Preventing Workers from Being Struck by Roadway Construction Equipment

Presenters:

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Mat Hause and Bob Hammer

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NIOSH Publication

Building Safer Highway Work Zones: Measures to Prevent Worker Injuries from Vehicles and Equipment

CDC
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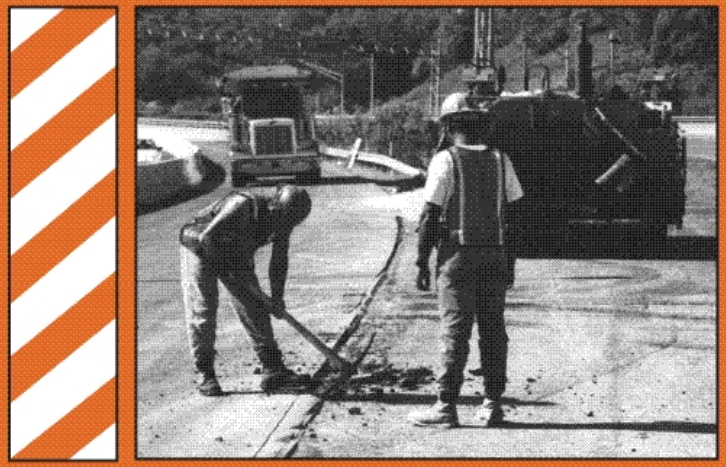

Building Safer Highway Work Zones:

Measures to Prevent Worker Injuries
from Vehicles and Equipment

Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

NIOSH

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For all people
Through research and prevention

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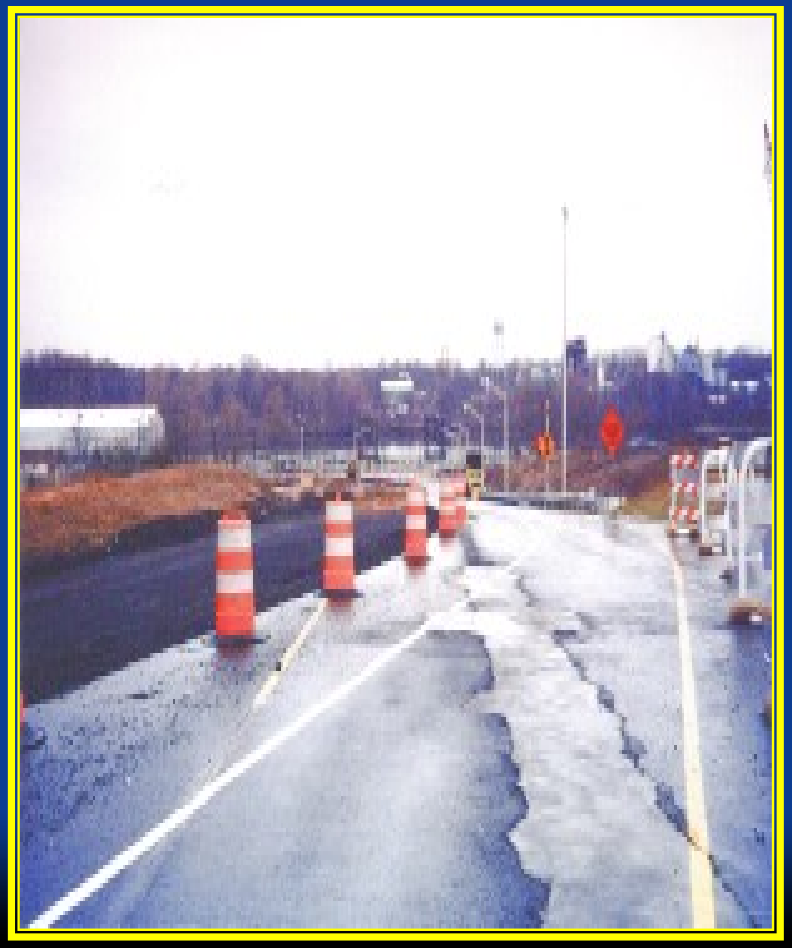
DHHS (NIOSH) PUBLICATION No. 2001-128

Outline

- Background
- Fatality Investigations
- Blind Area Measurements
- Prevention Measures
  - Administrative Controls
  - Engineering Controls

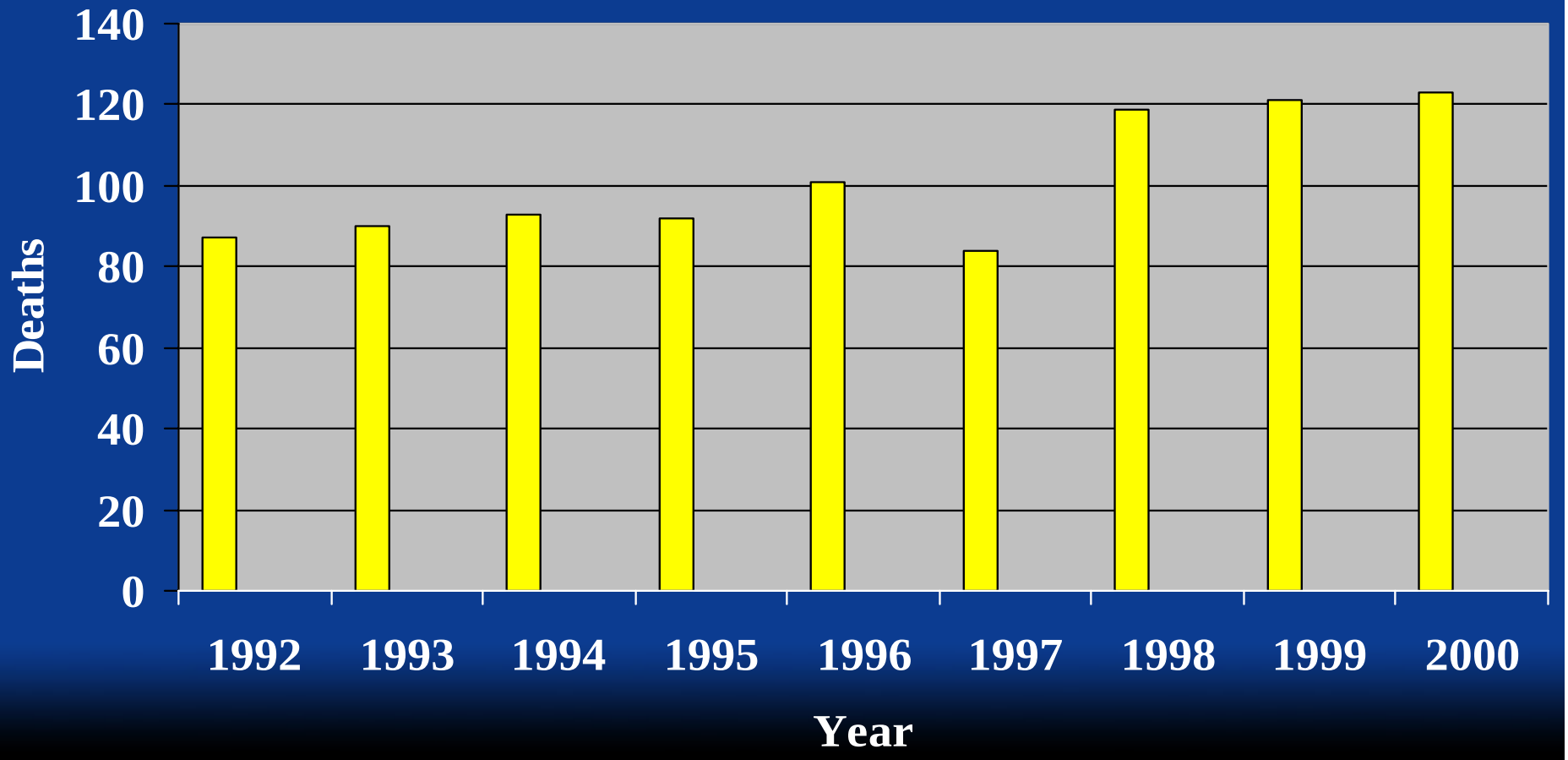
Background



- 910 worker deaths in work zones from 1992-2000
- 826 (91%) were vehicle or equipment-related (traffic vehicle, construction vehicle, or both)

Worker Fatalities in Roadway Construction

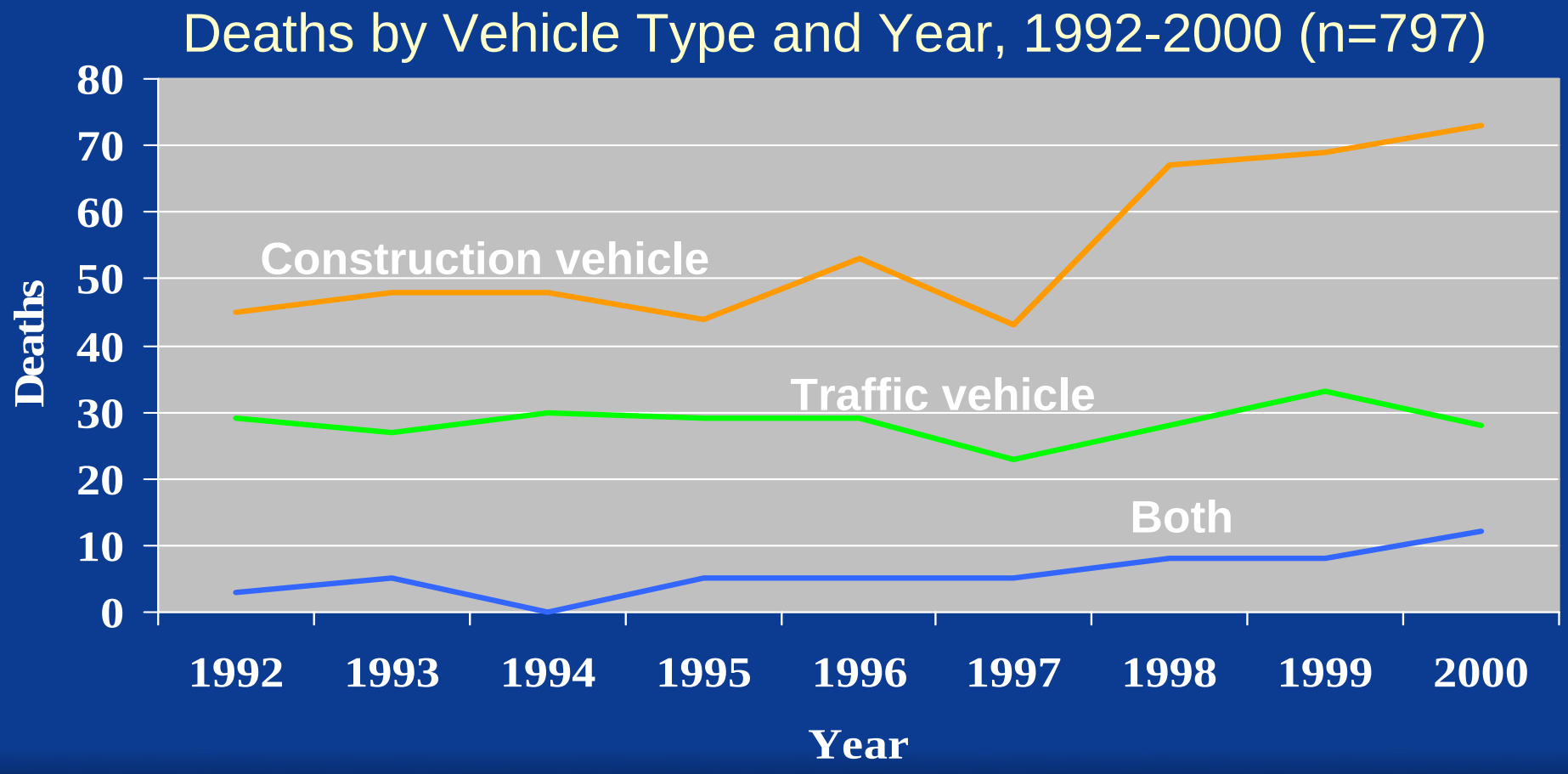
Trend from 1992-2000 (n=910)



Worker Fatalities in Roadway Construction

- Construction vehicles account for as many “worker on foot” deaths as traffic vehicles
- Construction vehicle deaths are responsible for the recent increase in worker deaths

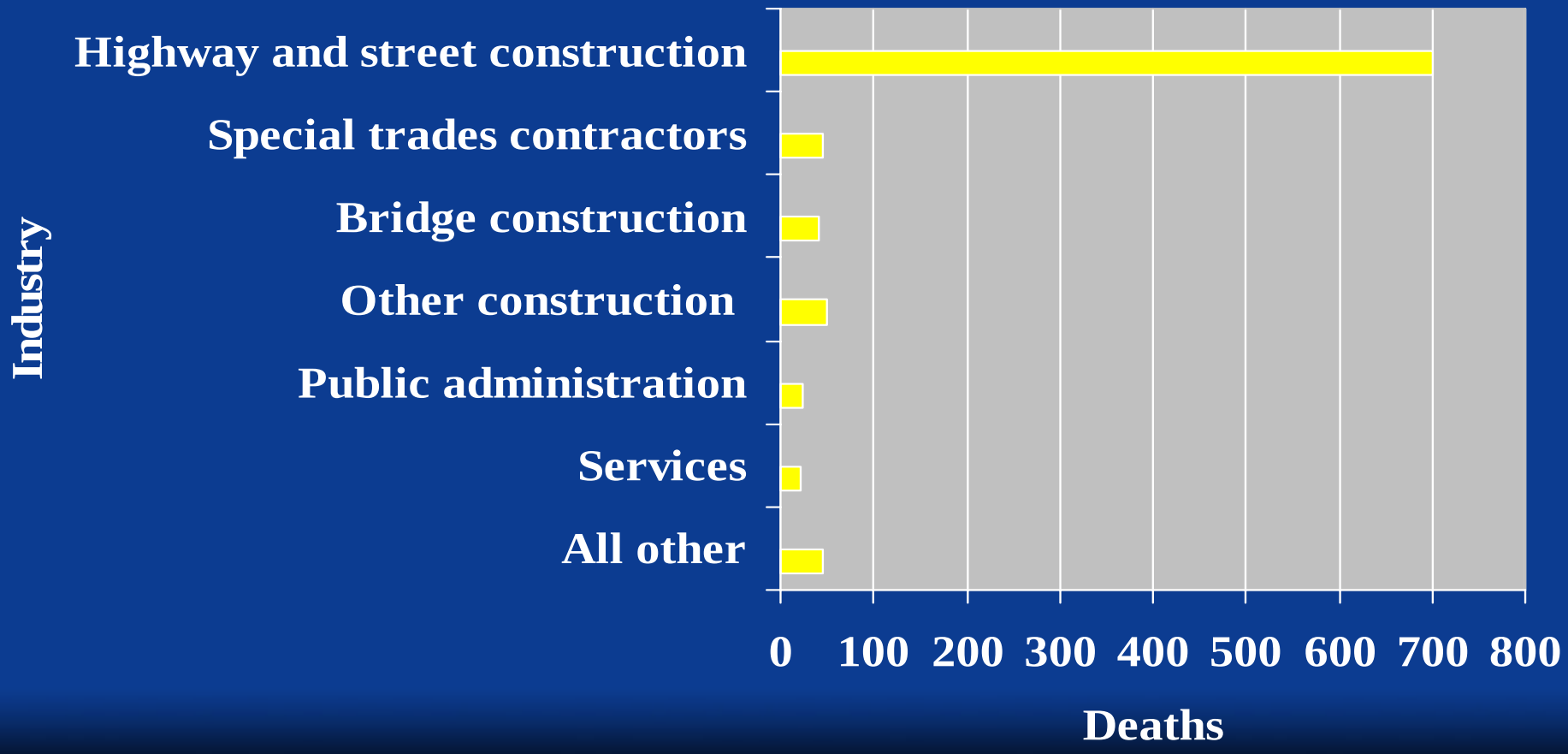
Worker Fatalities in Roadway Construction



Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)

Worker Fatalities in Roadway Construction

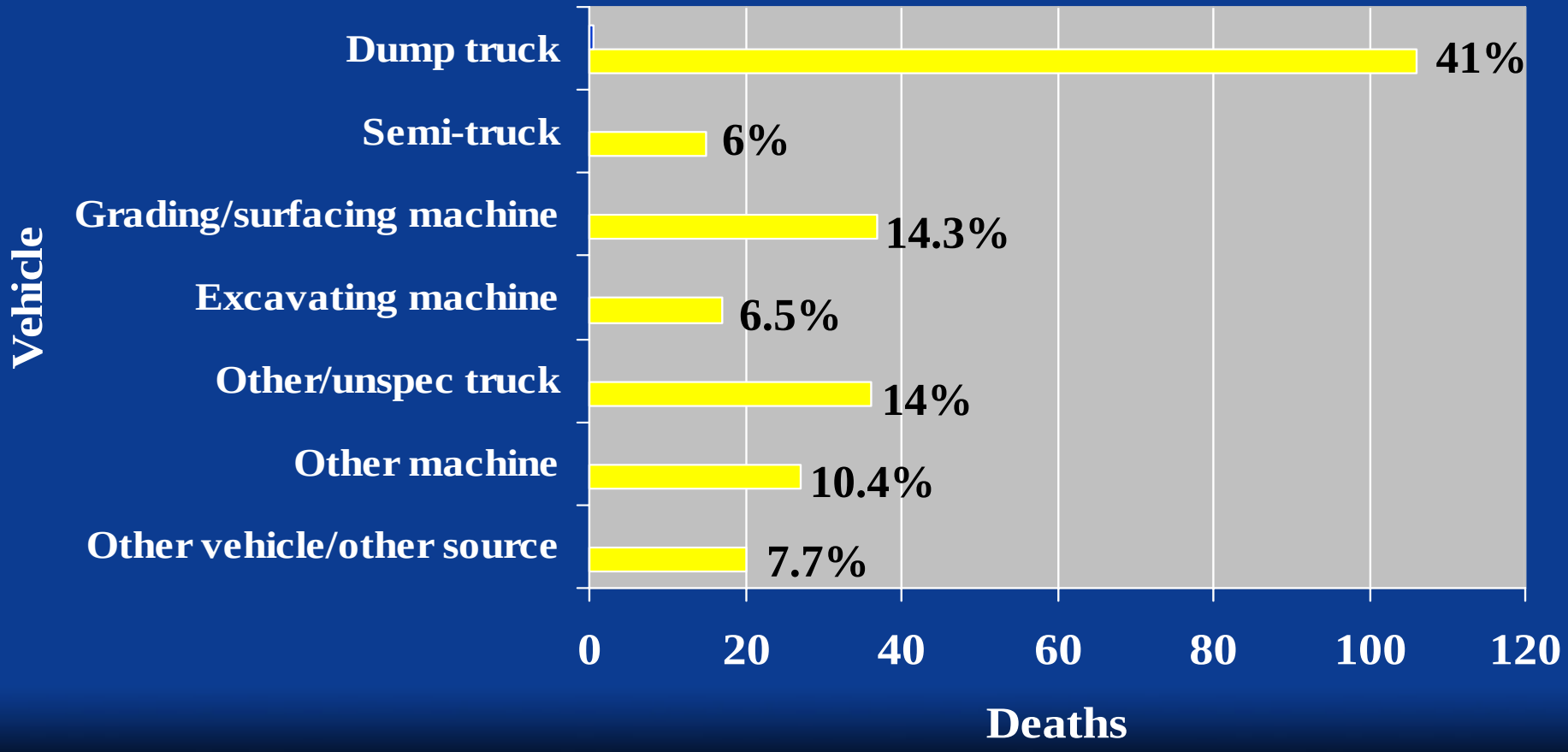
Deaths by Industry, 1992-2000 (n=910)



Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)

Workers on Foot – Construction Vehicle Only

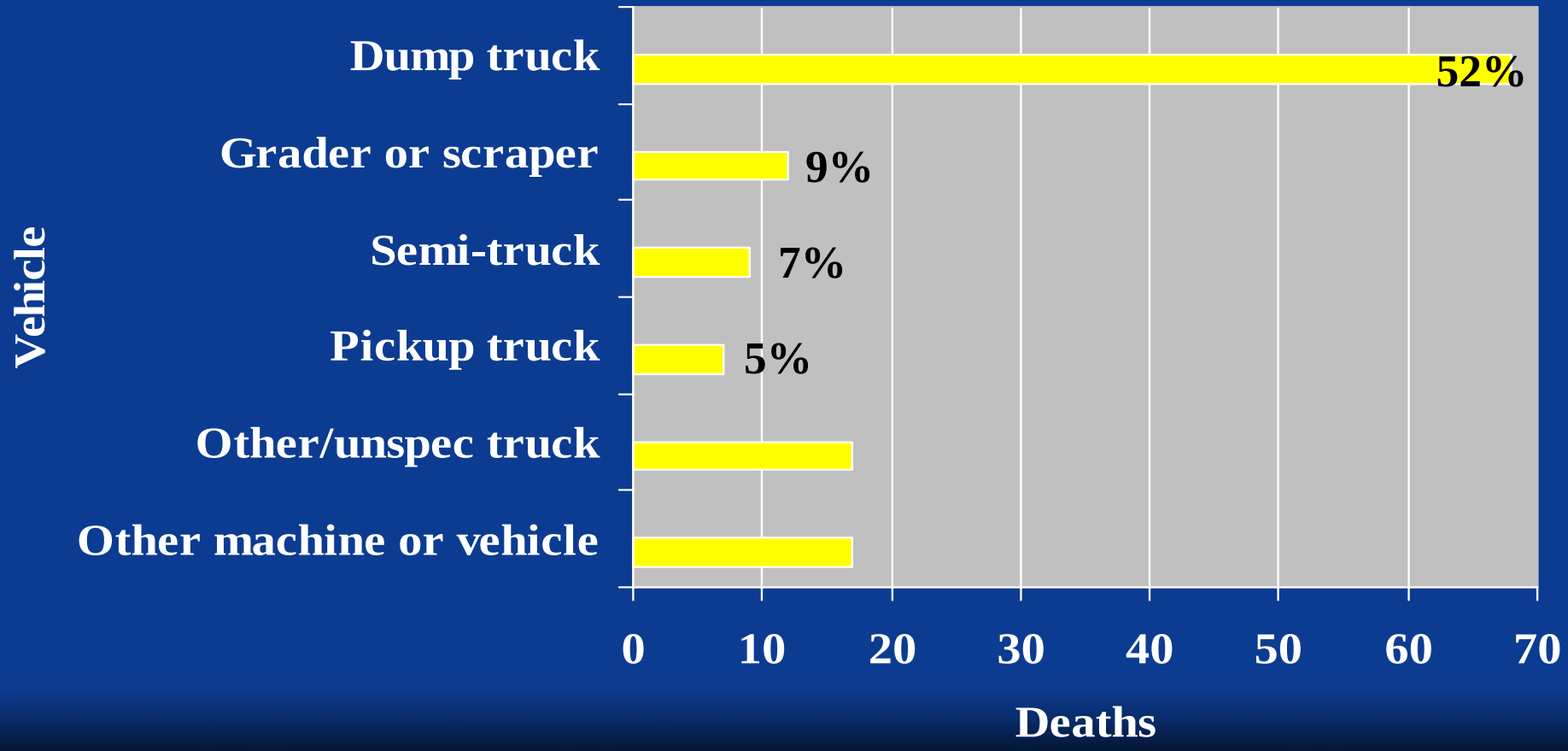
Deaths by Construction Vehicle Type, 1992-2000 (n=258)



Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)

Backing Fatalities in Roadway Construction

Deaths by Construction Vehicle Type, 1992-2000 (n=130)

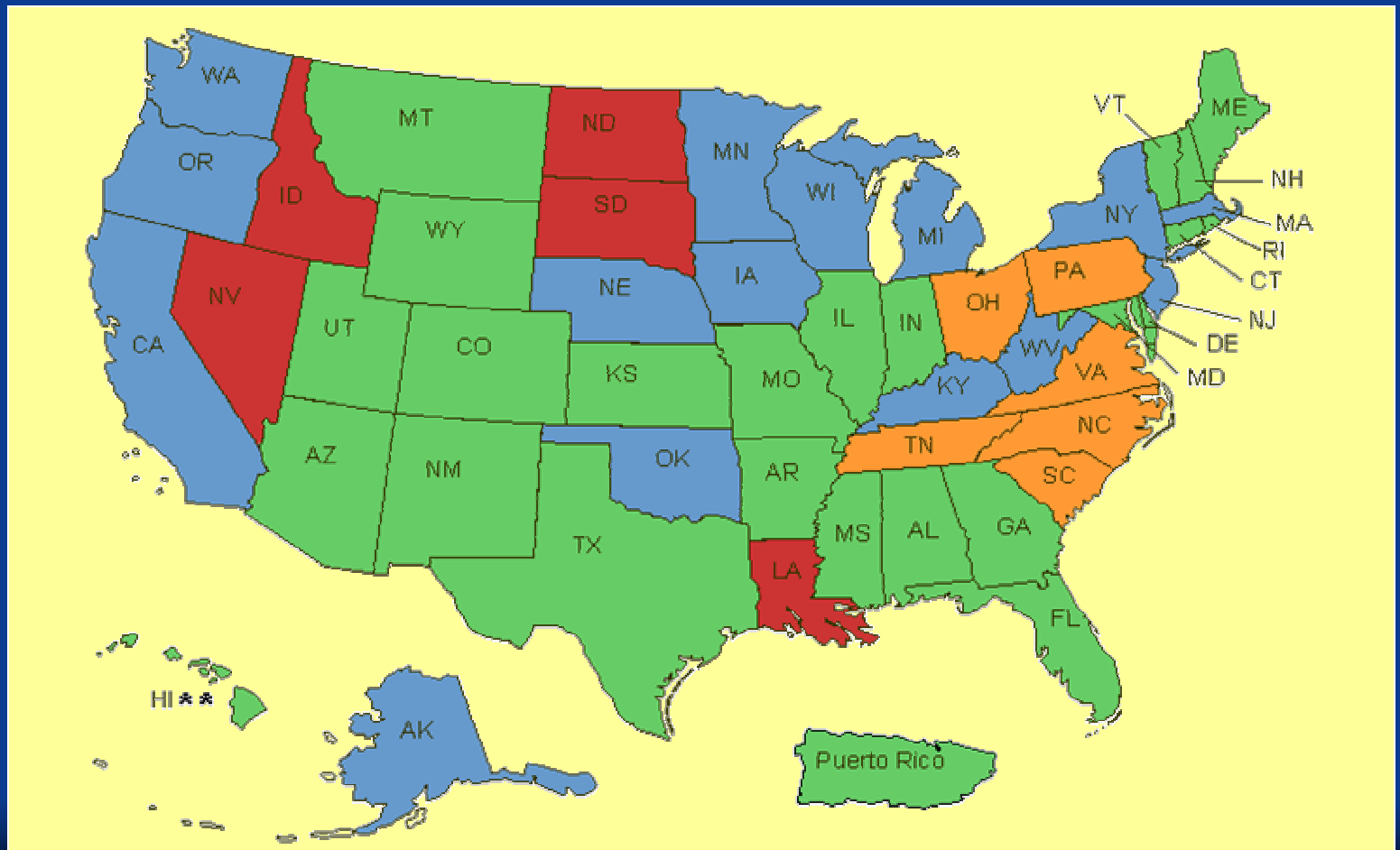


Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)

Fatality Investigations

http://www.cdc.gov/niosh/face/faceweb.html

Participating FACE States



Example Fatality Cases

Case 1: 45-year-old boom truck driver run over by dump truck that was backing during a repositioning maneuver.

Case 2: 31-year-old worker run over by front-end loader at the site of a crushing machine.

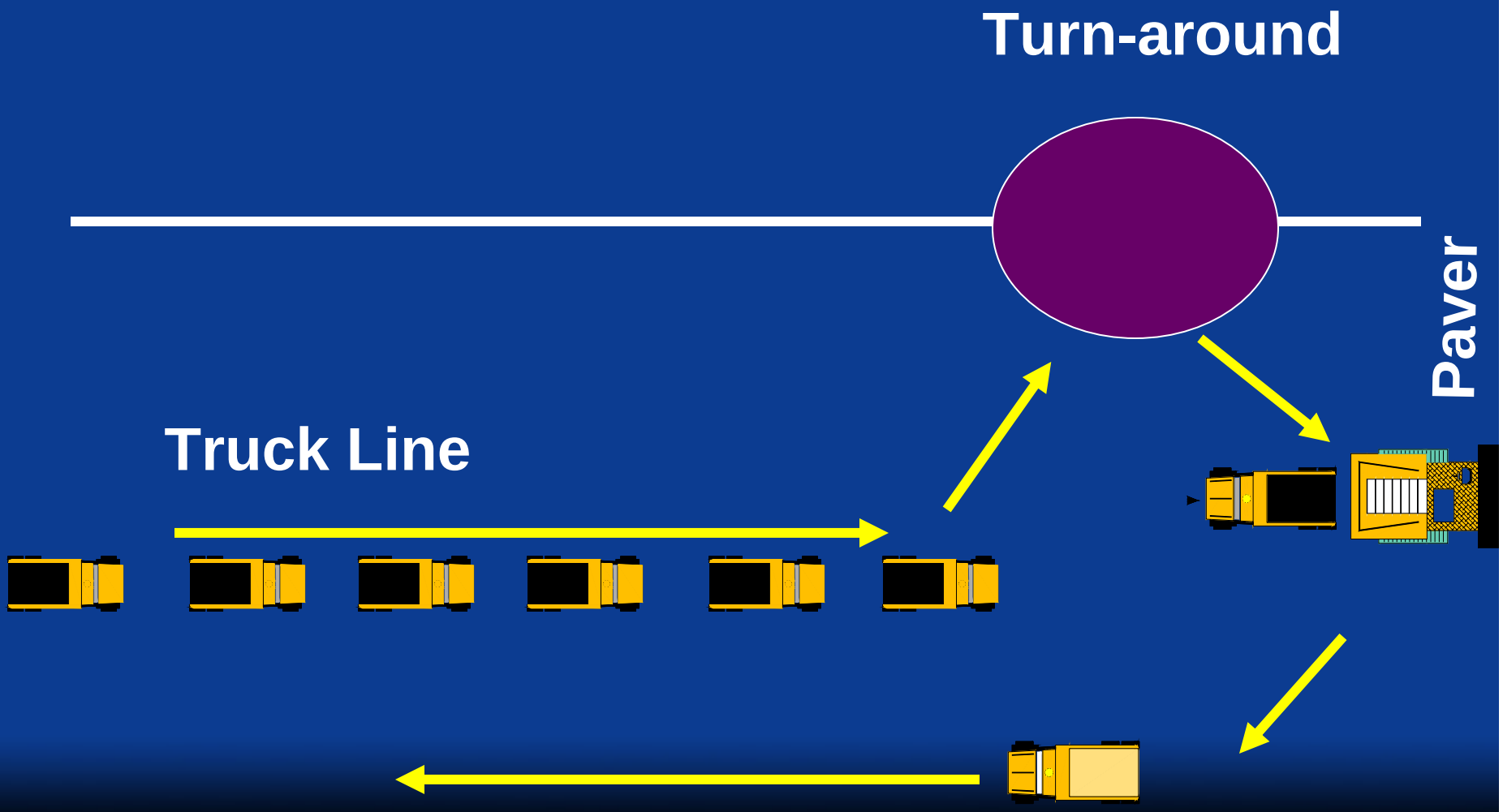
Case 3: 35-year-old laborer run over by dump truck at roadway resurfacing operation.

Case 4: 54-year-old laborer run over by motor grader at housing development roadway under construction.

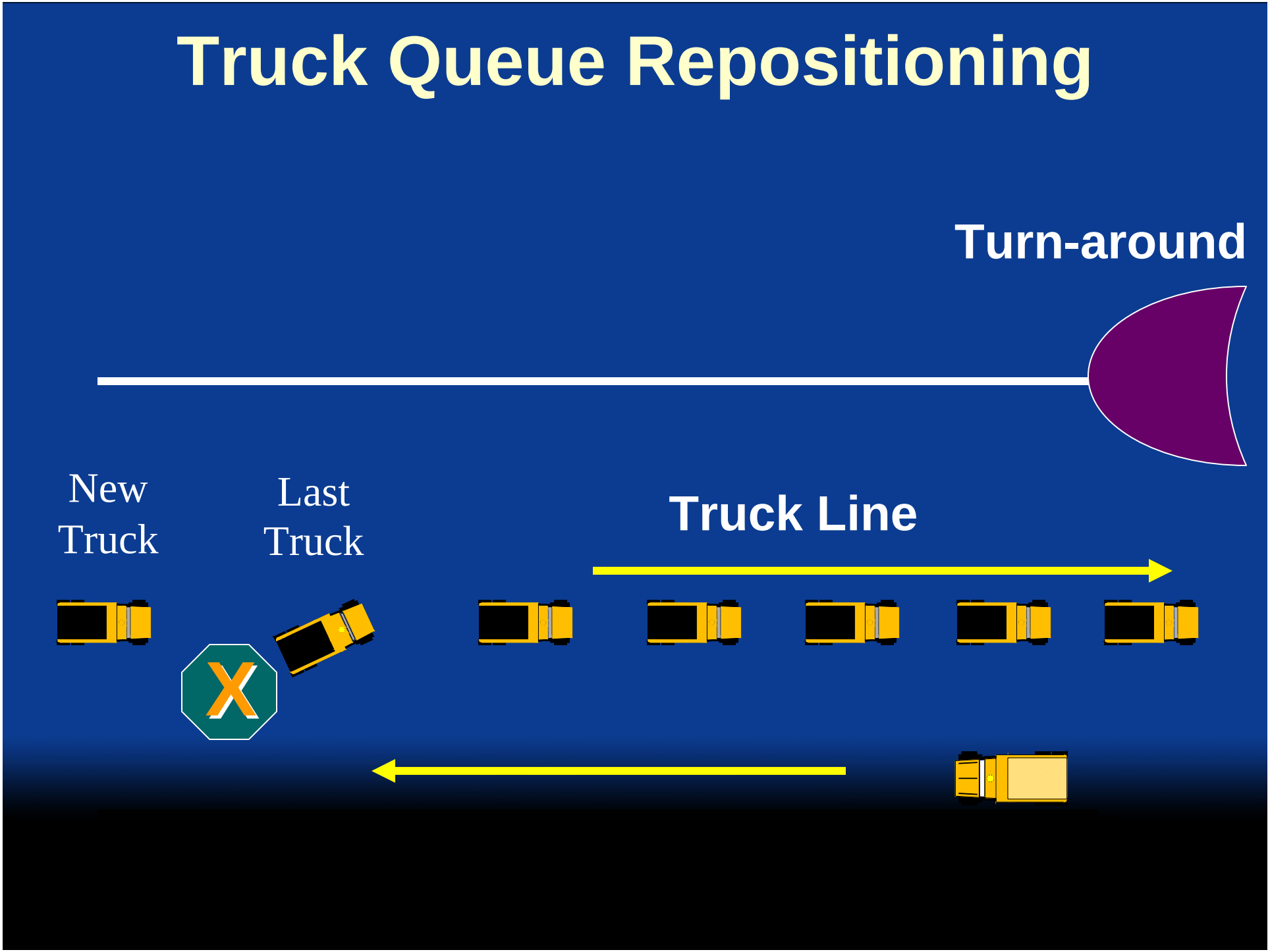
Case 1

Minnesota Face Program (MN9207)

Concrete Paving Operation Layout



Truck Queue Repositioning



Case 2

Minnesota FACE Program (98MN030)

Original Site Layout

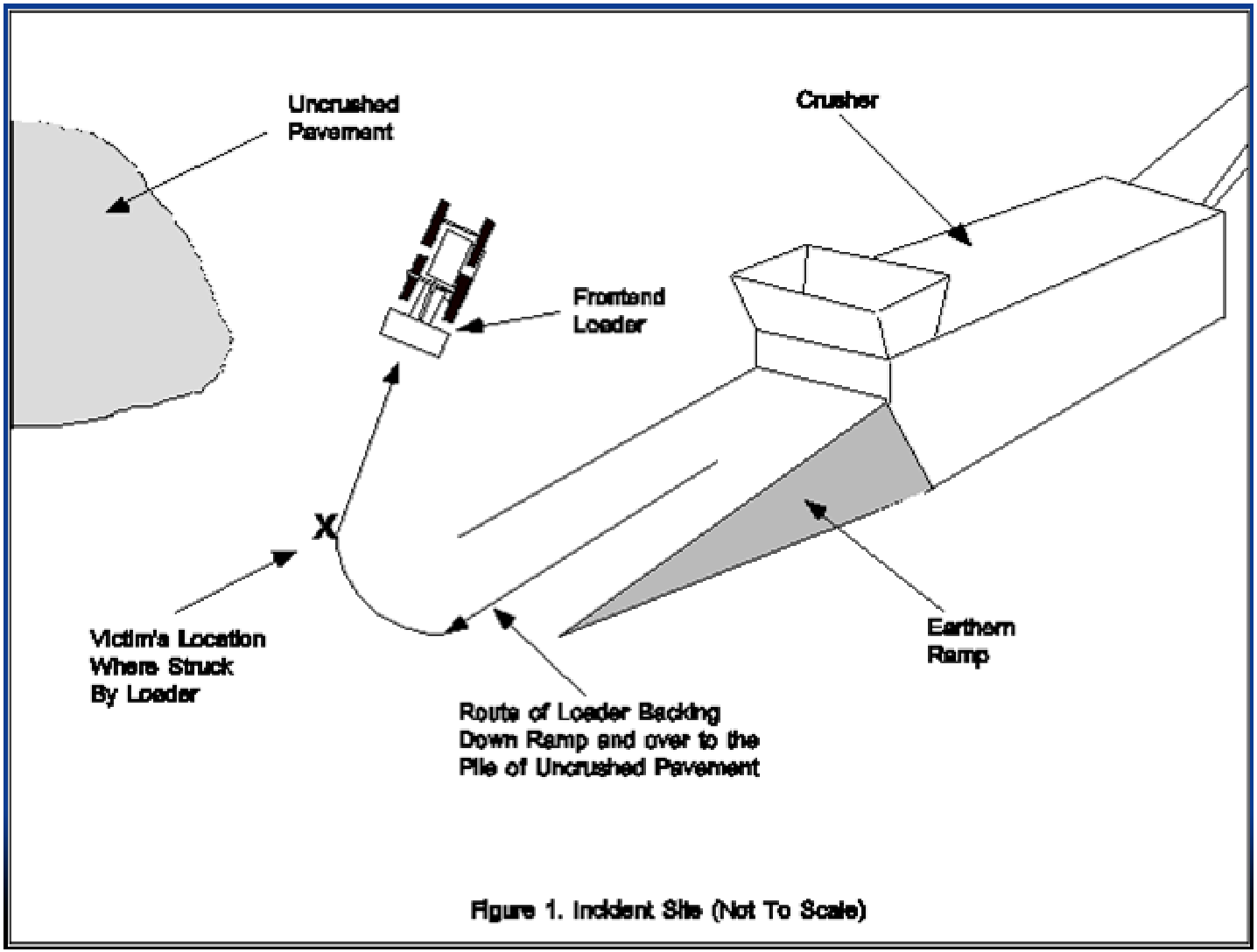
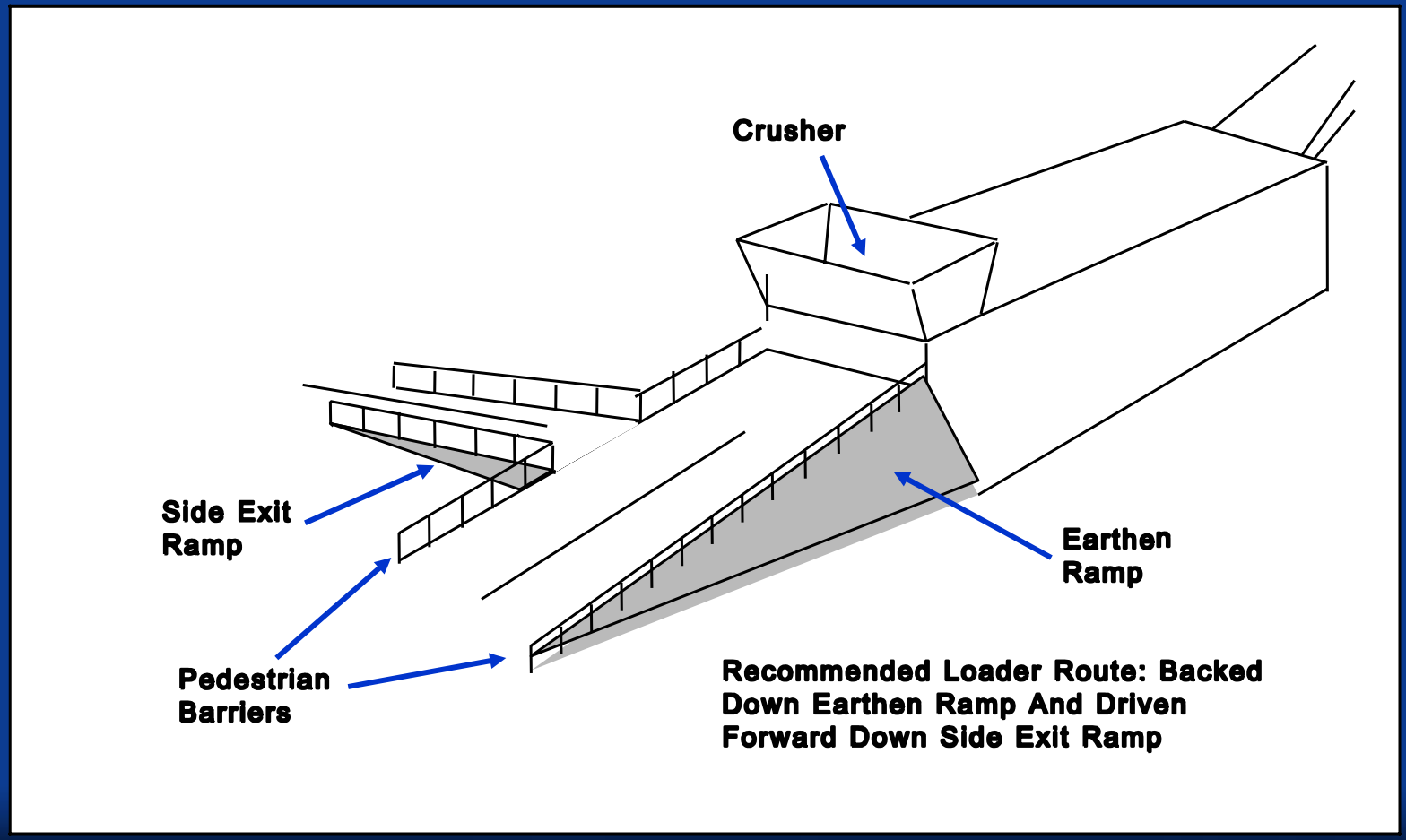
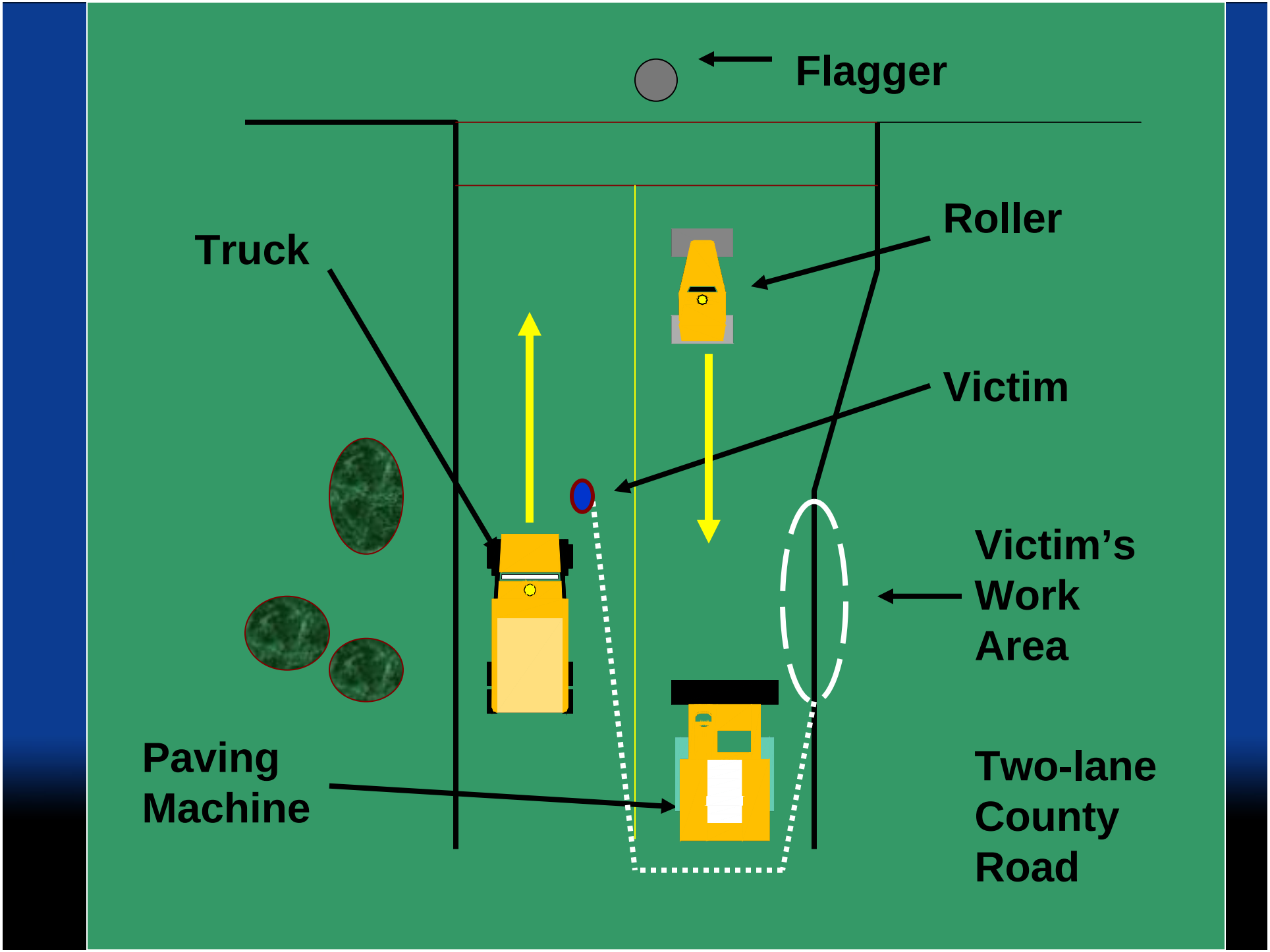


Figure 1. Incident Site (Not To Scale)

Redesigned Site Layout

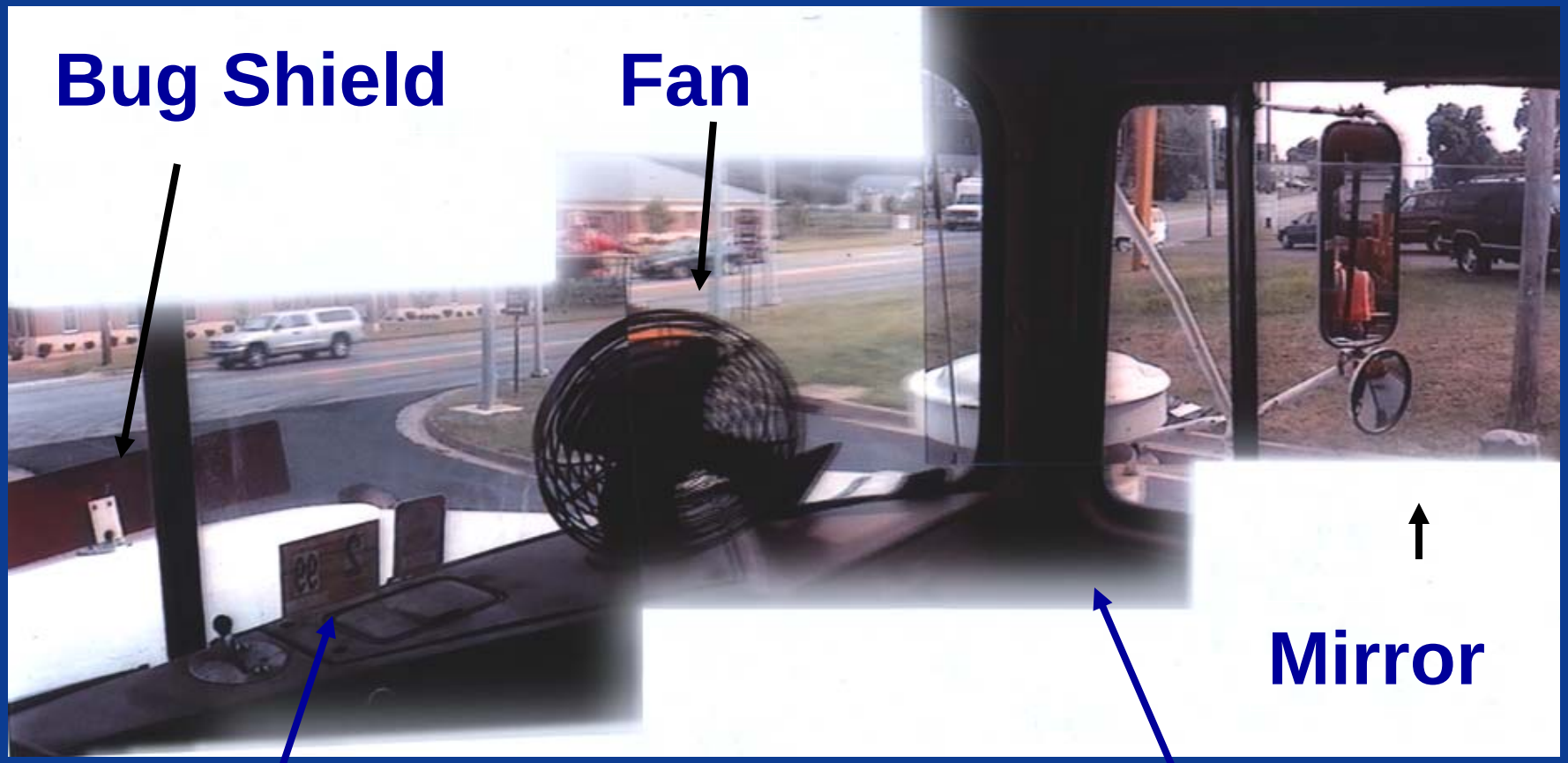


Case 3

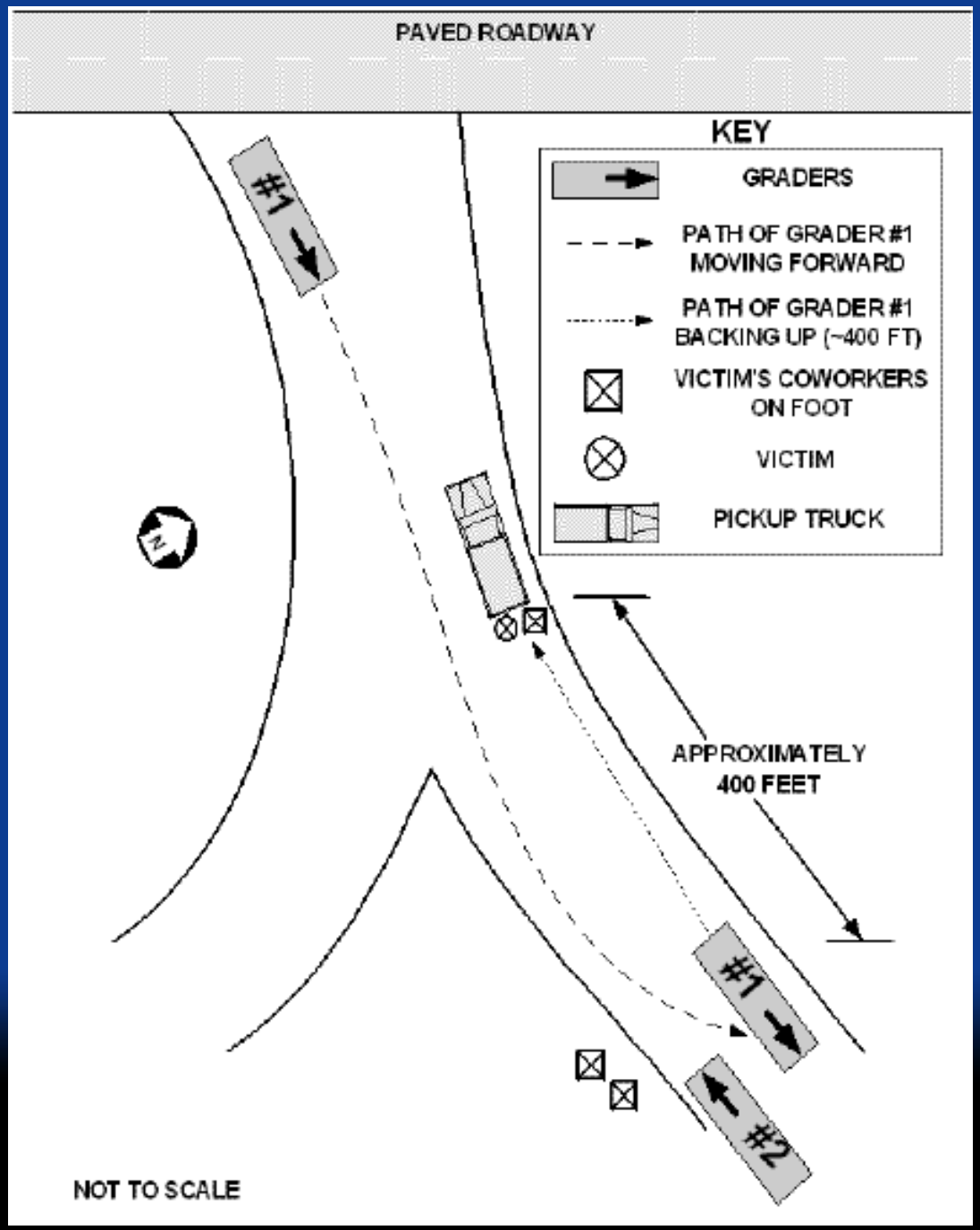

Flagger
Roller
Truck
Victim
Victim's
Work
Area
Paving
Machine
Two-lane
County
Road

View from the Street

View from Inside the Cab



Case 4


PAVED ROADWAY
KEY
GRADERS
PATH OF GRADER #1 MOVING FORWARD
PATH OF GRADER #1 BACKING UP (~400 FT)
VICTIM'S COWORKERS ON FOOT
VICTIM
PICKUP TRUCK
#1
#1
#2
APPROXIMATELY 400 FEET
N
NOT TO SCALE

View from Grader

Summary of Safety Hazards Identified in FACE Investigations

- Ensure that trucks are equipped with audible back-up alarm and look into installing rear sensing units
- Install strobe lights on all company-owned work trucks
- Maintain equipment
- Heavy equipment should be driven in the forward direction as much as possible

Summary of Safety Hazards Identified in FACE Investigations

- Have a comprehensive safety plan
- Conduct a pre-work safety meeting to discuss potential hazards
- Pedestrians should wear high visibility clothing and head gear

http://www.cdc.gov/niosh/face/faceweb.html

Any Questions???

JBeaupre@cdc.gov (304) 285-6185

www.cdc.gov/niosh

Prevention Measures

Include:

- Identifying Blind Areas
- Administrative Controls
  - Backing Safety Program
  - Internal Traffic Control Plans
- Engineering Controls
  - Proximity Warning Systems

Blind Areas

LCDR Mat Hause
Safety Engineer
NIOSH
Morgantown, WV

Definition of Blind Area

- A **blind area** is the area around a vehicle or piece of construction equipment that is not visible to the operators, either by direct line-of-sight or indirectly by use of internal and external mirrors.

Problem

- Workers must be near moving equipment
- Blind areas around equipment extensive

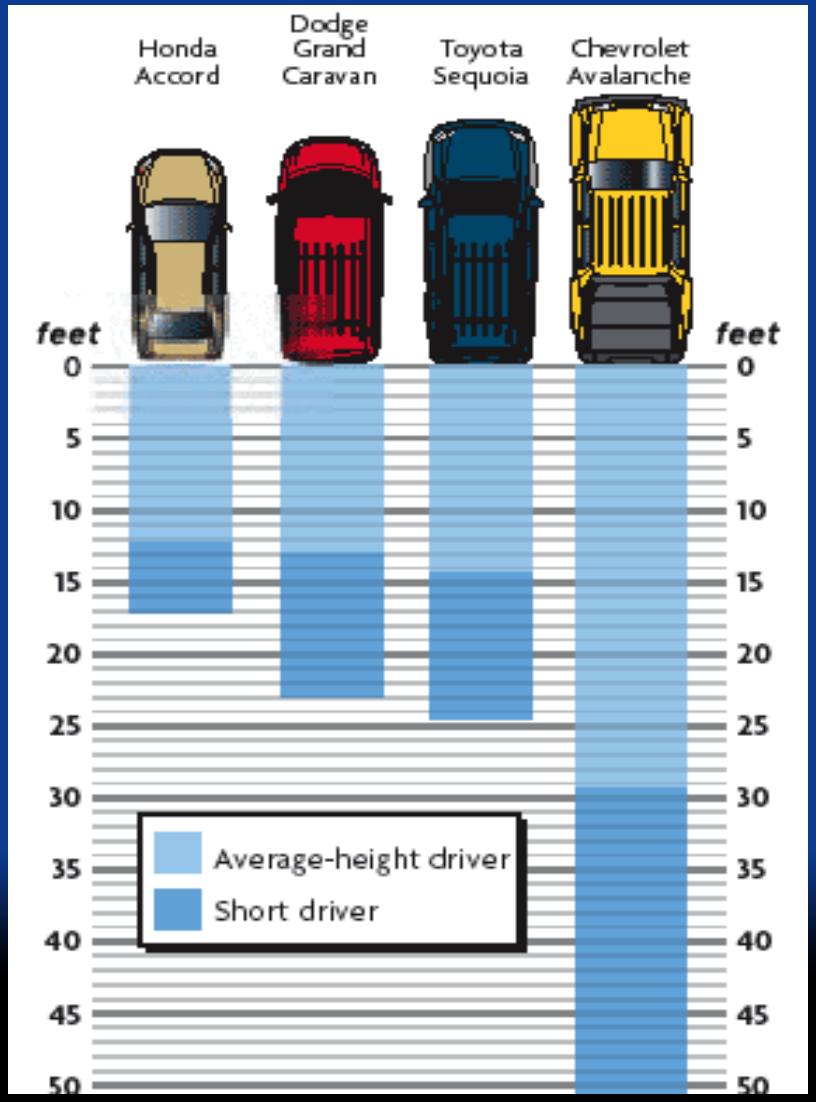
Vehicle Blind Spots

- Running over people
- Running over materials
- Striking other equipment and vehicles
- Rollovers
- Contact with utilities

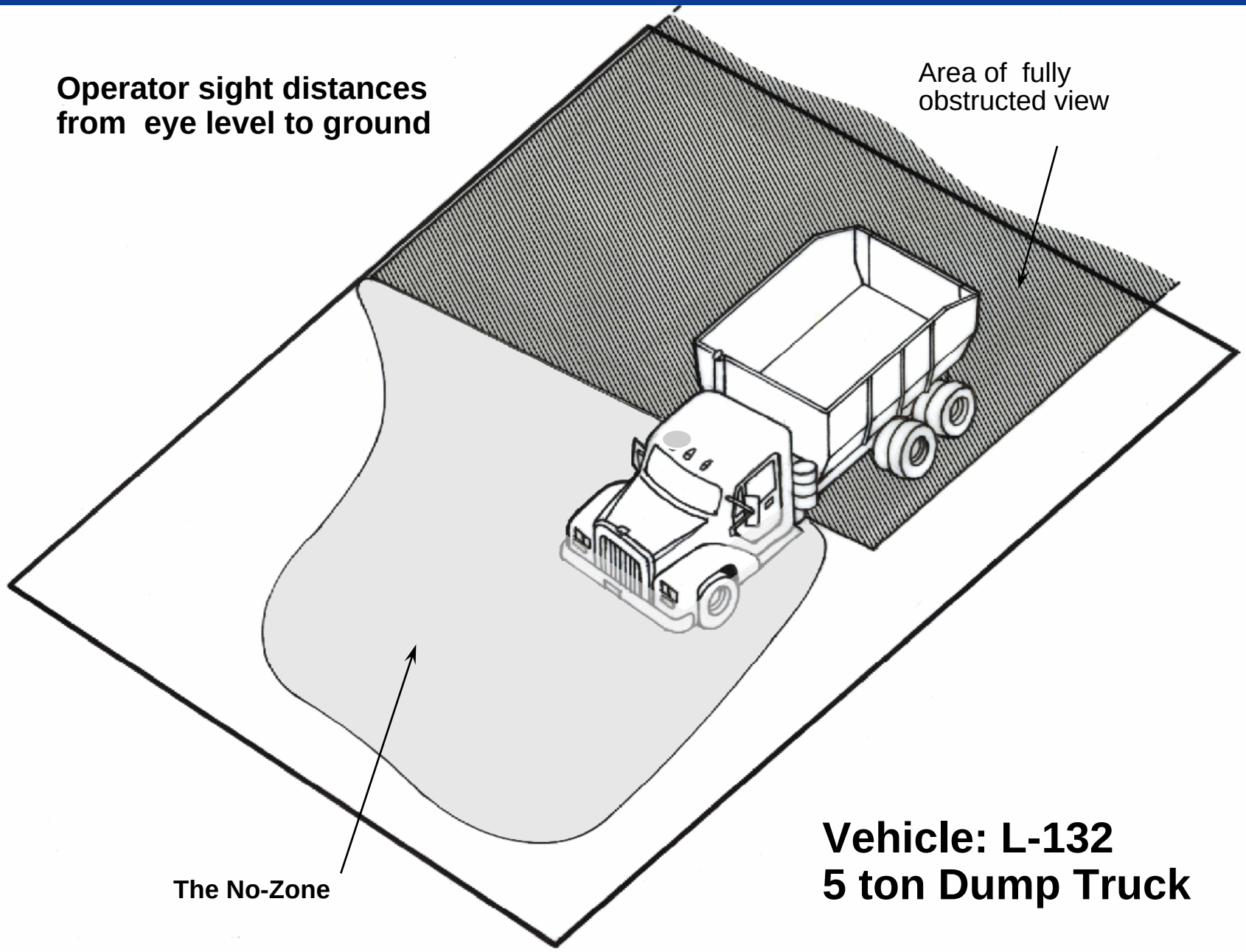
Working in Work Zones

Non-Construction Vehicle Blind Spot Measurements

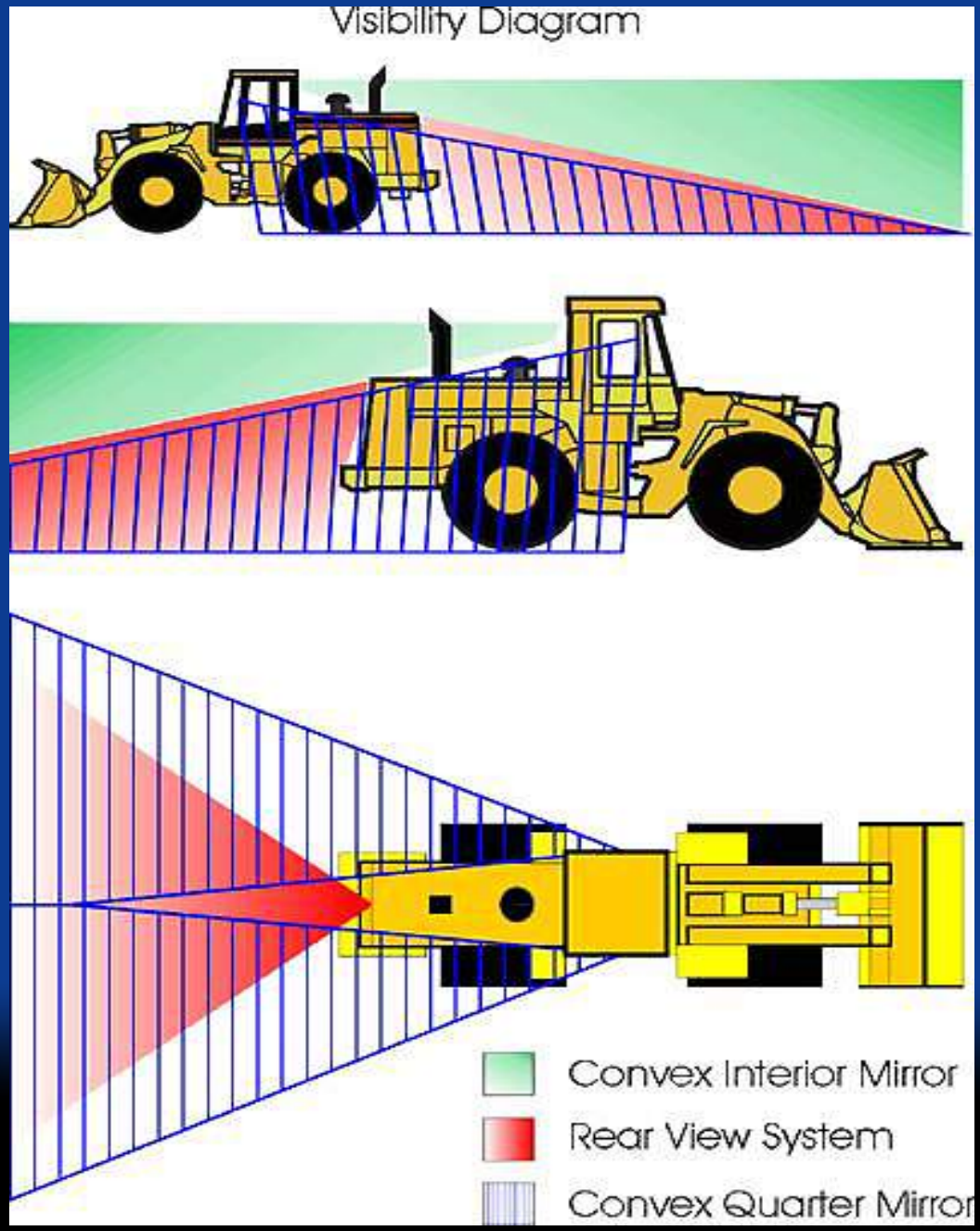
- What About Construction Equipment?



Operator sight distances from eye level to ground



Vehicle: L-132
5 ton Dump Truck


Visibility Diagram
Convex Interior Mirror
Rear View System
Convex Quarter Mirror

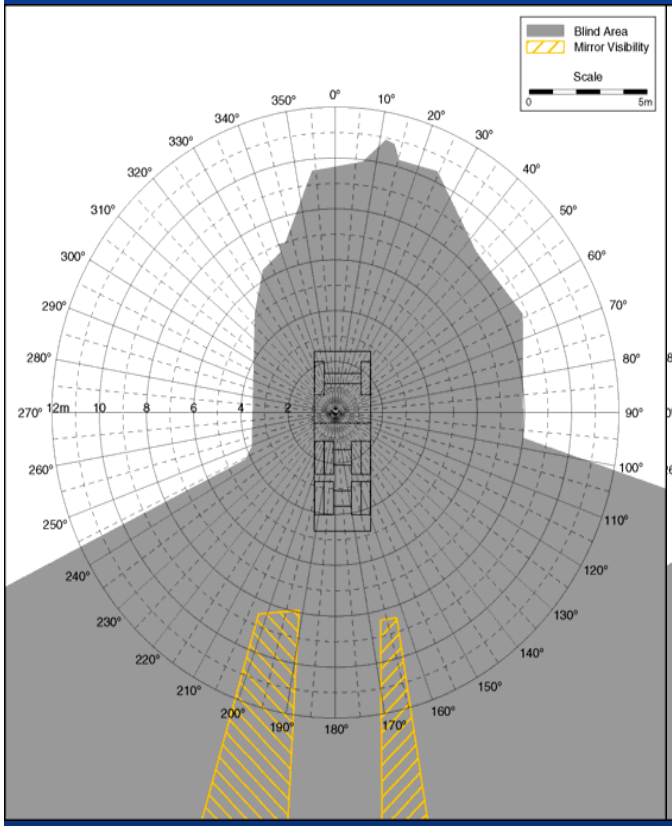
Methods

- Manual methods
- Computer method
- International Organization for Standardization (ISO) 5006

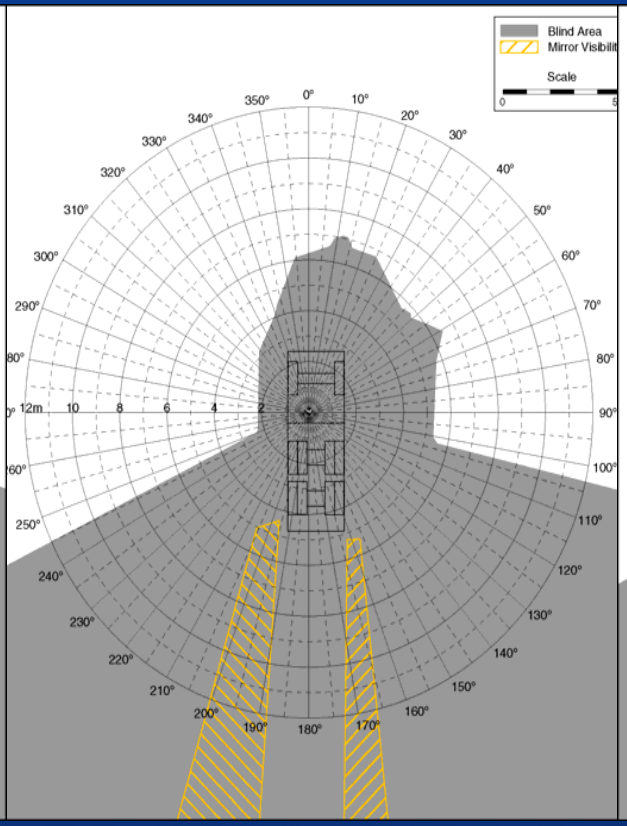
Manual Light Bar Method

Target Stand

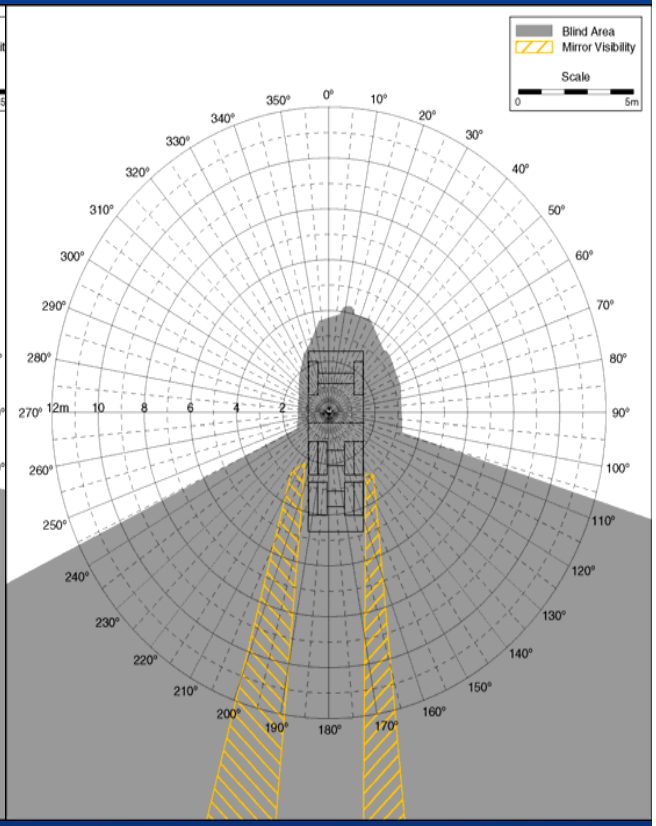
Blind Area Diagrams - Ford 880



Ground

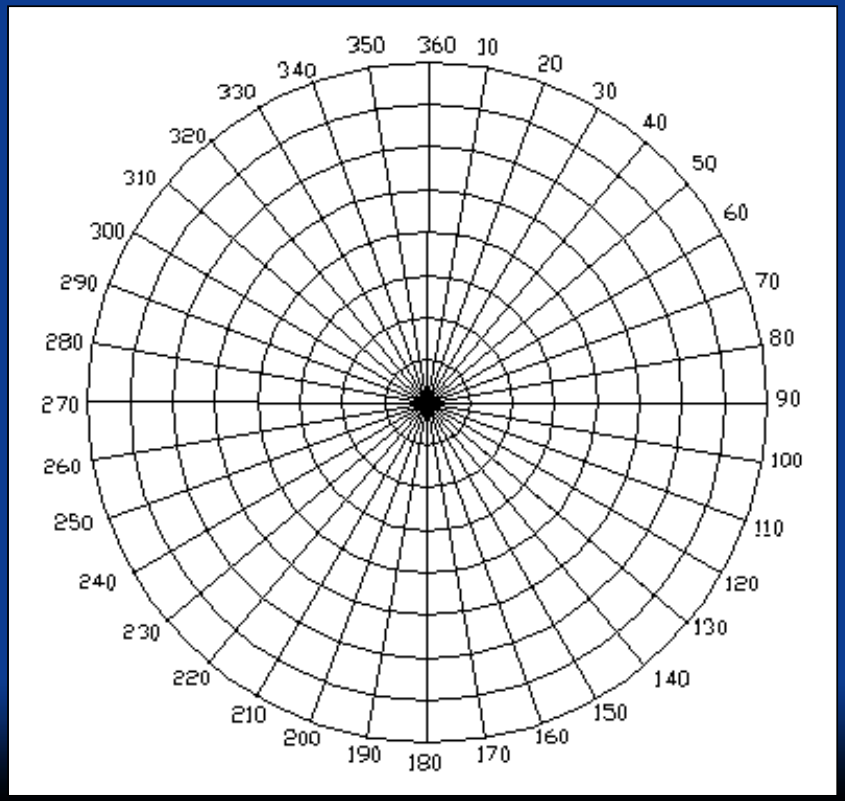


Construction Barrel ~3ft



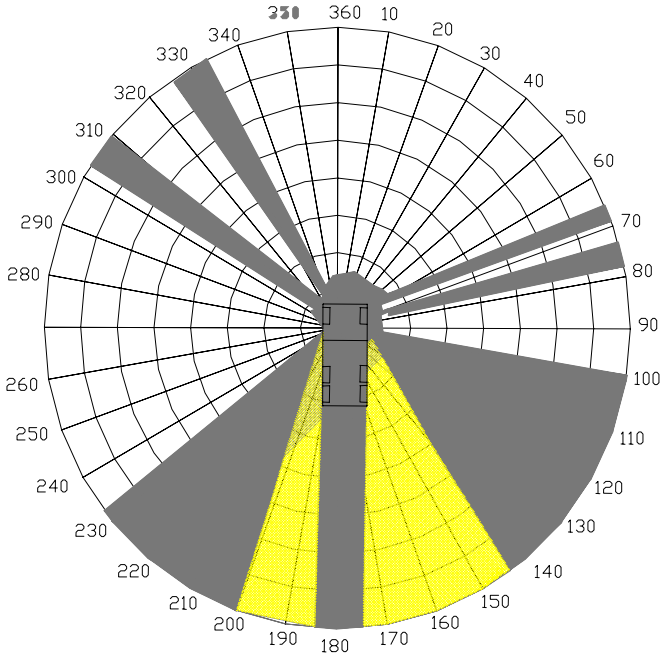
Worker partially bent over ~5ft

Marking Blind Areas Within a Polar Grid



Blind Area Determination

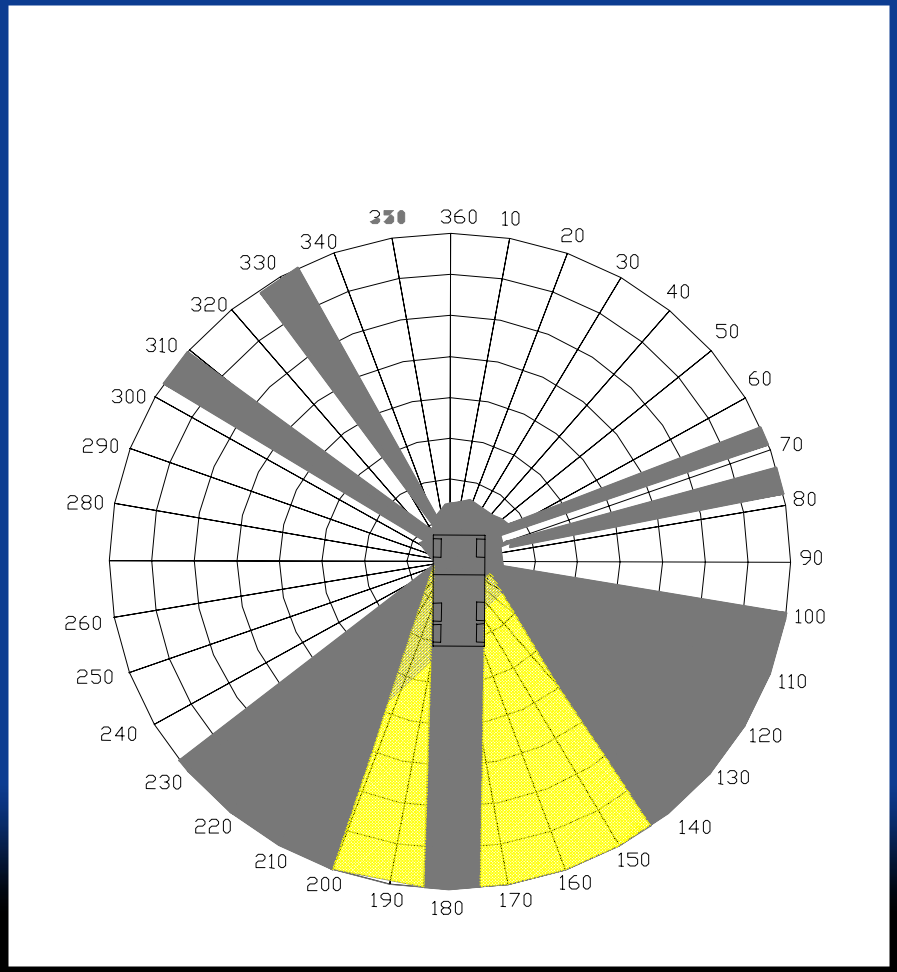
Blind Area



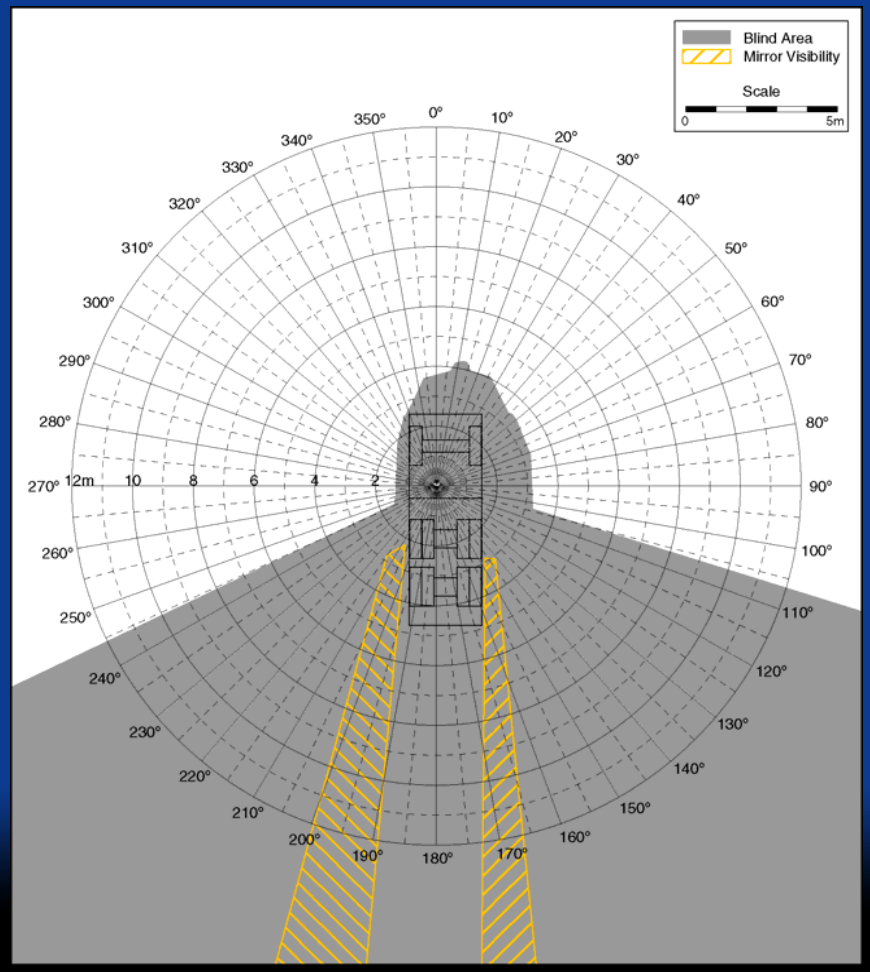
Not Visible to Operator

Visible in mirrors only

Comparison of Manual Methods



Field Crew

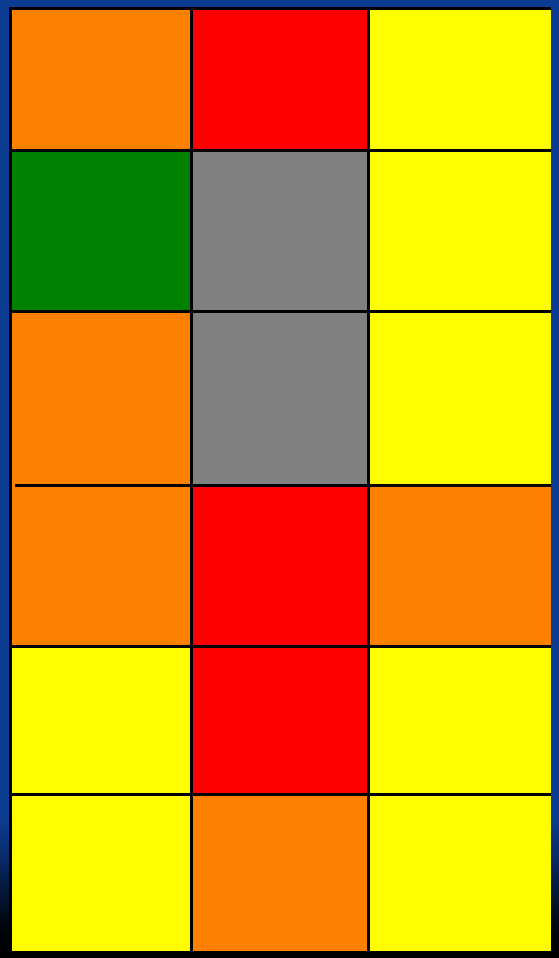


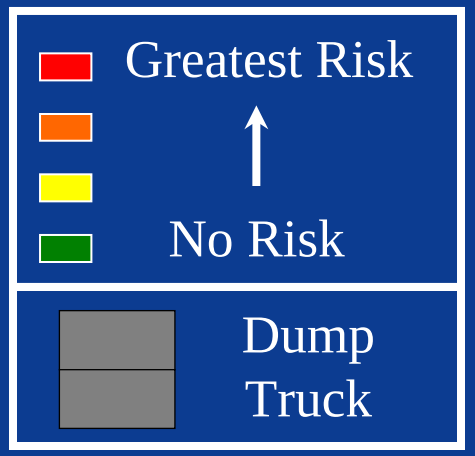
Light Bar

Hazard Area Analysis

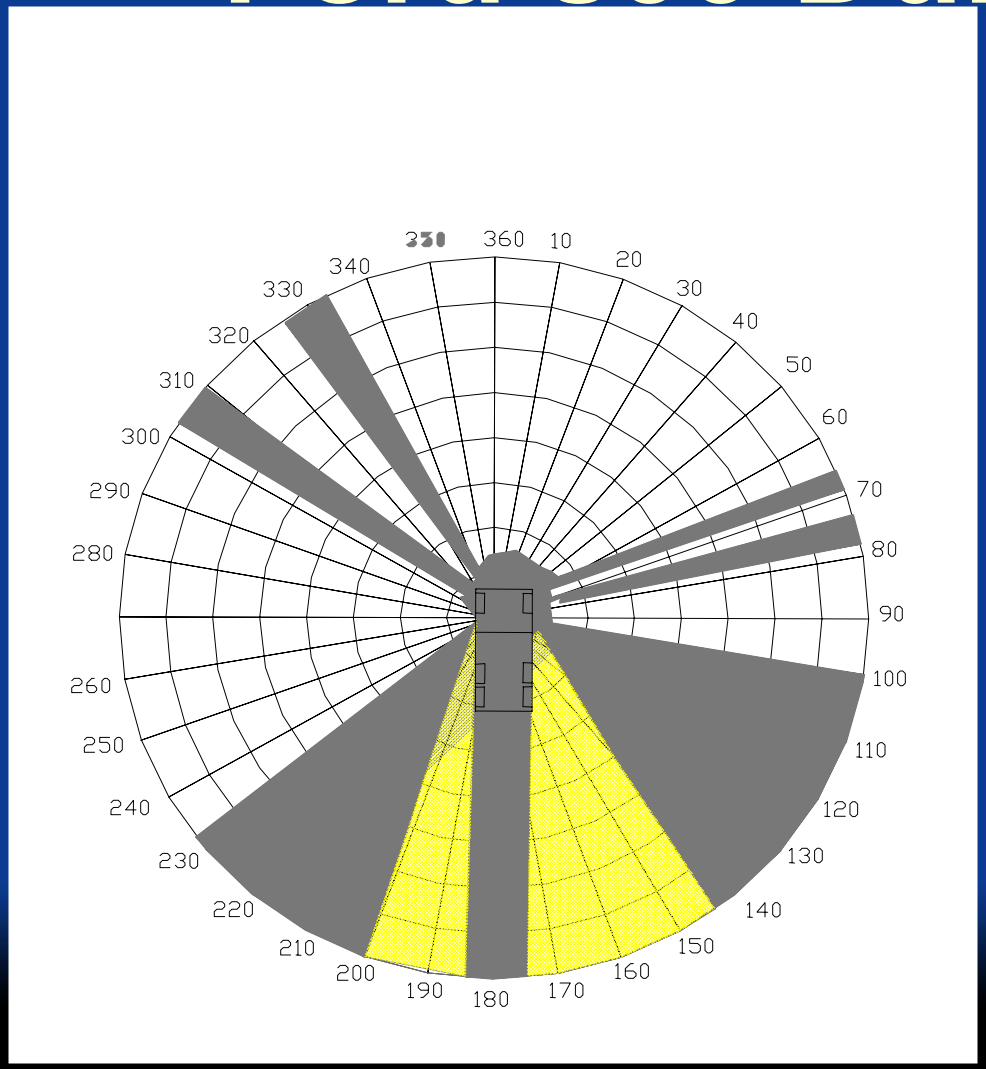
- Vehicle operating speeds
- Vehicle direction of movement
- Worker reaction time

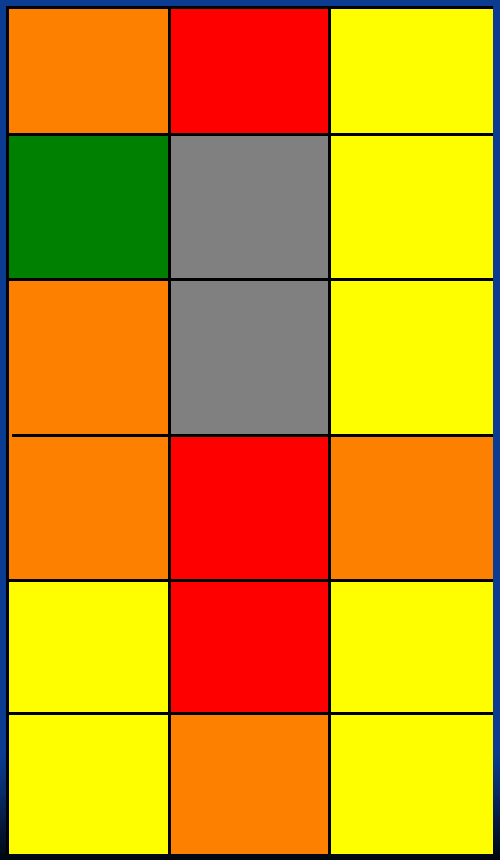
Hazard Area Around Ford 800 Dump Truck





Hazard Area Around Ford 800 Dump Truck





Future Work

- Complete blind area diagrams for 14-16 more pieces of construction equipment.
- Package and distribute comprehensive blind area diagram document.

Conclusions

- With these techniques, worker exposure assessments across the different types & makes of construction equipment are possible.

- Understanding where current visibility limitations are around heavy equipment, and what levels of risk exist, will aid in the development of new protective technologies, worker training, and safer operational procedures.

Contract Deliverable

Center for Disease Control and Prevention

Contract 200-2002-00563

"Construction Vehicle and Equipment Blind Area Diagrams"

Final Report


U.S. PUBLIC HEALTH SERVICE
1798
Building a Safer Industry...
Questions?
NIOSH
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

Prevention Measures (con't)

- Administrative Controls
  - Backing Safety Program
  - Internal Traffic Control Plans
- Engineering Controls
  - Proximity Warning Systems

Administrative Controls

Key Elements of a Vehicle Backing Safety Program

- Equipment designed to minimize blind areas
- Equipment inspections/preventative maintenance
- Layout work areas to avoid backing
- Use of spotters
- Training for operators and workers on foot
- Use of high visibility vests
- Use of other backing safety devices (engineering controls)

Backing Safety Program Prevention Measures

- Equipment designed to minimize blind areas

Backing Safety Program Prevention Measures

Operator Training:

- Avoid having to backup
- Do walk around
- Be aware of blind areas
- Use a spotter

Backing Safety Program Prevention Measures

Worker Training:

- Be aware of equipment blind areas
- Stay out of all blind areas and swing radius
- Make positive eye contact with operators

Operator Human Factors

- Expectancy
- Perception time
- Reaction time
- Ability

Backing Safety Program Prevention Measures

Worker Visibility:

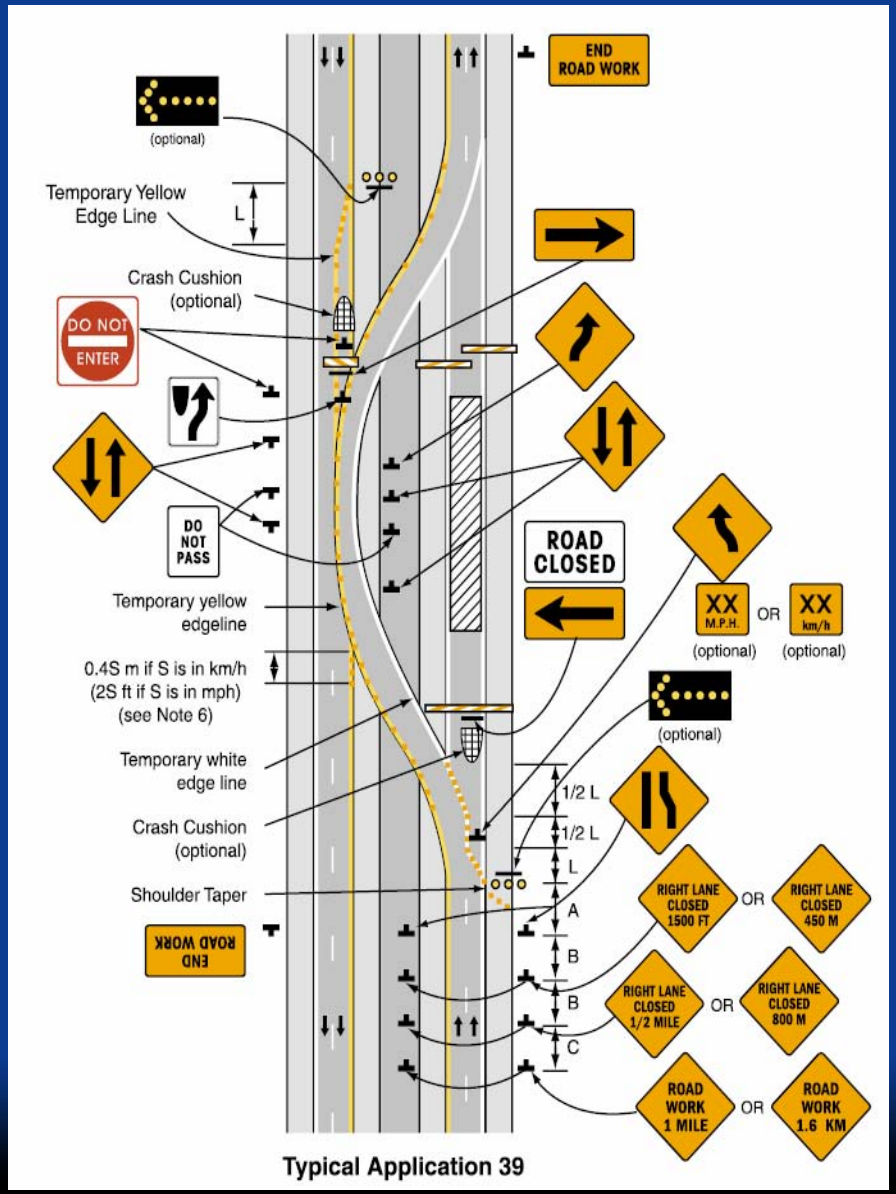
- Require workers to wear high-visibility clothing.
- Apparel that covers moving parts of the body is best.
- Consider apparel with different designs front and back.

Internal Traffic Control Plans

Why Develop an Internal Traffic Control Plan?

- Coordinate vehicle/equipment movement inside the work zone
- Limit exposure of workers on foot to construction traffic
- Reduce hazards for equipment operators

Traffic Control Plans



Typical Application 39

Proposed Definition of Internal Traffic Control Plans (ITCP)

"STRATEGIES TO CONTROL THE FLOW OF CONSTRUCTION WORKERS, VEHICLES AND EQUIPMENT ***INSIDE*** THE WORKZONE"

ITCP Principles of Safe Construction Traffic Control

- Reducing the need to back up equipment
- Limiting access points to work zones
- Establishing pedestrian-free areas where possible
- Establishing work zone layouts commensurate with type of equipment
- Providing signs within the work zone to give guidance to pedestrians, equipment and trucks
- Designing buffer spaces to protect pedestrians from errant vehicles or work zone equipment

ITCP Components

- Notes Page
  - Safety Points
  - Personnel
  - Equipment
- Legend
  - Method Specific
- Work Area Diagrams
  - Dimensions
  - Movement Flow
  - Workzone Limits
  - Signage

Internal Traffic Control Plan

Safety Points:

- No workers in traffic zone
- Spotter uses hands free radio to talk to trucks
- No workers on foot between a backing truck and the paver
- No rollers within 50 feet of the back of the paver
- Inspectors remain away from paving train and notify spotter before obtaining samples

Internal Traffic Control Plans

Symbols' Legend

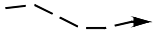
LIGHT(S)

CHANNELING DEVICE(S)

BARRIER

DIRECTION OF TEMPORARY TRAFFIC OR DETOUR

DIRECTION OF TRAFFIC



TRUCK MOVEMENT

SIGN (SHOWN FACING RIGHT)

PORTABLE LAVATORY

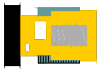
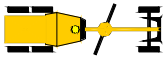
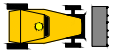
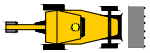
- On foot personnel classes -

	**PEDESTRIAN WORKER**		**FOREMAN**
	**SPOTTER**		**FLAGGER**
	**INSPECTOR**		**SURVEYOR**
	**PEDESTRIAN-FREE ZONE**		**OTHER CLASS**

Internal Traffic Control Plans

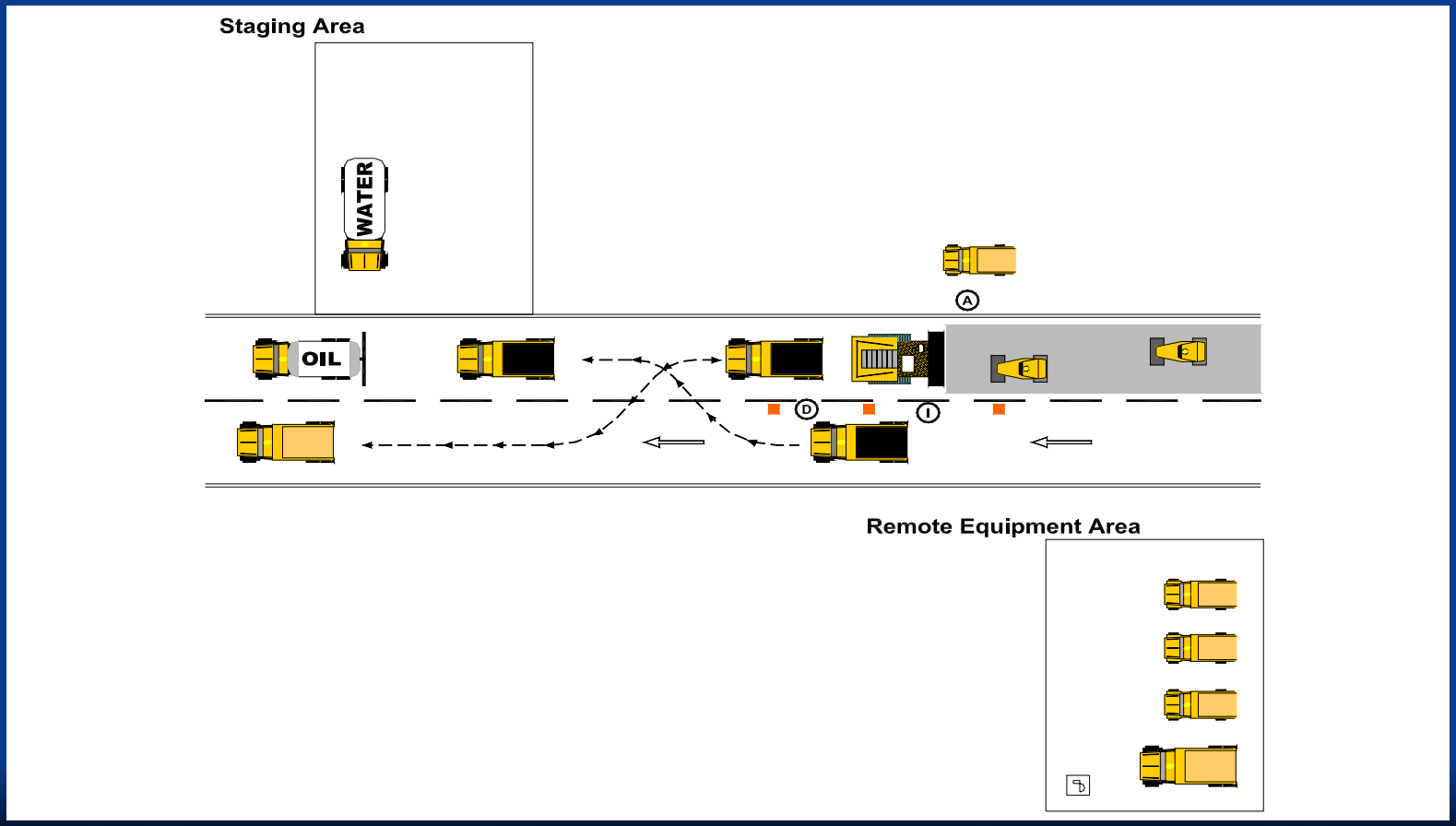
Symbols' Legend

- Vehicle Types -

	**ROLLER**		**PAVING MACHINE**
	**GRADER**		**FRONT LOADER**
	**BACKHOE**		**DUMP TRUCK (EMPTY)**
	**DOZER**		**DUMP TRUCK (FULL)**
	**OIL TRUCK**		**WATER TRUCK**
	**CRANE**		**FORKLIFT**
	**SWEEPER**		**BOTTOM DUMP**
	**PICKUP TRUCK**		**MILLING MACHINE**

Internal Traffic Control Plans

Paving Model Plan – Traffic Adjacent



Steps in Preparation of ITCPs

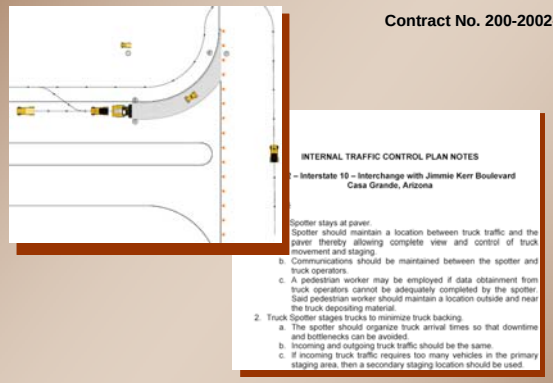
- Review TCP (for Work Zones) and Other Contract Documents
- Determine Site Specific ITCP Needs
- Draw Work Space
- Add Pedestrian and Equipment Paths
- Locate Staging Areas
- Prepare Notes and Plan

Internal Traffic Control Plan How-To Guide

Revised Internal Traffic Control Plan
Site 2

Internal Traffic Control Plans for
Asphalt Paving Operations
On Freeway Segments
Task 7.1

Contract No. 200-2002-00596



Submitted to the

CENTERS FOR DISEASE CONTROL
and PREVENTION
CONTRACTS MANAGEMENT BRANCH

Submitted by

C.L. Williams Consulting, Inc.
4720 W. Maverick Lane, Suite #103
Lakeside, Arizona 85929

May 16, 2003

Internal Traffic Control Plan
Draft Development Guide

Internal Traffic Control Plans for
Asphalt Paving Operations
On Freeway Segments
Task 8.1

Contract No. 200-2002-00596

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and PREVENTION
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Lakeside, Arizona 85929

June 19, 2003

Engineering Controls

Blind Spot Intervention Types

- Backup alarms
- Spotters
- Visual Devices
- Sensors/Parking Aids
- Other/Hybrid devices

Evaluating Systems

Which work best for construction sites?

- **Preliminary test in parking lot.**
  - Feasible to mount system on trucks?
  - Minimal false alarms?
  - Reliable detection of a person?
- **Long term test.**
  - System evaluation forms
  - Driver interviews
  - First hand observations during ride-along
  - Winter and summer tests

Systems Selected for Long Term Tests with WSDOT

Washington State
Department of Transportation

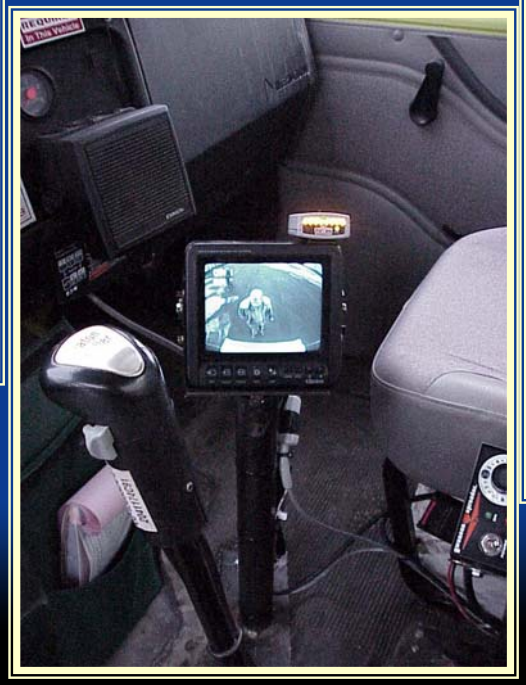
Radar Systems

Preview
Preco Electronics

Guardian Alert

Camera Systems

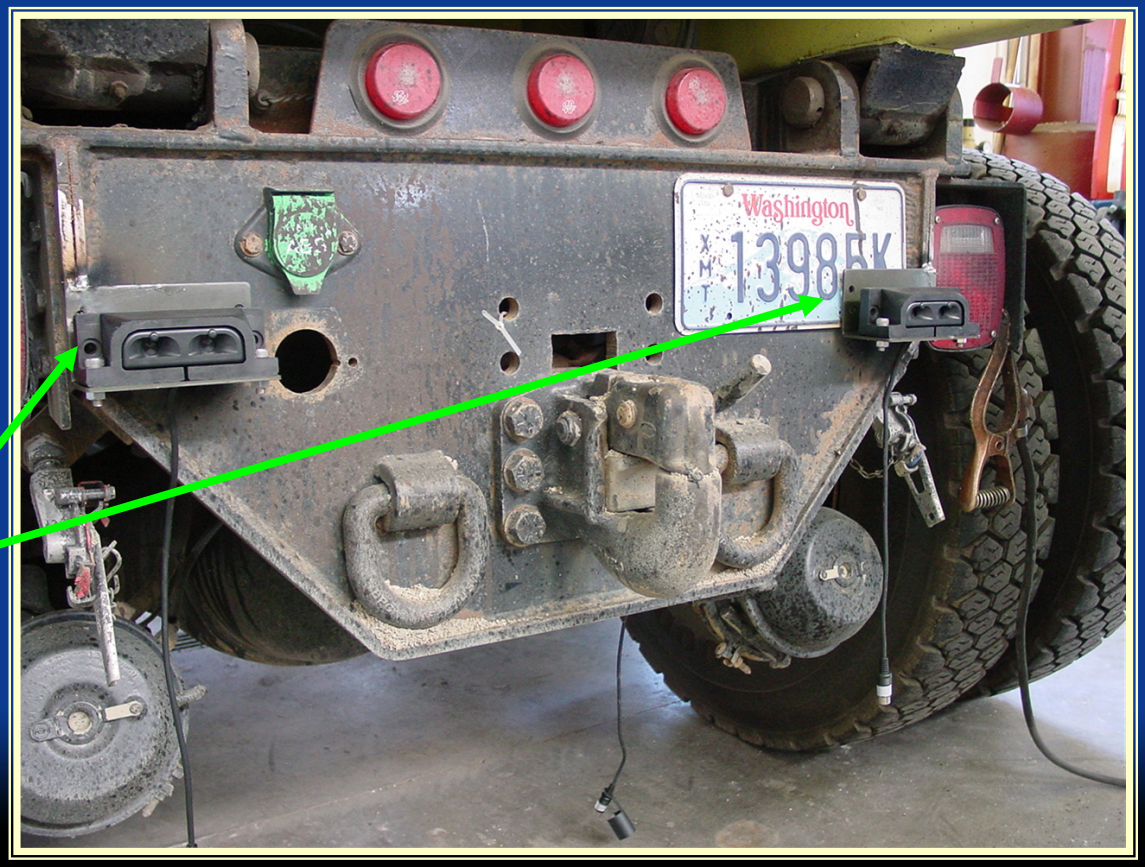
Clarion heated camera



Intec camera

Ultrasonic System

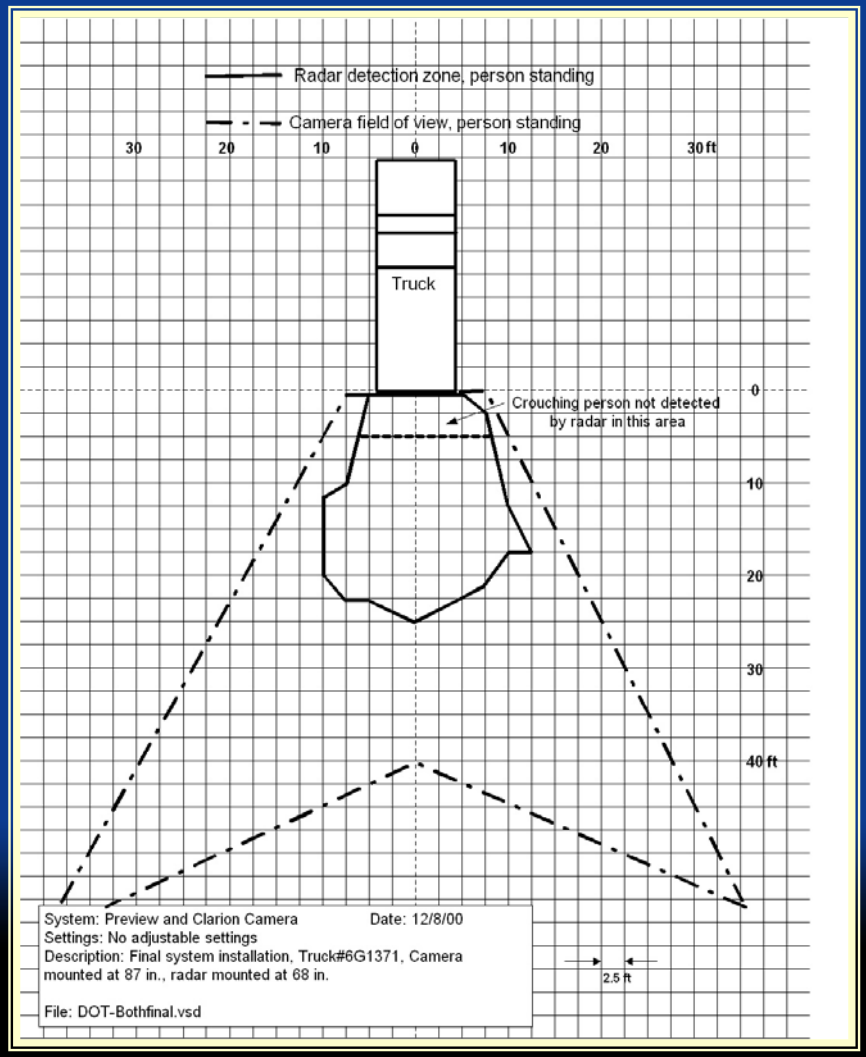
Hindsight 20/20



Camera and Radar
Sanding Truck

- **Two systems selected for winter tests on a sanding truck:**
  - Preco's Preview radar
  - Clarion heated camera with shield
- **2 month test (Dec. – Jan.) in harsh conditions**

Camera and Radar
Sanding Truck



Camera and Radar

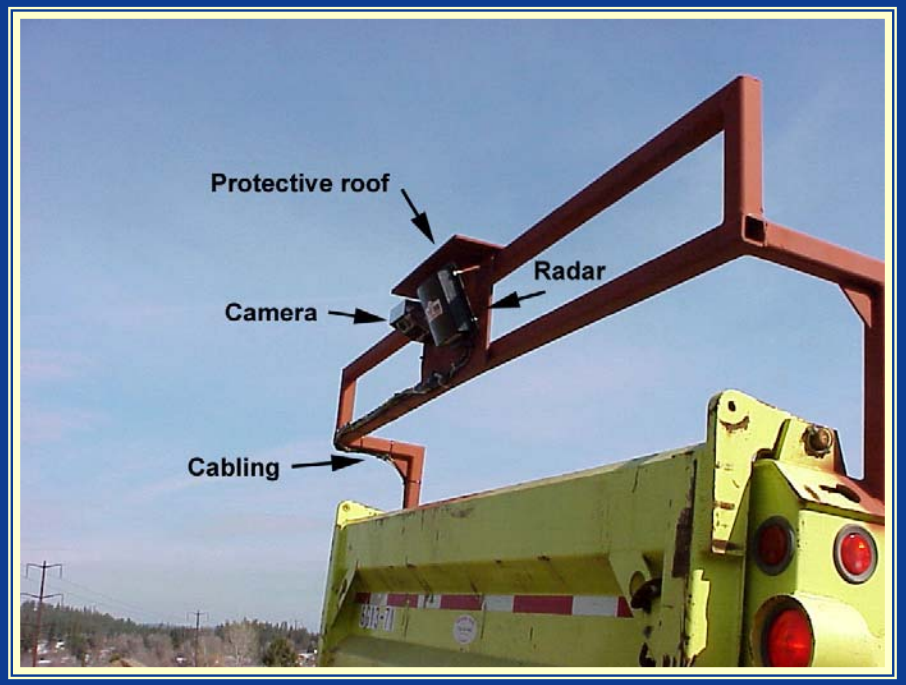
Sanding Truck

Results:

- **Camera and radar effective in dry conditions**
- **Problems in snow, rain:**
  - Snow, ice, mud build-up after 5 miles
  - Camera lens shield froze then broke
  - Radar false alarms from snow and mud on antenna
- **Improvements needed!**

Camera and Radar
Dump Truck

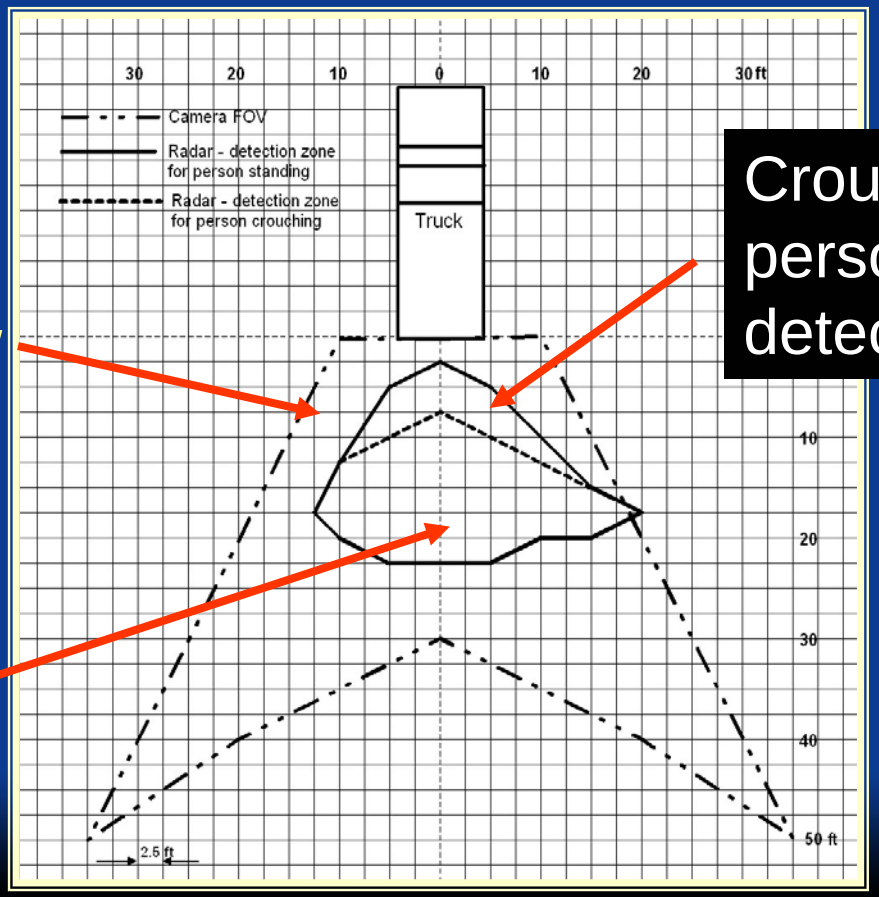
- Camera and radar worked best when mounted high
- Could not mount either system on the tailgate or hitch area
- Designed bridge for mounting systems



Camera and Radar
Dump Truck

Camera field of view

Radar detection of a standing person



Crouching person not detected here

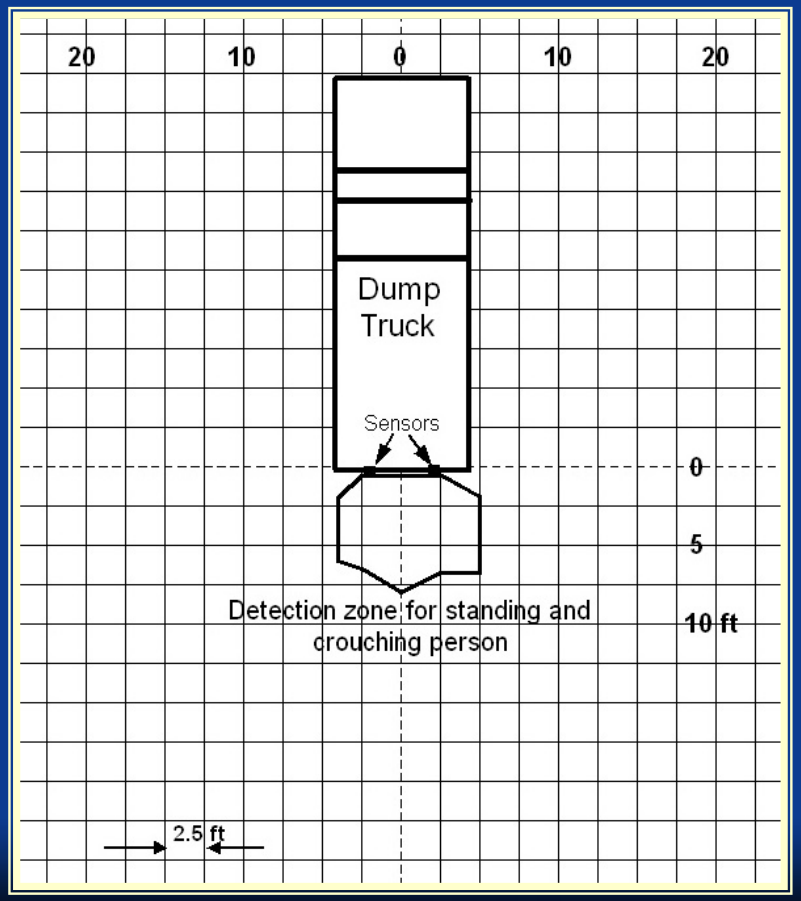
Camera and Radar
Dump Truck

Results:

- **Ride-along showed very few false alarms from radar, but camera more useful**
- **Clearance problem with bridge under asphalt loading bins and wheeled loaders**
- **Bridge won't work - camera and radar must be mounted on dump box**

Hindsight Sonar
Dump Truck

Ultrasonic-based system



Hindsight Sonar
Dump Truck

Results:

- Drivers said system is reliable in most conditions
- Concerned about detection range of 8 ft
- Some false alarms in heavy dust
- Constant false alarms when trailer is being pulled (optional trailer system needed)
- Tests continue on smaller vehicles

Intec Camera System
Dump Truck

- Small camera that can mount on side of dump box
- Size of 2 inch cube

Intec Camera System
Dump Truck

Results:

- Small size allowed for good mounting location
- Most drivers found it useful
- Reliable operation during 5 month test
- Would have problems in winter

Guardian Alert Radar System

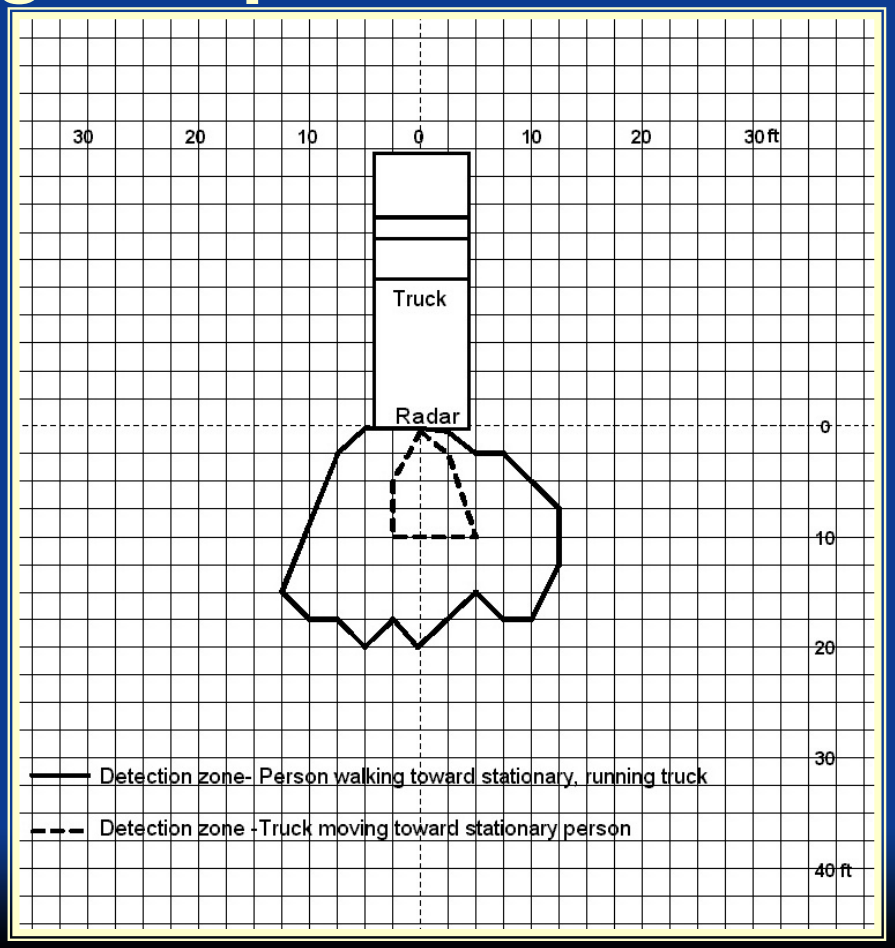
Dump and Bridge Insp. Trucks

Guardian Alert Radar System

Dump and Bridge Insp. Trucks

Results:

- Small and easy to mount
- Does not detect people very well
- Good detection of other objects



Conclusions

- **Sensor systems (radar, sonar, infrared):**
  - False alarms are possible
  - Nuisance alarms can be numerous in crowded work areas
- **Camera systems:**
  - Provide view of blind area
  - Do not alarm so potential collision may go unnoticed
  - May not work in winter conditions
  - Good solution for crowded work zones during warmer months
- **A combination of sensors and a camera may be best solution for warmer months**
  - Alarm prompts driver to check video
  - Video allows driver to check source of alarm

System Improvements

- **Previous test results prompted Preco to modify their radar system:**
  - Smaller package
  - Ignores some mud/snow on sensor face
  - Tests on 3 dump trucks this spring

System Improvements

- **Intec developing new cameras for winter-time use:**
  - Small, heated enclosure
  - Innovative methods to keep lens clean
  - Winter tests to be scheduled

New Ideas

The TagView System

How it Works

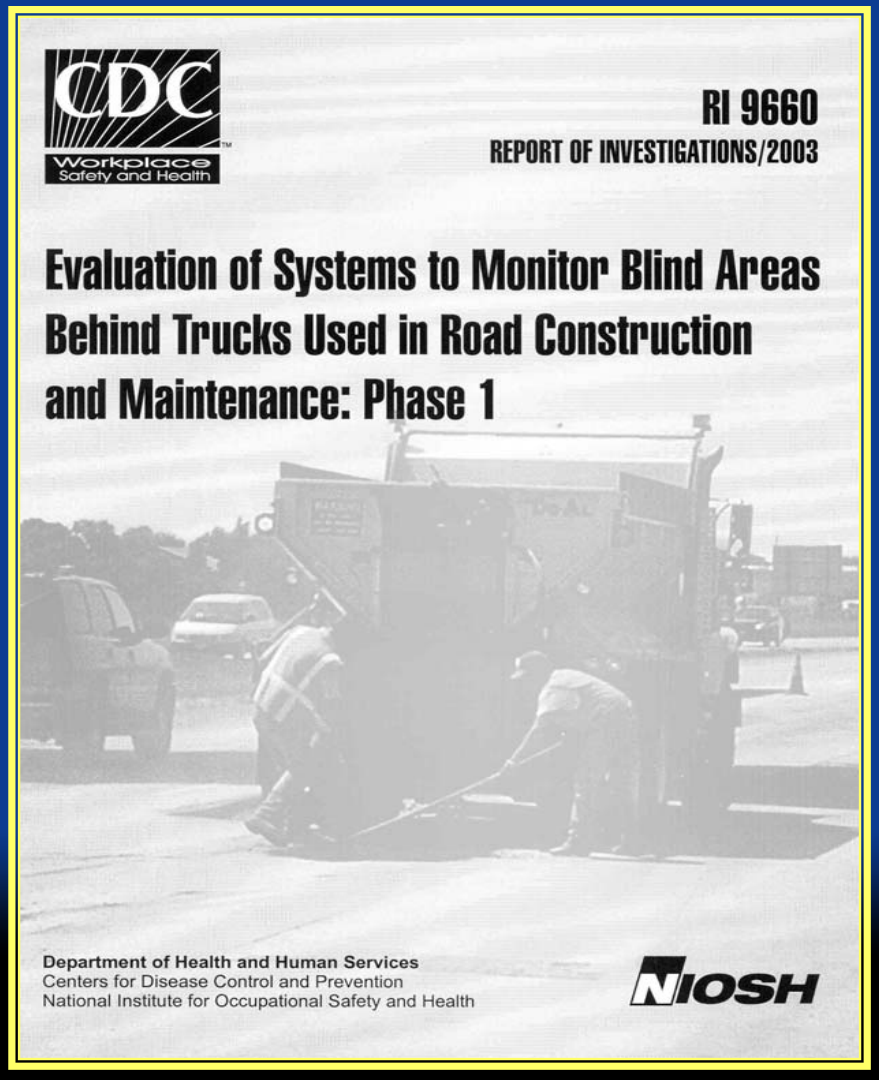
TagView™ has three main components:

- Small, low cost tags secured to each worker or embedded in an Electronic Guardrail™ in the area to be monitored
- Rugged reader units located on vehicles operating in the area
- LCD displays located in the vehicle cabs

The reader emits an interrogation signal which is detected by any tags within range (typically 50 to 100 feet). The tags respond with predetermined timing signals, which the reader interprets. The reader determines the distance to the closest tag, and a cab-mounted display unit alerts the vehicle operator with visual and/or audible warnings. The cab display can be programmed with warnings and alerts which change appropriately with tag distance.

NIOSH Publication

Evaluation of Systems to Monitor Blind Areas Behind Trucks Used in Road Construction and Maintenance: Phase 1



www.cdc.gov/niosh

Any Questions???

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