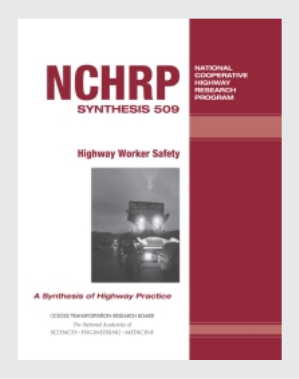

Highway Worker Safety

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 509

Highway Worker Safety

A Synthesis of Highway Practice

CONSULTANTS
John A. Gambatese
David Hurwitz
and
Zachary Barlow
Oregon State University
Corvallis, Oregon

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research is the most effective way to solve many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation results in increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

Recognizing this need, the leadership of the American Association of State Highway and Transportation Officials (AASHTO) in 1962 initiated an objective national highway research program using modern scientific techniques—the National Cooperative Highway Research Program (NCHRP). NCHRP is supported on a continuing basis by funds from participating member states of AASHTO and receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine was requested by AASHTO to administer the research program because of TRB's recognized objectivity and understanding of modern research practices. TRB is uniquely suited for this purpose for many reasons: TRB maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; TRB possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; TRB's relationship to the Academies is an insurance of objectivity; and TRB maintains a full-time staff of specialists in highway transportation matters to bring the findings of research directly to those in a position to use them.

The program is developed on the basis of research needs identified by chief administrators and other staff of the highway and transportation departments and by committees of AASHTO. Topics of the highest merit are selected by the AASHTO Standing Committee on Research (SCOR), and each year SCOR's recommendations are proposed to the AASHTO Board of Directors and the Academies. Research projects to address these topics are defined by NCHRP, and qualified research agencies are selected from submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academies and TRB.

The needs for highway research are many, and NCHRP can make significant contributions to solving 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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Cover figure: A variable message sign instructing drivers to slow their speed for the workers along the highway during night paving operations in Oregon. The photo was taken by an Oregon State University graduate student during a field visit for research conducted by John Gambatese.

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Tanya M. Zwahlen
Consultant
Transportation Research Board

The objective of this report is to identify how state departments of transportation (DOTs) implement policies using highway worker safety and health data to reduce injuries and manage risk. The report is a synthesis of current proactive safety practices that will be useful for DOTs developing new or updating existing policies, programs, or tools to minimize injuries, fatalities, and risk. The study also identifies gaps in knowledge and future research needs.

The information in this report was developed through a comprehensive literature review regarding the topics of worker safety and work site safety. Particular emphasis was placed on the prevalence and causality of injury and fatality incidents for highway workers, the availability of highway worker safety data, existing legal standards and policy recommendations related to highway workers, safety risk and human factors, stakeholders in highway worker safety, and safety program evaluation. The information found in the literature was supplemented with a survey of state DOTs. Six publicly available injury and fatality databases were also examined to quantify and compare injury and fatality incidence rates.

John A. Gambatese, David Hurwitz, and Zachary Barlow, Oregon State University, Corvallis, Oregon, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

HIGHWAY WORKER SAFETY

SUMMARY

Highway work sites can be dangerous places to work. Ask any person who regularly works in a highway work site, and he or she will agree. Traffic passing by at high speeds, multiple large construction and maintenance vehicles operating nearby, deep excavations, and transporting and maneuvering massive structural elements and amounts of material are some of the many hazardous conditions to which highway workers are exposed. Add in that the work often is performed at night with limited visibility and in extreme environmental conditions and potentially in the presence of impaired or distracted drivers, and it is easy to understand that the work shift for a highway worker is full of significant hazards. The job of keeping highway workers safe is arguably more difficult than performing highway work and, unquestionably, more important.

Keeping workers safe is everyone's concern. From the worker who is attentive while at a work site and knowledgeable about the safety hazards present for himself or herself and fellow crew members, up to the director of a state department of transportation (DOT), who regularly demonstrates commitment to safety and allocates funds to support safety, all employees are participants in safety. It is a collective effort. Consequently, state DOTs devote significant amounts of personnel, time, and resources to ensuring the safety of their employees. Safety programs are established to promote working safely, create safe working conditions, monitor safety performance, and learn from incidents that occur. A well-developed safety program enables a high level of safety performance. Safety programs, together with effective safety controls, mitigate the risk of injury associated with the many work site hazards to create safer work environments. State DOTs that lead the nation in safety performance commonly have innovative and unique safety programs.

Developing innovative safety programs requires multiple steps, beginning with identifying and assessing the hazards present and determining the root causes of injuries. In-depth study of incident data is necessary to understand the issues, conditions, and actions that contribute to worker injuries. Once the hazards are identified, assessment of each hazard's implications is required. Such assessment includes quantifying the amount of worker exposure to the hazards along with the frequency with which injuries of different severity levels are expected as a result of the exposure. These measures can be used to quantify the safety risk associated with a particular work site.

Preventing worker injuries requires knowledge of the root causes of incidents. Theories of incident causation have been developed to explain why incidents occur and workers experience injuries. For example, the distractions theory posits that occupational injuries stem from workers being distracted by their focus on work task achievement or external mental worries. For work sites, this theory can be extended from workers to work site crashes resulting from distracted drivers. These crash incidents are one of the more visible types of incidents that occur at work sites. Other incident theories encompass human behavior related to such characteristics as propensity to make mistakes, being absent-minded, ignorance (lack of education and training), having conflicting priorities (e.g., saving time versus being safe), high risk tolerance, and poor risk assessment. According to the prevailing theories, to improve occupational safety and health (OSH) safety programs must affect one or more of the root causes.

Means of controlling hazards have been developed and implemented to address the root causes of incidents. For example, the hierarchy of controls provides guidance on the effectiveness and reliability

of types of implementable controls. In order of decreasing effectiveness, the hierarchy is as follows: (1) elimination, (2) substitution, (3) engineering controls, (4) administrative controls, (5) behavior, and (6) personal protective equipment (PPE). Current OSH practice promotes a proactive approach to eliminating hazards founded on prevention through design of the physical, operational, and social systems that are present in the workplace. If the hazards cannot be eliminated through design, controls lower in the hierarchy may be suitable, with appropriate consideration given to the corresponding lower levels of reliability and effectiveness. Together all of the controls established and implemented constitute the safety and health program of an organization or project.

Important to the process of eliminating worker injuries is the establishment of safety and health programs that accurately respond to and reflect incident and injury claim history. Injury type, frequency, severity, and cause are metrics central to understanding OSH needs and performance. This injury incident data, coupled with information about the work task, worker traits, site conditions, and safety culture, enable the development of a plan to address work site safety. Using the collected data, organizational policies can be developed and safety program elements established. The process starts with having sufficient, accurate, and detailed data related to past worker injuries and includes effectively using the data to inform the development of hazard mitigation policies and programs.

Many state DOTs use OSH data to manage workplace safety. The ways in which DOTs collect, store, and retrieve the data vary from state to state. OSH data may be integrated with incident data, traffic volume data, roadway feature data, workers' compensation data, or other repositories. Connections are needed between OSH data and the causes of worker injuries and fatalities, to minimize exposure to hazards and manage risk. In addition, integrated data sources can help determine trends in injury history, potentially leading to new state DOT policies and procedures in planning, design, construction, operations, and maintenance of the highway system.

Recording, assessing, and disseminating information about state DOT safety programs, especially those that are innovative and unique, is the goal of this synthesis study. The study aims to present archival information that enables the development of new or improved policies, programs, and tools that can minimize exposure of transportation workers at construction and maintenance work sites to the risk of injury and death. A focus is placed intentionally on historical data associated with worker injuries and the means by which these data can be collected and used to influence and improve state DOT worker safety policies and programs. The study focuses solely on employees of state DOTs and not on the employees of construction, consulting, and inspection firms and other organizations at work sites.

To fulfill the synthesis study objectives, a multistep study plan was followed. The first step involved conducting a comprehensive literature review regarding the topics of worker safety and work site safety. Particular emphasis was placed on the prevalence and causality of injury and fatality incidents for highway workers; the availability of highway worker safety data; existing legal standards and policy recommendations related to highway workers; safety risk and human factors; stakeholders in highway worker safety; and safety program evaluation.

The study group supplemented the information found in the literature with an online survey of state DOTs. Survey questions solicited information related to state DOT safety program elements, data sources, and agency perspectives on effective safety policies and practices. From a contact list of the North American Association of Transportation Safety and Health Officials (NAATSHO), survey responses were received from 41 states (82% response rate, one response from each state). The survey responses were used as indicators of innovative and unique safety programs, and the survey was followed up with directed case examples of six state DOTs. The case examples provide in-depth explanations and assessments of safety programs in a handful of states of different sizes and regions in the United States; these may be replicated by other state DOTs.

Lastly, six publicly available injury and fatality databases were examined to quantify and compare injury and fatality incidence rates. The data in each database were analyzed, and each database was evaluated with respect to its benefits and limitations for use in highway worker safety management.

An abundance of prior research is available in the fields of traffic and construction engineering; that research provides a comprehensive understanding of the unique challenges at highway work sites. Much of the literature discusses the issues related to vehicles and their effect on safety at work sites. A significant amount of research exists regarding the hazards of work sites from the perspective of the highway workers and the theories of incident causation. An important takeaway from the literature review is that information is available to state DOTs that provides guidance on the factors that affect worker safety and recommended safety program elements.

The survey results reveal that the state DOTs are diverse. Each state DOT experiences its own set of issues and remains committed to improving the safety of its employees in highway work sites. With this diversity comes opportunity. There is not one set of safety programs used by all DOTs; each DOT employs the safety programs it perceives to be important, effective, and feasible to implement given resource limitations. From a nationwide perspective, sharing the research and program methods has the potential to be an economically efficient way to improve safety. Although institutional limitations may prevent some DOTs from implementing successful safety program elements found in other DOTs, understanding fellow state DOT programs can be useful in adapting the broad safety ideas to a new organizational context. Analysis of the survey responses reveals that improvements in data sharing and data availability are helpful in enabling states to make data-driven decisions for their own safety programs.

Making data-driven decisions requires the availability of data. The publicly available data sources analyzed, when used together, can help to quantify and describe current issues in highway worker safety. Understanding the functionality of each data set allows state DOTs to conduct effective research for developing new safety program elements and benchmarking the effectiveness of existing elements. It is suggested that highway worker safety be examined at national and state levels to understand general trends and causes of traumatic incidents. Each of these data sets has advantages and limitations. Although there are benefits to having access to various forms of the data, one of the limitations of this collection of data sources is the difficulty of combining them. They are most easily analyzed independently. It is likely that individual incidents appear in more than one of the archives, but the recording methodology for each program is different enough to make it challenging, if not impossible, to isolate a particular incident across multiple data sets. However, although state-specific data are the most useful for the state DOTs, nationwide statistics on highway worker safety can be beneficial for establishing a benchmark with which states can evaluate areas of highway worker safety where improvement is needed.

The program elements that are implemented and affect the safety of state DOT employees can be diverse. This diversity contributes to a multifaceted approach that is necessary to reduce the safety risk to highway workers. Examples of innovative and unique safety program elements found in some state DOTs include a near miss reporting program; monitoring of leading indicators; a return-to-work initiative; a work zone executive steering committee composed of state DOT and industry representatives; a design for safety initiative; a data-driven public relations and work site awareness program; and a worker safety idea incentive program. New program elements are commonly developed based on means other than data analytics.

Moving forward, additional work is required to identify ways to integrate national and state injury incident data in efforts to improve highway worker safety. Data integration is especially important when tracking the effectiveness of safety program elements. Budgetary restrictions can limit a safety program's components. Research is needed on how to utilize data to develop and implement a limited number of targeted safety programs for maximum impact, rather than simply trying an abundance of program elements that may not result in the same level of overall effectiveness. To assist state DOTs, research is needed that establishes risk factors for highway workers based on work site conditions and operations. The risk factors can be used to design and manage work operations to minimize safety risk. This type of research could be conducted effectively using experimental tools that simulate worker, driver, and equipment operator interaction in a safe, virtual environment.

CHAPTER ONE

INTRODUCTION

Safety on our nation's roadways is of utmost importance. State departments of transportation (DOTs) place safety of motorists, workers, emergency personnel, and others present on roadways as the top priority. This priority is present and respected during all phases of a roadway's life cycle, from initial planning and design through construction, operation, and maintenance. Although balancing safety with other transportation network performance criteria—such as access, mobility, sustainability, and economic feasibility—is important, ensuring safe roadways is the primary objective of all state DOTs.

The hazards present while traveling on a highway and to which employees are exposed when working in highway work sites make zero injuries and fatalities difficult to attain. Whether the result of crashes during roadway use or incidents on construction and maintenance jobsites, injuries and fatalities continue to occur across the United States. Employees present at highway work sites are exposed to an abundance of safety hazards. The hazards may be from passing traffic or work conditions to which employees are exposed. The safety risk can be high if sufficient controls are not in place to mitigate the risk associated with the hazards.

State DOTs take significant steps to implement safety controls to create safe work sites for their employees. To do so, state DOTs work to understand the nature of the hazards present, the associated level of risk, types of injuries likely to occur, and available controls to prevent injuries. This knowledge comes from analyzing and studying work sites and injury incidents along with experiential familiarity with working in the transportation industry. Data sources that provide information about injury incidents are primary sources and used periodically. These sources enable state DOTs to develop traffic control plans, safety training, worker safety programs, and other safety management resources. The data sources also enable data-driven decision making that leads to effective worker safety solutions.

Examples of effective worker safety programs are present in state DOTs across the country. Each state has found success through its own experience and knowledge. State DOTs have developed data resources and archiving processes to enable accurate and efficient access to pertinent data for safety management. One way to improve a state DOT's worker safety program is to learn from other state DOTs and implement practices that other state DOTs have found to be effective. The sharing of safety practices among state DOTs also enables building on current successes to enhance safety in all states. This synthesis report explores the policies and practices that state DOTs have in place for employee safety at highway work sites. It includes an in-depth investigation of the data sources used by state DOTs and how data are used for decision making related to safety programs. The report provides descriptions of policies and practices in place across the United States that state DOTs may learn from and adopt with the hope of preventing additional injuries and fatalities at roadway work sites.

This chapter provides a general background of the synthesis topic and highlights the report's areas of focus. The section also defines relevant terms used throughout the report. The methodology for the entire study and more detailed descriptions of the methods for the individual research tasks are included. The chapter concludes with a short description of the organization of the synthesis study that briefly discusses the outline of the various research tasks presented in the report.

PROBLEM STATEMENT SUMMARY AND SCOPE

Every year in the United States, highway workers who are employees of state DOTs are killed and injured while working at highway work sites. These worker injuries and fatalities are sad consequences of the high risks associated with working at active construction and maintenance work sites and on roadways near active traffic ways. One objective of state DOTs is to maintain effective safety programs and policies that minimize the safety risk to workers and the public at highway work sites. Health and safety data are often available to state DOTs to aid in the development of effective work site safety management techniques. However, these data may not be integrated with other institutional data available to state DOTs. Establishing this integration could benefit state DOT safety programs by making full use of available data and helping state safety officers detect injury and fatality trends in their state. In addition, the data can facilitate the evaluation of safety interventions to determine their effectiveness in reducing highway worker injury and fatalities.

Each state DOT is a unique agency. Although they perform the functions of owning, designing, constructing, operating, and maintaining elements of their state's transportation infrastructure, they all are structured differently and as a result have different responsibilities to their employees and the citizens of their state. To cover the full breadth of issues faced by the diverse set of state DOTs, this synthesis focuses on state DOT employees working at work sites on any roadway. In most cases, these roadways are the primary highways of the state; in others, they include local and county roads. This variety of functionally classed roadway environments produces various levels of risk for state DOT employees in work sites on roadways.

This synthesis study encompasses a narrow but rapidly growing area of safety practice among state DOTs. The use of data and data integration to inform and evaluate state DOT highway worker safety programs is an emerging area of research. State DOTs are at various stages of leveraging available data to reduce the risk to their workers at work sites. The volume of information, particularly that available in current literature and in the details of state programs based on data-driven policies, is limited owing to the relative novelty of this area of research and practice. FHWA has made the use of data for decision making a policy priority. One demonstration of this policy is the requirement that projects for the Highway Safety Improvement Program (HSIP) be selected through data-driven decision making. The HSIP is a program element of the Fixing America's Surface Transportation (FAST) Act, which was signed into law in 2015 (FHWA 2016c).

The purpose of this synthesis study is to examine state DOT health and safety policies and determine how the policies are implemented to help protect highway workers performing their duties in work sites. Although the study focuses on safety policies, it explores the current health and safety practices in state DOTs and describes the practices predominantly in terms of nationwide trends. Based on the findings of existing practice, the study identifies gaps in knowledge and high value areas for future research.

BACKGROUND

Ensuring safe work practices in highway work sites and understanding how safety programs are developed, monitored, and assessed are important issues for state DOTs. Protecting their employees is a challenging but vital role for safety officials in state DOTs. The following sections provide relevant background to the current state of national practice regarding state DOT policies and practice for ensuring safety in work sites.

Prevalence of Injuries and Fatalities

The scope of injuries and fatalities that occur in work sites can be considered in seeking a better understanding of the need for practices that promote highway work site safety. One of the unique characteristics of work sites is the proximity of public vehicles passing, albeit in a controlled manner, through the construction and maintenance site.

A primary incident of concern that occurs in highway work sites is crashes involving public automobiles; some such crashes result in injuries and fatalities to the occupants of the involved vehicle(s). In 2013, an estimated 67,523 crashes occurred in work zones throughout the United States. Of these crashes, 0.4% resulted in a fatality. Almost 73% of the crashes involved property damage only. Crashes in work zones represented 1.2% of the total number of crashes that occurred in the United States in 2013 (FHWA 2016b).

Roadway workers sometimes are involved in the crashes, injuries, and fatalities associated with public automobiles, but roadway workers also are the victims of work site incidents that do not involve public vehicles (e.g., falls, cave-ins, and contact with overhead electrical lines). Road construction and maintenance site fatalities, which represent between 1.5% and 3.0% of nationwide workplace fatalities, have seen a decrease since 2005 (FHWA 2016b). In 2010, the annual number of fatalities (106) for any incident in a roadway work zone was 36% lower than the number of road construction and maintenance worker fatalities in 2005 (165). In addition to the fatalities that occur in work zones, more than 20,000 workers are injured in work zones each year (FHWA 2016b). This figure includes all workers (contractors, etc.) who are injured, not just employees of state DOTs.

Common Work Site Safety Issues

Because most work sites across the nation are similar in structure and function, there are common work site conditions and worker behaviors that are intrinsic to the hazards and risks associated with highway work sites. Some hazards occur as a result of public automobiles in the work zone, whereas others are the result of the work operations being undertaken and the project being built.

FHWA identifies three primary categories of worker fatalities in roadway construction and maintenance. These categories, which include statistics relating to all fatalities in road construction and maintenance (not just state DOT employees), are as follows (FHWA 2016b):

- Run overs/Back overs—The most common cause (43% in 2010) of worker fatalities is workers being run over or backed over by vehicles. These vehicles can include construction vehicles or public automobiles.
- Vehicle collisions—This cause, which includes mobile equipment and can involve construction/maintenance and nonconstruction/maintenance vehicles and equipment, accounted for 19% of roadway construction and maintenance worker fatalities in 2010.
- Caught in between or struck by object—The cause of 8% of roadway construction and maintenance worker fatalities in 2010, these incidents were primarily caused by equipment and objects native to the construction or maintenance site.

In addition to fatalities, many workers are injured in work sites. According to Lincoln and Fosbroke (2010), between 2003 and 2008, each year more than 20,000 workers performing road construction and maintenance jobs were injured. The cause of the injuries, listed by percentage, is provided here (Lincoln and Fosbroke 2010):

- Contact with objects or equipment (35%);
- Slips, trips, or falls (20%);
- Overexertion (15%);
- Transportation incidents (12%); and
- Exposure to harmful substances or environments (5%).

The prevalence of the causes on this list indicate that, although incidents with public vehicles are an added risk to workers at highway work sites, the hazards intrinsic to the work operations, site conditions, and worker behavior at a construction or maintenance site result in most of the worker injuries. In a significant number of these incidents, particularly the fatalities, the workers are on foot at the time of the incident and do not have a vehicle or piece of equipment to offer protection from hazards.

Theories of Incident Causation

Theories of incident causation have been developed to explain why injury incidents occur in workplaces, on roadways, at home, and elsewhere. Initial insights into workplace injuries were presented by William Heinrich based on a study of industrial incidents. Heinrich developed an injury "pyramid" that depicted the relative number of injuries based on severity (Heinrich 1959). Based on his analysis of injury incidents, Heinrich found that of every 330 incidents, 300 were no-injury incidents, 29 were incidents with minor injuries, and one incident had a major injury (fatality) involved. Heinrich additionally presented a two-factor model of incidents, stating that incidents are the result of two primary factors: unsafe conditions and unsafe actions. Secondary factors include management error, design error, unintended action, and intended action; tertiary factors include violation, acts of God, slip, lapse, and mistake. Overall, Heinrich's analysis of injury incidents found that 88% were caused by unsafe acts of persons, 10% resulted from unsafe mechanical or physical conditions, and 2% were unpreventable (Heinrich 1959). Heinrich proposed that the predominant causes of no-injury incidents (near misses) are, in average cases, identical to the predominant causes of major injuries and incidentally also of those of minor injuries. Over the years, researchers have questioned Heinrich's findings and injury pyramid, claiming that the proposed relationship between injury severities does not accurately reflect the causes of incidents.

In concert with Heinrich's claim that most injuries that occur result from unsafe behavior, different theories of incident causation have been developed to address the behavior of workers. Prominent theories of incident causation focusing on worker behavior are described here:

- Accident proneness—This theory describes the likelihood that individuals will participate in a risky behavior based on their personal factors and personality traits (Vernon 1918; Kerr 1950). It suggests that some people, because of their personal nature, are more likely to sustain injuries than are others.
- Goals-Freedom-Alertness theory—This theory suggests that when a worker has well-defined and attainable goals and the freedom to work to achieve those goals, the worker is subsequently more alert and focused on achieving the goal, which leads to fewer incidents (Kerr 1950).
- Adjustment stress theory—This theory hypothesizes that workers are subject to stresses on and off the job that are both internal and external. These stresses affect workers' behavior and therefore potential for being injured based on the relative amount of stress of a particular life event (Kerr 1957).
- Distractions theory—This theory suggests that safety is situational with respect to the focus of the worker's attention (Hinze 2006): workers who focus on productivity and not on the surrounding safety hazards are distracted, which can lead to incidents. In addition, a worker's mental state can be distracting and therefore represents a hazard that can lead to an incident.

Kerr estimated that the adjustment stress theory explained 55% of incidents, whereas the goals-freedom-alertness and accident proneness theories explained 35% and 10%, respectively (Kerr 1957). These worker behavior-related theories can help reveal some causes of incidents that occur at highway work sites.

Human error models have been developed that take into consideration the human factors that affect worker performance. Wiegmann and Shappell (2001) prepared a human factors analysis and classification system (HFACS) to organize the factors that affect worker behavior. The HFACS categories are organizational influences, unsafe supervision, preconditions of unsafe acts, and unsafe acts. Categories of human error precursors also have been developed that contain indicators of when errors leading to injury incidents are likely (Hogan 2010). Examples of error precursors are time pressures, distractions/interruptions, unfamiliarity with task, and stress.

All incidents are the result of at least one of the following root causes, not listed in any particular order (Gambatese et al. 2016):

- Mistake/error: An unintentional miscalculation, blunder, or oversight in action or decision making.
- Absent-mindedness/forgetfulness: Unintentional preoccupied wandering of the mind from the present such that one is unaware of one's immediate surroundings. Lost in thought such that one does not realize current actions, surrounding conditions, and immediate hazards.

- Lack of caring/indifference: Showing little or no care or concern for personal protection or the safety of others, or giving other goals and values (e.g., profit, status, and personal opinion and feelings) higher priority than personal protection or the safety of others.
- Ignorance: Lack of knowledge, experience, or information about the conditions and actions at hand.
- Poor risk management: Insufficient or careless assessment of the safety risk associated with identified hazards and faulty or inferior decision making and control of the calculated risk.
- High-risk tolerance: A high permissible level of risk based on which the need for safety controls is determined.
- Other: Act of God.

The root causes can be independent, in that only one root cause is necessary for an incident to occur, but multiple root causes also can contribute to a single incident. The human behavior root causes listed can occur at any level within a project or an organization and lead to an incident at the work site. For example, a worker may make a mistake while operating a piece of equipment. In addition, a project manager can prioritize project schedule over safety and push workers to work unsafely. In another example, the root causes could be the result of inattentive motorists driving through the work site and motorists with high-risk tolerance.

Subsequent incident theories and models look beyond worker behavior to work operation, project, organization, and industry impacts. The chain of events (domino) theory, first proposed by Heinrich, states that incidents are the result of a series or chain of connected events. One event leads to another, which eventually results in an incident. If any event in the chain had not occurred, the incident may have been averted. Similar to the chain of events theory is the Swiss cheese model of incident causation (Reason 1990), which depicts controls as slices of Swiss cheese. A hazard results in a loss when the holes in the cheese (i.e., the defects in the safety controls) line up.

The constraint-response model (Suraji et al. 2001) starts with the Swiss cheese model and extends the scope to include management and organizational aspects. The model proposes two types of incident causation factors. Distal factors exist at the project management level and include project conception, design, and management constraints. Proximal factors occur at the site management and injured person levels and include such issues as inappropriate planning, site conditions, and work operations.

Taking an approach that expands the influence on workers, the construction accident causation model proposes a hierarchy of influences in construction incidents (Haslam et al. 2005). The influences nearest the worker are termed immediate incident circumstances (e.g., worker factors and site factors). Shaping factors are at the project level and include site constraints, work scheduling, and supervision. Lastly, originating influences exist beyond the project and include such factors as safety culture, risk management, client requirements, economic climate, and worker education.

There is growing recognition that incidents are caused by competing priorities and demands on workers and human performance. Based on a worker behavior model developed by Rasmussen et al. (1994), Mitropoulos et al. (2005) proposed hazard and loss of control zones that model proper task performance. For example, when management pushes for greater productivity, workers can be pushed from a safe zone into a hazard zone. If the push for productivity increases abnormally, the workers are further pressed into a loss of control zone, which eventually results in an incident.

Common Practices Implemented to Improve Safety

Overall, state DOTs have significant autonomy to maintain safety on their roadway networks, including within work sites. Therefore, the practices implemented to improve safety can vary widely from state to state. This autonomy has both benefits and drawbacks. The ability for a state DOT to prepare its safety plan to meet the unique challenges of the work sites under its purview allows the plans to be tailored to state-specific demographic and geographic constraints. However, this

internal focus at the individual state level discourages interstate collaboration and data sharing among state DOTs.

There are limitations to state DOT autonomy for highway work site safety. Nationwide policies and standards exist that are intended to limit risks to motorists and workers in highway work sites. These federally mandated policies are the most common national practices implemented to improve safety and are documented in the *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA 2009). Part 6 of the MUTCD, "Temporary Traffic Control," outlines the proper setup and operation of all temporary traffic control systems on roadways, including work sites. These standards, adopted by all state DOTs, provide practical policies and guidance that minimize worker and driver risk in work zones (FHWA 2009). In addition, states may produce their own supplements to the MUTCD to address unique traffic control situations present in their individual state. These supplements must be equal to, or more stringent than, the federal minimum standards presented in the MUTCD (FHWA 2009).

For states to receive federal transportation funding, the state DOTs are required to prepare a Strategic Highway Safety Plan (SHSP). These plans encompass all aspects of highway safety, not just work sites. However, work sites are a common element of the plans. States have the ability to develop the plans with the needs of their specific state in mind, but general guidance ensures similarities across state DOTs. The practice of producing and regularly updating the SHSP at the state level contributes to keeping safety (including work site safety) a priority for state DOTs (FHWA 2016a).

In 1970, Congress passed the Occupational Safety and Health Act (OSH Act). Part of this act established the Occupational Safety and Health Administration (OSHA). It is the responsibility of OSHA to ensure that employers provide "a safe and healthful workplace" and "assure safe and healthful workplaces by setting and enforcing standards, and providing training, outreach, education and assistance" (OSHA 2016a). The regulations established by OSHA, which include standards for all forms of construction and maintenance projects, apply to some state DOTs. Twenty-one states maintain an OSHA state plan. These state agencies carry the same regulative authority as the federal OSHA but only in the state in question. In addition, federal OSHA regulations allow states to adopt plans that cover local and state government workers only, which would include state DOT employees. Five additional states have this form of OSHA state plan. OSHA reviews and approves both forms of state plans (OSHA 2016b). Therefore, many of the minimum safety practices and standards states use are based on OSHA regulations.

These practices demonstrate the diversity of state DOTs. The potential for individuality—based on factors such as a state having a supplement to the MUTCD or operating a state plan OSHA program—creates an environment in which each state DOT is inherently unique. The state agencies also vary widely in their purview over the roadways of their state. For example, some states construct and maintain only the primary routes, whereas others are responsible for the construction and maintenance of all of roads in the state. Some state DOTs have a more supervisory role in managing contractors conducting work on the roads; others use their workforce directly to construct and maintain roadway infrastructure. The risks workers are exposed to in each state depend on the structure of the DOT in that state; as a result, the DOTs' practices for implementing safety programs also differ.

Beyond these practices, state DOTs can implement safety practices and policies that protect highway workers. These practices, in combination with the federal guidelines for safe work sites and risk reduction, can help to protect state employees who are performing their duties on public roadways.

TERMINOLOGY

Several terms used throughout the report require definitions specific to the context of this synthesis study.

- Incident: Any disruption in the normal flow of work involving a highway worker employed by a state DOT in a construction or maintenance site that involves an injury, fatality, property loss, damaged equipment, work stoppage, or near miss (Hinze 2006).

- Accident: An unplanned event that may or may not be associated with property damage, an injury, or a fatality (Hinze 2006). This term is not used in this report unless it appears in a quotation from a source or the literature reviewed specifically uses the word in its terminology. The word "incident" is used throughout this report to ensure clarity of meaning.
- Crash: A specific type of incident involving a public vehicle. This term is not used in this report unless the literature reviewed or data analyzed specifically used this term for the incident that occurred.
- Work site: Any location where construction or maintenance work is being done on state DOT right-of-way.
- Work zone: A particular type of work site, generally in place for extended periods with established traffic control. The term appears in this report when the literature reviewed or the data analyzed specifically used the term. Otherwise, the more general term of "work site," which includes a broader range of maintenance activities, is used.
- Near miss (near hit): An incident involving a highway worker employed by a state DOT in a construction or maintenance work site that did not result in an injury or fatality to the worker.
- Highway worker: An employee of a state DOT who is active in construction or maintenance work sites on state DOT right-of-way. Many of these workers are on foot within the work site. For the purpose of this synthesis, the definition does not include employees of consultants and contractors working on state-owned projects. Although this definition focuses on state DOT employees, local agency employees who are active in construction or maintenance work sites may experience work conditions similar to those of state employees, so the presented concepts and ideas related to highway workers in this report may be of value to local agencies.
- Industry/Construction industry/Maintenance industry: When the term "industry" appears in the report, unless otherwise stated, it is in reference to the broader construction and maintenance industry. It is not limited to construction or maintenance in highway work sites.
- Survey: The full process of developing, distributing, collecting, and analyzing data from targeted participants at state DOTs.
- Questionnaire: This term, which is commonly used in conjunction with the survey (e.g., survey questionnaire), refers to the data collection instrument containing the questions that were electronically distributed to the state DOTs to collect data regarding state DOT health and safety policies and practices.
- Participant: Any state DOT safety representative who was provided access to the survey questionnaire.
- Respondent: A participant in the survey process who completed the questionnaire regarding his or her state DOT's health and safety policies and practices.

The definitions of these terms, which are used in various chapters in this report, are necessary to convey the authors' intentions accurately and limit misinterpretation.

STUDY APPROACH

Four primary tasks were conducted for this synthesis report: literature review, survey, injury data analysis, and follow-up interviews. The four tasks were conducted in an order that ensured tasks that would benefit from information gathered in previous tasks would be executed in the proper order.

As the most time intensive task, the survey was one of the initial tasks undertaken. This task is also central to meeting the objective of a synthesis study. A survey questionnaire was created and after several revisions placed in an online format to collect responses easily. The survey questionnaire was distributed to a list of state DOT safety officers and employees. The list was provided by the North American Association of Transportation Safety and Health Officials (NAATSHO) through the NCHRP Review Panel established for the synthesis study. The goal was to achieve an 80% response rate from state DOTs (40 of 50). After several weeks, the goal was met, and 41 state DOT responses were recorded. Chapter three contains a detailed description of the methodology involved in the development and distribution of the survey questionnaire. After the survey data were collected, they were analyzed, and relevant visualizations were generated.

While the questionnaire was actively being distributed to state DOTs, the process of reviewing existing literature related to highway worker safety was continued. Two primary categories of literature

were considered and included in the review as appropriate background information for understanding current highway worker safety practice. The two categories were chosen to reflect the duality of safety challenges that are present in highway work sites. Highway work sites are unique in that they maintain all of the hazards of traditional construction and maintenance operation sites but are also associated with the added risk of roadway vehicles traveling through the work site. The two categories are:

- Research concerning primarily the safety issues related to the presence of public vehicles within highway work sites. These issues are those that are unique to highway construction and maintenance sites, such as the behavior of vehicles in a work site and the prevalence of incidents involving highway workers and public automobiles.
- The safety-related hazards, issues, and research for the construction and maintenance industry as a whole. The sources reviewed for this category applied to all work within work sites, which includes highway work sites. The focus of this category of research was safety issues that occur within the construction and maintenance areas of work sites, regardless of the presence of public vehicles. In addition, this category included documents that describe standard worker safety programs in the construction and maintenance industry and ways in which organizations can enhance the safety of their employees.

While the literature review was conducted, an analysis of publicly available data sets relating to highway worker safety also was being done. The data sets explored were determined in the scoping phase of the synthesis study. The seven data sets were:

- Bureau of Labor Statistics (BLS),
- Occupational Safety and Health Administration (OSHA),
- National Institute for Occupational Safety and Health (NIOSH),
- National Council of Compensation Insurance (NCCI),
- Fatality Analysis Reporting System (FARS),
- Strategic Highway Research Program (SHRP 2), and
- State DOT data.

The researchers determined that no easily accessible, publicly available data could be obtained from the NCCI database. Therefore, the data set was not included as a data source in the injury data analysis. The other six data sources were analyzed. The primary objective of the task was to gain an understanding of the types of data that are available in each of the sources. The researchers performed example analyses on the data sets to demonstrate the range and limitations of the each of the individual data sets.

After the survey responses were collected, they were searched for evidence of noteworthy safety program elements. The goal for determining these noteworthy elements was to follow up with the state DOTs about the programs and develop case examples that explored in detail the aspects of each of the safety programs. This exploration focused on the existing use of data in state DOT safety programs. One of the survey questions asked the respondents if they would be willing to participate in a short follow-up interview. Among the respondents who indicated they would participate in an interview, several state agencies were identified that showed the potential for providing a useful case example. The personnel in these states were contacted, and a short phone interview was scheduled. A protocol for the interviews was developed; the interview included questions that sought to determine the characteristics and history of the safety program and how data were used in the program implementation.

After the interviews were completed, the recorded interviews were transcribed to facilitate accurate documentation of the case examples. Information and documents provided by the interviewees during and after the interviews were included in the case example write-ups to describe more fully the safety program elements.

The following section describes how the various tasks were organized into the synthesis report.

REPORT ORGANIZATION

Based on the four primary tasks identified in the study approach, the report is organized into four sections that coincide with each of these tasks. The four main sections of the report are as follows:

- Chapter two—Issues in Highway Worker Safety. This chapter is based on the literature review and provides a brief overview of issues and research related to highway worker safety.
- Chapter three—Agency Practices and Perspectives on Highway Worker Safety. This chapter is based on the survey results and describes basic characteristics of the current practice of health and safety programs in state DOTs. The chapter focuses on elements of the health and safety programs that relate to state employees who are at highway work sites.
- Chapter four—Injury Data Analysis. Several publicly available databases of information relating to highway and worker incidents are available for reference. This chapter explores the general contents of these databases and their potential applications and limitations.
- Chapter five—State Department of Transportation Case Examples. To highlight specific practices identified in the previous chapters, this chapter provides detailed findings on safety programs that have been implemented in six state DOTs. The data were collected from follow-up interviews. The cases studies analyze how data are used in the development and implementation of the specific safety program elements.

Chapter six presents a summary of the key findings of the synthesis study. Appendices containing documents such as the survey questionnaire and the interview protocol guide are included at the end of the report.

CHAPTER TWO

ISSUES IN HIGHWAY WORKER SAFETY

INTRODUCTION

This chapter provides a review of the overarching issues related to highway worker safety. The information serves as background knowledge for the concepts and terminology presented in subsequent chapters and understanding the knowledge and concerns associated with worker safety that are required to develop effective highway worker safety management programs. The following sections are based primarily on a review of the literature regarding the topics of worker safety and work site safety in the United States. Focusing on the United States gives the information more relevancy to state DOTs that are subject to the same federal guidelines, such as OSHA or their OSHA-approved State Plan alternatives. Particular emphasis is placed on the following content areas:

- Prevalence and causality of injury and fatality incidents for highway workers,
- Availability of highway worker safety data,
- Existing legal standards and policy recommendations related to highway workers,
- Risk and human factors,
- Stakeholders in highway worker safety, and
- Evaluation of safety programs.

These content areas highlight contemporary safety issues associated with highway workers and expose how the issues are being addressed through research and practice and by national and state government policy. Subsequent chapters review existing programs and conditions to explore further the available data and current practices in state DOTs and attempt to determine the consequences of current practices.

PREVALENCE AND CAUSALITY OF HIGHWAY WORKER INCIDENCES

One of the most efficient ways to improve safety programs and reduce highway worker injuries and fatalities is to understand the causes and frequency of incidents associated with highway workers. Highway work sites potentially pose significant risk to motorists and workers; if the risks are not effectively controlled, injuries and fatalities for motorists and workers can result. Research has been conducted regarding specific types of work site incidents, comparing work site incidents to nonwork site incidents, and possible methods for eliminating or reducing incidents that lead to injuries and fatalities.

Some state agencies have also performed research to explore the causes and characteristics of work site crashes within their state. One study investigated crashes that occurred in Kansas work zones to better understand the characteristics of the crashes (Li and Bai 2007). The characteristics included demographic data, such as age and gender, and characteristics relating to the incident, such as day of the week and environmental factors. The researchers compared these characteristics between fatal and nonfatal work zone incidents. The researchers sought to determine the characteristics that may be linked to severity. The researchers argued that this comparison could provide improved guidance regarding how and where crash reduction strategies could be implemented to maximize their effect (Li and Bai 2007).

A 2009 study involving states from the Smart Work Zone Deployment Initiative (SWZDI) sought to determine the characteristics of work zone crashes in Iowa, Kansas, Missouri, Nebraska, and Wisconsin (Dissanayake and Akepati 2009). These characteristics included incident frequency infor-

mation based on light and weather conditions, as well as frequency information based on speed, driver behavior, and traffic control factors. The report presents the similarities and differences between work zone incidents in the five states. For these states, only slight differences between the incident characteristics were found (Dissanayake and Akepati 2009). This result is possible because all of these states are located in the Midwest region of the United States and are likely to have similar driver demographics, roadway conditions, and physical geography.

An Indiana DOT report (Ferreira-Diaz et al. 2009) identified two leading causes of worker fatalities in work zones. The first is workers being struck by passing motorists, and the second is workers being struck by moving equipment within the work zone. The study determined that the causes of these types of incidents primarily were the result of "negligence of a third party" and "lack of awareness from the injured worker" (Ferreira-Diaz et al. 2009). Causes of work zone incidents are varied; however, high-risk objects, such as fast-moving vehicles and large pieces of equipment, present the greatest risk to highway workers. Lack of awareness by the injured worker is perhaps a cause that can be effectively mitigated through a highway worker safety program that includes worker training, internal traffic control plans, a focus on worker behavior, and improving safety culture.

Although highway work sites are a specific and unique form of construction and maintenance sites, they retain many characteristics of other construction and maintenance sites. Therefore, it is also necessary to understand the prevalence and causality of incidents in all places where construction and maintenance work are performed. In his dissertation, Hallowell (2008) summarized construction and maintenance incident causation and analytic models for those incidents. He described five models of incident causation complexity, including the distractions theory, goals-freedom-alertness theory, adjustment stress theory, two-factor theory (unsafe acts and unsafe conditions), and the Swiss cheese model of incident causation. However, Hallowell also indicated that safety program elements that are physically implemented in organizations and work sites often lack connections to specific models of incident causation. That is, to be effective, it is important that safety programs take into consideration the established models of incident causation and target eliminating those behaviors, conditions, and operations that are shown to lead to incidents. Lacking such a connection, a safety program will not necessarily lead to improved safety.

The Construction Chart Book, published by The Center for Construction Research and Training, is a synthesis of data relating to all aspects of the construction and maintenance industry (CPWR 2013). It provides visual representations of construction industry statistics and simple, easy-to-comprehend descriptions of industry data. In this format, the data are summarized and presented in figures and tables. Figures 1 and 2 are example figures taken directly from *The Construction Chart Book* and show how injuries and fatalities are distributed by cause in the construction industry.

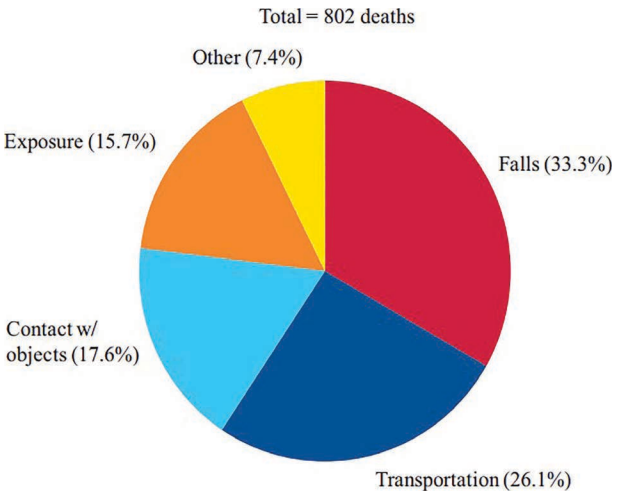

FIGURE 1 Distribution of leading causes of fatalities in construction in 2010. *Source*: CPWR 2013.

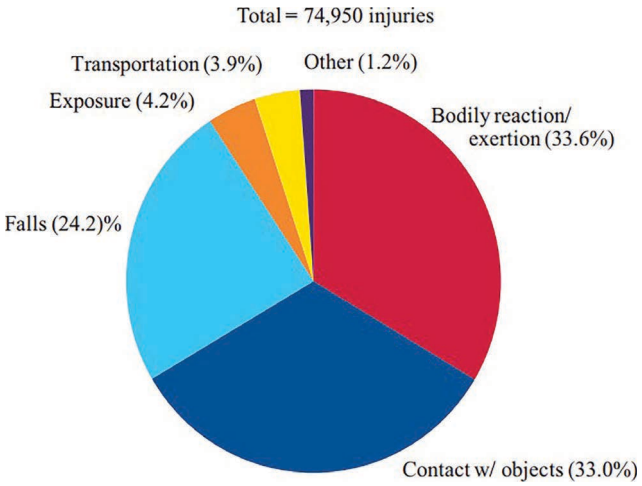

FIGURE 2 Distribution of leading causes of nonfatal injuries resulting in days away from work in construction in 2010.
Source: CPWR 2013.

These two figures provide a robust summary of construction incident causes. The data used for these figures relates to the construction industry as a whole and does not specifically target highway workers. *The Construction Chart Book* is one of the most comprehensive repositories of safety and other statistics in the construction industry.

AVAILABILITY OF HIGHWAY WORKER SAFETY DATA

Better understanding of the prevalence and causes of injury and fatality incidents for highway workers is possible through evaluation of data available to help quantify such incidents. This section explores the different sets of publicly available data and the background research that has used or sought to improve the data sets. The publicly available data sets are explored in greater depth for the specific information they provide to highway worker safety in chapter four. The data sets include those from the following entities:

- Bureau of Labor Statistics (BLS),
- Occupational Safety and Health Administration (OSHA),
- National Institute for Occupational Safety and Health (NIOSH),
- Fatality Analysis Reporting System (FARS),
- Strategic Highway Research Program (SHRP 2), and
- State DOT data.

These data sources publicly available databases report raw data. Chapter four explores the uses for these databases. This section explores the six databases and other published data sources that synthesize data related to highway worker safety.

BLS and OSHA are both divisions of the Department of Labor (DOL). BLS is responsible for collecting information on worker incidents through the agency's Injuries, Illnesses, and Fatalities (IIF) program. This information is published on the BLS website and is searchable by industry, allowing the identification of incidents that occurred in highway work sites (BLS 2016). OSHA also reports Investigation Summaries for fatalities and catastrophes that occur in the workplace. (Note: OSHA defines a catastrophe as a workplace incident that results in the overnight hospitalization of one employee.) These summaries are searchable by industry and key word in the online database (OSHA 2016). Hinze et al. (1998) highlighted the lack of specificity in root causes of construction and maintenance injuries and demonstrated that by increasing the detail of the database, the search results of relevant incidents would be more comprehensive. Since the publication of that journal article, OSHA has increased the specificity of crash causes in the database, particularly with detailed key words. Although the

ability to search specifics has been improved, it is still difficult to aggregate and quantify the records in OSHA's online database.

NIOSH, a division of the Centers for Disease Control and Prevention (CDC), researches specific workplace incidents and compiles the resulting reports within its Fatality Assessment and Control Evaluation (FACE) program. The reports are detailed and provide a description of the incident. Some of the reports are specifically related to fatality incidents in highway work sites (NIOSH 2016).

The FARS database, which is maintained by NHTSA, documents all fatal crashes on public roadways. The details of the incident that are recorded in the police report are collected and placed into the FARS database (NHTSA 2016). Over the years, the police crash reports have been inconsistent on how they document fatal crashes that occur in work zones. Because FARS is based on these police crash reports, the database coding has some different searchable factors over time. In 2004, a study published in the *Transportation Research Record* explored individual state reports and how the states quantified work zone incidents (Ullman and Scriba 2004). The study concluded that the database at the time might have been underreporting work zone crash fatalities by as much as 10% based on the variations in forms used between states (Ullman and Scriba 2004). The FARS database does not allow the user to select "work zone" as a filter for records dated before 2009. This limitation may be the result of the discrepancies found in the reporting of work zone incidents identified in the 2004 report (NHTSA 2016).

The Strategic Highway Research Program 2 (SHRP 2), which began in 2006 and ended in 2015, was a broad program to uncover data-driven solutions to transportation challenges (NAS 2016). One element of the SHRP 2 program was the Naturalistic Driving Study (NDS), which focused on improving highway safety. The project was administered by the National Academy of Sciences (NAS) and TRB and resulted in a database that, to different extents, can be used by researchers to better understand real-world driver behavior and analyze traffic incidents (Campbell 2012). Contractors for the study were the Virginia Tech Transportation Institute (VTTI), which collected the NDS data, and Iowa State Center for Transportation Research and Education, which collected the roadway information data. This research is ongoing but maintains an online database with some of the data collected to date.

State DOTs also maintain their own internal databases of traffic and worker incidents within their states. Each of these databases is different based on the type and volume of data the state chooses to collect and archive. Therefore, the detail and availability of the data from the state archives vary.

The Construction Chart Book presents data in the form of charts, figures, and graphs. Although this publication presents analyses of the entire construction industry, some visuals specifically relate to highway construction and maintenance (CPWR 2013). Figure 3 is an example directly from *The Construction Chart Book* that makes specific references to highway construction.

Figure 3 is representative of the type of data available in *The Construction Chart Book.* Although the data are more useful in determining overall trends and characteristics of the construction industry, select tables and figures provide insight into the nationwide highway construction and maintenance industry.

Another resource, "Safety Management in the Construction Industry" (McGraw Hill Construction 2013), attempts to quantify the existence and characteristics of safety policies and programs in the construction and maintenance industry. This resource also focuses on the types of safety practices that are in use, the impact of those safety practices, influence factors, and communication and education. All of these sections provide the reader with visual representations of the practices and how the practices affect (positively and negatively) the construction and maintenance industry. The data are particularly useful in that they show the frequency at which construction and maintenance firms use different programs and education methods (McGraw Hill Construction 2013).

The National Safety Council (NSC) publishes *Injury Facts,* an annual synthesis of injury statistics in the United States and around the world (NSC 2016). The content is not limited to any one industry

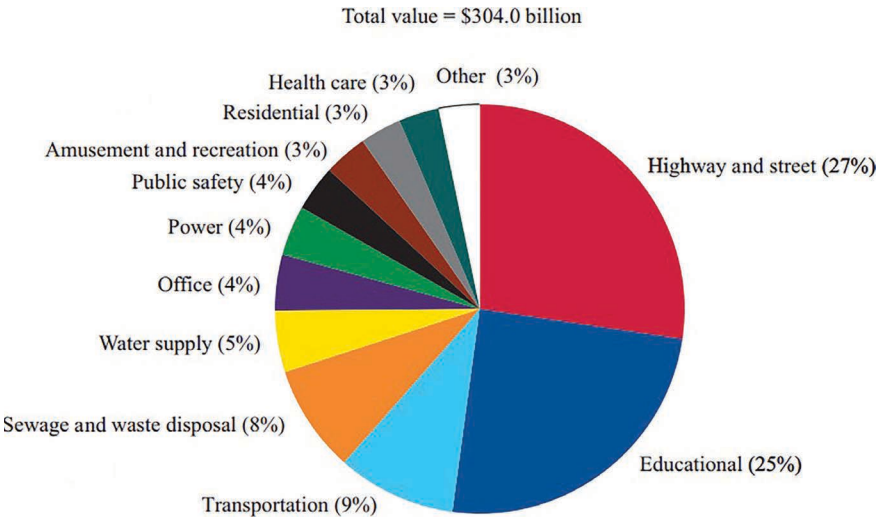

FIGURE 3 Share of dollar value of public sector construction, by type, in 2010.
Source: CPWR 2013.

or occupation. The statistics include a broad exploration of fatalities and injuries that occur from unintentional and intentional (homicide/suicide) incidents in the United States and, to a lesser degree of accuracy, the world. Subsequent sections of the publication divide nationwide statistics into categories, such as occupational, motor vehicle, and home and community incidents. The occupational category of injury and fatality incident statistics pertains most directly to highway workers because their occupation places them at risk of injury or death while on the job.

The 2016 edition of the NSC's *Injury Facts* section on occupational injuries and fatalities is general in its presentation of available statistics, so it is impossible to isolate specific statistics related to highway workers. However, some of the general information can provide context in the form of potential trends in occupational incidents related to highway workers who are employed by state DOTs. Using data from 2013, the NSC reports more than 1.1 million injuries and illnesses that resulted in time away from work that year. Of these, approximately 65,000 (6%) were state government employees. This is not limited to state DOTs and includes all agencies within state government. Approximately 190,000 of the national lost-time injuries and illnesses were recorded for local government employees; the remainder was for private industry employees (NSC 2016).

The NSC publication also provides general information on the estimated economic cost of occupational incidents. In addition to worker's compensation insurance, these costs include loss of productivity and administration expenses. In 2014, the NSC estimated that the cost of each death is approximately $1 million. For every medically consulted occupational injury, the average total cost is $29,000. In addition to the monetary cost, the NSC recorded the lost time. In 2014 in the United States, among all industries, the total time lost was 99 million days, with 65 million of those days lost because of work-related injuries (NSC 2016).

Other statistics, such as injury types and causes, are included in the NSC *Injury Facts.* However, the data categories most closely matching highway workers are the construction industry and government employees (NSC 2016). Neither of these provides enough detail to observe the unique risks and incidents associated with highway construction and maintenance workers.

Although the data sources mentioned are national databases or publications and are publicly available, individual states also maintain in-state records and data for the safety records for their individual agencies. More discussion on state data sources available to individual state DOTs is provided with the survey results in chapter three. States may choose to rely most heavily on their

in-agency data because it is likely the most pertinent to safety successes and issues within their state. However, national data can be used to normalize incident rates and find common areas of concern among different states.

LEGAL STANDARDS AND POLICY RECOMMENDATIONS RELATED TO HIGHWAY WORKERS

Federal agencies have implemented nationwide guidelines to help states improve their safety programs and protect highway workers. One of the most visible documents describing these programs is FHWA's *Work Zone Operations Best Practices Guidebook* (FHWA 2013). This report is published at the national level to assist states and provide guidance on common work zone issues. The best practices identified by this guidebook are categorized into 11 topics and 49 key words to allow users to search the practices by a particular topic.

States have enacted their own policies and guidance for improving safety in highway work sites. Strategic Highway Safety Plans (SHSPs) are a requirement for state DOTs that are a part of the Highway Safety Improvement Program (HSIP). This requirement has continued under the Fixing America's Surface Transportation (FAST) Act (FHWA 2016c). These programs direct the decision making of state DOTs based on the governing federal policies. Some of the state SHSPs that specifically outline priorities in work sites are summarized here.

- Illinois's SHSP notes that a particular issue in the state's work zones are incidents located on the Interstate system that involve heavy vehicles. The strategies for improving work zone safety involve the three Es: engineering, enforcement, and education. The report specifically identifies that Illinois work zone speed laws are weak and do not allow for adequate enforcement (Illinois Department of Transportation 2009).
- Massachusetts's SHSP focuses on the lack of ability to quantify nonfatal incidents in highway work zones. The report indicates options to improve safety that are being explored. In addition, it outlines strategies for improving work zone design and educating the public about safety in work zones (Massachusetts Department of Transportation 2013).
- Minnesota's SHSP presents detailed statistics for incidents that occurred in work zones. The data include types of incidents and the demographics of those involved in the incidents. The report specifically recognizes that, for Minnesota, there is an overrepresentation of commercial vehicles involved in work zone incidents and indicates this is a safety focus area for the state (Minnesota Department of Transportation 2014).
- South Carolina's SHSP identifies that the state has been seeing an increase in work zone fatal and severe injury collisions. The report identifies strategies to meet an objective of preventing a continued increase in work zone-related collisions; the state saw such an increase between 2008 and 2012. Some of the strategies include improved law enforcement and first responder training relating to work zones (South Carolina Department of Transportation 2015).
- Washington's work zone safety issues are handled by the state's Work Zone Safety Task Force (WZSTF). The SHSP outlines specific strategies of the WZSTF that focus on the visibility of workers and work zones. The report also states a WZSTF priority of maintaining worker training and improving public notification of work zones (Washington State Department of Transportation 2013).

State and federal policies drive decision making in terms of protecting highway workers and preventing incidents. These policies vary in effectiveness based on how they are communicated and how they are implemented. In addition, the policies need to be accepted as effective for improving safety to ensure continued compliance with the policies among state DOTs.

In addition to legal policies produced by state and federal government agencies, the construction and maintenance industry makes recommendations on programs and policies that have demonstrated the potential to improve safety. The following literature is a collection of documents describing research conducted for the construction and maintenance industry as a whole, elements of which can be directly applicable to highway work sites.

Construction and maintenance industrywide guidelines are available that provide broad recommendations to improve safety. One example is "Guide to Best Practice for Safer Construction: Principles," a nationwide guideline for Australia. The text presents six principles the authors think are important to fostering a healthy safety culture on a work site. These principles are (Fleming et al. 2007):

- Demonstrate safety leadership,
- Promote design for safety,
- Communicate safety information,
- Manage safety risks,
- Continuously improve safety performance, and
- Entrench safety practices.

These principles are described and promoted similarly in other publications on safety culture in the construction and maintenance industry. Although this document is not detailed and provides only general recommendations that accompany each principles, it is good source for the understanding of the different aspects of a safety program. In addition, because this document is an Australian publication, it can give safety officials in the United States a new perspective on safety programs.

As innovative safety initiatives are adopted by industry, it is important that research be produced to discuss and analyze such initiatives for the implementation of these program elements. Instituting safety programs that rely on leading indicators is becoming more accepted and more common in the construction and maintenance industry. Leading indicators represent the conditions and behaviors exhibited in a workplace that provide an indication of the level of safety performance. In contrast, lagging indicators (e.g., injury incidence rates) provide a retrospective assessment of safety performance. Monitoring leading indicators may be new to some state agencies. When a concept is in its infancy, it is more likely to be implemented incorrectly. To counter this possibility, the Construction Industry Institute (CII 2012) published a report that outlines a nine-step process for implementing active leading indicator safety ideas. Figure 4, which was provided in CII's report, explains the process

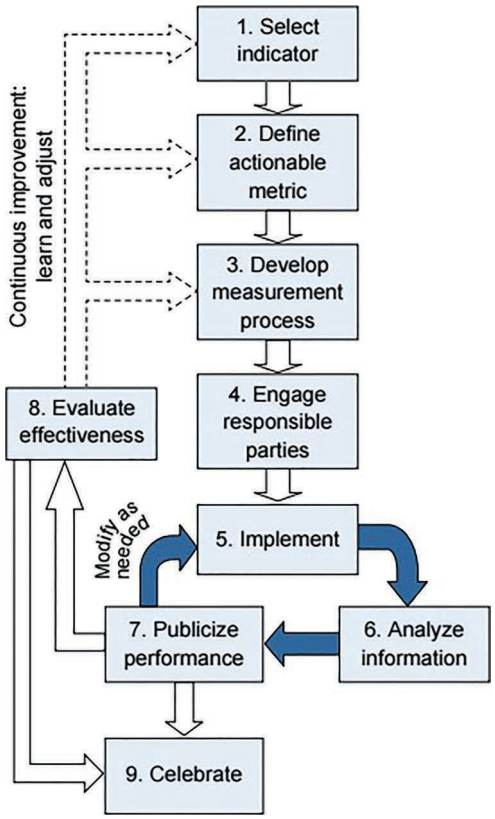

FIGURE 4 Flowchart for implementing active leading indicator initiative. *Source*: CII 2012.

in the form of a flowchart. The entire process is based on the idea of improvements and adjustments being made as necessary throughout the course of implementation.

Another initiative in the construction and maintenance industry is the "zero injury objective," whereby no incidents and therefore no recordable injuries occur on construction and maintenance sites. This objective is similar to the Toward Zero Deaths (TZD) vision the FHWA, state DOTs, and municipalities are currently championing. This is related primarily to the elimination of transportation user fatalities, as opposed to those of workers, but all are included (FHWA 2016d). According to FHWA, the TZD vision "uses a data-driven, interdisciplinary approach that FHWA has been promoting for many years. The TZD approach targets areas for improvement and employs proven countermeasures, integrating application of education, enforcement, engineering, and emergency medical and trauma services" (FHWA 2016d).

A report by Hinze and Wilson (2000) examines the progress in the construction and maintenance industry after the zero injury objective gained traction. The authors indicate that safety programs are becoming more common and more effective. Because safety programs are becoming more common, the next logical progression is evaluating the existing programs and making improvements.

In some cases, large private construction and maintenance companies draft their own safety programs and policies that are applied on all of their projects. This requirement adds consistency to the safety regimens from project to project, with the intention of improving institutional safety.

One such company is the Howard S. Wright Construction Co. (HSWCC). The companywide safety guide includes directives for administration officials and detailed requirements for workers in many common work scenarios; the directives concern issues such as personal protective equipment, fall protection, tools, heavy machinery, and specialty machinery (HSWCC n.d.). Another company with a comprehensive safety plan is Skanska. Skanska's guidelines include policies for common scenarios, and provisions for subcontractors and various emergency situations, such as natural disasters or terrorist activity (Skanska 2005).

Whether the safety measure is a federal, state, or company guideline or policy, it is important that workers follow it during the course of the work. Maintaining consistent safety programs that are easily understood by workers at highway work sites results in safer work sites for workers and motorists.

RISK AND HUMAN FACTORS

At any work site, there is a degree of risk to the safety of the workers. Understanding this risk and the hazards that create the risk is vital to protecting highway workers to the greatest degree possible. Some of the risk results from the inherent qualities of the work itself, including the geographic features of the work site. Risk of injury and fatality is also the result of human factors and human error on the part of the worker or motorists traveling within highway work sites.

Early investigations into work-related incidents were aimed at quantifying the extent to which human behavior contributes to injury incidents and revealed behavior to be a significant factor. For example, in an analysis of injury incidents, Heinrich (1959) found that 88% of incidents were caused by unsafe acts of persons (Heinrich 1959; Johnson 2011; Manuele 2011). Heinrich (1950) proposed that management personnel in an organization have the best opportunity and ability to initiate the work of prevention, so management assumes the responsibility. Contemporary literature strongly supports this axiom of management involvement and suggests examining the entire organizational and industry spectra to understand fully the causes of injuries and how to prevent them (Rasmussen et al. 1994; Suraji et al. 2001; Haslam et al. 2005; Gibb et al. 2014).

The roadway type also contributes to risk for workers near the roadside. The diversity of the structure of state DOTs means that, depending on which agency employs the worker, the worker could be exposed to different functional roadway classifications, each associated with a different level of exposure and risk. Many state DOTs construct and maintain primary routes, which generally have

higher speeds. The severity of crashes has been shown to increase as the speed of passing traffic increases (Aarts and van Schagen 2006). Therefore, the risk for employees is higher on routes that the state DOTs are more likely to construct and maintain.

According to this literature, to be effective the prevention measures implemented by an organization must address human factors at their foundational level and apply prevention measures at all levels in an organization. The facets of basic human behavior that exist as root causes of incidents include mistake/error, absent-mindedness, lack of caring/indifference, ignorance, poor risk management, and high-risk tolerance. These behaviors can exist anywhere within an organization and be the cause of an injury incident. For example, a worker at the front line may poorly assess the risk present in a situation and cause an injury incident. In addition, a decision made with indifference at a management level may cause a worker on the site to act in a certain way that leads to an injury. The cause in this case is the result of management's indifference and is not associated with the worker. The literature argues that safety management programs be designed to address all of these unsafe human behaviors and eliminate such behaviors at all levels within an organization.

With regard to worker injuries from crashes, multiple risk factors, including at-fault driver, environmental condition, crash information, road condition, driver error, and others, have been identified (Li and Bai 2009). The researchers determined how these risk factors affected the severity of work zone crashes in Kansas. Statistical analyses were used to determine which factors were significant, such as driver error, vehicle type, light conditions, age, and gender. The researchers concluded that additional efforts to improve compliance with existing work zone traffic laws could reduce driver risk. In another study, McAvoy et al. (2011) identified risk factors, which included roadway type, traffic density, and work zone type. The researchers used their risk factors to test the performance of alternative work zone configurations in a driving simulator environment.

The human factors literature related to crashes in work zones primarily concerns the behavior of motorists operating within work sites. In their respective studies, Reyes and Khan (2008) and Morgan et al. (2010) performed tests in a driving simulator to evaluate alternative work zone configurations. Driving simulation provides a safe medium for evaluating driver behavior in work zones. Reyes and Khan performed a study of how drivers changed their behavior based on the presence of different types of barriers that separated the travel way from the work zone, among other variables. One of the other variables, the level of activity in the work zone, influenced the speed of the drivers, with the average speed being lower for work zones with higher activity levels. Morgan et al. tested a lane reduction work zone with a reduced taper length. The study concluded that although the reduced taper width slightly reduced risk because of the shorter work zone, the overall risk to the motorists and workers increased because of the reduced taper. Other research has provided evidence of additional positive impact on safety risk and driver behavior from the use of temporary traffic control devices in work zones, including portable changeable message signs, radar speed trailers, and advisory speed signs (e.g., Zhang et al. 2014; Gambatese and Zhang 2016). Safety risk for highway workers is directly related to human factors, so understanding these factors and the types of hazards they create in work sites is important.

Hazards related to construction and maintenance operations and the behaviors of construction and maintenance workers themselves affect the safety of highway workers. One aspect of human behavior consists of risk taking. Some humans are more willing to exhibit risky behaviors than are others. In a 1991 study, evidence suggested that humans who are more prone to incidents are more likely to be risk takers (Dahlbäck 1991). Understanding the workforce at the construction and maintenance site and the level of risk the workers will accept may be an indicator of the severity and frequency of incidents on such a site.

One method for potentially reducing risk and taking advantage of natural human behavior is to incentivize safe practices. In a section of the CII's 2003 report "Safety Plus: Making Zero Accidents a Reality," the authors indicated that incentives (recognition and reward) for safe behavior are a common strategy in the construction and maintenance industry. The report concluded that although incentives may be effective if applied correctly, the progressive incentive (reward based on injury-free work hours) in particular was not shown to promote improved safety in the long run (CII 2003a).

In 2014, Gambatese reported that safety incentives in the workplace can have a positive effect on safety. However, the effect has not always been quantifiably proven, and many factors, such as the manner, type, and frequency of the incentive, can significantly influence the effectiveness of the incentive (Gambatese 2014). OSHA has indicated that safety incentive programs may result in employees being discouraged from reporting incidents in which injuries occur, particularly if the incentive is high (Fairfax 2012).

Safety culture is a more abstract concept but affects the risk workers are exposed to based on a collective awareness among a group or organization. Formal and informal policies, workplace norms and conditions, ethnic makeup, and social interactions, all of which collectively make up workplace culture, affect safety performance. The safest organizations understand that a positive safety culture can make a difference not only in worker safety performance but also in overall project performance. Although safety culture is a topic that has been identified as a factor influencing safety performance (Molenaar et al. 2009; Zou 2011; Gilkey et al. 2012), the specific attributes that make up safety culture, the magnitude in which these attributes affect safety culture, and the impact of safety culture on worker behavior and overall safety performance require in-depth study, confirmation, and quantitative measurement.

As the construction and maintenance industry continues to look for ways to improve safety performance, safety culture, with its effect on worker behavior, has been identified as having an impact (Molenaar et al. 2009; Gilkey et al. 2012; Zou 2011). The development of a positive safety culture has been identified as a means for affecting worker behavior to improve safety performance. Many definitions of safety culture have been developed. For example, in the National Occupational Research Agenda (NORA), safety culture is defined as the "organizational principles, norms, commitments, and values that relate to how safety and health is operationalized" (NORA 2008). Cultures are patterns of interacting elements and represent the accumulated learning of a group—the ways of thinking, feeling, and perceiving the world that have made the group successful (Schein 1999). Although establishing a positive culture in an organization is desirable, measuring an organization's culture is difficult, especially in the construction industry. Determining an organization's culture requires examining deeply held personal beliefs in connection with and in response to organizational principles and values. Approaches to measuring organizational culture have been developed, but there is no consensus regarding the most effective approach (for example, see Cameron and Quinn 1999; Schein 1999; Hofstede and Hofstede 2005). Additional difficulty in measuring culture exists in the construction and maintenance industry because of its fragmentation and project-centered focus. Culture becomes multifaceted with multiple cultures forming around different groups composed of individuals with commonalities (Sackman 1997). Cultures may also form at different levels (subcultures): for example, crew, project, organization, and industry (Schein 2004). NORA (2008) defines two levels of safety culture within an organization: top management and supervisor/subunit. Cultures formed around each project site are particularly influential because individuals assess a site culture quickly and intuitively (Hartley and Cheyne 2009).

The strength of safety culture is determined by group stability and shared history (Schein 2004). For the construction and maintenance industry, the short-term nature of construction projects, multiple work partners, and high frequency of change in employment make developing and maintaining a positive safety culture problematic. Given the dynamic nature of the partnerships and conditions on construction projects, Maloney (2003) highlights the need for research that investigates culture formation amid a changing environment.

Beyond the presence of a positive safety culture, an employee's interpretation of the safety culture and subsequent actions (behaviors) are important considerations when attempting to optimize safety performance. Worker response/behavior is reflected in the worker's recognition of safety hazards, comprehension of the implications of the hazards, valuation of the associated risk, selection of an appropriate control, decision to implement a control, and the quality and extent of control implementation. In their study of the creation of an impression of safety culture on construction sites, Hartley and Cheyne (2010) examine the connection between safety culture and worker behavior. The researchers found that construction sites and site personnel create an impression of safety culture, which is quickly assessed by new workers as they enter the site, and that this initial assessment influences their behavior. To ensure safe behavior, a positive safety culture was recommended to be

established and in place at the start of a project and maintained constantly. The study was conducted using a small sample of management personnel surveys and two focus group interviews of construction workers. Cautioning that discrepancies may exist between managers' beliefs about the behavioral consequences of interpreting safety culture on sites and the beliefs of the workers themselves, the authors recommended additional investigation; the type required would target workers and confirm that their actions coincide with their beliefs about the impacts of safety culture.

Current construction and maintenance safety research suggests a need to explore the interaction between employee interpretation/response and the safety culture in which the employee works. That is, a shift in thinking is needed to focus on the actions that lead to good safety performance by measuring employees' perceptions of the way safety is in operation on construction sites (i.e., the safety culture) (Choudhry et al. 2009). Safety culture is one part of comprehensive safety management, which also includes consideration of work operations, work site conditions, a dynamic work site, and worker behavior and risk tolerance within a safety management system.

Understanding the risks associated with construction, maintenance, and highway work sites and how motorists and workers respond in this environment can be useful in designing more effective work sites that better protect the employees and the public. Also important is having an understanding of worker behavior and how safety performance is influenced by behaviors to design effective highway worker safety management programs.

STAKEHOLDERS IN HIGHWAY WORKER SAFETY

The literature reveals that many different stakeholders have the potential to positively influence highway worker incidents that occur at work sites. These stakeholders are vital and, whether they realize it or not, have a significant impact on the safety of highway workers. In the construction and maintenance industry, the most frequently considered stakeholders are the owners, contractors, and workers. Other stakeholders interested in highway worker safety include insurance companies and transportation professionals.

The Indiana DOT's report *Worker Injury Prevention Strategies* specifically discusses the owner, contractor, and worker stakeholders for safety in work zones. This study revealed that all three groups have similar views about work zone realities, such as traffic in the work zone posing a high risk to workers. However, these three stakeholders have differing ideas of the effectiveness of prevention measures, such as law enforcement and efforts to improve safety. The study found that the workers, who are directly exposed to the hazards in work zones, were the least satisfied with safety efforts (Ferreira-Diaz et al. 2009). These results demonstrate the competing interests of stakeholders and indicate that workers believe they have the highest risk among all of the stakeholders.

The NCHRP report *Training and Certification of Highway Maintenance Workers* fundamentally acknowledges that state DOTs and workers are vital stakeholders in highway worker safety. According to the report, state DOTs understand the need for maintenance workers to understand the aspects of their maintenance job and the need for training in proper safety techniques. Many states incentivize their maintenance workers to partake in safety training (Laffey and Zimmerman 2015).

The project owner, which in the case of many highway construction and maintenance projects is the state DOT, can have a significant influence on the safety of the project based primarily on actions taken during the beginning stages of the project. A study by the CII looked specifically at ways that owners can have a role in construction and maintenance worker safety. Some of the findings included practical methods that reduce worker risk. These methods include the following (CII 2003b):

- Selecting contractors based on known safety records,
- Emphasizing safety requirements in project contracts,
- The owners being actively involved in safety throughout the project duration, and
- Selecting projects that incorporate characteristics such as design-build delivery methods and a 5-day or less work week.

Some of these methods are not as applicable to state DOTs that may use their own employees for a project or have little choice in the contractor that wins a project. However, an understanding that the owner's role in safety for all projects begins long before construction or maintenance starts and continues until construction or maintenance ends is important to reducing risks to workers throughout the duration of the project.

There also is significant literature regarding insurance companies as a vital stakeholder in the construction and maintenance industry. Insurance companies are incentivized to influence design to improve safety. In the report *Cost of Highway Work Zone Injuries,* the authors quantify the monetary costs associated with incidents in highway work zones (Mohan and Gautam 2000). This research was conducted when it was determined that highway work zone fatalities were not decreasing as were the overall construction and maintenance industry fatality rate and highway transportation fatality rate. The authors determined an average monetary value for different types of incidents that could occur in work zones, focusing on the costs associated with motorists who are involved in crashes in work zones (Mohan and Gautam 2000). Another study looked at the idea of prevention through design (PtD) from an insurance perspective. This historical look at PtD discusses how the cost of construction and maintenance incidents encourages insurance companies to be influential in the design of safety programs and practices to minimize costs in terms of money and human life (Braun 2008).

In the textbook *Construction Safety Management and Engineering,* two chapters specifically address the injury costs and the role of insurance in the construction and maintenance industry. The first chapter (Hill 2014) breaks down the worker compensation system that pays for construction and maintenance worker injuries. Hill (2014) argues that, to be successful, a safety administrator must understand the financial aspects of the system and the practical measures of reducing incidents. The second chapter (Ennis 2014) explains the construction and maintenance insurance industry. Although workers' compensation insurance is a portion of the insurance portfolio, Ennis explains that there are many other types of construction and maintenance insurance. A complete insurance portfolio is likely to include coverage for the workers, such as medical and disability benefits, as well as coverage for the project itself. This coverage can include commercial auto liability, commercial general liability, pollution liability, and insurance to cover the structures and equipment used in the project (Ennis 2014). These sources indicate that it is important to use economic data in the development and evaluation of safety programs. In 2012, Ikpe et al. proposed that there is a positive relationship between prevention costs and subsequent benefits. The report also suggested that there is an inverse relationship between incident costs and prevention costs. Although the figures differ based on the size of the construction firm, the benefits of incident prevention outweigh the economic and direct costs by an average of 3 to 1 (Ikpe et al. 2012). Looking at the raw economic costs of incidents could help to bolster the argument for a particular safety program at a state DOT.

Insurance companies recognize the institutional benefit of promoting safety in the workplace. Liberty Mutual, an insurance company that is involved with business insurance, published its "The Architecture of Safety Excellence" model. This initiative, designed to bring attention to all aspects of workplace safety, highlights four cornerstones of the risk management process. These cornerstones are as follows (Liberty Mutual Insurance 2003):

- Risk Assessment—identify and measure the existing levels of risk present in the workplace.
- System Analysis—determine if the system, for all parties involved, is working well.
- Integrated Solutions—three solutions, including implementing design solutions, adding education programs, and enhancing motivation, must be combined to improve the system
- Progress Measurement—determine if the programs put in place have had a positive impact on safety.

Insurance companies recognizing themselves as a stakeholder is an important step, but other stakeholders (i.e., construction and maintenance companies, owners, workers, etc.) regarding insurance companies as a legitimate stakeholder is more critical. Doing so not only protects human life but also reduces the costs related to highway construction and maintenance.

In a report on the OSHA standards that are important to professional engineers, Toole and Gambatese (2002) propose that in the construction and maintenance field, professional engineers are another stakeholder in worker safety through their designs. By understanding OSHA safety standards and accounting for them in construction and maintenance designs, professional engineers have the capacity to help reduce work site (including highway work zone) incidents (Gambatese et al. 2003). This concept is often referred to as designing for safety (DfS) or PtD. In the construction industry, safety on the construction site traditionally has been assigned to be the responsibility of the constructor. This responsibility reflects the constructor's control over the project site, workers, and work practices and procedures. However, engineers who design the project features can proactively play a role in site safety because their designs influence the hazards to which workers are exposed (Churcher and Alwani-Starr 1996; Smallwood 1996; Haslam et al. 2003; Driscoll et al. 2004; Gibb et al. 2004; Behm 2004, 2005; Gambatese et al. 2008). The basis for designer involvement is the OSH principle that the most effective and reliable means for ensuring worker safety is to eliminate safety hazards from the work site before workers are present. Designing to eliminate a hazard can be more effective than controlling the hazard or protecting the workers from the hazard (Manuele 2013).

Designing for safety is founded on the hierarchy of controls, which provides guidance on safety and health problem solving (Andres 2002; Manuele 2013). In order of decreasing effectiveness, the hierarchy is as follows: elimination, substitution, engineering control, administrative control, behavior, and personal protective equipment (PPE). If the hazards cannot be eliminated, controls lower in the hierarchy may be suitable with appropriate consideration given to the corresponding lower levels of reliability and effectiveness. When determining how to mitigate safety risk during construction and maintenance operations, eliminating hazards should be the first choice, according to the DfS concept. Designing for safety is one of the foremost methods for eliminating hazards and reducing risk regardless of work industry. By waiting to apply safety controls during construction and maintenance operations, frequently the most effective approach available is to warn workers of hazards, implement procedures, train employees, and provide personal protective equipment.

Research has uncovered examples of designing for safety in practice within the transportation industry and identified recommended DfS processes (Gambatese et al. 1997). A simple example is to design locations on roadway shoulders for construction and maintenance vehicles to park where they are protected from oncoming traffic. These parking spots could be adjacent to roadway lighting at locations where maintenance work is periodically needed to replace lamps. Another example is to design bridge guardrails such that they meet the guardrail height requirements set by OSHA for exposed edges (42 in. ± 3 in.). Permanent guardrails at this height provide protection for bridge users during construction and maintenance operations and eliminate the need for those conducting construction and maintenance work to install a temporary guardrail.

Processes have been developed to efficiently implement the DfS concept in the project development process (e.g., WorkCover 2001; Angelo 2004; Istephan 2004; Hecker et al. 2005; Weinstein et al. 2005; Toole and Gambatese 2011). In one example, Bovis Lend Lease (BLL), an international design and construction company, established and implemented the program ROAD—Risk and Opportunity at Design (Zou et al. 2008). ROAD aims to eliminate or minimize the risks of injury throughout the life of the product being designed by involving all decision makers who contribute to the life cycle of the product (ASCC 2006). ROAD incorporates the following key elements and considerations: person with control, product life cycle, systematic risk management, safe design knowledge and capability, and information transfer. BLL implements the ROAD process through the following nine steps (BLL 2004; Zou et al. 2008):

1. Building element assessment at the preconstruction phase.
2. Providing trade package assessment at the construction stage.
3. Recording the ROAD document and uploading it into the project management plan.
4. Including a ROAD agenda item on design program meetings.
5. Establishing action and status lists.
6. Updating and reporting status at each design review.
7. Considering actions from ROAD issues before approval for construction.

8. Holding environment, health, safety, and quality monthly management meetings to review the reporting of projects including the ROAD status.
9. Having a monthly update of the ROAD document as part of the project review.

Behm, in conjunction with Toole and Gambatese, further explored the DfS concept. Behm argues that, in a process known as design for construction safety and health, risk to workers and hazards on the construction site can be reduced or eliminated during the design process. In addition to safety, this process can increase overall project quality and cost effectiveness. However, Behm concedes that there are barriers to implementing this practice, including contractual, legal, and regulatory issues. These barriers arise from design for construction safety and health being less common in the United States than elsewhere, such as Europe and Australia (Behm et al. 2014).

Additional research has revealed other barriers, such as a lack of designer training with respect to safety, a fear of third-party liability for worker injuries, additional costs associated with implementing design for safety practices, and difficulty in identifying hazards before the start of the work on site (Hinze and Wiegand 1992; Gambatese et al. 2005; Hecker et al. 2005; Toole 2005; Gambatese 2008). Despite these barriers, professional engineers can still influence safety on construction sites (including highway work zones) through their designs, and designing for safety has been identified as a viable intervention in the construction industry (Gambatese et al. 2005).

Designing for safety is currently not a common intervention in the construction industry. However, as designing for safety diffuses throughout the industry, industry reactions and changes are expected. Toole (2001) showed how the characteristics of a construction task, process, and industry have caused innovative building products to follow one or more trajectories. The concept of trajectories can also be applied to the implementation of DfS. Toole and Gambatese (2008) identified four specific trajectories that PtD is likely to follow: (1) increased prefabrication; (2) increased use of less hazardous materials and systems; (3) increased application of construction engineering; and (4) increased spatial investigation and consideration. Owner organizations, including state DOTs, have been identified as key stakeholders and drivers of designing for safety on work sites (Toole et al. 2016).

Designing for safety is just one element that may be included in a state DOT's safety program. Although each stakeholder has a different interest in designing for safety, and highway worker safety as a whole, the collective group has the capacity to affect safety in work zones through cooperative action and mutual understanding. It is also clear from safety and health research in the construction industry that the top management within an organization is in a position to positively affect safety performance.

In addition to the stakeholders mentioned, many other groups have a role in highway worker safety. These include local agencies that often work closely with state DOTs for large projects. Other organizations, such as emergency medical services, law enforcement, state legislators, and public health officials, can have an impact on worker safety, particularly in setting policy and responding to incidents. Professional groups such as ASCE, ITE, and the Association of General Contractors also can contribute to worker safety programs at state DOTs to keep workers and the traveling public safe. All of these stakeholders have the opportunity to collaborate and combine their efforts to advance the state of the practice in highway worker safety.

MAINTENANCE WORKER ISSUES

As state DOT budgets tighten, the traditional focus on infrastructure development has transitioned to one with a greater priority given to maintenance of existing roadways rather than new construction. Maintenance on roadways presents different challenges and risks to the traveling public and state DOT employees performing maintenance work. In general, maintenance work is more frequently performed on roadways with higher demand, meaning vehicle-worker conflicts may be more prevalent. In addition, the temporary nature of maintenance work may limit the protections and visibility afforded to construction workers in more established work zones. These differences can result in greater levels of risk to highway workers.

FHWA recognizes this difference and the subsequent importance of highlighting unique maintenance worker safety issues. In a 2014 brief, FHWA indicated that workers establishing a maintenance work site can best identify the individual safety concerns of that particular site. The brief describes many low-cost mitigations that can be incorporated into a maintenance site based on the safety deficiencies identified by workers. These include solutions from signage and pavement markings to the physical road surface and roadside itself (FHWA 2014).

The *NCHRP Report 500* series is a 23-volume collection of reports that provide guidance for implementing AASHTO's Strategic Highway Safety Plan. Volume 17 of the series, *A Guide for Reducing Work Zone Collisions,* documents that, although maintenance work zones are generally in place for a short time, 8% of fatal work zone crashes in 2003 occurred in maintenance zones (Antonucci et al. 2005).

A 1998 report published in the *Transportation Research Record* describes the desired role of maintenance as an element of an overall infrastructure development program. The report argues that, to promote the safety of motorists and workers in maintenance sites, maintenance managers should be committed to continuing education so that they understand and implement the latest technology and policy initiatives to promote maintenance site safety (Byrd 1998).

NCHRP Report 475, which outlines options for planning nighttime highway construction and maintenance, acknowledges that it is desirable for many maintenance activities to be completed without restricting the full volume of the roadway. One approach to meeting this desire is to conduct nighttime maintenance work when road volumes are much lower, and some of the risks associated with daytime are reduced. However, nighttime work introduces alternative risks, such as reduced visibility and an increased incidence of drivers who are less alert and more likely to be impaired. The report presents potential strategies, such as increased traffic control, for minimizing the risks for nighttime maintenance work (Bryden and Mace 2002).

Another source for information relating to maintenance work site issues is the National Work Zone Safety Information Clearinghouse. This information repository is a resource for any stakeholder seeking to improve work zone safety for everyone who interacts with a work site, including highway workers (Clearinghouse 2015). One of the elements of the National Work Zone Safety Information Clearinghouse is a searchable database of publications related to work site safety available on their website (www.workzonesafety.org). This database, when filtered for publications relating to maintenance, provides several specific reports relating to maintenance worker safety (Clearinghouse 2015).

One of the resources from this database is the "Maintenance Work Zone Safety" pocket guide. This document, which provides excerpts from the MUTCD on temporary traffic control, is to be used in the field by maintenance workers to make their work sites as safe as possible. Because most maintenance operations are short term, this guide focuses on the short-term traffic control requirements presented in the MUTCD. It provides seven core principles of temporary traffic control that for incorporating into maintenance sites. These principles are as follows (American Traffic Safety Services Association 2008):

1. Plan for traffic safety.
2. Minimize interference with vehicular, bicycle, and pedestrian traffic flow.
3. Provide clear and positive guidance on how to get through the temporary traffic control zone.
4. Perform continuous inspection and maintenance of temporary traffic control zone devices.
5. Maintain roadside safety throughout the project.
6. Make sure workers receive the training that is required.
7. Maintain good public relations.

Another study, conducted at the University of Kentucky, sought to identify best safety practices for highway maintenance workers. A survey that solicited ideas from public and private maintenance workers in Kentucky was conducted to determine what practices could be implemented to improve their safety. Some of the recommendations from the report included closed cab tractors for mowers on the roadside, LED stop signs in maintenance sites, and additional lighting in nighttime conditions (Hancher et al. 2007).

The literature presented in this section highlights some of the unique safety issues that maintenance workers encounter on roadways as opposed to construction workers in more established work sites. These safety issues demonstrate the potential for high-risk exposure for maintenance workers. Therefore, the literature suggests, maintenance worker issues require particular attention, and state DOT safety plans should consider maintenance workers as a special element of their overall safety programs.

EVALUATION OF SAFETY PROGRAMS

To keep improving worker safety and determine if improvements are necessary to the existing policies and programs, it is necessary to evaluate the existing effectiveness of these policies and programs. Literature exists that relates to evaluating a state's record in highway work sites and to barriers to reducing work site incidents.

In one study, Minnesota DOT sought to determine, through a simulator study, the safety impacts of the potential implementation of automated speed enforcement (ASE) systems in work zones. The researchers, understanding that speed and distraction are key issues in worker safety incidents, found the ASE system did not significantly affect driver behavior. However, when the ASE system was combined with a dynamic speed display sign, there was improved driver attention, especially among younger and older drivers (Morris et al. 2016).

Virginia DOT (VDOT), which historically has used injury and fatality statistics to evaluate work zone performance, published a report outlining potential improvements in the evaluation system of work zones. Using a state-level database that contains information on weather and work zones and combining that information with raw incident statistics, VDOT established a rate measure to normalize the incident statistics based on the frequency of road construction and maintenance. This rate allows VDOT to better evaluate trends in work zone performance based on other factors (Kweon et al. 2016).

There are also barriers to the implementation of safety programs. A 2014 report from the Missouri DOT (MoDOT) observed survey response data suggesting that although MoDOT employees thought work zone setups accurately conveyed the hazards to the public, motorists more often perceived that the warning systems were inaccurate or did not provide enough information. Barriers such as driver education and lack of worker compliance with work zone requirements limit the effectiveness of the safety measures placed into the design of work zones (Long et al. 2014). Evaluating safety programs is critical to determining their effectiveness and identifying key areas of success that can be expanded and replicated.

A comprehensive NCHRP report outlines ways in which work zone data are collected and how the data are used to evaluate and assess the performance of work zones (Bourne et al. 2010). The report finds that safety programs are established at the state agency level and are based on federal guidance. Detailed programs that recognize and use available data are more likely to consider the effectiveness of work zone safety features during the entire design, construction, and maintenance process. This effectiveness includes the ability to use data to adjust the work zone safety features throughout the process as needed (Bourne et al. 2010). This document highlights how accurately evaluating work zone and highway worker safety programs is a necessary step in improving overall safety.

The literature cited earlier examines how the transportation engineering field evaluates safety programs in work sites and how the construction and maintenance industry explores the effectiveness of safety practices from the viewpoint of the organization, worker, and work site. In their report in *The American Professional Constructor,* Berryman et al. identified the five main factors that negatively influence safety programs (Berryman et al. 2006):

- Inadequate employee involvement,
- Lack of upper management enforcement,

- Inadequate monitoring and training,
- Improper means to measure safety performance, and
- Ineffective incentive programs.

These factors were determined through a literature search and could be used as metrics for determining if a program's structure has the potential to improve safety.

The use of leading indicators in construction and maintenance safety programs is becoming more widely used in the United States, including for highway work sites. However, it is important to be able to evaluate the effectiveness of programs that use leading indicators. A 2012 report from the CII identifies methods for evaluating safety performance in leading indicator programs. The report poses that the identification and measurement of leading indicators is critical to reaching the goal of zero work site incidents. This includes analysis of active (visible during the duration of the project) and passive (visible before construction or maintenance) leading indicators (CII 2012). It is also important to verify that collected leading indicators are correlated to incidents and properly mapped to lagging indicators. The evaluation of programs is critical because having an ineffective safety program can have high human and monetary costs.

CONCLUSIONS

This chapter has reviewed existing literature regarding current issues in highway worker safety. The collective research on the topic indicates that highway worker safety is a significant concern. Much of the literature discusses the issues related to vehicles and their effect on safety in work sites. A significant amount of research regarding the hazards of work sites from the perspective of the highway workers also exists that does not pertain to public vehicle crashes. All of this research, combined with the available data sources, provides a summary picture of current issues in highway worker safety.

The research included in this chapter has identified several elements that can be effective aspects of an agency's highway worker safety program. One of these elements is the option for the program to consider literature and data analysis practices from the traffic engineering and construction and maintenance engineering fields. Exploring recent trends in each of these fields can lead to a more comprehensive understanding of the unique challenges in highway work sites.

Data regarding highway work sites are collected at the federal and state levels. For state DOTs to be able to implement effective safety programs, it is beneficial to understand the data available so they can be analyzed in some of the ways the research described in this chapter has done. The data can be combined with knowledge of risk and human factors that are intrinsic to highway work sites. This additional knowledge can include driver behavior and worker behavior at the work sites.

In addition, the research has shown that identifying all of the stakeholders, including the owners, workers, and insurance companies, can better allow the natural efforts of these groups to improve safety to achieve a more efficient and effective product. Designers also play a key role in ensuring that designs minimize risk for workers who are constructing and maintaining state DOT infrastructure. Finally, evaluating existing programs and continually updating them as trends and data change can ensure the continued effectiveness of program elements.

CHAPTER THREE

AGENCY PRACTICES AND PERSPECTIVES ON HIGHWAY WORKER SAFETY

INTRODUCTION

In the United States, the primary highway system owners are state DOTs, and they maintain significant autonomy and authority in this function. Their involvement and influence extend beyond the physical roadways, which the state DOTs design, construct, operate, and maintain, to other aspects of transportation system ownership. Because constructing and maintaining these facilities predominantly require personnel to be located in potentially hazardous work sites close to active travel ways, state DOTs have a fiduciary and moral responsibility to promote the safety of their workers performing tasks within these work sites.

Although all state DOTs generally have the same role and responsibility of managing their state highway systems, each state has a unique structure for its safety program. States usually are responsible for the construction and maintenance of primary routes, but some state DOTs have a more supervisory role; others have a more involved role, even on local and county roads. Because factors such as size, geography, weather, and agency organization and purview vary widely from state to state, there is not a one-size-fits-all approach when it comes to safety programs. This chapter describes the safety program elements currently included in state DOT safety programs. The elements described provide examples that other state DOTs may elect to include in their safety programs. However, it is not the goal of this chapter to construct a "template" for a successful safety program that can be used by all of the states.

The goal of this chapter is to examine how safety programs are developed and operate in the state DOTs. Particular emphasis is placed on how incident and safety data are acquired, managed, and used. The chapter highlights sources of data that are more readily available, as well as data that may not be as available nationally. It is beneficial to understand in greater detail how agencies use the data for their safety programs.

It is hoped this chapter will provide a national overview of safety programs in a predominantly quantitative format so that the practices and trends can be visualized in figures and tables. Additional exploration of specific safety programs by state DOTs that have the potential to be transferred and implemented in other states is included in chapter five.

The primary mechanism to achieve these goals was a survey questionnaire developed and distributed to state DOTs. The methodology section of this chapter outlines the process for conducting the survey and the procedure for gathering responses. This chapter is organized according to the same outline as the questionnaire and contains the following sections:

- Methodology,
- Demographics,
- Incident reporting,
- Data collection, and
- Data utilization.

The five sections of the questionnaire and this chapter have two purposes. The first is to create a logical format and progression of items within the questionnaire document that are easily comprehended

by survey participants. The second is to have effective questions that solicit the following information about state DOT safety programs and practices:

- Data sources that are available to state DOTs, how the sources are archived, and their robustness;
- How data are analyzed and used by the state DOTs;
- Policies and practices that have been implemented to mitigate highway worker safety risk; and
- Agency perspectives on safety policies and practices.

The survey questions were not limited to understanding the state DOT practices. A subsequent chapter explores concepts beyond these points. However, the focus of the survey questions was improved understanding of national trends related to these aspects of state DOT policies and practices. The acquisition of information directly from state DOT employees allowed for the collection of firsthand information about safety programs from individuals who regularly work with such programs and are invested in their successful implementation. However, this also resulted in the possibility of data about safety programs being based on estimates or personal impressions by one or more state DOT employees.

METHODOLOGY

The goal of the survey was to obtain useful and detailed information about the safety programs currently in place within state DOTs across the United States. A critical consideration in conducting the survey was to balance the ability to obtain the desired information with keeping the questionnaire short and simple enough to navigate and understand to achieve a high response rate from state DOT safety offices. For the data gathered from the survey to be useful in summarizing national trends, a target response rate of 80% (40 of 50) of the states was established.

The survey questionnaire was drafted and underwent several internal revisions. The final draft of the survey questions was sent to the NCHRP Synthesis Topic 47-16 review panel for feedback. The questionnaire was edited based on the feedback. The survey questions were coded into the Qualtrics online survey software to provide an easy-to-navigate and common interface for the participants in the survey. A link to the Qualtrics-formatted questionnaire was sent to the panel to pilot test the questionnaire to ensure that the question progression logic in the software was programmed correctly. At this point, after the panel's review, the survey questionnaire was ready for nationwide distribution. The complete survey questionnaire that was distributed to the state DOTs is included in Appendix A.

With the assistance of NCHRP personnel, a link to the Qualtrics-formatted questionnaire was distributed to safety representatives in each state DOT. The questionnaire initially was distributed using an e-mail list of the members of the NAATSHO, an organization whose purpose is to communicate and distribute information regarding health and safety policies among state DOTs. The distribution of the results of this synthesis to state DOTs will help to fulfill NAATSHO's organizational objective "to promote and improve the efficiency and effectiveness of the occupational safety and health programs designed for the Highway and/or Transportation Departments in the United States, Canada and Mexico" (NAATSHO 2006). NAATSHO members are volunteers, most of whom are employees in the safety departments of state DOTs. For some states, the NAATSHO e-mail list contained multiple employees in the state. For these cases, e-mails were sent to all of the employees in the state on the list. As a result, e-mails containing the link to the survey questionnaire were sent to 63 NAATSHO members. In the initial distribution, two e-mails were returned as undeliverable.

After the initial e-mail and a reminder e-mail from NCHRP, the total number of survey responses received was between 15 and 20. More reminder e-mails were sent over the course of 2 weeks, and the total survey responses increased to approximately 30. To increase the survey representation to achieve the 80% response rate target, follow-up phone calls were conducted with and e-mails sent to NAATSHO members. In addition, colleagues at state DOTs who had not yet responded were contacted to find appropriate safety personnel who would be willing to take the survey. After 2 weeks of these approaches, the survey response target (at least 40 of the 50 states) was met. In total, 41 (82%) states had a representative respond to the survey questionnaire. This number of responses exceeded the initial goal of 40 (80%) states.

To preserve the anonymity of the respondents, the states, and the state safety programs, no state is specifically identified with a response unless permission has been granted by a representative of that state DOT. States may be identified as part of broad national regions. It is not the purpose of this chapter to identify specific state programs but instead observe general trends common to state DOTs across the nation.

State DOT size is a characteristic that can meaningfully differentiate states. To preserve the anonymity of the states and still provide general trends based on the characteristic of state DOT size, a categorical scheme was established. FHWA reported 2013 state DOT disbursements (total expenditures of each state DOT in 2013), and this measure was selected as a reasonable proxy for state DOT size. The following four ranges of disbursements were defined (FHWA 2013b):

- Less than $1 billion in disbursements,
- $1 to $2 billion in disbursements,
- $2 to $4 billion in disbursements, and
- Greater than $4 billion in disbursements.

These four ranges were selected to have an approximately equal number of states per category. Several of the questionnaire responses were sorted by these categories. These are included in the tables in Appendix B. In those tables, each code (e.g., A1, B3, C5, etc.) corresponds to a state. The "A" states are in the less than $1 billion in disbursement category and randomly sorted within the category. This method was used for the other categories as well. These categories allow trends between state sizes to be highlighted without compromising the anonymity of the questionnaire respondents. Some of the qualitative responses in Appendix B were edited to preserve state anonymity.

DEMOGRAPHICS

The questionnaire's first section asked the respondents basic demographic questions regarding their role in worker safety and general information about their agency. This information is important to understanding the background, experience, and job roles of the individuals completing the survey questionnaire. In addition, because all state DOTs are structured and function differently, it was necessary to try to quantify the diversity among the states.

The questions relating to the state DOT representative responding to the survey questionnaire included requesting his or her job title and the number of years worked with the current agency. Figure 5 shows a distribution of the number of years of experience of the respondents. In total, the 41 respondents had a combined 625 years of experience at their current agency, with an average of 15.2 years per respondent and a median of 15 years. The minimum was 1 year, and the maximum was 30 years.

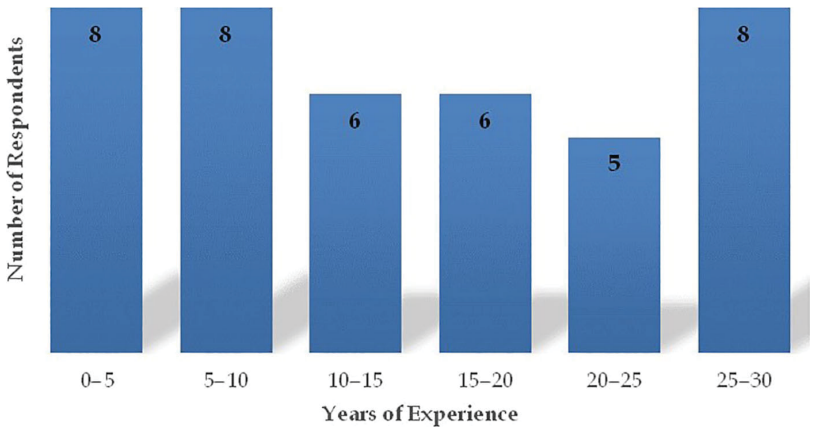

FIGURE 5 Frequency of responses by respondent's years of experience ($n = 41$).

TABLE 1
JOB TITLES OF RESPONDENTS THAT CONTAIN KEY WORDS

Key Word	Number of Titles	Percentage of Titles
Safety	36	88
Risk	5	12
Health	7	17
Manager/Coordinator	17	41
Director/Administrator	9	22

$n = 41$.

The job titles of the respondents varied widely and included such diverse titles as "safety and risk manager," "statewide safety security and emergency coordinator," and "highway safety inspector." Table 1 provides a summary of how frequently various safety and managerial-related words appeared in the respondents' job titles. There will be greater confidence in the survey results if the survey respondents have roles within the state DOT that provide accurate knowledge and perspectives of the state DOT safety programs and give them access to information about safety programs and incident reporting practices. The high frequency of the words in Table 1 serves as partial justification for the validity of the results of the survey.

Many of the job titles include multiple key words listed in Table 1. For example, the job titles "risk management safety officer" and "occupational safety and health training manager" contain three of the words in Table 1. It is not surprising that the word "safety" is well represented in the job titles. Of the 41 state representatives who responded, only five had titles that did not include the word "safety." Of these five, some contain the word "risk" or are generic "program director" or "program administrator" titles.

To demonstrate further that the respondents to the survey are knowledgeable about their state safety programs, the questionnaire asked the respondents how often they "work with worker injury claims and prevention programs." Figure 6 is a histogram distribution showing the frequency that the respondents work with injury claims and prevention programs.

The most striking aspect of Figure 6 is that a majority of the respondents (63%) work with injury claims and prevention programs on a daily basis. As a follow-up question to the frequency that they work with these programs, the respondents were asked to describe their specific role with these programs. The respondent who selected "Very rarely (yearly)" for the frequency question (see Figure 6) followed up that the particular "office oversees the Departments [sic] Safety program, but has no role in processing or overseeing claims." So even respondents who may not work frequently with claims and prevention programs still are invested in some aspect of the safety program in their agency.

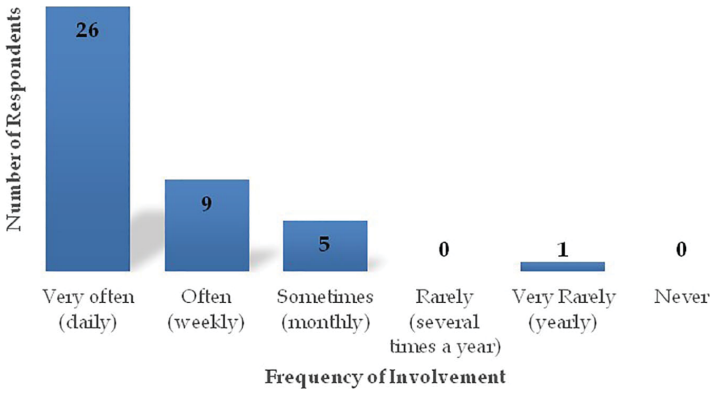

FIGURE 6 Frequency that respondents work with injury claims and prevention programs ($n = 41$).

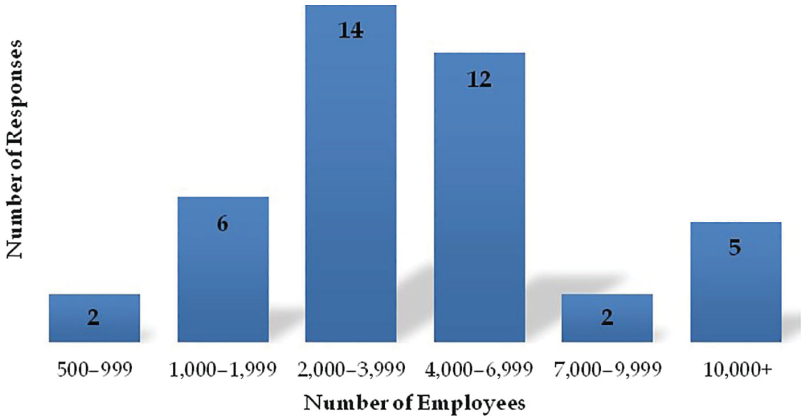

FIGURE 7 Distribution of state DOTs by number of employees ($n = 41$).

In response to the question asking the respondents to describe their role with worker injury claims and prevention programs, two general trends were present across the descriptions. The respondents are managers of these claims and programs. Their roles are to collect the information and manage the claims and programs based on the data collected. The second trend is that many of the respondents also are involved specifically in the implementation of safety programs, particularly the training aspects of the programs.

The other questions in this section of the questionnaire referred to the characteristics of the state DOT that the respondent was representing in the survey response. The questionnaire asked the following two questions regarding the characteristics of the agency:

- What is the approximate size of your agency in total number of employees?
- What is the approximate percentage of your agency's employees who are regularly on construction and/or maintenance sites?

Figures 7 and 8 are histogram distributions presenting the frequency of each response.

These questions aimed to demonstrate not only the diversity of the state DOTs but also the number of workers who are experiencing higher safety risk by spending time in highway work sites as a part of their job. Based on these two questions, a rough estimate of at least 75,600 state employees nationwide are regularly on construction or maintenance sites. This underscores the volume of human life that is at risk of injury in work sites and further justifies the importance of this synthesis report.

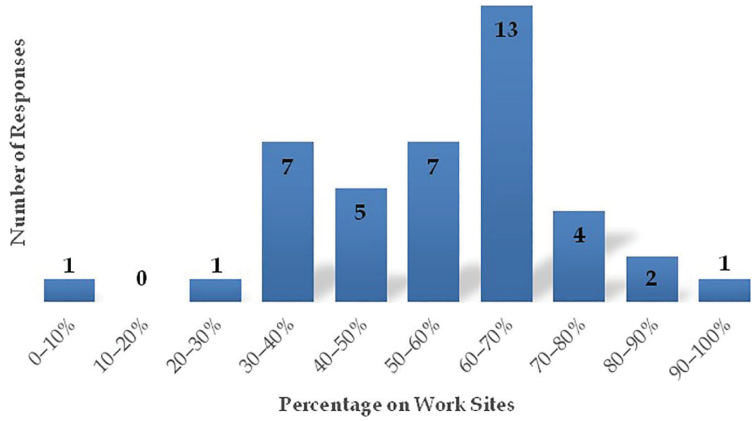

FIGURE 8 Distribution of state DOTs by percentage of employees who are regularly on work sites ($n = 41$).

INCIDENT REPORTING

The second section in the questionnaire related to how the agency responds when injury incidents occur with their employees. The focus of these questions is to get a sense of the national practice among state DOTs for the process followed when an injury incident occurs on a jobsite. The questions specifically relate to the process for reporting and archiving incidents that occur with state highway employees in highway work sites.

Postincident Steps

The first question in this section provided the respondent with a list of potential steps that could be taken by the state DOT after an incident has occurred in a highway work site. These work site incidents were separated into three types:

- Public automobile—incidents involving vehicles owned by the public that enter highway work sites.
- On-site vehicle/equipment—incidents involving vehicles and equipment that are allowed in the highway work site and are typically used to conduct the work.
- On-site hazard—incidents in the highway work site that do not involve a vehicle or equipment.

Figure 9 shows a summary of the frequency of each postincident step for each of the three types of work site incidents as defined by this synthesis report.

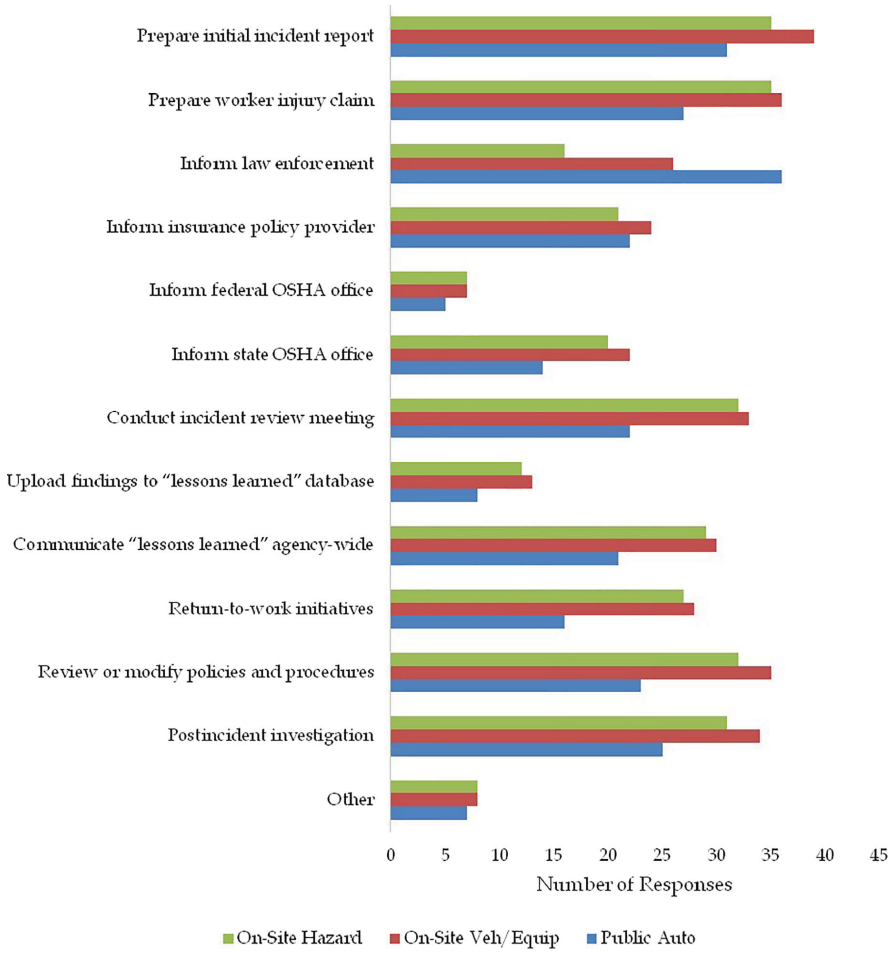

FIGURE 9 Frequency of postincident steps by type of incident ($n = 41$).

As seen in Figure 9, many of the steps listed in the questionnaire are taken by the state DOTs after a work site incident. The figure reveals that the steps have similar clusters around the three types of incidents. Generally, each step received a similar number of responses across the three incident types. This result indicates that the reporting procedures for the state DOTs are similar regardless of the type of incident. The notable exception is the "inform law enforcement" step, which is more frequently taken in public automobile incidents. This step appears far less common after the occurrence of the two other types of incidents. For all the incident types, "Upload findings to 'lessons learned' database" and "Inform federal OSHA" are the least employed of the steps listed.

To gauge the effectiveness of the steps that state DOTs identified, respondents were asked to rate the effectiveness of each step their agency took after an incident at a work site on a roadway. This effectiveness is judged according to how well the step contributes to the success of the agency's safety program. The respondents were asked to rate the effectiveness of each step using a scale of 1 to 5 (1 = not effective, 5 = very effective). The overall average effectiveness rating for the public automobile incident steps and on-site hazard steps was 3.7; for on-site vehicle/equipment incident steps, it was 3.8. Communicating lessons learned agencywide was indicated by the respondents as a "very effective" step across all three of the incident types (average rating = 4.0). The highest average effectiveness rating (4.3) was associated with informing federal OSHA for on-site vehicle/equipment incidents, and the lowest average (2.9) was related to informing law enforcement about incidents resulting from on-site hazards. Tables B1a through B1d in Appendix B present a summary of the average effectiveness of four selected postincident steps according to the self-reported respondent perspectives. These steps include communicating lessons learned agencywide, return to work initiatives, reviewing or modifying policies and procedures, and postincident investigations. Tables B1a through B1d divide responses based on the four disbursement categories and report the average effectiveness based on the categories for the three types of incidents.

Archiving Process

Three questions in this section of the questionnaire related to the state DOT's incident report archiving process. The first of these questions asked which departments at the agency are responsible for compiling and archiving incident reports. Figure 10 shows the frequency with which respondents identified particular departments as having a role in compiling and archiving incident reports. Respondents could select all departments that applied.

As is shown in Figure 10, the safety offices (regional or statewide) are the most frequently cited location for the compiling and archiving of incident reports. Many state DOTs have multiple departments across disciplines contributing to and maintaining the archive of incident reports. Some of the "Other" responses for this question included emergency operations and the claims office.

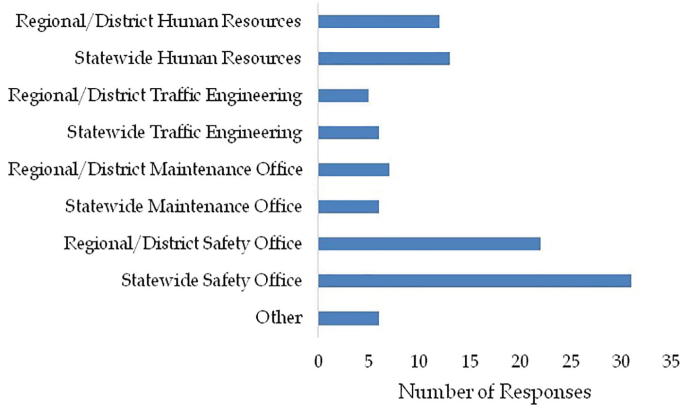

FIGURE 10 Frequency of agency departments that have archive responsibilities.

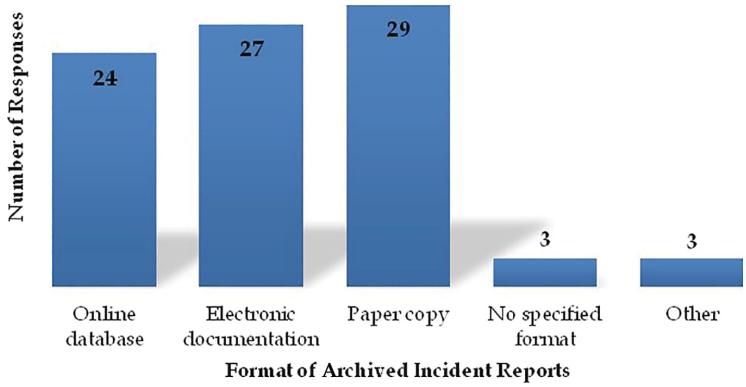

FIGURE 11 Frequency of format of archived incident reports.

The second question asked what format is used to archive incident reports at state DOTs. Figure 11 shows the frequency with which respondents identified particular formats used to maintain the archive of incident reports. Respondents could choose more than one format if their incident reports are archived in multiple ways.

The third question related to archival processes of incident reports asked respondents to identify how incident reports are categorized. Figure 12 presents a summary of the frequency with which respondents cited particular categorization types for the incident reports that state DOTs compile and archive.

It is encouraging that many state DOTs use multiple means of categorization to archive their incident reports. Of the 18 respondents who selected "Other," many indicated their data sources are also categorized by the date on which the incident occurred. Table B1d in Appendix B indicates that the largest states (with disbursements greater than $4 billion) are more likely to have an "Other" type of categorization. In fact, 78% of these states used an "Other" type of categorization, whereas between 30% and 38% of the states with $4 billion or less in disbursements used an "Other" type of categorization for incident reports. Maintaining several methods of categorization can allow the reports to be easily queried to find a specific incident or by using data to implement and evaluate safety initiatives.

Near Miss Reporting

Several of the questions in this section of the questionnaire referred to near miss incidents that occur on work sites. Only 44% (18 of 41) of the respondents indicated their agency has a system in place to report a near miss incident.

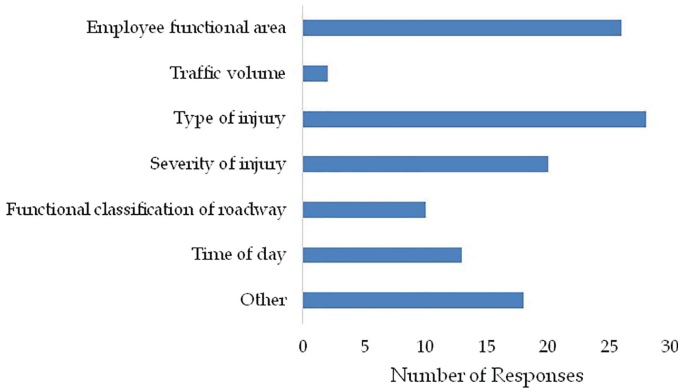

FIGURE 12 Frequency of categorization type for archived incident reports.

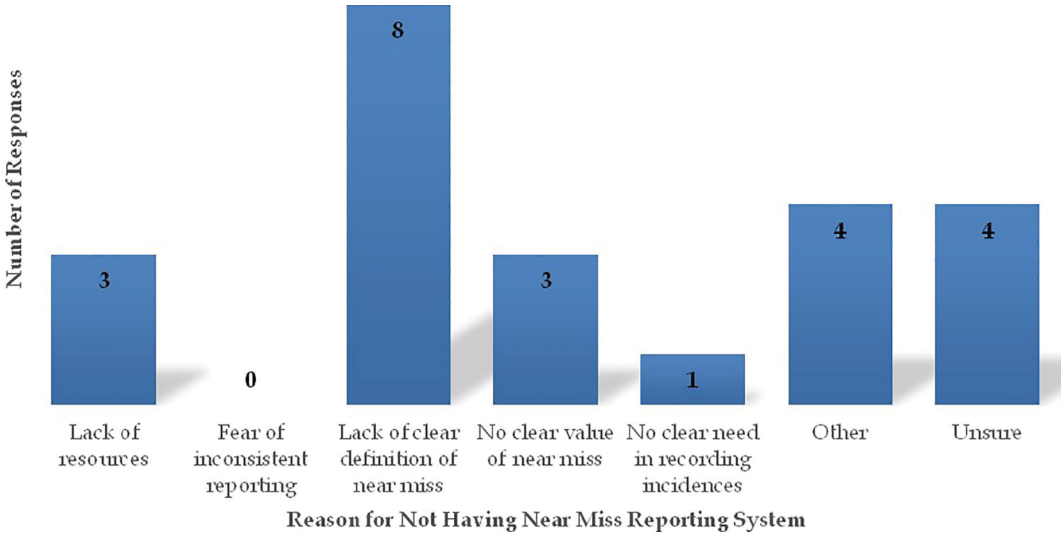

FIGURE 13 Distribution of reasons agencies do not have a near miss reporting system.

Of the 18 states that have a near miss reporting system, nine use the same reporting process for a near miss that is used for other incident types. Among the nine states that have a different reporting process for a near miss, some of the differences included the following:

- Similar forms to actual incidents but less detailed information for near misses,
- Near miss incident reporting is optional, and
- Different administrative communication tracks for near miss incidents.

Descriptions of the near miss reporting processes for states that have them are included in Tables B2a and B2d. One state DOT provided a particularly detailed account of its near miss reporting process. When a near miss incident occurs, the foreman reports the incident to the county manager. This manager reports the event to the state DOT's district safety coordinator, who completes a special notification form and submits it to an employee safety group. This group distributes details of the incident to the executive staff at the agency. This entire process takes only a few hours.

For states that do not have a reporting system for near misses, the questionnaire prompted the respondents to select from a list of choices the reason the agency does not have a near miss reporting system. Figure 13 shows a distribution of the reasons agencies do not have such a system in place.

The primary reason for not having a near miss reporting system was the lack of a clear definition of a near miss. Additional research and education efforts within state DOTs and the construction and maintenance industry more broadly could standardize the definition of a near miss so that the reporting of these incidents can become more common and standardized among state DOTs. A consistent definition of near miss incidents across state agencies could help identify national trends regarding such occurrences. In addition, educating state DOTs about the value in tracking near misses to overall safety performance and the connection of near misses to injury incidents would help promote the implementation of near miss reporting systems.

DATA COLLECTION

The third section of the questionnaire sought to determine the sources of data that are available and used by the state DOTs regarding highway worker safety. The first question in this section asked respondents to indicate if a particular data set is available to their agency. In addition, respondents were asked whether the available data sets are used by their agency. Figure 14 shows, for each of the data sets, how many state DOTs have the data available and how many actually use that data set.

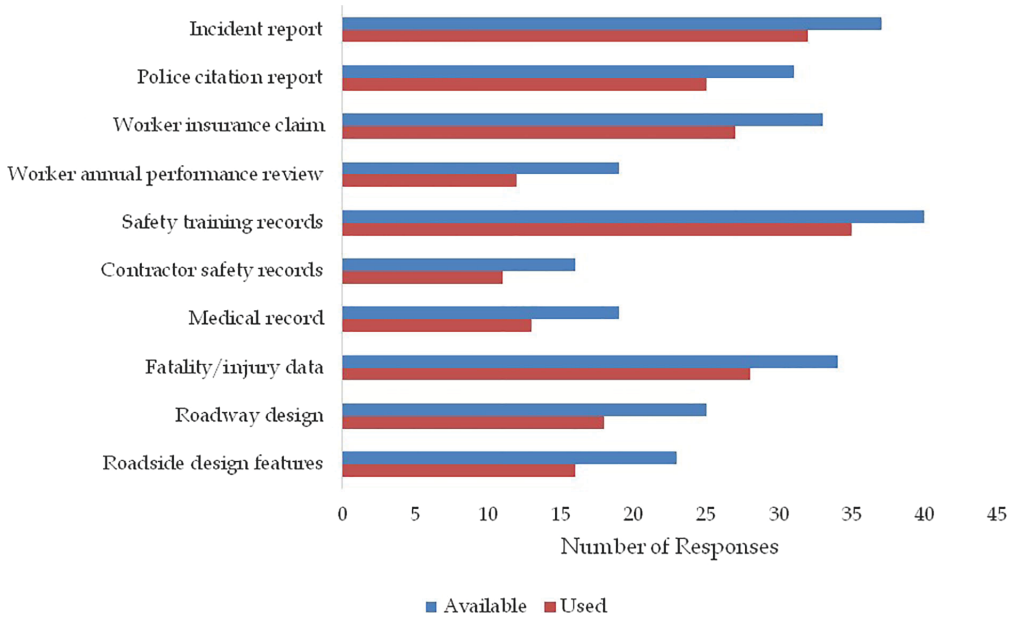

FIGURE 14 Frequency of availability and usage of data sets ($n = 41$).

The results shown in Figure 14 are indicative of how state policies and/or practices might restrict information from safety personnel because of confidentiality concerns. For example, the three data sets with the least availability to the state DOTs are "worker annual performance review," "medical records," and "contractor safety records." In some cases, it is possible that individual employee records (performance or medical) may be protected by state policy and cannot be used in the development of safety programs.

In addition, for each data set, some state DOTs have access to the data but the agencies do not currently make use of that particular data set. According to the survey responses, there were approximately six states with access to any one particular data set that were not using the data. Leveraging all pertinent and readily available data is one approach to improving data-driven safety programs. If pertinent data are being collected and archived, the costs associated with integration into a safety program are measurably reduced.

Respondents were asked, for data that was available or used by their agency, how complete the data are based on a scale of 1 to 5 (1 = very incomplete, 5 = very complete). For details on the results of this question and to see the data categorized by state DOT size, refer to Tables B3a through B3d in Appendix B. Table 2 shows the average completeness rating each data set received.

TABLE 2
AVERAGE COMPLETENESS RATING FOR EACH DATA SET

Data Set	Average Completeness Rating
Incident report	4.0
Police citation report	3.9
Worker insurance claim	4.2
Worker annual performance review	3.7
Safety training records	3.6
Contractor safety records	2.9
Medical record	3.3
Fatality/injury data	4.1
Roadway design	3.9
Roadside design features	3.9

1 = very incomplete; 5 = very complete.

Three of the data sets received an average rating of 4.0 or better in terms of their completeness: "Incident report," "Worker insurance claim," and "Fatality/injury data." These data sets contain some of the core safety documents used for developing safety initiatives, and the documents are likely required by law in their state. Therefore, it is not surprising these data sets received the highest completeness ratings.

The overall average completeness rating for all of the data sets is 3.7. This result is encouraging and indicates that, when the state DOTs have access to a particular data set, the data are reasonably complete and therefore would be beneficial in agency decision making regarding safety programs for workers in work sites.

Another important characteristic of the data sets is the length of time after an incident the data are available for use by the state DOT. The results showed that internal state DOT structure and processing have the greatest impact on the time after an incident that the data becomes available for use. No one data set generally takes more or less time than the others. For example, of the 41 survey responses, 21 state DOTs have access to all of their available data sets within 3 months. In contrast, ten state DOTs must wait more than 1 year to have access to all of their available data sets. This disparity indicates that no single data set takes a certain amount of time to become available. Table B4c provides a summary of the time required for data to be available to state DOTs. This table indicates that the smallest states (those with less than $1 billion in disbursements) may have access to data the soonest. Eighty-four percent of the data available to the smallest states are available within 1 month. No other size group has that level of data availability within that period. Further analyzing the processes of state DOTs that have quick turnarounds with their data sets would be beneficial for states that experience longer latencies between the occurrence of an incident and the availability of data sets.

Having data available to state safety personnel soon after an incident allows the statewide safety strategies to be updated and adjusted based on current trends. These adjustments ensure that safety strategies are based on current trends and thus are most effective at protecting state workers in highway work sites.

The ways in which state DOTs analyze available data to promote highway worker safety are also of interest. Respondents were asked if their agency has conducted "any research or data analysis regarding highway worker safety in work sites on roadways and workers' compensation related to injuries." Only 39% (16 of 41) of respondents stated that their agency conducts this type of research. For agencies that conduct this analysis, the primary method involves examining past incident statistics and other internal reviews of historic data. Some agencies partner with outside organizations, such as FHWA or an in-state university, to perform safety data analysis and research.

Thirteen of the respondents identified data sources not currently available to their agency but that they believe would be beneficial. Some of these desired data sources include data from other state DOTs and other government agencies (federal, municipal, etc.). Other respondents indicated they would like their agency to have more integration of its current databases to more effectively categorize and understand incidences. Tables B5a and B5b in Appendix B list the descriptions of data sources that respondents thought would be beneficial for their state. The following three responses exemplify types of desired data:

- An accident database with information about the types of vehicle crashes with state DOT equipment,
- Information from private road management companies working for the state and from local municipalities, and
- More detailed worker compensation data, including lost and restricted time.

Despite the presence of state DOT research and analysis regarding highway worker safety, it is important to make strides toward equipping state DOTs with the data that can be the most beneficial to state DOT safety programs. In addition, it is vital that state DOTs be able to conduct internal research and partner with research institutions to extract the most value from collected data.

DATA UTILIZATION

The fourth section of the questionnaire continued with querying respondents about data sources available to state DOTs. However, the questions in this section focused on how state DOTs implement data available to them as part of safety policies and practices.

To help determine the frequency that data are used, one question in the survey provided a list of policies and practices that could be developed from the data (either internal or external) and asked the respondents to indicate whether data were used in the development of the policy/practice. Table 3 is a summary of the list of policies and practices presented in the question and the number of respondents who indicated that their state DOT had used data to develop the listed policy or practice. Respondents were able to select all policies/practices that applied.

Additional training options were the most prevalent forms of data-driven implemented practices. For the four respondents who selected "Other," two cited programs relating to PPE. In addition, two respondents indicated that data have made their agency consider a safety incentive program, and one respondent used data to revise existing policies and procedures.

Table B6a separates the responses to this question regarding the use of data to develop programs or policies at state DOTs. For the "Driver awareness programs" and "Drug/Alcohol abuse programs," the smallest states (those with less than $1 billion in disbursements) more than any other group used data to implement such programs. The percentage of implementation was more than 20% higher than the implementation percentages for the two programs from state DOTs with disbursements of $1 billion or more.

Another question asked to what extent the state DOT shares the information it has collected with other organizations. The collection of data can be time consuming and expensive, so the more that existing information is shared, the more efficient and effective other organizations can be in terms of their safety programs. Table 4 presents a summary of the list of organizations presented in the question and the number of respondents who indicated that their state DOT shares data with that organization. The list of organizations was designed to include various levels of government agencies and nongovernmental entities. Respondents were able to select all agencies/organizations that applied.

Sharing data with other state DOTs was the most common response. This response is encouraging because state DOTs have similar roles and needs for similar forms of information. The respondents

TABLE 3
POLICIES/PRACTICES PRESENTED IN QUESTION AND NUMBER OF AGENCIES INDICATING THEY USED DATA TO DEVELOP THE POLICY/PRACTICE

Policy/Practice	Number of Responses	Percentage of Responses
Additional training for workers	37	90
Additional training for supervisors	34	83
New standards for work site traffic control plans	28	68
Driver awareness programs	27	66
Worker behavior assessment programs	13	32
Safety incentive programs	10	24
Drug/alcohol abuse programs	18	44
Other	4	10
None	0	0

$n = 41$.

TABLE 4
ORGANIZATIONS WITH WHICH STATE DOT SHARES DATA

Organization	Number of Responses	Percentage of Responses
Federal agencies	19	46
Other state DOTs	23	56
County/municipal governments	7	17
Private organizations	6	15
Other	10	24
None	9	22

n = 41.

who selected "Other" described an assortment of types of organizations. Some agencies share data with professional organizations, such as the American Traffic Safety Services Association. Other state DOTs share information with other state agencies or in-state research universities. A large percentage (22%; nine of 41) of the respondents indicated their state DOT does not share information with any other organization. All of these groups can benefit from sharing data with one another to make highway work sites safer.

The final question of the survey solicited ideas from the respondents regarding recommendations for other state DOTs to implement successful safety programs. The following are paraphrased examples of these recommendations:

- Encourage involvement in safety programs from all levels of the agency to ensure that management supports safety programs demonstrated to be effective for employees.
- Use the latest technology and keep the programs updated. Take advantage of online training.
- Share safety policies and practices with other states so that the successful programs can be shared among the state DOTs.

CONCLUSIONS

The approach of gathering information regarding state worker safety policies and practices through a survey captures some understanding of current state DOT safety programs. In addition, the survey allows for capturing circumstances and challenges experienced by state DOTs with respect to their safety programs. As described in this chapter, state DOTs are diverse. Each state DOT experiences its own set of issues but remains committed to improving the safety of its employees in highway work sites. With this diversity comes opportunity.

This synthesis obtained survey responses from 41 state DOTs, and the results capture much of the national diversity. The survey respondents represent states from all regions in the United States. Some state DOTs have invested time and money in a new safety program, but others have invested in other programs and ideas. From a nationwide highway worker safety perspective, sharing the research and program methods is an economically efficient way to potentially improve worker safety nationwide. Although institutional limitations may prevent some state DOTs from following the model of other state DOTs that have a successful safety program element, understanding fellow state DOT safety programs can be useful in adapting broad safety ideas to a new organizational context.

There are distinct limitations of the survey approach to gathering this information and making generalized conclusions with confidence. To make the questionnaire as user friendly as possible, the questions were limited predominantly to numerical and multiple-choice responses. This format may have limited the depth of some responses and directed the respondents' thinking in a way that would not have been the case if open response questions had been used. However, it was necessary to make the questionnaire simple and quick to complete to achieve the required response rate. Ten open response questions were included in the survey. Reporting results from such questions

and maintaining the anonymity of the states means the qualitative results can be reported only in broad terms.

Improvements in data sharing and data availability are helpful in allowing states to make data-driven decisions for their safety programs. It is the hope that this chapter provides a better understanding of national trends relating to state DOT data gathering and utilization practices for highway worker safety. This chapter highlights general opportunities for improvement that can be implemented at the state DOT level. The implementation of some of these opportunities can lead to more consistent nationwide safety practices and raise awareness of safety issues experienced by state employees working in highway work sites.

CHAPTER FOUR

INJURY DATA ANALYSIS

INTRODUCTION

This chapter provides detailed findings from the analysis of injuries and fatalities that occur at highway work sites. Specifically, the data analysis aimed to quantify and compare injury and fatality incidence rates according to injury type, severity, project type, and other related characteristics. The analysis is based on highway work site injury and fatality data that are publicly available on the Internet, including the following data sets:

- Bureau of Labor Statistics (BLS),
- Occupational Safety and Health Administration (OSHA),
- National Institute for Occupational Safety and Health (NIOSH),
- Fatality Analysis Reporting System (FARS),
- Strategic Highway Research Program (SHRP 2), and
- State DOT data.

In the original scope for this synthesis, the NCCI was targeted as a potential source of publicly available data that could be analyzed as a part of this chapter. However, after a thorough search of the NCCI website, no aggregate data sources were located. Much of the website required a username and password for access to the data. Therefore, it was deemed that any data the site may have did not meet the "publicly available" requirement for this portion of the study.

In addition to reporting findings from the data analysis, a summary of each data source is provided to describe its benefits and limitations for use in highway worker safety management. Each of the data sources contains useful information for understanding and quantifying incidences that occur in highway work sites; however, the data sources differ significantly and are related to highway worker safety to different degrees. To keep the analysis consistent between the different data sources, only the most recent 3 years of data available from each archive are considered. The analysis generally explores the years 2011 to 2013.

To develop a comprehensive view of highway worker safety that takes into account the variety of risk exposures present at highway work sites, state DOTs have the option to utilize all of the targeted sources when developing worker safety management programs. Each source has its own benefits and contributes value to safety management programs.

BUREAU OF LABOR STATISTICS DATA

OSHA and the BLS are both divisions of the DOL. Separate divisions within the DOL, OSHA, and BLS generally have and use the same data pertinent to highway worker safety. However, these data are organized and categorized differently between OSHA and the BLS.

The BLS collects a significant amount of data regarding all aspects of labor in the United States and has one program that specifically relates to safety in the workplace. The Injuries, Illnesses, and Fatalities (IIF) program is described on the BLS web page as a program that "provides annual information on the rate and number of work-related injuries, illnesses, and fatal injuries, and how these statistics vary by incident, industry, geography, occupation, and other characteristics" (BLS 2016).

Owing to the methodology used to obtain data by the IIF program, the data are separated into two primary categories: fatal occupational injuries and nonfatal occupational injuries and illnesses. The injury and fatality records in each of these two categories contain the same general information except that the fatality records are coded more specifically in terms of the type of industry. The records in the nonfatal injuries and illnesses category are not coded specifically enough to filter the data by industry and potentially isolate incidents related to highway workers. Therefore, this section explores only the fatality portion of the IIF program database because more detailed conclusions can be reached regarding fatal incidents involving highway workers.

The Data Tools section of the IIF program allows the user to generate tables that summarize characteristics of individuals and incidents by the following four attributes:

- Year (1992–2014);
- Area (nationwide or by an individual state, territory, or metropolitan area);
- Industry type (heavy and civil engineering construction, etc.); and
- Ownership (private, government, etc.).

These attributes allow the user to effectively limit the scope of the search and, in terms of this synthesis study, narrow the results as much as possible to focus on highway workers. To demonstrate the types of data that can be extracted from this database related to highway workers, the following figures and tables have been generated to serve as examples. These examples are in no way comprehensive of the results and observations that can be obtained from the data set. The examples were chosen to highlight the type of data available and potential uses for the data to help describe the current state of highway worker safety and inform the development of safety programs.

To limit the scope of inquiry to highway worker safety, the BLS data used for the following charts and tables uses the Data Tools feature of the IIF program. The Data Tools selection was performed for the Fatal Injury Numbers table type. Table 5 provides a description of the attributes selected to obtain the data set that isolated, to the degree possible, fatalities among highway workers in the United States.

For individual states conducting similar analyses for their safety programs, the selection can be limited to a specific state. Although limiting the selection to only government ownership was an option, inconsistencies among states regarding whether they report the specific type of ownership led to selecting all ownerships for this industry type to ensure the most complete data set possible.

With these selections, the IIF's Data Tools feature generates a table that presents the filtered fatalities according to several categories, including basic demographics, incident type, location, occupation, and others. These categories can be useful in determining different characteristics of fatalities in the highway, street, and bridge construction (HSBC) industry. According to the data set, 320 fatalities occurred in the industry between 2011 and 2013. This total includes fatalities that occurred on all types of roadways, not only highways, and as mentioned is inclusive of all types of ownership (not just state DOTs). All of these figures report results for the sum of the 3 years from 2011 through 2013. Figure 15 shows the age distribution of the workers who died in the incidents, and Figure 16 shows the distribution of workers by race or ethnic origin.

TABLE 5
EXAMPLE IIF FATALITY DATABASE–SELECTED ATTRIBUTES FOR HIGHWAY WORKERS

Criterion	Selection
Year	2011–2013 (inclusive)
Area	All United States
Industry type	Highway, street, and bridge construction (Code 2373XX)
Ownership	All ownership types

Source: BLS (2016).

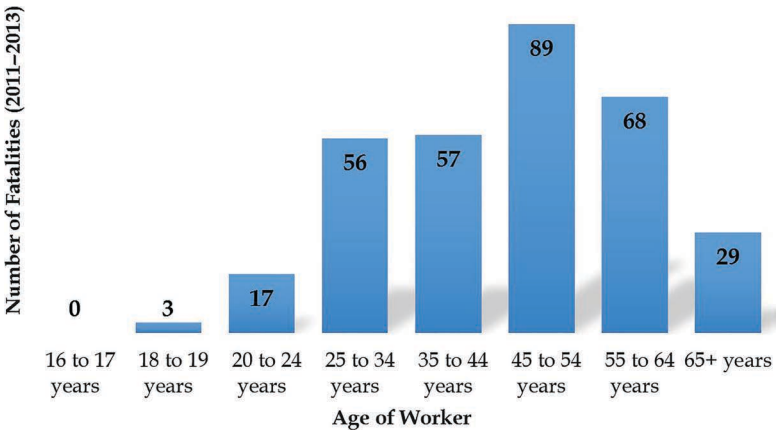

FIGURE 15 Fatality distribution by age for HSBC industry (2011–2013). *Source*: BLS 2016.

When these values are explored on a state-by-state level, individual state DOTs can determine how the fatality rates for these specific demographics align with available employment demographics in the highway, street, and bridge construction industry in that state. Discrepancies between the two, particularly in demographic divisions for which the fatality rate is higher, can indicate areas where state safety efforts might be focused.

The data set provides additional information regarding the causes of the incidents as well as a distribution based on the injured part of the body that resulted in the fatality. Figure 17 shows a chart of the primary sources of the fatalities. Figure 18 breaks down the types of vehicle incidents into subcategories. Figure 19 presents the part of the body that was injured, ultimately resulting in the fatality.

These statistics can be used to determine where safety efforts are to be focused. It is not surprising that most fatalities involve vehicles. When the individual vehicle types are considered (Figure 18), it can be determined that passenger vehicles are involved in only a small percentage of fatalities (20%). Trucks and multipurpose vehicles, which are more likely involved in the work conducted at the work site, account for most of the vehicle-related fatalities (75%). In the chart outlining the affected parts of the body, it is no surprise that the category multiple body parts is the one with the highest percentage, especially because these incidences are ones that resulted in fatalities.

There are limitations to these data in the context of developing highway worker safety management programs. The primary limitation of the BLS data is the lack of detailed industry coding in the

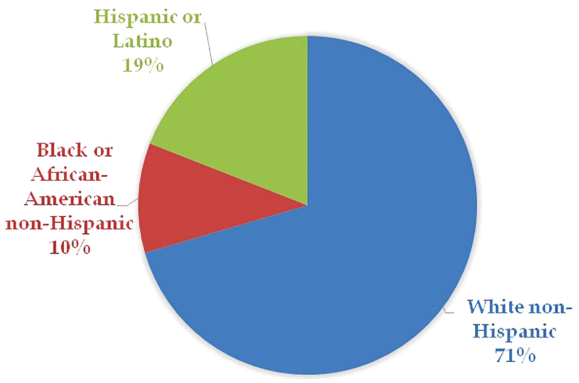

FIGURE 16 Fatality distribution by race for HSBC industry (2011–2013). *Source*: BLS 2016.

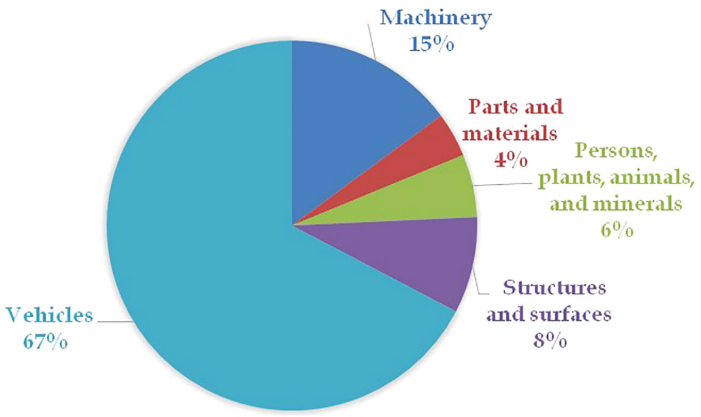

FIGURE 17 Fatality distribution by primary source for HSBC industry (2011–2013). *Source*: BLS 2016.

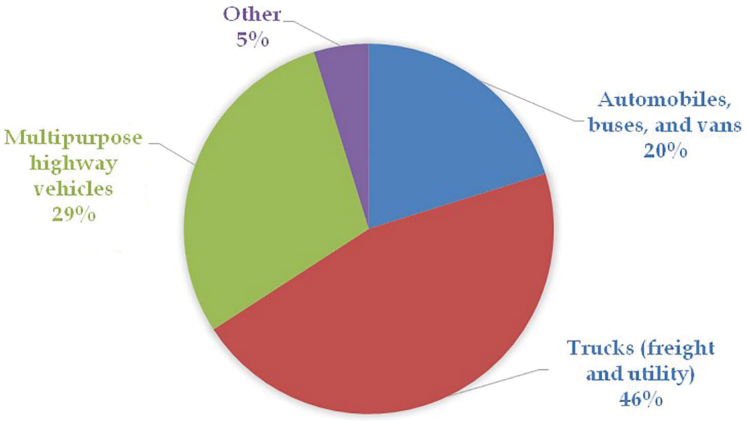

FIGURE 18 Fatality distribution by vehicle type for HSBC industry (2011–2013). *Source*: BLS 2016.

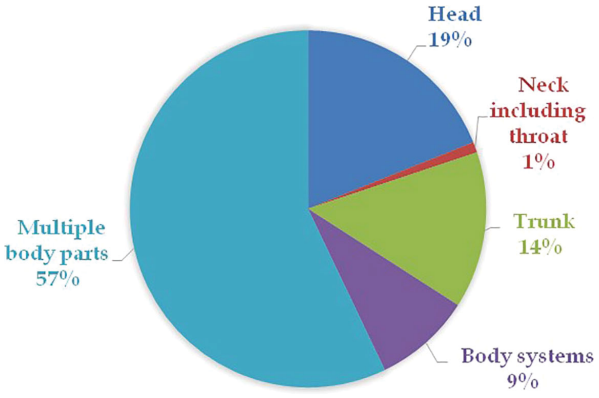

FIGURE 19 Fatality distribution by part of body injured for HSBC industry (2011–2013). *Source*: BLS 2016.

nonfatal illnesses and injuries category. Without this coding, it is not possible to isolate the nonfatal incidents involving highway workers. This limited coding, particularly in the nonfatal illnesses and injuries category, limits the robustness of data analysis. The ability to isolate government-owned projects would be particularly useful for state DOT users; however, nonuniformity of the data coding does not allow for type of project ownership to be an effective metric. In addition, this data set does not provide information about specific incidents and is limited to numerical statistics (such as is shown in the figures in this section). Finally, the inclusion of fatalities on multiple types of roadways (highways, streets, etc.) does not match the highway worker focus of this synthesis report.

Although this data set is not perfect, it allows for some quantitative understanding of incidents directly related to highway worker safety. The ability to separate these data by state could be particularly useful to state DOTs and complement their own worker safety data.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION DATA

Although only a small portion of the BLS data are related to highway worker injuries and fatalities, OSHA databases have more of a focus on workplace incidents for all employees. The Fatality and Catastrophe Investigation Summaries database available on the OSHA web page is a comprehensive collection of incident summaries that OSHA prepares after it investigates fatality and catastrophe incidents. The following are the OSHA definitions of fatality and catastrophe as used to collect and categorize the incident summaries (OSHA 2016):

> Fatality—"An employee death resulting from a work-related incident or exposure; in general, from an accident or an illness caused by or related to a workplace hazard."
>
> Catastrophe—"The hospitalization of three or more employees resulting from a work-related incident or exposure; in general, from an accident or an illness caused by a workplace hazard." Effective January 1, 2015, OSHA redefined catastrophe to be the overnight hospitalization of a single employee. However, none of the Catastrophe Investigation Summaries were from 2015 or later, so the original definition remains applicable to all of these summaries.

The database contains summaries for all incidents between 1984 and 2013. Each of the investigation summaries includes basic demographic information about the worker and the nature of the incident. This information includes details such as the age, sex, occupation, and cause of death of the worker, as well as brief descriptors of the project, such as the end use, project cost, and project type. In addition, a brief narrative of the incident describes how the worker was injured or killed (OSHA 2016). The nature of these reports, which contain a written summary of the incidents, necessitates qualitative methods for interpretation and analysis.

The database has several search parameters that allow the user to generate filtered lists of the investigation summaries. These parameters include the ability to search and filter the investigation summary list by

- Description,
- Abstract,
- Key word,
- Industry (Standard Industrial Classification code), and
- Event date.

These search parameters allow the user to effectively limit the scope of the search and, in terms of this synthesis study, narrow the results as much as possible to investigation summaries related to highway workers. To demonstrate the types of data that can be extracted from this database relating to highway workers, the following tables have been generated to serve as examples. These examples are in no way comprehensive of the results and observations that can be obtained from this data set. These examples were chosen to highlight the types of data available and potential uses for the data to help describe the current state of highway worker safety and develop highway worker safety management programs.

TABLE 6
NUMBER OF REPORTS BY TYPE FOR HIGHWAY AND STREET CONSTRUCTION (2011–2013)

Type	Number of Summaries	Percentage of Summaries
Fatality	91	54.5
Catastrophe	76	45.5

Source: OSHA (2016).

For the example data analysis for the Fatality and Catastrophe Investigation Summaries, the parameters were set to limit the summaries to 2011 to 2013 (inclusive). The industry filter was set to Standard Industrial Classification code 1611, which is for highway and street construction except elevated highways. With these two filters, there were 167 results of employees involved in fatalities or catastrophes from 2011 to 2013. Table 6 shows the breakdown of the investigation summaries by fatality and catastrophe.

The results can be filtered by key word. Table 7 shows the original 167 report summaries for highway and street construction between 2011 and 2013 disaggregated by each key word related to types of safety issues that occur in highway work sites. Some individual incidents contain multiple selected key words.

Key words, such as those listed in Table 7, can be selected to investigate common causes of the incident (such as "fall" or "struck by"), equipment or work operations involved in the incident (such as "vehicle" or "backing up"), or even the location of the injury (e.g., "leg" or "head"). Although there are other key words that could be used to filter the data to look for specific incidents, those in Table 7 illustrate the possibilities with this data set. Additional key words or searches in the report descriptions would allow a state DOT to search for reports that relate to their specific safety issues of interest.

Unfortunately, the data set has limitations. Although it is possible to narrow the search results by key word and description, there is no easy way to organize the data by common details. It is particularly difficult to organize incident reports by state. The definition of "catastrophe" for this data set is important, and for some incidents it may be up to the interpretation of the investigator regarding whether the incident qualifies as a catastrophe.

This data set allows for an improved qualitative understanding of highway and street construction and maintenance incidents. It also includes injuries and fatalities, so the results show a more comprehensive picture of occupational safety and health exposures associated with workers near a roadway.

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH DATA

NIOSH is a division of the Centers for Disease Control and Prevention (CDC). NIOSH's data collection program, the Fatality Assessment and Control Evaluation (FACE) program, is a two-tiered research program that thoroughly investigates work-related fatalities. The two tiers of the program

TABLE 7
NUMBER OF INCIDENT REPORTS THAT CONTAIN EACH KEY WORD (2011–2013)

Key Word	Number of Summaries	Percentage of Summaries
Struck by	79	41
Vehicle	33	17
Fall	22	11
Run over	18	9
Backing up	11	6
Leg	21	11
Head	9	5

$n = 167$.
Source: OSHA (2016).

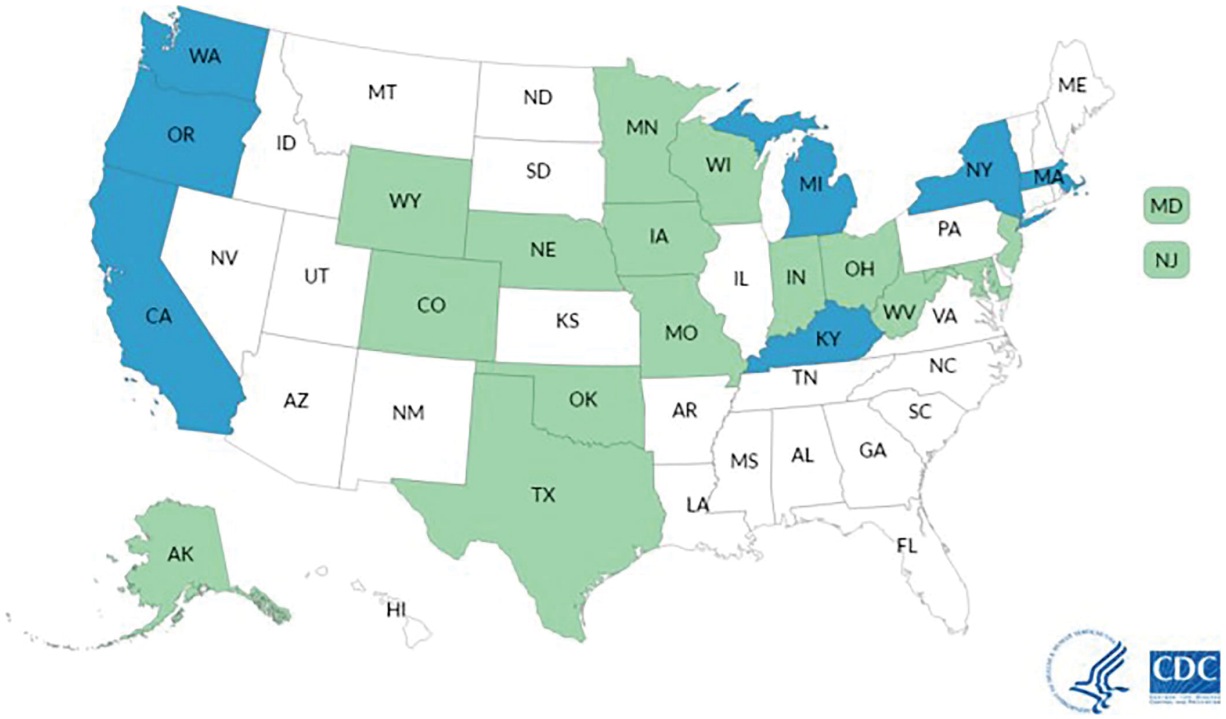

FIGURE 20 States with active and formerly active state FACE programs. *Source*: NIOSH 2016.

are the NIOSH (national) FACE reports and the state FACE reports. Some states have adopted the program and produced their own reports, but others have not. States that have not adopted the program are represented by the NIOSH (national) FACE reports. Figure 20 shows a map of the states that currently have a state FACE program and the states that formerly had a state FACE program.

The FACE program began in 1982. The goal of the program is to investigate "deaths associated with machinery, deaths of foreign born workers, energy production, and falls in construction." The program selects certain incidents to investigate and performs an in-depth investigation of the circumstances regarding the incident. Speculated causes of the incident are presented along with recommendations for preventing similar incidents in the future. The number of incidents investigated in highway work zones is small, but the thorough descriptions and the provided recommendations for preventing similar tragedies make these reports important and useful to highway worker safety.

The two-tiered system results in two sets of data, state FACE reports and NIOSH FACE reports. However, because the reports are categorized in the same way and there is no overlap between the two collections, they can be combined and queried as a single data set. This data set makes it simple to isolate highway worker safety. A location filter is provided that allows for the selection of reports that occur in highway work zones. Table 8 shows a summary of the count and dates for the NIOSH and state FACE reports.

Although the analyses of the other data sets explored cases between the years 2011 and 2013, neither the NIOSH nor state FACE programs have any reports available online from this date range. Given the small number of reports for highway work zones, a different time frame of reports was included in the analysis of the data set and is summarized in the following figures. All of the reports

TABLE 8
NIOSH AND STATE FACE REPORTS FOR HIGHWAY WORK ZONES

	Number of Records	Date Range of Records
NIOSH FACE	25	1984–2007
State FACE	73	1992–2014

Source: NIOSH (2016).

are provided in a common online format. The reports are detailed and lengthy. Both the NIOSH and state FACE reports follow the same format and include the following sections (NIOSH 2016):

- *Summary:* A brief overview of the incident with demographic information and the specific details of the incident. The final recommendations are summarized in this section.
- *Introduction:* A summary description of the employer, victim, equipment involved, and prior safety training that related to the victim.
- *Investigation:* An in-depth explanation of the incident, including relevant diagrams and photographs.
- *Cause of death:* A summary of the statement from the medical examiner's office regarding the cause of death.
- *Recommendations/Discussion:* A detailed list of recommendations for preventing similar incidents in the future and a discussion about how the recommendations could be implemented and how they could have affected the outcome of the incident.
- *References:* The research reports, government guidelines, and other documents that were used to help compile the report.

The report sections contain descriptions, photographs, sketches, and diagrams. The recommendations section is particularly emphasized in each report. The state where each incident occurred is mentioned in the report. The state FACE reports come only from states where there is an active or formerly active state FACE program. The NIOSH reports that represent the other states do not have a uniform geographic distribution. The state distribution for the highway work zone state FACE reports is shown in Figure 21, and the state distribution for the highway work zone NIOSH FACE reports is shown in Figure 22.

To identify trends in the types and characteristics of reports recently investigated by NIOSH, a subset of the data was considered. Given the sporadic nature of the highway work zone reports, the most recent 11 years of reports were used (2004–2014). In this range, there are 25 reports, 18 of which are state FACE reports; the other seven are NIOSH FACE reports. Based on an analysis of the general characteristics of the data, some general trends can be observed. Figure 23 highlights an overrepresentation in the FACE reports of incidents that involved vehicles going in reverse (backing up).

These vehicle-backing incidents all involve construction and maintenance-related vehicles such as dump trucks. Some of the other incidents involved vehicles or items and machinery that were in the work site by design. In the other cases, public motor vehicles entered a restricted area of the work site and struck workers. Figure 24 shows the number of incidents involving public motor vehicles compared with the number of incidents involving construction and maintenance vehicles permitted to be in the work site. The two nonvehicle reports included a piece of concrete falling on a worker and a worker being trapped in on-site machinery.

FIGURE 21 Distribution of all highway work zone state FACE reports by state. *Source*: NIOSH 2016.

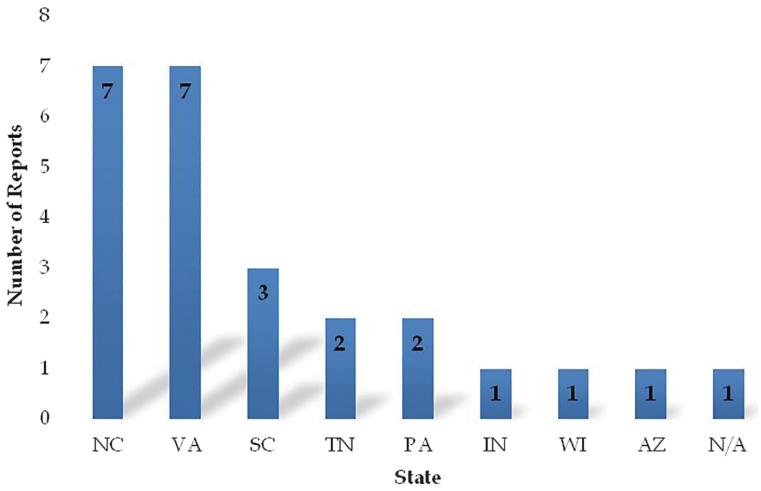

FIGURE 22 Distribution of all highway work zone NIOSH FACE reports by state. N/A = Not available. *Source*: NIOSH 2016.

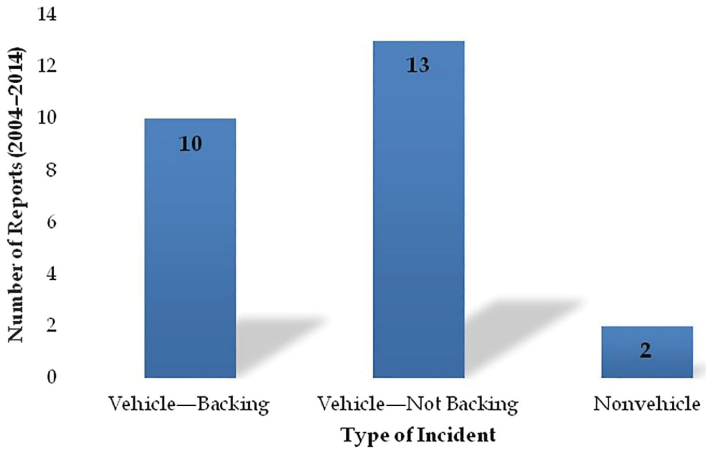

FIGURE 23 Distribution of recent highway work zone FACE reports by incident type. *Source*: NIOSH 2016.

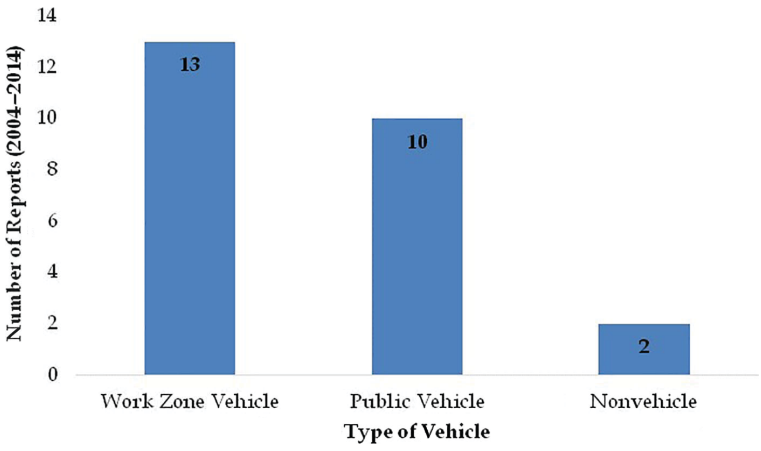

FIGURE 24 Distribution of recent highway work zone FACE reports by type of vehicle. *Source*: NIOSH 2016.

All of these figures show the limitations of these data in terms of nationwide investigation of worker fatalities in highway work sites. States that have their own FACE program do not necessarily conduct reports relating to highway work zones at the same frequency. For the NIOSH reports, the geographic representation is small (only nine states). More than half of the reports come from Virginia and North Carolina. Only one report represents a western state (Arizona). In addition, many of the reports are older (before 2004) and may not necessarily represent current issues in highway work site safety.

The NIOSH reports are excellent in that they bring necessary and detailed attention to specific incidents. This information can be useful for states that are experiencing specific problems in highway work sites.

FATALITY ANALYSIS REPORTING SYSTEM DATA

FARS is a database system for compiling motor vehicle crashes that have resulted in at least one fatality. The system is managed by NHTSA, is a division of U.S. DOT. The database contains detailed information for any vehicle crash on a public roadway that results in a fatality. Any of the information that is included in the police reports for the incident is searchable in the FARS system. These characteristics are thorough and include information regarding the vehicle, occupant, nonoccupants, and crash characteristics (NHTSA 2016).

One of the features of this database is its ability to query for fatal crashes occurring in a work zone on a public roadway. This feature is useful when utilizing FARS data to investigate highway worker safety because injured workers generally are located in highway work zones. Being able to compare fatal crashes occurring in work zones with those occurring elsewhere provides a mechanism for normalizing the work zone data.

The FARS selection options allow the fatal crashes to be disaggregated by time. Table 9 presents the frequency and percentage of all the fatal crashes throughout the United States between 2011 and 2013 by day of the week and if the crash occurred in a work zone or elsewhere. For example, 14,351 fatal crashes occurred on Sundays in areas that were not work zones. This is 16.0% of the total number of fatal crashes occurring outside of work zones for all the days of the week. This calculation was performed for each of the days of the week for both types of crashes.

The final column of Table 9 shows the difference in the percentages for the crashes occurring in work zones and those occurring elsewhere. By calculating this difference, the relative frequency of work zone crashes is compared with the far more frequently occurring crashes outside of work zone. When the percentage difference is above zero for a particular day, more fatal crashes occur in work zones on that particular day (as a percentage of total work zone crashes) than occur in outside of work

TABLE 9
SUMMARY OF WORK ZONE AND NONWORK ZONE FATAL CRASHES FOR 2011–2013 (by day of week)

Day of Week	NWZ Crashes	WZ Crashes	Percentage of Total NWZ	Percentage of Total WZ	Difference in Percentage (WZ-NWZ)
Sunday	14,351	188	16.0	11.6	-4.5
Monday	11,200	218	12.5	13.4	0.9
Tuesday	10,966	246	12.3	15.1	2.9
Wednesday	11,070	246	12.4	15.1	2.8
Thursday	11,633	272	13.0	16.7	3.7
Friday	13,691	248	15.3	15.3	0.0
Saturday	16,541	206	18.5	12.7	-5.8
Total	89,452	1,624			

Source: NHTSA (2016).
NWZ = nonwork zone; WZ = work zone.

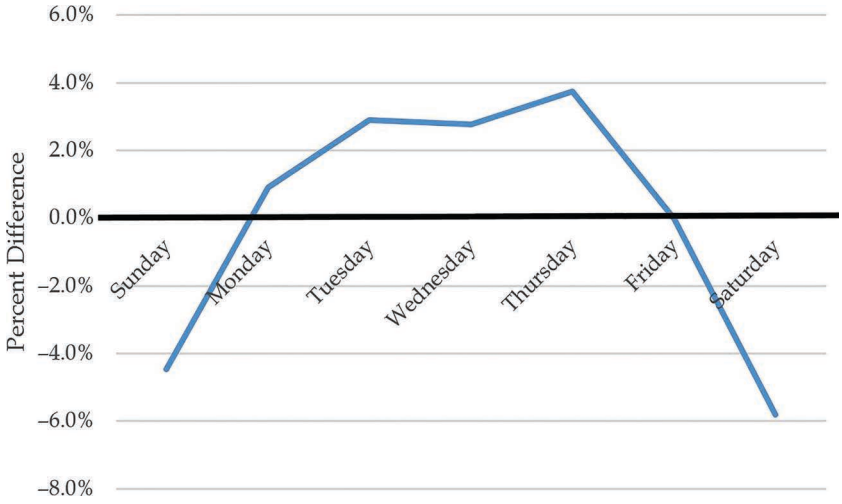

FIGURE 25 Percent difference between work zone and nonwork zone fatal crashes based on day of the week (2011–2013). *Source*: NHTSA 2016.

zones on that particular day (as a percentage of total crashes outside of work zones). Figure 25 shows a graph of the percent difference in crashes based on the day of the week to demonstrate a trend over the days of the week.

It is no surprise that work zone crashes are more likely to occur (compared with crashes outside of work zones) during the middle of the week, when there are more work zones operating, than on weekends, when there are fewer work zones operating.

Table 10 and Figure 26 show the results when using the same methodology described earlier but, instead of considering the day of the week, the number of fatal crashes is divided according to month of the year.

Not surprisingly, work zone crashes are more likely to occur (compared crashes outside of work zones) during the summer construction and maintenance season, when there are more work zones operating than in the winter months, when comparatively less road construction and maintenance is occurring.

The FARS database does not have the option to isolate highway workers. There are selections that can limit the data to crashes involving nonoccupants, which include highway workers in work zones. In particular, there is a query option for "non-motorist action circumstances at time of crash." This option can be cross tabulated with "work zone" to determine if there are any particular action circumstances that lead to fatalities of nonmotorists in work zones. Table 11 is a summary of this FARS cross tabulation with the categorized action circumstances.

The FARS data resource presents several limitations to the investigation of highway worker safety. Although these data are detailed, the resource's focus on fatal crashes limits how the data can be used to explore fatalities of highway workers. In addition, the database provides information only on fatalities; it does not account for crashes in work zones that did not result in a fatality. This significantly limits the effectiveness of the resource for the purposes of this synthesis study. However, it is still the most detailed and complete of all of the explored data sets. The FARS database is a numerically based complement to the other, more qualitative data sources.

STRATEGIC HIGHWAY RESEARCH PROGRAM 2 DATA

SHRP 2, which began in 2006 and ended in 2015, was a broad program to uncover data-driven solutions to the following three transportation challenges (NAS 2016):

TABLE 10
SUMMARY OF WORK ZONE AND NONWORK ZONE FATAL CRASHES FOR 2011–2013 (by month)

Month	NWZ Crashes	WZ Crashes	Percentage of Total NWZ	Percentage of Total WZ	Difference in Percentage (WZ-NWZ)
January	6,522	79	7.3	4.9	-2.4
February	5,879	80	6.6	4.9	-1.6
March	6,965	98	7.8	6.0	-1.8
April	6,937	135	7.8	8.3	0.6
May	7,626	156	8.5	9.6	1.1
June	7,935	170	8.9	10.5	1.6
July	8,225	178	9.2	11.0	1.8
August	8,311	182	9.3	11.2	1.9
September	7,937	172	8.9	10.6	1.7
October	8,129	153	9.1	9.4	0.3
November	7,586	125	8.5	7.7	-0.8
December	7,400	96	8.3	5.9	-2.4
Total	89,452	1,624			

Source: NHTSA (2016).
NWZ = nonwork zone; WZ = work zone.

- Improving highway safety,
- Reducing congestion, and
- Improving methods for renewing roads and bridges.

One element of the SHRP 2 program was the Naturalistic Driving Study (NDS), the largest naturalistic driving study ever conducted. The NDS specifically focused on the transportation challenge of improving highway safety. The project was administered through the National Academy of Sciences (NAS) and TRB. Contractors for the study were the Virginia Tech Transportation Institute (VTTI), which collected the NDS data, and Iowa State Center for Transportation Research and Education, which designed, built, and populated the Roadway Information Database. Researchers can use the database to better understand real-world driver behavior and analyze traffic incidents.

The strength of the NDS comes from the sheer volume of data collected. With the use of instrumented vehicles, many data types were collected about the more than 3,500+ drivers and vehicles

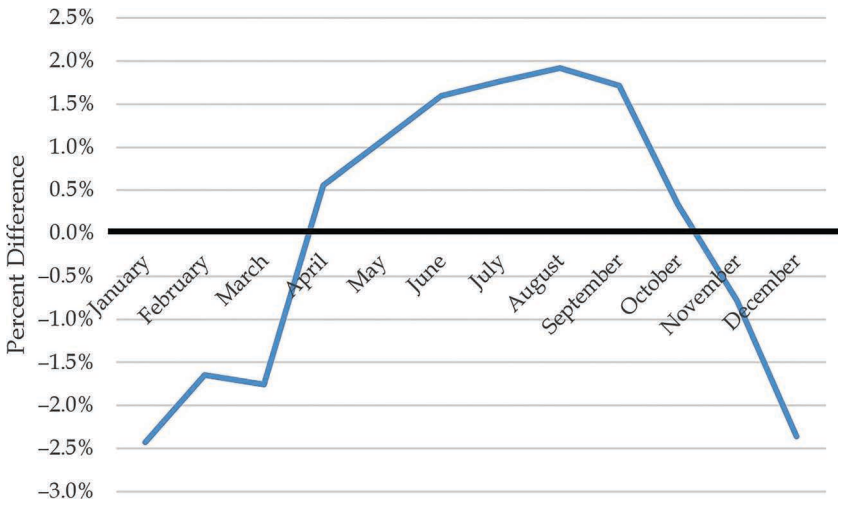

FIGURE 26 Percent difference between work zone and nonwork zone fatal crashes based on month of the year (2011–2013). *Source*: NHTSA 2016.

TABLE 11
SUMMARY OF WORK ZONE AND NONWORK ZONE FATALITIES FOR NONMOTORISTS FOR 2011–2013

Nonmotorist Action Circumstances at Time of Crash	NWZ Fatalities	WZ Fatalities
No improper action	1,248	44
Dart/Dash	664	8
Failure to yield right-of-way	1,447	16
Failure to obey traffic signs, signals, or officer	269	1
In roadway improperly (standing, lying, working, playing, etc.)	757	16
Entering/Exiting parked/standing vehicle	27	1
Inattentive (talking, eating, etc.)	119	1
Improper turn/Merge	40	0
Improper passing	5	0
Wrong-way riding or walking	117	0
Driving on wrong side of road	15	0
Improper crossing of roadway or intersection (jaywalking)	727	11
Failing to have lights on when required	11	0
Operating without required equipment	29	0
Improper or erratic lane changing	9	0
Failure to keep in proper lane or running off road	8	0
Making improper entry to or exit from trafficway	7	0
Operating the vehicle in other erratic, reckless, careless, or negligent manner	3	0
Not visible (dark clothing, no lighting, etc.)	824	11
Other	239	8
Not reported	168	5
Unknown	310	4
Total	7,043	126

Source: NHTSA (2016).
NWZ = nonwork zone; WZ = work zone.

participating in this study. With the drivers and vehicles, more than 5,400,000 trips have been logged and more than 36,000 incidents (crashes, near crashes, baseline events) have been recorded. The data were continuously recorded as the participants made any trip in their instrumented vehicle (Campbell 2012). All of the participants were located in one of the six cities designated as study centers for the SHRP 2 NDS. The NDS study centers were (VTTI 2016):

- Seattle, Washington;
- Bloomington, Indiana;
- Buffalo, New York;
- State College, Pennsylvania;
- Durham, North Carolina; and
- Tampa, Florida.

Data from each of these locations were collected in two forms. The first type was related to the vehicles and drivers. Through radar and other sensors attached to the vehicle and the cameras, demographic data, and postevent surveys that document the behavior of the drivers, it can be understand, in aggregate, the behaviors that were exhibited in public driving. The second type of data is roadway data. In the six study centers, researchers collected data about the roadways that the research participants used. This information was primarily geometric, such as number of lanes, lane characteristics, intersection types, and so forth (Campbell 2012). Combining these two sets of information, researchers had the opportunity to make new conclusions about a driver's relationship to the vehicle and the roadway infrastructure.

The SHRP 2 data set is not as publicly available to state DOT employees as are other data sets presented in this chapter. The data are owned by and housed at VTTI, and thus have more restrictions on availability and usage than do the other data sets, which are generally published by federal

government agencies. A subset of the SHRP 2 data that does not identify the particular drivers is made available for the user to view on a website that is maintained by VTTI. This website, where some of the nonidentifying data are archived, uses the following three different user access levels (VTTI 2016):

- Guest user,
- Registered user, and
- Qualified researcher.

The basic level, the guest user, allows the user to access only basic information about the SHRP 2 data set. The user can gain an understanding about some of the types of data that are available and have an opportunity to learn about the purpose of the SHRP 2 study. Some of the prepared summary graphs, particularly those with basic information about the vehicles, drivers, trips, and events used and observed in the study, are available to guest users (VTTI 2016).

The registered user level requires the user to fill out a registration form on the website and create an account. With this account creation, the user agrees to the terms of service and the privacy policy provided on the website. This access level provides the user with the same level of access available to guest users and allows the user to have and manage a profile on the website. Registered users have the ability to apply for qualified researcher status (VTTI 2016).

The qualified researcher level allows the user to view and query the different data sets available. All of the data sets that do not compromise the identity of the participant in the research program are available to people with qualified researcher access on the website. This level also allows for querying and cross tabulating the different data sets, including the crash, near crash, and baseline events. To obtain this status, a registered user must submit an application through the website to be approved as a qualified researcher. The primary component of the application is the submittal of a completed institutional review board (IRB) training certificate. When a SHRP 2 official has checked the application and confirmed that the training certificate is valid, the qualified researcher designation is conferred and the user gains access to the available data sets on the website (VTTI 2016). The IRB training certificate requirement limits the publicly available nature of the data set. All state DOT employees would not have access to IRB training programs and may not have the opportunity to achieve the qualified researcher status required for the data set.

Because of the highly sensitive nature of the data that has been collected through the SHRP 2 NDS (e.g., video of driver's face and behavior, detailed driver demographic information, etc.), most of the data are not made available on the website. For researchers who wish to have access to the more detailed and potentially identifying information, there is a process for obtaining a license to view parts of these data. However, this requires knowing specifically what subset of data is desired and working with the VTTI staff to pay for access to the data. The license also requires IRB approval, and the data can be viewed only in a secure venue (VTTI 2016).

Although the NDS has collected a tremendous amount of data regarding road user behavior in a variety of contexts, little data have been collected that relate specifically to highway worker safety. Because the data are collected through sensors and video onboard the vehicles, any data relating to highway workers and work sites can be collected only when the vehicles are involved in an incident (such as a vehicle crash) in a work site. The sensors and technology onboard the vehicle record incidents that involve the vehicle. These incidents, which are sometimes crashes or near crashes, are recorded, and their relationship to a construction zone is recorded (VTTI 2016). All of the events recorded are categorized as to whether or not they occurred in a construction zone. The categories are the following (VTTI 2016):

- Not construction zone-related,
- Construction zone (occurred in zone), and
- Construction zone-related (occurred in approach or otherwise related to zone).

Of the more than 36,000 incidents that have been recorded as part of the NDS, more than 1,400 occurred within a construction zone or were construction zone-related. A qualified researcher on

the website can cross tabulate these 1,400 incidents with any of the recorded metrics about the incidents. This analysis can include such information as crash severity, incident type, or information about the environment in which the incident occurred, such as location, weather, or time of day (VTTI 2016). The breadth of information collected by the instrumented vehicle during the incident allows incidents in work sites involving public vehicles to be observed in a unique combination of ways.

The SHRP 2 NDS data set provides valuable information to transportation officials and researchers regarding driver behavior but has some significant limitations to state DOTs interested in developing and modifying safety programs for highway workers. As stated, the data are limited to circumstances in which an instrumented vehicle was involved in an incident in or near a work site. No data are collected specifically about highway workers and how they might be involved in an incident unless they are mentioned in a postincident interview. Therefore, the entire data set is from the perspective of the vehicle and the driver, which limits work site applications.

In addition, the data are not as publicly available as are data from other data sets reviewed. As stated, the most detailed information can be obtained only through paying VTTI for the data, and the data sets on the web page can be accessed only with an IRB training certificate. The information for work sites also is limited to construction zones themselves. There is little information on how this specifically is coded, but it likely does not uniquely account for maintenance sites along the roadway. Incidents in maintenance work sites, depending on the consistency of the recording, may not be addressed at all in the existing incident counts.

STATE DEPARTMENT OF TRANSPORTATION DATA

In addition to nationally available data sets related to work zone safety, individual state DOTs maintain their own internal databases for vehicle and work zone incidents. State DOTs have the individual authority to collect and maintain data they believe to be the most beneficial to their individual responsibility as a state agency. Although there are common legal standards that require specific incident information to be collected, data beyond these minimums is left to the discretion of the state DOTs. Thus, each state database is different. State agencies use their resources to collect the information they think is the most beneficial to maintaining safety on their roadways. Because they have more direct control over the data, they can better use and analyze the data to make meaningful changes to improve safety within their state. This reality makes the state DOT data sets particularly valuable.

State-based data sets provide value, but they often are most valuable to the state in which the data were collected. The data sets are not as publicly available because they are collected and maintained internally and may contain sensitive personal information to varying degrees. Some states make some of their state databases available to the public, whereas others do not. Because the collection and distribution processes are all different, each state database is unique. Despite their uniqueness, general trends across the data sets can be uncovered that are common to most states owing to the common legal standards for incident reporting.

The data sets generally contain information regarding incidents that occur with vehicles on roadways. This information is generally in the form of police reports, and the usefulness of the data is dependent on the ability of the police officers to complete the reports and the ability of the reports to solicit the proper information from the officers reporting the incident. In addition, the format of the archive of the reports, including hard copy records, scans of hard copies, and fully digitized and searchable databases, influences how useful the records can be to the states for aggregation and analysis. For incidents that occur involving highway workers, the reports include whether they are isolated incidents within the work site or involve a public automobile. One potential problem with these incident reports is they may not all be archived in the same location, leading to incomplete data sources for the safety officials seeking to improve work site safety on construction and maintenance sites.

An area of focus that may vary across states is the level of attention given to collecting incident information (whether with workers or vehicles) in construction and maintenance sites. One example of a state DOT that found its state and national databases were not useful enough for improving work site safety is the California Department of Transportation (Caltrans). Existing Caltrans databases did not provide information that was detailed enough to allow safety officials to implement specific safety improvement measures in work sites. Therefore, Caltrans partnered with the University of California at Davis's Advanced Highway Maintenance and Construction Technology Research Center (AHMCT) to determine ways in which the existing data could be recodified to explore the cost-benefit of particular actions taken in work site management. The results of the project were published in the 2015 AHMCT report "Work Zone Injury Data Collection and Analysis."

The research team at AHMCT used police traffic collision reports for work site incidents between 2006 and 2010. Only reports that were related to work sites were included in the analysis to ensure the report focused as much as possible on unique work site issues. These reports from across the state were analyzed by the research group and codified for factors and potential causes of the incidents. The goal of this analysis was to create a decision-making tool to effectively communicate options for improving work site safety for motorists and highway workers within Caltrans work sites. The aggregation of work site incidents was something that was not possible with the previous organization of Caltrans incident data sets (Ravani et al. 2015).

An interesting finding was that Caltrans determined that the cost of work site incidents was far less than estimated. From the analysis, it was determined that during the 5-year period the data considered, the average annual cost of the incidents was $382 million. This amount was far less than the estimated $800 million. Caltrans was able to break down the costs by type of incident, such as fatality, injury, and property damage only (Ravani et al. 2015).

The outcomes of this project are that the safety personnel in the Caltrans districts can better understand the types of incidents that occur in the work sites within their jurisdiction. The online decision support tool can provide instantaneous information about the cost-benefit of particular mitigation measures available for different issues present in work sites (Ravani et al. 2015).

The limitations of the state databases, particularly in the area of highway worker safety, are as diverse as the characteristics of the state databases. Different states have different data limitations. States such as California recognize the limitations of their internal data and undertook time-consuming measures to adapt the existing data to more effectively apply to work site safety management. One of the other primary limitations of these data sets is their lack of availability to other agencies outside the state. The data sets are sometimes available only to the state that produces the report, which may limit the amount of collaboration among the state DOTs as they work to improve highway worker safety.

CONCLUSIONS

In conclusion, these data sets, when used together, can help to quantify and describe current issues in highway worker safety. Understanding the functionality of each data set allows effective research to be conducted and effective safety programs to be implemented. It is important that highway worker safety be examined at national and state levels to understand general trends and causes of traumatic incidents. Each of these data sets has advantages and limitations. Table 12 is a summary of the strengths and limitations of the worker injury and fatality data sets examined.

Although there are benefits to having access to various forms of the data, one of the limitations of this collection of data sources is the difficulty of combining them. The data sets are most easily analyzed independently. It is likely that individual incidents appear in more than one of the archives, but the recording methodology for each program is different enough to make it challenging if not impossible to isolate a particular incident across multiple data sets. The data sets present different aspects of incidents in a wide variety of formats. This diversity, which enhances the breadth of information regarding highway worker incidents that can be accessed, limits the potential integration of the data

TABLE 12
STRENGTHS AND WEAKNESSES OF WORKER INJURY AND FATALITY DATA SETS

Data Set	Strengths	Limitations
BLS	Able to separate by state; numerically based data separated by categories	Illness and injury data not well coded to isolate for highway work sites; little known about individual incidents
OSHA	Short written description regarding each incident	Difficult to search by state
NIOSH	Detailed reports and specific recommendations	Poor geographic diversity and few recent reports for highway work zones
FARS	Detailed, comprehensive database	Impossible to isolate highway worker data
SHRP 2	High volume of naturalistic driving information	Not as available to nonacademic researchers at state DOTs
State data	Highly applicable and focused to the individual state	Limited access by other states and varies state to state

sets. The data analysis could be more powerful if the data sets reviewed in this section could be more easily integrated and analyzed collectively.

Although state-specific data are the most useful for the state DOTs, the nationwide statistics on highway worker safety can be beneficial. The statistics can be used to establish a benchmark with which states can evaluate areas of highway worker safety where the states can most improve with respect to the rest of the United States.

CHAPTER FIVE

STATE DEPARTMENT OF TRANSPORTATION CASE EXAMPLES

INTRODUCTION

The purpose of this chapter is to further investigate and highlight specific examples of state DOT safety program elements that have been developed and found to be effective. The nature of the other research tasks, such as the injury data analysis and survey, is such that the tasks describe national trends and practices. Although this understanding is critical to an overall understanding of highway worker safety practice among the state DOTs, it is also important to document and share specific and interesting efforts by state DOTs that could benefit all agencies. These case examples are informative examples of various elements within state programs and are provided for illustration and educational purposes only. The case examples are one aspect of this synthesis study, which seeks to describe the current state of data-driven health and safety policies and practices in state DOTs.

To obtain the detailed information required to compose the case examples, it was necessary to identify which states to contact for follow-up interviews. Several factors guided the selection process for potential interviewees. The final question of the survey questionnaire sent to the state DOT safety representatives gave the respondent the option to include his or her name and contact information if he or she was interested in participating in a follow-up interview to discuss the safety program. Twenty-three of the respondents indicated their willingness to participate in the follow-up interview. The 23 responses were analyzed for mention of specific safety programs that could be highlighted in a case example format. Of the 23 responses, seven contained information about safety programs that warranted further exploration.

Although the population of interest for follow-up interviews was limited to states that participated in the questionnaire and were willing to provide contact information for a follow-up interview, case examples from state DOTs in different regions of the United States were identified to provide a distributed geographic representation. Nine states were contacted to participate in a follow-up interview. Phone interviews were coordinated and case examples approved with six of these state DOTs. These six state DOTs are listed here in alphabetical order:

- California,
- Maine,
- North Dakota,
- Oregon,
- South Carolina, and
- Washington.

These states represent various regions in the United States, including the northeast, northwest, southeast, and the plains. The state DOTs included are diverse in terms of state characteristics. The populations range from more populous states, such as California and Washington, to states with smaller populations, such as Maine and North Dakota. Table 13 lists the six states, their estimated 2015 population, and their population rank among the 50 states.

Once candidate states were identified, an interview protocol was drafted with primary and probing questions based on the case example objectives as defined by the project scope. The interview questions aimed to gather supplemental information to the survey responses and focused on the use and collection of data in the process of implementing and maintaining the specific safety program elements

TABLE 13
STATE POPULATION AND RANK FOR INTERVIEWED STATE DOTS

State	Population (2015 est.)	Population Rank (2015 est.)
California	39,144,818	1
Maine	1,329,328	42
North Dakota	756,927	47
Oregon	4,028,977	27
South Carolina	4,896,146	23
Washington	7,170,351	13

Source: U.S. Census Bureau (2015).

identified. The questions also sought to ascertain details on the agency's perspectives and evaluations of the program or initiative. Where documents were created by the state DOT that describe the safety program element, researchers asked the interviewee for copies of the pertinent documents (when possible, these are provided in Appendices C, D, and E) to review for inclusion in the case examples. The full interview protocol is included in Appendix C. After the protocol was completed, the interviews were conducted on the phone and audio recorded with the interviewees' permission. Each interview, which lasted between 15 and 35 minutes, allowed the state safety officer to explain the safety program element in his or her own words, with only guiding questions provided. After the interviews were completed, the audio files were transcribed to text to allow the case examples to be more easily drafted.

In addition to containing the information gathered from the interview process, each of the documented case examples includes basic information about the state DOT that implemented the safety program element. To gather this additional information, researchers reviewed online information about the state DOT that is publicly available on the state DOT's website and information in any documents provided by the interviewee that describe the state DOT's safety program elements. This was done to establish an appropriate context for each state DOT because the agencies vary in terms of size and the elements of the transportation network they construct and maintain. In each case example, only a portion of the overall state safety program is highlighted. This was done to provide sufficient detail about the program element discussed and allowed for the exploration of a variety of programs across the United States.

CALIFORNIA

DOT Size and Description

Caltrans is one of the largest state DOTs. The agency has approximately 20,000 employees who work together to effectively implement a $12 billion budget with the common goal of fulfilling Caltrans' mission to "provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability" (Caltrans 2016). This goal involves managing 15,000 centerline miles (51,900 lane miles) of highways that are located on 230,000 acres of right-of-way in the state of California (Caltrans 2014). The Caltrans survey response, included in chapter three, estimates that between 30% and 40% of the agency's employees are regularly on construction or maintenance sites throughout the state. Many of these workers are maintenance workers who have higher risk to high-speed traffic exposure because of their required work tasks.

Safety Risk Mitigation Policies and Practices

Although Caltrans is committed to no employee being involved in a roadside work site incident, the reality is that goal may not be achievable. When an incident involving a highway worker in a work site occurs in California, several steps are undertaken. These steps include preparing an initial incident report and processing the worker injury claim. Local law enforcement, the insurance policy provider, and the state OSHA office are informed of the incident. After many of the initial steps,

subsequent steps are taken to review and learn from the circumstances surrounding the incident. These steps include holding an incident review meeting and communicating lessons learned agencywide. A postincident investigation is conducted and relevant policies and procedures are reviewed to determine if any corrective actions can be taken to prevent similar incidents in the future.

An incident review meeting is conducted only when the incident does not involve a public automobile, and informing law enforcement is not a step taken when the incident involves an on-site hazard. The other postincident steps are taken for any incident, regardless of whether the incident involves public automobiles entering the work site, those that involve on-site construction vehicles and equipment, or those that involve on-site hazards (e.g., worker injury from a slip, trip, or fall).

For incident reports prepared in the aftermath of incidents that occur in work sites, several departments within Caltrans are responsible for compiling and archiving the incident reports. At the statewide level, the traffic engineering, maintenance, and safety groups share this responsibility. At the district level, district human resources and district traffic engineering play a role in the compilation and archival process. The University of California at Davis (UC Davis) also plays a role in the compilation and analysis of Caltrans' incident reports. UC Davis' Department of Mechanical and Aerospace Engineering is a part of the AHMCT that published a 2015 report about using Caltrans' incident reports from work zones. This report sought to accurately code and classify incident reports from work zones in California to provide a basis for the creation of a system that would facilitate the use of data to make cost-effective decisions to mitigate future incidents (Ravani et al. 2015).

Regarding postincident steps that Caltrans conducts after the occurrence of an incident in a work site, some elements were identified as being particularly effective at contributing to Caltrans' overall worker safety program. These included preparing the initial incident report, conducting an incident review meeting, communicating lessons learned agencywide, and conducting a postincident investigation. In addition, reviewing and modifying policies and procedures, which includes updating design standards to reduce future risk to workers, is a core component of the postincident steps taken at Caltrans. These steps are taken for all types of work zone incidents (public automobile, on-site vehicle/equipment, and on-site hazard).

Design for Safety Initiative

Highway worker safety is an important focus for any state DOT. In recent years, Caltrans has dedicated additional time and resources to ensuring that workers committed to constructing and maintaining the California highway system are as safe as possible. As one element of this overall goal, Caltrans has implemented a design for safety initiative. This is a program element of the State Highway Operation Protection Program (SHOPP) that addresses highway worker safety at Caltrans through funding of capital improvement projects. The design for safety initiative focuses on using data to identify particular areas where improvement is needed to reduce worker exposure and communicate these issues with the landscape architects and engineers so that they can produce designs that minimize or eliminate the potential risks placed on workers in the field. Subsequent sections of this case example describe the specific data used, how they were analyzed, and how that analysis influences design practice.

In 2012, a deputy directive, which is the second highest level of directive at the agency, focused on worker safety for the state highway system was distributed agencywide. This directive outlined the responsibilities for all Caltrans employees regarding their role in helping protect worker safety and minimizing potential risk. The deputy directive's involvement of all employees helped to motivate and integrate design landscape architects and engineers in the effort to improve work site safety. It also supported maintenance involvement in design decisions to reduce worker exposure.

To comply with the deputy directive and ensure that the available funding was appropriately used, officials at Caltrans looked to other state DOTs to see what guidance was available for effective worker safety programs. Little guidance was found regarding roadside worker safety specifically or guidance in designing for safety. Most of the available literature provided guidance solely for roadway traveler safety. Therefore, the implementation of a more robust worker safety initiative in California

needed to be more experimental and serve as an example of an initiative focused on construction and maintenance worker safety at a state DOT. The design for safety initiative is an integral part of the current worker safety programs at Caltrans.

The initiative suggests that all elements of the department can play a role in ensuring and maintaining worker safety. In particular, the initiative focuses on the impact that the designers can have on the safety of workers who construct and maintain their designs. During the implementation process, an analysis of worker injury and fatality records was conducted to establish the areas of highest risk for workers. Additional explanation of the data sets used and the subsequent analysis of the data is included in the Data Sources, Archiving, and Analysis section of this case example. In addition, statewide workshops were conducted in each of Caltrans' 12 districts with maintenance staff to solicit ideas from the people who regularly perform job tasks in the field to determine what actions would create a safer environment for them. This series of workshops, held between 2013 and 2014, identified more than 750 unique ideas. These ideas and results from the data analysis were used to create tools and training programs for the designers to use in practice. The department granted district level authority for the implementation of changes that can improve worker safety. This increases the efficiency with which design exceptions can be made and allows safety efforts to be implemented more quickly.

The Landscape Architecture Program in the Division of Design manages the SHOPP Roadside Safety Improvement Program. The Roadside Safety Improvement Program guidance document is included in Appendix D. This handout, intended for Caltrans employees, outlines the goals and objectives of the Roadside Safety Improvement Program. The document outlines, for many types of design decisions, the design options potentially eligible for funding through the program. The handout also describes types of work and decisions that do not qualify for SHOPP Roadside Safety Improvement Program funding. Although the handout contains the full list of approved and not approved design solutions for program funding, the program is based upon soliciting new design ideas that may improve highway worker safety. The design for safety initiative is one of the mechanisms in place at Caltrans to achieve the goals and objectives of the Roadside Safety Improvement Program.

There are additional guidance tools for the design for safety initiative. These practical measures better equip designers to incorporate safety into designs. One of these, the Roadside Management Toolbox (Caltrans 2014), is a web-based platform that provides options to designers for different circumstances. It describes the potential risks to highway workers for different design elements so that designers can make informed and intelligent choices. In addition, there are design guidance documents for different groups (e.g., landscape architecture) that provide recommendations specific to the work product of those functional groups.

The Caltrans Highway Design Manual (HDM) requires the Safety Review Committees in each district to approve all designs. These committees are an independent group operating in each of the districts that ensures the proposed construction and maintenance plans consider the implications to highway worker safety. These reviews ensure consistency across each district for promoting risk-reducing design decisions.

The design for safety initiative continues to be improved. SAFER is an acronym developed by the Landscape Architecture Program to highlight the different ways design decisions can improve worker safety in a way that is easy to remember. The acronym is short for:

- Site—site facilities in protected locations;
- Accessible—provide safe access for highway workers to work locations;
- Facilitate—facilitate the use of mechanical maintenance means;
- Eliminate—eliminate the need for recurring maintenance tasks; and
- Relocate—relocate facilities to protected locations.

One of the current goals is to get the SAFER design philosophy integrated into the HDM. For example, when deciding where to place a utility cabinet on a project site, a designer can consider if the box can be located in such a way that it is accessible to the workers while maximizing the distance to the travel way, thereby reducing the risk of exposure to adjacent traffic. As the design for safety initiative

continues to develop and become a more integral part of Caltrans' overall safety program, incorporating elements such as the SAFER philosophy will continue to reduce worker risk.

Data Sources, Archiving, and Analysis

The primary source of data that guided the development and implementation of the design for safety initiative was an existing database that contained fatality incident information between 1924 and 2007, as well as injury incident information between 1990 and 2006. Officials at Caltrans organized and analyzed the entirety of these data sets to determine trends and establish focus areas where interventions could contribute to the greatest reduction of risk. The analysis included evaluating each of the incidents for specific characteristics. These characteristics included the location of the worker at the time of the incident, the task the worker was conducting at the time of the incident, and the type of injury sustained by the worker. From the analysis of the data, the following five common factors were identified as areas or situations at which workers operate at the highest level of risk:

- Urban locations,
- High average daily traffic,
- Vehicle parked on the shoulder,
- Roadside work near the shoulder, and
- Employee on foot.

Although these five situations can occur independently on a work site, the risk to workers increases when multiple situations appear in a single work site. For example, an employee performing maintenance work on foot near the shoulder of a road in an urban area with high average daily traffic presents one of the highest risk situations to workers.

In the design for safety initiative, these five factors are the primary targets for available design solutions. Solutions to these worst-case situations were created to mitigate the safety risks for workers. These design solutions can be categorized by the components of the SAFER acronym and highlight specific strategies that can be implemented in a variety of situations. The injury and fatality database used by Caltrans made the identification of these issues possible and gave the engineers the opportunity to develop effective solutions to mitigate risks to workers in the field.

Monitoring and Evaluation

The primary method for monitoring and evaluating the design for safety initiative is an internal review. By continuing to implement additional training and maintaining employee participation in the program, the design for safety initiative can evolve naturally to accommodate the changing needs of the maintenance workers and the transportation network. Approximately 200 Caltrans employees, including landscape architects, planners, engineers, and maintenance employees, have participated in the Landscape Architecture Academy training, which focuses on work site safety. In addition, the Maintenance Leadership Academy has trained hundreds of maintenance staff in design for safety concepts. Continued annual funding of the SHOPP Roadside Safety Improvement Program is a way to monitor the health of the initiative from the perspective of agency leadership.

Caltrans has implemented an effort to document the specific changes that have been made in designs because of the design for safety initiative. In some cases, such as projects that relocate signal or utility control cabinets, these changes can be recognized and documented. However, documentation is far from complete because the goal of the initiative is to make thinking about safety in design something that is a standard part of the design process. These little changes occur in the day-to-day revisions of the designs to improve worker safety but are almost impossible to document as a part of a monitoring program for the initiative. In addition, although Caltrans collects injury and fatality data, such data are not actively used in the evaluation of the design for safety initiative. According to the Caltrans safety team, it is difficult to prove the direct correlation between a physical change and a reduction in the number or severity of incidents, so using incident data as a metric is not a practical method for managing roadside safety improvement investments.

Effectiveness of Safety Programs, Policies, and Practices

The design for safety initiative has been an element of a significant restructuring of Caltrans that has been in place for several years. There are still elements, such as the SAFER acronym, that are in the early implementation phase, but the bulk of the initiative structure has been established. Therefore, several metrics exist that demonstrate the effectiveness of the design for safety initiative at Caltrans.

One of the indicators for the success of the initiative has been the agency leadership's support. The SHOPP program, of which the design for safety initiative is an element, has enjoyed leadership approval and seen significant increases in funding as a result. In 2010, the SHOPP program had an annual budget of approximately $1.9 million. Through effective advocacy by program management to agency leadership, safety officials at Caltrans were able to demonstrate the specific needs for the safety program and were provided additional funding to meet identified statewide needs. Over the course of several iterations, the annual budget for the SHOPP Roadside Safety Improvement Program has increased to approximately $90 million today. This 47.4-fold increase in funding demonstrates the confidence of the leadership in the benefits of this initiative for the safety of highway workers.

The design for safety initiative has catalyzed tangible safety improvements at Caltrans. Beyond the designers making conscious choices daily to consider the safety implications for the construction and maintenance workers in design products, other long-term adjustments have been made as well. Chief among these was the modification of the standard construction plans that Caltrans uses for many of its projects. These standard plans save designers and the agency time and money, so it is advantageous to use them as often as possible. Caltrans was successful at changing the standard guardrail plans to include paving underneath the guardrail. This design prevents vegetation from growing and requiring trimming by maintenance workers at the edge of the travel way. Figure D1 in Appendix D is an example of a standard plan sheet that outlines the requirements for this vegetation control method that is installed on each side of the guardrail. The adoption of this standard plan has reduced the number of hours that maintenance workers have to be on foot at the edge of the roadway, where the guardrail is present. There have been additional changes to design standards that require vegetation control at structure approaches and other fixed objects.

Suggestions for Safety Programs, Policies, and Practices

The design for safety initiative requires interdepartmental cooperation at various levels of the organization to ensure that the initiative maximizes highway worker safety while maintaining its return on investment as an aspect of the overall Caltrans safety program. For Caltrans, the following suggested practices increase the possibility of having a continuing successful safety program:

- Recognize that all Caltrans divisions and programs can affect worker safety and that it is important to engage all groups and use them to contribute to reducing worker risk.
- Use existing data sources to highlight and understand contemporary safety concerns so that department resources can be properly allocated to maximize the return on investment.
- Maintain a robust training program to educate the necessary participants and stakeholders about the impact they can have on worker safety.
- Allow district autonomy to implement safety improvements to ensure that risks can be reduced as early as possible in the life cycle of the roadway and project.

MAINE

DOT Size and Description

Maine Department of Transportation (MaineDOT) was officially organized in its present form in 1972, at which time ferries, seaports, transit services, airports, and some railroads were all placed under the jurisdiction of the agency. Today, MaineDOT is responsible for the maintenance and operation of the following transportation infrastructure elements (MaineDOT 2016):

- Nearly 18,000 mi of highway, including 2,919 bridges;
- Seven ferry boats and terminals;

- Three seaports;
- Twenty-two transit operations with more than 420 transit vehicles; and
- Almost 500 mi of state-owned railroad.

MaineDOT is one of the smaller state DOTs in the nation with approximately 1,900 employees. However, 60% to 70% of the employees are regularly on construction or maintenance sites throughout the state.

According to the MaineDOT 2010 report "Connecting Maine," the mission of MaineDOT is to provide "a safe, efficient and reliable transportation system that supports economic opportunity and quality of life" (MaineDOT 2010). The report further elaborates on this mission by describing the vision of the agency as a desire to "maintain village and urban centers, connect communities and transportation modes, improve our existing transportation system performance for passengers and freight, provide a safe transportation network, and support Maine's economic vitality through connectivity to internal and external economic markets" (MaineDOT 2010). Part of reaching the goals of these statements is ensuring the safety of state employees. The following sections provide a brief overview of the general characteristics of MaineDOT's employee safety efforts, as well as a more detailed description of a safety incentive program implemented for the state employees.

Safety Risk Mitigation Policies and Practices

The postincident steps taken by a state DOT are important elements of the overall safety program. For MaineDOT, the agency uses postincident steps to document and learn from an incident that occurs in a work site. The process varies based on the type of incident that occurs in a work site. The following categories are the three types of work site incidents identified by this synthesis study:

- Public vehicle (e.g., work site crash);
- On-site construction and maintenance vehicle/equipment (e.g., worker injury resulting from contact with work vehicle); and
- On-site hazard (e.g., worker injury from a slip, trip, or fall).

MaineDOT implements common steps for all three incident types. These steps include preparing an initial incident report, preparing a worker injury claim, and conducting a postincident investigation. Informing law enforcement, informing the insurance provider, and reviewing or modifying policies are steps taken when a public automobile or on-site vehicle/equipment incident occurs in the work site, but such actions are not implemented with on-site hazard incidents. An incident review meeting is conducted after on-site vehicle/equipment and on-site hazard incidents. Return-to-work initiatives are available only after an on-site hazard incident. The steps of preparing the incident report, preparing the worker injury claim, and informing law enforcement are viewed as being the most valuable to the safety program for work site incidents at MaineDOT.

For the initial incident report that is compiled for all types of incidents that occur in work sites, the regional human resources department and the regional safety groups have the responsibility of archiving and maintaining such reports. The format for this archive is an online database. In addition, these reports are categorized according to a variety of attributes, including the employee's functional area, the type of injury, the severity of injury, the functional classification of the roadway, and the time of day.

Although these efforts are primarily reactionary safety measures to the occurrence of an incident in a work site, MaineDOT has also implemented safety programs that are proactive and strive to prevent incidents before they occur. The safety idea incentive program is an example of a proactive safety program implemented by MaineDOT.

Safety Idea Incentive Program

MaineDOT recognizes the importance of maintaining a safety program that continually adapts to changing attitudes and needs of the agency. It also recognizes that establishing safety programs from

the bottom up can be beneficial in encouraging employee participation in a program. Through discussions with work crews, the safety team at MaineDOT developed and implemented a safety idea incentive program in 2012.

The premise of the program was to collect safety ideas from the work crews around the state. The ideas were intended to be actionable ones that, if implemented, would reduce the risk to employees. The ideas included activities such as using automatic flaggers for work sites and painting lines on the sidewalks to indicate drop sites for snow and ice.

Every month, safety ideas were collected from work crews and evaluated at the regional level. The regional safety committees selected one winner from that region. The winner was selected by the committee based on the idea deemed to be most actionable and valuable to reducing the risk of the employees. The winning crew received 50 points per person in the committee. The winning ideas from each region were sent to the state safety office, where a statewide winner was selected. The same process that selected the regional winner was used to select the statewide winner. The crew that submitted the statewide winning idea received an additional 50 points per person. If any of the winning ideas were implemented statewide, the crew that submitted that idea received additional points.

The points were the incentive aspect of the program. Each 50 points equated to about $25. The points could be used to purchase safety-related items from a provided catalog. The custom catalog, created by MaineDOT, included items from various vendors. The catalog contained options for safety gear such as high-reflectivity shirts and jackets, winter gear such as hats and coats, and personal gear such as flashlights and tape measures. These items all contained the phrase “Safety Wins” on them to indicate they were acquired through the safety incentive program.

In addition to the crews receiving the incentives from submitting winning ideas to the program, the monthly regional and statewide winning ideas were published on posters that were distributed to the regional offices around the state.

Ultimately, the program was active for 3 years (2012–2014). Toward the end of the program, many of the safety ideas that were being submitted were repeats of previous ideas, and MaineDOT management was less involved with the process because many of the best ideas had been implemented. Many of the safety improvements made during the program are still in place statewide today, including the poisonous plant pocket guide, the inclusion of tick removal kits in first aid kits, and painting boxes on sidewalks to mark snow and ice drop zones. The safety officials at MaineDOT are shifting resources from this program to other programs that will continue to effectively engage state employees and reduce the risk to the state DOT workforce.

Data Sources, Archiving, and Analysis

The primary data source accessed for the safety idea incentive program was MaineDOT workers who participated in the program and submitted the safety ideas. As the ideas were submitted on a monthly basis, they were collected at the regional level and analyzed by a safety committee. This analysis yielded a regional winner, and the ideas were sent to the statewide safety office. At the state level, the safety ideas were analyzed again and a statewide winner was selected. Throughout this process, the ideas were collected and maintained in a database. This archival process also kept track of the number of ideas that had been accepted for statewide implementation and notes associated with some ideas that included barriers to implementation.

To complement the archival of the safety ideas, MaineDOT also collects statewide data on ten performance measures, such as incident rates and severity rates. These statistics serve as a quantitative metric for analyzing safety in the state. It is the combination of these data sources that identify and address perceived risks and document the actual incidents that occur that allows the state to effectively manage the risk experienced by the agency’s employees.

Monitoring and Evaluation

It was important for MaineDOT to consistently monitor and evaluate the safety incentive program to ensure that the funding for the program was being used as effectively as possible. By having a short turnaround time (1 month) for each of the safety idea competitions, the feedback on the program and the data collected were updated frequently.

The program was evaluated by the number of safety ideas received from the work crews each month. Some work crews were more involved with the program than were others. By having multiple ideas per region, the friendly competitive spirit among the work crews was higher, and the awareness of the program was also higher. Therefore, the number and quality of ideas were monitored by the officials administering the program.

In addition, the number of safety ideas that were implemented regionally or statewide was an indicator of the health of the program. Many of the regional ideas were implemented, particularly in the region where the safety idea originated. Statewide implementation was the most important metric of the effectiveness of the ideas because it indicated that the statewide administration personnel were invested in the valuable safety suggestions being proposed by the work crews.

Ultimately, effective monitoring led to the program being canceled in 2014. By recognizing that the safety ideas being submitted were starting to become repetitive, the officials in charge of the program realized that it might be valuable to turn the monetary resources to another safety program. As the ideas became more repetitive and the more pressing safety issues had been addressed, the regional managers were not as involved and fewer ideas were being implemented statewide. Therefore, the time and energy expended for the program became too great for the safety benefits, and the attention of the safety officials at MaineDOT turned to other programs.

Effectiveness of Safety Programs, Policies, and Practices

Several things indicated that the safety idea incentive program was an effective safety policy. The most obvious was the practical implementation of the safety ideas that were being proposed by the various work crews, especially at the statewide level. In addition, quarterly reports of safety statistics were distributed to the work crews to maintain awareness of the safety incentive program and, on a broader scale, remind the crews of the inherent risks associated with their jobs.

Even after the program was canceled by MaineDOT, elements of the success of the program continued to be evident. Primarily, during the duration of the program, many safety improvements were made statewide. These improvements continued to be implemented in the aftermath of the program. Therefore, even though the program no longer exists in practice, the risks the employees are exposed to on jobsites are less because of the time the program was active. In addition, the gear that was available to the employees as incentives for the program is still used by some of the crews that submitted winning safety ideas.

A safety representative of MaineDOT stated that it was “a cool program, but you know, everything wears out after a while.” This self-aware statement is a sign of a healthy safety program. By recognizing that the program had run its course, the safety team at MaineDOT began to focus its resources on a similar but different safety program. The new program, which is in the implementation phase, is establishing team awards for good safety records, such as no lost time and so forth. A program keeps the same spirit of the safety incentive program alive while approaching it from a different perspective to achieve continued involvement in MaineDOT safety initiatives.

Suggestions for Safety Programs, Policies, and Practices

It is important that an effective safety program be diverse and broad to account for the greatest variety of high-risk scenarios that employees of state DOTs encounter on a regular basis. MaineDOT’s safety program recognizes the importance of this idea and has developed a safety program responsive

to employee needs. The MaineDOT safety program, and particularly the safety incentive program, highlight the following suggestions:

- Monitor the safety program throughout its duration to assess the continued success of the effort.
- Understand that these safety programs may not be permanent, and know when it is time to shift focus to other strategies.
- Maintaining the agency management's participation in the program is vital to its continued success.
- Look for safety initiative ideas from the work crews themselves because the individuals who assume the most risk are also likely to contribute valuable insight on the most effective ways to mitigate that risk.
- Integrating work crew members into the safety management process helps to gain interest and buy-in from the workers regarding safety and improves the safety climate within the organization.

NORTH DAKOTA

DOT Size and Description

The North Dakota Department of Transportation (NDDOT) is one of the smaller state DOTs and has only approximately 1,100 employees (North Dakota State Government 2016). The responsibilities of the agency are broad and primarily include maintaining more than 8,500 mi of roadways and more than 4,800 bridges throughout the state as well as managing vehicle registrations and licensing. In addition, the agency has a role in the capital planning of highway, rail, transit, bicycle, and pedestrian facilities in North Dakota (NDDOT 2016). Despite a large section of the department being involved with the vehicle registration and licensing branch of the agency, it is estimated that between 60% and 70% of NDDOT employees are regularly on construction or maintenance sites, thereby being exposed to the higher safety risks associated with work tasks in these areas.

Safety Risk Mitigation Policies and Practices

NDDOT's safety program is committed to minimizing safety risk for the state employees while still allowing the agency to perform its necessary function for the citizens of North Dakota. The safety program is thorough and, when an incident involving a highway worker in a roadway work site occurs, the agency takes many postincident steps to document and learn from the incident. The steps undertaken involve those that create internal documentation of the incident for the agency. These include preparing initial incident reports and worker injury claims. NDDOT also informs the proper stakeholders, such as law enforcement and the insurance policy provider, that the incident occurred. Other steps include interagency communication, such as conducting incident review meetings, postincident investigations, uploading incident information to a lessons learned database, and communicating the lessons learned statewide. The remaining steps include implementing return-to-work initiatives, reviewing and modifying policies and procedures, and updating job safety analysis (JSA) documentation regarding the incident.

All of these postincident steps are taken by NDDOT for any incident that occurs in a work site. These incident types include those that involve public automobiles encroaching into the work site, those that involve on-site construction and maintenance vehicles and equipment, and those that involve on-site hazards (e.g., worker injury from a slip, trip, or fall).

The statewide safety office at NDDOT is responsible for compiling and archiving the incident reports, which ensures that all of the collected data are maintained under a single jurisdiction. This office is also working to adjust current practice and policy for some aspects of the safety program to further focus on leading indicators.

Leading Indicator Initiative

This case example highlights two parts of NDDOT's general safety program. The first is an agencywide push to focus more on being proactive in employee safety and not only react to incidents after they occur. The transition to proactive safety initiatives has led NDDOT to establish leading indicators

to be monitored and evaluated along with the traditional lagging indicators. The motivation for this change stemmed from similar initiatives being used in the plains region of the United States among private construction and maintenance firms. The following three points are the primary lagging indicators that NDDOT analyzes to evaluate and inform its safety program (NDDOT 2016):

- Incident rates,
- Experience modification rates associated with workers' compensation insurance premiums, and
- Motor vehicle accident rates.

The first step in the transition to relying more heavily on leading indicators was to identify which would be recorded and analyzed as part of the safety program. Several of the leading indicators include recording employee participation in various programs such as self-inspections, first aid/CPR training, the near miss program, and employee suggestion programs. Other leading indicators reflect the activities of employees with respect to safety, such as employees performing safety audits and leading pretask plan meetings. Still others include attendance at safety committee meetings and daily/weekly safety meetings. The combination of these many factors comprises the bulk of the leading indicators being monitored by NDDOT.

One particular aim of this initiative is to shift the safety culture away from finding fault in incidents. By focusing on the prevention measures for future incidents, the understanding of safety becomes a more future-oriented, proactive task rather than a reactive one. This effort is being motivated in part by needing employees to buy into the leading indicator idea.

A visible manifestation of this agency trend toward leading indicators is the implementation of the Job Hazard Analysis, a worksheet that is consistent with the industry standard JSA. A copy of the blank worksheet, courtesy of NDDOT, is included in Appendix E. The purpose of the worksheet is to document the various tasks that are accomplished by field personnel and identify the potential hazards associated with the task, which include issues related to the work location, the environmental hazards, and particularly risky characteristics of the task. One section provides a risk rating table so that the activity can be rated in relation to other risky tasks that could be undertaken and employees warned of the risks associated with the task. This risk rating table is shown in Figure 27.

The worksheet also includes a list of applicable precautions to be taken by the NDDOT employee for the task and the equipment that is recommended to complete the task safely. The final portion of the JSA is a description of the process that should be undertaken by the NDDOT employee to complete the task as safely as possible.

Return-to-Work Initiative

The second part of the safety program highlighted is NDDOTs return-to-work initiative. This initiative is being implemented concurrently with the leading indicator initiative, and both have overlapping

RISK RATING TABLE

This table is used to calculate whether the hazard you have identified is **Extreme: 9-10** **High: 7-8,** **Medium: 5-6** or **Low: 3-4**

The objective of rating the risk is to lower the risk by initiating risk control measures. The score is noted in the JSA risk score column on the next page – both before & after risk control measures have been nominated.

Likelihood: How likely is it to be that bad?	**Consequences:** how severe an injury?			
	Death	Serious Injuries	Medical Treatment Required	1st Aid Required
Almost Certain - Expected to Occur	10	9	8	7
Likely – could happen sometime	9	8	7	6
Moderate – could happen but not likely	8	7	6	5
Unlikely – *could* happen but very rare	7	6	5	4
Rare - *could* happen but probably never will	6	5	4	3

FIGURE 27 NDDOT JSA risk rating table. *Source*: NDDOT Job Hazard Analysis Form 2016.

goals. The primary leading indicator aspect of the return-to-work initiative is implementing an ergonomic assessment for all new hires in the state DOT.

The goal of this initiative is to be proactive in determining potential issues that could arise with a particular person in a particular position. At this point, this initiative has been implemented only in the vehicle registration and licensing area of the state DOT. An ergonomic assessment is conducted for any new employees working in the vehicle registration and licensing area of the state DOT. The ergonomic assessment is an unusual aspect of a return-to-work initiative because, in general, no incident has yet occurred. However, the justification is that if the ergonomic assessment allows the agency to be proactive in limiting preventable incidents, the need to return to work will not be necessary. In addition, even if an incident occurs, the ergonomic assessment can be used to tailor a return-to-work plan for that particular employee based on his or her individual needs.

NDDOT has one insurance program that is required to cover all state employees. This requirement results in a close relationship between the insurance company and NDDOT. The safety program takes advantage of this relationship to help implement programs such as the ergonomic assessment as part of a return-to-work initiative. The safety personnel can work in conjunction with the insurance company to promote and implement this plan, further increasing agencywide awareness of the initiative. The return-to-work initiative is in its early stages, but it is hoped the program will become more accepted and be implemented statewide for a range of employees and tasks.

Data Sources, Archiving, and Analysis

One of the primary data sources available for the leading indicator initiative is the state JSA form. This form is a valuable data repository for various tasks that are performed by NDDOT workers and contains detailed information about hazards and risks associated with a particular activity. However, the collection of the forms themselves serves as another data source. The more forms that are completed and archived, the more that leading indicators are recognized by the state employees and accepted as a part of the agency's safety culture. This results in a higher likelihood of safer outcomes and improvements in lagging indicators.

In addition to the collection of these worksheets that highlight the potential risk of various tasks, NDDOT has access to several data sources regarding highway worker safety and incidents and uses all of the available sources in its safety program implementation. These sources include incident reports, worker insurance claims, safety training records, medical records, and fatality/injury data. NDDOT integrates these sources to facilitate programmatic decision making to plan and mitigate risk and loss. The safety team is fortunate that for the data sources that are used, the data are available quickly after an incident. For most of the data sources, the information is available within 1 month of the incident. Only the safety training records, which can take more than 1 year to become available, are not available for quick analysis.

Monitoring and Evaluation

One of the challenges associated with focusing a safety program around leading indicators is that the indicators are more challenging to quantify and evaluate for their effectiveness. Therefore, the agency will continue to monitor the same lagging indicators evaluated previously. This effort particularly involves the understanding of incident rates and general trends associated with those rates. In addition, the monetary indicator for the insurance premiums is of particular concern to the agency officials, who want to ensure that North Dakota's tax dollars are well spent.

Another step taken by the agency is to determine the employee perspectives on the safety initiatives. To do so, NDDOT distributes an agencywide employee satisfaction survey. The results of this survey indicate that the safety programming elements of the agency have the highest satisfaction among the state DOT employees. In particular, employees are supportive of the trend of removing fault finding in the aftermath of incidents.

As the programs continue to be implemented and adjusted statewide, the monitoring and evaluation process will be further developed. Ultimately, lagging indicators, such as injury and fatality rates, will be used as a check on the impact of the full safety program that NDDOT has implemented to protect its workers.

Effectiveness of Safety Programs, Policies, and Practices

Because the safety programs described are still in the development phase, it is too early to ascertain the long-term effectiveness of the implementation of these initiatives. The implementation of the leading indicator initiative is only 60% to 70% complete, so the full results are unknown. Although leading indicators are more challenging to assess, the continued use of lagging indicators can partially demonstrate any effects the use of leading indicators among employee safety efforts may be having.

The first of these lagging indicators is the agency insurance premiums. This is a visible indicator and represents a significant budget item for the agency. As the focus at the agency has shifted to leading indicators, the insurance premiums have decreased, suggesting a perceived reduction in risk (and potentially a reduction in incidents) from the perspective of the insurance provider. Over the last 6 years, the agency has seen a decrease of 50% in their insurance premium. This change is a significant difference, bringing attention to the efforts of the safety officers at NDDOT.

The safety team at NDDOT also has determined that agency administration support is necessary for effective implementation. Initially, they received some skepticism for their program ideas. However, the team found that they received increased support from the administration because of positive outcomes of programs (from both the perspective of a more respected safety culture and the direct monetary savings from insurance). This recognition has resulted in the safety team being granted more autonomy to implement other "out of the box" initiatives aimed at improving safety within the agency.

Of the standard postincident steps that NDDOT takes after an incident, a few are particularly valuable to the effectiveness of the state's safety program for its workers. For all of the types of work site incidents (public automobile, on-site vehicle/equipment, and on-site hazard), NDDOT finds that the preparation of initial incident reports, preparation of worker injury claims, and return-to-work initiatives are effective and valuable to the overall safety program at the agency. For incidents that involve on-site construction and maintenance vehicles and equipment and those that involve on-site hazards, the steps of informing the insurance provider, communicating lessons learned statewide, and updating the JSA are effective.

Suggestions for Safety Programs, Policies, and Practices

The management of a successful safety program results from a variety of factors. These factors are necessary in the implementation stage of an initiative as well as the continued maintenance of a program. For NDDOT, the following suggested practices increase the possibility of having a successful safety program:

- Demonstrate to agency administration the benefits of safety initiatives to improve interagency relations and establish trust for the implementation of future programs.
- Transition data analysis from lagging to leading indicators through efforts such as a JSA for various work tasks.
- Shift agency culture from finding fault in incidents to finding solutions to prevent similar incidents.
- Collaborate safety initiatives across departments to take advantage of various pockets of expertise and success.
- Take advantage of opportunities to promote safety programs throughout the agency to educate employees about the benefits.

OREGON

DOT Size and Description

The Oregon Department of Transportation (ODOT) is an intermediate size DOT and is responsible for constructing and maintaining the multimodal transportation system in Oregon. The mission of ODOT, as stated on its website, is "to provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians" (ODOT 2016). To achieve this mission, ODOT has developed the following goals, which are published on its website (ODOT 2016):

- Safety—Engineering, educating, and enforcing a safe transportation system;
- Mobility—Keeping people and the economy moving;
- Preservation—Preserving and maintaining infrastructure;
- Sustainability—Sustaining the environment and livable communities; and
- Stewardship—Maximizing value from transportation investments.

As a large transportation agency with more than 4,500 employees, ODOT has a series of diverse public service roles within the state. The agency is divided into nine separate divisions that each serve a role in achieving the mission of the organization. The divisions, which correspond to the different transportation systems the agency oversees, are as follows (ODOT 2012):

- Central Services Division,
- Communications Division,
- Driver and Motor Vehicle Services Division,
- Transportation Development Division,
- Public Transit Division,
- Rail Division,
- Motor Carrier Transportation Division,
- Transportation Safety Division, and
- Highway Division.

The abundance of divisions performing various tasks indicates the level of responsibility entrusted to this agency. The largest of these divisions, the Highway Division, is responsible for maintaining more than 8,000 mi of roads and 2,700 bridges. In the 2010 to 2011 construction and maintenance season, almost $350 million of project funds were awarded for 145 projects around the state (ODOT 2012). These projects require that ODOT personnel be active in highway work sites. In total, it is estimated that 30% to 40% of ODOT's 4,500 employees are regularly in construction or maintenance work sites.

Safety Risk Mitigation Policies and Practices

Given the breadth of responsibilities that ODOT has in the different modes of transportation, the safety program is integrated into all of the different divisions and manifests itself in different ways to adapt to the requirements of each particular division. The following policies are specifically related to safety procedures and initiatives implemented in conjunction with the risks inherent with working in highway work sites.

When an incident occurs in a work site that is managed by ODOT, the following steps are taken depending on the type of incident. If the incident involves a public automobile (e.g., a work site crash), only two postincident steps are conducted by the agency: preparing an initial incident report and informing law enforcement. When an incident occurs in the work site that results from on-site construction and maintenance vehicles/equipment or other on-site hazards, ODOT implements the same steps for both of these types of incidents. These steps are numerous and include preparing an initial incident report, assisting workers to prepare a worker injury claim, informing the insurance policy provider, informing the state OSHA office (when there is a hospitalization or a fatality), conducting an incident review meeting, uploading findings to the incident tracker database, communicating the

lessons learned agencywide, implementing return-to-work initiatives, and reviewing or modifying policies and procedures indicated by the postincident analysis.

Of the steps that ODOT implements in the aftermath of an incident, the steps of preparing the worker injury claims, informing the insurance policy provider, and informing the state OSHA office were indicated by the interviewee to be the most valuable to ODOT's safety program.

The incident reports, which are created in response to incidents that occur in a highway work site, are compiled and archived centrally at the statewide human resources office and the statewide safety office. These reports are archived in various formats, including online databases, electronic files (e.g., pdf file), and paper copies. The reports are housed in the human resources office and accessible by safety staff electronically. For the archived incident reports, the reports are categorized by employee functional area and the type of injury sustained in the incident.

One of Oregon's initiatives that is specifically related to highway work zones is the semiannual meeting of the Oregon Work Zone Executive Strategy Steering Committee (OWZESSC). ODOT is one of the partners of this committee, which is specifically highlighted in the following sections of this case example as an example of a multiagency partnership that is focused on work site safety in Oregon.

Oregon Work Zone Executive Strategy Steering Committee

One of the more visible and unique aspects of Oregon's safety program relating to highway work zones is the OWZESSC. This committee, which was established in December 2013, is an initiative to focus on improving work zone safety by potentially adjusting work zone policy in Oregon. One of the motivations for this committee was a 2013 construction contractor fatality in a work zone. The event sparked discussion among transportation officials regarding how to enable vehicles (particularly heavy vehicles and commercial loads) to move more safely through work zones.

The OWZESSC was designed to have a partnership with state agencies and private organizations that all have an interest in work zone safety. The committee currently has representation by officials from the following six groups:

- Oregon Department of Transportation (ODOT);
- Oregon Trucking Association, Inc.;
- Associated General Contractors, Oregon Columbia Chapter;
- Oregon State University;
- American Automobile Association; and
- Oregon State Police.

Three task forces and one resource team were established among the committee members to address specific identified needs. The task forces are Separation and Mobility, Law Enforcement, Engineering Enhancements, and Communications Resource Team. Each task force is responsible for developing and proposing ideas for improving work zone safety. The ideas are presented at committee meetings for discussion by the full committee. Ideas found to be promising are further developed and implemented.

The committee is not "owned" by any one of the partner organizations, but it generally is hosted by ODOT. Members from each of the six partner groups meet semiannually to discuss priority work zone safety issues and establish statewide policy and goals for improving safety in highway work zones. The committee disseminates its initiatives to the various agency and organizational partners to communicate the changes to the individuals who work in or around work zones on a regular basis.

Model Structure and Data Sources

Although the OWZESSC is effective at mobilizing the leadership of the involved partners and working to promote work zone safety throughout the state of Oregon, the initiative is less data driven than

are some in that Oregon's work zone fatal and serious injury crashes have decreased over the last 10 years or so. Data were available with regard to similar committees during the implementation process to serve as a model for how to structure an effective committee.

Various officials with an interest in work zones and work zone safety saw an opportunity for an interagency partnership dedicated to work zone issues. In the development of the committee, there were several models of existing committees that had the desired structure of the proposed OWZESSC. In Oregon, existing governor's advisory committees (GACs) focus on aspects of transportation safety, such as motorcycle safety and driving under the influence of intoxicants. These committees, unlike the OWZESSC, are established through executive order by the governor of Oregon. However, the multiagency elements of these committees served as an example to the OWZESSC partners of the diverse committees with structures similar to a task force. Washington State had a similar multidisciplinary committee that dealt with issues relating to work zone safety. These existing committees served as the basis for the structure of the OWZESSC.

Monitoring and Evaluation

Given the nature of an executive committee, there are few tangible metrics for monitoring and evaluating its function and effectiveness. However, for the committee to remain effective, it will continue to conduct its regular semiannual meetings. Continuing participation of all six of the groups is necessary for its effectiveness. For the committee to be successful, active contribution from each of the partners is critical to maintaining a balanced and focused effort at improving safety in Oregon's work zones.

The volume of communication distributed from the committee as a result of the regular meetings is another method of monitoring the committee's activities. A newsletter is distributed after the quarterly meetings to highlight the committee's activities and promote the initiatives being discussed. Appendix F contains the full text of a 2015 ODOT newsletter that describes the activities and specific initiatives that are products of the OWZESSC. In summary, the article discusses how the OWZESSC is working to balance mobility within a work zone with the safety of the workers and that of the traveling public. In addition, the article highlights the engineering efforts being undertaken to improve work zones. This newsletter, and others like it, are a reminder to the employees of the involved groups of the work being done to improve worker safety in work zones.

Effectiveness of Safety Programs, Policies, and Practices

Because the OWZESSC has been in place for only a few years, it is perhaps too early to determine if the committee will be an effective long-term force in improving safety in highway work sites. However, there are some indications the committee's presence is having a positive effect on work sites. An ODOT safety official indicated that one of the effects of the committee has been a "real heightened awareness about the importance of safety in those settings [like] ODOT construction work [and] ODOT projects that are being constructed by contractors." Part of this increased awareness is the result of communication efforts from the OWZESSC.

The newsletter distributed to the ODOT employees that contains information about the committee's activities is distributed electronically and posted on bulletin boards for employees who do not have regular computer access. In addition to the newsletter, there is regular e-mail communication from the ODOT director and the Highway Division administrator regarding safety initiatives at ODOT, including safety initiatives relating to highway work sites. Through these means, reports of the activities of the upper management of ODOT are effectively distributed to the entire agency to help ensure the maintenance of an active safety culture at the agency.

Another aspect demonstrating the effectiveness of the committee is the education and promotion aspects of the committee. One of ODOT's construction managers has prepared a presentation on the OWZESSC and delivered the presentation to various groups within ODOT and outside of the agency to promote the activities of the committee and educate people about the efforts the committee has made to improve work site safety and mobility.

Suggestions for Safety Programs, Policies, and Practices

The implementation of a committee with the highest officials from various organizations and agencies throughout ODOT is a powerful tool for promoting work site safety from the top down in Oregon. The following points highlight some of ODOT's suggested policies and practices regarding the implementation of safety initiatives such as the OWZESSC:

- Create partnerships and relationships with public agencies and private organizations to work cooperatively to achieve mutual goals.
- Effective communication and coordination from the state DOT top management to the rest of the members of the agency is vital for the success and support of a safety initiative.

Involving upper management in the efforts to improve work site safety allows the agency leadership to directly invest in this important issue.

SOUTH CAROLINA

DOT Size and Description

The South Carolina Department of Transportation (SCDOT) is responsible for the operation and maintenance of the fourth largest state-maintained highway system in the nation, including more than 41,000 mi of roadway and 8,400 bridges. SCDOT has approximately 4,350 employees, thousands of whom serve in the maintenance and construction divisions and work in stationary and moving work zones on a daily basis; there are also numerous contractor personnel in stationary and moving work zones on a daily basis. The agency describes is statutory mission as follows:

> SCDOT shall have as its functions and purposes the systematic planning, construction, maintenance, and operation of the state highway system and the development of a statewide intermodal and freight system . . . the goal of the department is to provide adequate, safe, and efficient transportation services for the movement of people and goods (SCDOT 2016).

Safety Risk Mitigation Policies and Practices

In addition to these general policies and practices, SCDOT implemented several signature safety initiatives from 1999 to 2007 to reduce employee injuries and fatalities in work sites. The following section discusses the 27 in 7 Program that SCDOT implemented statewide to improve the state's infrastructure. Subsequent sections discuss the specific worker and motorist safety initiatives implemented from 1999 to 2007 as a result of the increased construction and maintenance work in the state.

Although South Carolina had programs and efforts in place to prevent employees being involved in work site incidents, despite best efforts, sometimes these incidents occurred. SCDOT had specific policies and procedures for the steps that were to be taken in the aftermath of a work site incident. For any incident involving an employee in a work site, whether the incident was the result of a public vehicle intruding into the work site, on-site vehicles or equipment, or an on-site hazard, the postincident steps taken to record and report the event were the same. These first steps included preparing the initial incident report and preparing the worker injury claim. Several groups were notified of the incident, including law enforcement as appropriate (if the incident involved a public vehicle/work zone crash), the insurance policy provider, and the appropriate OSHA office.

The final steps included a postincident investigation and a review of current policies and procedures to determine if it was necessary to modify them to prevent similar incidents in the future. The lessons learned were shared with the senior management of the agency in combination with the recommendations for changes that potentially could prevent future incidents. The state also implemented a return-to-work initiative to minimize the amount of time injured employees needed to be away from the job without compromising their safety.

During the program that ran from 1999 to 2007, incident reports that were completed in the aftermath of an incident were compiled and archived by the statewide SCDOT Safety Office. These reports were archived and categorized in an online database, known as the Risk Management Database; there was electronic documentation (e.g., pdf file) and a paper copy.

27 in 7 Program

In 1999, SCDOT initiated an extremely aggressive and innovative program to complete 27 years' worth of construction and maintenance projects in only 7 years. SCDOT contracted with two construction and resource management firms to implement the program. At the time, this public–private partnership was the largest of its type in the United States (FHWA 2016e). It was estimated that the 27 in 7 Program would increase the number of construction and maintenance work zones by as much as 400%. SCDOT was concerned about the safety of its employees in these construction and maintenance work zones, as well as the safety of the motoring public. This concern prompted an aggressive work zone safety initiative. The rapid increase in the number of construction and maintenance work sites in the state made it necessary to develop a program that was data driven and able to adjust quickly based on timely analysis of available data. Therefore, the foundation of the initiative was a database that could be cross-referenced and could produce reports on a timely basis. This allowed SCDOT safety officials to see what the data were showing so they could modify implementation efforts to meet the agency's strategic plan and the Safety Office's business plan goals and objectives.

"Let 'em Work, Let 'em Live" High-Visibility Work Zone Safety Enforcement Campaign

As an element of improving work site safety during the 27 in 7 Program, an aggressive, high-visibility statewide public information and education (PI&E) campaign was undertaken to promote safe driving in construction and maintenance work sites. When SCDOT developed the PI&E campaign, the first focus group was made up of SCDOT highway workers. The major concern they expressed was that "drivers were flying through the work zones . . . we are so scared we were going to get killed because people ignore the signs to slow down . . . they act like nobody is even there, they are not paying attention." This suggested a high degree of concern by SCDOT highway workers. Conversely, when the motoring public was interviewed in focus groups, nobody thought there was a problem within work sites. Based on the polar opposite beliefs, a campaign was created to put the public in the place of highway workers.

The overarching PI&E campaign slogan was "Let 'em Work, Let 'em Live." The campaign involved high-quality television public service announcements, radio ads, billboards, brochures, citation holders, and other materials. The television ads were the central focus of the campaign. They were highly creative and often put the motorist in the place of the highway worker, using some highly complex video graphics techniques. Some ads told the stories of workers killed in work zone crashes; others told the stories of motorists killed in work zone crashes. The total campaign included a series of ads, with messaging updated and changed to address what the data and campaign research information were showing at the time. The PI&E campaign was created, evaluated, and adjusted based on yearly focus groups conducted in different locations in the state, a statewide random digit dialing survey of a sample of motorists; and findings from an annual report of work zone safety statistics compared with previous years' data. Overall, findings indicated the campaign was well received by South Carolina residents and had a significant impact on perceptions and self-reported behavior by motorists traveling through work sites (SCDOT 2004). During the active campaign, 32 other states adopted elements of the SCDOT work zone safety campaign.

Safety Record Competition

In addition to educating the public about the safety issues in work sites, the state encouraged safe behavior among its employees. An annual safety record competition was held among all the counties in each of the agency's seven highway districts. The county with the best safety record was recognized during a luncheon, during which the agency director served as the keynote speaker. In addition, the state

highway engineer and the director of the Safety Office spoke and presented an award to the winning county. The employees of the winning county also received a special cash bonus. The structure of the award, bonus, and recognition program helped promote friendly competition to raise safety performance. The initiative was meant to ensure a balanced safety approach that took advantage of various opportunities and constituencies to improve safety for highway workers and the traveling public.

Other Components of the "Let 'em Work, Let 'em Live" Work Zone Safety Program

Numerous other components of SCDOT's comprehensive Work Zone Safety Program are not discussed specifically in this case example but contributed to the overall success of the program. These included the following.

- A Work Zone Safety Committee met quarterly to provide guidance and direction to the program. The Committee included key SCDOT personnel from various divisions, law enforcement representatives, emergency medical services representatives, and representatives from Carolinas Associated General Contractors.
- A mandatory comprehensive work zone safety training program provided flagger training, general work zone safety operations training, and three levels of work zone safety supervisor training for both SCDOT employees and contractor personnel.
- Testing of new equipment to improve work zone safety, including various types of signage and lighting was done, as was testing of lidar and other speed monitoring equipment.
- "Let 'em Work, Let 'em Live" signs were placed in advance of all long-term work zones across the state. The use of these signs continues today.
- A pocket-size employee safety manual was developed, adopted, published, and distributed to all SCDOT employees in conjunction with training.
- The National Work Zone Safety Memorial was shown on a statewide tour, which was combined with news conferences that involved family members of SCDOT employees killed in highway work zones.
- A state fair exhibit featured a miniature highway work zone that children and adults could "drive through" and learn about work zone safety.
- The statewide "Cruisers Curriculum" was developed by Clemson University and implemented in elementary, middle school, and high schools across the state. The curriculum included units on work zone safety, safety fairs at the school level, and classroom activities and speakers.
- News conferences with hundreds of highway workers, emergency medical services officials, and local and state law enforcement were held regionally across the state with each release of new television ads or key materials and products. Speakers in each region were local to the area in an effort to gain more news coverage.
- Local law enforcement and the South Carolina Highway Patrol used blitz enforcement, in the "Click It or Ticket" style, in highway work zones. Tickets were issued in special citation holders that explained why the driver was getting the ticket and the importance of work zone safety. Blitz-style enforcement waves were held periodically throughout the year. Participating agencies were eligible for incentive prizes, such as new radar units, new in-car video camera equipment, and other enforcement-oriented prizes. Statewide meetings were held with local and state law enforcement to explain the procedures for the program, provide the latest data and statistics, and coordinate blitz wave schedules.
- Sign displays or table tents explaining how to travel safely through work zones were designed, printed, and placed in restaurants, banks, and hotel rooms across the state.
- Brochures telling the real-life stories of SCDOT employees and members of the public who were killed in highway work zones were printed and distributed.
- A DVD telling the story of an SCDOT employee, nearing retirement, who received incapacitating injuries in a work zone crash was produced and distributed to schools and churches across the state to show in classrooms and youth meetings.
- Teleconferences regarding highway worker safety were coordinated with North Carolina and Georgia. Fourteen sites were set up in South Carolina for SCDOT employees to participate.
- Roadway signs showing the children of SCDOT employees and containing the message "Please slow down—my dad (or my mom) works here" were posted in highway work zones. SCDOT

employees were invited to submit photos of their children for selection for the signs. Children were selected from each highway district to have their individual photo on signs in that district. Television ads were created to accompany the signs, with children of employees imploring the public to please slow down so their mom or dad could come home after work.
- Leveraged media buys were made for television and radio advertisements; this saved the state thousands of dollars and resulted in prime time slots at approximately $39 per slot. An agreement with the state's outdoor advertisers resulted in the state paying fees only to post the boards, with no charges levied for the advertising space.
- Quarterly inspections of long-term work zones were done to ensure that their setups and operations were in compliance with the MUTCD and SCDOT requirements.
- New legislation was introduced and adopted by the South Carolina General Assembly that increased fines and penalties for speeding in work zones. SCDOT Safety Office staff worked with the General Assembly members to get the legislation introduced and gave testimony before legislative committees. They also provided facts and statistics as needed to demonstrate the need for the legislation.

Data Sources, Archiving, and Analysis

SCDOT used various sources of data for its specific safety initiatives. SCDOT leveraged traffic collision data, compiled first reports of injury, collected lost work day case information, computed the lost work day case rates, calculated the actual economic cost from the first report of injury and crash data as appropriate, and calculated the actual amount of payouts from the lost work day cases, as well as the estimated losses from the collision data. This information was compiled from data sets provided bimonthly through the state's Traffic Collision Database (operated by the SC Department of Public Safety); the Crash Outcomes Data Evaluation System (CODES) (operated by the South Carolina Office of Research and Statistics, South Carolina Budget and Control Board); and the SCDOT Risk Management Database (administered by the SCDOT Safety Office, which included risk management, claims, and OSHA units). SCDOT employees developed the Risk Management Database internally without benchmarking against other state DOT practices at that time. Beyond these databases, SCDOT also conducted focus group studies to collect public perception data on the PI&E work zone safety campaign that was being conducted. The collection and management of these data sources contributed to SCDOT's ability to improve highway worker safety in the state.

Monitoring and Evaluation

Given the fast pace of the 27 in 7 Program and the subsequent safety initiatives developed as a result of the increased volume of construction and maintenance sites, the ability to effectively monitor and quickly evaluate the current effectiveness of the programs was critical to the safety of the increased number of state employees and contractor personnel working in highway work sites. The safety officials believed that data-driven monitoring, which would give greater justification for decisions, would be the most effective for evaluating safety programs.

The development of a comprehensive set of cross-referenced databases allowed for accurate quantification of work-zone–related crash statistics and the identification of causal relationships. An example of data analysis between 2004 and 2008 shows that there were 5,444 traffic crashes in South Carolina that were work zone related. In total, 56 people died in these crashes and an additional 2,296 sustained nonfatal injuries. The leading probable cause for work-zone–related crashes from 2004 to 2008 was driving too fast for conditions, with 1,585 such crashes being recorded. The next five leading causes were failure to yield right-of-way (834); driver inattention (626); following too closely (540); improper lane change (386); and driver disregarding sign or signal (229) [SCDOT n.d.]. With the ability to quantify the incidents that occurred in work sites, SCDOT could understand the circumstances that resulted in incidents and effectively implement targeted responses to reduce the leading types of incidents.

To properly evaluate the PI&E work zone safety enforcement campaign, SCDOT needed to know if what the motoring public thought about work zones was changing because of the campaign. Survey

research data collected before and during the PI&E campaign were used to evaluate the campaigns. SCDOT used computer-generated random digit dialing to contact the public and take them through a survey process regarding their perceptions on work sites and specifically safety in work zones. In addition, SCDOT conducted focus groups in three different geographic regions of the state on an annual basis. Reports documenting the findings of the survey and focus groups were reviewed annually with Safety Office leadership and the research consultants. Appendix G contains the 2004 report from the focus groups and summarizes the results of the qualitative and quantitative findings from the focus groups regarding their views on the television ads SCDOT had been airing. This information was presented at the leadership meetings and used to determine how the messaging could be adjusted in the coming year to maximize the likelihood that particular incident outcomes and perspectives could be improved.

Effectiveness of Safety Programs, Policies, and Practices

Through activities such as the development of the comprehensive Risk Management Database, the development of high visibility PI&E campaigns, extensive work zone safety training for SCDOT and contractor employees, and the improvement of the safety culture across the agency, SCDOT was able to use data to show its loss history and use the SCDOT strategic plan and the Safety Office's associated business plan to demonstrate improvements in safety performance. Ultimately, the demonstration of reductions in serious injuries and fatalities and the presentation of the agency's comprehensive Work Zone Safety Program provided evidence to negotiate lower rates and lower insurance premiums. This demonstration was possible only because SCDOT was able to show its loss history and demonstrate the comprehensive approach that was being undertaken to reduce employee injuries and fatalities.

Some of the steps SCDOT took in the aftermath of an incident involving an employee in a work site were regarded as particularly effective in contributing to the success of the agency's safety program. These steps include thoroughly preparing the initial incident report, entering the information into the Risk Management Database in a timely manner, informing the appropriate OSHA office, and implementing a return-to-work initiative. Periodic safety data trend reports were issued to district engineering administrators, senior staff, and headquarters and district safety personnel that showed statewide and district statistics. Monthly briefings were held with headquarters and district safety personnel; these briefings included reviews of up-to-date data reports, discussions of specific injuries reported, and recommendations for methods to reduce or eliminate these types of incidents in the future. In addition, the reporting of lessons learned to senior management and providing recommendations for changes in policy based on the incident to prevent similar future incidents were found by SCDOT to be particularly valuable.

SCDOT's "Let 'em Work, Let 'em Live" Work Zone Safety Program was one of the winners of the FHWA 2007 National Roadway Safety Awards. In 2005, the program received a national award from the American Road and Transportation Builders Association (ARTBA). Data collected during the implementation period showed the following (SCDOT 2007):

- Employee injuries dropped by 30.44%, from 657 in 2000 to 457 in 2007.
- There was a 30.26% reduction in OSHA recordable cases, from 489 in 2000 to 341 in 2007.
- The OSHA incidence rate (average number of recordable injury cases per 200,000 h worked) decreased from 9.61 in 2000 to 6.68 in 2007, a 30.48% decrease.
- Lost workday cases decreased by 47%, from 268 in 2000 to 142 in 2007, the lowest lost time injuries in 18 years.
- The lost workday case rate (number of lost workday cases multiplied by 200,000 and divided by the number of man-hours worked) dropped from 5.27 in 2000 to 2.78 in 2007, a 47.24% reduction.
- During blitz enforcement periods, there was a 41.3% reduction in work zone crashes, a 40.9% reduction in work zone injuries, and a 52.2% reduction in work zone fatalities.

Suggestions for Safety Programs, Policies, and Practices

The increased exposure of SCDOT employees to the hazards of work zones from the 27 in 7 Program necessitated dramatic advancement in the safety program of SCDOT. A multifaceted approach, includ-

ing the development of several robust databases, an aggressive PI&E campaign, and shifts in the safety culture, contributed to improved work zone safety performance in South Carolina. SCDOT indicated the following suggested practices increase the possibility of having a successful safety program:

- High quality cross-referenced data are critical for being able to identify safety problems, develop mitigation strategies, and evaluate the impact of safety initiatives.
- Positively influencing the perceptions and behaviors of the motoring public is a vital component of a comprehensive work zone safety initiative.
- The implementation of a comprehensive work zone safety training program for highway workers, work zone supervisors, flaggers, and contractor personnel and that operates in conjunction with other components of the overall program is helpful.
- A robust safety culture in the state agency is a critical component of a robust work zone safety initiative, and its value cannot be underestimated.

WASHINGTON

DOT Size and Description

The Washington State Department of Transportation (WSDOT) oversees the state's multimodal transportation system, ensuring that people and goods move safely and efficiently (WSDOT 2016a). WSDOT is responsible for building, maintaining, and operating the state's highway and ferry systems. The agency works in partnership with other agencies (local, state, and federal) to maintain and improve local roads, railroads, and airports. WSDOT also supports alternatives to driving, such as public transportation, bicycles, and pedestrian programs (WSDOT 2016a).

The size of WSDOT and the state's transportation network can be illustrated using various metrics. The following metrics are reported on the agency's website (WSDOT 2016a):

- Operates and maintains approximately 18,000 lane miles of state highways.
- Owns, operates, and maintains more than 3,600 bridge structures.
- Runs the nation's largest ferry system, which moves 22.4 million passengers and 10 million vehicles a year.
- Partners with 32 public transportation systems to provide more than 220 million passenger trips a year.
- Owns three Talgo train sets in the Amtrak Cascades fleet and manages the Palouse River Coulee City Railroad.

In addition, WSDOT has approximately 7,000 to 8,000 employees throughout the agency, 60% to 70% of whom are regularly on construction and maintenance sites.

According to its strategic plan (WSDOT 2016b), WSDOT's mission is to provide and support "safe, reliable and cost-effective transportation options to improve livable communities and economic vitality for people and businesses." With respect to safety, one of WSDOT's values is to "promote the safety of the public and employees at all times." WSDOT has six agency goals, one of which (goal 2—modal integration) specifically addresses safety. A priority outcome for the goal is to "reduce number of fatal and serious injuries for all transportation modes." The multimodal safety strategy specified to attain this outcome is to "align multimodal safety policy-making across the agency" (WSDOT 2016b).

Safety Risk Mitigation Policies and Practices

WSDOT's safety program for its employees is multifaceted and extends agencywide in terms of locale and employee position within the agency. The safety program is founded on archived information associated with worker injuries and fatalities. This information is collected and disseminated through various means.

When an injury/fatality incident occurs, the supervisor prepares an initial incident report, and an incident review meeting is conducted with all involved and affected parties. In addition, a postincident

investigation is conducted to identify the issues surrounding the incident and cause(s) of the incident. As part of the incident review process, recommendations for how to prevent the incident from occurring in the future are solicited and developed. The findings from this effort are uploaded to a lessons-learned database for reference. In addition, the lessons learned are communicated statewide to inform all employees of the potential hazard(s), associated risk, and means of control and injury prevention.

The practices mentioned are in place for incidents that occur on a work site that do not involve a public vehicle or on-site construction and maintenance vehicle/equipment (e.g., worker injury from a slip, trip, or fall). For incidents that involve a public vehicle (e.g., work site crash) or on-site construction and maintenance vehicle/equipment, the protocol described is followed along with additional practices. The additional practices include preparing a worker injury claim; informing law enforcement of the incident when it involves a public vehicle; informing the state OSHA office; implementing a return-to-work initiative, and reviewing and modifying applicable policies and procedures to help prevent such incidents in the future.

The responsibility for compiling and archiving the incident reports and other information developed is spread across the agency. Offices charged with the duty include the Regional/District Maintenance Office, Regional/District Safety Office, and Statewide Safety Office.

Near Miss Reporting Program

WSDOT added an innovative near miss reporting component to its safety program within the past year. Modeled after a similar program developed by one of WSDOT's construction contractors, the near miss program aims to record near misses and generate ideas for eliminating the hazards that contributed to the near misses. No specific research was conducted by WSDOT to develop the program other than soliciting information about the contractor's program. Development of the program was informed by safety personnel within WSDOT based on their regular reading of articles on worker safety and new approaches to improving safety.

The near miss program is designed to encourage employees to provide information about near misses they experience and suggestions for preventing the near misses in the future. This program is not the same as that used for incidents resulting in an injury or fatality. The program initially was developed within a WSDOT region. The value of the program was recognized by WSDOT leadership personnel, who directed the expansion of the program statewide. The support provided by WSDOT leadership personnel is viewed as a significant contribution to its success. Currently the near miss program is implemented on all major projects in the state.

The near miss program has several parts. Employees who experience or witness a near miss are encouraged to provide a simple report containing a brief written description of the near miss, a description of the immediate actions taken to eliminate the hazard or mitigate the safety risk, and suggestions for preventing a near miss or injury in the future. The employee gives the report to his/her supervisor. The supervisor reviews the report, works with the employee to identify solutions, and communicates the information recorded to the safety personnel for review and analysis. In addition, the supervisor places the employee's name in a lottery for a drawing to win money or an item of some monetary value.

To enable communicating the details of the program and encourage implementing it in the field, WSDOT created a booklet that describes the program and provides guidance and forms for the workers. The instruction pages for the booklet are included in Appendix H. As shown in the figures, the booklet contains a definition of a near miss, a graphic depicting the frequency with which near misses occur relative to injury incidents of various severity (first aid only, recordable injury, serious injury, and fatality), and a list of safety strategy elements for preventing near misses. The safety strategy elements are commitment to excellence, employee driven culture, basics done well, focus on greatest potential improvements, and leadership support and accountability.

To further educate employees on safety management practices, the booklet presents five core functions of organizational risk management. The five core functions are define the scope of work,

analyze the hazards, develop and implement hazard controls, perform work within hazard controls, and provide feedback and continuous improvement. Safety risk management includes consideration of frequency and severity of injuries, which also are described in the booklet. Those using the booklet are presented definitions of low and high frequency and severity. Users are also asked to rate the frequency and potential injury severity of the near miss being reported.

To assist with the implementation process, the booklet includes a list of the steps associated with filling out a near miss report. Three steps are described as follows:

1. Submit a near miss or a safety suggestion to supervisor.
2. The supervisor works with employee to identify solutions.
3. Solutions may be implemented locally, regionally, or statewide.

The booklet is approximately 3 in. × 5 in. for ease of use and transport. The booklet was created with the assistance of personnel in the graphics department within WSDOT. It contains about 20 pages, including pages on which near misses can be recorded (see Appendix H). The Near Miss or Safety Suggestion Report form has fields in which the employee can record his or her name, the date and time, WSDOT organizational name and unit number, whether the incident involved personnel and/or equipment, a description of the near miss incident and immediate actions taken, and suggestions for preventing a similar occurrence of the incident. The report form usually takes no more than about 2 min to complete. After completing the report form, the employee gives the form to his or her supervisor. WSDOT is in the process of developing an online application that can be used instead of the report form.

As mentioned, the near miss program was developed within one region and then disseminated statewide with the assistance of WSDOT leadership personnel. Announcements about the program were first sent to key construction and maintenance personnel in each region. Promotional materials were developed and provided to the regional personnel. The program was communicated during normally scheduled, face-to-face meetings and during safety meetings. The communications described the program, how to use the booklet, how to fill out the report forms, who to give the booklet to, and how the overall near miss program works.

WSDOT has received about 35 near miss reports with suggestions from across the state. In the approximately 12 months since the near miss program started agencywide, some units within WSDOT have submitted four to eight reports, whereas only one report has been received from other units within the past year. The number of reports received is recognized as being affected by the extent to which management personnel within a region enthusiastically supported the near miss program when it was rolled out. More near miss reports and suggestions have been received from employees in the regions where greater support for the program was provided by regional management.

In some areas within WSDOT, the safety risk to employees is not high (e.g., for office staff). As a result, it is expected that some operational units will not have as many near misses, and fewer near miss reports will be generated. WSDOT has tracked this trend in the near miss reports generated. However, the near miss program is available to all operational units within WSDOT.

Some issues of concern were brought up during development of the near miss program. Unlike in private companies, in public organizations there often is sensitivity and reluctance to giving away money or gifts as incentives to employees. Care was taken to ensure that the incentive program was documented, fair/equitable, substantiated, and accessible by all employees. As a result, WSDOT elected to set the value of the lottery money/gift at $25. This was intended, in part, to limit concerns about excessive spending and fairness. However, it was recognized that $25 might not be enough to gain interest from employees and encourage them to complete and submit the near miss report, especially if their name only goes into a lottery and they may not receive the award. The low value might also be viewed as paltry. As a result, in some cases, regional personnel thought the amount too low and decided not to implement the incentive part of the program.

WSDOT representatives think that replication of the near miss program in other states is definitely possible. A state agency would simply need to develop the guidance and reporting forms and

disseminate the program through the agency. In addition, administrative capabilities must be in place to administer the incentive part of the program and collect and disseminate the lessons learned. According to WSDOT, states should be aware that a balance is needed between the number of near miss suggestions submitted and the incentive award. The near miss suggestions that qualify for including the employee's name in the lottery must be actionable and feasible. A suggestion that does not have a reasonable possibility of being implemented would not qualify the person to potentially win the incentive lottery award. However, in WSDOT's program, all suggestions were considered because there may be some way that the agency could benefit from the suggestion.

Data Sources, Archiving, and Analysis

As mentioned, WSDOT's safety program includes the preparation of a report after an injury incident. When created, the reports are archived in an online database and as a paper copy. Incidents are organized and tracked according to the following pieces of information: employee functional area, type of injury, time of day, and organizational unit. Data commonly used in analyzing the incident and evaluating the safety program comes from the following sources: incident report, police citation report, worker insurance claim, safety training records, medical records, fatality/injury data, roadway design, and roadway design features. The data used become available within 1 month of the incident. Currently, WSDOT does not integrate the incident data to facilitate programmatic decision making.

In some cases, WSDOT uses incident data as support information to develop policies and practices. The following are examples of documents and programs WSDOT developed in part based on incident data: additional training for workers, additional training for supervisors, new standards for work site traffic control plans, driver awareness programs, worker behavior assessment programs, safety incentive programs, and drug/alcohol abuse programs.

Monitoring and Evaluation

Monitoring and evaluation of the near miss program is part of WSDOT's administration of the program. Initial development included piloting the program in a few regions within the state. Since that time, the regions have implemented the program at their own pace. WSDOT has found that new programs such as the near miss program require internal marketing and salesmanship to motivate and support the regions to implement the program. In addition, endorsement from supervisors and managers is required. At first, the implementation may be spotty and inconsistent. Time is required to get the program effectively in place agencywide. In addition, resources are needed to ensure the program is implemented consistently from region to region.

The success of the near miss program ultimately will be measured by the number of near misses and worker injuries that occur in future years. These are lagging indicators of success. WSDOT also monitors leading indicators, such as the number of near miss reports received and the overall value of each suggestion for mitigating the near miss hazard. WSDOT has noticed that many of the initial suggestions are "low-hanging fruit." That is, the hazards identified and safety suggestions submitted are easy to spot and envision and often are site specific. Now WSDOT is looking for ideas that may have applicability to a broader audience. To enable implementation of the suggested practices, WSDOT is working to collect and present the information in such a way that it is applicable to other situations across the agency.

Effectiveness of Safety Programs, Policies, and Practices

Because the program was implemented approximately 1 year ago, there has not been a lot of time to determine the long-term effectiveness. However, the expansion of the program from a regional to a state level indicates agency leadership buy-in to the program, which improves its chances of being effective. More data related to the number of near miss reports and suggestions submitted and the immediate and long-term outcomes of the program need to be documented and analyzed to determine the full extent of the program's success. Of all the safety management program elements used by

WSDOT, the practices that are viewed by the interviewee as having the greatest value to overall success of the agency's safety program are preparing an initial incident report; conducting an incident review meeting; communicating the lessons learned agencywide; reviewing or modifying policies and procedures after an incident; and conducting a postincident investigation.

Suggestions for Safety Programs, Policies, and Practices

Safety management program success stems from multiple factors. These factors are both local to the employee and across the agency and extend from the initial development and rollout of the program to its continued implementation and monitoring. For WSDOT, the following suggested practices enhance the potential for success of a program:

- Having agency management personnel actively engaged around the safety effort.
- Having positive and continuous communications from top executives within the agency about the high priority of safety.
- Engaging project and unit managers in the safety program, with the same or higher level of engagement from supervisors and employees.
- Providing engaged, hands-on safety staff who continually strive to develop viable solutions to mitigate safety hazards.
- Employing safety staff who have a solution-minded, collaborative approach and constructive working relationships with frontline supervisors and employees.

CONCLUSIONS

Program elements that a state DOT implements that affect the safety of state DOT employees can be diverse. This diversity contributes to a multifaceted approach that is necessary for reducing the safety risk to highway workers. The case examples presented from California, Maine, North Dakota, Oregon, South Carolina, and Washington demonstrate the diversity of programs available to state DOTs for their safety measures. The descriptions of these programs serve as examples to state DOTs of the processes, stakeholders, and data needed to establish or modify safety programs in other state DOTs.

The six case examples highlight the diversity of safety programs being implemented by state DOTs across the country. Caltrans has implemented a design for safety initiative that encourages designers to consider the construction and maintenance safety issues for those implementing the projects. The safety idea incentive program in MaineDOT and the near miss program from WSDOT explore the potential of getting work crews involved with the safety programs that directly affect them. Oregon's OWZESSC demonstrates an effort to get the administration of work site safety stakeholders together to keep work sites a highly visible safety issue statewide. South Carolina used extensive public outreach and involvement to adjust and improve their safety program and educate the workers and public about the risks in work sites. Finally, NDDOT's leading indicator and return-to-work initiatives are tackling new forms of data to shift the culture of the safety program from reactionary to proactive. These programs demonstrate that data are not widely used in safety programs and the data available may affect only part of an overall safety program.

There are limitations to the applicability of the findings presented in this chapter. Given that only narrowly focused elements of six state DOT safety programs were explored, there are likely many other innovative safety programs being implemented in state DOTs across the nation. In addition, the information for the case examples, in most cases, was collected from only one source within the agency.

Despite these limitations, this chapter retains significant value as a portion of the synthesis on current safety practices for highway workers. The chapter provides an agency-level view of safety programs from the individuals who manage such programs on a daily basis. It demonstrates the details, challenges, and efforts required to maintain effective safety programs. This perspective complements the national trends of agency practice and perspective provided by the data analysis and survey results.

CHAPTER SIX

STUDY CONCLUSIONS

Every year in the United States, employees of state departments of transportation (DOTs) are killed and injured while at work in highway work sites. These highway worker injuries and fatalities are sad consequences of the high risk associated with working in active construction and maintenance work sites and on roadways near active traffic ways. The purpose of this synthesis study is to examine state DOT health and safety policies and determine how policies are implemented to help protect highway workers while they perform their duties in work sites.

SUMMARY OF FINDINGS

Four primary tasks were performed for this synthesis report: literature review, survey, injury data analysis, and follow-up interviews (case examples). Highlights of the findings from each task are detailed in this section.

The collective research examining current issues in highway worker safety indicates this topic is one of significant concern. Much of the literature discusses issues related to vehicles and their effect on safety in work sites. There is also a significant amount of research regarding the hazards of work sites from the perspective of the highway workers. Several elements that can be effective aspects of an agency's highway worker safety program have been defined in the literature. Considering the literature and data analysis practices from the traffic engineering, construction engineering, and maintenance fields can help with the development of aspects of highway worker safety programs. Exploring recent trends in each of these fields can lead to a more comprehensive understanding of the unique challenges in highway work sites. Previous research has shown that identifying all of the stakeholders, including the owners, workers, emergency medical services, law enforcement, designers, local agencies, and insurance companies, can better allow the natural efforts of these groups to improve safety to achieve a more efficient and effective product. Finally, the evaluation of existing programs and continual updating of them as trends and data change can ensure the continued effectiveness of program elements.

The survey results reveal that the state DOTs are diverse. Each state DOT experiences its own set of issues and remains committed to improving the safety of its employees in highway work sites. With this diversity comes opportunity. Some state DOTs have invested time and money into a new safety program, and others have invested into other programs and ideas. From a nationwide highway worker safety perspective, sharing the research and program methods is an economically efficient means to potentially improving safety. Although institutional limitations may prevent some state DOTs from following the model of other state DOTs that have a successful safety program element, understanding fellow state DOT programs can be useful in adapting the broad safety ideas to a new organizational context.

Making data-driven decisions requires the availability of data. The four publicly available data sources analyzed, when used together, can help to quantify and describe current issues in highway worker safety. Understanding the functionality of each data set allows state DOTs to conduct effective research for developing new safety program elements and benchmarking existing elements to monitor their effectiveness. Highway worker safety needs to be examined at the national and state levels to understand general trends and causes of traumatic incidents. Although state-specific data are the most useful for the state DOTs, these nationwide statistics on highway worker safety can be

beneficial. The statistics can be used to establish a benchmark with which states can evaluate areas of highway worker safety in which the states can most improve with respect to the rest of the United States. States can rely on their individual state databases to effect change within their state. The existing national data sets explored for this synthesis were diverse and presented data in a variety of ways. This is helpful for understanding the breadth of available data, but the lack of integration across data sets poses limits on certain types of analysis. The current structure of the data sets reviewed does not allow for the information regarding individual incidents to be identified across different archives.

The program elements that are implemented by a state DOT and affect the safety of state DOT employees can be diverse. This diversity contributes to a multifaceted approach that is necessary to reduce the safety risk to highway workers. Examples of innovative and unique safety program elements found in some state DOTs include a near miss reporting program, monitoring leading indicators, a return-to-work initiative, a work zone executive steering committee composed of state DOT and industry representatives, a design for safety initiative, a data-driven public relations and work site awareness program, and a worker safety idea incentive program. New program elements are commonly developed based on means other than data analytics. In-depth investigation into each safety program element reveals an agency-level view of safety programs from the individuals who manage such programs on a daily basis. These safety program elements vary in their application of data to drive implementation or evaluation. Data do not appear to be used extensively in health and safety programs for state DOT workers, particularly in the evaluation of the existing programs. Significant details, challenges, and efforts are required to maintain effective safety programs. This perspective is an excellent complement to the national trends of agency practice and perspective highlighted by the data analysis and survey results.

BARRIERS TO WIDESPREAD IMPLEMENTATION

Various barriers contribute to obstructing the widespread implementation of data-driven highway worker safety policies and programs. The barriers identified through the literature review, survey, data analysis, and follow-up interviews conducted for this synthesis include aspects of organizational design, culture, technology, funding, and interorganizational collaboration. More specifically, the following barriers were identified:

- Data regarding highway work sites are collected at the federal and state levels. Moving forward, state DOTs could work to integrate national and state injury incident data in efforts to improve highway worker safety.
- Data integration is especially important when tracking the effectiveness of safety program elements. Budgetary restrictions can limit the number of components included in a safety program.
- Analysis of the survey responses revealed that improvements in data sharing and data availability could be helpful in allowing states to make data-driven decisions for their safety programs.
- Currently, freely available public data sources are a challenge to combine. It is likely that individual incidents appear in more than one of the archives, but the recording methodology for each of the programs is different enough to make it challenging if not impossible to isolate a particular incident across multiple data sets.
- There is a significant need for rigorous quantitative evaluation of highway worker safety programs and policies. Many of the novel programs identified through the survey and follow-up interviews had not yet undergone evaluation to quantify their impact.

SUGGESTIONS FOR FUTURE RESEARCH

There is an opportunity for future research to advance what is known about highway worker safety and worker safety practices within state DOTs. Suggestions for future research needs include, but are not limited to, the following:

- State DOTs could benefit from future research on how to use data to develop and implement a limited number of targeted safety programs for maximum impact rather than simply trying an overabundance of program elements that may not result in the same level of overall effectiveness.

- To assist state DOTs, future research is suggested that establishes risk factors for highway workers based on work site conditions and operations. The risk factors can be used to design and manage work operations to minimize safety risk. This type of research could be conducted effectively using experimental tools that simulate worker, driver, and equipment operator interaction in a safe, virtual environment.
- State DOTs require a framework for conducting quantitative evaluations of individual safety program elements. The framework would require a data dictionary to define relevant performance measures for particular types of program elements, guidance on how to structure the implementation for the purpose of increasing the validity of the evaluation, and a mechanism for determining the overall return on investment for a particular intervention.
- One critical aspect of highway worker safety is the safety culture of state DOTs. There is a need for a robust procedure to evaluate the safety culture of state DOTs so that safety program elements aimed at improving safety culture can be evaluated objectively.
- The existing databases of national health and safety data that are collected and compiled by various agencies, such as the Occupational Safety and Health Administration (OSHA) and the Bureau of Labor Statistics (BLS), present various aspects of helpful information, but there is little integration of these data sets. New research could be conducted to determine ways these data sources could be integrated to offer more detailed and flexible health and safety information to state DOTs. In addition, efforts to improve usability and access to publicly available data sets (such as National Council of Compensation Insurance data) could be useful to state DOTs.
- The exploration of "near miss" incidents across state DOTs and the establishment of an easily understood standard definition could limit underreporting (or inconsistent reporting) of near miss incidents that occur in highway work sites.
- The state DOTs each have a unique structure based on the individual needs of that state. This diversity of structure could motivate future research investigating how the organizational structure of a state DOT leads to improved safety.

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APPENDIX A

Survey Questionnaire

Part 1: Demographics

NCHRP Topic 47-16

Survey Questionnaire - Highway Worker Safety

Highway worker safety is of utmost concern to state Departments of Transportation. However, there is little information on available data and best practices to eliminate or minimize highway worker incidents. This questionnaire is part of NCHRP Synthesis Topic 47-16 to gather information on state DOT perspectives on highway worker safety. We are interested in collecting information about reporting policies, data collection practices, and data utilization by agencies regarding incidents in work sites with highway workers employed by state DOTs. We are interested in the experience and opinions of agencies regardless of whether they have data, research, or programs that look at highway worker safety in work sites on roadways. The questionnaire has 23 questions, and you may be asked to complete only a subset of these based upon your agency's policies and procedures relating to highway worker safety. Trial use in a survey pre-test shows that the questionnaire can be completed within 30 minutes.
The following definitions are used in this questionnaire:

- **Incident**: An unplanned event or disruption to the work involving a highway worker employed by a state Department of Transportation (DOT) in a construction or maintenance work site that resulted in, or could have resulted in, an injury or fatality.

- **Near miss (near hit)**: An incident involving a highway worker employed by a state DOT in a construction or maintenance work site that did not result in an injury or fatality to the worker.

- **Highway Worker:** An employee of a state DOT that is active in construction or maintenance work sites. For the purpose of NCHRP Topic 47-16, this definition does not include employees of contractors working on state owned projects.

What is the name of the agency that you work for?

What is your job title or position at the agency?

How many years have you worked with your current agency?

What is the approximate size of your agency in total number of employees?

- <500
- 500-999
- 1000-1999
- 2000-3999
- 4000-6999
- 7000-9999
- 10000+

What is the approximate percentage of your agency's employees who are regularly on construction and/or maintenance sites?

- 0-10%
- 10-20%
- 20-30%
- 30-40%
- 40-50%
- 50-60%
- 60-70%
- 70-80%
- 80-90%
- 90-100%

How often do you work with worker injury claims and prevention programs?

- ○ Very often (daily)
- ○ Often (weekly)
- ○ Sometimes (monthly)
- ○ Rarely (several times a year)
- ○ Very rarely (yearly)
- ○ Never

What is your role with worker injury claims and prevention programs?

Part 2: Incident Reporting

If an injury or fatality incident involving a highway worker occurs in a work site on a roadway, what steps does your agency take to document and report the incident? Identify the steps taken for incidents involving public automobiles, on-site construction vehicles and equipment, and on-site hazards (incidents not involving a vehicle/equipment). Please check all that apply.

	Public Automobile	On-site Vehicle/Equipment	On-Site Hazard
Prepare initial incident report	☐	☐	☐
Prepare worker injury claim	☐	☐	☐
Inform law enforcement	☐	☐	☐
Inform insurance policy provider	☐	☐	☐
Inform Federal OSHA office	☐	☐	☐
Inform State OSHA office	☐	☐	☐
Conduct incident review meeting	☐	☐	☐
Upload findings to "lessons learned" database	☐	☐	☐
Communicate 'lessons learned' agency-wide	☐	☐	☐
Return to work initiatives	☐	☐	☐
Review or modify policies and procedures	☐	☐	☐
Post-incident investigation	☐	☐	☐
Other	☐	☐	☐

The following table includes the post-incident steps you indicated that your agency takes. For each of the steps, please rate the effectiveness of each step according to its contribution to the success of your agency's safety program using a scale of 1 to 5 (1 = not effective, 5 = very effective).

	Public Automobile	On-Site Vehicle/Equipment	On-site Hazard
Prepare initial incident report	▼	▼	▼
Prepare worker injury claim	▼	▼	▼
Inform law enforcement	▼	▼	▼
Inform insurance policy provider	▼	▼	▼
Inform Federal OSHA office	▼	▼	▼
Inform State OSHA office	▼	▼	▼
Conduct incident review meeting	▼	▼	▼
Upload findings to 'lessons learned' database	▼	▼	▼
Communicate 'lessons learned' agency-wide	▼	▼	▼
Return to work initiatives	▼	▼	▼
Review or modify policies and procedures	▼	▼	▼
Post incident investigation	▼	▼	▼
Other	▼	▼	▼

Which department(s) at your agency has the responsibility of compiling and archiving the incident reports? Please check all that apply.

- ☐ Regional/District Human Resources
- ☐ Statewide Human Resources
- ☐ Regional/District Traffic Engineering
- ☐ Statewide Traffic Engineering
- ☐ Regional/District Maintenance Office
- ☐ Statewide Maintenance Office
- ☐ Regional/District Safety Office
- ☐ Statewide Safety Office
- ☐ Other (State Department)
- ☐ None

If incident reports are archived, what is the format of the archive? Please check all that apply.

- ☐ On-line database
- ☐ Electronic documentation (e.g., .pdf file)
- ☐ Paper copy
- ☐ No specified format
- ☐ Other

If incident reports are archived, how is the data categorized? Please check all that apply.

- [ ] Employee functional area
- [ ] Traffic volume
- [ ] Type of injury
- [ ] Severity of injury
- [ ] Functional classification of roadway
- [ ] Time of day
- [ ] Other

If a "near miss" incident occurs in a work site, is there a system to report these incidents within your agency?

- ( ) Yes
- ( ) No

Please briefly describe your agency's near miss reporting system.

For your agency's "near miss" reporting, is the process the same as for incidents resulting in an injury or fatality?

- ( ) Yes, the process is the same
- ( ) No, a separate process is used

Please briefly describe any differences in the process.

What is the reason why your agency does not have a reporting system for "near miss" incidences? Please check all that apply.

- ( ) Lack of resources
- ( ) Fear of inconsistent reporting
- ( ) Lack of clear definition of "near miss"
- ( ) No clear value of "near miss"
- ( ) No clear need in recording incidences
- ( ) Other
- ( ) Unsure

Part 3: Data Collection

What highway worker health and safety data is available to your state DOT and what data is used by your state DOT? Please check all that apply. For data that is available, how complete is it (1 = very incomplete, 5 = very complete)

	Available	Used	How complete is the data?
Incident report	☐	☐	▼
Police citation report	☐	☐	▼
Worker insurance claim	☐	☐	▼
Worker annual performance review	☐	☐	▼
Safety training records	☐	☐	▼
Contractor safety records	☐	☐	▼
Medical record	☐	☐	▼
Fatality/injury data	☐	☐	▼
Roadway design	☐	☐	▼
Roadside design features	☐	☐	▼
Other	☐	☐	▼

For the data identified in the previous question as being used by your agency, is this data integrated to facilitate programmatic decision making, and if so, how?

How long after an incident is data available to your agency for review and analysis?

Incident report	▼
Police citation report	▼
Worker insurance claim	▼
Worker annual performance review	▼
Safety training records	▼
Contractor safety records	▼
Medical records	▼
Fatality/injury data	▼
Roadway design	▼
Roadside design features	▼
Other	▼

Are there any worker safety and health data sources that would be beneficial to your state DOT that you currently do not have or have access to?

- ☐ Yes
- ☐ No

Please briefly describe any data sources that would be beneficial.

Has your agency conducted any research or data analysis regarding highway worker safety in work sites on roadways and worker compensation related to injuries?

- ○ Yes
- ○ No

Please briefly describe the research or data analysis, and provide a link to the report(s), if available.

Part 4: Data Utilization

Has your agency used its own data or other data relating to highway worker safety to develop any of the following policies/practices for highway workers in work sites on roadways? Please check all that apply.

- ☐ Additional training for workers
- ☐ Additional training for supervisors
- ☐ New standards for work site traffic control plans
- ☐ Driver awareness programs
- ☐ Worker behavior assessment programs
- ☐ Safety incentive programs
- ☐ Drug/alcohol abuse programs
- ☐ None
- ☐ Other

Does your agency share incident data with other organizations regarding highway worker safety? If so, which organizations? Please check all that apply.

- ☐ Federal agencies
- ☐ State DOTs
- ☐ County/Municipal governments
- ☐ Private organizations
- ☐ None
- ☐ Other

APPENDIX B

Complete Tabulated Data for Selected Survey Questions

TABLE B1a
DOCUMENTATION STEPS AND ARCHIVAL CATEGORIZATION

	Steps taken (by type of incident) to document and report injury and fatality incidents, and perceived effectiveness of step toward the success of agency's safety program (1 = not effective, 5 = very effective)												**If incident reports are archived, how is data categorized? (Select all that apply)**						
Step	Communicate lessons learned agency-wide			Return to work initiative			Review or modify policies and procedures			Post-incident investigation			Employee functional area	Traffic volume	Injury type	Injury severity	Roadway functional classification	Time of day	Other
Type of Incident	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.							
A. State DOTs with <$1 billion in disbursements (2013)*																			
A1	5	5	5		2	2		3	3	5	5	5	X		X	X			X
A2	4	4	4				5	5	4	4	4		X		X	X			
A3	5	5	5	3	3	3	4	4	4	5	5	5	X		X	X		X	
A4	5	5	5	3	5	5	5	5	5	5	5	5	X		X	X	X	X	
A5		3	3		3	3		3	3		4	4	X		X	X	X		
A6								3	3		3		X		X	X	X	X	
A7	3			3			3			3			X						
A8																			X
A9	4	4	4				5	4	4										X
Avg.	**4.3**	**4.3**	**4.3**	**3.0**	**3.3**	**3.3**	**4.4**	**3.9**	**3.7**	**4.4**	**4.3**	**4.8**							
Count													**7**	**0**	**6**	**6**	**3**	**3**	**3**
Percent													**78%**	**0%**	**67%**	**67%**	**33%**	**33%**	**33%**

*Disbursement categories for all tables created from FHWA reported expenditure data (FHWA 2013b).

TABLE B1b
DOCUMENTATION STEPS AND ARCHIVAL CATEGORIZATION

	Steps taken (by type of incident) to document and report injury and fatality incidents, and perceived effectiveness of step toward the success of agency's safety program (1 = not effective, 5 = very effective)												**If incident reports are archived, how is data categorized? (Select all that apply)**						
Step	Communicate lessons learned agency-wide			Return to work initiative			Review or modify policies and procedures			Post-incident investigation			Employee functional area	Traffic volume	Injury type	Injury severity	Roadway functional classification	Time of day	Other
Type of Incident	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.							
B. State DOTs with $1–$2 billion in disbursements (2013)																			
B1		3	3		4	4		2	2		2	2	X		X				
B2				4	4	4				4	2	2	X		X	X			
B3		4	4		5	5		3	3		5	5			X	X			
B4				5	5	5	5	5	5	4	4	4	X		X				X
B5	1	4	4	1	5	5	2	5	5	1	3	3	X						X
B6																			X
B7	4	3	4		2	3	4	4	4	4	4	4	X		X	X	X	X	
B8		4	4		3	3		4	4		4	4	X		X	X	X	X	
B9	5	5	5	2	2	3	5	5	5	5	5	5			X				
B10				4	4	4	3	3	3	4	4	4	X						
B11	3	3	3				2	2	2	3	3	3	X		X	X			
B12							3	3	3								X		X
B13	4	5	5	5	5	5	1	3	4	1	4	4							X
Avg.	**3.4**	**3.9**	**4.0**	**3.5**	**3.9**	**4.1**	**3.1**	**3.5**	**3.6**	**3.3**	**3.6**	**3.6**							
Count													**8**	**0**	**8**	**5**	**3**	**2**	**5**
Percent													**62%**	**0%**	**62%**	**38%**	**23%**	**15%**	**38%**

TABLE B1c
DOCUMENTATION STEPS AND ARCHIVAL CATEGORIZATION

	Steps taken (by type of incident) to document and report injury and fatality incidents, and perceived effectiveness of step toward the success of agency's safety program (1 = not effective, 5 = very effective)												**If incident reports are archived, how is data categorized? (Select all that apply)**						
Step	Communicate lessons learned agency-wide			Return to work initiative			Review or modify policies and procedures			Post-incident investigation			Employee functional area	Traffic volume	Injury type	Injury severity	Roadway functional classification	Time of day	Other
Type of Incident	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.							
C. State DOTs with $2–$4 billion in disbursements (2013)																			
C1																			X
C2	4	4	4	4	4	4	4	4	4	4	4	4	X	X	X	X	X	X	
C3	5	5	5										X		X	X			X
C4							3	3	3	2	3	3			X	X		X	
C5	5	5	5	5	5	5	5	5	5	5	5	5	X		X	X	X	X	
C6	3	2	2				4	3	2	4	4	4			X				
C7		4	4		4	4		3	3		4	4	X						X
C8	4	4	4	5	5	5	4	4	4	3	3	3			X				
C9	5	4	2	5	5	5	4	4	2	4	4	2	X		X	X			
C10	2	3	3	3	4	4	2	2	2	2	3	3			X	X		X	
Avg.	**4.0**	**3.9**	**3.6**	**4.4**	**4.5**	**4.5**	**3.7**	**3.5**	**3.2**	**3.4**	**3.8**	**3.5**							
Count													**5**	**1**	**8**	**6**	**2**	**4**	**3**
Percent													**50%**	**10%**	**80%**	**60%**	**20%**	**40%**	**30%**

TABLE B1d
DOCUMENTATION STEPS AND ARCHIVAL CATEGORIZATION

	Steps taken (by type of incident) to document and report injury and fatality incidents, and perceived effectiveness of step toward the success of agency's safety program (1 = not effective, 5 = very effective)												**If incident reports are archived, how is data categorized? (Select all that apply)**						
Step	Communicate lessons learned agency-wide			Return to work initiative			Review or modify policies and procedures			Post-incident investigation			Employee functional area	Traffic volume	Injury type	Injury severity	Roadway functional classification	Time of day	Other
Type of Incident	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.	Public auto	On-site veh.	On-site haz.							
D. State DOTs with >$4 billion in disbursements (2013)																			
D1	4	4	2	2	2	1	5	5	5	5	5	5	X		X	X			X
D2		4	3		3	3		4	4		4	4							X
D3	5	5	5	5	5	5	4	4	4	4	4	4	X		X			X	
D4	4	4	4	3	4	4	4	4	4	4	4	4	X		X			X	X
D5															X	X			X
D6	4	4	4	2	2	2	4	4	4	4	4	4	X		X	X			X
D7					5														X
D8				4	4	4	4	4	3	5	4	3	X	X	X	X	X	X	X
D9													X		X		X	X	
Avg.	**4.3**	**4.2**	**3.6**	**3.2**	**3.6**	**3.2**	**4.2**	**4.2**	**4.0**	**4.4**	**4.2**	**4.0**							
Count													**6**	**1**	**7**	**4**	**2**	**4**	**7**
Percent													**67%**	**11%**	**78%**	**44%**	**22%**	**44%**	**78%**

TABLE B2a
NEAR MISS REPORTING PROCESS

	Does the agency have a process to report near misses?		Reason for not having a process for reporting near misses						
State	Yes/No	Description of near miss reporting process	Lack of resources	Fear of inconsistent reporting	Lack of clear definition of "near miss"	No clear value of near miss	No clear need in recording near miss incidents	Other	Unsure
A. State DOTs with <$1 billion in disbursements (2013)									
A1	Y	Districts report a near miss on the same forms used to report injury/illnesses, and indicate injury as "non-reportable".							
A2	N				X				
A3	N					X			
A4	Y	All safety committees review and discuss near miss reports submitted.							
A5	N							X	
A6	Y	The process is the same process used for injuries. However, near miss reports may not be submitted unless agency management staff becomes aware of the near miss.							
A7	Y	Employees are encouraged to report all near misses.							
A8	N								X
A9	Y	Verbally and by email.							
Count	**Y [5] N [4]**				**1**	**1**		**1**	**1**

TABLE B2b
NEAR MISS REPORTING PROCESS

	Does the agency have a process to report near misses?		Reason for not having a process for reporting near misses						
State	Yes/No	Description of near miss reporting process	Lack of resources	Fear of inconsistent reporting	Lack of clear definition of "near miss"	No clear value of near miss	No clear need in recording near miss incidents	Other	Unsure
B. State DOTs with $1–$2 billion in disbursements (2013)									
B1	Y	An incident report form is used. Separate near miss report forms have been developed by three different offices within the agency.							
B2	N				X				
B3	Y	The employee who witnessed or experienced the near miss fills out and submits a form to the safety office. The completed forms are periodically reviewed and discussed by the safety staff within the region to identify and develop solutions. The solutions are then communicated back to all employees.							
B4	N								X
B5	N				X				
B6	N							X	
B7	Y	Included within the standard incident reporting process.							
B8	N				X				
B9	N						X		
B10	N					X			
B11	N				X				
B12	N				X				
B13	Y	Hardcopy report submitted by employee for review.							
Count	**Y [4] N [9]**				**5**	**1**	**1**	**1**	**1**

TABLE B2c
NEAR MISS REPORTING PROCESS

	Does the agency have a process to report near misses?		Reason(s) for not having a process for reporting near misses (Select all that apply)						
State	Yes/No	Description of near miss reporting process	Lack of resources	Fear of inconsistent reporting	Lack of clear definition of "near miss"	No clear value of near miss	No clear need in recording near miss incidents	Other	Unsure
C. State DOTs with $2–$4 billion in disbursements (2013)									
C1	N					X			
C2	N				X				
C3	Y	Near misses are reported in the same system used to report injuries and illnesses.							
C4	N								X
C5	Y	Near misses are reported in a Safety Incident System							
C6	N		X						
C7	Y	Employees complete a near miss report form. The report submittal and review process is the same as that for an injury.							
C8	Y	An incident report is filled out. The report includes a description of the actions taken to prevent the incident in the future							
C9	N							X	
C10	N							X	
Count	**Y [4] N [6]**		**1**		**1**	**1**		**2**	**1**

TABLE B2d
NEAR MISS REPORTING PROCESS

	Does the agency have a process to report near misses?		Reason(s) for not having a process for reporting near misses (Select all that apply)						
State	Yes/No	Description of near miss reporting process	Lack of resources	Fear of inconsistent reporting	Lack of clear definition of "near miss"	No clear value of near miss	No clear need in recording near miss incidents	Other	Unsure
D. State DOTs with >$4 billion in disbursements (2013)									
D1	Y	The foreman on the site reports the incident to the county manager who then reports the incident to the district safety coordinator. The district safety coordinator completes an appropriate form and submits to the safety division. The safety division then reports the information via email to the executive staff. This process usually takes only a few hours from the initial report.							
D2	N		X						
D3	Y	Depends on the regional office. Some offices have a form that is completed. In some cases, a description of the incident is sent out to all employees who could be impacted by a similar event. A meeting with key participants and stakeholders is also held to review and discuss the incident.							
D4	Y	Simple written report with suggested actions submitted by employee.							
D5	Y	N/A							
D6	N				X				
D7	N		X						
D8	N								X
D9	Y	Description of the event is communicated via the phone to the safety office. A near miss form is also completed and submitted for review.							
Count	**Y [5] N [4]**		**2**		**1**				**1**

TABLE B3a
AVAILABILITY AND USE OF HEALTH AND SAFETY DATA

State	Highway worker health and safety data: Available [A]? (Yes/No) / Used [U]? (Yes/No) / Completeness [C] if available (1 = very incomplete, 5 = very complete)																															
	Incident report			Police citation report			Worker insurance claim			Worker annual performance review			Worker safety training records			Contractor safety records			Injured worker medical record			Injury/ fatality data			Roadway design			Roadside design features			Other data		
	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C
A. State DOTs with <$1 billion in disbursements (2013)																																
A1	Y	N	3	Y	Y	4	Y	N	1	Y	N	3	Y	Y	4	Y	Y	1	Y	N	1	Y	Y	5	Y	Y	4	Y	Y	4	N	N	
A2	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	N	N		Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	N	N	
A3	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	N	2	Y	N	4	Y	Y	4	Y	N	2	Y	N	2	N	N	
A4	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	4	N	N	
A5	Y	Y	4	Y	Y	3	Y	Y	3	N	N		Y	Y	4	N	N		N	N		Y	Y	5	N	N		N	N		N	N	
A6	Y	Y	4	Y	Y	3	N	N		N	N		Y	Y	4	Y	Y	4	N	N		Y	Y	4	Y	Y	4	Y	Y	4	N	N	
A7	Y	N	3	Y	N	3	Y	N	3	Y	N	3	Y	Y	3	N	N		Y	N	3	N	N		N	N		N	N		N	N	
A8	Y	N	1	Y	N	1	Y	N	1	Y	N	1	Y	N	1	Y	N	1	Y	N	1	Y	N	1	Y	N	1	Y	N	1	N	N	
A9	Y	Y	5	Y	Y	4	Y	Y	5	N	N		Y	Y	5	N	N		Y	N		N	N		Y	Y	5	Y	Y	5	N	N	
No. avail.	**9**			**9**			**8**			**6**			**9**			**5**			**7**			**7**			**7**			**7**			**0**		
No. used		**6**			**7**			**5**			**3**			**8**			**3**			**2**			**6**			**5**			**5**			**0**	
Avg.			**3.7**			**3.4**			**3.3**			**3.3**			**3.8**			**2.6**			**3.0**			**4.0**			**3.6**			**3.4**			
B. State DOTs with $1–$2 billion in disbursements (2013)																																
B1	Y	Y	4	N	N		Y	Y	5	Y	N	3	Y	Y	4	N	N		Y	Y	2	Y	Y	4	Y	Y	3	Y	Y	3	N	N	
B2	Y	Y	5	Y	N		Y	Y	5	Y	Y	5	Y	Y	5	N	N		Y	Y	5	Y	Y	5	N	N		N	N		N	N	
B3	Y	Y	4	Y	N		Y	Y	4	Y	N		Y	Y	1	N	N		N	N		Y	Y	5	Y	N		Y	N		N	N	
B4	Y	Y	5	Y	Y	4	Y	N		Y	N		Y	Y	4	N	N		N	N		Y	Y	5	Y	N		Y	N		N	N	
B5	Y	Y	4	Y	Y	4	Y	Y	5	Y	N	4	Y	Y	4	Y	N	3	Y	Y	4	Y	Y	5	Y	N	3	Y	N	4	N	N	
B6	Y	Y	3	N	N		N	N		N	N		Y	Y		N	N		N	N		Y	Y	3	N	N		N	N		N	N	
B7	N	Y	4	Y	Y	3	Y	Y	4	N	N		Y	Y	3	Y	Y	2	Y	Y	3	Y	Y	3	Y	Y	4	Y	Y	4	N	N	
B8	Y	Y	3	Y	Y	3	N	N		Y	Y	4	Y	Y	4	Y	Y	4	N	N		Y	Y	3	N	N		N	N		N	N	
B9	N	N		Y	Y	5	Y	Y	5	N	Y		Y	Y	5	N	N		N	N		N	N		N	N		N	N		N	N	
B10	Y	Y	5	Y	Y	5	Y	Y	5	N	N		Y	Y	5	N	N		Y	Y	4	Y	Y	4	N	N		N	N		N	N	
B11	Y	Y	3	Y	Y	5	Y	Y	5	N	N		Y	Y	3	N	N		N	N		Y	Y	2	Y	Y	4	Y	Y	4	N	N	
B12	Y	Y	4	N	N		Y	Y	4	N	N		Y	Y	4	Y	Y	4	N	N		N	N		N	N		N	N		N	N	
B13	Y	Y	5	N	N		Y	Y	5	N	N		Y	Y	3	N	N		Y	Y	3	Y	Y	5	N	N		N	N		N	N	
No. avail.	**11**			**9**			**11**			**6**			**13**			**4**			**6**			**11**			**6**			**6**			**0**		
No. used		**12**			**7**			**10**			**3**			**13**			**3**			**6**			**11**			**3**			**3**			**0**	
Avg.			**4.1**			**4.1**			**4.7**			**4.0**			**3.8**			**3.3**			**3.5**			**4.0**			**3.5**			**3.8**			

TABLE B3b
AVAILABILITY AND USE OF HEALTH AND SAFETY DATA

State	Highway worker health and safety data: Available [A]? (Yes/No) / Used [U]? (Yes/No) / Completeness [C] if available (1 = very incomplete, 5 = very complete)																																
	Incident report			Police citation report			Worker insurance claim			Worker annual performance review			Worker safety training records			Contractor safety records			Injured worker medical record			Injury/ fatality data			Roadway design			Roadside design features			Other data		
	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C	A	U	C
C. State DOTs with $2-$4 billion in disbursements (2013)																																	
C1	N	N		N	N		Y	N		Y	N		Y	N		N	N		N	N		Y	N		N	N		N	N		N	N	
C2	Y	Y	4	Y	Y	3	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	3	Y	Y	4	Y	Y	4	Y	Y	4	N	N	
C3	Y	Y	5	Y	Y	5	N	N		N	N		Y	Y	3	N	N		N	N		N	N		N	N		N	N		N	N	
C4	Y	Y	5	Y	Y	3	N	N		N	Y		Y	Y	3	N	N		N	N		N	N		Y	Y	3	N	N		N	N	
C5	Y	Y	4	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	1	N	N		Y	Y	5	Y	Y	4	Y	Y	5	Y	Y	5	N	N	
C6	Y	N		Y	Y	2	Y	Y	4	N	N		Y	Y	3	N	N		Y	N		Y	Y	5	N	N		N	N		N	N	
C7	Y	Y	4	N	N		Y	Y	5	N	N		Y	Y	5	Y	Y	3	N	N		Y	Y	5	Y	N	5	Y	N	5	N	N	
C8	Y	Y	4	N	N		Y	Y	5	N	N		Y	Y	4	Y	Y	3	Y	Y	4	Y	Y	4	Y	Y	5	Y	Y	5	N	N	
C9	Y	Y	5	Y	Y	5	Y	Y	5	N	N		Y	Y	5	Y	N	3	N	N		Y	N		N	N		N	N		N	N	
C10	Y	Y	2	N	N		Y	Y	3	N	N		Y	Y	2	N	N		N	N		Y	Y	4	N	N		N	N		N	N	
No. avail.	**9**			**6**			**8**			**3**			**10**			**4**			**4**			**8**			**5**			**4**			**0**		
No. used		**8**			**6**			**7**			**3**			**9**			**3**			**3**			**6**			**4**			**3**			**0**	
Avg.			**4.1**			**3.8**			**4.4**			**4.5**			**3.3**			**3.3**			**4.0**			**4.3**			**4.4**			**4.8**			
D. State DOTs with >$4 billion in disbursements (2013)																																	
D1	Y	Y	5	Y	Y	5	N	N		Y	N	4	Y	N	3	N	N		N	N		Y	N	5	Y	Y	5	Y	Y	5	N	N	
D2	N	N	4	N	N	4	N	N	3	N	N	3	N	N	4	N	N	1	N	N	3	N	N	4	N	N	5	N	N	5	N	N	
D3	Y	N	5	Y	N	5	Y	N	5	N	N		Y	N	3	N	N		N	N		Y	N	5	N	N		N	N		N	N	
D4	Y	Y	3	Y	Y	3	Y	Y	4	Y	N	4	Y	Y	4	N	N		Y	Y	2	Y	Y	4	Y	Y	4	Y	Y	4	N	N	
D5	Y	Y	3	Y	N	3	Y	N	3	N	N		Y	N	3	N	N		N	N		Y	Y	4	Y	Y	3	Y	Y	3	Y	Y	3
D6	Y	Y	4	Y	Y	3	Y	Y	3	N	N		Y	Y	4	Y	N	2	N	N		Y	Y	4	Y	Y	3	Y	Y	3	N	N	
D7	Y	N	4	Y	N	4	Y	Y	5	N	Y	3	Y	N	3	N	N		N	N		Y	N	3	Y	N	4	Y	N	4	N	N	
D8	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	Y	Y	4	N	N	
D9	Y	Y	5	Y	Y	5	Y	Y	5	Y	Y	4	Y	Y	5	Y	Y	3	N	N		Y	Y	3	Y	Y	5	N	N		N	N	
No. avail.	**8**			**8**			**7**			**4**			**8**			**3**			**2**			**8**			**7**			**6**			**1**		
No. used		**6**			**5**			**5**			**3**			**4**			**2**			**2**			**5**			**6**			**5**			**1**	
Avg.			**4.1**			**4.0**			**4.0**			**3.7**			**3.7**			**2.5**			**3.0**			**4.0**			**4.1**			**4.0**			**3.0**

TABLE B3c
SUMMARY OF AVAILABILITY AND USE OF HEALTH AND SAFETY DATA

	Group A		Group B		Group C		Group D	
	<$1 billion in disbursements		$1–$2 billion in disbursements		$2–$4 billion in disbursements		>$4 billion in disbursements	
Average	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
No. available	6.7	75%	7.5	58%	5.5	55%	5.6	63%
No. used	4.5	51%	6.5	50%	4.7	47%	4.0	44%
Difference	2.2	24%	1.1	8%	0.8	8%	1.6	18%

TABLE B3d
AVERAGE OF ALL COMPLETENESS METRICS FOR ALL HEALTH AND SAFETY DATA TYPES BY GROUP

	Group A	Group B	Group C	Group D
	<$1 billion in disbursements	$1–$2 billion in disbursements	$2–$4 billion in disbursements	>$4 billion in disbursements
	Average across all data sources	Average across all data sources	Average across all data sources	Average across all data sources
Completeness across all data sources	3.4	3.9	4.1	3.6

TABLE B4a
TIME FOR DATA AVAILABILITY

	How long after an incident until the document/data becomes available for review and analysis? (months)										
State	Incident report	Police citation report	Worker insurance claim	Worker annual performance review	Worker safety training records	Contractor safety records	Injured worker medical record	Injury/ fatality data	Roadway design	Roadside design features	Other data
A. State DOTs with <$1 billion in disbursements (2013)											
A1	<1	<1	1–3	3–6	<1	3–6	6–12	<1	<1	<1	
A2	<1	<1	<1	<1	<1		<1	<1	<1	<1	
A3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
A4	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
A5	<1	1–3	<1		<1			<1			
A6	<1	<1			<1	<1		1–3	<1	<1	
A7	>12	>12	>12	>12	>12		>12				
A8	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
A9	<1	<1	<1		<1				<1	<1	
B. State DOTs with $1–$2 billion in disbursements (2013)											
B1	>12		>12	>12	>12		>12	>12	>12	>12	
B2	>12	>12	>12	>12	>12		>12	>12			
B3	<1	<1	<1	>12	<1			<1	<1	<1	
B4	1–3	<1	1–3		1–3			6–12			
B5	>12	>12	>12	6–12	>12	6–12	>12	>12	>12	>12	
B6	>12				>12			>12			
B7		6–12	1–3		3–6	3–6	3–6	>12	6–12	6–12	
B8	<1	<1		<1	<1	<1		<1			
B9		<1	1–3		<1						
B10	<1	<1	<1		<1		1–3	1–3			
B11	<1	<1	<1		<1			<1	<1	<1	
B12	1–3		<1		3–6	6–12					
B13	<1		<1		>12			<1			

TABLE B4b
TIME FOR DATA AVAILABILITY

	How long after an incident until the document/data becomes available for review and analysis? (months)										
State	Incident report	Police citation report	Worker insurance claim	Worker annual performance review	Worker safety training records	Contractor safety records	Injured worker medical record	Injury/ fatality data	Roadway design	Roadside design features	Other data
C. State DOTs with $2–$4 billion in disbursements (2013)											
C1					1–3			6–12			
C2	>12	>12	>12	>12	>12	>12	>12	>12	>12	>12	
C3	<1	<1			<1						
C4	<1	<1			<1				<1		
C5	<1	<1	<1	<1	<1		<1	<1	<1	<1	
C6	<1	<1	<1		<1		<1	<1			
C7	>12		>12		>12	>12		>12	>12	>12	
C8	<1		<1		<1	<1	<1	<1	<1	<1	
C9	<1	<1	<1		<1	<1		<1			
C10	>12		>12		>12			>12			
D. State DOTs with >$4 billion in disbursements (2013)											
D1	>12	>12		>12	>12			>12	>12	>12	
D2											
D3	>12	>12	>12		>12			>12			
D4	<1	<1	<1	<1	<1		<1	<1	<1	<1	
D5	>12				>12			<1	>12	>12	
D6	>12	>12	>12		>12			>12	>12	>12	
D7	<1	<1	<1		1–3			1–3	<1	<1	
D8	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
D9	<1	<1	<1	<1	<1	<1		<1	<1		

TABLE B4c
SUMMARY TIME FOR DATA AVAILABILITY

Group A			**Group B**			**Group C**			**Group D**		
<$1 billion in disbursements			$1–$2 billion in disbursements			$2–$4 billion in disbursements			>$4 billion in disbursements		
Time	Count	Percent	Time	Count	Percent	Time	Count	Percent	Time	Count	Percent
<1 month	61	84%	< 1 month	31	39%	< 1 month	36	61%	< 1 month	33	57%
1–3 months	3	4%	1–3 months	8	10%	1–3 months	1	2%	1–3 months	2	3%
3–6 months	2	3%	3–6 months	4	5%	3–6 months	0	0%	3–6 months	0	0%
6–12 months	1	1%	6–12 months	7	9%	6–12 months	1	2%	6–12 months	0	0%
>12 months	6	8%	>12 months	29	37%	>12 months	21	36%	>12 months	23	40%

TABLE B5a
BENEFICIAL DATA SOURCES

	Are there any worker health and safety data sources that would be beneficial to your agency which you currently do not have or do not have access to?	
State	Yes/No	If so, describe the data sources
A. State DOTs with <$1 billion in disbursements (2013)		
A1	N	
A2	N	
A3	N	
A4	Y	N/A
A5	N	
A6	N	
A7	N	
A8	N	
A9	N	
Count	**Y[1] N[9]**	
B. State DOTs with $1–$2 billion in disbursements (2013)		
B1	N	
B2	Y	N/A
B3	N	
B4		
B5	N	
B6	Y	An accident database with information about the types of vehicle crashes we are having with our equipment.
B7	N	
B8	Y	Database that will keep the records of the incidents involving the employees and a clear way to assess near misses.
B9	N	
B10	N	
B11	N	
B12	N	
B13	N	
Count	**Y[3] N[9]**	

TABLE B5b
BENEFICIAL DATA SOURCES

	Are there any worker health and safety data sources that would be beneficial to your agency which you currently do not have or do not have access to?	
State	Yes/No	If so, describe the data sources
C. States DOTs with $2–$4 billion in disbursements (2013)		
C1	Y	In-agency Human Resources records
C2	N	
C3	Y	More detailed worker compensation data including lost and restricted time. This information is held by a separate state department.
C4	N	
C5	Y	N/A
C6	Y	National trends and data from other state DOT's.
C7	N	
C8	N	
C9	Y	Different types of summary reports on workers' compensation claims.
C10	N	
Count	**Y[5] N[5]**	
D. State DOTs with >$4 billion in disbursements (2013)		
D1	Y	Information from the state private road management companies and from our local municipalities.
D2	Y	N/A
D3	Y	OSHA inspection records for contractor work zones.
D4	N	
D5	Y	An integrated system of the various existing data sources.
D6	N	
D7	N	
D8	Y	An integrated safety data source where incidents can be analyzed across all available state health and safety databases.
D9	N	
Count	**Y[5] N[4]**	

TABLE B6a
USE OF DATA FOR AGENCY PROGRAMS

	Has your agency used its own data or other data related to worker health and safety to develop any of the following policies/practices for highway workers in work sites on roadways?							
State	Additional training for workers	Additional training for supervisors	New standards for work site traffic control plans	Driver awareness programs	Worker behavior assessment programs	Safety incentive programs	Drug/alcohol abuse programs	Other
A. State DOTs with <$1 billion in disbursements (2013)								
A1	X	X		X	X		X	X
A2			X	X				
A3	X	X	X	X			X	
A4	X	X	X	X	X		X	
A5	X	X	X	X				
A6	X	X	X	X		X	X	
A7	X						X	
A8	X	X	X	X	X			
A9	X	X	X	X			X	
Count	**8**	**7**	**7**	**8**	**3**	**1**	**6**	**1**
Percent	**89%**	**78%**	**78%**	**89%**	**33%**	**11%**	**67%**	**11%**
B. State DOTs with $1–$2 billion in disbursements (2013)								
B1	X	X	X	X		X	X	
B2	X	X	X	X	X			
B3	X	X			X	X		
B4	X	X	X	X			X	X
B5	X	X						
B6	X	X		X	X	X		
B7	X	X	X	X	X			
B8	X	X	X	X			X	
B9	X	X	X	X			X	
B10	X			X				
B11	X	X						
B12	X		X	X			X	
B13	X	X	X		X			
Count	**13**	**11**	**8**	**9**	**5**	**3**	**5**	**1**
Percent	**100%**	**85%**	**62%**	**69%**	**38%**	**23%**	**38%**	**8%**

TABLE B6b
USE OF DATA FOR AGENCY PROGRAMS

	Has your agency used its own data or other data related to worker health and safety to develop any of the following policies/practices for highway workers in work sites on roadways?							
State	Additional training for workers	Additional training for supervisors	New standards for work site traffic control plans	Driver awareness programs	Worker behavior assessment programs	Safety incentive programs	Drug/alcohol abuse programs	Other
C. State DOTs with $2–$4 billion in disbursements (2013)								
C1	X	X						X
C2	X	X	X	X	X	X	X	
C3	X	X	X					X
C4	X	X	X	X	X		X	
C5	X	X	X	X	X	X		
C6	X	X						
C7	X	X	X	X				
C8	X	X					X	
C9						X		
C10		X		X			X	
Count	**8**	**9**	**5**	**5**	**3**	**3**	**4**	**2**
Percent	**80%**	**90%**	**50%**	**50%**	**30%**	**30%**	**40%**	**20%**
D. State DOTs with >$4 billion in disbursements (2013)								
D1	X	X	X	X		X		
D2	X	X	X				X	
D3	X	X	X	X	X	X	X	
D4	X	X	X	X	X	X	X	
D5	X	X		X		X	X	X
D6	X	X	X	X				
D7	X							
D8	X	X	X					
D9	X	X	X	X				
Count	**9**	**8**	**7**	**6**	**2**	**4**	**4**	**1**
Percent	**100%**	**89%**	**78%**	**67%**	**22%**	**44%**	**44%**	**11%**

APPENDIX C

Interview Protocol

Worker Safety Interview Protocol
Last Updated: April 25, 2016

Concept:	Interview Question:	Probing Questions:
Introduction	Ask how the participant is doing. Introduce myself. State the purpose of the interview: "To follow-up on your responses to the survey and explore specific safety program/initiatives that have worked well in your state". We are enthusiastic to know everything about your experience with this topic in your state, so if I don't ask about particular element of your experience that you think may be of interest to us, please feel free to share those details with us. You can choose not to answer any of the questions and may stop the conversation at any time for any reason. Ask if it is okay to report the name of the state and details of their successful safety program/initiative in the final report. Ask if it is okay to record the conversation.	
Safety Program/initiative	In the survey response, you highlighted your agency having a particular safety program/initiative relating to _____ (varies by survey response). Could you elaborate on the details of that program/initiative? How long has your agency been using this particular program/initiative? Does this program/initiative only apply to agency employees (not contractor's and contractor's employees)? Do you collaborate with any other states on your safety program/initiatives? How has the program/initiative affected: • Highway worker safety? • Highway worker behavior? Do you feel that the program/initiative has been a success, and why?	Is the program/initiative data driven (in terms of either the development of the program or the continued implementation of the program)? Is the program/initiative still in its early phases or is it well established? Is there documentation that describes the program and, if so, could we get a copy to include in our report? What were some of the challenges in implementation? If no, have you had good compliance with the program/initiative from contractors? If yes, which states and how long have you been collaborating?

		Have there been impacts to other agency goals such as quality, productivity, cost, etc.? Are there any changes that you would make to the program/initiative to make it more successful? What would you recommend to other states that want to implement a similar program/initiative?
Research Used	Did your agency use any research when implementing this program/initiative? Were other agencies or organizations involved when the program/initiative was implemented or adjusted?	Was the research conducted Internally? Was the research conducted Externally? Could you provide examples of the research? Did those agencies include: • Law enforcement? • Other states? • Construction divisions? • Traffic divisions? • Contractors? • Insurance providers?
Data Used	What data sources does this program/initiative use? Were these data sources available to the agency before the implementation of this program/initiative?	Are these data sources internal? What data is used from these sources, and how is it used? Was that data source cleaned or re-organized for this program? Was that data source previously collected by the agency?
Program Process	Does the program/initiative use a reporting processes or common forms?	If yes, would you be willing to provide that documentation to be included in the report? If preferred, state identifying and other information can be removed.

Worker Safety Interview Protocol
Last Updated: April 25, 2016 Page 3 of 3

Participants	What personnel/offices within your agency are involved with implementing the program/initiative? Which office within your agency has responsibility for the program/initiative?	How is the program/initiative communicated to the participants? Is training provided?
Evaluation	What metrics are you using to evaluate the effectiveness of your safety program/initiative?	Is the agency doing the analysis or a vendor? Are reductions in incidents or costs being considered?
Agency Perspectives	What is your agency's leadership's view of this safety program? What are regional and local agency perspectives of this safety program?	Is the leadership maintaining support for the program/initiative? Are the compliance levels high?
Conclusion	Are there any other aspects of the safety program/initiative that you feel are important that were not covered in our conversation? "Thank You very much for your time" **Stop Recorder**	

APPENDIX D

California: Roadside Safety Improvement Program Handout

201.235 Roadside Safety Improvements Program Guidance for Development of PIDs for the 2014 and 2016 SHOPP and Calculating Performance Output

Roadside Safety Improvements (201.235) is the only Roadside program to receive funding targets in the 2013 10-Year SHOPP Plan. Worker safety and SRRA drinking water and waste water quality compliance are included in the program definition for the Roadside Safety Improvements Program. Projects that provide comprehensive solutions for worker safety issues and reduce the frequency and duration of worker exposure in areas without other identified projects will be given funding priority.

The Goals of the Roadside Safety Improvements Program are to:

1. Reduce roadside worker fatalities to zero by minimizing the frequency and duration of highway worker exposure to traffic, and
2. Maintain the traveler safety benefits provided by the Safety Roadside Rest Area System by preventing closures due to noncompliance with drinking water quality and waste water treatment standards.

The primary objectives of the Roadside Safety Improvements Program are to:

1. Eliminate the need for workers on foot adjacent to the travel way,
2. Increase worker access from locations off of the traveled way,
3. Accommodate mechanized maintenance activities,
4. Minimize the need for recurrent damage repair by relocating equipment and irrigation systems away from traffic,
5. Make the worksite safer for maintenance activities,
6. Ensure swales and ditches are accessible and perform as designed, and
7. Bring rest areas up to compliance for drinking water and waste water quality standards.

The risk of injury or fatality increases with the length of time an employee is exposed to traffic without protection. 77% of employee fatalities since 1974 were Maintenance employees, and of those, 64% were workers on foot. During the scoping and design of projects for the Roadside Safety Improvements Program, the PDT should consider that the common factors of these fatalities are urban location, high ADT, roadside work near shoulder, vehicle parked on shoulder, and employee on foot.

The following types of work qualify for the 201.235 Roadside Safety Improvements Program. Use the information below to calculate the performance output for the updating the 10-year SHOPP Plan and the SHOPP Tool.

Safe Access

1. Gates (walk and drive) – each gate = 1 location
2. Light duty vehicle trails – 2000 square feet = 1 location
3. Shoulder widening/turnout – 2000 square feet = 1 location
4. Staircases – each staircase = 1 location
5. MVP's – each MVP = 1 location

Signs, Lighting, Vehicle Detection, Ramp Meters, CMS, Irrigation, etc.

1. Upgrade safety rails on overhead signs to CalOSHA mandates – each sign = 1 location
2. Relocate control boxes and pull boxes to safe locations – each clustering of equipment = 1 location
3. Relocate signs and lighting to safe locations a minimum of 30' from ETW or at gate – each sign or light standard = 1 location
4. Make exit signs safer to replace or repair or relocate out of the gore to minimize damage – each sign = 1 location
5. Relocate and cluster irrigation control boxes and valves to safe locations – each clustering of equipment = 1 location
6. Shield equipment where relocation isn't possible – each location = 1 location
7. Combine various types of electrical equipment into fewer cabinets – each clustering of equipment = 1 location
8. Remove duplicate/excessive signage– each sign removed = 1 location

Chain Control Areas

1. Lighting
2. Signage
3. Additional paving

Barriers

1. Upgrade guardrail to concrete (non-median spot areas no greater than 200' in length to protect equipment that can't be relocated) – each spot location = 1 location
2. Fencing at spot locations to minimize unauthorized access to R/W – each run = 1 location
3. Safety rail on retaining walls – each wall = 1 location
4. Upgrade barrier and rail end treatments to compression (compressor) type in high hit areas – each end treatment = 1 location

Miscellaneous Paving/Treatment

1. Areas beyond the gore – each location = 1 location
2. Narrow areas in front of walls, barriers or other roadside features – 2000 sq. ft. of paving = 1 location
3. Slope paving under and adjacent to bridge structures – each bridge slope = 1 location
4. Under existing guardrail and around sign posts – 500 linear feet or each sign = 1 location
5. At equipment clusters – each cluster = 1 location
6. At access points – each apron = 1 location

7. Rumble strip installation where not required for traffic safety for audio clue for workers on foot – 1000 linear feet = 1 location

Vegetation Control

1. Preserve visibility to signage, safety hardware, maintain sight distance, etc. – each location = 1 location
2. Facilitate drainage in ditches, swales, inlets and outlets – each location = 1 location
3. Minimize homeless and transient activity – each location = 1 location
4. Minimize herbicide use and erosion – ¼ acre = 1 location
5. Replace vegetation with inert materials – 2000 sq. ft. = 1 location
6. Prevent accumulation of snow and ice – each location = 1 location
7. Create fire strip next to shoulder and reduce fuels that could spread fires to wild lands or adjacent development – 500 linear feet = 1 location
8. Remove inappropriate high maintenance/high water use plant material and replace with sustainable native or similar species on temporary irrigation systems – ¼ acre = 1 location

Irrigation Systems

1. Relocate equipment to safe locations a minimum of 30' from ETW
   a. Mainlines, valves, control wires and pull boxes near R/W line – each cluster = 1 location
   b. Backflow preventers, booster pumps, controller enclosure cabinets and electrical cabinets to protected area or near access points away from shoulder – each cluster = 1 location
   c. No irrigation heads near shoulder
2. Upgrade system
   a. Manual or automatic systems to Remote Irrigation Control System and/or control by remote handheld devices – each controller upgraded = 1 location
   b. Flow sensors/automatic shut off – each sensor = 1 location
   c. Remove nozzle line & replace with irrigation system – each line = 1 location

Drainage/Storm Water Facilities

1. Provide access by employees and equipment to facilities for inspection and cleaning – each location = 1 location
2. Correct concentrated flow issues that are causing erosion – each location = 1 location

Graffiti

1. Plant shrubs or vines at base of wall in high exposure/high vandalism areas – 500 linear feet = 1 location

SRRA Water Quality Compliance - each SRRA = 1 location

1. Sewage systems
2. Drinking water systems

The following types of work DO NOT qualify for the 201.235 Roadside Safety Improvements Program:

Non-Repetitive Maintenance Activities

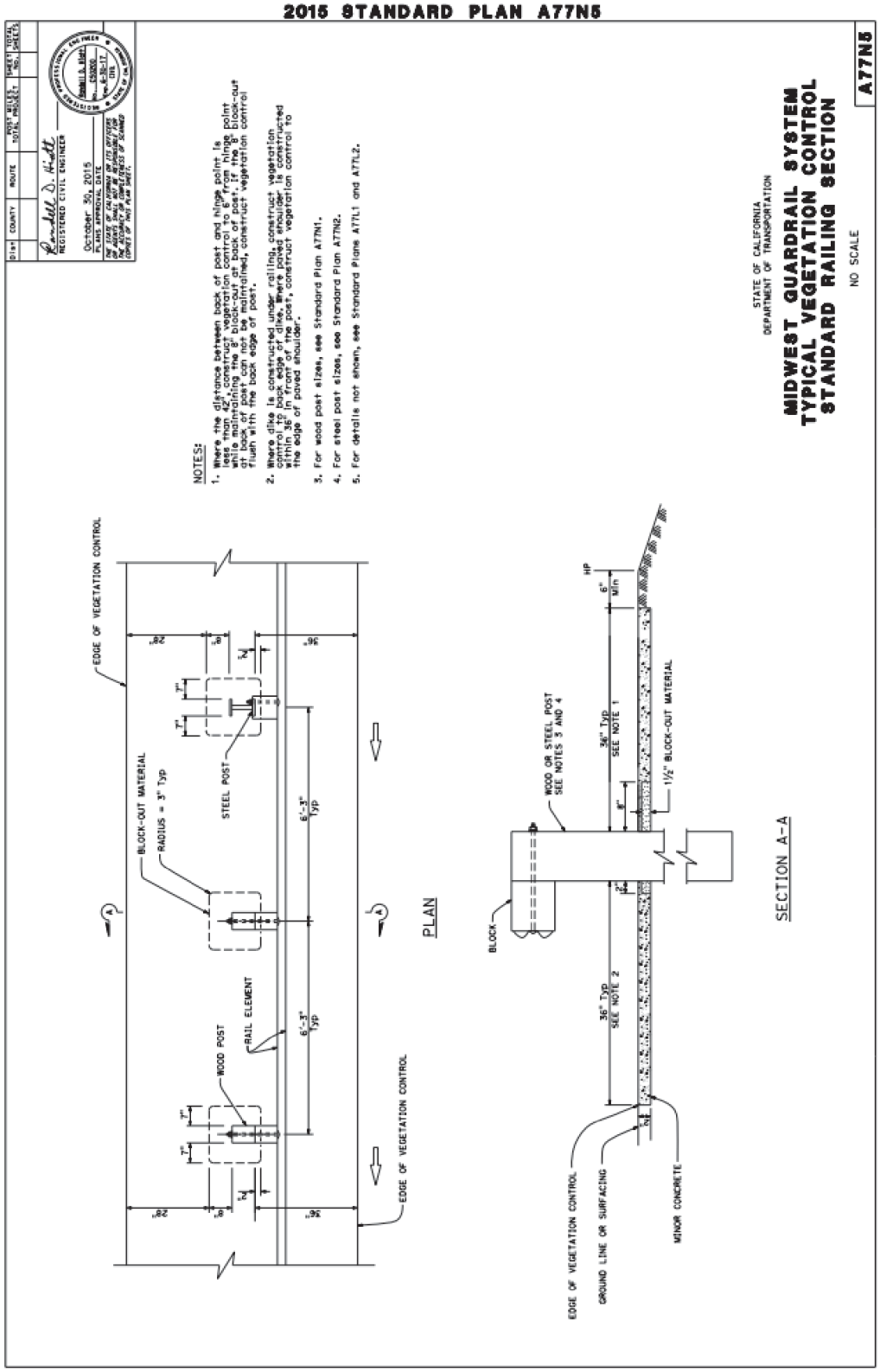
1. Tree removal
2. Emergency work

Highway Planting

1. Replacement planting except that where critical for slope stability, erosion control, or storm water compliance mandate or court order.

CALIFORNIA: SAMPLE STANDARD PLAN

FIGURE D1 Vegetation Control Standard Plan



APPENDIX E

North Dakota: Job Hazard Analysis Form

Job Hazard Analysis

ACTIVITY OR TASK:	
JSA Preparation & task work team:	

Location / Project:	
Job Number:	
JSA Number:	JSA Revision:

Competence = Relevant Training/Qualifications + Experience

Competence/ Qualific'n req'd to complete work safely			
JSA approved by person responsible i.e. Team Leader / Tradesman	Name:	Position / Competence/ License:	Date:

Codes of Practice & Legislation that are applicable:	

2. HAZARD IDENTIFICATION Identify hazards that may be present by ticking items on the list below.

WORK LOCATION		HAZARDOUS AREA		HIGH RISK		HIGH RISK	
Difficult Entry/Exit		Hazardous Substances - attach MSDS to JSA		Falling Objects		Suspended loads	
Oxygen Deficiency				Poor Lighting		Poor Visibility	
Wind/storm/lightning		Working at Heights		Slippery Surfaces		Inhalable Dusts/Fibres	
Engulfment (trench collapse)		Remote Area		Multiple Electrical Feeds		High Noise Levels	
Poisonous Gas Present		Motor Room Hazards		Trip Hazards		Use of Chemicals	
Temperature Extremes		Toxic Substances		Electrical Hazards - LV		Elevated Work Platform	
Defined Confined Space		Potential for Difficult Rescue		Electrical Hazards - HV		Difficulty to Communicate amongst workers	
Explosive Gas Present				Manual Handling		Moving Machinery	

HAZARDOUS SUBSTANCES in work area / to be used -attach MSDS	Sharp Materials		Tools & Equipment	
	Ladders used in the task		Heat/ Sunlight/ Radiation	
	Working at Heights		Traffic Movement	
	Working near Crane & Crane Runways		Working near Operation Processing Lines	
	Rail Movement		Live Rails	
	Pressurised Fluids		Pneumatics	
	Flamm. Materials Present			

3. PRECAUTIONS: hard hat, safety glasses, safety boots etc.

ADDITIONAL PRECAUTIONS		PERMITS	
Gloves: Work			
Goggles/Eye Protection			
Full Face Shield			
High Visibility Vest			
Harness			
Fire Extinguishers			
Barricades			
Ventilation			
Lighting		PERMIT NUMBER	
Erect Scaffolding to access			
Respirator or Dust mask			
Erect Warning signs			
Hearing Protection			
Hard Hat			
Welding screen			
Fall Arrest systems			
Welding Face Shield			

4. ENVIRONMENTAL HAZARDS – (IMPACTS) tick those identified

Air Pollution (dust, fumes)		Spills to ground		Other:	
Noise (plant & equipment)		Soil Erosion			
Spills to drains/waterways		Hazard to Flora /Fauna			

5. EQUIPMENT RECOMMENDED:

Static Plant & Equipment	
Mobile Plant & Equipment	
Safety / Emergency Equip't	

RISK RATING TABLE

This table is used to calculate whether the hazard you have identified is **Extreme: 9-10** **High: 7-8,** **Medium: 5-6** or **Low: 3-4**

The objective of rating the risk is to lower the risk by initiating risk control measures. The score is noted in the JSA risk score column on the next page – both before & after risk control measures have been nominated.

Likelihood: How likely is it to be that bad?	Consequences: how severe an injury? Death	Serious Injuries	Medical Treatment Req'd	1st Aid req'd
Almost Certain - Expected to Occur	10	9	8	7
Likely – could happen sometime	9	8	7	6
Moderate – could happen but not likely	8	7	6	5
Unlikely – *could* happen but very rare	7	6	5	4
Rare - *could* happen but probably never will	6	5	4	3

Job Hazard Analysis

NAME OF TASK:	JSA Number: Rev:

Step No. Logical sequence	**Sequence of Basic Job Steps** Break down Job into steps. Each step should accomplish a major task and be logical.	**Potential Safety & Environmental Hazards/Impacts** Identify the hazards (health and safety or environmental) associated with each step, examine each to find all possible risk factors	**Risk Rating** Use table on the previous page to score risk	**Recommended Corrective Action or Procedure** Determine what actions are necessary to eliminate or minimize all hazards that could lead to an accident, injury, illness or environmental incident. The risk must be reduced or controlled to a level that is acceptable before work commences.	**Risk Rating** Of the risk following corrective action
1					
2					
3					
4					
5					
6					
7					
8					

Job Hazard Analysis

CONSULTATION & SIGN-OFF RECORD

I confirm by my signature below, that I have attended a briefing on the requirements of the attached Job Safety & Environment Analysis and agree to perform the work in the manner detailed on it.
I confirm that copies of the relevant Permits, MSDS's, Isolation Plans etc. have been reviewed.

JSA NAME | JSA No:

NAME (Please print)	SIGNATURE	DATE

THIS SAFE WORK BRIEFING / TRAINING WAS CARRIED OUT BY (responsible person at that location) :

Name:	Signature:	Date:

APPENDIX F

Oregon: OWZESSC Newsletter

ODOT News

January 2015

Leaders work together to make work zones safer

Together they're taking a fresh look at safety

The group's charge was clear; look for new ways to increase safety in work zones.

More than 26 leaders from the construction and trucking industries, law enforcement, federal and state government, and other interested people came together in December for the third meeting in a series of executive strategy sessions on work zone safety. They are examining current practices and looking for new ways to keep workers and travelers safe.

"I'm pleased to see a lot of people from a lot of organizations working to make things better," said Brian Gray with Knife River Corporation, one of the members of the group.

At two earlier meetings, the group identified four areas of focus and formed task forces to identify and prioritize issues and action items:

- Separation and mobility
- Enforcement
- Continued engineering enhancements
- Stakeholder engagement and education

Safety and mobility can coexist

The separation and mobility task group met several times to discuss "perceived" challenges between the trucking and construction industries. The task group soon found that they were on the same page; safety and mobility do go together.

"You don't have to choose between mobility and safety," Gray said. "We can coexist. It doesn't have to be one or the other."

The task group recommended several actions including drafting a strong statement (guiding principle) that emphasizes balance between mobility and worker safety; adding a construction industry partner as a stakeholder on ODOT's Mobility Committee; drafting a decision tree that engineers and project managers can use during the design phase and improving written and verbal communication between stakeholders throughout the process.

"We have a process in the Traffic Control Plans Design Manual that outlines procedures and options for work zones, but a decision tree or checklist might clarify things," said ODOT Traffic/Roadway Engineer Bob Pappe.

Law enforcement resources are a top issue

For the law enforcement task group, the top two issues identified are resources/staffing and presence, which include looking at alternatives to officer presence such as photo radar and lights.

"Everyone agreed that more enforcement was needed, especially outside of the larger cities," said Captain Dave Anderson with Oregon State Police. "Staffing shortages make it difficult for Oregon State Police and local law enforcement agencies to meet some work zone commitments."

Possible solutions discussed include increasing funding and staffing for law enforcement agencies, decreasing or eliminating the fund match requirement for federal grants, developing a statewide method for prioritizing projects that need enhanced law enforcement for work zone safety and addressing barriers in how funding is distributed. For example, federal work zone safety enforcement funds usually can't be spent on maintenance projects.

"We can work together on finding funding solutions," said Bob Russell, interim president of the Oregon Trucking Association.

"Working with our federal partners, maybe we can find a way to make federal grant matching requirements a little less onerous," said ODOT Director Matt Garrett.

Continuing to look for new engineering approaches

The engineering enhancement task group reviewed current processes for how ODOT traffic control plans are put together and then discussed issues and ideas. Together they came up with five recommendations:

- Improve clarity around requirement to use traffic control supervisors as a bid item
- Better construction sign management
- Changing the look of some construction signs
- Mounting radar speed reader boards on moving vehicles in the work stream
- Use smart work zone devices to improve information and driver messages

"We must continue to evaluate tools and tactics to make sure they are working for us and helping us achieve our goals," said Oregon State University Professor Dr. John Gambatese, who conducts work zone safety research as part of his job.

"It's a good idea to refresh our knowledge about the tools and options available to us," said Joe Squire, ODOT construction and materials engineer.

Looking for new ways to reach out

The single biggest cause of work zone crashes is driver inattention. The other major contributing factor is speed. If drivers pay attention and obey posted speeds in work zones, safety increases for everyone. But, as we all know, people don't always make the best choices when they're driving.

"We need to look for new ways to remind people about the importance of driving safely through work zones," Gray said.

During the 2014 construction season, in addition to the traditional public services announcements, billboards, ads and new stories that ODOT coordinates, the group developed and distributed a series of articles about work zone safety targeted at the construction industry, ODOT employees, law enforcement and other partners (this is the seventh article in that series). More than 2,074 people viewed the stories on the Internet meaning that partners shared the stories through blogs, newsletters and other means beyond the initial list of 500 recipients.

In addition, this summer, the group shared a dramatic video put together by an ODOT Maintenance crew. The video tells the story of a near miss incident. It quickly became one of the most popular on ODOT's YouTube channel.

What's next?

The Oregon Work Zone Executive Steering Committee will meet again in the spring. In the meantime, the task group will work on turning some of their recommendations into actions.

"I'm impressed with the efforts you've put forth," Garrett told the group. "You've given your valuable time and effort to this. I think you've identified some actions that we can put our collective weight behind."

How can you get involved?

Everyone in the group agreed that no matter what role you play in work zone safety, effective communication is essential. We must continue to talk to each other. Whether it's a pre-construction meeting between the project team, contractors and freight haulers, or a mid-project check-in with local law enforcement, or a "Hey did you hear about . . ." conversation with a coworker, or asking family and friends to travel carefully through work zones, everyone can help.

Visit the ODOT Work Zone Safety webpage for additional resources and information.

This is the seventh in our series of articles taking a fresh look at work zone safety. You are welcome to share these articles with a wider audience through newsletters, email blasts or other means. The articles will be posted here and sent out via an electronic mailing list. If you aren't already subscribed, you can subscribe online.

If you have questions or ideas for future articles, please contact Anne Holder (503) 986-4195 or Sally Ridenour (503) 986-3359.

APPENDIX G

South Carolina: 2004 Focus Group Report

A MarketSearch *Topline*

SC DOT Work Zone Safety Campaign Evaluation and Development September 2004

This report presents the findings of a focus group study conducted on behalf of the South Carolina Department of Transportation and Fisher Communications to test new concepts for the Work Zone Safety campaign, along with evaluation of previous ads and discussion of traffic safety issues.

Two focus groups were conducted on September 9th, 2004 -- one among licensed drivers under the age of 35 and one among drivers between the ages of 36 and 65.

Respondents discussed their general driving habits and attitudes toward enforcement before viewing and evaluating seven previous ads for Work Zone Safety. Following the evaluation and discussion of each of the previous ads, new concepts were presented and discussed.

Findings presented in this report are based on a sample size of 21 respondents -- 9 under 35 and 12 over 35. These findings are qualitative in nature and not necessarily statistically valid.

Selected respondent comments have been included throughout the report for illustrative purposes. While these comments have been taken directly from transcripts of the group sessions, they may have been edited or paraphrased for readability.

Overview

Findings tend to identify high levels of awareness and support for the Work Zone Safety campaign. Work zone safety issues consistently come up on an unaided basis when discussing driving safety in the state, and most respondents identify familiarity (both unaided and aided) with multiple spots used for the campaign.

The Marine, *Gentle Giant*, and *The Children* spots tend to have the highest levels of awareness and appeal. Most feel these are easy to relate to, effective in making the situation more meaningful and motivating behavior.

The new concepts tested tend to generate positive response among study respondents. While findings suggest that there may be some differences in reactions based on age, the general concept and its dynamic combination of enforcement and emotional appeal is felt to be appropriate, attention-getting, and impacting.

Overall, findings identify solid support for the new concepts as they are or with minor executional enhancements.

Study Findings

General Driver Habits and Attitudes toward Highway Safety in South Carolina

- Consistent with previous consumer studies conducted on behalf of the SCDOT, respondents tend to identify a variety of concerns relative to driver habits and/or road conditions in South Carolina.

  Although each driver tends to have his own pet peeve about drivers and/or highway safety, issues most likely to be mentioned on an unaided basis relate to: inattentive driving (i.e.: while on a

cell phone), poor road conditions, drunk driving, and driving too fast.

"I think people are very distracted these days driving."

"Careless driving. Using cell phones or putting on makeup. It's actually like impaired driving. I mean, if you're talking on the cell phone, it's almost equivalent of being impaired, either on alcohol or drugs, or, you know, whatever. Your attention's not on the road."

"You always hear a lot about drunk driving. That's always a concern."

"My biggest pet peeve -- we've got the worst county roads I believe in the Southeast, and I travel a lot, and I can say that we probably have, and it's probably eroded. In the past, I'd say the past two to three years it's gotten worse than I've ever seen it. Our county roads are really, really bad."

"Potholes."

"I see a lot of people not wearing seatbelts - and that is great concern to me. And they're not necessarily the younger people . . . a lot of adults don't wear them."

"Well, they tend to drive in the passing lane here. I mean, I'm from Pennsylvania originally, but people just seem like they, they pull over in that passing, they don't realize it's a passing lane, I just noticed that about South Carolina."

"Too much speeding. I almost got T-boned two times in the last month because of speeders."

"There's just no courtesy here in driving."

"I've noticed that they're, they don't put their turn signals on until they get to a turn."

"We were wondering why our insurance here was so much higher than it was in Virginia, and they were explaining there are so many poor drivers, numbers of people who aren't from here, and they said the worst drivers they've ever seen in South Carolina. But what unnerves me is I never see this anywhere else, are those turn lanes that are generic, you know, left turn, right turn, and I don't like seeing somebody coming at me in the same lane. They're going that way and I'm going that way. That just doesn't strike me as a very good idea to have those, you know, a generic turn lane."

"They need better signs, though, because I know we just moved here from Florida, and North Carolina before that, and to me they don't put signs well enough ahead. It's like all of a sudden, boom, your exit's right here and so you have to get over. [laughter] To me they should put them a little farther ahead because of the out-of-state drivers that are coming through there from Florida going up north. They come right through here."

- In addition, work zone safety issues also come up on an unaided basis in both groups while discussing highway safety.

  Some of the issues introduced by respondents relative to work zone safety relate to: speeding or other non-compliance by drivers while in work zones, limited enforcement of posted speed limits, inconsistency in signage, absence of workers, and concern for workers working at night.

"I think they have more signs now which alerts more people, but I'm not saying necessarily that people stop, I mean, or are going to go slower. I think you're always going to have somebody that's going to speed through there."

". . . There is no consistency as to where that first sign notifying you that there is road work ahead, and the left lane merges with the right lane. It could be 200 feet, it could be 100 feet, it could be 400 foot. There's no real consistency. I guess that's left up to the road crews to decide from a visibility and position standpoint, but . . . the regular signs that show 70 mph might or might not be covered up. Sometimes they're not, and then all of a sudden you get a sign that says, '40-45 mph. Work crew ahead', and, you know, boom, you're there."

"On the interstate from Camden to Columbia I've noticed that they're doing a lot of that work at night. I'm sure it's so we're not having to put up with that during the day, which is nice, but I just wonder how safe it is for the workers. That's where I always think there's probably DUIs or people out speeding, and I just worry about their safety. I mean, I appreciate it for myself, but I wonder about the workers out there, and what kind of risk they're being put—"

"I don't think they take it [the work zone safety signs] seriously. And then I can tell you why. We were traveling through North Carolina and it said, 'Slow down, Work zone, Slow down'. Nobody in sight. Nobody. And that's, that happens an awful lot. We travel on the interstate a good bit, and I've seen that many times, particularly in North Carolina. They'll have the sign—and, you know, you can do that so many times before you think, "Well, nobody's out there." You know?"

"People speed through them work zones."

"Well, I think that for one, they leave the signs up too long. You know, 'Work Zone, $200 fine, 30 days in Jail'. Well, nobody's working. You know, you can go a whole week and the sign's up. I think people tend to ignore them if the project isn't being done. Get it done, get the signs down when it's done, I think people would be more aware of the zone and respect the area if it wasn't just this ongoing thing where, "Oh, the sign's up again. No one's really working." You know, speed on through it. I think they just leave them up and stretch these projects out so long."

- Most indicate that they're more likely to obey posted speed limits in work zones if there are workers present. Even then, however, several say that they slow, but not necessarily to the speed limit.

"You feel like if you slow down to 45, uh-oh, you're going to be causing more problems than you're solving."

"None of us wants to go out and hit a guy, but if we hit a cone who cares, you know?"

"You have to slow down for some of them because they're torn up a little bit around the edges, but you don't have to slow down as much if there aren't workers there."

"I pretty much just go with the flow of traffic."

"If people don't see anybody, they don't respect it, but if they see people out working on the, then, yeah, they will."

SCDOT Work Zone Safety Ad Development Testing

- Still, comments from several indicate that they have been influenced to change their driving behavior in work zones by one or more factors. These factors include: enforcement, awareness of specific accidents, and/or the Work Zone Safety campaign.

  "Well, I'll tell you what made a difference to me. I got a ticket for $200 . . . I slow down now."

  "I don't care who's behind me or how many cars. I go the speed limit in a work zone. I don't want to get a ticket."

  "I think the ads that they're putting up are good. You know, like, "My dad works here." That gets you."

Evaluation of Existing Ads

- Reactions to current and prior executions for the Work Zone Safety campaign tend to be positive overall. There are, however, clear favorites.

- Respondents were shown each of the ads used for the Work Zone Safety campaign over the past several years. Each one was rated on the dimensions of: *being attention-getting*, *motivating*, and *overall.* Ratings were on a scale from one to ten, where ten is the most positive rating.

- Overall, *The Marine* (mean *"overall"* rating of 7.9), *Gentle Giant* (7.8), and *The Children* (7.8) tend to be rated most positively.

  These are rated significantly more positively than *The Other Children* (6.0), *At the Office* (6.0), and *In the Elevator* (5.9).

  They are also considered to be the most attention-getting and motivating by a significant margin.

Ad Evaluations			
	Overall	Attention-Getting	Motivating
The Marine	7.9	7.8	7.9
The Children	7.8	8.2	8.2
Gentle Giant	7.8	7.5	8.0
The Other Children	6.0	6.0	6.0
At the Office	6.0	6.4	6.3
In the Elevator	5.9	6.0	5.9

- Findings identify some differences in evaluations between the two age segments.

  In general, drivers under 35 tend to be more positive than their older counterparts in their evaluations of *The Marine*, *The Children*, and *Gentle Giant*.

  In addition, the younger segment tends to rate all the ads as being more motivating than attention-getting, while older audiences tend to rate the adds as being more attention-getting than motivating.

Ad Evaluation "Overall"			
	Total	<35	36+
The Marine	7.9	9.0	7.1
The Children	7.8	8.3	7.4
Gentle Giant	7.8	8.8	7.1
The Other Children	6.0	6.4	5.8
At the Office	6.0	5.8	6.2
In the Elevator	5.9	5.9	5.9

Ad Evaluation "Attention-Getting"			
	Total	<35	36+
The Children	8.2	9.2	7.4
The Marine	7.8	8.4	7.3
Gentle Giant	7.5	8.2	7.0
At the Office	6.4	6.0	6.7
The Other Children	6.0	6.6	5.7
In the Elevator	6.0	6.1	6.0

Ad Evaluation "Motivating"			
	Total	<35	36+
The Children	8.2	9.2	7.4
Gentle Giant	8.0	9.1	7.1
The Marine	7.9	9.0	7.0
At the Office	6.3	6.6	6.2
The Other Children	6.0	6.3	5.8
In the Elevator	5.9	6.1	5.8

- Respondent comments tend to reinforce the strength of *The Marine*, *Gentle Giant*, and *The Children*.

  The Marine and ***Gentle Giant*** spots are familiar to most respondents. The testimonial format and dimension of reality are viewed as effective in getting attention and motivating changes in behavior. In addition, they both tend to be viewed as effective in generating emotion and expanding Work Zone Safety beyond the workers and the drivers themselves.

  "I think it's [The Marine] the most effective. Even more than the children. Because he's a real person."

"I just like how they go to where it happened at for you to see the real place."

"It's reality."

"He has a real family. I mean, the kids are saying, "It could be my mom," "It could be my dad out here working." I mean, I think anybody that has lived here in Columbia has lived that day that that happened. I mean, if you heard the news."

". . . Show the public what's at stake, what really could happen as a result of speeding in a work zone, or speeding on the highway, or going too fast through a 30 mph zone during, you know, peak rush hour or something in the city or in the township. People relate better to the reality as opposed to what if."

"If you don't care about yourself, think about the other person. That's what I think it's saying."

"They did that one there pretty good I think because it shows the overall, whole perspective."

"That hits more close to home because you realize that could have been my brother or, you know, father or something like that, so it hits close to home."

"You instantly put yourself in that position, 'What if I was his wife and I was left with two small children'"

"I'd put this one at the top because they showed his picture and they showed his family."

". . . This guy was just trying to follow the rules and do what he's supposed to do, and he got caught in the, someone who was doing their own thing, and had a consequence on him."

"I think it was very good because it showed him and his fiancée and how it affected her."

The Children is also very familiar to most respondents and viewed as particularly motivating by incorporating the appeal of children.

"It catches you more because it's children. I don't care if you got 'em or not. It's more motivating, uh-huh [yes]. Because I think when you're a grownup, it's about time you knew stuff, knew these things, you know?"

"Yeah, I think that makes a bigger impression on me maybe just because I have children, but I think anybody sees that, that would hit you more than—"

"That just did more for me than the grownups."

"That spot helps you relate more to the situation because of the fact you know what's at risk when someone is injured or killed or at risk at the roadside because there are children involved. People relate better to the fact that there are children involved as opposed to grownups. It's human nature is what it is, basically. You know everyone sitting here, if those same actors were grownups and did those same things, it would be, you know, kind of a little flinch, but the fact that they were children amplified and magnified the punch."

"That got my attention because when the car was about to hit the little girl I was like, "Oh," so it really got my attention. It was really scary."

"The first two was talking about how it would affect you. This one's talking about how it affects somebody else. It also put the family more into it. It gives you more, less, you're thinking about the kids. Everybody has to go home to their kids or whatever, and it's just showing the kids and with their parent, I guess. It gets you to think about the whole family when they're out there working, so you're not just looking at them. You're looking at them going home to their family."

"Everybody sympathizes with children."

"I guess it's like they're saying, getting back to the realistic part. You know, when you're going to the kids you're getting toward a more realistic, you have to think about the family."

The Other Children does not generate the same level of appeal as *The Children*. Several comments suggest that simply having children talk about their parents in such a fashion is inappropriate and/or unbelievable. Further, this execution tends to be viewed as more limited in who is affected by an accident in a work zone.

"I think it didn't have the umph like with the other ones did. It wasn't about the workers. It was about the drivers."

"Those poor kids. Why aren't they crying? You can look at them and say, 'Well, is it true?'"

"That was pitiful. It really was. The children were just, it was so sad to watch them straight-faced talking about their parents being dead. You know, like, 'My parents were so irresponsible. Look what they did.' It was almost deadpan. It's sad, you know, the thought. I think it has less impact."

"It seemed kind of fake. Or too scripted."

"This was completely different. They weren't even talking about the workers."

"They should have used the people's parents, not the kids. With the parents and said, 'You know, our son, we taught him, but he wouldn't, he just sped through it.'"

"No, I don't think, I think it's just because they were judging their parents, but, I mean, they're like 5 years old. They can't judge their parents for how they drive. They don't drive."

"And who would really want to believe it, because of the fact that, you know, 'My parents were just killed, my mother was just killed in a car accident,' and no tears involved. I mean, it's, 'Okay, should I believe this child?'"

"Who would make that kid do that?"

The Office and ***In the Elevator*** are generally considered to deliver a meaningful message with a surprise factor. Overall, however, they are viewed as much less engaging and compelling (especially among the younger segment). Many feel that they would never get to the end to get the impact.

"Well, it grabs your attention. The last thing you expect to see is a car going through the office, and it just zoomed through there, so. The first, I remember the first time I saw it, and I thought, "Wait a minute. What is this?" You know, so it made an impression on me."

"It makes you think about the workers and how they feel."

"It helps you associate yourself with them more or less. All of us here, maybe none of us have or will work on a road crew. We work in an office atmosphere. It helps us to associate that type of conditions and be aware of that could be us out there."

"The end is a zinger."

"His voice, his tone. It was awful . . . He's boring. The beginning was too boring."

"The impact wasn't until the end so you're probably not even paying attention to it."

"You turn it off before you get to that point of what it's about."

"He was complaining about something that everybody complains about, too. I connected with him right away."

Evaluation of New Ad Concept

- Response to the new ad concept is positive.

  Respondents give the new concept an overall rating of 6.2 on the 10-point scale and a rating of 6.5 for being *attention-getting* and 6.6 for being *motivating*.

  Although the new concept is not rated quite as favorably as *The Marine*, *Gentle Giant*, and *The Children* on any of the dimensions, they fall well into the positive end of the scale. Further, it is difficult to make direct comparisons because the current and prior spots were tested in finished video format while the concept was in storyboard format only.

SCDOT Work Zone Safety Ad Development Testing

Ad Evaluations			
	Overall	Attention-Getting	Motivating
The Marine	7.9	7.8	7.9
The Children	7.8	8.2	8.2
Gentle Giant	7.8	7.5	8.0
NEW	6.2	6.5	6.6
The Other Children	6.0	6.0	6.0
At the Office	6.0	6.4	6.3
In the Elevator	5.9	6.0	5.9

- The younger driver segment tends to rate the new concept much more favorably than the older segment.

Evaluation of NEW CONCEPT			
	Total	<35	36+
Overall	6.2	7.4	5.3
Attention-Getting	6.5	7.4	5.8
Motivating	6.6	7.9	5.6

- Respondent comments indicate that combining the children with the dimension of enforcement is attention-getting and effective in motivating behavior modification.

  "I think it makes a difference to say that they're going to enforce it. It does."

  "The enforcement would have worked because I know I got a ticket two weeks ago for speeding. I wasn't in a work zone or anything like that, but now when I go through that area, I'm doing a couple miles under the speed limit."

  "I liked it. Just to me it says just the facts, you know. Either listen here, if you don't listen there then listen to me, and this is going to happen if you break the rules."

  "Enforcement rules in the work zone."

- A few respondents (particularly those in the younger segment), however, identify some opportunities for further enhancing the impact of the spots by making a few minor changes (i.e., not referring to the enforcement period as a "blitz.").

  "Yes, I have one issue in particular with this. It says 'unprecedented'. Why put that in there? It's going to make people think that, you know, they're just doing it because they feel like doing it. There's no reason to say unprecedented. It's just, it's going to make people resent it because it's going to make it feel like they don't have a reason for doing this enforcement blitz."

  "It makes it sound like they're just going to do it for a short time. They're going to do it for this one period of this blitz, and then it's over."

  "Maybe, 'We've been asking you for a while. Now we're telling you.'"

APPENDIX H

Washington: Near Miss/Safety Suggestion Booklet Pages

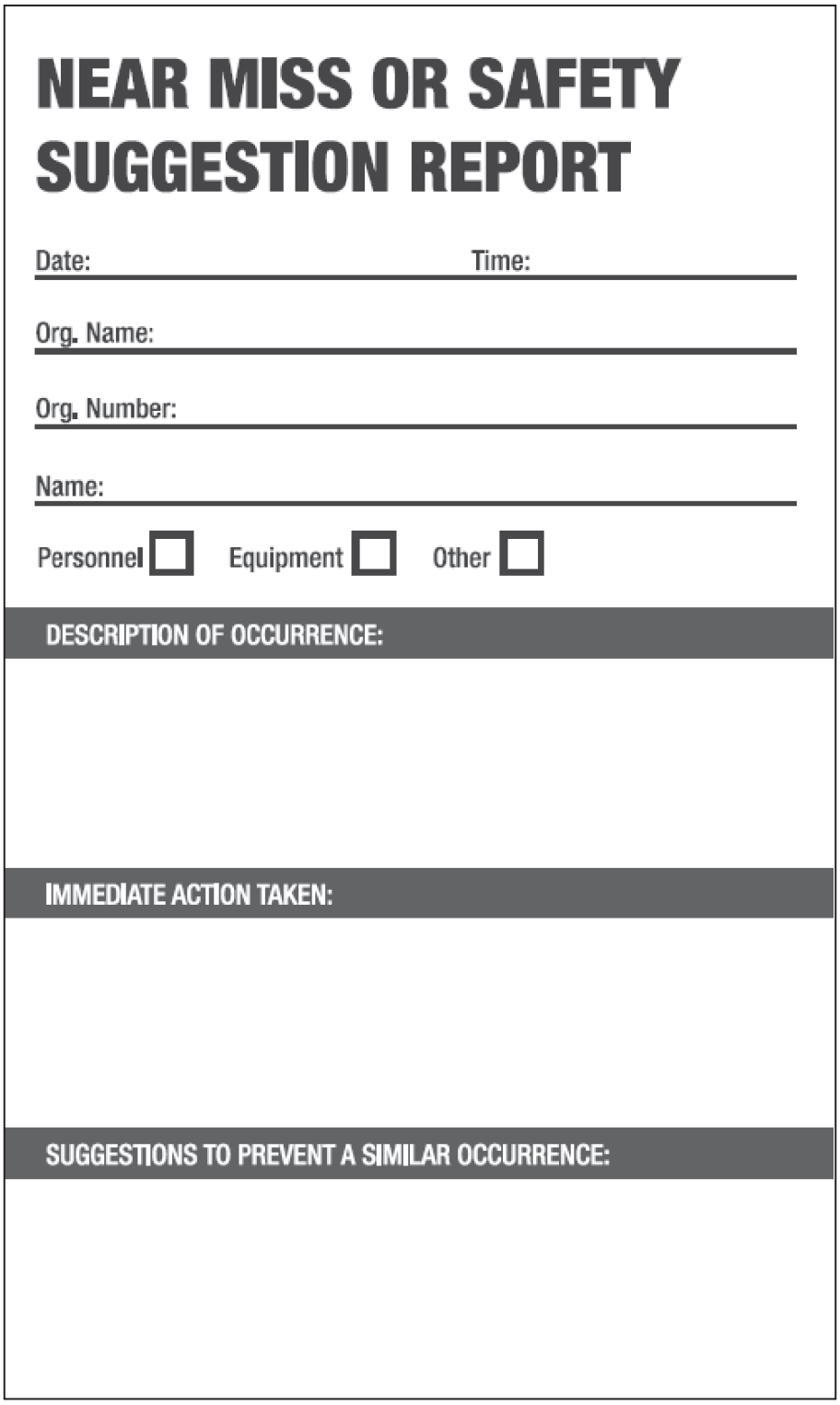
FIGURE H1 Booklet introduction pages.

FIGURE H2 Booklet introduction pages.

FIGURE H3 Booklet introduction pages.

FIGURE H4 Booklet introduction pages.

FIGURE H5 Booklet introduction pages.



NEAR MISS OR SAFETY SUGGESTION REPORT

Date: Time:

Org. Name:

Org. Number:

Name:

Personnel ☐ Equipment ☐ Other ☐

DESCRIPTION OF OCCURRENCE:

IMMEDIATE ACTION TAKEN:

SUGGESTIONS TO PREVENT A SIMILAR OCCURRENCE:

FIGURE H6 Near miss or safety suggestion report form.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	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
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	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
TDC	Transit Development Corporation
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

TRANSPORTATION RESEARCH BOARD
500 Fifth Street, NW
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