Guías Prácticas para la Selección e Inspección de Barreras y Dispositivos de Seguridad en Auditorías de Seguridad de Carreteras

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12 de Mayo de 2016
Colegio de Ingenieros y Agrimensores de Puerto Rico
Salón Ing. Estéban Terrats

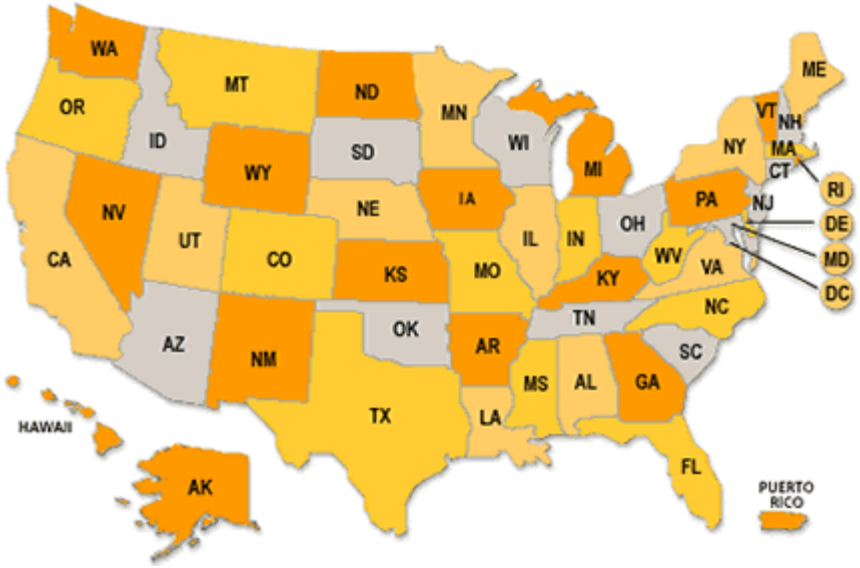
Transportation Technology Transfer Center Puerto Rico and US Virgin Islands

30th Years of Excellence in the Training of Transportation Officials at Municipal, State and Federal Level in Puerto Rico and Virgin Islands

Sra. Grisel Villarrubia
Sra. Jesenia Carrero

Our Center

- Located in the **C**ivil **E**ngineering **D**epartment of the **U**niversity of **P**uerto **R**ico, **M**ayaguez Campus
- Puerto Rico LTAP (El Centro-**T²**) is part of a network of **58** LTAP Centers in United States



Tribal Centers :

- East Mississippi
- Colorado
- California
- North Valleys
- Alaska
- North East
- Oklahoma

Objectives

- Provide technical assistance to municipalities and local transportation agencies in Puerto Rico and the US Virgin Islands
- Provide information regarding planning, design, construction, maintenance and operation of transportation facilities

Resources

- Full Time Staff
  - Benjamín Colucci, Director
    Spokesperson of the Decade of Action for Road Safety: 2011-2020
  - Administrative Officials
    - Mrs. Grisel Villarrubia
    - Mrs. Irmalí Franco
    - Mrs. Jesenia Carrero
  - Part time undergraduate and graduate students from engineering and other faculties at UPRM




Activities

- Training Program in Puerto Rico and USVI
- Implementation of Every Day Counts (EDC) Initiatives in Puerto Rico: Technical Oversight

- Bilingual Newsletter- "*El Puente*"
  - Hard copy and electronic version

- Technical Information Services
  - Technical Library/Audiovisual

Technical Seminars

- Work Zone Safety and Temporary Traffic Control
- Highway Safety
- Traffic Engineering
- Tort Liability
- Road Diets
- Accelerated Bridge Construction
- Warm Mix Asphalt
- Environmental
- Highway Capacity
- Urban Congestion
- Quality Control
- Drainage
- Parking
- Gabions
- Pavement (Design & Maintenance)
- Geographic Information systems
- Geotechnical Soils
- Surveying

Continuing Education Credits through IACED, CIAPR

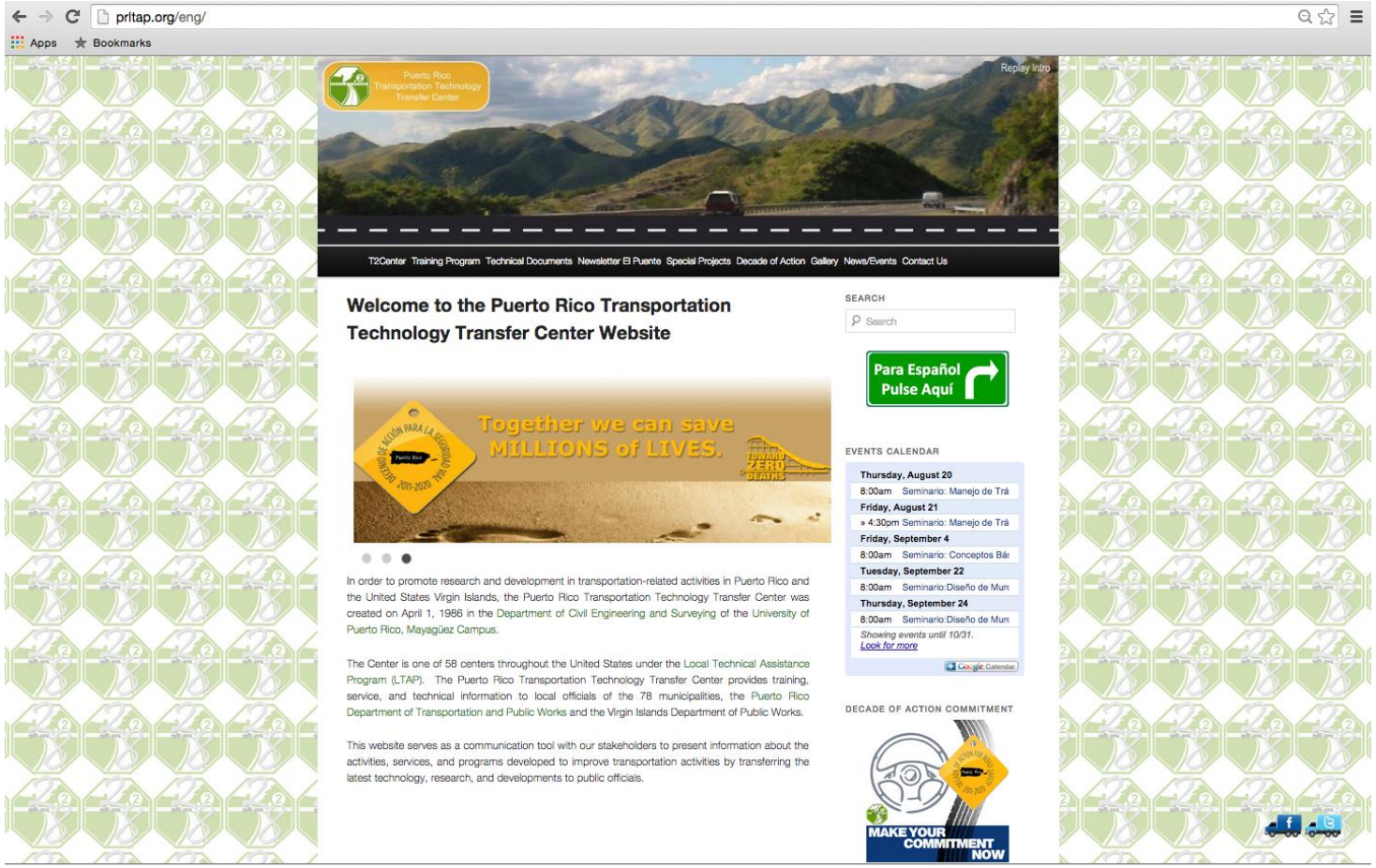
Universidad de Puerto Rico
Departamento de Ingeniería Civil y Agrimensura
CENTRO DE TRANSFERENCIA DE TECNOLOGÍA EN TRANSPORTACIÓN

Auspiciado por

Manuel E. Acevedo Rivera

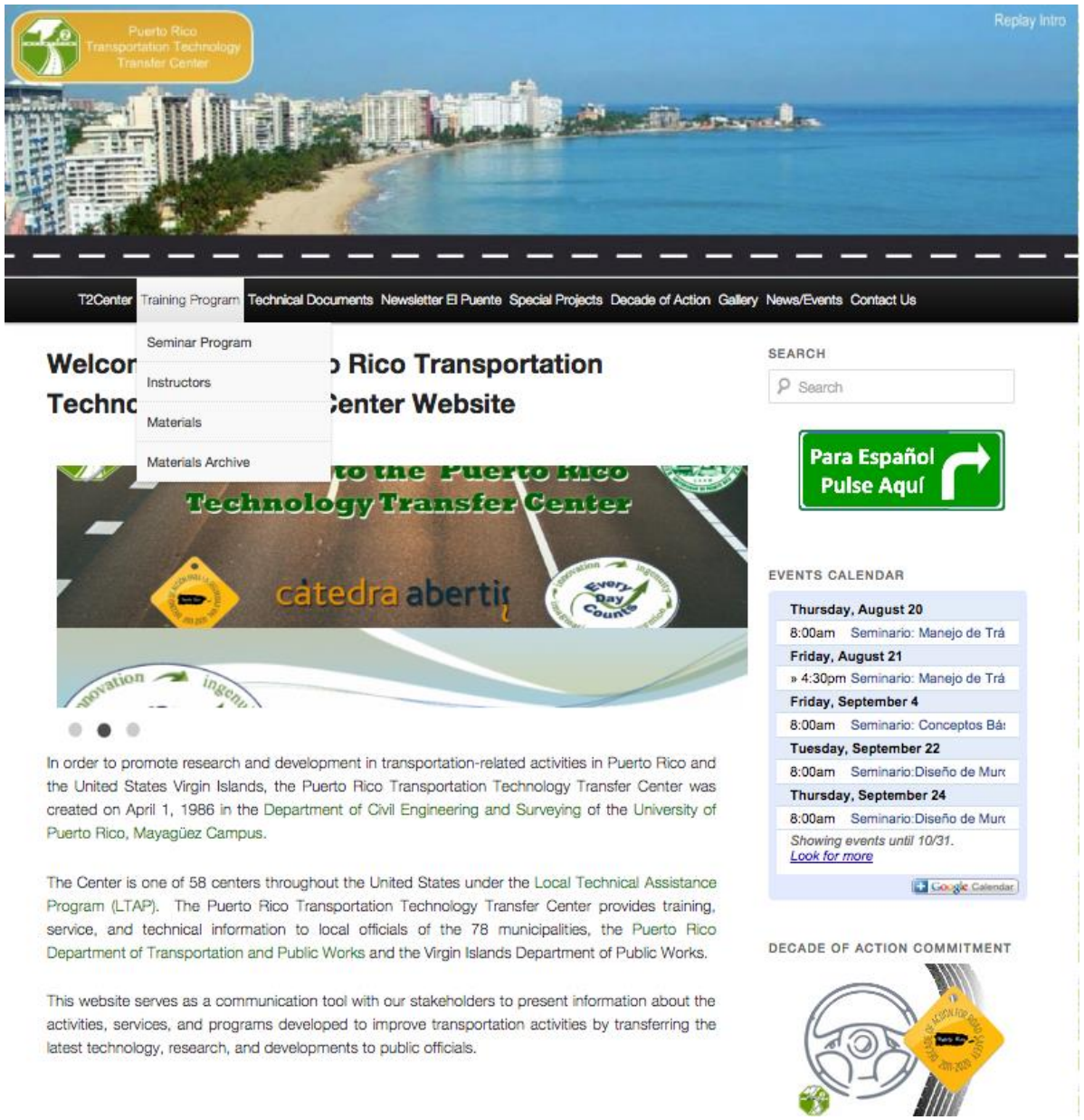
ha completado un curso corto en
Requisitos del MUTCD para la Seguridad en Zonas de Construcción
Horas Contacto: 12
en Mayagüez, Puerto Rico el 26 y 27 de marzo de 2015.

Seminar Materials



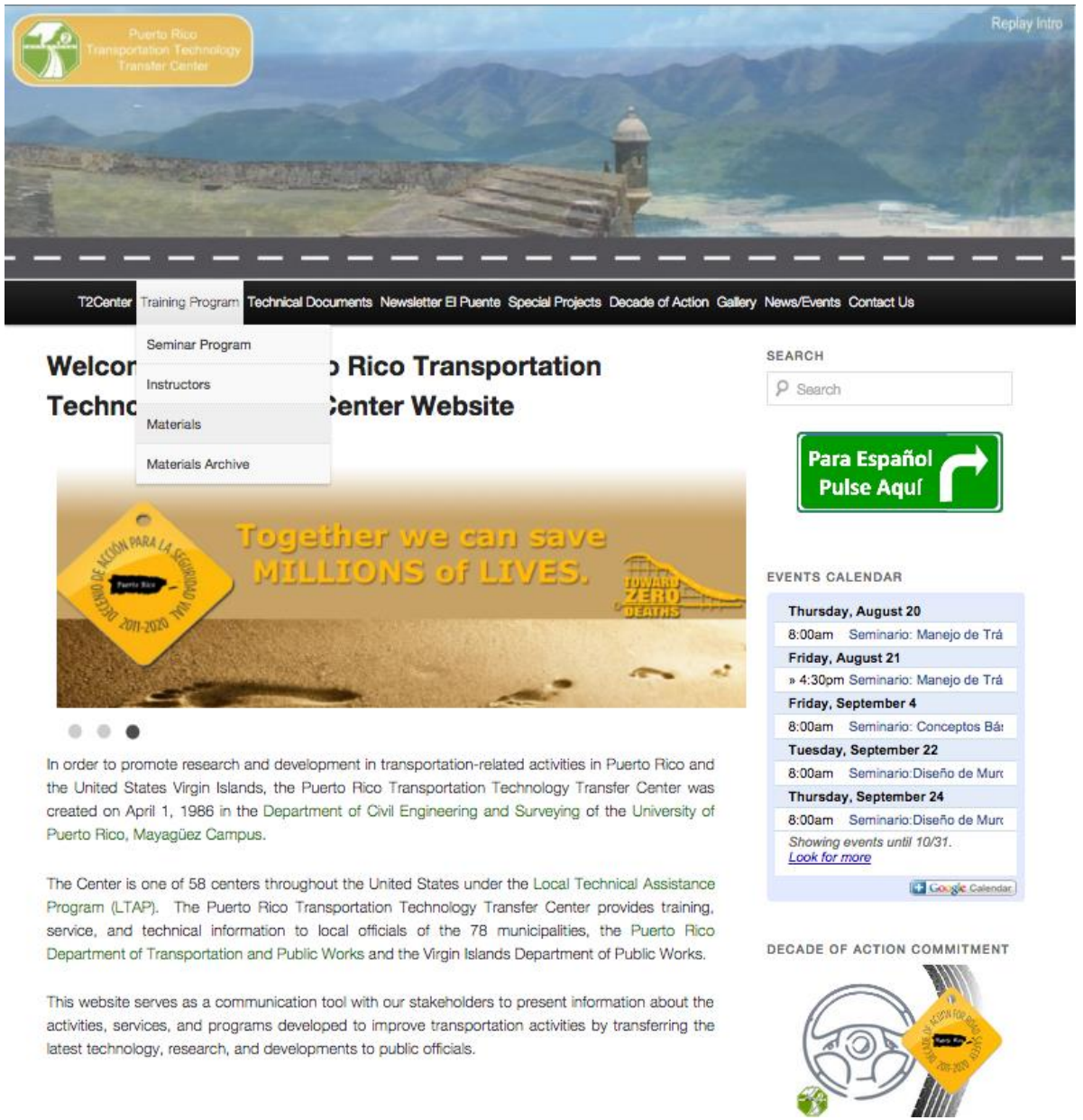
Access: www.prltap.org

Seminar Materials



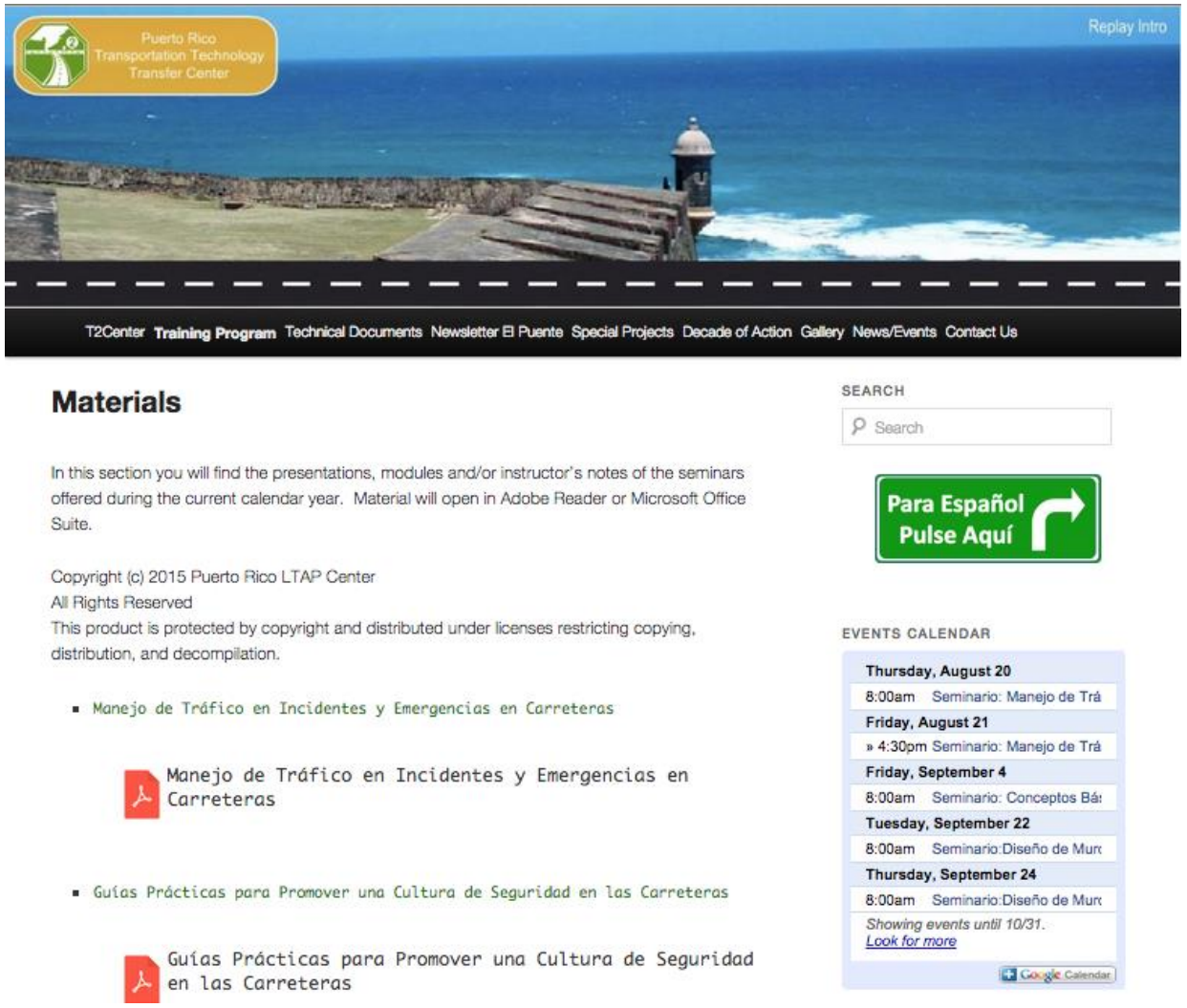
Select **Training Program**

Seminar Materials



Select **Materials**

Seminar Materials



Select the **title** of the seminar

Additional Information …

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Web Page:
http://www.prltap.org

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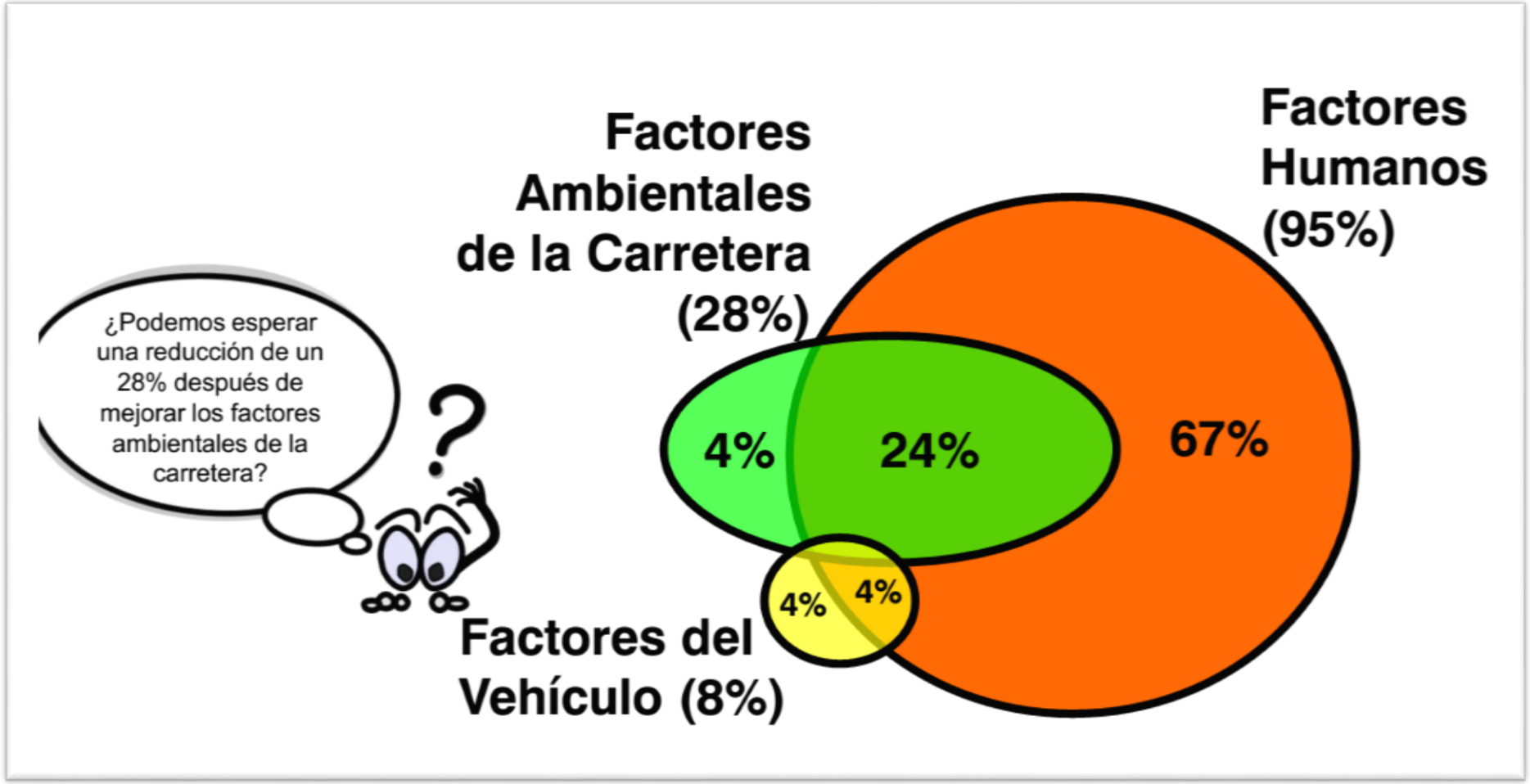
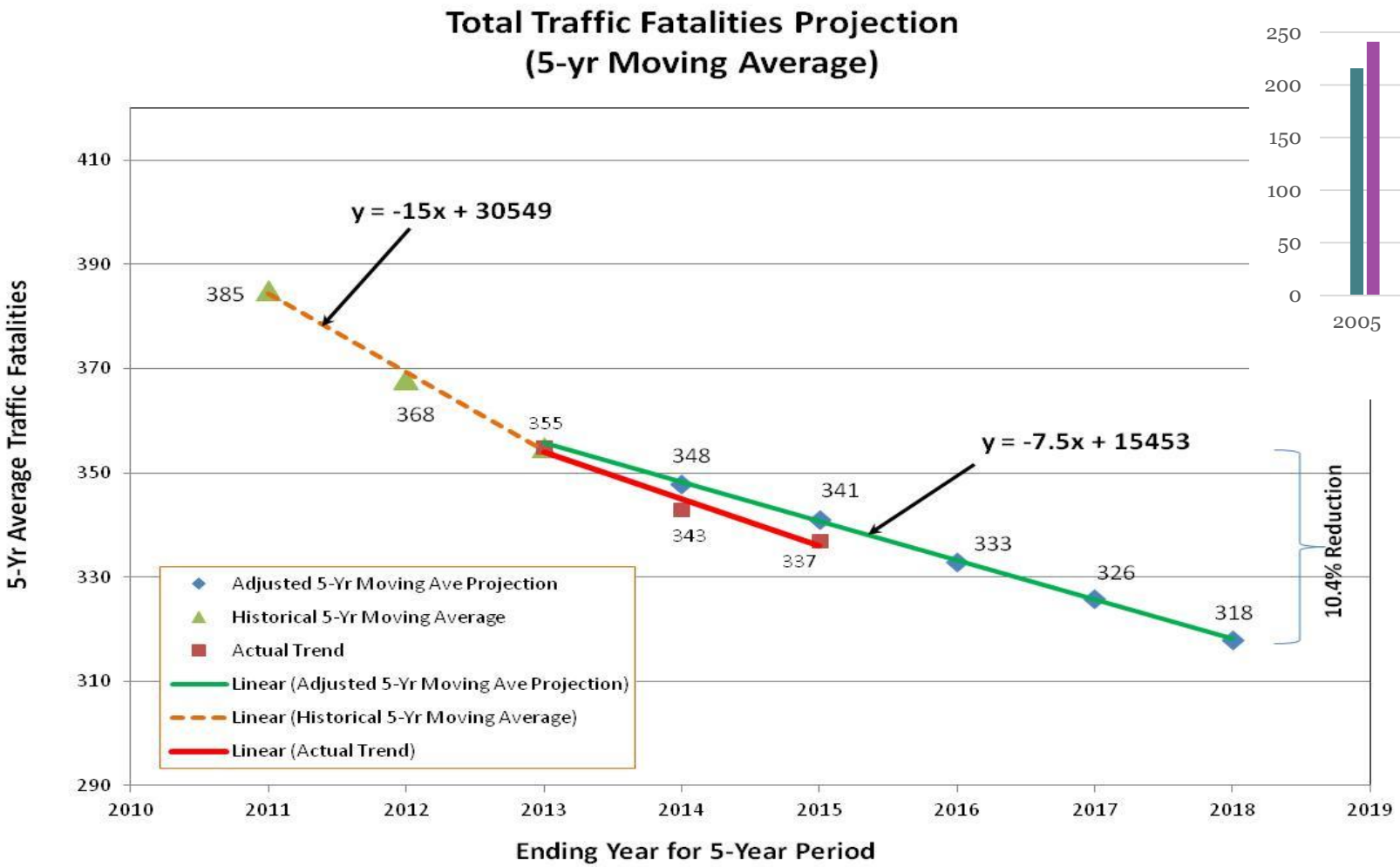
Puerto Rico LTAP
Década de Acción para la Seguridad Vial en Puerto Rico

¿Por qué necesitamos realizar Auditorías de Seguridad Vial (ASV)?

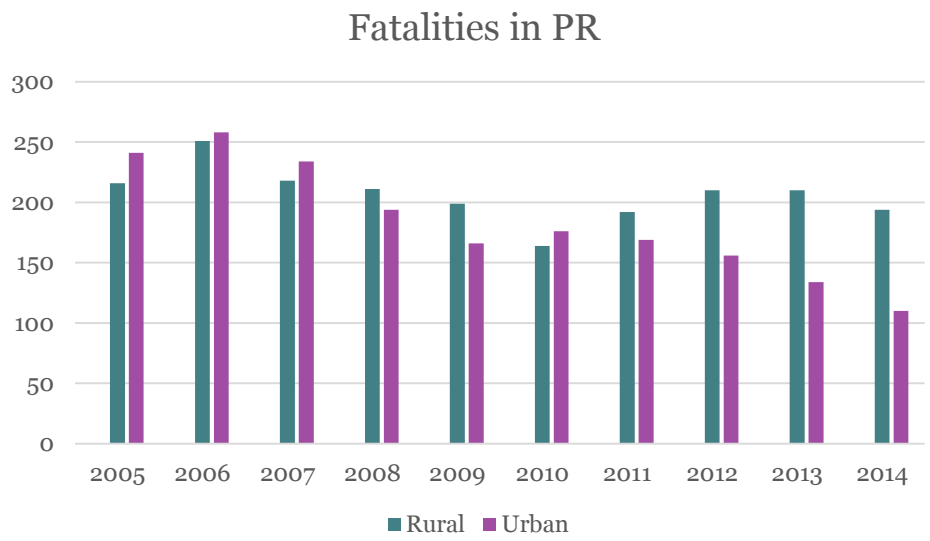
CAUSAS TÍPICAS EN CHOQUES DE TRÁNSITO



PR Crash Statistics

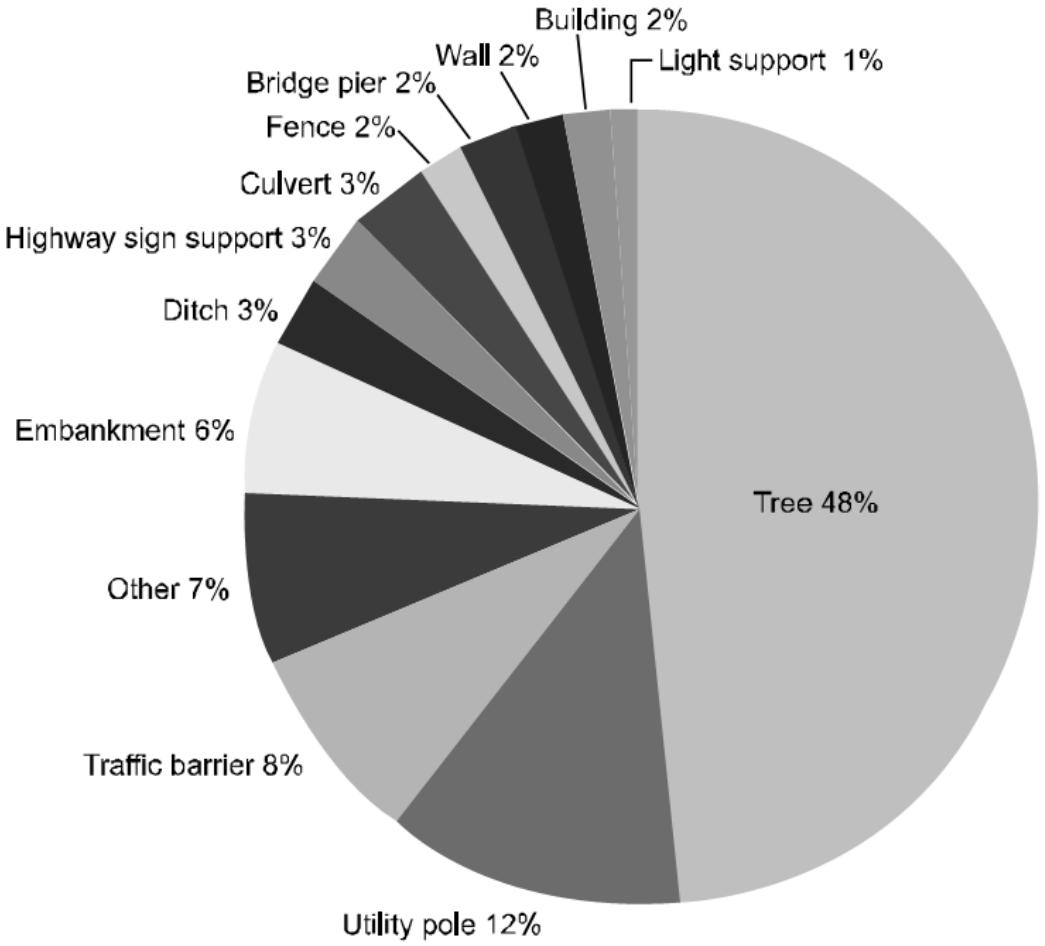


ACT



FARS

Percent Distribution of Fixed-Object Fatalities by Object Struck, 2008



Source: AASHTO Roadside Design Guide

Choques Fuera de la Vía de Rodaje

- Objetos fijos típicamente impactados a la orilla de la carretera
  - Árboles
  - Postes de alumbrado / utilidades
  - Rótulos
  - Barreras de seguridad
- Otros peligros
  - Pendientes laterales excesivas
  - Barrancos/Acantilados
  - Ganado/Caballos
  - Peatones

Razones por la cuales un vehículo se puede salir de la via de rodaje...

1. Fatiga del conductor
2. Distracción dentro del vehículo (niños, usando el radio, maquillándose, uso de cámara o video, etc.)
3. Exceso de velocidad
4. Conduciendo bajo los efectos de alcohol o sustancias controladas
5. Desperfecto del vehículo

Razones por la cuales un vehículo se puede salir de la via de rodaje...

6. Maniobra evasiva de choque
7. Resplandor de otros vehículos y/o del sol (glare)
8. Poca visibilidad (iluminación inadecuada, neblina, etc.)
9. Desperfecto en la carretera (hoyos, agregado pulido, depresión aislada)
10. Resbalamiento sobre el pavimento con lámina de agua (Hydroplanning)

Problemas de Seguridad en las Carreteras

- Obstáculos a la orilla de la carretera
- Condiciones de la superficie del pavimento
  - Deterioro / defectos
  - Pérdida de fricción
- Secciones transversales de ancho reducido
  - Distancia lateral libre de objetos
  - Medianas
  - Terraplenes y cortes
- Problemas de control de acceso

Problemas de Seguridad en las Carreteras

- Diseño de intersecciones
  - Carriles de viraje confusos
  - Puntos ciegos / falta de visibilidad
  - Dispositivos de control de trafico o rótulos inadecuados
- Zonas de trabajo
  - Objetos y zonas de trabajo sin proteger
  - Marcado y delineación inadecuados
  - Rótulos no visibles e inadecuados
- Limitaciones en el diseño de las carreteras
- Conflicto con peatones y ciclistas

Problemas de Mantenimiento

Defectos/Inconsistencias de Diseño

Carreteras sin Compasión

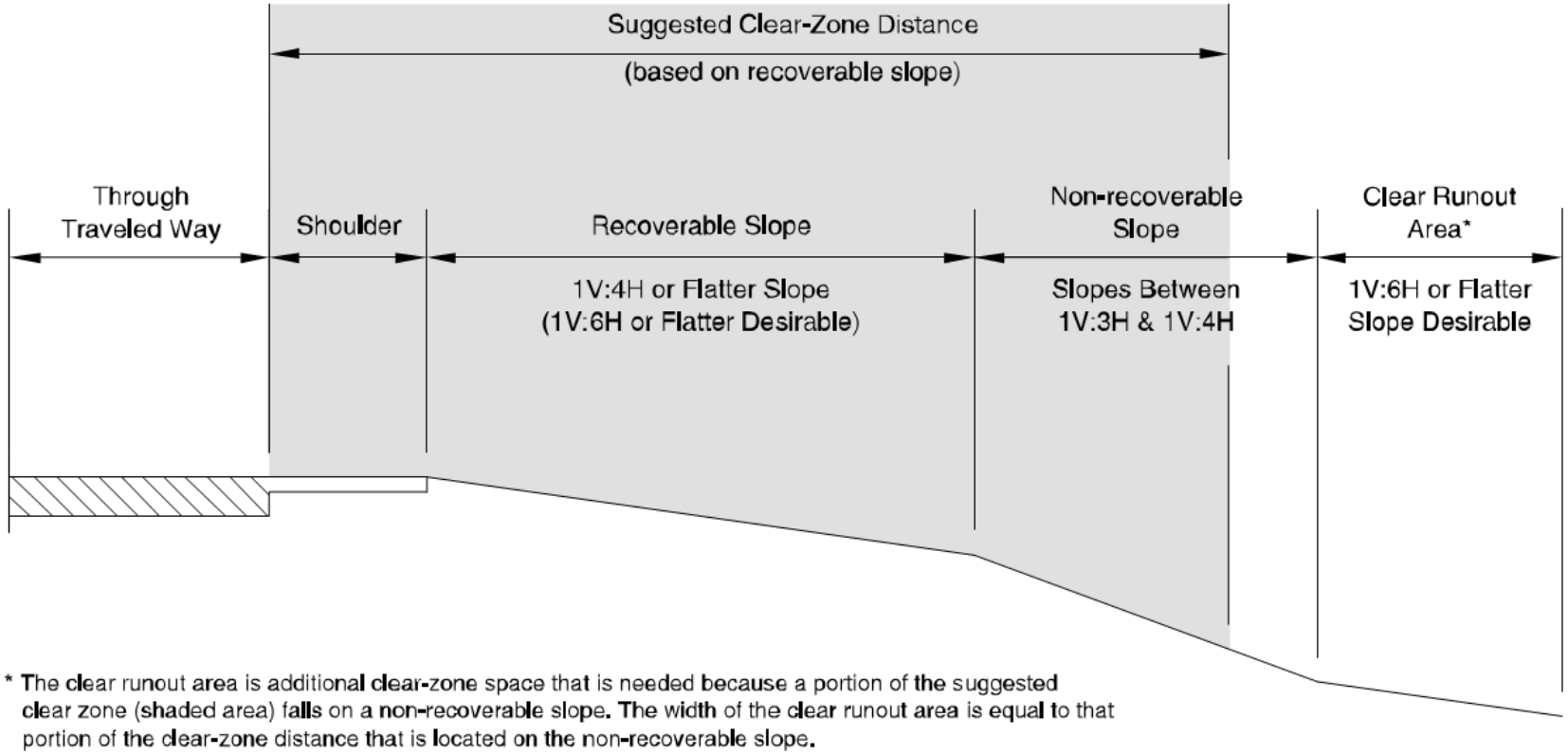
Engineering Measures to Improve Highway Safety

- Roadside improvements
  - Provide better chance to recover from a lane departure
  - Reduce severity of roadside crashes

Elementos de Sección Transversal

- *Traveled way* – vía de rodaje, calzada de la carretera (carriles)
- *Roadway* – incluye la calzada y los paseos
- *Roadside* – ancho de la servidumbre fuera de la calzada y los paseos; zona aledaña a la carretera
- *Encroachment* – desvío inadvertido de un vehículo de la vía de rodaje
- *Slope* – pendiente, talud, declive
- *Foreslope (embankment)* – cuneta, contratalud
- *Backslope (cut slope)* – talud exterior o talud del corte
- *Ditch* – zanja/cuneta

Clear Zone for Non-Recoverable Parallel Foreslope



* The clear runout area is additional clear-zone space that is needed because a portion of the suggested clear zone (shaded area) falls on a non-recoverable slope. The width of the clear runout area is equal to that portion of the clear-zone distance that is located on the non-recoverable slope.

Source: AASHTO Roadside Design Guide

Opciones de Diseño para Reducir el Impacto Adverso de Objetos Fijos

- Remover el obstáculo
- Rediseñar el obstáculo de tal manera que sea fácil atravesarlo
- Relocalizarlo a un lugar menos probable de ser impactado
- Reducir la severidad del impacto utilizando dispositivo apropiado que ceda al impacto
- Escudar el obstáculo (uso de vallas, barreras, atenuadores, etc.)
- Delinear el obstáculo (controversial)

What is a Road Safety Audit (RSA)?

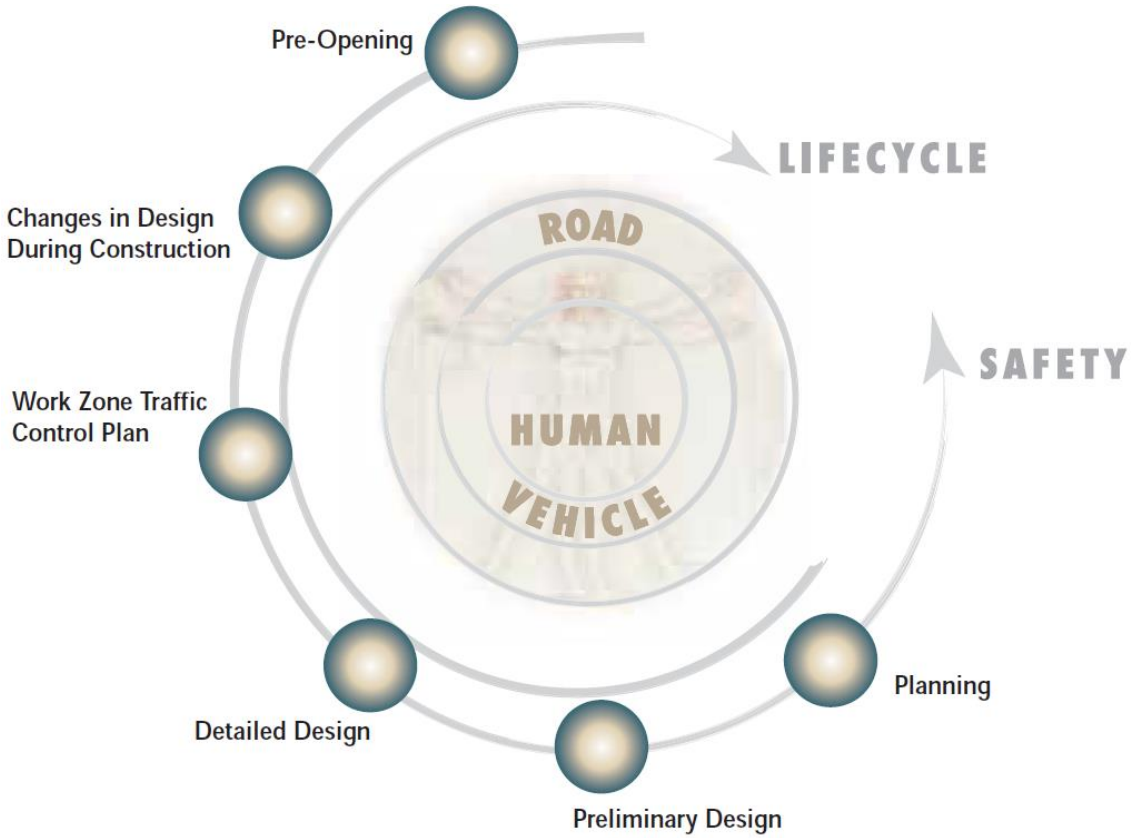
- **Formal** safety performance **examination** for road projects
- **Proactive** procedure
  - Assess safety needs
  - Compliance of highway projects
  - Multidisciplinary
  - External auditing
- Considers multiple project aspects concerning safety
- Can be performed at various stages of the project's progress—the earlier, the better!

Benefits of performing an RSA

- Identifies **otherwise neglected** aspects of traffic safety
- **Early** intervention reduces needs for costly/difficult corrective measures during construction and operation
- Process is **low cost** ($1,000-$10,000 per audit) and requires **small amount of time** (typically 1-2 weeks), per audit
- Can be incorporated to all road infrastructure projects
- Can recommend highly effective, low-cost measures
- Considers **full spectrum of users**

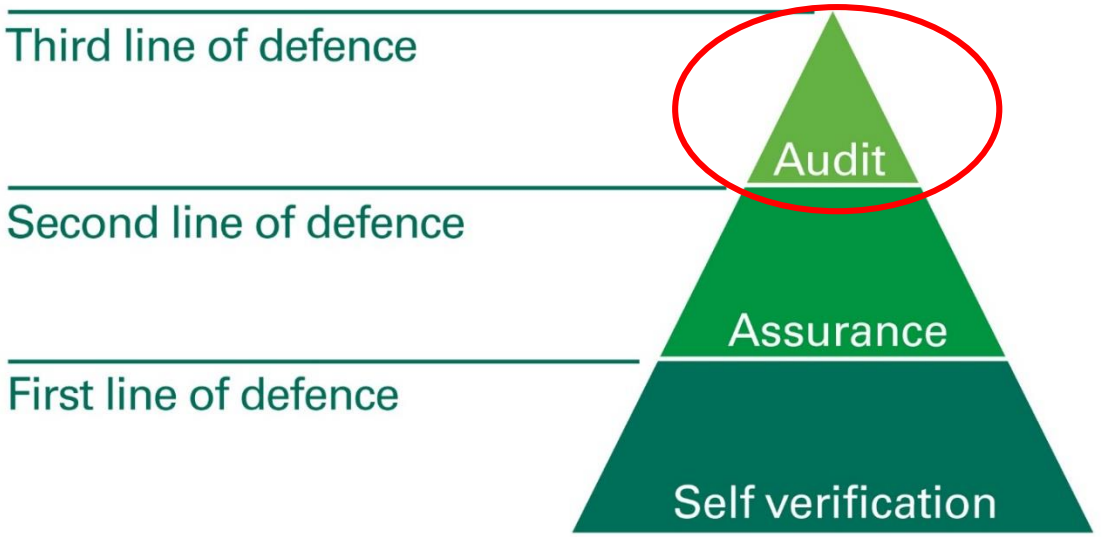
RSAs as part of the highway project's full process

- **Earlier** intervention allows for **more effective** measures
- RSAs include **auditing report** from the audit team
- RSAs require a **response report** from the project authors (design team, construction team, agency owning/operating facility)
- RSAs can bring financial and logistical benefits to projects
- Best option: **perform** RSAs **at different** project **progress stages**



RSAs do not…

- **Replace** other safety evaluation procedures
- Follow a rigid recipe to use in all projects, regardless of circumstances
- Appraise or criticize **non-safety related aspects** of projects
- Rank highway **projects** for priority purposes → projects instead are ranked for **RSA implementation**



Critical questions RSAs answer

- What **elements** of the road may present a **safety concern**: to what extent, to which road users, and under what circumstances?

- What **opportunities** exist to **eliminate or mitigate** identified **safety concerns**?

Implementation of RSAs

RSA as part of transportation policy

- High flexibility allows **adaptation** to local and regional needs
- State, territory, tribal and local DOTs can develop **standardized methodologies** compatible with their other policies
- Main members of **Audit teams** can be defined in accordance to the public agency system of the jurisdiction
- Developing criteria to determine eligibility of projects for **RSA implementation**

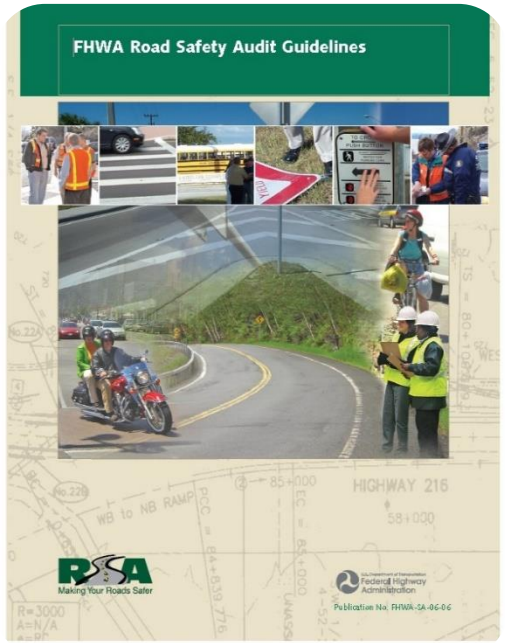
Recommended resources for RSA program

- Manual or guidebook for the RSA process specifically made for the jurisdiction using it
  - Project selection criteria
  - RSA team membership
  - Auditing protocol for different project stages
  - Auditing protocol for different categories of roadway facilities
  - Auditing protocol for different categories of users
  - RSA guidelines and prompt lists
  - RSA documentation format

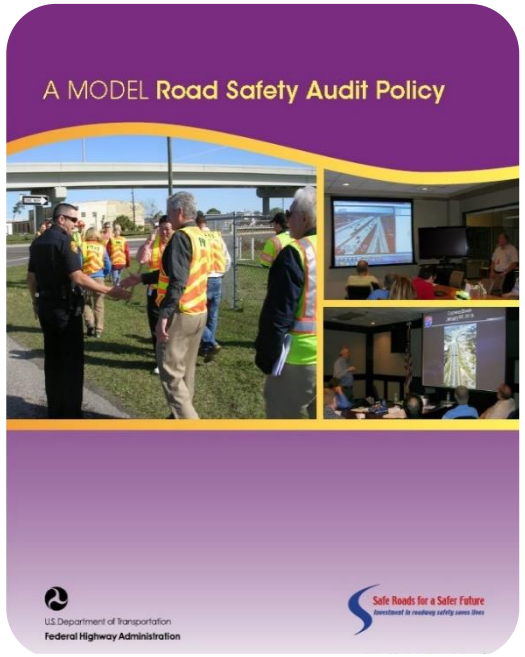
Recommended resources for RSA program

- Assign DOT personnel to administer the RSA program
  - Infrastructure design (ACT)
  - Traffic Safety (CSP)
- Detailed and timely traffic safety data
  - Identify most dangerous locations in the road network
  - Identify most pressing traffic safety issues
  - Follow-up data to determine effectiveness of RSAs
- Coordinate with Strategic Highway Safety Plan

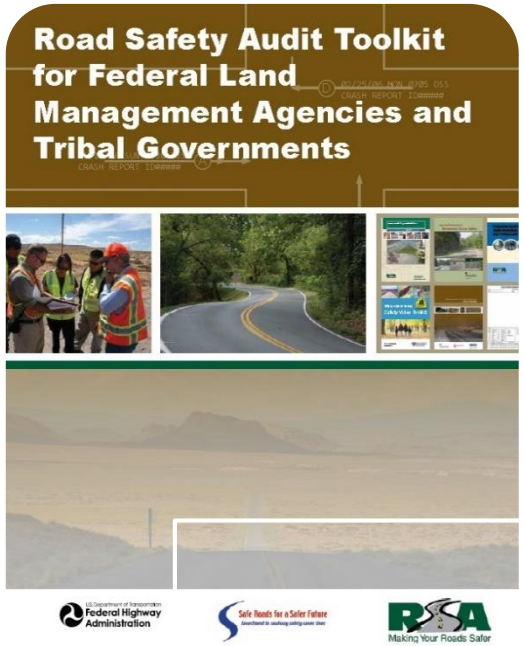
Available RSA guidelines published by the FHWA



FHWA Road Safety Audit Guidelines

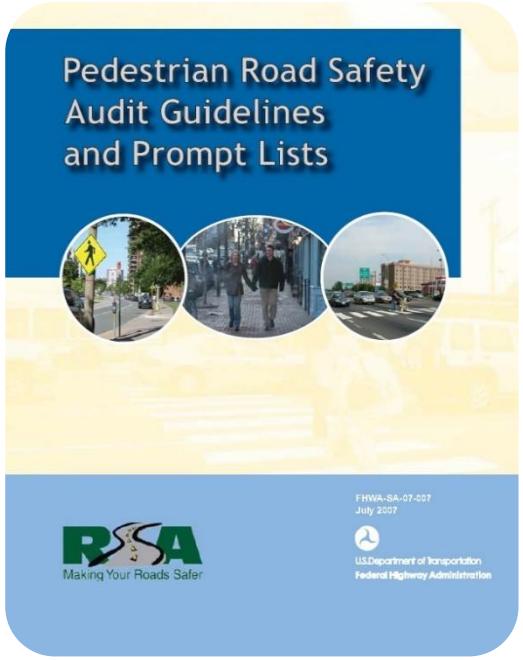


A Model Road Safety Audit Policy

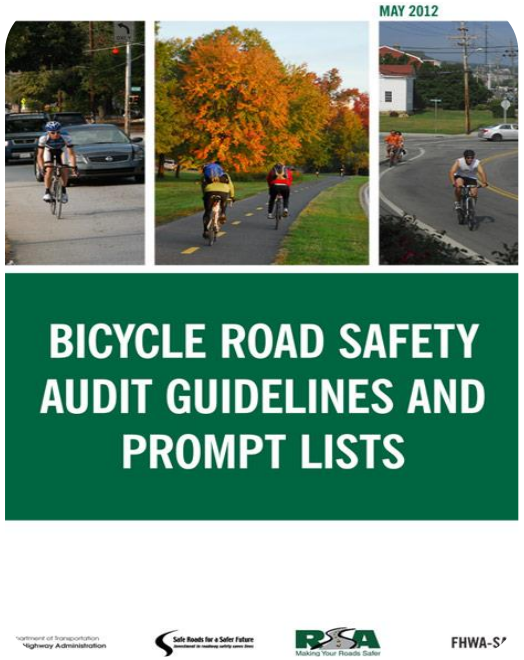


Road Safety Audit Toolkit for Federal Land Management Agencies and Tribal Governments

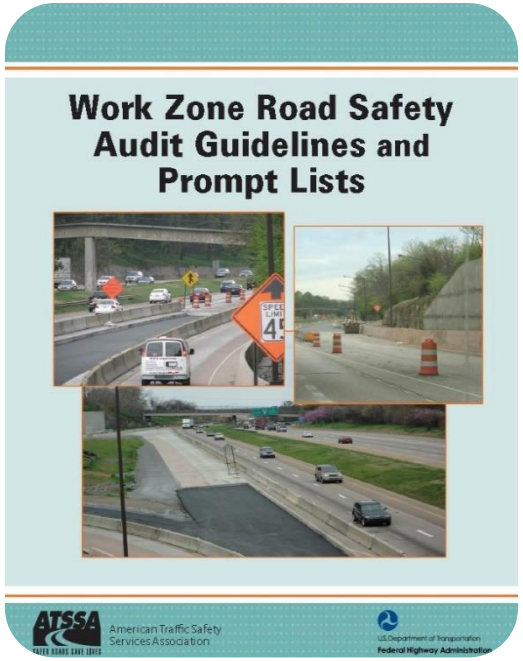
Available RSA guidelines published by the FHWA



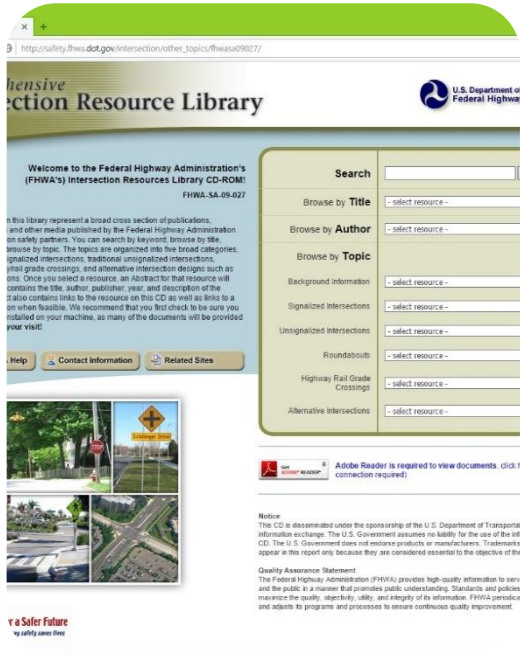
Pedestrian Road Safety Audit Guidelines and Prompt Lists



Bicycle Road Safety Audit Guidelines and Prompt Lists

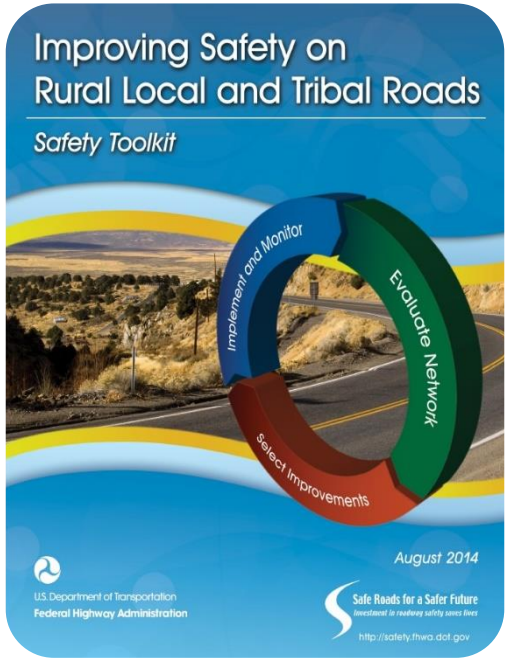


Work Zone Road Safety Audit Guidelines and Prompt Lists

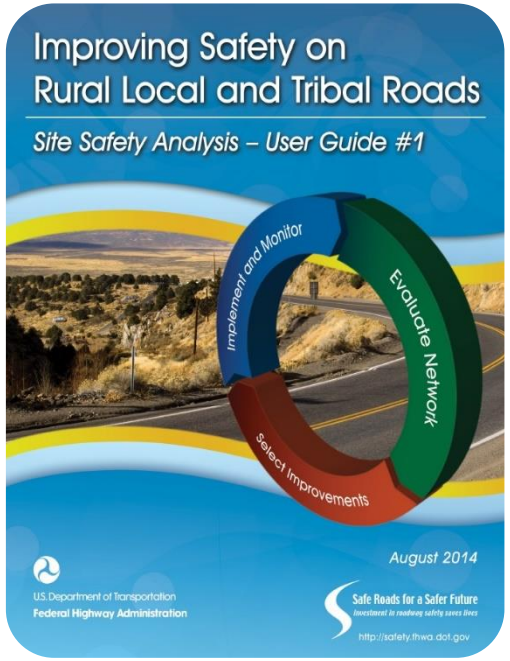


Comprehensive Intersection Resource Library

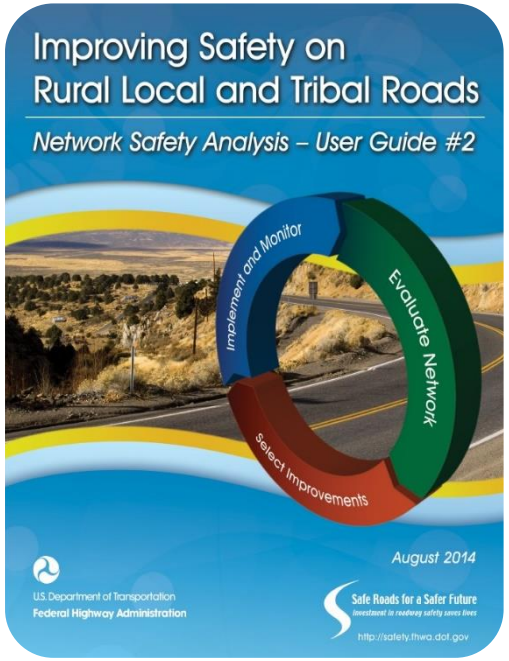
Available RSA guidelines published by the FHWA



Improving Safety on Rural Local and Tribal Roads: Safety Toolkit

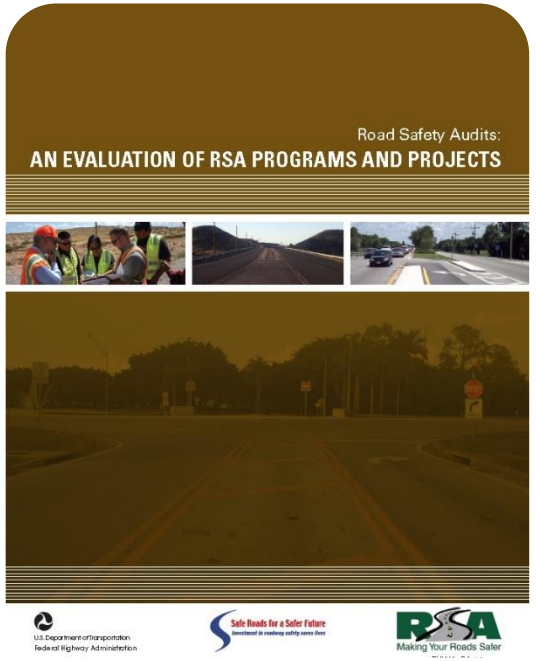


Improving Safety on Rural Local and Tribal Roads: Site Safety Analysis

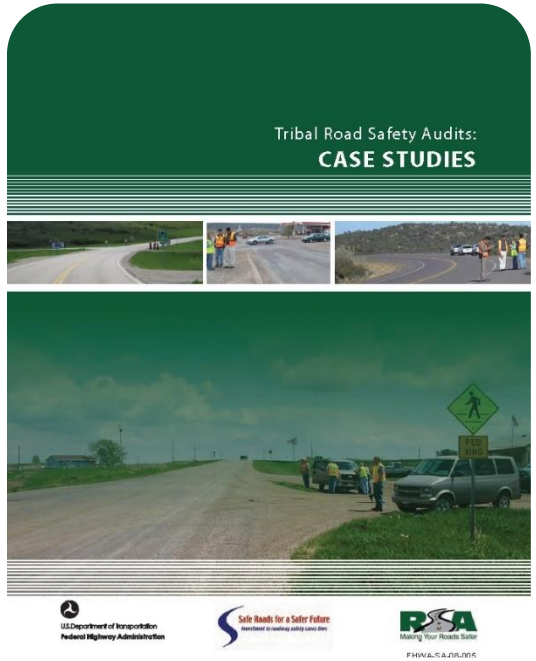


Improving Safety on Rural Local and Tribal Roads: Network Safety Analysis

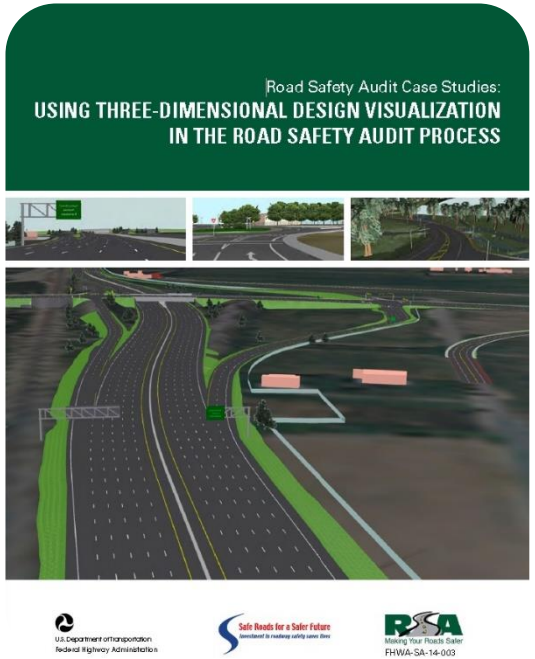
Example case studies published by the FHWA



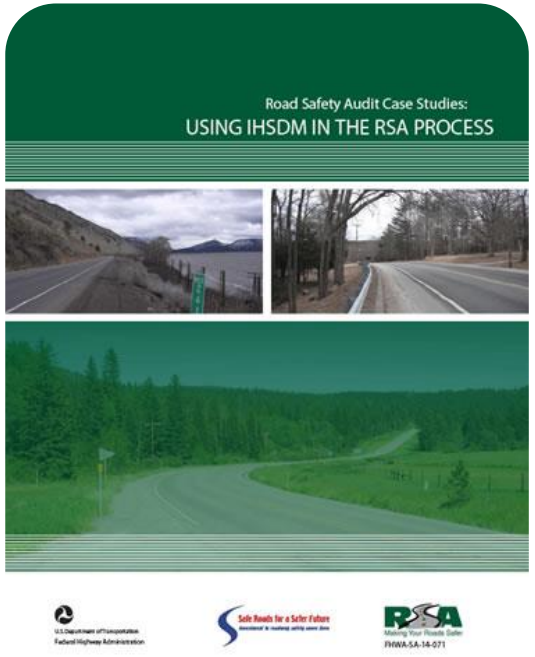
Road Safety Audits: An Evaluation of RSA Programs and Projects



Tribal Road Safety Audits: Case Studies

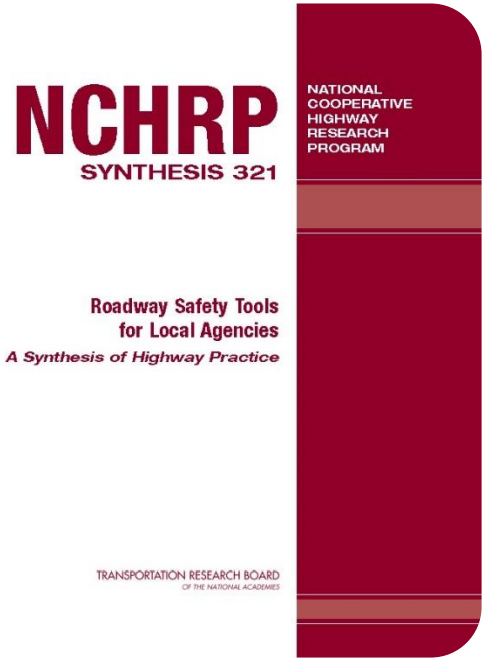


Road Safety Audit Case Studies: Using Three-Dimensional Design Visualization in the RSA Process

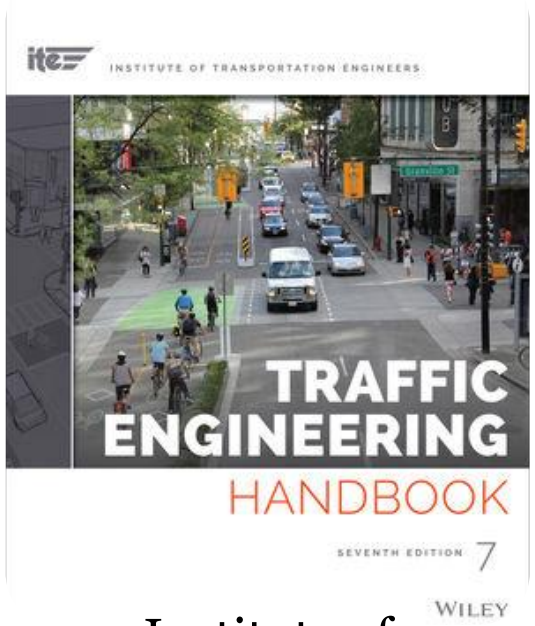


Road Safety Audit Case Studies: Using the Interactive Highway Safety Design Model in the RSA Process

Other valuable documentation for Road Safety Audits

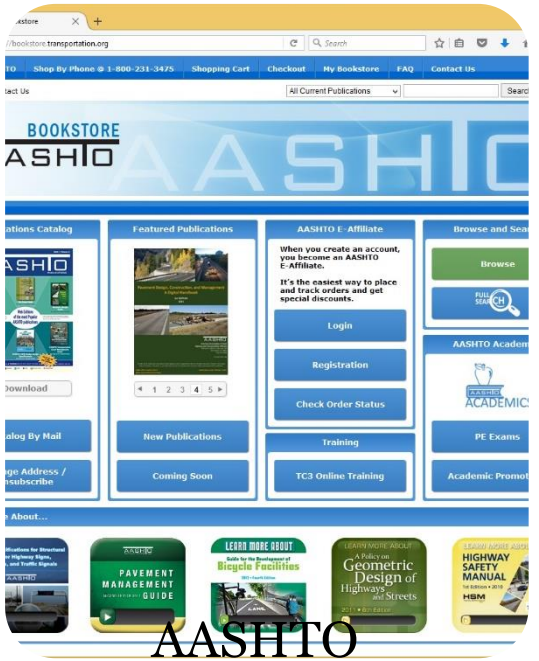


National Cooperative Highway Research Program publications



Institute of Transportation Engineers' publications: Traffic Engineering Handbook

Crash Modification Factors Clearinghouse: database with data for crash reduction analysis



AASHTO bookstore: books, guides and manuals for design of all roadway components

Concerns involving legal liability of government agencies and the State

- **Extensive legislation and federal case law** dictates that any documentation identifying safety issues and generated by transportation agencies or by individuals or institutions hired or consulted for such purpose **cannot be used in demands against the State or government agency** (immunity against tort liability)
  - Safety documentation can be used by State or government agency as a defense
  - Litigants must generate their own documentation and studies to prove a safety problem if he/she/it wishes to file a lawsuit against the State or Agency

Concerns involving legal liability of government agencies and the State

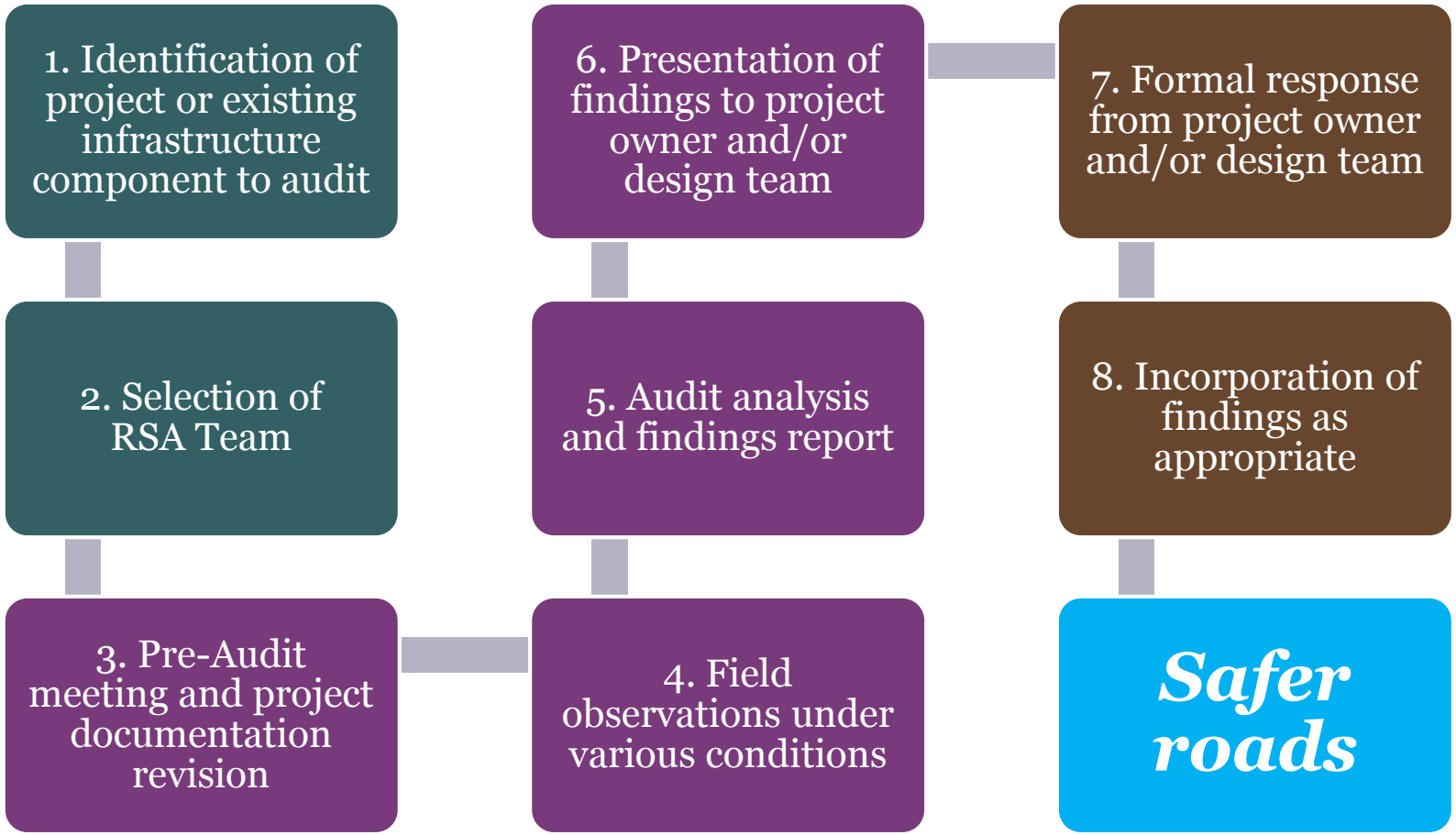
- Said legislation does not necessarily mean the RSA documentation is to be withheld from the public
  - States with public disclosure law are required to make information available
  - Freedom of Information Act
  - Case law rejecting requests to prevent disclosure
  - States may require specific legislation in order to prevent disclosure
- States **must incorporate legal liability issues** as part of their RSA policy
- Option: use RSA documentation for internal agency purposes only

Reminder

- Engineering judgement: just because a design is in compliance of regulations does not necessarily mean it's the safest or more practical choice → **recommend something better when the situation warrants it!**

The RSA Process

Steps for typical Road Safety Audits



El Proceso de ASV

- **Paso 1** - Identificar el proyecto o carretera existente que se desea auditar
  - Alcance
  - Agenda
  - Requisitos para el equipo
  - Tareas de la auditoría
  - Formato y contenido del reporte
  - Expectativas de la respuesta del reporte

El Proceso de ASV

- Paso 2 - Request for Qualification (RFQ)

El Proceso de ASV

- Paso 3 - Reunión Inicial
  - Propósito
  - Expectativas
  - Responsabilidades

El Proceso de ASV

- Paso 4 - Inspecciones de campo y análisis

- Elementos claves a observar:

1. Características del lugar
2. Características del tráfico
3. Uso del terreno
4. Factores humanos

El Proceso de ASV

- Paso 5 - Análisis de auditoría y preparar informes de los hallazgos
  - Asuntos de **seguridad** son **identificados y destacados**
  - Establecer **sugerencias** y/o **posibles acciones**

Audit analysis and findings report

Priority Matrix of Crash Countermeasure Implementation				
Crash Frequency	Crash Severity			
	Highest	High	Medium	Low
Pervasive	Greatest	Greatest	Great	Medium
Common	Greatest	Great	Medium	Moderate
Uncommon	Great	Medium	Moderate	Low
Rare	Medium	Moderate	Low	Lowest

El Proceso de ASV

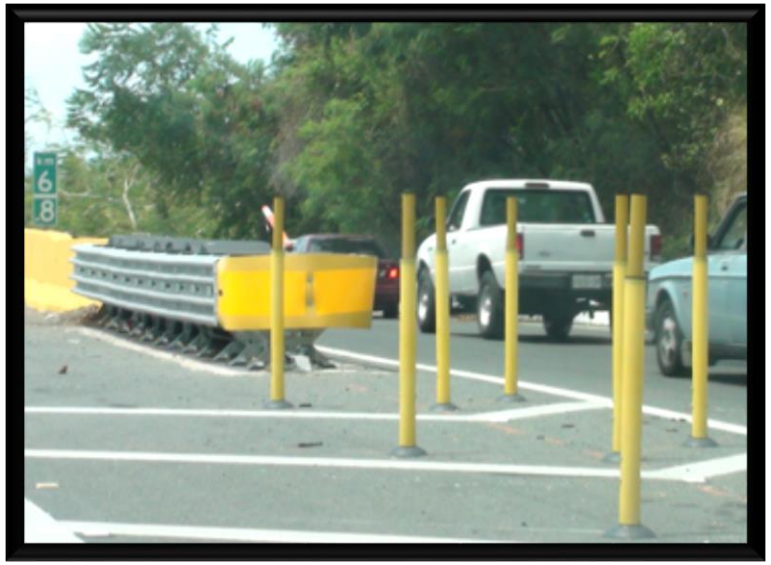
- Paso 6 - Reunión de presentación de los hallazgos
  - Informe oral al dueño del proyecto y al equipo de diseño

El Proceso de ASV

- Paso 7 - Preparar la respuesta formal
  - Respuesta documentada
    - Establecen **acciones correctivas**
  - Plan de implantación de las posibles medidas

El Proceso de ASV

- Paso 8 - **Implementación** de los acuerdos en el proyecto



Estimado de tiempo de duración de cada etapa de ASV

Step	1	2	3	4	5*	6	7	8
Description	Identify Project	Select RSA Team	Conduct Start-Up Meeting	Perform Field Reviews	Conduct Analysis & Prepare Report	Present Findings to Project Owner	Prepare Formal Response	Incorporate Findings
			Conduct RSA Workshop: Write RSA Report				Develop Plan to Address RSA Findings	Implement Suggestions
Duration	Depends upon project selection process; est. 1 day - 1 year+	Depends upon team composition & availability; est. 1 day - 1 month	RSA Workshop: Typically 1/2 - 3 days RSA Report: Typically 1/2 day - 3 weeks				Several days - 1 month	***short-term:*** up to 1 year ***intermediate:*** 1-5 years ***long-term:*** 5+ years

Cinco (5) elementos **esenciales** de un ASV

1. **Compromiso** de la administración y el dueño de la obra
2. Un **acuerdo** sobre la política/proceso a llevarse a cabo
3. Administradores del proyectos **informados** del proceso, su **alcance e impacto** a todos los usuarios
4. Un programa de **entrenamiento** y **capacitación**
5. Equipo de trabajo **cualificado**

Retos Asociados al Proceso de ASV y Mecanismos para Enfrentarlos

- Retos:
  - Riesgos administrativos
  - Financiamiento
  - Selección del equipo
  - Destrezas profesionales de cada miembro
- Mecanismos para enfrentarlos:
  - Las agencias deben **documentar** los hallazgos de la ASV y sopesar/como implantarlos
  - Existen varios programas federales que sirven de **fuente de financiamiento** para ASV (ver próxima diapositiva)
  - Lo propone el consultor, lo selecciona la agencia o la FHWA provee asistencia técnica para identificar los posibles miembros (“**Peer-to-Peer Program**”)
  - Oportunidades de **adiestramiento** con el NHI de FHWA, Centros de Transferencia de Tecnología en Transportación (T2) entre otras.

Fuentes potenciales de fondos federales para el financiamiento de un ASV

- Highway Safety Improvement Program (HSIP)
- Surface Transportation Program (STP)
- Transportation Enhancement (TE)
- Safe Routes to School (SRTS) Program
- National Scenic Byway Program
- Park Roads and Parkways Program
- Refuge Roads Program
- Forest Highway Program
- Public Lands Highway Discretionary (PLHD) Program

Metas y medidas de desempeño establecidas

- Metas:
  - Proveer entrenamiento a X por ciento de personal
  - Llevar a cabo X cantidad de ASV por año
  - Reducir daños y fatalidades por X por ciento por año con mejoras para implantarlas a corto plazo y costo-efectivo
- Medidas de desempeño:
  - Por ciento de personal entrenado para llevar a cabo un ASV
  - Número de ASV llevados a cabo por año
  - **Cantidad total** de choques o tipos específicos de choques en lugares donde los ASV son llevados a cabo

Costos y Beneficios Esperados asociados a un ASV

- Costos:
  - Servicios profesionales del equipo auditor
  - Dueño de la obra
  - Cambios de partidas asociadas a posibles mejoras al diseño bajo consideración
- Beneficios Esperados:
  - Potencial de **reducción** de costos de choques
  - Reducción del ciclo de vida del proyecto de ASV
  - Proporcionar **seguridad más allá** de los estándares y normas establecidos por las agencias
  - Aumentar la **consistencia y uniformidad** entre todos los proyectos
  - Establecer el **concepto de seguridad** vial a través de todas las etapas del diseño de un proyecto
  - Resalta la **calidad de las inspecciones** de campo en proyectos viales
  - Promueve la calidad total con enfoque de seguridad a través de todas las etapas del proyecto

RSAs During Different Stages of Highway Projects

Pre-Construction Phase

- Planning
- Preliminary Design
- Detailed design

Construction Phase

- Work Zones
- Change orders
- Pre-Opening

Post-Construction Phase

- Particular design components
- Existing road facilities
- Notorious safety problems
- New safety featur

Land use

- Long term changes in existing projects
- Preparation in anticipation of demographic or economic shifts

AASHTO's Roadside Design Guide: Roadside Barriers & End Treatments

Overview

- Roadside Barrier
  - “Longitudinal barrier used to shield motorists from natural or man-made obstacles located along either side of the traveled way”

Overview

- Roadside Barrier
  - It could also be used to shield pedestrians and cyclists from vehicles

Performance Requirement

- Primary Purpose: reduce the probability of an errant vehicle to hit a fixed object that is less forgiving than the barrier itself; this could be achieved by containing and redirecting the vehicle

Performance Requirement

Test level	Vehicle	Angle	Speed
TL-1	2,420lb car	25º	31 mph
TL-2	5,000lb pickup truck		44 mph
TL-3			62 mph
TL-4 (mod. TL-3)	17.6kip SUT	15º	56 mph
TL-5	80kip tractor-trailer (van)	15º	50 mph
TL-6	80kip tractor-trailer (tanker)	15º	50 mph

Test Levels Suggested Applications

Test Level	Selection Criteria
TL-1	Work zones with low posted speed, and low volume local streets
TL-2	Work zones, and most local and collector roads with low posted speeds and a low number of heavy vehicles expected
TL-3	High speed arterials with low mixtures of heavy vehicles and with favorable site conditions
TL-4	High speed highways, freeways, expressways, and Interstate highways with a mixture of trucks and heavy vehicles; poor geometrics
TL-5	Same locations as TL-4 where a significant percent of the ADT is made of large trucks or where there are unfavorable site conditions
TL-6	Same locations as TL-4 where a significant percent of the ADT is made of tanker trucks, and unfavorable site conditions exist

AGENDA ACTUAL

1/1/2017 MASH 16: requerimientos adicionales para barreras de cable

1/1/2018 Defensas de acero y barreras de concreto fijas

30/6/2018 Terminales de defensa metálica

1/1/2019

- Barreras de cable y sus terminales
- Amortiguadores de impacto

1/1/2020

- Barreras de Puentes
- Transiciones
- Barreras de concreto temporales
- Bases de señales
- Elementos de seguridad y señalización en zonas de construcción
- Amortiguadores de camiones

Barrier Recommendation

- Only install if it will reduce the severity of a potential crash
- A benefit-cost analysis should be made; cost with and without the barrier are used to evaluate three options:
  1. Remove or reduce the area of concern
  2. Install an appropriate barrier
  3. Leave the area of concern unshielded

Barrier Recommendation

- If is decided to shield the area of concern, highway conditions can be labeled as:
  - embankments, or roadside obstacles

Inspección y Mantenimiento

Establecer Necesidades de Seguridad en las Carreteras

- Identificar zonas de peligros y sus condiciones
- Realizar una auditoria de la carretera
  - Recolecte y analice datos sobre el record de seguridad
    - Reportes policíacos / base de datos de choques
    - Registro de quejas de usuarios
    - Record de mantenimiento
    - Archivos de video de la carretera
    - Planos de construcción
  - Crear un diagrama de condición del lugar
    - Familiarizarse con las condiciones de la zona
    - Observar la operación del trafico
    - Recolectar información y dimensiones
    - Identificar las deficiencias de seguridad

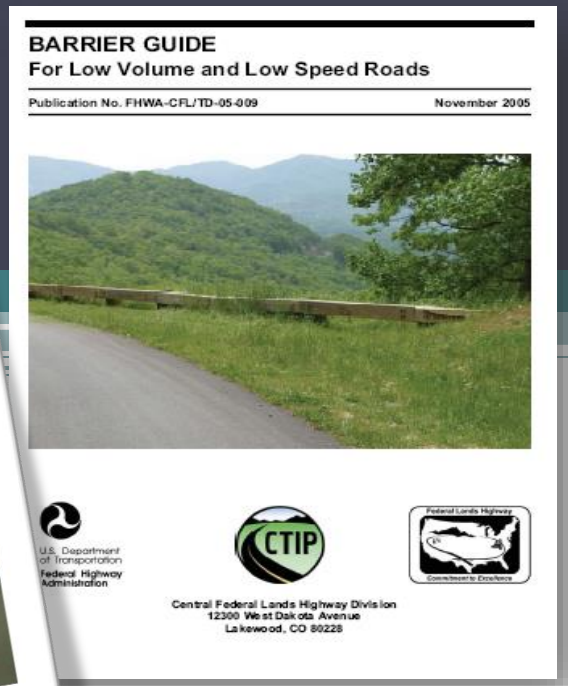
Establecer Necesidades de Seguridad en las Carreteras

- Seleccionar y llevar a cabo estudios para la zona
  - Volumen de tráfico y velocidad de operación
  - Distancia de visibilidad
  - Capacidad de la carretera e intersección
  - Tiempo de respuesta de servicios de policía y emergencias para despejar incidentes
- Evaluar los resultados del estudio
- Determinar las deficiencias operacionales y de seguridad
- Identificar mejoras significativas de seguridad y de operación para el lugar
- Escoger las mejoras apropiadas de acuerdo a un análisis de costo-efectividad, reducción potencial, etc.

Establecer Necesidades de Seguridad en las Carreteras

- Establecer prioridades para la implementación del proyecto en la red
- Programar y ejecutar proyectos de seguridad
- Evaluar efectividad de las mejoras de seguridad implantadas

Identification of Hazards


BARRIER GUIDE
For Low Volume and Low Speed Roads

Publication No. FHWA-CFL/TD-05-009 November 2005

U.S. Department of Transportation
Federal Highway Administration

CTIP

Federal Lands Highway

Central Federal Lands Highway Division
12300 West Dakota Avenue
Lakewood, CO 80228

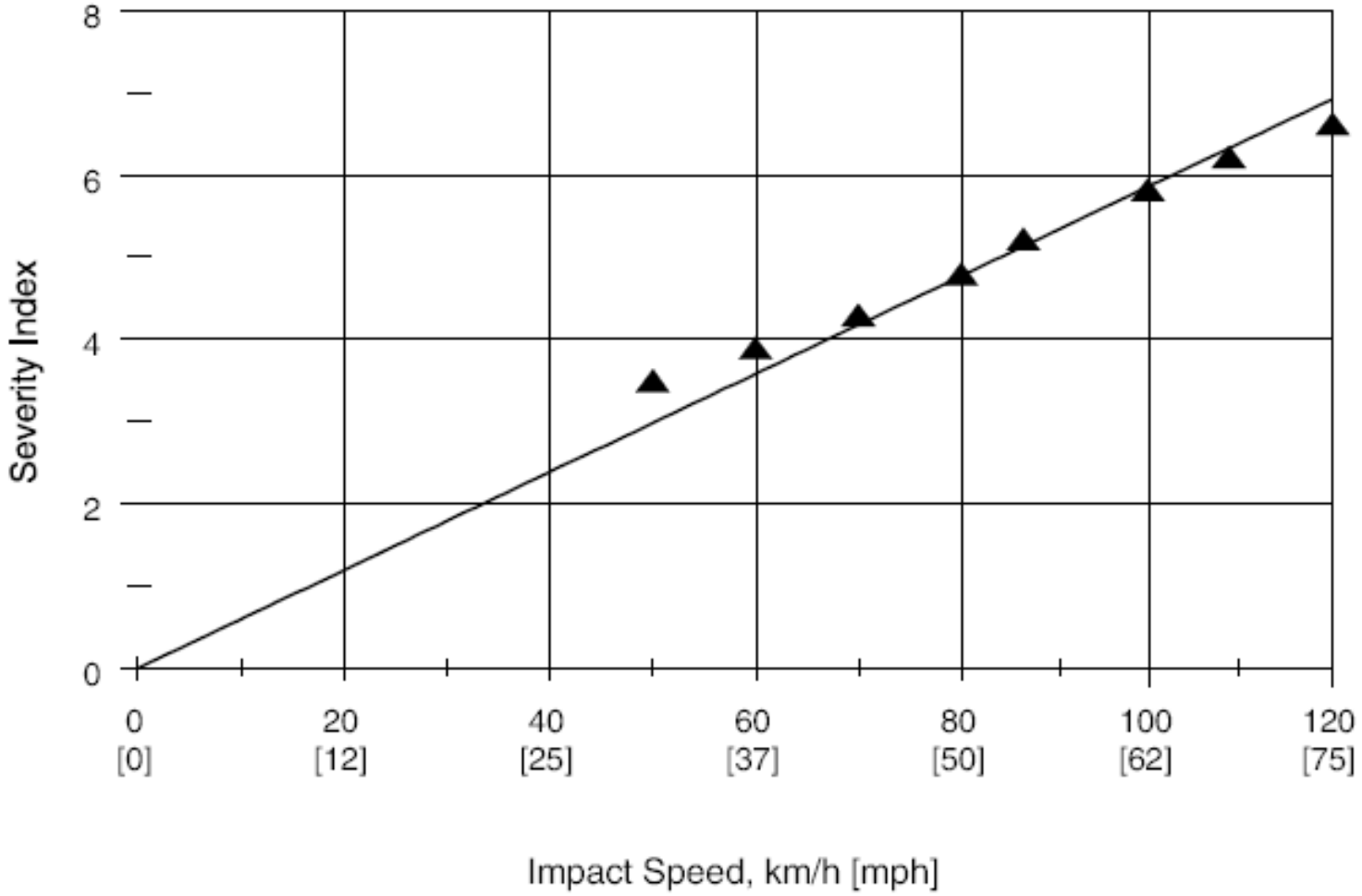
Hazard Severity Classification

- Severity Index is a measure of the consequences of crashes once a hazard or condition is struck, regardless of probability
- Severity indices are estimated at 100 km/h (62mph), but generally will have the same relative meaning at lower speeds
  - Function of speed and the relative seriousness of crash
  - Measured by the mix of likely crash types: fatal, injury and property-damage-only
  - Measured by a severity index using a 0 to 10 scale
  - Severity Index of 5.0 implies that of all the crashes that might occur, 15% will be PDO, 77% will be injury crashes and 8% will be fatal crashes

Severity Index and Injury Level

Severity Index (SI)	Injury Level (%)						
	None	PDO1	PDO2	C	B	A	K
0.0	100.0	—	—	—	—	—	—
0.5	—	100.0	—	—	—	—	—
1.0	—	66.7	23.7	7.3	2.3	—	—
2.0	—	—	71.0	22.0	7.0	—	—
3.0	—	—	43.0	34.0	21.0	1.0	1.0
4.0	—	—	30.0	30.0	32.0	5.0	3.0
5.0	—	—	15.0	22.0	45.0	10.0	8.0
6.0	—	—	7.0	16.0	39.0	20.0	18.0
7.0	—	—	2.0	10.0	28.0	30.0	30.0
8.0	—	—	—	4.0	19.0	27.0	50.0
9.0	—	—	—	—	7.0	18.0	75.0
10.0	—	—	—	—	—	—	100.0

Relation of Severity Index with Impact Speed



Typical Crash Costs per Crash Severity

Crash Severity	*Roadside Design Guide*	FHWA Comprehensive Cost
Fatal Crash	$1,000,000	$2,600,000
Severe Injury Crash	200,000	180,000
Moderate Injury Crash	12,500	36,000
Slight Injury Crash	3,750	19,000
PDO Crash Level 2	3,125	2,000
PDO Crash Level 1	625	2,000

* Crash cost figures are based upon the 1996 edition of the *Roadside Design Guide* and a 1994 FHWA memorandum entitled "Update of Value of Life and Injuries for Use in Preparing Economic Evaluations."

Hazard Severity Index

- Group 3 - Severity index of 5 and higher (may be more severe than a crash into a barrier)
  - Currently acceptable roadside barriers are estimated to have a severity index of 4.9
- Group 2 - Severity index of 3 to 4.9 (some possibility of serious injury and fatality, but probably less severe than barriers)
  - Should be considered for the same corrective actions as Group 3 if they have crash histories or are located so that a vehicle could strike more than one hazard in the same run-off-the-road event
- Group 1 - Severity index of below 3 (fatalities are unlikely)

Severity Classification of Fixed Objects

Potential Hazard	Group 1 (Low Severity)	Group 2 (Moderate Severity)	Group 3 (High Severity)
Bridge piers, abutments and railing ends			X
Boulders, less than 0.3 m (1 ft) in diameter		X	
Boulders, 0.3 m (1 ft) in diameter or larger			X
Non-breakaway sign and luminaire supports		X	
Individual trees, greater than 100 mm (4 in) and less than 200 mm (8 in) diameter	X		
Individual trees, greater than 200 mm (8 in) diameter		X	
Groups of trees, individually greater than 100 mm (4 in) diameter*			X
Utility poles		X	

* Because of driver expectancy, a group of trees at a consistent offset for lengthy distances may experience lower encroachment rates, even though the offset may be within the clear zone. In such instances, it may be appropriate to consider the trees a Group 2 hazard.

Severity Classification of Cross Drainage Features

Potential Hazard	Group 1 (Low Severity)	Group 2 (Moderate Severity)	Group 3 (High Severity)
Cross Drain Culvert Ends:			
Exposed culvert ends with no headwalls, 1 m (36 in) in diameter or less		X	
Exposed culvert ends with no headwalls, greater than 1 m (36 in) in diameter			X
Sloped culvert ends, less than 1.2 m (4 ft) in diameter	X		
Sloped culvert ends, greater than 1.2 m (4 ft) and less than 2.4 m (8 ft) in diameter		X	
Sloped culvert ends, 2.4 m (8 ft) or greater in diameter			X
Vertical headwalls, less than 1.0 m (3 ft) in height		X	
Vertical headwalls, 1 m (3 ft) or higher			X
Headwalls with parallel sloped wingwalls, 0.6 m (2 ft) or less height		X	
Headwalls with parallel sloped wingwalls, greater than 0.6 m (2 ft) height			X
Headwalls with flared and sloped wing walls, 1.0 m (3 ft) or less height		X	
Headwalls with flared and sloped wing walls, greater than 1.0 m (3 ft) height			X
Culvert end sections with crashworthy grates	X		

Severity Classification of Parallel Drainage Features

Potential Hazard	Group 1 (Low Severity)	Group 2 (Moderate Severity)	Group 3 (High Severity)
Parallel Drain Culvert Ends:			
Exposed culvert ends with no headwalls, less than 0.6 m (2 ft) in diameter	X		
Exposed culvert ends with no headwalls, 0.6 m (2 ft) and less than 1.2 m (4 ft) in diameter		X	
Exposed culvert ends, 1.2 m (4 ft) or greater in diameter			X
Mitered culvert ends, less than 1 m (3 ft) in diameter	X		
Mitered culvert ends, 1 m (3 ft) or greater in diameter		X	
Vertical headwalls, less than 1 m (3 ft) above ditch section		X	
Vertical headwalls, 1 m (3 ft) or higher above ditch section			X

Severity Classification of Parallel Ditches

Potential Hazard	Group 1 (Low Severity)	Group 2 (Moderate Severity)	Group 3 (High Severity)
Parallel Ditches:			
Ditches outside the preferred cross section on Figures 3.6 and 3.7 of the *RDG* and with foreslope flatter than 1V: 3H	X		
Ditches with foreslopes 1V: 3H or steeper (Deep ditches should also meet the foreslope criteria below)		X	

Severity Classification of Slopes

Potential Hazard	Group 1 (Low Severity)	Group 2 (Moderate Severity)	Group 3 (High Severity)
Slopes			
1V: 3H foreslope less than 2 m (7 ft) high*	X		
1V: 3H foreslope 2 m (7 ft) and higher*		X	
1V: 2H to 1V: 1.5H foreslope less than 4 m (13 ft) high*		X	
1V: 2H to 1V: 1.5H foreslope 4 m (13 ft) high and higher			X
Vertical foreslope or fill wall less than 2 m (7 ft) high		X	
Vertical foreslope or fill wall 2 m (7 ft) and higher			X
Backslopes that are uneven, or with deep erosion ruts, large rocks, and trees		X	
Vertical backslope with horizontal projections of 200 mm (4 in) or smaller	X		
Vertical backslope with horizontal projections larger than 200 mm (4 in)		X	
Downward intersecting slope (transverse to travel way, such as a river bank) 1V: 4H or steeper, between than 0.5 (2 ft) high to 2 m (6 ft) high		X	
Downward intersecting slope (transverse to travel way, such as a river bank) 1V: 4H or steeper, 2 m (6 ft) or higher			X
Upward intersecting slope (transverse to travel way, such as an overpass fill) 1V: 4H to flatter than 1V: 1.5H, greater than 0.3 m (1 ft) high		X	
Upward intersecting slope (transverse to travel way, such as an overpass fill) 1V: 1.5 H or steeper, greater than 0.3 m (1 ft) high			X

Severity Classification of Other Features

Potential Hazard	Group 1 (Low Severity)	Group 2 (Moderate Severity)	Group 3 (High Severity)
Parallel smooth retaining wall or cut slope	X		
Retaining wall parallel or flared away from approaching traffic at flatter than 1:8	X		
Retaining wall flared away from approaching traffic at 1:8 or steeper		X	
Water at a depth of 0.3 m (1 ft) to 1 m (3 ft)		X	
Water at a depth of 1 m (3 ft) or deeper			X

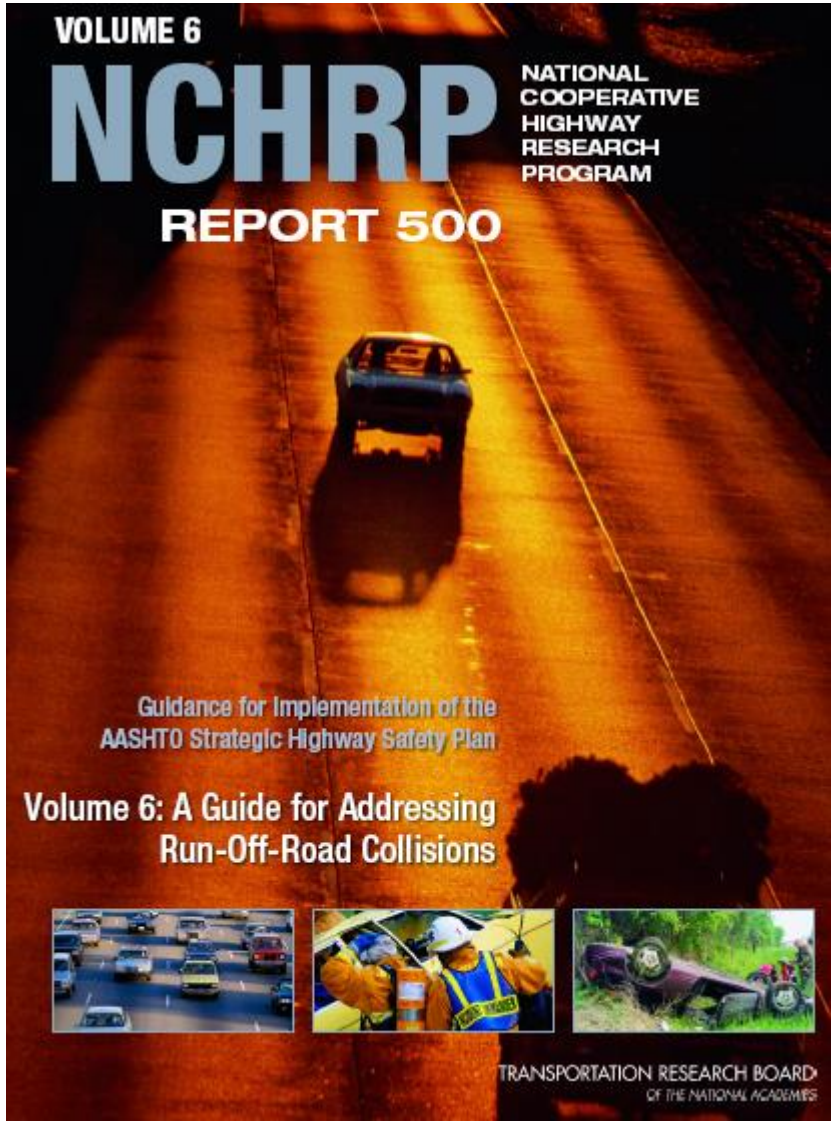
Other Safety Considerations

- Crash history
  - Assist in identifying and evaluating hazards
  - History of several years is needed
    - Three to five years is usually sufficient, but even longer periods are useful for low volume roads
  - Crash analysis should look for patterns of crashes at several sites that share common characteristics, such as roadway features and hazard types
- Presence of bystanders

Suggested Corrective Actions

- Group 3
  - Evaluate for possible use of roadside barriers if it is too expensive or impractical to eliminate either the hazard or make it crashworthy
  - If a barrier is found not to be warranted or if an alternate treatment is less expensive than a barrier, treat as a Group 2 hazard
- Group 2
  - Consider cost-effective strategies to reduce probability, eliminate the hazard or reduce the severity of the hazard
  - Because these hazards generally do no warrant shielding with a roadside barrier, the cost of a corrective action should be less than the expected cost of a barrier
  - If a new road, avoid placing Group 2 hazards in the clear zone
- Group 1
  - Avoid placing these conditions in the clear zone or take simple, low-cost corrective actions, if possible
  - Accept the risk and leave the hazard

AASHTO Safety Plan



Estrategias Para Reducir Choques Fuera de la Vía de Rodaje

Objetivos	Estrategia
1. Evitar que los vehículos salgan de la vía de rodaje	1.1 Mejorar la geometría de la carretera en curvas
	1.2 Mejorar la delineación y el marcado en curvas cerradas
	1.3 Instalar “rumble strips” en el paseo, instalar marcadores en el borde de la carretera o en el medio del carril en lugares sin paseo
	1.4 Prevenir desniveles en los bordes (“edge drop-offs”) o ensanchar o pavimentar paseos
	1.5 Proveer superficies de pavimento resistentes a resbalamiento
	1.6 Proveer marcado retroreflectivo

Estrategias Para Reducir Choques Fuera de la Vía de Rodaje

Objetivos	Estrategia
2. Minimizar la probabilidad de chocar con un objeto o volteo si un vehículo se sale del paseo	2.1 Diseñar pendientes laterales y canales para prevenir volteos
	2.2 Remover / relocalizar objetos en lugares peligrosos
	2.3 Delinear arboles o postes con franjas retroreflectivas
3. Reducir la severidad de un choque	3.1 Mejorar el diseño de utilidades en las carreteras (postes, rótulos, rieles)
	3.2 Mejorar el diseño y aplicación de barreras y sistemas de atenuadores

Estrategias Para Reducir Choques con Arboles

Objetivos	Estrategia
1. Prevenir que arboles crezcan en lugares peligrosos	1.1 Desarrollar, revisar e implantar guías de siembra de arboles en aéreas aledañas a la carretera
	1.2 Usar guías de control y poda de vegetación
2. Eliminar la condición peligrosa o reducir la severidad de un posible choque	2.1 Remover arboles en lugares peligrosos
	2.2 Escudar a los motoristas de chocar un árbol
	2.3 Modificar la zona libre en la cercanía a arboles
	2.4 Delinear arboles en lugares peligrosos

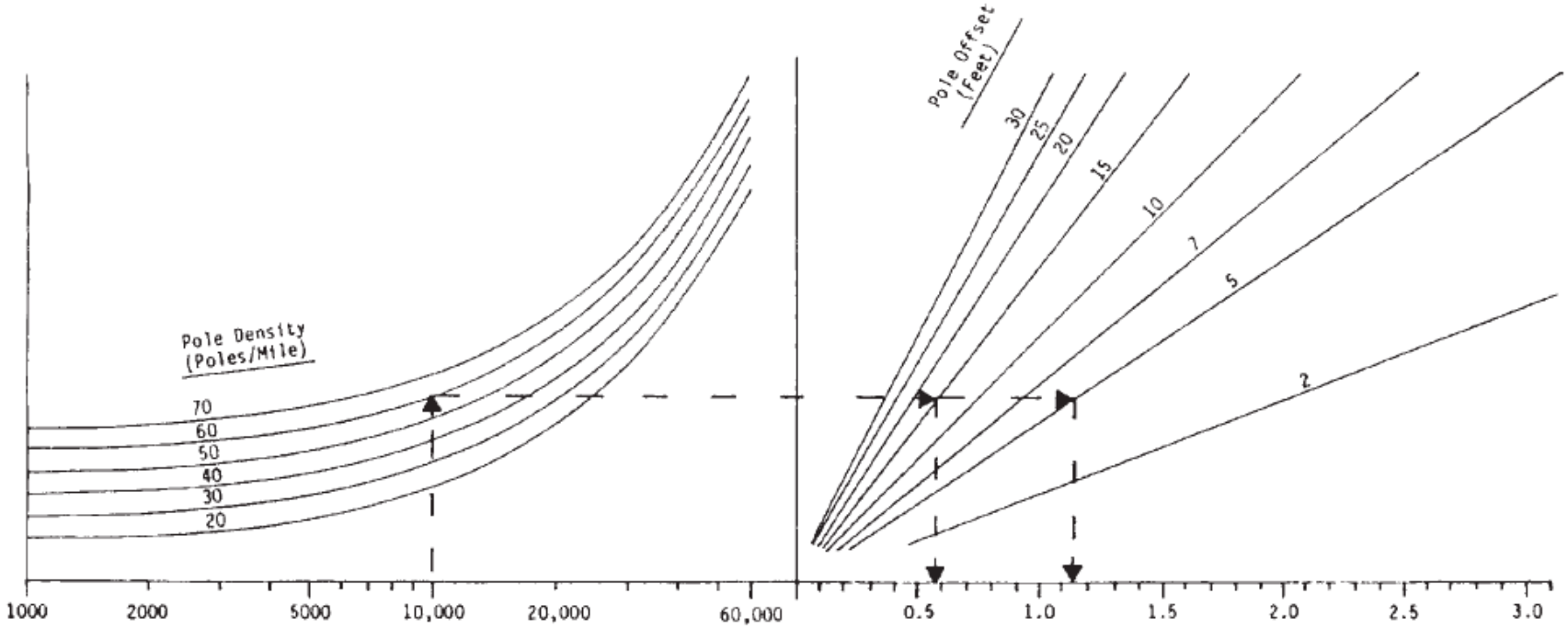
Estrategias Para Reducir Choques con Postes

Objetivos	Estrategia
1. Tratar postes de utilidades ubicados en lugares de alto riesgo y alta frecuencia de choques	1.1 Remover los postes en lugares peligrosos
	1.2 Relocalizar postes en lugares peligrosos
	1.3 Utilizar postes que ceden al impacto
	1.4 Escudar a los motoristas de los postes en lugares peligrosos
	1.5 Delinear postes en lugares peligrosos
	1.6 Usar estrategias para reducir las velocidades en lugares de alto riesgo

Estrategias Para Reducir Choques con Postes

Objetivos	Estrategia
2. Prevenir localizar postes en lugares de alto riesgo	2.1 Desarrollar,, revisar e implantar políticas para prevenir localizar o reemplazar postes dentro de la zona libre
3. Atender series de postes en un corredor para minimizar la probabilidad de chocar con un poste si un vehículo se sale de la vía de rodaje	3.1 Colocar utilidades bajo tierra
	3.2 Relocalizar postes en el corredor alejados de la vía de rodaje o un lugar menos vulnerable
	3.3 Reducir el numero de postes en el corredor

Nomograma para Estimar Choques Anuales con Postes por Milla



Note:

1 foot = 0.3 m
1 pole/mile = 0.6 poles/km
1 accident/mile/year = 0.6 accidents/km/year

Minimizar errores = cumplir con especificaciones, planos modelos, etc. + uso de un buen juicio ingenieril

(Checklist)

Guia de Cotejo

- Observar la condición de las barreras existentes
  - Frecuencia de haber sido impactadas
  - Erosión en la base de los postes (escorrentía excesiva)
  - Corrosión en los tornillos, conexiones que no son galvanizados
  - Asentamiento de valla (por debajo de altura mínima)
  - Consolidacion del terreno alrededor de la barrera

Guia de Cotejo

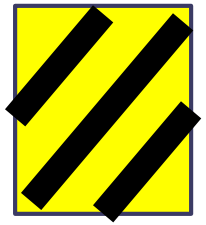
- Altura de la barrera
- Espaciamiento de los postes (crítico en los “end treatment”)
- Distancia del borde de la carretera hasta la barrera de seguridad
- Distancia de la barrera de seguridad con respecto al obstáculo u objeto fijo
- Conocimiento de la deflexión máxima de la barrera.
- Particularidades de segmento “flare” vs paralelo

Guia de Cotejo

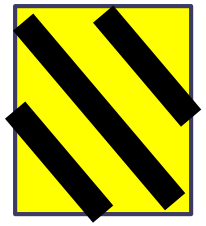
- Reemplazo de bloque de acero por madera o plástico en sistema National Highway System (NHS) para cumplir con TL-3
- Suficiente “recovery area” detrás del terminal
- Aspectos del terminal: gating vs. Non-gating
- Pendiente plana (deseable 10H: 1V) frente a la barrera de seguridad

Guia de Cotejo

- Object markers y delineadores en donde correspondan según los planos
- Panel al frente de terminal con la orientación adecuada de las franjas
  - + 45° en la orilla derecha de la vía (contiguo al carril lento)



  - - 45° en la orilla izquirda de la vía (contiiguo al carril rápido)



Guia de Cotejo

- Diámetro de postes de hormigón que van instalados en barreras tipo F
  - No deben exceder el ancho superior de la barrera.
- Cable de anclaje en terminal no debe estar bien tenso (ni demasiado suelto)
- Terminal en barrera de hormigón debe pintarse de color amarillo y el standard section de color blanco.
- Pasadores lisos entrelazando los módulos de hormigón portátiles (PCB) para que funcione como un sistema

Guia de Cotejo

					Ranking				
ITEM	**N/A**	**Yes**	**No**	**Priority**	**Good**	**Regular**	**Poor**	**Km**	**Comments**
				High, Medium, Low	>9	6<R<8.9	< 6		
CRASH BARRIERS AND CLEAR ZONES									
1. Clear zones									
Is the clear zone width traversable?									
Is the clear zone width free of rigid fixtures? (if not, can all of these rigid fixtures be removed or shielded?)									
Are all power poles, trees, etc., at a safe distance from the traffic paths?									
Is the appropriate treatment or protection provided for any objects for any objects within the clear zone?									
2. Crash barriers									
Are crash barriers installed where necessary?									
Are crash barriers installed at all necessary locations in accordance with the relevant guidelines?									
Are the barrier systems suitable for the purpose?									
Are the crash barriers correctly installed?									
Is the length of crash barrier at each installation adequate?									
Is the guardrail attached correctly to bridge railings?									
Is there sufficient width between the barrier and the edge line to contain a broken-down vehicle?									

Fuente: Tesis de maestría de Wilson Arias
Recinto Universitario de Mayagüez

Guia de Cotejo

ITEM	N/A	Yes	No	Priority	Ranking			Km	Comments
					Good	Regular	Poor		
				High, Medium, Low	>9	6<R<8.9	< 6		
3. End treatments									
Are end treatments constructed correctly?									
Is there a safe run-off area behind breakaway terminals?									
4. Fences									
Are pedestrian fences frangible?									
the barrier is:									
Rigid:									
F-Shape									
New Jersey									
Vertical Concrete barrier									
Single Slope barrier									
Tall wall									
Stone Mansory wall									
Semi- rigid:									
W-beam strong post									
Steel block out									
Plastic block out									
Wood block out									
Thrie beam strong post									
Steel block out									
Plastic block out									
Wood block out									

Fuente: Tesis de maestría de Wilson Arias
Recinto Universitario de Mayagüez

Guia de Cotejo

					Ranking				
ITEM	**N/A**	**Yes**	**No**	**Priority**	**Good**	**Regular**	**Poor**	**Km**	**Comments**
				High, Medium, Low	>9	6<R<8.9	< 6		
Flexible									
Weak post									
3-stand cable									
W-beam									
Modified W-beam									
Ironwood Aesthetic barrier									
5. Visibility of barriers and fences									
Is there adequate delineation and visibility of crash barriers and fences at night?									

Fuente: Tesis de maestría de Wilson Arias
Recinto Universitario de Mayagüez

Dos Categorías de Mantenimiento

1. **Rutina** - Consiste en revisiones periódicas para verificar condiciones del sistema

2. **Reparación** - Consiste en arreglos luego de ser impactado el sistema

W-BEAM GUARDRAIL REPAIR

A Guide for Highway and Street Maintenance Personnel

INTRODUCTION

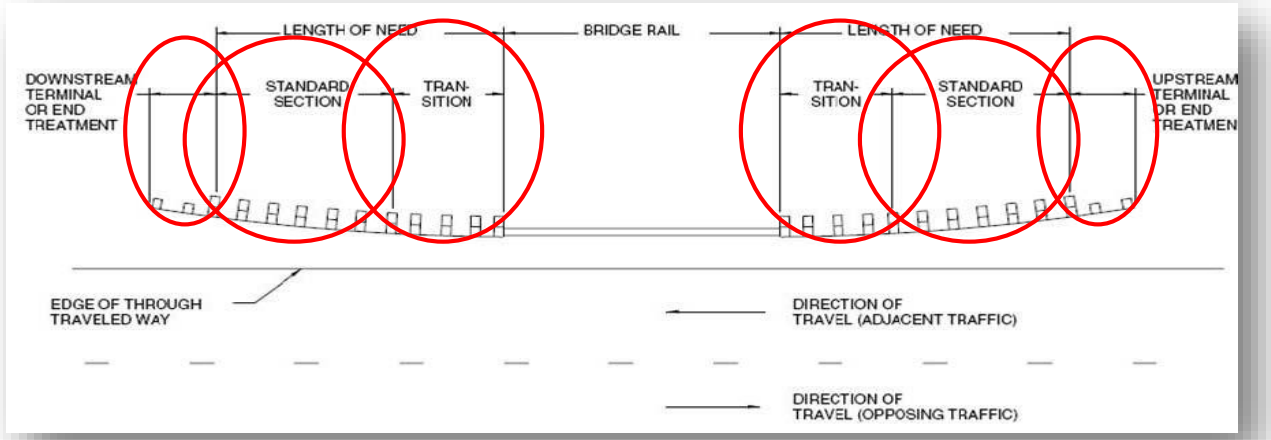
- Roadside barrier shield drivers of errant vehicles from roadside hazards
  - Barriers themselves can be hazards – should shield conditions more hazardous
  - AASHTO “Roadside Design Guide” is a guide for when and where to install barriers

Focus of Guide

- Most widely used barriers – strong post W-Beam guardrail
- W-beam rail element and strong posts (wood or steel) spaced at 6ft 3in, with the rail blocked out from the posts.
  - FHWA "W-Beam Guardrail Repair" is a Guide for repair of strong post W-Beam guardrail

SECTIONS OF GUARDRAIL

- *Standard* section – main section for shielding obstacle
- *Transition* section – where guardrail ties into bridge rail or other stiffer barrier
- *Terminal* section (or *End Treatment*) – beginning and end of the guardrail



W-Beam Guardrail Crash Site Review

- Define the extent or severity of damage to guardrail relative to roadway functional class and crash history

IDENTIFY PROBLEMS AND PLAN APPROPRIATE ACTION

On-site review of the damage

- Clear the damage site of debris
- If guardrail nonfunctional, use temporary warning devices
- Assessment of timing of repair
  - Resources, hazard exposure, hazard severity
  - Follow agency guidance

ASSESSMENT OF DAMAGE

- Determine extent of damage

- Three categories of functionality:
  1. No longer functional
  2. Should function adequately under most impacts (bent less than 12”)
  3. Functional (bent less than 6”)

DAMAGE TO STANDARD SECTION

- Damage categories 1,2 ,3
  1. No longer functional
     - Rail element separated or torn or rail height is less than 24 inches
     - 3 or more broken, bent, or separated posts and rail out of alignment less than 12 inches
     - Rail is out of alignment more than 18 inches, regardless of post damage
  2. Should function adequately under most impacts
     - Rail bent or pushed out-of-line less than 12”
     - No more than 2 posts are broken/bent
  3. Functional
     - No damage other than rail bent or pushed out-of-line less than 6”

DAMAGE TO STANDARD SECTION

- Length of W-Beam repair depends on total length of the barrier and extent of damage
- Repair should ensure the following:
  - Full-tension capability of beam restored
  - Current height standard is met
  - Agency's current standards are complied with
- Checklist provided in Guide

Repaired W-beam Checklist

1. Tension capability is intact:
   a. No tears.
   b. Eight ⅝-in splice bolts in each rail connection.
   c. No rail subjected to a cutting torch is reused; any new holes are drilled.
2. Height is according to standard.
3. Posts are intact and firmly bedded in ground. Use a longer post (7 ft+) in front of a fill slope when there is less than 1 ft of relatively flat ground behind the post.
4. No washers under rail-to-post bolt head.
5. Available deflection distance in back of W-beam to a rigid vertical object (W-beam deflects as it develops tension — 3 ft is the standard distance provided; if 3 ft is not available, then add posts and/or nest rail to stiffen the system).
6. Lap rail elements in the direction of traffic (upstream {approach} rail is in front of downstream {leave} rail).
7. For wood block on wood posts, use toenails to restrain blocks from rotating, preferably one on each side of the block, 2 inches from the top or bottom.
8. Guardrail-mounted delineators in damaged section replaced. If no guardrail-mounted delineators previously existed, install delineators per MUTCD and/or highway agency policy.

(Items 3 and 5 are most applicable for high-speed facilities and could be less restrictive for lower speed facilities.)

DAMAGE TO TRANSITION SECTION

- Damage categories 1,2 ,3
  1. No longer functional
     - W-beam element not attached to rigid object
     - W-Beam is severely pocketed
  2. Should function adequately under most impacts
     - Rail flattened and bent/pushed out of line less than 12 inches
     - Rail intact and securely attached
  3. Functional
     - Rail flattened and bent/pushed out of line less than 6 inches
     - Rail intact and securely attached

DAMAGE TO TRANSITION SECTION

- All repairs should incorporate four features:
  - Strong tension connection between W-Beam and rigid object
  - More and/or larger posts close to rigid object
  - Nested rail element for last 12.5 ft
  - Means to prevent wheel snagging – rub rail/curbing
- Checklist provided in Guide

Repaired Transition Checklist

1. Tension capability is intact:
   a. No tears in rail elements.
   b. Minimum of four ⅞-in-high strength bolts/threaded rods in connection to rigid object — ensure the bolt heads or nuts on the threaded rods protrude no more than ¾ inches from the face of the connection plate.

   c. All splices are intact (eight splice bolts in each rail connection)
   d. No rail subjected to a cutting torch.
2. Extra/larger posts — the last post spacing in advance of the rigid object should be 1 ft, 6¾ in.
3. Nested last rail element.
4. Rub rail or curb to prevent wheel snagging.
5. Bridge shoe lapped in the direction of the near-side traffic.
6. Damaged or knocked-down object (hazard) marker (if any) replaced on or adjacent to bridge parapet.

DAMAGE TO END TREATMENT SECTIO

- Damage categories 1,2 ,3
  1. No longer functional
     - Energy-absorbing head off rail
     - Partially or fully destroyed and presents a blunt end
  2. Should function adequately under most impacts
     - Impact head should absorb most of a vehicle's energy end-on impacts
  3. Functional
     - Post #1 is intact and rail adequate

DAMAGE TO END TREATMENT SECTION

- Replace turndown or breakaway cable terminal (BCT)
- Buried-in backslope (BIB)

Repaired/Replaced End Treatment Checklist:

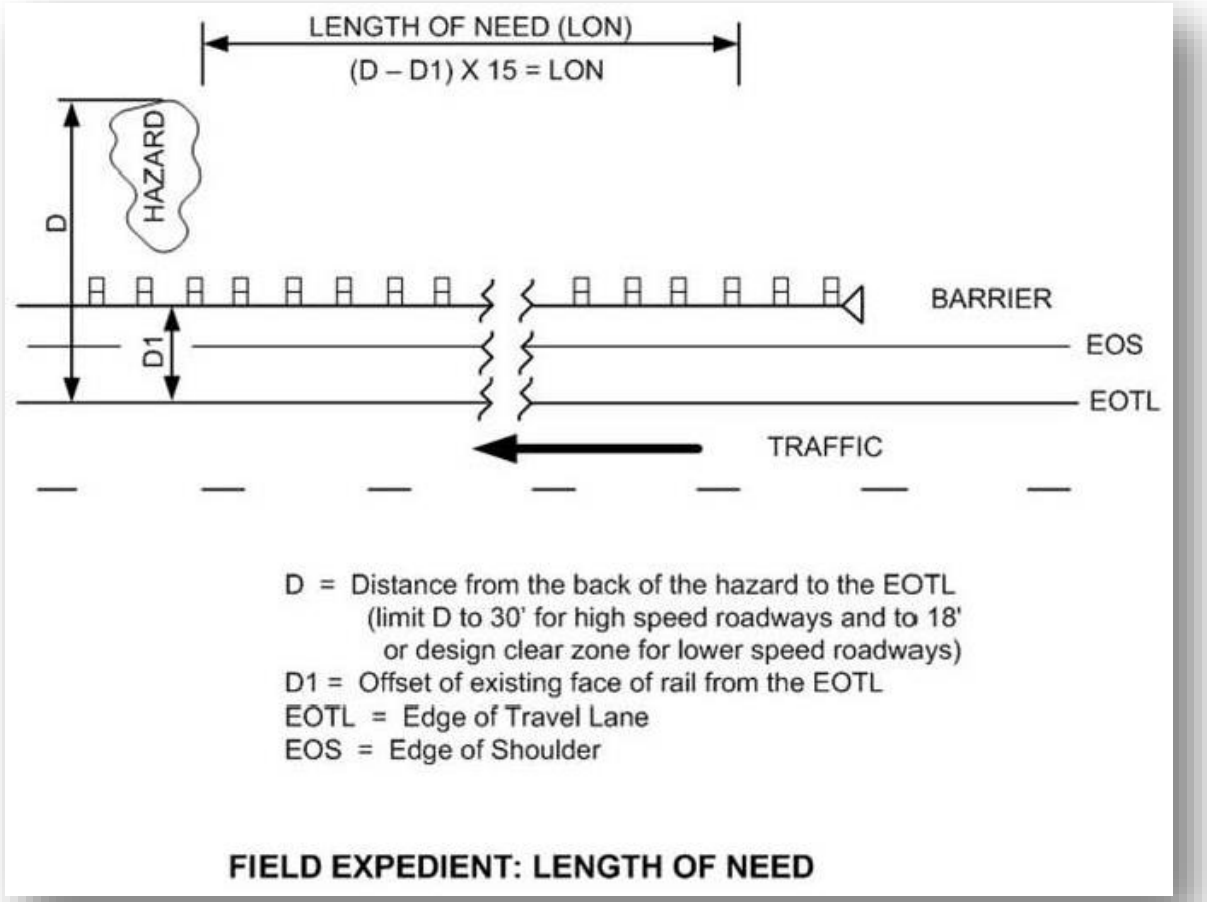
1. Use no interchanged parts from different manufacture's systems for parts unique to the particular end treatment being repaired.
2. For energy-absorbing systems, place the head completely onto the rail element.
3. For energy-absorbing systems, the cable anchorage to the rail element allows the cable to release from the rail if the head slides.
4. Post 1's top part will separate from its foundation for end-on impacts.
5. Replace any damaged posts within the end treatment that were originally breakaway or yielding posts with breakaway or yielding posts approved by the system's manufacturer.
6. Grading provides no more than 4 inches above ground to the strut or to what will remain as a stub.
7. Bearing plate is properly oriented.
8. Cable is tightened to a ***taut*** condition; cannot lift up on the cable more than 1 inch.
9. Retroreflective object (hazard) marker in place on non-buried end treatments per highway agency policy.

LENGTH OF NEED (LON)

- Ideally, length of need (LON) should be provided
- Distance in advance of the hazard

- Calculation

  (D – D1) * 15



DAMAGE TO END TREATMENT SECTION

- Replace turndown or breakaway cable terminal (BCT)
- Buried-in backside (BIB)
- Repairs should ensure the following:
  - Ideally, LON should be provided
  - Use “energy absorbing systems”, if LON not acceptable and grading not satisfactory
  - Grading
- FHWA Guidelines for the Selection of W-Beam Barrier Terminals (e-mail report.center@fhwa.dot.gov to request CD-ROM)
- Checklist provided in Guide

REPAIR SEQUENCE GUIDANCE

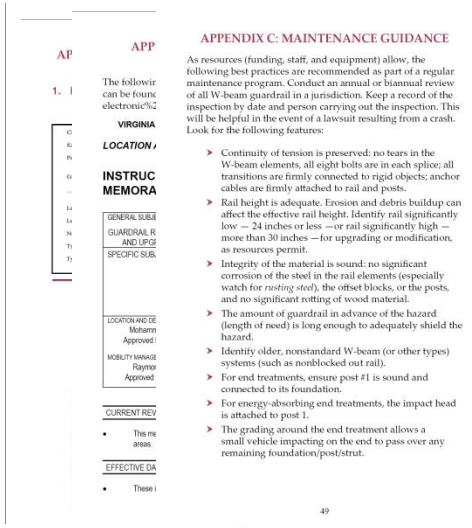
- Critical actions to take before the actual repair include the following:
  - Use temporary traffic control according to MUTCD approved plans
  - Contact local Dig Safe utility protection before site visit
  - Take enough signs/channelizing devices/personnel to mark the repair zone
  - Ensure workers wear OSHA approved equipment – safety vests, safety glasses and protective shoes
- Detailed sequences for standard, transition and end treatment sections in Guide

REPAIR RECORD

- All agencies must maintain records of maintenance
- If agency does not have a complete record system, then the following alternatives could be used
  - *Completed Work Inspection Checklist* (see Appendix A of Guide)
  - Keep a copy of *Checklist of Materials for Repair* worksheet (see Appendix A, Item 2)
  - Take pictures of the before and after repair conditions

USING THE GUIDE

- Appendices:
  - Appendix A: Estimating Resources for W-Beam Guardrail Repair
  - Appendix B: Virginia DOT Repair Guidance
  - Appendix C: Maintenance Guidance
  - Appendix D: Clear Zone Description



APPENDIX C: MAINTENANCE GUIDANCE

As resources (funding, staff, and equipment) allow, the following best practices are recommended as part of a regular maintenance program. Conduct an annual or biannual review of all W-beam guardrail in a jurisdiction. Keep a record of the inspection by date and person carrying out the inspection. This will be helpful in the event of a lawsuit resulting from a crash. Look for the following features:

- Continuity of tension is preserved: no tears in the W-beam elements, all eight bolts are in each splice; all transitions are firmly connected to rigid objects; anchor cables are firmly attached to rail and posts.
- Rail height is adequate. Erosion and debris buildup can affect the effective rail height. Identify rail significantly low — 24 inches or less —or rail significantly high — more than 30 inches —for upgrading or modification, as resources permit.
- Integrity of the material is sound: no significant corrosion of the steel in the rail elements (especially watch for *rusting-steel*), the offset blocks, or the posts, and no significant rotting of wood material.
- The amount of guardrail in advance of the hazard (length of need) is long enough to adequately shield the hazard.
- Identify older, nonstandard W-beam (or other types) systems (such as nonblocked out rail).
- For end treatments, ensure post #1 is sound and connected to its foundation.
- For energy-absorbing end treatments, the impact head is attached to post 1.
- The grading around the end treatment allows a small vehicle impacting on the end to pass over any remaining foundation/post/strut.

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USING THE GUIDE (continued)

- Suggestions on how to use:
  - Provide copy of Guide to each staff person
  - Use presentation as training resource on rainy day
- Contact your LTAP center if specific questions arise http://www.ltapt2.org/centers/

WRAP-UP

- Guardrails shield drivers of errant vehicles from roadside hazards
- Guardrails should be checked on damage notification followed by proper damage assessment and repair
- Be sure to follow proper personnel and equipment safety procedures during guardrail repair and maintenance operations


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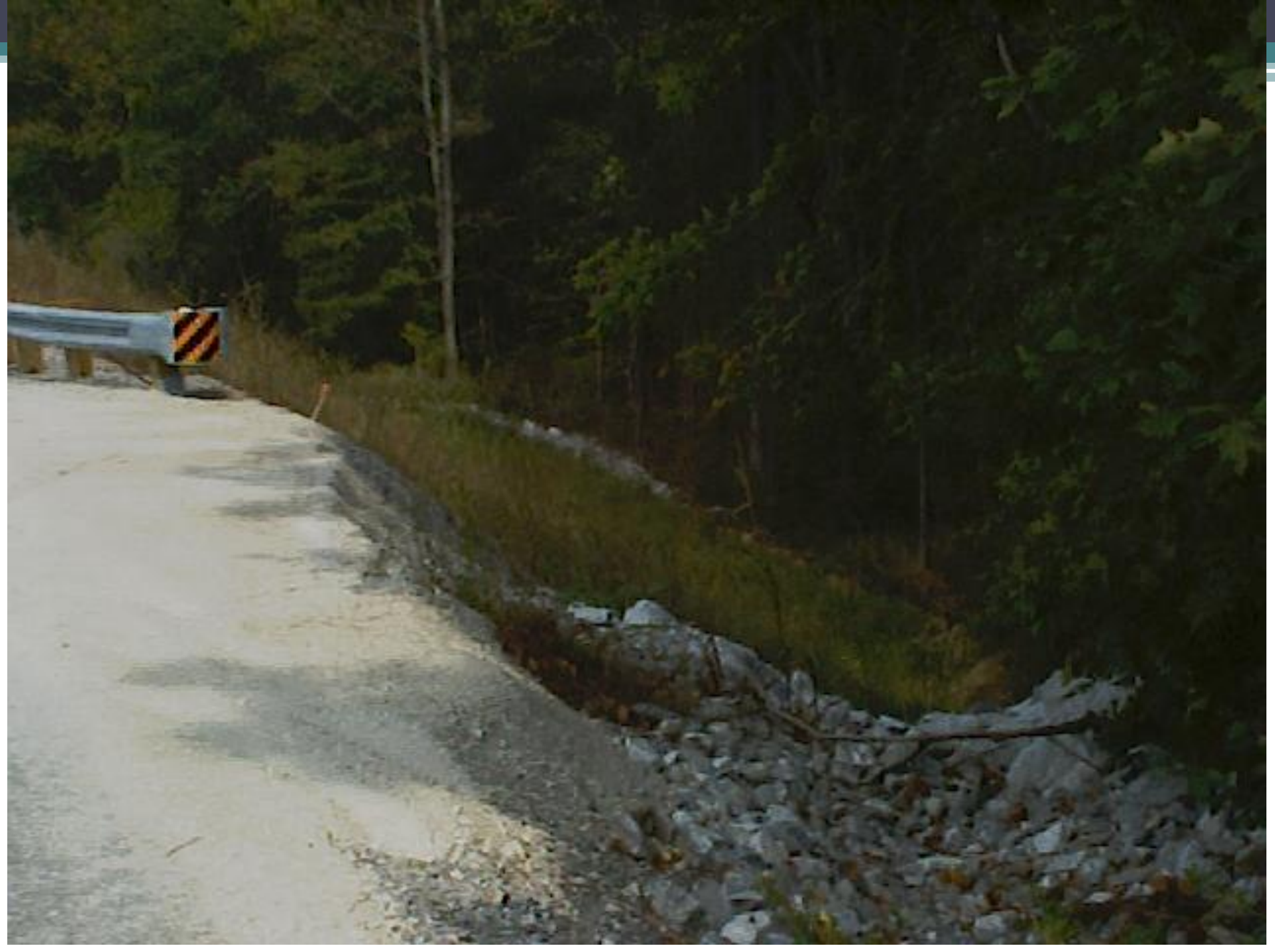
Ridgewood
Oradell
EXIT 1/2 MILE

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San Juan
Condado Centro
Santurce Pda. 18
26 ESTE
Carolina
Aeropuerto
Isla Verde


Is this a
good installation?

Is this a good installation?

Is this a good installation?

Is this a good installation?

Is this a good installation?

Is this a good installation?

Is this a good installation?

Is this a good installation?

Not proper use of longitudinal barrier

¡Buenos Tardes y que Tengan un Viaje Seguro a sus Casas!

Muchas Gracias por su Atención