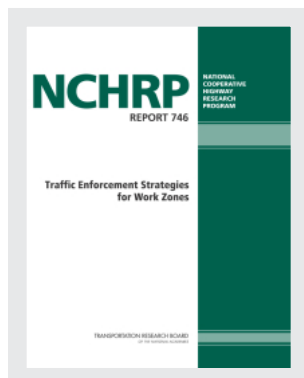


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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 746

Traffic Enforcement Strategies for Work Zones

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2013

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The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The researchers wish to express their gratitude to the members of the project panel for their guidance and patience during the performance of this research. In addition to the project panel members, the authors gratefully acknowledge the assistance of numerous state DOT personnel who participated in a survey of state practices. Finally, this research could not have been completed without the special assistance of several members of the New York State DOT, California DOT, New Jersey DOT, North Carolina DOT, Kansas DOT, and Tennessee DOT who coordinated access to work zone projects for the various field studies and driver surveys performed during the course of this research. Similarly, the assistance of members of the New York State Police, the California Highway Patrol, New Jersey State Police, North Carolina Highway Patrol, Kansas Highway Patrol, and Tennessee Highway Patrol is also gratefully acknowledged.

FOREWORD

By **B. Ray Derr**

Staff Officer

Transportation Research Board

This report presents guidance for the safe and effective deployment of traffic enforcement strategies in work zones on high-speed highways (those with speed limits of 45 mph or greater). The planning, design, and operation of traffic enforcement strategies are discussed, as well as administrative issues that should be addressed. The report will be useful to traffic and construction engineers engaged in these types of projects.

The safety of motorists and workers in construction and maintenance work zones is a key concern of state transportation agencies. Traffic law enforcement by uniformed officers or other means can be effective in reducing undesirable driver behavior that contributes to crashes, but little objective guidance exists on selecting projects where enforcement would be most beneficial or on developing a traffic enforcement strategy for a work zone. Public awareness techniques are sometimes used to improve compliance with traffic laws (e.g., variable message signs showing the number of tickets issued, “Get the Picture. Listen to the Signs.”), and guidance, based on existing information, is needed on the effectiveness of these techniques.

Although improved compliance with traffic laws would be beneficial in all work zones, traffic enforcement tends to be used more in work zones on high-speed roads because the risks are greater. In addition to enforcing traffic laws, enforcement officers often carry out other duties in work zones (e.g., handling traffic and investigating crashes). This project did not consider those types of activity.

In NCHRP Project 03-80, the Texas A&M Transportation Institute and their research team surveyed the literature and practice and identified technologies that can supplement or supplant law enforcement personnel. They then conducted structured group interviews to gain additional insights into the benefits and concerns associated with law enforcement in work zones. Knowledge gaps pertaining to work zone traffic enforcement were identified and, insofar as resources allowed, addressed through the collection and analysis of field data. They then prepared the guidebook so that practitioners can apply the knowledge gained during the course of the research.

The contractor’s final report providing background information for the project is available on the TRB website as *NCHRP Web-Only Document 194*.

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S U M M A R Y

Traffic Enforcement Strategies for Work Zones

Current federal regulations require all state highway agencies to have a policy in place regarding the use of law enforcement in work zones. Requirements pertaining to reimbursement of enforcement costs are also outlined in the federal regulations. While the regulation does identify a number of topics that agencies need to address in their policies, it does not describe how to address those topics. Rather, agencies are left to decide how best to fund, administer, and implement traffic law enforcement efforts in work zones under their jurisdiction. As part of the development process, agencies must consider such questions as:

- When and where should law enforcement be used?
- How much enforcement should be used?
- What type(s) of enforcement strategies should be used?
- How should the enforcement efforts be paid for?
- How should the use of enforcement in work zones be monitored and administered?
- How should the effectiveness of enforcement be measured, and how much benefit is achieved?
- What work zone design features best accommodate enforcement activities?
- What alternatives and/or supplements to enforcement (speed display trailers, portable changeable message signs, etc.) are most appropriate to implement?
- What public awareness and motorist notification techniques best complement work zone enforcement efforts?

Within work zones, both overt and covert law enforcement strategies are appropriate for use, depending on the desired objectives of the highway agency, types of work zone hazards present, and traffic characteristics. In some cases, the presence of enforcement as a traffic-calming technique near temporary hazards such as work crews or where traffic queues occur is also a useful safety enhancement in work zones. The use of circulating patrols through the work zone and of pack enforcement strategies (including the stationing of an officer within the work area to identify traffic law violators for subsequent apprehension downstream of the work zone) are likewise appropriate enforcement strategies in some instances. A few states have had positive experiences with automated speed enforcement deployments in work zones, although this strategy is currently not an option for many state highway agencies until changes are made in their state traffic laws or vehicle code enabling the use of this technology.

A number of conditions in work zones may justify and warrant enforcement use. A distinction can be made between those hazards related specifically to work activities and thus are present only at certain times and locations, and those that are related to the geometrics and alignment of the work zone design and thus are present at all times. While the desired effect of enforcement provided for a work activity hazard is an immediate and significant

reduction in speed (and increase in driver attention) in the vicinity of the hazard, the desired effect of enforcement to address work zone design hazards is a continuous change in driving behavior, including those times when the enforcement officer and vehicle are not present.

Ideally, work zone enforcement would best be used where its benefits equal or exceed the costs of providing that enforcement. Intuitively, the benefit of using enforcement in a work zone is an improvement in safety in terms of reduced work zone crash costs, although there may be some situations where the traffic-calming effect of enforcement could improve traffic flow and result in reduction in motorist delay costs. The extent to which enforcement can influence driver behavior (and ultimately safety) depends on many site-specific factors such as:

- The type of enforcement strategy being employed;
- The number of travel lanes, traffic volumes, percentage of local and non-local motorists, and vehicle mix on the facility;
- The difference between the work zone speed limit that is posted and the current operating speeds of drivers; and
- The type and amount of public information disseminated about the work activity.

Safe work zones are the result of good planning and execution. This is especially true with regards to the utilization of law enforcement. Simply hiring an off-duty officer or two and leaving them to figure out their role once they travel to the work zone is not sufficient to achieve the types of safety benefits desired. Rather, effective enforcement deployment and use in work zones requires cooperation and communication between highway agency, enforcement agency, and highway contractor personnel directly involved with the project. This preparation includes ensuring that details about the work activity that will impact where and how the officer is positioned within the work zone are discussed, and establishing methods of maintaining communication between highway agency, highway contractor, and law enforcement personnel at the project.

Several work zone geometric design features can significantly impact the ability of enforcement personnel to function either in an active enforcement or in a traffic-calming role within the work zone. Similarly, choices regarding regulatory and advisory work zone speed limits, supplemental traffic control devices to manage speeds and raise driver awareness, and motorist notification of enforcement efforts can likely benefit or constrain enforcement effectiveness.

Experiences nationally indicate that work zone enforcement can be administered in several different ways, depending on the amount and type of work zone enforcement typically required by the highway agency, the amount of staff time and resources the highway and/or enforcement agencies can devote to managing work zone enforcement efforts, and the working relationship between the highway and enforcement agencies. A memorandum of understanding (MOU) between a highway and an enforcement agency is a highly-valuable tool in the administration of work zone enforcement. In most instances, the MOU is between the state highway and state enforcement agencies; in some cases, though, the highway agency and a local enforcement agency may enter into an MOU. Costs for work zone enforcement are eligible for reimbursement through the Federal-aid program, and the regulations allow enforcement services to be funded on a project-by-project basis as part of the individual construction contracts, or on an overall program-wide basis by setting aside a portion of the overall construction budget of the agency for enforcement activities. In addition, a few states have enacted legislation that returns a portion of the fines received from work zone enforcement efforts back to fund future work zone enforcement.

Payment procedures are another important consideration of work zone enforcement administration. Typically, one of three main methods is used:

- Work zone enforcement efforts are paid by the highway agency on a program-wide or project-by-project basis to the enforcement agency as reimbursement of officer hours worked
- Work zone enforcement efforts are paid directly by the contractor to either the individual officer or to the enforcement agency as part of the construction contract for hours worked
- The highway agency (or other part of state government) establishes a grant arrangement to go directly to the enforcement agency to fund the work zone enforcement efforts

In many cases, work zone enforcement is accomplished through the use of officers hired on an overtime basis. Although most enforcement agencies leave it to the individual officers to monitor their own level of effort and limit their off-duty assignments to a reasonable level, a few enforcement agencies track these efforts more closely and may even cap the number of off-duty hours the officer can take on in a given week.

It is recommended that those officers participating in work zone enforcement efforts receive proper training. The purpose of such training is to ensure that officers are aware of the purposes of providing law enforcement in work zones, understand the basic practices and procedures related to the use of law enforcement officers in work zones, understand the purpose and application of the various traffic control devices in use in work zones, and understand that there are acceptable and unacceptable locations for enforcement personnel to be located upstream and within a work zone.

CHAPTER 1

Introduction

The provision of traffic law enforcement at a highway work zone is recognized as one of the most effective means available for reducing speeding, speed variability, and undesirable driving behaviors such as tailgating and unsafe lane changes, thereby improving traffic and worker safety in the work zone. The presence of work zone enforcement is also believed to raise driver awareness and level of alertness, reducing perception-reaction times in response to unexpected hazards encountered. As was noted in the Final Rule creating a new Subpart K to 23 CFR Part 630, Temporary Traffic Control Devices (1):

“A number of conditions may indicate the need for or benefit of uniformed law enforcement in work zones. In general, the need for law enforcement is greatest on projects with high traffic speeds and volumes, and where the work zone is expected to result in substantial disruption to or changes in normal traffic flow patterns. Specific project conditions should be examined to determine the need for or potential benefit of law enforcement, such as the following:

- (i) Frequent worker presence adjacent to high-speed traffic without positive protection devices;
- (ii) Traffic control setup or removal that presents significant risks to workers and road users;
- (iii) Complex or very short term changes in traffic patterns with significant potential for road user confusion or worker risk from traffic exposure;
- (iv) Night work operations that create substantial traffic safety risks for workers and road users;
- (v) Existing traffic conditions and crash histories that indicate a potential for substantial safety and congestion impacts related to the work zone activity, and that may be mitigated by improved driver behavior and awareness of the work zone;
- (vi) Work zone operations that require brief stoppage of all traffic in one or both directions;
- (vii) High-speed roadways where unexpected or sudden traffic queuing is anticipated, especially if the queue forms a considerable distance in advance of the work zone or immediately adjacent to the work space; and
- (viii) Other work site conditions where traffic presents a high risk for workers and road users, such that the risk may be reduced by improving road user behavior and awareness.”

As a result of this federal rulemaking, all state highway agencies must have a policy in place regarding the use of law enforcement in work zones (see Figure 1). Requirements pertaining to reimbursement of enforcement costs are also outlined in federal regulations (see Figure 2).

While the regulation does identify a number of topics that agencies need to address in their policies, it does not describe how to address those topics. Rather, each agency is left to decide how best to fund, administer, and implement traffic law enforcement efforts in work zones under its jurisdiction. As part of the development process, agencies must consider a number of basic staffing and implementation questions, such as:

- When and where should law enforcement be used?
- How much enforcement should be used?
- What type(s) of enforcement strategies should be used?
- How should the enforcement efforts be paid for?
- How should the use of enforcement in work zone be monitored and administered?
- How should the effectiveness of enforcement be measured, and how much benefit is achieved?

In addition to answering these questions, agencies must also decide how to best design and manage their work zones so as to maximize the effectiveness of law enforcement when it is used. This includes consideration and implementation of the following:

- Work zone design features that best accommodate enforcement activities;
- Selection and implementation of appropriate alternatives and/or supplements to enforcement (speed display trailers, portable changeable message signs, etc.); and
- Appropriate public awareness techniques to complement work zone enforcement efforts.

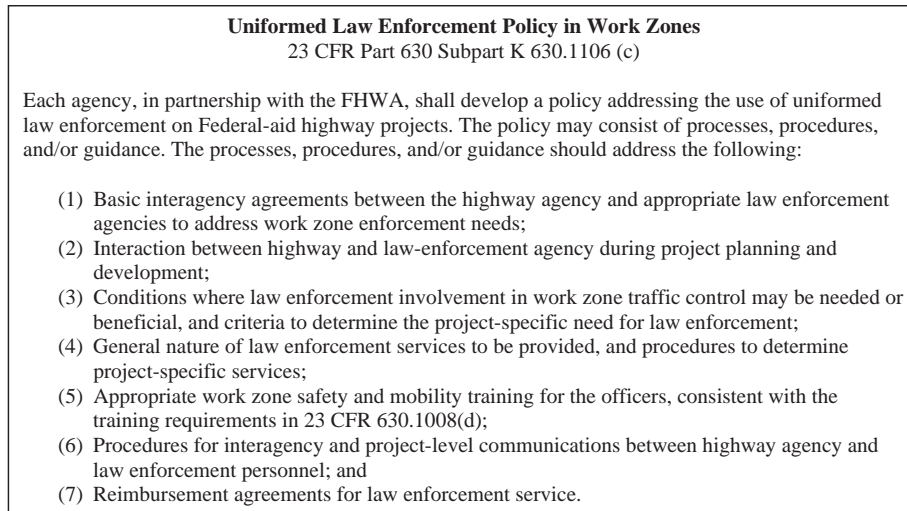


Figure 1. Federal work zone law enforcement policy requirements.

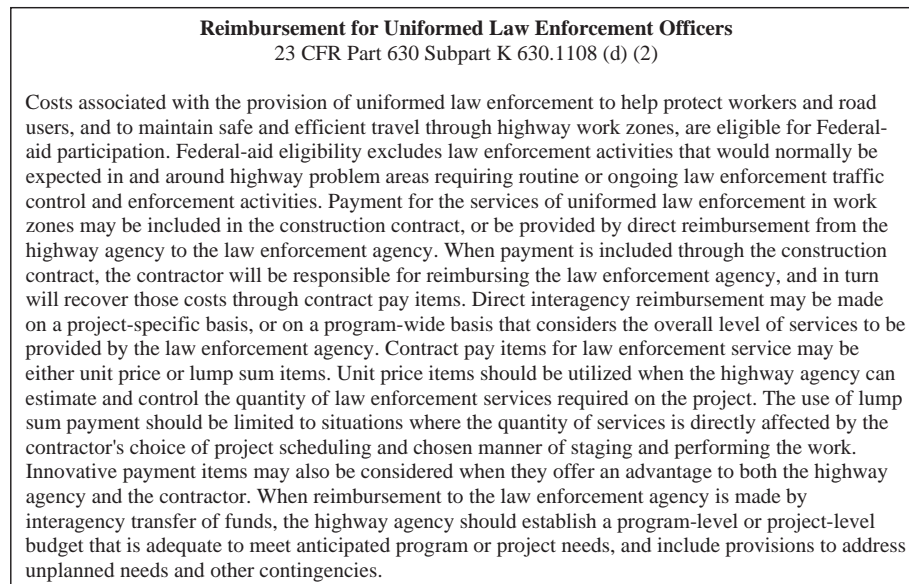


Figure 2. Federal work zone law enforcement reimbursement requirements.

The guidelines presented in this document are intended to aid agencies in answering these and other questions in establishing an effective, holistic approach to work zone enforcement efforts that are consistent with each agency's goals and constraints. The following topics are covered in these guidelines:

- Traffic Enforcement Strategies for Various Work Zone Situations,
- Enforcement Considerations in Work Zone Planning and Design, and
- Administrative Considerations of Work Zone Traffic Enforcement.

CHAPTER 2

Traffic Enforcement Strategies for Various Work Zone Situations

Law enforcement agencies employ a range of techniques and strategies as part of their normal traffic enforcement duties. Most of these strategies are appropriate for use in work zone locations as well. In addition, several unique enforcement approaches or strategies exist to address unique challenges of some of the work zone situations listed herein.

Basic Enforcement Philosophies

Overt Versus Covert Enforcement Strategies

Generally speaking, traffic enforcement efforts are overt or covert in nature. **Overt enforcement** strategies emphasize visibility through the use of marked patrol vehicles and officers positioned in full view of approaching traffic, the use of emergency vehicle warning lights, and sometimes even advance notification about the location and time of enforcement via the media or advance warning signs. Some departments also instruct their officers involved in overt enforcement activities to turn on their radar units as an additional method of announcing their presence in the area. Conversely, **covert enforcement** strategies are performed in relative obscurity with unmarked vehicles or marked vehicles parked and partially hidden from view. Whereas the intent of overt enforcement is to maximize driver awareness that enforcement is present, the goal of covert enforcement tactics is to create the sense among drivers that enforcement **may be** present at any location and time. It is believed that if drivers do not know when and where enforcement is present, they will better regulate their driving behavior over the entire highway system at all times. Studies comparing the effectiveness of overt versus covert enforcement, and those comparing the behaviors of drivers with and without radar detectors, tend to support this line of thinking (2, 3).

Overt strategies do attract considerable attention of passing motorists. Care should be taken to position officers and their vehicles at the work zone where this attention will not

adversely affect driving behavior, such as at critical merge or diverge locations, key decision points, etc.

Cooperative Versus Dedicated Enforcement Efforts

When discussing work zone enforcement efforts, it is important to distinguish between cooperative and dedicated enforcement activities. Cooperative enforcement is provided as part of normal enforcement agency operations if officers are available. Officers are usually on regular duty and not overtime. Usually, cooperative enforcement is not reimbursed by the highway agency. In contrast, dedicated enforcement involves officers who are specifically hired for, or assigned to, a work zone for the shift, and are not available for other non work zone assignments unless an extreme emergency situation arises. Officers on dedicated enforcement assignments are often on overtime pay (but not always), and the enforcement agency is typically (but not always) reimbursed for their costs by the highway agency. In many locations, a combination of cooperative and dedicated enforcement efforts is used in highway work zones.

Active Enforcement Versus Presence-Only (i.e., Traffic Calming) Strategies

Within work zones, many highway agencies make the distinction between law enforcement efforts to identify, pursue, and cite traffic law violators, versus efforts to increase driver attention, reduce speed, and generally calm traffic in the vicinity of the enforcement vehicle. In a traffic-calming mode, enforcement personnel usually remain at a location with or without lights flashing, but do not actively engage in identifying traffic violators and then pursuing and issuing citations.

Nationally, there is support and opposition for both approaches. The support for the active enforcement approach (and opposition for the traffic-calming approach) generally

comes from state DOT office and enforcement agency personnel who believe the potential threat of citation must be maintained at all times to avoid a loss of enforcement agency credibility with the motoring public. There have been anecdotal comments by some agencies that extensive reliance on traffic-calming enforcement practices has resulted in a lack of driver response to enforcement vehicles over time. Conversely, support for the traffic-calming enforcement strategies in work zones tends to come mainly from highway agency field personnel and highway contractors. These groups note that when enforcement personnel engage in pursuit of a traffic law violator to issue a citation, the traffic-calming effect of the enforcement vehicle is no longer present where the enforcement vehicle was originally located. For work zone situations where the traffic-calming effect is desired at a particular location, such as near where work crews are working in a closed travel lane without positive protection between them and traffic, the constant pursuit of traffic violators significantly reduces the desired traffic-calming effect of enforcement in the vicinity of that work crew.

Many agencies employ a combination of the two approaches depending on the work zone situation of concern. However, there are some entities that strictly employ either one approach or the other in its work zones. Recent studies to evaluate such an exclusive practice indicates that drivers do indeed “learn” over time that only traffic-calming behaviors are being used (4). However, drivers in those situations also reported that they “learned” to associate the presence of the enforcement vehicle in a work zone with a true need to slow down and be more attentive (i.e., they anticipated the presence of a traffic queue or of workers located close to moving traffic). Field studies further verified that the magnitude of speed reductions upon encountering an enforcement vehicle sitting on the shoulder in a work zone was essentially the same regardless of whether the region relied exclusively on active work zone enforcement or on traffic-calming enforcement presence in work zones (4).

Work Zone Enforcement Techniques

Several different techniques can be used by enforcement personnel in work zones. The choice depends on the characteristics of the work zone, existing traffic behaviors, primary traffic operations and safety concerns, whether the majority of traffic using the roadway is local repeat drivers or non-local through drivers, automobile/large truck mix, and other factors.

Stationary Deployment Techniques

The most common technique used in work zones is the deployment of an officer and marked vehicle somewhere within or upstream of a work zone adjacent to the travel lanes. If the emphasis is on active identification and citation



Figure 3. Example of a stationary marked enforcement vehicle at a work zone.

of traffic law violators, the enforcement officer may choose either an overt strategy by sitting in full view of approaching traffic, or a covert strategy by utilizing an unmarked vehicle or positioning his or her vehicle out of view of oncoming traffic. If the goal is to alert approaching drivers and calm traffic, the officer and marked vehicle are positioned close to the travel lanes with emergency lights flashing in full view. A stationary enforcement vehicle and officer will typically create a greater speed reduction than circulating patrols, but the effect will be localized. Specifically, speeds will be reduced from just before the officer and vehicle to approximately one mile beyond where the officer and vehicle are located (see Figure 3). Therefore, where speed reductions at a spot location are desired, the officer and vehicle should be positioned a short distance (1000 feet is suggested) prior to where the speed reduction is needed. Although average speed reductions as much as 14 miles per hour (mph) have been recorded, 5 to 7 mph reductions are more common, especially on high-volume, high-speed roadways.

Pack Enforcement Strategy

In situations where active enforcement efforts (i.e., identification and citation of traffic law violators) are desired, some agencies utilize a pack enforcement strategy. In this case, one enforcement vehicle (marked or unmarked) and officer are positioned to identify traffic law violators. The officer then calls out descriptions and license plate numbers of traffic law violators to one or more officers at a downstream location for apprehension and citation. In this way, the speed reduction and traffic-calming effect of the upstream enforcement vehicle is maintained while the active enforcement efforts downstream contribute to a lasting change in driving behavior.

The advantages of this strategy are the following:

- This approach eliminates the pursuit of the violator into and/or through the work zone in order to issue a citation.
- This approach maintains the visibility and traffic-calming effect of the upstream enforcement vehicle at a point, since it does not have to leave its location.
- This approach means that multiple officers are in the vicinity of the work zone in the event of an emergency.

The disadvantages of this strategy are the following:

- This approach requires the use of multiple officers and vehicles. This requirement increases costs and places increased pressure on available law enforcement personnel and equipment resources in a region.
- Under this approach, the violating vehicle does not get pulled out of the traffic stream until after exiting the work zone.

One work zone-specific pack enforcement strategy that several agencies are using is to “camouflage” a law enforcement officer with a flagger vest and positioning the officer and speed-measuring lidar or radar within the work area on or near work

equipment. The camouflaged officer identifies a violator and communicates the vehicle description and license plate number to officers stationed downstream of the work zone who apprehend and cite the vehicle. Initially termed “Operation Hard Hat,” it has also been termed “Operation Yellow Jacket” by some agencies (see Figure 4).

Initially, the concept was envisioned to be a covert enforcement activity. However, many agencies now alert drivers in advance that this effort is underway in order to achieve better driver response and immediate speed reductions at the targeted work zone. This information is provided via media announcements and through portable changeable message signs (e.g., WORKZONE/RADAR/ENFORCED, REDUCE/SPEED/NOW) upstream of the work zone to increase driver compliance and thus improve safety through the work zone.

Queue Protection Strategy

Another stationary enforcement strategy employed by some agencies is to position the vehicle and officer approximately 0.25 miles upstream of lane closures where traffic queues are anticipated. The enforcement vehicle and officer serve a traffic-calming and attention-getting function, reduc-

OPERATION HARD HAT SET UP

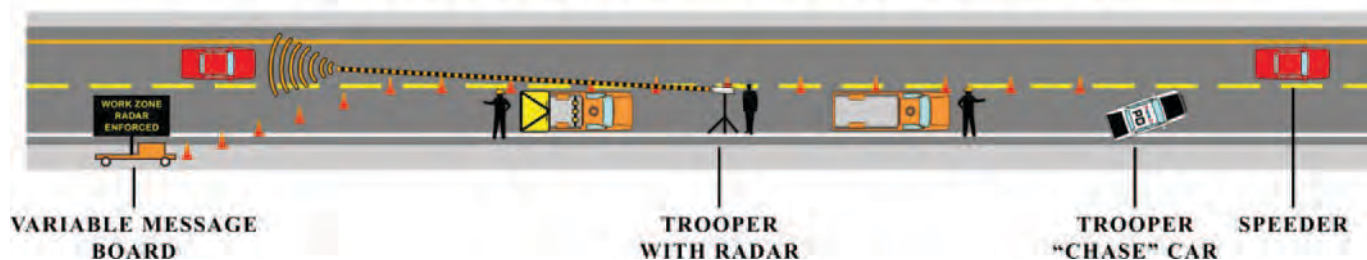


Figure 4. Examples of the operation hardhat pack enforcement strategy (Source: Florida and New York State departments of transportation).

ing the likelihood of high-speed rear-end crashes between approaching traffic and vehicles already in the queue. As the upstream end of the queue grows or dissipates over time, the officer moves the vehicle along the shoulder to remain approximately 0.25 miles upstream of the queue.

The advantage of this strategy is the following:

- The traffic-calming effect of the enforcement vehicle is believed to reduce the likelihood of rear-end crashes at the upstream end of the queue, and to reduce the severity of crashes that may occur.

The disadvantages of this strategy are the following:

- The strategy sometimes requires the officer to move the enforcement vehicle backwards along the shoulder to maintain a 0.25 mile distance to the queue.
- The strategy can only be used where a shoulder exists for the enforcement vehicle to be parked and driven on if necessary. In some work zones, the shoulder is closed or converted to a temporary travel lane, which eliminates this strategy from consideration.

Police Traffic Controller Strategy

This strategy requires officers to be positioned outside of their vehicles for the purpose of reducing speeds and calming traffic. The officer does not perform specific traffic control duties such as stopping vehicles, indicating to drivers where to travel, etc. Rather, the emphasis is simply on being visible, establishing eye contact, and using other non-verbal communication techniques (such as the “slow down” flagger hand signal) with the approaching driver.

The advantages of this strategy are the following:

- The visibility of the officer outside of the enforcement vehicle establishing eye contact with approaching drivers can result in significant speed reductions.
- This technique does not require the use of an official enforcement vehicle, which can reduce costs (however, some enforcement agencies may require the officer to utilize an enforcement vehicle and still require payment for its use in this situation).

The disadvantages of this strategy are the following:

- Being out of the vehicle, the officer is placed at increased risk from approaching traffic.
- The officer cannot easily initiate pursuit of any vehicle deemed a “significant hazard” by the officer (e.g., driving while severely impaired, engaging in a speeding contest, etc.).

Circulating (or Mobile) Enforcement Techniques

Circulating patrols through the work zone can be accomplished in both marked and unmarked vehicles, depending on whether overt or covert enforcement activities are desired. As with stationary techniques, the effect of circulating patrols on speeds is most pronounced in the immediate vicinity of the enforcement vehicle (which is moving along the roadway section). However, the average speed reductions achieved with this technique tend to be somewhat smaller (on the order of 2 to 4 mph) than those achieved with stationary techniques. This effect can vary depending on the deployment schedule utilized. For example, a circulating patrol at the posted work zone limit on a two-lane roadway effectively limits the speed of the traffic stream to the speed of the enforcement vehicle and discourages passing by higher speed vehicles. For work activities that are occurring immediately next to the travel lanes, this approach can reduce speeds next to the work crew, which is believed to improve overall worker safety.

Although the majority of circulating patrols rely on enforcement vehicles, a few agencies have utilized fixed-wing aircraft or helicopters as part of their mobile patrol efforts. Obviously a covert enforcement activity, aircraft patrols identify potential speed violators on a facility and time the suspect between marked locations on the roadway. If the elapsed time is too fast, enforcement personnel in the aircraft notify an officer and vehicle on the ground to actually stop the violator and issue the citation. This technique is relatively expensive to operate, and so is used infrequently.

The advantages of this strategy are the following:

- Continuous circulation of the enforcement vehicle does not allow drivers to limit their speed reductions to a specific location where they “know” the officer is located (either through experience or by communication with other motorists in the vicinity)
- The circulating enforcement patrol can simultaneously serve a roadway monitoring and incident detection/response role, helping to identify drivers in need due to stalls, no fuel, etc.

The disadvantages of this strategy are the following:

- The influence of the enforcement vehicle varies by location as it traverses the roadway, making this technique less useful for work zone situations that benefit from a speed reduction and increased driver awareness at a particular spot (e.g., entering a work zone lane closure, passing by a road work crew, etc.).
- The use of aircraft for enforcement is costly.

Automated and Semi-Automated Speed Enforcement Techniques

Presently, the Illinois DOT, the Washington State DOT, and the Maryland State Highway Administration (MDSHA) all utilize semi-automated speed enforcement technology to electronically identify violators in work zones and to capture an image of the vehicle embedded with speed, location, date, and time information about the violation. The agency then determines the registered owner of the vehicle via the license plate number, and issues a citation in the mail. In the semi-automated approach used in Illinois and Washington, an officer operates the equipment from inside a specially-marked van (see Figure 5). The officer is thus present to verify that the vehicle selected was indeed in violation of the speed limit (plus an additional tolerance), which allows the citation to remain a moving vehicle violation as is the case for traditional speeding citations. The citation is still mailed to the owner of the vehicle.

In most states, specific legislation must first be passed to allow this technology to be used. In Illinois, the legislation required

additional signing to be provided in advance of the work zone when the van is present. In addition, the van itself includes a driver feedback display to indicate the measured speed of the approaching vehicle. If the vehicle still continues to speed excessively past the van, a photograph with the pertinent violation information is combined into an encrypted file for further processing and citation issuance. Tests indicate that speeds in the vicinity of the enforcement vehicle reduce 3 to 6 mph.

The advantages of this strategy are the following:

- The technology eliminates the need for an officer to pursue and cite the traffic law violator at the time the violation is observed, or to use multiple officers in a pack arrest strategy.
- Because no pursuit is required, a higher number of citations can be issued. To counteract this, some states require that a substantial (i.e., 12 mph) tolerance over the work zone speed limit be granted before issuing a citation.

The disadvantages of this strategy are the following:

- Specific legislation authorizing the use of this technology is required.
- Those operating the equipment must be specially trained in order to ensure the legality of the citations.
- The equipment is relatively expensive. In Illinois, the amortized cost of the van, equipment, and training was \$2,950 per month. In addition, there was a cost of an officer to operate the system. However, these costs may be offset somewhat by the higher citation rate that can be achieved.

Deciding When Enforcement Is Needed

It is important that specific reasons for providing enforcement at a work zone exist and can be articulated by the affected stakeholders (the highway agency, the law enforcement agency, and the highway contractor). Enforcement costs are not insignificant, and represent an additional burden on enforcement agency manpower and equipment resources in a region, even when highway agency funds are being used to pay for such efforts. If enforcement is to be used, it should have a specific objective, and the implementation strategy should be consistent with that objective.

Matching enforcement efforts to the specific needs of the work zone requires consideration of both the characteristics of the work zone safety hazard being targeted, and the expected benefits versus costs of enforcement deployment.

Considering the Characteristics of the Work Zone Hazard

A distinction can be made between those hazards related specifically to work activities (and thus present only at certain times and locations) and those that are related to the



Figure 5. Semi-automated work zone speed enforcement in Illinois.

geometrics and alignment of the work zone design (and thus present at all times). Work activity-related hazards include:

- Temporary closure of shoulders or travel lanes during the work shift, including the creation of any traffic queues that may develop due to the reduction in roadway capacity;
- Work activities themselves in close proximity to travel lanes, including during the setup and takedown of other temporary traffic control devices;
- Materials and work equipment located close to travel lanes; and
- Work area ingress and egress by construction vehicles and equipment.

Similarly, work zone geometric and alignment design hazards include such things as (5):

- Narrowed or closed shoulders;
- Narrowed or long-term closures of travel lanes;

- Pavement edge drop-offs;
- Irregular pavement surfaces and/or uneven joints;
- Lane shifts; and
- Horizontal curvature at median crossovers or temporary diversions designed to a lower design speed than the prevailing or expected travel speeds.

Some highway agencies go so far as to require project personnel to formally document when and for what reasons enforcement is desired in the work zone. This request is then reviewed and approval granted if so warranted. An example of a request form is provided in Figure 6.

In general terms, the existence of one or more of the features listed does not imply that work zone enforcement is automatically needed. Indeed, many work zones are safely and successfully completed with these types of constraints without any type of work zone enforcement provided. However, if the work zone planner/designer is concerned about a particular

REQUEST FOR USE OF WORK ZONE ENFORCEMENT <i>[Highway Agency]</i>	
<p>The <i>[name of responsible person at highway agency]</i> or his/her designee must approve any use of <i>[name of enforcement agency]</i> support on a project. Upon approval, such use must also be reported to <i>[name or division within highway agency tracking use of enforcement in work zones]</i>.</p>	
<p>Justification for Request (check all that apply):</p> <ul style="list-style-type: none"> <input type="checkbox"/> Major construction project <input type="checkbox"/> Full roadway or ramp closure required for roadway maintenance <input type="checkbox"/> Closure of <i>[one, two, etc.]</i> or more travel lanes on a freeway or expressway <i>[having three or more lanes in each direction]</i> <input type="checkbox"/> Expectation of queues <input type="checkbox"/> Night work activity <input type="checkbox"/> Situations involving temporary traffic flow disruptions (erection of overhead structure, movement of large equipment, traffic signal repairs) <input type="checkbox"/> An unusual increase in crashes at a location, or work zone design features that require drivers to reduce their speed to safely negotiate (this requires one week of daily [4 hours each] enforcement followed by 3-4 days [4 hrs each] per week) <input type="checkbox"/> Other _____ 	
<p>Date of Request _____ Date(s) of Requested Enforcement _____</p> <p>Beginning Time _____ am/pm Ending Time _____ am/pm</p> <p>Project Location _____</p> <p>Number of troopers requested per shift _____</p>	
<p>Approval:</p> <p>Recommended by _____ Approved by _____ <small>(district engineer)</small></p> <p>Date _____ Date _____</p>	

Note: sections in italics may be added to increase specificity if desired

Figure 6. Example of a highway agency work zone enforcement request form.

feature, or if crashes in a particular work zone increase significantly in the vicinity of such a feature, the provision of work zone enforcement to modify driving behavior on a continuous basis may be appropriate.

For work activity-based hazards, the need to provide enforcement is dictated by when and how often such work activities are to occur. For these situations, highly-visible stationary enforcement located just upstream of the hazard meets the desired objectives most effectively. As noted previously, these officers and vehicles can operate strictly in a traffic-calming role (without pursuit and citation of traffic violators), as part of a pack enforcement strategy, or with the intent to pursue and cite traffic law violators themselves as needed. If the latter strategy is selected, however, the traffic-calming and attention-getting benefits of enforcement at the location of the hazard will be diminished during those times the officer leaves to pursue and cite the violator.

For work zone design-related concerns, it will be necessary to establish an active enforcement regime that is substantial enough to achieve a change in driving behavior. Providing only occasional traffic-calming presence or sporadic enforcement will generally not suffice. Rather, an initial period of intense enforcement that emphasizes identification, pursuit, and citation of traffic law violators will be required to establish an expectation of increased enforcement presence within the work zone. This emphasis will then lead to a continuous change in driving behaviors (i.e., a speed decrease, heightened awareness) at all times, including those times when enforcement is not present. This strategy can be accomplished using either overt or covert enforcement methods (or both), and can involve stationary or circulating patrols. Once this expectation is established, the amount of enforcement provided can be reduced, but still must be maintained at some minimal level to keep drivers from reverting back to pre-enforcement behavior.

The saturation enforcement approach has been used as part of the selective traffic enforcement program (STEP) in many states for years. Although definitive minimum enforcement requirements to achieve this type of behavioral change in drivers do not exist for most conditions, studies and anecdotal evidence suggests that providing enforcement in a work zone approximately 4 hours per day for each of 5 days in a row is sufficient to alter driving behavior (6). Once the initial period is completed, enforcement must be provided twice or three times a week (again for about 4 hours per day) to maintain the behavioral change in drivers. This level should be considered a minimum; the level of enforcement on high-volume urban freeways may need to be significantly greater. The actual amount of effort needed will depend on whether most of the traffic on the facility consists of local, repeat drivers who travel the work zone several times a week or of through drivers passing through the work zone infrequently. The law enforcement

agency with jurisdiction over the facility will have a good feel for the level of effort that will be required.

Considering the Safety Benefits of Enforcement Versus Enforcement Costs

Ideally, work zone enforcement would best be used where its benefits equal or exceed the costs of providing that enforcement. Other practical considerations, such as the amount of enforcement staffing available, the other enforcement tasks that are deferred in the region in order to provide work zone support, etc., also influence decisions. However, from a simple justification perspective, the expected benefits of using enforcement in a work zone is an improvement in safety in terms of reduced work zone crash costs (although there may be some situations where the traffic-calming effect of enforcement could improve traffic flow and result in reduction in motorist delay costs). Unfortunately, it is difficult to assess the crash cost reductions due to enforcement with any certainty. The extent to which enforcement can influence driver behavior (and ultimately safety) depends on many site-specific factors such as:

- The type of enforcement strategy being employed;
- The number of travel lanes, traffic volumes, percentage of local and non-local motorists, and vehicle mix on the facility;
- The difference between the work zone speed limit that is posted and the current operating speeds of drivers; and
- The type and amount of public information disseminated about the work activity.

Other factors, such as various work zone conditions listed earlier, will also influence enforcement effects on motorists. To date, though, specific analyses of the relationship between these factors and crash reductions due to enforcement have not been performed. One study suggested that a 10 to 20 percent reduction in crashes could be reasonably achieved through the adoption of enhanced enforcement efforts in work zones (7); in other studies, the range of crash reductions attributed to work zone enforcement range between 0 and 45 percent (8–10). It should be noted that these values represent overall changes in crash frequencies during a period of time when enforcement efforts were expanded above normal levels. *The actual effect that a given enforcement officer and vehicle may have on crash risk when physically present at a location could be even greater.* Interestingly, these numbers are not inconsistent with recent research on the safety effects of strategies to reduce vehicle speeds in circumstances other than work zone-related enforcement. According to that research, 5 mph speed reductions on high-speed (60 to 70 mph) roadways can correspond

to a 22 to 25 percent reduction in non-fatal injury crashes, and to a 33 to 42 percent drop in fatal crashes (11).

Nationally, enforcement costs can also vary widely. A review of interagency agreements in various states found that loaded hourly rates for enforcement ranged from about \$25 to \$100 per hour per officer (12). Revenues generated through active enforcement efforts in the work zone could possibly offset these costs somewhat, but would not if enforcement is used primarily in a traffic-calming mode (which could be a significant consideration when considering the deployment of multiple officers in the work zone at a time for pack enforcement or combined traffic-calming/active enforcement teams). Consequently, the hourly costs depend on both the number of officers used and the method of enforcement desired.

The fact that neither enforcement effectiveness nor the actual work zone crash costs expected at a location can be predicted with much precision, coupled with the wide range of possible costs of deploying enforcement in a work zone, makes it difficult to establish definitive criteria as to when enforcement can be justified from an economic perspective. As an example, Table 1 illustrates the annual average daily traffic (AADT) values at which various costs of enforcement would be offset by reduced work zone crash costs at a freeway work zone. Two scenarios are considered:

- A favorable benefit assessment (enforcement assumed to lead to a 50 percent reduction in work zone crash costs when present, work zone crash costs without enforcement assumed to be at the 95th percentile level of expected costs); and
- A conservative benefit assessment (enforcement assumed to lead to a 25 percent reduction in work zone crash costs, work zone crash costs without enforcement assumed to be at the average level of expected costs).

Under the favorable-benefit scenario, the use of enforcement can almost always be justified, even when enforcement costs are fairly high. For example, enforcement efforts that cost \$100 per hour are estimated to be offset by reduced work zone crash costs once the AADT reaches at least 20,000 vehicles per day (vpd) for work operations being performed during the day, and 65,000 vpd if the work operation is being performed at night. Work zone crash costs are lower per hour at night than during the day for a given AADT because most of the traffic flow each 24-hour period occurs during the day. Less expensive enforcement costs correspond to lower AADT thresholds.

On the other hand, an assessment based on more conservative assumptions indicates that AADTs must be much higher before a reduction in work zone crash costs will offset the same enforcement cost values. In fact, the AADT values associated with the highest enforcement cost level would imply that enforcement would almost never be cost effective on freeway facilities, a result that is very counter-intuitive. Overall, the values in Table 1 highlight the uncertainty associated with this type of analysis. Depending on the assumed cost of enforcement being considered, the break-even AADT level can differ between 15,000 to more than 150,000 vpd under the two different assumptions. Similar comparisons could be performed for other roadway types and work operations, but the same general trends would likely exist.

The AADT thresholds shown in Table 1 under the favorable-benefit scenario could be used as an initial guide for justifying enforcement use on most roadway types (recognizing somewhat lower AADT values might be justifiable on non-freeway facilities given their typically higher crash rates). In reality, though, available funding, availability of enforcement staff, and other considerations will often limit enforcement use to facilities with higher volumes than those shown.

Table 1. Comparison of enforcement benefits and costs at freeway work zones.

Enforcement Costs	AADT Where Enforcement Benefits are Approximately Equal to Enforcement Costs	
	Favorable-Benefit Scenario	Conservative-Benefit Scenario
\$25 per hour		
Daytime work zone	5000 vpd	20,000 vpd
Nighttime work zone	20,000 vpd	45,000 vpd
\$50 per hour		
Daytime work zone	10,000 vpd	35,000 vpd
Nighttime work zone	35,000 vpd	100,000 vpd
\$75 per hour		
Daytime work zone	15,000 vpd	50,000 vpd
Nighttime work zone	50,000 vpd	150,000 vpd
\$100 per hour		
Daytime work zone	20,000 vpd	70,000 vpd
Nighttime work zone	65,000 vpd	200,000 vpd

vpd = vehicles per day

Work Zone Enforcement Deployment Procedures

Safe work zones are the result of good planning and execution. This is especially true with regard to the utilization of law enforcement. Simply hiring an off-duty officer or two and leaving them to figure out their role once they travel to the work zone is not sufficient to achieve the types of safety benefits desired. Rather, effective enforcement deployment and use in work zones requires cooperation and communication between highway agency, enforcement agency, and highway contractor personnel directly involved with the project. The following section describes a number of important procedures that should be followed as part of work zone enforcement deployment. The information pertains primarily to enforcement use in a traffic-calming role for particular work activities. However, some of the key items described, such as the officer making initial contact with the highway agency to discuss specific details about the project, are recommended for all types of enforcement use in work zones.

Officer Arrival Procedures

When officers are requested to be present for a particular work activity, it is desirable for the officer(s) providing that support to arrive at the work zone prior (15 minutes is sometimes suggested) to the start of the activity. If it is the first time that the officer has been to the work zone, it is beneficial to drive up and down the roadway segment to become aware of such things as the locations of signs and channelizing devices, worker staging areas, ingress and egress points to the work zone and to the roadway facility, width, and continuity of shoulders across bridges, etc.

After becoming familiarized with the project, the officer should contact the highway agency point-of-contact (POC) and the highway contractor POC. Cell phone numbers for the POCs should be provided to the officer as part of the request process so that this contact can be made. Specific details about the work activity that will impact where and how the officer is positioned within the work zone should be discussed, including:

- Location Where The Temporary Traffic Control For The Work Activity Will Begin And End;
- Number Of Lanes (If Any) That Will Be Closed;
- Anticipated Start Time And Duration Of The Work Activity;
- Safest And Most Effective Location For Enforcement To Be Located;
- Where And How Many Construction Vehicles Will Be Entering And Exiting The Work Area, And Where The Entry And Exit Points Will Occur;

- Whether Traffic Congestion Is Expected To Develop, And How Far Upstream It Is Expected To Extend;
- Any Other Traffic Concerns That The POCs Have Based On Previous Or Current Conditions At The Site;
- Any Changes In Traffic Control That Might Occur During The Shift; And
- Exchange Of Cell Phone Numbers Or Other Means Of Contact Between The Officer And POCs, In Case The Need Arises To Contact Each Other During The Shift.

It must be remembered that the lanes that are closed and the lane closure start and end points may change over the course of a work shift. In these cases, keeping the officer aware of the surrounding work activities would be very important. It may be necessary to notify the officer when changes to the traffic control layout occur so as to avoid putting the officer into an unsafe situation.

As part of the initial meeting, the officer should verify which of the POCs (if more than one) has the authority to request a change in what the officer is doing. Situations can arise in which the priorities of the highway agency and highway contractor POCs relative to the use of enforcement are not the same, so authority for work zone decisions should be clarified in advance.

Officer Deployment Within the Work Zone

The determination of where the officer should be positioned during a work activity should be discussed prior to each work shift. Figures 7 through 12 illustrate some typical officer deployments. These illustrations are taken from the 2009 *Manual on Uniform Traffic Control Devices* (MUTCD) (13), modified to show recommended locations of enforcement for various work zone conditions. Table 2 and Table 3 also come from the MUTCD. The safety of both the officer and the motoring public is the top priority in determining the appropriate enforcement location. When the enforcement vehicles are stationary or moving at low speeds (i.e., 20 mph or more below the normal speed of traffic), they should generally be located on the shoulder, in a closed travel lane beyond the buffer area of a merging taper, or protected by a shadow vehicle (preferably with a truck-mounted attenuator). Ideally, the enforcement vehicle will also be positioned such that motorists have adequate time to detect and react to the presence of enforcement prior to making path changes required by the work zone. Enforcement presence does attract significant motorist attention, and it is desirable that such attention not overload the driver's ability to react safely to the established temporary traffic control for the work zone. It is also desirable that the enforcement vehicle be located on the same side of the roadway as the work area, although this may not be possible when the work area is located in a median lane and no median shoulder exists.

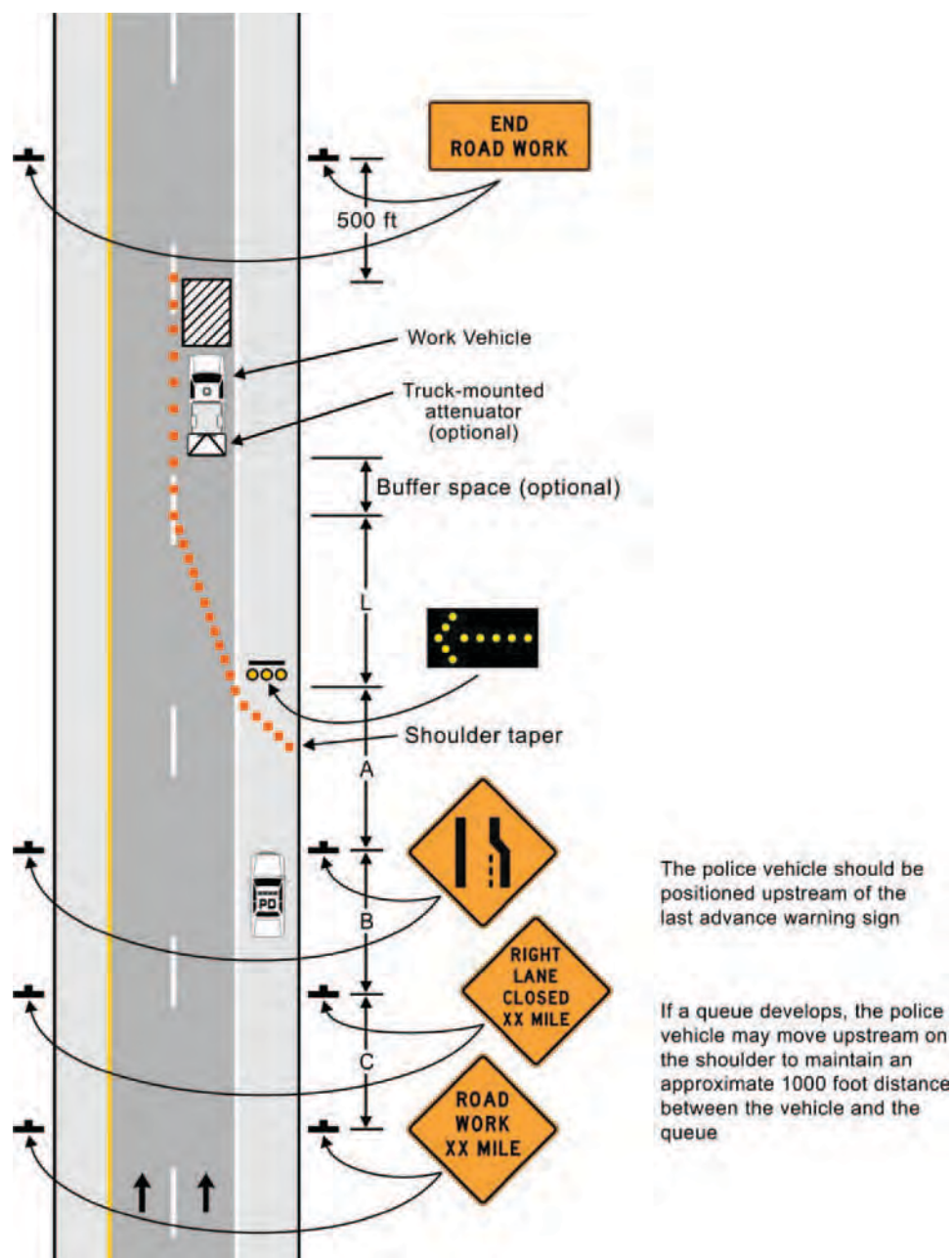


Figure 7. Suggested stationary enforcement position for lane closure when work activity area is less than 1 mile from the merging taper.

These figures should be considered guides because site-specific factors such as shoulder widths, overpasses, work area access points, etc., can all influence the positioning of the enforcement vehicle. In some work zones, the appropriate location for enforcement may change over the course of a work shift as traffic conditions change. For example, traffic queuing that develops once a lane closure is installed may necessitate that the officer be positioned upstream of the work zone beyond the expected limits of the queue with lights flashing to warn approaching motorists. The officer may then adjust position as the queue grows or dissipates. At

some time during the work shift, traffic volumes may drop to the point where queuing no longer occurs. At that time, the POCs may contact the officer and request a repositioning within the closed lane just upstream of the work activity area.

If the officer has deployed to the desired location to function in a traffic-calming role, a number of additional items should be checked and monitored:

- The vehicle should be as visible as possible, with emergency lights flashing (however, the headlights of the vehicle should be off),

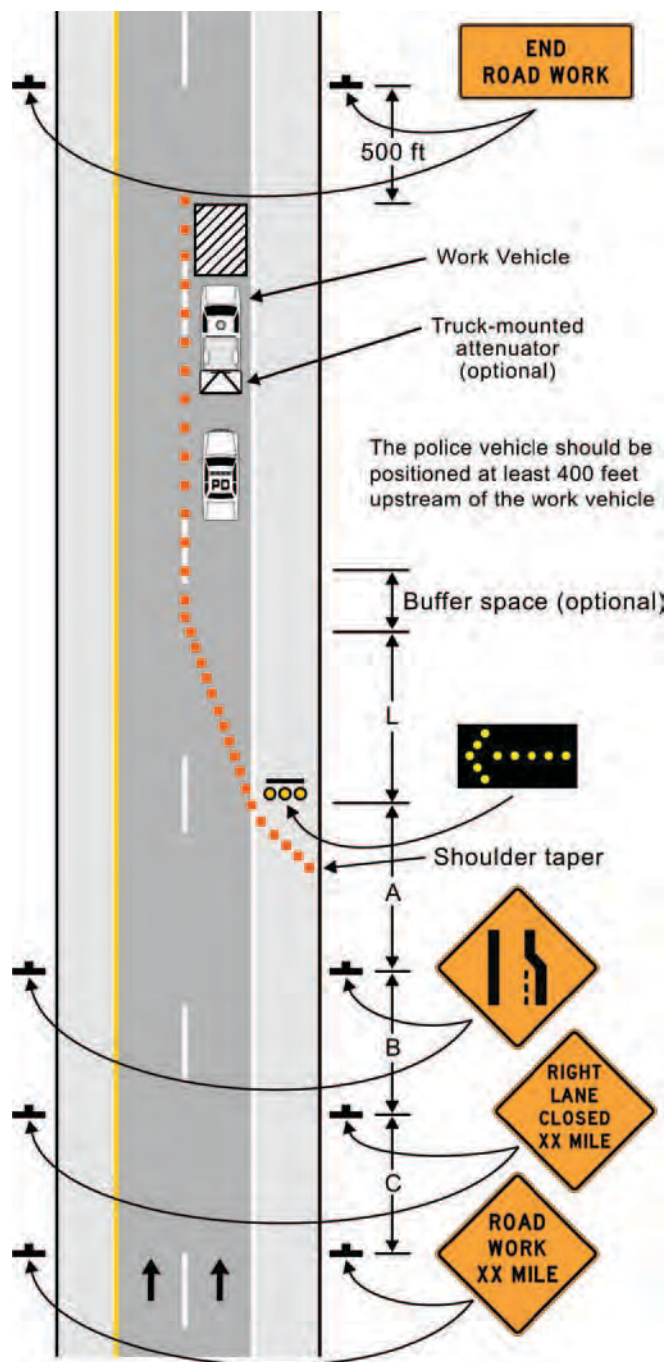


Figure 8. Suggested stationary enforcement position at lane closure when work activity area is more than 1 mile from merging taper.

- If the officer is located outside of the vehicle to function as a police traffic controller, appropriate ANSI-approved safety apparel must be worn, and
- The condition of traffic flow should be monitored, and the POCs notified if problems develop.

Obviously, these items would not necessarily apply when active enforcement was being used in or around the work zone. If a circulating patrol strategy is being utilized, officers should also be vigilant for any problems with the temporary traffic control set-up (i.e., arrow panel or portable changeable message sign quits working, signs or channelizing devices are knocked down, etc.), and should report those problems to the highway agency and/or contractor POCs as quickly as possible.

Officer Departure Procedures

At the conclusion of each work shift, the POCs and the officer should again meet briefly to discuss any issues that arose. In addition, many agencies require specific documentation to be completed verifying the following:

- The presence of the officer [name(s) and/or badge number(s)];
- Hours worked;
- Type of enforcement support provided; and
- Whether any traffic crashes occurred that were witnessed by the officer.

If the purpose of providing an officer was for actual traffic law enforcement purposes, the enforcement agency may want to record the number of stops made, and the number of tickets written by type of traffic violation that occurred as a way to track officer productivity. Often, the highway agency or highway contractor POC will need to sign the documentation to verify its accuracy. This documentation should occur away from the edge of the travel lanes, if possible, to minimize risks.

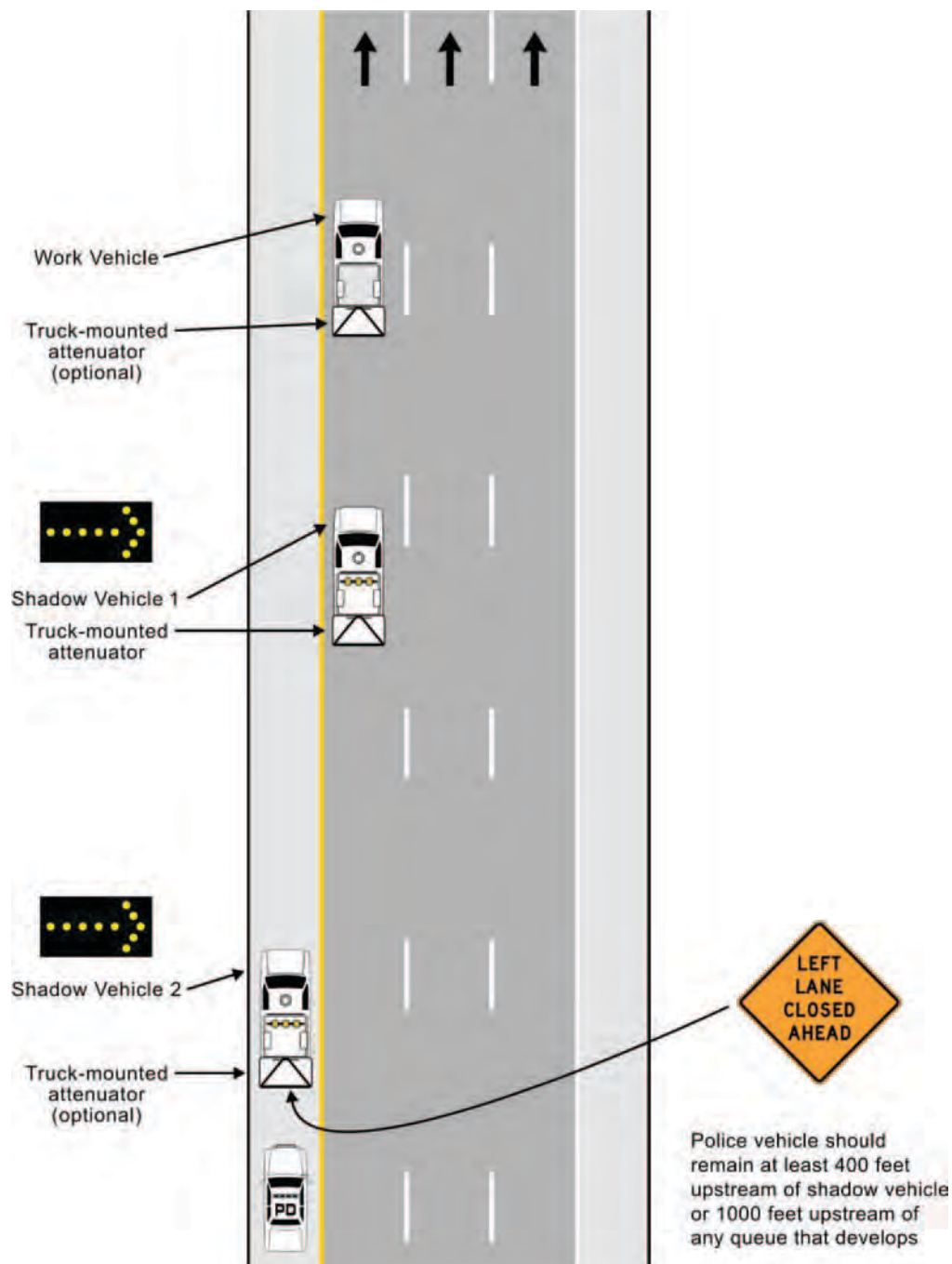


Figure 9. Suggested enforcement positioning in mobile operation convoy when continuous shoulder is available for travel.

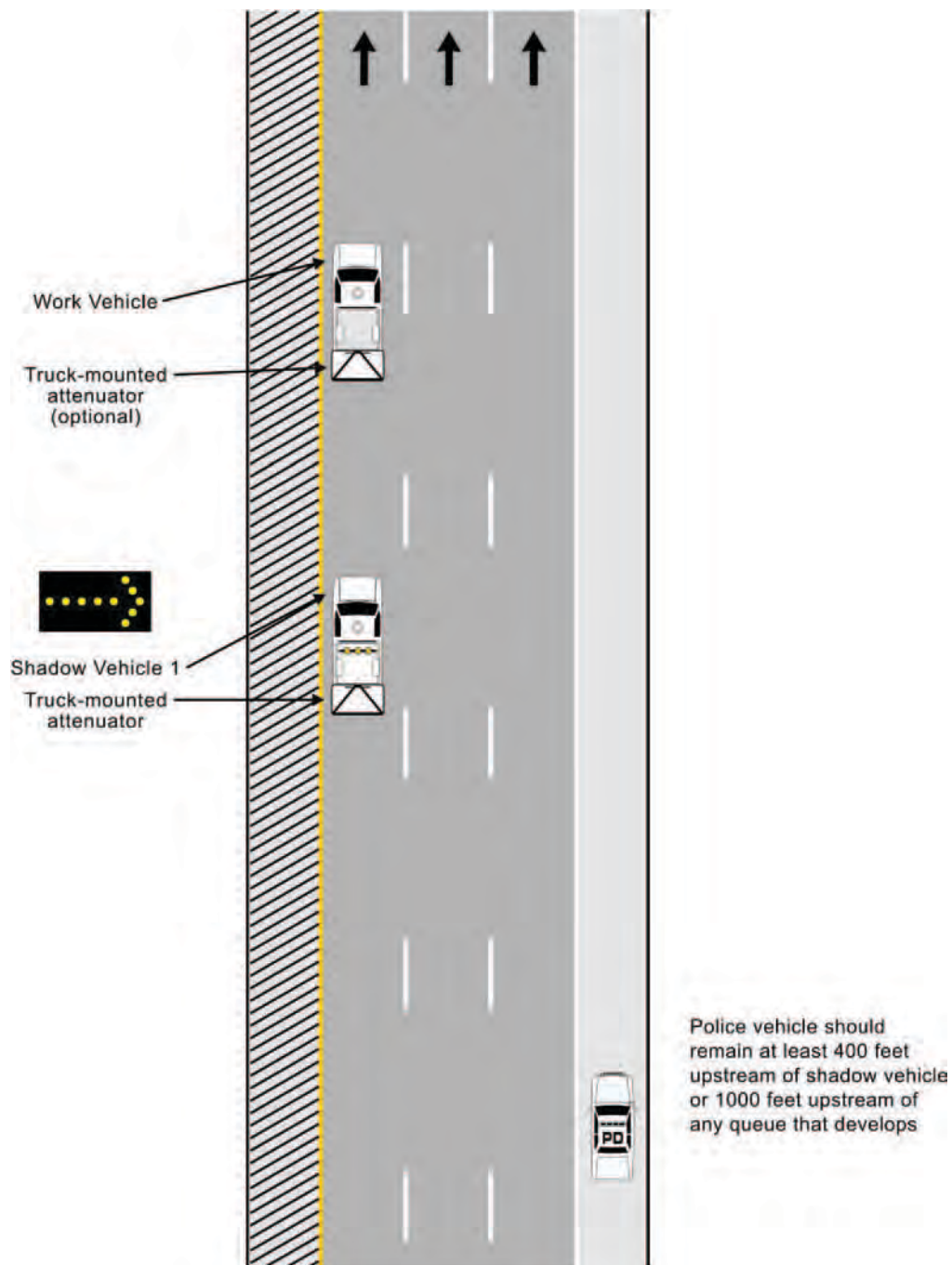


Figure 10. Suggested enforcement positioning in mobile operation convoy in left lane when a continuous right shoulder is available for travel.

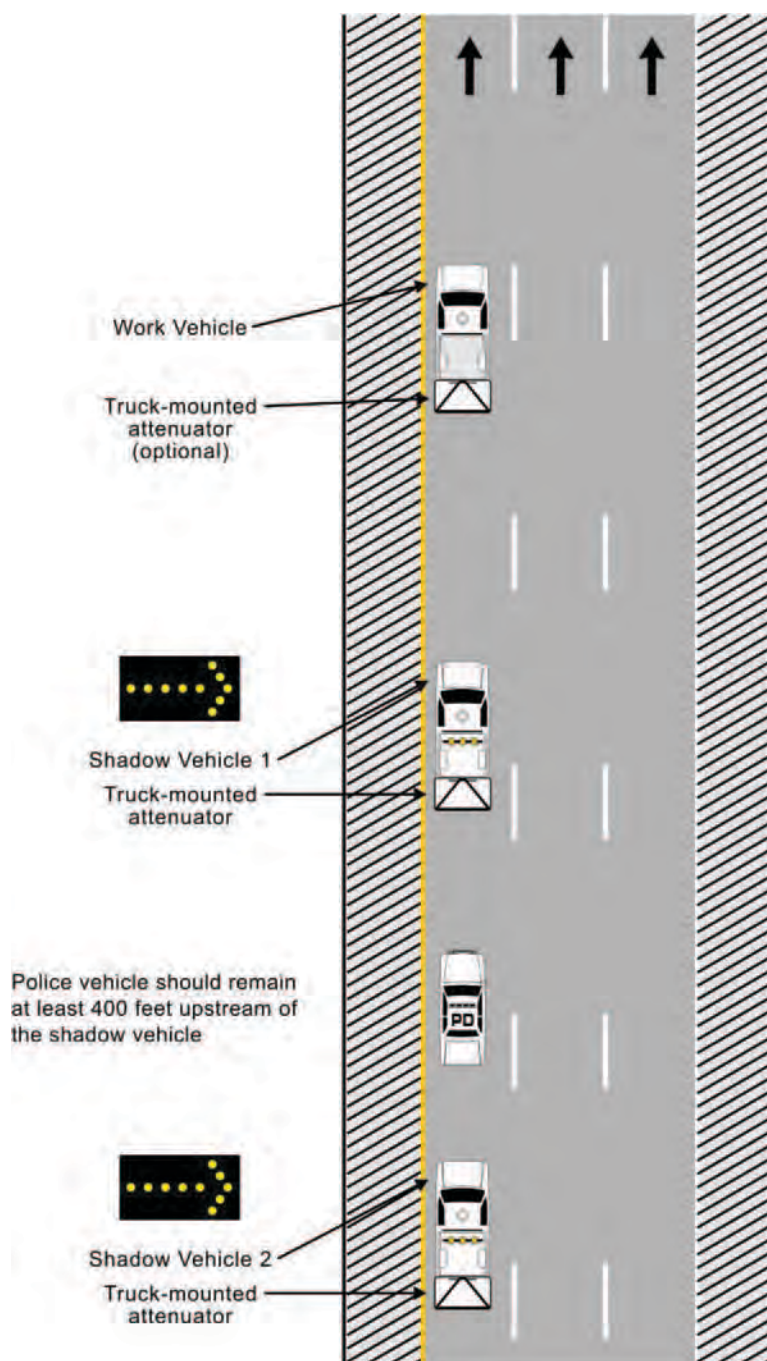


Figure 11. Suggested enforcement positioning in mobile operation convoy when no continuous shoulder is available for travel.

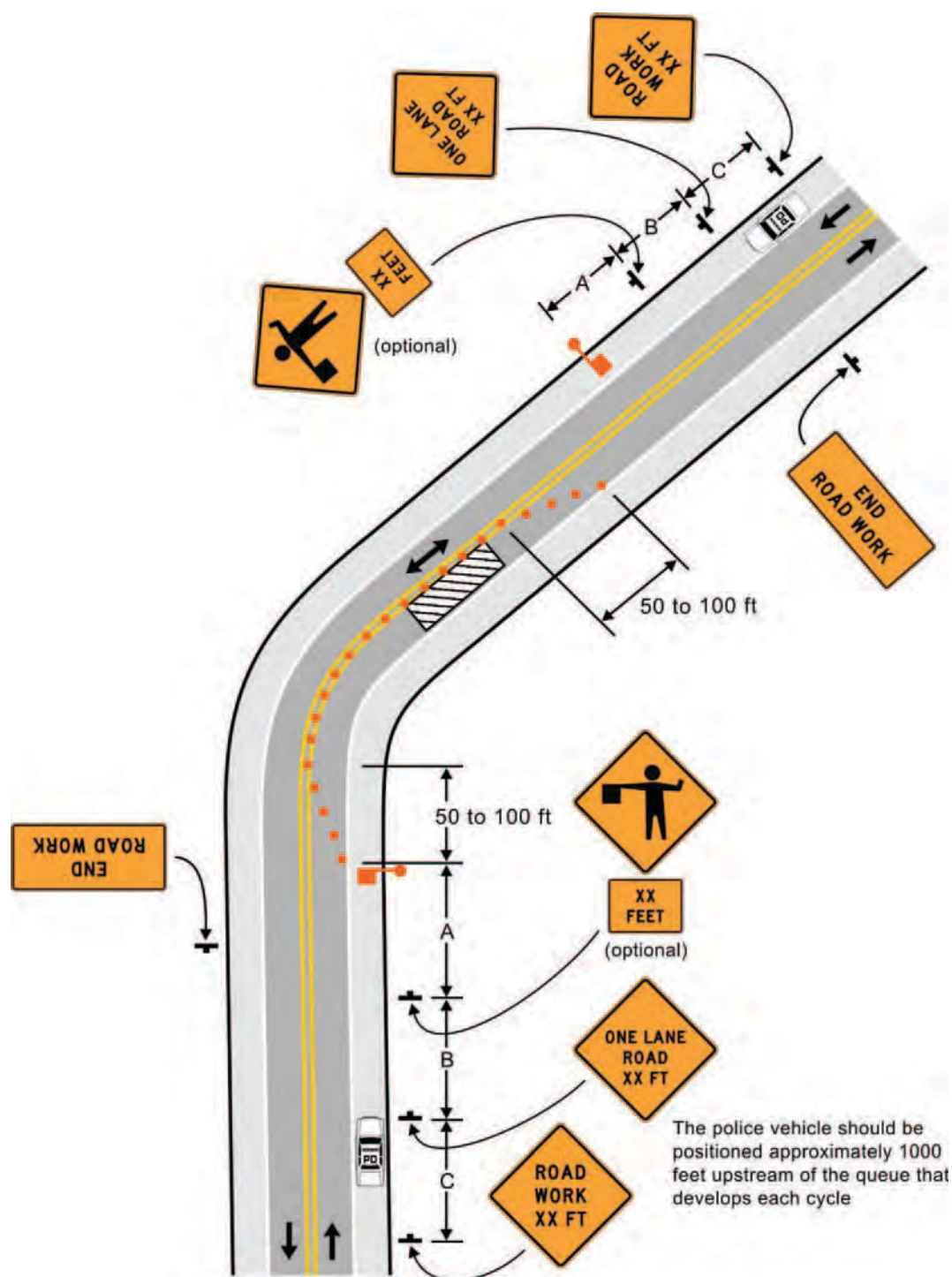


Figure 12. Suggested stationary enforcement position at alternating one-lane operations.

Table 2. Symbols used in typical enforcement applications (adapted from 13).














Symbols	Description
	Arrow board
	Arrow board support or trailer (shown facing down)
	Changeable message sign or support trailer
	Channelizing device
	Crash cushion
	Direction of traffic
	Flagger
	Shadow vehicle
	Sign (shown facing left)
	Police vehicle
	Truck-mounted attenuator
	Work space
	Work vehicle

Table 3. Advance warning sign spacing (13).

Road Type	Distance Between Signs**		
	A	B	C
Urban (low speed)*	100 feet	100 feet	100 feet
Urban (high speed)*	350 feet	350 feet	350 feet
Rural	500 feet	500 feet	500 feet
Expressway / Freeway	1,000 feet	1,500 feet	2,640 feet

* Speed category to be determined by the highway agency

** The column headings A, B, and C are the dimensions shown in Figure 7 through Figure 12. The A dimension is the distance from the transition or point of restriction to the first sign. The B dimension is the distance between the first and second signs. The C dimension is the distance between the second and third signs. (The "first sign" is the sign in a three-sign series that is closest to the TTC [Temporary Traffic Control] zone. The "third sign" is the sign that is furthest upstream from the TTC zone.)

CHAPTER 3

Enforcement Considerations in Work Zone Planning and Design

Introduction

As previously stated, the utilization of law enforcement in work zones can have a significant safety benefit to both motorists and highway workers. However, the extent to which enforcement can be effectively utilized is dependent upon the design and traffic control characteristics of the work zone itself. Several work zone geometric design features can significantly detract from the ability of enforcement personnel to function either in an active enforcement or in a traffic-calming role within the work zone (or both). Similarly, choices regarding regulatory and advisory work zone speed limits, supplemental traffic control devices to manage speeds and raise driver awareness, and motorist notification of enforcement efforts can either benefit or constrain enforcement effectiveness.

The following key points should normally be considered as part of the work zone planning and design process:

- Establish realistic design speeds and speed limits;
- Consider the need, extent, and type of police enforcement to be used;
- Limit the length of shoulder closures;
- Consider the need for enforcement pullout areas;
- Consider speed management alternatives and supplements to enforcement;
- Consider public awareness efforts regarding work zone enforcement; and
- Consider motorist notification efforts regarding work zone enforcement.

Establishing Realistic Design Speeds and Speed Limits

Highway agencies have varying policies, guidelines, and standards for establishing work zone speed limits. In some states, traffic laws require speed limit reductions in work zones when workers are present, or during other specific conditions.

Sometimes, the design speed through the work zone is used to determine the speed limit to be posted. It may be tempting to use a lower design speed within a work zone to minimize costs of temporary pavements for crossovers, restriping requirements, and other work zone features. However, in many instances, drivers do not voluntarily reduce speeds to that lower design speed, and simply posting a reduced speed limit in the work zone does not necessarily reduce speeds to the lower design speed. Consequently, this practice may produce a number of undesirable effects, such as:

- Requiring a high and continuous level of enforcement during the project to maintain good driver compliance with the reduced speed limit;
- Having a large number of drivers who are exceeding the design speed and posted speed limit;
- Increasing speed differentials in the work zone; and
- Decreasing the credibility of all types of traffic control devices in the work zone.

Section 6B.01 of the MUTCD specifically states that road user movement should be inhibited as little as practical and that temporary traffic control at work sites should be designed on the assumption that drivers will only reduce their speeds if they clearly perceive a need to do so (13). Additional guidance pertaining to work zone speed reductions and speed limits is then found in Section 6C.01 pertaining to temporary traffic control (TTC) plan development, several excerpts of which are provided herein (13):

“Reduced speed limits should be used only in the specific portion of the TTC zone where conditions or restrictive features are present. However, frequent changes in the speed limit should be avoided. A TTC plan should be designed so that vehicles can travel through the TTC zone with a speed limit reduction of 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 TTC zone.



Figure 13. Examples of some technologies to implement short-term speed limits in work zones.

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 TTC warning devices should be used.”

“Reduced speed zoning (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.”

“Research has demonstrated that large reductions in the speed limit, such as a 30 mph reduction, increase speed variance and the potential for crashes. Smaller reductions in the speed limit of up to 10 mph cause smaller changes in speed variance and lessen the potential for increased crashes. A reduction in the regulatory speed limit of only up to 10 mph from the normal speed limit has been shown to be more effective.”

Reduced speeds should only be posted in the vicinity of work being performed or where necessitated by road conditions. Depending on state law, it may also be appropriate to post a reduced speed limit only during times of actual work activity (if the work activity itself is what constitutes the need for reduced speeds), and then cover or remove the signs when work is not active. Various technologies also exist to assist in implementing these types of short-term speed limits, a couple of which are shown in Figure 13.

Considering the Need, Extent, and Type of Police Enforcement to Be Used in the Work Zone

Certain work zone design features and work activities may trigger the need for incorporating work zone enforcement into the overall transportation management plan for a particular project. Early recognition of the potential need for enforcement at an upcoming work zone is beneficial from a programmatic

perspective, as it allows agencies to better estimate costs and manpower resources that will be needed, as well as to identify time periods and regions where possible resource constraints that could develop so that contingencies can be established.

Certain states have legal requirements regarding the use of enforcement in some categories and certain work zones. Meanwhile, some highway agencies have pre-established criteria regarding enforcement use and even the type of enforcement strategy incorporated into their policies and procedures. In some instances, the amount of funding available for enforcement use in work zones serves as the controlling criteria. In these instances, it is very important that projects that are likely to benefit most significantly from enforcement use be identified early so that they can be considered in the overall resource allocation process.

While identification of enforcement needs during project planning and design is highly desirable, it is not always possible. Changes in the type of work being performed, field changes in the overall traffic control plan and project phasing, or higher than expected crash rates, are all possible reasons for making a decision to incorporate enforcement into a project after it begins. Most highway agencies recognize that this uncertainty exists, and account for possible additional needs in their work zone enforcement funding and resource allocation efforts each year.

Work Zone Design Features Related to Enforcement

Limiting the Length of Shoulder Closures

As shown in Figure 14, shoulders must be closed in many work zones, using portable concrete barrier or other devices, for work activities or for use as temporary travel lanes while work occurs on another part of the roadway cross-section. Unfortunately, such closures eliminate locations for enforcement personnel to safely position themselves and/or pull over violators to issue a citation. If used, shoulder closures should be kept as short as possible to minimize their adverse effects on enforcement activities. Generally speaking, such shoulder closures should be limited to three continuous miles or less (14). Limiting shoulder closure lengths also improves overall traffic safety and flow, ensuring that there will be opportunities for disabled vehicles to find refuge on a shoulder section instead of stopping in an active travel lane.

Considering the Need for Enforcement Pullout Areas

In some cases, it may not be possible to limit shoulder closures to three miles. In these instances, consideration should be given to including periodic enforcement pullout areas within



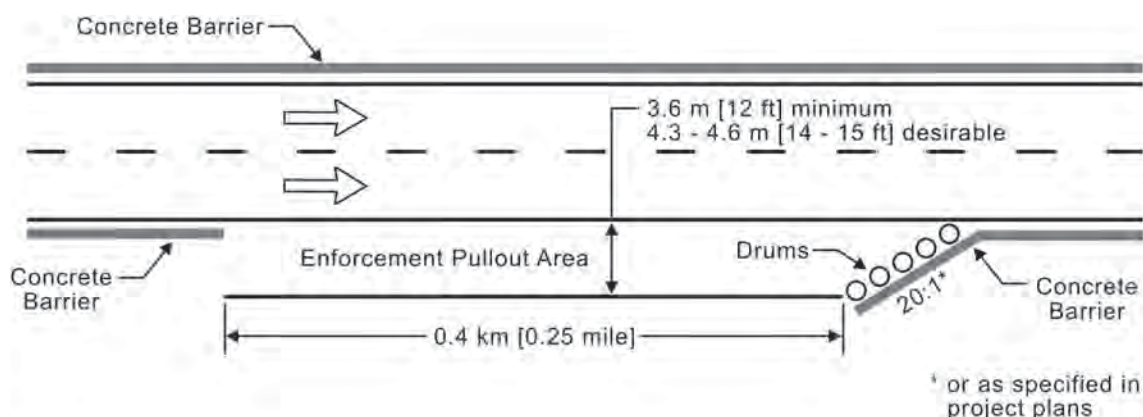
Figure 14. Lengthy shoulder closures make enforcement efforts in work zones more difficult.

the work zone. Enforcement pullout areas must be adequately designed to allow them to be properly used by enforcement personnel and motorists. Enforcement pullout areas in work zones should be:

- Wide enough to allow enforcement personnel to exit their vehicle and safely move in the area to issue a citation;
- Long enough to allow safe entry to and exit from the normal traffic stream; and
- Spaced close enough to be useful to enforcement personnel, but far enough apart so that they do not interfere with work progress.

Experiences with enforcement pullout areas in high-occupancy vehicle lanes indicate that the width of the pullout should be at least 12 feet (15). Where possible, pullout areas should be located on the right side of the roadway to avoid creating driver expectancy problems, and should preferably be 0.25 miles long to allow adequate space for an enforcement vehicle and the stopped vehicle to safely pull into the area, and have enough space left to safely pull out of the area once the enforcement activity has been concluded (see Figure 15).

Research indicates that pullout areas spaced approximately every 3 miles are an effective compromise between enforcement needs and those of the highway contractor completing



Note: refer to the MUTCD (13) and the AASHTO Roadside Design Guide (16) for proper treatment of the ends and slope of the concrete barrier

Figure 15. Example work zone enforcement pullout area (4).

the work (14). The location of the pullout area should be such that there exists adequate sight distance upstream and downstream.

Speed Management Alternatives and Supplements to Enforcement

For work zones where traffic demands do not justify the use of enforcement or where enforcement needs exceed enforcement resources, other speed management technologies and supplements can be considered for implementation in the work zone. Common speed management technologies include:

- Speed display trailers;
- Radar-activated portable changeable message signs (PCMS);
- Citizen-band radio information systems;
- Temporary transverse rumble strips;
- Drone radar emitters; and
- Narrowed lanes using channelizing devices.

Speed display trailers and *radar-activated PCMS* are similar in that both include a radar device pointed upstream to measure the speed of the approaching vehicle, and display that speed electronically (see Figure 16). The speed display trailer is more limited in that it will only display the vehicle speed, whereas a radar-activated PCMS with radar can display other messages (e.g., YOU/ARE/SPEEDING, SLOW/DOWN/NOW) in addition to actual speeds. Early experiences with these types of devices found that some drivers tested their vehicles by seeing how fast they could get the display to read. Consequently, both of these types of displays now incorporate a maximum display threshold into their logic. These devices can result in small (2–3 mph) reductions in average speeds, although reductions as much as 10 mph have been documented in a few instances. The effectiveness of these devices is dependent upon roadway geometrics (more effective on two-lane highways than on multi-lane facilities) and traffic volumes (the devices often do not provide accurate speed indications when traffic volumes are too high). The devices also tend to be ignored by more drivers if the work zone speed limit is far below the normal operating speed of the facility and there is no obvious reason for the reduced speed limit.

Citizen-band (CB) radio information systems are self-contained units that allow an agency to record a message that is then continuously broadcast over a selected CB channel. These devices target primarily long-haul truckers who rely on CB radios for communication, and can achieve small (2 mph or less) reductions in truck speeds, depending on the message used. This technology is most applicable for addressing truck-specific hazard warnings within work zones. One concern with this technology is that it may increase speed differentials between automobiles and trucks.



(a) Speed Display Trailer



(b) Radar-Activated Portable Changeable Message Sign

Figure 16. Speed display trailer and radar-activated portable changeable message sign.

For work zones that are stationary for several hours or days, *temporary transverse rumble strips* can be placed in advance of the work zone or at key locations within the work zone where additional driver attention is desired. These devices do not result in large decreases in speed (generally no more than 2 to 5 mph), but provide both tactile and auditory feedback to the driver that is believed to increase alertness. Some types of temporary rumble strips are adhered to or cut into the pavement. Other temporary rumble strips are heavier, and are simply placed on the pavement without the need for adhesives or other connection to the pavement.

Drone radar transmitters have been on the market for several years now. These devices consist of a small k-band radar transmitter and battery housed in a case. These transmitters can be attached to work vehicles or traffic control devices within or upstream of a work zone to activate radar detectors in approaching vehicles. The effects of the transmitters on average speeds are fairly modest (3 mph or less), since only a limited number of vehicles have radar detectors in them. The devices may also increase speed differentials between vehicles with radar detectors and those without, and so should not be used in locations where a reduced speed limit that is far below the normal operating speed of traffic is posted. However,

Table 4. Speed management alternatives and supplements to enforcement.

Technology	Advantages	Disadvantages	Deployment Considerations
Speed display trailers	<ul style="list-style-type: none"> - Well understood by motorists - Easily deployed and moved - Relatively low cost 	<ul style="list-style-type: none"> - Ignored if reason for speed reduction is not apparent - Overused in some areas, reducing credibility - Does not work well on high-volume roadways 	<ul style="list-style-type: none"> - Should be moved regularly - Best use is upstream of a specific hazard - Important to ensure adequate sight distance to the device - Should be positioned to minimize risk of impact by errant vehicle
Radar-activated PCMS	<ul style="list-style-type: none"> - Can display speeds or other speed-related messages - Display is higher off the ground, increasing sight distance - Can be used for other than speed-related messages if desired 	<ul style="list-style-type: none"> - More costly than speed-display trailers - Requires sign programming expertise (setting messages, thresholds, etc.) - The display of speeds will not work well on high-volume roadways 	<ul style="list-style-type: none"> - Best use is upstream of a specific hazard - Should be positioned to minimize risk of impact by errant vehicles
CB radio information systems	<ul style="list-style-type: none"> - Does not contribute to visual information workload - Allows for truck-driver-targeted messages to be disseminated - Allows longer messages - Allows drivers to hear message more than once 	<ul style="list-style-type: none"> - Proprietary device - Information dissemination is limited to those with CB radio receivers 	<ul style="list-style-type: none"> - Most effective where most truck traffic is long-distance haulers - Message design should be based on highway advisory radio (HAR) guidelines
Transverse rumble strips	<ul style="list-style-type: none"> - Provides both tactile and auditory warning to raise driver alertness level - Fairly low cost 	<ul style="list-style-type: none"> - Effect on vehicle speeds is minimal - Strips adhered to the pavement cannot be easily reused at another location 	<ul style="list-style-type: none"> - Noise generated by rumble strips may be objectionable near residential areas
Drone radar emitters	<ul style="list-style-type: none"> - Low cost - Easily moved and removed 	<ul style="list-style-type: none"> - Warning effect only reaches those with radar detectors - Can increase speed differentials between vehicles with and without detectors - Radar detectors are prohibited in some states 	<ul style="list-style-type: none"> - Devices are often vandalized or stolen, so use is most effective during work activities and removed immediately afterwards
Narrowed lanes with channelizing devices	<ul style="list-style-type: none"> - Can be created during traffic control device setup 	<ul style="list-style-type: none"> - Requires constant monitoring to maintain devices in proper locations - may reduce capacity and increase congestion and queues 	<ul style="list-style-type: none"> - Effect is likely to be greater with larger devices (i.e., drums) and closer device spacing

PCMS = Portable Changeable Message Sign

it is commonly assumed that those drivers who have radar detectors generally travel faster than those without detectors, implying that this technology may be beneficial in reducing the percentage of very high speed vehicles in the traffic stream. One final consideration is that a number of states prohibit radar detectors in commercial vehicles, and a few states prohibit detectors in all types of vehicles.

Narrowed lanes using channelizing devices is another technique that has been shown to reduce speeds slightly within work zones. The placement of channelizing devices so as to create 11 or even 10.5 foot travel lanes can result in speed reductions up to 5 mph, although the reductions will normally be smaller than that. Also, the effect of this technique will be greatest when only a single lane is available for travel through the work zone, since the channelizing devices do not provide the same “closed in” sensation to drivers when there are two or more lanes traveling in the same direction. One disadvantage to this technique is that it will increase the frequency of channelizing devices that are knocked down or out of position within the work zone, which will require additional effort by traffic control personnel to constantly

maintain the devices in the correct arrangement. Another possible concern is that the combination of narrowed lanes and channelizing devices may reduce lane capacity, resulting in increased congestion and development of traffic queues.

Table 4 summarizes the advantages, disadvantages, and key deployment considerations for each of the technologies discussed herein.

Public Awareness for Work Zone Safety and Enforcement

Public awareness programs for work zone safety have been in place for many years. Nationally, the “Give ‘em a Brake” program is perhaps the most common, although several states have developed their own programs and slogans, such as the “Slow for the Cone Zone” program in California (see Figure 17). Other unique initiatives can be found on the National Work Zone Safety Information Clearinghouse website (www.workzonesafety.org) by clicking on the “public awareness” link.

Agencies should periodically review the programs in place elsewhere, and consider adapting one for use in their jurisdic-



Figure 17. Examples of speed-related work zone public awareness campaigns (17).

tion. Changing the way in which the message to slow down and pay attention in work zones is presented should help keep the message fresh in the minds of motorists, and help encourage good driving behavior in work zones. A new work zone public awareness program is best “rolled out” at the beginning of the construction season, in conjunction with the National Work Zone Awareness Week that occurs the first week of April each year.

Motorist Notification for Work Zone Safety and Enforcement

In most states, fines for speeding and/or other traffic violations are doubled or otherwise increased in work zones. In many cases, the fines are increased if workers are present at the time of the violation. The law in some states requires signing to notify the driver about the increased fines.

Implementation of the increased fine laws can be problematic for enforcement personnel in work zones that are extremely lengthy or when work activities occur outside of what are considered normal working hours. In these situations, officers have difficulty knowing for certain whether workers are indeed present. Likewise, motorists approaching the work zone do not yet know whether workers are present and that fines are increased. One way to address this issue is through the implementation and use of special signing to notify motorists and enforcement personnel that a work zone exists and that workers are present at the work site. A highway agency inspector or contractor supervisor is responsible for activating this workers present sign at the beginning of a work shift, and then turning it off when the shift is over. This last task is particularly important, as failure to de-activate the sign will quickly degrade its credibility with both

the motoring public and law enforcement personnel. Permanent and portable changeable message signs could also be used to remind motorists that fines are increased for traffic violations in work zones, as illustrated in Figure 18.

Normally, motorists need not be notified about active enforcement activities currently occurring in a work zone. One goal of work zone enforcement efforts is to establish an expectation that enforcement personnel may be present in any work zone at any time, and thus discourage drivers from ever violating traffic laws. That being said, there are two specific active enforcement strategies where the use of real-time notification of enforcement efforts does make sense. The first of these is in conjunction with “Operation Hardhat” pack-enforcement initiatives. Although the placement of an officer in a construction worker vest and hardhat within the work zone is intended to allow covert enforcement efforts to occur, this approach can be viewed negatively by the public as a type of speed trap intended solely for increasing revenues, especially if the speed limit has also been reduced through the work zone. If efforts are made to warn approaching motorists that an enforcement effort is occurring in the work zone, the perception of a speed trap can largely be avoided. An example of an acceptable message on a typical 8-character, two-phase PCMS to notify approaching drivers is shown in Figure 19. In certain cases, the highway and enforcement agency may even choose to notify the media about the work zone location where the enforcement efforts will occur that day.

Another enforcement strategy that usually requires motorist notification in advance of the enforcement location in the work zone is semi-automated or automated speed enforcement technology. This warning is likely to be explicitly required as part of the enabling legislation in order to make the citation valid (the



Figure 18. Examples of motorist notification signing pertaining to work zone enforcement.



Figure 19. Example of advance warning of work zone enforcement activities.

signing required for the automated enforcement program in Illinois is illustrated in Figure 20). Again, the primary concern is with avoiding the perception that the enforcement effort is intended for revenue generation rather than safety enhancement. Consequently, agencies will generally err on the side of caution and provide multiple opportunities for motorists to slow down prior to reaching the enforcement point. In addition to static advance signing left in place at all times, speed display trailers or boards that may be mounted on an enforcement van provide a real-time notification to speeding drivers to allow them to reduce their speed prior to reaching the enforcement point.



Figure 20. Example of motorist notification signing used with the Illinois work zone automated speed enforcement program.

CHAPTER 4

Administrative Considerations of Work Zone Enforcement

Introduction

Experiences nationally indicate that work zone enforcement can be administered in several different ways, each with its own set of advantages and disadvantages. The choice as to which approach is most appropriate for a given situation depends on several factors, including:

- The amount and type of work zone enforcement typically required by the highway agency,
- The amount of staff time and resources the highway and enforcement agencies can devote to managing and administering work zone enforcement efforts, and
- The working relationship between the highway and enforcement agencies.

Generally speaking, the administration of work zone enforcement efforts involves consideration of three basic issues:

- Defining roles and responsibilities, lines of authority and communication, and other administrative details between the highway and enforcement agency through the establishment of a memorandum of understanding between agencies;
- Determining how work zone enforcement needs will be funded; and
- Determining how work zone enforcement efforts will be paid.

Establishing a Memorandum of Understanding (MOU) for Work Zone Enforcement Support

In general terms, a memorandum of understanding (MOU) is a document describing a bilateral agreement between parties pertaining to a common line of action. An MOU is often established between a highway and an enforce-

ment agency as a formal statement of the intent to work together in the provision of enforcement personnel in work zones. The purpose of the MOU is to document specific roles of each agency, the intent to coordinate and cooperate, the lines of authority and communication that will be followed, and other details.

In most instances, the MOU is between the state highway and state enforcement agencies; in some cases, though, the highway agency and a local enforcement agency may enter into an MOU. Although the actual development and approval of an MOU can take some time and effort by both agencies, both will ultimately benefit by having this agreement in place. Although the specific wording used between agencies will vary depending on differences in terminology, legal staff who are involved in crafting agreements, etc., a properly-designed MOU for work zone enforcement usually contains details on the following major items:

- *Estimated amount of funding expected to be available for enforcement accomplished under the agreement*—The expectations for all parties of the amount of funding available is provided so that the enforcement agency can better plan for the officer resources to be requested, and the highway agency can assess its upcoming needs for enforcement and establish or modify criteria for enforcement use on projects to make best use of the limited resources available. The agreement may also describe how the amount of available funding will be established and communicated to the enforcement agency each year or construction season.
- *Types of costs allowed to be charged*—The officers' wage rates (regular and overtime), associated benefits, and taxes will usually be covered under the agreement. In addition, the agencies may also agree to other items to include (e.g., fuel, insurance, vehicle usage, enforcement office supervision and staff support, etc.).
- *Billing information requirements*—Details are provided as to which agency is responsible for paying the officers (officers

can be paid directly by the highway agency or directly by the contractor if all support is done via overtime hours, or by the enforcement agency which is then reimbursed by the highway agency or the contractor). Reports or timesheets that the officer or enforcement agency may need to provide the highway agency or contractor will also be spelled out in this section.

- *Names and contact information of key responsible persons in each agency*—Primary points of contact regarding the overall MOU should be provided as part of the agreement.

In addition, highway and enforcement agencies may choose to formalize the agreement on several other topics:

- *Specific officer responsibilities during each shift*—The expectations of the officer while on duty at the work zone can be specified as part of the MOU, including a description of the expected method of enforcement (e.g., active enforcement, traffic-calming efforts, intersection or driveway traffic control, etc.) to be used. This is often referred to as the “Scope of Services.”
- *Right to terminate agreement*—Language describing the rights of the various parties to end enforcement activities under the MOU is sometimes included. Project duration, available staffing, untimely payment or other items that might otherwise describe a breach of contract, may be criteria specified to trigger the termination of the agreement.
- *Minimum notification time to schedule enforcement support*—Some agencies define the minimum notification time to schedule enforcement support. The time required will depend on the size of the enforcement agency and amount of work that may necessitate enforcement support, state or local union rules, etc. Examples exist of MOUs with minimum notification times of anywhere between 3 and 14 days, although shorter or longer times could certainly be specified if so desired. Usually, the MOU will also indicate that the enforcement agency may accept a request for support scheduled on shorter notice, but is not required to do so.
- *Minimum notification time to cancel a request*—When included, this clause defines the minimum time required for the requested enforcement support to be canceled. Such a clause is generally used when enforcement support is being provided primarily through officer overtime. Nationally, one can find examples of MOUs that specify minimum cancellation times of 24 to 36 hours. Again, though, the actual requirement will depend on local labor union rules and other factors, and may be shorter or longer than this range. Failure to cancel a request in time often involves a payment penalty. Although a 2- to 4-hour minimum charge for failure to cancel in time is common, it will also depend on local labor agreements and union requirements.

- *Law enforcement agency right of first refusal for providing support*—In regions where the enforcement agency is providing regular-time officer support (and possibly supplementing with overtime effort) to meet work zone enforcement requests, a clause may be included to ensure that the enforcement agency has the first opportunity to provide support. If an officer or officers are not available, the highway agency is then allowed to use other enforcement agencies for assistance.
- *Payment schedule*—This statement defines the reimbursement payment period (biweekly, monthly, etc.) and what supporting documentation is needed to be provided to support the reimbursement request.
- *Required law enforcement participation in pre-construction meetings*—When included, this clause specifies that the enforcement agency provides an officer during the project pre-construction meetings to ensure that enforcement concerns for the project are presented and discussed.
- *Officer training requirements*—In some jurisdictions, the MOU may also specify that the officers be trained on providing safe and effective law enforcement in work zones.
- *Documentation requirements*—Highway agency reimbursement of work zone enforcement efforts usually requires some level of documentation of enforcement efforts to support payments. Documentation after each shift (as described above) is the simplest way to meet these requirements. Invoicing may occur after each event, or be done on a regular (weekly, bi-weekly, monthly) basis.
- *Cooperative enforcement support to be provided*—A highway agency and enforcement agency may also choose to include language that specifies how much cooperative work zone enforcement will be done as part of the existing enforcement agency budget.

Funding Approaches for Work Zone Enforcement

As specified in federal regulations (1), costs for work zone enforcement are eligible for reimbursement through the Federal-aid program. The regulations allow enforcement services to be funded on a project-by-project basis as part of the individual construction contracts, or on an overall program-wide basis by setting aside a portion of the overall construction budget of the agency for enforcement activities. Examples of both types of funding arrangements exist across the country. In addition, a few states have enacted legislation that returns a portion of the fines received from work zone enforcement efforts back to fund future work zone enforcement. The preferred funding approach for a particular agency depends on a number of factors, the most significant of which are summarized in Table 5.

Table 5. Advantages and disadvantages of available work zone enforcement funding approaches.

Funding Method	Advantages	Disadvantages
Program-wide enforcement funding	<ul style="list-style-type: none"> - Administrative and support staff costs needed to manage the program can be recouped by the highway agency - Can improve the degree of enforcement consistency across projects regionally or statewide - Increases flexibility to increase enforcement use at a project due to unforeseen circumstances 	<ul style="list-style-type: none"> - Management and support staff manpower requirements to administer a program can be substantial - Some of the funding is used for administrative purposes, reducing the number of officer hours that can be funded
Project-by-project enforcement funding	<ul style="list-style-type: none"> - Administrative costs are generally lower, resulting in more officer hours on site for a given level of funding - Decisions on when and where to use enforcement can be made more quickly 	<ul style="list-style-type: none"> - Enforcement application can be inconsistent from project to project - Can be more difficult to accommodate an increased need for enforcement (beyond that originally budgeted) if unforeseen circumstances arise
Revenues generated from citations issued in work zones are used to pay for work zone enforcement	<ul style="list-style-type: none"> - The impact of providing work zone enforcement on the overall highway agency construction budget is reduced 	<ul style="list-style-type: none"> - Usually, specific state legislation is required authorizing the use of the work zone citation revenues for this purpose - Use of enforcement for traffic-calming purposes in the work zone is viewed less favorably, since this strategy does not result in citations being issued

Program-wide work zone enforcement funding can be established at either the statewide or a district or region level. The amount of funding may be based on a preliminary assessment of work zone enforcement needs identified by project engineers and collated across the state or district for a funding cycle. Another approach followed by some agencies is to simply establish the program as a percentage of the anticipated letting budget by the agency for that cycle. This percentage may then be adjusted slightly in subsequent years if the allocated funds are found to be excessive or deficient to cover the actual enforcement costs that were actually incurred.

One of the primary advantages of establishing program-wide work zone enforcement funding is that it can facilitate coordination and consistency in work zone enforcement application across projects in the state or district. This approach can also allow agencies to be more responsive to changes in enforcement needs that occur over the course of projects, and reallocate resources from projects where needs are found to be lower than anticipated to those projects whose needs are found to be greater. In addition, a program-wide funding approach allows for any management and support staff costs associated with administering the program (reviewing and approving requests for enforcement use, gathering the required documentation for reimbursement, issuing payments, tracking expenses over time, etc.) to be reimbursed as well. Of course, the consequence of this approach is that some of the funding allocated for work zone enforcement does not equate to actual officer time at a project. Because of these characteristics, a program-wide funding approach is more suited to agencies with larger construction

and maintenance budgets and thus a larger number of projects with work zone enforcement needs.

In contrast to program-wide funding, a *project-by-project work zone enforcement funding* approach tends to be simpler in nature. Agencies that utilize this method estimate enforcement funding needs for individual projects as part of the overall project planning and bid preparation process. Each project engineer then has responsibility for ensuring that the allocated funds from the project budget are used appropriately. This approach is simpler to implement, and decisions on when to utilize enforcement can usually be made more quickly. Conversely, this approach is less flexible in terms of accommodating unexpected additional enforcement needs during a particular project. Also, differences may exist in how enforcement is used from one project to the next.

Finally, the *use of increased fine revenues for work zone enforcement* is an attractive funding approach conceptually for agencies, especially since most states already increase fines for traffic violations that occur in their work zones. The extra revenues that are generated can be assigned to fund work zone enforcement without adversely affecting other governmental operations that are based on enforcement revenue. Theoretically, the overall impact of providing work zone enforcement upon the highway construction budget for an agency would be reduced. However, one key disadvantage of this funding approach is that it inherently favors active enforcement efforts over passive, traffic-calming techniques. In addition, this type of funding approach can result in increased public scrutiny over the speed limits set in work zones, since there is a perceived

benefit to the agency to establish speed limits that increase the number of speeding citations issued and thus the amount of increased work zone enforcement funding generated.

Payment Methods for Work Zone Enforcement

Just as multiple methods exist for funding work zone enforcement efforts, different methods of paying for the work zone enforcement activities that occur are also available. Typically, one of three main methods is used:

- Work zone enforcement efforts are paid by the highway agency on a program-wide or project-by-project basis to the enforcement agency as reimbursement of officer hours worked,
- Work zone enforcement efforts are paid directly by the contractor to either the individual officer or to the enforcement agency as part of the construction contract for hours worked, or
- The highway agency (or other part of state government) establishes a grant arrangement to go directly to the enforcement agency to fund the work zone enforcement efforts.

Characteristics of each payment method are summarized in Table 6. Regardless of whether the highway agency or the contractor is reimbursing the enforcement agency, payments are made based on detailed invoices submitted periodically by the enforcement agency for efforts expended. If payment is provided by the contractor, a pay item for enforcement use is typically provided in the contract, although it may be included in other items of work as an overhead expense in some instances. Federal regulations allow contract pay

items for enforcement work to be either unit price or lump sum items (1). Unit price items should be utilized when the highway agency can estimate and control the quantity of law enforcement services required on the project. The use of lump sum payment should be limited to situations where the quantity of services is directly affected by the contractor's choice of project scheduling and chosen manner of staging and performing the work. It is important to make sure that all parties (highway agency field personnel, enforcement officers, and highway contractor personnel) understand who has authority to decide how the officers are to be utilized while at the job site (i.e., for active enforcement or for traffic-calming purposes). In most locations, the highway agency retains the authority to make such decisions, even if the highway contractor is providing payment for services.

The use of grant arrangements for work zone enforcement transfers much of the administrative effort to manage and document expenses from the highway agency to the enforcement agency. The arrangement is viewed positively by most enforcement agencies, as it allows them to better manage its manpower resources and recoup some of its administrative expenses. In some locations, the arrangement allows the enforcement agency to hire additional officers than would otherwise be possible with its existing budget, and thereby reduce the amount of enforcement that is done with overtime hours that come at a cost premium. In a few instances, these additional officers are dedicated exclusively to work zone enforcement efforts, and results in officers who are more trained and experienced in operating in work zones. Overall, this approach may provide an improved level of enforcement and cooperation between enforcement and highway agency personnel than could otherwise be obtained. In a few cases, the grant arrangement has been established with a requirement

Table 6. Characteristics of various work zone enforcement payment approaches.

Payment Method	Characteristics
Enforcement efforts reimbursed directly by highway agency	<ul style="list-style-type: none"> - Based on detailed invoices submitted by enforcement agency for work performed - Can be done either program-wide or on a project-by-project basis
Enforcement efforts reimbursed by highway contractor	<ul style="list-style-type: none"> - Based on detailed invoices submitted by enforcement agency for work performed - Usually a pay item in contract, but can be done as part of overhead expense on other work performed - Pay item can be unit price or lump sum based, depending on whether highway agency or contractor controls amount of enforcement used
Grant provided by highway agency or other source directly to enforcement agency for work zone enforcement efforts	<ul style="list-style-type: none"> - Highway agency requests work zone enforcement support, but enforcement agency pays for efforts directly through grant funds - May involve some level of matching support by enforcement agency

that the enforcement agency provide a certain funding match (such as 20 percent) to be dedicated to work zone enforcement. Once the grant is in place, the highway agency submits requests for enforcement support on specific projects as needed, the same way as is done under the other payment methods.

Other Work Zone Enforcement Administrative Considerations

Management of Officer Overtime

Work zone enforcement is often accomplished through the use of officers hired on an overtime basis. This arrangement is attractive to most officers, as it allows them to significantly supplement their normal income received from the enforcement agency. Officers must normally volunteer for such duty, and so can adjust their level of participation as they see fit. For the most part, this approach does work well. There are a few locations, however, where the demand for work zone enforcement support is so high that officers can spend much of their non-work time providing supplemental work zone enforcement.

Although most enforcement agencies leave it to the individual officers to monitor their own level of effort and limit their off-duty assignments to a reasonable level, a few enforcement agencies track these efforts more closely and may even cap the number of off-duty hours the officer can take on in a given week. Since many off-duty shifts are in support of night work activities, concerns arise over lack of sleep and strained family relationships that can occur if officers take on excessive amounts of off-duty work. Tired officers are also more prone to mistakes on their regular shifts, which is another reason some agencies establish maximums for their officers.

Officer Work Zone Safety Training

Some highway agencies require officers who are providing work zone enforcement support to receive training about basic work zone traffic control and other facets of work zone safety prior to their deployment in a particular work zone. The purpose of such training is to ensure that officers are aware of the reasons for providing law enforcement in work zones, understand the basic practices and procedures related to the use of law enforcement officers in work zones, understand the purpose and application of the various traffic control devices in

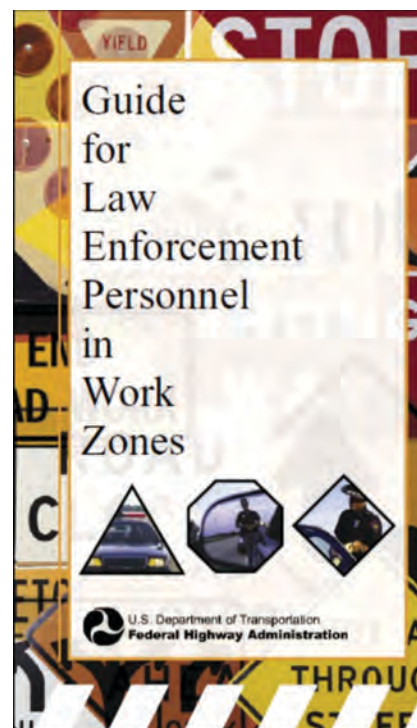


Figure 21. FHWA work zone law enforcement pocket guide.

use in work zones, and understand that there are acceptable and unacceptable locations for enforcement personnel to be located upstream and within a work zone. It can be beneficial to include both the officers and highway agency field personnel in these training efforts. This approach ensures that all parties are clear as to the role of enforcement in work zones. Joint training can also facilitate discussions between officers and field staff regarding site conditions that can influence enforcement strategy selection, and can help foster a good working relationship between both groups.

Some enforcement agencies have developed their own training program to meet this need. FHWA has developed law enforcement work zone training. Available products include an instructor's manual; participant's guide; pocket guide (see Figure 21); and PowerPoint training modules. These materials can be obtained directly from FHWA (18). In addition, some vendors are offering train-the-trainer courses of the material. These opportunities can be found on the National Work Zone Safety Information Clearinghouse as well (19).

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Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI-NA	Airports Council International-North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation