to allow a motorist sufficient distance to decelerate from the statutory speed limit to the work area speed limit. In urban areas where lower speed limits exist, the 800-foot distance should be decreased to from 200 to 500 feet, depending on the reduction in speed limit that is being implemented through a work area.

The first speed limit sign with the "FINES DOUBLE" plate should be placed in advance of the start of the actual work area.

In reduced speed areas, a speed limit sign with the R2-1wz "FINES DOUBLE" plate shall be repeated at no greater than one mile intervals.

The appropriate standard R2-1 speed limit sign shall be installed immediately following the End Road Work, Thank You Drive Safety sign.

Recordkeeping

It is necessary to keep a daily log of work area speed limits, in the event a court case results from a driver being given a citation for exceeding the speed limit.

The daily log should identify the date, hours the speed limit is in effect, value of the speed limit being implemented, highway number, starting and ending reference posts of the work area speed zone, and in the event a speed limit is implemented on one side of a divided highway, the direction of travel.

404.16 BRIDGE APPROACH GUARD RAILS

On construction projects that require the removal of guardrail at the approaches to bridges, or if the rail has not yet been installed, the following minimum traffic controls

should be in place at all unprotected bridge ends whenever traffic is permitted to use the highway:

Two-Lane, Two-Way Condition

Three Type III barricades should be in place to the right of the lane approaching the bridge. The barricades should be placed at 15 m (50 foot) centers, with the last barricade placed at the unprotected bridge end.

One Type III barricade should be in place to the right of the lane leaving the bridge (facing traffic approaching from the opposite direction). The barricade should be placed at the unprotected bridge end.

Divided Highway Condition

Three Type III barricades should be in place both to the right and to the left of the lanes approaching the bridge. The barricades should be placed at 15 m (50 foot) intervals, with the last barricade placed at the unprotected bridge end.

Barricades are not required on the lanes leaving the bridge.

In addition to the barricades at bridge ends, normal signing warning traffic that they are approaching a construction area should be in place.

These traffic controls are applicable to both active construction projects and projects that are held over the winter for completion in the next construction season.

The above traffic controls are intended for use only during the period of time when construction activities require that a bridge end remain unprotected. The replacement of guardrail should be accomplished at the earliest possible date, to eliminate the unprotected bridge end condition.

903.03 CONSTRUCTION METHODS

Standard plan for Traffic Control Devices for Construction and Maintenance, is a part of all guardrail project plans. Field personnel shall insure that project traffic (whether local only or traffic maintained condition are in effect) is controlled and workmen protected so this work is performed under safe conditions for all involved. Generally, guardrail work would be considered to require traffic control procedures similar to the situation sketches for minor maintenance of short duration or road repair.

The specifications are very detailed on construction methods and the field personnel must insure that these methods are used. All connections must be tightened, etc. Cables that are anchored in concrete cannot be tightened until the concrete has attained 2000 psi (14 Mpa). The work is not complete until the contractor has tightened all turnbuckles, cables, nuts, etc. [3].

SECTION 422 - TEMPORARY TRAFFIC CONTROL DEVICES

422.01 – Description

1. This work consists of furnishing, installing at the locations shown in the plans, operating, maintaining, and when work is complete, removing the temporary traffic control devices described in this Section.

2. General Requirements:
    a. All traffic control devices shall be located according to and meet all requirements prescribed in the MUTCD. Failure of the Contractor to erect and maintain traffic protective devices shall be reason to temporarily suspend the work in accordance with Subsection 108.06 [4].

2.2 Iowa Department of Transportation (IaDOT)

The Iowa Department of Transportation utilizes two major documents for providing guidance for construction, work-zone traffic control, and barrier placement and use. These documents include the *Construction Manual* [5] and the *Standard Specifications for Highway and Bridge Construction* [6]. Chapter 5 of the *Construction Manual* primarily covers safety, while Sections 5.20 and 5.21 address work zone traffic control and denote which national guidelines are to be followed. Chapter 12 of the *Construction Manual* covers incidental construction, while Section 12.30 addresses forged steel beam guardrail. However, no guidance is provided in terms of guardrail construction adjacent to traffic within the *Construction Manual*.

The *Standard Specifications for Highway and Bridge Construction* provides guidance for guardrail construction and removal, safety closure, and traffic control in Sections 2505, 2518, and 2528, respectively. In *Section 2505.03 - Construction and Removal of Guardrail – Part D Limitations*, guidance is provided for addressing the level of construction to be completed for allowing vehicle traffic nearby. In *Section 2518.03 - Construction – Part A Erection*, guidance is provided for addressing the hazard closures. Finally, *Section 2528.01 – Description – Part A General*, provisions are noted for incorporating traffic control according to national MUTCD standards. The relevant IaDOT guidance is provided below for convenience.

5.20 CONSTRUCTION WORK ZONE TRAFFIC CONTROL

5.21 TRAFFIC CONTROL SPECIFICATION REFERENCES

Contract documents include references to traffic control requirements in many locations. Project plans contain references to traffic control requirements in the traffic control plan tabulation usually found on estimate of quantities sheet. Plans may also contain project specific traffic control and/or staging details. An extensive list of information sources regarding traffic control is found in Appendix 5-8.

Traffic control requirements may also be found in the specifications for specific construction activity.

ATSSA Quality Guidelines for Temporary Traffic Control Devices and Features

The American Traffic Safety Services Association (ATSSA) “Quality Guidelines for Temporary Traffic Control Devices and Features” is intended to be used by field personnel to help them inspect the work zones. The guide is a defacto national industry standard to determine an acceptable quality level for a typical work zone traffic control device. The guide includes examples of acceptable, marginal, and unacceptable work zone traffic control devices. It is intended to further define the language in the Manual on Uniform Traffic Control Devices which requires that "devices used are clearly visible, clean, and in good repair."

2505.03 CONSTRUCTION AND REMOVAL OF GUARDRAIL

Furnish and install posts, beams or cables, end anchors, and special connections and fittings required in the contract documents. Install to the specified line and mounting height. Changes in the installed length require the Engineer’s approval.

D. Limitations

1. General

a. Do not stress attachments to new concrete or to bolts set in epoxy resin until the new concrete or epoxy resin has attained an age of 3 calendar days. Concrete foundations for posts and end anchors may be subjected to cable tensioning after 3 calendar days. These time requirements may be lengthened by the Engineer during cool weather.

b. Complete grading work, if required, prior to removal of existing guardrail or installation of new guardrail.

c. When a roadway is open to traffic during construction, complete guardrail installations within 5 working days from the day the structure, barrier rail, pavement, or shoulder (whichever is the controlling item of work) is sufficiently completed to allow guardrail installation. Each installation exceeding the 5 working day completion requirement will be subject to a contract price adjustment of $100 per working day. For high tension cable guardrail, this price adjustment will be waived when the installation serves as crossover protection only and no guardrail or concrete barrier has been removed.

d. When a roadway is closed to public traffic for construction, complete all guardrail installations before opening the road to traffic.

2. Steel Beam Guardrail and Low Tension Cable Guardrail

a. In areas where guardrail construction is not restricted by other construction, remove existing guardrail (if any) and construct new guardrail, except for end

anchors requiring concrete, on the same working day. Place concrete for the final end anchor no later than the next working day.
b. For steel beam guardrail installations requiring end anchors, use a Type E Terminal Section, a Type II Barricade, and a Type A Warning Light to end the installations until the final anchor is finished.

3. High Tension Cable Guardrail

a. In case of a discrepancy between these Specifications and the manufacturer's recommendations, these Specifications will govern.

b. At locations where the proposed guardrail installation does not interfere with the functioning of the existing guardrail, do not remove the existing guardrail until the high tension cable guardrail system is fully functional. Once the installation is fully functional, remove existing guardrail within 5 working days.

2505.03 CONSTRUCTION

A. Erection

1. Road Closures

a. Place a fence meeting the requirements of Article 2518.02 across the roadway from outside edge of shoulder to outside edge of shoulder. Securely support the fence so it is in a vertical position without sagging.

b. Place a Type III barricade, described in Part 6 of the MUTCD, immediately in front of the fence at the approximate roadway centerline. Mount a ROAD CLOSED (RII-2) sign on the Type III barricade.

c. Erect road closures as specified in the contract documents. Erect them on the mainline of the roadway where public traffic is diverted onto an on-site detour and where public traffic is prohibited from entering the work area.

d. Erect road closures beginning with the start of the contract period as specified in the contract documents, or when the work commences.

2. Hazard Closure

a. Place a fence meeting the requirements of Article 2518.02 across the roadway from outside edge of shoulder to outside edge of shoulder. Securely support the fence so it is in a vertical position without sagging.

b. Place a Type III barricade, described in Part 6 of the MUTCD, immediately in front of the fence at the approximate roadway centerline.

c. Erect hazard closures as specified in the contract documents. Erect them at locations within a work area when construction involves major hazards on existing or relocated roadways. Such hazards may be located at streams, gullies, railroads, bridge approaches, and driveway locations. Through public traffic should not normally encounter a hazard closure.

d. Erect hazard closures beginning with the start of the contract period as specified in the contract documents, or when the work commences.

B. Responsibility

1. Maintain the location and condition of the safety closures. Any Contractor who temporarily moves the safety closure for equipment or delivery of materials, shall replace it in its original position and is responsible for the restriction of public traffic into the closed area.

2. If a safety closure placed by the Contractor is required for an area after the Engineer's approval of completed work for that specific area, maintenance of that safety closure will become the responsibility of the Contracting Authority. The Engineer will document in writing the transfer of authority.

3. The Engineer will notify the Contractor of the date of removal of safety closures. The safety closure remains the property of the installing Contractor. If the safety closure is not removed by the date specified in the notification, it will become the property of the Contracting Authority and the Contractor will be charged for any removal costs.

2.3 Kansas Department of Transportation (KDOT)

The Kansas Department of Transportation (KDOT) utilizes two major documents for providing guidance for construction, materials, work-zone traffic control, and barrier placement and use. These documents consist of the 2010 *Construction Manual* [7] and the 2007 *Standard Specifications for State Road and Bridge Construction* [8]. Part I of the *Construction Manual* addresses general items. Section 1.07 handles safety, while subsection 1.07.02 covers vehicular traffic and the need to follow national MUTCD policies. Chapter 8 of the *Standard Specifications for State Roads and Bridge Construction* provides guidance for incidental construction. Section 805 covers work zone traffic control and safety, while Section 827 addresses guardrail and guideposts.

During an email correspondence with KDOT [9] information on typical practices was offered, and an example of the type of procedures used for guardrail construction was provided, as shown in Appendix A. The relevant KDOT guidance is provided below for convenience.

> **1.07.02 VEHICULAR TRAFFIC**
>
> Traveling public - Today's high volume of traffic combined with difficult construction near highly populated areas makes it imperative that project personnel be concerned with not only maintaining construction standards and schedules, but also the safe and smooth operation of traffic in and around construction areas. Intensive supervision and inspection by field personnel is necessary to obtain guidance and protection of traffic through work areas on the construction project. Place adequate traffic control devices where they are most needed and effective. Handle traffic control in accordance with the Standard Traffic Control Sheets incorporated in the plans, Standard Specifications and latest edition of the Manual on Uniform Traffic Control Devices for Streets and Highways.
>
> Use flaggers where needed. All flaggers should be familiar with instructions and procedures contained in the State of Kansas Traffic Control Handbook for Flaggers. They shall be provided with and wear proper apparel. Signs and barricades should leave no doubt as to when roads are completely closed and where detours are located. Remove or cover traffic control devices, when no longer needed.
>
> On each project, assign an inspector the responsibility for checking traffic control. Make checks and document the condition, placement and adequacy of traffic control devices throughout the duration of their use on a daily basis (more often if

necessary), on weekends and on holidays or shutdown periods. Make periodic inspections at night to verify that traffic control devices are operating as intended. If the person noting the defect cannot make the correction, notify the proper party; this would be the Area/Metro Engineer for KDOT signs and devices, or the Contractor's representative for their signs and devices [7].

Email Correspondence: KDOT practice really depends on the project and site specific details. Generally, KDOT will place a barrier (TL-3) with an appropriate end treatment before traffic is allowed adjacent to the barrier. However, in special situations, KDOT may also delineate the hazard with cones or barrels and not install a barrier. The final configuration is determined by the designer based on the site conditions. Factors usually considered are ADT, offset to hazard, speed, and duration of exposure.

On guardrail end terminal upgrade projects, KDOT has a special provision that allows the contractor a limited number of days to leave the leave the bridge rail transition connection exposed. The number of days depends on the project conditions, urban vs. rural.

Standard detail sheets are used to handle specific situations where traffic is allowed on nearby roads. Speed limit reductions are often used under these situations.

Temporary traffic control plans always refer to the current edition of the MUTCD. KDOT standard detail sheets either meet or exceed what is either required or recommended by the MUTCD.

Special provisions have been used to limit exposure during guardrail replacements. Often, these issues are identified in the construction sequencing of the plans [9].

2.4 Wyoming Department of Transportation (WyDOT)

The Wyoming Department of Transportation (WyDOT) utilizes the 2003 *Standard Specifications for Road and Bridge Construction* [10] for providing guidance for construction, materials, work-zone traffic control, and barrier placement and use. The Wyoming Department of Transportation does not have written policies or procedures for opening roads to traffic in barrier construction nearby but offered information on typical practices through email correspondence [11]. Additionally, the Wyoming *Standard Specifications* [10] denote that work zone traffic control shall follow national MUTCD policies. The relevant WyDOT guidance is provided below for convenience.

> **Email Correspondence:** There are no written policies or specifications concerning the issues you have raised although frequently some of these items are covered in a special provision written specifically for each project called the 'Construction Requirements'. Let me explain what our typical practices are.
>
> On roadways which are not carrying traffic, such as divided highways where traffic is moved to the other side of the median and undivided highways which are either placed on a new alignments (pretty rare these days) or have detours, we would require the facility to have all traffic control devices, guardrails, etc. in place before allowing traffic on them. Again, many times these provisions are covered in the Construction Requirements which are written for each specific project.
>
> For roadways carrying traffic, we would have temporary barrier in place (say to protect bridge ends, or bridge railing which might have been removed, or other significant hazards). For short duration activities, such as removing and resetting guardrail or moving to facilitate paving, we would require a speed reduction and increased levels of traffic control, mainly consisting of additional barrels, wands or other devices to alert motorists of the increased hazard potential. Since we have bid items for traffic control, this is not an issue for contractors to comply with. Even when we have traffic control set up as lump sum, we tell the contractor what traffic control must be in place for a given situation.
>
> Our construction engineers also work diligently to get the contractors to complete guardrail installations in their entirety once started. Most contractors understand their own liability is increased if they fail to get fully functional roadside safety devices in place as expeditiously as possible [11].

107.11.4 Temporary Traffic Control

Provide, install, and maintain necessary devices to control traffic, ensure safety of the public, and protect the work. Use barricades to protect highways closed to traffic. Erect warning signs before places where work may interfere with the road's use by traffic and at intermediate places where the project crosses or coincides with an existing road, bike path, or sidewalk.

Where it is impossible or impractical to divert traffic on existing roads or detours, perform the work under traffic. Provide for traffic movement in accordance with the approved traffic control plan. As necessary, use flagging, pilot car escorts, or both.

Provide, install, and maintain temporary traffic control devices in accordance with the contract and the MUTCD. Temporary traffic control is incidental to associated pay items when not included as a pay item in the contract [10].

2.5 Missouri Department of Transportation (MoDOT)

The Missouri Department of Transportation (MoDOT) utilizes the *Standard Specifications for Highway Construction* [12] to provide guidance for the construction, repair, and removal of guardrail, end terminals, and cable barriers, as well as for addressing temporary traffic control. In *Section 606 – Guardrail, Crashworthy End Terminals, One-Strand Restraint Cable, and Three-Strand Guard Cable* denotes limited provisions for barrier construction and opening roadways to adjacent vehicle traffic. In *Section 616 – Temporary Traffic Control*, provisions are provided for implementing the work zone according to national MUTCD guidelines. The relevant MoDOT guidance is provided below for convenience.

606.3 Construction Requirements

606.3.1 General Work on guardrail or guard cable removal and replacement when the adjacent travel or auxiliary lane is open to traffic during non-working hours shall adhere to the following requirements:

(a) The contractor shall provide a schedule of work prior to the beginning of work.

(b) Remove no more guardrail or guard cable than can be replaced in the same day.

(c) Schedule guardrail and guard cable installation to ensure guardrail beam or guard cable is properly attached to all installed posts at the end of each work day.

(d) Ensure end sections or terminals exposed to traffic meet current standards. Guardrail or guard cable shall be maintained to within 3 inches (75 mm) of the nominal barrier height shown on the plans.

(e) Notify the engineer prior to delivery of the material to the project.

606.3.1.1 If guardrail or three-strand guard cable cannot be replaced the same day as removal, traffic control measures meeting the approval of the engineer shall be provided. The contractor will not be compensated for any additional traffic control items required to perform this work. In all cases, the contractor shall ensure that the guardrail or guard cable installation is fully anchored before opening the adjacent lane to traffic.

606.3.1.2 The shoulders and slopes shall be in accordance with all standards shown on the plans or shall be as directed by the engineer before the installation of any guardrail, guard cable or end treatments.

616.3 Safety Requirements

616.3.1 All workers within highway right of way who are exposed to traffic or construction equipment shall wear high-visibility safety apparel meeting Class 2 or Class 3 requirements of ANSI/ISEA 107-2004 publication entitled, "American National Standard for High-Visibility Safety Apparel and Headwear".

616.3.2 All traffic control devices shall be in accordance with the MUTCD and any applicable safety and design codes.

616.3.3 The contractor shall furnish a manufacturer's certification of crashworthiness, per NCHRP 350 Evaluation Criteria, for FHWA Category 1 traffic control devices and appurtenances. The contractor shall furnish the FHWA acceptance letter for FHWA Category 2 and Category 3 traffic control devices and appurtenances. The FHWA acceptance letter shall indicate that the device and appurtenance complies with the crash test requirements of NCHRP 350, Test Level 3 (TL-3). Regardless whether the device meets NCHRP 350 criteria, the engineer reserves the right of final approval. Installation of a device prior to the engineer's approval will be at the contractor's risk.

616.3.4 The contractor shall:

(a) Designate a trained person at the project level who has the primary responsibility, with sufficient authority, for implementing the traffic management plan and other safety and mobility aspects of the project. The name of that person, proof they successfully completed MoDOT's Advanced Work Zone course, ATSSA's Traffic Control Supervisor course or an approved equivalent training course, and a 24-hour contact number for that person shall be provided to the engineer at the pre-construction meeting. Re-certification will be required as dictated by the organization providing the training.

(b) Ensure all contractor personnel are trained in traffic control to a level commensurate with their responsibilities.

(c) Advise the engineer, as required, at least two working days before any work requiring a lane closure begins and 14 calendar days prior to the imposition of height, width and weight restrictions.

(d) Perform quality control of work zones to promote consistency and ensure compliance with contract documents, policies and guidelines.

2.6 South Dakota Department of Transportation (SdDOT)

The South Dakota Department of Transportation (SdDOT) uses a document entitled *Standard Specifications for Roads and Bridges* to provide guidance for the installation, repair, and removal of guardrail systems as well as to address work zone needs within *Division II – Construction Details, Part F – Incidental Construction* [13]. More specifically, Sections 629, 630, and 634 cover three cable guardrail, steel beam guardrail, and traffic control, respectively. Within this guidance, work zones are to be implemented according to national MUTCD guidelines. The relevant SdDOT guidance is provided below for convenience.

629 THREE CABLE GUARDRAIL

629.3 CONSTRUCTION REQUIREMENTS

E. Completion Requirements:

On projects where existing cable or steel beam guardrail is to be removed and replaced or reinstalled, and the roadway will be open to traffic during construction, the guardrail installation shall be completed within fourteen (14) calendar days from the day the controlling item of work is sufficiently complete to allow guardrail installation to commence. A guardrail installation is defined as each individual run of guardrail (i.e., a typical bridge would have 4 guardrail installations). Controlling items for guardrail include but are not limited to: structure, structure end block and surfacing work. Typically, there will be a sequence of controlling items for guardrail. Prior to any guardrail removal, a written construction schedule for work in the guardrail area shall be developed by the Contractor and approved by the Engineer. In no case shall work cease between controlling items of work for more than four (4) working days.

Once the existing guardrail is removed from any item of concern (bridge end, box culvert, bridge column, etc.), the Contractor shall place drums or Type II Barricades at 25-foot intervals at each location where existing guardrail is removed. These devices shall extend 175 feet beyond the item of concern for each direction of traffic. Drums or Barricades shall remain in place until new guardrail has been installed. Cost for furnishing, installing and maintaining drums or barricades shall be incidental to the contract lump sum price for Traffic Control Miscellaneous.

Post end, beam, and end terminal sections shall be erected in a continuous operation within each individual run of guardrail. Incomplete guardrail installations shall be marked by delineation as noted in the previous paragraph.

If the Contractor fails to complete the required work within the time allowed, the Contractor shall install an approved safety treatment that complies with NCHRP 350, level 3, to protect the site.

630 STEEL BEAM GUARDRAIL

630.3 CONSTRUCTION REQUIREMENTS

F. Completion Requirements:

On projects where existing cable or steel beam guardrail is to be removed and replaced or reinstalled, and the roadway will be open to traffic during construction, the guardrail installation shall be completed within fourteen (14) calendar days from the day the controlling item of work is sufficiently complete to allow guardrail installation to commence. A guardrail installation is defined as each individual run of guardrail (i.e., a typical bridge would have 4 guardrail installations). Controlling items for guardrail include but are not limited to: structure, structure end block and surfacing work. Typically, there will be a sequence of controlling items for guardrail. Prior to any guardrail removal, a written construction schedule for work in the guardrail area shall be developed by the Contractor and approved by the Engineer. In no case shall work cease between controlling items of work for more than four (4) working days.

Once the existing guardrail is removed from any item of concern (bridge end, box culvert, bridge column, etc.), the Contractor shall place drums or Type II Barricades at 25-foot (7.6 m) intervals at each location where existing guardrail is removed. These devices shall extend 175 feet (54 m) beyond the item of concern for each direction of traffic. Drums or Barricades shall remain in place until new guardrail has been installed. Cost for furnishing, installing and maintaining drums or barricades shall be incidental to the contract lump sum price for Traffic Control Miscellaneous.

Post end, beam, and end terminal sections shall be erected in a continuous operation within each individual run of guardrail. Incomplete guardrail installations shall be marked by delineation as noted in the previous paragraph.

If the Contractor fails to complete the required work within the time allowed, the Contractor shall install an approved safety treatment that complies with NCHRP 350, level 3, to protect the site.

634 TRAFFIC CONTROL

634.1 DESCRIPTION

This work consists of furnishing, installing and maintaining required traffic control devices in accordance with the current edition of the Federal Manual on Uniform Traffic Control Devices [13].

2.7 Ohio Department of Transportation (OhDOT)

The Ohio Department of Transportation (OhDOT) utilizes the 2010 *Construction and Materials Specifications* [14] for providing guidance for the installation, repair, and removal of guardrail systems and for maintaining traffic within work zones. More specifically, Item 202 addresses the removal of structures and obstructions, while Item 614 covers needs associated with maintaining traffic. Within this guidance, work zones are to be implemented according to the Ohio and national MUTCD guidelines. The relevant OhDOT guidance is provided below for convenience.

ITEM 202 REMOVAL OF STRUCTURES AND OBSTRUCTIONS

202.09 Guardrail and Fence Removed Carefully dismantle and store existing guardrail (including anchor assemblies and terminal assemblies, and any attached posts, signs, and delineators) and fence when designated for reuse or storage by the Department. Dispose of wood posts and other materials not considered salvageable according to 202.02.

When fence is designated for replacement, do not remove the existing fence until the replacement material is on site. Begin the new installation within 7 workdays of beginning the removal process.

When guardrail is designated to be replaced and traffic is being maintained in the adjacent lane, do not leave hazards unprotected except for the actual time required to remove the existing guardrail and install the proposed guardrail in a continuous operation. Do not remove the guardrail until the replacement material is on the site and ready for installation. The Engineer will suspend work for failure to comply with this requirement.

Backfill the cavity created by the removal item according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

ITEM 614 MAINTAINING TRAFFIC

614.03 Traffic Control General Conform to the requirements of the plan, standard construction drawings shown on the plans, and the OMUTCD, for the installation, maintenance, and operation of all traffic controls and traffic control devices. When the plans or standard construction drawings do not cover a specific traffic control situation, place the necessary traffic control devices according to the OMUTCD and use the procedures required by the OMUTCD.

Use portable changeable message signs pre-qualified according to Supplement 1061.

Use drums, signs, sign supports, barricades, impact attenuators, and other traffic control devices that are certified to meet NCHRP 350 safe-crash standards or as modified by Contract Documents. Do not use heavy non-yielding devices or supports that do not conform to the current standards of NCHRP 350 unless allowed by Contract Documents.

Use Type G, H or J reflective sheeting complying with 730.19, 730.192 and 730.193, respectively, for faces of construction signs, barricades, vertical panels, object markers, and stripes on glare screen panels. In addition, the Contractor may also use Type G sheeting referred to as damage control for these devices, provided it meets 730.19.

Use fluorescent orange reflective sheeting for all orange construction signs, object markers, and stripes on glare screen paddles. Use standard orange or fluorescent orange reflective sheeting for the orange portions of drums, barricades and vertical panels.

Furnish drums with reboundable reflective sheeting complying with the requirements of 730.191. Ensure that owner identification markings on construction drums are no more than 1 inch (25 mm) in character height and are located at least 2 inches (50 mm) below the reflectorized bands or on the top or bottom horizontal surfaces of the drum. Ballast the drums according to the manufacturer's recommendations.

Furnish traffic cones consisting of a highly visible orange predominant color. Ensure that the pavement markings for traffic maintenance conform to Item 640.

Furnish warning signs in advance of channelizing devices such as barricades, drums, vertical panels, and cones. Keep retroreflective materials clean and in good condition.

If equipment, vehicles, and material are stored or parked on highway rights-of-way, locate them not less than 6 feet (2 m) behind existing guardrail or not less than 30 feet (9 m) beyond the traveled way unless otherwise permitted by the Engineer. At night if any such material or equipment is stored between the side ditches, or between lines 6 feet (2 m) behind any raised curbs, clearly outline them with dependable lighted devices that are approved by the Engineer.

All temporary traffic control devices shall conform to the Quality Standards for Temporary Traffic Control Devices available at the following address: http://www.dot.state.oh.us/Divisions/HighwayOps/Traffic/publications2/qualityguidelines/Pages/default.aspx

614.07 Traffic Maintained Where the highway under construction is being used by through traffic, including periods of suspension of the work, furnish and maintain pavement markings, lights, construction signs, barricades, guardrail, sign supports, and such other traffic control devices. Maintain pre-existing roadside safety hardware at an equivalent or better level than existed prior to project implementation. Also, provide law enforcement officers, watchmen, and flaggers as necessary to maintain safe traffic conditions within the work limits as directed by the Engineer.

The Department will furnish and erect regulatory signs and guide signs, unless otherwise shown on the plans, within the work limits on all traffic maintained projects. The Contractor is responsible for maintenance of these signs. The Engineer will approve the erection and removal of any regulatory signs not shown on the plans.

Keep existing signs and traffic control devices in use within the work limits during the construction period unless otherwise indicated on the plans. If existing signs and other traffic control devices must be relocated or modified as a consequence of the work, provide suitable supports and modify the devices with prior approval of the Engineer and the concurrence of the maintaining agency. Keep existing STOP or YIELD signs functioning at all times. The Contractor may adjust the position of these signs with the Engineer's approval. Relocate existing signs that must be adjusted laterally according to the OMUTCD. Restore relocated or modified signs to the position and condition that existed before construction as directed by the Engineer. When signs are to be covered, provide an opaque covering that covers the entire message, symbol and all of the sign within the border. Do not use fastenings that damage the sign or reflective face; however, the Contractor may use rivets to attach rigid overlay panels. Do not apply adhesive tapes directly to the face of the sign.

When an existing signal operation must be interrupted for a period of time, provide a traffic control method approved by the Engineer.

Whenever it is necessary to divert the flow of traffic from its normal channel into another channel, clearly mark the channel for such diverted traffic with cones, drums, barricades, vertical panels, pavement markings, or flashing arrow panels. Also use this method of marking where working adjacent to the part of the highway in use by the public.

Obtain the approval of the Engineer before closing a traffic lane or establishing a one-way traffic operation [14].

2.8 Illinois Department of Transportation (ILDOT)

The Illinois Department of Transportation (ILDOT) follows the 2007 *Standard Specifications for Road and Bridge Construction* [15] and the 2002 *Bureau of Design and Environment (BDE) Manual* [16] for addressing work zone traffic control adjacent to barrier construction, general design, and roadside safety design. Sections 701.04 and 701.17 found within *Division 700 – Work Zone Traffic Control and Protection, Signing, and Pavement Marking* denote the need to follow national MUTCD guidelines to guide what level of barrier construction must be completed prior to opening lanes to traffic, respectively [15]. Chapter 55 of the BDE Manual also covers work zone traffic control – work-zone design speed and positive protection. The relevant ILDOT guidance is provided below for convenience.

SECTION 701 – WORK ZONE TRAFFIC CONTROL AND PROTECTION

701.04 General

Work zone traffic control and protection shall be according to the traffic control plan and the MUTCD.

The traffic control shown on the plans represents the minimum required combination of traffic control devices needed for a particular construction operation. Conditions created by the Contractor's operation which are not covered by the plans shall be delineated by devices as directed by the Engineer at no additional cost to the Department. Revisions or modifications of the traffic control shall have the Engineer’s written approval.

Traffic control shall be installed sequentially in the direction of the traffic flow and removed in reverse order. Advance warning signs shall be erected prior to channelizing devices and shall remain until all devices have been removed from the pavement.

The traffic control shall remain in place only as long as needed and shall be removed when directed by the Engineer. Signs that do not apply to current conditions shall be removed, covered, or turned from the view of motorists. All existing pavement markings which conflict with the revised traffic pattern shall be removed according to Section 783.

At the preconstruction conference, the Contractor shall furnish the name and telephone number of the individual in the Contractor's direct employ who is to be responsible, 24 hours-a-day, for the installation and maintenance of traffic control for the project. When the actual installation and maintenance are to be accomplished by a subcontractor, consent shall be requested of the Engineer at the time of the preconstruction conference.

This shall not relieve the Contractor of furnishing a responsible individual in the Contractor's direct employ. The Department will provide the Contractor with the name of its representative who will be responsible for administration of the traffic control.

701.17 Specific Construction Operations

Additional requirements for specific construction operations shall be as follows.

(f) Guardrail

Where guardrail is temporarily removed or where the guardrail installation is incomplete, devices shall be placed at 50 ft (15 m) centers.

On staged construction bridge projects, the parapets shall have the guardrail installed and attached prior to switching traffic.

Guardrail removal and/or installation shall be scheduled so no installations are left unfinished when the work is suspended for the winter or other extended periods of time [15].

CHAPTER 55 – WORK ZONE TRAFFIC CONTROL (PART VI of BDE)

55-3 DESIGN CONSIDERATIONS

The following sections present design criteria which apply to temporary crossovers on divided highways, existing roadways through work zones, and detours specifically designed for construction projects (e.g., crossovers, runarounds). These criteria do not apply to detours over existing routes which are presented in Section 55-6.04.

55-3.01 Work Zone Design Speed

The work zone design speed applies to the design of the geometric elements through the work zone. It does not apply to the regulatory speed limits that are used for posting the speed limit through the work zone and construction site. Regulatory speed limits are discussed in Section 55-2.01(b). When selecting the work zone design speed, consider the following factors:

1 Posted Speed Limit

The work zone design speed should reflect the following:

- the existing posted speed limit of the facility before construction begins,
- the anticipated posted speed limit through the work zone, and
- the posted speed limit of the facility immediately prior to the work zone.

The work zone design speed normally should not be more than 10 mph (15 km/h) below the posted speed limit prior to construction. Under restricted conditions, the

maximum speed reduction may be 15 mph (25 km/h) below the post speed limit prior to construction.

2 Urban/Rural

Work zone design speeds in rural areas should generally be higher than those in urban areas. This is consistent with the typically fewer constraints in rural areas (e.g., less development).

3 Terrain

Lower work zone design speeds may be applicable for rolling terrains. This is consistent with the typically higher construction costs as the terrain becomes more rugged.

4 Traffic Volumes

For some facilities, the work zone design speed may vary according to the traffic volumes; i.e., use higher design speeds as traffic volumes increase.

55-4 ROADSIDE SAFETY

Through a work zone, drivers are often exposed to numerous hazards (e.g., restrictive geometrics, construction equipment, opposing traffic). A total elimination of work zone hazards is impractical. Therefore, the designer must devote special attention to reducing a motorist's exposure to potential hazards. The following sections offer roadside safety criteria which apply only to the roadside elements within the work zone. These criteria do not apply to detours over existing routes.

55-4.01 Positive Protection

Desirably, the designer should consider traffic control designs which do not require the use of positive protection, minimize the hazard exposure, and maximize the separation of workers and traffic. However, in many work zones, positive protection is typically required. The following are locations where the designer should consider using positive protection:

- exposed ends of temporary concrete barriers;
- untreated guardrail ends in two-way, two-lane operations;
- bridge piers;
- bridge rail or parapet ends;
- structure foundations (e.g., bridge falsework, sign foundations);
- excavations and rock cuts;
- gap in median between dual bridges;
- excessive pavement edge and shoulder drop-offs (consult Bureau of Operations); and

- other locations where construction will increase the potential hazards of existing conditions.

Consider the following factors when assessing the need for positive protection:

- duration of construction activity (14 days or more),
- traffic volumes (including seasonal and special event fluctuations),
- nature of hazard,
- length and depth of dropoffs,
- work zone design speed,
- highway functional class,
- length of hazard,
- proximity between traffic and construction workers,
- proximity between traffic and construction equipment,
- adverse geometrics which may increase the likelihood of run-off-the-road vehicles,
- two-way traffic on one roadway of a divided highway,
- transition areas at crossovers, and
- lane closures or lane transitions.

Other factors may apply, and the above list is not considered all inclusive.

55-4.02 Appurtenance Types

In addition to Chapter 38 and the *Highway Standards*, the following sections provide additional information on the roadside safety appurtenances used by the Department in work zones [16].

2.9 Wisconsin Department of Transportation (WisDOT)

The Wisconsin Department of Transportation (WisDOT) utilizes three major documents for providing guidance for construction, materials, work-zone traffic control, and barrier placement and use. These documents consist of the 2010 *Standard Specifications for Highway and Structure Construction* [17], the 2010 *Facilities Development Manual* [18], and the *Construction and Materials Manual* [19].

Part 1 of the *Standard Specifications for Highway and Structure Construction* addresses general requirements and covenants, while Part 6 covers incidental construction, including barrier systems, end treatments, and traffic control. Chapter 11 of the *Facilities Design Manual* addresses design, while Section 50 covers traffic control. Chapter 1 of the *Construction and Materials Manual* provides guidance on general provisions, while Section 45 addresses traffic control. The relevant WisDOT guidance is provided below for convenience.

104.6 ROADWAY MAINTENANCE AND TRAFFIC CONTROL (SSHSC)

104.6.1 General

1. The contractor is not liable for damages to or failure of existing facilities unless the damage or failure results from the contractor's own operations, negligence, or noncompliance with the contract.

2. The contractor shall maintain only those facilities or portions of facilities, including the roadbed surfaces, on which construction has begun or been completed, or has been damaged by the contractor's operations or has been damaged due to the contractor's negligence or noncompliance with the requirements of the contract.

3. The contractor is not responsible for snow removal or ice control operations to maintain traffic on highways open to traffic or closed to through traffic.

4. Maintain the safety of the traveling public and control traffic using barricades, signs, flaggers, and temporary barrier as specified in part VI, of the MUTCD and ensure that the contractor's use of the right-of-way conforms to 107.9. Furnish, erect, and maintain traffic control devices and facilities conforming to section 643,or as the engineer directs, throughout the life of the contract. Use drums, barricades, and temporary barrier to delineate and shield abrupt drop-offs and other hazards. Adequately train flaggers in the methods described in the department's flagger's

handbook and associated videotape before allowing them to control traffic. These provisions do not relieve the contractor of responsibility for injury or damage caused by the contractor's negligence in properly safeguarding public travel. Costs for flagging and guidance services, and signs associated with flagging and guidance, are incidental to the contract.

5. The contractor is responsible for all damages to the work due to failure of barricades, signs, lights, flaggers, watchers, and temporary barrier to protect it. The engineer may order the contractor to immediately remove and replace or otherwise repair the damaged work at no additional expense to the department.

104.6.5 Opening Section of Closed Road to Traffic before Work is Completed

1. For contracts with the road or portions of the road closed to traffic during construction, the engineer may direct or authorize the contractor to open sections of the road to public traffic before the work is completed. The engineer may direct the contractor to open sections of the road for the convenience of the traveling public. The engineer may authorize the contractor to open sections of the road to public traffic due to the contractor's request. Do not open the road to public traffic without the engineer's written direction or written authorization. By opening sections to public traffic, the contractor is not relieved of performing the maintenance. However, the department will assume all costs for repair and maintenance solely attributable to public traffic use, and beyond the control and without fault of the contractor. These maintenance expenses include costs associated with those traffic control devices or facilities specified in this section. The engineer's direction or authorization to open sections of the road to public traffic does not constitute partial acceptance under 105.11.1 and waives no other contract provisions.

2. Furnish, erect, and maintain those traffic control devices as may be required for the safe accommodation of the traffic.

3. The contractor is not liable for injuries or damages sustained by a person using the opened highway except for injuries or damages resulting from the contractor's own operations, negligence, or noncompliance with the requirements for traffic control under 104.6.1.

4. Whenever opening the road or a portion of the road to traffic, conduct the remainder of the construction operations in a manner that causes the least obstruction to traffic.

104.6.6 Road Open to All Traffic

1. If the contract provides for the maintenance of all traffic over or along the road while undergoing improvement or reconstruction, keep the road open to all traffic. Furnish, erect, and maintain the traffic control devices as required to keep the portions of the road being used by public traffic in a condition to safely and adequately accommodate pedestrian and vehicular traffic. The department will pay for necessary

work and materials to maintain the roadway at the contract unit prices of the bid items used or as extra work if the necessary bid items are not included in the contract.

CHAPTER 11 – DESIGN (FDM)
SECTION 50 – TRAFFIC CONTROL

11-50-20 – Safety in Work Zones

20.1 General Requirements

This procedure, along with FDM 11-50-40 and FDM 11-60-10, is intended to assure the maximum safety of motorists, pedestrians, and construction workers on all WisDOT construction projects.

The guidance for the design of Work Zone Traffic Control is found in Part VI of the MUTCD. Part VI contains national requirements for all roads, with the consideration that a state trunk highway has characteristics and traffic volumes greater than the minimum type of roadway which Part VI addresses. For this reason statewide policy has been developed concerning long term work zone traffic control on the state trunk highway system. When WisDOT administers projects on the local system, the devices used must meet WisDOT specifications and the minimum requirements of Part VI; however, the layout for the work zone traffic control itself should meet the maintaining authority's policy which may differ from WisDOT policy.

Attachment 20.1 of this procedure presents WisDOT's policy on "Traffic Safety in Highway and Street Work Zones." This policy is intended to define the traffic handling procedures required to accomplish a project.

20.5 Speed Limits During Construction

Some motorists respond to a reduced speed, while others do not see a need to slow down. This may cause a differential in speed among drivers which is at times more dangerous than consistent higher speeds. Studies have indicated motorists will drive the speed they feel comfortable driving. Unless there appears to be a physical limitation to their speed they will typically not reduce their speed unless there is an enforcement presence. Part of the difficulty in enforcing lower speeds is the difficulty of stopping a vehicle in the work zone. This means enforcement must be stationed on either end of the work zone to ticket vehicles.

In 1994, Wisconsin legislature passed a law doubling the fines in work zones for certain moving violations. Speeding in a work zone is one of the violations for which the fine is doubled. For this law to be effective, reduced speed limits must be warranted, consistently set, and clearly posted in the work zone. On projects which have tourist traffic, congested conditions, major traffic volumes or other factors which make speed or other moving violations a major concern, the sign "Fines Double in Work Zones" (W21-61 or W21-62) may be placed on either end of the project.

Accepted practice has been to reduce the speed limit on some roads while the road is under construction. The speed reduction is typically limited to 10 mph below the regular posted speed limit on the rural 65 mph freeway. It is normally not recommended to reduce the speed on a rural freeway which is normally posted at 55 mph. On some freeways in urban areas a reduction from 55 mph to 45 mph may be warranted if geometrics during construction are modified from the preconstruction situation. Cases where the speed is usually reduced include where traffic is shifted over to run two-way on a two lane roadway. The rural speed limit (typically 65 mph) should be reduced because of the crossover geometrics and, at times, narrowed lanes and shoulders. The length of the reduced speed zone should be as short as feasible. The public seems to understand this sort of speed reduction.
A reduction in regulatory speed limit on a rural 2 lane highway normally posted at 55 mph is not needed in most cases. If the method of construction and staging of traffic requires a reduced speed, it should most frequently be handled by posting an advisory speed at the geometric problems.

If it is decided a reduced regulatory speed is warranted, the reduction can be a maximum of 10mph. Factors to consider when exploring a reduced regulatory speed include proximity of the work to the traffic lanes, separation method of vehicles from the work area, and type of work being performed.

Where only one lane is closed and workers are not present, conformance to a reduced speed is poor.

Safety of motorists through a work zone can be handled by a combination of advisory speeds and the actual speed limits. Workers need to be protected, but staging to remove traffic from areas near the workers, or providing positive separation such as barrier is a better way to enhance worker safety than is a reduced speed zone.

The reduction in speed should be considered on a case by case basis and must have region traffic approval and a declaration prepared to make the speed enforceable.

Projects with anticipated capacity or other traffic handling problems typically have extra enforcement.

In some cases, some of the design elements of the temporary traffic control are designed at less than the posted speed. In these cases, if the feature is isolated or at a spot location, this can be handled by posting an advisory warning sign with a subsign with the appropriate speed.

11-50-35 – Concrete Barrier Temporary Precast in Work Zone

35.3 Guidelines for CBTP Use

If the work area closure is anticipated to last more than three continuous days and nights without a change to the traffic control layout or staging, CBTP is recommended for the following situations:

1. A bridge deck or culvert replacement/rehabilitation where any of the following conditions is anticipated to exist for more than three consecutive days and nights:
- Full-depth holes in the deck,
- Railing removed,
- Confined/restricted work area.

2. Dropping/removing a bridge deck over roadway if the work activity is more than three consecutive days and nights.
3. A bridge painting project over the roadway.

4. To separate counter directional traffic where two or more lanes in each direction are provided during the work and posted speed limit >= 45 mph.

Depending on the significance of the factors listed at the beginning of this procedure, other common situations which may justify CBTP, include:

A. Spot (or isolated) locations where the work area closure will last for more than three continuous days and nights without a change to the traffic control layout or staging, and either of the following conditions is anticipated:

- Exposed hazard that is at the same spot for more than three consecutive days and nights and is closer to an open traffic lane than:

1. 15 - 20 feet on freeway or expressway,

2. 10 - 15 feet on non-freeway/expressway where the posted speed limit is >= 45 mph,

3. 8 - 10 feet if AADT is less than 1,500 or the posted speed limit is less than 45 mph.

- Examples include footings, abutments, and construction activities such as false work.

The distance between the edge of the open traffic lane and the work is less than 6 feet (4 feet if non freeway/expressway) and the work is anticipated to continue for more than three consecutive days and nights at the same spot location.

If the work area closure and hazard will last for extended length of time (e.g., more than 2 months), lateral clearance should be greater than noted above, or CBTP should be considered.

Whenever feasible, it is preferable to remove the hazard and avoid the need for CBTP. Where the hazard cannot be removed, an option in lieu of CBTP to shield some hazards is to use attenuators, or crash cushions as described in FDM 11-45-1.

1.45.9 TRAFFIC CONTROL DEVICES (CMM)

1.45.9.1 General Requirements

Before allowing work operations to start or to continue, the engineer should ensure that the contractor provides effective and credible signing and properly installs warning signs, barricades, changeable message signs, arrow panels, and other traffic control devices according to project plans, the MUTCD, Work Zone Safety handbook, or other approved plans. If a flagger is required, flagging operations must be performed in accordance with the WisDOT flagger handbook. The contractor must provide adequate warning to the traveling public of any obstruction in the road or work operations that may be a hazard to traffic.

The "Quality Guidelines for Temporary Traffic Control Devices" handbook published by American Traffic Safety Services Association (ATSSA) is available at the traffic section of each region office. The handbook shows three levels of device quality: acceptable, marginal, and unacceptable. A traffic control device introduced to the work site must be in acceptable condition. It may degrade to marginal quality during the project, but once an item has been determined to be unacceptable it must be replaced with an acceptable device.

Temporary traffic control devices must be monitored and maintained throughout the course of construction, including utility and maintenance operations. The contractor is required to provide a level of inspection necessary to ensure ongoing compliance with the quality guidelines.

Where the traffic is maintained on a construction project, advance warning is required sufficiently in advance of construction operations to alert drivers in time for them to become aware of conditions ahead before entering the work area. The number of signs and their proper positions relative to the work area will be largely influenced by the type, volume, and rate of speed of the prevailing traffic. Projects carrying large volumes of traffic at relatively high speed will require more and larger signs at greater spacing than is required for those having comparatively light and slow traffic. Refer to Part VI of MUTCD produced by FHWA.

1.45.9.4 Responsibility for Shielding Drop-offs and Other Hazards

If a change from the original contract staging and traffic control plans becomes necessary, the contractor is responsible to provide safety measures for the traveling public. Drop-offs and other hazards may need to be shielded using longitudinal temporary traffic barriers. The duration of the hazard and depth of the drop-off both factor into the justification for using longitudinal temporary traffic barriers.

According to 23 CFR 630.1108, the use of longitudinal temporary traffic barriers must be based on an engineering study. Also refer to MUTCD Section 6F. The temporary barrier must be designed following the guidelines in FDM 11-50-35. The department will not pay for the cost of the installation unless it is responsible for the change that caused the additional work. Refer to Temporary Concrete Barrier in this section for more details.

2.10 Minnesota Department of Transportation (MnDOT)

The Minnesota Department of Transportation (MnDOT) uses the 2005 *Standard Specifications for Construction* [20] to provide guidance on road and bridge construction as well as to address traffic control. Further, the *Minnesota Manual on Uniform Traffic Control Devices* (MnMUTCD), a state-maintained version of the MUTCD, provides additional guidance for work zone traffic control implementation and devices. The relevant MnDOT guidance is provided below for convenience.

1710 TRAFFIC CONTROL DEVICES
1710.1 GENERAL

All traffic control devices and methods shall conform to the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), Minnesota Standard Signs Manuals Parts I and II and the appropriate Material Specifications, and the following:

(a) Specification 3352.2A2a - Standard No. 1 Reflective Sheeting - White reflective sheeting, when used in conjunction with orange reflective sheeting (normally a barricade board application), shall meet all but the durability requirement.

(b) All signs, paddles, and other traffic control devices, including those used for daytime operations, shall be reflectorized.

1715 OPENING SECTIONS OF THE PROJECT TO TRAFFIC

Opening of sections of the roadbed to traffic prior to completion of the entire Contract may be required by the Special Provisions or may be ordered by the Engineer in the event of unforeseen necessity or desire. Opening of a section of the roadbed to traffic shall not constitute acceptance of the uncompleted portions of the Project, nor shall it act to waive any provisions of the Contract.

On all sections of the roadbed that are opened to traffic prior to completion, the Contractor will not be required to assume any expense entailed in maintaining the roadbed for traffic, but shall not be relieved of responsibility for the repair of damages to the work that are not attributable to traffic. In the absence of Contract prices covering roadbed maintenance, the Department may require its performance as Extra Work or may perform it with its own forces.

When a section of the roadbed is opened to traffic by order of the Engineer for unforeseen reasons not the fault of the Contractor, the Department will reimburse the Contractor for additional expenses incurred in completing the remaining work under traffic, and may extend the time for completion if justified, in which case an Agreement

shall be executed in advance, setting forth the conditions agreed upon. On those sections of the Project that are opened to traffic prior to completion, as a requirement of the Contract, or that are opened by order of the Engineer as a result of failure or negligence on the part of the Contractor, the remaining construction operations shall be conducted so as to cause the least possible obstruction to traffic, and the Contractor shall not receive any additional compensation or extension of time due to increased costs or changed working conditions occasioned by opening of the road to traffic prior to its completion.

Nothing herein shall relieve the Contractor of obligations for maintenance of traffic over roads undergoing improvements, as provided for in 1404, nor shall anything apply to temporary use of the road by traffic during periods of winter suspension [20].

2.11 New York State Department of Transportation (NYSDOT)

The New York State Department of Transportation uses the *Highway Design Manual* [21] and the *Standard Specifications* [22] to provide guidance regarding roadside design, guardrail construction and repair, work zone traffic control, speed control, as well as for the opening of roads to vehicle traffic near barrier construction. Within the *Highway Design Manual*, revision 57 of *Chapter 10 – Roadside Design, Guiderail, and Appurtenances* was published in June 28, 2010. Sections 100 and 600 of the *Standard Specifications* cover general provisions and incidental construction, respectively.

Further, the *New York State supplement to the Manual on Uniform Traffic Control Devices* (NYS MUTCD) along with the national MUTCD provide additional guidance for work zone traffic control implementation and devices. The relevant NYSDOT guidance is provided below for convenience.

10 – ROADSIDE DESIGN, GUIDERAIL, AND APPURTENANCES (HDM)
10.5 SPECIAL TOPICS

10.5.7 Resetting Guide Rail

Frequently, maintenance or construction work requires that existing guide rail be taken down. On any projects that require the temporary removal of guide rail, the designer and EIC should try to minimize the amount of time that roadside hazards are unshielded. The plans should note that,

> "Portions of runs should not be removed until it is necessary to remove them. Any portions of a run should be restored to service as soon as it is practical to do so. Leading ends of guide railing should not be left exposed to traffic without any shielding."

Where the risks will be more frequent or significant, the guidance in Section 10.5.7.4 should be followed.

Often, the guide rail is suitable for resetting. This section provides the guidance to be followed for resetting, salvaging, or rejecting existing guide rail. The term "guide rail" is here meant to cover posts, cable, rail elements, anchor assemblies, and splices for both median barriers and guide railing.

As noted previously in Section 10.3.1.2 B, the adequacy of a guide rail's type, placement (including point of need), anchorage, etc. must be carefully reviewed before specifying its resetting to existing conditions.

SECTION 100 GENERAL PROVISIONS (SS)
105 CONTROL OF WORK

105-20 Opening Highway To Traffic Prior To Acceptance

When directed, in writing by the Regional Director, the Contractor shall open to traffic any portion of new pavement and/or structures before final acceptance of the contract. Traffic on these portions of highway so opened to travel by the Regional Director, shall be maintained and protected in accordance with all the provisions of the Maintenance and Protection of Traffic items in the contract.

Should the Contractor be dilatory in completing certain features of the work on the portion of the highway directed to be opened, the Regional Director may order all or a portion of the said highway open to traffic; and in this event the Contractor shall not be relieved of its liability and responsibility during the period the work is so opened prior to final acceptance.

These provisions apply not only to the reconstruction of existing highways, but also to work on new locations where traffic is not maintained during construction.

SECTION 600 INCIDENTAL CONSTRUCTION (SS)

606 GUIDE RAILING
606-3.01 General

All barrier systems and transitions described by these specifications shall be subject to the following requirements.

F. End Terminals and Assemblies - The following shall apply to end terminals or assemblies to be installed under this section.

> **1. Drawings -** For end terminals and end assemblies not shown on standard sheets or detailed in the plans, the Contractor shall submit two copies of the manufacturer's drawings, modified as necessary to reflect site conditions, to the Engineer for approval prior to ordering any materials required under this section. Drawings of parts not detailed on the plans, but which are necessary to develop the full performance of the end assemblies or terminals shall also be provided. The Contractor shall commence work of installation of end assemblies or terminals only after approval of the above mentioned drawings and authorization from the Engineer to do so.
>
> **2. Manuals -** In addition to the drawings mentioned above, the Contractor shall deliver to the Engineer two (2) copies of design manuals, installation manuals,

parts lists, and maintenance manuals prepared for each type end terminal or assembly being installed but not shown on the standard sheet.

3. Coordination with Other Work - The work of furnishing and installing all types of end assemblies shall be coordinated with the removal of existing impact attenuators or end assemblies, the installation of guide railing or median barrier, or the installation of the object to be shielded, so as to minimize the time that motorists are exposed to the possibility of collision with the shielded object, unprotected ends of barriers, or incomplete end terminals or assemblies. Also, the contractor shall minimize exposure of approaching vehicular traffic to the possibility of impact on the back of the end assembly. Unless modified in the Contract Documents, minimization shall mean seven (7) or fewer calendar days.

4. Traffic Protection - Traffic protection devices, such as cones, drums, lights, signs, barricades, or other articles directed by the Engineer, shall be provided and maintained under their respective pay items. These devices shall not be removed until the end assembly, including required transition pieces, is fully operational. If the end assembly is to be installed in lighted areas, or in areas to be lighted, the mentioned traffic protection articles shall also be maintained until the lighting system is operational.

606-3.03 Box Beam Guide Railing and Median Barrier

Rail sections for tangent runs shall be at least 18 feet long. Rail splices shall be a minimum of 18 inches from the centerline of any post.

During non-working hours, exposed approach ends (free ends) of the box beam guide railing or median barrier shall be temporarily terminated with box beam guide railing end assemblies utilizing two splice plates and eight bolts per temporary termination connection. No posts for anchorages will be required. Special temporary splice plates will be needed to adapt box beam guide railing end assemblies to box beam median barrier.

606-3.04 Corrugated Beam Guide Railing and Median Barrier, and Heavy Post Blocked-Out Corrugated Beam Guide Railing and Median Barrier

In the erection procedures, the free end of the rail element shall not be allowed to swing free and cantilever around the mounting bolt. The free end shall be supported in a manner approved by the Engineer while the splice bolts and mounting bolts are fastened.

During non-working hours, exposed approach ends (free ends) of the guide railing or median barrier shall be dropped to the ground and pinned in a manner approved by the Engineer.

A. Corrugated Beam Guide Railing and Median Barrier - The rail elements shall be installed so the weight of the beam rests on the double nutted support bolt before the 5/16 inch mounting bolts are torqued. Before the final torquing, six of the 5/16 inch mounting bolts in the installation shall be selected at

random and with a suitable torque wrench tightened to failure. The six readings shall be averaged, the six failed bolts replaced and all the mounting bolts in the installation torqued to 50% of the average value.

Support bolts shall be installed on all the guide rail posts except the three posts adjacent to the anchors.

B. Heavy Post Blocked-Out Corrugated Beam Guide Railing and Median Barrier - The heavy post blocked-out corrugated beam guide railing shall be erected from the approach end anchorage unit and downstream along the flow of traffic.

The heavy post blocked-out median barrier shall be erected from one of the anchorage sections and shall be completed as the work progresses. During non-working hours no uncompleted anchorage units or heavy posts without rail will be permitted on either heavy post blocked-out guide railing or median barrier.

606-3.06 Resetting Guide Railing, Median Barrier and Precast Concrete Barrier

The Contractor shall remove, store, clean and reset railing, posts, and precast concrete barrier as shown on the plans or as directed by the Engineer. The reset guide railing and/or median barrier shall be placed in accordance with the requirements of §606-3.01 General. Reset concrete barrier shall be placed in accordance with the requirements of §606-3.05 Concrete Barrier.

During non-working hours, exposed approach ends (free ends) of the reset guide railing and/or median barrier shall be temporarily terminated as follows: Box beam guide railing and/or median barrier shall be temporarily terminated with box beam guide railing end assemblies utilizing two (2) splice plates per temporary termination connection. No posts for anchorages shall be required. Special temporary splice plates will be needed to adopt box beam guide rail end assemblies to box beam median barriers. Corrugated guide railing and/or median barrier, and heavy post blocked-out corrugated guide railing and/or median barrier shall be temporarily terminated by dropping the exposed approach ends (free ends) of the rail element to the ground and pinning it in a manner approved by the engineer. Any rail element or component of the barrier damaged shall be replaced by the Contractor.

619 WORK ZONE TRAFFIC CONTROL
619-3 CONSTRUCTION DETAILS

619-3.01 General

The Contractor shall each designate a trained, responsible person who has the primary responsibility and sufficient authority for implementing the work zone traffic control plan and other safety and mobility aspects as necessary. The Contractor's responsible person shall be appropriately experienced and trained in accordance with the level of decisions

that the individual will be required to make, reflecting current industry practices and Department requirements.

The Contractor shall generally maintain a traveled way suitable for moving traffic, in accordance with the contract documents. Construction operations shall be conducted to ensure a minimum of delay to traffic. Stopping traffic for more than 5 minutes shall not be permitted unless specifically authorized in the contract documents or in writing by the Engineer. All operations shall be carried out in a manner that provides workers with safe access to the worksite and protects workers from moving traffic. Unless otherwise noted, temporary items supplied in accordance with this section shall remain the property of the Contractor.

When pedestrians are not prohibited from the street or highway, sidewalks, walkways, or other accommodations shall be provided to allow their safe passage as shown in the contract documents. When sidewalks, walkways, or shoulders must be temporarily closed to facilitate construction operations, accommodations for safe pedestrian passage shall be maintained on at least one side of the roadway at all times, unless other temporary pedestrian accommodations are provided in the contract documents or are approved by the Engineer.

The requirements in this section refer to posted speed limits. If prevailing or operating speeds for a highway exceed the preconstruction posted limits, the contract documents may direct the Contractor to assume that the preconstruction posted speed limits are different than posted.

619-3.02 Basic Work Zone Traffic Control

The Contractor shall control traffic so that a person who has no knowledge of conditions may safely and with a minimum of discomfort and inconvenience ride, drive, or walk, day or night, over all or any portion of the highway and/or structure under construction where traffic is to be maintained.

The Contractor shall cease operations and restore the traveled way to safe operating condition during any specific periods listed in the contract documents, at such times as traffic renders conditions unsafe to continue work, and during periods of darkness (before sunrise or after sunset), fog, snow or rain, high winds, or other inclement weather that renders conditions unsafe to continue work, for either the traveling public or the workers. The Engineer will determine when traffic or weather conditions render work operations unsafe.

E. Maintain Existing Guide Rail, Median Barrier, and Bridge Rail

When construction operations require the temporary removal of existing bridge rail, guide rail or median barrier; or when existing rail will be removed and replaced with new rail, the Contractor shall schedule operations to minimize the time period that rail is not installed. Unless otherwise specified in the contract

documents, guide rail or median barrier shall be replaced or the location otherwise protected within 14 calendar days.

Bridge rail shall be maintained in service at all times on any structure on which vehicle or pedestrian traffic is maintained, unless a temporary barrier is installed, or other means are used to ensure that vehicles, bicyclists and pedestrians are not exposed to the unprotected edge of a bridge.

During any overnight period when existing guide rail or median barrier is temporarily removed, the Contractor shall install and maintain channelizing devices along the edge of the shoulder or median in the location where the guide rail or median barrier was removed. The maximum spacing of the channelizing devices shall be 80 feet when shoulder widths are 4 feet or greater, and 40 feet for shoulder widths less than 4 feet, except that a minimum of three devices shall be provided for each individual run of guide rail or median barrier that has been removed. Channelizing devices consisting of drums, free-standing tubular markers, Type II construction barricades, or 36 inch traffic cones may be substituted for the post-mounted vertical panels, subject to approval by the Engineer.

During non-work hours when traffic is being maintained on the facility, all temporary ends (free ends) of guide rail, median barrier and bridge rail shall be temporarily terminated and marked with a channelizing drum or object marker equipped with a Type B flashing warning light. Corrugated beam guide rail and median barrier, and heavy-post, blocked-out, corrugated beam guide rail and median barrier shall be temporarily terminated by having the exposed ends (free ends) dropped to the ground and pinned. The approach ends of box beam guide rail, median barrier and bridge rail shall be temporarily terminated with box beam guide rail end assemblies utilizing two splice plates and the proper number of bolts per connection. No posts for anchorages will be required. Special temporary splice plates are required to adapt box beam guide rail end assemblies to box beam median barriers.

3 REFERENCES

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4 APPENDICES

Appendix A. Drawings and Plans

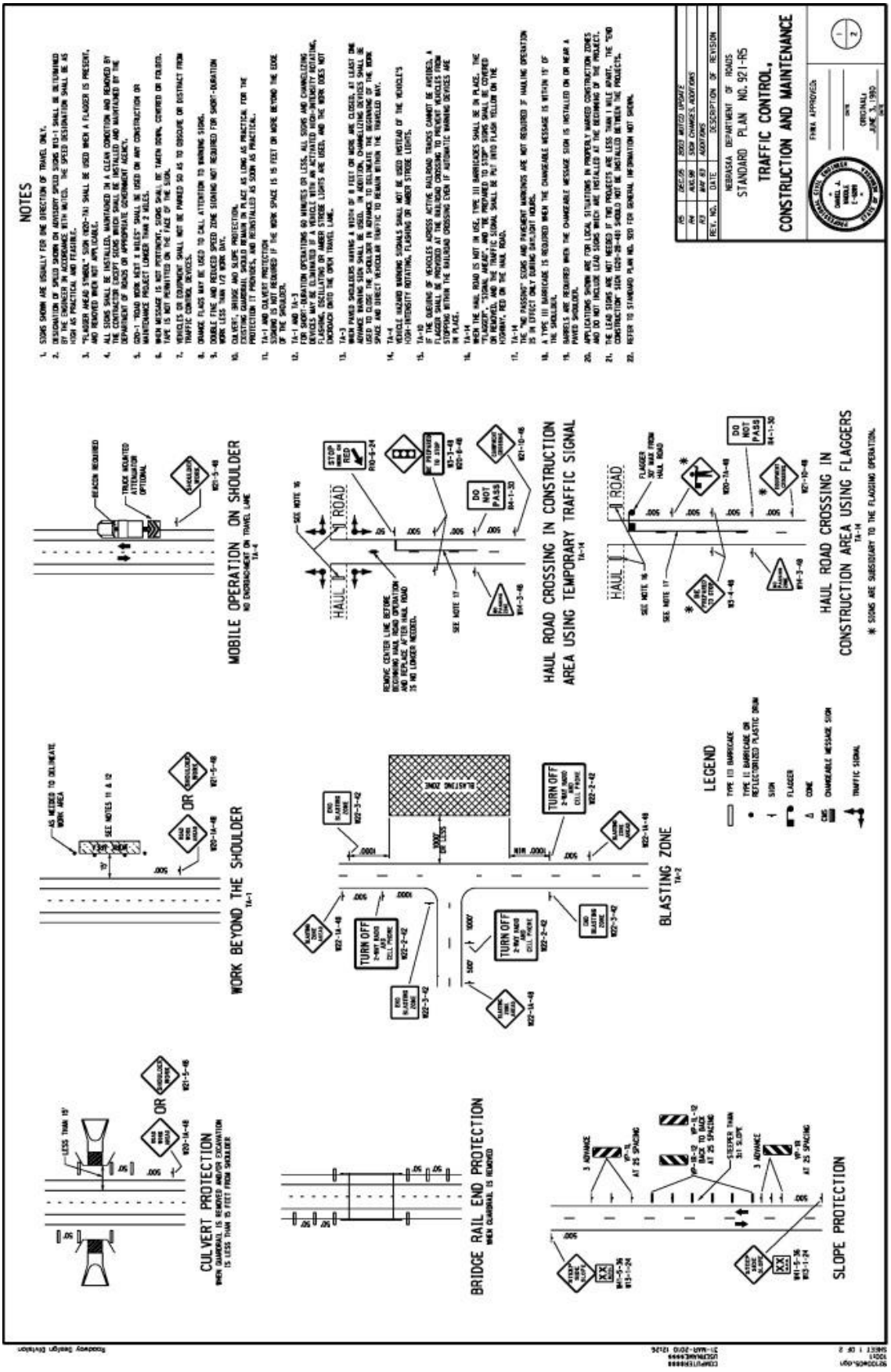

Figure A-1. Nebraska Bridge and Culvert Guardrail Removal Standard Plan

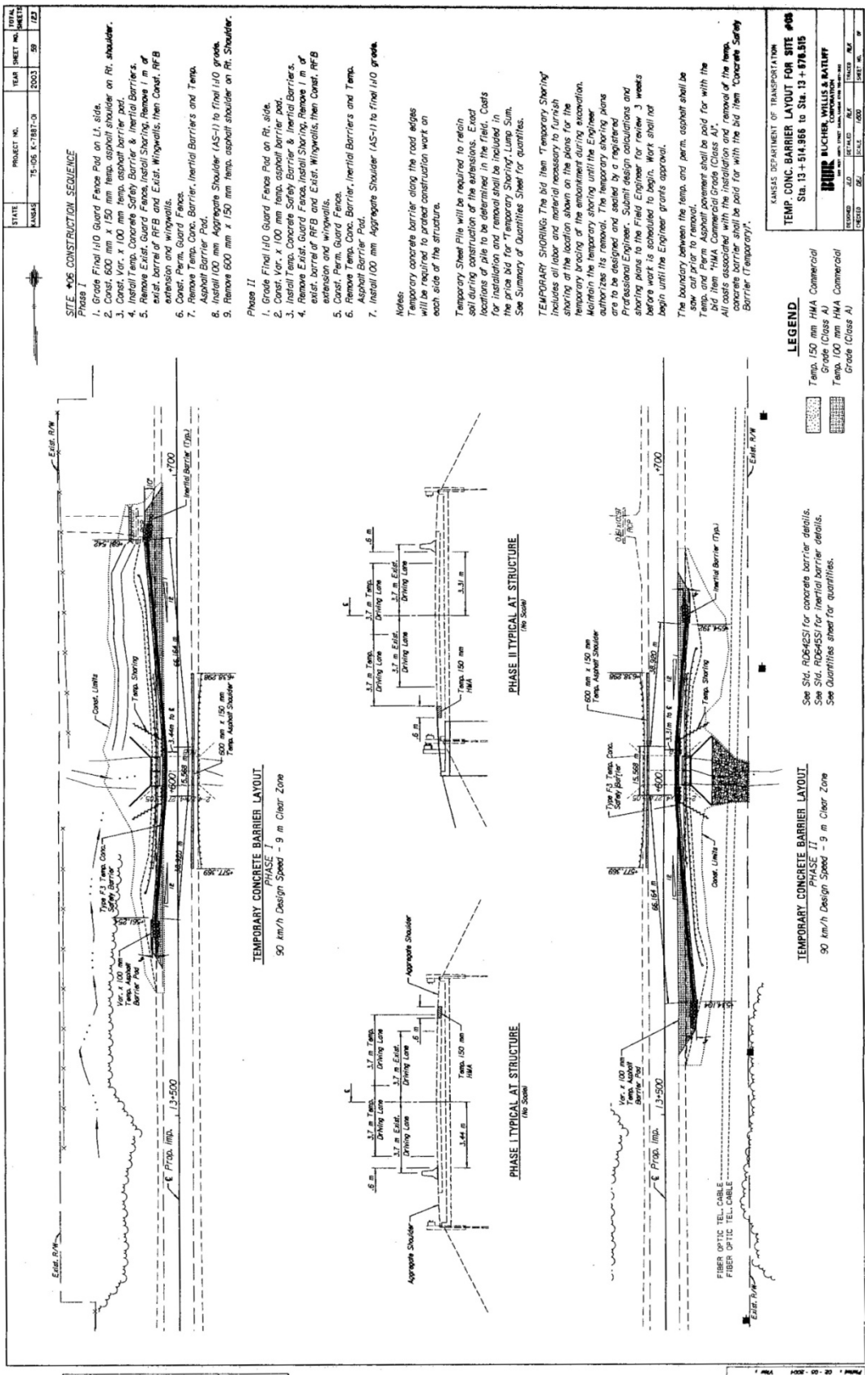

Figure A-2. Kansas Guardrail Construction Example Traffic Control Plan

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