TRANSPORTATION MANAGEMENT PLANS DESIGN MANUAL

NCDOT Work Zone Traffic Control Section

Purpose

This manual was developed to be a traffic control plan design resource for Transportation Management Plan designers. It will also foster uniformity and consistency in temporary traffic control plans statewide. Since motorists are dependent on the design and placement of traffic control devices, consistent and uniform plans are essential in keeping motorists traversing through work zones safely.

This manual is not intended to provide a fail-proof solution to all design problems or substitute for engineering knowledge, experience and judgment; nor is it intended to establish a legal requirement for installation of devices or design of plans.

Legal Responsibility

According to the Federal Highway Administration, all highway construction projects require a transportation management plan to be included. North Carolina has adopted the Manual on Uniform Traffic Control Devices (MUTCD) to provide basic principles and guidelines for the design, application, installation and maintenance of traffic control devices. North Carolina uses the MUTCD as a minimum requirement and in most cases requires the NCDOT Standard Specifications for Roads and Structures and the NCDOT Roadway Standard Drawings as the plan standard. This Manual is not intended to replace the MUTCD, but rather, to customize its principles to meet the specific requirements and conditions of the State of North Carolina.

Revisions

To expedite updates, this manual is available on-line. The on-line version is to be considered as the official document. As an on-line document, it will not be published and distributed as a traditional publication and there is no user list for update notifications. It is the user's responsibility to verify they are using the most current version of the manual as their reference. Update information will be detailed and listed on the NCDOT Work Zone Traffic Control Section's webpage as they occur.

References

Design information that can be found in textbooks, Federal and State publications, and other sources of transportation related information has not been repeated unless it is frequently utilized by design personnel. References to sources will be made throughout this manual so the presented material can be traced, documented, and revised as necessary.

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Chapter 1: Drainage (Temporary & Permanent)

1.1 Introduction

The purpose of this chapter is to set guidelines for the Work Zone Traffic Control Section concerning drainage and how it affects the phasing in Traffic Control Plans.

Drainage is used to keep roadways and roadsides clear from ponding/standing water, to allow safe passage of all vehicles, and to extend the life of the pavement. Both temporary and permanent drainage are factors in developing a Temporary Traffic Control Plan. All drainage issues need to be addressed by Roadway Design Unit, Structure Design Unit, Hydraulics Unit and/or Work Zone Traffic Control Section with the Division Construction Engineer during the Final Design / Combined field inspections. If temporary drainage is required, the hydraulics engineer is to be notified by the FDFI.

1.2 Definitions & Abbreviations

Drainage – A natural or artificial means of intercepting and removing surface or subsurface water (usually by gravity) from the roadways and roadsides.

Ponding/Standing – A term used when water collects in an area and resembles a pond.

Detention – The temporary storage of excess storm water.

Retention – The permanent storage of excess storm water.

Phased – A drainage written sequence of how to install the proposed and/or temporary drainage (found in Traffic Control Plans).

Open-cut – A pipe installation/removal process that excavates the existing ground and/or pavement for the placement/removal of a crosspipe.

Trenchless construction – A pipe installation process that allows the crosspipe to be placed without excavation. Examples are the auger boring (same as bore and jacking), microtunneling, Tunnel Boring Method (TBM) and pipe ramming.

Plug and fill – In reference to a pipe, plug the ends of a pipe with bricks or cement and fill the pipe with flowable material. Process performed to allow existing pipe to remain in place.

Retrofitting – In reference to a pipe, place a smaller diameter pipe inside of a larger existing pipe and fill any voids with flowable material. Rarely done.

Cap/Cover – A load bearing cover which temporarily closes the top of a drainage structures until the appropriate time.

Traffic Bearing Inlet/Grate/Junction Box – Drainage structures that allow water to flow through to remove water from the roadways and roadsides.

RCP – Reinforced Concrete Pipe

CSP – Corrugated Steel Pipe

TBGI – Traffic Bearing Grated Inlet

TBJB – Traffic Bearing Junction Box

TDE – Temporary Drainage Easement

DI – Drainage Inlet

RCBC – Reinforced Concrete Box Culvert

CB – Catch Basin

HW – Headwall

1.3 Design Criteria

Areas in the work zone where the ponding/standing of storm water could pose a threat to the traveling public:

- Median crossovers
- Low lying areas or sags
- Portable concrete barriers on both edge lines (creating a cattle chute effect where water can pond)
- Super elevations (Low Side)

Operations where temporary or permanent drainage will have to be written out in the Phasing of the Traffic Control Plan:

- Open cut installation
- Staged box culvert construction where water flow must be maintained during construction.
- Good Technique is to identify all sag vertical curves located in profile view in order to know where storm water will collect. Also identify all elevated/grade change areas found by reviewing the x-sections for possible temporary drainage needs.

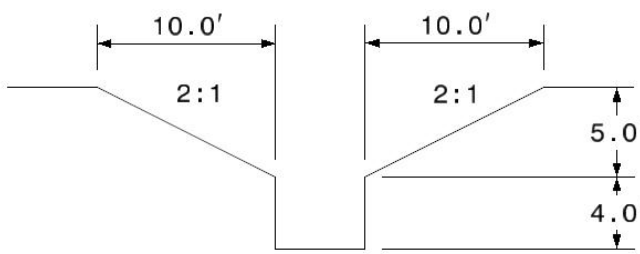
1.4 Other Considerations

REMOVAL OF DRAINAGE:

- To minimize cost, pipes can be plugged and filled, rather than removed. The Hydraulics Unit makes the initial recommendation of removal or plug and fill. However, the decision may be revised after receiving recommendations from the Division Construction Engineer, the Work Zone Traffic Control Section and the Roadway Design Unit. For example, if a pipe is covered by a paved road and a high fill (5 feet+), it may be cost effective to plug and fill than to remove. Also, if the traffic count is high, the plug and fill method is less disruptive to traffic. Not all issues are this straightforward and ultimately the Division Construction Engineer makes the final decision.

CONSTRUCTION METHODS/OPTIONS TO BE DISCUSSED AT FIELD INSPECTIONS FOR DRAINAGE PIPE INSTALLATION:

- Off-site detour.
- On-site detour.
- Trench boxes, temporary shoring or laybacks (any open cuts require a 2:1 lay back above the 4' height). Example: A layback for a 9' deep excavation will make width of the open cut more than 20' wide at the top.
- Trenchless construction



RESOURCES:

- Hydraulics Unit
- NCDOH Guidelines for Drainage Studies and Hydraulic Design Division Construction Engineer
- Work Zone Traffic Control Project and Project Design Engineers (Supervisors)
- AASHTO Roadside Design Guide

1.5 Guidelines

Temporary drainage can be encountered in work zones that have to be modified to accommodate changing traffic patterns. Temporary drainage problems normally occur with grade changes, widening of existing roadways, altering super elevations, flow diversion and/or stage construction. Temporary drainage is normally recommended and designed by the

Hydraulics Unit, however, the Work Zone Traffic Control Section may request additional temporary drainage due to phasing sequence.

Permanent drainage, both existing and proposed, is shown on the Roadway Plans and is designed by the Hydraulics Design and Structure Units. Coordination, either during the field inspections and/or constructability meetings, with these units is required to ensure that the construction of this drainage is adequately addressed in the Traffic Control Plans.

Chapter 2: Drop-Offs

2.1 Introduction

The intent of this chapter is to provide general guidelines for mitigating longitudinal pavement edge or terrain drop-off conditions created by construction operations in highway work zones. All measures employed to mitigate drop-offs within construction, maintenance and utility work zones shall be utilized in conformance with the current editions of the Manual on Uniform Traffic Control Devices (MUTCD), North Carolina Supplement to the MUTCD for Streets and Highways, North Carolina Standard Specifications for Roads and Structures, NC Roadway Standard Drawings and the North Carolina Maintenance/Utility Traffic Control Guidelines. (MUTCG)

2.2 Definitions & Abbreviations

Drop-off – The difference in elevation between existing pavement or terrain and the lowest elevation created by construction operations.

Edge of Pavement (EOP) – The longitudinal joint where the roadway joins the shoulder, or curb and gutter line.

Edge of Shoulder (EOS) – The longitudinal edge of the shoulder away from the roadway at which a shoulder break occurs transitioning to the side slope.

Edge of Travelway (EOT) – The longitudinal edge of the travelway used by traffic, normally defined by pavement marking edgeline or channelizing devices.

Intermediate-term Stationary – Work that occupies a location more than one daylight period up to three (3) days, or nighttime work more than one (1) hour.

Long-term Stationary – Work that occupies a location more than three (3) days.

Roadway – A roadway shall be defined as contained in the Uniform Vehicle Code, "That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the berm or shoulder". Furthermore, as pertains to the work zone environment, a roadway may or may not be utilized by traffic in a particular phase of construction. Therefore, for communication purposes, the roadway is the actual pavement regardless of whether or not it is being utilized by traffic.

Short Duration – Work that occupies a location up to one (1) hour.

Short-term Stationary – Daytime work that occupies a location for more than one (1) hour within a single daylight period.

Traffic Barrier- A guardrail that keeps vehicles within their roadway and to prevent collisions with obstacles or cars in another lane. A traffic barrier is also used in order to prevent cars from entering steep slopes or deep water.

Travelway – A travelway shall be defined as the portion of the highway utilized by traffic, that is designed and intended for vehicular use. In a work zone environment this may include locations such as the roadway, shoulders, temporary pavements, detour routes, or other locations where traffic may be placed during the progress of construction. If a lane has been closed to traffic, the closed lane will not be considered a travelway since it no longer is intended to be used by traffic.

Travel Lane – A travel lane is one part of the travelway, which may be divided into one or more lanes designating the direction and separation of traffic flow.

2.3 Design Resources

"Traffic Control Strategies in Work Zones with Edge Drop-Offs", CTRE Project 97-15. Study performed by Iowa State University Department of Civil and Construction Engineering for the Iowa Department of Transportation.

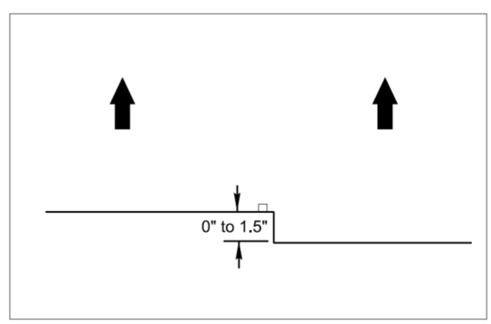
2.4 Guidelines

LONGITUDINAL DROP-OFFS

Pavement Edge Drop-offs Within or adjacent to the Travelway

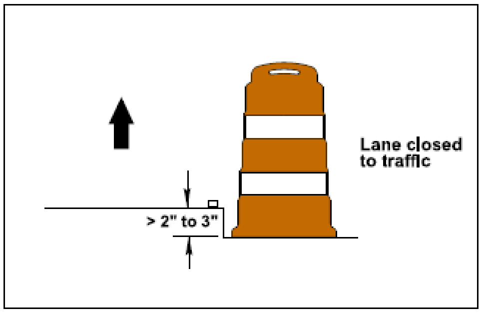
Drop-offs located within a travelway where traffic is expected to traverse during a lane change maneuver, or a passing situation. This includes all multilane and two-lane, two-way travelways regardless of existing passing or no-passing zones.

A) Drop-offs less than or equal to 1.5 inches:
For drop-offs less than or equal to 1.5 inches no protection or channelizing devices are required. However, advance warning “UNEVEN LANES” signs (W8-11) shall be installed 500 feet in advance and installed once every half mile where the posted speed is less than 45 mph and installed once every mile where the posted speed is greater than or equal to 45 mph throughout the length of the drop-off area.



B) Drop-offs greater than 2 inches but less than or equal to 3 inches:

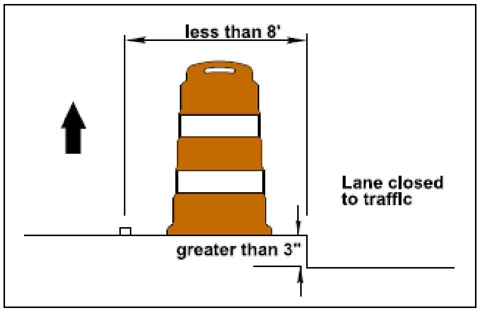
Where a drop-off in a travelway exceeds 2 inches but is less than or equal to 3 inches the affected lane(s) shall be closed to traffic. Advance warning "UNEVEN LANES" signs (W8-11) shall be installed 500 feet in advance and installed once every half mile where the posted speed is less than 45 mph and installed once every mile where the posted speed is greater than or equal to 45 mph throughout the length of the drop-off area.



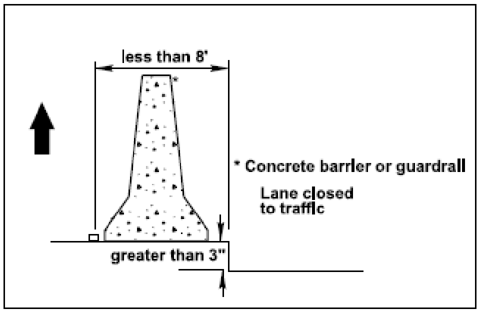
C) Drop-offs greater than 3 inches:

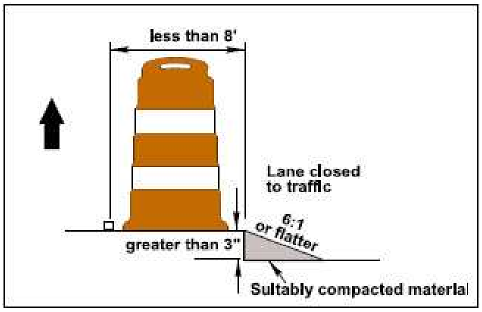
Where a drop-off in a travelway is greater than 3 inches the affected lane(s) shall be closed to traffic and the drop-off protected with traffic barrier, sloped wedge, drums, or cones as follows:

- Drop-offs greater than 3 inches and within 8 feet of an open travel lane may be protected with drums or cones provided work operations are Short Duration or Short-term Stationary, are of short lengths (200 feet maximum), the work is being performed in the drop-off area, and the drop-off will not remain overnight.

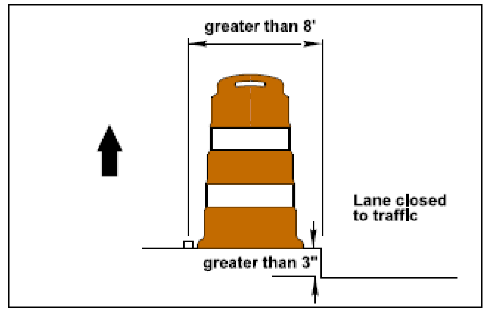


- Drop-offs greater than 3 inches and within 8 feet of an open travel lane in work zones where operations are LONG-TERM STATIONARY or INTERMEDIATE-TERM STATIONARY must be protected by traffic barrier (concrete barrier or guardrail) or a 6:1 or flatter sloped wedge of suitable material compacted in a manner that will provide stability for errant vehicles while maintaining the lane closed.





- If there is a lateral clearance greater than 8 feet between the edge of an open travel lane and 3 inch or greater drop-off is located behind a closed lane and within the roadway, drums may be used as separation.

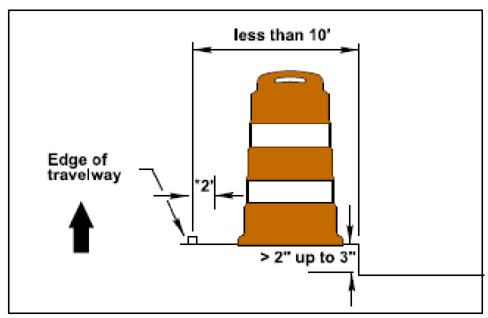


Drop-offs within 10 Feet of the Travelway

Drop-offs not located in, but within 10 feet of a travelway where traffic is not expected to cross in a lane change maneuver except accidentally or for shoulder use.

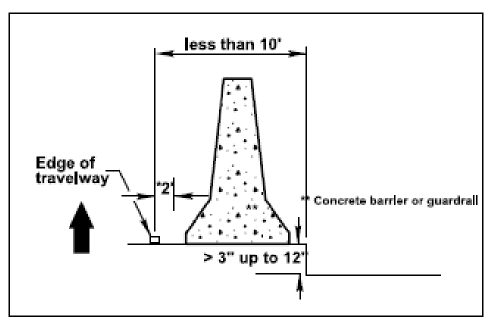
A) Drop-offs less than 2 inches:
Where a drop-off of 2 inches or less exists within 10 feet of a travelway, no protection or channelizing devices are required. However, advance warning "LOW SHOULDER" signs (W8-9) shall be installed 500 feet in advance and once every mile throughout the length of the drop-off area.

B) Drop-offs greater than 2 inches but less than or equal to 3 inches:
Where a drop-off within 10 feet of a travelway is greater than 2 inches but is less than or equal to 3 inches the drop-off shall be protected with drums or cones. Advance warning "LOW SHOULDER" signs (W8-9) shall be installed 500 feet in advance and once every half mile throughout the length of the drop-off area.

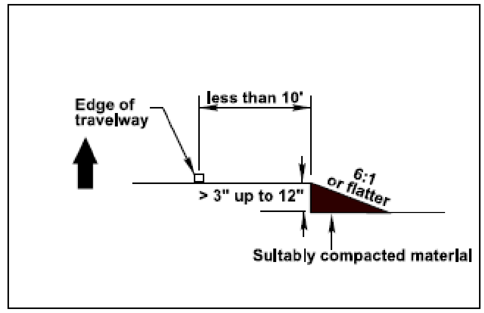


C) Drop-offs greater than 3 inches but less than or equal to 12 inches:
Where a drop-off greater than 3 inches exists within 10 feet of a travelway the drop-off shall be protected with one of the following treatments:

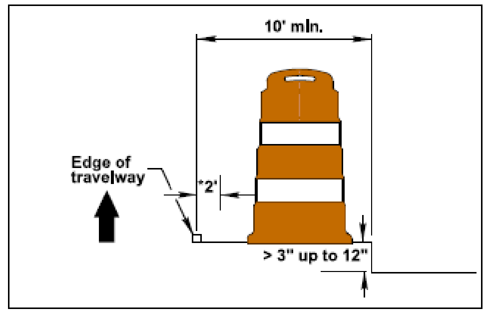
1. Drop-off protected by traffic barrier (concrete barrier or guardrail)



2. Drop-off protected with a 6:1 or flatter wedge slope of suitable material compacted in a manner that will provide stability for errant vehicles and drums or cones installed for separation.



3. Provide a lateral distance of 10 feet from the drop-off to the open travel lane by shifting traffic and installing drums or cones for separation.

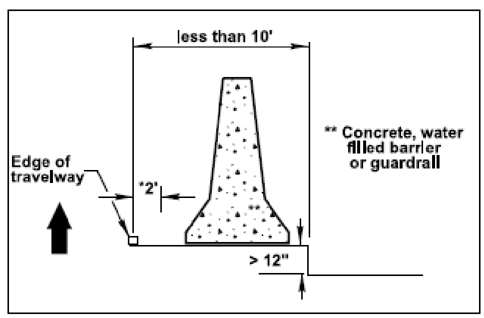


Advance warning “SHOULDER DROP-OFF” signs (W8-9a) shall be installed 500 feet in advance and once every one mile throughout the length of the drop-off area.

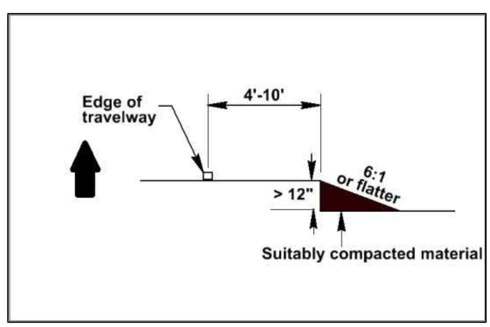
D) Drop-offs greater than 12” (posted speed limits less than 45 mph):

Where a drop-off greater than 12 inches exists within 10 feet of a travelway the drop-off shall be protected with one of the following treatments:

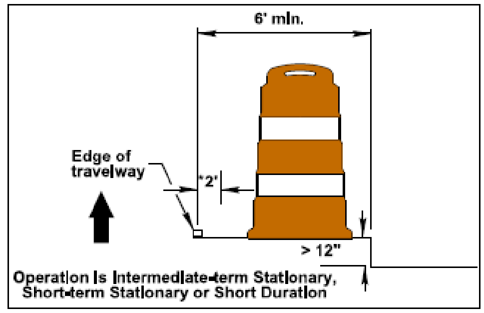
1. Drop-off protected by traffic barrier (concrete or water filled barrier or guardrail)



2. Drop-off protected with a 6:1 or flatter wedge slope of suitable material compacted in a manner that will provide stability for errant vehicles



3. Provide a lateral distance of 6 feet from the drop-off to the open travel lane by shifting traffic; if the situation exists for 3 days or less, the drop-off shall be delineated with drums installed at ½ the normal spacing; if the drop-off will remain for more than 3 days, traffic barrier (concrete or water-filled barrier or guardrail) shall be used to separate the traffic from the drop-off. In situations where drums are used to delineate the drop-off, the traffic control shall be inspected no less than once every 8 hours.

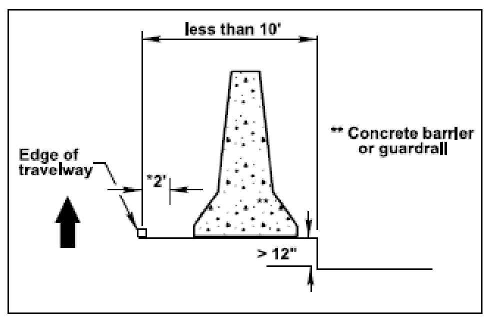


Advance warning "SHOULDER DROP-OFF" signs (W8-9a) shall be installed 500 feet in advance and once every half mile throughout the length of the drop-off area.

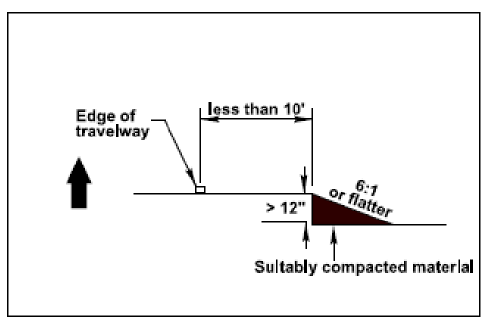
E) Drop-offs greater than 12" (posted speed limits of 45 mph or greater):

Where a drop-off greater than 12 inches exists within 10 feet of a travelway the drop-off shall be protected with one of the following treatments:

1. Drop-off protected by traffic barrier (concrete barrier or guardrail)



2. Drop-off protected with a 6:1 or flatter wedge slope of suitable material compacted in a manner that will provide stability for errant vehicles and drums or cones installed for separation.



Advance warning "SHOULDER DROP-OFF" signs (W8-9a) shall be installed 500 feet in advance and once every mile throughout the length of the drop-off area.

F) Localized excavations (construction inactivity):

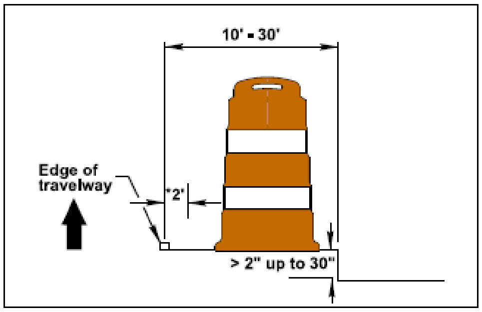
Localized excavations (for drop inlets, drainage boxes, bore & jack pits, etc.) existing within 10 feet of a travelway which exceed 36” during periods of construction inactivity shall be protected with one of the following treatments:

- Traffic barrier (concrete barrier or guardrail)

Drop-offs 10 to 30 Feet from the Travelway

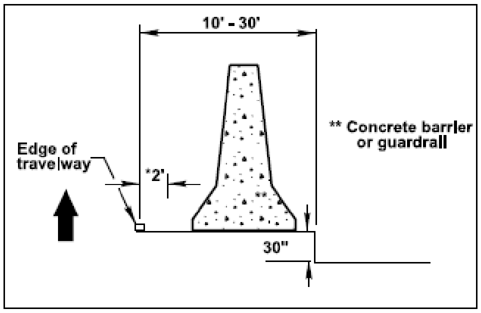
A) Drop-offs 2 inches or less:
Where a drop-off of 2 inches or less exists between 10 feet and 30 feet of a travelway, no protection or channelizing devices is required. However, advance warning “LOW SHOULDER” signs (W8-9) shall be installed 500 feet in advance and once every mile throughout the length of the drop-off area.

B) Drop-offs greater than 2 inches but less than or equal to 30 inches:
Where a drop-off exists between 10 feet and 30 feet of a travelway is greater than 2 inches but is less than or equal to 30 inches the drop-off shall be protected with drums or cones. Advance warning “LOW SHOULDER” signs (W8-9) shall be installed 500 feet in advance and once every half mile throughout the length of the drop-off area.



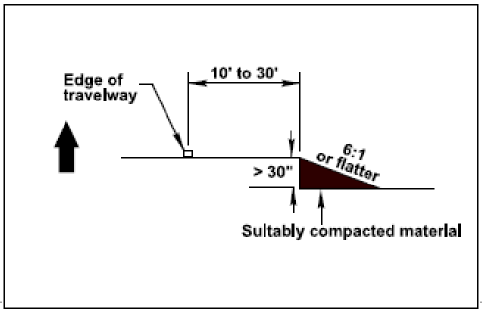
C) Drop-offs greater than 30 inches:

Where a drop-off greater than 30 inches exists between 10 feet and 30 feet of a travelway the drop-off shall be protected with one of the following treatments:



1. Drop-off protected by traffic barrier (concrete barrier or guardrail)

2. Drop-off protected with a 6:1 or flatter wedge slope of suitable material compacted in a manner that will provide stability for errant vehicles and drums or cones installed for separation.



TERRAIN HAZARDS

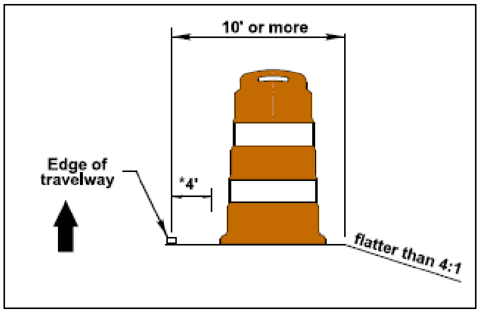
Hazards Located 10 Feet and Greater from the Travelway

Terrain hazards located 10 feet and greater from the travelway where traffic is not expected to cross, unless accidentally.

A) Embankment or fill slopes (recoverable):

Recoverable slopes (flatter than 4:1) existing 10 feet and greater from the travelway shall be protected with the following treatment:

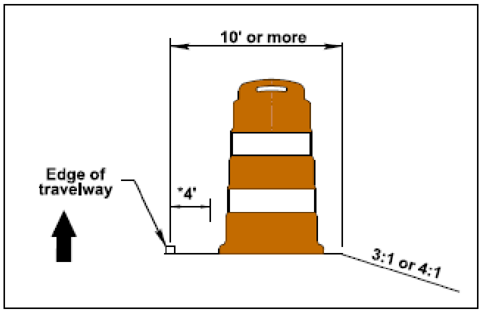
- Drums or cones



B) Embankment or fill slopes (non-recoverable):

Non-recoverable slopes (3:1 and 4:1) existing 10 feet and greater from the travelway shall be protected with the following treatment:

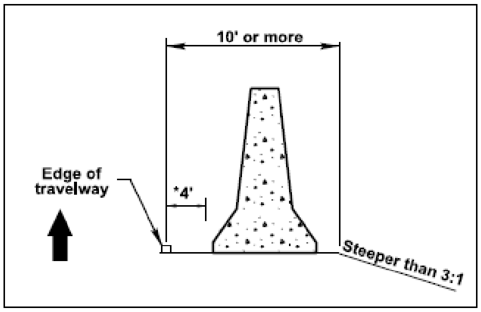
- Drums or cones



C) Critical Slopes:

Critical slopes (steeper than 3:1 existing 10 feet and greater from the travelway shall be protected with the following treatment:

- Traffic barrier (concrete barrier or guardrail)



D) Curbs:

- Guardrail adjacent to curb (guardrail face installed even with the curb face)
- Concrete barrier installed in front of curb face (on the gutter line)
- Concrete barrier placed a maximum of 9 inches behind curb face if work is being performed within the travelway or a minimum of 13 feet behind the curb face if work is being performed behind curb.

FIXED OBSTACLES

Fixed and Non-traversable Hazards 10 - 30 Feet from the Travelway

Fixed and non-traversable hazards existing 10 to 30 feet from the travelway where traffic is not expected to cross, unless accidentally. Fixed and non-traversable hazards existing less than 10 feet from the travelway require a lane closure.

A) Portable Changeable Message Signs and Arrow Panels Existing 10 – 30 Feet from the Travelway:

Portable changeable message signs and arrow panels existing between 10 and 30 feet from the travelway shall be protected with one of the following treatments:

- Drums or cones

B) Portable Highway Sensors Existing 10 - 30 Feet from the Travelway:

Portable highway sensors existing between 10 and 30 feet from the travelway shall be protected with the following treatment:

- Drums or cones

Chapter 3: Minimal Acceptable Lane Widths

3.1 Introduction

The lane width of a roadway is a determining factor in making the motorist feel secure and at ease. Some lane widths enhance the sight distance of roads where terrain and other objects limit the vision of the motorist. Lane widths of 9’ to 12’ are common in North Carolina on roads and 12’ lanes are almost always used on multi-lane, divided facilities.

In the Work Zone, the motorist should feel the lanes are generally consistent from before the beginning point of construction to beyond the end. Tapers, shifts and lane narrowing are sometimes needed during construction, but are often minimized for the comfort of the motorist.

The purpose of this chapter is to give the designer a feel for the guidelines set forth by the Work Zone Traffic Control Section concerning lane widths in the Work Zone and how to best utilize the resources used in designing Traffic Control plans.

3.2 Definitions & Abbreviations

The primary definitions/abbreviations needed for this chapter will be the following:

2L2W – Two lane two way road, one lane going in each of two directions

Expressway – A divided highway with partial control of access

Four-lane, divided highway – Any highway or expressway that has two lanes going in each of two directions separated by a median

Freeway – A divided highway with full control of access

Multi-lane, undivided – Any roadway that has more than one lane going in each of two directions

Rural facility – Roads that accommodate moderate to low volumes of traffic that connect all, or mostly all, incorporated areas with populations of 50,000 or less

Suburban facility – Roads that accommodate moderate to high volumes of traffic around, but not necessarily connecting, incorporated areas with populations of 50,000 or more

Traveled way – The portion of the roadway for the movement of vehicles, exclusive of shoulders

Urban facility – Roads that accommodate high volumes of traffic in, and around, incorporated areas with populations of 50,000 or more

Work Zone – Any continuous tract or area of a roadway in which construction or maintenance is being performed

3.3 Guidelines

For capacity purposes, and when feasible, lane widths in the Work Zone should match the existing roadway in order to provide the highest level of comfort for the motorist. However, on some projects, the lane widths may have to be reduced to less than the existing roadway for constructability purposes or for right of way restraints. In these cases, concurrence between the Division Construction, Regional Traffic Engineer, Division Traffic Engineer and the Traffic Control Unit will be needed. This matter needs to be discussed at the Field Inspection, or before. For minimum lane widths, the decision made should be based on posted speed limit and traffic volumes. This guideline is not designed to override any decisions made in the field.

Freeways and Expressways

For freeways, expressways and other divided highways, maintain a minimum of 11 foot lanes with a 2 foot shoulder or 2 foot offset to positive protection.

Undivided Highways

While 11 foot lanes with a 2 foot shoulder is desirable, for a reduced width lane on undivided highways, maintain a minimum of 10 foot lanes with a 1 foot shoulder or 1 foot offset to positive protection. If the existing lane width is less than 10 feet, then maintain the existing lane width as a minimum.

One Lane, Two Way Patterns

While a 16 foot lane with 2 foot shoulders is desirable, maintain a minimum of a 14 foot lane with 1 foot shoulders on one lane, two way patterns.

3.4 Design Resources

Design resources other than this book include:

AASHTO A Policy on Geometric Design of Highways and Streets
Manual on Uniform Traffic Control Devices, Part 6

Chapter 4: Temporary Pavement

4.1 Definitions & Abbreviations

Temporary Pavement – Additional pavement that is needed for maintenance of traffic during a particular phase of construction and may or may not be removed later in the construction sequence.

Temporary Alignment – A horizontal and/or vertical alignment that differs from both the existing and proposed alignments. It is requested by Work Zone Traffic Control Section for the maintenance of traffic and designed by Roadway Design.

4.2 Policies

The Work Zone Traffic Control Section is responsible for identifying the need of temporary pavement or temporary alignment based on maintenance of traffic needs. In addition, the Work Zone Traffic Control Section is responsible for contacting and coordinating with the Roadway Design Unit about any temporary pavement needs. The following is information that WZTCS need to provide to the Roadway Design Unit:

- Locations of the temporary pavement such as station limits
- Width of temporary pavement
- Duration
- ADT and percent of truck traffic

The Roadway Design Unit is responsible for calculating the temporary pavement quantities and will contact the following:

- Pavement Management Unit: To determine a pavement design for the temporary pavement.
- Division Construction Engineer: To ensure there are no unforeseen problems with the temporary pavement.
- Hydraulics Unit: To design temporary drainage that may be needed due to the addition of temporary pavement and/or temporary alignment.
- Right-of-Way Branch: To include additional right-of-way or easements that may need to be acquired if the temporary pavement is located outside the proposed right-of-way. If additional ROW or easements cannot be acquired, other measures or options to maintain traffic may need to be considered.
- Utilities Section: To address Utilities conflicts that may arise, especially if the temporary pavement is located outside the footprint of both the existing and proposed roadways.

4.3 Design Issues/Criteria

Temporary pavement is often an option for maintaining traffic on projects where the width of the proposed or existing roadway in a particular phase is insufficient to maintain the desired traffic pattern. There are other options that may be considered in lieu of temporary pavement such *as shoring, flaggers, detours, etc.*

Temporary pavement is also an option on Interstate Projects where traffic is shifted to the existing shoulder. If the existing shoulder's pavement structure is not adequate to carry the required traffic load and/or rumble strips exist, it will be necessary to remove or mill the existing shoulder pavement structure and replace it with a new pavement structure. The Pavement Design Unit will make that determination.

Temporary pavement can either be a lateral extension of the existing or proposed pavement or may follow a completely different alignment with different vertical and horizontal profiles from the existing or proposed alignments. Temporary alignments will be required when the temporary pavement can not to be constructed up to the edge and elevation of the existing or proposed pavement, or does not follow the existing pavement profile. The Roadway Design Unit will design temporary alignments and details of the design will be part of the Roadway plans. The addition of temporary pavement may require installation of temporary guardrail, temporary shoring, and/or temporary drainage.

The Designer should make every effort to identify a need for temporary pavement and/or temporary alignments and contact the Roadway Design Unit as early as possible.

Chapter 5: Positive Protection (Temporary Barriers)

5.1 Introduction

The primary purpose of a temporary barrier is to prevent a vehicle from striking an obstacle or terrain feature that is considered more hazardous than the barrier itself in the work zone. Typical applications include: preventing traffic from entering work areas, providing positive protection for workers, separating two-way traffic, protecting construction and other exposed objects, and separating pedestrians from vehicular traffic.

5.2 Definitions & Abbreviations

Temporary Barrier – A device used to prevent vehicular access into construction or maintenance work zones and to redirect an impacting vehicle so as to minimize damage to the vehicle and injury to the occupants while providing worker protection.

ADT – Average Daily Traffic

Anchored PCB – PCB designed to accommodate mounting bolts to secure the barrier to the roadway.

Area of Concern – An object or roadside condition that may warrant safety treatment.

Clear Zone – The total roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired width is dependent upon the traffic volumes and speeds and on the roadside geometry.

Crash Cushion – Device that prevents an errant vehicle from impacting fixed objects by gradually decelerating the vehicle to a safe stop or by redirecting the vehicle away from the obstacle.

Crashworthy – A feature that has been proven acceptable for use under specified conditions either through crash testing or in-service performance.

Deflection – The distance barrier moves (lateral displacement) when impacted.

Drainage PCB – PCB designed with a slot on the bottom to allow for rainwater drainage.

Flare Rate – Rate of diversion of barrier from traveled way, e.g., 12:1.

Impact Angle – The angle at which the vehicle strikes the barrier.

Impact Severity – The force at which the vehicle impacts the barrier.

Length of Need – Total length of a longitudinal barrier needed to shield an Area of Concern.

Longitudinal Barrier – Traffic barrier oriented parallel or nearly parallel to the roadway. Beam guardrail, cable barrier, bridge rail, and concrete barrier are longitudinal barriers.

MSE Wall – A mechanically stabilized earth wall constructed by various methods to hold back a fill section.

NCHRP Report 350 – National Cooperative Highway Research Program (NCHRP) Report 350, "Recommended Procedures for the Safety Performance Evaluation of Highway Features". FHWA policy requires that devices used on the National Highway System must be successfully tested in accordance with the guidelines contained in the report.

NCHRP 350 Test Level 2 and Test Level 3 – NCHRP Report 350 test level 2 (TL-2) and test level (TL-3) require successful tests of a 1,800 lb. car impacting a barrier at an angle of 20 degrees and a 4,400 lb. pickup truck impacting a barrier at an angle of 25 degrees at speeds of 45 mph and 60 mph, respectively.

NCHRP 350 Test Level 4 – NCHRP Report 350 test level 4 (TL-4) requires a successful test of a 17,650 lb. truck impacting a barrier at an angle of 15 degrees at a speed of 50 mph.

Non-Recoverable Slope - is a slope which is considered traversable but on which an errant vehicle will continue to the bottom. Embankment slopes between 1V:3H and 1V:4H may be considered traversable but non-recoverable if they are smooth and free of fixed objects.

Recoverable Slope - is a slope on which a motorist may, to a greater or lesser extent, retain or regain control of a vehicle by slowing or stopping. Slopes flatter than 1V:4H are generally considered recoverable.

Offset – Term used when defining either the lateral distance barrier will be placed from the traveled way or the lateral distance barrier will be placed from the Area of Concern it is protecting.

PCB – Portable Concrete Barrier

QMB – Quickchange Moveable Barrier (Zipper System)

Roadside Design Guide – A document developed by AASHTO that presents a combination of current information and operating practices related to roadside safety.

Runout Length – The theoretical distance required for a vehicle that has left the roadway to come to a stop.

Shy Distance – The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an obstacle by the typical driver to the extent the driver will change the vehicle's placement or speed.

TMA – Truck Mounted Attenuator

Transition – A section of barrier between two different types of barrier or, more commonly, where a roadside barrier is connected to a bridge railing or to a rigid object such as a bridge pier.

Traversable Slope is a slope from which a motorist will be unlikely to steer back to the roadway but may be able to slow and stop safely. Slopes between 1V:3H and 1V:4H generally fall into this category**.**

Traveled Way – The portion of the roadway for the movement of vehicles, exclusive of shoulders.

5.3 Guidelines

INTRODUCTION

Positive protection is defined by Federal Highway Administration (FHWA) as *"devices that contain and/or redirect vehicles and meet the crashworthiness evaluation criteria contained in NCHRP Report 350."* By this definition, positive protection devices should then also prevent intrusion into the work area.

These guidelines address the use of positive protection devices in work zones to supplement the Work Zone Safety and Mobility Policy and comply with the Federal Highway Administration Final Rule Subpart K to CFR Part 630. These guidelines are not intended to be a rigid standard or policy; rather, they are guidance to be used in conjunction with engineering judgment. These guidelines are not a stand-alone document on work zone application of positive protection and must be used in conjunction with other traffic control standards and resources.

EXPOSURE CONTROL MEASURES

Prior to including positive protection in a transportation management plan, careful consideration must be given to alternatives which would avoid or minimize exposure for workers and road users. Alternatives that are often considered include detouring traffic, minimizing exposure time, or maximizing the separation between traffic and workers. A more inclusive list of potential exposure control measures include:

- Removal of the hazard from the clear zone
- Full road closure/ramp closure with traffic detoured
- Road closure with diversion (i.e. onsite detour, median crossover, temporary pavement)
- Performing work during off-peak periods when traffic volumes are lower
- Accelerated construction techniques
- Directional detours or alternate route detours
- Rolling road blocks

WARRANT

A warrant for using positive protection in a work zone is based on the premise that positive protection will reduce the severity of potential crashes. Positive protection in work zones is considered warranted whenever an engineering study indicates any of the following:

- Consequences of striking a fixed object or running off the road are believed to be more serious than striking the positive protection
- Consequences of striking a worker or pedestrian are believed to be more serious than striking the positive protection

TYPICAL APPLICATION

The following provides a list of areas where positive protection has been used in the past. However, this list is intended to provide guidance and should not be used in place of performing an engineering study.

- Objects that are within the clear zone such as:
  - Temporary shoring locations
  - Bridge piers
  - Overhead sign supports including foundations
  - Staged pipe or culvert construction
  - Stored construction material or equipment
  - Pavement edge drop offs
  - Non-traversable slope or steep/rough embankments within the clear zone
- Staged bridge construction
- Worker's or pedestrian safety is at risk due to the proximity of work to travel lanes
- Separation of opposing traffic

ENGINEERING STUDY AND ANALYSIS

An Engineering Study is a process which will integrate data, analysis, judgment, and creativity to determine the best strategy for a given scenario. An Engineering Study does not take the place of good engineering judgment, but should be used in conjunction with engineering judgment to guide the decision making process. It is most important to understand that one individual factor cannot independently determine if positive protection is needed. Considering all the factors will provide the fundamental information for the designer to analyze if an individual operation warrants the need for positive protection.

The Engineering Study performed to determine the need for positive protection shall take into consideration clear zone distances, roadway geometry, anticipated construction year traffic volumes, traffic speeds, roadside geometry, workers safety, pedestrian safety, etc. The following describes in more detail how these areas of concern are considered.

1. PRIMARY FACTORS TO CONSIDER

A. Clear Zone Distances

The *Roadside Design Guide* (RDG) defines the principles of clear zone. Objects outside the clear zone will generally not require positive protection. A designer must determine if a fixed object or worker will be within this lateral distance from the travel way. Clear zones can be determined using Table 3-1 from the *RDG*.

Chapter 9 of the *RDG* provides information specifically for work zones. Table 9-1 provides example work zone clear zones. This table can be considered, using good engineering judgment, when evaluating the need for positive protection.

The lateral distance from the travel way to a drop off or embankment could affect the need for positive protection. The height of a fill section is related to the slope a vehicle would have to travel toward the obstacle. Figure 5-1(b) of the *RDG* helps to determine if positive protection is needed for a given fill height.

B. Roadside Geometry

The depth and slope of the drop off or an embankment (roadside geometry) is an important factor to consider and will affect the decision to use positive protection.

- *Pavement Edge Drop off*

"Safety in Construction Zones Where Pavement Edges and Drop-Offs Exist", shown in the appendix as Figure 16, provides guidance on a correlation between the depth of a drop off, the distance the drop off is from the travel lane, and the roadside slope.

The Center for Transportation Research and Education (CTRE) in Iowa summarized the other state's drop-off criteria shown in the appendix from "Traffic Control Strategies in Work Zones with Edge Drop-Offs"

- *Embankment*

Figure 5-2(b) of the *Roadside Design Guide*, shown in the appendix indicates the relationship between the roadside slope, the height of an embankment and the traffic volume.

C. Anticipated Traffic Volumes

For best analysis, the construction year traffic volumes would provide a more realistic "anticipated" traffic volume than the current or the design year volumes. When analyzing the traffic volumes, the traffic mix should be considered. This includes the percent of truck traffic as well as motorists unfamiliar with area including seasonal tourists or for special events.

With higher traffic volumes, night work is often used as an exposure control measure. Night work may present unique challenges that must be taken into account such as, increased speeds, glare from portable lighting, driver's impaired visibility, and possible increase of inattentive drivers. Nightly installation and removal of positive protection devices will increase time and traffic exposure and may offset any advantage associated with the use of positive protection, except in cases where it can be installed and left in place for extended periods. These items need to be considered prior to requiring night work.

Higher volumes increase the risk to road users and roadway workers. Therefore, positive protection will more likely be used in locations with higher volumes.

D. Traffic speeds

For best analysis, the prevailing speed provides a more realistic speed than the speed limit or design speed for the roadway. If a speed study is available, use the 85th percentile speed. The higher the speed the more likely positive protection will be needed.

E. Roadway Geometry

The geometry of the roadway may affect the site distance for motorists, especially at entrance ramps. If the construction operation is on the outside curve of a road, the clear zone distance may be affected. Table 3-2 of the *RDG* provides adjustment factor for the clear zone. This data considers ADT, speed, and the roadway geometry. The tighter the curve, the clearer the zone distance is needed.

F. Duration

Duration is the length of time the hazard potentially requiring positive protection will be present. A designer must consider the exposure time associated with completing the operation versus the risk of installing the positive protection. In addition, the percent increase in duration must be considered when the installation of the barrier is included in the operation. If the duration to install the positive protection is longer than the construction operation itself, then positive protection may not be justified.

"Safety in Construction Zones Where Pavement Edges and Drop-Offs Exist" provides a figure to determine when temporary barrier may be justified to shield a drop-off as it relates to the ADT and duration/ exposure time of the drop off condition. This is shown in the appendix as Figure 16.

2. SPECIAL FACTORS TO CONSIDER

A. Worker's Safety

Where worker's exposure to traffic cannot be adequately managed through the application of an exposure control measure, positive protection should be considered. Consider positive protection in situations that place workers at increased risk from motorized traffic. Consideration must be given to an increase in worker's exposure during the installation and anchorage of positive protection.

B. Pedestrian Safety

Positive protection should be considered if there is a high potential for vehicle intrusion into pedestrian paths.

C. Separating Opposing Traffic

Positive separation should be considered in situations where multilane divided facilities are temporarily shifted to a 2-lane 2-way traffic pattern for periods lasting longer than three days. Conditions that may influence the decision to use positive protection would be high speed facilities, narrowed lanes, and high traffic volumes.

3. SECONDARY FACTORS TO CONSIDER

While the primary factors to consider are the driving force in the decision to use positive protection, secondary factors should not be dismissed especially in situations where a clear decision is not evident. The following are a list of secondary factors that may influence the decision to use positive protection:

- <u>Crash History</u>. Crash history of the area prior to construction Lessons learned from the crash history of previous work zone projects may be helpful in determining the need for positive protection. The Traffic Safety Unit is a good resource to help identify any potential areas of concern.
- <u>Impacts on Project Cost and Duration</u>. Positive protection will have an impact on the overall project duration and cost.
- <u>Impacts on available lane widths</u>. Restricted lane widths due to the use of positive protection may affect mobility for road users and the contractor. Consideration must be given to wide loads and equipment requirements to complete the work.
- <u>Roadway Classification</u>. The roadway classification is indicative of the characteristics of the road. Characteristics that may have an effect on the decision to use positive protection may include, speed, access, rural vs. urban, etc.
- <u>Work Area Restrictions</u>. Access to and from the work area for the delivery of materials and equipment should be considered. In addition, consideration should be given to the area needed for storage of equipment and materials and the area needed for equipment operation.

- <u>Bridge Construction</u>**.** Positive protection could affect the weight posting of the bridge for overweight vehicles. In addition, the ability to anchor positive protection to an existing bridge may be limited.

CONCLUSION

In conclusion, there are great benefits to using positive protection in appropriate situations. Positive protection techniques, when properly implemented, can help improve safety for workers and the motoring public. However, careful evaluation needs to be exercised before installing positive protection. The decision to use positive protection should be based on the best overall management of safety, mobility, constructability, cost, and overall project duration. These guidelines are meant to be coupled with engineering judgment in determining the use of positive protection.

5.4 Temporary Barrier Types

5.4.1 NC Standard Portable Concrete Barrier

The North Carolina approved Standard Portable Concrete Barrier (NC- PCB) meets NCHRP 350 test level 3. It is a "New Jersey Shape" free-standing, pre-cast concrete section that is 10 ft. long, 24 in. wide at the base, and 32 in. high, see Figure 1. A section weighs approximately 3,900 lbs., thus requiring heavy equipment for the installation and removal. PCB sections are joined end to end using a triple loop and drop-pin connection system. Adequate longitudinal reinforcement and positive connection ensure that the individual segments act as a smooth, continuous unit although the joint remains the weakest point.

The NC-PCB has two other versions- anchored and drainage. Anchored NC-PCB is a standard PCB designed to accommodate a maximum of 4 anchor bolts (2 on each side) and is used when the expected unanchored NC-PCB or other barrier deflections are greater than the space available. Drainage NC-PCB has a slot cast in the bottom designed to accommodate water flow under the barrier where surface water runoff could cause a hazardous accumulation of water on the traveled way.

5.4.2 Quickchange Moveable Barrier (QMB)

Quickchange Moveable Barrier (QMB) or zipper systems meets NCHRP 350 test level 3. It is a system composed of a chain of reinforced "F-Shape" pre-cast concrete sections that is designed to be moved laterally across the roadway quickly, safely and in one continuous operation. Each barrier section is 37 in. long, 24 in. wide at the base, and 32 in. high with a weight of approximately 1,500 lbs., see Figure 1. The top of the barrier is "T" shaped to permit it to be picked up by the transfer vehicle. A transfer vehicle is able to pick up and move continuous lengths of barrier a minimum of 4 feet to a maximum of 24 feet across the roadway at speeds up to 10 mph.

Quickchange Moveable Barrier (QMB) is designed to accelerate construction, improve traffic flow, and reduce work zone congestion by enabling more lanes to be open during peak hour traffic while safeguarding work crews and motorists. QMB is ideal for reconstruction, re-paving, and bridge and tunnel rehabilitation. Since the QMB system requires higher operating and maintenance costs, it should only be considered where the cost and/or impacts of the traditional freeway widening alternative is prohibitive.

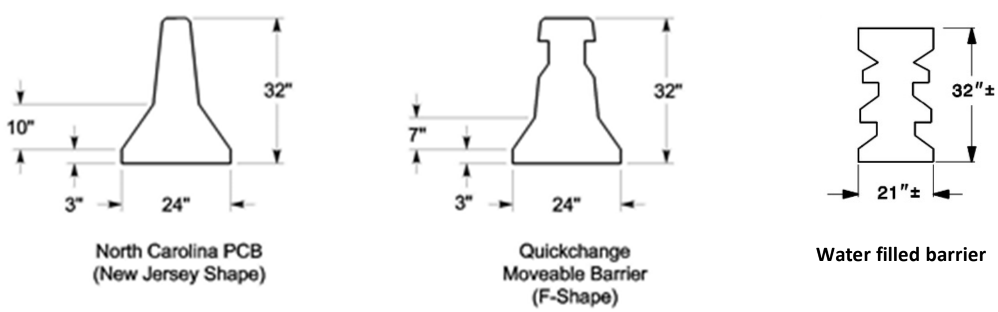


Figure 1 – PCB Standard Safety Shapes

5.4.3 Water-Filled Barrier

The only NCDOT approved water-filled barrier at this time is Triton Water- Filled Barrier. It has been approved for use only as a NCHRP 350 test level 2 device, which is for speed-zones of 45 mph or less. Each plastic barrier section is 7 ft. long, 21 in. wide at the base, and up to 43" tall. It weighs approximately 140 lbs. when empty and approximately 1,350 lbs. when filled. Water-Filled Barrier consists of alternating orange and white plastic barrier sections that are joined end to end with connection pins and then filled with water after being positioned at the project site. The first barrier section is turned upside down to serve as the crash cushion and does not receive any water.

The advantage of this type of system is the short installation and removal time. Each section can be unloaded and positioned by two people without the use of cranes or special equipment. The disadvantages are the cost and higher deflection as compared to concrete barrier.

5.4.4 Temporary Guardrail

Temporary guardrail most commonly consists of W-section rails of single or double rails with faces of different combinations attached to wood or steel posts. Although specified in the Traffic Control Plans for temporary conditions, guardrail is a function of the Roadway Design Unit. When specifying guardrail in the Traffic Control Plans, it should be closely coordinated with the Roadway Design Unit as it pertains to placement and calculation of quantities.

5.4.5 Other

Other types of barrier that may be used in work zone applications include thrice beam guiderail, 2 and 3 bar bridge rail, cable guiderail, single-face concrete barrier, earth berms, and various other permanent types of barrier. Consult with your supervisor and Roadway for help in choosing alternate barrier types.

5.5 Performance Attributes

The following chart is a quick reference for the barrier approved for use by the Work Zone Traffic Control Section. Support information to the chart can be found in the following subsections.

	North Carolina PCB	Quickchange Movable Barrier (QMB)	Water-Filled Barrier	W-Beam Guardrail
Maximum Deflection	See Note 1	53 in. (NCHRP 350 TL-3)	12 ft. 10 in. (NCHRP 350 TL-2) See Note 2	See Note 3
Installation Surface	Pavement	Pavement		Soil
Length of Barrier Tested See Note 4	200 ft.	250 ft.	100 ft.	Consult with Roadway

Figure 2 – Performance Attributes Chart

Notes:

1. See Figures 4 & 5 below for NC-PCB deflection distances derived from a crash data analysis program developed for the WZTCS by NC State University. Deflection distances can also be derived using the deflection program discussed in Section 2.5.5.2.
2. Water-Filled Barrier can only be used for speed zones of 45 mph or less.
3. Because of different construction elements of guardrail, deflection distances will vary with each manufacturer. Consult with Roadway to verify deflection distances after the barrier is chosen.
4. The distance shown is the total length of barrier tested during NCHRP 350 crash testing. It is also the same length used by NC State University for the deflection analysis of the NC-PCB. Use engineering judgment when using barrier less than what is shown because the barrier deflection distance could be greater and vehicle containment could be compromised.

5.5.1 NC-PCB Deflection Charts

The following charts, Figures 4 & 5, are the result of a crash data analysis program developed for the WZTCS by NC State University. Since the deflections shown are based on speed and impact angle, the designer will be able to better judge offset distances for barrier placement. The "Offset" distances shown and used to determine the "Impact Angle" are based on the assumption of 12-feet lane widths and a 2-foot offset of the barrier from the traveled way, see Figure 3. You will have to use the chart and interpolate for different distances or use the deflection program discussed in the next subsection.

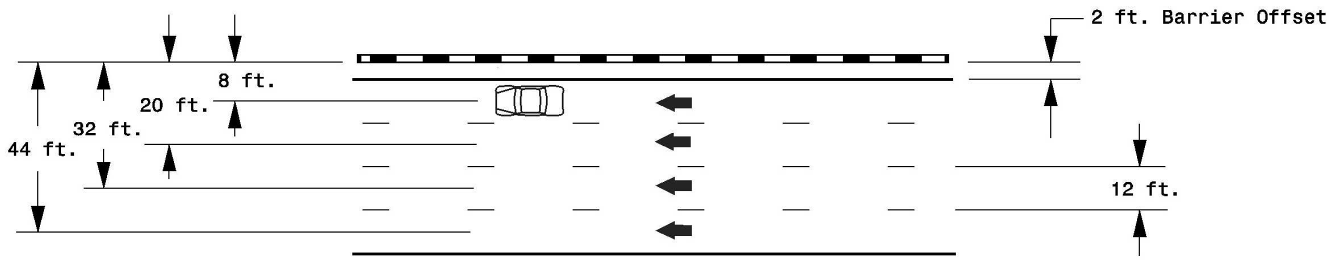


Figure 3 – Vehicle Lateral Distance

Impact Angle (degree)/ Maximum Deflection (in)			Design Speed (mph)					
			30	**40**	**50**	**60**	**70**	**80**
Offset (ft)	**8**	**Impact Angle**	11.1	10.4	9.6	8.7	7.7	6.7
		Maximum Deflection	23.00	25.86	28.04	31.86	35.72	39.12
	14	**Impact Angle**	12.7	12.1	11.4	10.5	9.3	8.0
		Maximum Deflection	25.16	27.42	30.43	34.25	37.02	41.45
	20	**Impact Angle**	13.2	12.8	12.2	11.5	10.9	10.3
		Maximum Deflection	26.52	28.94	33.30	35.89	38.77	42.51
	26	**Impact Angle**	13.3	12.9	12.6	12.0	11.3	10.5
		Maximum Deflection	27.14	30.11	34.68	37.62	39.74	43.14
	32	**Impact Angle**	13.3	13.0	12.7	12.4	12.1	11.8
		Maximum Deflection	28.56	30.71	35.99	38.82	41.56	44.38
	38	**Impact Angle**	13.3	13.1	13.0	12.6	12.2	12.0
		Maximum Deflection	29.34	33.23	37.92	40.31	42.89	45.51
	44	**Impact Angle**	13.4	13.2	13.0	12.8	12.7	12.6
		Maximum Deflection	30.45	33.93	40.14	42.12	44.53	47.21
	50	**Impact Angle**	13.4	13.2	13.0	12.9	12.9	12.8
		Maximum Deflection	30.95	34.62	40.92	42.89	46.00	48.70
	56	**Impact Angle**	13.6	13.2	13.0	13.0	12.9	12.9
		Maximum Deflection	31.42	35.24	41.34	43.78	46.27	49.53
	62	**Impact Angle**	13.6	13.2	13.0	13.0	12.9	12.9
		Maximum Deflection	31.87	35.86	41.62	44.56	46.72	50.18

Figure 4 – NC-PCB impact design table for ASPHALT pavement

Impact Angle (degree)/ Maximum Deflection (in)			Design Speed (mph)					
			30	**40**	**50**	**60**	**70**	**80**
Offset (ft)	**8**	**Impact Angle**	11.1	10.4	9.6	8.7	7.7	6.7
		Maximum Deflection	16.68	17.45	20.21	21.70	24.20	25.74
	14	**Impact Angle**	12.7	12.1	11.4	10.5	9.3	8.0
		Maximum Deflection	18.43	19.42	22.33	24.05	25.76	28.39
	20	**Impact Angle**	13.2	12.8	12.2	11.5	10.9	10.3
		Maximum Deflection	21.28	21.70	23.61	25.37	27.51	30.05
	26	**Impact Angle**	13.3	12.9	12.6	12.0	11.3	10.5
		Maximum Deflection	22.12	23.02	25.22	26.49	29.45	33.27
	32	**Impact Angle**	13.3	13.0	12.7	12.4	12.1	11.8
		Maximum Deflection	23.24	24.62	26.12	27.98	31.30	34.26
	38	**Impact Angle**	13.3	13.1	13.0	12.6	12.2	12.0
		Maximum Deflection	23.87	25.36	26.89	29.18	32.32	35.47
	44	**Impact Angle**	13.4	13.2	13.0	12.8	12.7	12.6
		Maximum Deflection	24.19	25.45	27.04	29.85	33.46	36.12
	50	**Impact Angle**	13.4	13.2	13.0	12.9	12.9	12.8
		Maximum Deflection	25.11	25.70	27.42	31.24	34.14	36.85
	56	**Impact Angle**	13.6	13.2	13.0	13.0	12.9	12.9
		Maximum Deflection	25.48	25.80	27.83	31.54	34.51	37.12
	62	**Impact Angle**	13.6	13.2	13.0	13.0	12.9	12.9
		Maximum Deflection	25.55	26.20	28.16	31.80	35.15	37.34

Figure 5 – NC-PCB impact design table for CONCRETE pavement

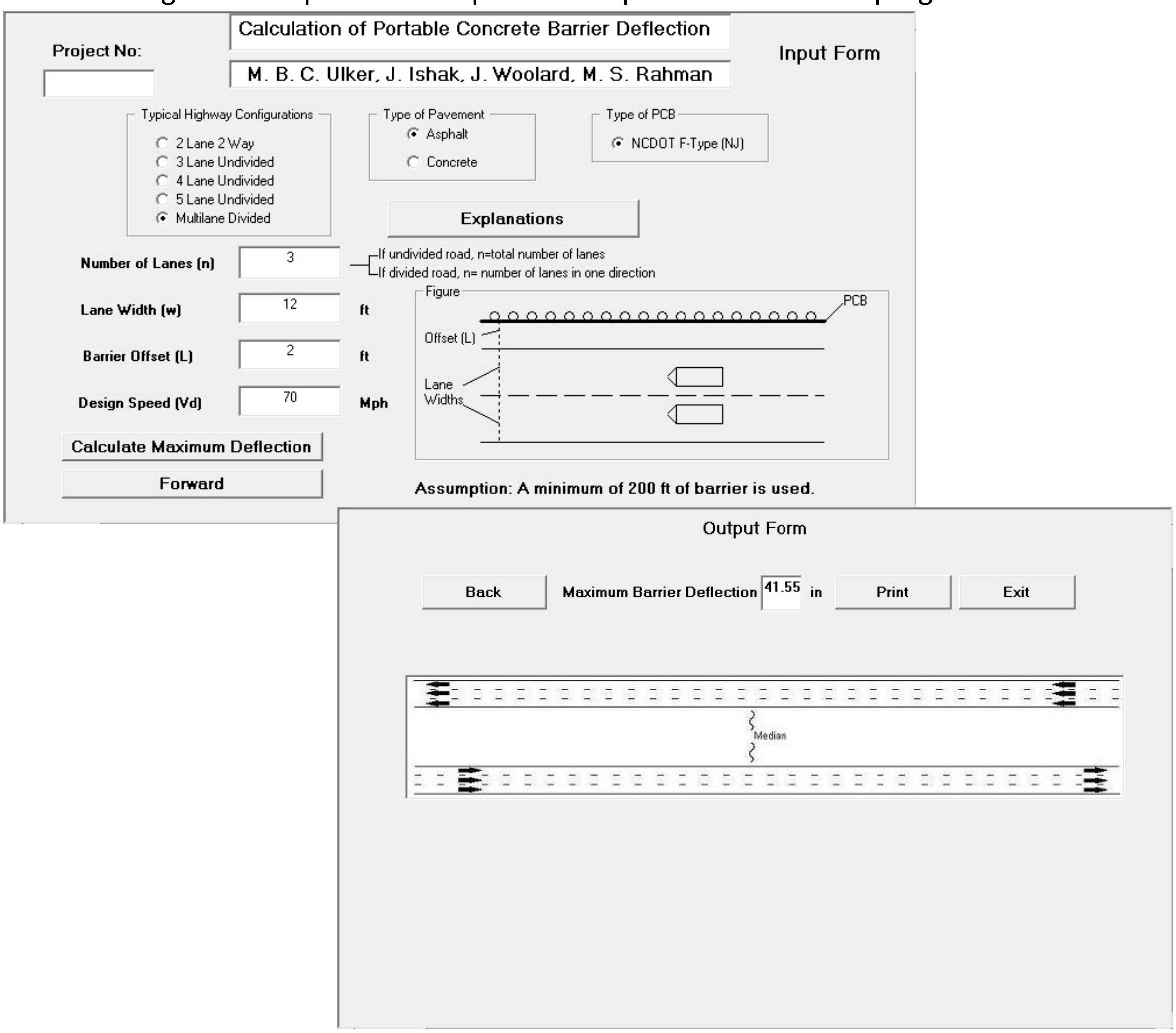
5.5.2 Barrier Deflection Calculation

The WZTCS has a computer program that will calculate the maximum deflection for NC-PCB. The Deflection program was developed for the unit by NC State University and can be found on your computer under the WZTCS Tools shortcut folder on your desktop.

The calculations are based on:

- Road type (divided or undivided)
- Number of lanes
- Type of pavement
- Type of barrier
- Lane widths
- Design speed

The following are examples of the input and output screens for the program:



5.6 Temporary Barrier Usage

5.6.1 Warrants for Temporary Barrier Usage

The Roadside Design Guide was introduced to promote the safety of the motorist that may inadvertently run off the roadway. With that purpose, the Roadside Design Guide established the concept of the Clear Zone (The total roadside border area, starting at the edge of the traveled way that is available for safe use by errant vehicles). While the principles governing the placement of barrier to protect the motorist from striking objects in the clear zone are generally the same, the work zone and permanent roadside environments are very different. Materials, equipment and workers are inherent of the work zone "clear zone" which is not the same as the objects found in the permanent roadside "clear zone". Therefore, experience and judgment must be used to identify hazardous features. The following is a small list of hazards that may warrant the use of barrier in the work zone:

- Construction equipment and materials
- Existing permanent guardrail/concrete barrier
- Exposed ends of temporary barrier
- Bridge piers
- Bridge rail or parapet ends
- Culvert installations

In addition to shielding hazards, barrier may necessary for the following:

- Protect the workers.
- Separate two-way traffic.
- Shield and/or guide pedestrians around the work site.

5.6.2 Guidelines for Barrier Usage

In addition to the examples listed above, the following is a list of guidelines to help determine the need for temporary barrier.

5.6.2.1 Drop-offs

Drop-Offs greater than 3 inches need special attention when located within or near the traveled way. See Chapter 2.2 Drop-Offs in the WZTCS Design Manual for guidelines in the use of temporary barrier.

5.6.2.2 Roadside Slopes

If a roadside is not flat, a vehicle leaving the roadway will encounter an embankment slope (negative grade), a cut slope (positive grade), or a channel (change in slope from negative to positive). Each of these features has an effect on a vehicle's lateral encroachment and trajectory. Embankment or fill slopes are categorized as recoverable, non-recoverable, or critical:

- Recoverable Slopes are 4H:1V or flatter where a vehicle may be stopped or slowed enough to return to the roadway safely.
- Non-Recoverable Slopes between 3H:1V and 4H:1V are traversable, but from which most motorists will be unable to stop or return to the roadway safely.
- Critical Slopes steeper than 3H:1V may cause vehicle overturn.

Slopes steeper than 3H:1V should be protected by some type of barrier.
See Chapter 2.2 Drop-Offs in the WZTCS Design Manual for guidelines in the use of temporary barrier to protect slopes.

5.6.2.3 Shoring and MSE Walls

Shoring or a MSE wall located in the Clear Zone may require temporary barrier to protect the motorist. See the Temporary Shoring Special Provision SP11R02 and WZTC Standard Drawing "Portable Concrete Barrier at Temporary Shoring Locations" for guidelines.

5.6.3 Assessing the use of Temporary Barrier

Even though a hazard has been identified, engineering judgment needs to be used to determine if temporary barrier should be utilized. It must be remembered that the installation of temporary barrier also represents a hazard to the motorist and it is a safety issue for the worker who must install and remove the barrier. The following are a few factors to consider when assessing the need for positive protection:

- Duration of the construction activity
- Traffic volumes (ADT)
- Work zone design speed
- Highway functional class
- Length of hazard
- Proximity between traffic and construction workers and/or equipment
- Adverse geometrics which may increase the likelihood of run-off-the-road vehicles

Consult with your supervisor for alternatives to barrier that can be used, e.g., drums for delineation, portable changeable message signs to alert the motorist and a TMA to shield the hazard. Other solutions may be a temporary detour or lane closure.

5.7 Selection Criteria

Once it has been decided to use temporary barrier, engineering judgment is needed in the selection and placement of temporary barrier in the work zone. The following summarizes some factors that should be considered before making the final selection:

- The barrier chosen must be structurally able to contain and redirect the vehicle
- Expected deflection of the barrier should not exceed available deflection distance
- Slope and surface may limit some barrier types
- The barrier chosen may have to be capable of transitioning to other barrier types and bridge railings
- Other considerations are the duration of construction activity, work zone speed, ADT and barrier cost

5.7.1 Surface

The type of surface the barrier will be installed on is an important design element in choosing the correct temporary barrier type.

5.7.1.1 Paved

PCB (including anchored and drainage), QMB (Zipper System) and water filled barrier must be installed on paved surfaces**. If necessary, temporary pavement may be placed on an unpaved area next to the travel lane for barrier installation. A paved surface is also required when the barrier is flared away from the traveled way.**

5.7.1.2 Unpaved

If placing temporary pavement is not an option, consider using temporary guardrail or guiderail. Coordinate the selection and placement of guardrail/guiderail with Roadway Design Unit.

5.7.1.3 Bridge Decks

PCB is predominantly used on bridge decks. Coordinate with Structure Design on whether the structure rating is sufficient to accommodate the weight of the barrier or if the barrier can be anchored to the bridge deck. If the existing structure is aged to the point where concrete barrier cannot be supported; then guardrail can be considered and should be coordinated with Structure Design and Roadway Design.

5.7.1.4 Slopes

The Roadside Design Guide does not recommend placing barrier on slopes steeper than 10H:1V. Per the Roadside Design Guide, “When barrier is placed on slopes steeper than 10H:1V, studies have shown that for certain encroachment angles and speeds an errant vehicle may go over many standard roadside barriers or impact them too low.” Since PCB, QMB and water-filled barrier must be placed on a paved surface, slope will probably not be an issue. For Water-Filled Barrier it is recommended not to exceed slopes steeper than 20H:1V. When slopes are steeper than 10H:1V, consult with roadway for a guardrail or guiderail that may be suitable.

5.7.2 Performance

After the Area of Concern that needs to be protected has been identified, a barrier should be chosen that has a level of performance that can properly protect the area. The first concern will be to insure that the deflection of the barrier chosen will not encroach into Area of Concern when impacted. After reviewing the speed zone and lane width for worst case impact severity, refer to the charts in Section 2.5.5 Performance Attributes to find the deflection distance of the NC-PCB. (In the past, the designer could only use the deflection distances reported from the NCHRP 350 test data and use that distance as a worst case for deflection. The charts now give the designer the deflection distance that better matches the work zone). The designer can also use the deflection program. If the designer is using Water-Filled barrier, guardrail or another NCDOT approved barrier, the designer should use the deflection distance reported from the NCHRP 350 test data for that barrier as the worst case deflection.

Another consideration in the performance of the barrier is the type of traffic and work zone location. The PCB approved and most W-Beam guardrail meets NCHRP 350 TL-3 which has been crash tested for cars and light trucks. If your work zone is located in an urban area with a 35 mph speed zone, then Water-Filled barrier may be a better choice.

5.8 Installation Guidelines

The following guidelines are to be used whenever possible for the proper installation of barrier. When deviations are necessary, consult with your supervisor.

5.8.1 Lateral Offsets (General Information)

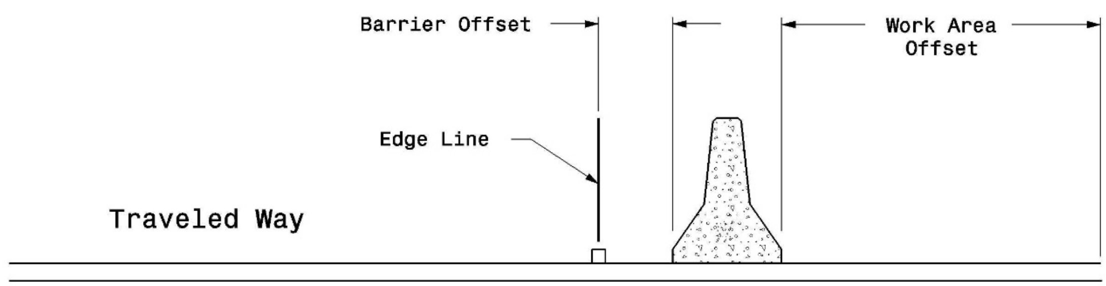


Figure 8 – Typical Barrier Layout

5.8.1.1 Maximum Lateral Offset from Traffic

There is no maximum lateral offset of barrier from traffic within the clear zone. A larger lateral offset gives an errant motorist more time to regain control of the vehicle and provides better sight distance around curves and intersections. However, larger lateral offsets may allow for a larger impact angle with the barrier, thus creating the potential for a more severe crash. Barrier placement beyond the clear zone is usually not necessary and engineering judgment should be used to determine if protecting the motorist from a hazard beyond the clear zone is warranted. Lateral offsets of 4 to 10 feet should be avoided, see False Shoulder Effect below.

Approach ends of the barrier should be flared beyond the clear zone if possible, see Flare Rate Chart on page 23. If this is not possible, the barrier approach ends should have acceptable crashworthy end treatments.

5.8.1.2 False Shoulder Effect

If a wide shoulder exists for barrier placement, a barrier offset of 4 to 10 feet from the traveled way should be avoided where possible. Offsets in this range may create an effect that can lure drivers into thinking there's a useable shoulder when in actuality there is not sufficient room to park in a safe manner. For example, a passenger car can normally fit in an 8-foot wide space, but this space does not allow room for opening a door.

5.8.1.3 Minimum Lateral Offset from Traffic

As a general rule, a minimum offset of 2 feet between the barrier and the traveled way is preferred. See Chapter 3 for minimum lane widths.

5.8.1.4 Lateral Offset from Work Area or Hazard

Barrier must be offset from the hazard to allow for deflection. If construction is being performed behind the barrier then the offset distance chosen must also provide adequate space for the work to be performed. The larger offset of the two should be the one used. For example, if the space needed for equipment to operate behind barrier exceeds that which is required for deflection, then that higher offset should be used. The offset from the barrier to the work area will vary depending on the type of work or hazard. During the design stage, construction procedures and equipment that will be used must be thoroughly analyzed before the barrier layout is finalized. Construction personnel, such as the Construction Unit, Division Personnel, Resident Engineer, and manufacturers should be contacted for details on construction procedures and equipment operations, so that the barrier offset can be correctly determined.

Common minimum offsets from barrier to work operations:

- Asphalt pavement widening: 1 ft.
- Concrete pavement widening: 2.5 ft.
- Temporary roadside slopes: – 1.5:1 slopes: 3.3 ft.
  – All other slopes: 2.5 ft.

5.8.2 Slopes

Special consideration has to be given when placing barrier on any slope since most roadside barriers are designed for and tested on level terrain. Per the Roadside Design Guide, "roadside barriers perform most effectively when they are installed on slopes of 10H:1V or flatter. Caution should be taken when considering installations on slopes as steep as 6H:1V and any such installations should be offset so that an errant vehicle is in its normal attitude at the moment of impact. Since PCB, QMB and water-filled barrier must be placed on a paved surface, slope will probably not be an issue. The Roadside Design Guide has recommendations for placement of barrier on roadside locations and median locations, but the information is too great to summarize in this chapter. Also, since the barrier to be used in this situation will probably be guardrail or guiderail, it is suggested to consult with Roadway for the proper choice and placement.

5.8.3 Curbs

The trajectory of a vehicle striking a curb will depend on the vehicle's characteristics such as height, weight, suspension type, impact speed and impact angle, and the height and shape of the curb itself. Preferably, barriers should be placed in line with the curb face, or in front of the curb. If these conditions cannot be met, then the barrier should be located a minimum of 12 feet behind the face of the curb to eliminate vaulting.

5.8.4 Bridge Decks

PCB used on bridge decks should be anchored if the clearance from the back of the barrier to the edge of the deck is 6 feet or less as shown in Figure 10.

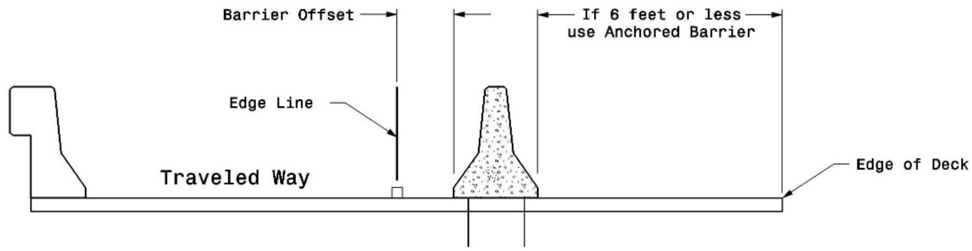


Figure 10 – Barrier installed on a Bridge Deck

5.8.5 Shoring and MSE Walls

See WZTC Standard Drawing “Portable Concrete Barrier at Temporary Shoring Locations” for installation guidelines.

5.8.6 Access Openings

Openings in barriers should be avoided if possible. Where necessary, PCB approach ends should have acceptable crashworthy end treatments. Refer to the Figures 11 and 12 for placement guidelines.

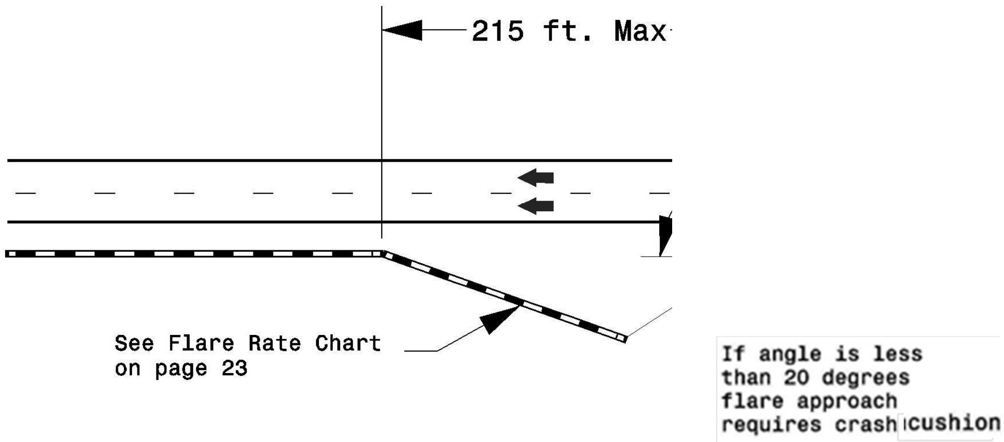


Figure 11 – Flared Installation

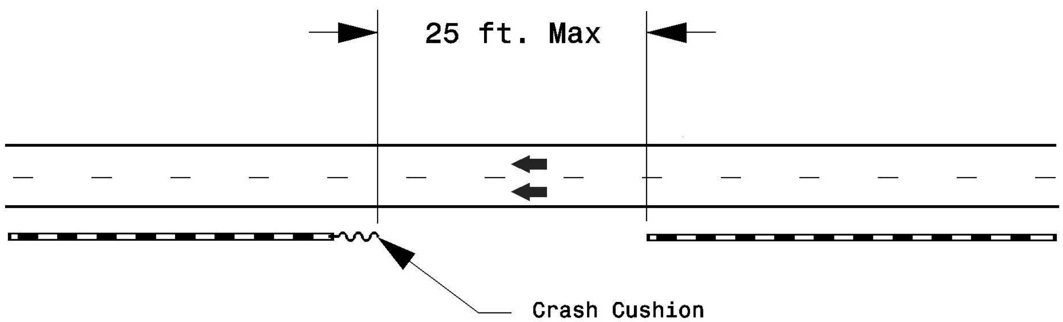


Figure 12 – Parallel Installation

5.8.7 Two-Way Traffic

When barrier is warranted for separation of two-way traffic, its selection will depend directly on the amount of allowable deflection. Barrier selection and placement should be designed so that upon impact, the barrier does not deflect into an opposing lane. Factors that will affect the deflection of the barrier are:

- The number of lanes adjacent to barrier can increase impact angle
- Posted speed limit
- Barrier type
- Type of traffic, e.g., heavy truck traffic

Once the number of lanes is determined, the impact angle and impact severity can be selected. Refer to Section 5.5 Performance Attributes to determine deflection. If there is not enough offset available to keep the barrier from deflecting into the traveled way, then the following alternatives should be considered:

- Anchor the barrier
- Another type of barrier may be selected that can accommodate the estimated deflection
- Or, other traffic control methods may be considered so that the offset from the barrier to the edge lines is equal to or greater than the estimated deflection. Other traffic control methods may include reducing lane widths or shifting lanes onto shoulders.

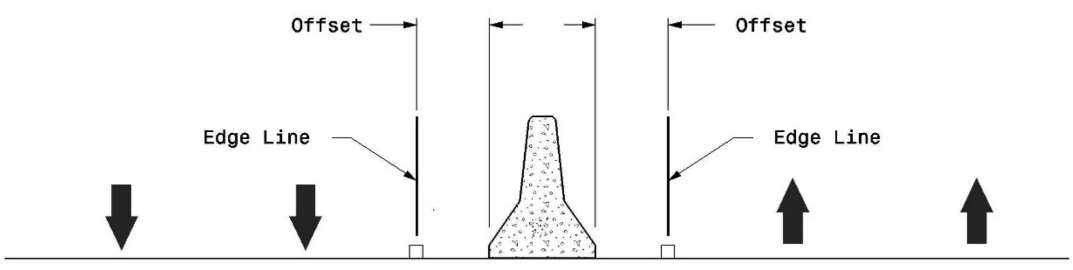


Figure 13 – Two-Way Traffic

5.8.8 Transitions

Transition sections of barrier are necessary to provide continuity of protection when two different barriers are joined, or when a barrier is attached to a rigid object such as a bridge pier. Transition sections are needed between adjoining barriers with different deflection characteristics, such as between guardrail and concrete barrier. A transition section provides for a uniform deflection to occur when a more flexible system attaches to a more rigid system. This will reduce the possibility of the vehicle pocketing, snagging, or penetrating. There are a number of methods to transition barrier depending on the two systems involved. Increased post spacing on guardrail, use of transition panel end shoes, rubrails, and larger size or stronger posts are some examples.

Various Roadway Standard Drawings and special details show methods for transitioning guardrail to bridge rail and guardrail to concrete barrier for pier protection. Contact the Plans and Standards Management Section of the Project Services Unit to have the proper detail sheet designed and included in the Roadway Plans.

5.8.9 Anchored Barrier

Anchored PCB is used in locations where the required deflection distance cannot be obtained. There are three approved methods of anchoring concrete barrier depending on the type of surface the barrier is going to be installed on, but one common factor between the different methods is that the barriers have to be anchored to asphalt or concrete pavement. There is no approved method of anchoring concrete barrier to soil (Refer to Roadway Standard Drawing 1170.01 for detailed information relating to the methods of anchored barrier installation).

Note: <u>Water-filled barrier does not have an anchoring system.</u>

5.8.10 Drainage Barrier

Drainage PCB is used in locations where surface water runoff could cause a hazardous accumulation of water on the traveled way. Drainage PCB is designed with a drainage slot at the base of the barrier that permits water to flow through the bottom of barrier. Refer to Roadway Standard Drawing 1170.01 for more information regarding the drainage slot on the barrier.

Below are guidelines of where and where not to use concrete drainage barrier after the decision has been made to use some type of concrete barrier:

- Drainage PCB should be used on the low side of a horizontal curve, because any water on the roadway will flow downward toward the barrier and can escape through the drainage slot.
- Unless there is a drainage system behind the barrier, drainage PCB **should not** be used on the high side of a horizontal curve because any water on the backside of the barrier may run through the barrier and onto the roadway creating a potential for hydroplaning.
- Drainage PCB should be used at the low point of a sag vertical curve because any water on the roadway will run to the low point on the roadway. Once the water reaches the low point on the curve, it can escape through the drainage slot.

5.9 Required Length of Need

This section covers the design procedure for determining the Length of Need (X) for temporary barriers. The following variables are considered when placing temporary barrier to effectively shield an area of concern:

- Clear Zone (L_C)
- Run-out Length (L_R)
- Flare Rate (a:b)
- Lateral extent of Area of Concern (L_A)
- Tangent Length upstream from Area of Concern (L_1)
- Lateral Offset of barrier from traveled way (L_2)
- Lateral Offset from traveled way to beginning of need (Y)

5.9.1 Length

The following figures show the relationship of the variables when calculating the Length of Need:

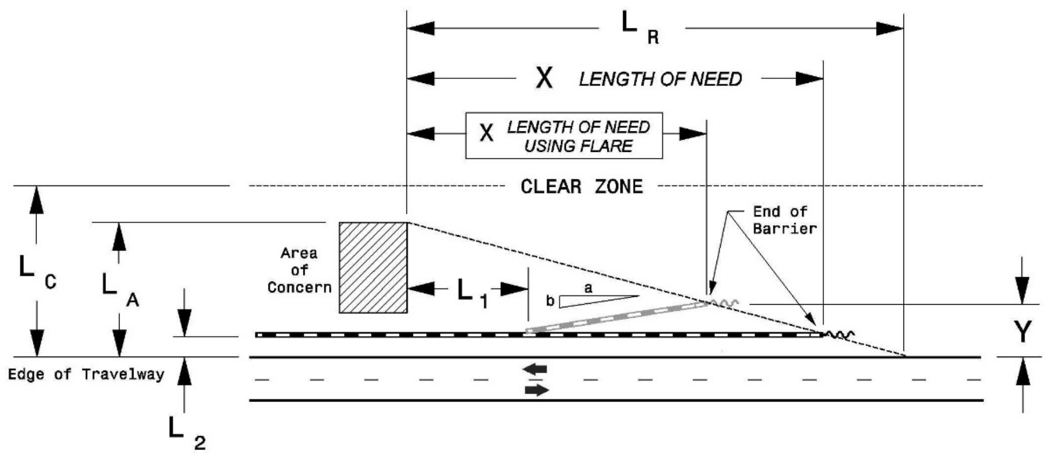


Figure 14 – Layout for “Adjacent Traffic”

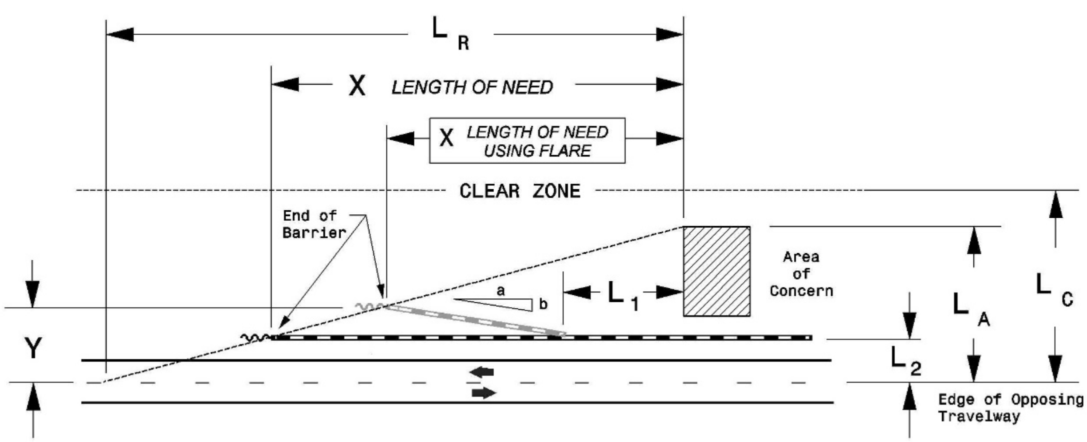


Figure 15 – Layout for “Opposing Traffic”

5.9.1.1 Length of Need (X)

The Length of Need (X) is the total length of longitudinal barrier needed to shield an area of concern. The Length of Need can be calculated by inputting the variables into the following formulas:

$$\text{Without Flare } X = \frac{L_A - L_2}{L_A / L_R} \qquad \text{With Flare } X = \frac{(L_A - L_2) + (b/a)(L_1)}{b/a + (L_A / L_R)}$$

5.9.1.2 Clear Zone (L_C)

The Clear Zone (L_C) is the total roadside border area, starting at the edge of the shoulder and including a recoverable slope, a non-recoverable slope, and/or a clear run-out area. Barrier ends that are within the clear zone will need a crashworthy end treatment. In addition, there are three ranges of Clear Zone width, L_C, that deserve special attention for an approach barrier for "Opposing Traffic":

- If the barrier is located beyond the "Opposing Traffic" Clear Zone (L_C), no additional barrier is required. However, a crashworthy end treatment should be considered based on ADT, distance beyond the clear zone and roadway geometrics.
- If the barrier is located within the "Opposing Traffic" Clear Zone (L_C), but the area of concern is beyond it, no additional barrier is required, but a crashworthy end treatment should be used.
- If the area of concern extends well beyond the "Opposing Traffic" Clear Zone (L_C), the designer may choose to shield only that portion which lies within the clear zone by setting L_A equal to L_C

The Roadside Design Guide discusses in Chapter 9 how the work zone "clear zone" differs from the before-construction "clear zone" and it states - "Engineering judgment must be used in applying the "clear zone" to work zones". Because the manual does not publish clear guidance for work zone "clear zone" ranges, it is suggested to use the following chart from the Roadside Design Guide which shows the appropriate "clear zone" ranges used for permanent construction:

Design Speed (mph)	Design ADT	Foreslopes			Backslopes		
		1V:6H or flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or flatter
40 or less	Under 750	7 – 10	7 – 10	*	7 – 10	7 – 10	7 – 10
	750-1500	10 – 12	12 – 14	*	10 – 12	10 – 12	10 – 12
	1500-6000	12 – 14	14 – 16	*	12 – 14	12 – 14	12 – 14
	Over 6000	14 – 16	16 – 18	*	14 – 16	14 – 16	14 – 16
40-50	Under 750	10 – 12	12 – 14	*	8 – 10	10 – 12	10 – 12
	750-1500	12 – 14	16 – 20	*	10 – 12	12 – 14	14 – 16
	1500-6000	16 – 18	20 – 26	*	12 – 14	14 – 16	16 – 18
	Over 6000	18 – 20	24 – 28	*	14 – 16	18 – 20	20 – 22
55	Under 750	12 – 14	14 – 18	*	8 – 10	10 – 12	10 – 12
	750-1500	16 – 18	20 – 24	*	10 – 12	14 – 16	16 – 18
	1500-6000	20 – 22	24 – 30	*	14 – 16	16 – 18	20 – 22
	Over 6000	22 – 24	26 – 32	*	16 – 18	20 – 22	22 – 24
60	Under 750	16 – 18	20 – 24	*	10 – 12	12 – 14	14 – 16
	750-1500	26 – 30	26 – 32	*	12 – 14	16 – 18	20 – 22
	1500-6000	26 – 30	32 – 40	*	14 – 18	18 – 22	24 – 26
	Over 6000	30 – 32	36 – 44	*	20 – 22	24 – 26	26 – 28
65-70	Under 750	18 – 20	20 – 26	*	10 – 12	14 – 16	14 – 16
	750-1500	24 – 26	28 – 36	*	12 – 16	18 – 20	20 – 22
	1500-6000	28 – 32	34 – 42	*	16 – 20	22 – 24	22 – 24
	Over 6000	30 – 34	38 – 46	*	22 – 24	26 – 30	28 – 30

* The width of the clear zone has to be extended to an equal width of the non-recoverable slope width.

Figure 16 – Suggested Clear Zone Widths (ft.)

5.9.1.3 Run-out Length (L_R)

The Run-out Length (L_R) is the theoretical distance needed for a vehicle that has left the roadway to come to a stop.

Design Speed (mph)	Traffic Volume (ADT)			
	Over 6000 vpd	2000 - 6000 vpd	800 - 2000 vpd	Under 800 vpd
	L_R (ft)	L_R (ft)	L_R (ft)	L_R (ft)
70	475	445	395	360
60	425	400	345	330
55	360	345	315	280
50	330	300	260	245
45	260	245	215	200
40	230	200	180	165
30	165	165	150	130

Figure 17 – Suggested Run-out Lengths for Barrier Design

5.9.1.4 Flare Rate (a:b)

Flare is defined as the variable offset distance of a barrier to move it farther from the traveled way. The flare rate is the rate of diversion that the barrier moves away from the traveled way.

Design Speed (mph)	Flare Rate for Barrier	
	Anchored	Un-Anchored
70	20:1	15:1
60	18:1	14:1
55	16:1	12:1
50	14:1	11:1
45	12:1	10:1
40	10:1	8:1
30	8:1	7:1

Figure 18 – Suggested Flare Rates for Barrier Design

5.9.1.5 Lateral Extent of Area of Concern (L_A)

The Lateral Extent (L_A) is the distance from the edge of the traveled way to the far side of the hazard or work area, or to the edge of the Clear Zone (L_C). The distance L_A controls the temporary barrier Length of Need (X), and therefore, is important that this area be properly identified.

5.9.1.6 Tangent Length upstream from Area of Concern (L_1)

The Tangent length (L_1) is the length of barrier upstream from the Area of Concern to the beginning of the flare. This is a variable length selected by the designer when the barrier cannot be flared, such as a transition when barriers of different flexibility are tied together, i.e., when concrete barrier ties to guardrail.

The designer may need to define the Lateral Offset (Y) to insure that barrier with flare will be positioned on a paved surface, i.e., barrier placed on a narrow shoulder. In this situation, the governing factor will be the distance for L_1. To calculate for L_1, first solve for Length of Need (X) with the first equation and use that result in the second equation:

$$X = \frac{Y - L_A}{L_A/L_R} \qquad\qquad L_1 = \frac{X(b/a + L_A/L_R) - (L_A - L_2)}{b/a}$$

5.9.1.7 Lateral Offsets of Barrier from Travel Way (L_2)

The Lateral Offset (L_2) of barrier from traveled way is the distance from the edge of the traveled way to the face of the temporary barrier. Refer to Section 2.5.8.1.3 Minimum Lateral Offsets from Traffic for minimum offset requirements.

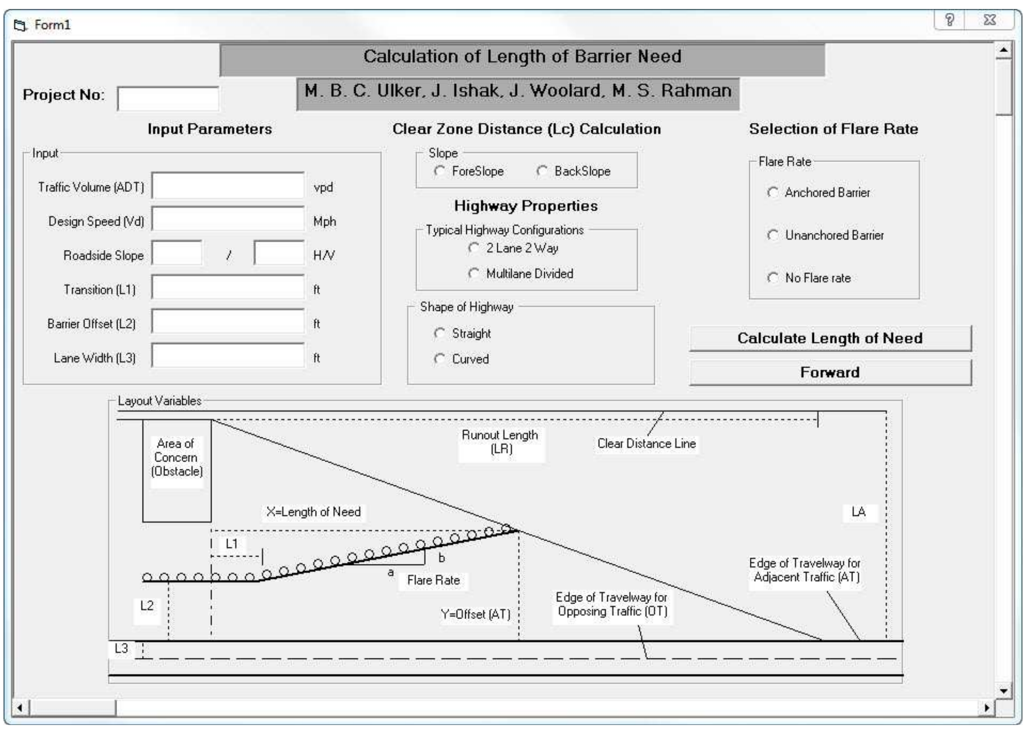
5.9.1.8 Lateral Offsets from Travel Way to Beginning of Need (Y)

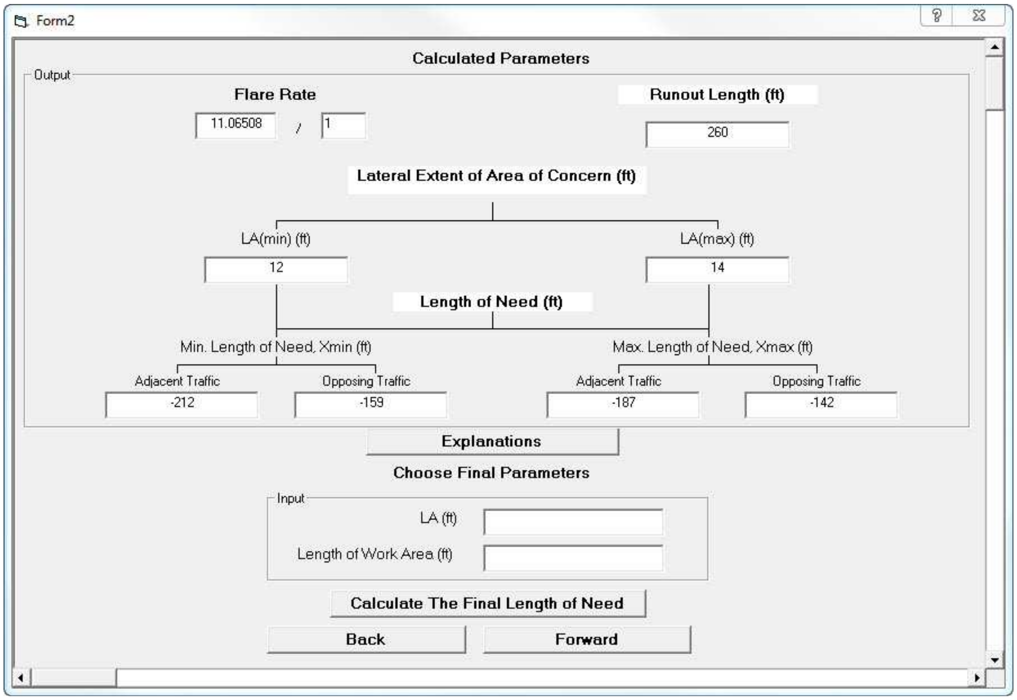
The Lateral Offset (Y) from the edge of the traveled way to the beginning of the Length of Need (X) when barrier is flared can be calculated by using the following equation:

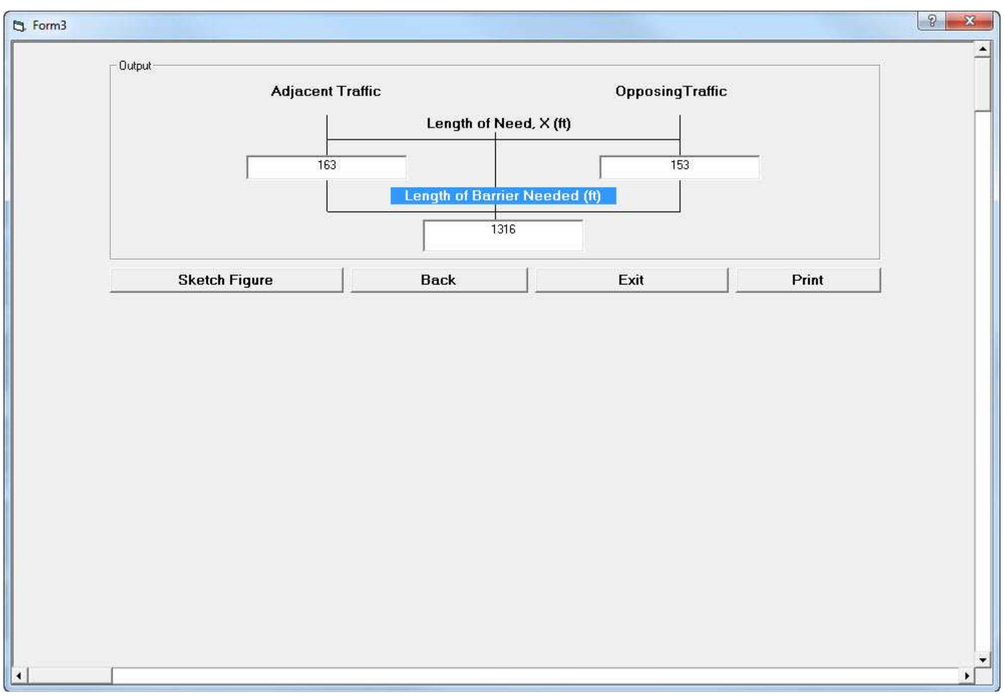
$$Y = L_A - \frac{L_A}{L_R} X$$

5.9.1.9 Length of Need Program

The WZTCS has a computer program that will calculate the results for all the equations discussed. The Length of Need program was developed for the WZTCS by NC State University. The following are examples of the input and output screens for the program:




Form2
Calculated Parameters
Output
Flare Rate
11.06508
/
1
Runout Length (ft)
260
Lateral Extent of Area of Concern (ft)
LA(min) (ft)
12
LA(max) (ft)
14
Length of Need (ft)
Min. Length of Need, Xmin (ft)
Adjacent Traffic
-212
Opposing Traffic
-159
Max. Length of Need, Xmax (ft)
Adjacent Traffic
-187
Opposing Traffic
-142
Explanations
Choose Final Parameters
Input
LA (ft)
Length of Work Area (ft)
Calculate The Final Length of Need
Back
Forward


Form3
Output
Adjacent Traffic
OpposingTraffic
Length of Need, X (ft)
163
153
Length of Barrier Needed (ft)
1316
Sketch Figure
Back
Exit
Print

5.9.2 Area of Concern on a Horizontal Curve

The Length of Need equation discussed above is applicable to straight highway alignment **only**. A vehicle leaving the road on the outside of a curve will generally follow a tangential runout path. Therefore, rather than using the theoretical L_R distance to calculate the Length of Need (X), use the tangent line from the curve to the outside edge of the hazard (or Clear Zone distance if the hazard extends past the Clear zone). The barrier Length of Need then becomes a function of the barrier offset from the traveled way edge and can be obtained graphically by scaling. A flare should not be used along horizontal curves 3 degrees or greater. A crashworthy end treatment is required if the barrier approach end is within the Clear Zone.

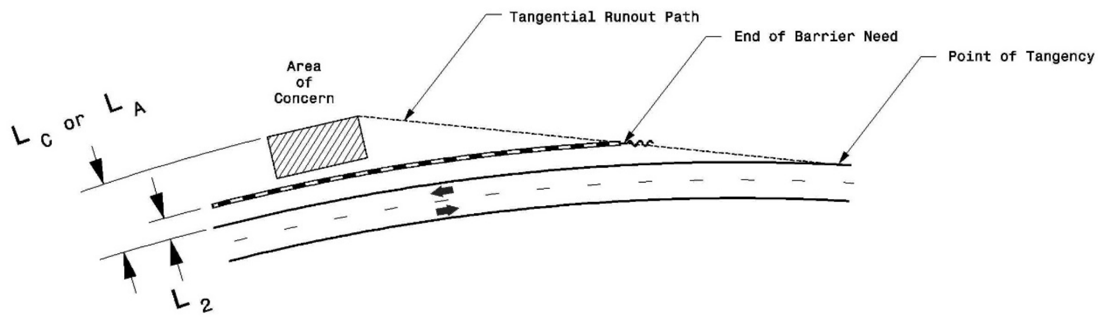


Figure 22 – Area of Concern on a Horizontal Curve

5.9.1 Appendix A Graphs & Charts

Table 3-1 Clear-zone distance in feet from edge of through traveled way
***Roadside Design Guide* p. 3-3**

[U.S. Customary Units]

DESIGN SPEED	DESIGN ADT	FORESLOPES			BACKSLOPES		
		1V:6H or flatter	1V:5H TO 1V:4H	1V:3H	1V:3H	1V:5H TO 1V:4H	1V:6H or flatter
40 mph or less	UNDER 750	7 - 10	7 - 10	**	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	**	10 - 12	10 - 12	10 - 12
	1500 - 6000	12 - 14	14 - 16	**	12 - 14	12 - 14	12 - 14
	OVER 6000	14 - 16	16 - 18	**	14 - 16	14 - 16	14 - 16
45 - 50 mph	UNDER 750	10 - 12	12 - 14	**	8 - 10	8 - 10	10 - 12
	750 - 1500	12 - 14	16 - 20	**	10 - 12	12 - 14	14 - 16
	1500 - 6000	16 - 18	20 - 26	**	12 - 14	14 - 16	16 - 18
	OVER 6000	18 - 20	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	UNDER 750	12 - 14	14 - 18	**	8 - 10	10 - 12	10 - 12
	750 - 1500	16 - 18	20 - 24	**	10 - 12	14 - 16	16 - 18
	1500 - 6000	20 - 22	24 - 30	**	14 - 16	16 - 18	20 - 22
	OVER 6000	22 - 24	26 - 32 *	**	16 - 18	20 - 22	22 - 24
60 mph	UNDER 750	16 - 18	20 - 24	**	10 - 12	12 - 14	14 - 16
	750 - 1500	20 - 24	26 - 32 *	**	12 - 14	16 - 18	20 - 22
	1500 - 6000	26 - 30	32 - 40 *	**	14 - 18	18 - 22	24 - 26
	OVER 6000	30 - 32 *	36 - 44 *	**	20 - 22	24 - 26	26 - 28
65 - 70 mph	UNDER 750	18 - 20	20 - 26	**	10 - 12	14 - 16	14 - 16
	750 - 1500	24 - 26	28 - 36 *	**	12 - 16	18 - 20	20 - 22
	1500 - 6000	28 - 32 *	34 - 42 *	**	16 - 20	22 - 24	26 - 28
	OVER 6000	30 - 34 *	38 - 46 *	**	22 - 24	26 - 30	28 - 30

* Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear zone distances greater than the clear zone shown in Table 3-1. Clear zones may be limited to 3D II for practicality and to provide a constant roadway template if previous experience with similar projects or designs indicates satisfactory performance.

* Since recovery is best likely on the unshielded, traversable 1V:3H slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery area at the toe of slope should take into consideration right-of-way availability, environmental concern, economic factors, safety needs, and crash histories. Also, the distance between the edges of the <u>shoulder</u> traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited by several factors, the foreslope parameters which may enter info determining a maximum desirable recovery area are illustrated in Figure 3.2.

Table 3-2 Horizontal Curve Adjustments
***Roadside Design Guide* p. 3-4**

K_{CZ} (Curve Correction Factor) [U.S. Customary Units]

RADIUS [ft]	DESIGN SPEED [mph]						
	40	45	50	55	60	65	70
2860	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2290	1.1	1.1	1.2	1.2	1.2	1.3	1.3
1910	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.4	1.5
1430	1.2	1.2	1.3	1.3	1.4	1.4	--
1270	1.2	1.2	1.3	1.3	1.4	1.5	--
1150	1.2	1.2	1.3	1.4	1.5	--	--
950	1.2	1.3	1.4	1.5	1.5	--	--
820	1.3	1.3	1.4	1.5	--	--	--
720	1.3	1.4	1.5	--	--	--	--
640	1.3	1.4	1.5	--	--	--	--
570	1.4	1.5	--	--	--	--	--
380	1.5	--	--	--	--	--	--

$$CZ_C = L_C * K_{CZ}$$

Where:

CZ_C = clear zone on outside of curvature, meters [feet]
L_C = clear-zone distance, meters [feet] (Figure 3.1 or Table 3.1)
K_{CZ} = curve correction factor

Note: The clear-zone correction factor is applied to the outside of curves only. Curves flatter than 900 m [2860 ft] do not require an adjusted clear zone.

Table 9-1 Example of clear-zone widths for work zones
***Roadside Design Guide* p. 9-2**

Speed (km/h)	Widths (m)	Speed [mph]	Widths [ft]
100 - 110	9	[60 - 70]	[30]
90	7	[55]	[23]
70 - 80	5	[45 - 50]	[16]
50 - 60	4	[30 - 40]	[13]

Figure 5-1b Comparative risk warrants for embankments
***Roadside Design Guide* p. 5-6**

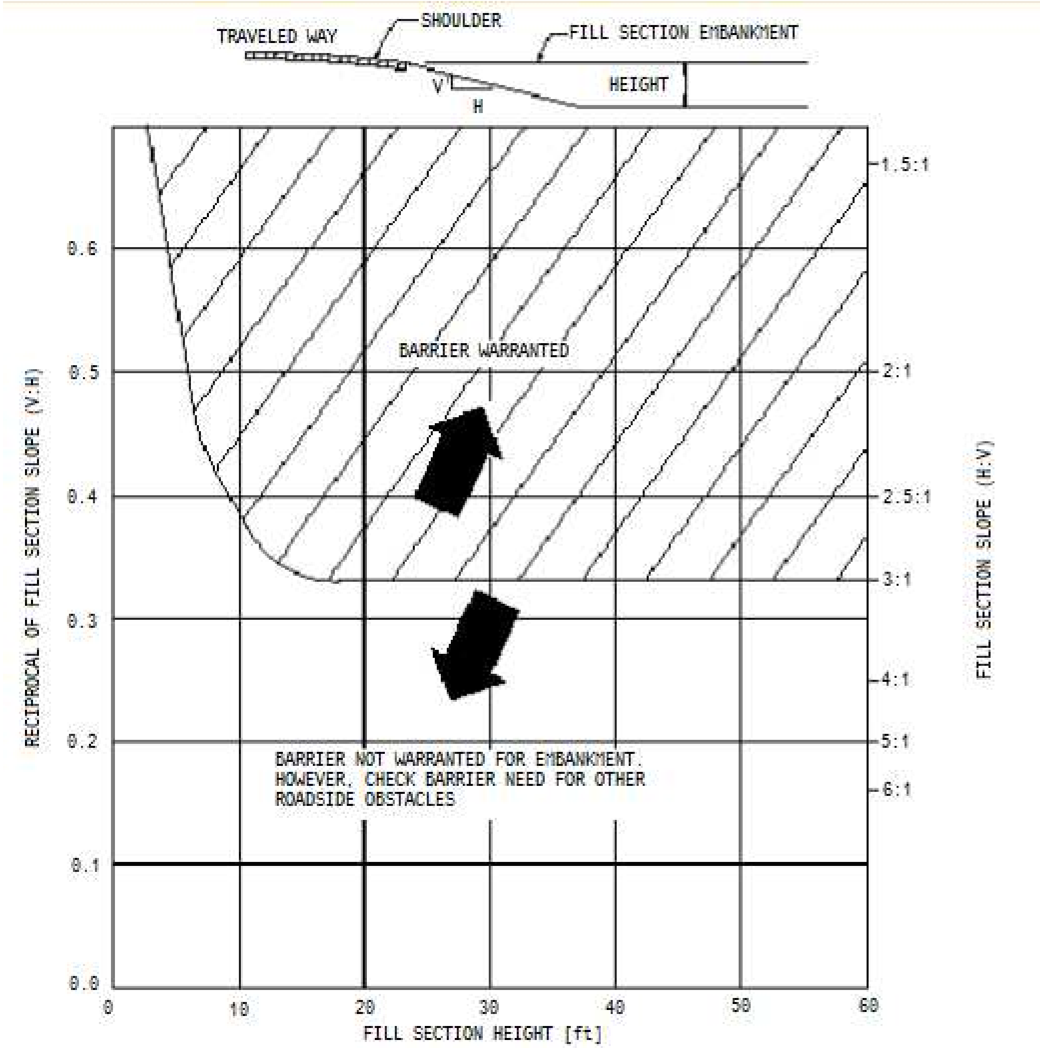


Figure 5-2b Example design chart for embankment warrants based on fill height, slope, and traffic volume
***Roadside Design Guide* p. 5-7**

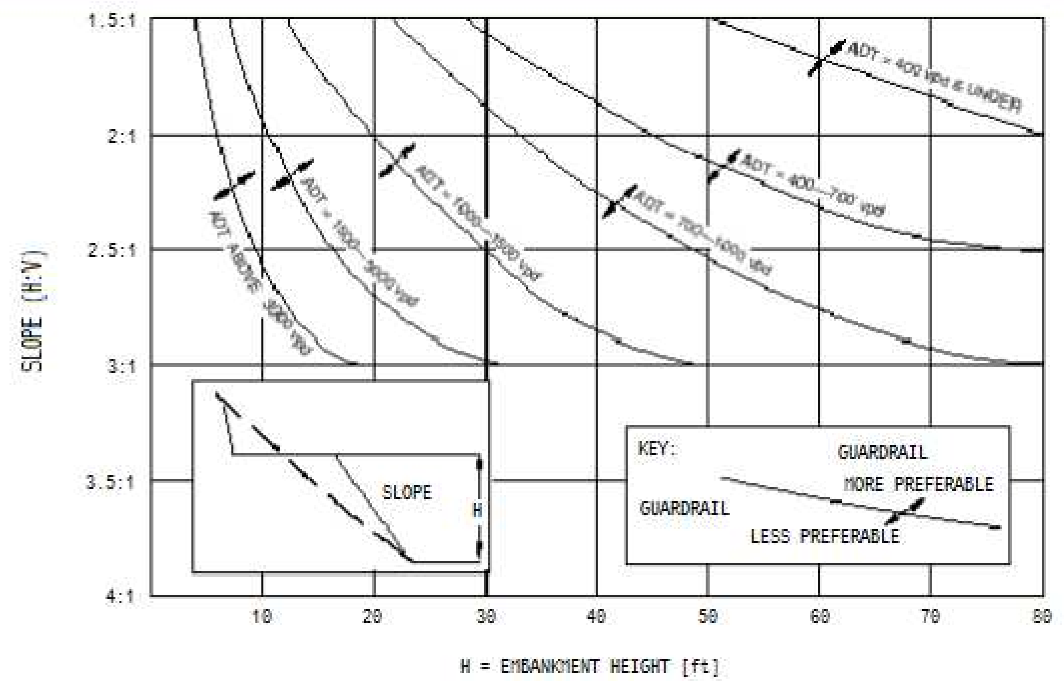
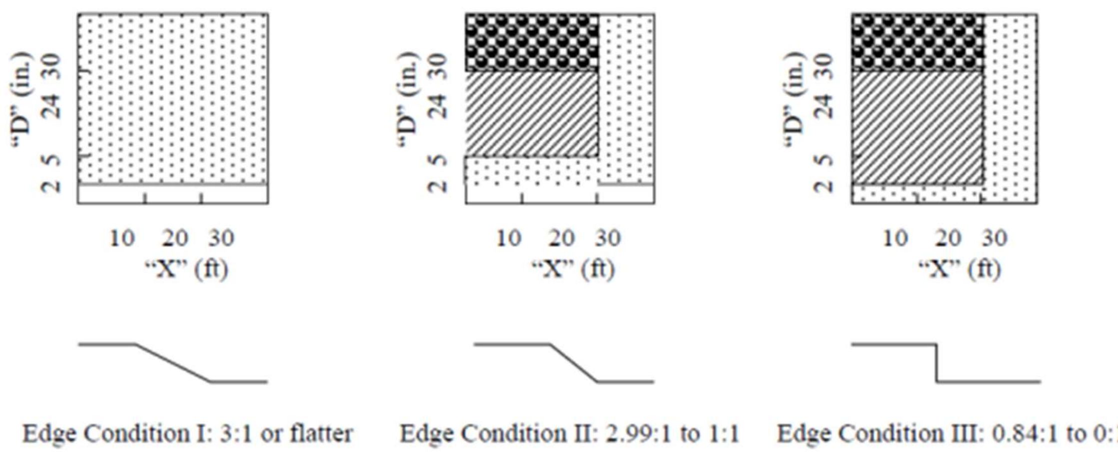
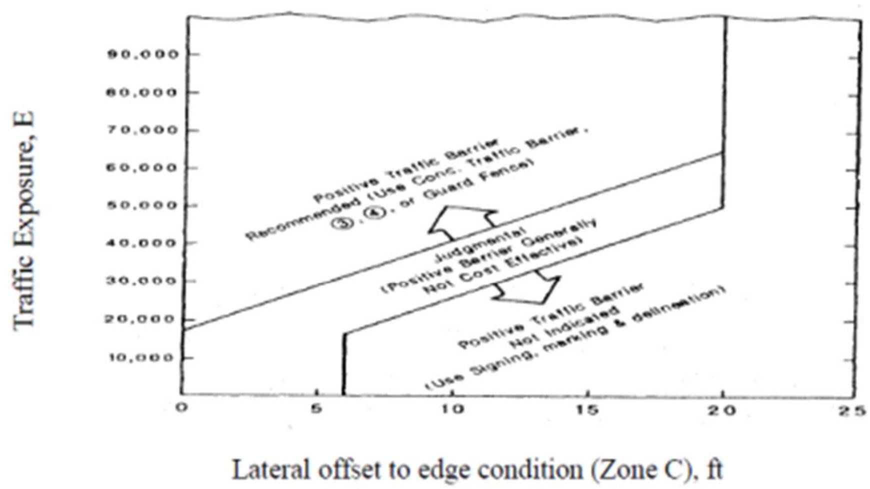


Figure 16 **Definition of Treatment Zones and Treatment Selection Guidelines for Various Edge Conditions**
CTRE Iowa State University: *Traffic Control Strategies in Work Zones with Edge Drop-offs* p. 38



Zone	Usual Treatment
A	SHOULDER DROP-OFF or UNEVEN LANES signs plus vertical panels.
B	SHOULDER DROP-OFF or UNEVEN LANES signs plus drums with steady burn lights. Where restricted space precludes the use of drums, use vertical panels. An edge fill may be provided to change the edge slope to that of the preferable Edge Condition I.
C	Check indications for positive barrier. Where positive barrier is not indicated, the treatment shown above for zone B may be used after consideration of all other applicable factors.

Figure 17 **Conditions Indicating Use of Positive Protection**
CTRE Iowa State University: *Traffic Control Strategies in Work Zones with Edge Drop-offs* p. 39



Notes:

1) E = ADT * T, Where ADT is that portion of the average daily traffic volume traveling within 20 feet (generally two adjacent lanes) of the edge dropoff condition and, T is the duration time in years of the dropoff condition.
2) Primarily applicable to high speed conditions only.
3) Barrel Mounted Guard Fence may be used in lieu of CTB where speeds of 45 mph or less and impacting angles of 15 degrees or less are anticipated.
4) An approved end treatment should be provided for any positive barrier end located within a lateral offset of 20' from the edge of the travel lane.

Table 17 Typical Criteria for Consideration for Temporary Traffic Positive Protection CTRE Iowa State University: *Traffic Control Strategies in Work Zones with Edge Drop-offs* p. 76

State	Criteria
Iowa	Drop-off depth > 10 inches, located within 10 feet of travel way (informal)
Arkansas	Drop-off depth > 5 feet
California	Drop-off depth > 6 inches, located within 8 feet of travel way; special engineering consideration for all drop-offs > 2.5 feet
Florida	Drop-off depth > 3 inches, located within 12 feet, project duration > 1 day
Minnesota	Optional for drop-off depth > 4 inches, if no wedge, located adjacent to travel way, speed > 30 mph, project duration > 3 days, length < 50 feet; if 12 inches, recommended
Missouri	Alternative for use with lane closures when drop-off depth > 2 inches
Montana	Drop-off located within 30 feet of travel way, if no wedge provided, exposures exceeding 48 hours, spacing factor < 20 feet by formula)
New York	Drop-off depth > 2 feet, speed limit > 45 mph, AADT ≥ 7500, project duration ≥ 60 days
North Dakota	Drop-off depth > 5 inches located between travel lanes, drop-offs depth > 12 inches, located adjacent to travel way, speed limit> 30 mph, project duration > 7 days, project length > 50 feet.
Ohio	Drop-off depth > 5 inches located between travel lanes, drop-off depth > 2 feet located within 30 feet of travel way, overnight exposure
Texas	Drop-off depth > 2 feet, speed limit > 40 mph
West Virginia	Drop-off depth > 3 inches, project duration > 48 hours, speed limit > 45 mph, located within 30 feet of travel way on multilane highways, located within 20 feet of travel way on undivided highways

NC Drop-off Guidelines Criteria
Drop-off depth < 2 inches, located within 10 feet or less of travel way
Drop-off depth within 2 - 3 inches, located within 10 feet or less of travel way
Drop-off depth > 3 inches, located within 8 feet of travel way
Drop-off depth within 3 – 12 inches, located within 10 feet or less of travel way
Drop-off depth > 12 inches, located within 10 feet or less of travel way
Drop-off depth within 2 – 30 inches, located within 10 to 30 feet of travel way
Drop-off depth > 30 inches, located within 10 to 30 feet of travel way

***Refer to NC Drop-off Guidelines in WZTC Design Manual**

5.9.2 Appendix B Examples

Engineering Study to determine if Positive Protection is warranted

Problem:
Culvert extension to one side of a 2L2W. Shoring is required to hold back existing fill slope once existing wings and headwall removed. Shoring location is approximately 15' right of the travelway. Several drives are within the possible barrier length of need.

Exposure Control Measures investigated:

1. No available detour routes.
2. Using temporary pavement or on-site detour not practical due to stream/environmental impacts on the opposite side of the road.

Clear Zone:
Per Roadside Design Guide, the clear zone is 20 - 24' based on 60 mph speed and ADT of 6000. Since this is a work zone, assume the low end of this range.

The hazard is inside this range.

Traffic Speeds:
Posted speed is 55 mph but 85% is probably around 60 as this is a rural route; not heavily congested.

Roadway Geometry:
Favorable; relatively flat and straight.

Duration:
Traffic expected to be exposed to the hazard for 1 month or less based on input from the Resident.

Impacts on project cost:
Significant. If PCB was used, as many as 4 crash cushions would be necessary due to breaks in the PCB for the driveways.

Conclusion:
The hazard is within the clear zone for a final design, however it is fairly close to the limit. It should be expected that motorist would have a heightened sense of awareness due to advance warning signage and delineation. With this said, whether or not the hazard is within the clear zone in a work zone application is debatable.

It could be argued that the severity of crash would be worse striking PCB here and then redirected into the path of oncoming traffic.

Multiple crash cushions due to the drives significantly raises costs and the breaks in the PCB over a short length would lessen the effectiveness of PCB.

Based on this, in combination with the relatively short duration, the recommendation was not to use PCB at this site. However, we did recommend increasing the level of delineation at the site by using water-filled barrier, not as positive protection, but as a superior delineator to drums or cones. This would also add a minor degree of positive protection that is much more forgiving than PCB.

Engineering Study to determine if positive protection is warranted

Problem:
End Bent #2 shall be constructed during a full road closure under a 60 day ICT. Upon completion, the road will be reopened to traffic on the existing alignment with the exposed EB about 10 ft from the SB travel lane.

Exposure Control Measures investigated:

1. There is an available detour. However, three schools are located within 1 mile of the project and the Division as well as the School Board will only support an offsite detour during the summer months. This period will be used to construct the end bent.
2. Using temporary pavement or an on-site detour is impossible due to the proximity of the existing structure, environmental impacts to the existing stream, and possible impacts to a historic property within the project limits.

Clear Zone:
Per the RDG, Table 3-1, the clear zone is 16 to 20 ft. based on a posted speed of 50 mph and a construction year ADT of 1300 vpd. Since this is a work zone and there are 30 mph design exceptions in the roadway plan, we went with the low end of this range.

The hazard is 10 ft from the travel way; clearly within the clear zone even if a 30 mph speed is used for clear zone analysis.

Roadside Geometry
The geometry was quite adverse based on horizontal curvature of 15 degrees and a slope of 8%.

Duration:
The traffic was expected to be exposed to the hazard for 1 to 3 months. Hazards associated with installation of PCB are a non-issue because the PCB can be installed while the detour is in place.

Conclusion:
Positive Protection was warranted due to the long term presence of a rigid object clearly within the clear zone. Roadside geometrics were also clearly adverse. It was reasonable to assume a higher than normal percentage of drivers would be inexperienced due to the proximity of a high school. Offsite and onsite detours were investigated as a means to lessen the exposure of motorist. Neither was determined to be practical or feasible.

5.10 Design Resources

"Manual on Uniform Traffic Control Devices", *Federal Highway Administration,* Washington, DC, November 2009

"Roadside Design Guide", *American Association of State Highway and Transportation Officials*, Washington, DC, 2002

"NCHRP Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features," *Transportation Research Board*, Washington, DC, 1993.

NCHRP Report 350 Test 3-11 of the North Carolina Department of Transportation, Design Portable Concrete Barrier for FHWA Approval Test #2, Test No.:020104

Precast Concrete Barrier Crash Testing, Final Report SPR 330, December 2001, Oregon Department of Transportation.

Energy Absorption Systems, Inc., One East Wacker Drive, Chicago, IL, 60601.

Barrier Systems Inc., 180 River Road Rio Vista, CA. 94571

American Association of State Highway and Transportation Officials. Roadside Design Guide.

Ivey, Don L., King K. Mak, Harold D. Cooner, and Mark A. Marek. "Safety in Construction Zones Where Pavement Edges and Drop-Offs Exist." Transportation Research Record 1163, 1988, pp. 43-62.

Center for Transportation Research and Education, Department of Civil and Construction Engineering, Iowa State University, "Traffic Control Strategies in Work Zones with Edge Drop-Offs", August 2002 p. 76.

Federal Highway Administration. Manual on Uniform Traffic Control Devices (MUTCD). U.S. Department of Transportation, Washington, D.C.

Bryden, James and Mace, Douglas (2002). Guidelines for Design and Operation of Nighttime Traffic *Control for Highway Maintenance and Construction,* National Cooperative Highway Research Program Report NCHRP-476, Transportation Research Board of the National Academies, Washington, D.C.

Chapter 6: Law Enforcement Usage

6.1 Introduction

We all associate law enforcement officers with protecting the public, maintaining order, preventing and detecting crime, and enforcing traffic laws and criminal laws. Law enforcement officers have earned our trust and respect because of their professionalism in regards to public safety.

Because of this trust and respect, they have been a useful resource in other traffic-related functions. They are regularly used to help direct traffic during major sporting events, visits from dignitaries, unexpected roadway incidents that disrupt normal traffic flow, and similar special events.

Additionally, law enforcement officers may also be used to direct traffic during roadway construction activities where their presence has more impact than that of a contractor flagman (flagger) or used to assist in speed compliance.

6.2 Definitions & Abbreviations

Law Enforcement – The governmental department charged with the regulation and control of the affairs of a community, established to maintain order, enforce the law, and prevent and detect crime.

6.3 Policies

Law enforcement is used for 4 primary purposes in work zones:

1. To provide a “presence” for lane closures on interstates by using their blue lights to regulate/control speeds, when available
2. To provide flagging through signalized intersections
3. To assist with rolling roadblock operations when the Contractor elects to not use Truck Mounted Attenuators (TMAs)
4. To provide targeted enforcement on high risk work zones identified through the HAWKS Program

HAWKS (Help All Work Zones Keep Safe) Program

This program is through the State Highway Patrol and is already funded by NCDOT. No additional compensation in terms of a contract pay item is necessary. The off duty patrolmen serve as speed enforcement for work zones that qualify for this program. Potential Hawks projects are scored based on 4 or 5 criteria. Projects are evaluated by the State Work Zone Operations & Programs Engineer to determine eligibility for HAWKS. During construction, the Resident Engineer may request an additional evaluation for HAWKS based on field conditions.

6.4 Design Issues

The Traffic Control Plan designer should analyze all of the construction activities on the project to determine if the use of law enforcement officer might be better suited for a particular construction operation. The following are some construction situations, which the designer might want to consider using law enforcement:

- At the road closure and/or detour point/s when installing bridge girders over a travelway
- When construction affects traffic at a signalized intersection
- When relocating or installing a new traffic signal under traffic
- Bringing traffic to a halt on a major roadway
- Directing traffic through an interchange ramp
- Pacing traffic
- Patrolling to ensure speed compliance

The use of law enforcement during roadway construction activities is only a supplement to the traffic control design for the particular operation. The Traffic Control Plan designer needs to design or refer to the appropriate Roadway Standard Drawing in the Traffic Control Phasing for the operation which law enforcement presence is deemed necessary. Additionally, the designer should show the suggested location of the law enforcement presence on the detail sheet that shows the construction activity.

6.5 Design Criteria

The recommended use of law enforcement for a particular construction activity is at the discretion of the designer.

"Law Enforcement" is a Traffic Control contract pay item and is paid for in the number of hours law enforcement usage is deemed necessary for a given project. The designer will have to calculate the number of hours that law enforcement officers are needed on the project and include this value in the estimate.

6.6 Design Resources

The following are good resources for helping to determine whether or not law enforcement should be used for a particular construction activity:

- Traffic Control Project Design Engineer
- Traffic Control Project Engineer
- Division Construction Engineer
- Resident Engineer

Chapter 7: Ramps / Ramp Treatment

7.1 Introduction

Stop signs used at ramps are no longer an accepted standard of practice in NC. When traffic control interferes at a ramp entrance to an interstate or freeway, proper acceleration length and yield signs are required. If the proper acceleration length can't be maintained, the ramp shall be closed. The minimum acceleration length (full acceleration lane) is 400' followed by a 300' merge taper. The same design standard applies when mainline traffic is shifted onto the shoulders. When this occurs, the existing acceleration lane length shall be maintained or at least the 400' full acceleration with 300' taper. If this can't be maintained, the ramp shall be closed.

The purpose of this chapter is to give the designer a feel for the guidelines set forth by the Work Zone Traffic Control Section concerning stop signs and ramps in the Work Zone and how to best utilize the resources used in designing Traffic Control plans.

7.2 Definitions & Abbreviations

The primary definitions/abbreviations needed for this chapter will be the following:

Acceleration Lane – The auxiliary lane leading from a ramp to a highway and designed to enable the motorist to accelerate and merge into highway traffic at highway speed.

Deceleration Lane – The auxiliary lane leading from a highway to a ramp and designed to enable the motorist to decelerate from highway speed to safely stop at the end of a ramp.

Entrance Ramp – The portion of a ramp that, in the flow of traffic, the motorist is encouraged to accelerate in order to merge with highway traffic.

Exit Ramp – The portion of a ramp that, in the flow of traffic, the motorist is encouraged to decelerate in order to stop at the intersection of another roadway.

Gore Area – In the case of an exit ramp, the part of a roadway at which the ramp and the highway become two separate roadways or the last place the motorist must decide if he/she will exit the highway or continue. In the case of an entrance ramp, the part of a roadway at which the ramp and the highway become one roadway or the place the motorist must start merging with traffic.

Terminal Section – The portion of a ramp where it intersects with (or t's into) another roadway.

Work Zone – Any continuous tract or area of a roadway in which construction or maintenance is being performed that will impact the acceleration lane of an entrance ramp.

7.3 Guidelines

Due to the extremely dangerous intersection angle that is created, the practice of designing a stop condition at an entrance ramp is strongly discouraged. Closure of the ramp should be investigated for feasibility as well as utilizing temporary acceleration lanes of sufficient length (400'+/- - 75% of existing acceleration lane or whichever is greater) or matching existing length.

A yield condition for the ramp with adequate signing warning the motorist is the most accepted method of moving traffic through the Work Zone (See Roadway Standard Drawings No. 1101.02). In these instances, lowering the highway speed limit aides the ramp traffic in acquiring adequate merging speed. The right lane should be closed sufficiently in advance to stabilize traffic flow before encountering the merge (See Roadway Standard Drawings 1101.02).

Engineering judgment is to be used in all instances. However, certain criteria can be used to justify stopping traffic on a ramp. For example, ramps approaching stop signs should be perpendicular or nearly perpendicular to the crossroad and be nearly level for storage of several vehicles. Open lines of communication to discuss justification amongst the Work Zone Traffic Control Section, Regional Traffic Engineer, and the Division Construction Engineer will be needed when considering a stop condition. Factors to consider on the ramp and the highway include stopping sight distance, average daily traffic, posted speed limits, and existing level of service of the ramp.

Additional consideration for stopping ramp traffic is setting a time limit on the ramp stop condition. Limiting the ramp stoppage to off peak hours or to three consecutive days or less will considerably improve the safety and management of the Work Zone area. However, stopping traffic on a ramp is still dangerous, even if only for a short time, and is still discouraged.

7.4 Design Resources

Design resources other than this book include:

AASHTO A Policy on Geometric Design of Highways and Streets
Highway Engineering Concepts Course textbook
Roadway Design Manual
Manual on Uniform Traffic Control Devices, Part 6
Roadway Standard Drawings

Chapter 8: Reduce Speed

8.1 Introduction

Speed Reductions

Speed Reductions are intended to be used as a traffic operational tool. Reduced speed limits should be used only in the specific portion of the work zone where special conditions or restrictive features are present. However, frequent changes in the speed limit should be avoided.

A traffic control plan should be designed so vehicles can reasonably and safely travel through the work zone. That design may or may not require a speed limit reduction. If a speed reduction is required, it should be no more than 10 mph. A reduction of more than 10 mph in the speed limit should be used only when required by restrictive features in the work zone. Where restrictive features justify a speed reduction of more than 10 mph, additional driver notification should be provided. The speed limit should be stepped down in advance of the location requiring the lowest speed, and additional traffic control devices should be used.

Lowering the regulatory speed limit should be avoided as much as practical because drivers will reduce their speeds only if they clearly perceive a need to do so.

Speeding Penalty

Speeding Penalties are intended to be used to strengthen the existing speed limit or a reduced speed limit in a work zone. Speeding Penalties should be used only when a speeding problem exists or is anticipated.

Speeding Penalties should be used sparingly to ensure enforcement and credibility. If used everywhere, the penalty would lose its worth with the administrative parties and the public.

8.2 Guidelines

Speed Reductions

Speed Reductions require a speed ordinance signed by the State Traffic Engineer in order for the reduced speed to be legally enforced. It is the Work Zone Traffic Control Section's responsibility to make sure the motorist is aware of the speed reduction by using advance warning signs. It is also our responsibility to make sure an ordinance is written for speed reductions before the traffic control associated with the speed reduction is incorporated into a traffic control plan.

Speeding Penalties

Speeding Penalties require an ordinance signed by the State Traffic Engineer in order for the penalty to be legally enforced. It is the Work Zone Traffic Control Section's responsibility to make sure the motorist is aware of the speeding penalty by using advance warning signs. It is also our responsibility to make sure an ordinance is written for speeding penalties before the traffic control associated with the speeding penalty is incorporated into a traffic control plan.

Best Practice

North Carolina Department of Transportation has two different methods and criteria for establishing work zone speed limit reductions. The most commonly used method is temporary speed reduction using portable devices such as portable changeable message signs and portable signs to reduce the speed limit. This method is a short term solution, as it can only be applied for up to 30 days. This first method is typically used during lane closure activities on freeways or interstates with speed limits of 60 MPH or higher to improve worker safety. The second approach is to use standard speed limit signs to reduce speed for a more long term impact on a larger project. This second approach is normally used where significant changes in lane geometry have occurred, lane widths are significantly reduced, and/or the shoulders have been essentially eliminated. This method is typically used to improve motorist safety due to work zone conditions on freeways or interstates with a speed limit of 60 MPH or higher which have significant lane geometry alterations and/or shoulder restrictions throughout the length of the project. For both applications, $250 fine signs are implemented in addition to the speed reduction signs. All of these types of signs must be approved first by the State traffic Engineer before they can be implemented. These methods improve driver compliance with work zone speed limits and lead to a smother traffic flow and less speed variance in the work zone which ultimately contributes to fewer crashes.

8.3 Procedures/Standard Practice

8.3.1 Work Zone Ordinance Request Form (Click to Retrieve Form)

8.3.2 Guidelines for WZ Speed Limit Reduction Ordinances

Standard Practice For Work Zone Speed Limit Guidelines for NC Highway Construction and Maintenance Activities on High Speed Facilities

Purpose: This guideline provides guidance and uniformity on the establishment of work zone speed limits for highway work zones.

Objective: The objective of this guideline is to identify conditions where it's appropriate to reduce the speed limit on freeways with existing speed limits of 65 MPH and above for work being performed in construction and maintenance work zones.

Guideline: The Work Zone Traffic Control Section in consultation with the Regional Traffic Engineering staff has developed these guidelines to provide guidance and uniformity in the implementation of reducing the speed limit in work zones. The intent is to coordinate and implement "best strategies" to address work zone speed limits for construction and maintenance activities. In accordance with the provisions described in Chapters 6B,C and D of the MUTCD, this guideline has been crafted to ensure thorough engineering study prior to implementation of interim speed limit reductions.

Speed limit reductions are made in the interest of safety for the motoring public due to active project conditions, or they can be made if the reduction is intended for the safety of the construction worker. Before a speed limit reduction is implemented, an analysis is to be made by the engineer to determine if a speed limit reduction strategy is the best solution.

This guideline has been developed to address the need and application for "Work Zone" speed limit reductions, which focus on the 'static' type of construction zones. These projects generally contain restrictive features throughout their entire length, which may require added decision making, increased reaction times, and other driver focused actions where slower speeds can allow for better driver recognition and reaction.

However, this guideline can not cover every situation that may be encountered in construction and maintenance work zones. There are many factors that can come into play that are not covered in this guideline which may justify the use of a Work Zone speed limit reduction. Therefore exceptions can be made on a case by case basis which may justify the use of a "Work Zone" speed limit reduction. Appropriate judgment must be used in applying the guidelines**.** Exceptions to the required criteria below will be considered on a case by case basis. Whenever these arise, the Work Zone Traffic Control Section will coordinate with the Regional Traffic

Engineers to evaluate the conditions and associated operations to recommend the most appropriate course of action.

The State Traffic Engineer will have the final decision making authority as to whether the "Work Zone" speed limit is implemented. Below are the definition, criteria and application for work zone speed limits.

A **"Work Zone" Speed Limit** is one that reduces the existing speed limit with standard stationary mounted speed limit signing and enacted ordinances for freeways with speed limits of 65 MPH and above. These speed limits are intended for continuous posting with regulatory signs on projects with long duration work (greater than 30 days).

Also, these speed limits should be used where it is imperative for the motorists to reduce speeds in order to safely navigate through lane restrictions and other potential obstacles encountered in the construction zone. These speed limits should only be posted when and where the roadway construction environment continuously dictates the need for a reduced speed. The factors that led to the need to establish a lower speed limit should also be present 24 hours a day. Only the specific portion of the work zone where conditions warrant or restrictive features are present shall receive consideration for the speed reduction. In addition, only certain phases of construction may warrant this reduction.

After the State Traffic Engineer signs the ordinance, the "Work Zone" speed limit signs can be installed on the project according to the drawings. In addition, if a project warrants a "Work Zone" Speed Limit reduction, it automatically qualifies for the $250 speeding penalty. This additional speed fine is also to be ordinanced by the State Traffic Engineer.

After the restrictive feature or features necessitating the "Work Zone" speed limit are mitigated, the State Traffic Engineer is to be notified to rescind the ordinance, the work zone speed limit signs are to be removed, and the existing speed limit restored. In addition, the State Traffic Engineer will also rescind the $250 speeding penalty ordinance and the $250 speeding penalty signing will be simultaneously removed.

The Work Zone Speed Limit criteria is defined below. In order for a project to "qualify" for this treatment, it must meet all of the warrants in Section I and at least 1 warrant in Section II. If Section II warrants aren't met, the project must meet at least 2 warrants in Section III to qualify.

ORDINANCE CRITERIA

SECTION I

The work zone must meet **ALL** of the following warrants to be considered for the "**Work Zone Speed Limit**" Reduction ordinance. If Section I warrants aren't met, the project doesn't qualify for a "**Work Zone Speed Limit**" reduction ordinance.

1. Existing Speed Limit is 65 MPH or greater

2. Speed reduction applies to an area 1 mile in length or greater.

3. Work zone is of longer duration (Greater than 30 days) where there are continuous obstacles which may create difficult navigation for the motorists. Some of these include long-term median cross-overs, continuous lane closures, on-site detours, narrowed lanes, non-usable shoulders, sharp roadway curvature, etc.

AND

SECTION II

The work zone shall meet **at least one** of the following warrants to be further considered for the "**Work Zone Speed Limit"** Reduction ordinance:

1. **The work zone is adjacent to other project/s where the "Work Zone" speed limit reduction is ordinanced.**

2. Long-term median cross-overs (In continuous use for a period longer than 30 days) where the design speed is lower than the existing posted speed limit

3. Long-term Stationary Lane Closures (In continuous use for a period longer than 30 days) where traffic queuing is expected to be at least ½ mile or more

4. On-site detours (continuously in use longer than 30 days) where the design speed is lower than the existing posted speed limit.

5. The work zone utilizes traffic shifts of more than 6 feet while using a **Minimum** shifting taper and/or the alignment design speed is less than the posted speed limit

6. The work zone eliminates a usuable outside shoulder (less than 8') **AND** either permanent barrier/guardrail/guiderail or temporary barrier/guardrail/guiderail prevents vehicle pull-off into the median for a distance greater than ½ mile.

7. The work zone creates travel lane widths less than 11’ for a distance that exceeds ½ mile.

8. Work zone includes a minimum of one interchange per mile of length.

OR

SECTION III

The work zone shall meet **at least two** of the following warrants in Section III to be further considered for the Work Zone Speed Limit reduction ordinance.

1. Site conditions are such that safe navigation requires consideration of a speed limit reduction, examples may include an old concrete pavement experiencing structural failure with construction joints and pavement marking alignment conflicts. Another may be adverse roadway geometry (below current standards) or sight distance due to grade or alignment changes, tunnels, etc.

2. The accident rate and/or severity crash rate for the facility (prior to construction) is higher than the statewide rates as compared to other similar facilities.

3. The work zone crash rate and/or work zone severity crash rate for the corridor (prior to construction) is higher than the 5 year average as compared to similar facilities.

4. Current Truck Traffic levels greater than 15% of the AADT in the work zone

SECTION IV-IMPLEMENTATION PROCESS

1. Process initiated by contract from the Work Zone Traffic Control Section of the Transportation Mobility and Safety Division to the Regional Traffic Engineer’s office requesting an engineering investigation. The initiation may come from the Division office or others.

2. Engineering Investigation will include a review of the existing posted speed limit and the 85th percentile speeds.

3. In addition, the Work Zone Speed Limit Reduction Criteria will be reviewed by the Work Zone Traffic Control Section to determine if the project meets the above criteria.

4. The Work Zone Traffic Control Section and the Regional Traffic Engineer will discuss and collaborate on the results of the review and determine whether to implement the Work Zone Speed Limit Reduction.

5. If it is determined the existing speed limit should be lowered, then the $250 fine for speeding should also be used.

6. If the ordinances are approved, the Regional Traffic Engineer will notify the Resident Engineer and the Work Zone Traffic Control Section.

7. Also, if implemented, it may only be for a specific segment of the work zone, or it may only be for a specific phase for the work zone.

8. In order for the Work Zone Speed Limit to be a valid and enforceable speed limit, the ordinance has to be approved and signed by the State Traffic Engineer. No work zone speed limit signs are to be installed before the ordinance is in effect.

9. Notify the Regional Traffic Engineer to rescind the ordinance once the Work Zone Speed Limit is no longer warranted.

10. Once the ordinance is rescinded the existing posted speed limit shall be returned.

11. See attached drawings for the correct signs and sign locations for this application.

SECTION V- SIGNING APPLICATION

Whenever a project warrants a “Work Zone” speed limit reduction, the existing speed limit signs are to be removed and the work zone speed limit displayed with appropriate supplemental signing attached, to include the $250 fine signs. Typical speed limit reductions are 10 MPH below the existing posted speed limit. In 70 MPH speed zones, a maximum 15 MPH speed reduction may be used. It is strongly recommended that no speed limits below 55 MPH be posted on fully controlled access facilities. The Regional Traffic Engineer, after consulting with the Division, will determine the speed limit with the final approval being made by the State Traffic Engineer.

The advance warning for the upcoming “work zone” speed limit will be the speed reduction warning signs W3-5 and W3-5A. The “begin” location for the $250 fine is the place where the “BEGIN ROAD WORK” sign is located and the associated “BEGIN $250 FINE” sign is mounted below it. The beginning location for the “work zone” speed limit will typically be at the project limits and most often will be signed as 55 MPH. The “work zone” speed limit signs with have a black on orange “WORK ZONE” panel above the speed limit sign (R2-1) and a black on white “250 FINE” sign mounted below. However, this location does not always have to begin at the project limit. It may initiate inside the project if the conditions warranting the reduction are located well inside the project. Also, the project may warrant the “work zone” speed limit for a certain phase of work instead of the entire project duration. When this occurs, the speed limit shall be returned and the $250 fine signs removed when the conditions warranting the “work zone” speed limit are mitigated. The termination point for the “Work Zone” speed limit will typically be at the ending project limit and will be indicated with a regulatory, speed limit sign with the in-place speed limit for the roadway ahead. This is to inform the drivers that the “Work Zone” speed limit has ended. However, it’s possible the “work zone” speed limit may end before the end of the project limit. When this occurs, the “in place” speed limit for the roadway ahead shall be displayed at the location where the conditions warranting the “work zone’ speed limit are mitigated. The end location for the $250 fine is the place where the “END ROAD WORK” sign is located and the associated “END $250 FINE” sign mounted below it. The required signing is shown on a separate drawing.

8.3.2.1 Drawing for WZ Speed Limit Reduction (Link to PDF)

Contact Work Zone Traffic Control for CADD files if necessary.

8.3.3 Guidelines for “Variable” Speed Limit Reduction Ordinances

Guidelines For Work Zone “Variable” Speed Limits For NC Highway Construction and Maintenance Activities on High Speed Facilities

Purpose: This guideline provides guidance and uniformity on the establishment of “variable” speed limits for highway work zones.

Objective: The objective of this guideline is to identify conditions where it’s appropriate to reduce the speed limit on freeways with existing speed limits of 65 MPH and above for specific, short-term work being performed in construction and maintenance work zones.

Guideline: The Work Zone Traffic Control Section in consultation with the Regional Traffic Engineering staff has developed these guidelines to provide guidance and uniformity in the implementation of reducing the speed limit for specific, short-term activities in work zones. The intent is to coordinate and implement “best strategies” to address appropriate work zone speed limits for construction and maintenance activities. In accordance with the provisions described in Chapters 6B,C and D of the MUTCD, this guideline has been crafted to ensure thorough engineering study prior to implementation of interim speed limit reductions.

Work zone “variable” speed limit reductions are implemented in the interest of safety for the construction worker and/or they can be applied if the reduction is intended for the safety of the motoring public due to active project conditions or a combination of both. The focus for this type of application is the short term and/or moving type of work zones which generally have traffic controls implemented such as lane closures, temporary shortterm cross-overs, short-term onsite detours and other temporary patterns and or conditions which may last from 1 to 30 days. During these operations, lane merging, traffic queuing, and non-standard patterns may require added decision making time, increased reaction times, and other driver focused actions where slower speeds can allow for better driver recognition and reaction.

However, this guideline can not cover every situation that may be encountered in construction and maintenance work zones. There are many factors that can come into play which may not be covered in this guideline which may justify the use of a Work Zone “variable” speed limit reduction. Therefore exceptions can be made on a case by case basis. Appropriate judgment must be used in applying the guidelines. Exceptions to the required criteria below will be considered on a case by case basis. Whenever these arise, the Work Zone Traffic Control Section will coordinate with the Transportation Mobility and Safety Division and Division personnel to evaluate the conditions and associated operations to recommend the most appropriate course of action.

The State Traffic Engineer will have the final decision making authority as to whether the work zone “variable” speed limit is implemented. Below are the definition, application and criteria for work zone “variable” speed limit reductions.

A Work Zone “Variable” Speed Limit is one that temporarily reduces the existing speed limit for short-term activities in work zones. These speed limits are intended for passive temporary traffic control activities such as lane closures and other temporary traffic pattern alterations lasting from 1 day up to 30 days at a given location. The Work Zone “Variable” Speed Limit can not be in operation continuously (24/7) for a period exceeding 30 calendar days. If the conditions warrant a longer period, the Work Zone Speed Limit shall be used.

These “variable” speed limits are intended for use where it is imperative to reduce high speed entry into a work area where passive traffic controls are in place or where traffic controls significantly alter the existing traffic patterns. These speed limits should only be posted when and where the traffic controls necessitate a slower speed entry to either provide the workers an environment with fewer high speed encroachments into their work space or for the motorists to safely navigate the temporary traffic controls in place.

Only the specific portion of the work zone where conditions warrant or restrictive features are present shall receive consideration for the work zone “variable” speed reduction. In addition, only certain phases of construction may warrant this reduction.

After the State Traffic Engineer signs the ordinance, the Work Zone “Variable” Speed Limit signs/sign messages can be installed on the project according to the drawings. In addition, if a project warrants a Work Zone “Variable” Speed Limit, it automatically qualifies for the $250 speeding fine. This additional speeding fine is also to be ordinanced by the State Traffic Engineer.

The Work Zone “Variable” Speed Limit warrants are defined below. In order for a project/activity to “qualify” for this treatment, it must meet all of the warrants in Section I and at least 1 warrant in Section II.

ORDINANCE CRITERIA

SECTION I

The work zone must meet of the **ALL** following warrants to be considered for the Work Zone "Variable" Speed Limit ordinance**.** If Section I warrants aren't met, the project doesn't qualify for the "Work Zone Speed Limit" ordinance.

1. The existing Speed Limit is 65 MPH or greater.

2. Work at a "spot location" is of short duration (1 day up to 30 days) with the traffic control usually removed within the same day. A Work Zone "Variable" Speed Limit can NOT be in operation continuously (24/7) for a period exceeding 30 calendar days.

SECTION II

The work zone shall meet **at least one** of the following criteria to be further considered for the **Work Zone "Variable " Speed Limit** ordinance.

1. The work requires temporary 'significant' alterations in the existing traffic pattern such as continuous lane closures (up to 30 days), temporary median cross-overs, temporary on-site detours, and/or temporary "All Exit" road closures and or temporary road closures that involve the stopping of traffic.

2. The worker is actively and visibly performing work behind the passive lane closure.

3. Multiple lane closures on a mega-multi laned facility

4. Night work requiring the use of temporary lane closures.

5. Uneven pavement elevations between travel lanes greater than 2"

6. Work that involves the changing the traffic pattern/s where markings are placed in a revised location and the old markings removed.

If the above criteria are met, the existing speed limit may be reduced. The Division, Work Zone Traffic Control Section and the Traffic Safety Unit will coordinate and provide the required analysis and final determination if a work zone "variable" speed limit is the appropriate action.

When appropriate, the Work Zone "Variable" Speed Limit will be ordinanced by the Regional Traffic Engineer and signed by the State Traffic Engineer. No speed limit information is to be displayed on any device without a signed ordinance by the State Traffic Engineer.

Once the ordinance is signed by the State Traffic Engineer, the Regional Traffic Engineer will contact the Resident Engineer's Office and the Work Zone Traffic Control Section for notification and approval for its use.

SECTION III- IMPLEMENTATION PROCESS

1. Process initiated by contact from the Work Zone Traffic Control Section of the Transportation Mobility and Safety Division to the Regional Traffic Engineer's office requesting an engineering investigation.

2. Engineering Investigation will include a review of the existing posted speed limit and the 85th percentile speeds.

3. In addition, the Work Zone "Variable" Speed Limit Criteria will be reviewed by the Work Zone Traffic Control Section to determine if the project meets the above criteria.

4. The Work Zone Traffic Control Section and the Regional Traffic Engineer will discuss and collaborate on the results of the review and determine whether to implement the Work Zone "Variable" Speed Limit reduction.

5. If the ordinance is approved, the Regional Traffic Engineer will notify the Resident Engineer and the Work Zone Traffic Control Section.

6. Also, if implemented, it may only be for a specific segment of the work zone, or it may only be for a specific phase for the work zone.

7. If it is determined the existing speed limit should be lowered, the $250 fine for speeding should also be used.

8. In order for the Work Zone "Variable" Speed Limit to be valid and enforceable, the ordinance has to be approved and signed by the State Traffic Engineer. No work zone speed limit messages/signs are to be installed in the work zone before the ordinance is in effect.

9. The Resident Engineer will notify the Regional Traffic Engineer to rescind the ordinance once the Work Zone "Variable" Speed Limit is no longer warranted.

10. Once the ordinance is rescinded, the existing posted speed limit shall be returned.

11. See attached drawings for the correct signs and sign locations for this application.

SECTION IV-SIGNING APPLICATIONS

Since these speed limit reductions are utilized for short-term activities, the recommended application is the use of either portable/dynamic message signs or portable speed limit signs. Changeable message signs, due to their size and greater visibility, provide the largest target value possible. In addition, these devices can provide the motorists more information concerning the upcoming conditions and expectations. Messages pertaining to the upcoming speed limit reduction, conditions related to the speed limit reduction and finally the reduced speed limit message are all possible through their usage. These portable devices are also capable of being moved along the project as work progresses, as well as having their messages either changed and/or removed.

However, portable speed limit signs (R2-1) are also a valid and less expensive technique to reduce the speed limit for short-term activities. The Regional Traffic Engineer, the Division and the Work Zone Traffic Control Section will collaborate on the technique used for each work zone.

If changeable message signs are utilized, the messages reducing the speed limit and/or $250 speeding fine are to be displayed when workers are visibly present and active work is taking place.

At the end of the work period, when the temporary traffic control devices are removed, so shall the work zone "variable" speed limit and $250 fines by removing the reduced speed limit and $250 fine messaging on the portable/dynamic message signs. However, if lanes are to be reopened to uneven elevations, the work zone "variable" speed limit reduction and $250 fine may remain in place until this situation is mitigated.

If portable speed limit signs are utilized, they shall be removed along with the $250 fine signs when the temporary traffic control devices are removed and traffic returned to their normal patterns. However, if lanes are to be reopened to uneven elevations, the work zone "variable" speed limit reduction and $250 fine may remain in place until this situation is mitigated.

When a work zone "variable" speed limit is in affect, all existing stationary speed limit signs shall be covered. Immediately upon completion of the work activity necessitating the speed limit reduction, all existing speed limit signs shall be uncovered at no cost to the Department.

After the project/work activity is complete, the State Traffic Engineer is to be notified so the work zone "variable" speed limit ordinance will be rescinded.

Typical speed limit reductions are 10 MPH below the existing posted speed limit. In 70 MPH speed zones, a maximum 15 MPH speed reduction may be used.

It is strongly recommended that no speed limits below 55 MPH be posted on fully controlled access facilities. The Regional Traffic Engineer, after consulting with the Division, will determine the speed limit with the final approval being made by the State Traffic Engineer.

The concluding sign should be a portable, regulatory Speed Limit sign with the in-place speed limit for the roadway ahead. This is to inform the drivers the work zone "variable" speed limit has ended. Each of these signing applications is shown on separate drawings.

8.3.3.1 Drawing for WZ "Variable" Speed Limit Reduction (Link to PDF)

Contact Work Zone Traffic Control for CADD files if necessary.

8.3.4 Guidelines for $250 Speeding Fine Ordinances

Standard Practice For $250 Speeding Fine Guidelines for NC Highway Construction and Maintenance Activities on High Speed Facilities

Purpose: This document provides guidance and uniformity on the establishment of $250 speeding fines in work zones.

Objective: The objective of this guideline is to identify conditions where it's appropriate to implement a $250 speeding fine on roadways with existing speed limits of 60 MPH and above for work being performed in construction and maintenance work zones.

Guideline: The Work Zone Traffic Control Section in consultation with the Regional Traffic Engineering staff has developed these guidelines to provide guidance and uniformity in the implementation of the $250 speeding fine in work zones. The intent of the $250 speeding fine is to increase the impact of receiving a speeding citation whenever road conditions and/or site conditions dictate a need for the driver to be more focused on maintaining a safe speed. Another component of the $250 speeding fine is to encourage "uniform" speeds by reducing speed differential in the travel stream through the work zone. Therefore, it's imperative this application only be used whenever it's appropriate.

The $250 penalty can be applied to work zones where the existing speed limit remains, or it can be implemented during times when the speed limit is reduced. Work Zone speed limits can be reduced in two (2) methods. The first is the long term type where the speed limit signs (R2-1) are changed to a lower speed limit and are displayed continuously. This method is referred to as the "Work Zone Speed Limit Reduction". The other method is done for specific activities during the project and the lower speed limits are displayed only for the activities that warrant the lower speeds. The speed limits are displayed on either portable speed limit signs or displayed as a number on changeable message signs. This method is referred to as the "Work Zone Variable Speed Limit Reduction".

This guideline has been established to ensure thorough engineering review and analysis prior to implementation of the $250 speeding fine. Typically, road conditions that warrant this strategy have been altered and generally contain restrictive features throughout its length, which may require added decision making, increased reaction times and other driver focused actions. Adhering to the speed limit allows for better driver recognition and reaction and hopefully the negative consequence of an added $250 speeding fine will obtain the desired result of uniform speeds through the work zone. However, this guideline can not cover every situation that may be encountered in a work zone; therefore, appropriate judgment must be used in applying the guidelines. Exceptions to the criteria below will be considered on a case by case basis.

The $250 speeding fine ordinance warrants are defined below. In order for a project to "qualify" for this treatment, it must meet all warrants in Section I and at least 1 warrant in Section II. If Section II warrants aren't met, the project must meet at least 2 warrants in Section III to qualify for the $250 fine. If Section I warrants aren't met, the project doesn't qualify for the $250 Fine.

ORDINANCE CRITERIA

SECTION I

The work zone **must meet all** of the following warrants to be considered for the $250 fine ordinance:

1. The work zone is located on a facility where the existing posted speed limit is 60 MPH or higher.

2. The work zone is greater than 1 mile in length.

3. The work zone is long term duration (greater than 30 days)

AND

SECTION II

The work zone shall meet **at least one** of the following warrants to be further considered for the $250 fine ordinance:

1. **The existing Posted Speed Limit within the work zone is reduced during construction by either a Work Zone Speed Limit Reduction or by a Work Zone Variable Speed Limit Reduction.**

2. The work zone is adjacent to other work zones where a $250 ordinance is in effect.

3. Significant amount of work requiring "frequent use" of Short-term stationary lane closures (daytime work occupying a particular location for more than 1 hour) and/or Intermediate-term stationary lane closures during construction (work occupying a particular location for more than one daylight period up to 3 days or night work lasting more than 1 hour).

   Note: "*frequent use*" pertains to more than 25% of total duration of project

OR

SECTION III

The work zone shall meet **at least two** of the following warrants in Section III to be further considered for the $250 fine ordinance:

1. The 85th percentile speeds within the work zone are 10 miles per hour or higher than the posted speed limit (speed study should be done during off-peak hours and prior to beginning of work).

2. The accident rate and/or severity crash rate for the facility (prior to construction) is higher than the statewide rate as compared to similar facilities

3. The work zone crash rate and/or work zone severity crash rate for the corridor (prior to construction) is higher than the 5 year average as compared to similar facilities

4. Current Truck Traffic levels greater than 15% in work zone.

SECTION IV- IMPLEMENTATION PROCESS

AUTHORIZATION

Senate Bill 649 amended Senate Bill 30 to allow flexibility in the designation of segments of Work Zones subject to the $250 speeding penalty. It became effective on December 1, 2009. This Bill rewrote Section (j2) of General Statue 20-141. In this Bill, it says "the additional penalty imposed by this subsection applies only if sign (signs) are posted at the beginning and end of any segment of the highway work zone stating the penalty for speeding in that segment of the work zone. The Secretary shall ensure that work zones shall only be posted with penalty signs if the Secretary determines, after engineering review, that the posting is necessary to ensure the safety of the traveling public due to a hazardous condition. Described below is a process to implement this Bill.

IMPLEMENTATION

1. Process initiated by contact from the Work Zone Traffic Control Section of the Transportation Mobility and Safety Division to the Regional Traffic Engineer's office requesting an engineering investigation. The initiation may come from the Division office or others.

2. Engineering Investigation will include a review of the existing posted speed limit and the 85th percentile speeds and the need for the increased penalty of up to $250 for speeding in the work zone.

3. In addition, the $250 fine ordinance criteria will be reviewed by the Work Zone Traffic Control Section to determine if the project meets the criteria.

4. The Work Zone Traffic Control Section and the Regional Traffic Engineer will discuss and collaborate on the results of the review and determine whether to implement the $250 speeding fine.

5. If it is determined that the increased fine for speeding in the work zone applies to this location, it can be used without a speed limit reduction.

6. Further, if it is determined in a separate review, the existing posted speed limit should be lowered in the work zone, the $250 fine for speeding should also be used.

7. If the ordinance is approved, the Regional Traffic Engineer will notify the Resident Engineer and the Work Zone Traffic Control Section.

8. In order for the $250 speeding fine to be in effect, the ordinance has to be approved and signed by the State Traffic Engineer. No "$250 fine" signs are to be installed in the work zone before the ordinance is in effect.

9. See attached drawings for the correct signs and sign locations for this application.

10. Once the conditions that warranted either the $250 alone or in conjunction with a speed limit reduction are removed, so shall the ordinance. The Resident Engineer will notify the Regional Traffic Engineer to rescind the ordinance. For example, once traffic is placed in their final pattern, the $250 fine signs need to be removed.

SECTION V- $250 Signing Applications

The $250 Speeding Penalty can be applied in a variety of applications and scenarios within an application. The Traffic Control Designer, the Division and Regional Traffic Engineer need to evaluate to determine which application is the best method for the project. The first scenario is when the $250 fine implemented without reducing the speed limit. The others are when the $250 fine is implemented where the speed limit **IS** reduced through a Work Zone Speed Limit Reduction or a Work Zone "Variable" Speed Limit Reduction. Each is shown on separate drawings.

8.3.4.1 Drawing for $250 Speeding Fine (Link to PDF)

Contact Work Zone Traffic Control for CADD files if necessary.

Chapter 9: Temporary Shoring

9.1 Introduction

NCDOT established a policy that determined when the contractor would and would not be paid for the installation of temporary shoring. This policy states that any time shoring is necessary to maintain traffic, it will be paid for. Shoring not necessary for the maintenance of traffic will not be paid for but will be considered incidental to the operation for which the shoring is needed.

9.2 Definitions & Abbreviations

Temporary Shoring – That sheeting, shoring, and bracing required to laterally support the sides of an excavation or embankment to prevent slope failure. This typically consists of sheet piling of some kind.

Shoring for the Maintenance of Traffic – That shoring necessary to provide lateral support to the side of an excavation or embankment parallel to an open travelway when a theoretical 2:1 or steeper slope from the bottom of the excavation or embankment intersects the existing ground line closer than five (5) feet from the edge of pavement of the open travelway.

Temporary Shoring - Barrier Supported – Shoring used when portable concrete barrier (PCB) is located within three (3) feet of the shoring, measured to the back face of the PCB, and a drop-off of at least three (3) feet exists behind the shoring, requiring the shoring to be designed to resist lateral movement of the PCB – when struck by a vehicle.

9.3 Shoring Guidelines

A. Identify the need (or potential need) for Shoring for the Maintenance of Traffic and determine approximate locations, based on the following details:

1. Cross sections from the Roadway Plans can be used to show the relationship between existing and proposed alignments. This will help identify the distance between structures and grade differences between alignments.
2. Structure Design's preliminary drawings should include dimensions and depths of the footings, end bents, bents (of structures over traffic), and culverts; type of footing and end bents; distance between proposed and existing structures (if applicable). Typically, five (5) feet minimum of working area is required between bridges.
3. From the lowest elevation that will be excavated, provide one to two (1-2) feet minimum for construction room and then use a 2:1 slope to determine if the excavation

will encroach on the existing travel lanes. If the toe of the slope is within five (5) feet of the existing travel lane, then temporary shoring is needed. This is true for both structure and roadway work.

B. Discuss the need for shoring at the first field inspection. Make sure that the need for temporary shoring is documented in the Traffic Control-field inspection minutes and the field inspection notes from the Division.

C. If deemed necessary, schedule and conduct a Temporary Shoring for the Maintenance of Traffic meeting.

1. Invite Roadway Design, Structure Design, and Geotechnical to the Shoring meeting.
2. During the meeting, show Traffic Control's findings from the preliminary check for shoring and explain why it may be needed.
3. Ask Structure Design if they are going to require shoring around the end bents, internal bents, between structures, or around footings.
4. Complete and distribute shoring meeting minutes. Include in the minutes what was discussed and who will supply what information and when.
5. Give approximate locations of proposed temporary shoring to the Geotechnical Engineering Unit. They will verify the locations and provide Traffic Control with a letter, which includes the finalized shoring locations, soil parameters, offsets, and a shoring quantity.

D. Using the information received from the Geotechnical Engineering Unit, show the following on the Traffic Control Plan:

- Show using appropriate line style at each location that requires temporary shoring.
- Label the beginning and ending stations and offsets at each location of shoring.
- Show soil parameters at each shoring location on appropriate CADD sheet created for same, "Temporary Shoring Notes."

9.4 Design Issues

Before committing to using temporary shoring, investigate ways that can eliminate the need for the shoring, including, but not limited to:

Consider using a 1.5:1 temporary slope instead of a 2:1 slope. Sometimes using a 1.5:1 slope will move the toe of the fill/cut far enough away to eliminate the need for shoring. Use of a 1.5:1 slope **must be coordinated with the Geotechnical Engineering Unit.**

Consider using a soil fabric wall instead of conventional shoring. Geotechnical will make the final call on whether a soil fabric wall can be used, so make sure to coordinate with them.

See the PCB at Temporary Shoring Location Details for required barrier offset distances when using soil fabric walls. Any shoring necessary to build part of the project (e.g. end bents, bents, retaining walls, etc.) but is not necessary to maintain traffic, **does not get paid for as shoring and is not the responsibility of Traffic Control.**

9.5 Design Criteria

Temporary Shoring for the Maintenance of Traffic is required when the toe of a 2:1 or steeper slope from an excavation or fill necessary for construction comes **closer than five (5) feet** to the edge of an existing travel lane.

Temporary Shoring - Barrier supported is required when **both** of the following occur:

1. Portable concrete barrier (PCB) is **within three (3) feet** of the top of the shoring, measured from the shoring to the back of the PCB, and;

2. There is a **three (3) foot or greater** drop-off behind the shoring

9.6 Design Resources

The following are good resources for dealing with temporary shoring:

- Temporary Shoring Tutorial
- Traffic Control Project Engineers and Project Design Engineers
- Geotechnical Engineering Unit

Chapter 10: Traffic Signals

10.1 Introduction

Traffic signals are a factor in Work Zone Traffic Control in several ways. Existing traffic signals can be encountered in work zones and often have to be modified to accommodate changing traffic patterns through the life of a project. New traffic signals are often recommended for projects and need to be phased into the project at the appropriate time. Traffic signals are sometimes required for temporary off-site detours and for controlling traffic during one-lane two-way traffic during the staged construction of a bridge. Since traffic signals are recommended by the Regional Traffic Engineer, designed by the Signals and Geometrics Section, and operated by the Highway Divisions, extensive coordination is required to ensure that traffic signals are adequately addressed in the traffic control plans.

10.2 Definitions & Abbreviations

AFAD – Automated Flagger Assistance Device. A portable, trailer mounted, remotely operated, temporary traffic control device, similar to that of a conventional flagging operation, but involve one trained flagger/operator instead of two.

Driveway Signal – A portable, trailer mounted signal for the express purpose of regulating vehicles from driveways that fall within a 1-lane, 2-way traffic pattern.

Portable Traffic Signal System – A system of trailer mounted, temporary traffic signals that can be easily transported and reused at different locations.

RTE – Regional Traffic Engineer. The member of the Transportation Mobility & Safety Field Operations Section that is responsible for making traffic signal recommendations. Among the recommendations made are where new permanent traffic signals are required and whether temporary signals are necessary on detour routes or temporary haul roads.

Temporary Signal Design – A signal plan that accommodates temporary traffic patterns.

Temporary Traffic Signal – A traffic signal that is installed for a limited time period then removed when conditions no longer warrant a signal.

Traffic Signal – Any power-operated traffic control device that alternately assigns right of way.

10.3 Design Criteria

Temporary Signals on Detour Routes

- Coordinate with the RTE and Signals and Geometrics if you recognize the need for a Temporary Signal or modifications to an existing signal along the detour.
- Signals and Geometrics will determine stop line locations and locate on the signal plans.
- Phase the signal installation or modification into the Traffic Control plans.
- Use of "Temporary signal" sign. (See Figure 1 below)

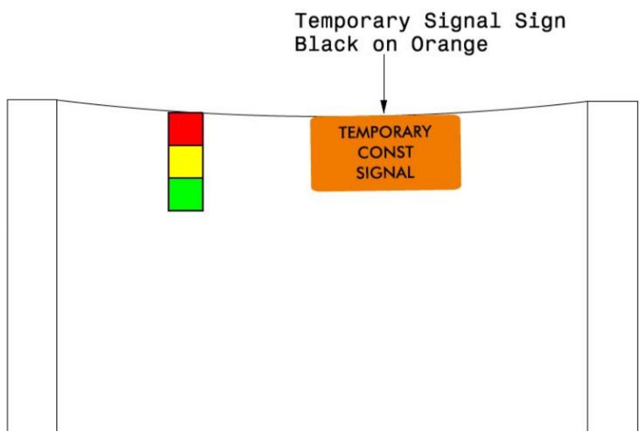


Figure 1 – Temporary Construction Signal

Temporary Signal Systems for One Lane, Two Way Patterns

- Portable Signal Systems are temporary traffic signals intended to direct and control traffic through the work zone and serve as a substitute to a conventional flagging operation on one lane, two way patterns. These systems are utilized for construction operations lasting longer than a single work period (Long Durations). Refer to RSD 1101.02 and project special provisions. (See Figure 2)
    - If Portable Signal Systems are utilized, Driveway Signals may be used to regulate driveway traffic located within the one lane operation. All signals within the system described communicate with one another. Refer to project special provisions. (See Figure 3)
- AFADs (Automated Flagger Assistance Device) increase worker safety while maintaining positive temporary traffic control. A trained flagger is still needed to operate the device and should be available to step in as a manual flagger in case of a malfunction. AFADs are typically used for short-term or intermediate-term lane closures. Refer to project special provisions. (See Figure 4)

Figure 2 – Portable Traffic Signals

Figure 3 – Driveway Assistance Device

Additional information and or guidance may be obtained within NCDOT RSD 1101.02 and Project Special Provisions - follow links below:

[NCDOT-Roadway Standard Drawings (RSD) Division 11]
[WASP – Project Special Provisions]

AFAD - Type I

AFAD - Type II

Figure 4 – Automated Flagger Assistance Devices

Additional information and or guidance may be obtained within the NCDOT Maintenance / Utility Traffic Control Guidelines (MUTCG) and Project Special Provisions - follow links below:

[MUTCG - Chapter 2]
[WASP – Project Special Provisions]

Other Considerations

Early Signal Installations

- Proposed signals are normally installed during the final phases of construction. Occasionally, the RTE will recommend that the proposed signal be installed at the start of construction. If this is the case, early installation needs to be phased into the Traffic Control plans. Signals and Geometrics should notify Traffic Control of early signal installations.

Left Turn Lanes

- When a temporary traffic shift impacts a signalized intersection with existing left turn lanes, every effort should be made to allow for left turn lanes during the traffic shift.

Chapter 11: Signing

11.1 Introduction

The Work Zone Traffic Control Section (WZTCS) signing covers a broad range of issues including sign types, placement, specifications, and design. In almost all cases, the designer will be required to use some form of signing in designing a traffic control plan, and in rare cases a pavement marking plan. Signing is the most important form of communication in or out of the work zone and helps to ensure the safety of the motorist and construction worker. Therefore, it is important to choose the most effective message or series of messages when designing traffic control plans in an effort to optimize safety on and off of the work zone. This chapter will discuss how to use the best signing applications and how they are integrated into the traffic control plan.

The purpose of this chapter is to give the designer guidelines set forth by the Work Zone Traffic Control Section concerning sign usage and placement in the work zone and how to best utilize the resources used in designing Traffic Control plans.

11.2 Definitions & Abbreviations

Advance Warning Sign (AWS) – A work zone sign that is located in advance or at the end of a work zone.

Barricade Mounted Sign – A sign mounted on the front face of a barricade.

Dynamic Sign – A type of sign that allows the message portrayed on the sign face to change, i.e. Portable Changeable Message Boards or Dynamic Message Boards.

Grade B Fluorescent Orange: Retroreflective sheeting materials meeting Grade B, commonly referred to as "intermediate grade", are typically of unmetallized microprismatic construction. Grade B shall be used for all school zone signs, bicycle and pedestrian crossing signs (fluorescent yellow-green); and highway-rail crossing signs (fluorescent yellow).

MUTCD – Manual on Uniform Traffic Control Devices

Portable Sign – A sign erected with a portable sign stand assembly.

RSD – Roadway Standard Drawings. This Standard Manual is used to display the most appropriate signing and the placement of signing. Every designer should have a copy of the English version of the RSD.

Special Sign Design – A sign design that is not standard and requires design from the Signing Section.

Stationary Sign – A sign erected with a stationary ground mounted post.

11.3 Policies

Signing in a work zone is a very important part of designing the traffic control plan. There are three types of static signs: stationary, portable, and barricade mounted (see definitions). These sign types in addition to dynamic signs which include Portable Changeable Message Signs (CMS), Dynamic Message Signs (DMS), and Flashing Arrow Boards (FAB), make up the communication devices used to help the motoring public navigate through a work zone safely. It is the responsibility of the designer to provide the clearest communication possible in a work zone area to keep the public and construction worker safe during the life of the project.

Part of ensuring that a sign is legible is to use a sheeting material on each sign that allows the motorist to read the sign clearly at an appropriate distance. NCDOT standard policy states that all work zone signs are to utilize Grade B fluorescent orange retro-reflective sheeting or better.

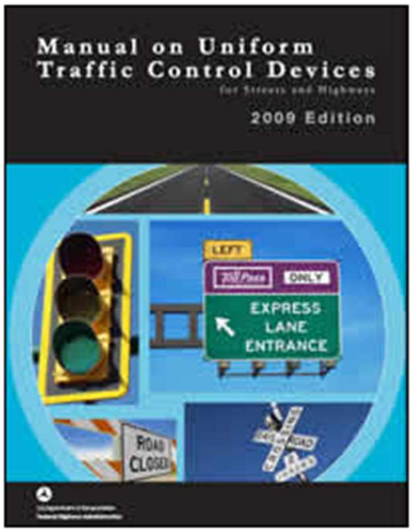
11.3.1 Work Zone Traffic Control Design Resources

Engineering judgment is required when determining the placement of signs. In most cases, the designer can refer to a standard resource to help determine sign placement. Design resources are discussed below.

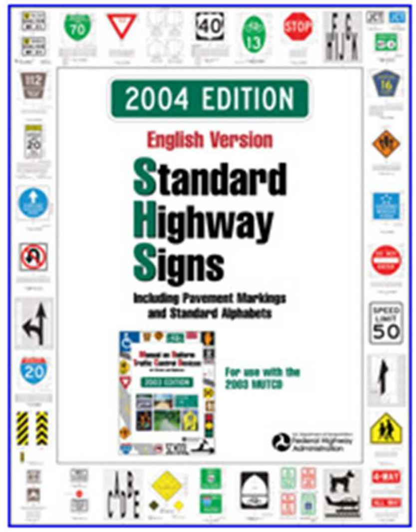
The **Roadway Standard Drawings (RSD)** are used in designing a work zone for a phase or a step within a phase. They assist the designer in selection of the best traffic control strategy, including proper signing, to move motorists through a construction work zone safely and efficiently. WZTC designers will use Division 11 for work zone signing issues. Engineering judgment is required to determine the most appropriate RSD. This includes ensuring the signing communicates the proper message to the motorist. In some cases, the most appropriate RSD will not exactly fit the design required for the work zone, so signs may need to be added, removed, or changed to accommodate the needs of the work zone. Coordinate with your supervisor to determine how best to address changes to a RSD for a specific project and ensure MUTCD minimum standards are met.

When changes to a RSD are required and apply to the majority of projects, revised sheets are drawn and inserted in the traffic control plan in place of the outdated RSD. Updated or revised RSD's will be posted on WZTC webpages until incorporated within the next publication.

The NCDOT strives to meet the standards found within the **MUTCD** and the RSD meets or exceeds to its minimum requirements. Therefore, the MUTCD is another reliable source to refer to when the RSD does not apply. There are various chapters in the MUTCD that pertain to signing issues, but the primary chapter that a WZTC designer will refer to for such issues is Chapter 6F. When consulting the MUTCD the WZTC designer should remember that the MUTCD is the minimum standard.



http://mutcd.fhwa.dot.gov/



https://mutcd.fhwa.dot.gov/SER-SHS_MILLENNIUM.HTM

The prevailing **Standard Specifications for Roads and Structures** is the official manual for sign specifications, placement and installation, mounting heights, etc. WZTC designers will refer to Division 11 for work zone signing issues.

The information found in the **NCDOT – Maintenance/Utility Traffic Control Guidelines** is similar to the Standard Specifications for Roads and Structures and lists information about sign credibility. It is primarily useful to contractors, D.O.T. inspectors, and field units, but can also be a good source when performing a work zone review.

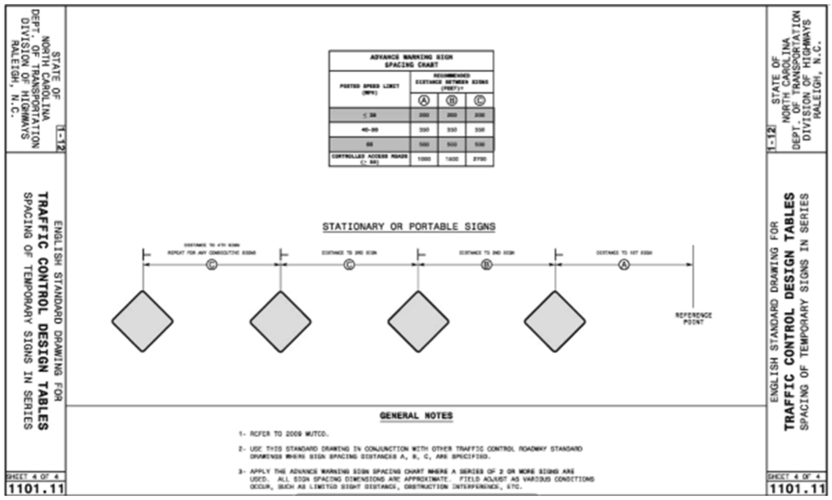
Should the designer not find any information about a particular signing question in any design resource or another experienced WZTCS employee, the designer can ask a member of the Signing Section.

11.3.2 Sign Placement

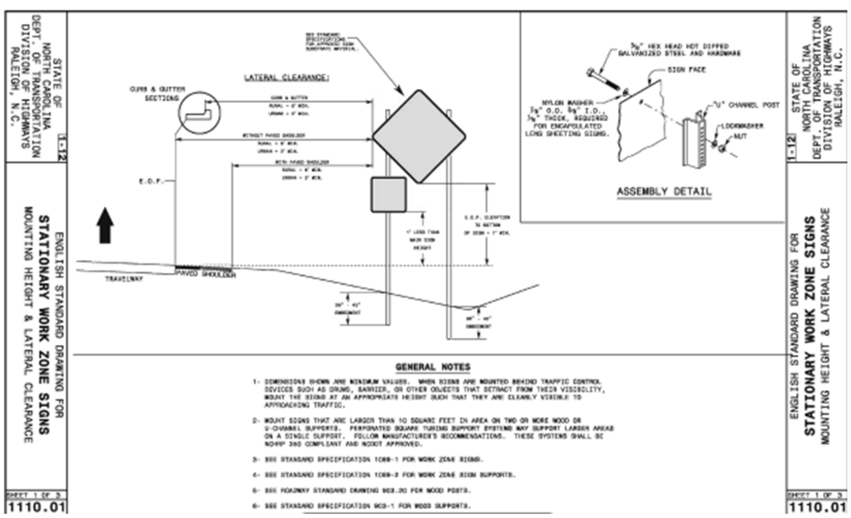
Work Zone sign placement is another important part of communicating sign messaging to the public. It is important to give the motorist an appropriate amount of time to read, comprehend, and execute the action required by the sign messaging. The RSD sheets detail the distances that signs are to be placed in advance of and within the work zone area. The drawings listed below give more specific information on how to accomplish this.

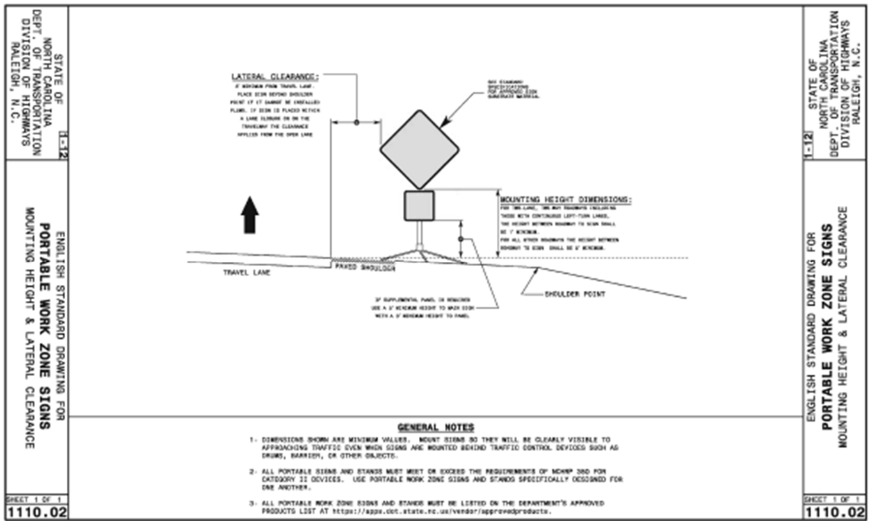
- **RSD 1101.11** These sheets include design tables and diagrams to help the designer determine the placement of signs in advance of a work zone and should be used in accordance with RSD 1101.02, 1101.03, 1101.04, 1101.05, and any other designs the designer may be required to create.

https://connect.ncdot.gov/resources/Specifications/Pages/2018-Roadway-Standard-Drawings.aspx



- **RSD 1110** series is used to determine mounting heights and lateral clearances for stationary and portable signs.





Sign placement is also important in regards to off-site detours. After determining the most appropriate off-site detour route the designer can determine the best locations of the signs for the detour route.

11.4 Off-Site Detour Design

Off-site detour routes for bridge closures, in most cases, are already resolved prior to the development of the traffic control plan. These detours are usually shown in the planning or environmental document or on the title sheet of the roadway plan. The designer should not assume that the proposed detour is the best route. In all cases, the designer should investigate all detour routes to ensure that the route corresponds to what has already been proposed within the Roadway Plans and the Planning or Environmental document. The designer should ensure that all traffic will be able to maneuver across all roadways, bridge structures, culverts, and intersections. To accomplish this task, the designer should check the following: detour vertical and horizontal curves, sight distances, pavement conditions, pavement marking/marker conditions, structure weight limit postings, deck width clearances on structures, intersection skew angles, the off-detour length, and the detour user costs.

When the Force Account document requires the contractor to install off-site detour signing for a project, the designer must also design the off-site detour in the traffic control plan. This requires the designer to:

1. Determine the appropriate off-site detour route signing locations (discussed in 3.11.3.2 Sign Placement),

2. Design the sign assemblies for the detour route, and

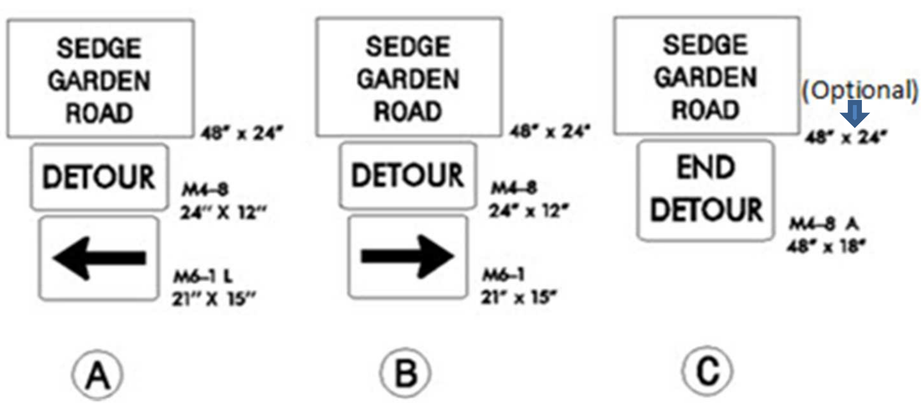
3. Request special sign designs for non-standard signs or local roads from the Signing Section. This manual will focus on the latter two steps.

11.4.1 Off-site Detour Sign Assembly Procedure

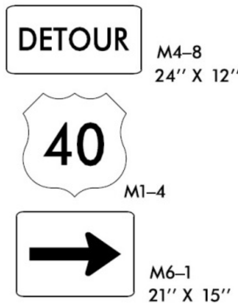
A traffic control related memorandum on Approved Traffic Control Plan Implementation Committee Recommendations (dated 08/06/97) has determined the procedure for mounting off-site detour signing assemblies. The letter has been paraphrased for the benefit of the designer to fully understand the procedure.

For all off-site detours the actual detour [message] should consist of a three-sign assembly mounted on a single post and paid for under the pay item [estimate] for "Work Zone Signs (Stationary)".

For off-site detours for local roads the sign assembly will consist of three signs. The top sign should be the local road name and would require a special design from the Signing Section. The middle sign should be sign M4-8 "Detour." The bottom sign should be a directional arrow informing the motorist of an upcoming change in the direction of the detour. "End Detour" sign assemblies may consist of two signs. When utilizing two signs, the top sign (optional) should be the local road name and the bottom sign should be the M4-8a "End Detour" sign.



For off-site detours for US, NC, or Interstate routes, the sign assemblies shall consist of three signs. The top sign should be sign M4-8 “Detour”. The middle sign should be the standard route sign. The bottom sign should be a directional arrow informing the motorist of an upcoming change in the direction of the detour. “End Detour” sign assemblies shall consist of two signs. The top sign should be sign M4-8a “End Detour” and the bottom should be the standard route marker.



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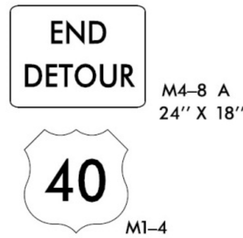
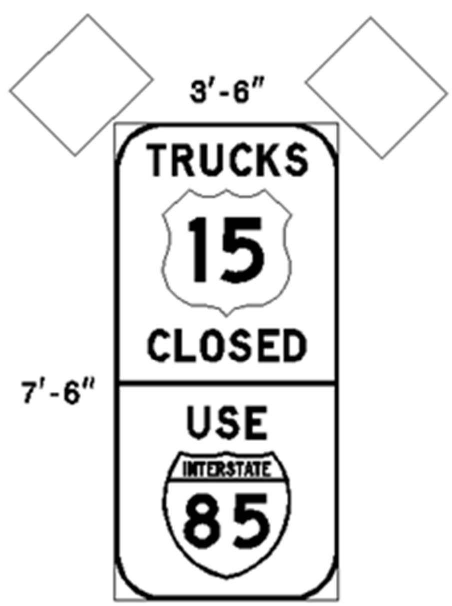


B

In rare cases, some projects require placement of detour signs on overhead or ground mounted guide signs. In these cases, the designer should determine the most appropriate message for the sign, consult with your supervisor, then coordinate with the Signing Section to ensure the sign is designed properly. This is especially important when designing large temporary signs for interstates and highways. These signs are a Signing pay item.

I



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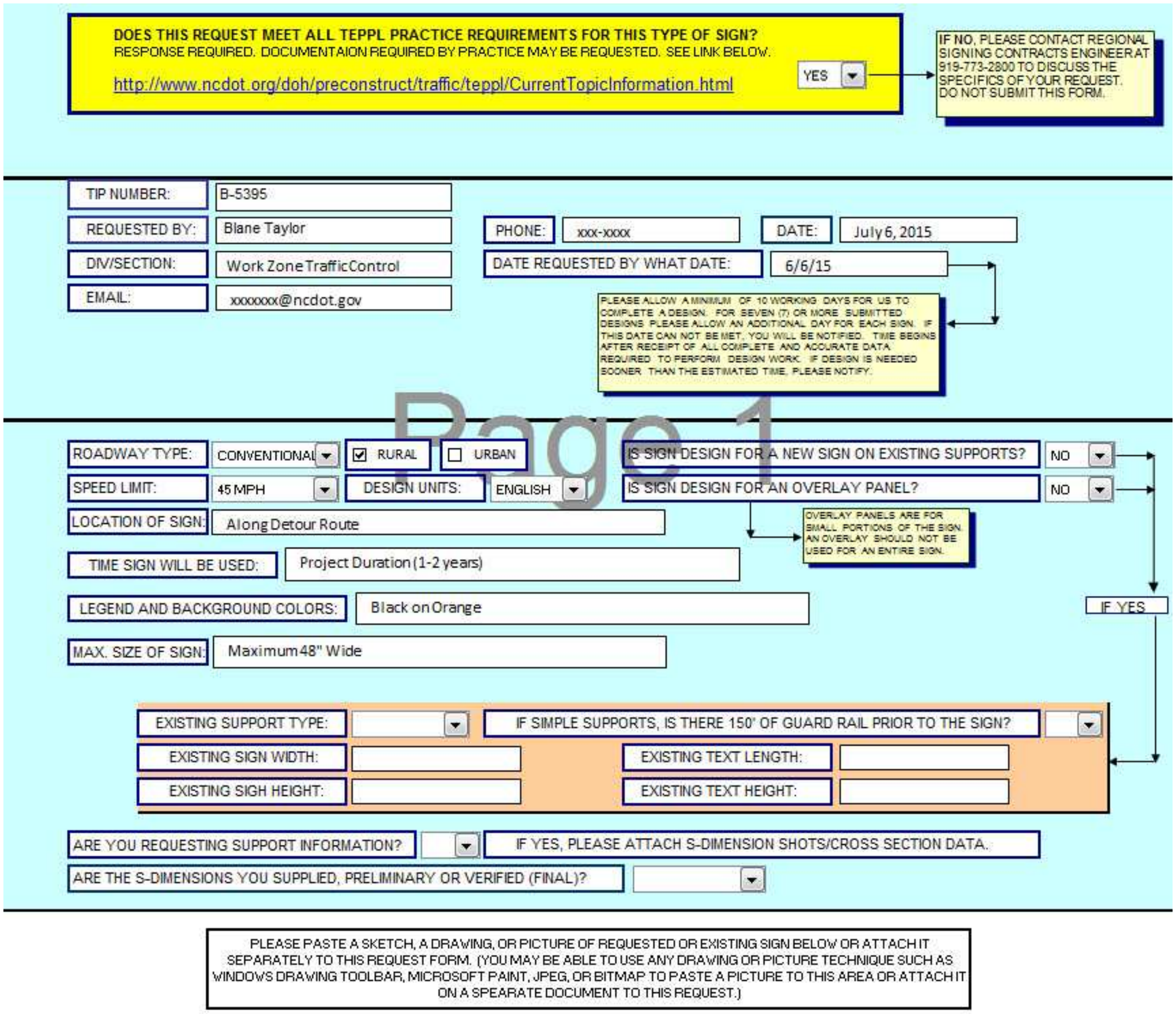
11.4.2 Special Sign Design Procedure

There are often projects which the designer is required to have a sign that is not a standard sign listed within the MUTCD or the RSD. In such cases it is necessary for the designer to request a special sign. WZTCS coordinates with the Signing Section as a part of the special sign design process.

1. To begin the design, the designer needs to determine the message needed to communicate to the public what instruction is to be carried out.

2. Once this is determined, complete the sign design form: located at https://connect.ncdot.gov/projects/wztc/pages/design-resources.aspx .Attach the form to an e-mail, and send the e-mail to the appropriate project personnel in the WZTC section. Before sending the e-mail, be sure to:
   - Include a picture of the requested sign in the form (any program with photo editing capabilities can be used. See the note on the Sign Design Request Form for examples of these programs).
   - Under the comment section request the following:
     - Have electronic copies of the sign design files sent to the designer.
     - The appropriate widths of the sign. This is to ensure that the sign itself does not become a safety hazard to the motorist.
       - For local road signs and all other signs mounted on U-channel posts, the maximum width of the sign should be between 42” to 48”.
       - For overhead and ground mounted signs, coordinate with your supervisor and the Signing section.
       - State that the sign is for temporary use and give the approximate duration the sign will be needed.


DOES THIS REQUEST MEET ALL TEPPL PRACTICE REQUIREMENTS FOR THIS TYPE OF SIGN?
RESPONSE REQUIRED. DOCUMENTAION REQUIRED BY PRACTICE MAY BE REQUESTED. SEE LINK BELOW.
http://www.ncdot.org/doh/preconstruct/traffic/teppl/CurrentTopicInformation.html
YES
IF NO, PLEASE CONTACT REGIONAL SIGNING CONTRACTS ENGINEER AT 919-773-2800 TO DISCUSS THE SPECIFICS OF YOUR REQUEST. DO NOT SUBMIT THIS FORM.

TIP NUMBER: B-5395
REQUESTED BY: Blane Taylor
DIV/SECTION: Work Zone Traffic Control
EMAIL: xxxxxxx@ncdot.gov
PHONE: xxx-xxxx
DATE: July 6, 2015
DATE REQUESTED BY WHAT DATE: 6/6/15
PLEASE ALLOW A MINIMUM OF 10 WORKING DAYS FOR US TO COMPLETE A DESIGN. FOR SEVEN (7) OR MORE SUBMITTED DESIGNS PLEASE ALLOW AN ADDITIONAL DAY FOR EACH SIGN. IF THIS DATE CAN NOT BE MET, YOU WILL BE NOTIFIED. TIME BEGINS AFTER RECEIPT OF ALL COMPLETE AND ACCURATE DATA REQUIRED TO PERFORM DESIGN WORK. IF DESIGN IS NEEDED SOONER THAN THE ESTIMATED TIME, PLEASE NOTIFY.

Page 1

ROADWAY TYPE: CONVENTIONAL ☑ RURAL ☐ URBAN
IS SIGN DESIGN FOR A NEW SIGN ON EXISTING SUPPORTS? NO
SPEED LIMIT: 45 MPH DESIGN UNITS: ENGLISH
IS SIGN DESIGN FOR AN OVERLAY PANEL? NO
LOCATION OF SIGN: Along Detour Route
OVERLAY PANELS ARE FOR SMALL PORTIONS OF THE SIGN. AN OVERLAY SHOULD NOT BE USED FOR AN ENTIRE SIGN.
TIME SIGN WILL BE USED: Project Duration (1-2 years)
LEGEND AND BACKGROUND COLORS: Black on Orange
IF YES
MAX. SIZE OF SIGN: Maximum 48" Wide

EXISTING SUPPORT TYPE:
IF SIMPLE SUPPORTS, IS THERE 150' OF GUARD RAIL PRIOR TO THE SIGN?
EXISTING SIGN WIDTH:
EXISTING TEXT LENGTH:
EXISTING SIGH HEIGHT:
EXISTING TEXT HEIGHT:

ARE YOU REQUESTING SUPPORT INFORMATION?
IF YES, PLEASE ATTACH S-DIMENSION SHOTS/CROSS SECTION DATA.
ARE THE S-DIMENSIONS YOU SUPPLIED, PRELIMINARY OR VERIFIED (FINAL)?

PLEASE PASTE A SKETCH, A DRAWING, OR PICTURE OF REQUESTED OR EXISTING SIGN BELOW OR ATTACH IT SEPARATELY TO THIS REQUEST FORM. (YOU MAY BE ABLE TO USE ANY DRAWING OR PICTURE TECHNIQUE SUCH AS WINDOWS DRAWING TOOLBAR, MICROSOFT PAINT, JPEG, OR BITMAP TO PASTE A PICTURE TO THIS AREA OR ATTACH IT ON A SPEARATE DOCUMENT TO THIS REQUEST.)

3.To utilize completed sign designs, follow the steps below.

- Create a blank design file.
- Attach the saved sign design created by the Signing Section as a reference file
- Scale reference file as desired and place blank sheet border. (DO NOT COPY THE SIGN DESIGN INTO YOUR ACTIVE DESIGN FILE AS IT WILL NOT PLOT CORRECTLY)
- Number sheet(s) sequentially within the 2 series of sheets. Example: TMP-2A, TMP-2B, etc.
- Title each sheet “SPECIAL SIGN DESIGNS”
- Plot full size plan sheet (Ensure all data can be reproduced and legible)

11.5 Design Resources

Design resources other than this book include:

Roadway Standard Drawings
Manual on Uniform Traffic Control Devices
Federal Standard Highway Signs
WZTCS Webpage
Work Zone Traffic Control Rodeo Notebook
Approved TCP Implementation Committee Recommendations: Off-Site Detour Routing and Signing

Chapter 12: Wedging

12.1 Introduction

The purpose of this chapter is to establish the guidelines set forth by the Traffic Control Unit concerning wedging and tie-ins in the work zone and how to best utilize the resources available for designing traffic control plans.

Wedging and tie-ins are an integral part of work zone design. The terms wedging and tie-ins are used to describe asphalt paving operations where lanes shift, superelevations change, or any place where proposed grades meet existing pavements. It is a series of variable depth pavement lifts that are used to "tie together" proposed grade surfaces with existing roadways. (See Figures on page 3 for sample details.) Over the years, wedging has become standard practice in the highway construction field to update roadways to new design speeds and improve safety in curves. In some cases, in concert with milling operations, wedging operations modify vertical clearances under overhead structures.

Tie-ins are usually designed where a smooth transition is needed to maintain traffic at a certain posted speed limit or to keep driveways to businesses and residences operational during construction.

12.2 Definitions & Abbreviations

The primary definitions needed for this chapter will be the following:

Base Course – The part of the pavement structure between the surface course (or intermediate course, if recommended) and the subgrade.

Centerline – The longitudinal mid-point of all travel lanes (Surveyed stations are normally on the centerline of travel lanes or median).

Cross Section – Produced by a vertical plane cutting through the roadway at right angles to the centerline showing the profile of existing and proposed earth.

Grade Point – The point where the proposed grade is referenced or tied to the typical section.

Intermediate Course – The part of the pavement structure between the surface course and the base course (not used in all cases).

Layer – A pavement structure design consisting of a lift or lifts of pavement types.

Lift – A single or series of variable depth applications of pavement types within a layer (pavement structure design).

Milling – The removal of existing pavement to lower the vertical elevation and/or to improve the riding surface.

Overlay Resurfacing – The placement of a new lift of asphalt over the existing pavement surface.

Pavement Schedule – The identification and thickness of the asphalt pavement design.

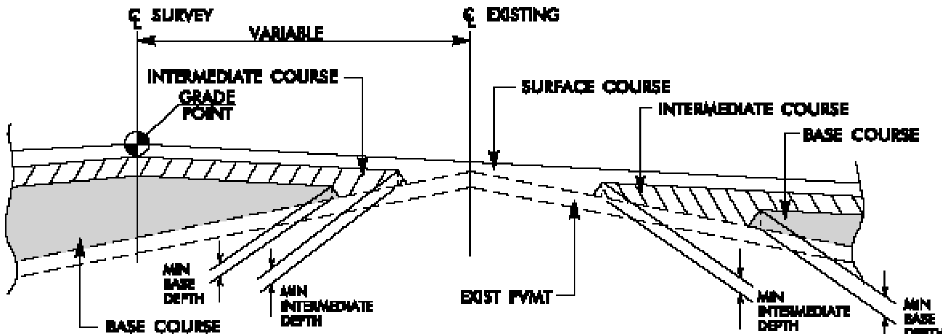
Profile Grade – A longitudinal side view of the roadway showing the engineered (designed) “up and down” (rise and fall) of the roadway.

Superelevation – The pavement cross slope of the roadway.

Surface Course – The top layer or riding surface of the pavement structure.

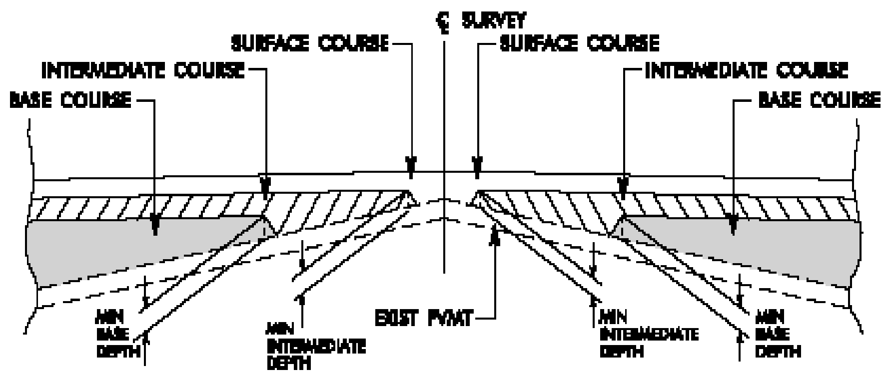
Typical Section – A cross-sectional view of a roadway showing how the structure of the roadway would appear after it is completed

Work Zone – Any continuous tract or area of a roadway in which construction or maintenance is being performed.



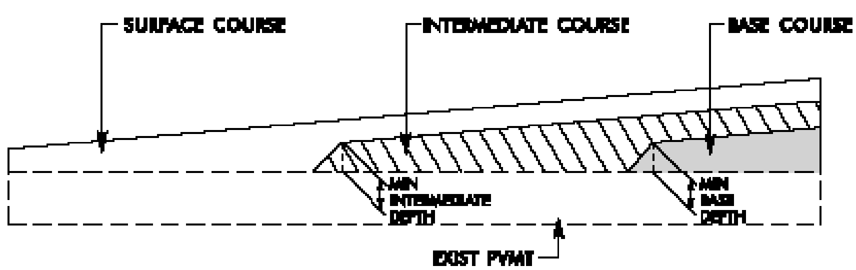
Sample Detail Showing Method Of Wedging for Lane Shifts

Figure 1 (Non-Symmetrical Widening) Grade Point Shift



Sample Detail Showing Method of Wedging for Roof Top Wedging

Figure 2 (Symmetrical Widening) Pavement Slope Change



Sample Wedging Detail For Resurfacing for EOP Wedging Tie ins

Figure 3 Raising the Grade Point

12.3 Guidelines

Over the years, wedging limits have varied from almost zero inches to three feet or more. The most important thing to remember is that wedging limits are a constructability issue more than a pavement issue. Whenever the proposed grade is higher than the existing pavement by **less** than the thickness of the proposed pavement, wedging is needed.

Whenever the proposed grade is higher than the existing pavement by **more** than the thickness of the proposed pavement, the decision to wedge or not is a coordinated decision between the designer, Resident and Division Construction Engineer, Roadway Designer and the Roadway Construction Engineer.

All lifts of pavement used in North Carolina have maximum and minimum values. Some of these values are listed below:

Minimum/Maximum Lifts for Pavement Types

Mix Type	Minimum Lift Thickness	Maximum Lift Thickness
SF9.5A	1.0”	1.5”
S9.5X	1.5”	2.0”
S12.5X	2.0”	2.5”
I19.0X	2.5”	4.0”
B25.0X	3.0”	5.5”

Note: For the most up to date minimums and maximums, see a current Pavement Schedule or see the Roadway Design Manual, Part II, 6-1D.

Remember that the number of lifts that can be constructed under traffic is dependent on how long the designer is willing to have traffic maintained in a temporary traffic pattern.

Wedging pavement under traffic is a slow process and the inconvenience to the motoring public can be enough to change the design of a roadway construction sequence. See the User Cost Chapter of this manual for more details.

12.4 Design Resources

Roadway Design Manual, Part II
Pavement Designer
Division Construction Engineer
Roadway Construction Engineer

Traffic Control Safety Design

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Chapter 1: Introduction

When a project being constructed affects traffic in any way, there needs to be a plan put in place in order to mitigate the concerns of and issues faced by the involved parties. However, there are rules and regulations set that have to be followed while making this plan, leaving it somewhat inflexible. This part of the manual will provide a set of guidelines to follow to assist in making the most feasible and informed plan possible in order to resolve this matter while adhering to those regulations that limit the breadth of possibilities.

These guidelines were established to aid the plan developer in understanding the expectations of North Carolina Department of Transportation Work Zone Traffic Control throughout the developmental stages of a Traffic Management Plan (TMP).

Chapter 2: Transportation Management Plan (TMP)

2.1 About Transportation Management Plans (TMPs)

A Transportation Management Plan (TMP) lays out a set of coordinated transportation management strategies and describes how they will be used to manage the work zone impacts of a road project.

A Transportation Management Plan (TMP) is required for all projects/activities. The scope, content, and level of detail of a TMP may vary based on NCDOT Work Zone Safety and Mobility Policy and the anticipated work zone impacts of the project. The type of TMP needed for a project is based on whether the project is determined to be a "significant project" as described in detail within the North Carolina Department of Transportation Work Zone Safety and Mobility Policy.

The basic objective of each TMP is to permit the contractor to work within the public right of way efficiently and effectively while maintaining a safe, uniform flow of traffic. The construction work and the public traveling through the work zone in vehicles, bicycles, or as pedestrians must be given equal consideration when developing a TMP.

2.2 Components of a Transportation Management Plan (TMP)

Below is a list of the possible TMP components:

- Traffic Control (TC) Plan: Required for all projects/activities.
- Transportation Operations (TO) Plan: Required for Significant Projects/Activities and other Projects/Activities as needed.
- Public Information (PI) Plan: Required for Significant Projects/Activities and other Projects/Activities as needed.

Chapter 3: Coordination

3.1 About Coordination

Plan Developers shall be responsible for the following:

I. Coordinate and document all investigative measures with WZTC and other NCDOT Personnel (including Municipal Personnel, when applicable) concerning possible utility conflicts, the need for temporary shoring, any potential drainage problems, etc. Please note this coordination may require additional meetings.

II. Coordinate with Division personnel to identify feasible detour routes during construction. In addition, coordinate with the NCDOT Permit Section when overweight, over height, and/or wide load detours are necessary.

III. Coordinate and/or address any constructability concerns with WZTC, Division, and other NCDOT Units as needed.

Project Contact (PEF)

All inquiries concerning the project shall be directed to the Work Zone Traffic Control (WZTC) Project Engineer or Project Design Engineer. The PEF should not contact internal units of the NCDOT unless directed to do so by the WZTC Section. This policy is effective throughout the life of the project.

Chapter 4: Traffic Control (TC) Plan Format

4.1 CADD

Workspace

- Utilize the most up to date Work Zone Traffic Control CADD Workspace (see NCDOT CADD Services web-site)
  - This workspace will provide standard drawing levels to utilize along with other valuable tools and guidance when developing Traffic Control Plans and must be adhered to.

Scales

- All scales listed pertain to full size plan sheets. Full Size plan sheets shall be 22" x 34" with a 3" border on the left side and be derived from sheet cells found in cell libraries contained in the WZTC CADD workspace. Half size reproducible copies shall be on 11" x 17" sheets.
  - **Overview Drawings**: 1" = 100" (*English*) || 1:1000 (*Metric*)
  - **Detail Drawings:** 1"=50' (*English*) || 1:500 (*Metric*)

Note: Any deviation from the above must be approved by the WZTC Project Design Engineer.

Electronic File Naming and Sheet Numbering Convention

- Examples for individual plan detail drawings:
  - B4289_TC_TMP_1.DGN or B4289_TC_TMP_01.DGN
- Examples for individual plan base maps:
  - B4289_TC_TCP_BTMP_1.DGN or B4289_TC_TCP_BTMP_01.DGN
- All electronic design files are to contain one sheet **ONLY**. However, this is not critical for Title, Phasing and General Note sheets.

TCP Base Maps

- All electronic base maps created for use as a reference file to Traffic Control Overview and/or Detail plan sheets shall be coordinately correct.

TCP Overview and Plan Details

- All drawings should be consistent.
- Orientation of all drawings or sheets should match Roadway Plans as applicable.
- Station callouts should read from “Left to Right” and “Bottom to Top” whenever possible.
- All electronic data files (roadway, drainage, topography, etc.) and (TC base maps) for which overview and or detail plan view drawings are based shall be attached as reference files with a direct 1:1 scale relationship. (Exceptions for the scaling of a reference file are to occur only for supplemental blow up details shown on plan sheets to assist in plan interpretation).

- All Text Fonts shall be 71 utilizing the NCDOT font resource library (ncdotFont.rsc).

  Text sizes for the various drawing elements can be derived from the WZTC Menu within the WZTC CADD workspace.

  - Please make note of and adhere to the following rule of thumb:

    DRAWING TEXT SIZE RULE: If using a scale other than those built into the WZTC Menu application it is up to the plan developer to determine the proper factor to apply to each of the text categories thus assuring that ALL TEXT stays the same size relevant to the drawing border regardless of the scale of the elements drawn.

    Example: General Text @ 1”=200’ = 28; General Text @ 1”=50’=7;

    Therefore General Text @ 1”=100’=14

- All drawing elements are to be placed on proper levels as provided and defined within the WZTC Menu within the WZTC CADD workspace.

4.2 Traffic Control Plan (TCP) Layout and Numbering scheme

As more of the project information is determined and brainstorming begins, the layout style needs to be addressed. WZTC Project Design Engineer/Project Engineer and the Plan Developer will agree on the TCP layout style in the TMP-Scoping meeting. All subsequent submittals shall comply with the layout style that is agreed to in this meeting. Keep in mind the layout style is just as important as the information contained on the sheets. Some common layout styles are listed below; however, new and innovative ideas are always welcome.

Standard Sheet Layout and Numbering scheme:

TMP-1 Series of Sheets: *(Required all Plans)*

- TMP-1 Title Sheet / Project Vicinity or Location Map / Index of Sheets
- TMP-1A List of Applicable Roadway Standard Drawings, and Legend
- TMP-1B Transportation Operations Plan: (Management Strategies, General Notes, and Local Notes)

TMP-2 Series of Sheets: *(As necessary)*

Example 2 Series Sheets (List not inclusive) – Use as needed – Number sheets accordingly

- TMP-2 Portable Concrete Barrier at Temporary Shoring Locations
- TMP-2A Temporary Shoring Data
- TMP-2B “Work Zone” Speed Limit Reduction
- TMP-2C Sign Designs (for Speed Reduction)
- TMP-2D Thermoplastic Rumble Strip Placement
- TMP-2E Thermoplastic Rumble Strips for Signalized Intersection Alert
- TMP-2F Special Sign Design(s)

TMP-3 Series of Sheets: *(Phasing)*

Note: Phasing for small projects (i.e. Offsite Detours) may be placed on Sheet TMP-1B if desired. “Renumber subsequent plan sheets accordingly”

Further Note: Phasing may be presented as the beginning sheet for each phase of construction throughout the plans. (This scheme is useful went staging the construction by Areas).

TMP-4 & Subsequent Sheets *(TMP – Detail Drawings)*

Possible Layout Styles:

<u>Small Projects</u> - (i.e. Offsite Detours)

Layout Style 1:

- TMP-1 Title Sheet / Project Vicinity or Location Map / Index of Sheets
- TMP-1A List of Applicable Roadway Standard Drawings, and Legend
- TMP-1B Transportation Operations Plan: (Management Strategies, General Notes, and Local Notes, Phasing*)*
- TMP-2 Special Sign Design(s)
  (Number subsequent sheets TMP-2A, etc. as needed)
- TMP-3 … Detail Drawing(s)

Layout Style 2:

- TMP-1 Title Sheet / Project Vicinity or Location Map / Index of Sheets
- TMP-1A List of Applicable Roadway Standard Drawings, and Legend
- TMP-1B Transportation Operations Plan: (Management Strategies, General Notes, and Local Notes)
- TMP-2 Special Sign Design(s)
  (Number subsequent sheets TMP-2A, etc. as needed)
- TMP-3 Phasing Sheet
- TMP-4 … Detail Drawing(s)

<u>Large Projects</u>

Layout Style 3:

- TMP-1 Title Sheet / Project Vicinity or Location Map / Index of Sheets
- TMP-1A List of Applicable Roadway Standard Drawings, and Legend
- TMP-1B Transportation Operations Plan: (Management Strategies, General Notes, and Local Notes, Phasing*)*

TMP-2 Series of Sheets: *(As necessary)*

Example 2 Series Sheets (List not inclusive) – Use as needed –
Number sheets accordingly

- TMP-2 Portable Concrete Barrier at Temporary Shoring Locations
- TMP-2A Temporary Shoring Data
- TMP-2B “Work Zone” Speed Limit Reduction
- TMP-2C Sign Designs (for Speed Reduction)
- TMP-2D Thermoplastic Rumble Strip Placement
- TMP-2E Thermoplastic Rumble Strips for Signalized Intersection Alert

- TMP-2F Special Sign Design(s)
- TMP-3 … Phasing Sheet(s)
- TMP-4 … Project Overview Sheet (per phase - Optional) or Detail Drawing(s)

Layout style 4:

- TMP-1 Title Sheet / Project Vicinity or Location Map / Index of Sheets
- TMP-1A List of Applicable Roadway Standard Drawings, and Legend
- TMP-1B Transportation Operations Plan: (Management Strategies, General Notes, and Local Notes, Phasing*)*

TMP-2 Series of Sheets: *(As necessary)*

Example 2 Series Sheets (List not inclusive) – Use as needed – Number sheets accordingly

- TMP-2 Portable Concrete Barrier at Temporary Shoring Locations
- TMP-2A Temporary Shoring Data
- TMP-2B “Work Zone” Speed Limit Reduction
- TMP-2C Sign Designs (for Speed Reduction)
- TMP-2D Thermoplastic Rumble Strip Placement
- TMP-2E Thermoplastic Rumble Strips for Signalized Intersection Alert
- TMP-2F Special Sign Design(s)
- TMP-3 Project Overview Sheet for Areas
- TMP-4 Project Overview Sheet Phase 1
- TMP-5 Phasing Construction Phase 1
- TMP-6 … Phase 1 Detail Drawings

Repeat for each construction phase

- TMP-x Project Overview Sheet for Areas
- TMP-x Project Overview Sheet Phase 1
- TMP-x Phasing Construction Phase 1
- TMP-x … Phase 1 Detail Drawings

Chapter 5: Plan Development Considerations

5.1 Constructability Considerations

1. Earthwork balance through project (Are we constructing areas of fill before the areas of borrow where we will be getting the earth?)
2. Tie in/grade differences
3. Grade changes at –Y– lines
4. Utility issues
5. Temporary Shoring- needs, locations, quantities, etc.
6. Temporary pavement
7. Drainage/pipes, culverts- depth, installation, sags in Roadway, super-elevations, where will water go during construction?, etc.
8. Phasing of drainage: For instance, build ½ of road then other ½ of road, how will this affect the pipes installation/ drainage
9. Drainage slope, pipes, CB installation and conflicts with temp alignments
10. Stream relocations
11. Phasing clarity, safety, constructability
12. Stabilization as it relates to construction phasing and intersections
13. Undercut
14. Cross over wedging and drop offs
15. Width of temporary bridge to be used - coordinate with Division; Reason: Temporary bridge may require a larger footprint (including sub-structure) than what has been provided. This can effect shoring requirements and locations.
16. Can you begin construction of bridge before closing the road?
17. Make sure everything that is supposed to be constructed is constructed.

5.2 Safety Considerations

1. For new location, which –Y– lines are being crossed?
2. Changes in traffic patterns/ intersection changes
3. Crash data on project. Are there any roadway improvements needed?
4. Site distances for lane closures both vertical and horizontal
5. Advisory Speed Panels

5.3 Mobility Considerations

1. What projects are surrounding the one you are working on?
2. Pedestrian/Bike issues? Detours required?

5.4 Other Considerations

1. User cost (especially pertaining to contract times)
2. Time Restrictions, ICTs, etc.
3. Moratoriums (and how they affect TMP)
4. Environmental commitments
5. Environmental Documents
6. Overhead signs and are they included in TMP (even off project limits)
7. Signal installation (on and off project limits- loop installation on existing road even though project is new location, etc.)
8. Pavement design typical sections for final layer (1 ½" or 2" for asphalt)? Is diamond grinding specified for concrete pavement?

5.5 Coordination Considerations

1. ADA and pedestrian issues
2. Cooperation between contractors clause needed in contract?
3. Changes in cross sections or typical sections after 25% roadway plans?
4. Is coordination with Railroad necessary?
5. Is coordination with EMS or schools necessary?

5.6 Temporary Pavement Considerations

1. Conflicts at intersections in pavement marking plans
2. Design pavement marking for best traffic operations
3. Crosswalks
4. Tie pavement markings to existing

Chapter 6: Site Visits

6.1 Purposes of Site Visits

The plan developer should visit the project site at least once before the project is Let. (WZTC plan developers should seek supervisor's approval). It is recommended that the site visit be made prior to completing the 1st Submittal - Staging Concept, because there are many useful things that can be learned by visiting the project site that cannot be determined from a set of plans or aerial photography.

These include:

- Who the local stake holders are: such as hospitals, types of businesses, schools, types of residences, etc.
- Existing sidewalks and/or pedestrian walkways or paths
- Emergency service providers
- Interconnectivity and the surrounding road network
- Nature of the traffic: local, commuter, traffic speeds
- Congestion of area
- Condition of existing road
- Existing pavement markings and markers (condition, type and layout)
- Existing traffic signals
- Existing stop signs

Chapter 7: Meetings

7.1 Meeting Responsibility

The Plan Developer shall be responsible for the following:

- Attend and present the proposed TMP at the Final Design Field Inspection (FDFI), Combined Field Inspection (CFI), Pre-Let Field Inspection (PLFI), Internal Constructability Review (ICR), External Constructability Review (ECR) meetings and/or any other meeting as needed.
- Take Meeting Minutes focusing on project information pertinent to Traffic Control (TC) at all project meetings and submit a draft of these minutes for approval within 3 business days following the meeting. After approval, the Plan Developer shall distribute the minutes to all attendees and any other party involved with the project as required.
    - NOTE: Obtain a copy of the meeting attendance list at the meeting.
- Maintain written documentation of all coordination between all parties concerning the project. Provide Documentation of all written, oral, and electronic coordination at Each Submittal.
- Additional meetings may be required after project is Let for construction. Such meetings may include pre-construction conference, periodic construction meeting, and/or any other meetings as required.

7.2 Scoping Meeting

General

Before any TMP design begins, a Transportation Management Plan Scoping Meeting must be held between the Plan Developer and the WZTC Project Design Engineer and/or Project Engineer. The decisions made in this meeting will set the course for the TMP. During meeting preparation, the plan developer should refer to the "Transportation Management Plan - Scoping Meeting Checklist," which provides potential traffic control issues for consideration. The plan developer shall come prepared and able to present, discuss and establish the following items at the Transportation Management Plan Scoping meeting.

Items to discuss and agree upon during the meeting:

- General traffic control strategy (discuss potential issues listed in the TMP – Scoping Meeting Checklist)
- Design parameter considerations: (for example: Do we need a temporary speed limit reduction; Are we keeping all temporary pavement within the R/W footprint, What is the minimum lane width we are going to use during construction; What is our minimum PCB offset during construction; ….Other).

Decisions to be made during the meeting:

- The need for Traffic Counts and who will perform same.
- TCP layout and style
- TCP scales (if different from those listed within chapter "TC Plan Format")
- Estimated number of plan sheets needed to complete the TCP.
- Man-day estimate.
- Cost estimate (applicable to PEF only)
- Project Schedule - Number and dates of Submittals

NOTE: PEF negotiations may require multiple iterations or possible meetings.

SCOPING CHECKLIST

The purpose of this checklist is to provide the plan developer a general list of potential traffic control related issues that should be considered when preparing for the TMP Scoping Meeting. This checklist will help the plan developer and the WZTC Project Design Engineer or Project Engineer determine the traffic control scope of work for the project.

Gather the following for analysis:

- Project folder
- Planning Document. If this is not in the project folder, contact PDEA and ask if it has been completed or if a draft is available.
- Roadway Plans and Cross Sections
- ADT (including major –Y– lines)
- Identify all other ongoing or upcoming projects in the area
- County and State Map to examine the network
- Structural data if available
- Project Commitments

Study the gathered materials to determine the trouble areas in order to set a general direction for the Traffic Management Plan. Be prepared to discuss your findings with the WZTC Design Engineer or Project Engineer at the Traffic Management Plan - Scoping Meeting.

The following is a list of typical potential issues that should be investigated in regards to maintaining traffic in preparation for the meeting:

- Check proposed pavement designs. Do these pose any problems?
- Check the typical sections. Do these pose any problems?
- Check for grade change problems. Develop preliminary alternatives to resolve the problem.
- Check all tie-in locations. Develop preliminary alternatives to resolve any tie-in problems.
- Check for proposed bridges or culverts. Determine how these will be constructed (away from traffic, road closure, stage construction, etc.).
- Check for existing signals. How will these be affected by construction?
- Are any temporary signals anticipated? (where, why, when)
- Determine the work zone capacity. Are traffic counts necessary?
- Check for any traffic operation issues.
- Check the need for temporary shoring (where, why, when). [see Temporary Shoring Policy on WZTC webpage]
- Check the need for temporary pavement (where, why, when).
- Check the need for temporary drainage and drainage conflict concerns.
- Check the need for temporary guardrail/barrier (where, why, when).
- Are there any seasonal concerns that could affect the project?
- Will “wide-loads” be a concern? (where, why, when)
- Is the need for any blasting anticipated?
- Will there be any issues with Contractor access?
- Will the earthwork need to be phased in?
- Should we pursue accelerated construction or some other innovative techniques?
- Check for pedestrian issues. Are there existing sidewalks, worn footpaths, schools, or other areas that are likely to attract pedestrians?
- Are there any other observations that could impact the project?

After analyzing these potential issues, the plan developer should establish a general traffic management strategy for constructing the project to be presented at the Transportation Management Plan - Scoping Meeting. See TMP-Scoping Meeting for other elements for which the plan developer is also responsible.

7.3 Field Inspection Meeting

Field Inspection meetings are scheduled by the Roadway Design Unit and generally run by the Division Construction Engineer. The Roadway Design Unit will send plans to all appropriate personnel, for one of the three possible types of Field Inspections:

Final Design Field Inspection (FDFI) (See requirements all meetings)
This meeting is normally held 3 months prior to R/W, and is formerly known as the Preliminary Field Inspection. At the FDFI, the roadway design should be reviewed very closely. The types of information that should be finalized during this meeting are drainage, turn lanes, right of way, and utilities. This includes any design features that affect the slope stake limits. The plan developer will:

- Present the staging concept (unless a separate meeting is held with the Division to discuss the TMP)
- Identify and discuss temporary pavement locations
- Identify and discuss temporary shoring for maintenance of traffic
- Identify and discuss offsite detour improvement concerns
- Identify and discuss constructability issues

Combined Field Inspection (CFI) (See requirements all meetings)
This meeting is intended for smaller projects and is held in lieu of a FDFI and PLFI. The meeting is normally scheduled 3 months prior to R/W. The plan developer will:

- Present the staging concept (unless a separate meeting is held with the Division to discuss the TMP)
- Identify and discuss temporary pavement locations
- Identify and discuss temporary shoring for maintenance of traffic
- Identify and discuss offsite detour improvement/concerns
- Identify and discuss constructability issues

Pre-Let Field Inspection (PLFI) (See requirements all meetings)
This meeting is normally held 5 months before LET date, and is formerly known as the Final Field Inspection. The purpose of the PLFI is to discuss implementation of the design shown in the construction plans, the erosion control plans, the permit application drawings, and the project "green sheet" or environmental commitments. The plan developer will confirm the final TMP with the Division at this meeting.

<u>Field Inspection Notification Letter</u>

A Field Inspection notification letter will be sent to WZTC from the Roadway Design Unit. This is the notice to the plan developer to proceed with the checklists below before, during, and after a Field Inspection meeting:

- Send Division Traffic Engineer Force Account letter, form and a ½ size copy of Roadway Title Sheet within 2 business days of receiving the notification. **(WZTC plan developers ONLY)**
- Bring the following items to each meeting:
  - ✓ Staging Concept Plans
  - ✓ Current Roadway plans with cross sections
  - ✓ Project File

<u>During the meeting:</u>

I. Prepare for meeting by making a list of appropriate questions to ask at the field inspection meeting:

- **Time restrictions**:
  - <u>Lane Closures:</u> YES / NO (requires hourly counts)
  - <u>Holidays:</u> YES / NO (hourly counts not required)
  - <u>Special Events:</u> YES / NO (city, county, state, sporting events, fairs, etc)
  - <u>Hauling:</u> YES / NO (peak hours)
  - <u>Road Closures</u> (elevation problems, tie-in, drainage installation, etc)
  - <u>Emergency / Public Services</u> (hospitals, fire departments, police, schools)
- **Signing:**
  - <u>Permanent signing</u> (responsibility - Contractor or the State Forces)
  - <u>Off-site detour</u> (responsibility - Contractor or the State Forces)
  - <u>On-site detour</u> (responsibility - Contractor or the State Forces)
- **Temporary Pavement Markings, Markers & Delineators**:
  - <u>Temporary Pavement Markings</u> (Type)
  - <u>Temporary Pavement Markers:</u> YES / NO
- **Signals:** YES / NO (hauling, temporary, revised, new)
- **Department Furnished Equipment**: (Changeable Message Signs, Truck Mounted Attenuator, Temporary Crash Cushion, Arrow Boards, Portable Concrete Barrier, Movable Concrete Barrier with transfer/transport vehicle, Signal equipment, etc.)
- **Problem Areas**:

- Temporary shoring for traffic maintenance
- Temporary drainage
- Temporary slope construction
- Hauling across R/R, roadways
- Pavement removal/milling
- Drainage (deep cuts, boring & jacking, removal/plugging, curb & gutter)

- Drainage installation (precast structures, stage construction culvert)
- Off-site detours (bridges limits, widths, roadway's condition & widths, flooding problems, upgrades required [resurfacing, pavement markings, markers])
- Tie-ins (incidental stone, ICTs)
- Work zone protection (PCB with special detail for connection to existing/detour structures or guardrail or sheet piling
- Temporary pavement
- Railroads
- Utilities
- Wide load (detours)
- Earthwork

II. Present TMP-Staging Concept Plan.

III. Take notes at Field Inspection meetings, focusing on project information pertinent to Traffic Control.

Chapter 8: Submittals

8.1 Requirements for Submittals

- Stamp or label the title sheet in each TMP Submittal with the corresponding submittal. (i.e. Staging Concept, etc.)
- Submit half-size copies of the previous marked up submittal.
- Submit half-size copies of each required submittal for review and approval. The # of copies required for each submittal will be agreed on at the TMP - Scoping Meeting.
- Submit an electronic copy in PDF file format of the TMP at each required submittal. (PEF ONLY)
- Provide half-size copies of the TMP for distribution at the FDFI, CFI, PLFI, ICR, and ECR meetings. The number of copies required for each submittal will be agreed on at the TMP Scoping Meeting.

NOTE: Each Submittal must be reviewed and approved prior to distribution or presentation at any meeting.

- Make timely Submittals of the Transportation Management Plan according to the schedule agreed upon.
- Advise WZTC Lead Project Personnel a minimum of one (1) week in advance of each planned submittal if adjustments of the dates are necessary.

8.2 1st Submittal – Traffic Management Concept

This submittal is required for all projects with the exception of the very basic and least complex of projects. The decision whether this submittal is required or not will be made at the Scoping Meeting.

I. PURPOSE:

The purpose of the Traffic Management Concept is to organize and sequence the construction requirements in a safe and efficient manner. It is utilized to determine and convey the design decisions that are necessary to provide constructability of the project, while providing a method to maintain a safe flow of traffic through the construction zone. The Traffic Management Concept shall be developed in a manner that will provide the Contractor with the flexibility to work simultaneously in as many areas of the project as possible, and to expedite the project's completion. In doing so, the major items of work are to be identified and how they impact traffic. In addition, other "features" such temporary pavement, shoring, alignments, drainage, signals etc. are to also be identified and shared with the appropriate Division personnel, and also other NCDOT design sections and consultants that may be involved.

The Traffic Management Concept plan will be presented at the Final Design Field Inspection (FDFI) or Combined Field Inspection (CFI) for concurrence or. A separate constructability meeting is strongly recommended for complex projects. The need for a separate constructability meeting should be determined at the project scoping meeting. It's extremely important that all affected parties understand this Traffic Management Concept as it may affect the accuracy and completion of their plans, and therefore their attendance at the presentation of the Traffic Management Concept is very important, so that their requirements and suggestions can be incorporated into the Traffic Management Plan. *See Requirements for all Meetings*

II. SUBMITTAL REQUIREMENT: *Also, See Requirements for all Submittals*

The Traffic Management Concept plan should consist of the following elements:

- Written Traffic Management Concept Staging
- Traffic Management Concept drawings (Overview Drawings)
- Cross Section Views (Identifying Work areas and Traffic patterns)

Written Traffic Management Concept Staging:

- The Plan Developer shall provide a simple written description that "outlines" the sequence of work operations that are to take place in each "Phase" of construction and answers the following questions: What/Where is construction is taking place?
- What traffic control method is being used (lane closures, road closure, away from traffic, flaggers, etc.)?
- Where is traffic at the end of the workday?

Example:

Away from traffic, construct the following: -L-, -Y1-, -Y2- and -Y3- (include common road names). Traffic remains on existing alignment during this construction (See TCP-X).

OR

Using flaggers and lane closures, construct the tie-in of proposed -Y2- with existing -Y2-. Traffic will be on proposed -Y2- alignment at the end of the workday (See TCP-X).

The written Traffic Management Concept should be placed on the Traffic Management Concept drawings (Overview Sheets).

Traffic Management Concept Drawings (Overview Drawings):

Provide easy to understand overview drawings that show where construction is occurring and where traffic is being maintained during each specific phase of construction. **These drawings are intended to communicate a concept, not a final detailed plan; therefore, keep the**

drawings as simple as possible. Each phase of work shall be shown on separate drawings. The use of separate, supplemental detail sheets may be necessary for more complicated areas.

Format / Layout (roll-out plots and/or border sheets) shall be determined at the TMP – Scoping Meeting. All drawings shall utilize appropriate scales that convey a clear and understandable view of the construction and location of traffic for each phase. ”For complicated plans (with a large number of sheets, interchanges, flyovers, ramps and loops, etc.), it is helpful if the TMP sheets appear much the same as the roadway plan sheet for the area being described (scale, orientation, match lines, etc.). Details may be used for clarification, on the same sheet or on another, when the scale is too small to clearly show the intended construction.

All drawings, at a minimum shall show the following:

- Existing roads
- North Arrow
- Traffic flow arrows
- Existing and proposed road alignment designations **along with their common names**
- Horizontal alignment station tick labels and station ticks
- Driveways
- Cross Section views and locations (See category below)
- Match lines / Break lines
- Proposed and completed construction for the specific phase of work
- Provide any additional information that helps to explain the project

Show only areas under construction shaded in gray utilizing MicroStation WZTC Level: Gray Area Fill Shapes. Minimal color may be used on the Staging Concept Drawings if determined at the TMP- Scoping Meeting.

All areas that have been completed shall show the proposed features, and shall not be shaded.

Cross Sections:

Provide cross sections that illustrate the spatial relationship (both horizontal and vertical) with dimensions between traffic lanes and the proposed construction during each specific phase of construction. Show the traffic control devices to be used to separate opposing travel lanes and/or to separate traffic from construction. Identify each station location or station range, along with traffic flow arrows, road names/designations, and other features necessary to clearly define the elements drawn within each cross section view. For Bridge and/or Culvert sites, clearly identify the width of the proposed bridge or culvert that is to be constructed, the working room, traffic control device and offset, and width of travel lanes. Place the cross sections either on the overview or detail sheets.

Additionally the Traffic Management Concept plan shall contain the following if applicable:

- ☐ The location of any temporary pavement, temporary shoring and/or temporary signals needed during construction.
- ☐ Any potential needs and methods that are required for maintenance of pedestrian/bicycle traffic during construction.
- ☐ Any potential off-site detour route(s) and/or Oversize/Overweight detours required during construction. Ensure that the detour route's pavement conditions are able can handle the additional traffic. (i.e. bridge weight limits, widths, roadway condition and widths, flooding problems, upgrades required, etc.)
- ☐ Identify any Lane and Road Closures (both intermittent and/or long term) that may be necessary, make initial recommendations for lane closure, road closures, continuous operations, and other lane closure/road closures restrictions. If a long term closure is needed, then begin discussions on the amount of time required for this activity. Coordinate these with the Contract Time Officer
- ☐ Temporary drainage issues (deep cut, boring & jacking, removal/plugging, curb and gutter, etc.)
- ☐ Drainage installation (steel plates, precast structures, stage construction)
- ☐ Any potential temporary crossovers or on-site detour route(s) used during construction of the project
- ☐ Work zone protection (PCB, Water Filled Barrier, Guardrail, Drums, etc.)
- ☐ Utility issues (water & sewer – if available)
- ☐ Night work (may affect phasing)/Lighting
- ☐ Retaining walls
- ☐ Wedging, Pavement Removal & Replacement, Undercut, Tie-in areas (incidental stone, etc.)
- ☐ Roadway Typical Section (i. e. pavement design, drop-off's, soil stabilization, curing times, asphalt vs. concrete, milling, condition of existing shoulders, curb & gutter)
- ☐ Balancing Earthwork (cut/fill), Temporary slopes (confirm maximum allowable slope)
- ☐ Work Zone access (hauling, material delivery, staging area, etc.)
- ☐ Bridge Construction (girder installation, temporary bents, staged construction, bent construction, etc.)
- ☐ Overhead Signs (spanning entire travel way, cantilevered)

<u>Submittal Package:</u>

Items to be included with the submittal package should be discussed and agreed upon at the project scoping meeting. Submittal may include some or all of the items listed below. Submit items to the WZTC Project Design Engineer for review no later than the date agreed upon at the TMP - Scoping Meeting. If the project schedule has changed since the TMP - Scoping Meeting, contact the WZTC Project Design Engineer to discuss if the submittal date may be adjusted. Typically, the 1st Submittal –Traffic Management Concept is due no later than one month prior to the Final Design or Combined Field Inspection meeting. (For PEF's, this submittal date is typically two months prior to the Final Design or Combined Field Inspection meeting).

- ☐ Hard copy of the roadway plans and cross-sections.*
- ☐ Project File*
- ☐ Half-size copy(s) of the Traffic Management Concept.
- ☐ Traffic Counts, if applicable and any recommendations for time restrictions.
- ☐ Notes from TMP - Scoping Meeting.
- ☐ Notes from Site Visit (if applicable).
- ☐ Written Justification of Engineering Judgment
- ☐ Temporary Shoring Investigation (if applicable).
- ☐ List of items/questions to be discussed at the FDFI/CFI.

* This item may not be required from PEFs.

Approval of this submittal will complete the Traffic Management Concept of the Transportation Management Plan.

(PEF ONLY) Payment for the Traffic Management Concept will not be approved until after the FDFI or CFI meeting.

8.3 2nd Submittal – Midpoint

The 2nd Submittal-Midpoint is optional on some less complex projects. The decision on whether or not the Midpoint submittal is required will be made at the Scoping Meeting.

I.PURPOSE:

This submittal should consist of the TCP developed from either the TMP Scoping Meeting, the 1st Submittal – Staging Concept or both, as applicable, and include all revisions requested during those reviews.

II.SUBMITTAL REQUIREMENT: *<u>Also, see Requirements for All Submittals</u>*

The 2nd Submittal-Midpoint should contain, but not be limited to the following:

<u>**General:**</u>

- The Layout of the TCP agreed upon in the Transportation Management Plan – Scoping Meeting.
- All revisions to the Traffic Control Plan requested from the Staging Concept Submittal Review, field inspections and/or constructability meetings if applicable.
- Details developed from the Staging Concept. NOTE: Overviews may be included as well depending on the layout and complexity.

<u>**Title Sheet:**</u>

- Finalized listing of applicable Roadway Standard Drawings.
- Index of Sheets.
- Indicate the Midpoint Submittal stamp (cell) on this sheet.

<u>**Project Notes Sheet:**</u>

- General Notes
  - Include a finalized list of Project Notes specific to the project on the Project Notes Sheet.
  - Include all final lane and road closure time restrictions with this submittal.
- Local Notes
  - Include a finalized list of Local Notes specific to the project on the Project Notes Sheet.

NOTE: If Local Notes are used, they shall be referenced in the Phasing.

Traffic Control Phasing:

The phasing at this submittal shall be expanded from the brief summary described in the Staging Concept including any requested changes made at that time.

- Address the following three main points when developing the Phasing:
  - What construction is taking place?
  - What Traffic Control method is used to maintain traffic during this construction; (i.e. is construction away from traffic or are lane closures and flaggers used during construction).
  - Where is traffic at the end of the workday?
- Include a written description of how traffic will be maintained during each phase and step of construction. Refer to the proper Roadway Standard Drawing as applicable to describe how traffic will be maintained during construction at that time.
- Refer to the traffic control details and cross section view sheet numbers.
- Step out traffic shifts.
- Describe installation of temporary and final traffic signal(s).
- Refer to the Roadway, Signal, Signing, Structure and Pavement Marking Plans when relevant.
- Identify any Intermediate Contract Times (ICT's) needed throughout the project's duration. In addition, coordinate with field personnel and the Contract Time Engineer in Project Services concerning any issues pertaining to the duration and the scope of work included in these Intermediate Contract Times. Place a box around ICT's (see example below).

NOTE: As mentioned, Phasing is more detailed and specific than the summary described in the Staging Concept review submittal. For example the following could be written:

Working in a continuous manner, complete the work required in Step 1 in X days:

Step 1: -Using Roadway Standard Drawing 1101.02, sheet 1 of 9, complete the following:

- Construct the tie-in of proposed -Y2- and existing -Y3- from -Y2- Sta. X+XX to -Y2- Sta X+XX up to but not including the final surface layer. (See TCP-X).
- Place the final surface layer, Pavement Markings and Pavement Markers on -Y2-, Sta X+XX to Sta X+XX, and -Y3-, Sta X+XX to Sta X+XX.
- Activate the final traffic signal (Signal # XXXXX - See Signal Plans) at the -Y2- / -Y3- intersection. (See Final Pavement Marking Plans)
- Open traffic to the final pattern.

Traffic Control Overviews:

At this submittal, Overviews, if used, should show any proposed work that is started, under construction or completed during each particular phase of construction. Overviews may also show the location of Traffic Control Devices such as: drums, barricades, temporary signals, portable concrete barrier (PCB), etc.

Traffic Control Details:

- Include detailed plan views and cross section views that illustrate where construction is occurring and how traffic is maintained in relation to the construction.
- Shade **only** proposed work that is started, under construction or completed during each particular step or phase of construction. Previously completed work is shown with solid lines and is not shaded.
- Each construction phase shall be shown on separate drawings. Show directional flow arrows indicating traffic patterns and include a north arrow. Show all necessary traffic control devices, required signing, and any temporary pavement markings on detail sheets and in cross section views. Label all roads (include all known designations, names, and alignment data) and other relevant features described below:
  - Maintained Lane Widths
  - Temporary Pavement Marking and Marker Designation Labels
  - Match Lines
  - Additional Legends if applicable
  - TIP (if applicable) and Sheet Numbers, etc.

- Label all information on the detail drawings that has been referred to in the Phasing (i.e. station numbers, etc.)

Off-site Detour Signing and Temporary Guide Signs:

- Whenever an off-site detour is required and the Contractor is responsible for installing, furnishing, and removing the off-site detour signing, the Plan Developer shall obtain the required off-site detour sign designs or temporary guide signs from the Signing and Delineation Section when applicable.
- Include all off-site detour signing detail sheets with this submittal. These detail sheets will show the locations and type of signs used.

Advance Work Zone Warning Signs:

- Include all Advance Work Zone Warning Sign detail sheets applicable to the project.

NOTE: Include all notes found on the Advance Work Zone Warning Sign detail sheets within the Project Notes section of your plans if the Advance Work Zone Warning Signs are depicted on your plan details instead.

Additionally, the information identified in the 2nd Submittal shall include, but is not limited to, the following:

- All time restrictions used in the Construction Phasing and Project Notes. (Based on discussions)
- Any speed reduction and/or $250.00 penalty ordinance as coordinated with field personnel and the Regional Traffic Engineer.
- Areas which require temporary shoring, (if not identified in the Staging Concept Submittal).
- Areas which require temporary drainage, (if not identified in the Staging Concept Submittal).
- Coordination with the Utility Section and identification of any utility conflicts, if applicable.
- Any temporary alignment for on-site detours or temporary pavement. These temporary alignments should be coordinated with Roadway Design Personnel, (if not identified in the Staging Concept Submittal).

Submittal Package:

Submit the 2nd Submittal - Mid-point Traffic Management Plan for review and approval by the date agreed upon in the TMP-Scoping Meeting.

Approval of this submittal will complete the 2nd Submittal of the Traffic Management Plan.

(PEF ONLY) Payment beyond the 2nd Submittal Mid-point will not be approved until after the FDFI, CFI or ICR meeting.

NOTE: Most projects require an Internal Constructability Review Meeting unless otherwise indicated by WZTC lead personnel at the TMP - Scoping meeting.

8.4 3rd Submittal – Pre-Final

The 3rd Submittal - Pre Final TMP should basically complete the TMP and be taken to the Pre Let Field Inspection (if applicable) to discuss with construction personnel.

I. PURPOSE:

This submittal shall consist of the final TMP as developed from requested revisions or comments from previous meetings and reviews.

II. SUBMITTAL REQUIREMENT: *See Requirements for all Submittals*

This Submittal will be required for all TIP projects, and shall include the following:

- All final Traffic Control Plan Detail Sheets.
- All revisions to the Traffic Control Plan as requested from previous review.
- All requirements from previous submittals even if bypassed for your particular project.
- An Engineer's Estimate that includes calculations of estimated quantities for Traffic Control items. (Submit all calculations and or worksheets providing the basis of the estimate quantities submitted).
- A list of any Project Special Provisions (Standard and Non-Standard) and Specifications that will be needed for the project.
- Any speed reduction and/or $250.00 penalty ordinance as coordinated with field personnel and the Regional Traffic Engineer.

Submittal Package:

Submit the Pre-Final TMP to the WZTC Project Design Engineer for review and approval no later than the date agreed upon at the TMP-Scoping Meeting. If the project schedule has changed since the TMP-Scoping Meeting, contact the WZTC Project Design Engineer to discuss if the submittal date may be adjusted. Typically this submittal shall be made prior to the Pre-Let Field Inspection.

Approval of this submittal will complete the 3rd submittal of the Transportation Management Plan.

(PEF ONLY) Payment beyond the Pre-Final TMP will not be approved until after the Pre-Let Field Inspection.

8.5 4th Submittal – Final

I. PURPOSE:

The 4th Submittal shall consist of the final TMP developed from the previous submittal.

II. SUBMITTAL REQUIREMENT:

The TMP submitted at this time should be complete and include the following:

- Completed Transportation Management Plan with all revisions incorporated as requested from the pre-final submittal as well as any changes from Field Inspection meetings.
- Final Traffic Control quantity estimate. (Submit all final calculations and / or worksheets providing the basis for the estimate quantities submitted).
- A Full Sized electronically sealed .pdf and all electronic drawings and documents of the Final Traffic Control Plan, including any Project Special Provisions and ICT's. (Include all electronic files that plan sheets are referenced to and dependent upon for accurate representation). (Applies to PEF)
- NOTE: Electronic data may be delivered on a CD/DVD or through the FTS (File Transfer System) established by the NCDOT. (Applies to PEF)
- All correspondence with other units or agencies relating to the Transportation Management Plan.
- Return any borrowed materials previously provided by NCDOT, if applicable. (applies to PEF)
- User Cost Package (WZTC plan developers ONLY).

<u>Submittal Package:</u>

Submit the final TMP to the WZTC Project Design Engineer for review no later than the date agreed upon at the TMP - Scoping Meeting. If the project schedule has changed since the TMP – Scoping Meeting, contact the WZTC Project Design Engineer to discuss if the submittal date may be adjusted.

Approval of this submittal will complete 100% of the Transportation Management Plan.

8.6 Project Turn-In

Turn the following into the Roadway Project Engineer / Squad Leader in Roadway Design or Project Services:

Submittal Package:

- ☐ Electronically Signed/Sealed full size Transportation Management Plan in .pdf format placed in proper folder on the "Project Store" (Project Server).
- ☐ Full Size hard copy of TMP generated from the Signed/Sealed .pdf.
- ☐ Completed and signed Final Transportation Management Plans submittal letter which contains a listing of any attachments and Roadway Pay Item quantities required for Temporary Pavement, Temporary Shoring and Temporary Guardrail.
- ☐ Copy of Transport Quantity Estimate.
- ☐ Copy of Force Account Estimate, if applicable. (Include in Transport)
- ☐ Copy of any Intermediate Contract Times (ICT).
- ☐ Copy of any Project Special Provisions. (Electronically Signed/Sealed)

Final Procedures:

- Distribute copies of appropriate plans (pdf), and data per the Final TMP Submittal letter.
- Purge project folder(s) and file.
- Finalize the Project User Cost Package, if necessary and turn-in to appropriate WZTC personnel.

Chapter 9: References/Design Standards

All plans, designs, specifications and estimates shall conform to the NCDOT standard practices for highway construction, which are based on the latest edition of the following publications and or materials:

1. **AASHTO** – A policy on Geometric Design of Highways and Streets
2. **AASHTO** – Roadside Design Guide
3. **Manual on Uniform Traffic Control Devices** (MUTCD)
4. **NC Supplement to Manual on Uniform Traffic Control Devices** (MUTCD)
5. **NCDOT** – Standard Specifications for Roads and Structures (mainly Divisions 10, 11, and 12)
6. **NCDOT** – Roadway Standard Drawings (mainly Divisions 11 and 12)
7. **FHA** – MUTCD Standard Highway Signs
8. **Highway Capacity Manual** (All associated software shall be used as applicable, including any modifications as may be directed by NCDOT during the life of the project. See Congestion Management Guidelines for more details)
9. **NCDOT WZTC Design Manual**
10. **MicroStation and GEOPAK software** (see NCDOT web-site)
11. **NCDOT WZTC web-site**

Guidelines for Transportation Management Plan Development

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Chapter 1: Introduction

Usercost can affect many items in the total contract including how the TCP is phased, the construction duration and cost, therefore each program used requires engineering judgment. Usercost concepts are now required by FHWA in the TMP (Traffic Management Plan), a part of the final rule.

WZTC Design Engineers are mandated by the MUTCD to develop a plan that considers the safety of both road users and workers, efficient movement of road users through the work zone, and the efficient completion of construction activity.

To be able to successfully analyze usercost, a designer must understand the concept of Work Zone Capacity, how to use the available and various programs to determine usercost, and how to package the usercost so that the Contract Times Committee can make sound decisions regarding liquidated damages and overall contract time. Liquidated damages are the delay in completing work due to public inconvenience, obstruction to traffic, interference with business, and the increasing of engineering, inspection and administrative costs to the Department who will determine the amount of liquidated damages.

Usercost analysis should ultimately result in a balance between the needs of the road users and the efficient completion of construction activity.

Chapter 2: Suggested Minimum Volumes

NOTE: *The* ***vehicles per hour****, (vph) and* ***vehicles per hour per lane****, (vphpl) shown below are the suggested volumes facilities should have before imposing day & time restrictions to the contract. Every facility must be evaluated for mitigating factors such as signalization, schools, industry businesses, etc. These factors dramatically reduce the capacity of the facility. Truck traffic over 15% will reduce these also.*

I: **2 Lane, 2 Way Roadways**

- During a flagging operation, the work zone capacity range for a two lane, two way Rural facility is approximately 750 vph to 1000 vph, (the total of both directions).
- During a flagging operation, the work zone capacity range for a two lane, two way Suburban facility is approximately 500 vph to 750 vph, (the total of both directions).
- During a flagging operation, the work zone capacity range for a two lane, two way Urban and/or Mountain facility is approximately 250 vph to 500 vph, (the total of both directions).

II: **4 Lanes, 2 Way Divided, Controlled Access**

- The work zone capacity required for a 4 -lane divided rural - controlled access facility is approximately 1,200 vphpl or greater during a lane closure.
- The work zone capacity required for a 4-lane divided urban - controlled access facility is approximately 1,500 vphpl or greater during a lane closure.

Note: Consult the Highway Capacity Manual, (HCM) Chapter 6 for freeways in excess of 4 lanes, complete control of access with more than 2 lanes in each direction for work zone capacity.

NOTE: Many facilities do not fall into any of the previous categories. Multi-lane undivided facilities are prime examples: 500-750 vph are good estimates to use as thresholds to begin lane closure restriction.

Chapter 3: Detour Program

3.1 Introduction

The purpose of the Detour User Cost Program is to calculate an estimated daily usercost (an estimation of the inconvenience in dollars) to the road users that are placed on an offsite detour. The daily detour user costs are derived from the estimated operating, delay, and slope and turn costs for the cars and trucks that are being detoured. The costs that this program calculates are a part of the Detour Usercost Package which assists the Contract Time Engineer in determining the liquidated damages to place on the project. If the detour delay caused by this construction is calculated to be at least $1000 then an ICT is needed unless the detour is the result of a full road closure for the project duration.

3.2 Process

Step 1: Open the Detour user Cost program.

Step 2: Input in the TIP No., date, and your name in the appropriate boxes.

DETOUR USER COST

TIP No:	
Date:	
Prepared by:	

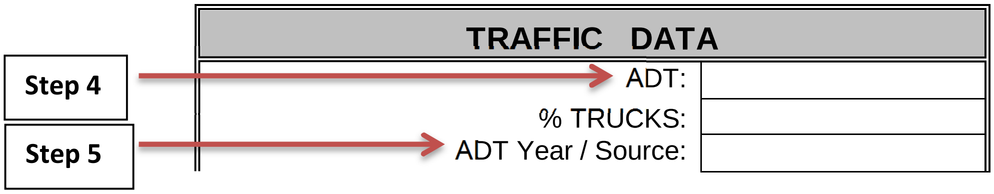
Step 3: In the description box, enter the name of the road being closed, as well as any additional information you feel might be helpful to explain the purpose of the detour.

DESCRIPTION

Step 4: In the <u>ADT</u> box, input the ADT (Average Daily Traffic)

Guidance: The Roadway Plans, ADT maps, traffic counts, and the NCDOT G.I.S. Unit are possible sources to determine the ADT.

Step 5: In the ADT Year/Source box, input the source from which the ADT data was obtained.

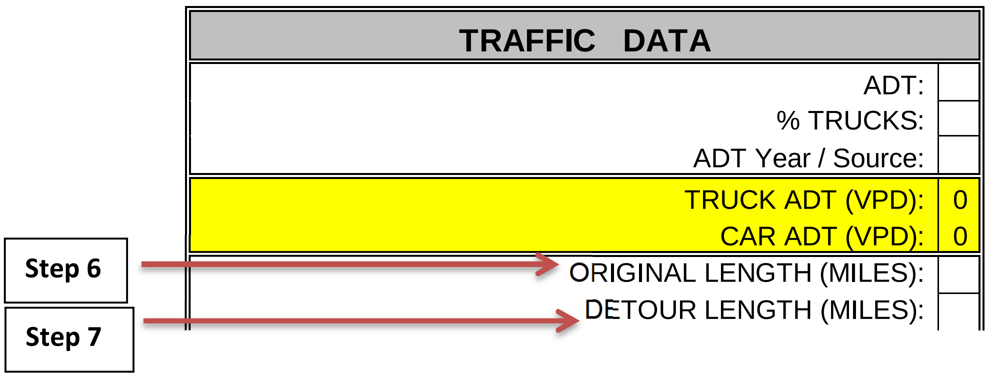


Step 6: In the Original Length (Miles) box, input the length of the original road.

Guidance: The original road length should be from the point the detour begins to the point the detour ends, along the original road.

Step 7: In the Detour Length (Miles) box, input the length of the detour route.

Guidance: The length of the detour route should be from the point the detour begins to the point the detour ends along the detour route.

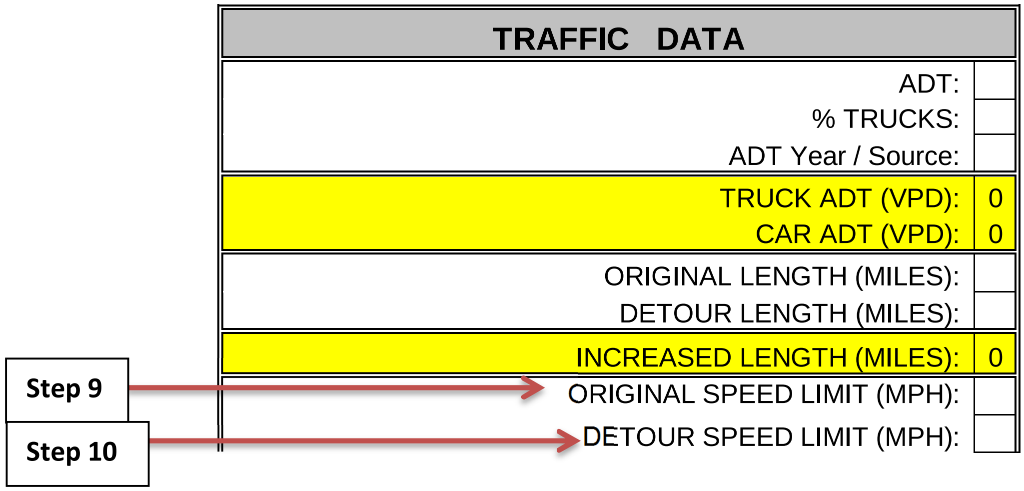


Step 9: In the Original Speed Limit (MPH) box, input the speed limit of the original road.

Guidance: The speed limit for the –L– line may be found on the Roadway Title Sheet or in the Planning Documents. Free Flow Speed for this road would be calculated as the posted speed limit plus 10 MPH. However, the Highway Capacity Manual will provide you more guidance on this topic. The speed limit for all roads may be obtained through the NCDOT G.I.S. Unit (SDV Online).

Step 10: In the Detour Speed Limit (MPH) box, input the average speed limit for the roads on the detour route.

Guidance: The speed limit for all roads may be obtained through the NCDOT G.I.S. Unit (SDV Online) .



Step 11: Calculate the highest aggregate value for the number of left turns, right turns, and stops along the detour route and input the associated turns and stops in the appropriate boxes. See Guidance below for instructions.

*Guidance: Calculate the movements along the detour route for the thru traffic (not local traffic) in the clockwise direction and then in the counterclockwise direction to determine the highest aggregate value. The stops have the highest impact on traffic (value of 1), followed by the left turns (value 0.5), and then the right turns (value of 0.25). Example: 2 stops + 1 left + 1 right = 2*1 + 0.7 + 0.25 = 2.75. Once the highest aggregate value is determined, input the associated number of left turns, right turns, and stops in the appropriate boxes.*

- *A stop is counted when thru traffic comes to a stop sign or traffic signal.*
- *A left is counted when thru traffic has to turn left, without having to stop as indicated above for the stop condition.*
- *A right is counted when thru traffic has to turn right, without having to stop as indicated above for the stop condition.*

Step 11

TRAFFIC DATA	
ADT:	
% TRUCKS:	
ADT Year / Source:	
TRUCK ADT (VPD):	0
CAR ADT (VPD):	0
ORIGINAL LENGTH (MILES):	
DETOUR LENGTH (MILES):	
INCREASED LENGTH (MILES):	0
ORIGINAL SPEED LIMIT (MPH):	
DETOUR SPEED LIMIT (MPH):	
INCREASED TRAVEL TIME (MINUTES):	
LEFT TURNS:	
RIGHT TURNS:	
STOPS:	
AGGREGATE (STOPS/VEHICLE):	0

Step 12: Input the Analysis Year Consumer Price Index.

Guidance: Refer to onscreen instructions for value to input.

Step 13: See total daily user cost for detouring traffic in bottom row of program. Print a copy for the User Cost Package and save an electronic copy to the User Cost folder under the project.

Step 12

Step 13

USER COST	TOTAL PER DAY
ANALYSIS YEAR CONSUMER PRICE INDEX	218
COST UPDATE FACTOR	1.67
TRUCK OPERATING COST	$0.00
TRUCK DELAY COST	$0.00
CAR OPERATING COST	$0.00
CAR DELAY COST	$0.00
STOP AND TURN COST	$0.00
TOTAL	***$0.00***

Step 14: Include a detour map that indicates the distances used in calculating the Original Length and Detour Length as indicated in steps 7 and 8 and the direction used in determining the highest aggregate values (step 11).

Chapter 4: Flagger Program

4.1 Introduction

The purpose of the Flagger Program is to calculate an estimated daily user cost (an estimation of the inconvenience in dollars) to the road users that are impacted by a flagging operation on a two-lane, two-way roadway. The daily flagging costs are derived from the relationship between the hourly traffic volumes, length of lane closure, and the time that traffic is stopped. The costs that this program calculates are a part of the Usercost Package, which assists the Contract Time Engineer in determining the liquidated damages to place on the project.

4.2 Process

Step 1: Open the Flagger Program

Step 2: If there is any data already shown in the program you may select the "Clear Worksheet" button on the right side of the program to clear the data from the program.

Step 3: Input the <u>TIP No.</u> and the <u>description</u> in the appropriate boxes.

Guidance: The description should provide the road name and specific construction operation involved.

Step 4: In the <u>Project No.</u> box, input the WBS #

Guidance: The WBS # can be found on the Roadway Title Sheet.

Step 5: In the Project <u>County</u> box, input the county the project is located in.

Step 6: In the <u>Percent Trucks</u> box, input the truck percentage

Guidance: the % trucks for the –L– line may be found on the Roadway Title Sheet.

Step 7: In the <u>Critical Lane Width (ft)</u> box, input the lane width for 1 direction of traffic.

Guidance: The Critical Lane Width is the width of the open lane at the narrowest point between the two ends of the flagging operation. The width of the roadway can be found on the roadway plan sheets, usually labeled on the road.

Step 8: In the <u>Grade %</u> box, input the average grade of the road that will be flagged.

Guidance: The Roadway profile sheets show the grades of the road.

Step 9: In the Approaching Velocity (mph) box, input the existing speed limit for the road before the flagging operation is installed.

Guidance: The existing speed limit for the –L– line road maybe be determined from the Roadway Title Sheet by subtracting 5 mph from the Design Speed indicated (applies for most cases). Other sources to determine the existing speed limit may include the Planning Documents, Google Maps (ground view),and through NCDOT GIS Unit resources (SDV Online).

Step 10: In the Work Zone Velocity (mph) box, input the anticipated work zone velocity.

Guidance: Due to elements of the work zone, including the flagging operation, vehicle speeds will most likely be slower. The typical speed to input is 10 mph to 20 mph less than the existing speed limit.

Step 11: In the Distance between Flaggers (ft) box, input the estimated distance between the two flaggers.

Guidance: The typical distance to input is either 500 ft or 1000 ft.

Step 12: In the Max. Flagging Time (min) box, input the estimate time that a flagger will hold traffic in one direction.

Guidance: The typical time to input is 5 minutes. Note: Flagging operations should not hold traffic for more than 15 minutes.

Step 13: In the Hourly Volume boxes, input the hourly volumes for both directions combined.

Guidance: Method 1 – If hourly traffic counts are available, input the hourly volumes. Method 2 – If no hourly volumes are available, select the "Convert ADT to Hourly Volumes" button, and input the Average Daily Traffic (ADT) for the road. The ADT for the roads may be found in the Roadway Plans, Traffic Volume Maps, planning documents or through the NCDOT GIS Servers (SDV online). In the same pop-up menu where the ADT is inputted, select what type of route the road is and the day of the week that flagging will primarily occur.

At this juncture you will be creating two different runs.

*Steps 14-17 will be the **first** in which you will determine the worst case scenario of a flagging operation for an entire 24 Hour period.*

Step 14: In the hourly restrictions box located at the top of the form, select the "Ignore hourly restrictions" option

Guidance: This will be your inputs for the 24 hour run which will provide you the highest hourly cost and the total daily cost for the worst case scenario.

Step 15: Select the "Simulate Flagging Operation" button. Select the "Return to Input Sheet" button.

Step 16: Select the "Print" button. Gather your print out.

Step 17: Select the "Save Flagger Data" button.

Guidance: Save the flagger data in the "usercost" folder under the project's working directory. This will allow you to have access to it in the future if you need to revisit it for any reason. The saved file can be brought back into the FLAGGER Program by selecting the "Load Flagger Data" button and selecting the appropriate file.

*The **second** run will determine user cost after applying any lane closure time restrictions.*

****** Perform Step 18 if you have any lane closure time restrictions on the road being analyzed; otherwise, go to Step 20.******

Step 18 & 19 will cover the second scenario.

Step 18: Select the "Use hourly restriction" option at the top of the form. Then, in the Lane Closures Restrictions? box, toggle the "No" to "Yes" if applicable for the hours that lane closures will not be allowed.

Guidance: This will be your inputs for the time restrictions run which will provide a cost to help determine the liquidated damages if the contract exceeds the Contract Time.

Step 19: Repeat Steps 15, 16, and 17. Then go to Step 20.

Step 20: Select the "Exit Program" button to close out of the program.

NOTE: The "Clear Worksheet" button may be selected if there are multiple flagging analysis that need to be run. The "Clear Worksheet" button will remove all information inputted into the program. IMPORTANT: Be sure to print and save the file (if you want to keep it) before selecting the "Clear Worksheet" button.

Chapter 5: Quewz Program

5.1 Introduction

Quewz is a computerized version of commonly used manual techniques for estimating the queue lengths and additional road usercosts resulting from work zone lane closures. It simulates traffic flows through freeway segments both with and without a work zone lane closure in place and estimates the changes in traffic flow characteristics and additional road usercosts resulting from a lane closure whose time schedule and lane configuration are described by the user. Quewz can also apply the same traffic flow simulations to identify time schedules for lane closures that will not produce excessive queue lengths and delays.

5.2 Process

I. INPUT DATA REQUIREMENTS

Lane closure configurations are described by the number of directional roadways in which lanes are closed (1 or 2), total number of lanes in each direction, number of open lanes through the work zone in each direction, length of the lane closure, and capacity of the work zone.

- *The total number of lanes, number of open lanes, and per-lane capacities may be different in each direction. The length of the lane closure, however, must be the same when both directions are evaluated in the same run of the model. If necessary, a separate data set may be created and run for each direction.*

Schedule of work activity is defined by the hours the lane closure begins and ends and the hours that work activity begins and ends.

- *The hours the lane closure begins and ends define the time period during which the lane closure is in place. The hours of actual work activity must be totally contained within, and may be the same as or different from the hours when the lane closure is in place. That is, work activity may be underway during any part, or all, of the time period during which lanes are closed. Work activity may be specified only during hours when lanes are closed.*
- *For example, long-term lane closures may be implemented during a construction activity, for which lanes are closed from midnight to midnight on any given day, but the hours of actual work activity might be only from 7:00 am to 4:00 pm. On the other hand, for a short-term maintenance activity, lanes might be closed only from 9:00 am to 3:00 pm, and the hours of work activity would be essentially the same.*

Traffic volumes are required and can be satisfied by providing either directional hourly volumes for the period of interest or AADT of the roadway, the day of the week when the lane closure will be in effect, and the general location of the freeway (urban or rural).

- *The most accurate form of input would be directional hourly volumes obtained from traffic counts taken at the site of the work zone. The AADT volume option uses two sets of adjustment factors (one for urban freeways and the other for rural freeways) to estimate directional hourly volumes from the AADT input. These factors represent the average daily, hourly, and directional variations in traffic volumes.*
- *For Peak Hour restrictions, multiple Quewz runs are required and the total user cost must be added together. For night work, flip the hours. When inputting the hourly volumes, begin with noon being "0". Therefore, the night work volumes will be continuous. For further explanation on each of these, see your supervisor.*

Default values for model constants include cost update factor, percentage of trucks, speed-volume relationship, work zone capacity, definition of excessive queuing, and pollutant emissions rank.

1. **Cost update factor:** Adjusts the road user costs for the effect of inflation.
2. **Percentage of trucks:** Influences the calculations of work zone capacities and road user costs.
3. **Speed-volume relationship:** Used to estimate the normal approach speed on the freeway and the average speed through the work zone.
4. **Work zone capacity:** Appears to vary depending on whether or not there is work activity in the work zone.
5. **Definition of excessive queuing:** Either a critical length of queue in miles or a maximum acceptable delay to motorists in minutes.
6. **Pollutant emission rates:** The specific pollutants considered are hydrocarbons, carbon monoxide, and nitrogen oxide.

II. USING THE PROGRAM

- Once you have opened the QUEWZ program select Prompt 1 and enter. The following is guidance to help you answer the questions listed in this prompt:
  - For the Problem Title, enter the specific construction operation involved. If extra space is needed hand write information after the run is printed
  - For the Major Highway, enter the road name. If there will be multiple runs on this road, you may need to number each run for clarity.
  - The Free Flow Speed on a facility is generally the posted speed limit plus 10 MPH. The Highway Capacity Manual can provide further guidance on this topic.
  - The Level of Service D/E breakpoint is also based on information in the Highway Capacity Manual. You may determine this number for your specific project or you may select the default speed the program provides.
  - The Capacity Speed is also based on information in the Highway Capacity Manual. You may determine this number for your specific project or you may select the default speed the program provides.
  - Crossovers have a slightly greater effect on the user cost in each direction of travel than just a lane closure. This is why the program asks you if your lane closure is a cross over or not.
  - Since you are just using only 1 direction of traffic volumes, you may select inbound or outbound. However, in a special circumstance where a Quewz run is completed for each direction, it will be important to designate the change in direction.
  - Input the appropriate hours work is allowed. For example, a 24 hour run would show the traffic control being set up at “0” and removed at “24”.
  - The actual work will begin after the traffic control is set up.
  - Currently, we use 135% of 1981 dollars to determine the usercost.
  - Input the total number of lanes for the direction you are calculating.
  - Input the total number of open lanes once the lane closure is in place.
  - Input the % trucks of the roadway.
  - How long will the lane closure be? Refer to the General Notes of the project as guidance. Often for multilane facilities there will be a limit of approximately 1 mile for a lane closure. However, this distance may vary depending on the operation and traffic volumes.
  - For capacity information (the hourly capacity, the LOS DE Breakpoint volumes, and the Work Zone capacity), please see the below chart and the Highway Capacity Manual.
    - The following are guidelines for ideal conditions without work zone for the Maximum service flow rate and LOS DE Breakpoint:

Maximum service flow rate or capacity volumes:

Free Flow Speed, (FFS) - Level of Service, (LOS)

- **FFS $\geq$ 70 mph 2,400 pcphpl**
- **FFS = 65 mph 2,350 pcphpl**
- **FFS = 60 mph 2,300 pcphpl**
- **FFS = 55 mph 2,250 pcphpl**

Level of service D/E breakpoint volumes:

- **FFS = 75 mph 2,100 pcphpl**
- **FFS = 70 mph 2,050 pcphpl**
- **FFS = 65 mph 1,975 pcphpl**
- **FFS = 60 mph 1,875 pcphpl**
- **FFS = 55 mph 1,750 pcphpl**

Work Zone volumes:

Refer to minimum requirements on page 1 because these change for the type of facility.

- Select Prompt 2. Volumes should be one directional (inbound or outbound). If you do not have hourly volumes for one direction, use the ADT and the higher directional split for one direction DO NOT USE THE TOTAL ADT.
- Prompts 3-5 may be used to edit any information you entered and to check for accuracy.
- Run the program by selecting Prompt 6.
  - A 24 hour run, determines the highest hourly cost as well as the total daily cost for the worst case scenario. This cost is used in determining penalties if the contractor exceeds the time restrictions for lane closures. To print and save this run, see instructions below.
  - An allowable work hour run determines the Daily User Cost for that particular traffic control operation. This cost is used in determining final damages if contractor exceeds THE CONTRACT TIME (or project completion date) shown in the contract proposal. You can begin this by selecting Prompt 3 and changing questions 7-10. This is a little tricky if you only have peak hour restrictions or if you only allow night work. See your supervisor on how best to handle your specific project. Once you have completed Prompt 3, select Prompt 6 to analyze the data. To print and save this run, see instructions below.
- Prompt 7 allows you to print the results or display then on the screen for review.
- Prompt 8 will allow you to save the information before exiting or continuing to the time restriction run. This may be saved to the project file, but you will have to type the exact path.

- <u>Prompt 10</u> allows you to exit the program.
- If there are no hourly lane closure restrictions, make the 24 hour run only.

Chapter 6: Guidelines for Completing Usercost Package

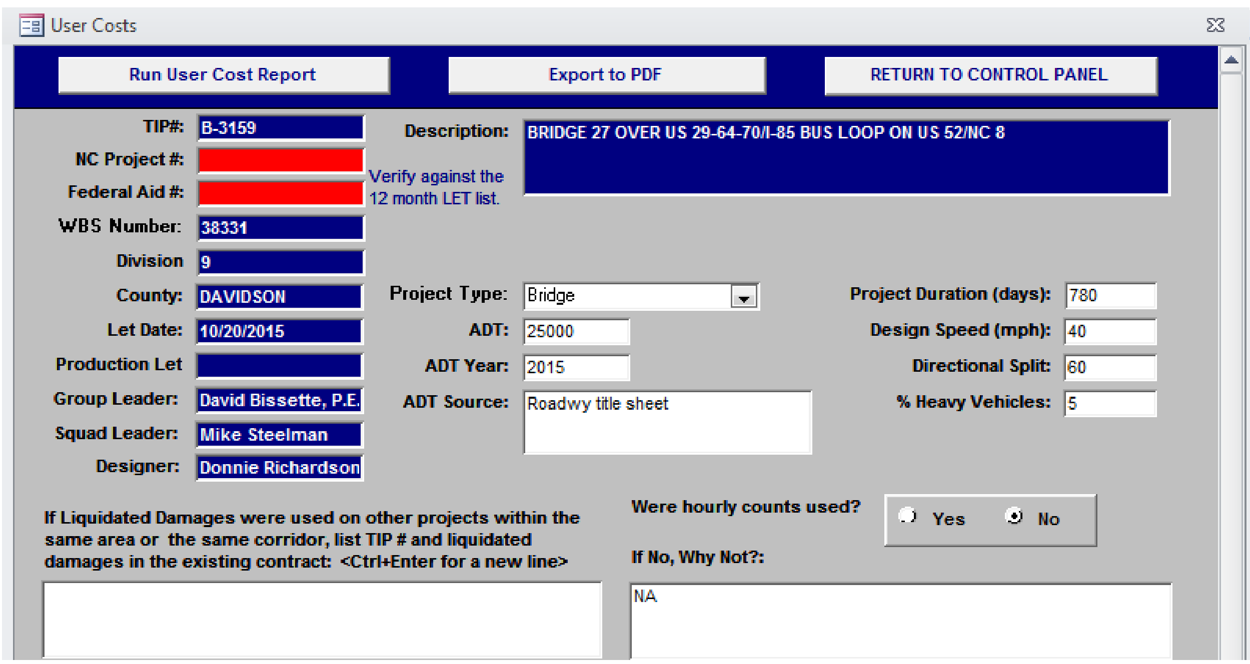
6.1 Introduction

When creating a Usercost Package there are multiple items that need to be acknowledged that will affect the user during the life of the project. For instance, users can be affected by different situations such as construction duration, onsite/offsite realignment, need for ICTs, order of construction, liquidated damages, use of crossovers, accelerated construction, and time restrictions. With this there are certain guidelines and forms that should be completed to ensure that the usercost for the project isn't more than what can be accommodated.

6.2 Guidelines

GENERAL INFORMATION:

NOTE: OBTAIN ALL SUPPORTING INFORMATION BEFORE BEGINNING



ADT/ADT Source:

- Use Average Daily Traffic, (ADT) volumes from the roadway title sheet if there are no hourly volumes available.

- Specify the source of your ADT: Roadway title sheet, Traffic Surveys Unit, Automatic Traffic Recorder locations, Division Traffic Counts, etc. (Make sure you include this information with your User Cost Package).

Note: Consult with Project Engineer before ordering counts.

Project Type:

- The **project type** aides in determining the volumes of vehicles per hour per lane, (vphpl) capacity numbers that are used to determine if time restrictions are required.
- If your **project description** does not match one of the program options, hand write in the proper description.
- The **description** should include information such as, urban; rural; light, moderate, or heavy roadside development, frequent signalized intersections, etc.

Project Duration:

- The Contract Time Engineer within the Proposals and Contract Management Section calculates the roadway construction times for your project. **DO NOT GUESS TIMES TO CONSTRUCT!** See your supervisor if you have questions.
- The Structures Engineer, calculates the structure construction times for your project. **DO NOT GUESS TIMES TO CONSTRUCT!** See your supervisor if you have questions.
- Be prepared to provide any needed information as necessary such as project phasing, roadway plans, etc. when discussing with either the Contract Time Engineer or Structures Engineer.

Hourly Counts:

Attach any hourly counts obtained to the user Cost Package. *Exception: Off-site Detours do not require hourly counts. The ADT shown on the roadway plan will suffice.*

Liquidated Damages on Corridor/Area Projects:

- Make a copy of all adjoining project's Intermediate Contract Time from their proposal and include this information with your UCOST package.
- If you're not sure whether or not your project qualifies, ask your supervisor for assistance.

User Cost Database:

DETOURS [If none, enter "N/A" in Description]					
Description	Road	Duration (days)	ADT	Daily User Cost	ProRated User Cost
Y7 (Phase I, step 6)	Piedmont Dr	90	200	$31.92	$3.68

A. DETOUR (ROAD CLOSURE)

DESCRIPTION

- Please provide a description of the work operation requiring the detour.
- Provide the name of the road that is being detoured, (this is not referring to the project description).

ROAD

- Name of the Detoured Roadway.

DURATION (days)

- For off-site bridge projects (single structure), match the Contract Time (project duration) set by The Contract Time Engineer or Structures Engineer.
- For Intermediate Contract Times (ICT's), match the ICT recommended by the Division Construction Engineer, the Contract Time Engineer, or the Structures Engineer. **(Before contacting CTE or SE discuss the Intermediate Contract Time with the Division Construction Engineer or Resident Engineer).**

ADT

- Do not order counts for off-site detours. Use the ADT from the roadway plans or county map.
- Use ADT of the road **that is being detoured**.

DAILY USER COST

- Enter amount from the Detour User Cost Program.

PRORATED USER COST

- Program Calculates.

FLAGGING OPERATIONS [If none, enter "N/A" in Description]						
Description	Road	Highest Hourly Cost	Duration (days)	ADT	Daily User Cost	ProRated User Cost
24 hr run	NC 8	$1,409.01	0	25000	$12,458.76	$0.00
Restricted 7am to 9am and 4pm to 6pm (General note A)	NC 8	$797.98	80	25000	$5,325.63	$546.22

B. FLAGGING OPERATIONS: (TWO LANE, TWO-WAY LANE CLOSURES)

1. *If time restrictions are NOT applicable, do the following*:

DESCRIPTION

- The construction operation that is necessitating the flagging operation, (this is not referring to the project description).

ROAD

- The road name that the flagging operation is on.

HIGHEST HOURLY COST/DAILY USER COST

- This is taken from the flagger program 24 hour run output and entering the correct duration of time.

DURATION

- This number should be equal to the time required for completion of the specific work operation. Review the items of work to be completed and discuss with the Division Construction Engineer or Resident Engineer before reviewing with the Contract Time Engineer, or the Structures Engineer.
- Note: The total duration of ALL ROADS should match the number of hours/(8hrs/day X 2 flaggers) that were required in the final quantity estimate.

ADT

- Should match the Flagger Program ADT and should include BOTH directions.

DAILY USER COST

- Should match the Flagger Program.

PRORATED USER COST

- Program calculates.

2. *If time restrictions ARE applicable, 2 lines of input will be required as follows:*

<u>DESCRIPTION (FOR BOTH LINES OF INPUT)</u>

- The construction operation that is necessitating the flagging operation, (this is not referring to the project description).

<u>ROAD (FOR BOTH LINES OF INPUT)</u>

- The road name that the flagging operation is installed on.

<u>HIGHEST HOURLY COST/DAILY USER COST (FIRST LINE)</u>

- This is taken from the flagger program 24 hour run output. This is required to see a "worst case delay/cost scenario". This is also used to determine Liquidated Damages per hour.

<u>HIGHEST HOURLY COST/DAILY USER COST (SECOND LINE)</u>

- This is taken from the flagger program that shows hours of time.

<u>DURATION (FIRST LINE)</u>

- Enter a "0" for the duration time.

<u>DURATION (SECOND LINE)</u>

- Enter the correct duration of time. (Note: The total duration of <u>ALL ROADS</u> should match the number of hours/(8hrs/day X 2 flaggers) that were required in the final quantity estimate.)
- This number should be equal to the time required for completion of the specific work operation. Review the items of work to be completed and discuss with the Division Construction Engineer or Resident Engineer before reviewing with the Contract Time Engineer or the Structures Engineer.

<u>ADT</u>

- Should match the Flagger Program ADT and should include BOTH directions.

<u>DAILY USER COST</u>

- Should match the Flagger Program.

<u>PRORATED USER COST</u>

- Program calculates.

LANE CLOSURES [If none, enter "N/A" in Description]

Description	Road	Highest Hourly Cost	Duration (days)	ADT	Daily User Cost	ProRated User Cost
24 hr run	I-85 Bus	$349.00	0	27000	$1,788.00	$0.00
Restricted 5am to 10pm	I-85 Bus	$0.00	60	27000	$0.00	$0.00

C. LANE CLOSURES

1. *If time restrictions are NOT applicable, do the following:*

DESCRIPTION

- The construction operation that is necessitating the lane closure, (this is not referring to the project description).

ROAD

- The road name that the lane closure is on.

HIGHEST HOURLY COST/DAILY USER COST

- This is taken from the Quewz program 24 hour run output and entering the correct duration of time.

DURATION

- This number should be equal to the time required for completion of the specific work operation. Review the items of work to be completed and discuss with the Division Construction Engineer or Resident Engineer before reviewing with the Contract Time Engineer, or the Structures Engineer.

ADT

- Should match the Quewz Program ADT and the highest direction should be used.

DAILY USER COST

- Should match the Quewz Program.

PRORATED USER COST

- Program calculates.

2. *If time restrictions ARE applicable, 2 lines of input will be required as follows:*

DESCRIPTION (FOR BOTH LINES OF INPUT)

- The construction operation that is necessitating the lane closure, (this is not referring to the project description).

ROAD (FOR BOTH LINES OF INPUT)

- The road name that the lane closure is installed on.

HIGHEST HOURLY COST/DAILY USER COST (FIRST LINE)

- This is taken from the Quewz program 24 hour run output. This is required to see a "worst case delay/cost scenario". This is also used to determine Liquidated Damages per hour.

HIGHEST HOURLY COST/DAILY USER COST (SECOND LINE)

- This is taken from the quewz programs that show hours of time.

DURATION (FIRST LINE)

- Enter a "0" for the duration time.

DURATION (SECOND LINE)

- Enter the correct duration of time.
- This number should be equal to the time required for completion of the specific work operation. Review the items of work to be completed and discuss with the Division Construction Engineer or Resident Engineer before reviewing with the Contract Time Engineer, or the Structures Engineer .

ADT

- Should match the Quewz Program ADT and the highest direction should be used.

DAILY USER COST

- Should match the Quewz Program.

PRORATED USER COST

- Program calculates.

INTERMEDIATE CONTRACT TIMES				
Description	Operation Type:	Recommended by:	Why Recommended:	Liquidated Damages
NC 8 dailyand holiday restrictions 7am to 9am and 4pm to 6pm	Lane Closure	WZTC	Peak hour traffic volumes	$0.00
I-85 Bus cannot be closed from Monday at 5am thru Friday at 10pm, Saturday 5am to 10pm,	N/A	WZTC and Division	For all overhead work (proposed bridge, exist bridge	$0.00

D. INTERMEDIATE CONTRACT TIME SUMMARY

*NOTE: Every specified **ICT** included in the Transportation Management Plan will have the associated delay/cost that justifies the restriction. If the restriction cannot be justified by the delay/cost then the **ICT** will be recommended to be removed from the Transportation Management Plan unless safety concerns exist.*

DESCRIPTION

- Always state road name (i.e.: I-95) and type of ICT (i.e.: day, time and holiday restriction) List the time, day & special event restrictions first.
- List other restrictions in the order as they appear in the project phasing.
- Include all ICTs that are in the TMP.
- ICTs should be separated per type needed and by road.

OPERATION TYPE

- List the construction operation that will be required to be performed in the ICT: detour, lane closure, flagging operation, etc.

RECOMMENDED BY:

- The WZTCS should always be recommending, sometimes in conjunction with one or more of the following: DTE, RTE, DCE, RCE

WHY RECOMMENDED:

- Description of Usercost implication.

NOTE: If during the evening hours with a low road capacity this is where you must use your engineering judgment and the capacity of the road verses the volume of the roads. It is also important to have a balance between the time restrictions and providing the contractor adequate time to get the work done. The more restrictive contract results in a longer duration and a higher cost.

E. USERCOST PACKAGE ASSEMBLY

Include the following in all Usercost Packages, in this order: & place in appropriate folder within the project store (server).

1. Usercost Summary or Report
2. ICTs
3. TMP General Notes
4. TMP Phasing Notes
5. Roadway Title Sheet
6. Detour Usercost (if applicable)
7. Detour Plan (one for each detour) (if applicable)
8. Flagging Operation Cost (if applicable)
9. Lane Closure Cost (if applicable)
10. Hourly Counts (if applicable)
11. Project Duration as established by the Contract Time Engineer.

Note: Please staple. Paper clips come off.

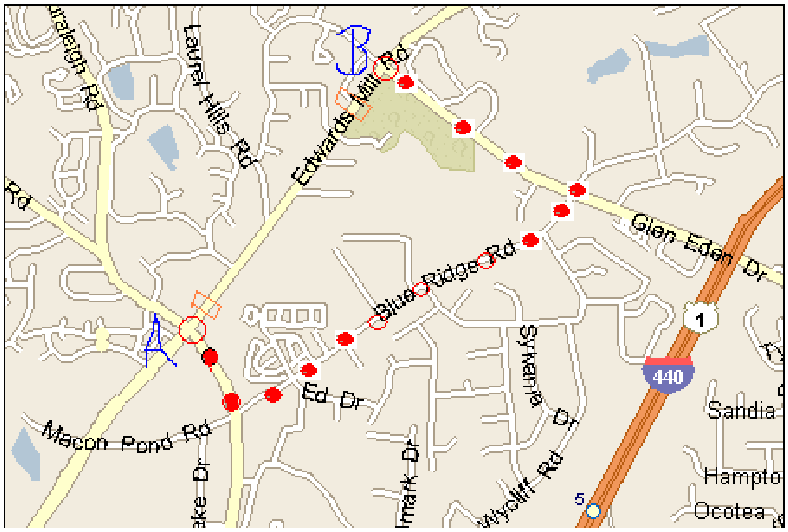
F. USER VALUE:

User value tries to place the "value" of having a facility completed and open to traffic. Typically, this type of analysis is performed on a corridor such as a Bypass project. Currently, we have no software that performs this analysis, but one can "extrapolate" a User Value with some known information and some "inferred" or "projected" assumptions. The most common way to address this request is to assume the road has been constructed and is open for traffic. Then assume it must be closed and the traffic detoured. Run a Detour User Cost to determine a User Cost for this situation. In some cases, the Lane Closure program may also be used to help determine this user value.

Chapter 7: Frequently Asked Questions

This section contains frequently asked questions about Usercost Estimating.

1. How do I calculate the detour and original length?



The original length is the length from A to B (see above) along the road that is being closed.
The detour length is the length from A to B (see above) along the detour route.

2. Where do I find the ADT maps?
http://www.ncdot.gov/travel/statemapping/trafficvolumemaps/

3. What if my detour is only at night to hang girders?
Use the approximate ADT for the hours the road will be closed (you should have hourly volumes for the higher volume facilities).

4. How do I know if I need hourly restrictions?
This is where you must use your engineering judgement and the capacity of the road verses the volumes of the roads. It is also important to have a balance between the time restrictions and providing the contractor time adequate to get the work done. The more restrictive the contract is results in a longer duration and a higher cost.

5. How do I know what Free Flow Speed is?
This is generally the posted speed limit plus 10 mph. However, the Highway Capacity Manual will provide you more guidance on this topic.

6. What if I only have peak hour restrictions or night work, how do I run a quewz program?

For peak Hour restrictions, multiple quewz runs are required and the total user cost must be added together.

For night work, flip the hours. When inputting hourly volumes, begin with noon being "0". Therefore, the night work volumes will be continuous.

For further explanation on each of these, see your supervisor.

7. What do I do when asked to run a User Value Run?

User value tries to place the "value" of having a facility completed and open to traffic. Typically, this type of analysis is performed on statewide or regional tier facility projects. Currently, we have no software that performs this analysis, but one can "extrapolate" a User Value with some known information and some "inferred" or "projected" assumptions. The most common way to address this request is to assume the road has been constructed and is open for traffic. Then assume it must be closed and the traffic detoured. Run a Detour User Cost to determine a User Cost for this situation. In some cases, the Lane Closure program may also be used to help determine this user value.

Part 5 – Traffic Control Usercost Estimating

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