State of California
DEPARTMENT OF TRANSPORTATION

California State Transportation Agency

Memorandum

Making Conservation a California Way of Life

To: DISTRICT DIRECTOR
DEPUTY DIRECTOR
DIVISION CHIEFS

Date: October 2, 2019

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Subject: **DESIGN INFORMATION BULLETIN 79-04**

Design Information Bulletin (DIB) 79 "Design Guidance and Standards for Major Pavement Roadway Rehabilitation Projects and Certain Other Non-Freeway Projects" has been updated to version 79-04 and is now available on the Division of Design DIB external website <https://dot.ca.gov/programs/design/design-information-bulletins-dibs>. This DIB is effective as of the date of this memorandum and is to be implemented with the procedures in the *Highway Design Manual Index 82.5* "Effective Date for Implementing Revisions to the Design Standards."

BACKGROUND

Federal regulations allow for projects to accomplish resurfacing, restoration and rehabilitation (3R) of the pavement and roadway. This work is not subject to the full design standards and policies as would be required for new construction. This work is prescribed to take place in such a manner that considers the traffic, safety, economic, physical, community, and environmental needs of the project. Since the issuance of the previous version of DIB 79, the California Department of Transportation (Caltrans) implemented various policy and procedural updates for district design delegation, traffic safety devices, complete streets, and asset management. Additionally, State law and policies have amended the process for management and selection of State Highway Operation and Protection Program (SHOPP) projects for Caltrans.

These updates are incorporated in this revision of major pavement rehabilitation guidance and is consistent with the current process for scoping SHOPP projects.

SUMMARY OF SIGNIFICANT CHANGES

- Consistent with the process for district design delegation and the involvement with headquarters and district/region personnel.
- Updated with the Manual for Assessing Safety Hardware (MASH) criteria.
- Included the Complete Streets concept and scoping requirements.
- Included the process for asset management and scoping.
- Process for applying design standards and guidance for design standard decision documents.
- Added glossary of abbreviations.

Project specific applicability and questions should be referred to the Project Delivery Coordinators or the District Pavement Program Advisors.

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DESIGN INFORMATION BULLETIN NUMBER 79-04

California Department of Transportation
Division of Design - Office of Standards and Procedures
Division of Maintenance - Pavement Program

Design Guidance and Standards
For
Major Pavement Roadway Rehabilitation Projects

[Pavement Focused (2R) and Resurfacing, Restoration, and Rehabilitation (3R) Projects]

And

Certain Other Non-Freeway Projects

[Storm Damage, Protective Betterment, Operational Improvement and Safety-funded Projects]

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1.0 Capital Pavement Improvements to the State Highway System

The focus of this Design Information Bulletin (DIB) is to provide guidance on design procedures and standards for roadway rehabilitation pavement anchor projects, both 2R and 3R, and to provide guidance on how to include safety enhancements and other upgrades in these projects. This DIB is also applicable for 2R or 3R level pavement work as a satellite asset when part of another major asset anchor project. This DIB supplements the highway design guidance and standards provided in the California Department of Transportation *Highway Design Manual (HDM)*. The standards established herein are communicated in the same manner as defined in Chapter 80 of the *HDM*. When this DIB is silent on a subject covered in the *HDM*, the design guidance in the *HDM* applies.

Segments of highway involving pavement reconstruction of the entire pavement cross section and geometric changes such as realignment or widening is required to follow new construction design guidance in the *HDM*. See *HDM Index 603.5* for additional information.

This DIB is not a textbook or a substitute for engineering knowledge, experience or judgment. Many of the instructions given herein are subject to amendment as conditions and experience may warrant. Unique situations may call for variation from the policies and procedures described in this document, subject to Division of Design or delegated approval, or such other approval as may be specifically provided for in the text.

Additional information regarding highway design for roadway rehabilitation projects can be found in the *American Association of State Highway and Transportation Officials* (AASHTO) *Roadside Design Guide* and AASHTO *"Highway Safety Design and Operations Guide - Chapter 4: "Rural Highways."* Copies of these publications can be ordered through the AASHTO website. Other resources that are available and should be reviewed include:

- *DIB 82: Pedestrian Accessibility Guidelines for Highway Projects;*
- *Storm Water Quality Handbook "Project Planning and Design Guide;"*
- *Traffic Safety Systems Guidance;*
- *California MUTCD;*
- *Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians,* issued 2010, which is available through the Headquarters Division of Traffic Operations;
- *HDM Pavement Engineering Chapters 600 through 670*;
- *Concrete Pavement Guide;* and the,
- *Life-Cycle Cost Analysis (LCCA) Procedures Manual.*
- *Project Development Procedures Manual (PDPM)*
- *District/Regional Design Directives (not to conflict with the guidance in this DIB)*

1.1 State Highway Operation and Protection Program (SHOPP) Roadway Rehabilitation Projects

A performance-based approach for identifying pavement projects was implemented beginning with the 2018 SHOPP that utilizes an asset management process required by state and federal regulation. This strategic and systematic process of operating, maintaining, and upgrading physical assets—e.g. pavement—effectively through their lifecycle focuses on business and engineering practices. Additionally, this process includes resource allocation and utilization developed as part of the *Transportation Asset Management Plan* (*TAMP*) adopted by the California Transportation Commission. The *TAMP* is operationalized through the *State Highway System Management Plan* (*SHSMP*) using California Transportation Commission adopted asset classes, performance measures and targets. The *SHSMP* guides the selection of projects for the SHOPP and sets performance targets for each roadway classification on the State Highway System (SHS). For purposes of this design bulletin, a performance driven process for identifying pavement projects is required. This process strives to effectively manage pavement with the most cost-effective strategies over the long term. In developing projects to improve pavement performance, other asset needs may also be combined into one project scope. These projects are defined as multi-objective projects.

Multi-objective projects provide numerous benefits through project delivery efficiencies, reduced impacts to system users, and asset life cycle optimization. Performance outcomes are maximized by applying asset management principles that emphasize improving and preserving physical assets, considering both engineering and economic principles, to achieve an agreed level of service or condition at a minimum practical cost.[1] A life cycle planning (LCP) approach is used to determine the optimum time to rehabilitate or replace an asset, or a combination of assets. LCP uses many of the same economic analysis principles as Life-Cycle Cost Analysis (LCCA) methods; however, LCP applies these at a network-level. For preservation, rehabilitation or reconstructive pavement projects, other performance objectives and assets should be considered within the project scope when similar asset life expectancies or safety benefits can be realized. These performance objectives and assets should be consistent with performance targets and Departmental goals if feasible, practical, and cost-effective. Key benefits of a multi-objective project scope are as follows:

- Maximizes efficiencies in project delivery by developing a project scope and schedule that leverages support costs and minimizes disruptions to the traveling public.
- Reduces user costs, mobilization, traffic control, and related construction costs resulting from combined work activities.
- Includes work with identified needs to achieve performance targets established in the Transportation Asset Management Plan, State Highway System Management Plan, CTC Guidance, and Federal regulations.

[1] FHWA publication Using a Life Cycle Planning Process to Support Asset Management dated November 2017. https://www.fhwa.dot.gov/asset/pubs/life_cycle_planning.pdf

- Minimizes life cycle costs, which could include considering longer-life strategies with higher initial cost or strategic combinations of different pavement treatments within the project limits. Strategy combinations that rehabilitate severely deteriorated lanes and maintain less deteriorated lanes or segments along the project length should be evaluated.

Optimizing asset repair or replacement timing can be determined by considering:

- Remaining service of the asset(s)
- Previous and future planned work along the corridor
- Life expectancy of the proposed treatments
- Associated costs

Additional resources and tools are available on Caltrans Pavement Management (PaveM) Portal website at https://maintenance.onramp.dot.ca.gov/pavemgmtperf/pavem-portal.

1.2 Project Development Guidance for 2R and 3R Pavement Projects

Chapter 9 of the *PDPM* describes the project development process for roadway pavement rehabilitation projects. This DIB should be used for major pavement rehabilitation projects including both pavement resurfacing and restoration (2R) and pavement resurfacing, restoration, and rehabilitation (3R). In addition, the publication entitled *Main Street, California, A Guide for Improving Community and Transportation Vitality* should be consulted for guidance during the scoping process. For further information see the Department Division of Design, Main Street California website at https://dot.ca.gov/programs/design/lap-landscape-architecture-and-community-livability/lap-main-street-california.

1.2.1 Purpose and Need

The purpose and need for 2R and 3R projects is to restore the facility to a state of good repair. See *HDM Topic 612* for further guidance on Department standards related to pavement design life. 2R Projects are to be programmed such that their primary goal is to extend the design life of the identified pavement structure; while 3R Projects, in addition to extending the design life of the pavement structure, also replace and upgrade other highway appurtenances and facilities within the project limits that are failing, worn out or functionally obsolete and beyond their service life. The 2R and 3R objective is combined with the Department's asset management goals to formulate multi-objective projects.

Typically, if pavement work is over 50% of a project scope, or constitutes most of the work among multiple assets, then it would generally be considered the anchor asset as long as it aligns with the purpose and need. Engineering judgment can also be used to determine the anchor if there are two or more assets that equally split the majority of work. Regardless of whether pavement is the anchor or satellite asset of a project, the condition of the existing pavement would determine whether a pavement project is warranted. For more on asset management of pavements, refer to the *State Highway System Management Plan*.

The development of the purpose and need of 2R and 3R projects is based on the appropriate strategy. Pavement rehabilitation strategies should be carefully analyzed before making a recommendation. When selecting major pavement rehabilitation (2R or 3R) strategies, consider:

- Pavement age, performance history, and design life requirements (see *HDM Topic 612*);
- Pavement smoothness and existing distress conditions;
- Minimizing maintenance effort and worker exposure;
- Consistency with adjacent corridor pavement type and service life;
- Long term corridor plans;
- Constructability;
- Traffic handling during construction; and,
- Cost-effectiveness (both initial and life cycle – see LCCA Procedures Manual and *HDM Topic 619*).

The determination of which highway guidance to implement, to proceed as either a 2R or 3R pavement project, is to be made after the Safety Screening has occurred and during the pre-PID phase; see Section 1.2.3 for further guidance.

1.2.2 Existing Pavement Conditions

Roadway rehabilitation projects vary in scope depending on the existing pavement type, distress conditions, project performance history, identified safety enhancements, and facility upgrades to other assets needed within the project limits. Accurately quantifying the project needs will determine whether the project scope is best suited for pavement preservation (HM-1), minor pavement rehabilitation (CAPM), or major pavement rehabilitation (2R or 3R). Pavement needs are generally described as follows:

- Pavement Preservation (HM-1 Program)
  Pavement preservation primarily consists of non-structural maintenance strategies funded under the HM-1 program to maintain existing pavement in good condition. Preservation is not addressed by this DIB; however, more information is available in *HDM Topic 612* and the annual Highway Maintenance Program Work Plan memorandum.

- Minor Pavement Rehabilitation (CAPM)
  Minor pavement rehabilitation (CAPM) is a planned pavement management strategy to make cost-effective repairs on existing roadways in generally fair condition with considerable remaining service life (15-30 years). Minor pavement rehabilitation is typically applied to moderately extensive existing structural distress to extend pavement service life about 5-10 years, before costlier major pavement rehabilitation is required. CAPM guidelines for minor pavement rehabilitation are addressed in *DIB 81*.

- Major Pavement Rehabilitation (2R/3R)
  Major pavement rehabilitation (2R and 3R) is a planned pavement management strategy to make major repairs on existing roadways in generally fair and poor condition at the end of their service life. Major pavement rehabilitation typically applies to segments with extensive existing structural distress and requires a comprehensive pavement structure design engineered for future traffic loading over a 20 or 40-year design life (refer to *HDM Chapter 610*).

Distress Criteria:
Major pavement rehabilitation treats pavement segments with:

- Alligator B cracking > 30%
- 3rd Stage cracking > 7% by lane requiring slab replacement[2]
- Faulting severity > 0.15" with extent > 25%
- MRI > 170 inches/mile[3]
- Other types of extensive minor concrete distress (non-structural cracking, spalling, settled corner cracks, etc.)

Concrete Pavement Criteria

[2] Project segments with a high number of previously replaced slabs should be deferred or planned as a 2R or 3R level project based on predicted condition in the RTL year. Refer to *Concrete Pavement Guide Chapters 320 and 400* for more detailed information.

[3] Grinding, grooving, or continuous profile grinding work should only be considered where MRI or faulting thresholds are met. Grinding individual slab replacements and existing areas of localized roughness can be considered.

For network-level project planning, pavement condition data from the PaveM Pavement Management System will help identify potential project locations based on structural and ride quality related distresses. However, at each level of project development, all network-level condition data should be verified and supplemented by field review and use of images and tools available online through the PaveM Portal website at https://maintenance.onramp.dot.ca.gov/paveprogram/pavement-smoothness.

Localized failures should be identified and pre-overlay repairs included in the scope of all pavement rehabilitation projects. Additional project-level information including testing data and materials analysis may be necessary to make pavement management decisions and develop designs, such as deflection studies during PA&ED for 2R or 3R projects with flexible pavement and inertial profile testing for pavement smoothness (IRI) during PS&E.

Communicate with the HQ Pavement Program advisor and District Maintenance Engineer throughout project development when analyzing distress condition data and evaluating alternative pavement strategies for the project. Refer to Section 2.0 for further guidance on scoping roadway pavement rehabilitation projects and the *PDPM* regarding the Scoping Team Review process, field reviews, deflection studies, and project delivery documentation. Refer to *HDM Topics 624, 625, 635, and 645* for further guidance on pavement strategies and design requirements.

1.2.3 Safety Screening to Identify 2R Pavement Guidance

Safety Screening to identify and analyze the collisions within the limits of all proposed roadway rehabilitation projects is required, regardless of highway type; see *HDM Index 62.3*. A review of collision data and other relevant information is required to determine if the highway segment in need of pavement repairs qualifies as a 2R project, or if it should be repaired and upgraded as a 3R

project. The District Traffic Operations will perform the Safety Screening prior to the initiation of the PID phase. The results of the Safety Screening, in addition to the results of the pavement condition analysis, will be used to determine and adequately define the scope of the project. The completed 2R Project Certification form, see Attachment 2, documents the safety screening that recommends a 2R project. Integrating targeted (e.g., addition of protection devices, such as Midwest Guardrail System) and cost-effective safety improvements (e.g., signing, striping) into 2R projects is an effective way for the Department to preserve both mobility and safety. District Traffic Safety can be contacted to obtain more details on the Safety Screening process and procedures.

If the Safety Screening determines that targeted and cost-effective traffic operation strategies are the only needed safety enhancements within the project limits, the project can be identified as a "pavement-focused" 2R project. If the Safety Screening results in the determination that more extensive safety work is required, which is beyond the targeted and cost-effective traffic operation strategies mentioned above, then the project will be identified as a 3R project. In either case, the scope of the project should incorporate the recommendations of the Safety Screening.

If during the Safety Screening, a safety issue is identified and recommended for corrective action, District Traffic Safety will consider initiating a separate safety improvement project. In most cases, safety enhancements incorporated into 2R and 3R projects are considered proactive safety measures.

For further information, please reference the "Safety Screening Procedures for 2R Projects" on the Division of Traffic Operations' website: https://traffic.onramp.dot.ca.gov/screening.

1.2.4 Alternative Countermeasures to Reconstruction for Safety Improvement

In some cases, reconstruction measures to enhance safety in a corridor are impractical. When that is the case for a given location or segment of highway, it is important to remember that there exists a broad range of alternative measures that can be used alone or in combination with others to improve the safety along an existing highway. The Headquarters Division of Traffic Operations Highway Safety Improvement Program website has additional guidance on countermeasures to reconstruction which provides a list of General Countermeasures for collision patterns and their probable cause that may aid designers. Table 1 in this DIB serves as a supplement to the Highway Safety Improvement Program guidance and provides a partial list of alternative countermeasures to reconstruction for various existing geometric conditions.

1.3 Applicability to Certain Other Types of Projects

Certain storm damage repair, protective betterment, operational improvement and safety-funded nonfreeway projects, as defined below, are to be designed using the geometric design guidance provided in Section 3.3 of this DIB:

- All projects costing less than the Minor A dollar limit (excluding the cost of Right of Way and Environmental Mitigation).

- Projects costing more than the Minor A dollar limit and do not involve extensive grading, paving, or retaining structures that are not spot locations.
- Projects that are considered "spot" improvements; typically, these projects can be up to approximately one-half mile in length. Examples of this type of work include storm damage repairs, curve improvements, adding turn pockets, miscellaneous pavement widening, culvert replacement, and rock slope protection.
- Permanent restoration projects, triggered due to fire, earthquake, slides or storm damage, that do not include structures such as walls or bridges, may be restored to the "condition" that existed prior to the damage.
- The 2R and 3R guidance in this DIB also applies to bridge deck rehabilitation projects funded from the Bridge Rehabilitation (20.xx.201.110) Program that necessitate the inclusion of improvements to the geometric features, and other improvements, in addition to the work being performed to restore the bridge deck.

TABLE 1
ALTERNATIVE COUNTERMEASURES TO RECONSTRUCTION

Existing Geometric Condition:	Alternate Countermeasure:
Narrow lanes and shoulders	♦ Pavement edge lines ♦ Raised pavement markers ♦ Recessed pavement markers in snow areas ♦ Post (roadside) delineators ♦ Rumble strips
Steep side slopes	♦ Shield with guardrail ♦ Roadside delineators
Roadside obstacles	♦ Remove or relocate obstacle ♦ Slope flattening (including ditches) ♦ Add breakaway hardware to obstacle ♦ Shield with guardrail ♦ Delineate
Narrow bridge	♦ Traffic control devices ♦ Approach guardrail ♦ Object markers ♦ Rumble strips placed on approaches
Poor sight distance at vertical crest	♦ Traffic control devices ♦ Fixed-object removal ♦ Relocate driveway or local road to a location with better sight distance ♦ Lighting
Sharp horizontal curve	♦ Traffic control & warning devices ♦ Add lighting ♦ Shoulder widening ♦ Appropriate superelevation ♦ Slope flattening ♦ Pavement antiskid treatment ♦ Obstacle removal ♦ Obstacle shielding
Various Intersection Issues	♦ Traffic control devices ♦ Traffic signalization (warrants must be met) ♦ Safety lighting ♦ Speed controls ♦ Add turn lanes ♦ Increase sight distance

1.4 Major Pavement Scoping (2R and 3R)

The scope of roadway pavement rehabilitation projects considers all modes of travel and the context of the facility being rehabilitated. Using a corridor management approach that considers

past project investments and performance, current needs, and future planned work will provide context to help frame project-level scoping decisions, such as selecting a design life and including satellite assets and facilities.

- 2R pavement-focused major rehabilitation projects can be pursued for roadway locations that meet the Safety Screening criteria described in Section 1.3.3. 2R projects include fewer assets and only require limited design documentation for standards that are affected by the project scope.
- 3R major pavement rehabilitation projects have a comprehensive scope, including upgrades to multiple facility assets with established needs. 3R projects require additional functional unit coordination and comprehensive design standard documentation for all existing and proposed nonstandard features.
- Life-cycle cost analysis must be performed for major pavement rehabilitation projects during the PID and PA&ED phases to assist the decision-making process and analyze potential pavement strategies within the project limits.

Major pavement rehabilitation (2R or 3R) projects may strategically use a combination of pavement strategy levels for segments with different pavement needs and varying distress conditions within the project limits. Examples of multiple pavement strategies in a single project scope include:

- Multi-lane concrete routes where outside lanes are completely replaced (major pavement rehabilitation (2R or 3R)), while inside lanes receive individual slab replacement (minor CAPM).
- Multi-lane asphalt concrete routes where inside lanes receive a seal coat or thinner overlay (pavement preservation) than outside lanes rehabilitated with a thicker cold plane and overlay (minor (CAPM) or major pavement rehabilitation (2R or 3R)).
- A project with a preservation or minor pavement rehabilitation (CAPM) strategy on a freeway ramp while addressing a major pavement rehabilitation strategy (2R) on the freeway mainline.
- Non-mainline pavement such as ramps, connectors, and shoulders with different repair needs at individual locations.
- Long corridor-based projects with variable existing pavement conditions.

There are many more possibilities beyond these scenarios. When a project consists of both major and minor pavement rehabilitation strategies, the applicable design guidance (*DIB 79* or *81*) for the project will correspond to the major or minor pavement rehabilitation strategy used in the longitudinal highway segment of the project. If both major and minor pavement rehabilitation strategies occur within the same longitudinal highway segment, the major pavement rehabilitation guidance in this DIB governs for those segments. Short segments for localized full-depth repairs or isolated features such as concrete bus pads, intersection approaches, ramp termini, etc. are not considered major pavement rehabilitation strategies.

Consult with the PD Coordinator as early as possible when considering more than one pavement strategy on a project and communicate with the HQ Pavement Program Advisor and District Maintenance Engineer throughout project development when analyzing distress condition data and evaluating alternative pavement strategies for the project. The Maintenance Supervisor for the project area should also be contacted for input on highway deficiencies and safety upgrades. Field Maintenance personnel are typically familiar with their highway system segments and can often suggest upgrades or identify often overlooked deficiencies such as drainage issues, localized pavement failures, collision locations, bicycle and pedestrian deficiencies, slope stability problems, maintenance pullout location needs, safety concerns, and other problematic issues.

If the identified upgrades or deficiencies are significant and most highway appurtenances are failing, worn out, functionally obsolete, require additional right of way, and have environmental considerations, the project should be pursued as a 3R project.

Refer to the *PDPM* for current Departmental requirements, practices, and procedures about project scoping and project delivery documentation. Refer to *HDM Topic 619* and the *LCCA Procedures Manual* for additional LCCA guidance. Contact the Project Delivery (PD) Coordinator for project- specific recommendations and questions about this guidance. See Attachment 1, Capital Pavement Improvements to the State Highway System, for further pavement project scoping information.

2.0 2R Pavement Projects

2.1 General Guidance

The previous guidance in Section 1.0 applicable to 2R projects applies in addition to the guidance in Section 2.0. 2R pavement rehabilitation strategies do not differ from those used on 3R projects. Additional guidance for 3R projects is in Section 3.0 of this DIB.

2.1.1 Pedestrian Accessibility and the Americans with Disabilities Act (ADA)

Pedestrian accessibility and compliance with the ADA are to be followed in accordance with *DIB 82* and *HDM Topic 105*. Upgrades and additions to pedestrian facilities must be considered on projects covered by this DIB. Federal and State law require the installation of curb ramps at intersections with curbs where they are absent. Pedestrian facilities that are altered must be upgraded to current ADA accessibility standards. If the project does not alter pedestrian facilities, consideration should still be given to upgrading the facilities, especially if pedestrian safety can be enhanced. Upgrades such as walkway (sidewalk) gap closures, pedestrian crossings, widening sidewalks to current standards, upgrading curb ramps to current standards, relocating path width obstructions, sidewalk cross slope, accessible driveways and the addition of other pedestrian facilities are to be evaluated and considered. Where pedestrians will use the shoulder in locations where sidewalks are not needed, see Section 2.1.9 of this DIB

for further guidance. Facilities near key destinations (i.e., school zones, rail grade crossings, parks, playgrounds, job centers, commercial areas, etc.) and other uses that have the potential to generate pedestrian activity are to be evaluated. The Departmental website, under Traffic Operations, should also be visited to obtain guidance in the *California Manual on Uniform Traffic Control Devices (California MUTCD)* and additional Departmental guidance on work zone requirements during construction related to pedestrians.

2.1.2 Bicyclist Accommodation

Bicyclist safety must be taken into consideration on all 2R projects. On 2R projects it may be appropriate to widen shoulders; see Section 2.1.9 of this DIB for further guidance. It may also be appropriate to add bike lane striping and signage, see *HDM Chapters 300 and 1000* for additional guidance. *HDM Index 301.2* should also be reviewed for guidance on bicycle lane widths when bicycle lanes are adjacent to on-street parallel vehicle parking to avoid conflicts between the parked vehicle doors, the bicyclists and the vehicles in the traveled way.

Additionally, see *HDM Chapter 1000* for further bicycle design criteria noting *HDM Indexes 1003.5(1) and 302.1* regarding surface quality and the use of rumble strips. Also see *HDM Index 1003.5(2)* for requirements pertaining to drainage inlet grates. Refer to the Traffic Operations and the Office Engineers websites for further guidance in Part 3 of the *California MUTCD* and the appropriate *Standard Plans* on rumble strips and their placement related to the needs of bicyclists. The Traffic Operations website also provides guidance on work zone requirements during construction related to the needs of bicyclists in the *California MUTCD* and related Departmental guidance.

2.1.3 Storm Water Management

Features required for compliance with the Caltrans National Pollutant Discharge Elimination System (NPDES) Permit / Storm Water Management Plan (SWMP) must be included in the scope of work for 2R projects. This not only involves the Best Management Practices (BMPs) required based on the work performed as part of the pavement repair strategies, plus any appurtenance and facility upgrades, but may also include BMPs for NPDES Permit compliance.

Contact the District Storm Water Coordinator for guidance on the current Caltrans NPDES Permit requirements and BMPs to include in the project. After consulting the District Storm Water Coordinator, consult with the District Maintenance Supervisor for the area to discuss the proposed BMPs and issues related to their maintenance.

2.1.4 Pavement Transitions

2.1.4.1 Vertical Drop-offs

Pavement edge drop-offs or ruts can develop at the edge of paved surfaces and must be analyzed for safety concerns. Consider adding tapered edges and shoulder backing, potentially reconstructing the embankment, or paving transitions to unpaved driveways to prevent pavement edge drop-offs from developing.

- A tapered edge is a sloped pavement edge that provides an opportunity for smooth reentry of vehicles that leave the pavement surface. Refer to *HDM Index 302.3* for further tapered edge guidance.
- Shoulder backing is a granular material used to provide edge support, protect the outside pavement edge from cracking, avoid pavement edge loss, and minimize edge drop-offs. Refer to *HDM Topic 672* for more information and the Pavement Program website for "Shoulder Backing" Pavement Tech Notes at https://maintenance.onramp.dot.ca.gov/downloads/maintenance/files/pave_program/docs/ShoulderBackingGuideline.pdf.

Longitudinal edge elevation differences along the finished grade of the pavement surface are problematic for bicycles and motorcycles and should be avoided. Driveways and intersections with public and private roads should be evaluated on a location-by-location basis and paved with transitions to prevent pavement edge drop-offs from developing.

Overlays (including Open Graded Friction Courses) must extend to the edge of paved shoulder. Refer to *HDM Index 635.2(1).*

2.1.4.2 Longitudinal Pavement Transition Tapers

Longitudinal pavement transition tapers provide a smooth vertical transition from one pavement type, overlay, or surface to another. *Standard Plan P30* details several pavement transition types, but project-specific construction details may be needed in some cases. Refer to the Pavement Tech Notes available online at the Pavement Program website for more information. at https://maintenance.onramp.dot.ca.gov/paveprogram/pavement-program.

2.1.4.3 Transverse Pavement Transition Tapers

Both JPCP and CRCP concrete pavement require special consideration of joint placement and paving widths at ramp transitions and lane drops. Refer to *Standard Plans P33, P34, and P35* for more details.

2.1.5 Pavement Smoothness

Pavement smoothness must be taken into consideration on all rehabilitation projects. Smooth roads improve highway safety, extend pavement life, and reduce greenhouse gases and vehicle user costs. Ride quality is quantified by International Roughness Index (IRI) in units of inches per mile, which is measured for each wheel path in a lane. The average IRI of both wheel paths in a lane is referred to as the Mean Roughness Index (MRI) and is measured annually on the State highway network by the Automated Pavement Condition Survey (APCS). For concrete pavement, faulting can also trigger a ride quality issue. For preliminary project planning purposes, network-level MRI and faulting data can be accessed for individual project segments online through the Pavement Condition Report tool on the PaveM Portal. See website at https://maintenance.onramp.dot.ca.gov/paveprogram/pavement-smoothness.

For developing detailed project-level pavement designs during PS&E, it may be necessary for district personnel to perform project specific inertial profile testing. Final pavement strategy selection may depend on analysis of MRI data for the existing roadway segment. Prepaving corrections may need to be considered for areas of localized roughness. In extreme cases, pavement removal and replacement may be required to correct smoothness. Other typical concrete pavement smoothness strategies include grinding, unbonded concrete overlay, and HMA overlay. Flexible pavement smoothness strategies include micromilling, cold planing, and thicker or multiple-lift HMA overlays. Refer to the Pavement Program website and *HDM Topics 610 through 670* for additional smoothness guidance.

2.1.6 Curbs and Dike

Curb and dike placement, removal, and replacement may be included. Curbs and dikes have safety implications and must be evaluated based upon *HDM Topic 303*. Current practice involves placing or replacing curb and dike only when necessary and after all safety aspects have been considered. Curb and dike that is currently nonstandard should be removed or replaced based on the guidance in *HDM Topic 303*, unless specific circumstances dictate otherwise. The District Hydraulics unit, District Landscape, and Maintenance Supervisor in the area of the project should review any design proposals that involve dike removal or placement to ensure that there are no impacts to an erodible slope. The designer should consult the District Traffic Safety Systems Coordinator when curbs or dikes are identified along guardrail end treatments and crash cushions, to determine if the curbs or dikes should be modified.

2.1.7 Drainage Facilities

Only drainage repairs for structural deficiencies and the restoration of function and capacities are to be included in 2R projects. The Maintenance Supervisor in the area of the project should be contacted to assist in identifying such drainage facility needs. District Maintenance should be contacted to have their culvert inspection crew(s) check all of the culverts to identify any structural deficiencies and possible need for replacement. Projects with extensive modifications to address or mitigate fish passage (e.g., grade control structures, step pools), will be identified as a 3R project.

2.1.8 Vertical Clearance at Structures

On 2R projects, improving nonstandard vertical clearance should be based on the Safety Screening. However, where existing vertical clearance does not meet the requirements stated in *HDM Index 309.2* and cannot be achieved by milling prior to overlaying the pavement, the removal and replacement of the existing pavement may be necessary.

2.1.9 Shoulders on and Connections to Conventional Highways

Shoulders are important for many functions and users. 2R projects on conventional highways should be brought to the attention of the District Design Liaison (DDL) as early as possible in the project development process to collaborate on the appropriate shoulder width(s) for the project. Shoulders on conventional highways may need to be widened in urbanized areas, suburban areas

with commercial and residential development adjacent to central business districts, and other locations where it is known or anticipated that shoulder usage by pedestrians and bicyclists is common. The DDL should also be made aware of the number and frequency of residential road and commercial connections to the conventional highway to determine if widening the existing shoulder is desirable.

2.1.10 Traffic Operation Strategies

Targeted and cost-effective traffic operation strategies such as roadside safety devices, signing, and striping to address correctable collision patterns should be included on 2R projects as needed. The Safety Screening completed by District Traffic Operations should be used to identify and determine what features are to be added to each 2R project.

2.1.10.1 Roadway Safety (Protection) Devices

The District Traffic Safety Systems Coordinator must be consulted regarding the application of and appropriate use of all roadway safety devices. Roadway safety devices typically include W-beam guardrail (MBGR and the Midwest Guardrail System), guardrail end treatments, crash cushions, median barrier, bridge rail, and bridge approach transition railing. The designer should contact their district Technical Liaison Engineer to assess the bridge rails in their project.

Roadway safety devices that do not meet the Manual for Assessing Safety Hardware 2016 (MASH 2016) criteria (or the latest crashworthiness criteria adopted by Caltrans) are to be identified during the project's Safety Screening and upgraded or replaced with MASH 2016 compliant devices. Refer to the Division of Traffic Operations MASH 2016 webpage for the latest MASH 2016 resources. Roadway safety devices and safety barriers may also require reconstruction when pavement overlays, shoulder backing, or slope changes necessitate adjusting their heights to meet the indicated tolerances in the *Traffic Safety Systems Guidance*. MBGR should be replaced with the Midwest Guardrail System. Consult with the District Traffic Safety Systems Coordinator to identify and discuss all of the roadway safety devices that may require an adjustment in height.

2.1.10.2 Traffic Signs and Delineation

Traffic signs and pavement markings within the project limits should be evaluated for replacement and/or upgrading. This evaluation should consider visibility performance, conformance with existing policies, appearance, and legibility for both day and night conditions. Refer to the HQ Division of Traffic Operations, Office of Traffic Engineering for current signs and pavement markings policy and guidance.

2.1.10.3 Shoulder and Centerline Rumble Strips

Shoulder and Centerline Rumble strips are an effective strategy in reducing run-off-road or cross centerline collisions. Rumble strips can be used adjacent to the outside lane and along the centerline of undivided highways, or adjacent to both inside and outside lanes of divided highways. Consideration should also be given to adding a centerline buffer zone with rumble strips on highway segments where collision data exhibits a high number of cross centerline

collisions. Consult with District Traffic regarding potential locations for installation of shoulder and centerline rumble strips. The Traffic Operations and the Office Engineers websites should be visited on the Department website to obtain further guidance in Part 3 of the *California MUTCD* and the appropriate *Standard Plans* on rumble strips.

2.1.11 All Other Highway Appurtenances and Design Features

The purpose of a 2R project is to focus on repairing the pavement to extend the service life of the facility. If the Safety Screening for the segment of highway under consideration as a 2R project indicates that the highway segment needs repairs and upgrading of its appurtenant facilities, the highway must be scoped as a 3R project. See Section 1.2.3 for further Safety Screening information. If this is the case for a proposed project, a decision will need to be made to either rescope or modify the project in some manner to conform to the 2R guidance in this DIB.

2.2 Documentation of Design Exceptions

The philosophy of 2R pavement projects is that the geometric features and the safety of the facility will not be degraded by the pavement strategy. If the Safety Screening concludes that a 2R project is appropriate, a design standard decision document is not required to document exceptions to both boldface and underlined standards of existing geometric design features. But, design standard decision documents for both boldface and underlined standards are required for all nonstandard geometric design features proposed by the addition of geometric features, using Section 3.0 of this DIB as applicable, with documentation included in the Project History File. All proposed nonstandard satellite asset features as well as newly proposed nonstandard features must be documented in a design standard decision document using the procedures in the *PDPM Chapter 21*.

Pavement designs for 2R projects must meet the requirements found in *HDM Chapters 600 through 670*.

Exceptions to Accessibility Design Standards on 2R projects are to be documented following the guidance provided in *DIB 82*.

3.0 3R Pavement Projects

3.1 3R Pavement Rehabilitation Strategies

Alternative pavement rehabilitation strategies should be carefully analyzed before making a recommendation. The strategies consistent with the project purpose and need is described in Section 1.2.1.

Pavement repair techniques and rehabilitation strategies should be developed in coordination with District Materials, District Maintenance, and the Pavement Program. Refer to the *HDM Pavement Engineering Chapters 600 through 670* and the Departmental Pavement website for additional pavement guidance and information. Exceptions to the pavement design standards in the *HDM* must be documented by a design standard decision document.

3.2 3R Project Scoping Guidance

The previous sections under 1.0 applicable to 3R projects apply. The guidance provided in Section 2.0 applies to 3R projects in addition to the guidance that follows.

3.2.1 General Guidance

3R projects differ from New Construction and Reconstruction projects in that they do not include capacity improvements, major highway realignments, or major upgrades to geometric features to meet current standards. The guidance provided for 2R projects in Section 2.1 of this DIB also applies to 3R projects except that the project "no longer qualifying as a 2R project" because the upgrades needed to eliminate the identified deficiencies are significant (e.g., most highway appurtenances are failing, worn out or functionally obsolete, work necessary to upgrade the geometric design features requires additional right of way, environmental impacts are encountered that require additional study), upgrades that are not appropriate for 3R projects may warrant the initiation and programming of a New Construction or Reconstruction project.

3.2.2 Pedestrian Accessibility and the Americans with Disabilities Act (ADA)

The guidance provided for 2R projects in Section 2.1.1 of this DIB also applies to 3R projects.

3.2.3 Bicyclist Accommodation

The guidance provided for 2R projects in Section 2.1.2 of this DIB also applies to 3R projects.

3.2.4 Storm Water Management

The guidance provided for 2R projects in Section 2.1.3 of this DIB also applies to 3R projects.

3.2.5 Pavement Transitions

The guidance provided for 2R projects in Sections 2.1.4.1, 2.1.4.2, and 2.1.4.3 of this DIB also applies to 3R projects.

3.2.6 Curbs and Dike

The guidance provided for 2R projects in Section 2.1.6 of this DIB also applies to 3R projects.

3.2.7 Drainage Facilities

On 3R projects, the guidance in *HDM Indexes 803.3 and 804.3* regarding the need for repair, replacement, and upgrading of existing drainage facilities applies. In addition, the Maintenance Supervisor in the area of the project should be contacted to assist in identifying the drainage facility needs. District Maintenance should be contacted to have their culvert inspection crew(s) check all of the culverts to identify any structural deficiencies and possible need for replacement.

Where shoulders carry roadway drainage, the hydraulic capacity should be verified. If the cross slope is modified, the designer should be aware that additional pavement thickness or cross slope modifications may require modifying drainage facilities such as dikes, inlets, and slotted pipe.

Drainage features can present clear recovery zone issues and should be evaluated for modification. Refer to the AASHTO *Roadside Design Guide* for further information on traversable drainage features. However, if traversable drainage features in the *Roadside Design Guide* are being considered for use, the District Hydraulics unit needs to be contacted to discuss their utilization.

3.2.8 Structures

3.2.8.1 Vertical Clearance

In addition to the guidance provided for 2R projects in Section 2.1.8 of this DIB and *HDM Index 309.2*, the following guidance also applies to 3R projects:

- Structures Maintenance must be contacted to determine the past history of structure "hits" to existing structures within the project limits. When it is proposed to reduce the existing vertical clearance of a structure, either temporarily or permanently, the Transportation Permits Region Manager must be contacted to determine the potential use of the roadway at the structure location by over-height and over-width permit loads.
- Milling, grinding, or replacing the existing pavement should always be considered to avoid reducing the vertical clearance. Raising the structure is another option that may be considered.
- The final decision should include consideration of adjacent structure clearances and the likelihood of over-height loads passing beneath the structure in question. Vertical clearance signs should be modified, as necessary.

3.2.8.2 Structural (Bridge) Capacity

Existing structures within the project limits may have inadequate load capacity to meet the Transportation Permits Program needs. Consequently, the Transportation Permits Region Manager should be contacted to determine the potential use of the facility by overweight vehicles and the impacts of any load-restricted bridges within the project limits. If a bridge is determined to require strengthening for loads, the bridge reconstruction work should normally be considered as a part of the project depending on district target levels and funding availability. Although strongly discouraged, under certain circumstances, structure reconstruction can be deferred to avoid delaying the overall project due to environmental and/or right of way clearance issues, structure design time constraints, etc. The guidance regarding the deferral of a structure widening provided in the *PDPM* may also be applied to the deferral of a structure replacement.

3.2.8.3 Bridge Rail and Other Structure Improvements

Departmental Policy (Structures Maintenance and Investigations Policy and Procedures Memo Number 2003.1) states that the upgrade of bridge rail classified as not meeting currently acceptable standards will be made on a Department-wide programmatic basis for all bridges on the State highway system. On 3R projects, bridge rail within the project limits that does not meet MASH 2016 criteria (or the latest crashworthiness criteria adopted by Caltrans) are to be identified

during the project's Safety Screening and considered for upgrading or replacing by the project depending on district target levels and funding availability. This need should be identified early on during the project development process when scoping the 3R project. The Office of Structure Design Technical Liaison Engineer should be contacted to discuss the need, if any, to upgrade the bridge rails within the project limits and any other structure improvements identified in the *Structures Replacement And Improvement Needs (STRAIN) Report*.

3.2.9 Maintenance

Maintenance vehicle pullouts should be placed upstream of recurrent work areas so the maintenance vehicles can shield the workers from errant vehicles. Similarly, it is appropriate to locate work areas downstream of large "fixed shields" such as structures, while keeping in mind sight distance for ingress/egress. The designer should look for opportunities to provide vehicle parking and access from adjacent parallel facilities (local roads) through use of gates and pathways. See *HDM Index 107.2* for further guidance on providing features that can enhance the personal safety of maintenance workers and law enforcement officers that work on the State highway system.

3.2.10 Traffic Operation Strategies

3.2.10.1 Roadway Safety (Protection) Devices

The guidance provided for 2R projects in Section 2.1.10.1 of this DIB also applies to 3R projects.

3.2.10.2 Signs and Delineation

All signs and pavement markings within the project limits should be evaluated for replacement and/or upgrading. This evaluation should consider visibility performance, conformance with existing policies, appearance, and legibility for both day and night conditions.

District Traffic should be contacted for guidance when additional signs, markings, or other traffic control devices are being considered as a possible mitigation for a nonstandard geometric feature or to address a safety issue.

Vertical Clearance signs and interchange exit numbers shall be installed or updated per the current policy in the CA MUTCD. Updated information regarding interchange exit numbers have been posted at: http://www.dot.ca.gov/trafficops/exit/.

3.2.10.3 Shoulder and Centerline Rumble Strips

The guidance provided for 2R projects in Section 2.1.10.3 of this DIB also applies to 3R projects.

3.2.11 Highway Appurtenances

The effects on accessibility, relating to both existing and proposed highway appurtenances, on all roadway users must be carefully reviewed and appropriately addressed.

Also, the need to adjust highway appurtenances such as object markers, sign supports, luminaries, irrigation systems, etc., should be reviewed for potential or known maintenance worker safety issues. Although the highway appurtenances will be analyzed during the Safety Screening for the

project, every functional unit, particularly Maintenance, should also evaluate them. See *HDM Index 210.6* for guidance regarding safety railing, fences, and concrete barriers that may be appropriate to include in the project. For additional guidance, see Section 3.3.3.6.3, Clear Recovery Zone, in this DIB.

3.2.12 Landscaping

Typically, projects covered under this DIB do not involve landscape work. However, there may be a need to replace existing landscaping due to construction activities. Consult with the District Landscape Architect regarding the Roadside Program and the need for replacement planting and/or other roadside features.

3.2.13 Pavement Smoothness

Pavement smoothness must be taken into consideration on all 3R projects. The guidance provided for 2R projects in Section 2.1.5 of this DIB also applies to 3R projects.

3.3 Geometric Design Guidance

3.3.1 Projects on Freeways, Expressways, and Multilane Conventional Highways

3R projects on freeways, expressways, and multilane conventional highways shall not degrade the safety or the geometric features of the facility. 3R projects on these facilities are required to meet the current geometric standards for new construction as stated in the *HDM* and the additional guidance that is provided in Section 3.3.2 of this DIB. Documentation of nonstandard geometric design features are applicable as would be for any new construction project. Any exceptions to boldface and underlined standards are to be documented per the instructions in the *PDPM Chapter 21*.

3.3.2 Additional Geometric Design Guidance for Projects on Freeways and Expressways

3.3.2.1 Cross Slope (Traveled Way)

To achieve an economy in materials and to minimize the impact on median facilities such as slotted drains, drainage inlets, and median barriers, it may be acceptable to reduce the thickness of the overlay on the inner lanes of the traveled way to the minimum thickness and cross-slope tolerances. Breaks or crowns in the resurfacing should occur at the lane lines, not in the wheel paths. However, before it is decided to reduce the thickness of the overlay and adjust the various cross slopes, the District Materials and Hydraulics units need to be consulted with to concur with these decisions.

In addition, on expressways and multilane conventional highways, where the existing traveled way cross slope exceeds the standard and it is not reasonable to adjust the existing curb, gutter, and sidewalk, milling or removal and replacement of the existing pavement may be necessary.

3.3.2.2 Ramps and Gore Areas

Removing or relocating fixed objects such as overhead signs, lighting, curbs, and existing crash cushions in the vicinity of on-ramp and off-ramp gores should be considered. A review should be made of the collision and maintenance history of "hits" into existing signs and crash cushions to determine the advisability of removing or relocating the signs and crash cushions. District Traffic and Maintenance should assist when performing this evaluation.

Gore curbs that are not in accordance with the guidance in *HDM Indexes 504.3(11) and 504.2(5), and Topic 303* should be removed. When the overlay thickness matches or exceeds the height of curb, it may be unnecessary to remove the curb pending an investigation for the need to convey runoff.

When rehabilitating ramps on the National Network or on Service Terminal Access routes, consideration should be given to modifying the ramps to accommodate Surface Transportation Assistance Act (STAA) of 1982 design vehicles. Consult with the District Truck Service Manager for routes on and connecting to National Network and Terminal Access routes. See *HDM Index 404.3* for further guidance on the use of truck turn templates.

Consideration should be given to paving areas that will reduce the maintenance worker's exposure to traffic and removing, or relocating, maintainable features such as: inlets, controller cabinets, ITS equipment, etc. See *HDM Chapter 500* for guidance related to gore paving. Contact the local area Maintenance Supervisor for assistance in determining these locations. Also see *HDM Index 706.1* for further guidance on roadside management of these areas.

3.3.2.3 Interchange Spacing

A design exception for interchange spacing as stated in *HDM Indexes 501.3 and 504.7* is not required unless the project involves a new interchange, or an interchange is being relocated. If the project involves a new or relocated interchange, *HDM Indexes 501.3 and 504.7* must be consulted.

3.3.3 Geometric Design Guidance for Two- and Three-Lane Conventional Highways

Federal Code, Title 23 CFR Section 625.2(b), states: "Resurfacing, restoration and rehabilitation (RRR) projects, other than those on the Interstate system and other freeways, shall be constructed in accordance with standards which preserve and extend the service life of highways and enhance highway safety." The following additional guidance applies to projects on two- and three-lane conventional highways.

3.3.3.1 Selection of Design Speed

The criteria for design speed discussed in *HDM Index 101.1* applies to projects on two- and three-lane conventional highways covered by this DIB. The DDL should be consulted regarding the design speed, and the design speed should be documented in the PID or PR.

3.3.3.2 Stopping Sight Distance at Grade Crests and Sags

The criteria for stopping sight distance at vertical curves in *HDM Indexes 201.1, 201.4, and 201.5* apply to projects covered by this DIB. The Safety Screening should also be used to identify and determine which, if any, grade crests or sags may warrant improvement. The vertical alignment within the limits of the project shall be evaluated for possible improvements at "spot" locations taking into consideration the collision data at the location. Performing this evaluation at all "spot" locations is not meant to imply that all of the vertical curves should be upgraded. District Traffic Operations should be consulted to assist with determining which vertical curves should be upgraded.

Particular attention should be given to crest vertical curves where the available sight distance corresponding to the design speed of the crest vertical curve is 20 mph or more below the 85th percentile speed of the section of highway preceding the curve; District Traffic Operations can assist in estimating the 85th percentile. Where this condition exists and the crest vertical curve conceals highway features such as intersections, driveways, horizontal curves, narrow bridges, at-grade railroad crossings, etc., consideration must be given to reconstructing these vertical curves or removing these features. If a crest vertical curve is not upgraded following the evaluation because reconstruction is not feasible, consider installing warning signs or using other mitigation strategies.

Sag vertical curves are rarely related to collisions because drivers have adequate sight distance during daylight hours, and at night the driver's range of sight is restricted to the vehicle's headlight limitations. If necessary, street lighting can be added to mitigate reduced stopping sight distance on sag vertical curves. Discussions should be held with District Electrical regarding the feasibility of lighting. Sag vertical curves can be slightly improved during overlays with little extra cost or impacts.

3.3.3.3 Superelevation

The criteria for superelevation contained in *HDM Index 202.2* apply to projects covered by this DIB. If nonstandard superelevation rates exist, they must be evaluated for possible improvement.

Superelevation improvements can often be attained inexpensively with minimal impact on overlay projects and should therefore be incorporated. Where as-built plans do not exist or no longer reflect the current conditions, a Digital Inclinometer (Smart Level) may be used to estimate the superelevation rate.

3.3.3.4 Horizontal Alignment

The criteria for horizontal alignment contained in *HDM Index 201.6 and Topic 203* apply to projects covered by this DIB. Horizontal alignments shall be evaluated for possible improvements at "spot" locations. The evaluation of horizontal curves must consider collision data. District Traffic Operations should assist when performing this evaluation. Typically, nonstandard horizontal curves requiring additional right of way and/or that result in significant environmental impacts are not upgraded without supporting collision data that justifies the additional costs or

impacts. Where the radius of a curve is less than 300 feet, with an interior angle greater than 60 degrees, consideration must be given to providing additional lane width to accommodate vehicle offtracking. See *HDM Topic 404 and Index 504.3(1)(b)* for more information and widening criteria.

Although individual horizontal and vertical curves may meet design criteria, their use in combination must be considered to avoid undesirable alignments. For example, the alignment of a segment of highway may consist of a series of curves. The first curve in this series, particularly if it follows a long tangent, must receive greater attention because, once a driver safely passes through it, the driver should be prepared for the subsequent curves in the series. To prepare a driver for a series of curves, the design speed of this first curve, especially if it follows a long tangent, should be at least equal to the design speed of the tangent section of highway leading into it; which is important because drivers tend to travel at higher speeds on tangent segments of highway. The other curves in the series should only differ from the design speed of the curve that follows or precedes it by 10 mph; which is the desired maximum reduction or increase in speed between curves in a series. Particular attention should also be given to any curve within a series of curves that has a significantly smaller radius than the other curves. If improvements are being considered at any of the curves in a series of curves, the effects of the proposed change(s) to an individual curve will need to also be evaluated on the entire series of curves. This particularly needs to be done to curves adjacent to the one being improved. The intended outcome from this analysis is to avoid "moving" a collision concentration from one curve in the series to another. See *HDM Index 203.3* for additional information regarding alignment consistency.

Also see *HDM Index 204.6* and the AASHTO document *A Policy on Geometric Design of Highways and Streets* for guidance of desirable and undesirable alignment combinations. The following should be considered when evaluating horizontal curves for improvements:

- Reconstruction with a larger horizontal radius.
- Correction or improvement of superelevation.
- Widening the shoulders.
- Installing rumble strips.
- Widening lanes or providing a buffer for truck offtracking.
- Flattening fill slopes that are 4:1 or steeper on the inside and outside of the curve. For slopes between 3:1 and 4:1, check for adequate run out distance. See the AASHTO *Roadside Design Guide* for methods of determining the run out distance.
- Installation of roadside barrier. See the *Traffic Safety Systems Guidance* on the Department website, under Division of Traffic Operations, and discuss with the District Traffic Operations personnel for guidance.
- Permanently removing vegetation or cutting back slopes to provide a "sight bench" at locations where the stopping sight distance is reduced by vegetation growth or cut sections.
- Consult with District Traffic Operations about adding signs, delineation, and/or markers to mitigate operational deficiencies.
- Add lighting.
- Move intersections outside of curves.

3.3.3.5 Intersections (Public and Private Connections) and Driveways

3.3.3.5.1 General

Road connections (both public and private) and driveways must be evaluated for possible improvements. The decision to improve intersections can often be made by observing vehicle, bicycle, and pedestrian movements during field visits. *DIB 82* and *HDM Topic 105* should be reviewed for pedestrian accessibility and compliance with the ADA.

The use of traffic islands can be effective in channelizing vehicles and providing pedestrian refuge islands. See the *HDM Index 405.4* for more information.

3R projects also present an opportunity for driveway upgrades. Contact the District Encroachment Permits office to see if there are issues with any existing driveways that may need to be addressed.

To facilitate movements in and out of driveways and local streets, connections should be paved to the edge of the right of way or far enough beyond the right of way line so that the rear drive wheels of longer vehicles can accelerate on a paved surface. This is to prevent vehicle wheels from spinning while attempting to enter the highway. It also serves to prevent rock and debris from collecting on the mainline shoulder, which can be an issue for both bicycles and pedestrians.

HDM Topic 205, *HDM Indexes 405.7, 405.8, and 405.9* provide further guidance on the design of public road intersections and driveways.

3.3.3.5.2 Corner Sight Distance

The corner sight distance guidance in *HDM* Index *405.1* applies to 3R projects, except the corner sight distance should equal the stopping sight distance. All intersections shall be evaluated for possible improvements. The evaluation of corner sight distance must consider collision data. District Traffic should assist when performing this evaluation. It is often difficult to obtain corner sight distance per *HDM Index 405.1* at all intersections, but that does not preclude the need to evaluate cost effective solutions (e.g., those that do not physically impact homes, businesses, historic buildings, large natural land features) at each location.

3.3.3.5.3 Left- and Right-Turn Channelization

Left- and/or right-turn channelization should be considered at intersections to public roads and other potential higher volume intersections.

Consult with both District Traffic Operations and Traffic Safety when establishing the need for turn channelization. See *HDM Indexes 405.2 and 405.3* for further geometric guidance on right- and left-turn channelization. Also see *Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians,* issued 2010, which is available through Headquarters Division of Traffic Operations.

3.3.3.5.4 Skew Angle

The criteria pertaining to intersection skew in *HDM Index 403.3* applies and should be reviewed. The Safety Screening should also be used to identify and determine which, if any, skewed intersections may warrant realignment. Skew angles less than 75 degrees must be investigated for potential upgrades. If realigning the local street will require a large expense of funds and right of way impacts are significant, an intersection is typically not modified.

Skewed "T" intersections are typically easier to upgrade than through streets because they impact only one side of the highway. Small radius curves can be added on the cross street because speeds on the cross street are typically low due to the stopped condition. When "T" intersections cannot be upgraded without extensive realignments, improvements may be accomplished by minor widening at the curb returns and the striping realigned to an angle closer to perpendicular; see Section 3.3.3.5.5, "Truck Turning," in this DIB for issues related to pedestrian movements when increasing the curb return radii. Also see *HDM Index 403.3* for additional discussion on the angle of intersections.

3.3.3.5.5 Truck Turning

The criteria for truck turning in *HDM Index 404.3* apply to these projects. Intersections experiencing frequent truck use should be evaluated to accommodate truck offtracking. See *HDM Topic 404* and *HDM Index 405.8* for further information on designing for offtracking. Designers should inspect the ground adjacent to intersection curb returns for physical evidence of vehicle offtracking, which can identify those locations most in need of upgrades.

It is often impractical to provide for truck turning on most local streets due to the infrequency of truck use at these locations. Where truck volumes are low, bus turning may be a more appropriate application, especially if it is a school bus or transit route. There are several factors affecting the decision to increase the curb return radii at these locations:

- Large curb return radii could promote higher than desirable speeds for motor vehicles making right turn moves.
- Assure trucks and buses will off-track into same direction lanes and shoulders of the receiving roadway and not intrude upon the lanes in the opposite direction of travel.
- Pedestrian crossings will become longer; therefore, the additional length of the pedestrian crossings and its impacts to wheelchair ramp placement (see *DIB 82* for additional guidance on ADA design issues) will need to be evaluated.
- Pedestrians waiting to cross are set further from turning vehicles, which might place pedestrians out of the field of vision of the driver.
- Impacts to adjacent property and right of way cost.

3.3.3.6 Cross Section Design Elements

3.3.3.6.1 Widths

3.3.3.6.1.1 Traveled Way

All lane widths for projects covered by this DIB shall be 12 feet except as follows:
Lane width standards are specified in *HDM Indexes 301.1, 405.2, 405.3, and 504.3(1)(b)* The lower speeds in the left- and right-turn lanes make it reasonable to use narrower widths in urban areas. As an order of importance, the right-turn lane is typically reduced first because the left-turn lane is adjacent to oncoming traffic. Truck turning can be an important factor when reducing lane widths under these conditions. A truck usage study and turning analysis must be applied to each location where turning lane widths are reduced. Further reductions in right-turn lane width to 10 feet are sometimes warranted in severely constrained situations. Deviation from standard will be recorded in a design standard decision document.

See Section 3.3.3.4 of this DIB for guidance on lane widening to accommodate truck offtracking on radii less than 300 feet.

3.3.3.6.1.2 Shoulders

3.3.3.6.1.2.1 Roadbed

The shoulder widths given in Table 2 shall be the minimum paved shoulder width for two-lane conventional highway projects covered by this DIB. Shoulders less than the "Minimum Existing In-Place Shoulder Width" shall be widened to the "3R Shoulder Width." Shoulders at or above the "Minimum Existing In-Place Shoulder Width" may be rehabilitated at their existing widths, including minor widening for lateral support or uniformity of pavement width, **unless pavement widening or realignment is performed, then the 3R shoulder width criteria applies. If the Safety Screening recommends widening beyond the "Minimum Existing In-Place Shoulder Width," the roadbed shall be widened to the "3R Shoulder Width" or the "3R Bridge Shoulder Width,"** as appropriate.

Shoulders are important for many functions and users. The minimum usable shoulder for bicycles and pedestrians is 4 feet, but wider shoulders may be more appropriate. Wider shoulders should be considered on highways with higher vehicular volumes and speeds.

The truck, bus and recreational vehicle usage on the highway should be taken into account when determining shoulder widths. When truck, bus and/or recreational vehicle volumes are generally higher than 10%, particularly on curvilinear highways, shoulder widths greater than those in Table 2 should be considered.

When adding passing or climbing lanes or right-turn lanes, the minimum width of the adjacent shoulder shall be 4 feet.

Where a left-turn lane is provided and a right-turn lane is not, the right shoulder width shall be the "3R shoulder width" as provided in Table 2, but not less than 4 feet (5 feet where a gutter is present). The minimum right shoulder width adjacent to right-turn pockets shall be 4 feet (5 feet where a gutter is present).

TABLE 2
Two-Lane Conventional Highway 3R Standards for Shoulder Widths

Existing ADT (vehicles)	3R Bridge Shoulder Width (ft)	3R Shoulder Width (ft)	Minimum Existing In-Place Bridge Shoulder Width (ft)	Minimum Existing In-Place Shoulder Width (ft)
0-250	4	0*	0	0
251-1,000	4	2*	2	0
1,001-3,000	8	4*	4	2
3,001-6,000	8	8	6	4
6,001-18,000	8	8	8	4
Over 18,000	8	8	8	8

*** See discussion in Section 3.3.3.6.1.2.1, "Roadbed." Under certain conditions, the minimum width of the adjacent right shoulder shall be 4 feet, or 5 feet where a gutter is present.**

3.3.3.6.1.2.2 Bridges

The bridge shoulder widths given in Table 2 shall be the minimum paved bridge shoulder for two-lane conventional highway projects covered by this DIB. The structure clear width (width between curbs or rails, whichever is less) shall equal or exceed the approach roadbed width. Shoulders less than the "Minimum Existing In-Place Bridge Shoulder Width" shall be widened to the "3R Bridge Shoulder Width." Bridge shoulders at or above the "Minimum Existing In-Place Bridge Shoulder Width" may be rehabilitated at their existing widths.

Upgrading existing bridge rail, approach guardrail, and guardrail transition railing connections is to be included in the project regardless of the bridge shoulder width requirements discussed above. **If bridge rail is being replaced, the shoulders shall be widened to the bridge 3R shoulder width.** The Headquarters Bridge Preservation Program Manager must be consulted in determining if a bridge rail type requires upgrading.

Bridge replacement strategies shall meet new construction standards.

3.3.3.6.2 Cross Slopes

3.3.3.6.2.1 Traveled Way
The criteria in *HDM Index 301.3* apply.

3.3.3.6.2.2 Shoulders
The shoulder cross-slope criteria contained in *HDM Indexes 302.2 and 307.2* also apply, except as follows: **On tangent sections of conventional urban highways with operating speeds of less than or equal to 45 mph and where it is necessary to match existing curb and gutter, the maximum shoulder cross slope shall be 8% except when snow and ice conditions prevail.** Locations with snow and ice removal operations are to follow the guidance in *HDM Index 302.2 (3)*.

When shoulder widths are 2 feet or less, shoulder cross slopes shall match the traveled way cross slope, but may be increased to 9% if necessary for drainage.

When curb ramps are present, shoulder cross slopes greater than 5% may exceed ADA standards. See *DIB 82* for further guidance regarding compliance with the ADA.

Where shoulder cross slopes do not meet the above criteria and it is not reasonable to adjust existing curb, gutter and sidewalk, grinding or removal and replacement of the pavement may be necessary. Each project must be evaluated on an individual basis. Where shoulders carry roadway drainage, the hydraulic capacity of the shoulder should be verified.

See *HDM Indexes 301.3 and 302.2* for the maximum grade break between edge of traveled way and shoulder cross slopes.

3.3.3.6.3 Clear Recovery Zone (CRZ)
The horizontal clearance criteria in *HDM Index 309.1* apply to these projects with the exception of the following: It is not the intent to flatten all of the side slopes within the project limits. Typically, existing side slopes are not flattened unless the project incorporates grading on a slope, or there are CRZ concerns identified in the Safety Screening. When widening or modifying existing embankment slopes, 4:1 or flatter side slopes should be used. Although cut slopes represent a form of fixed object and should also be 4:1 or flatter, less emphasis is placed on them. In any case, slopes should be designed as flat as is reasonable. Slopes steeper than 4:1 may require special erosion control features as described in the *Storm Water Quality Handbook, "Project Planning and Design Guide" (PPDG)*. See *HDM Topic 304* and the *Traffic Safety System Guidance,* on the Headquarters Division of Traffic Operations website, for further guidance on side slopes and their relation to the CRZ and placement of roadside safety devices at the top of embankment slopes.

The Safety Screening process will look at the CRZ associated with the segment of highway being evaluated. The absence of collisions should not be used as a reason to not include CRZ strategies

in the scope of a project. Improving the CRZ is an effective proactive measure in reducing the occurrence or severity of run off-road collisions along corridors. Refer to Table 1 for alternative countermeasures regarding roadside obstacles.

The AASHTO publication *Roadside Design Guide* provides detailed design guidance for creating a forgiving roadside environment. Also, see the *Traffic Safety Systems Guidance,* on the Headquarters Division of Traffic Operations website.

3.3.3.6.4 Side Slopes

The following geometric design standard from *HDM Topic 304* is permissive for two- and three-lane conventional highway projects:

> In projects involving grading where slopes catch in a distance less than 18 feet from the edge of the shoulder, a uniform catch point, at least 18 feet from the edge of the shoulder, should be used.

This should be done not only to improve errant vehicle recovery and aesthetics, but also to promote the use of large production grading equipment, which can reduce the construction costs associated with grading on the project.

4.0 Glossary of Abbreviations

2R	Resurfacing and restoration (also known as Pavement Focused)
3R	Resurfacing, restoration and rehabilitation
AASHTO	American Association of State Highway Transportation Officials
ADA	Americans with Disabilities Act of 1990
APCS	Automated Pavement Condition Survey
BMP	Best Management Practices
CAPM	Capital Preventive Maintenance
CPG	Concrete Pavement Guide
CRCP	Continuously reinforced concrete pavement
CRZ	Clear recovery zone
CTC	California Transportation Commission
DDL	District Design Liaison
DIB	Design Information Bulletin (current version)
FHWA	Federal Highway Administration
HDM	Highway Design Manual
HM	Highway Maintenance
HMA	Hot mixed asphalt
IRI	International roughness index
JPCP	Jointed plain concrete pavement
LCCA	Life-Cycle Cost Analysis
LCP	Life Cycle Planning
MASH	Manual for Assessing Safety Hardware
MBGR	Metal beam guardrail

MRI	Mean Roughness Index
MUTCD	Manual on Uniform Traffic Control Devices
NPDES	National Pollutant Discharge Elimination System
PA&ED	Project approval and environmental document
PaveM	Pavement Management
PD	Project Delivery
PDPM	Project Develop Procedures Manual
PID	Project Initiation Document
PPDG	Project Planning and Design Guide
PS&E	Plans, Specifications and Estimates
RTL	Ready-to-List
RRR	Resurfacing, restoration and rehabilitation
SHOPP	State Highway Operation and Protection Program
SHS	State Highway System
SHSMP	State Highway System Management Plan
STAA	Surface Transportation Assistance Act
STRAIN	Structures Replacement And Improvement Needs
SWMP	Storm Water Management Plan
TAMP	Transportation Asset Management Plan