Table of Contents

CHAPTER 10 – DIVISION OF DESIGN 10-1
Topic 11 – Organization and Functions 10-1
Index 11.1 – Organization 10-1

CHAPTER 20 – DESIGNATION OF HIGHWAY ROUTES 20-1
Topic 21 – Highway Route Numbers 20-1
Index 21.1 – Legislative Route Numbers and Descriptions 20-1
21.2 Sign Route Numbers 20-1

CHAPTER 40 – FEDERAL-AID 40-1
Topic 41 – Enabling Legislation 40-1
Index 41.1 – General 40-1
Topic 42 – Federal-Aid System 40-1
42.1 National Highway System 40-1
42.2 Interstate 40-1
Topic 43 – Federal-Aid Programs 40-2
43.1 Surface Transportation Program (STP) 40-2
43.2 California Stewardship and Oversight Agreement with FHWA 40-2
43.3 Congestion Mitigation and Air Quality Improvement Program (CMAQ) 40-2
43.4 Bridge Replacement and Rehabilitation Program 40-3
43.5 Federal Lands Program 40-3
43.6 Highway Safety Improvement Program 40-3
43.7 Special Programs 40-3
Topic 44 – Funding Determination 40-3
44.1 Funding Eligibility 40-3
44.2 Federal Participation Ratio 40-4
44.3 Emergency Relief 40-4

CHAPTER 60 – NOMENCLATURE 60-1
Topic 61 – Abbreviations 60-1
Index 61.1 – Official Names 60-1

Topic 62 – Definitions 60-1
62.1 Geometric Cross Section 60-1
62.2 Highway Structures 60-3
62.3 Highway Types 60-5
62.4 Interchanges and Intersections at Grade 60-6
62.5 Landscape Architecture 60-8
62.6 Right of Way 60-8
62.7 Pavement 60-9
62.8 Highway Operations 60-13
62.9 Drainage 60-15
62.10 Users 60-15

CHAPTER 80 – APPLICATION OF DESIGN STANDARDS 80-1
Topic 81 – Project Development Overview 80-1
Index 81.1 – Philosophy 80-1
81.2 Highway Context 80-1
81.3 Place Types 80-2
81.4 Type of Highway 80-5
81.5 Access Control 80-6
81.6 Design Standards and Highway Context 80-6
Topic 82 – Application of Standards 80-6
82.1 Highway Design Manual Standards 80-6
82.2 Approvals for Nonstandard Design 80-9
82.3 FHWA and AASHTO Standards and Policies 80-10
82.4 Mandatory Procedural Requirements 80-10
82.5 Effective Date for Implementing Revisions to Design Standards 80-10
82.6 Design Information Bulletins and Other Caltrans Publications 80-11
82.7 Traffic Engineering 80-11

CHAPTER 100 – BASIC DESIGN POLICIES 100-1
Topic 101 – Design Speed 100-1
Index 101.1 – Highway Design Speed 100-1

101.2 Highway Design Speed Standards 100-3
Topic 102 – Design Capacity & Level of Service 100-4
102.1 Design Capacity (Automobiles) 100-4
102.2 Design Capacity and Quality of Service (Pedestrians and Bicycles) 100-5
Topic 103 – Design Designation 100-5
103.1 Relation to Design 100-5
103.2 Design Period 100-6
Topic 104 – Control of Access 100-6
104.1 General Policy 100-6
104.2 Access Openings 100-6
104.3 Frontage Roads 100-7
104.4 Protection of Access Rights 100-8
104.5 Relation of Access Opening to a Median Opening 100-8
104.6 Maintaining Local Community Access 100-8
104.7 Cross References 100-8
Topic 105 – Pedestrian Facilities 100-8
105.1 General Policy 100-8
105.2 Sidewalks and Walkways 100-9
105.3 Pedestrian Grade Separations 100-11
105.4 Accessibility Requirements 100-12
105.5 Guidelines for the Location and Design of Curb Ramps 100-13
105.6 Pedestrian Crossings 100-14
Topic 106 – Stage Construction and Utilization of Local Roads 100-14
106.1 Stage Construction 100-14
106.2 Utilization of Local Roads 100-16
Topic 107 – Roadside Installations 100-17
107.1 Roadway Connections 100-17
107.2 Maintenance and Police Facilities on Freeways 100-17
107.3 Location of Border Inspection Stations 100-18
Topic 108 – Coordination With Other Agencies 100-18
108.1 Divided Nonfreeway Facilities 100-18
108.2 Transit Loading Facilities 100-19

108.3 Commuter and Light Rail Facilities Within State Right of Way 100-21
108.4 Bus Loading Facilities 100-22
108.5 Bus Rapid Transit 100-22
108.6 High-Occupancy Toll and Express Toll Lanes 100-23
108.7 Coordination with the FHWA 100-23
Topic 109 – Scenic Values in Planning and Design 100-24
109.1 Basic Precepts 100-24
109.2 Design Speed 100-24
109.3 Aesthetic Factors 100-24
Topic 110 – Special Considerations 100-25
110.1 Design for Overloaded Material Hauling Equipment 100-25
110.2 Control of Water Pollution 100-26
110.3 Control of Air Pollution 100-31
110.4 Wetlands Protection 100-32
110.5 Control of Noxious Weeds - Exotic and Invasive Species 100-33
110.6 Earthquake Consideration 100-33
110.7 Traffic Control Plans 100-34
110.8 Safety Reviews 100-36
110.9 Value Analysis 100-38
110.10 Proprietary Items 100-38
110.11 Conservation of Materials and Energy 100-39
110.12 Tunnel Safety Orders 100-41
Topic 111 – Material Sites and Disposal Sites 100-45
111.1 General Policy 100-45
111.2 Investigation of Local Materials Sources 100-46
111.3 Materials Information Furnished to Prospective Bidders 100-47
111.4 Materials Arrangements 100-48
111.5 Procedures for Acquisition of Material Sites and Disposal Sites 100-48
111.6 Mandatory Material Sites and Disposal Sites on Federal-aid Projects 100-50
Topic 112 – Contractor's Yard and Plant Sites 100-50
112.1 Policy 100-50
112.2 Locating a Site 100-51

Topic 113 – Geotechnical Design Report 100-51
113.1 Policy 100-51
113.2 Content 100-51
113.3 Submittal and Review 100-51
Topic 114 – Materials Report 100-52
114.1 Policy 100-52
114.2 Requesting Materials Report(s) 100-52
114.3 Content 100-53
114.4 Preliminary Materials Report 100-53
114.5 Review and Retention of Records 100-54
Topic 115 – Designing for Bicycle Traffic 100-54
115.1 General 100-54
Topic 116 – Bicyclists and Pedestrians on Freeways 100-55
116.1 General 100-55

CHAPTER 200 – GEOMETRIC DESIGN AND STRUCTURE STANDARDS 200-1
Topic 201 – Sight Distance 200-1
Index 201.1 – General 200-1
201.2 Passing Sight Distance 200-1
201.3 Stopping Sight Distance 200-3
201.4 Stopping Sight Distance at Grade Crests 200-3
201.5 Stopping Sight Distance at Grade Sags 200-3
201.6 Stopping Sight Distance on Horizontal Curves 200-4
201.7 Decision Sight Distance 200-4
Topic 202 – Superelevation 200-5
202.1 Basic Criteria 200-5
202.2 Standards for Superelevation 200-10
202.3 Restrictive Conditions 200-12
202.4 Axis of Rotation 200-12
202.5 Superelevation Transition 200-19
202.6 Superelevation of Compound Curves 200-22
202.7 Superelevation on City Streets and County Roads 200-22

Topic 203 – Horizontal Alignment 200-22
203.1 General Controls 200-22
203.2 Standards for Curvature 200-24
203.3 Alignment Consistency 200-24
203.4 Curve Length and Central Angle 200-24
203.5 Compound Curves 200-25
203.6 Reversing Curves 200-25
203.7 Broken Back Curves 200-25
203.8 Spiral Transition 200-25
203.9 Alignment at Bridges 200-25
Topic 204 – Grade 200-26
204.1 General Controls 200-26
204.2 Position With Respect to Cross Section 200-26
204.3 Standards for Grade 200-27
204.4 Vertical Curves 200-27
204.5 Sustained Grades 200-29
204.6 Coordination of Horizontal and Vertical Alignment 200-31
204.7 Separate Grade Lines 200-31
204.8 Grade Line of Structures 200-32
Topic 205 – Road Connections and Driveways 200-35
205.1 Access Openings on Expressways 200-35
205.2 Private Road Connections 200-35
205.3 Urban Driveways 200-36
205.4 Driveways on Frontage Roads and in Rural Areas 200-37
205.5 Financial Responsibility 200-38
Topic 206 – Pavement Transitions 200-38
206.1 General Transition Standards 200-38
206.2 Pavement Widenings 200-38
206.3 Pavement Reductions 200-40
206.4 Temporary Freeway Transitions 200-40
Topic 207 – Airway-Highway Clearances 200-40
207.1 Introduction 200-40

207.2 Clearances 200-41
207.3 Submittal of Airway-Highway Clearance Data 200-41
Topic 208 – Bridges, Grade Separation Structures, and Structure Approach Embankment 200-46
208.1 Bridge Lane and Shoulder Width 200-46
208.2 Cross Slope 200-48
208.3 Median 200-48
208.4 Bridge Sidewalks 200-48
208.5 Open End Structures 200-48
208.6 Bicycle and Pedestrian Overcrossings and Undercrossings 200-48
208.7 Equestrian Undercrossings and Overcrossings 200-49
208.8 Cattle Passes, Equipment, and Deer Crossings 200-49
208.9 Railroad Underpasses and Overheads 200-49
208.10 Bridge Barriers and Railings 200-50
208.11 Structure Approach Embankment 200-55
Topic 209 – Structure Approach Slabs 200-59
209.1 Purpose and Application 200-59
209.2 General Considerations 200-59
209.3 Structural Approach System Drainage 200-61
209.4 Structure Approach Slab Rehabilitation Considerations 200-61
Topic 210 – Reinforced Earth Slopes and Earth Retaining Systems 200-63
210.1 Introduction 200-63
210.2 Construction Methods and Types 200-64
210.3 Alternative Earth Retaining Systems (AERS) 200-70
210.4 Value Engineering Change Proposal (VECP) 200-71
210.5 Aesthetic Consideration 200-72
210.6 Safety Railing, Fences, and Concrete Barriers 200-72
210.7 Design Responsibility 200-73
210.8 Guidelines for Type Selection and Plan Preparation 200-73

CHAPTER 300 – GEOMETRIC CROSS SECTION 300-1
Topic 301 – Traveled Way Standards 300-1

Index 301.1 – Lane Width 300-1
301.2 Class II Bikeway (Bike Lane) Lane Width 300-1
301.3 Cross Slopes 300-4
Topic 302 – Highway Shoulder Standards 300-5
302.1 Width 300-5
302.2 Cross Slopes 300-5
302.3 Tapered Edge 300-7
Topic 303 – Curbs, Dikes, and Side Gutters 300-8
303.1 General Policy 300-8
303.2 Curb Types and Uses 300-9
303.3 Dike Types and Uses 300-11
303.4 Curb Extensions 300-13
303.5 Position of Curbs and Dikes 300-16
303.6 Curbs and Dikes on Frontage Roads and Streets 300-17
Topic 304 – Side Slopes 300-17
304.1 Side Slope Standards 300-17
304.2 Clearance From Slope to Right of Way Line 300-19
304.3 Slope Benches and Cut Widening 300-19
304.4 Contour Grading and Slope Rounding 300-19
304.5 Stepped Slopes 300-20
Topic 305 – Median Standards 300-21
305.1 Width 300-21
305.2 Median Cross Slopes 300-23
305.3 Median Barriers 300-23
305.4 Median Curbs 300-23
305.5 Paved Medians 300-23
305.6 Separate Roadways 300-24
Topic 306 – Right of Way 300-24
306.1 General Standards 300-24
306.2 Right of Way Through the Public Domain 300-24
Topic 307 – Cross Sections for State Highways 300-24
307.1 Cross Section Selection 300-24

307.2 Two-lane Cross Sections for New Construction 300-26
307.3 Two-lane Cross Sections for 2R, 3R, and other Projects 300-26
307.4 Multilane Divided Cross Sections 300-28
307.5 Multilane All Paved Cross Sections with Special Median Widths 300-28
307.6 Multilane Cross Sections for 2R and 3R Projects 300-32
307.7 Reconstruction Projects 300-32
Topic 308 – Cross Sections for Roads Under Other Jurisdictions 300-32
308.1 City Streets and County Roads 300-32
Topic 309 – Clearances 300-33
309.1 Horizontal Clearances for Highways 300-33
309.2 Vertical Clearances 300-36
309.3 Tunnel Clearances 300-42
309.4 Lateral Clearance for Elevated Structures 300-42
309.5 Structures Across or Adjacent to Railroads 300-42
Topic 310 – Frontage Roads 300-47
310.1 Cross Section 300-47
310.2 Outer Separation 300-48
310.3 Headlight Glare 300-48

CHAPTER 400 – INTERSECTIONS AT GRADE 400-1
Topic 401 – Factors Affecting Design 400-1
Index 401.1 – General 400-1
401.2 Human Factors 400-1
401.3 Traffic Considerations 400-2
401.4 The Physical Environment 400-2
Table 401.3 400-3
401.5 Intersection Type 400-3
401.6 Transit 400-4
Topic 402 – Operational Features Affecting Design 400-4
402.1 Capacity 400-4
402.2 Collisions 400-5
402.3 On-Street Parking 400-5

402.4 Consider All Users 400-6
402.5 Speed-Change Areas 400-6
Topic 403 – Principles of Channelization 400-6
403.1 Preference to Major Movements 400-6
403.2 Areas of Conflict 400-6
403.3 Angle of Intersection 400-7
403.4 Points of Conflict 400-8
403.5 (Currently not in Use) 400-9
403.6 Turning Traffic 400-9
403.7 Refuge Areas 400-11
403.8 Prohibited Turns 400-11
403.9 Effective Signal Control 400-11
403.10 Installation of Traffic Control Devices 400-13
403.11 Summary 400-13
403.12 Other Considerations 400-13
Topic 404 – Design Vehicles 400-14
404.1 General 400-14
404.2 Design Considerations 400-14
404.3 Design Tools 400-15
404.4 Design Vehicles and Related Definitions 400-16
404.5 Turning Templates & Vehicle Diagrams 400-18
Topic 405 – Intersection Design Standards 400-26
405.1 Sight Distance 400-26
405.2 Left-turn Channelization 400-30
405.3 Right-turn Channelization 400-36
405.4 Traffic Islands 400-37
405.5 Median Openings 400-40
405.6 Access Control 400-41
405.7 Public Road Intersections 400-43
405.8 City Street Returns and Corner Radii 400-43
405.9 Widening of 2-lane Roads at Signalized Intersections 400-43
405.10 Roundabouts 400-46

Topic 406 – Ramp Intersection Capacity Analysis 400-52

CHAPTER 500 – TRAFFIC INTERCHANGES 500-1
Topic 501 – General 500-1
Index 501.1 – Concepts 500-1
501.2 Warrants 500-1
501.3 Spacing 500-1
Topic 502 – Interchange Types 500-1
502.1 General 500-1
502.2 Local Street Interchanges 500-2
502.3 Freeway-to-Freeway Interchanges 500-7
Topic 503 – Interchange Design Procedure 500-10
503.1 Basic Data 500-10
503.2 Reviews 500-11
Topic 504 – Interchange Design Standards 500-11
504.1 General 500-11
504.2 Freeway Entrances and Exits 500-11
504.3 Ramps 500-16
504.4 Freeway-to-Freeway Connections 500-37
504.5 Auxiliary Lanes 500-38
504.6 Mainline Lane Reduction at Interchanges 500-38
504.7 Weaving Sections 500-40
504.8 Access Control 500-46

Chapters 600 – 670 Pavement Engineering 600-1
Chapter 600 – General Aspects 600-1
Topic 601 – Introduction 600-1
Topic 602 – Pavement Structure Layers 600-1
Index 602.1 – Description 600-1
Topic 603 – Types of Pavement Projects 600-3
603.1 New Construction 600-3
603.2 Widening 600-4

603.3 Pavement Preservation 600-4
603.4 Roadway Rehabilitation 600-6
603.5 Reconstruction 600-6
603.6 Temporary Pavements and Detours 600-7
603.7 Stage Construction 600-7
Topic 604 – Roles, Resources, and Proprietary Items 600-7
604.1 Roles and Responsibilities for Pavement Engineering 600-7
604.2 Pavement Recommendations 600-9
604.3 Other Resources 600-9
Topic 605 – Record Keeping 600-11
605.1 Documentation 600-11
605.2 Subsequent Revisions 600-11
Topic 606 – Research and Special Designs 600-11
606.1 Research and Experimentation 600-11
606.2 Special Designs 600-12
606.3 Mechanistic-Empirical Design 600-12
606.4 Proprietary Items 600-14

CHAPTER 610 – PAVEMENT ENGINEERING CONSIDERATIONS 610-1
Topic 611 – Factors In Selecting Pavement Type 610-1
Index 611.1 – Pavement Type Selection 610-1
611.2 Selection Criteria 610-1
Topic 612 – Pavement Design Life 610-2
612.1 Definition 610-2
612.2 New Construction and Reconstruction 610-2
612.3 Widening 610-2
612.4 Pavement Preservation 610-3
612.5 Roadway Rehabilitation 610-3
612.6 Temporary Pavements and Detours 610-3
612.7 Non-Structural Wearing Courses 610-3
Topic 613 – Traffic Considerations 610-4
613.1 Overview 610-4

613.2 Traffic Volume Projections 610-4
613.3 Traffic Index Calculation 610-5
613.4 Axle Load Spectra 610-6
613.5 Specific Traffic Loading Considerations 610-9
Topic 614 – Soil Characteristics 610-19
614.1 Engineering Considerations 610-19
614.2 Unified Soil Classification System (USCS) 610-19
614.3 California R-Value 610-20
614.4 Expansive soils 610-22
614.5 Other Considerations 610-22
Topic 615 – Climate 610-23
Topic 616 – Existing Pavement Type and Condition 610-24
Topic 617 – Materials 610-26
617.1 Availability of Materials 610-26
617.2 Recycling 610-26
Topic 618 – Maintainability and Constructability 610-27
618.1 Maintainability 610-27
618.2 Constructability 610-27
Topic 619 – Pavement Life-Cycle 610-29
619.1 Life-Cycle Cost Analysis 610-29
619.2 Life-Cycle Assessment 610-30

CHAPTER 620 – RIGID PAVEMENT 620-1
Topic 621 – Types of Rigid Pavements 620-1
Index 621.1 – Continuously Reinforced Concrete Pavement (CRCP) 620-1
621.2 Jointed Plain Concrete Pavement (JPCP) 620-1
621.3 Precast Concrete Pavement (PCP) 620-1
Topic 622 – Engineering Requirements 620-3
622.1 Engineering Properties 620-3
622.2 Performance Factors 620-3
622.3 Types of Concrete 620-3
622.4 Pavement Joints 620-6

622.5 Transitions Panels, Terminal Joints and End Anchors 620-7
622.6 Joint Seals 620-9
622.7 Dowel Bars and Tie Bars 620-10
622.8 Base Interlayer 620-11
622.9 Texturing 620-11
622.10 Pavement Smoothness 620-12
Topic 623 – Engineering Procedure for New, Widening, and Reconstruction Projects ...620-12
623.1 Catalog. 620-12
Topic 624 – Engineering Procedures for Pavement Preservation 620-26
624.1 Preventive Maintenance 620-26
Topic 625 – Engineering Procedures for Pavement Rehabilitation 620-27
Topic 626 – Other Considerations 620-30

CHAPTER 630 – FLEXIBLE PAVEMENT 630-1
Topic 631 – Types of Flexible Pavements & Materials 630-1
Index 631.1 – Hot Mix Asphalt (HMA) 630-1
631.2 Dense Graded HMA 630-1
631.3 Rubberized Hot Mixed Asphalt Gap Graded (RHMA-G) 630-1
631.4 Open Graded Friction Course (OGFC) 630-2
631.5 Rubberized HMA (RHMA) Use 630-2
631.6 Other Types of Flexible Pavement Surface Courses 630-3
631.7 Warm Mix Asphalt Technology 630-3
631.8 Pavement Interlayers 630-4
Topic 632 – Asphalt Binder 630-5
632.1 Binder Classification 630-5
632.2 Binder Selection 630-5
Topic 633 – Engineering Procedures for New Construction and Reconstruction 630-7
633.1 Empirical Method 630-7
633.2 Mechanistic-Empirical Method 630-12
634.1 Preventive Maintenance 630-16
634.2 Capital Preventive Maintenance (CAPM) 630-16
Topic 635 – Engineering Procedures for Flexible Pavement Rehabilitation 630-18

635.1 Rehabilitation Warrants 630-18
635.2 Empirical Method 630-18
635.3 Rehabilitation of Existing RHMA-G Surfaced Flexible Pavements 630-33
635.4 Mechanistic-Empirical Method 630-34
Topic 636 – Other Considerations 630-36
636.1 Traveled Way 630-36
636.2 Shoulders 630-36
636.3 Intersections 630-37
636.4 Roadside Facilities 630-37
Topic 637 - Engineering Analysis Software 630-37

CHAPTER 640 – COMPOSITE PAVEMENTS 640-1
Topic 641 – Types of Composite Pavement 640-1
Index 641.1 – Asphalt Over Concrete Composite Pavement 640-1
641.2 Concrete Over Asphalt Composite Pavement 640-2
Topic 642 – Engineering Criteria 640-2
642.1 Engineering Properties 640-2
642.2 Performance Factors 640-2
642.3 Overlay Limits 640-2
Topic 643 – Engineering Procedures for New Construction and Reconstruction 640-3
643.1 Empirical Method 640-3
643.2 Mechanistic-Empirical Method 640-3
Topic 644 – Engineering Procedures for Pavement Preservation 640-3
644.1 Preventive Maintenance 640-3
644.2 Capital Preventive Maintenance (CAPM) 640-3
Topic 645 – Engineering Procedures for Pavement Rehabilitation 640-4
645.1 Empirical Method 640-4
645.2 Mechanistic-Empirical Method 640-5

CHAPTER 650 – PAVEMENT DRAINAGE 650-1
Topic 651 – General Considerations 650-1
Index 651.1 – Impacts of Drainage on Pavement 650-1
651.2 Drainage System Components and Requirements 650-1

Topic 652 – Subsurface Drainage and Storm Water Management 650-5
Topic 653 – Other Considerations 650-5
653.1 New Construction Projects 650-5
653.2 Widening Projects 650-7
653.3 Rehabilitation and Reconstruction Projects 650-7
653.4 Ramps 650-7
653.5 Roadside Facilities 650-7

CHAPTER 660 – PAVEMENT FOUNDATIONS 660-1
Topic 661 – Engineering Considerations 660-1
Index 661.1 – Description 660-1
661.2 Purpose 660-1
Topic 662 – Types of Bases 660-1
662.1 Aggregate Base 660-1
662.2 Treated Base 660-2
662.3 Treated Permeable Base 660-2
662.4 Subbase 660-3
Topic 663 – Engineering Properties for Base and Subbase Materials 660-4
663.1 Selection Criteria 660-4
663.2 Base and Subbase for Rigid Pavements 660-4
663.3 Base and Subbase for Flexible Pavements 660-4
Topic 664 - Subgrade Enhancement 660-7
664.1 Overview 660-7
664.2 Mechanical Subgrade Enhancement 660-7
664.3 Chemical Stabilization 660-7
664.4 Subgrade Enhancement Geosynthetics 660-8
Topic 665 – Subgrade Enhancement Geosynthetic Fabrics 660-8
665.1 Purpose 660-8
665.2 Properties of Geosynthetics 660-9
665.3 Required Tests 660-9
665.4 Mechanical Stabilization Using SEG 660-9
665.5 Selecting Geosynthetic Type and Design Parameters 660-10
665.7 Other Design Considerations 660-12

665.9 SEG Abbreviations and Definitions 660-13
Topic 666 – Foundation Strength Parameters for Mechanistic-Empirical Design of New Construction and Rehabilitation of Flexible Pavements 660-15
666.1 Resilient Modulus 660-15

CHAPTER 670 – TAPERS AND SHOULDER BACKING 670-1
Topic 671 – Pavement Tapers 670-1
Index 671.1 – Background and Purpose 670-1
671.2 Engineering Requirements and Considerations 670-1
671.3 Tapers into Existing Pavement or Structure 670-2
Topic 672 – Shoulder Backing 670-8
672.1 Background and Purpose 670-8
672.2 Alternate Materials and Admixtures 670-8
672.3 Design 670-9

CHAPTER 680 – PAVEMENT DESIGN FOR WIDENING PROJECTS 680-1
Topic 681 – Pavement Widening Overview 680-1
Index 681.1 – Background 680-1
Topic 682 – Design Considerations 680-1
682.1 Standards 680-1
682.2 Pre-Design Evaluation 680-2
682.3 Pre-Design Considerations 680-2
682.4 Scoping, Estimating, and Detailing 680-3
682.5 Other Considerations 680-8
682.6 Life-Cycle Cost Analysis for Widening Projects 680-10

CHAPTER 700 – MISCELLANEOUS STANDARDS 700-1
Topic 701 – Fences 700-1
Index 701.1 – Type, Intent and Purpose of Fences 700-1
701.2 Freeway and Expressway Access Control Fence 700-2
701.3 Private Fences 700-4
701.4 Temporary Fences 700-4
701.5 Other Fences 700-4
Topic 702 – Miscellaneous Traffic Items 700-5

702.1 References 700-5
Topic 703 – Special Structures and Installation 700-5
703.1 Truck Weighing Facilities 700-5
703.2 Rockfall Restraining Nets 700-5
Topic 704 – Contrast Treatment 700-6
704.1 Policy 700-6
Topic 705 – Materials and Color Selection 700-6
705.1 Special Treatments and Materials 700-6
705.2 Colors for Steel Structures 700-6
Topic 706 – Roadside Management and Vegetation Control 700-7
706.1 Roadside Management 700-7
706.2 Vegetation Control 700-8
Topic 707 – Slope Treatment Under Structures 700-8
707.1 Policy 700-8
707.2 Guidelines for Slope Treatment 700-9
707.3 Procedure 700-9

CHAPTERS 800 – 890 HIGHWAY DRAINAGE DESIGN 800-1
CHAPTER 800 – GENERAL ASPECTS 800-1
Topic 801 – General 800-1
Index 801.1 – Introduction 800-1
801.2 Drainage Design Philosophy 800-1
801.3 Drainage Standards 800-1
801.4 Objectives of Drainage Design 800-2
801.5 Economics of Design 800-3
801.6 Use of Drainage References 800-3
Topic 802 – Drainage Design Responsibilities 800-4
802.1 Functional Organization 800-4
802.2 Culvert Committee 800-6
802.3 Bank and Shore Protection Committee 800-6
Topic 803 – Drainage Design Policies 800-7
803.1 Basic Policy 800-7

803.2 Cooperative Agreements 800-7
803.3 Up-Grading Existing Drainage Facilities 800-7
Topic 804 – Floodplain Encroachments 800-8
804.1 Purpose 800-8
804.2 Authority 800-8
804.3 Applicability 800-9
804.4 Definitions 800-9
804.5 Procedures 800-10
804.6 Responsibilities 800-10
804.7 Preliminary Evaluation of Risks and Impacts for Environmental Document Phase 800-11
804.8 Design Standards 800-12
804.9 Coordination with the Local Community 800-12
804.10 National Flood Insurance Program 800-12
804.11 Coordination with FEMA 800-16
Topic 805 – Preliminary Plans 800-17
805.1 Required FHWA Approval 800-17
805.2 Bridge Preliminary Report 800-17
805.3 Storm Drain Systems 800-17
805.4 Unusual Hydraulic Structures 800-17
805.5 Levees and Dams Formed by Highway Fills 800-18
805.6 Geotechnical 800-18
805.7 Data Provided by the District 800-18
Topic 806 – Definitions of Drainage Terms 800-19
806.1 Introduction 800-19
806.2 Drainage Terms 800-19
Topic 807 – Selected Drainage References 800-45
807.1 Introduction 800-45
807.2 Federal Highway Administration Hydraulic Publications 800-45
807.3 American Association of State Highway and Transportation Officials (AASHTO) 800-47
807.4 California Department of Transportation 800-48

807.5 U.S. Department of Interior - Geological Survey (USGS) 800-48
807.6 U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) 800-49
807.7 California Department of Water Resources 800-49
807.8 University of California - Institute of Transportation and Traffic Engineering (ITTE) 800-49
807.9 U.S. Army Corps of Engineers 800-49
Topic 808 – Selected Computer Programs 800-49

CHAPTER 800 – HYDROLOGY 810-1
Topic 811 – General 810-1
Index 811.1 – Introduction 810-1
811.2 Objectives of Hydrologic Analysis 810-1
811.3 Peak Discharge 810-2
811.4 Flood Severity 810-2
811.5 Factors Affecting Runoff 810-2
Topic 812 – Basin Characteristics 810-3
812.1 Size 810-3
812.2 Shape 810-3
812.3 Slope 810-4
812.4 Land Use 810-4
812.5 Soil and Geology 810-4
812.6 Storage 810-4
812.7 Elevation 810-5
812.8 Orientation 810-5
Topic 813 – Channel and Floodplain Characteristics 810-5
813.1 General 810-5
813.2 Length and Slope 810-6
813.3 Cross Section 810-6
813.4 Hydraulic Roughness 810-6
813.5 Natural and Man-made Constrictions 810-6
813.6 Channel Modifications 810-7

813.7 Aggradation - Degradation 810-7
813.8 Debris 810-7
Topic 814 – Meteorological Characteristics 810-8
814.1 General 810-8
814.2 Rainfall 810-8
814.3 Snow 810-9
814.4 Evapo-transpiration 810-9
814.5 Tides and Waves 810-9
Topic 815 – Hydrologic Data 810-10
815.1 General 810-10
815.2 Categories 810-11
815.3 Sources 810-11
815.4 Stream Flow 810-12
815.5 Precipitation 810-13
815.6 Adequacy of Data 810-13
Topic 816 – Runoff 810-13
816.1 General 810-13
816.2 Overland Flow 810-13
816.3 Subsurface Flow 810-13
816.4 Detention and Retention 810-14
816.5 Flood Hydrograph and Flood Volume 810-14
816.6 Time of Concentration (Tc) and Travel Time (Tt) 810-15
Topic 817 – Flood Magnitude 810-19
817.1 General 810-19
817.2 Measurements 810-19
Topic 818 – Flood Probability And Frequency 810-20
818.1 General 810-20
818.2 Establishing Design Flood Frequency 810-22
818.3 Stationarity and Climate Variability 810-23
Topic 819 – Estimating Design Discharge 810-24
819.1 Introduction 810-24
819.2 Empirical Methods 810-24

819.3 Statistical Methods 810-31
819.4 Hydrograph Methods 810-32
819.5 Transfer of Data 810-34
819.6 Hydrologic Software 810-36
819.7 Region-Specific Analysis 810-37

CHAPTER – 820 CROSS DRAINAGE 820-1
Topic 821 – General 820-1
Index 821.1 – Introduction 820-1
821.2 Hydrologic Considerations 820-2
821.3 Selection of Design Flood 820-2
821.4 Headwater and Tailwater 820-3
821.5 Effects of Tide and Storm 820-4
Topic 822 – Debris Control 820-37
822.1 Introduction 820-37
822.2 Debris Control Methods 820-37
822.3 Economics 820-38
822.4 Classification of Debris 820-38
822.5 Types of Debris Control Structures 820-38
Topic 823 – Culvert Location 820-38
823.1 Introduction 820-38
823.2 Alignment and Slope 820-38
Topic 824 – Culvert Type Selection 820-39
824.1 Introduction 820-39
824.2 Shape and Cross Section 820-39
Topic 825 – Hydraulic Design of Culverts 820-40
825.1 Introduction 820-40
825.2 Culvert Flow 820-40
825.3 Computer Programs 820-41
825.4 Coefficient of Roughness 820-41
Topic 826 – Entrance Design 820-41
826.1 Introduction 820-41

826.2 End Treatment Policy 820-42
826.3 Conventional Entrance Designs 820-42
826.4 Improved Inlet Designs 820-43
Topic 827 – Outlet Design 820-44
827.1 General 820-44
827.2 Embankment Protection 820-44
Topic 828 – Diameter and Length 820-45
828.1 Introduction 820-45
828.2 Minimum Diameter 820-45
828.3 Length 820-45
Topic 829 – Special Considerations 820-46
829.1 Introduction 820-46
829.2 Bedding and Backfill 820-46
829.3 Piping 820-47
829.4 Joints 820-48
829.5 Anchorage 820-48
829.6 Irregular Treatment 820-48
829.7 Siphons and Sag Culverts 820-49
829.8 Currently Not In Use 820-49
829.9 Dams 820-49
829.10 Reinforced Concrete Box Modifications 820-50

CHAPTER 830 – TRANSPORTATION FACILITY DRAINAGE 830-1
Topic 831 – General 830-1
Index 831.1 – Basic Concepts 830-1
831.2 Highway Grade Line 830-2
831.3 Design Storm and Water Spread 830-2
831.4 Other Considerations 830-3
831.5 Computer Programs 830-6
Topic 832 – Hydrology 830-6
832.1 Introduction 830-6
832.2 Rational Method 830-6

832.3 Time of Concentration 830-6
Topic 833 – Roadway Cross Sections 830-7
833.1 Introduction 830-7
833.2 Grade, Cross Slope and Superelevation 830-7
Topic 834 – Roadside Drainage 830-7
834.1 General 830-7
834.2 Median Drainage 830-7
834.3 Ditches and Gutters 830-8
834.4 Overside Drains 830-10
Topic 835 – Dikes and Berms 830-11
835.1 General 830-11
835.2 Earth Berms 830-11
835.3 Dikes 830-11
Topic 836 – Curbs and Gutters 830-12
836.1 General 830-12
836.2 Gutter Design 830-12
Topic 837 – Inlet Design 830-13
837.1 General 830-13
837.2 Inlet Types 830-13
837.3 Location and Spacing 830-17
837.4 Hydraulic Design 830-18
837.5 Local Depressions 830-20
Topic 838 – Storm Drains 830-21
838.1 General 830-21
838.2 Design Criteria 830-22
838.3 Hydraulic Design 830-22
838.4 Standards 830-22
838.5 Appurtenant Structures 830-23
Topic 839 – Pumping Stations 830-25
839.1 General 830-25
839.2 Pump Type 830-25
839.3 Design Responsibilities 830-25

839.4 Trash and Debris Considerations 830-25
839.5 Maintenance Consideration 830-26
839.6 Groundwater Considerations 830-26

CHAPTER 840 – SUBSURFACE DRAINAGE 840-1
Topic 841 – General 840-1
Index 841.1 – Introduction 840-1
841.2 Subsurface (Groundwater) Discharge 840-1
841.3 Preliminary Investigations 840-2
841.4 Exploration Notes 840-2
841.5 Category of System 840-2
Topic 842 – Pipe Underdrains 840-4
842.1 General 840-4
842.2 Single Installations 840-4
842.3 Multiple Installations 840-4
842.4 Design Criteria 840-4
842.5 Types of Underdrain Pipe 840-5
842.6 Design Service Life 840-5
842.7 Pipe Selection 840-6

CHAPTER 850 – PHYSICAL STANDARDS 850-1
Topic 851 – General 850-1
Index 851.1 – Introduction 850-1
851.2 Selection of Material and Type 850-1
Topic 852 – Pipe Materials 850-3
852.1 Reinforced Concrete Pipe (RCP) 850-3
852.2 Concrete Box and Arch Culverts 850-3
852.3 Corrugated Steel Pipe, Steel Spiral Rib Pipe and Pipe Arches 850-4
852.4 Corrugated Aluminum Pipe, Aluminum Spiral Rib Pipe and Pipe Arches 850-7
852.5 Structural Metal Plate 850-9
852.6 Plastic Pipe 850-10
852.7 Special Purpose Types 850-11

Topic 853 – Pipe Liners and Linings for Culvert Rehabilitation 850-11
853.1 General 850-11
853.2 Caltrans Host Pipe Structural Philosophy 850-12
853.3 Problem Identification and Coordination 850-12
853.4 Alternative Pipe Liner Materials 850-12
853.5 Cementitious Pipe Lining 850-14
853.6 Invert Paving with Concrete 850-14
853.7 Structural Repairs with Steel Tunnel Liner Plate 850-17
Topic 854 – Pipe Connections 850-17
854.1 Basic Policy 850-17
Topic 855 – Design Service Life 850-20
855.1 Basic Concepts 850-20
855.2 Abrasion 850-23
855.3 Corrosion 850-34
855.4 Protection of Concrete Pipe and Drainage Structures from Acids, Chlorides and Sulfates 850-35
855.5 Material Susceptibility to Fire 850-40
Topic 856 – Height of Fill 850-41
856.1 Construction Loads 850-41
856.2 Concrete Pipe, Box and Arch Culverts 850-41
856.3 Metal Pipe and Structural Plate Pipe 850-42
856.4 Plastic Pipe 850-43
856.5 Minimum Height of Cover 850-43
Topic 857 – Alternate Materials 850-61
857.1 Basic Policy 850-61
857.2 Alternative Pipe Culvert Selection Procedure Using AltPipe 850-61
857.3 Alternative Pipe Culvert (APC) and Pipe Arch Culvert List 850-64

CHAPTER 860 – ROADSIDE CHANNELS 860-1
Topic 861 – General 860-1
Index 861.1 – Introduction 860-1
861.2 Hydraulic Considerations 860-2

861.3 Selection of "Design Flood" 860-3
861.4 Safety Considerations 860-3
861.5 Maintenance Considerations 860-4
861.6 Economics 860-5
861.7 Coordination with Other Agencies 860-5
861.8 Environment 860-5
861.9 Unlined Channels 860-5
861.10 Lined Channels 860-6
861.11 Water Quality Channels 860-6
861.12 References 860-6
Topic 862 – Roadside Drainage Channel Location 860-7
862.1 General 860-7
862.2 Alignment and Grade 860-7
862.3 Point of Discharge 860-8
Topic 863 – Channel Section 860-8
863.1 Roadside and Median Channels 860-8
863.2 Triangular 860-8
863.3 Trapezoidal 860-8
863.4 Rectangular 860-9
Topic 864 – Channel Stability Design Concepts 860-9
864.1 General 860-9
864.2 Stable Channel Design Procedure 860-10
864.3 Side Slope Stability 860-12
Topic 865 – Channel Linings 860-12
865.1 Flexible Verses Rigid 860-12
865.2 Rigid 860-13
865.3 Flexible 860-15
865.4 Composite Lining Design 860-17
865.5 Bare Soil Design and Grass Lining 860-17
865.6 Rolled Erosion Control Products 860-22
Topic 866 – Hydraulic Design of Roadside Channels 860-23
866.1 General 860-23

866.2 Flow Classifications 860-23
866.3 Open Channel Flow Equations 860-24
866.4 Water Surface Profiles 860-29
Topic 867 – Channel Changes 860-29
867.1 General 860-29
867.2 Design Considerations 860-30
Topic 868 – Freeboard Considerations 860-30
868.1 General 860-30
868.2 Height of Freeboard 860-30

CHAPTER 870 – BANK PROTECTION – EROSION CONTROL 870-1
Topic 871 – General 870-1
871.1 Introduction 870-1
871.2 Design Philosophy 870-1
871.3 Selected References 870-3
Topic 872 – Planning and Location Studies 870-4
872.1 Planning 870-4
872.2 Class and Type of Protection 870-6
872.3 Geomorphology and Site Consideration 870-6
872.4 Data Needs 870-27
872.5 Rapid Assessment 870-28
Topic 873 – Design Concepts 870-28
873.1 Introduction 870-28
873.2 Design High Water and Hydraulics 870-29
873.3 Armor Protection 870-30
873.4 Training Systems 870-52
873.5 Summary and Design Check List 870-59
873.6 Coordination with the Division of Engineering Services and Structures Maintenance and Investigations 870-61

CHAPTER 880 – SHORE PROTECTION 880-1
Topic 881 – General 880-1

Index 881.1 – Introduction 880-1
881.2 Design Philosophy 880-1
881.3 Selected References 880-2
Topic 882 – Planning and Location Studies 880-2
882.1 Planning 880-2
882.2 Class and Type of Protection 880-3
882.3 Site Consideration 880-4
Topic 883 – Design 880-5
883.1 Introduction 880-5
883.2 Design High Water, Design Wave Height and Sea-Level Rise 880-5
883.3 Armor Protection 880-21

CHAPTER 890 – STORM WATER MANAGEMENT 890-1
Topic 891 – General 890-1
Index 891.1 – Introduction 890-1
891.2 Philosophy 890-1
Topic 892 – Storm Water Management Strategies 890-1
892.1 General 890-1
892.2 Types of Strategies 890-2
892.3 Design Considerations 890-3
892.4 Mixing with Other Waste Streams 890-3
Topic 893 – Maintenance Requirements for Storm Water Management Features 890-5
893.1 General 890-5

CHAPTER 900 – LANDSCAPE ARCHITECTURE – ROADSIDES 900-1
Topic 901 – Landscape Architecture General 900-1
Index 901.1 – Landscape Architecture Program 900-1
901.2 Landscape Architecture Design Standards 900-1
901.3 Landscape Architecture Administered Facilities 900-4
Topic 902 – Sight Distance and Clear Recovery Zone Standards 900-4
902.1 Landscape Sight Distance and Clear Recovery Zone Standards 900-4
Topic 903 – Landscape Site Design 900-4

903.1 Landscape Site Analysis 900-4
903.2 Landscape Site Layout 900-5
903.3 Roadside Amenities 900-5
903.4 Additional Roadside Site Design Considerations 900-5
Topic 904 – Planting Design 900-5
904.1 Planting Design General 900-5
904.2 Site Preparation 900-6
904.3 Plant Selection 900-7
904.4 Locating Plants 900-8
904.5 Locating Trees 900-9
904.6 Locating Plants in Conformance with Sight Distances 900-10
904.7 Vine Planting 900-12
904.8 Planting in the Vicinity of Airports and Heliports 900-12
904.9 Plant Establishment 900-12
Topic 905 – Irrigation Design 900-13
905.1 Irrigation Design General 900-13
905.2 Water Supply 900-13
905.3 Irrigation Conduit 900-13
905.4 Irrigation System Equipment 900-14
905.5 Temporary Irrigation 900-16
Topic 906 – Erosion Control 900-16
906.1 Erosion Control General 900-16
906.2 Soil Surface Protection 900-16
906.3 Planting 900-17
906.4 Sediment Control 900-18
906.5 Permanent Erosion Control Establishment 900-18

CHAPTER 910 – LANDSCAPE ARCHITECTURE – ROADSIDE SITES 910-1
Topic 911 – General 910-1
Index 911.1 Roadside Sites General 910-1
Topic 912 – Roadside Sites Design 910-1
912.1 Roadside Sites Layout 910-1

912.2 Parking Area Design 910-2
912.3 Site Furnishings 910-4
Topic 913 – Safety Roadside Rest Areas 910-4
913.1 Safety Roadside Rest Areas General 910-4
913.2 Safety Roadside Rest Area Site Selection 910-5
913.3 Safety Roadside Rest Area Layout 910-5
913.4 Safety Roadside Rest Area Buildings and Structures 910-6
913.5 Safety Roadside Rest Area Utilities and Facilities 910-7
913.6 Safety Roadside Rest Area Parking 910-9
913.7 Safety Roadside Rest Area Signage 910-9
913.8 Public Information Display 910-10
913.9 Vending Facilities 910-10
Topic 914 – Vista Points 910-11
914.1 Vista Points General 910-11
914.2 Vista Point Site Selection 910-11
914.3 Vista Point Amenities 910-11
914.4 Vista Point Parking 910-12
Topic 915 – Park & Ride Facilities 910-12
915.1 Park & Ride Facilities General 910-12
915.2 Site Selection 910-13

CHAPTER 1000 – BICYCLE TRANSPORTATION DESIGN 1000-1
Topic 1001 – Introduction 1000-1
Index 1001.1 – Bicycle Transportation 1000-1
1001.2 Streets and Highways Code References 1000-1
1001.3 Vehicle Code References 1000-2
1001.4 Bikeways 1000-2
Topic 1002 – Bikeway Facilities 1000-3
1002.1 Selection of the Type of Facility 1000-3
Topic 1003 – Bikeway Design Criteria 1000-5
1003.1 Class I Bikeways (Bike Paths) 1000-5
1003.2 Class II Bikeways (Bike Lanes) 1000-16

1003.3 Class III Bikeways (Bike Routes) 1000-16
1003.4 Trails 1000-17
1003.5 Miscellaneous Criteria 1000-18

CHAPTER 1100 – HIGHWAY TRAFFIC NOISE ABATEMENT 1100-1
Topic 1101 – General Requirements 1100-1
Index 1101.1 – Introduction 1100-1
1101.2 Objective 1100-1
1101.3 Terminology 1100-2
1101.4 Procedures for Assessing Noise Impacts 1100-2
1101.5 Prioritizing Construction of Retrofit Noise Barriers 1100-2
Topic 1102 – Design Criteria 1100-3
1102.1 General 1100-3
1102.2 Noise Barrier Location 1100-5
1102.3 Noise Barrier Height and Position 1100-16
1102.4 Noise Barrier Length 1100-16
1102.5 Alternative Noise Barrier Designs 1100-17
1102.6 Noise Barrier Aesthetics 1100-17
1102.7 Maintenance Consideration in Noise Barrier Design 1100-17
1102.8 Emergency Access Considerations in Noise Barrier Design 1100-17
1102.9 Drainage Openings in Noise Barrier 1100-17

Table of Contents
Figures and Tables

CHAPTER 10 – DIVISION OF DESIGN 10-1
Figure 11.1 Division of Design Functional Organization Chart 10-2

CHAPTER 20 – DESIGNATION OF HIGHWAY ROUTES 20-1
Figure 21.1 Interstate Highway System in California 20-2

CHAPTER 60 – NOMENCLATURE 60-1
Figure 62.2 Types of Structures 60-4

CHAPTER 80 – APPLICATION OF DESIGN STANDARDS 80-1
Table 82.1A Boldface Standards 80-12
Table 82.1B Underlined Standards 80-19
Table 82.1C Decision Requiring Other Approvals 80-26

CHAPTER 100 – BASIC DESIGN POLICIES 100-1
Table 101.2 Vehicular Design Speed 100-3
Figure 105.6 Typical Pedestrian Crossings at “T” Intersections 100-15
Figure 110.12 California Mining and Tunneling Districts 100-43

CHAPTER 200 – GEOMETRIC DESIGN AND STRUCTURE STANDARDS 200-1
Table 201.1 Sight Distance Standards 200-2
Table 201.7 Decision Sight Distance 200-5
Figure 201.4 Stopping Sight Distance on Crest Vertical Curves 200-6
Figure 201.5 Stopping Sight Distance on Sag Vertical Curves 200-7
Figure 201.6 Stopping Sight Distance on Horizontal Curves 200-8
Figure 201.7 Decision Sight Distance on Crest Vertical Curves 200-9
Table 202.2A Minimum Radii for Design Superelevation Rates, Design Speeds, and emax=4% 200-13
Table 202.2B Minimum Radii for Design Superelevation Rates, Design Speeds, and emax=6% 200-14

Table 202.2C Minimum Radii for Design Superelevation Rates, Design Speeds, and emax=8% 200-15
Table 202.2D Minimum Radii for Design Superelevation Rates, Design Speeds, and emax=10% 200-16
Table 202.2E Minimum Radii for Design Superelevation Rates, Design Speeds, and emax=12% 200-17
Figure 202.2 Maximum Comfortable Speed on Horizontal Curves* 200-18
Figure 202.5A Superelevation Transition 200-20
Figure 202.5B Superelevation Transition Terms & Definitions 200-21
Figure 202.6 Superelevation of Compound Curves 200-23
Table 204.3 Maximum Grades for Type of Highway and Terrain Conditions 200-27
Figure 204.4 Vertical Curves 200-28
Figure 204.5 Critical Lengths of Grade for Design 200-30
Table 204.8 Falsework Span and Depth Requirements 200-34
Figure 205.1 Access Openings on Expressways 200-36
Figure 206.2 Typical Two-lane to Four-lane Transitions 200-39
Figure 207.2A Airway-Highway Clearance Requirements (Civil Airports) 200-42
Figure 207.2B Airway-Highway Clearance Requirements (Heliport) 200-43
Figure 207.2C Airway-Highway Clearance Requirements (Military Airports) 200-44
Figure 207.2D Airway-Highway Clearance Requirements (Navy Carrier Landing Practice Field) 200-45
Figure 208.1 Offsets to Safety-Shape Barriers 200-47
Figure 208.10A Vehicular Railings for Bridge Structures 200-51
Figure 208.10B Combination Vehicular Barrier and Pedestrian Railings for Bridge Structures 200-52
Figure 208.10C Pedestrian Railings for Bridge Structures 200-53
Figure 208.11A Limits of Structure Approach Embankment Material 200-57
Figure 208.11B Abutment Drainage Details 200-58
Figure 209.1 Structure Approach Slab Layout 200-60
Figure 209.4A Structure Approach Drainage Details (Rehabilitation) 200-62
Figure 209.4B New Structure Approach Pavement Transition Details 200-64
Table 210.2 Types of Reinforced Earth Slopes and Earth Retaining Systems(1) 200-65
Figure 210.8 Type Selection and PS&E Process for Reinforced Earth Slopes and Earth Retaining Systems 200-75

CHAPTER 300 – GEOMETRIC CROSS SECTION 300-1
Figure 301.2A Typical Class II Bikeway (Bike Lane) Cross Sections 300-3
Table 302.1 Boldface Standards for Paved Shoulder Widths on Highways 300-6
Table 303.1 Selection of Curb Type 300-10
Figure 303.3 Dike Type Selection and Placement(1) 300-12
Figure 303.4A Typical Bulbout with Class II Bikeway (Bike Lane) 300-14
Figure 303.4B Typical Bulbout without Class II Bikeway (Bike Lane) 300-15
Figure 305.6 Optional Median Designs for Freeways with Separate Roadways 300-25
Table 307.2 Shoulder Widths for Two-lane Roadbed ..... New Construction Projects 300-26
Figure 307.2 Geometric Cross Sections for Two-lane Highways (New Construction).... 300-27
Figure 307.4A Geometric Cross Sections for Freeways and Expressways 300-29
Figure 307.4B Geometric Cross Sections for Freeways and Expressways 300-30
Figure 307.5 Geometric Cross Sections for All Paved Multilane Highways 300-31
Table 309.2A Minimum Vertical Clearances 300-38
Figure 309.2 Department of Defense Rural and Single Interstate Routes 300-39
Table 309.2B California Routes on the Rural and Single Interstate Routing System 300-40
Table 309.5A Minimum Vertical Clearances Above Highest Rail 300-43
Figure 309.5A Typical Horizontal Railroad Clearance from Grade Separated Structures 300-44
Figure 309.5B Permanent Railroad Clearance Envelope 300-45
Table 309.5B Minimum Horizontal Clearances to Centerline of Nearest Track.... 300-46

CHAPTER 400 – INTERSECTIONS AT GRADE 400-1
Table 401.3 Vehicle Characteristics/Intersection Design Elements Affected 400-3
Figure 403.3A Angle of Intersection (Minor Leg Skewed to the Right) 400-8
Figure 403.3.B Class II Bikeway Crossing Railroad 400-8
Figure 403.6A Typical Bicycle and Motor Vehicle Movements at Intersections of Multilane Streets without Right-Turn-Only Lanes 400-10
Figure 403.6B Bicycle Left-Turn-Only Lane 400-12
Figure 404.5A STAA Design Vehicle 56-Foot Radius 400-19

Figure 404.5B STAA Design Vehicle 67-Foot Radius 400-20
Figure 404.5C California Legal Design Vehicle 50-Foot Radius 400-21
Figure 404.5D California Legal Design Vehicle 60-Foot Radius 400-22
Figure 404.5E 40-Foot Bus Design Vehicle 400-23
Figure 404.5F 45-Foot Bus & Motorhome Design Vehicle 400-24
Figure 404.5G 60-Foot Articulated Bus Design Vehicle 400-25
Table 405.1B Application of Sight Distance Requirements 400-28
Figure 405.1 Corner Sight Distance (b) 400-29
Table 405.1A Corner Sight Distance Time Gap (T_g) for Unsignalized Intersections 400-29
Figure 405.2A Standard Left-turn Channelization 400-31
Figure 405.2B Minimum Median Left-turn Channelization (Widening on one Side of Highway) 400-32
Figure 405.2C Minimum Median Left-turn Channelization (Widening on Both Sides in Urban Areas with Short Blocks) 400-33
Table 405.2A Bay Taper for Median Speed-change Lanes 400-35
Table 405.2B Deceleration Lane Length 400-35
Table 405.4 Parabolic Curb Flares Commonly Used 400-39
Figure 405.4 Pedestrian Refuge Island 400-40
Figure 405.5 Typical Design for Median Openings 400-42
Figure 405.7 Public Road Intersections 400-44
Figure 405.9 Widening of Two-lane Roads at Signalized Intersections 400-45
Figure 405.10 Roundabout Geometric Elements 400-47
Table 406 Vehicle Traffic Flow Conditions at Intersections at Various Levels of Operation 400-54
Figure 406A Spread Diamond 400-55
Figure 406B Tight Diamond 400-56
Figure 406C Two-quadrant Cloverleaf 400-57

CHAPTER 500 – TRAFFIC INTERCHANGES 500-1
Figure 502.2 Typical Local Street Interchanges 500-3
Figure 502.2 Typical Local Street Interchanges (Cont.) 500-4
Figure 502.3 Typical Freeway-to-freeway Interchanges 500-9

Figure 502.3 Typical Freeway-to-freeway Interchanges (Cont.) 500-10
Figure 504.2A Single Lane Freeway Entrance 500-13
Figure 504.2B Single Lane Freeway Exit 500-14
Figure 504.2C Location of Freeway Ramps on a Curve 500-15
Table 504.3 Ramp Widening for Trucks 500-17
Figure 504.3A Typical Freeway Entrance Loop Ramp Metering (1 GP Lane + 1 HOV Preferential Lane) 500-19
Figure 504.3B Typical Successive Freeway Entrance Ramp Metering (1 GP Lane + 1 HOV Preferential Lane) 500-20
Figure 504.3C Restrictive Condition Freeway Entrance Ramp Metering (1 GP Lane) 500-22
Figure 504.3D Restrictive Condition Freeway Entrance Loop Ramp Metering (1 GP Lane) 500-23
Figure 504.3E Typical Multilane Freeway Diagonal Entrance Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane) 500-25
Figure 504.3F Typical Multilane Freeway Loop Entrance Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane) 500-26
Figure 504.3G Typical Freeway-to-Freeway Connector Ramp Metering (1 GP Lane + 1 HOV Preferential Lane) 500-28
Figure 504.3H Typical Freeway-to-Freeway Connector Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane) 500-29
Figure 504.3I Location of Ramp Intersections on the Crossroads 500-33
Figure 504.3J Transition to Two-lane Exit Ramp 500-34
Figure 504.3K Two-Lane Connectors and Entrance/Exit Ramps 500-35
Figure 504.4 Diverging Branch Connections 500-39
Figure 504.7A Design Curve for Freeway and Collector Weaving 500-41
Figure 504.7B Lane Configuration of Weaving Sections 500-42
Table 504.7C Percent of Through Traffic Remaining in Outer Through Lane (Level of Service D Procedure) 500-43
Figure 504.7D Percentage Distribution of On- and Off-ramp Traffic in Outer Through Lane and Auxiliary Lane (Level of Service D Procedure) 500-44
Figure 504.7E Percentage of Ramp Traffic in the Outer Through Lane (No Auxiliary Lane) (Level of Service D Procedure) 500-45
Figure 504.8 Typical Examples of Access Control at Interchanges 500-47

CHAPTER 600 – GENERAL ASPECTS 600-1
Figure 602.1 Basic Pavement Layers of the Roadway 600-5

CHAPTER 610 – PAVEMENT ENGINEERING CONSIDERATIONS 610-1
Table 613.3A ESAL Constants 610-7
Table 613.3B Lane Distribution Factors for Multilane Highways 610-7
Table 613.3C Conversion of ESAL to Traffic Index 610-8
Table 613.5A Traffic Index (TI) Values for Ramps and Connectors 610-11
Figure 613.5A Shoulder Design for TI Equal to Adjacent Lane TI 610-13
Figure 613.5B Shoulder Design for TI Less Than Adjacent Lane TI 610-14
Table 613.5B Minimum TI's for Safety Roadside Rest Areas 610-19
Table 614.2 Unified Soil Classification System (from ASTM D 2487) 610-21
Figure 615.1 Pavement Climate Regions 610-25

CHAPTER 620 – PAVEMENT ENGINEERING CONSIDERATIONS 620-1
Figure 621.1 Types of Rigid Pavement 620-2
Table 622.1 Concrete Properties Used in Developing Rigid Pavement Design Catalog 620-4
Table 622.2 Concrete Pavement Performance Factors 620-5
Figure 622.5A Concrete Pavement to Asphalt Pavement Transition Panel 620-7
Table 622.5 Use of Terminal Joints and Expansion Joints in CRCP 620-8
Figure 622.5B Expansion Terminal Joint System Between CRCP and Structure Approach Slab 620-9
Figure 623.1 Rigid Pavement Catalog Decision Tree 620-13
Table 623.1A Relationship Between Subgrade Type(1) 620-13
Table 623.1B Rigid Pavement Catalog (North Coast, Type I Subgrade Soil)(1), (2), (3), (4), (5) 620-14
Table 623.1C Rigid Pavement Catalog (North Coast, Type II Subgrade Soil) (1), (2), (3), (4), (5) 620-15
Table 623.1D Rigid Pavement Catalog (South Coast/Central Coast, Type I Subgrade Soil) (1), (2), (3), (4), (5) 620-16

Table 623.1E Rigid Pavement Catalog (South Coast/Central Coast, Type II Subgrade Soil) (1), (2), (3), (4), (5) 620-17
Table 623.1F Rigid Pavement Catalog (Inland Valley, Type I Subgrade Soil) (1), (2), (3), (4), (5) 620-18
Table 623.1G Rigid Pavement Catalog (Inland Valley, Type II Subgrade Soil) (1), (2), (3), (4), (5) 620-19
Table 623.1H Rigid Pavement Catalog (Desert, Type I Subgrade Soil) (1), (2), (3), (4), (5) 620-20
Table 623.1I Rigid Pavement Catalog (Desert, Type II Subgrade Soil) (1), (2), (3), (4), (5) 620-21
Table 623.1J Rigid Pavement Catalog (Low Mountain/South Mountain, Type I Subgrade Soil) (1), (2), (3), (4), (5) 620-22
Table 623.1K Rigid Pavement Catalog (Low Mountain/South Mountain, Type II Subgrade Soil) (1), (2), (3), (4), (5) 620-23
Table 623.1L Rigid Pavement Catalog (High Mountain/High Desert, Type I Subgrade Soil) (1), (2), (3), (4), (5) 620-24
Table 623.1M Rigid Pavement Catalog (High Mountain/High Desert, Type II Subgrade Soil) (1), (2), (3), (4), (5) 620-25
Table 625.2 Thicknesses for Crack, Seat, and Flexible Overlay 620-29
Figure 626.1 Preferred Limits of Rigid Pavement at Flexible Pavement Ramp or Connector Gore Area 620-31
Table 626.2 Shoulder Concrete Pavement Designs (“S” Dimension) 620-33
Figure 626.2A Rigid Shoulders Through Ramp and Gore Areas 620-33
Figure 626.2B Widened Slab Shoulder with Concrete Remainder Designs 620-34
Figure 626.4 Rigid Bus Pad 620-36

CHAPTER 630 – FLEXIBLE PAVEMENT 630-1
Table 632.1 Asphalt Binder Performance Grade Selection 630-6
Table 633.1 Gravel Equivalents (GE) and Thickness of Structural Layers (ft) .. 630-10
Table 633.2 Selecting ME Project Testing Level 630-14
Table 633.3 Minimum Reliability Depending on Project Testing Level 630-15
Table 635.2A Tolerable Deflections at the Surface (TDS) in 0.001 inches 630-22
Table 635.2B Gravel Equivalence Needed to Reduce Surface Deflection 630-23
Table 635.2C Commonly Used Gf for Flexible Pavement Rehabilitation 630-24
Table 635.2D Reflective Crack Retardation Equivalencies (Thickness in feet) 630-26

Table 636.4 Minimum Pavement Structures for Park & Ride Facilities 630-38

CHAPTER 650 – PAVEMENT DRAINAGE 650-1
Figure 651.2A Typical Section with Treated Permeable Base Drainage Layer 650-3
Figure 651.2B Cross Drain Interceptor Details For Use with Treated ..... Permeable Base 650-5
Figure 651.2C Cross Drain Interceptor Trenches 650-6

CHAPTER 660 – PAVEMENT FOUNDATIONS 660-1
Table 663.2 Base and Subbase Material Properties for Rigid Pavement ..... Catalog 660-5
Table 663.3 Gravel Factor and California R-value for Bases and Subbases ..... Used in Flexible Pavement Design 660-6
Figure 665.5 Flowchart for SEG Selection 660-11
Table 666.1A Typical Resilient Modulus and Poisson's Ratio for Standard Base ..... and Subbase Materials Used in ME-Based Flexible Pavement ..... Design 660-16
Table 666.1B Typical Resilient Modulus and Poisson's Ratio for Subgrade Soils ..... Used in ME-Based Flexible Pavement Design 660-17

CHAPTER 670 – TAPERS AND SHOULDER BACKING 670-1
Figure 671.2A Tapering Into a Previously Overlaid Pavement 670-2
Figure 671.2B New Structure Approach Pavement Transition Details 670-3
Figure 671.3A Transverse Transition Tapers for Pavement Preservation Projects . 670-5
Figure 671.3B Longitudinal Tapers at Shoulders, Curbs, Dikes, Inlets, and ..... Guardrail 670-6
Figure 671.3C Transition Taper Underneath Overcrossing/Bridge 670-7
Figure 672.3A Typical Application of Shoulder Backing 670-10
Figure 672.3B Alternative Placement for Existing Slopes Steeper than 6:1 670-10
Figure 672.3C Placement of Shoulder Backing Thickness Greater Than 0.50 ..... foot for Slope Repair 670-11
Figure 672.3D Placement of Shoulder Backing Behind Dikes 670-11
Figure 672.3E Longitudinal Drainage (Roadside Ditches/Gutters) 670-12

CHAPTER 680 – PAVEMENT DESIGN FOR WIDENING PROJECTS 680-1
Figure 682.4A Typical Concrete Pavement Widening Median Lane ..... and Outer Lane 680-5

Figure 682.4B Widening Previously Cracked, Seated, and HMA Overlay Concrete Pavement in Good Condition 680-7
Figure 682.4C Widening Asphalt Pavement in Good Condition 680-9

CHAPTER 800 – GENERAL ASPECTS 800-1
Figure 804.7A Technical Information for Location Hydraulic Study 800-13
Figure 804.7B Floodplain Evaluation Report Summary 800-15
Table 808.1 Summary of Related Computer Programs and Web Applications 800-50

CHAPTER 800 – HYDROLOGY 810-1
Figure 812.1 Automated Watershed Delineation 810-3
Figure 813.1 Post-Fire Debris 810-8
Figure 816.5 Typical Flood Hydrograph 810-14
Table 816.6A Roughness Coefficients For Sheet Flow 810-16
Table 816.6B Intercept Coefficients for Shallow Concentrated Flow 810-17
Figure 816.6 Velocities for Upland Method of Estimating Travel Time for Shallow Concentrated Flow 810-18
Figure 816.7 Digital Elevation Map (DEM) 810-19
Figure 817.2 Gaging Station 810-20
Figure 817.3 High Water Marks 810-20
Figure 818.1 Overtopping Flood 810-22
Figure 818.2 Maximum Historic Flood 810-22
Figure 819.2A Runoff Coefficients for Undeveloped Areas Watershed Types 810-27
Table 819.2B Run off Coefficients for Developed Areas(1) 810-28
Figure 819.2C Regional Flood-Frequency Regions 810-30
Figure 819.4 Basic Steps to Developing and Applying a Rainfall-runoff Model for Predicting the Required Design Flow 810-34
Table 819.5A Summary of Methods for Estimating Design Discharge 810-35
Figure 819.7A Desert Regions in California 810-38
Table 819.7A Regional Regression Equations for California's Desert Regions ... 810-39
Table 819.7B Runoff Coefficients for Desert Areas 810-41
Table 819.7C Watershed Size for California Desert Regions 810-41
Figure 819.7B Example Depth-Area Reduction Curve 810-43
Table 819.7D Hydrologic Soil Groups 810-44

Table 819.7E Curve Numbers for Land Use-Soil Combinations 810-46
Figure 819.7C San Bernardino County Hydrograph for Desert Areas 810-48
Figure 819.7D USBR Example S-Graph 810-49
Table 819.7F Channel Routing Methods 810-51
Table 819.7G Channel Method Routing Guidance 810-52
Table 819.7H Design Storm Durations 810-53
Table 819.7I Bulking Factors & Types of Sediment Flow 810-55
Figure 819.7E Soil Slips vs. Slope Angle 810-55
Figure 819.7F Alluvial Fan 810-56
Table 819.7J Adjustment-Transportation Factor Table 810-60
Figure 819.7H Recommended Bulking Factor Selection Process 810-61

CHAPTER – 820 CROSS DRAINAGE 820-1
Figure 821.1 Annual exceedance probability (AEP) of daily maximum ..... ocean water level 820-6
Table 821.1 Boundaries, Locations and Length Scales of Water-level ..... Provinces 820-8
Figure 821.2 California Open Coast and Bayfront Water Level Province Map 820-9
Figure 821.3A One-Percent Compound Frequency Curve for Province 1, ... (Based on NOAA # 9419750, Crescent City) 820-10
Figure 821.3B One-Percent Compound Frequency Curve for Province 2, ... (Based on NOAA # 9418767, North Spit, Humboldt) 820-11
Figure 821.3C One-Percent Compound Frequency Curve for Province 2a, ... (Based on NOAA # 9414290, Golden Gate Bridge) 820-12
Figure 821.3D One-Percent Compound Frequency Curve for Province 3, ... (Based on NOAA # 9413450, Monterey) 820-13
Figure 821.3E One-Percent Compound Frequency Curve for Province 4, ... (Based on NOAA # 9412110, Port San Luis) 820-14
Figure 821.3F One-Percent Compound Frequency Curve for Province 5, ... (Based on NOAA # 9411340, Santa Barbara) 820-15
Figure 821.3G One-Percent Compound Frequency Curve for Province 6, ... (Based on NOAA # 9410660, Los Angeles) 820-16
Figure 821.3H One-Percent Compound Frequency Curve for Province 7, ... (Based on NOAA # 9410230, La Jolla Scripps Pier) 820-17

Figure 821.3I One-Percent Compound Frequency Curve for Province 8, (Based on NOAA # 9414750, Alameda) 820-18
Figure 821.3J One-Percent Compound Frequency Curve for Province 9, (Based on NOAA # 9415056, Pinole Point, San Pablo Bay) 820-19
Figure 821.3K One-Percent Compound Frequency Curve for Province 9a, (Based on NOAA # 9415144, Port Chicago) 820-20
Figure 821.3L One-Percent Compound Frequency Curve for Province 10, (Based on NOAA # 9414523, Redwood City) 820-21
Figure 821.3M One-Percent Compound Frequency Curve for Province 11, (Based on NOAA # 9410170, San Diego Bay, Navy Pier) 820-22
Figure 821.3N One-Percent Compound Frequency Curve for Province 12, (Based on Otay River Sonde) 820-23
Figure 821.4 Distances needed to guide interpolation 820-24
Figure 821.5 Weighting factor, Kx for interpolation 820-25

CHAPTER 830 – TRANSPORTATION FACILITY DRAINAGE 830-1
Table 831.3 Desirable Roadway Drainage Guidelines 830-4
Figure 834.3 Side Gutter and Trapezoidal Channel 830-9
Figure 837.1 Storm Drain Inlet Types 830-14
Table 838.4 Minimum Pipe Diameter for Storm Drain Systems 830-23

CHAPTER 840 – SUBSURFACE DRAINAGE 840-1
Table 842.4 Suggested Depth and Spacing of Pipe Underdrains for Various Soil Types 840-6

CHAPTER 850 – PHYSICAL STANDARDS 850-1
Table 851.2 Manning "n" Value for Alternative Pipe Materials(1) 850-2
Table 853.1A Allowable Alternative Pipe Liner Materials 850-13
Table 853.1B Guide for Plastic Pipeliner Selection in Abrasive Conditions(2) to Achieve 50 Years of Maintenance-Free Service Life 850-15
Table 854.1 Joint Leakage Selection Criteria 850-21
Figure 855.1 Minor Bedload Volume 850-24
Figure 855.2 Abrasion Test Panels 850-25
Table 855.2A Abrasion Levels and Materials 850-26
Table 855.2B Bed Materials Moved by Various Flow Depths and Velocities 850-30

Table 855.2C Guide for Anticipated Service Life Added to Steel Pipe by Abrasive Resistant Protective Coating (2) 850-31
Table 855.2D Guide for Anticipated Wear to Metal Pipe by Abrasive Channel Materials 850-32
Table 855.2E Relative Abrasion Resistance Properties of Pipe and Lining Materials* 850-32
Table 855.2F Guide for Minimum Material Thickness of Abrasive Resistant Invert Protection to Achieve 50 Years of Maintenance-Free Service Life 850-33
Figure 855.3A Minimum Thickness of Metal Pipe for 50-Year Maintenance-Free Service Life (2) 850-36
Figure 855.3B Chart for Estimating Years to Perforation of Steel Culverts 850-37
Table 855.4A Guide for the Protection of Cast-In-Place and Precast Reinforced and Unreinforced Concrete Structures(5) Against Acid and Sulfate Exposure Conditions(1),(2) 850-38
Table 855.4B Guide for Minimum Cover Requirements for Cast-In-Place and Precast Reinforced Concrete Structures(3) for 50-Year Design Life in Chloride Environments 850-39
Table 856.3A Corrugated Steel Pipe Helical Corrugations 850-44
Table 856.3B Corrugated Steel Pipe Helical Corrugations 850-45
Table 856.3C Corrugated Steel Pipe 2⅔" x ½" Annular Corrugations 850-46
Table 856.3D Corrugated Steel Pipe Arches 2⅔" x ½" Helical or Annular Corrugations 850-47
Table 856.3E Steel Spiral Rib Pipe ¾" x 1" Ribs at 11½" Pitch 850-48
Table 856.3F Steel Spiral Rib Pipe ¾" x 1" Ribs at 8½" Pitch 850-49
Table 856.3G Steel Spiral Rib Pipe ¾" x ¾" Ribs at 7½" Pitch 850-50
Table 856.3H Corrugated Aluminum Pipe Annular Corrugations 850-51
Table 856.3I Corrugated Aluminum Pipe Helical Corrugations 850-52
Table 856.3J Corrugated Aluminum Pipe Arches 2⅔" x ½" Helical or Annular Corrugations 850-53
Table 856.3K Aluminum Spiral Rib Pipe ¾" x 1" Ribs at 11½" Pitch 850-54
Table 856.3L Aluminum Spiral Rib Pipe ¾" x ¾" Ribs at 7½" Pitch 850-54
Table 856.3M Structural Steel Plate Pipe 6" x 2" Corrugations 850-55
Table 856.3N Structural Steel Plate Pipe Arches 6" x 2" Corrugations 850-56
Table 856.3O Structural Aluminum Plate Pipe 9" x 2½" Corrugations 850-57

Table 856.3P Structural Aluminum Plate Pipe Arches 9" x 2½" Corrugations..... 850-58
Table 856.4 Thermoplastic Pipe Fill Height Tables..... 850-59
Table 856.5 Minimum Thickness of Cover for Culverts..... 850-60
Table 857.2 Allowable Alternative Materials 850-63

CHAPTER 860 – ROADSIDE CHANNELS 860-1
Figure 861.1 Small Roadside Channel..... 860-1
Figure 861.2 Roadside Channel Outlet to Storm Drain at Drop Inlet 860-2
Figure 861.3 Damaged Channel 860-4
Figure 861.4 Concrete Lined Channel with Excessive Weed Growth 860-5
Figure 862.1 Small-Rock Lined Channel Outside of Clear Recovery Zone..... 860-7
Figure 863.1 Small-Rock Lined Triangular Channel with Rounded Bottom 860-9
Figure 865.1 Steep-Sloped Channel with Composite Vegetative Lining 860-13
Table 865.1 Concrete(2) Channel Linings..... 860-14
Figure 865.2 Concrete Lined Channel 860-14
Figure 865.3 Long-Term Flexible Lining..... 860-16
Figure 865.4 Grass-Lined Median Channel 860-18
Table 865.2 Permissible Shear and Velocity for Selected Lining Materials(2) 860-20
Table 866.3A Average Values for Manning's Roughness Coefficient (n) 860-26
Figure 866.3C Specific Energy Diagram..... 860-27
Table 868.2 Guide to Freeboard Height..... 860-31

CHAPTER 870 – BANK PROTECTION – EROSION CONTROL 870-1
Table 872.1 Guide to Selection of Protection..... 870-3
Figure 872.1 Stream Classification 870-10
Figure 872.2 Diagram of a Braided River Channel 870-11
Figure 872.3 Bed Load and Suspended Load..... 870-14
Figure 872.4 Longitudinal Encroachments..... 870-15
Figure 872.5 Slope Failure Due to Loss of Toe..... 870-19
Table 872.2 Failure Modes and Effects Analysis for Riprap Revetment 870-20
Figure 872.6 Mature Valley with Meandering Stream 870-23
Figure 872.7 Alternative Highway Locations Across Debris Cone 870-25

Figure 872.8 Alluvial Fan 870-26
Figure 872.9 Desert Wash Longitudinal Encroachment 870-26
Figure 872.10 Stage Construction 870-27
Figure 873.3A Stone Shape 870-35
Table 873.3A RSP Class by Median Particle Size(3) 870-36
Table 873.3B RSP Class by Median Particle Weight(3) 870-37
Figure 873.3B Medium Density Vegetation 870-44
Figure 873.3C Gabion Lined Streambank 870-45
Figure 873.3D Rock Slope Protection 870-46
Figure 873.3E Concreted-Rock Slope Protection 870-47
Figure 873.3F Toe Failure – Concreted RSP 870-48
Figure 873.4A Thalweg Redirection Using Bendway Weirs 870-53
Figure 873.4B Bendway Weir Typical Cross Section and Layout 870-55
Figure 873.4C Bendway Weir Rock Size Chart 870-56
Figure 873.4D Example of Spur Design 870-57
Figure 873.4E Bridge Abutment Guide Banks 870-58
Figure 873.6A Bridge Abutment Failure Example 870-61
Figure 873.6B Habitat Enhancement Example 870-62
Figure 873.6C Lateral Stream Migration Within a Canyon Setting Example 870-63
Figure 873.6D Conceptual Geotechnical Failures Resulting from Abutment Scour 870-63

CHAPTER 880 – SHORE PROTECTION 880-1
Figure 883.2A Nomenclature of Tidal Ranges 880-7
Figure 883.2B Significant Wave Height Prediction Nomograph 880-11
Figure 883.2C Design Breaker Wave 880-12
Figure 883.2D California 12 Tide Gauges 880-14
Figure 883.2E Crescent City Example 880-16
Table 883.1A Crescent City Example Comparison for 2060 880-17
Table 883.1B Projected Sea-Level Rise (feet) at Crescent City 880-18
Figure 883.2F Crescent City MHHW 880-20
Figure 883.2G Wave Run-up on Smooth Impermeable Slope 880-22

Figure 883.2H RSP Lined Ocean Shore 880-22
Table 883.2 Dimensionless Breaker Parameter and Wave Types 880-24
Figure 883.2I Rock Slope Protection 880-26
Figure 883.2J Typical Groin Layout with Resultant Beach Configuration 880-29
Figure 883.2K Alignment of Groins to an Oblique Sea Warrants Shortening Proportional to Cosine of Obliquity 880-30
Figure 883.2L Typical Stone Dike Groin Details 880-31

CHAPTER 890 – STORM WATER MANAGEMENT 890-1
Figure 892.3 Example of Cumulative Hydrograph With and Without Detention 890-4

CHAPTER 900 – LANDSCAPE ARCHITECTURE – ROADSIDES 900-1
Table 904.5 Large Tree Setback Requirements on Conventional Highways 900-11

CHAPTER 910 – LANDSCAPE ARCHITECTURE – ROADSIDE SITES 910-1
Table 912.2 Vehicle Parking Stall Standards 910-3

CHAPTER 1000 – BICYCLE TRANSPORTATION DESIGN 1000-1
Figure 1003.1A Two-Way Class I Bikeway (Bike Path) 1000-7
Figure 1003.1B Typical Cross Section of Class I Bikeway (Bike Path) ..... Parallel to Highway 1000-9
Table 1003.1 Bike Path Design Speeds 1000-11
Figure 1003.1C Minimum Length of Bicycle Path Crest Vertical Curve (L) ..... Based on Stopping Sight Distance (S) 1000-12
Figure 1003.1D Minimum Lateral Clearance (m) on Bicycle Path ..... Horizontal Curves 1000-13
Figure 1003.5 Railroad Crossing Class I Bikeway 1000-19