2022 Purdue Road School

151. INDOT Work Zone Safety Update

Katherine Smutzer and Mischa Kachler
Work Zone Safety Section

INDOT Work Zone Safety Update

Part 1 – Katherine Smutzer

- Barrier Transitions
- IDM Update

Part 2 – Mischa Kachler

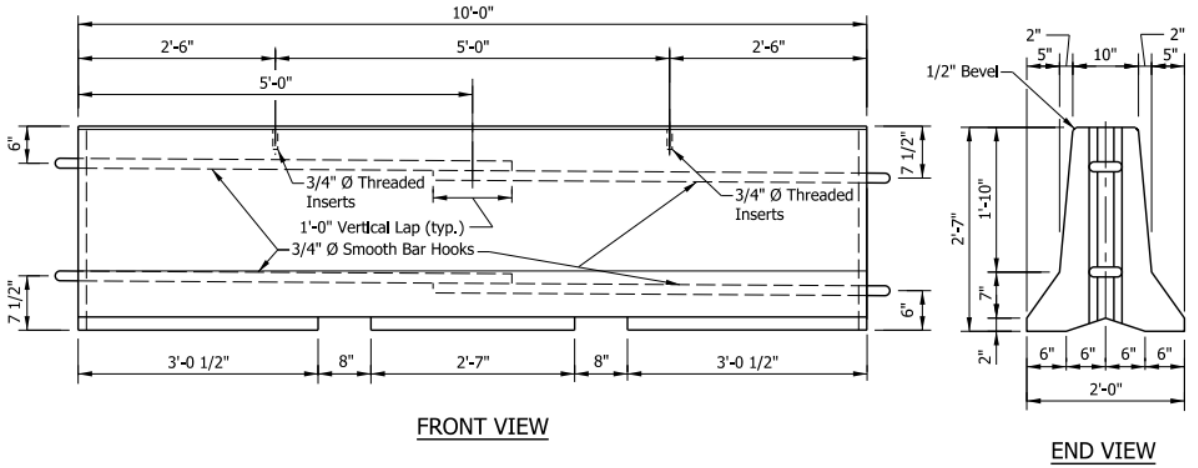
MOT Design Considerations

- Parts of a Work Zone
- Improving Safety in Transition Areas
- Transition Areas Case Study

Barrier Transitions
Katherine Smutzer

Barrier Transitions

- INDOT Temporary Traffic Barrier is Different than other State DOT Temporary Traffic Barrier.
  - 10 ft segment lengths, rather than 12 ft
  - 31 in. height rather than 32 in.
  - Less Reinforcement
  - Anchored Barrier is only anchored on the work zone side of the barrier. (Good)



- INDOT has just entered into an agreement with a testing facility to test INDOT Temporary Traffic Barrier in the following configurations:
  - Free-Standing
  - Anchorage into Bituminous
  - Transition between Free-Standing and Anchored Barrier.

NextLevel INDIANA

Barrier Transitions

- INDOT does not have a crash tested barrier transition between temporary traffic barrier and w-beam guardrail or between temporary traffic barrier and permanent concrete barrier (median or bridge railing).
- Future Testing Request May Include
  - Transitions between Temporary Traffic Barrier and W-Beam Guardrail
  - Transitions between Temporary Traffic Barrier and Permanent Median Barrier and Permanent Bridge Rail

NextLevel INDIANA

Barrier Transitions

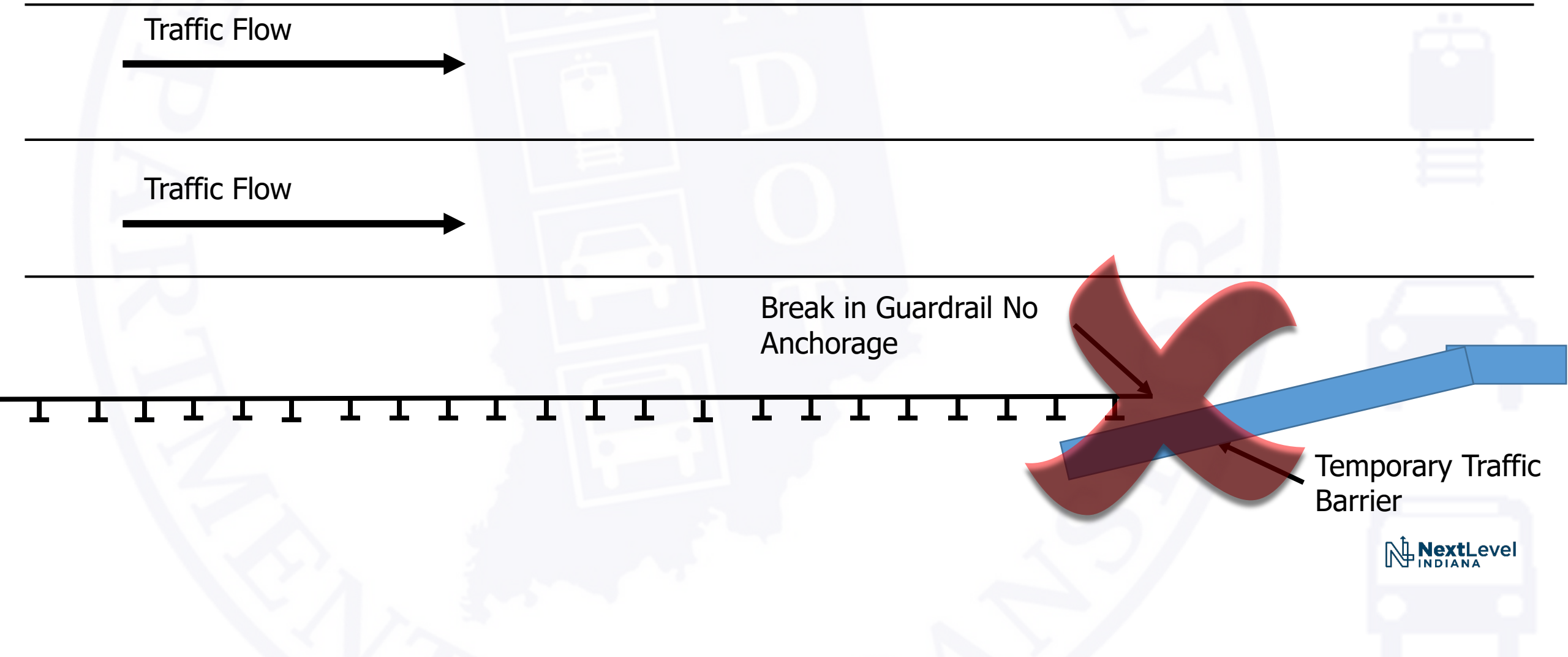
- Standards for other State DOT temporary traffic barrier transitions should not be used with INDOT temporary traffic barrier.
- These transitions are being tested but not with INDOT Temporary Traffic Barrier

Barrier Transitions

- Incorrect Transition between Temporary Traffic Barrier (TTB) and W-Beam Guardrail.
- Incorrect Placement of Type II TTB. The last 100 ft, or so, of the w-beam guardrail could gate and allow a vehicle to get behind the w-beam guardrail. The TTB blunt end could still be a hazard.

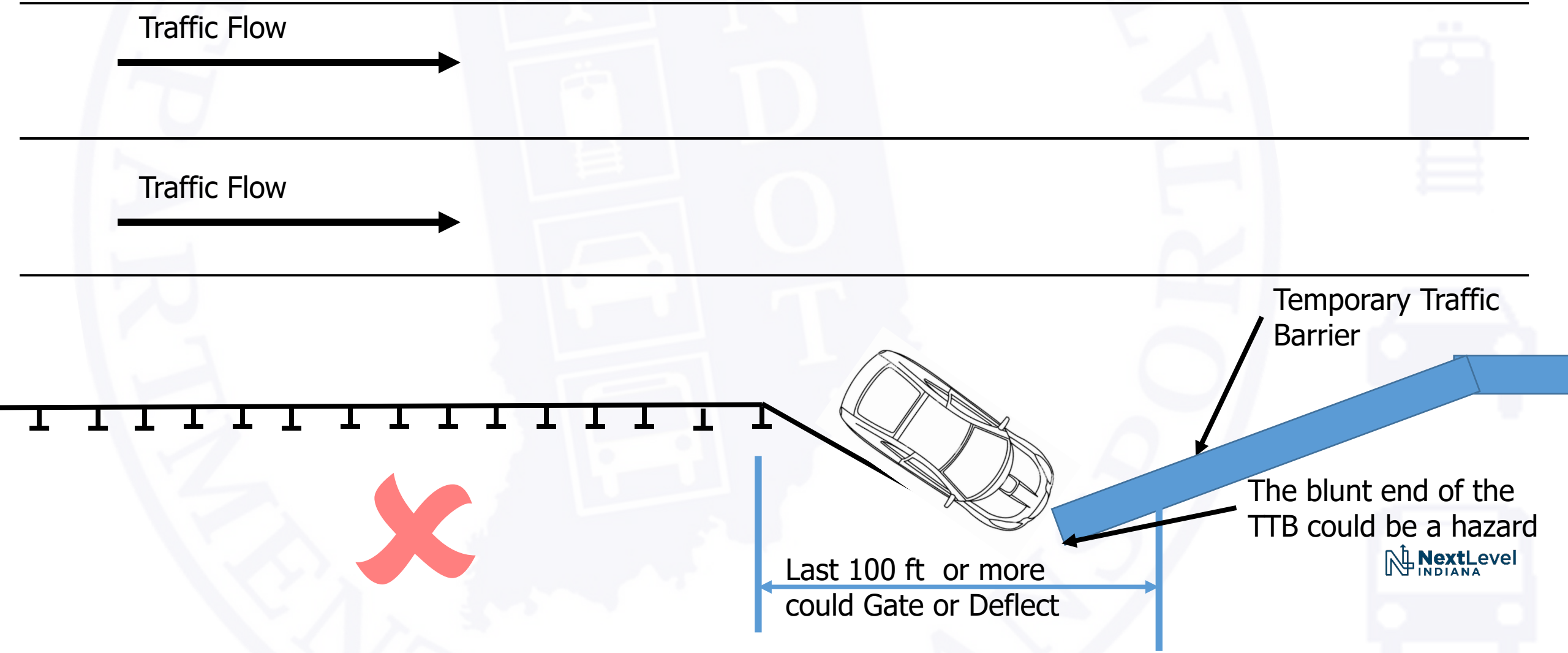
Barrier Transitions

- Original Configuration as shown in the previous photo



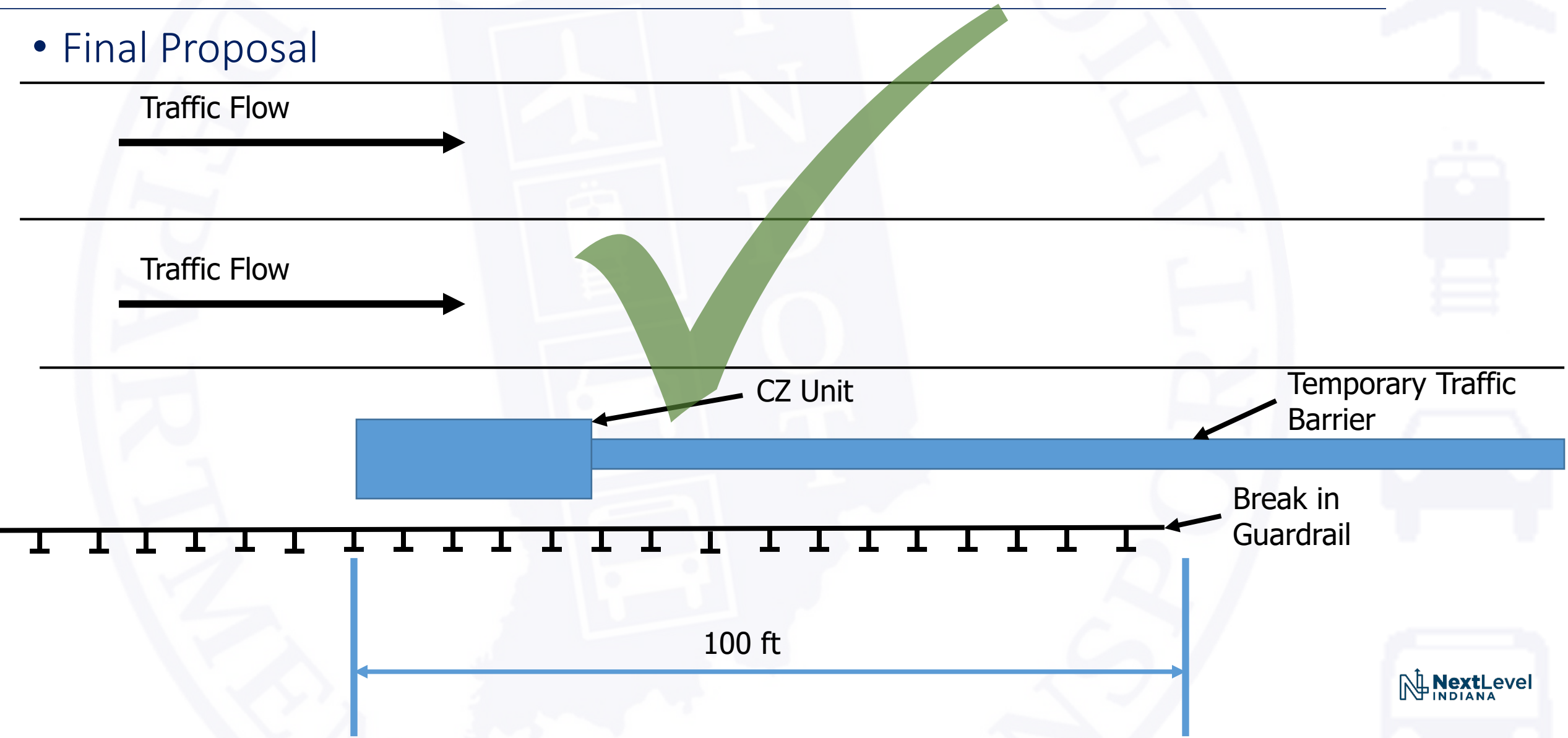
Barrier Transitions

- Possible Gating or Deflection of W-Beam Guardrail Exposing the Blunt End or the TTB



Barrier Transitions

- Final Proposal



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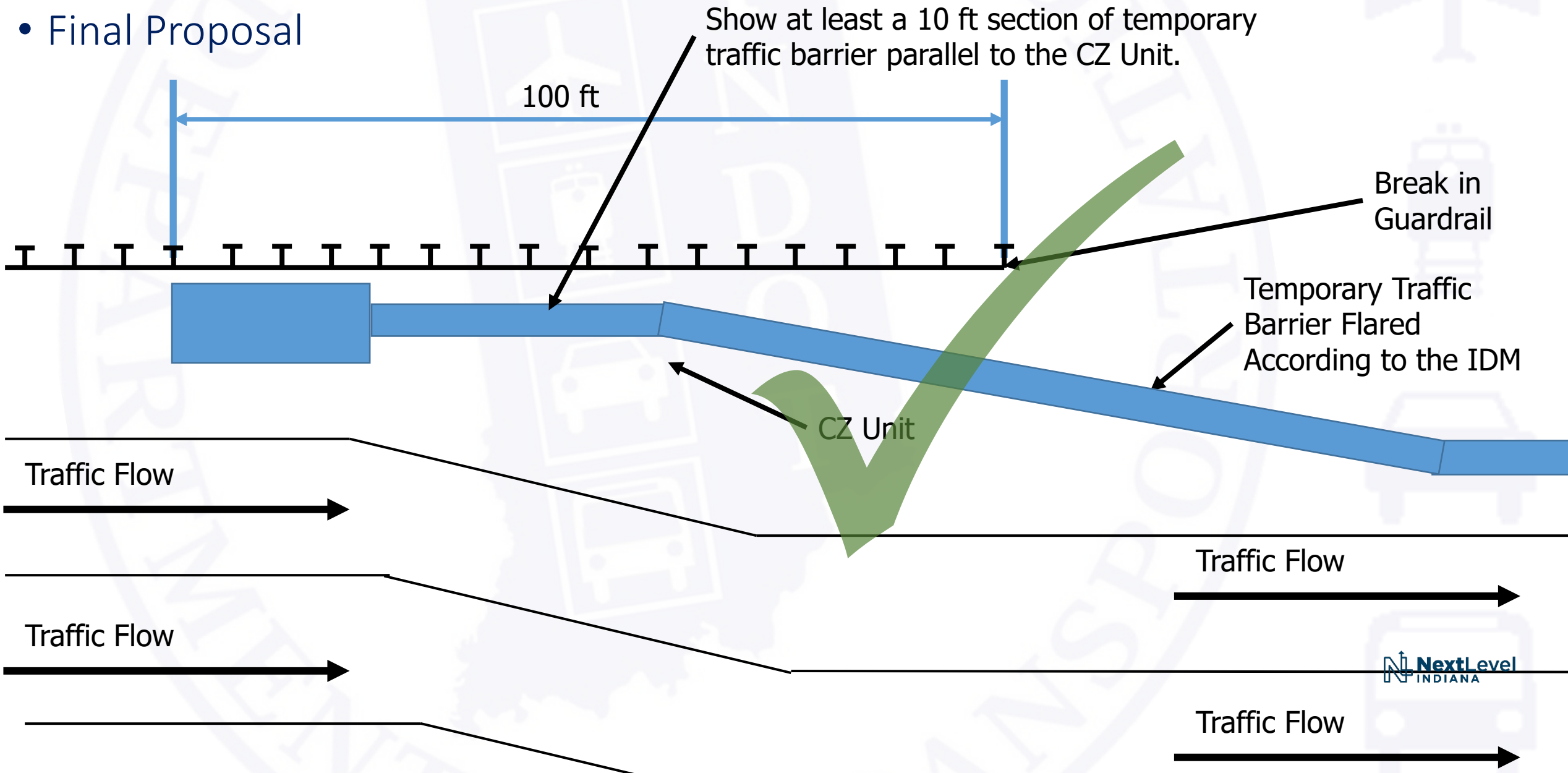
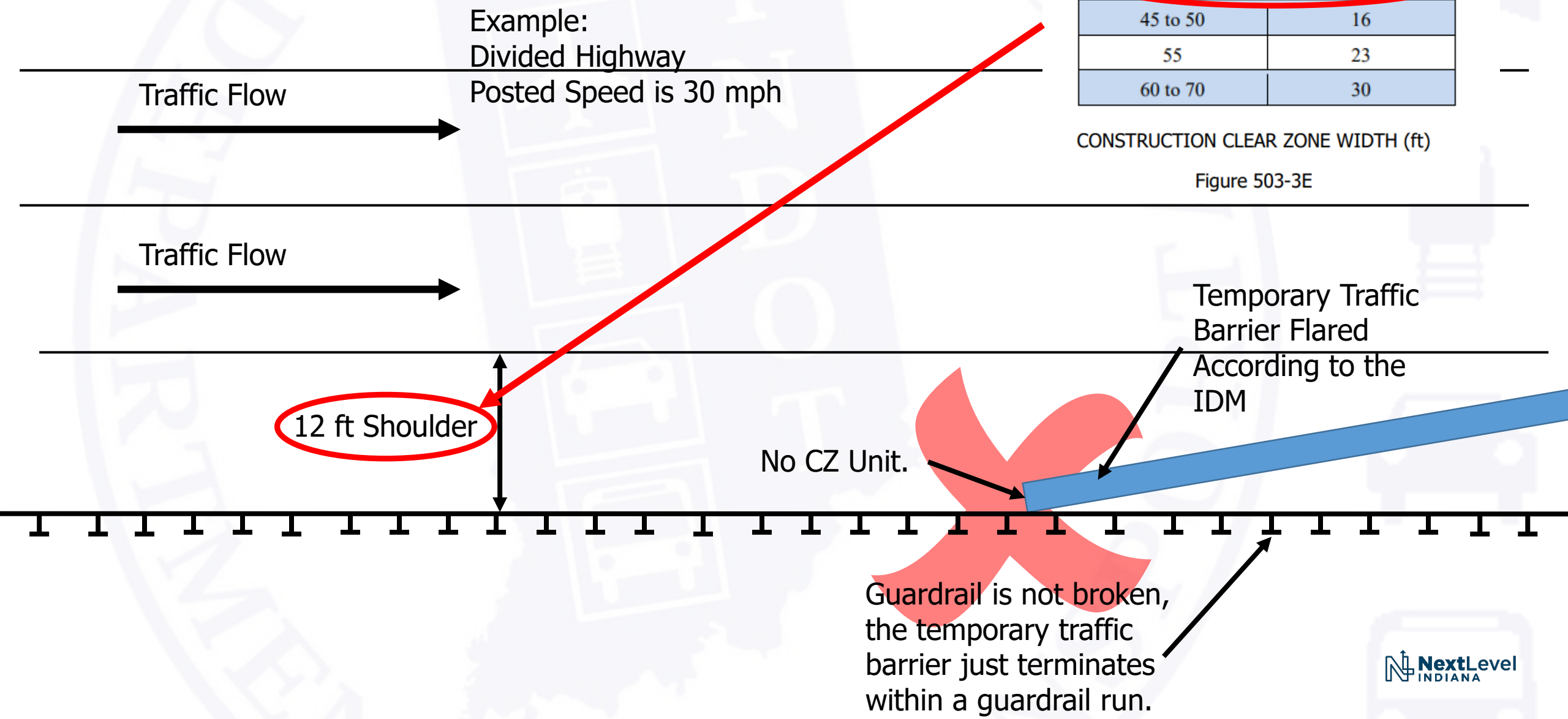


Barrier Transitions

Speed (mph)	Width[1] (ft)
30 to 40	13
45 to 50	16
55	23
60 to 70	30

CONSTRUCTION CLEAR ZONE WIDTH (ft)

Figure 503-3E



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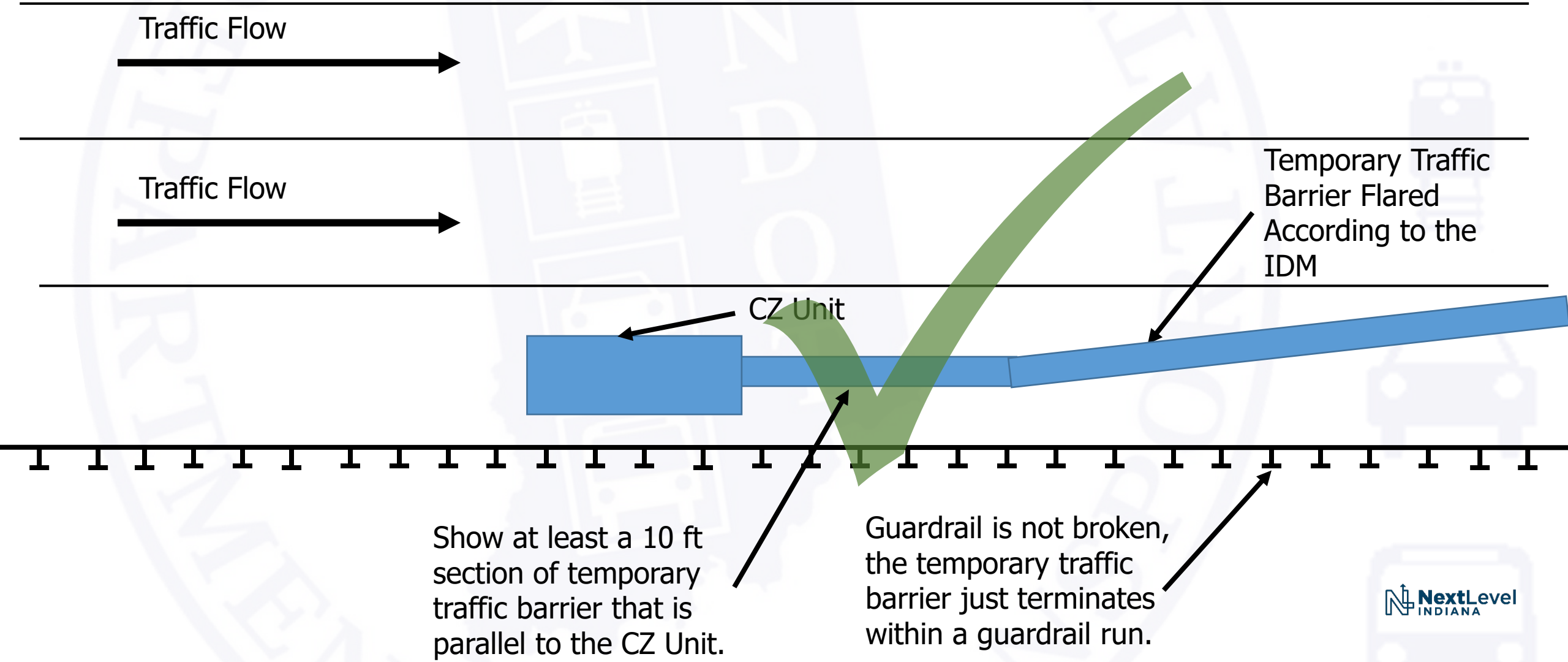

Barrier Transitions

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30 to 40	13
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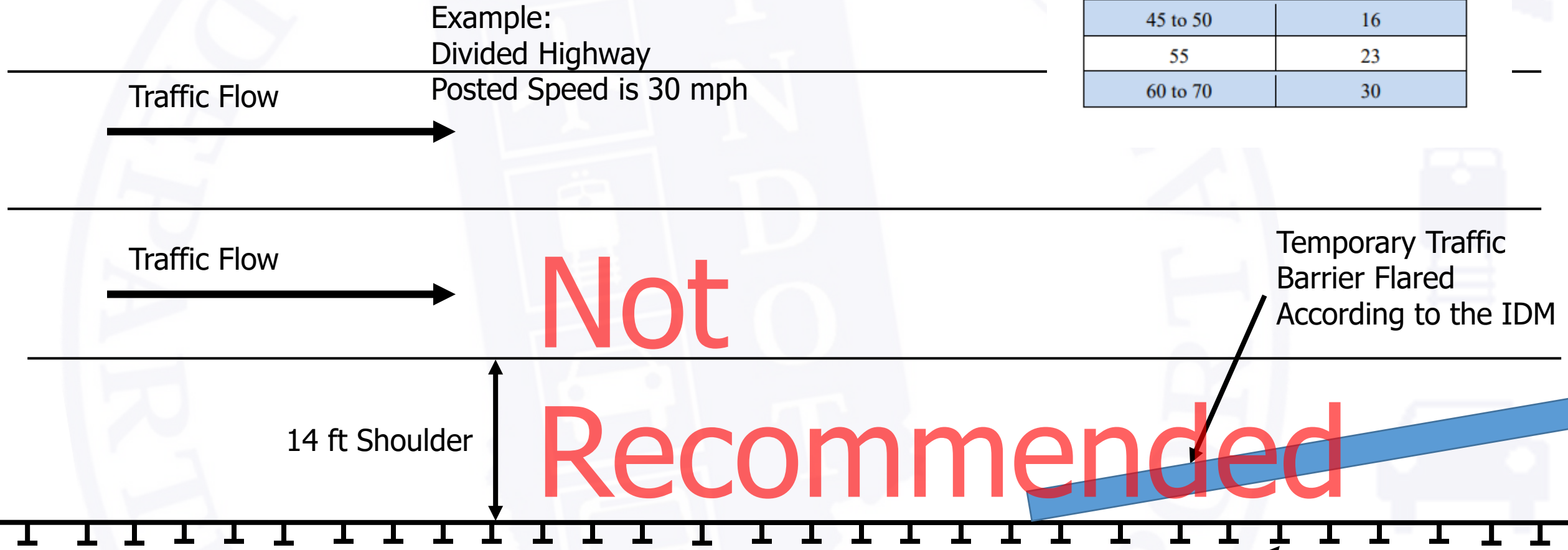
55	23
60 to 70	30

Example:
Divided Highway
Posted Speed is 30 mph



NextLevel INDIANA

Barrier Transitions

Speed (mph)	Width[1] (ft)
30 to 40	13
45 to 50	16
55	23
60 to 70	30

Example:
Divided Highway
Posted Speed is 30 mph

Traffic Flow

Traffic Flow

14 ft Shoulder

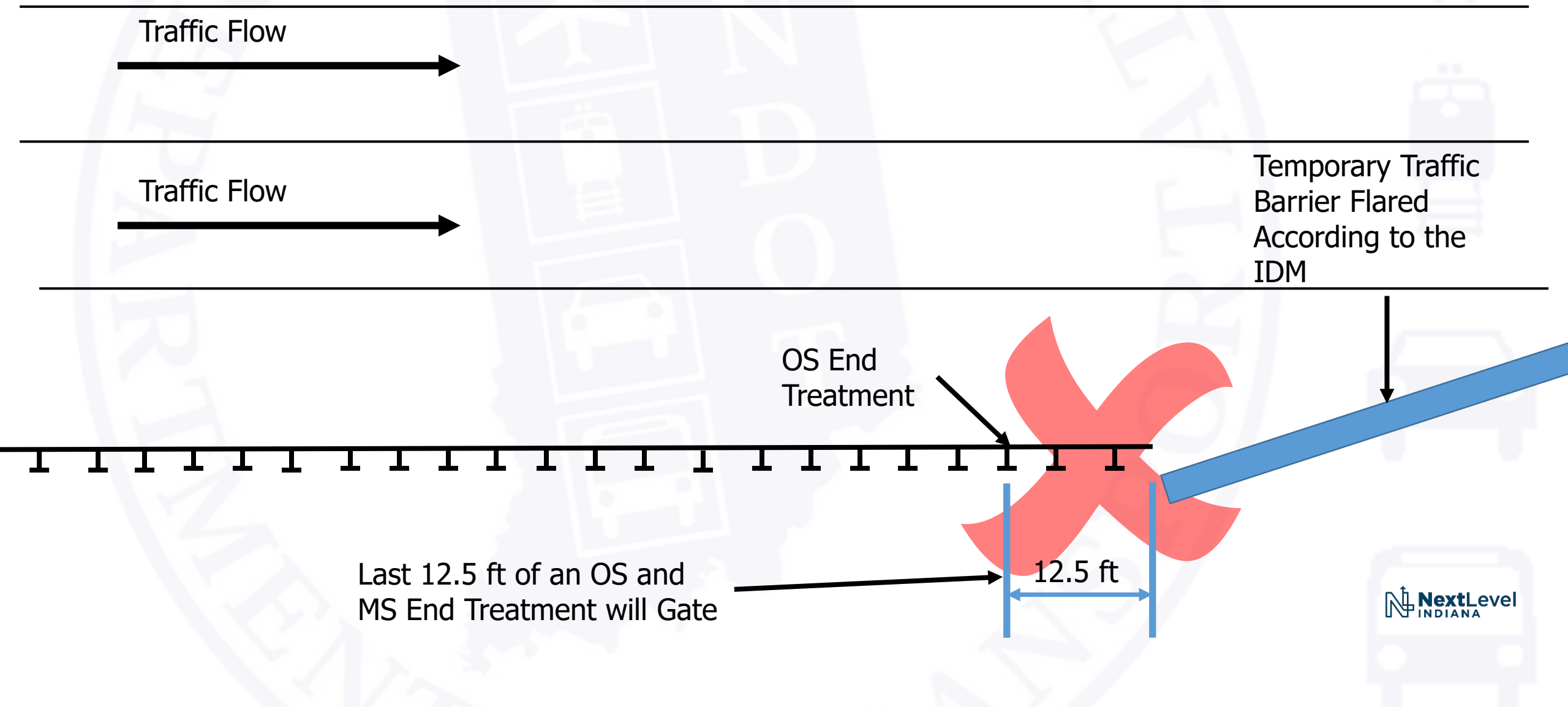
Temporary Traffic Barrier Flared According to the IDM

Guardrail is not broken, the temporary traffic barrier just terminates within a guardrail run.

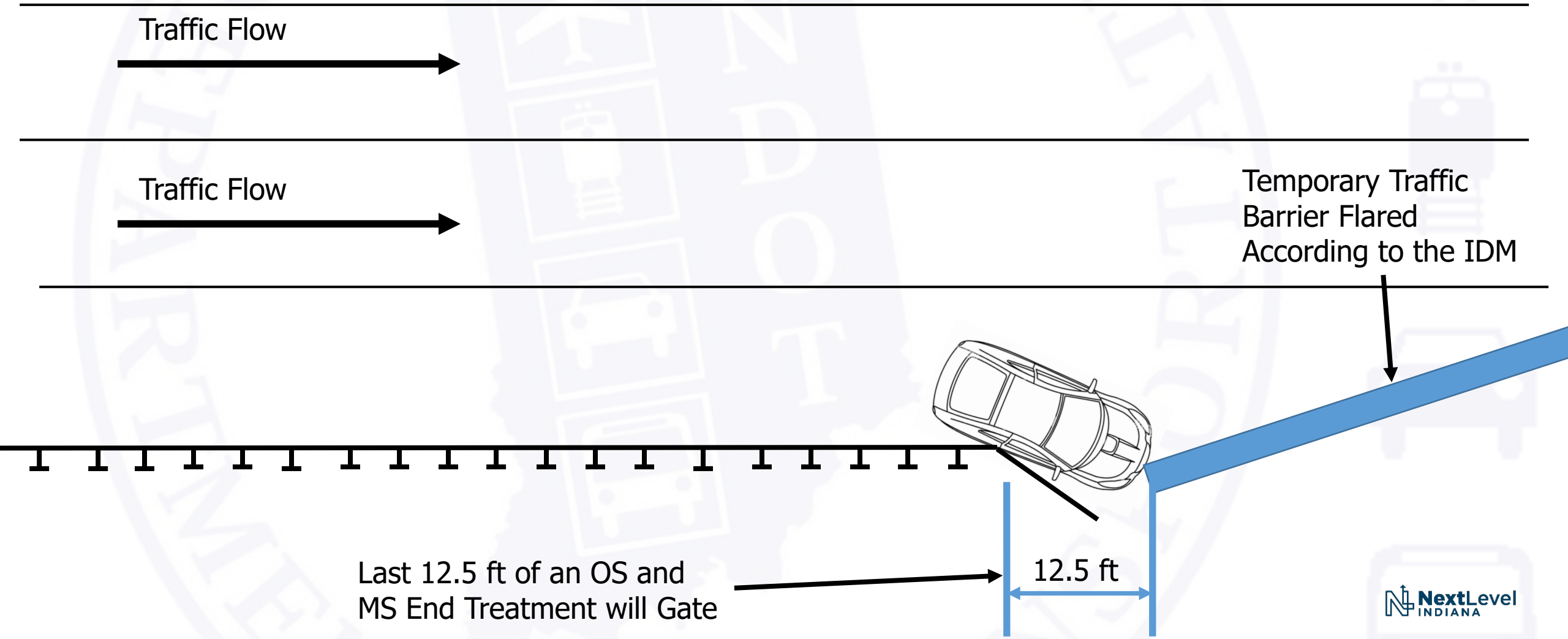
Consider What Could Happen

NextLevel INDIANA

Barrier Transitions

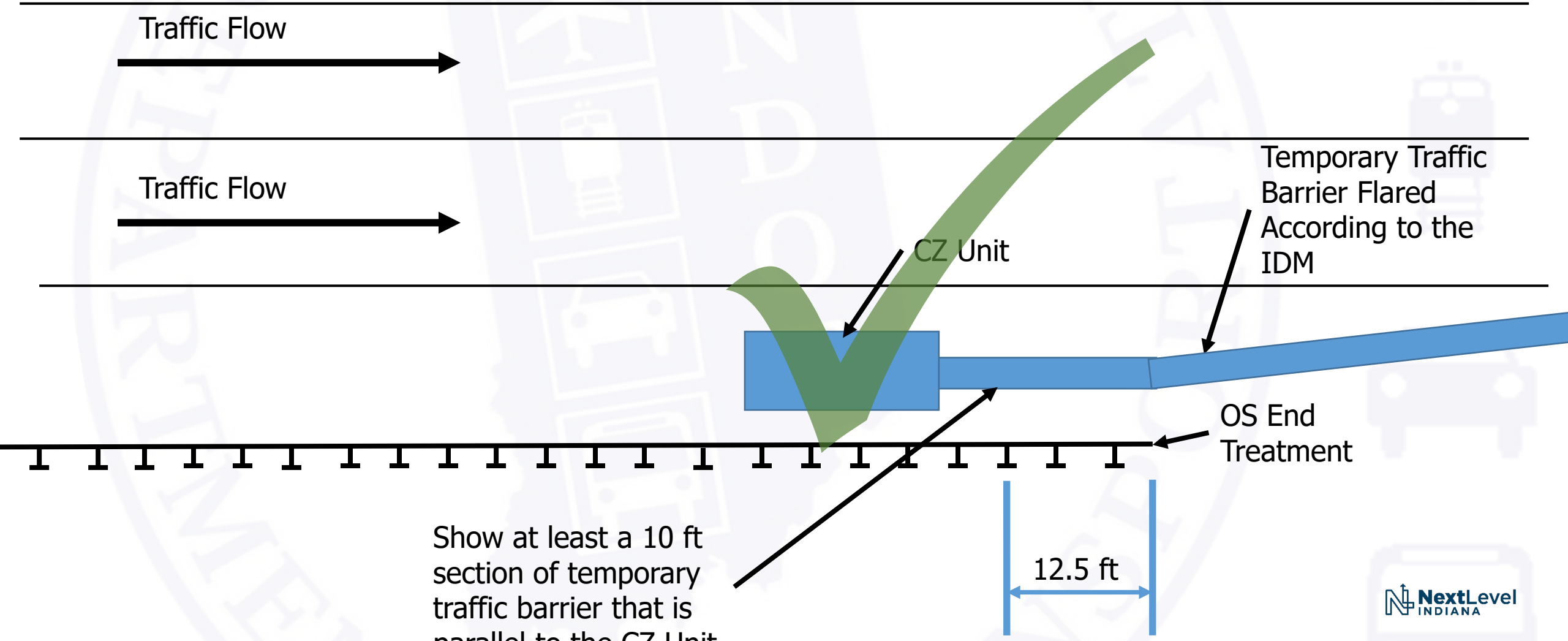


Barrier Transitions



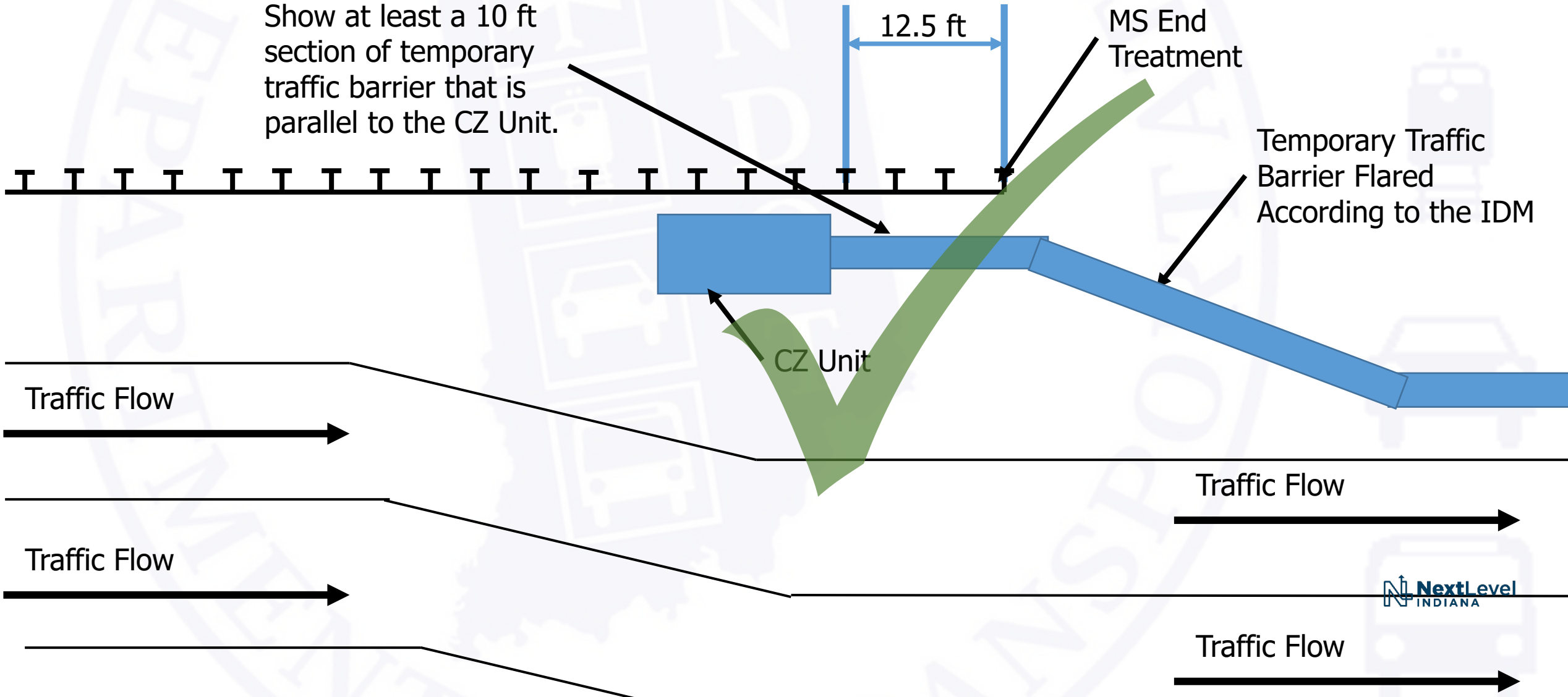
Barrier Transitions

- Final Proposal

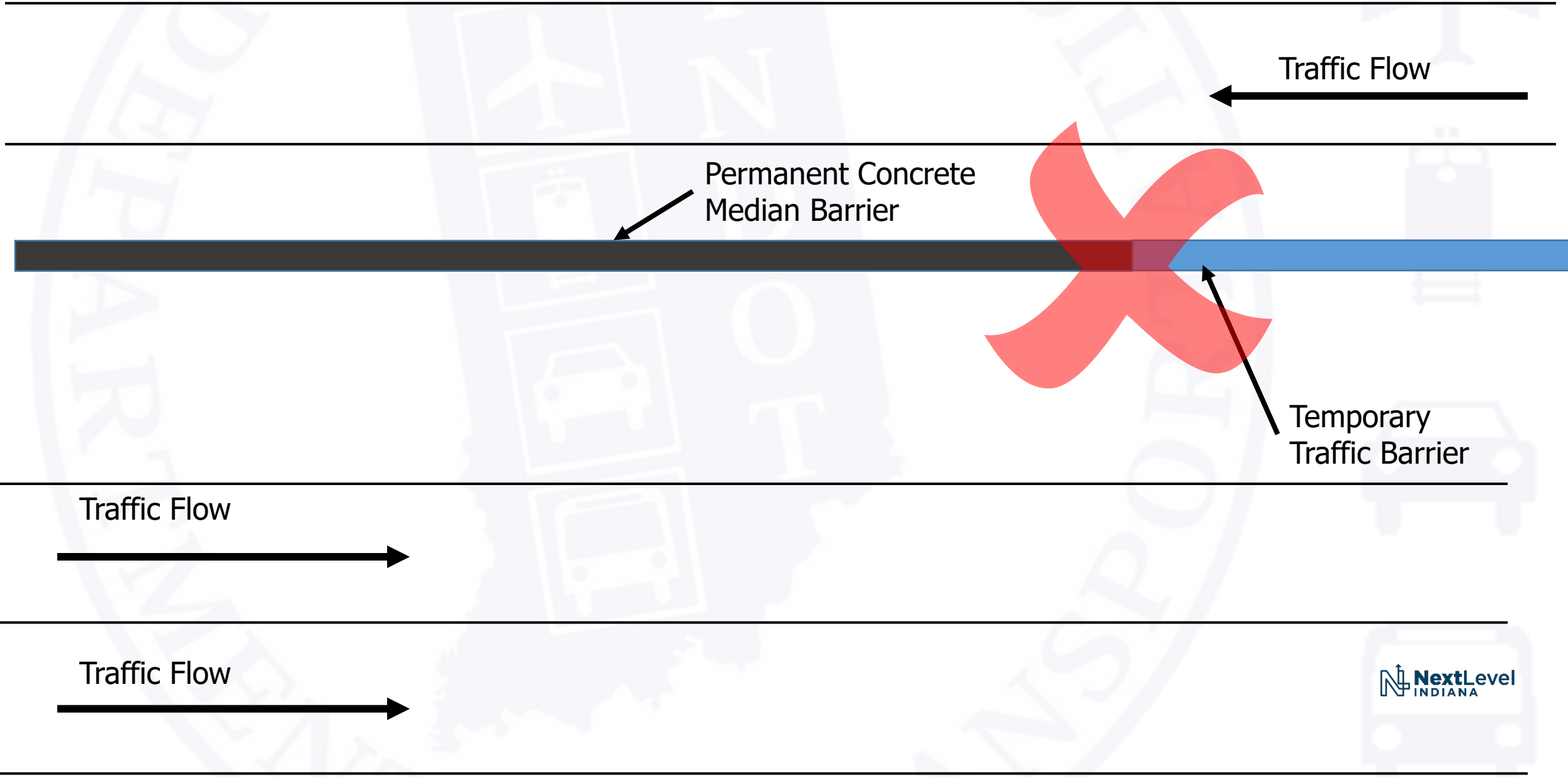


Barrier Transitions

- Final Proposal

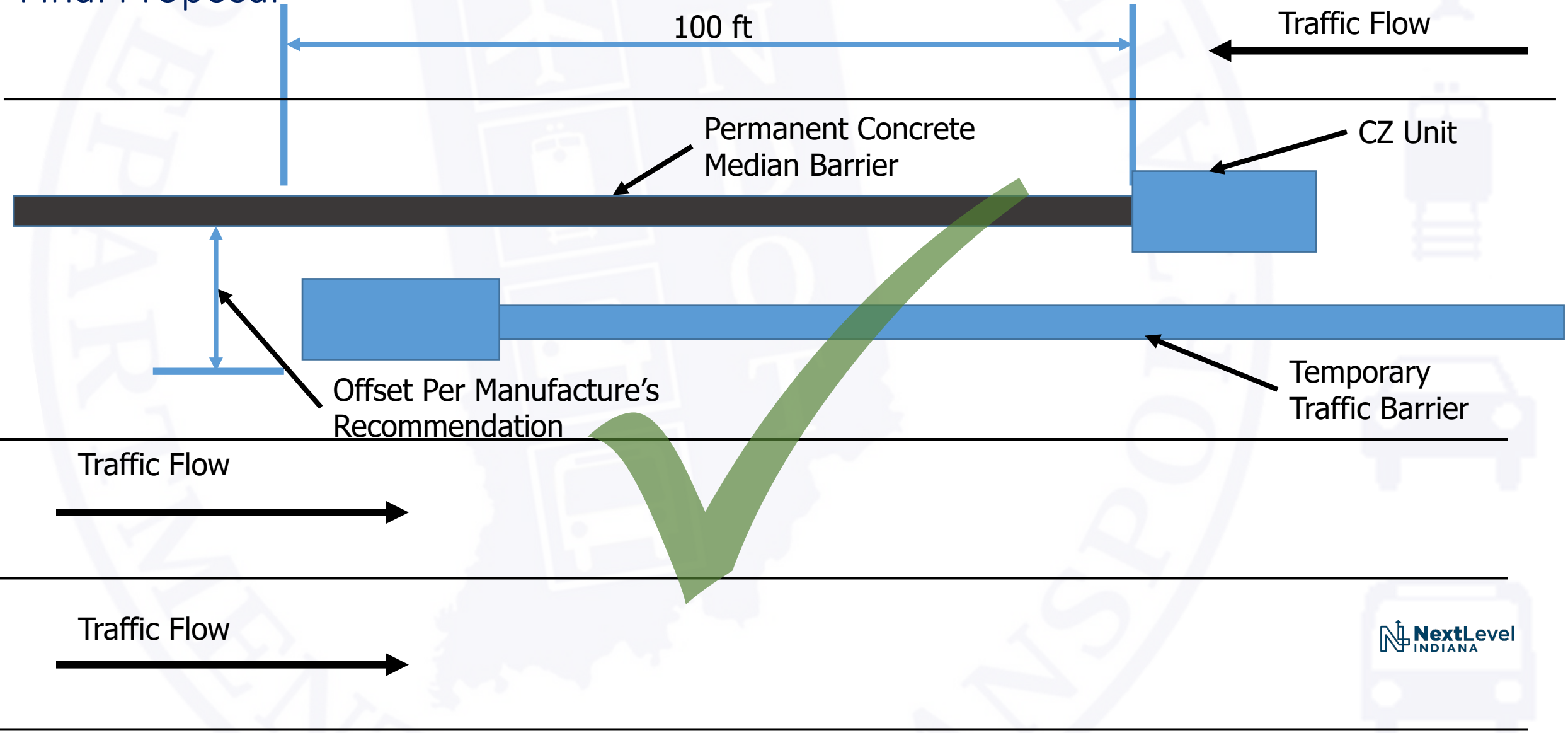


Barrier Transitions



Barrier Transitions

- Final Proposal

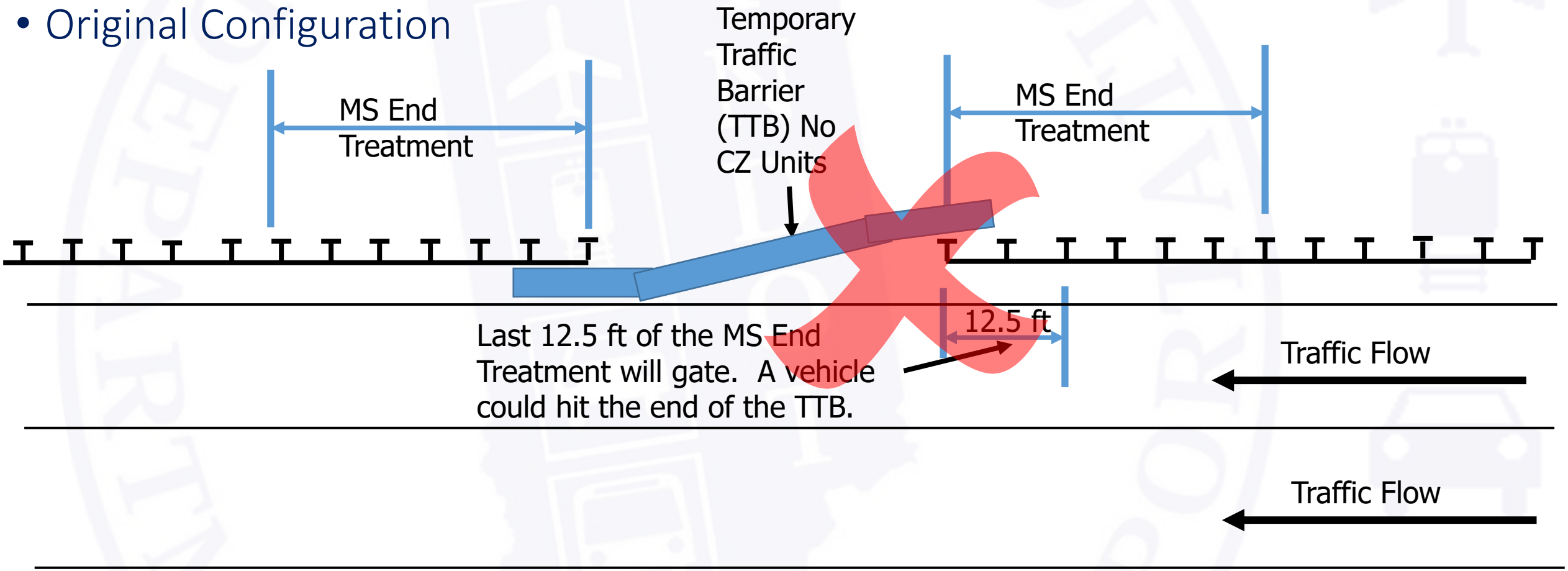


Barrier Transitions

- Incorrect Barrier Transition between TTB and W-Beam Guardrail OS End Treatments.

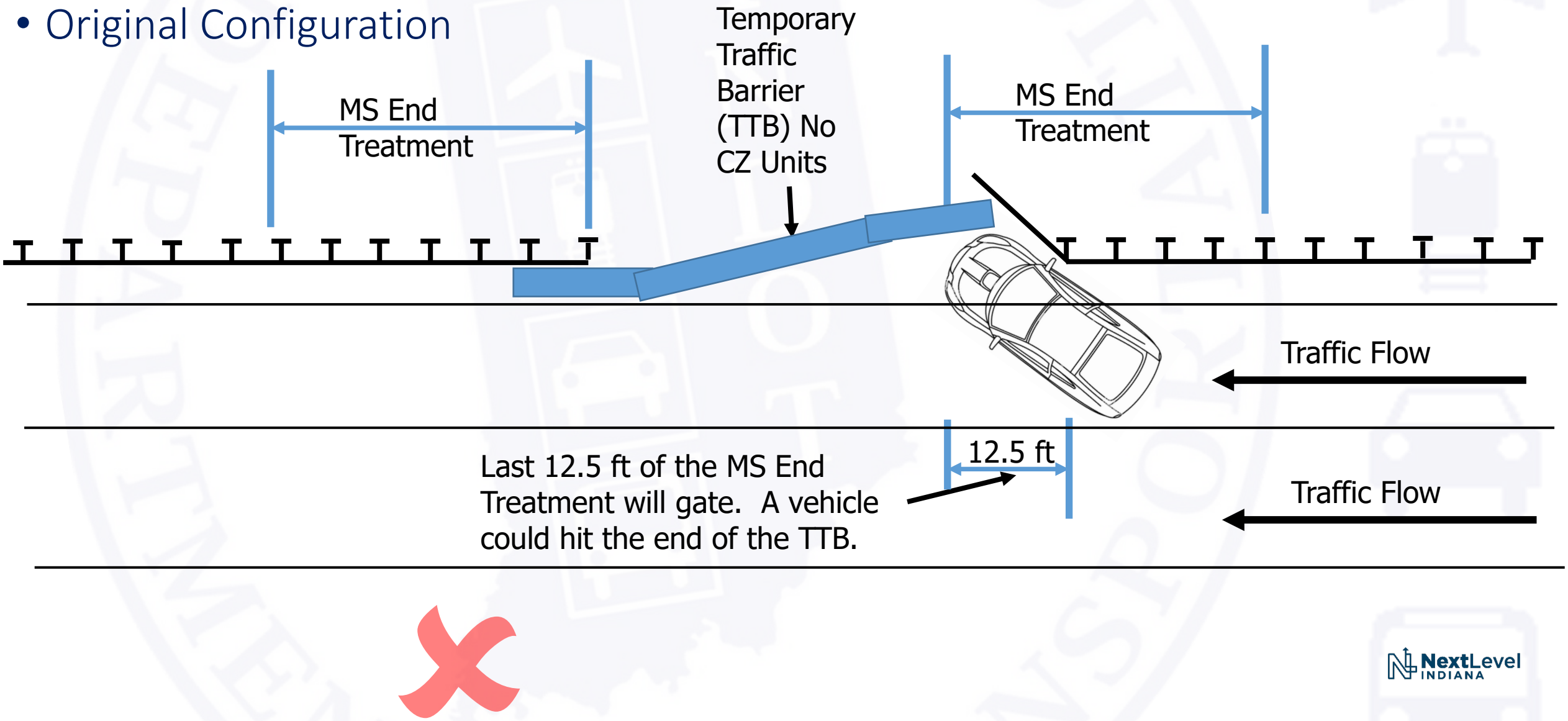
Barrier Transitions

- Original Configuration



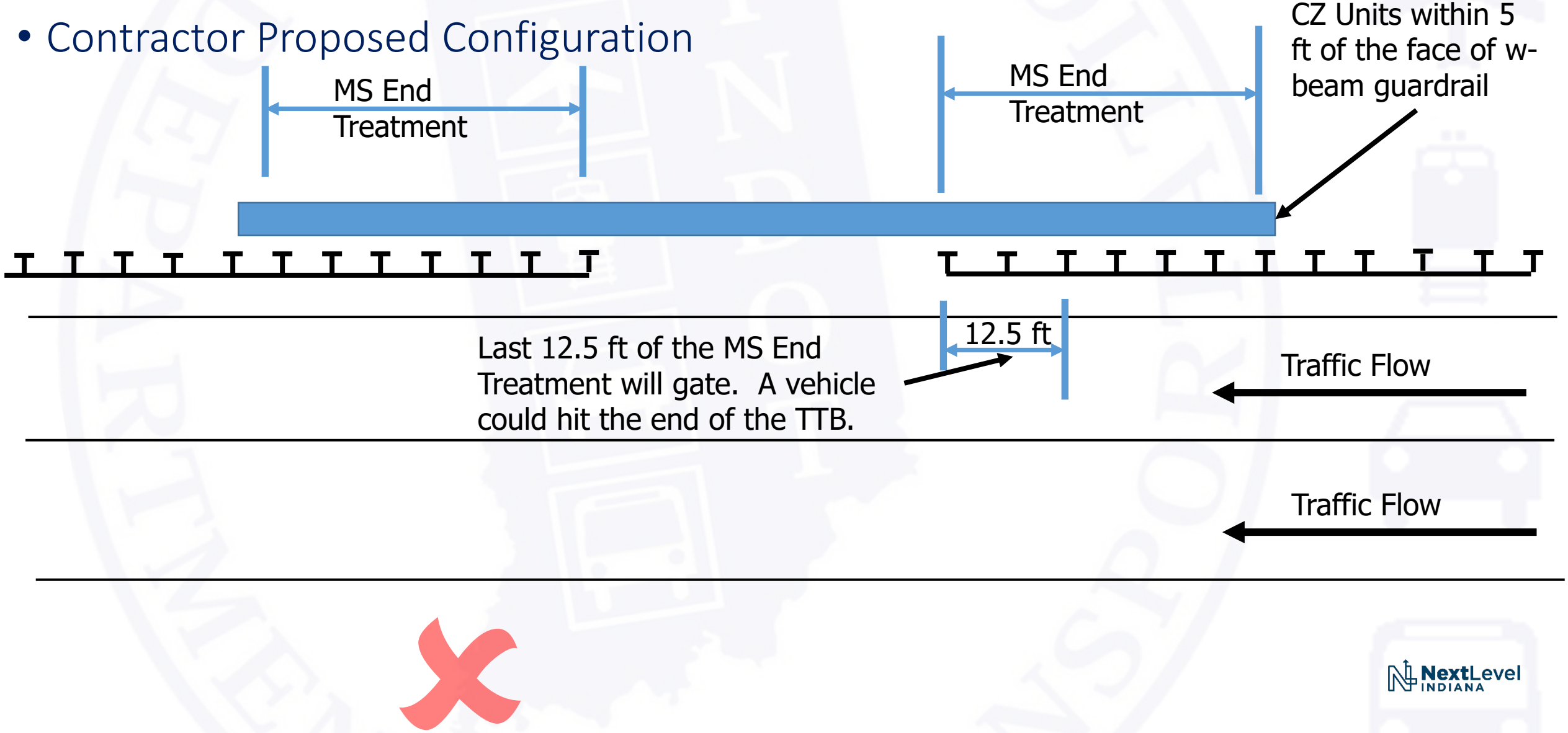
Barrier Transitions

- Original Configuration



Barrier Transitions

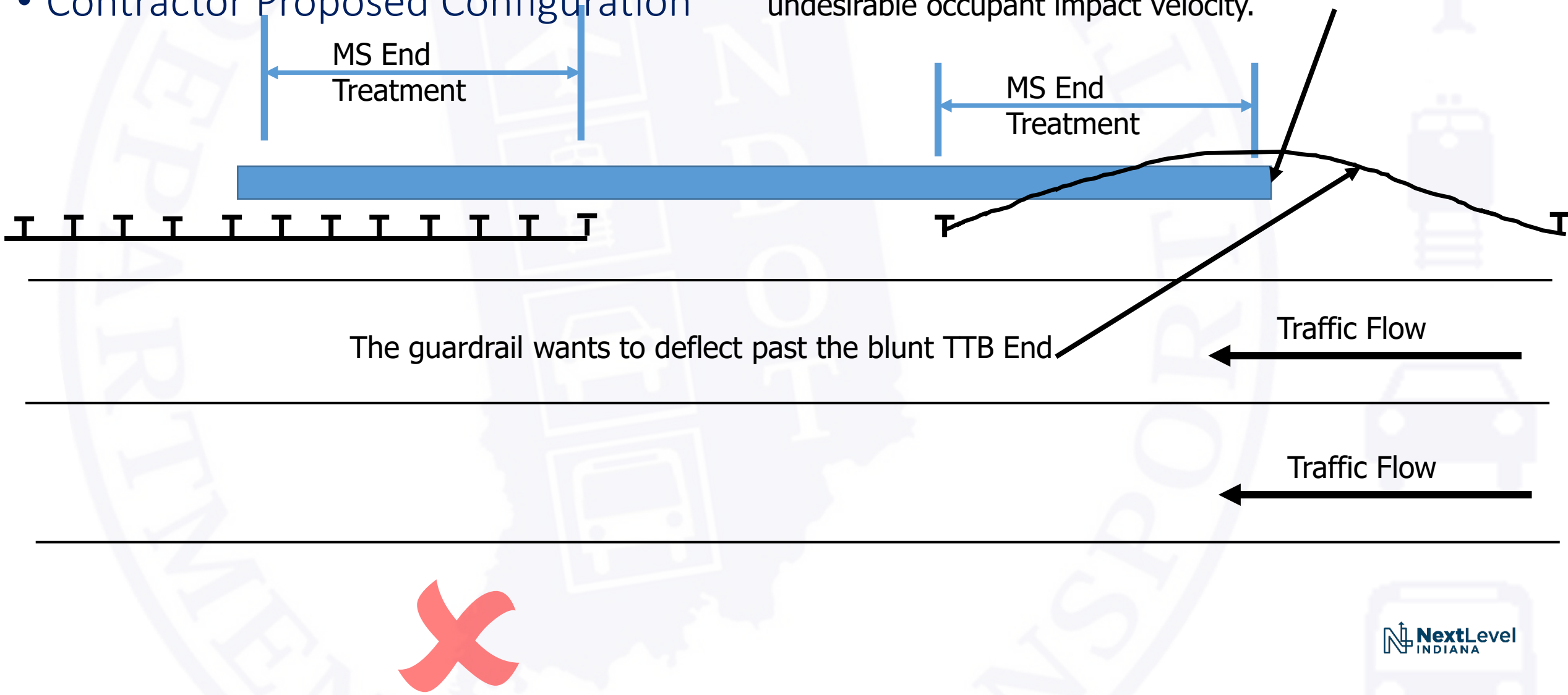
- Contractor Proposed Configuration



Barrier Transitions

- Contractor Proposed Configuration

The blunt TTB end is within the deflection area of the guardrail and the guardrail will not be able to deflect as designed, stopping a car more suddenly imposing undesirable occupant impact velocity.



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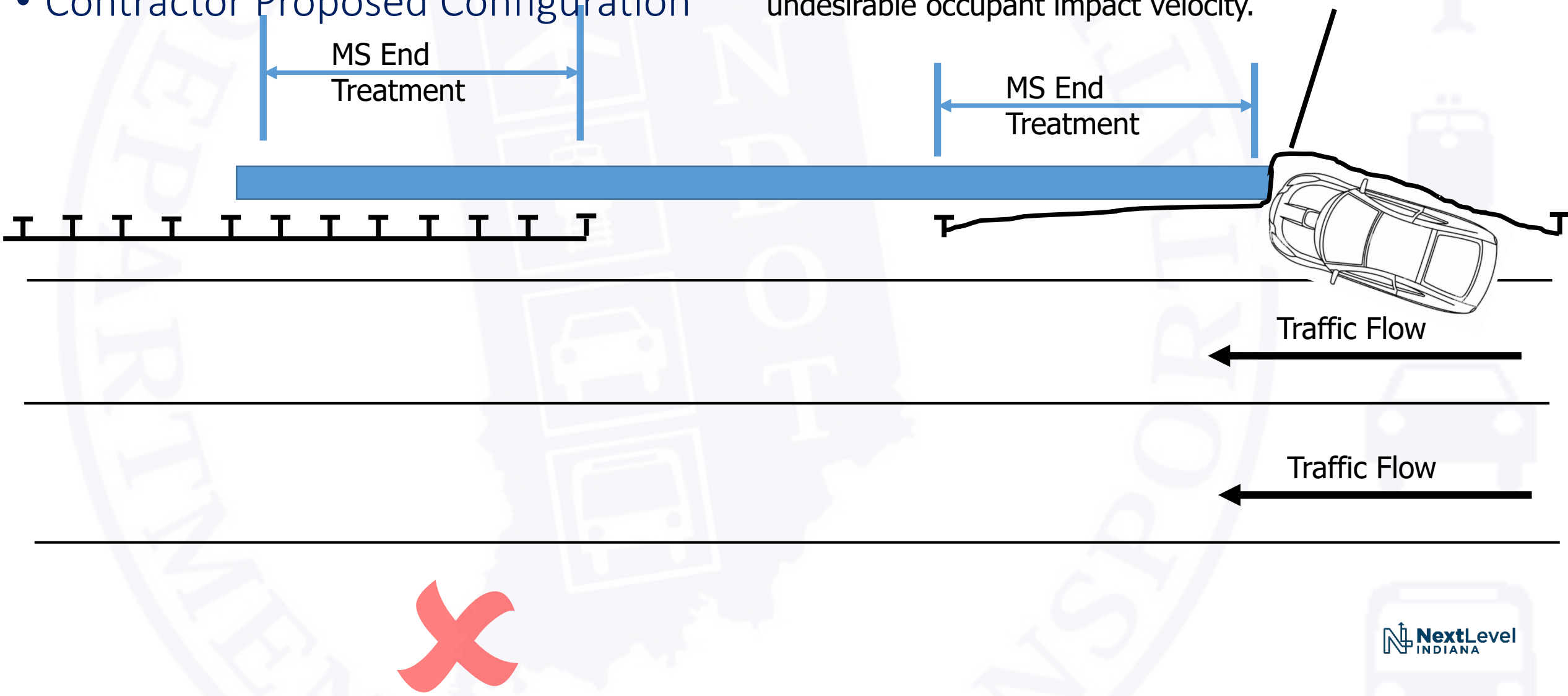

Barrier Transitions

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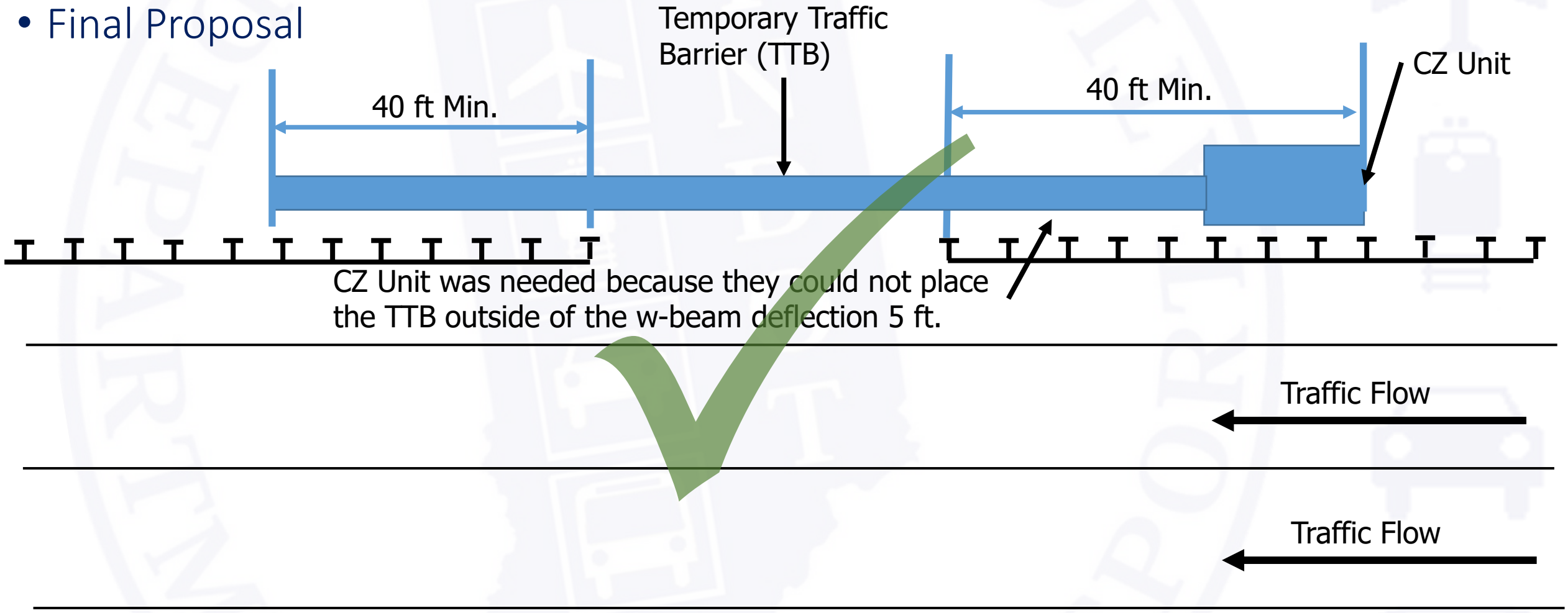

Barrier Transitions

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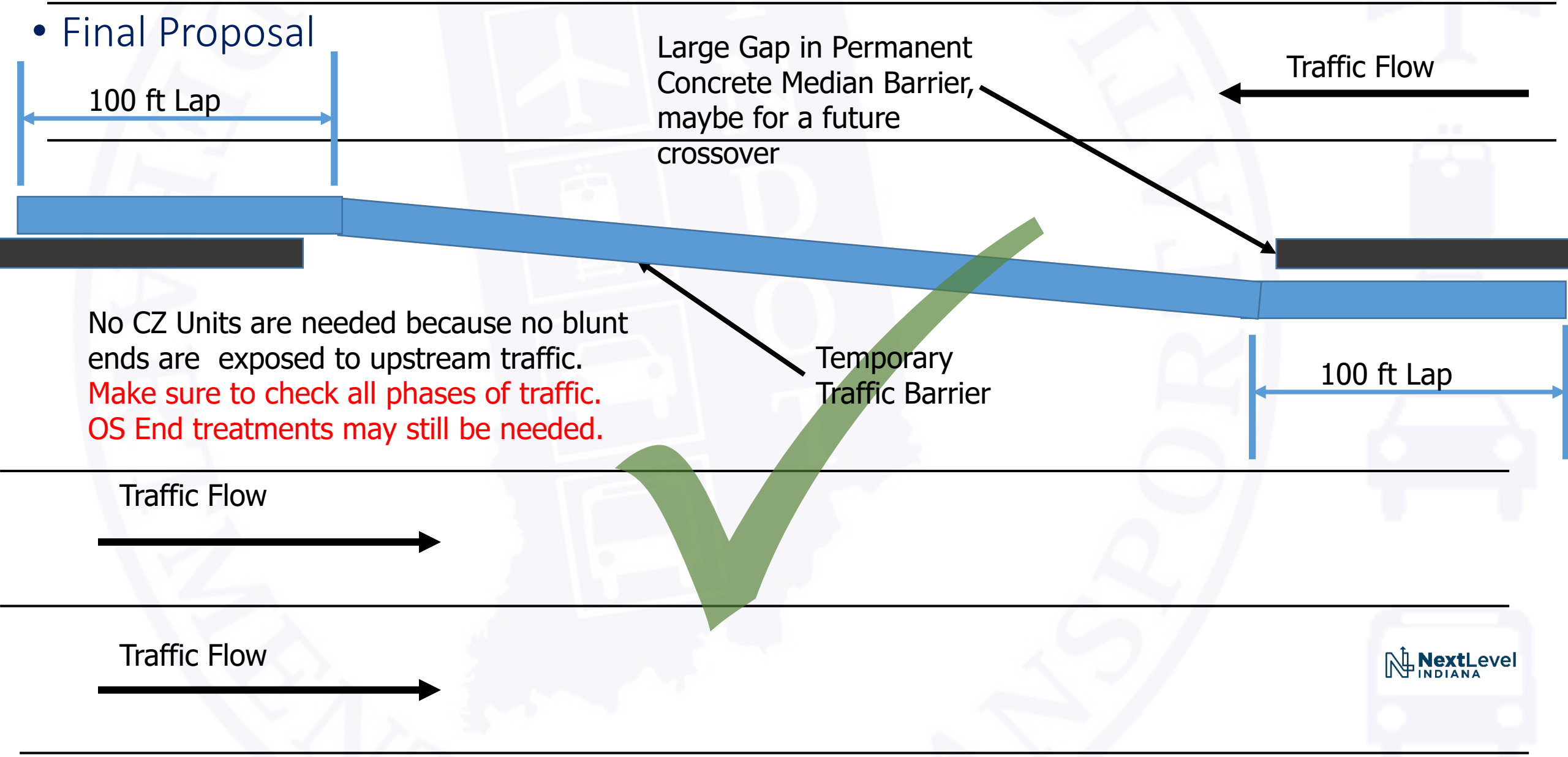
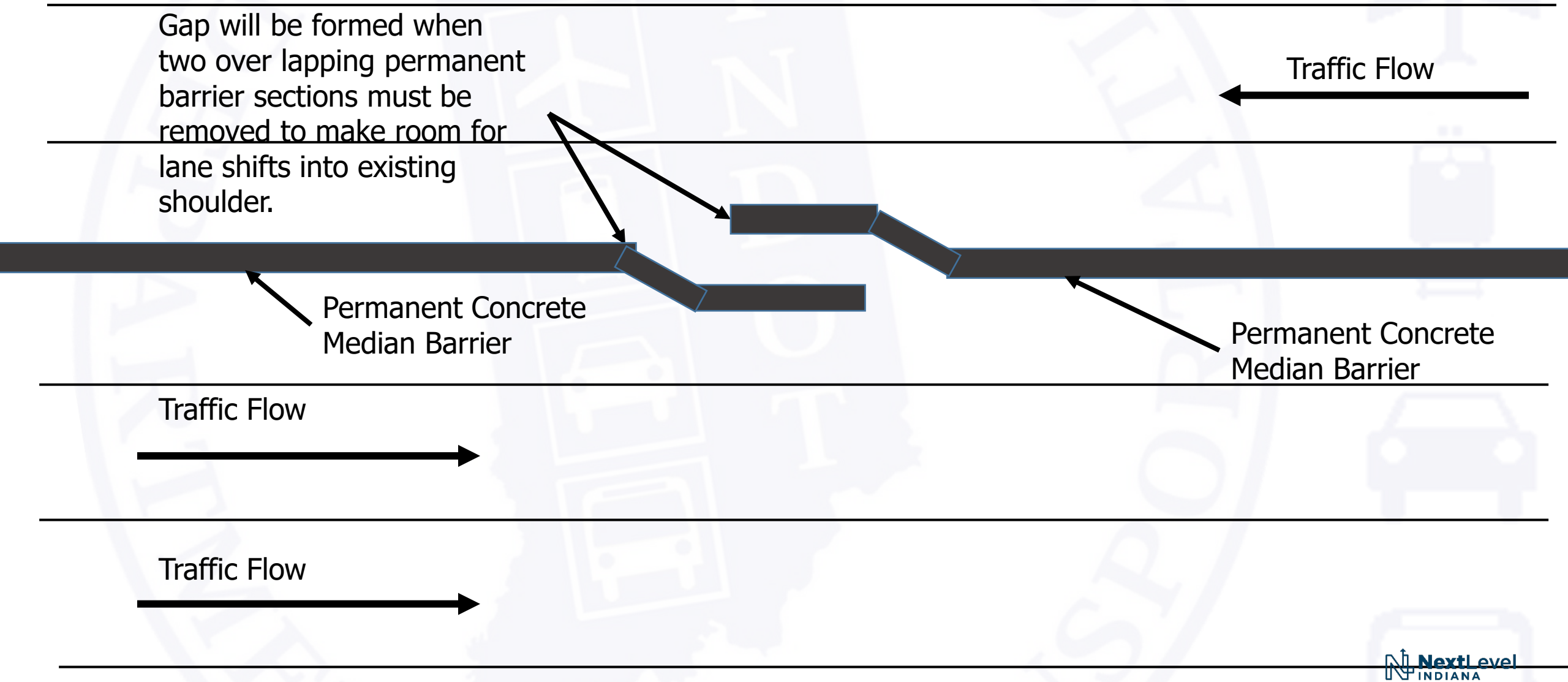


Barrier Transitions



Barrier Transitions

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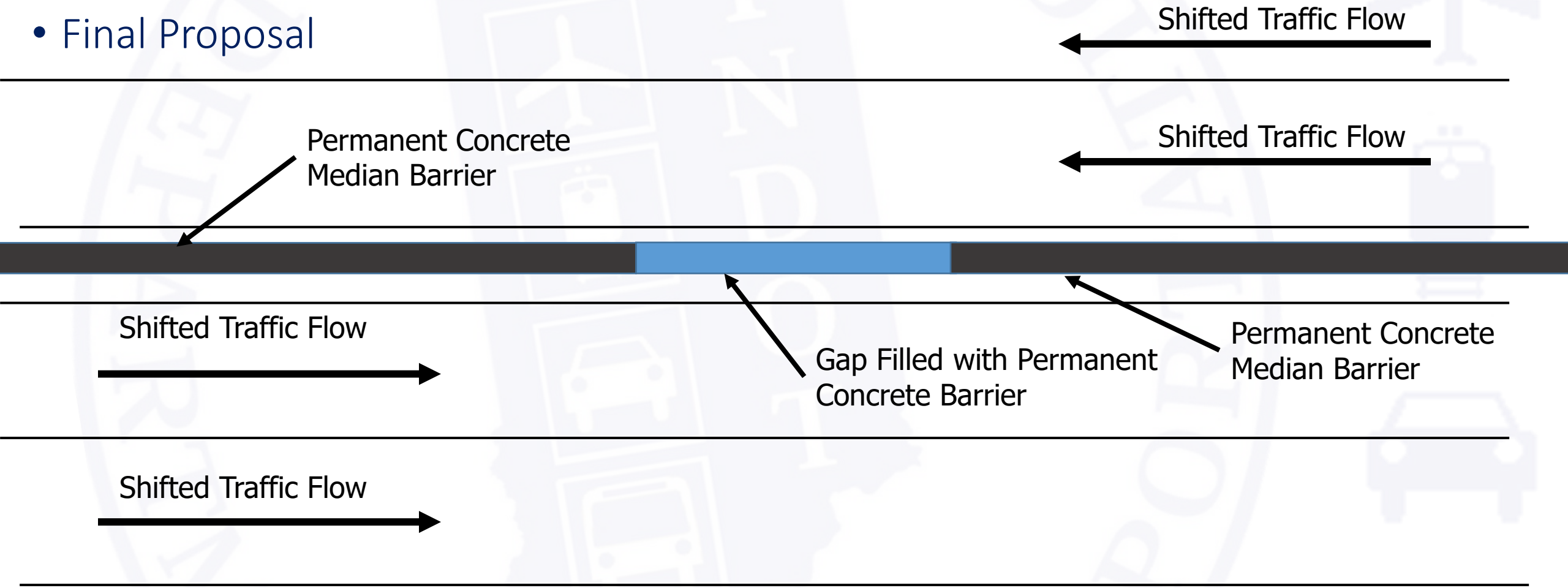


IDM Update
Katherine Smutzer

Design Memo 21-08

Indiana Design Manual Chapter 14 Updates

- All projects, Significant and Non-Significant, MOT plans will need to be completed by stage 2,
  - Effective for Projects with a Stage 1 Submittal Date On or After August 2021
  - All Plan Submittal Sections within Chapter 14 have been updated to reflect the completion of MOT plans at Stage 2 or equivalent.
  - Ensures that all Stage 2 comments have been addressed at Stage 3.

Design Memo 21-08

When and What to submit for a Transportation Management Plan (TMP).

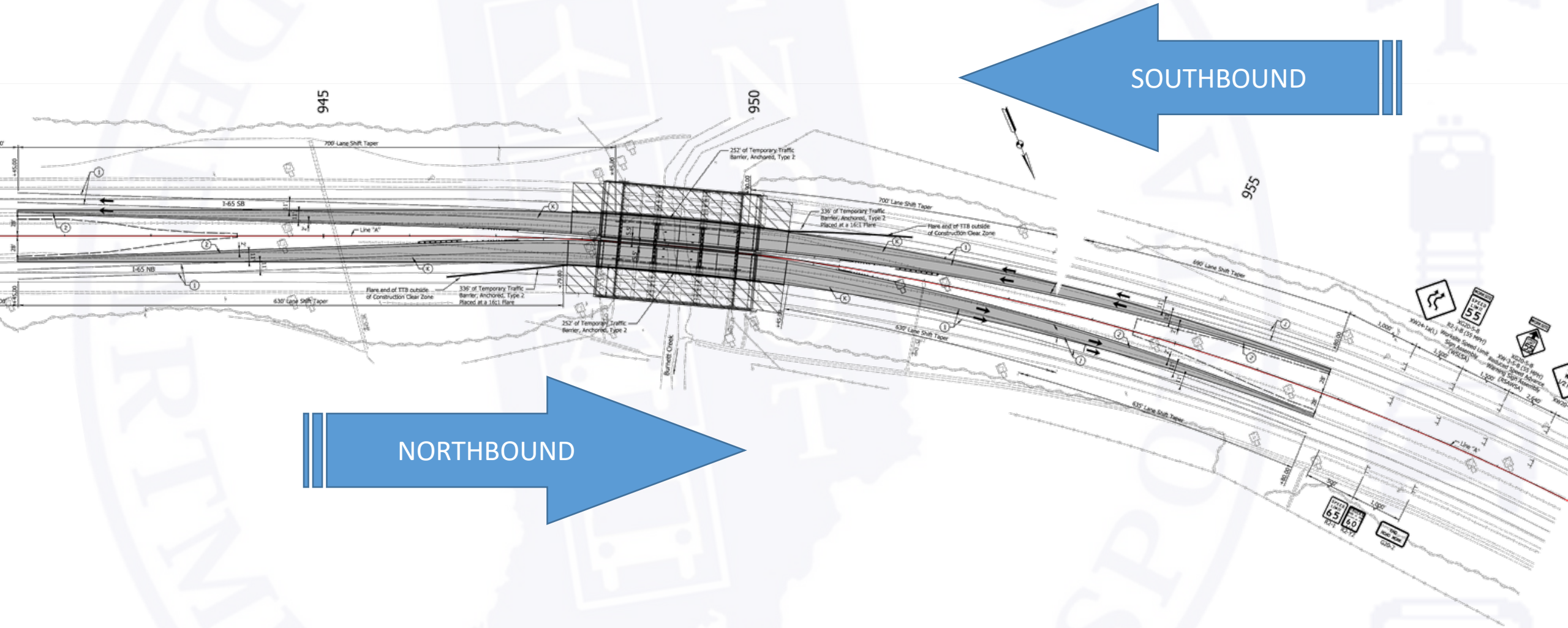
- All projects, Significant and Non-Significant, require a TMP, see IDM 503-2.02(01)
  - Significant Projects
    - TMP must include the Temporary Traffic Control Plan (TTCP), Transportation Operations Plan (TOP), and Public Information Plan (PIP).
    - For all Significant projects, draft TMP reports will need to be completed at different stages of the project to help designers submit the final TMP at Stage 3.
  - Non-Significant Projects
    - TMP must include the Temporary Traffic Control Plan (TTCP). (Minimum)
    - The Transportation Operations Plan (TOP), and Public Information Plan (PIP) are encouraged but could be documented on a small scale, e.g., documented meeting minutes, emails, or phone calls.

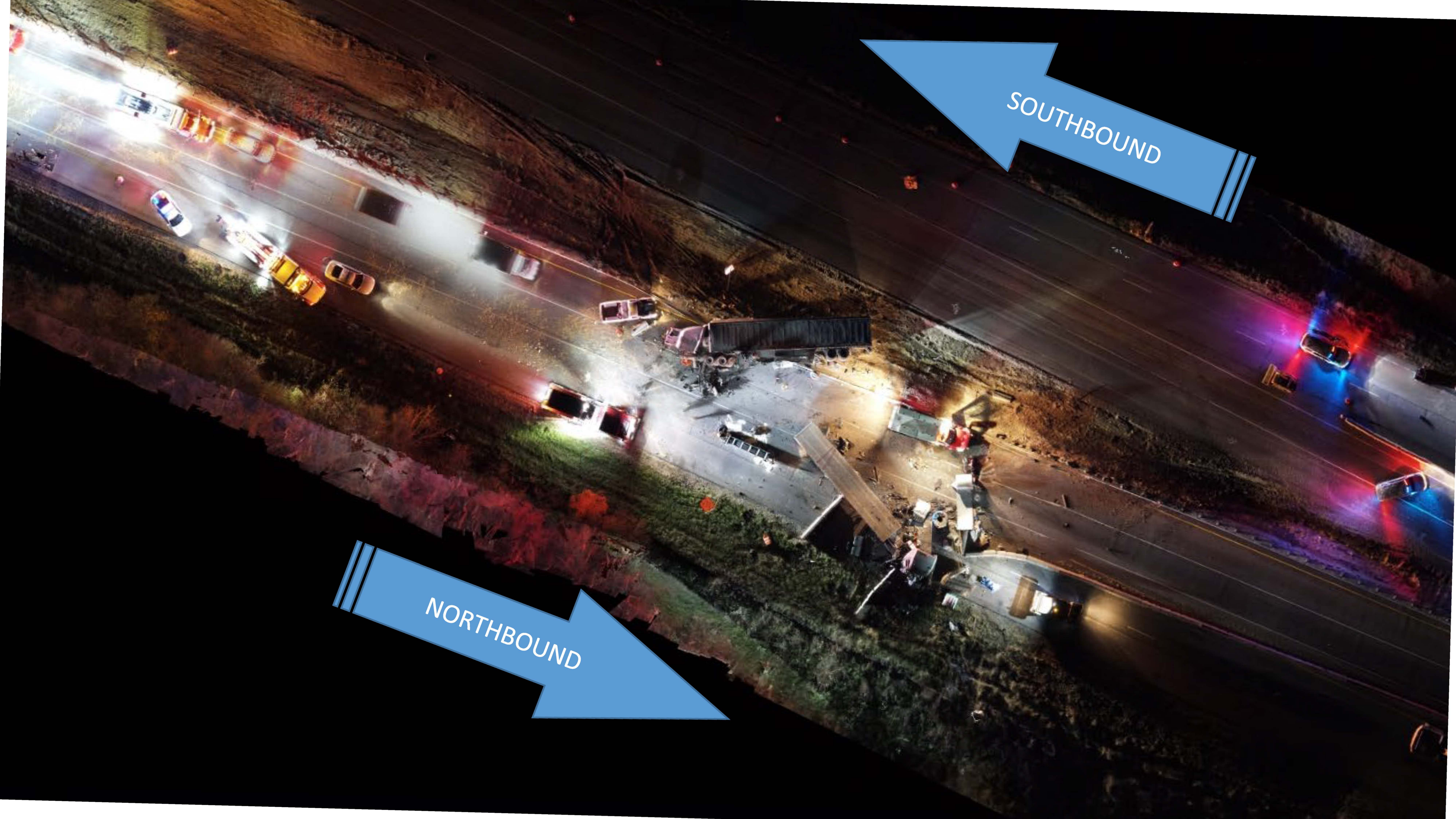
NextLevel INDIANA

MOT Design Considerations
Mischa Kachler


SOUTHBOUND
NORTHBOUND

MOT Plan


SOUTHBOUND
NORTHBOUND
945
950
955
I-65 SB
I-65 NB
700' Lane Shift Taper
630' Lane Shift Taper
635' Lane Shift Taper
690' Lane Shift Taper
252' of Temporary Traffic Barrier, Anchored, Type 2
336' of Temporary Traffic Barrier, Anchored, Type 2 Placed at a 16:1 Flare
Flare end of TTB outside of Construction Clear Zone
Line "A"
Burnett Creek


SOUTHBOUND
NORTHBOUND

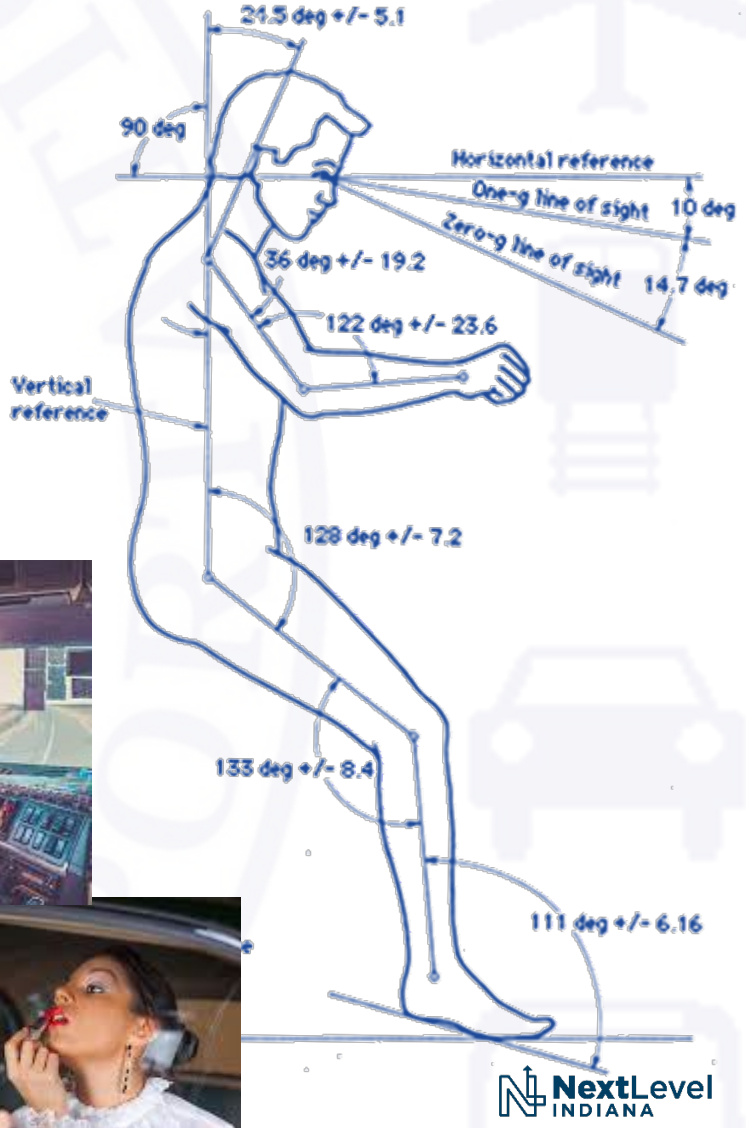
Earlier…

i.e., some background first

General Considerations for MOT Design

Keep Human Factors in Mind:

- Perception-Reaction Time
- Motorists Age
- Familiarity (area, work zone)
- Typical Motorist Behavior
- other factors…



NextLevel INDIANA

General Considerations for MOT Design

TTC should provide clear, positive guidance to

1. Alert motorists
2. Inform motorists
3. Instruct motorists

NextLevel INDIANA

General Considerations for MOT Design

- Human Factors
  - Perception-Reaction Time
  - Motorists Age
  - Familiarity (area, work zone)
  - Typical Motorist Behavior
- Provide clear positive guidance
  1. Alert motorists
  2. Inform motorists
  3. Instruct motorists

- Basically:
  - Don’t overload motorists
  - Provide smooth transitions
  - **NO SURPRISES!**

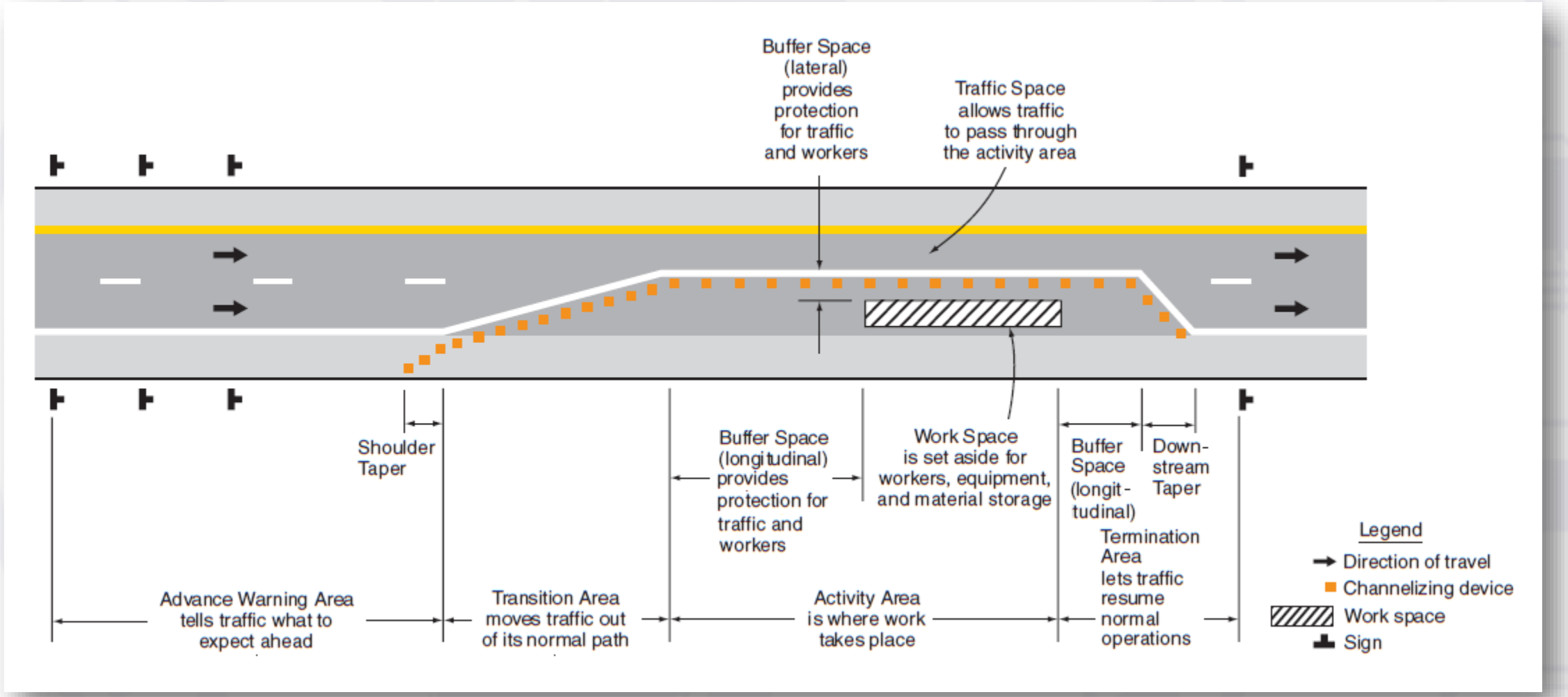
NextLevel INDIANA

General Considerations for MOT Design

- Consider Work Zone Strategy (Type) as early as possible.
  → If applicable, involve TMP stakeholders
- For interstates, perform queue analysis as early as possible to guide decision making.
- For interstates, consider the Interstate Highways Congestion Policy as early as possible → queue mitigation strategies.
- Construction Zone Design Speed: desirably same as Design Speed; not arbitrarily reduced; if reduced, desirably, not by more than 10 MPH.
- Consider lane and shoulder widths IDM 503-3.04(02):
  - Off a structure, the "Available Cross Section" extends from ROW to ROW
  - If clear travel width < 12 ft 4 in, Restricted Widths requirements apply
- Consider pavement and shoulder strength and condition.
  → Consider the effect of corrugations

Parts of a Work Zone (a brief review)

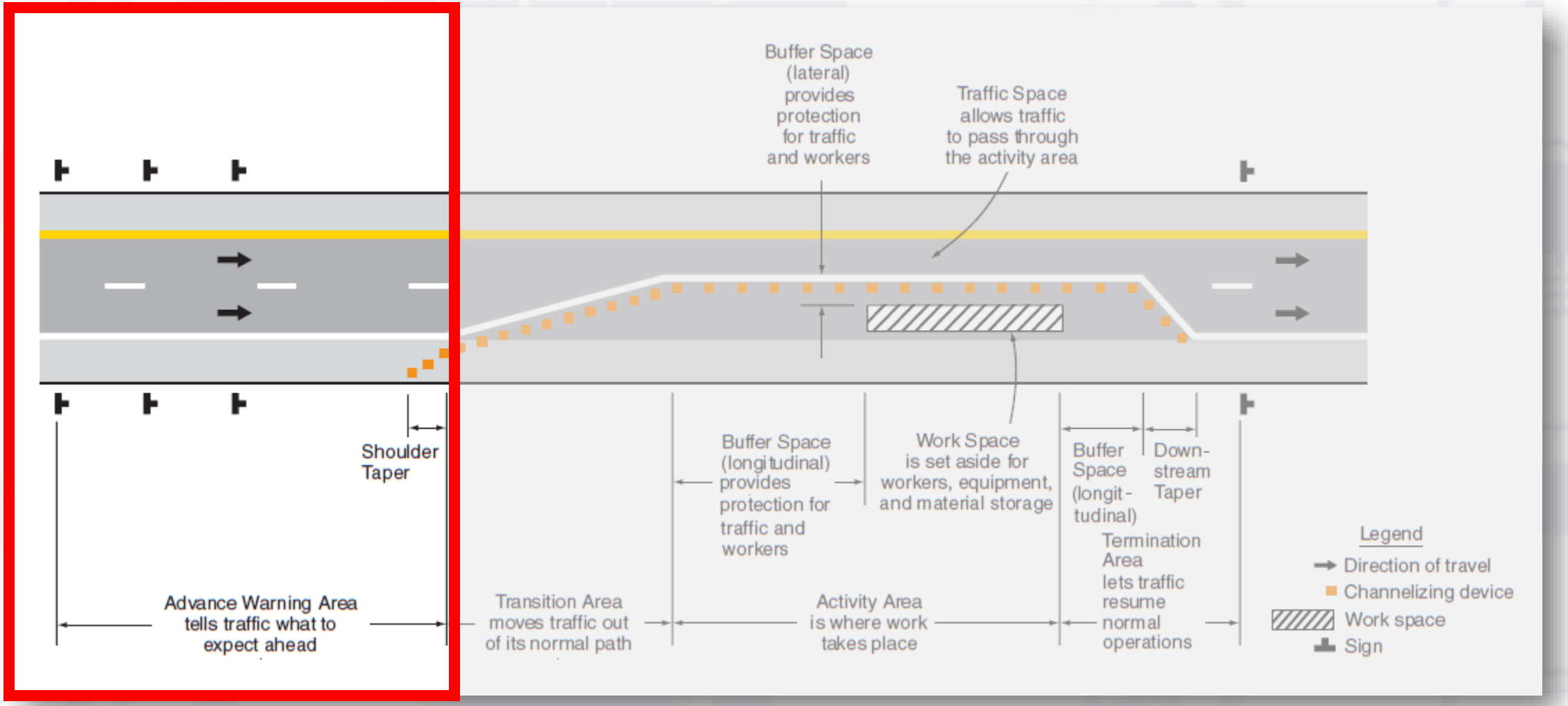
Parts of a Work Zone



Source: MUTCD

NextLevel INDIANA

Parts of a Work Zone: Advance Warning Area



Source: MUTCD

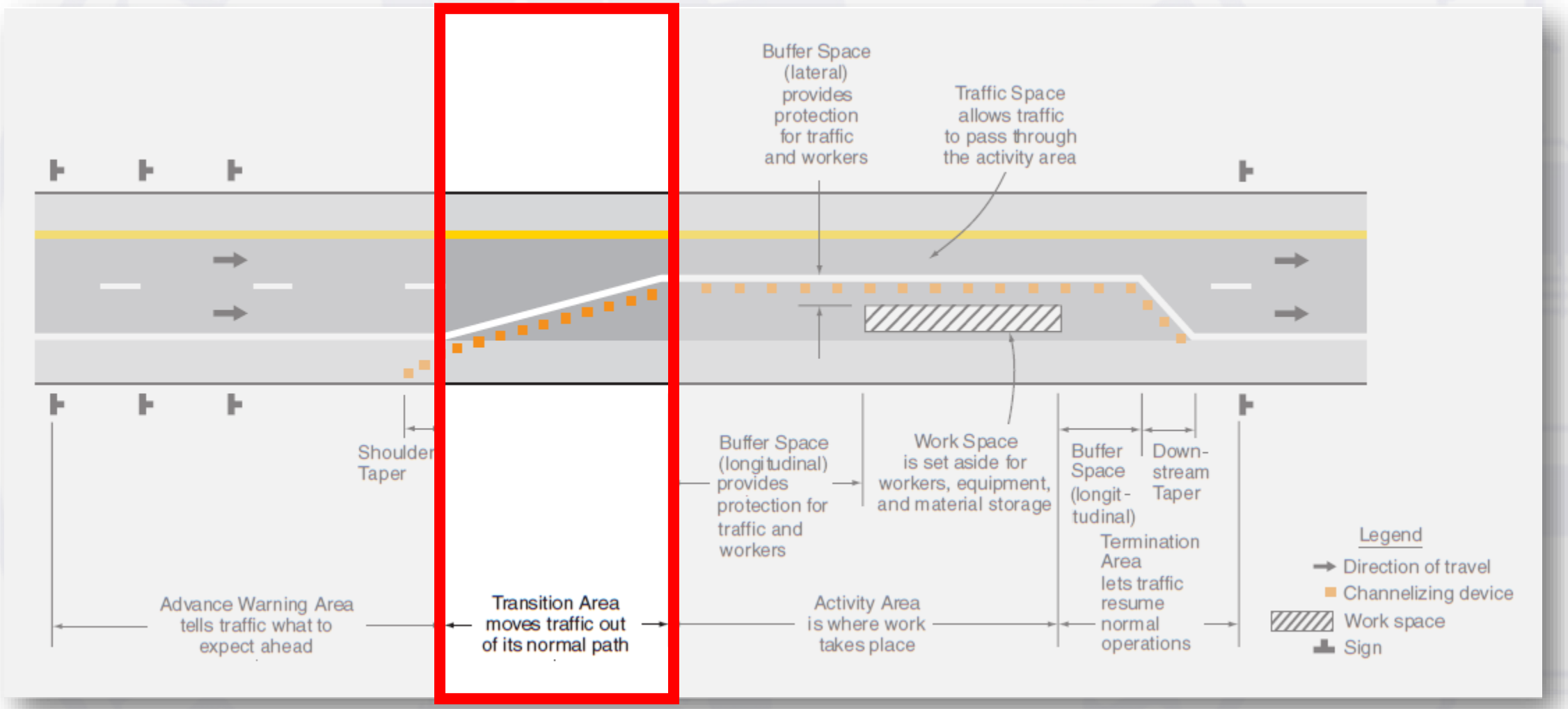
NextLevel INDIANA

Advance Warning Area

- First opportunity to provide clear positive guidance
  1. Alert motorists
  2. Inform motorists
  3. Instruct motorists

- Advance Signing with Warning Lights
  → Provide the minimum required separation distance between signs
- Speed Limit Reduction (Worksite Speed Limit)
- PCMS (Stand alone or part of Queue Detection and Warning System)
- Buzz Strips
  → Always immediately follow with guidance for the motorist
- Consider Presence Lighting to provide additional conspicuity at night

Parts of a Work Zone: Transition Area



Source: MUTCD

NextLevel INDIANA

Transition Area

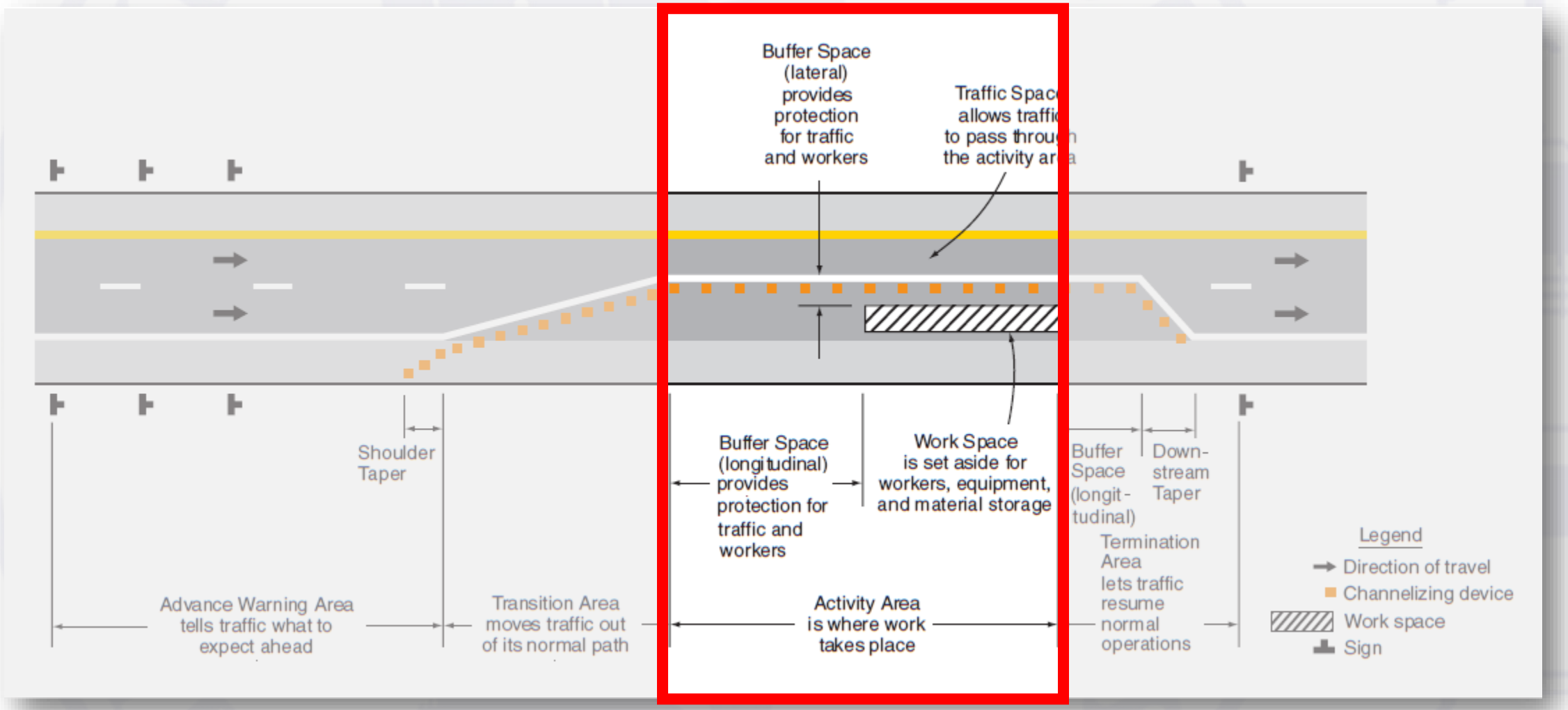
- Areas of the work zone where road users are directed out of their normal path:
  - Lane Merges and Lane Shifts
  - Lane Width Reductions
  - Cross Overs and Diverging/Converging Lanes
- First transition area into work zone will have greatest speed differential
  → Elongate transition tapers using upstream non-work zone speed limit
- Consider how large vehicles (trucks) will be affected by transition area
  → Provide additional space through transition areas
- Remember: multi-lane lane shifts require temporary lane markings, regardless how short the duration
- Provide a tangent length between successive tapers:

  → 2L tangent for a merge taper followed by a merge taper. (IMUTCD TA-37)

  → ½L tangent for a merge taper followed by a lane shift. (IMUTCD TA-32)

NextLevel INDIANA

Parts of a Work Zone: Activity Area



Source: MUTCD

NextLevel INDIANA

Always Provide an SSD-Based Long. Buffer Space*

* Unless there is a justifiable reason for not doing so

- Often not provided in MOT plans or of insufficient length
- IMUTCD 6C.06 and Table 6C-2

Table 6C-2 Stopping Sight Distance as a Function of Speed	
Speed (mph)	Distance (ft)
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645
70	730
75	820

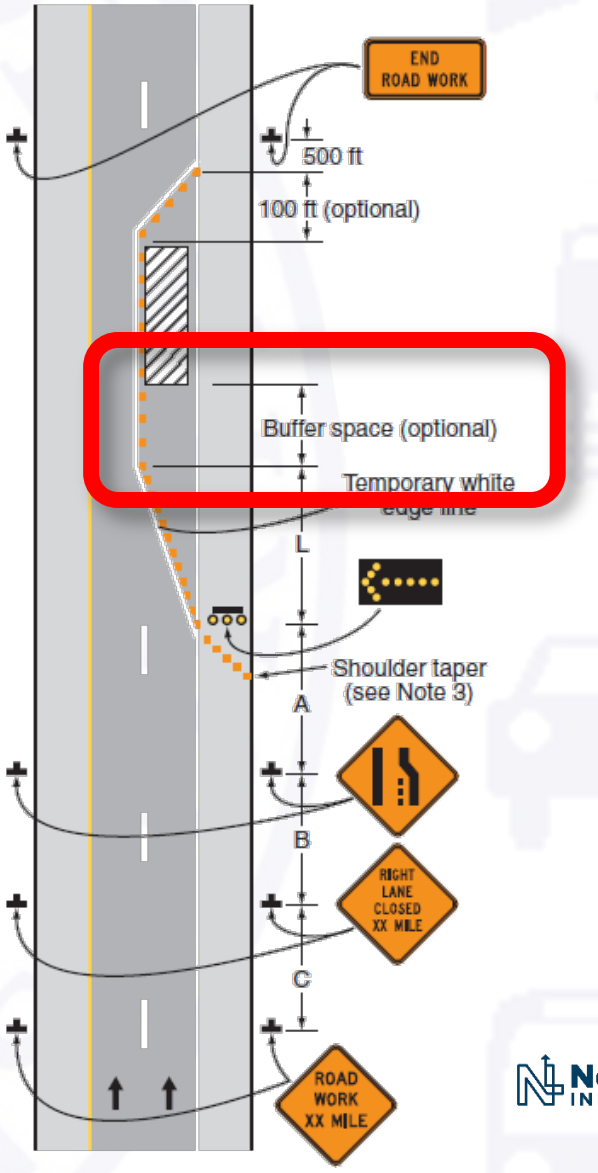
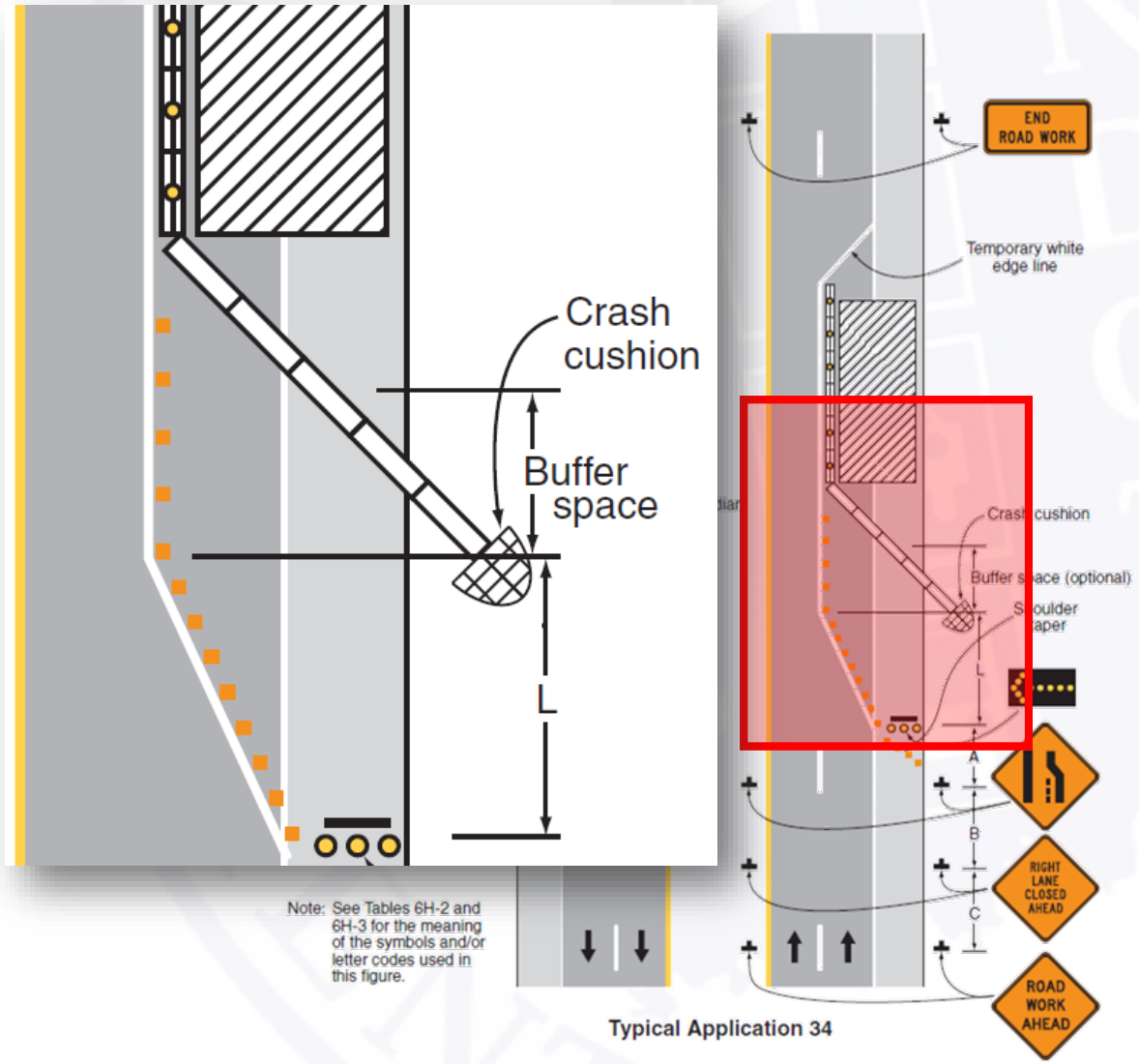
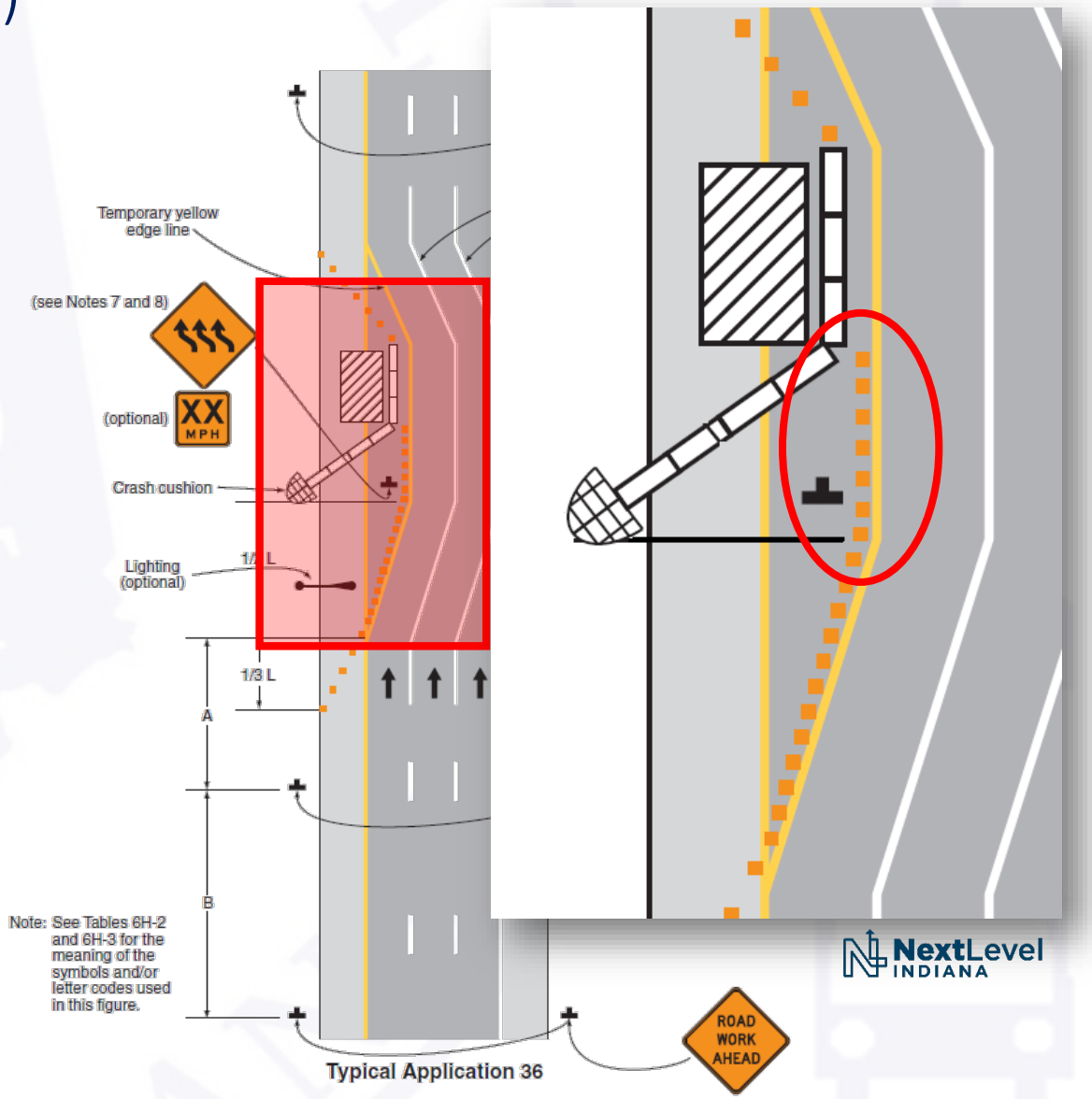


Figure 6H-33. (TA-33)

Delineation at Temporary Traffic Barrier Flares

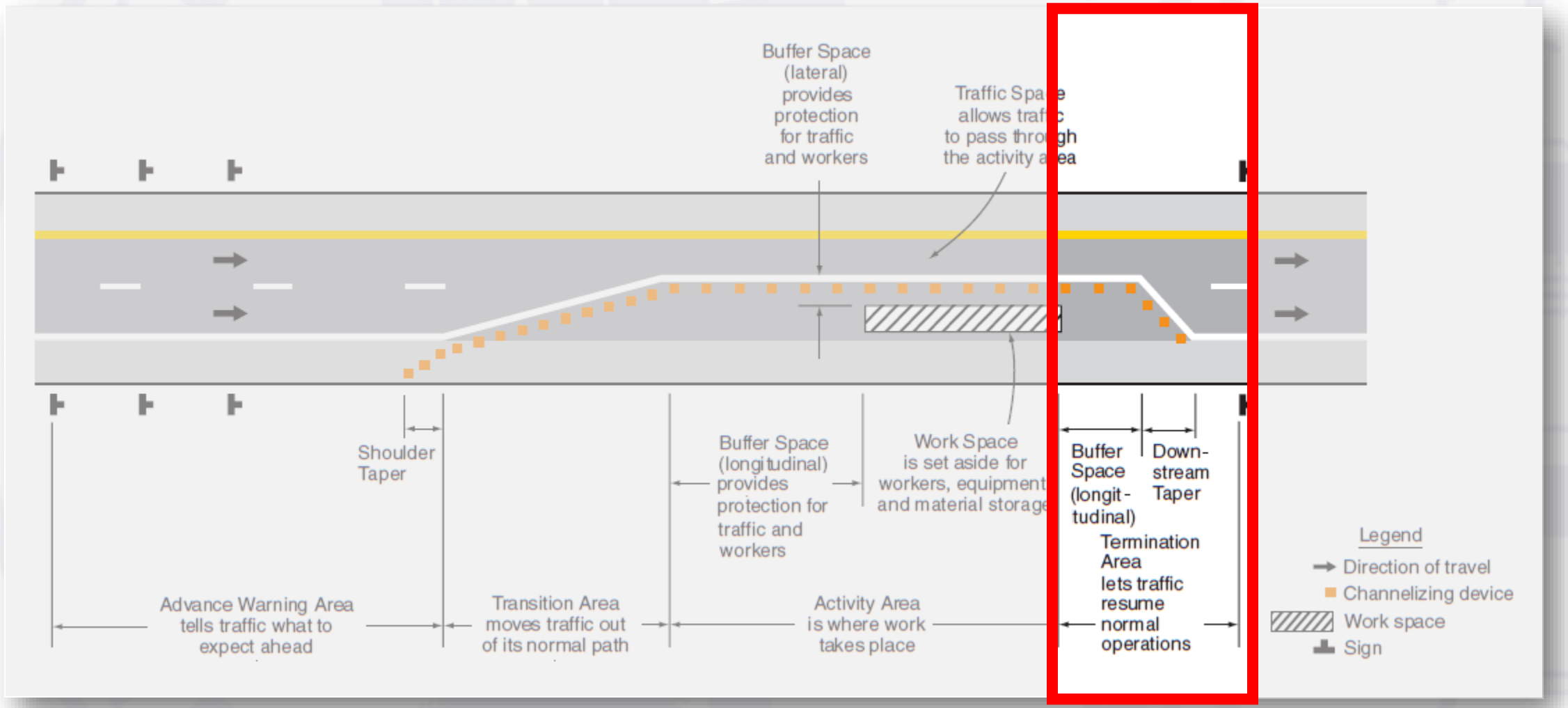
- IMUTCD, TA-34 (MERGE) and TA-36 (SHIFT)





NextLevel INDIANA

Parts of a Work Zone: Termination Area



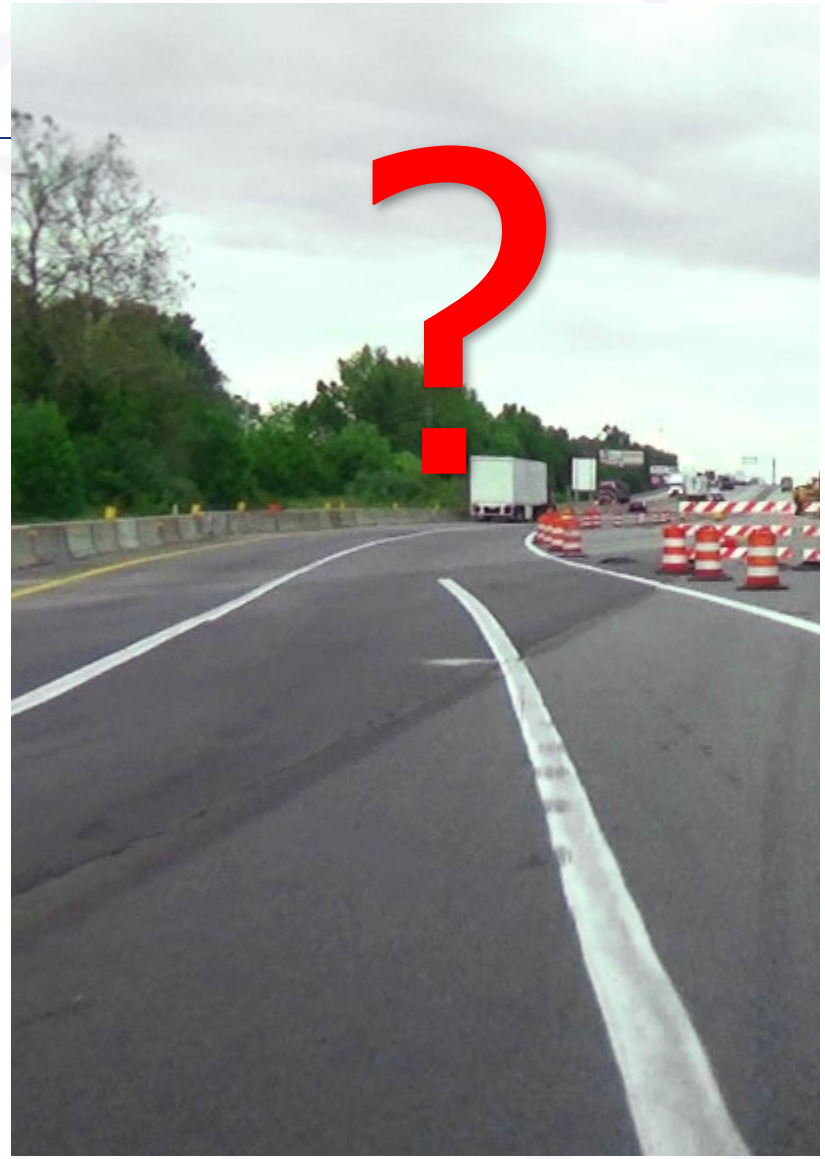
Source: MUTCD

NextLevel INDIANA

Improving Safety in Transition Areas

Separate Transitions

- Do not combine transition areas:
  - A merge and lane shift taper.
  - Even worse: merge + shift + lane width reduction
  - Even worse: merge + shift + lane width reduction ending at end of TTB flare
- Avoid transitions near or within:
  - Horizontal and vertical curves
  - System Interchanges/Entrance ramps
  - Points of ingress/egress to construction area
  - Other factors
- If possible, provide a tangent length between successive transition areas.



NextLevel INDIANA

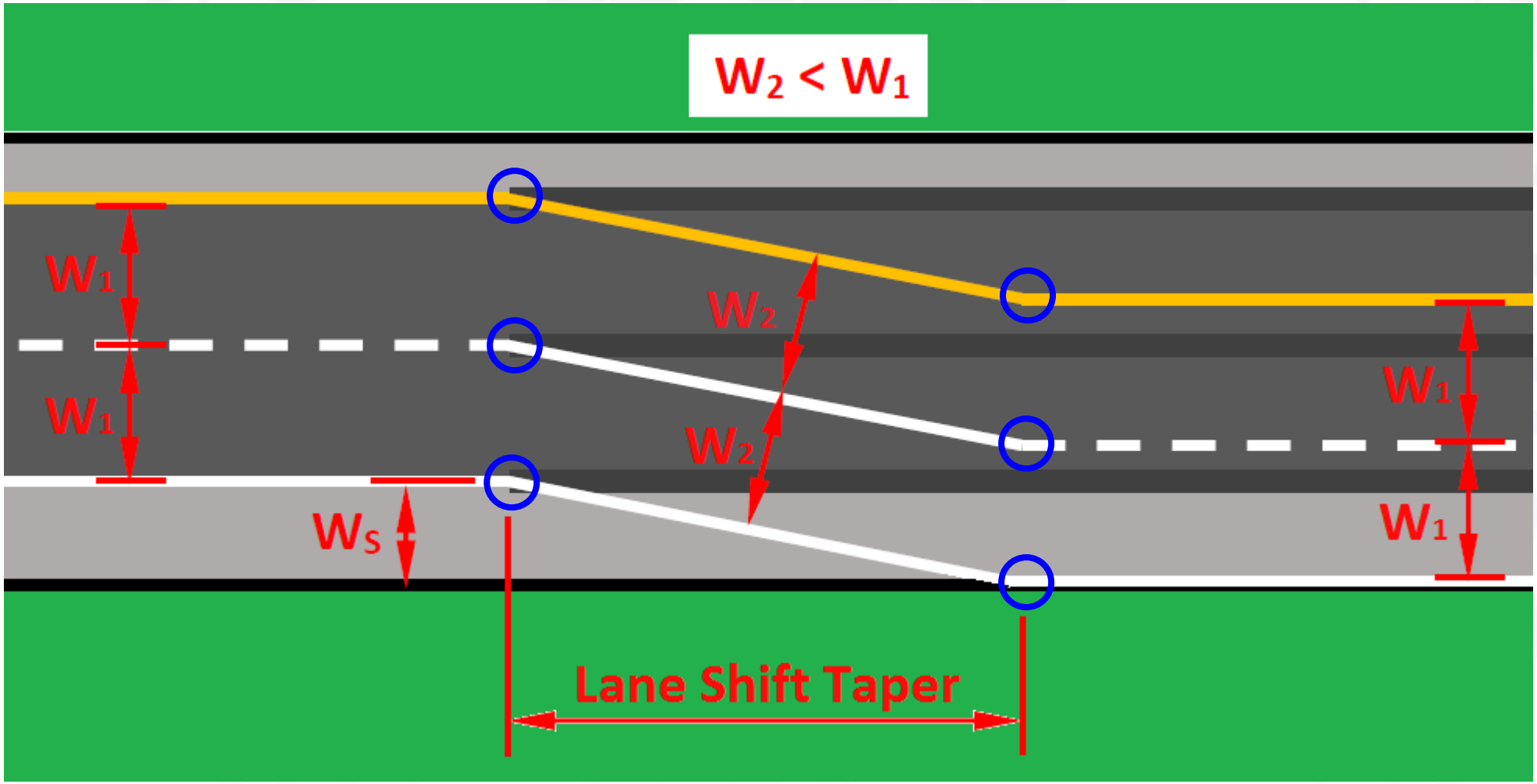
Improve Transitions Into and Within the Work Zone

- Use **longer tapers** into the work zone by using the upstream existing Speed Limit.
- Provide **additional lane width** (NOT LESS!) through transitions
  - lane width reduction → use staggered lane lines
  - multi-lane shifts → use staggered lane lines
  - cross-overs → staggering works for curves, too
- Provide sufficient **shoulder width** (lateral buffer space) – optimally, 2 ft minimum
- **Delineate merge and shift tapers** with construction drums and pavement markings – NOT TEMPORARY TRAFFIC BARRIER (TTB)!
- Provide **longitudinal Buffer Space** based on SSD to allow errant vehicles space to recover
  → Especially after merge tapers and BEFORE TTB!
- Consider nighttime **presence lighting** of transition areas.

NextLevel INDIANA

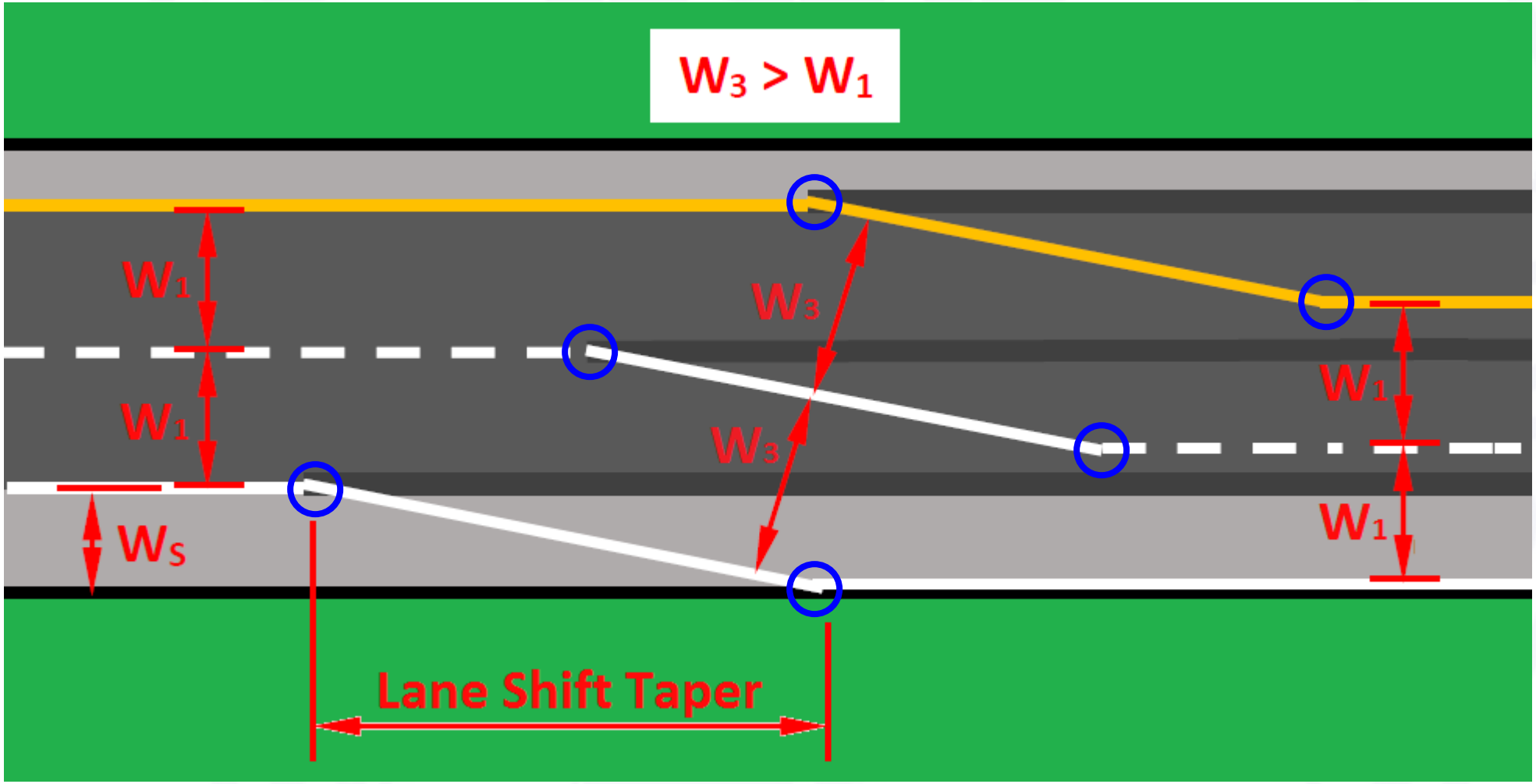
Widen Lanes through Shifts by Staggering the Start

- If all lanes start at same station, lane width decreases through shift!

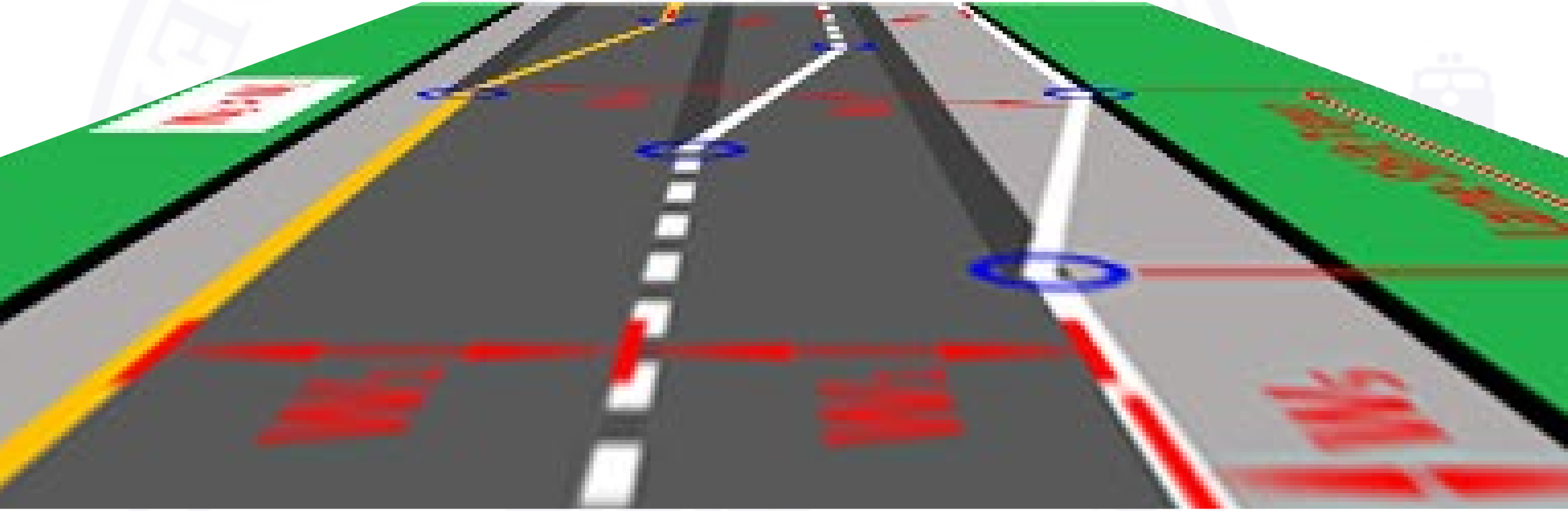


Widen Lanes through Shifts by Staggering the Start

- To ensure wider lanes through shifts, stagger the start of the lane shift lines.



Widen Lanes through Shifts by Staggering the Start



Lane Width Reduction

For a 1 ft lane reduction on all lanes…

Lane 3 experiences a 3 ft lane shift while undergoing the 1 ft restriction.

Lane 2 experiences a 2 ft lane shift while undergoing the 1 ft restriction.

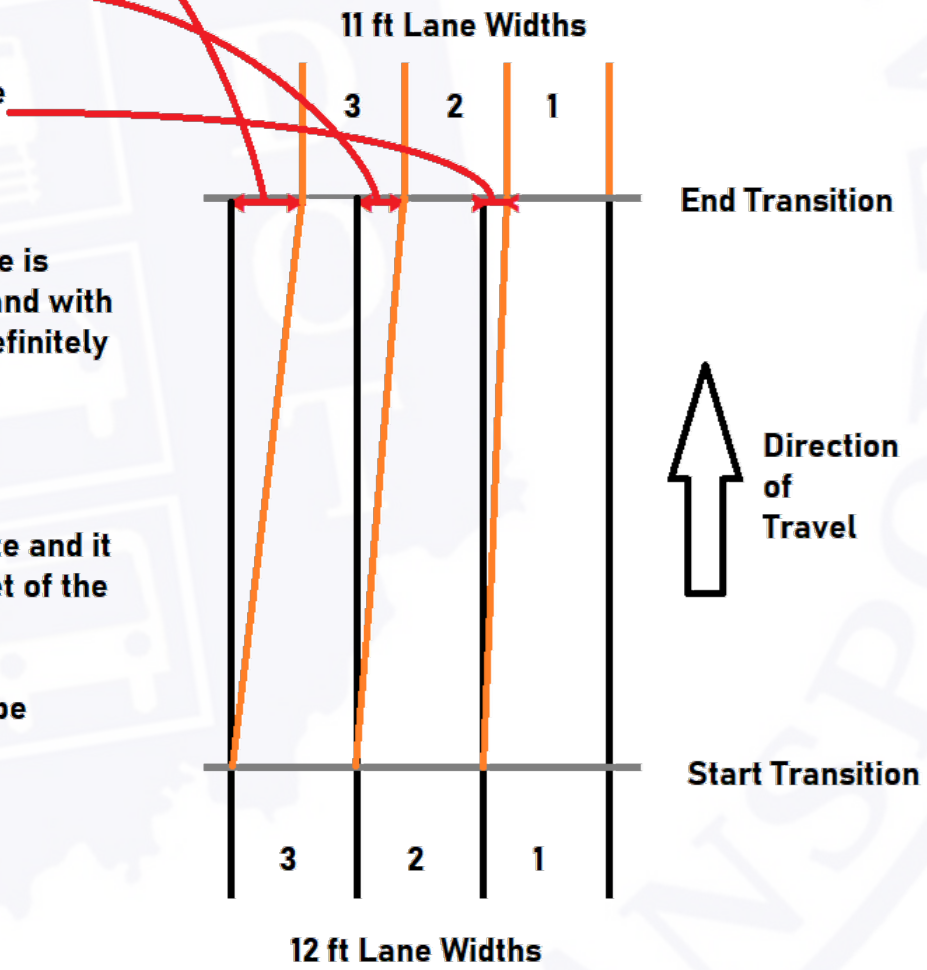
Lane 1 experiences a 1 ft lane shift while undergoing the 1 ft restriction.

When lane widths are reduced, each lane is being shifted, but by different amounts and with different taper rates. These are most definitely lane shifts.

By applying the stagger:

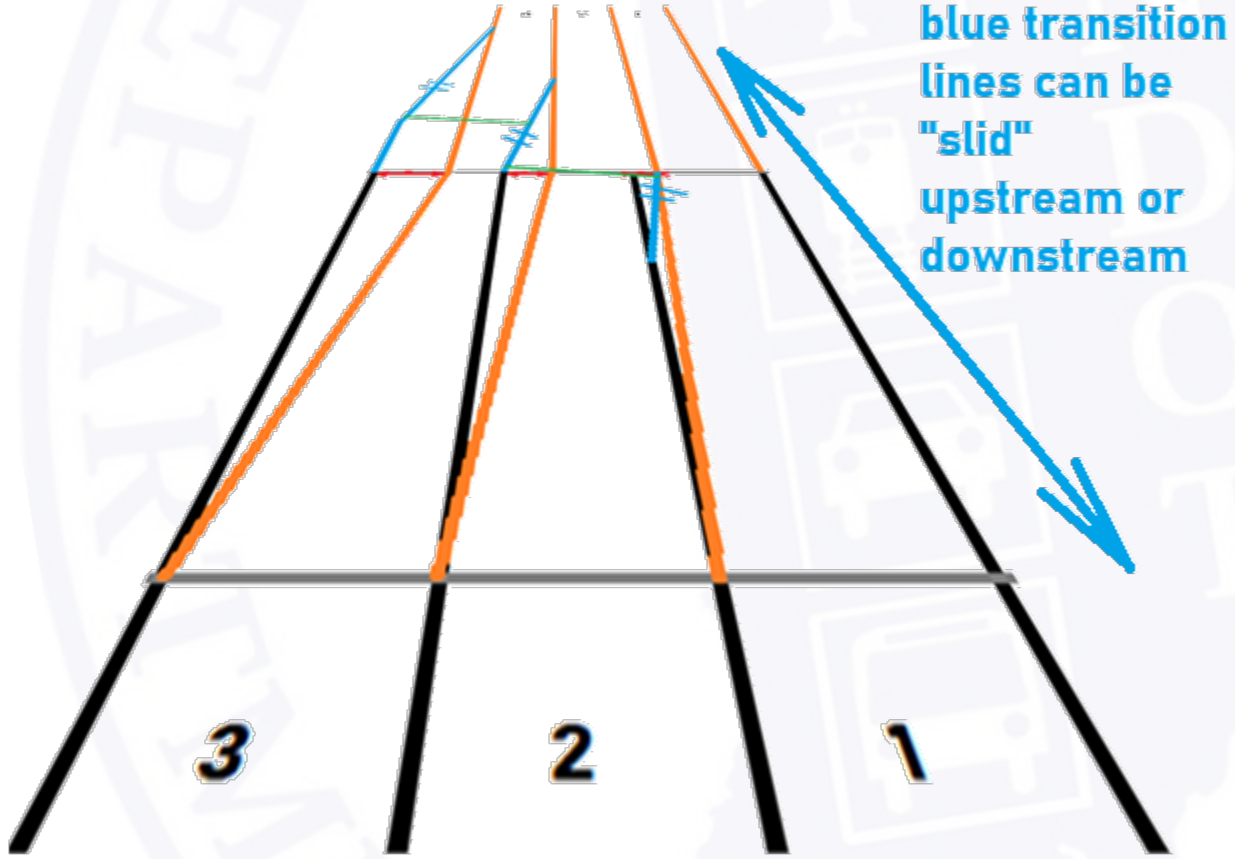
(1) all lanes will have the same taper rate and it will be the appropriate rate for the offset of the shift.

(2) through the transition the lanes will be wider and a consistent width.

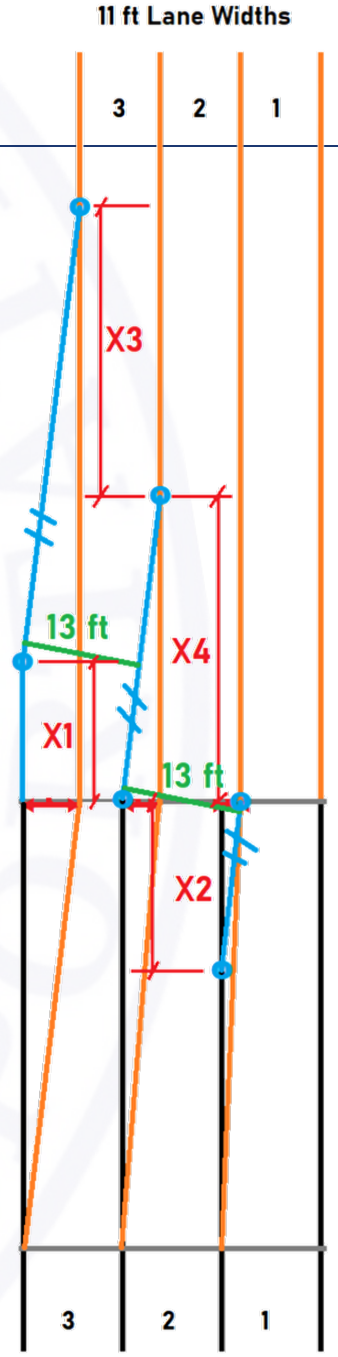


Staggered Lane Width Reduction

Perspective View

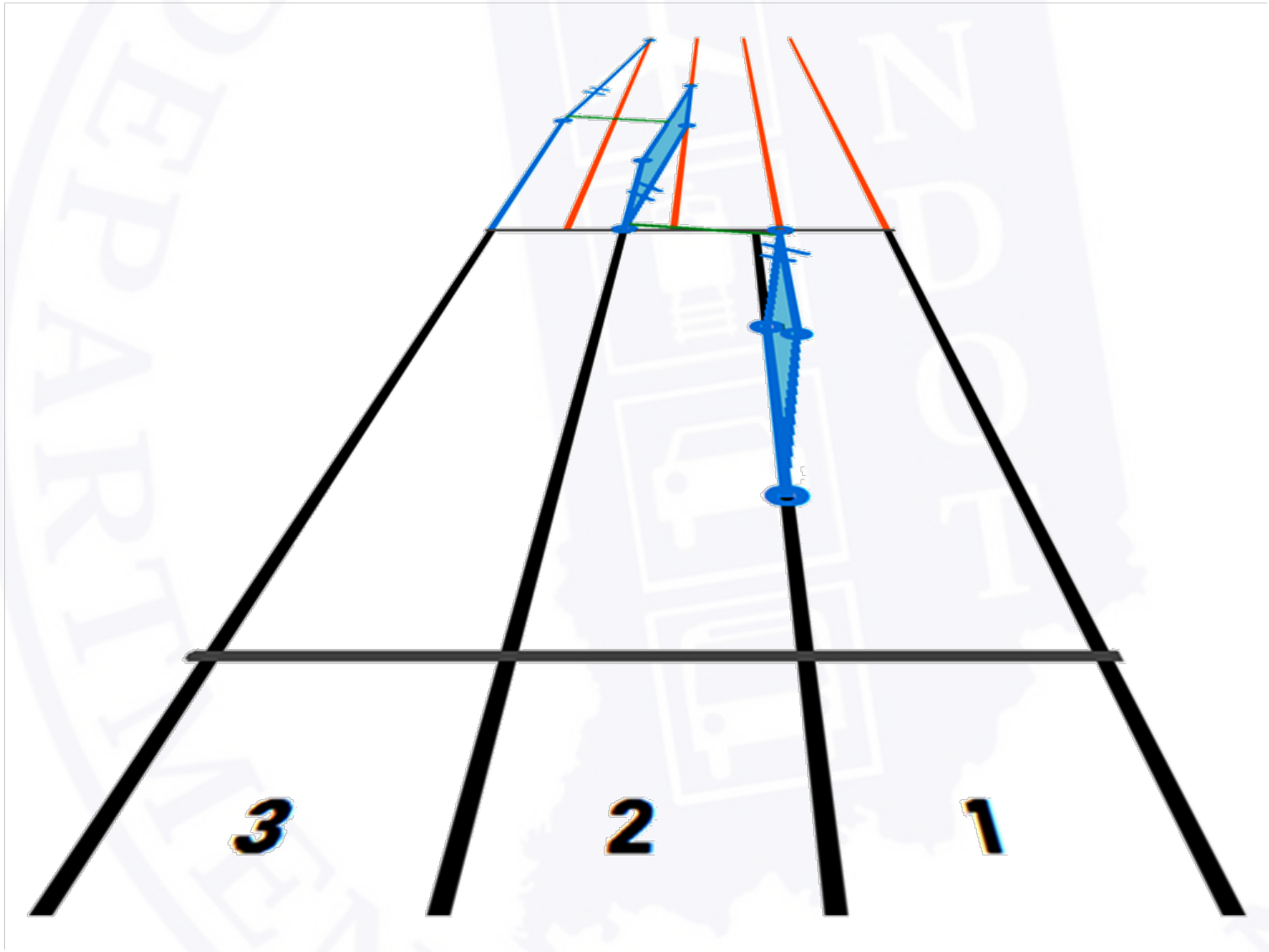


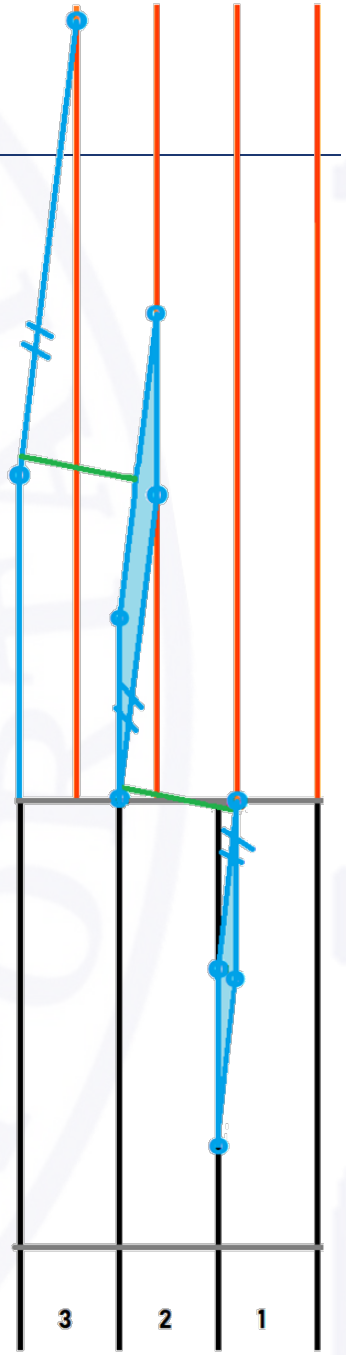
The staggered blue transition lines can be "slid" upstream or downstream



NextLevel INDIANA

Staggered Lane Width Reduction





12 ft Lane Widths

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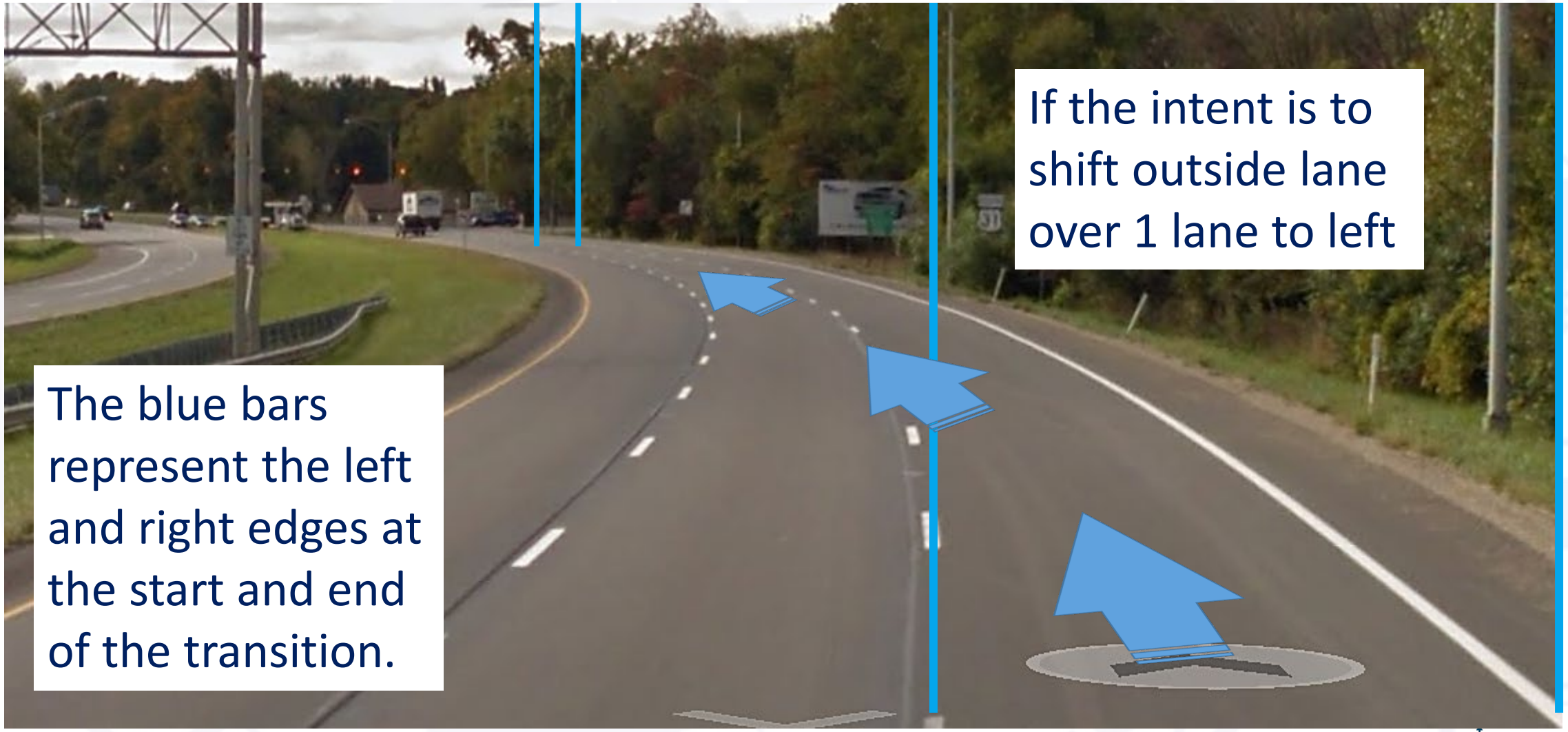
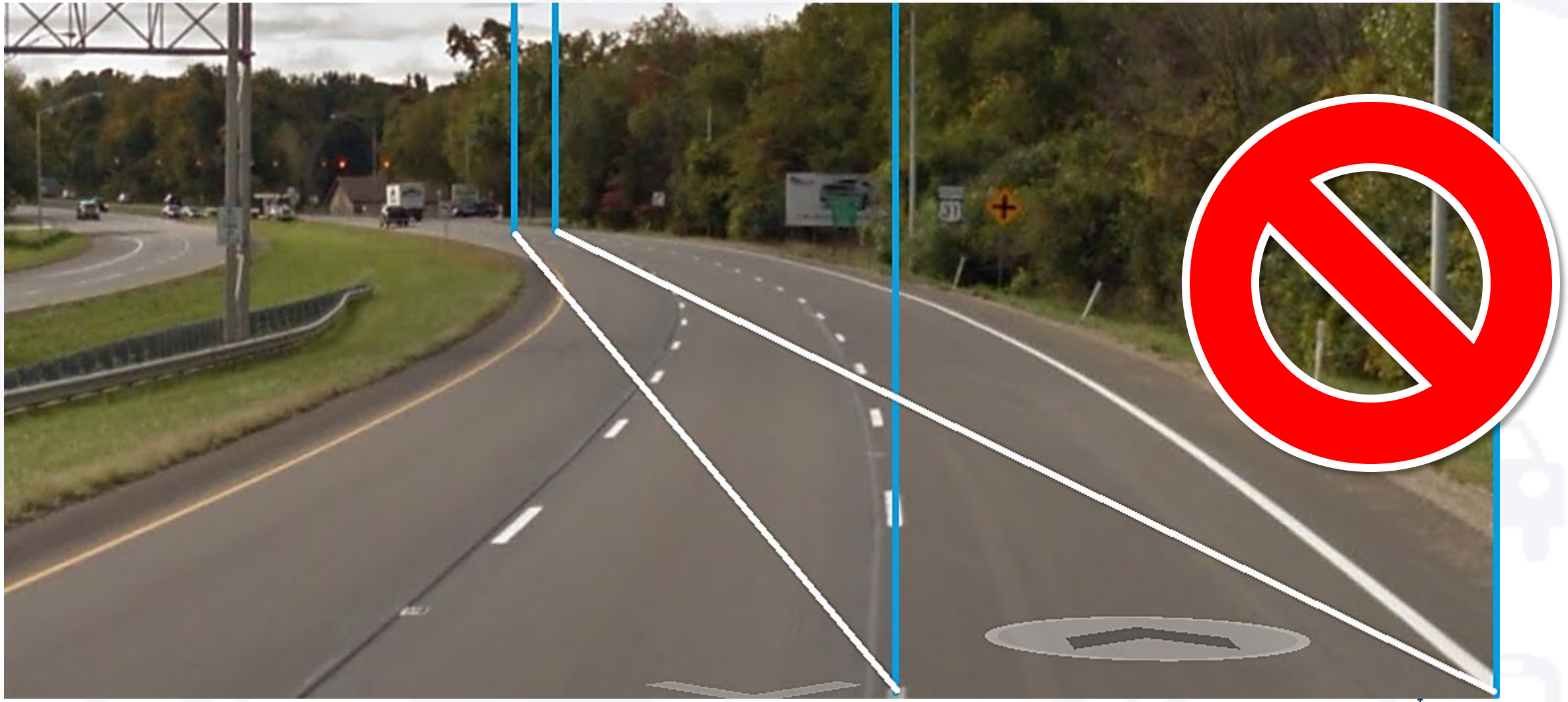
Transition Along Curve – Why Avoid?

Transition Along Curve

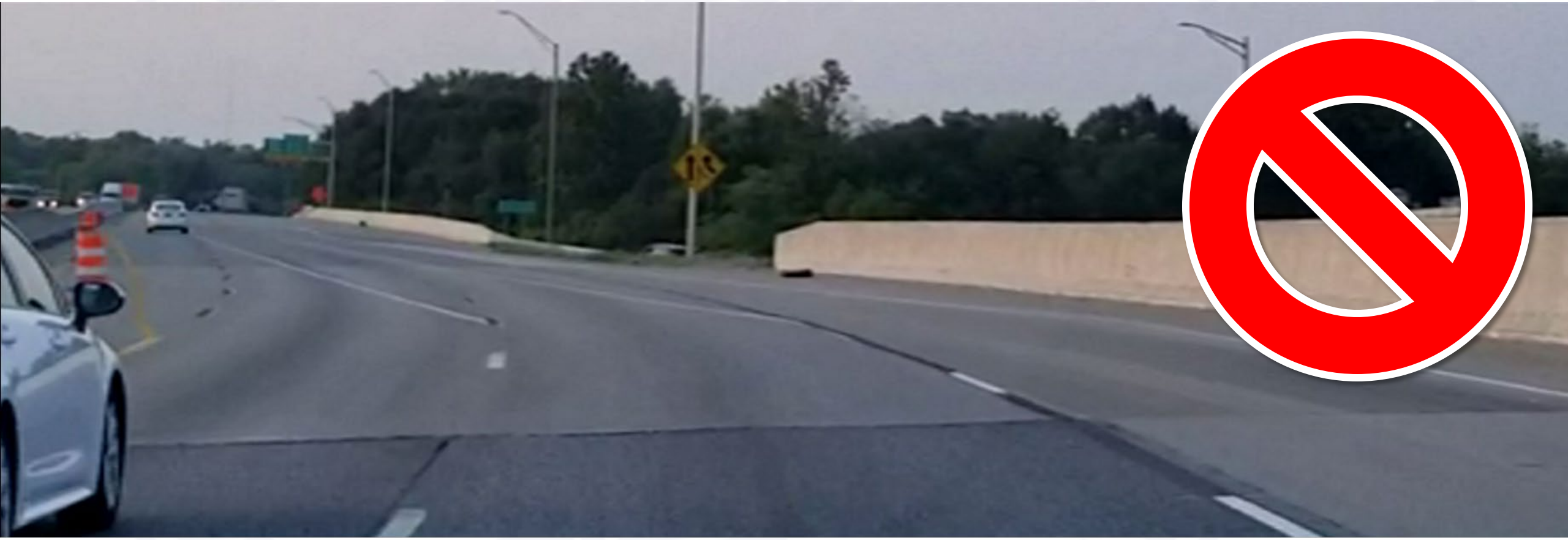
Transition Along Curve



Straight Line Transition Along Curve

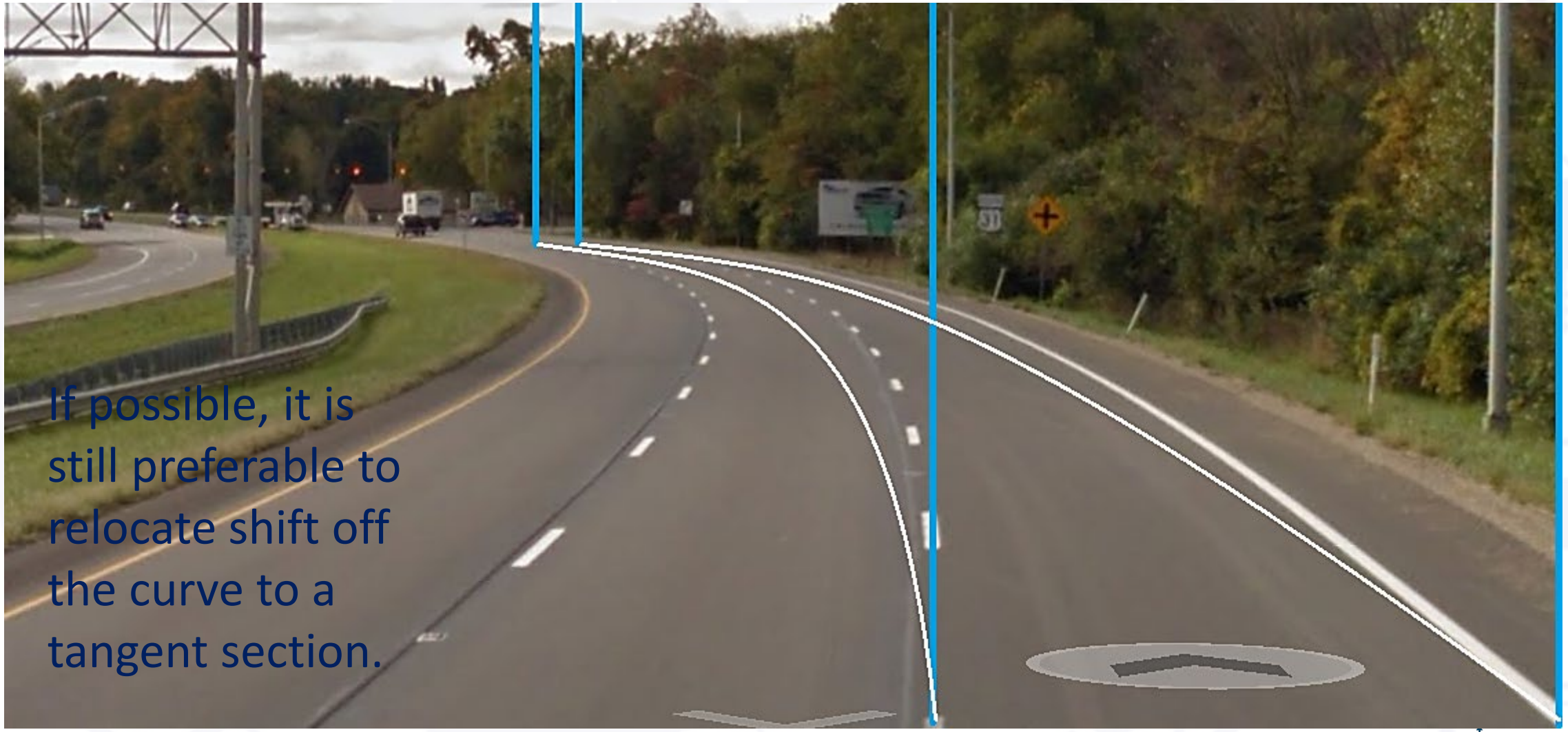


Straight Line Transition Along Curve

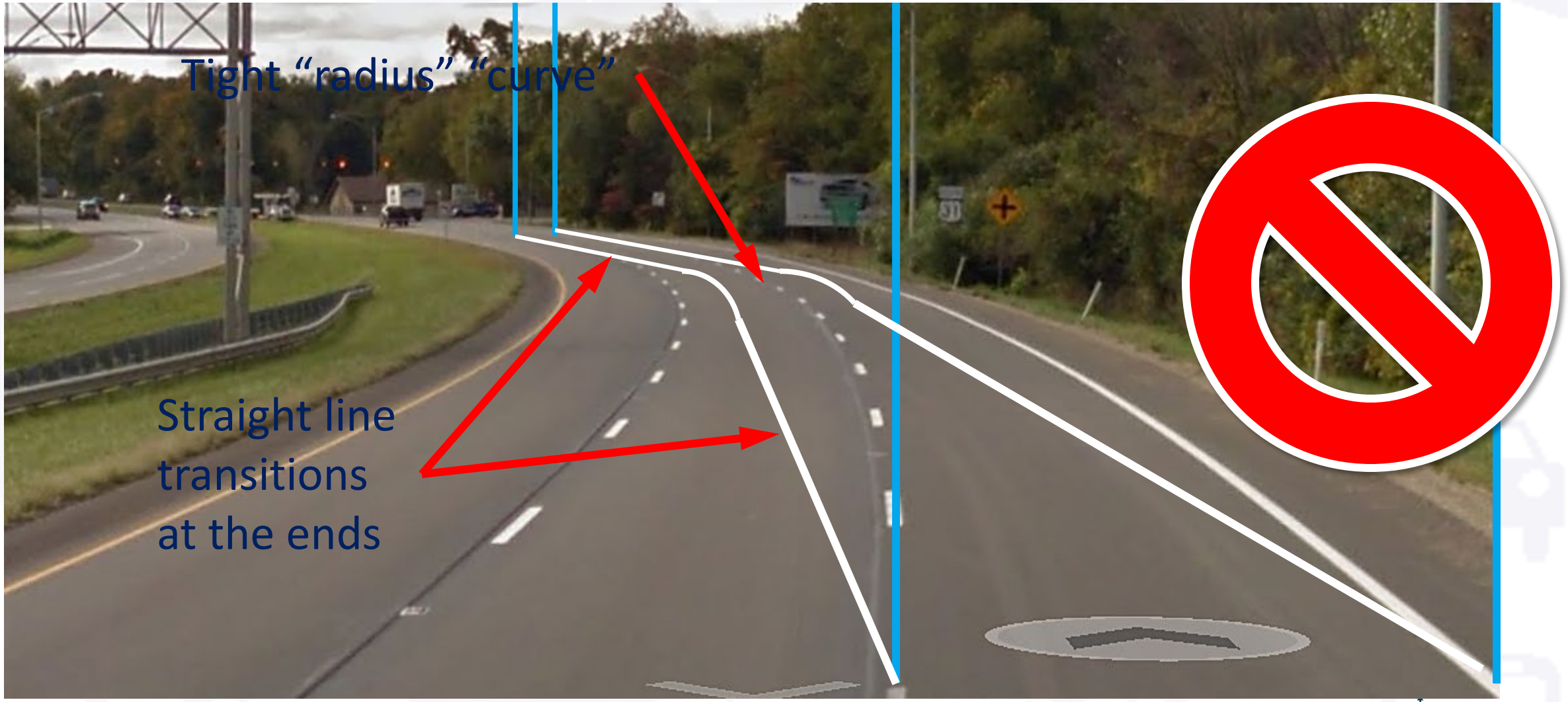


Straight Line Transition Along Curve

Linear Transition Along Curve (Spiral) - Theoretical

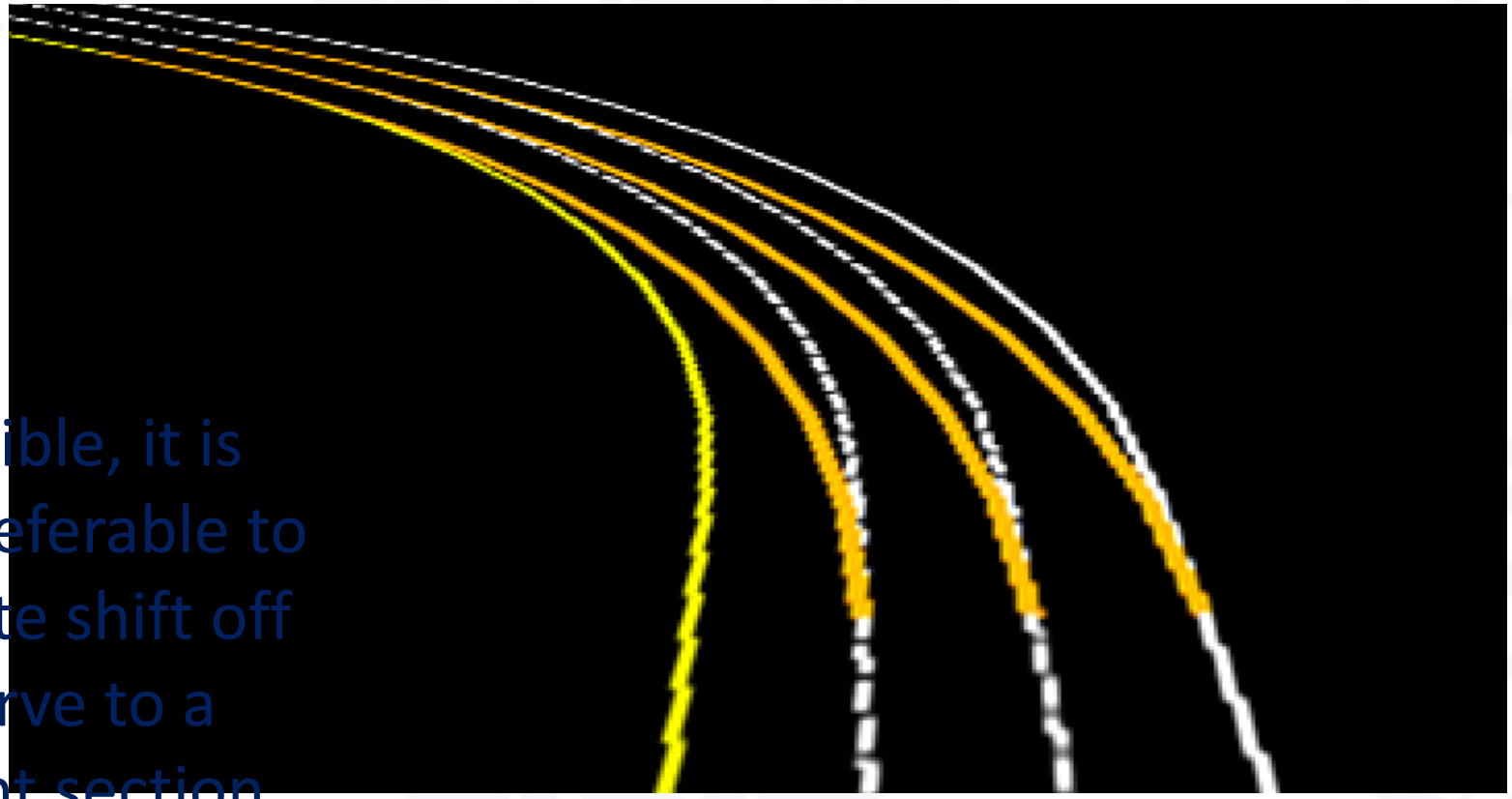


Linear Transition Along Curve (Spiral) - Reality



Single Radius Curve Transition (Compound Curve)

- Tangent at both ends of the transition curve: very smooth

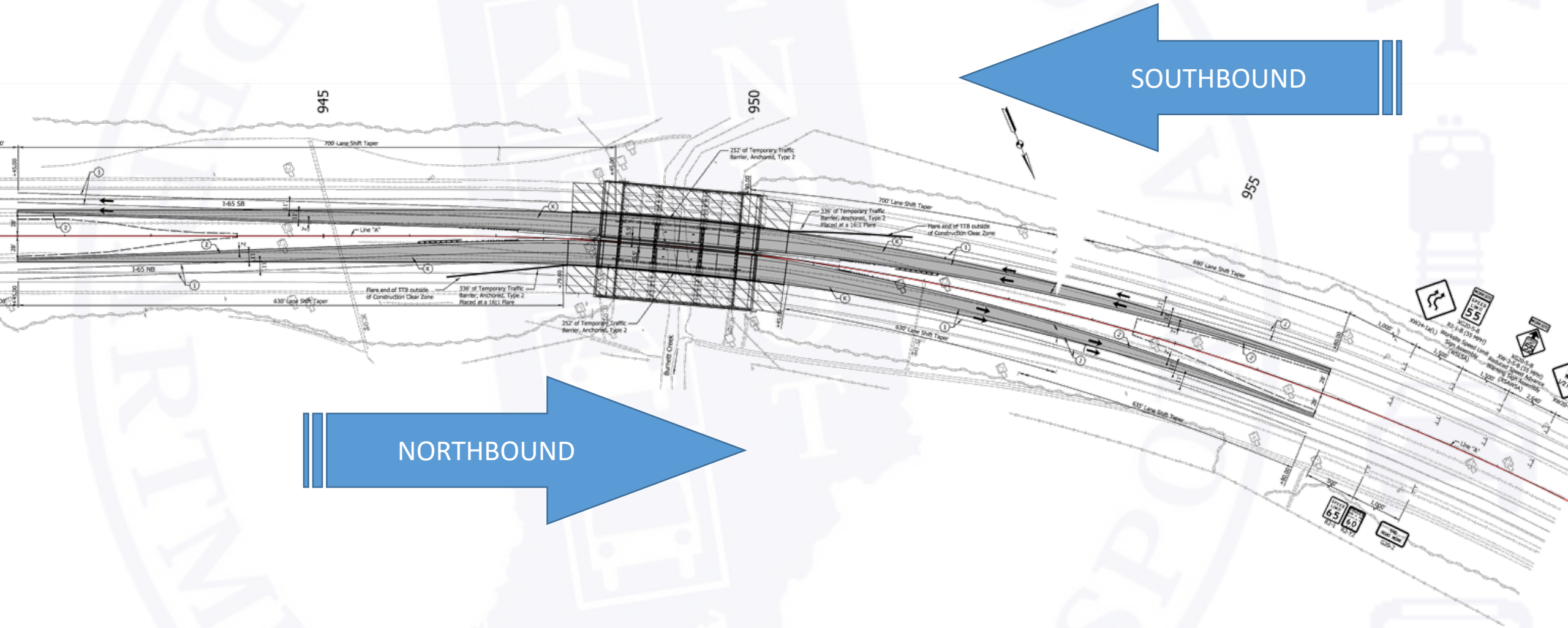


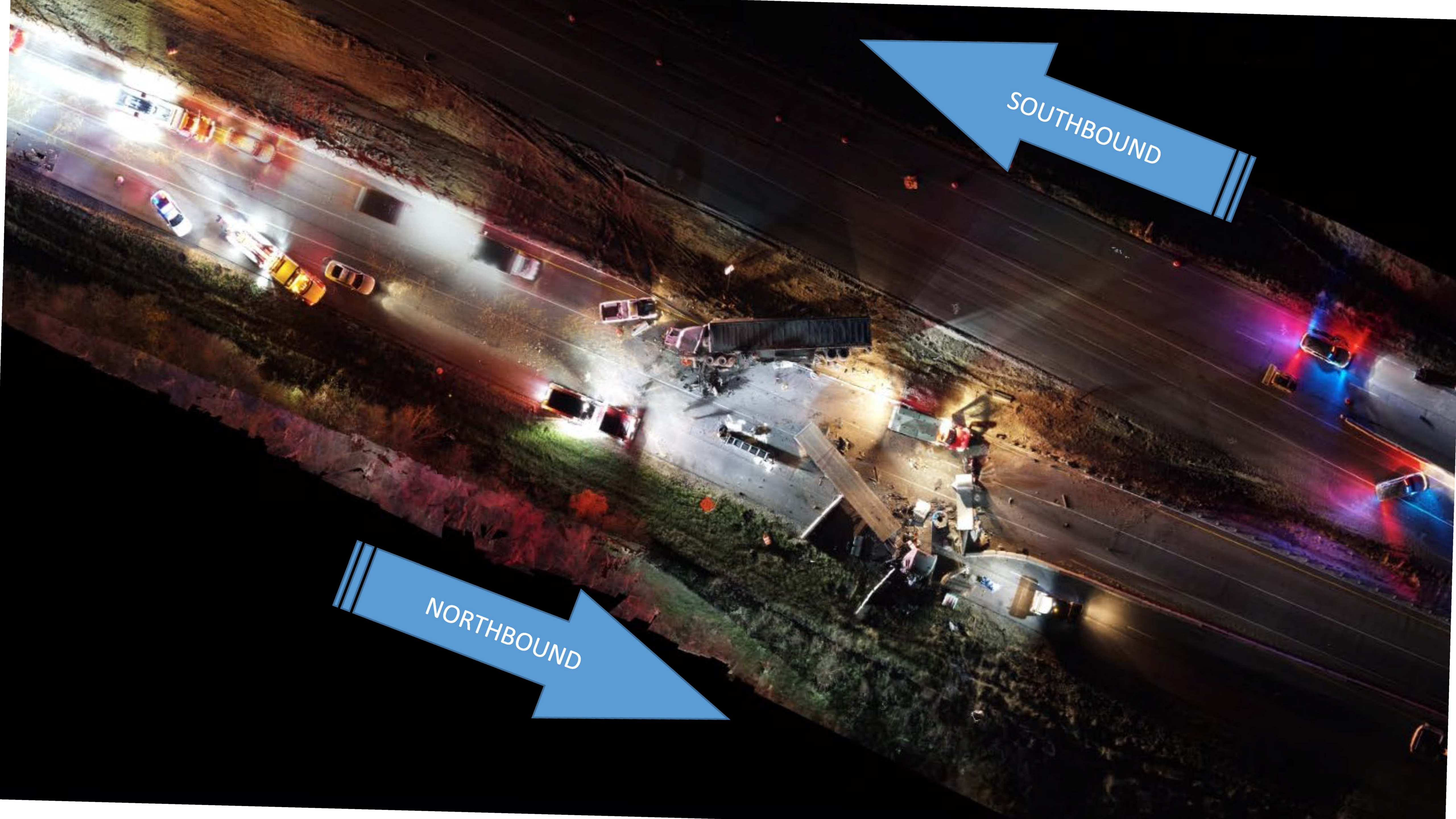
If possible, it is still preferable to relocate shift off the curve to a tangent section.

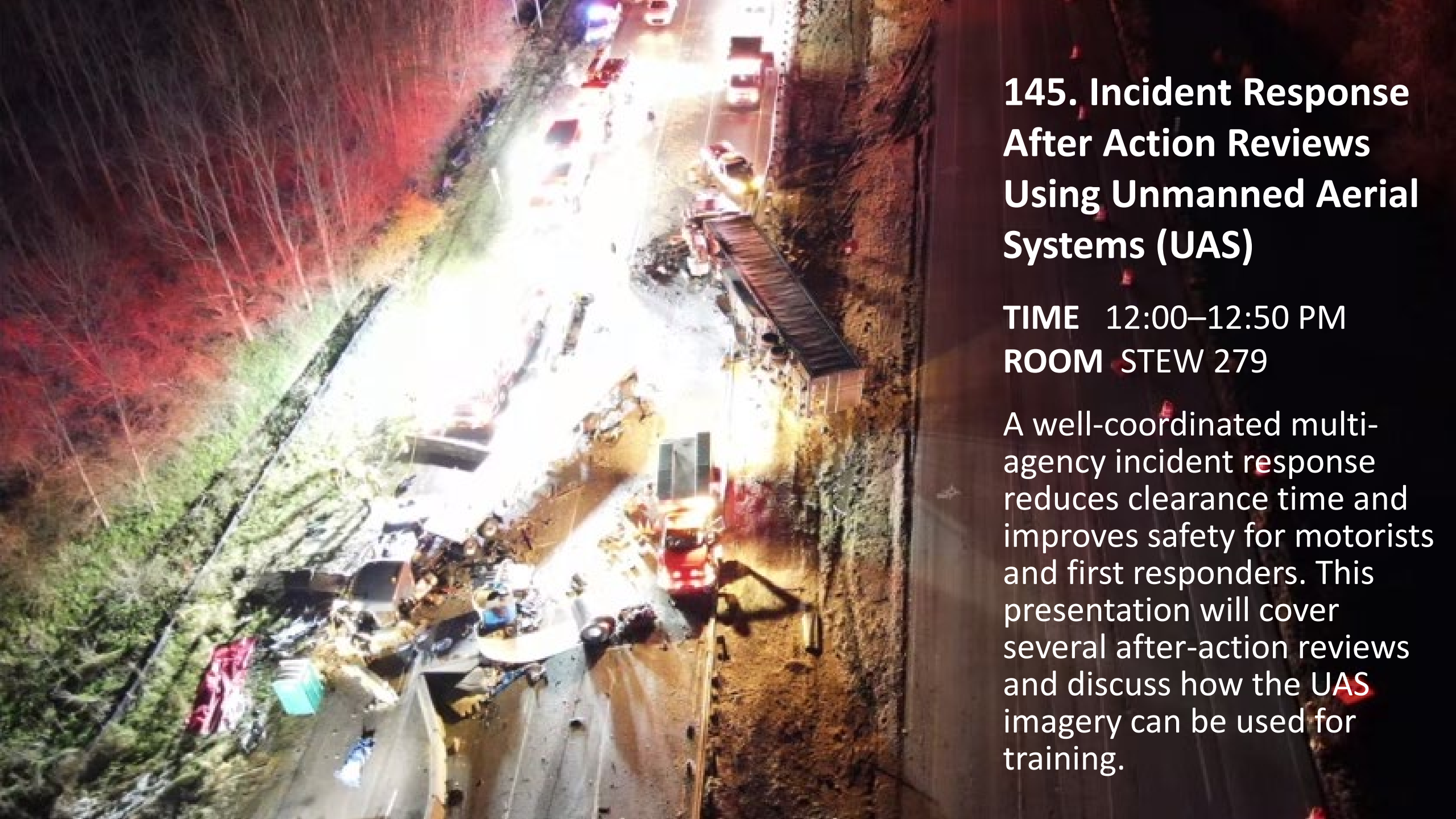
Transition Areas Case Study


SOUTHBOUND
NORTHBOUND

MOT Plan


SOUTHBOUND
NORTHBOUND
945
950
955
I-65 SB
I-65 NB
700' Lane Shift Taper
630' Lane Shift Taper
635' Lane Shift Taper
690' Lane Shift Taper
252' of Temporary Traffic Barrier, Anchored, Type 2
336' of Temporary Traffic Barrier, Anchored, Type 2 Placed at a 16:1 Flare
Flare end of TTB outside of Construction Clear Zone
Line "A"
Burnett Creek


SOUTHBOUND
NORTHBOUND

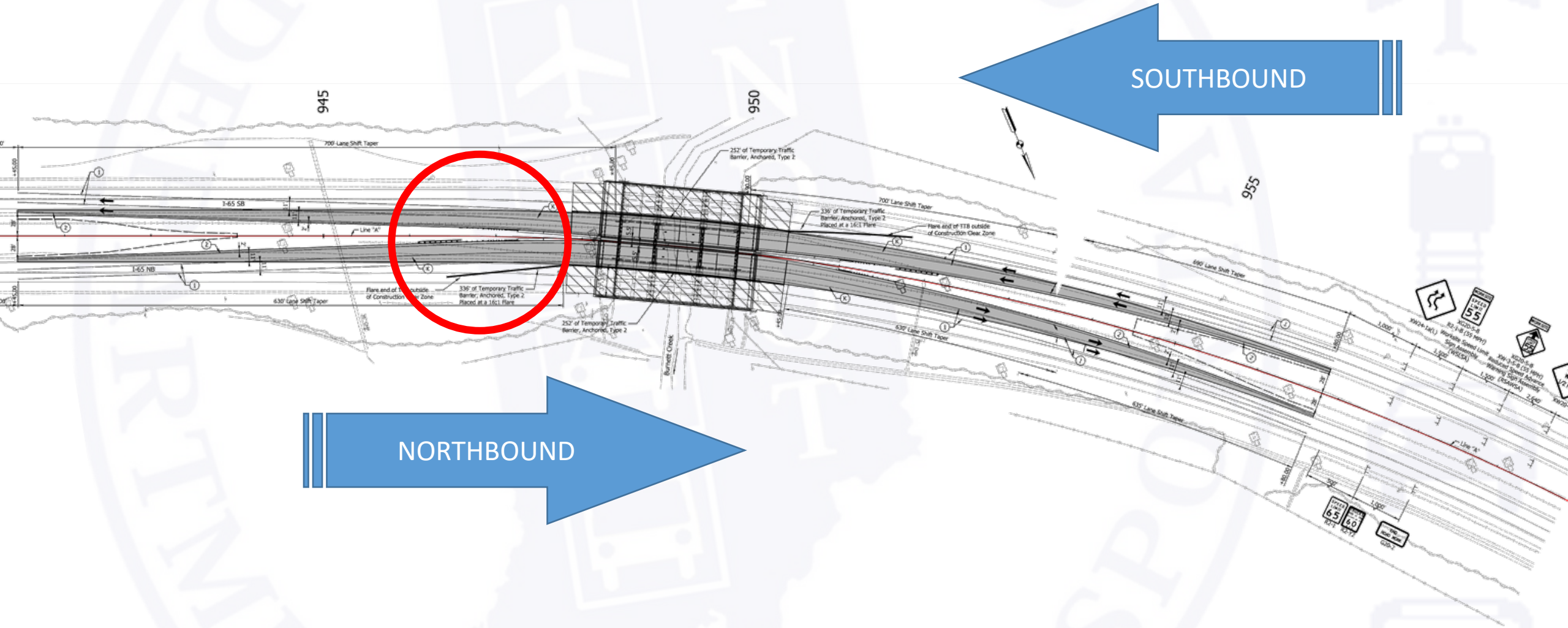


145. Incident Response After Action Reviews Using Unmanned Aerial Systems (UAS)

TIME 12:00–12:50 PM
ROOM STEW 279

A well-coordinated multi-agency incident response reduces clearance time and improves safety for motorists and first responders. This presentation will cover several after-action reviews and discuss how the UAS imagery can be used for training.

MOT Plan – Crash Location

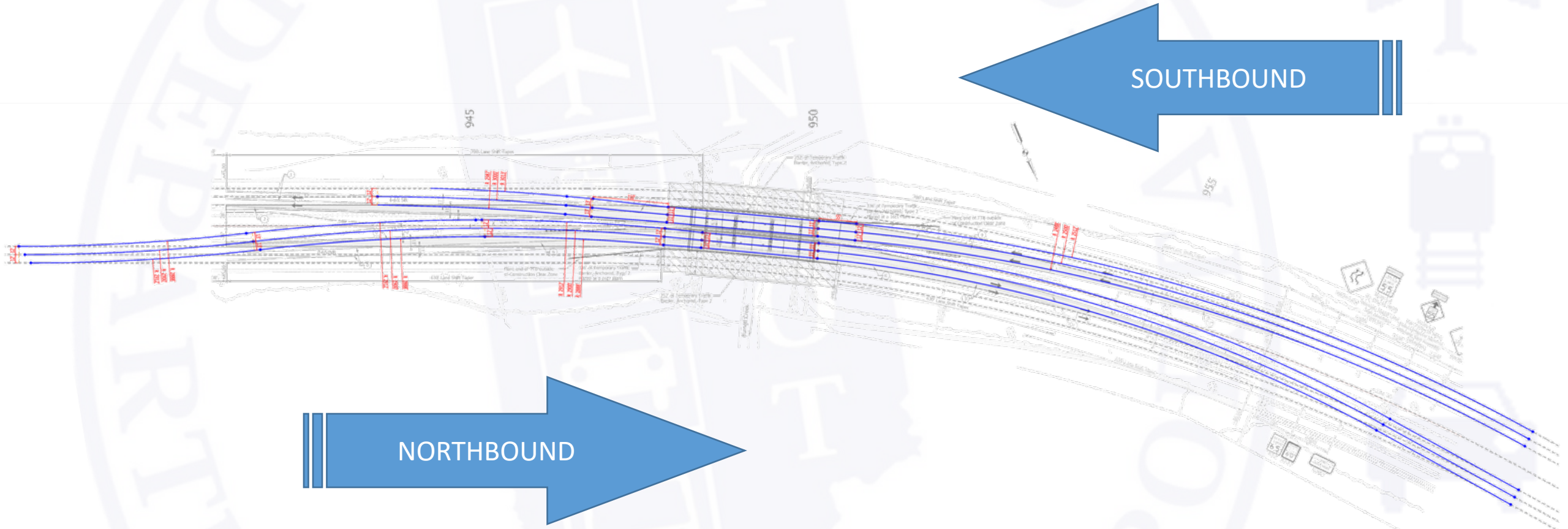


NextLevel INDIANA

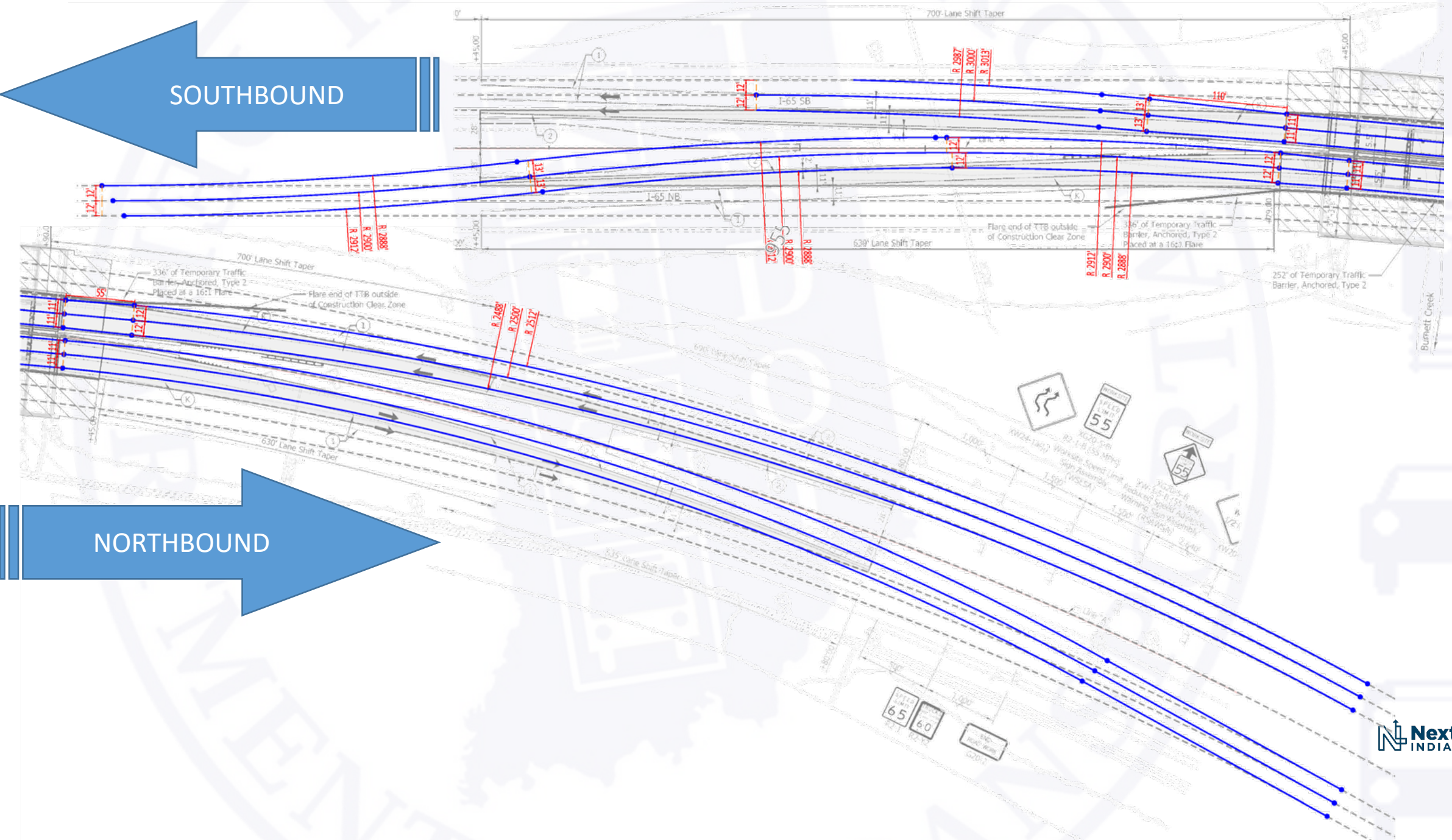
Work Zone Conditions

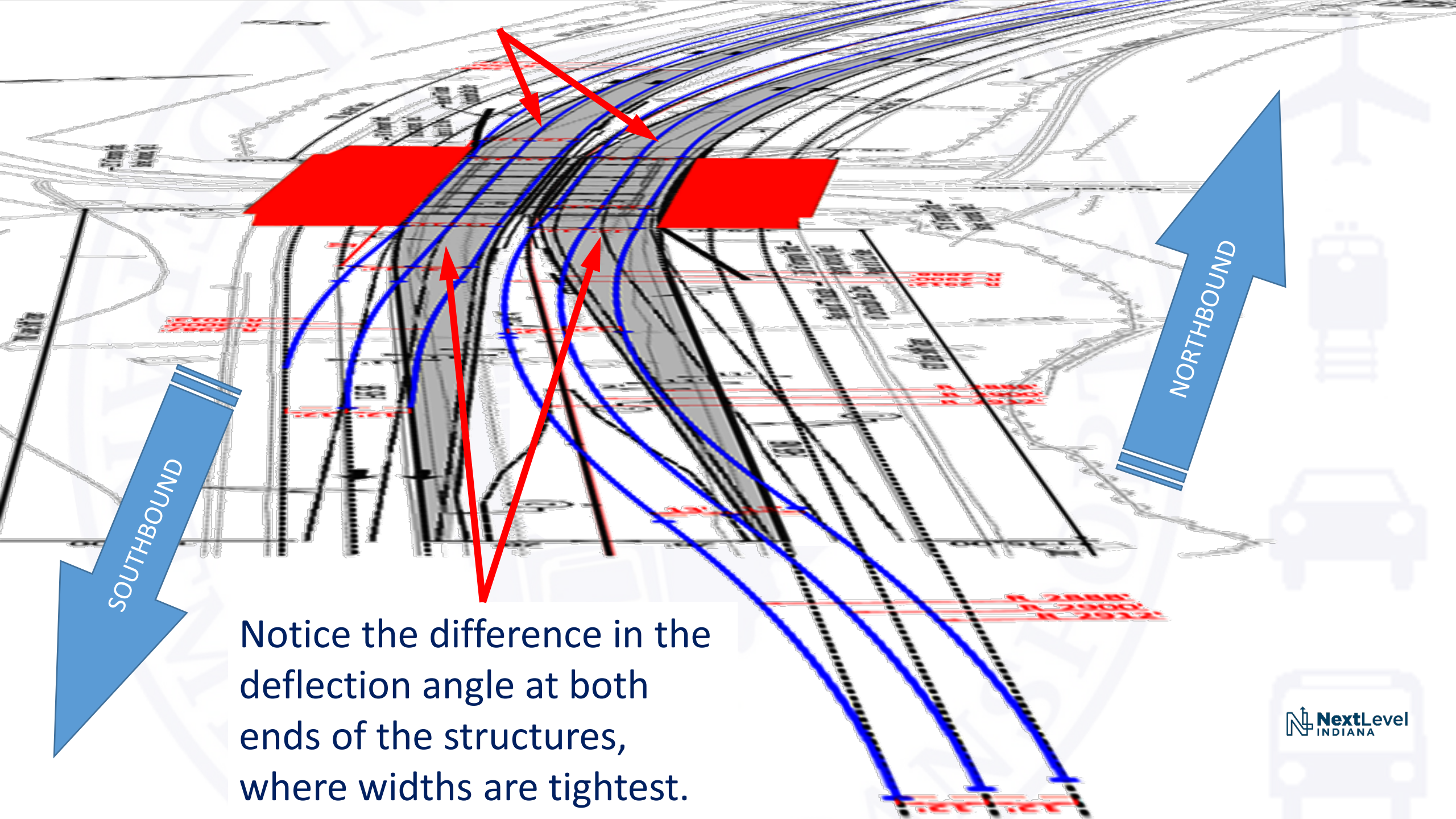
- Narrow Lane Width Across Structure
- Narrow Shoulder/Buffer Width Across Structure
- Lane Width Transition in combination with Lane Shift Taper
- TTB Along Transitions
- Along Horizontal Curve
- Along Vertical Curve
- Long, straight, flat stretch of roadway preceded work site
- Traffic Speeds above posted limit
- Rural Area, Dark at Night

For Consideration



- Southbound recommendations were feasible during construction.
- Northbound geometry was not feasible given current configuration of construction.

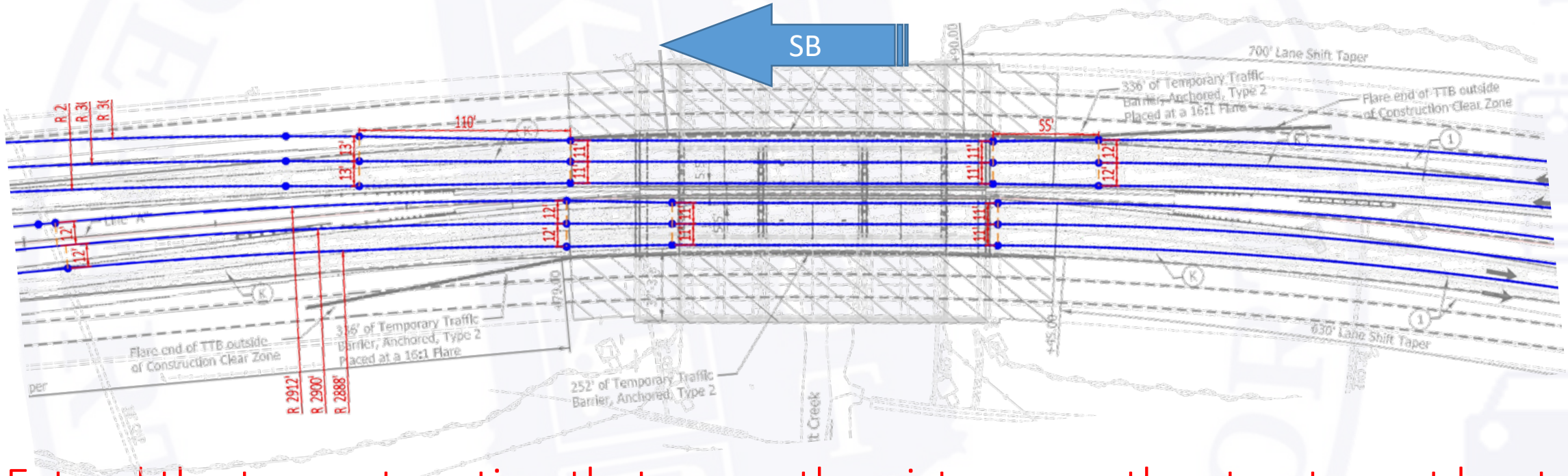

SOUTHBOUND
NORTHBOUND
700' Lane Shift Taper
I-65 SB
I-65 NB
630' Lane Shift Taper
Flare end of TTB outside of Construction Clear Zone
336' of Temporary Traffic Barrier, Anchored, Type 2 Placed at a 16:1 Flare
252' of Temporary Traffic Barrier, Anchored, Type 2
Burnett Creek
NextLevel INDIANA



Notice the difference in the deflection angle at both ends of the structures, where widths are tightest.

SB direction, at Structure:

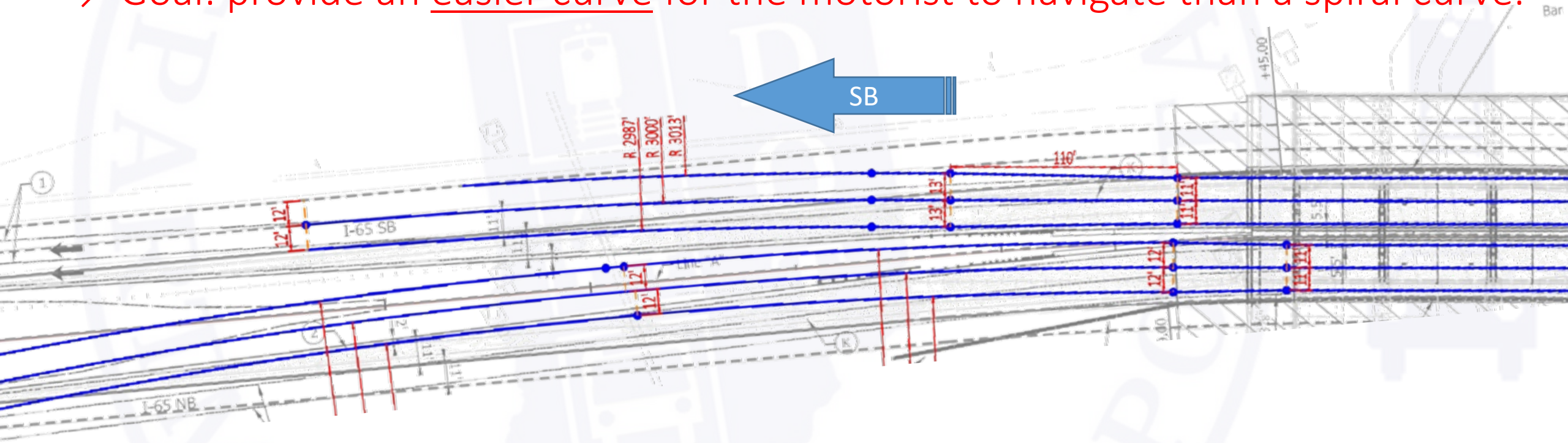
- No changes across the bridge (due to existing construction underway)



- Extend the tangent section that currently exists across the structure at least 100 ft upstream and downstream of the structure.
  → Goal: have trucks aligned in lane prior to bridge and have trajectory across the bridge be a straight line for the driver.

SB direction, Downstream Transition

- Provide single radius transitions from the existing lanes to extended tangent section.
  → Goal: provide an easier curve for the motorist to navigate than a spiral curve.

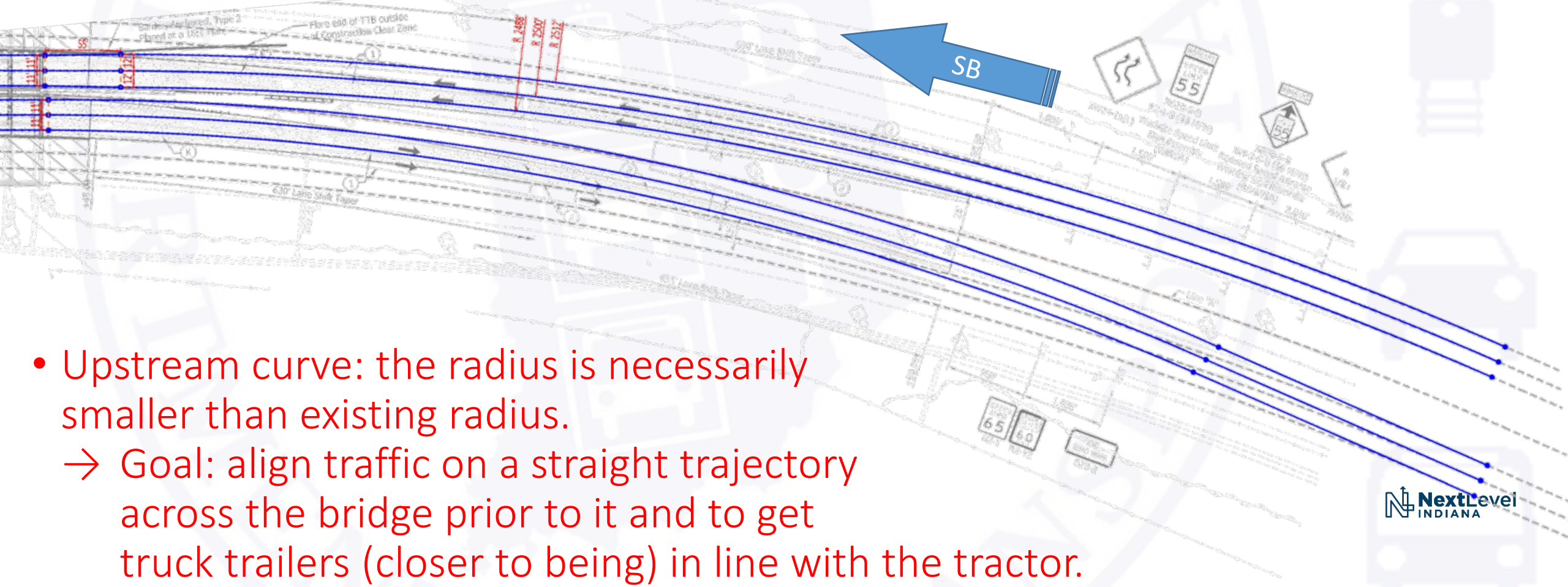


- The downstream curve can be as large and comfortable as the pre-construction curve.

NextLevel INDIANA

SB direction, Upstream Transition (similar)

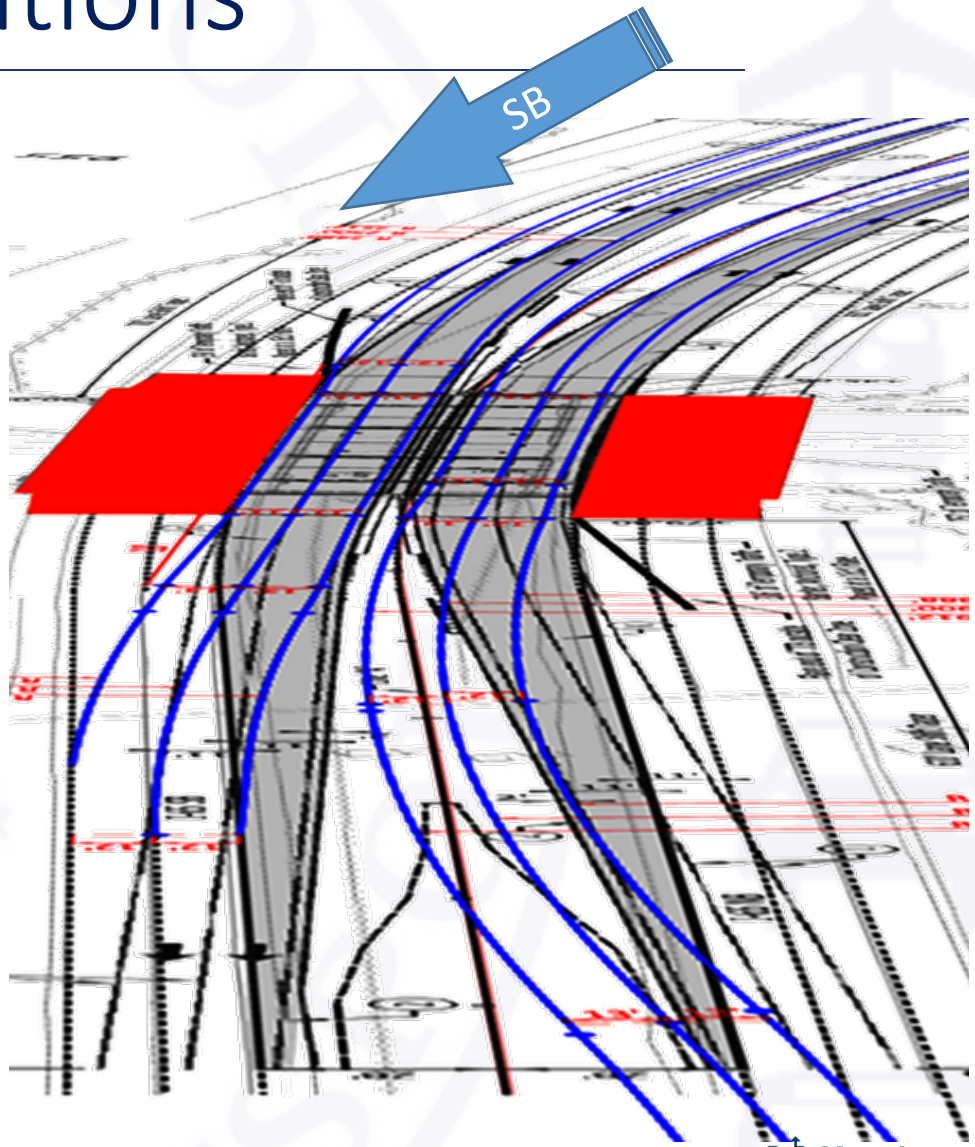
- Provides single radius transitions from the existing lanes to extended tangent section.
  → Goal: provide an easier curve for the motorist to navigate than a spiral curve.



- Upstream curve: the radius is necessarily smaller than existing radius.
  → Goal: align traffic on a straight trajectory across the bridge prior to it and to get truck trailers (closer to being) in line with the tractor.

SB direction, Lane Width Transitions

- Provides 12 ft lane width along the entire length of curve.
  → Goal: make it easier for trucks and other vehicles to stay in their lanes.
- Places lane width reduction and widening transitions along the tangent between the curves and off the bridge.
  → Goal: reduce driver anxiety by separating tasks and also making the narrowing down of the lanes easier.



SB direction, TCB placement

- Relocate/realign the TCB beyond the bridge to follow the lane width transitions and to provide 2 ft of clearance where the 12 ft lane end and begin, upstream and downstream of the bridge, respectively.
  → Goal: provide room for the realignment and greater lane width through the curves.
- The TCB upstream will need to be shortened and the attenuator relocated.
  → This is due to the realignment of the TCB and to maintain construction access.

SB direction, Additional Delineation

W1-8L
Chevron (Left)

- Delineate the outside edge of the curve on the approach to the bridge beginning at the point of compound curvature. This can be accomplished with construction drums and chevrons (W1-8L).
  → Goal: (chevrons) highlight the change of the radius of the compound curve is tightening and (construction drums) to delineate the right edge line along the transition and then the TCB.

SB direction, Additional Notes

Notes about curve radii used

- Cross over standards (E 801-TCCO-01 → -03) are for speeds up to 55 MPH
- Cross over standards require an outside edge line radius of 1,345 ft.
- This recommendation provided outside edge line radii:
  - 2,012 ft upstream
  - 3,000 ft downstream.

Mitigate radius change (reduction) by:

- Addressing the speeding through additional upstream signage and enforcement
- Informing the motorist of the curve through signage and delineation
- Delineating the curve well, especially the point of compound curvature where the radius of the pre-construction curve becomes the tighter temporary curve.

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Bonus Material:

Construction Zone Design Speed and Speed Limits

Construction Zone Design Speed (CZDS)

- IDM 503-3.04(01)
- Speed for which MOT geometric elements are designed.
- Should desirably be the same as the Design Speed.
- Should not be arbitrarily reduced.
- If reduced, desirably, not by more than 10 MPH. (IMUTCD 6C.01)
- **Should match or exceed the posted speed limit in the work zone.**

CZDS ≥ WZSL

Speed Limits in Work Zones

When selecting a work zone speed limit, the selected CZDS should **not be exceeded**.

Consult District Traffic office when determining Construction Zone Design Speed and Speed Limit for the work zone.

NextLevel INDIANA

Speed Limits in Work Zones (briefly)

Speed Limits may be reduced in work zones via

- Official Action (not covered here)
- Worksite speed limit (CM 14-06 and next slides)

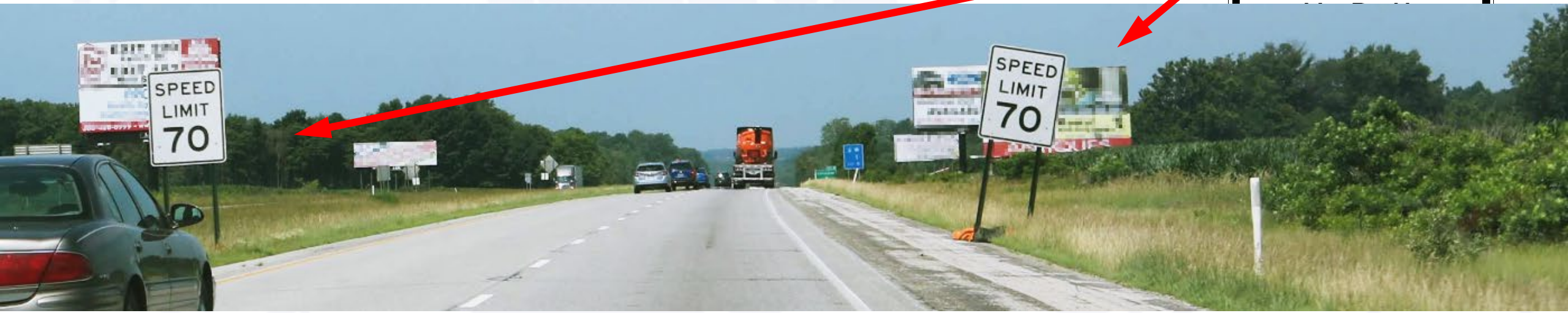
Temporary Worksite Speed Limit (TWSL) requirements:

- If reduced, Speed Limit MUST be reduced by at least 10 MPH [IC 9-21-5-11(b)]
- Reductions greater than 15 MPH MUST be done in 2 increments
- All TWSL Sign Assemblies (TWSLSA) must have the “WORKSITE” plaque
- TWSLSA’s required on both left and right sides if multiple lanes
- Provide TWSLSA’s at a maximum spacing of 2 mile intervals (ISP prefers 1 mi)

Speed Limits in Work Zones (briefly)

Temporary Worksite Speed Limit (TWSL) requirements (cont.):

- Reestablish the existing (established) speed limit by placing sign(s) 500 ft downstream of “END CONSTRUCTION” sign
- Reestablish the truck speed limit (65 MPH) for rural interstates



Speed Limits in Work Zones (briefly)

Continuous TWSL requirements:

- No warning lights or flashing strobes
- Cover or remove any conflicting speed limit signs within TWSL

Intermittent TWSL requirements:

- Must have Flashing Strobes and “WHEN FLASHING” plaque
- Place TWSLSAs by existing (established) speed limit signs or cover them

Combination Continuous + Intermittent TWSL requirements:

- The first 2 TWSLSA’s must be staged separately to have 2 steps: continuous first, then intermittent
- After first 2, downstream continuous and intermittent TWSLSA’s may be placed together

Speed Limits in Work Zones - References

- IDM 503-7.01(02) Regulatory Signing
- Construction Memo CM 14-06
- Standard Drawings E 801-TCDV-10, -11, -12
- Standard Specifications 801.15(c)
- IC 9-21-5 (Title 9 – Motor Vehicles;
  Article 21 – Traffic Regulation;
  Chapter 5 – Speed Limits)