

**Ohio Department of Transportation
Traffic Engineering Manual (TEM)
Office of Roadway Engineering
October 18, 2013 Revision**

To Holders of the Traffic Engineering Manual (TEM):

As of October 18, 2013, this publication has been revised.

This revision involves updates of the Title Sheet and other preface materials, and Parts 3 (Markings), 4 (Signals), 6 (Temporary Traffic Control), 12 (Zones and Traffic Engineering Studies), and 14 (Miscellaneous).

The updated publication and the separate revision package are available from the ODOT Design Reference Resource Center <http://www.dot.state.oh.us/drrc/Pages/default.aspx>, or from the **Office of Roadway Engineering's** Traffic Standards website at <http://www.dot.state.oh.us/Divisions/Engineering/Roadway/DesignStandards/traffic/Pages/default.aspx>
The revision package includes a detailed Revision Log.

**The TEM Revision package is set up to print double-sided sheets.
Per ODOT policy, revisions will only be available via the web pages noted above.**

For questions, comments, or concerns please contact either:

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Traffic Engineering Manual Revision Log

October 18, 2013 Revision

(of the October 2002 Edition)

The following is a detailed list of the changes made in the Preface Materials and Parts 3, 4, 6, 12 and 14 of the Traffic Engineering Manual (TEM) as of October 18, 2013:

Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
* Key for Revision Type: Change - change in a standard, new information, revising text to provide clarification, updating references, or correcting a mistake in the text, more than simple editorial change; Deletion - deleting a section, form, table or figure; Editorial - correcting a simple typing or drawing mistake, simple editorial changes such as rephrasing a statement or making a format change.				
Preface materials [top of page]				
Title Page	i	i	Editorial	Updated to reflect the October 18, 2013 date for this revision.
	ii – iv	ii – iv	—	Reprinted as part of the revision set.
Pub. Record	v – xvi	v – xvi	Editorial	Updated and revised the format to conserve space.
Table of Contents	Xvi – xlv	xvii – xlv	Editorial	Updated per this revision.
Part 1, General [top of page]				
Part 2, Signs [top of page]				
Part 3, Markings [top of page]				
302-1	3-15	3-15	Change	Raised Pavement Markers, General. In the last paragraph, revised “Section 605-11.12, SCDs MT-95.70, 96.11 and 99.30” to “Section 605-11 and SCD MT-99.30.” TRPMs are no longer referenced in MT-96.11, and the reference in MT-95.70, basically just cross-references MT-99.30.
302-3	3-15	3-15	Change	Raised Pavement Markers, Admin. Responsibilities. In item 1 revised “Office of Traffic Engineering (OTE)” to “Office of Traffic Operations (OTO).”
	3-16	3-16	—	Reprinted as part of the Revision Set.
Part 4, Highway Signals [top of page]				
	4-1 – 4-8	4-1 – 4-8	—	Table of Contents. Updated.
	4-11	4-11	—	Reprinted as part of the Revision Set.
401-4	4-12	4-12	Change	TC Signals – General, 632, Removal of Traffic Signal... In item 3.c, revised “W3-H12” to “W24-H2b.”
442-4	4-67	4-67	Editorial	Plan Notes, 632, Removal of Traffic Signal Installation. Deleted comma after 632 in title.
442-5	4-67	4-67	Editorial	Plan Notes, 632, Interconnect Cable, Misc.: (by Size)... Deleted comma after 632 in title.
442-6	4-68	4-68	Editorial	Plan Notes, 632, Loop Detector Units, by Type... Deleted comma after 632 in title.
442-9	4-68	4-68	Editorial	Plan Notes, 632, Loop Detector Lead-In Cable, Direct... Deleted comma after 632 in title.
442-10	4-69	4-69	Editorial	Plan Notes, 632, Combination Signal Support, Type... Deleted comma after 632 in title.
442-11	4-69	4-69	Editorial	Plan Notes, 632, Combination Strain Pole, Type... Deleted comma after 632 in title.

Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
442-13	4-69 – 4-70	4-69	Change	Plan Notes, 632, Vehicular Signal Head, Color,... Deleted “(LED)” from the title and added “Material,” after “Color.” Also deleted the comma after 632 in the title. In the first line deleted “Item” and the second “CMS.” Deleted item 2 and renumber the remaining item. These changes are because polycarbonate vehicular signal heads have been added to the Spec Book.
442-14	4-70	4-70	Editorial	Plan Notes, 632, Power Service, As Per Plan. Deleted comma after 632 in title.
442-16	4-70	4-70	Editorial	Plan Notes, 633, Alternate Bid Item. Deleted comma after 633 in title.
442-17	4-71	4-71	Change	Plan Notes, 632 Vehicular Signal Head, Colot,... Deleted “(LED)” from the title and added “Material,” after “Color.” In the first paragraph, deleted the numbered group about Signal Sections. In the second paragraph, updated the item description. In the first sentence of the Designer Note, deleted “LED/incandescent lamp and aluminum/polycarbonate.” These changes are because polycarbonate vehicular signal heads have been added to the Spec Book.
442-18	4-72	4-71	Deletion	Plan Notes, 632 Pedestrian Signal, (LED), ... Deleted existing note because polycarbonate pedestrian signal heads have been added to the Spec Book. Reserved the note number, and inserted temporary text to explain what happened to the existing Note.
		4-72 – 4-75	—	Text shifted.
442-30	4-79	4-76	Change	Plan Notes, Pull Box, 24” (600 mm) x (875 mm) x... Deleted the metric values.
442-31	4-79	4-76 – 4-77	Change	Plan Notes, 632 Pole Entrance Fitting. Deleted the metric values.
442-33	4-79	4-78	Deletion	Plan Notes, 804 Fusion Splicer. Deleted because the information is in a new Supplemental Specification. Reserved the note number, and inserted temporary text to explain what happened to the Note.
442-34	4-80	4-79	Deletion	Plan Notes, 804 Fiber Optic Termination Tool Kit. Deleted because the information is in a new Supplemental Specification. Reserved the note number, and inserted temporary text to explain what happened to the Note.
442-35	4-80	4-79	Deletion	Plan Notes, 804 Cleave Tool. Deleted because the information is in a new Supplemental Specification. Reserved the note number, and inserted temporary text to explain what happened to the Note.
442-36	4-80	4-79	Deletion	Plan Notes, 804 Optical Time Domain Reflectometer. Deleted because the information is in a new Supplemental Specification. Reserved the note number, and inserted temporary text to explain what happened to the Note.
442-37	4-81	4-79	Deletion	Plan Notes, 804 Mechanical Splice Tool Kit. Deleted because the information is in a new Supplemental Specification. Reserved the note number, and inserted temporary text to explain what happened to the Note.

Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
442-38	4-81	4-79	Deletion	Plan Notes, 804 Fiber Optic Training. Deleted because the information is in a new Supplemental Specification. Reserved the note number, and inserted temporary text to explain what happened to the Note.
		4-80	—	Text shifted.
442-41	4-84	4-81	Editorial	Plan Notes, 633 – Uninterruptible Power Supply... Deleted dash after 633 in title.
442-43	4-84	4-81	Editorial	Plan Notes, 633 – Stop Bar Detection Radar. Deleted dash after 633 in title.
442-44	4-86	4-82	Editorial	Plan Notes, 633 – Controller Unit, Type 2070L... Deleted dash after 633 in title.
442-45	4-86	4-83	Change	Plan Notes, 632 – Signal Support, Mechanical... Deleted dash after 632 in title; corrected 48 feet to 59 feet in line four of the first paragraph.
442-46	4-87	4-84	Editorial	Plan Notes, 632 – Signal Support, (By Type)... Deleted dash after 632 in title.
442-47	4-87	4-84	Editorial	Plan Notes, 632 – Signalization, Misc.: Unlash and... Deleted dash after 632 in title.
442-48	4-88	4-84	Editorial	Plan Notes, 632 – Signalization, Misc.: FAA Type... Deleted dash after 632 in title.
442-49	4-89	4-85	Editorial	Plan Notes, 632 – Signalization, Misc.: Bridge... Deleted dash after 632 in title.
		4-86 – 4-90	—	Text shifted. Inserted some blank pages to avoid changes in page numbering for the following Chapters.
443	4-91	4-91	Change	Specifications. Added a reference to SSs 840 and 940; and deleted the reference to Supplement 1046, which is no longer used.
		4-92	—	Included as part of the Revision Set.
460-2	4-91	4-119	Change	Maintenance/Operations, Responsibilities. In the first line revised “Office of Traffic Engineering (OTE)” to “Office of Traffic Operations (OTO),” and in two more places on page 4-119 revised “OTE” to “OTO.”
460-3	4-91	4-120 – 4-121	Change	Maintenance/Operations, Preventive Maintenance. In Subsection 460-3.2 , replaced the second sentence with “Incandescent lamps shall no longer be used.” In the first paragraph, revised “eighty-four months” to “seven years” and “ninety-six months” to “eight years”; and in the last paragraph, revised “10” to “ten.” In Subsection 460-3.3 , Added the statement “Incandescent lamps shall no longer be used”; revised “Every twenty-four months incandescent lamps behind all lenses” to “Every seven years, all LED lamps”; and replaced “; and” with a period.
460-7	4-122	4-122	Change	Maintenance/Operations, Training. In the first paragraph and in item 2 revised “Office of Traffic Engineering” to “Office of Traffic Operations.”
Part 5, Low-Volume Roads [top of page]				
Part 6, Temporary Traffic Control [top of page]				
	6-1 – 6-12	6-1 – 6-12	—	Table of Contents. Updated title for Section 641-19.

Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
605-5	6-35	6-35	Change	TTC Zone Devices, Flagger Sign. In the first line of Subsection 605-5.8 , corrected the sign code designation for the Flagger sign to W20-7.
	6-36	6-36	—	Reprinted as part of the Revision Set.
	6-53	6-53	—	Reprinted as part of the Revision Set.
605-20	6-54	6-54	Change	TTC Zone Devices, Increased Barrier Delineation. In Subsection 605-20.1 , to clarify the intent, revised “increased barrier delineation” to “one of the alternate delineation methods for increased barrier delineation shown in MT-101.70.”
	6-121	6-121	—	Reprinted as part of the Revision Set.
641-11	6-122	6-122	Change	Plan Prep./Production, Flagger Closing One Lane... In the second sentence, revised “Flagger Ahead sign (W20-7a)” to “Flagger symbol sign (W20-7).”
	6-127	6-127	—	Reprinted as part of the Revision Set.
641-18	6-128	6-128	Editorial	Plan Prep./Production, Road Closure Using Type III... Corrected “Type III” to “Type 3” in the Section title.
641-19	6-128	6-128	Change	Plan Prep./Production, Portable Barrier and Impact... Deleted “Portable” from the Section title.
Part 7, School Area Traffic Control [top of page]				
Part 8, Rail Grade Crossings [top of page]				
Part 9, Bicycles [top of page]				
Part 10, Reserved for Future Use [top of page]				
Part 11, Highway Lighting [top of page]				
Part 12, Zones and Traffic Engineering Studies [top of page]				
	12-1 – 12-6	12-1 – 12-6	—	Table of Contents. Updated. Inserted blank page to avoid changes in page numbering.
1213-1	12-59	12-59	Change	Other TE Studies, General. Revised the sentence to end after “engineering studies.”
1213-2	12-59 – 12-60	12-59	Change	Other TE Studies, Ball Bank Studies for Determining... Revised the Section title to “Determining Curve Advisory Speeds.” In Subsection 1213-2.1 , revised and reduced the discussion to one paragraph. In Subsection 1213-2.2 , deleted “Mechanical” from the title, and revised and rewrote the first four paragraphs into a new single paragraph, and replaced the last paragraph with text about the form. Replaced Subsection 1213-2.3 with the text of existing Section 1213-3, with minor editing and deleting the existing last paragraph of 1213-3 (“Safe speeds on horizontal...”). Deleted Subsection 1213-2.4 . This is basically now covered in Subsection 1213-2.2.
1213-3	12-60	12-59	Deletion	Other TE Studies, Calculation Method to Determine... With minor editing this material was relocated to become a new Subsection 1213-2.3.
1213-4 Now 1213-3	12-60	12-60	Change	Other TE Studies, Delay Studies. Renumbered existing Section. Revised “OTE” to “ORE.”

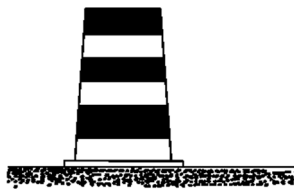
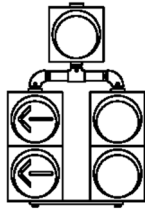
Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
1213-5	12-61		Deletion	Other TE Studies, Speed Studies. Deleted. The information is addressed in Section 1203-3, and this was basically just a cross-reference.
1213-6 Now 1213-4	12-61	12-60 – 12-65	Change	Other TE Studies, SSTP Program. Revised Section number references throughout. Removed the three sample tables (they are now shown in a new Figure 1298-2), and updated related references. Made some editorial changes, such as “peak hour” to “peak-hour” and “turn lane” to “turn-lane”; and in the Project Scope Subsection (on page 12-63), revised “(Mr. David Gardner)” to “Traffic Monitoring.” On page 12-65, revised “Office of Traffic Engineering” to “Office of Traffic Operations” in two places.
1213-7 Now 1213-5	12-61	12-65 – 12-66	Change	Other TE Studies, Road Safety Audits (RSAs). Revised Section number references throughout. In the paragraph just before the table, revised “Ohio” to “ODOT.”
1220	12-71		Deletion	Material and Equipment.
1250	12-71		Deletion	Construction.
1280	12-71		Deletion	Research.
1295	12-71		Deletion	Reference Resources.
		12-67 – 12-72		To maintain existing paging for now, inserted some blank sheets.
1296	12-73	12-73 – 12-68	Change	Forms Index. Revised the entry for Form 1296-11, Curve Study Sheet, by deleting the last sentence, and deleting “if an Advisory Speed plate should be used to supplement a curve (or turn) Warning Sign and, if used,” from the first sentence. Also updated information about Forms 1296-12 and 1296-13 (the existing forms have been deleted).
	12-93	12-93	—	Reprinted as part of the Revision Set.
1296-11	12-94	12-94	Change	Form 1296-11. Curve Study Sheet. Inserted new sample form.
1296-12	12-95	12-95	Deletion	Form 1296-12. Completed Curve Study Sheet. Deleted. Revised the title to “Reserved – Existing Form Deleted.”
1296-13	12-96	12-96	Editorial	Form 1296-13. Reserved for Future Information. Deleted the reference to the “Red Flag Summary Form” and revised the title to “Reserved – Existing Form Deleted.”
1298	12-117	12-117	Change	Figures Index. Revised the title and text about Figure 1298-2.
	12-118	12-118	—	Reprinted as part of the Revision Set.
	12-123	12-123	—	Reprinted as part of the Revision Set.
1298-2	12-124	12-124	Change	Figure 1298-2. Mechanical Ball Bank Indicator. Revised the title to “Examples of Signal Timing and Phasing Improvements” and replaced the existing picture of a mechanical ball bank indicator with the three tables that were previously in Section 1213-6 (now 1213-4).
Part 13, ITS [top of page]				
Part 14, Miscellaneous [top of page]				

Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
	14-1 – 14-2	14-1 – 14-2	—	Table of Contents. Updated.
1400	14-3	14-3	Change	General. Added a reference to ORE in the first paragraph, and made some minor editing changes. Added a second paragraph providing references to material in Part 1.
1401-1	14-3	14-3	Change	Training Available, General. Added references to ORE and LTAP, revised “OTE” to “OTO,” and made some editorial updates.
1401-2	14-3	14-3	Change	Training Available, Traffic Academy. Updated the web address to ORE’s website.
1401-3	14-3	14-3	Change	Training Available, Overhead Sign Supports. Deleted the course length information. This will be provided when the applicant calls. In the Program Manager line, deleted “Traffic Control Section” and “Contact Number,” and revised “Office of Traffic Engineering” to “Office of Traffic Operations.”
1401-4	14-4	14-4	Change	Training Available, NEMA TS-1 Traffic Signal... Deleted “TS-1” in the title and the first paragraph. In the second paragraph, deleted “two-day.” In the third paragraph, deleted “TS-1” in the third bullet item, and added “and TS-2” after “TS-1” in the fourth bullet item. In the last paragraph, deleted Kevin Duemmel’s name and contact information. Revised “OTE” to “OTO” in two places.
1401-5	14-4	14-4	Change	Training Available, 170 Traffic Signal Maintenance. Revised “170” to “2070” in the title and throughout the Section. In the first paragraph, deleted “This course requires completion of the NEMA TS-1 course.” In the second paragraph, deleted “two-day.” In the last paragraph, deleted Kevin Duemmel’s name and contact information. Revised “OTE” to “OTO” in two places.
1401-6	14-5	14-5	Change	Training Available, Strain Pole Design... In the first paragraph, deleted reference to OTE, updated the web address to ORE’s, and made some minor editorial changes. In the second paragraph, and deleted “four hour.” In the last paragraph, replaced Kevin Duemmel’s name and contact information with a reference to the “ORE Traffic Control Design Section.”
1402	14-7 – 14-8		Deletion	Other OTE Services. Deleted this Chapter. The time-lapse and real-time video services are no longer available.

Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
1415-1	14-9	14-5	Change	Rumble Strips & Stripes in the Roadway, General. Added text in paragraph 1 to more fully describes the uses of rumble strips. In paragraph 2, deleted the reference to ORE and rearranged the remaining sentence. In paragraph 3, added "Permanent" at the beginning of the first sentence, revised "4 inches" to "2 inches" in the last sentence, and made a couple of editorial changes. Moved the last sentence of paragraph 5 to be the last sentence of paragraph 6. Added a new last paragraph to clarify that "rumble stripes" are a <u>type</u> of "rumble strip."
1415-2	14-9	14-6	Change	Rumble Strips & Stripes in the Roadway, Transverse... In Subsection 1415-2.1 , added a sentence in paragraph 1 specifying that rumble strips consist of "parallel 4-inch grooves cut at 1-foot intervals." Added a new paragraph 4 describing a typical rumble strip installation. Updated the code designation for the RUMBLE STRIPS sign. In Subsection 1415-2.2 , added a new last paragraph with placement information. In Subsection 1415-2.3 , rewrote and expanded the information about rumble strips at RR grade crossings. Relocated the text from previous Section 1415-4 about rumble strips on freeways and expressways to become a new Subsection 1415-2.4 (with minor editing). Renumbered existing Subsection 1415-2.4 to 1415-2.5 and deleted "Two-Lane" from the title.
1415-3	14-10	14-8	Change	Rumble Strips & Stripes in the Rdwy, Rumble Stripes.. Revised the Section title to "Rumble Stripes." Updated the sign code designation in Subsection 1415-3.1 , and revised the text to clarify that "rumble stripes" are simply "longitudinal rumble strips." In Subsection 1415-3.2 , added "or Lane" in the title, added a sentence about lane line rumble stripes, and made some editorial revisions. In Subsection 1415-3.3 , made editorial changes to revise the section to address only information that has not already been discussed in the general sections on rumble strips. Also, revised the shoulder width criteria to reference a "paved" shoulder, and generally revised the text to update references to "urban areas" to "built-up areas" and includes some examples of intent. Rephrased paragraph 5, and updated the Office reference in the last paragraph.
1415-4	14-11		Deletion	Rumble Strips & Stripes in the Rdwy, Rumble Stripes.. Moved the information from this Section to Section 1415-2 with the other Transverse Rumble Strips.
1415-5 Now 1415-4	14-12	14-9	Change	Rumble Strips & Stripes in the Rdwy, Rumble Stripes... Renumbered this Section.
1416 New		14-10	Change	Other Devices. Added Chapter.

Revision Involves:			Type *	Section Title and Revision Description
Chapter or Section	Page	New Page		
1416-1 New		14-10	Change	Other Devices, Driveway Mirrors. Added a Section on the topic to provide background and guidance when questions arise.
1420	14-13		Deletion	Materials and Equipment. Deleted Chapter. Considered unnecessary.
1430	14-13		Deletion	Planning / Programming . Deleted Chapter. Considered unnecessary.
1450	14-13		Deletion	Construction. Deleted Chapter. Considered unnecessary.
1480	14-13		Deletion	Research. Deleted Chapter. Considered unnecessary.
1495	14-13		Deletion	Reference Resources. Deleted Chapter. Considered unnecessary.
1496	14-15		Deletion	Forms Index. Deleted.
1496-1	14-17		Deletion	Form 1496-1. Video Request Form. Deleted. No longer used.
Part 15, Appendix (new) [top of page]				

Traffic Engineering Manual



October 23, 2002 Edition
(Includes revisions through October 18, 2013.)

**Ohio Department of Transportation
Office of Roadway Engineering**

Revisions of this Manual are published on a quarterly basis, as needed. They are published only on-line, at the Office of Roadway Engineering (ORE) and DRRC websites noted below.

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Web addresses:

ODOT: <http://www.dot.state.oh.us>

Office of Roadway Engineering (ORE):

<http://www.dot.state.oh.us/divisions/Engineering/Roadway>

Office of Traffic Engineering (OTE):

<http://www.dot.state.oh.us/divisions/Operations/traffic/>

ODOT Publications (Design Reference Resource Center (DRRC)):

<http://www.dot.state.oh.us/drrc>

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PREFACE

The **Traffic Engineering Manual (TEM)** has been developed to assure uniformity in application of **ODOT** traffic engineering policies, guidelines, standards and practices. The **OMUTCD** establishes the basic, minimum traffic control standards for all public highways in **Ohio**, and all supplemental **ODOT** traffic engineering design, construction and operations related information is either contained in the **TEM** or referenced from it.

This Manual contains standards, policies, etc. established for use in **ODOT** work; however, various situations will present themselves where engineering knowledge, experience and judgment will have to be used to determine how to apply the information included herein to specific situations. Comments, questions and proposed revisions should be submitted to the **Office of Roadway Engineering, Design Standards Section, Ohio Department of Transportation** at the address noted on page ii.

**Ohio Department of Transportation
MISSION STATEMENT**

To provide easy conveyance of people and goods from place to place, we will:

- **Take care of what we have**
- **Make our system work better**
- **Improve safety**
- **Enhance capacity**

PUBLICATION RECORD

2002 October 23, 2002 Edition, effective December 2, 2002

New edition, updating and consolidating information previously published in the ODOT Traffic Control Application Standards Manual, the Traffic Control Design Information Manual, the Construction Guidelines for Traffic Control Devices and various separate policies, guidelines and procedures.

2003 January 17, 2003 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet, Publication Record, and Table of Contents;**
- **in Part 1**, a revised Table 197-1;
- **in Part 2**, a revised Section 208-3, and editorial changes in Section 205-2.3.1;
- **in Part 3**, a revised Table of Content, revised Sections 304-2, 342-2, 342-3, 342-4, 342-5 and 343, and editorial changes in Sections 301-1, 301-3, 302-1, 304-1, 304-3, 304-6, 306, 307, 320-4, 320-5, 340-1, 340-2, 340-3 and 350-2;
- **in Part 4**, a revised Table of Content, revised Sections 442-3, 442-5, 442-9, 442-10, 442-11, 442-15, 442-16 and 442-19, deleted Sections 442-14, 442-17 and 442-18, and editorial changes in Sections 401-1, 403-1, 404-1, 420-1, 421-1, 441-9, 442-4, 442-6, 442-7, 442-8, 442-12, 442-13, 443, 450-3.2 thru 450-3.6, 450-4.1, 450-4.3, 450-4.4, 450-6.2, 450-6.3, 450-8.2, 450-8.5, 450-8.7, 450-8.8, 450-9, 450-10.2 thru 450-10.7 and 450-11.1 thru 450-11.8;
- **in Part 6**, a revised Table of Content, a new Section 605-8.4, revised Sections 605-6.5, 607-40, 607-41, 640-14, 640-24.1, 641-8.4, 641-10.5, 642-3, 642-9, 642-16, 642-17, 642-19, 642-20, 642-21, 642-24, 642-25, 642-26, 642-27, 642-28, 642-30, 642-31, 642-32, 642-35, 642-39, 642-41, 670-7 and Figure 698-3a, and editorial changes in Sections 605-2.1, 605-7.3, 605-11.3, 605-11.4.1, 605-11.5, 605-11.10.2, 606-2, 606-12, 606-14, 606-15, 607-1, 620-3, 620-6.1, 620-6.2, 620-6.3, 640-1, 640-8, 640-11.3, 640-11.6, 640-11.7, 640-18.2, 640-21, 640-22, 641-2.6, 641-5.1 thru 641-5.4, 641-5.6, 641-6.1 thru 641-6.5, 641-7.2, 641-8.5, 641-9.6, 641-9.7, 641-10.4, 641-10.8, 641-11, 641-12, 641-13, 641-14, 641-15, 641-16, 641-17, 641-19, 642-2, 642-4, 642-5, 642-6, 642-9, 642-10, 642-12, 642-18, 642-22, 642-29, 642-33, 642-34, 642-36, 642-37, 642-38 and 642-40;
- **in Part 11**, a revised Table of Content, revised Sections 1141-3.1, 1142-2 thru 1142-19, 1142-21 thru 1142-23, 1142-26, 1142-31, 1142-32 and 1142-34, and editorial changes in Sections 1142-20, 1142-24, 1142-25, 1142-27 thru 1142-30, 1142-33, 1142-35 and 1143;
- **in Part 12**, a revised Table of Content and revised Section 1215; and
- **in Part 14**, the Index was revised.

2003 April 18, 2003 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- new **Cover Sheet, Publication Record and Table of Contents;**
- **in Part 2**, revised Section 201-8 and Table 297-9;
- **in Part 3**, revised Sections 302-3 and 343; and editorial corrections in Section 302-2 and Table 397-1;
- **in Part 4**, new Sections 442-17, 442-18 and 442-19; a revised Table of Contents and revised Sections 442-1 thru 442-16 and Figures 498-3 and 498-5;
- **in Part 6**, a revised Table of Contents, and revised Sections 602-5.3, 605-10.2, 642-1 thru 642-32 and Table 697-9; and editorial changes in Sections 605-11.4.1, 640-12.2, 640-20, 640-23.3.4, 640-23.5, 641-7.4, 641-15, 642-9, 642-36;
- **in Part 11**, new Sections 1150-1 thru 1150-21 and 1160-11 thru 1160-14; a revised Table of Contents; and editorial changes in Section 1100-1, 1140-4.3.5, 1140-5.6.2, 1140-5.7.2, 1140-7.3, 1141-4.2.3, 1142-16, 1142-17 and 1142-18; and
- **in Part 12**, revised Section 1202-1.

2003 October 17, 2003 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet and Table of Contents**, and an updated **Publication Record;**
- **in Part 1**, a revised Table of Contents, and revised Sections 100-2, 100-5, 101-1, 101-2, 101-3.2, 101-3.3, 101-3.4, 101-4, 101-5, 102-2, 102-3.2, 102-3.4, 102-3.5, 102-5, 103-3.1, 103-3.3, 103-3.8, 103-4, 103-5, 104-1, 104.2, 105-1, 106-2, 106-3, 130-2.1, 130-2.3, 140-2.6, 194-9, 197 and 198, and Form 196-3, Tables 197-1, 197-2, 197-3, 197-9 and 197-10, and Figures 198-1a, 198-1b, 198-1c and 198-2; deleted Section 106-4 and Figure 198-1d; editorial changes in Sections 100-1.4 and 103-3.4; and general editorial/formatting changes;
- **in Part 3**, a new Section 301-14; revised and renumbered Sections 301-12.4 and 301-12.5 (now Sections 301-12 and 301-13, respectively); a revised Table of Contents, and revised Sections 301-1, 301-4 through 301-11, 302-1, 303-1, 303-2, 304-1, 304-3, 304-5, 304-6, 305, 306 and 310, and Figures 398-1, and 398-3 through 398-5; deleted Sections 301-12.1 through 301-12.3; editorial changes in Sections 301-2 and 320-1; and general editorial/ formatting changes;
- **in Part 4**, new Sections 401-6 through 401-8, 402-3.5, 403-7, 408-2, 440-5 and 440-6, and Forms 496-8 through 496-18; a revised Table of Contents, and revised Sections 400-1, 401-1, 401-3, 401-4, 402-1, 402-3.1 through 402-3.4, 403-1 through 403-3, 403-5, 403-6.1, 404-1 through 404-3, 405-1, 406-1 through 406-3, 407-2, 408-1, 420-4.1 through 420-4.4, 420-4.7, 420-4.8, 421-1, 441-3, 450-10.4, 450-10.6, 496 and 497, and Table 497-3; and general editorial/reformatting changes;
- **in Part 5**, revised Sections 500 and 595;
- **in Part 7**, a revised Table of Contents, and revised Sections 700, 701, 702-1 through 702-5, 702-7 and 704; and general editorial/reformatting changes;
- **in Part 8**, a revised Table of Contents, and revised Sections 800, 801-1, 801-2.2, 802-1, 802-2, 803, and 804; and general editorial/reformatting changes;

- in **Part 9**, a revised Table of Contents and revised Section 900; and general editorial/ reformatting changes;
- in **Part 10**, revised Sections 1000 and 1095; and
- in **Part 11**, a revised Table of Contents, and Sections 1100-1, 1103-6.8, 1140-4.6.2, 1142-14, 1142-15, 1142-25, 1160-6 and 1160-8; and an editorial change in Section 1160-13.

2004 January 16, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 2**, a revised Table of Contents, and revised Sections 200-1, 201-1 through 201-3, 201-5, 201-7, 201-8, 201-10 through 201-13, 202-1, 202-4 through 202-7, 203-1, 203-2, 204-1 through 204-4, 205-1, 205-2.1, 205-2.3.3, 205-3, 206-1, 206-3 through 206-15, 207, 207-1, 207-2.1, 207-3.1, 207-4, 207-5, 207-6.1, 207-6.3, 207-6.4, 207-7, 208-1, 208-2, 208-3, 208-4, 208-6, 209-1, 209-2.2, 209-2.3, 209-3, 209-4, 209-5, 210-2, 211-1, 212-1, 220-7, 240-2.3, 240-3, 250-3.1, 295-2, 297 and 298, and Tables 297-1 and 297-4, and Figures 298-1, 298-2, 298-4a, 298-4b, 298-5a through 298-5d, 298-6a, 298-6b, 298-7, 298-22 and 298-24; deleted Sections 201-6, 206-2 and 295-3, and Figure 298-6c; and general editorial/formatting changes;
- in **Part 3**, editorial corrections in Section 398;
- in **Part 6**, new Sections 605-5.12 through 605-5.15, 606-19, 606-20, 640-26, 642-42 through 642-45, 670-6.1 through 670-6.3; a revised Table of Contents, and revised Sections 601-1, 602-4.1, 602-4.4.4, 602-5.1 through 602-5.6, 602-5.8, 602-6, 602-7, 603, 604, 605-1 through 605-3, 605-4.2, 605-4.3, 605-5.1 through 605-5.11, 605-6, 605-7, 605-8, 605-9.605-10.1, 605-10.2, 605-11.1 through 605-11.9, 605-11.10.1, 605-11.11 through 605-11.13, 605-12, 605-13, 605-14.1, 605-14.2, 605-14.5, 605-15.1, 605-15.2.2, 605-15.2.3, 605-16 through 605-20, 606-1 through 606-18, 607-1 through 607-15, 620-3, 620-6.1, 640-4, 640-5.3, 640-12.1, 640-12.4, 640-18.2, 640-20, 640-22, 641-5.2, 641-5.3, 641-6.3, 641-6.5, 641-7.3, 641-8.3, 641-9.3, 641-9.6, 641-10.3, 641-10.4, 641-11 through 641-13, 641-15, 641-17, 641-19, 642-24, 642-27, 642-31 through 642-34, 660-2, 670-6 through 670-8, 695-2, 697, 698, and Tables 697-5 through 697-9, and Figures 698-1 through 698-4; deleted Sections 605-6.1 through 605-6.5, 605-9.1 through 605-9.3, 605-10.3, 605-11.14, 607-16 through 607-44, 670-9, 670-10, and Tables 697-10 through 697-14, and Figures 698-5 through 698-49; editorial corrections in Sections 620-2.2, 642-5, 642-30; and general editorial/formatting changes.
- in **Part 11**, revised Section 1141-3.1;
- in **Part 12**, a revised Table of Contents, and revised Sections 1210, 1211, 1212-1, 1212-2.2, 1212-2.3, 1213-1, 1213-2, 1213-3, 1214, 1215, 1220-3, 1220-5.1, 1230-2.1 and 1230-6.13; and editorial corrections in Sections 1220-5.7 and 1230-6.9.
- in **Part 13**, a revised Table of Contents, and revised Sections 1301-2, 1301-3, 1305, 1312 and 1399, and general editorial/formatting changes.

2004 April 16, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, a new Section 140-7; and revised Tables 197-1 and 197-10;
- in **Part 2**, a new Section 240-8; a revised Table of Contents and Sections 240-1 and 295-2;
- in **Part 3**, a new Section 350-3; a revised Table of Contents, revised Sections 301-1, 301-2, 301-14, 302-2 thru 302-4, 304-4, 320-1, 320-5, 340-2 thru 340-4, 342-2, 343 and 397, and revised Table 397-1; deleted Sections 342-3 thru 342-5; and a minor editorial correction in Section 301-10;
- in **Part 4**, a new Section 440-7; a revised Table of Contents and Section 440-1;
- in **Part 6**, new Sections 630-5, 641-23 and 642-46, and Figures 698-5 through 698-9; a revised Table of Contents, revised Sections 606-16, 606-17, 607-10, 607-12, 607-13, 607-15, 630-1, 640-12.1, 640-12.4, 640-23.3.1 and 698; and editorial corrections/changes in Sections 640-2, 642-44 and 642-45

2004 July 16, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, a revised Table of Contents and Sections 10-1.3, 100-5, 101-3.3, 101-4, 101-5, 102-3.1, 102-3.2, 102-3.3, 102-5, 103-4, 103-5, 104-3, 140-2.3, 140-2.4, 140-7, 150-1, 160, 193-10.2, 194-14 and 198, and Figures 198-1a and 198-2; deleted Figures 198-1b and 198-1c; and editorial corrections/changes in Sections 100-1.1, 100-1.4, 100-6, 101-2, 101-3.2, 101-3.4, 102-1, 102-2, 102-3.6, 103-1, 140-2.2, 140-2.5, 140-2.6, 193-10.1, 193-11, 193-12, 194-3, 194-6, 194-9, 194-10, 194-11 and 194-17.
- in **Part 2**, five renamed sections: existing Sections 205-2, 205-3, 205-3.1, 205-3.2 and 209-1.1 are now 205-3, 205-4, 205-4.1, 205-4.2 and 211-3, respectively; new Sections 202-8, 205-2, 205-5, 206-16, 207-8, 209-6, 209-7 and 211-2, and Figures 298-28 thru 298-36; a revised Table of Contents, and Sections 200-1, 201-1, 201-4, 201-5, 201-7, 201-8, 202-4 thru 202-7, 203-1, 203-2, 204-1 thru 204-4, 205-1, 205-2.1, 205-2.2, 205-2.3.2, 205-2.3.3, 206-1, 206-3, 206-4, 206-5.1, 206-5.2, 206-5.5, 206-6, 206-7.2, 206-7.3, 206-8, 206-14, 206-15, 207-1, 207-2.1 thru 207-2.3, 207-3.1, 207-5.2, 207-5.3, 207-6.2, 207-6.3, 207-7, 208-1 thru 208-4, 208-6, 209-1, 209-2.1, 209-2.2, 209-3, 209-4.1, 209-4.2, 209-5, 210-2, 211-1, 211-2, 212-1 thru 212-3, 220-4 thru 220-7, 220-8.2, 220-8.3, 220-8.5, 221-1, 240-2.1, 240-2.2, 240-3, 240-4.3, 240-4.5, 240-4.7 thru 240-4.9, 240-5.3, 240-5.6, 240-5.7, 240-6.3, 240-6.4, 240-7.1 thru 240-7.3, 240-8, 241-1, 241-3, 241-7, 242-1 thru 242-4, 250-2, 250-3.1, 250-4.3, 250-5.3, 250-5.7, 250-8.1, 260-1, 260-4.2, 260-4.3, 260-6.1 and 298, and Tables 297-1 and 297-6, and Figures 298-5a thru 298-5d and 298-22; and editorial corrections/changes in Sections 200-3, 201-2, 201-3, 201-10 thru 201-13, 202-1, 205-2.4, 206-7.1, 206-7.4, 207-2, 207-4.2, 207-4.4, 207-5.1, 207-6.1, 207-6.4, 209-2.3, 209-2.5, 209-2.6, 220-8.4, 221-5, 240-7.5 thru 240-7.7, 241-2, 241-6, 242-5, 250-3.2, 250-3.3, 250-4.1, 250-4.2, 250-4.6, 250-5.2 and 250-6.2, and Tables 297-2, 297-4, 297-9, 297-11.

- in **Part 3**, four renamed sections: existing Sections 340-2, 340-3, 340-4 and 340-5 are now 341-2, 341-3, 341-4 and 341-5, respectively; new Sections 340-2, 341, 341-1, 350-4, 360-1, 360-2 and 360-3; a revised Table of Contents and revised Sections 301-14.1, 302-1, 340-1, 350-3 and 360; and a minor editorial corrections/changes in Sections 300-1 and 301-14.4;
- in **Part 4**, new Sections 442-20, 442-21, 442-22 and 442-23; a revised Table of Contents and Sections 401-6 and 440-7, and Form 496-13; and editorial corrections/changes in Sections 442-1, 442-3, 442-4, 442-5, 442-6, 442-7, 442-8, 442-9, 442-10, 442-11, 442-12, 442-13, 442-14, 442-15, 442-16 and 442-19;
- in **Part 6**, new Sections 630-6 and 640-27, and Form 696-1; a revised Table of Contents, revised Sections 605-4.3, 605-5.3, 605-5.12 thru 605-5.15, 605-11.3, 630-4, 630-5, 640-12.2, 642-24, 642-27, 642-33, 696 and 698, and Figures 698-3a, 698-3b and 698-4; and editorial corrections/changes in Sections 607-10, 607-13, 607-15, 640-18.2, 642-14, 642-15, 642-42 and 642-46.
- in **Part 11**, new Sections 1141-3.7 thru 1141-3.9; a revised Table of Contents and Sections 1140-6.1.1.4, 1140-6.1.2.2, 1141-2, 1141-3.1 thru 1141-3.6 and 1141-4; and an editorial corrections in Section 1142-35.
- in **Part 14**, a revised listing.

2004 October 22, 2004 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, a revised Table of Contents and Section 103-3.2; and editorial corrections/changes in Sections 100-3.3 and 140-7;
- in **Part 4**, editorial corrections/changes in Sections 442-20, 442-21 and 442-23; and
- in **Part 6**, new Section 642-47; a revised Table of Contents, revised Sections 605-11.3, 640-18.2, 641-5.1, 641-6.1, 642-9, 642-19 and 642-24.

2005 January 21, 2005 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised **Preface** and an updated **Cover Sheet, Revision Record** and **Table of Contents**;
- in **Part 1**, new Sections 194-21 and 194-22; a revised Table of Contents and Sections 100-3, 100-4, 101-3.3, 102-1, 102-3.4, 103-3.1, 103-3.2, 103-3.4, 103-3.7, 103-5, 105-1, 105-3, 120-1 thru 120-3, 140-7, 193-3, 193-10.1, 193-14, 193-15, 194-1, 194-2, 194-13, 194-15, 194-16 and 194-19, Tables 197-2, 197-8 and 197-9, and Figure 198-1; editorial corrections or changes in Sections 101-2, 101-4, 101-5, 102-2, 102-3.2, 102-3.5, 102-3.6, 102-4, 103-4, 104-1 thru 104-3, 106-1, 106-3, 130-2.3, 130-3, 130-4, 130-6, 140-1, 140-2.4, 140-2.6, 140-2.7, 140-5, 150-1, 150-2, 160, 193-5, 193-10.2, 193-12, 193-20, 194-5, 194-9 thru 194-11, 195-1, 196, 197 and 198, Forms 196-1 thru 196-4, Tables 197-3 thru 197-6, 197-7 and 197-10; and minor format changes.
- in **Part 2**, new Sections 205-6 and 210-3; revised Table of Contents and Sections 205-4, 209-4 and 240-8, and Table 297-7;
- in **Part 4**, new Forms 496-19 and 496-20, and Table 497-6; a revised Table of Contents, revised Sections 403-5, 403-6, 403-6.1, 403-6.4, 403-7, 440-3, 440-5 thru 440-7, 441-2, 441-3, 441-8, 441-11, 496 and 497, and revised Forms 496-3 and 496-4; editorial corrections in Form 496-6; and deleted Section 403-6.5; and
- in **Part 6**, a revised Table of Contents, revised Sections 605-4.3, 605-10.1, 642-21, 642-28, 642-30 thru 642-32 and 642-44; and editorial corrections or changes in Sections 642-33, 642-34, 642-36, 642-37, 642-40 thru 642-43, 642-45 and 642-47, and Tables 697-3 thru 697-5.

2005 April 15, 2005 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and **Table of Contents**, and an updated **Publication Record**;
- in **Part 1**, revised Tables 197-2 and 197-3;
- in **Part 3**, a revised Table of Contents, revised Sections 301-1, 301-7, 301-14.4, 302-2, 302-6, 307-2, 310, 320-1, 320-4, 341-1, 342-2 and 343, and Table 397-2; and minor editorial/format changes;
- in **Part 4**, a revised Table of Contents, Sections 401-6, 401-7, 404-2, 442-20, 442-21, 442-22 and 442-23, Form 496-2, and Table 497-5; deleted Forms 496-12 through 496-18; editorial revisions in Forms 496-8 through 496-11, and 496-19, Table 497-6, and Figure 498-37; and minor editorial/format changes;
- in **Part 6**, a revised Table of Contents, revised Sections 630-4, 630-5, 640-23.4, 640-23.5, 641-9.6, 641-23, 642-46 and Form 696-1; and minor editorial/format changes;
- in **Part 11**, a revised Section 1142-30;
- in **Part 12**, a revised Section 1220-5.6; and
- in **Part 13**, added copies of ODOT Policies 16-004(P), 22-007(P), 25-005(P), 122-002(P), 322-002(P), 512-002(P), and Standard Procedures 122-004(SP) and 510-005(SP); revised Sections 1301-2, 1310, 1312, 1314 and 1399; and minor editorial/format changes.

2006 January 20, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Preface, Publication Record** and **Table of Contents**;
- in **Part 1**, a new Section 193-11; deleted Section 193-14; three renumbered Sections (Sections 193-11 thru 193-13 are now Sections 193-12 thru 193-14); a revised Table of Contents, Sections 101-2, 101-3.2 thru 101-3.4, 101-4, 101-5, 102-2, 102-3.4 thru 102-3.6, 102-4, 103-3, 103-3.4 thru 103-3.6, 103-4, 103-5, 104-4, 106-1 thru 106-3, 120-1, 120-2, 130-2.2, 130-2.3, 140-2.3, 140-2.4, 193-4 thru 193-7, 193-9, 193-15 thru 193-18, 194-1 thru 194-3, 194-6 thru 194-8, 194-19, Chapter 197, Forms 196-1 thru 196-4, Tables 197-1 thru 197-3 and 197-5 thru 197-10, and Figures 198-1 and 198-2; and editorial revisions in Sections 100-1.2, 100-1.4, 100-4 thru 100-6, 101-3.1, 102-3.1 thru 102-3.3, 102-5, 103-3.2, 104-2, 105-1, 120-3, 130-1, 130-

2.1, 130-5, 140-1, 140-2.6, 140-2.7, 140-3, 140-4, 140-5, 140-7, 193-1, 193-2, 193-10, 194-4, 194-21 and 195-1, and Chapters 160 and 180;

- in **Part 5**, revised Chapters 500 and 595;
- in **Part 7**, revised Chapter 704, Sections 702-5, 702-6, 705-1, 705-2 and 705-4; and editorial revisions to the Table of Contents, Chapters 795 and 796, and Forms 796-4 and 796-5;
- in **Part 8**, revised Chapters 803, 805 and 840, Sections 801-2.2, 801-2.3, 802-1, 802-2, 880-2, 895-1, 895-2, 895-3, and 895-4; and editorial revisions to Chapters 850 and 860, Sections 830-1 880-1;
- in **Part 9**, a new Section 995-4; revised Table of Contents, Chapters 900, 930, 940 and 950, and Sections 995-1 and 995-2; and
- in **Part 10**, revised Chapters 1000 and 1095

2006 April 21, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- in **Part 2**, a new Figure 298-37; deleted Figure 298-5d; a revised Table of Contents, Chapter 243, Sections 200-1, 201-1 thru 201-4, 201-8, 201-10 thru 201-13, 202-5, 202-7, 202-8, 203-2, 204-1, 204-2, 205-2, 205-4 thru 205-6, 206-1, 206-3, 206-4, 206-5.2, 206-6, 206-7.2, 206-8, 206-10 thru 206-12, 206-14, 206-15, 207-1, 207-4.4, 207-5.1, 207-6.1, 207-6.3, 207-6.4, 207-7, 208-1, 208-2, 208-4 thru 208-6, 209-1, 209-4.1, 209-5 thru 209-7, 211-1 thru 211-4, 212-1, 212-3, 220-4, 220-5, 221-2, 221-4, 240-2.2, 240-3, 240-4.1, 240-4.2, 240-4.6, 240-4.8, 240-4.9, 240-5.3 thru 240-5.5, 240-6.2, 240-7.2, 240-7.3, 240-7.6, 240-7.7, 241-5, 242-4, 250-2, 250-3.1 thru 250-3.4, 250-4.2 thru 250-4.6, 250-5.2 thru 250-5.8, 250-6.2, 250-6.4, 250-6.5, 250-7.1, 250-7.2, 250-7.4 thru 250-7.6, 250-8.1, 250-8.2, 260-4.2, 260-4.3, 260-5, 260-6.1, 260-6.2, 295-1 thru 295-4, Figure Index, Figures 298-4a and 298-5a thru 298-5c; and editorial revisions in Chapter 230, Sections 200-2, 201-5, 201-9, 202-1, 202-4, 202-6, 203-1, 204-4, 205-1, 206-2, 206-5.1, 206-7.1, 207-2.2, 207-2.3, 207-3.1, 207-3.2, 207-3.3, 207-5.2, 207-5.3, 209-2.5, 209-4.2, 210-1, 210-3, 220-1, 220-7, 220-9, 221-1, 221-3, 221-5, 240-1, 240-2.1, 240-4.3, 240-4.5, 240-4.7, 240-5.7, 240-6.3, 240-7.4, 240-7.5, 240-8, 241-1, 241-6, 241-7, 242-1, 250-4.1, 250-5.1, 250-6.1, 250-6.3, 260-1, 260-4.1 and Figure 298-22; and minor editorial/format changes;
- in **Part 3**, new Sections 304-7, 341-6, 342-3 thru 342-5, and 350-5 thru 350-8; deleted Section 360-3; a revised Table of Contents, a revised title for Chapter 303, revised Chapters 310 and 343, Sections 300-1, 300-3, 301-1 thru 301-4, 301-6 thru 301-12, 301-14.1, 301-14.2, 301-14.4, 301-14.5, 302-1, 302-5, 303-1, 303-3, 304-2, 304-6, 307-2, 320-1, 320-4, 341-2, 341-5, 342-2, 360-1 and 360-2, Form 396-1, Figures Index, and Figures 398-2 thru 398-5; and editorial revisions to the Tables Index, Sections 300-2, 301-13, 303-4, 304-3, 340-1, 340-2, 341-1, 341-4, 342-1, 350-3 and 350-4, Chapters 330, 370 and 380, and Table 397-1; and minor editorial/format changes; and
- in **Part 4**, new Sections 442-24 thru 442-29, revised Table of Contents, Chapter 443, Sections 400-1, 401-2, 401-3, 401-6, 403-2, 403-7, 404-2, 404-3, 406-2, 407-2.2 thru 407-2.4, 420-4.2, 420-4.8, 440-6, 441-7, 441-8, 442-3, 442-13, 442-17 thru 442-19, 450-1, 450-3.2 thru 450-3.5, 450-6.2, 450-6.3, 450-8.4, 450-8.5, 450-10.2 thru 450-10.7, 450-11.2, 450-11.5 thru 450-11.8, 460-3.4, 495-1, Forms Index, Table 497-5, Figures Index, and Figures 498-7, 498-23 and 498-27; and editorial revisions to Chapters 430, 470 and 480, Sections 400-2, 400-3, 401-4, 402-1, 402-2, 402-3.1 thru 402-3.3, 402-4, 403-1, 403-3, 403-5, 403-6.1, 403-6.2, 404-1, 406-1, 407-1, 408-1, 408-2, 420-2, 420-4.1, 420-4.4, 420-4.5, 420-5, 440-1 thru 440-3, 440-5, 440-7, 441-1, 441-2, 441-5, 441-10, 441-11, 442-1, 450-5, 450-6.1, 450-8.1, 450-10.1, 460-5, 460-7, 460-8, 460-9.2, 460-9.3, and Forms 496-2, 496-6 and 496-7; and minor editorial/format changes.

2006 July 21, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- in **Part 4**, new Section 450-12; a revised Table of Contents and Section 420-4.6;
- in **Part 6**, new Sections 600-6, 606-21, 606-22, 642-48 thru 642-52, and Table 697-10; deleted Section 605-14.5; a revised Table of Contents, Sections 601-2, 602-3, 602-5.1, 602-5.3, 602-5.6, 602-5.7, 603-2, 603-3, 604-2, 604-3, 604-6, 605-1, 605-2.1 thru 605-2.3, 605-4.3, 605-5.1, 605-5.2, 605-5.5 thru 605-5.7, 605-5.9 thru 605-5.15, 605-6, 605-7.2, 605-7.3, 605-8.4, 605-9, 605-10.1, 605-10.2, 605-11.1 thru 605-11.13, 605-12.1 thru 605-12.5, 605-13.1, 605-14.1, 605-14.2, 605-14.4, 605-15.1, 605-16 thru 605-18, 605-20, 606-1, 606-3, 606-6 thru 606-9, 606-11 thru 606-20, 607-1, 607-6, 607-10, 607-13, 607-15, 620-3, 620-5, 630-5, 640-2, 640-5.2, 640-9, 640-12.1, 640-13.2, 640-18.1, 640-18.2, 640-22, 640-24.1, 640-24.2, 640-25, 640-26, 641-5.4, 641-5.6, 641-6.4, 641-8.4, 641-9.6, 641-10.6, 641-11 thru 641-14, 641-18, 641-23, 642-4, 642-6, 642-17, 642-21, 642-24, 642-25, 642-27, 642-39, 642-44, 642-46, 670-5 and Tables Index; and editorial revisions in Chapter 643, Sections 600-1 thru 600-5, 602-1, 602-5.8, 602-6, 602-7.1, 602-7.3, 602-8, 603-1, 604-1, 604-4, 605-3.1, 605-4.1, 605-4.2, 605-5.8, 605-7.1, 605-8.1, 605-8.3, 605-13.2, 605-15.2, 605-19, 606-2, 606-5, 606-10, 607-4, 607-7, 607-11, 607-12, 620-1, 630-1, 630-3, 630-4, 640-1, 640-3, 640-4, 640-5.1, 640-6, 640-7.1, 640-8, 640-11.3, 640-11.5, 640-13.1, 640-14, 640-16, 640-17, 640-19 thru 640-21, 640-23.1, 640-23.3, 640-23.4, 641-1, 641-2.1, 641-2.3, 641-2.5, 641-2.7, 641-2.8, 641-3, 641-4, 641-5.1 thru 641-5.3, 641-6.1 thru 641-6.3, 641-6.5, 641-7.1, 641-7.3, 641-8.1, 641-8.3, 641-9.3, 641-10.1, 641-10.3, 641-10.7, 641-15 thru 641-17, 641-19, 642-1, 642-10, 642-30, 642-43, 642-47, 650-1, 660-1, 660-2, 670-1, 670-2, 670-6.2, 695-1, 695-2, 695-5, 695-6 and Table 697-1d; and minor editorial/format changes;
- in **Part 11**, deleted Section 1142-32; a revised Table of Contents, Chapter 1150, Sections 1104-3, 1130-5, 1140-4.2, 1140-4.4, 1140-4.6, 1140-5.7, 1140-5.9, 1140-7.3, 1141-3.6, 1142-14, 1142-15, 1142-24, 1160-2, 1160-3.1 and Figures Index; editorial revisions in Chapter 1195, Sections 1100-1, 1100-2, 1100-3, 1103-6.6, 1103-6.8, 1104-1, 1104-2, 1105-1 thru 1105-3, 1106-2.2, 1107-3, 1120-3, 1130-2, 1130-3.1, 1130-4, 1140-1, 1140-3.2, 1140-3.3, 1140-3.5, 1140-4.3, 1140-4.7, 1140-5.3 thru 1140-5.6, 1140-5.8, 1140-6.1, 1140-6.2, 1140-8, 1141-1, 1141-2, 1141-3.1 thru 1141-3.3, 1141-4.1 thru 1141-4.5, 1142-8, 1142-13, 1142-25, 1142-28, 1142-31, 1142-35, 1160-1, 1160-4, 1160-13.5, the Tables Index, Tables 1197-4 thru Table 1197-7 and Figure 1198-4; and minor editorial/format changes.

2006 September 5, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**; and
- **in Part 6**, deleted Table 697-6; a revised Table of Contents, Sections 605-8.4, 605-12.2, 605-15.2, 606-10, 606-16, 607-10, 630-5, 640-5.1, 640-9, 641-5, 641-6.2, 641-6.4, 641-11, 641-18, 641-19, 642-10, 642-42, Tables Index, and Figures 698-6 and 698-8; and editorial revisions in Sections 601-2, 630-4, 630-6, and Table 697-10; and minor editorial/format changes.

2006 October 20, 2006 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 3**, revised Form 396-1;
- **in Part 4**, revised Section 420-4.2;
- **in Part 6**, a revised Table of Contents and Sections 642-26, 642-50 and 642-51;
- **in Part 8**, revised Chapter 805; and
- **in Part 12**, new Sections 1215-1 thru 1215-5 and 1230-7, Form 1296-13, Table 1297-5 and Figures 1298-17 thru 1298-40; a revised Table of Contents, Chapters 1210 and 1211, Sections 1201-1 thru 1201-5, 1202-1, 1212-2, 1212-3, 1213-1, 1213-2, 1220-2, 1220-6, 1230-1 thru 1230-3, 1230-6, 1250-2, Forms Index, 1296-1, 1296-2, 1296-11, 1296-12, Tables Index, Figures Index and Figures 1298-2, 1298-6, 1298-7, 1298-10, 1298-11, 1298-12, 1298-15, 1298-16; and editorial revisions in Chapters 1200, 1214, 1280 and 1295, Sections 1212-1, 1212-4, 1213-3, 1220-1, 1220-3 thru 1220-5, 1250-1; and minor editorial/format changes.

2007 January 19, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 1**, revised Figure 198-1;
- **in Part 2**, new Sections 202-9, 202-10, 204-5, 204-6, 220-10 and 221-6, Tables 297-12 and 297-13, and Figures 298-38 through 298-44; a revised Table of Contents, Sections 201-1, 201-3, 202-7, 203-1, 205-3, 208-1 and 221-5, Tables Index, Figures Index, Figure 298-6, 298-14, 298-15 and 298-27; editorial corrections in Sections 200-1, 201-5, 201-7, 204-4, 207-5, 207-6, 240-4, 250-4, 250-7 and 260-5, Table 297-4, and Figures 298-26 and 298-28 through 298-32; and minor editorial/format changes;
- **in Part 4**, new Sections 442-30, 442-31 and 442-32, and Figures 498-39, 498-40, 498-41 and 498-42; a revised Table of Contents and Figures Index; editorial corrections in Sections 407-2 and 450-10, and Figure 498-1; and minor editorial/format changes;
- **in Part 6**, a new section 620-7; a revised Table of Contents and Sections 605-1, 605-2, 605-11, 620-2, 620-4, 640-18, 642-24, 642-27, 642-33 and 642-34; editorial corrections in Sections 605-4, 605-5, 620-1, 641-17 and 641-19; and minor editorial/format changes; and
- **in Part 7**, revised Chapter 704.

2007 April 20, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 1**, revised Sections 103-3, 103-4, 104-2 and 104-3, Table Index, and Tables 197-1 through 197-3, and 197-5 through 197-10;
- **in Part 2**, a revised Table of Contents, Section 207-4, Figures 298-15 and 298-22; and editorial corrections in Figures 298-12, and 298-13 ;
- **in Part 4**, new Sections 402-5 and 402-6, and Tables 497-7 and 497-8; a revised Table of Contents, Forms Index, Forms 496-12 and 496-13, and Tables Index; editorial corrections in Sections 402-3, 404-2, 404-3 and 450-8, and Figures 498-6 through 498-8, 498-21, 498-26, and 498-28 through 498-35; and minor editorial/format changes;
- **in Part 6**, new Sections 641-24 and 642-53, a revised Table of Contents and Sections 602-2, 605-14, 607-12, 607-13, 640-1, 640-12, 641-23, 642-9, 642-21, 642-22, 642-30, 642-31, 642-44 and 642-48; editorial corrections in Sections 640-2, 641-6, 641-7, 641-19, 642-10, 642-11, 642-16 and 642-42; and minor editorial/format changes;
- **in Part 11**, revised Section 1140-5; and
- **in Part 12**, a revised Table of Contents and Section 1220-3.

2007 July 20, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- **in Part 1**, new Sections 120-7, 150-3, 195-3 through 195-7 and Figures 198-3 through 198-6; revised Table of Contents, Chapters 106, 160, 180 and 195, Sections 100-1, 100-4, 101-2, 101-5, 102-1 through 102-3, 120-1 through 120-6, 130-2, 140-7, 193-9 and 195-1, Forms 196-1 and 196-3, Tables 197-2, 197-3, 197-9 and 197-10, and Figures Index; editorial corrections in Sections 193-7, 193-10, 193-15 and 193-16; and minor editorial/format changes;
- **in Part 2**, a revised Table of Contents and Sections 220-2, 220-3, 240-4, 260-4 and 295-2;
- **in Part 3**, revised Sections 320-2 and 320-3;
- **in Part 4**, new Sections 401-9 and 440-8; a revised Table of Contents and Sections 401-2, 404-3, 420-2, 420-3 and 420-4;

- in **Part 6**, new Chapter 608, Section 695-7, Forms 696-2 through 696-9, and Figure 698-10; a revised Table of Contents, Sections 600-4, 600-6, 601-2, 602-3, 602-5, 605-3, 605-14, 605-17, 605-19, 606-14, 606-20, 630-4, 630-5, 640-12 through 640-14, 640-18, 641-2, 641-24, 642-35, 642-51, 642-52, 695-6, Forms Index, Form 696-1 and Figures Index; editorial corrections in Sections 607-13, 620-7, 630-1, 630-6, 640-23, 640-26, 641-6 and Figure 698-1; and minor editorial/format changes;
- in **Part 8**, revised Chapter 805;
- in **Part 11**, a revised Table of Contents and Sections 1120-3 through 1120-5;
- in **Part 12**, new Chapters 1203, 1204 and 1205, a revised Table of Contents, Chapters 1200, 1201, 1202, 1210, 1211, 1212, 1213, 1220, 1250, 1280, Forms Index, Form 1296-1, Tables Index, Figures Index, and Figures 1298-1, 1298-3 through 1298-5, 1298-21 and 1298-24; deleted Chapters 1213 through 1215, and 1230; editorial corrections in Form 1296-2 and Figures 1298-21 and 1298-24; and minor editorial/format changes;
- in **Part 13**, new title, Table of Contents and Chapters replaced existing text, which was relocated Part 15;
- in **Part 14**, new title, Table of Contents, Chapters 1400, 1401, 1402, 1415, 1420, 1430, 1450, 1480, 1495, Forms Index, and Form 1496-1; and deleted the index; and
- added **Part 15**.

2007 October 19, 2007 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- in **Part 1**, revised Table of Contents, Section 120-4, and Tables 197-1 and 197-2; an editorial correction in Sections 101-2; and minor editorial/format changes;
- in **Part 2**, revised Figures 298-10 and 298-29 through 298-32; editorial corrections in Section 240-4 and Figures 298-8, 298-9, 298-11 and 298-26; and minor editorial/format changes;
- in **Part 3**, an editorial correction in Table 397-1;
- in **Part 4**, a revised Table of Contents and Section 406-3; deletion of Section 402-6; and an editorial correction in Section 401-9;
- in **Part 6**, revised Table of Contents and Sections 641-12, 641-13, 641-14, 641-15, 642-30, 642-39 and 642-41;
- in **Part 11**, a revised Table of Contents; and editorial corrections to Chapters 1103 and 1120, and Section 1150-3;
- in **Part 13**, a revised Section 1301-3, Forms Index, and Form 1396-1.

2008 January 18, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- in **Part 4**, new Section 460-10 and Table 497-9; a revised Table of Contents, Sections 440-4, 442-13, 442-17, 442-24, and Tables Index; and minor editorial/format changes;
- in **Part 6**, new Form 696-6; renumbered Forms 696-1 through 696-9 (now Forms 696-1a, 696-1b, 696-2a, 696-2b, 696-3a, 696-3b, 696-4a, 696-4b and 696-5); a revised Table of Contents, Sections 605-2, 605-9, 605-13, 605-14, 605-18, 606-6, 606-16, 630-5, 640-2, 640-12, 640-19, 641-9, 641-10, 642-18, 642-39, 642-44 and 695-7, and Forms Index; editorial corrections in Sections 606-1, 640-11, 641-1, 641-12 through 641-15, and Figure 698-3a; and minor editorial/format changes; and
- in **Part 13**, revised Sections 1301-1 and 1301-2, Forms 1396-1 and 1396-2, and Table 1397-1.

2008 April 18, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- in **Part 1**, revised Tables 197-2 and 197-9; ;
- in **Part 2**, revised Table of Contents and Sections 240-4 through 240-6; and minor editorial/format changes;
- in **Part 3**, revised Table of Contents, Sections 342-3, 350-7 and 350-8; and minor editorial/format changes;
- in **Part 4**, new Section 401-10; a revised Table of Contents, Chapter 443, Sections 403-6, 403-7, 440-2, 440-6, 441-6, 441-9, 442-1, 442-3, 442-6, 442-11, 442-17 through 442-24, 450-3, 450-8, 450-10, 450-11, 460-4, 460-7, 460-8, Forms Index, Forms 496-14, 496-15, 496-19, Tables 497-1, 497-4, and Figures 498-10, 498-22, 498-25, 498-34 and 498-37; editorial corrections in Section 442-32, the Figures Index and Figure 498-37; and minor editorial/format changes;
- in **Part 6**, new Section/Plan Note 642-54; a revised Table of Contents, Sections 605-9, 605-11, 605-13, 620-6, 640-2, 641-10, 642-39; and minor editorial/format changes; and;
- in **Part 7**, new Chapter 742 with new Sections 742-1 and 742-2; a revised Table of Contents, and Section 702-4; and minor editorial/format changes
- in **Part 11**, editorial correction in Section 1142-25; and minor editorial/format changes;
- in **Part 13**, deleted Form 1396-2; revised Table of Contents, Section 1301-1, Forms Index and Figures Index; and minor editorial/format changes.

2008 July 18, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new **Cover Sheet** and an updated **Publication Record** and **Table of Contents**;
- in **Part 2**, new Section 206-17 and Table 297-14; a revised Table of Contents and Sections 201-6, 240-4, 260-5, the Table Index and Figure 298-18; and minor editorial/format changes;
- in **Part 3**, revised Table of Contents; deleted Sections 341-6, 342-4 and 342-5;
- in **Part 4**, new Section 440-9; a revised Table of Contents and Section 440-3;

- in **Part 6**, new Section 604-21, a revised Table of Contents, Sections 605-11, 605-18, 605-20, 607-15, 640-2, 642-24, 642-39, 642-41 and 642-50; and minor editorial/format changes;
- in **Part 7**, revised Table of Contents and Section 702-4; and minor editorial/format changes; and
- in **Part 12**, new Forms 1296-14 through 1296-16, and Table 1297-6; revised Table of Contents, Chapters 1201 and 1202, Sections 1203-1 through 1203-5, the Forms Index, Forms 1296-1, 1296-3, 1296-4, 1296-11, the Tables Index, the Figures Index, Figures 1298-3 through 1298-5; and minor editorial/format changes.

2008 October 17, 2008 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, new Section 201-14; a revised Table of Contents and Section 210-3;
- in **Part 3**, new Table 397-5; revised Table of Contents, Section 350-2 and Tables 397-1, 397-3 and 397-4; deleted Figure 398-6; editorial changes in Sections 301-13, 302-2, 303-3, 307-2, 320-4, 350-6, 350-7, 350-8, the Tables Index and the Figures Index; and minor editorial changes;
- in **Part 4**, a revised Table of Contents, Chapter 430, and Sections 401-3, 442-26, 442-28, 460-2 and 460-2; editorial changes in Sections 401-10 and 403-3; and minor editorial changes;
- in **Part 6**, a revised Table of Contents, Sections 605-13, 605-20, 620-6, 640-18, 640-23, 641-23, 642-24, 642-25, 642-48 and 642-50; editorial changes in Sections 602-6, 605-2, 605-9, 605-10, 605-11, 605-19, 608-2, 620-3, 620-7, 641-9, 641-10, 641-24, 642-21, 642-27, 642-41, 642-54 and 670-6; and minor editorial/format changes;
- in **Part 7**, revised Table of Contents; and an editorial change in Section 702-2;
- in **Part 11**, revised Figure 1198-12;
- in **Part 12**, new Section 1213-6; revised Table of Contents, Chapter 1210, Section 1213-1 and Forms 1296-1 and 1296-14; editorial changes in Section 1212-10; and minor editorial/format changes; and
- in **Part 13**, new Figures 1398-2 and 1398-3; revised Table of Contents, Sections 1301-1, 1301-2, 1301-3, Form 1396-1 and Table 1397-3; and editorial changes in the Forms Index and the Figures.

2009 January 16, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents and Sections 201-3 and 240-5; and minor editorial/format changes;
- in **Part 3**, new Section 342-4; and a revised Table of Contents;
- in **Part 4**, new Sections 442-33 through 442-39; a revised Table of Contents, Sections 403-5, 440-3, 440-4 and 450-8, Tables Index, Tables 497-4 and 497-5, Figures Index and Figures 498-3 through 498-5, 498-12, 498-35 and 498-37; editorial change for Section 401-10; and minor editorial changes;
- in **Part 6**, new Section 641-19 and renumbered existing Sections 641-19 through 641-24, a revised Table of Contents, Sections 603-2, 605-5, 605-11, 605-13, 640-6, 640-22, 640-24, 640-25, 641-9, 641-10, new 641-21 (formerly 641-20), new 641-22 (formerly 641-21), 642-4, 642-6, 642-14, 642-15, 642-35, 642-38 and 642-39; editorial change in Section 642-41; and minor editorial/format changes
- in **Part 11**, revised Figure 1198-12; and
- in **Part 13**, new Section 1301-4 and Form 1396-2; deleted Figure 1398-1 and renumbered Figures 1398-2 and 1398-3; revised Table of Contents, Sections 1301-1 through 1301-3, Forms Index, Form 1396-1, Tables Index, Table 1397-1, and the Figures Index; editorial corrections in Table 1397-3; and minor editorial/format changes.

2009 March 6, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents; and
- in **Part 2**, a revised Section 240-4.

2009 April 17, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents; and
- in **Part 2**, new Tables 297-15, 297-16, 297-17 and 297-18; a revised Table of Contents, Sections 206-8, 206-13, 207-2, 207-3, 240-4, the Tables Index, and Figures 298-5a and 298-5b; editorial change in Section 207-4; and minor editorial/format changes;
- in **Part 3**, new Sections 301-15 and 341-6; and a revised Table of Contents and Sections 301-10, 302-1 and 341-4; and editorial changes in Chapters 350, 360, 370, 380, 395 and Table 397-2;
- in **Part 4**, a revised Table of Contents, Chapter 443, Sections 401-7, 403-2, 440-3, 440-6, 442-7, 442-8, 442-13, 442-17, 442-18, 442-25 and 442-32, and Figure 498-5; editorial changes for Sections 442-20 and 442-22; and minor editorial changes;
- in **Part 6**, new Section 604-5 and renumbered existing Sections 604-5 and 605-6, new Section 640-28, and new Section 641-19 and renumbered existing Sections 641-19 through 641-25, and new Figures 698-11 and 698-12; a revised Table of Contents, Sections 601-2, 605-2, 605-5, 605-11, 605-14, 605-19, 606-10, 620-4, 640-9, 640-11, 640-12, 640-19, 640-22, 640-23, 641-5, 641-6, 641-9, 641-10, 641-17, 641-18, new 641-20 through 641-22 (formerly 641-19 through 641-21), new 641-24 through 641-26 (formerly 641-23 through 641-25), 642-6, 642-14, 642-15, 642-18, 642-30, 642-31, 642-36, 642-37, 642-44, 642-46, 642-50, 642-53, and 642-54, the Tables Index, and the Figures Index; editorial changes in Sections 641-8 and 642-24, and Form 696-1a; and minor editorial/format changes;

- in **Part 9**, new Sections 940-1 and 940-2, and a new Chapter 942, with new Sections 942-1 and 942-2; a revised Table of Contents and Chapter 940;
- in **Part 12**, a new Section 1213-7; a revised Table of Contents, Chapter 1210, Sections 1203-2, 1203-3, 1213-1, the Forms Index, Form 1296-2 and Form 1296-14; editorial changes in Sections 1203-1 and Form 1296-1; and minor editorial/format changes;
- in **Part 13**, a revised Table of Contents, Sections 1301-1, 1301-2, 1301-3 and 1301-4, and Form 1396-1; and minor editorial/format changes; and
- in **Part 15**, a revised Table of Contents, Chapter 1505, and Section 1501-3; and minor editorial/format changes.

2009 July 17, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, new Section 195-8, a revised Table of Contents, Chapter 106, Sections 100-1, 100-4, 100-5, 101-4, 101-5, 102-1, 102-3 through 102-5, 103-1, 103-3 through 103-5, 104-1 through 104-4, 105-1, 120-3, 120-6, 130-2, 130-4 through 130-6, 140-7, 193-7, 193-11, 194-1, 194-17, 194-18, 195-3 through 195-6, Forms Index, Forms 196-1 and 196-3, Tables Index, Tables 197-1 through 197-3, Tables 197-9 and 197-10, and Figure 198-2; editorial changes in Section 140-2 and Figure 198-6; and minor editorial/format changes;
- in **Part 2**, new Sections 202-11 and 242-6; a revised Table of Contents, Sections 201-3, 201-6, 201-8, 201-11, and Section 295-2; editorial changes in Sections 202-6 and 206-11; and minor editorial/format changes;
- in **Part 3**, revised Chapter 343, Sections 302-5, 304-3, 320.1, 320-5, and Form 396-1; editorial changes in Sections 301-3, 301-7, 301-10, 301-14, 350-7 and Table 397-1; and minor editorial changes;
- in **Part 4**, new Section 403-8; a revised Table of Contents, Chapter 443; Sections 402-2, 402-3, 408-2, 420-1, 421-1, 421-2, 440-3, 440-8, 441-7, 442-27, 442-29, 450-1, 460-7, 460-9, and the Forms Index; editorial changes in Sections 440-4, 442-5, 442-22, 442-32 and 442-33; and minor editorial changes;
- in **Part 6**, a revised Table of Contents, Sections 600-4, 605-4, 605-11, 605-13, 605-14, 608-4, 608-11, 608-12, 620-3, 620-7, 640-9, 641-3, 641-4, 641-10, 642-50, 650-2, 650-3, 660-3, 670-3, 695-2, 695-4, 695-6, and 695-7; editorial changes in Sections 601-2, 604-5, 605-9, 605-10, 608-2, 608-4, 630-4, 630-5, 640-23, 640-26, 642-43, 642-44, and the Forms Index; and minor editorial/format changes;
- in **Part 13**, revised Sections 1301-3 and 1301-4, the Forms Index, and the Tables Index; editorial change in Section 1301-1; and minor editorial/format changes.

2009 October 16, 2009 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, new Section 140-8, a revised Table of Contents; revised Sections 120-4 and 193-19, and Table 197-2; and minor editorial/format changes;
- in **Part 3**, a revised Section 342-2;
- in **Part 4**, a revised Table of Contents, Sections 420-5, 440-7, 450-10, 450-11, Forms 496-4 and 496-6, the Figures Index, and Figures 498-3 through 498-5, 498-23, 498-27, 498-29, 498-30 and 498-33; an editorial correction in Sections 420-4; and minor editorial changes;
- in **Part 11**, a revised Table of Contents; revised Sections 1140-4, 1142-24 and 1142-26, and Figure 1198-12; editorial corrections in Sections 1140-6, 1140-8, 1142-25; and minor editorial/format changes.

2010 January 15, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, revised Section 101-5, Forms 196-3 and 196-4, and Table 197-2;
- in **Part 2**, new Sections 202-12, 202-13 and 260-7, a revised Table of Contents and Sections 201-8 and 240-2;
- in **Part 3**, new Section 301-16, and a revised Table of Contents, Section 301-14 and Table 397-2;
- in **Part 4**, a revised Table of Contents and Section 440-3; and minor editorial changes.

2010 April 16, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, new Sections 130-7 and 140-9; a revised Table of Contents and Sections 140-8, 195-2, and Tables 197-2 and 197-9; and an editorial correction in Section 130-6;
- in **Part 4**, new Sections 403-9, 403-10, 442-40, 442-41 and 442-42; a revised Table of Contents and Sections 402-3, 403-3, 403-6 and 420-5; and minor editorial/format changes;
- in **Part 8**, new Sections 804-1 through 804-4, 830-3, 830-4, 840-1 through 840-4, 895-5, a new Forms Index and Form 896-1, and a new Figures Index and Figure 898-1; a revised Table of Contents, Chapters 804 and 840, Section 830-1; and minor editorial/format changes; and
- in **Part 10**, a revised Chapter 1000.

2010 May 14, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 6**, new Section 660-4 and new Figures 698-13 and 698-14; a revised Table of Contents and Section 660-1, and a revised Figures Index; editorial corrections in Sections 601-2, 608-4, 608-6, 608-8, 630-4, 630-5, 640-1, 640-13, 640-14, and Figure 698-1; and minor editorial/format changes.

2010 July 16, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 2**, a revised Table of Contents and Sections 202-4, 202-12, 202-13 and 205-3, Tables 297-1, 297-4, 297-12, 297-13 and 297-17, and Figures 298-20, 298-22 and 298-28; editorial corrections in the Figures Index and Figure 298-10; and minor editorial/format changes;
- **in Part 3**, a revised Table of Contents and Sections 301-1, 301-8 and 301-15; and an editorial correction in Section 301-16;
- **in Part 4**, a revised Table of Contents and Sections 440-3, 442-25, 442-26, 442-27, 442-28, 442-29, 442-31, 442-40, 442-41 and 450-8;
- **in Part 6**, a revised Table of Contents and Sections 605-6, 605-8, 642-41, 642-44 and 670-4, Table 697-1b, and Figure 698-3b;
- **in Part 7**, a revised Section 742-2; and
- **in Part 9**, new Chapters 901 and 902; a revised Table of Contents and Chapter 900, and Sections 940-1 and 940-2.

2010 October 15, 2010 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents; ;
- **in Part 1**, a revised Table of Contents and Sections 140-7 and 195-8, and Table 197-9;
- **in Part 2**, a revised Table of Contents and Sections 209-2, 211-1 through 211-4 and 240-8; editorial corrections in Tables 297-16 and 297-17; and minor editorial/format changes;
- **in Part 3**, revised Chapter 343, Sections 302-1, 304-1, 304-3, 307-1, 320-5, 341-2, 350-3, 350-6 and 350-8; and minor editorial changes;
- **in Part 4**, a revised Figure 498-21;
- **in Part 6**, a revised Table of Contents and Sections 602-8, 605-11, 606-16, 607-10, 640-12, 641-9, 641-21, 641-25 and 695-4; an editorial correction in Section 640-18; and minor editorial changes; and
- **in Part 9**, a revised Table of Contents and Chapter 930 (replacing the existing text with new Sections 930-1 and 930-2).

2011 January 21, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 2**, a revised Table of Contents and Sections 212-1 through 212-3, 240-4 , 240-7, 250-4, 250-5, 250-7 and 250-8; and minor editorial/format changes;
- **in Part 3**, revised Table of Contents and Section 301-9, the Figures Index, and Figure 398-1;
- **in Part 4**, a revised Table of Contents and Sections 403-6, 420-4, 440-2, 440-5, 440-7, 442-27, 442-29, Tables 497-1 and 497-6; and an editorial change in Figure 498-38;
- **in Part 6**, a revised Table of Contents and Sections 605-19, 605-20, 607-10, 642-50 and 642-51 and Figures 698-3a and 698-3b,
- **in Part 8**, a revised Section 804-4; and
- **in Part 11**, a revised Table of Contents and Chapter 1142, deleting fourteen Plan Notes, while renumbering and revising the others.

2011 April 15, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- **in Part 1**, revised Forms 196-3, 196-4 and 197-9, and Figure 198-1;
- **in Part 2**, revised Sections 241-6;
- **in Part 4**, a revised Sections 440-5, 441-7, 441-10, 442-10, 460-2 and 460-3; editorial changes in Sections 440-3, 440-8, 441-3, 441-5, 441-6, 442-12 and 442-14; and other minor editorial/format changes;
- **in Part 6**, new Section 650-4; a revised Table of Contents and Sections 600-2, 602-6, 602-8, 603-3, 605-2, 605-14, 605-15, 608-5, 608-8, 620-7, 640-4, 640-11, 640-12, 640-13, 640-17, 640-18, 641-2, 641-5, 641-6, 641-7, 641-8, 641-9, 641-25, 642-6, 642-24, 642-26, 642-30, 642-31, 642-33, 642-48, and 650-3, the Tables Index, and Table 697-7; editorial changes to Sections 600-5, 602-4, 602-5, 602-7, 604-5, 605-4, 605-5, 605-6, 605-7, 605-11, 605-13, 605-17, 605-18, 605-19, 605-20, 606-6, 606-7, 606-9, 607-10, 630-5, 640-2, 640-5, 640-25, 640-28, 641-10, 641-12 through 641-17, 641-19, 641-20, 641-21, 641-26, 642-9, 642-10, 642-15, 642-16, 642-19, 642-21, 642-25, 642-27, 642-28, 642-34, 642-35, 642-39, 642-40, 642-41, 642-50 through 642-54, 670-6 and 695-4, Tables 697-1c, 697-2, 697-4, 697-8 and 697-9, and the Figures Index; and other minor editorial/format changes;
- **in Part 8**, a revised Section 804-4.
- **in Part 12**, new Forms 1296-6b, 1297-7b, 1296-17, 1296-18 and 1296-19; a revised Table of Contents, Chapter 1250, Sections 1203-1, 1203-2, 1203-3, 1203-4, 1203-5, 1204-2, 1204-5, the Forms Index, Forms 1296-6a, 1296-7a and 1296-16, the Tables Index, Table 1297-7, the Figures Index and Figure 1298-1; and editorial changes in Forms 1296-2, 1296-4, 1296-11 and 1296-12; and other minor editorial/format changes; and

- in **Part 14**, a revised Table of Contents, the Chapter 1415 title and Sections 1401-1, 1401-2, 1401-3, 1401-6, 1402-1, 1415-1, 1415-2, 1415-3; editorial changes in Sections 1401-4 and 1401-5, the Form Index, and Form 1496-1; and other minor editorial/format changes.

2011 July 15, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents and Section 206-5;
- in **Part 4**, an editorial change in Section 460-8; and
- in **Part 11**, a revised Table of Contents, Section 1140-4, the Figure Index, and Figure 1198-6; and other minor editorial/format changes.

2011 October 21, 2011 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents;
- in **Part 3**, revised Sections 301-5 and 350-4; and other minor editorial changes;
- in **Part 4**, revised Sections 420-4 and 450-8; and other minor editorial changes;
- in **Part 6**, revised Sections 642-37 and 642-41; and a minor editorial correction; and
- in **Part 11** a revised Table of Contents; revised Section 1120-5; deleted Section 1142-15; and other minor editorial changes.

2012 January 20, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, revised Forms 196-3 and 193-4, and Table 197-3; and made editorial corrections in Sections 100-1 100-4, 101-4, 101-5, 102-4, 102-5, 103-1, 103-4, 103-5, 104-1 104-3, 104-4, 105-1, 106, 195-3, 195-5, 195-6, 195-8, 196-1, 196-2, 196-3, and 196-4;
- in **Part 3**, revised Chapters 305, 306, and 310, Sections 300-1, 301-1, 301-4, 301-5, 301-6, 301-7, 301-8, 301-9, 301-10, 301-11, 301-12, 301-14, 303-1, 303-2, 304-1, 304-3, 304-5, 304-6, 341-2, 342-2, 342-4, 350-3, 350-5, 350-6, 350-7, 350-8, Table 397-2, and Figures 398-2, and 398-3;
- in **Part 4**, a revised Table of Contents; Sections 400-1, 401-7, 403-2, 403-6, 403-10, 404-3, 405-1, 406-1, 406-3, 407-2, 408-1, 408-2, 420-4, 420-5, 421-1, 441-3, 450-10, Table 497-3; and deleted Section 403-7;
- in **Part 5**, revised Chapter 500;
- in **Part 6**, revised Sections 602-5, 602-6, 604-5, 604-6, 604-7, 605-3, 605-5, 605-6, 605-7, 605-9, 605-10, 605-11, 605-12, 605-13, 605-14, 606-15, 605-17, 605-18, 605-21, 606-14, 606-18, 606-19, 606-21, 606-22, 607-1, 607-2, 620-6, 640-18, 640-26, 641-5, 641-7, 641-8, 641-9, 641-10, 641-12, 641-13, 641-14, and 641-15;
- in **Part 8**, a new Part Title; a revised Table of Contents, Chapters 800, 803 and Sections 802-1, 804-1, 804-2, 804-3, 830-3, 840-2, 840-3, and 840-4;
- in **Part 9**, revised Chapter 900;
- in **Part 10**, contents have been incorporated into Part 8; Part 10 now reserved for future use; and
- in **Part 11**, a revised Table of Contents, and Section 1141-4.

2012 April 20, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, a revised Table of Contents; revised Sections 101-2, 101-3, 101-4, 102-2, 102-3, 102-5, 103-2, 103-3, 103-5, 120-4, 120-6, 120-7, 130-6, 140-7, 193-7, 193-15, 193-19, 194-6, 194-10, 194-14, 195-3, and 195-4; revised Tables 197-1, 197-2, 197-9, 197-10; and revised Figures 198-1, 198-5 and 198-6.
- in **Part 2**, a revised Table of Contents; new Sections 202-14 and 242-7; revised Sections 200-1, 201-1, 201-2, 201-3, 201-5, 201-6, 201-7, 201-8, 201-10, 201-11, 201-12, 201-13, 202-1, 202-4, 202-5, 202-6, 202-7, 202-9, 202-10, 202-11, 202-12, 203-1, 203-2, 204-2, 204-3, 204-4, 205-1, 205-2, 205-3, 205-4, 205-5, 205-6, 206-1, 206-3, 206-4, 206-5, 206-6, 206-7, 206-8, 206-10, 206-11, 206-12, 206-14, 206-15, 206-16, 206-17, 207-1, 207-2, 207-3, 207-4, 207-5, 207-6, 207-7, 207-8, 208-1, 208-2, 208-3, 208-4, 208-5, 209-1, 209-2, 209-3, 209-4, 209-5, 209-6, 209-7, 210-3, 211-1, 211-2, 211-3, 211-4, 212-1, 212-2, 220-5, 220-6, 220-7, 220-10, 221-1, 221-2, 221-3, 221-4, 221-5, 221-6, 240-2, 240-3, 240-4, 240-5, 240-6, 240-7, 240-8, 241-5, 242-3, 242-4, 242-5, 242-6, 250-3, 250-4, 250-5, 250-6, 250-7, 260-2, 260-4, 260-5, 295-2; deleted Section 210-2; revised Tables 297-1, 297-2, 297-8f, 297-9, 297-10, 297-12; and deleted Table 297-13; revised Figures Index, revised Figures, 298-4a, 298-4b, 298-5a, 298-5b, 298-7, 298-9, 298-11, 298-12, 298-13, 298-15, 298-18, 298-29, 298-30, 298-31, 298-32, 298-42; and deleted Figure 298-10
- in **Part 3**, a revised Table of Contents, new Section 342-5; revised Sections 301-4, 301-9, 301-10, 301-13, 301-14, 302-6, 304-4, 304-5, 304-6, 340-2, 341-2, 342-2, and 350-8; revised Chapter 305, deleted Chapter 303; and other minor editorial/format changes.
- in **Part 4**, a revised Table of Contents, new Sections 442-43 and 442-44; revised Sections 401-7, 402-2, 402-3, 403-2, 404-2, 404-3, 407-2, 420-1, 420-4, 421-1, 440-3, 440-7, 441-6, 441-8, 442-5, 442-9, 442-19, 442-21, 442-25, 442-29, 442-36, 442-39, 442-40, 442-41, 450-3, 450-6, 450-8, 450-10, 460-3; revised Table Forms 496-2 and 496-5; revised Table 497-3, revised Figures Index, and revised Figures 498-1, 498-3, 498-4, and 498-5; and other minor editorial/format changes.

- in **Part 6**, a revised Table of Contents, revised Chapter 643; revised Sections 602-4, 602-8, 605-10, 606-7, 607-1, 607-15, 620-7, 640-21, 640-26, 640-28, 641-5, 641-6, 641-9, 641-17, 642-41, 650-2, 660-2, and 660-3; and revised Figures 698-13 and 698-14.
- in **Part 11**, a revised Table of Contents; and deleted Section 1142-4.

2012 July 20, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 1**, a revised Table of Contents; revised Chapter 106; revised Sections 100-1, 100-4, 100-5, 100-6, 101-4, 102-4, 102-5, 103-1, 103-3, 103-4, 105-1, 105-2, 120-5, 193-1, 193-3, 194-1, 194-22, 195-1, and 195-2; revised Form 196-3; revised Tables Index; deleted Tables 197-1 and 197-2 (with subsequent Tables renumbered).
- in **Part 2**, a revised Table of Contents; new Section 241-8; revised Sections 202-14, 240-4; and Revised Figures 298-5b, 298-6a, 298-6b, 298-6c, 298-6d, 298-7, 298-8, 298-9, 298-22, 298-28, 298-29, 298-30, 298-31, 298-32, 298-33, 298-34, 298-35, 298-36, 298-39, 298-40, 298-41, 298-42, and 298-43.
- in **Part 3**, a revised Table of Contents; new Section 341-6; revised Sections 301-8, 301-12, 301-14, 302-6, 304-4, 304-5, 304-6, and 307-2; revised Figures Index; deleted Section 341-5; and deleted Figure 398-1 (with subsequent Figures renumbered).
- in **Part 4**, a revised Table of Contents; new Sections 403-7, 442-45, 442-46, and 442-47; revised Sections 440-3, 442-4, 442-21, and 442-44; and deleted Section 442-42.
- in **Part 6**, a revised Table of Contents; new Section 642-46; revised Chapters 643, and 695; revised Sections 604-5, 605-14, 605-18, 605-19, 605-20, 608-10, 620-1, 620-7, 630-5, 640-2, 640-6, 640-19, 640-28, 641-6, 641-9, 641-10, 641-13, 641-17, 641-19, 641-20, 641-21, 642-26, 642-35, 642-41, 642-45, 642-50, 660-2, and 660-4; revised Table 697-5; revised Forms Index; revised Figures Index; deleted Form 696-5; and deleted Figures 698-11 and 698-12 (with subsequent Figures renumbered).
- in **Part 7**, a revised Table of Contents; new Section 702-8; revised Chapters 701 and 704; revised Sections 702-2, 702-3, 702-4, 702-5, 702-6, 702-7, 705-1, 705-2 and 705-4; revised Forms Index 796; revised Forms 796-2 and 796-3; and an editorial correction in Table 797-1.
- in **Part 11**, a revised Table of Contents; and revised Sections 1140-5, 1140-6, 1142-10, 1142-12, 1142-16 and 1142-18.
- in **Part 12**, a revised Table of Contents; revised Chapter 1202; revised Sections 1211-1, 1211-4, 1211-10, 1212-1, 1212-8, 1212-10, 1213-6, and 1213-7; revised Forms Index; deleted Form 1296-13; revised Tables Index; deleted Table 1297-5; and an editorial correction in Table 1297-4.

2012 October 19, 2012 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, revised Sections 207-7, 208-6, 220-8 and 242-6; an editorial correction in Section 208-4;
- in **Part 3**, revised Section 302-5; and editorial corrections in Sections 301-16 and 341-6;
- in **Part 4**, a revised Table of Contents; a new Figure 498-43; revised Chapter 443, Sections 401-8, 403-3, 403-6, 403-8, 403-9, 404-2, 407-2, 420-1, 420-4, 421-1, 421-2 and 450-10, the Forms Index, and the Figures Index; and an editorial correction in Section 440-3;
- in **Part 6**, a revised Table of Contents; revised Sections 605-5, 606-6, 641-3, 641-4 and 642-37; and
- in **Part 12**, revised Sections 1213-6 and 1213-7.

2013 January 18, 2013 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a new Cover, Title Sheet and an updated Publication Record and Table of Contents;
- in **Part 2**, a revised Table of Contents; new Sections 240-9 and 242-8; revised Sections 240-4, 241-7, 242-5 and Table 297-4; and an editorial correction in Section 240-8;
- in **Part 4**, a revised Table of Contents; new Sections 405-3, 442-48, 442-49 and 442-50; revised Chapter 443; revised Sections 403-9, 420-1, 420-5, 421-1, 440-3, 440-5, 440-7, 442-44, 450-3, 450-6, 450-8 and 450-10; and miscellaneous minor editorial/format corrections;
- in **Part 6**, revised Sections 642-41 and 670-6;
- in **Part 9**, a revised Table of Contents; and revised Section 902-2; and
- in **Part 11**, a revised Table of Contents; revised Sections 1103-6 and 1140-4; and an editorial correction in Section 1120-5.

2013 April 19, 2013 – Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents; and
- in **Part 6**, revised Table of Contents; revised Sections 642-41 and 642-46, and deleted Section 642-45.

2013 July 19, 2013 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- in **Part 4**, revised Section 403-10; and an editorial correction in Section 442-32;
- in **Part 6**, revised Table of Contents; added new Figure 698-11; revised Sections 601-2, 602-5, 603-2, 605-2 – 605-5, 605-7, 605-11 – 605-14, 605-17 – 605-19, 606-10, 606-11, 606-13, 606-16, 606-17, 607-1, 607-7, 607-10, 607-12, 607-13, 607-15,

608-6 thru 608-11 (now 608-5 thru 608-10), 608-13 (now 608-11), 620-3, 620-4, 620-7, 630-4, 630-5, 640-2, 640-5, 640-6, 640-9, 640-11 thru 640-13, 640-15, 640-18, 640-19, 640-22, 640-25, 640-26, 640-28, 641-2 – 641-19, 641-21 – 641-26, 642-6, 642-14, 642-15, 642-21, 642-24, 642-30, 642-31, 642-34, 642-44, 642-53, 650-3, 660-2, 660-4, 670-3, 670-6, 670-7, 695-2 and 695-4; 695-7 (now 605-6); revised Forms Index; revised Tables Index, Table 697-5 and renumbered Tables 697-8 – 697-10 (now 697-6 – 697-8); revised Figures Index, revised and renumbered Figures 698-3a and 698-3b (now 698-2), and renumbered Figures 698-4 and 698-6 thru 698-12 (now 698-3 thru 698-11); deleted Sections 608-5, 608-12, 650-4, 695-6, Form 696-5 (now Figure 698-11), Tables 697-6 and 697-7, and Figures 698-2 and 698-5; editorial corrections in Sections 600-1, 600-2, 600-5, 605-6, 606-14, 607-3, 640-8 and 640-24; and miscellaneous minor editorial/format corrections;

- **in Part 7**, revised Table of Contents; revised Chapters 701 and 704, Sections 702-6, 705-2, 705-4, 742-1 and 742-2; deleted Chapter 795; editorial corrections in Sections 702-3, 702-4, 702-5 and 705-1, and Form 796-2; and miscellaneous minor editorial/format corrections;
- **in Part 9**, revised Table of Contents; revised Chapters 900, 901 and 950, Sections 902-1, 930-1, 930-2, 940-1, 942-2, 995-1, 995-2 and 995-4 (now 995-3); deleted Chapter 980 and existing Section 995-3; and miscellaneous minor editorial/format corrections; and
- **in Part 12**, revised Form 1296-17.

2013 October 18, 2013 - Revision consists of the following (as well as related pages needed for double-sided printing of the revised pages):

- a revised Title Sheet, Publication Record and Table of Contents;
- **in Part 3**, revised Sections 302-1 and 302-3;
- **in Part 4**, revised Table of Contents; revised Chapter 443, Sections 401-4, 442-13, 442-17, 442-30, 442-31, 442-45, 460-2, 460-3 and 460-7; deleted existing Sections/Plan Notes 442-18, 442-33 – 442-38; editorial corrections in Sections/Plan Notes 442-4 – 442-6, 442-9 – 442-11, 442-14, 442-16, 442-41, 442-43, 442-44 and 442-46 – 442-49; and miscellaneous minor editorial/format corrections;
- **in Part 6**, revised Table of Contents; revised Sections 605-5, 605-20, 641-11, 641-19; editorial corrections in Sections 641-18; and miscellaneous minor editorial/format corrections;
- **in Part 12**, revised Table of Contents; revised Sections 1213-1, 1213-2, 1213-4 (now 1213-3), 1213-6 (now 1213-4), 1213-7 (now 1213-5), the Forms Index, Forms 1296-11, the Figures Index, and Figure 1298-2; deleted Chapters 1220, 1250, 1280 and 1295, Sections 1213-3 and 1213-5, and Form 1296-12; editorial corrections in Form 1296-13; and miscellaneous minor editorial/format corrections; and
- **in Part 14**, revised Table of Contents; new Chapter 1416 and Section 1416-1; revised Chapter 1400, Sections 1401-1 through 1401-6, 1415-1 – 1415-3, 1415-5 (now 1415-4); deleted Chapters 1402, 1420, 1430, 1450, 1480, 1495, Section 1415-4, the Forms Index and Form 1496-1; and miscellaneous minor editorial/format corrections.

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302 RAISED PAVEMENT MARKERS**302-1 General**

Raised Pavement Markers (RPMs) are a special form of pavement markings described in **OMUTCD Sections 3B.11 through 3B.14**. Plowable RPMs were developed for use in states that typically have to deal with snow. **CMS Item 621** and **CMS 721** establish the specifications for RPMs and **Supplement 1062** addresses testing procedures. Information about the proper installation of RPM castings and reflectors, and inspection guidelines are provided in **Chapters 350 and 360**, respectively.

As noted in **OMUTCD Sections 3B.12 through 3B.14**, RPMs may be used as positioning guides, or to supplement or substitute for the standard pavement markings. **ODOT's** RPM program basically uses them as positioning guides.

Temporary raised pavement markers are addressed in **Section 605-11.12** and **SCD MT-99.30**. **Supplement 1056** specifies the Prequalification Procedure for Work Zone Raised Pavement Markers.

302-2 Guidelines and Placement Standards

RPMs should be used on **ODOT**-maintained highways. They should be included in new construction and resurfacing projects on **ODOT**-maintained highways. They may also be included in the plans at other locations.

SCDs TC-65.10 and 65.11 detail the placement standards and guidelines for RPMs used with center lines, lane lines, edge lines and channelizing lines in general. Various specific typical situations, such as one-lane bridges, stop approaches, curves, two-way left-turn lanes and intersections are also addressed in these **SCDs**.

Each **District** should periodically inspect their RPMs to determine if nighttime retroreflectivity is still adequate. Reflectors that are cracked, abraded, missing or have marginal optical performance should be scheduled for maintenance. Cracked or loose castings should be removed and replaced as soon as practicable. Systematic replacement of RPM reflectors should be scheduled on a two to four year cycle. A statewide average reflector maintenance rate of 33 percent per year is expected.

302-3 Administrative Responsibilities

Responsibilities for this program are as follows:

1. The **Office of Traffic Operations (OTO)** shall:
 - a. Develop specifications and standards;
 - b. Evaluate new RPM materials; determine the method of RPM installation, maintenance and replacement;
 - c. Administer the term purchase contract for RPM materials; and
 - d. Conduct Quality Assurance Reviews (QARs) at least every two years in each **District**.
2. The **District** shall:
 - a. Carry out the RPM program in a manner to install 100 percent of the RPMs on all eligible **ODOT**-maintained highways;

- b. Replace RPMs that are removed/disturbed, for whatever reason, as soon as practicable;
- c. Maintain a roadway inventory of all RPMs; and
- d. Systematically replace RPM prismatic reflectors.

302-4 Maintenance

To be effective, RPMs must be properly maintained to keep prismatic reflectors and castings in good condition. Proper maintenance can be best accomplished by a program which emphasizes replacement of removed/disturbed RPMs as soon as practicable in conjunction with a systematic replacement of RPM reflectors on a two to four year cycle. The length of the replacement cycle would be dependent upon factors such as traffic volumes, traffic composition and environmental conditions. Most highways should have reflectors replaced on a three year cycle. A four year replacement cycle might prove to be adequate for low-volume highways; while heavily traveled freeways and expressways with high volumes of truck traffic might need reflector replacement based on a two-year cycle.

RPMs shall be removed prior to resurfacing and disposed of by the contractor.

302-5 Raised Pavement Markers in Villages

The **District** may install RPMs on state highway extensions in **Villages**, upon request by and approval of the legislative authority of a **Village**. "Request by, and approval of, the legislative authority of a **Village**" shall be in the form of **ODOT Form No. MR-689** (available on-line at <http://portal.dot.state.oh.us/Divisions/Operations/MaintAdmin/Pages/MandR.aspx>, a web page maintained by the **Office of Maintenance Administration**) and shall describe the state highway extensions covered by the Ordinance. All such maintenance ordinances (**MR-689**) shall be filed in the office of the **District Deputy Director**. The installation of RPMs upon request of a **Village** does not obligate **ODOT** to maintain them.

302-6 Narrow and One-Lane Bridges

RPMs shall be installed in accordance with **SCD TC-65.11** at narrow and one-lane bridges. The center line pavement marking shall be stopped 160 feet in advance of a one-lane bridge. **Figure 398-2** illustrates signing and markings guidelines for narrow and one-lane bridges. Additional information is also provided in **Sections 202-5, 202-14.2 and 304-5**.

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401 TRAFFIC CONTROL SIGNALS - GENERAL**401-1 General**

OMUTCD Chapter 4D presents information on the design, location and use of traffic control signals. Construction details are shown on the **SCDs TC-81.10 through TC-85.20**. Traffic signal equipment is specified in **CMS Items 632 and 633**, and **CMS 732 and 733**.

401-2 Installation of Traffic Signals on State Highways

Policy 516-002(P) documents **ODOT** policy regarding installation of traffic control signals and intersection control beacons on state highways. A copy has also been included in the Appendix of this manual (**Chapter 15**).

401-3 Periodic Review of Signals

As noted in **OMUTCD Section 4B.02**, changing traffic patterns may render an existing traffic signal either inefficient or no longer necessary. Therefore, the responsible agency should periodically conduct a traffic engineering study to evaluate the efficiency and necessity of traffic signals under its jurisdiction and determine if revisions may be needed. This traffic engineering study may lead to changing the signal timing, signal phasing, vehicle or pedestrian detection, roadway geometry, or the complete removal of the traffic signal.

Traffic signal installations that are not properly designed and maintained for current traffic conditions, or are no longer warranted, can result in the following conditions:

1. Excessive traffic delay.
2. Increased disobedience of the signal indications.
3. The use of less adequate routes in order to avoid such signals.
4. Increased accident frequency, especially rear-end accidents.

Some signalized intersections and/or signalized corridors may be eligible to apply for, and participate in, the Systematic Signal Timing & Phasing Program (SSTPP). See **Section 1213-6** for more information about this program.

401-4 Removal of Traffic Signals Under ODOT Jurisdiction

If a traffic engineering study indicates that the traffic signal is no longer justified, the traffic signal should be removed by a uniform procedure that will consider public input, accidents, site considerations and an appropriate replacement type of traffic control device. Therefore, when **ODOT** determines that an existing traffic signal installation no longer meets signal warrants as contained in the **OMUTCD**, or is no longer the appropriate form of traffic control, the **District** shall proceed through the following removal process to document and determine if the signal installation should be removed:

1. To determine if the traffic signal is still needed, the **District** shall prepare a traffic engineering study for the signal installation documenting the following information, as appropriate:
 - a. Warrant analysis summary. If reasons other than the standard warrants were used to justify the signal installation, determine if these reasons are still valid.
 - b. Accident history.
 - c. Site conditions, especially sight distance problems.

- d. Public, business, school board or governmental complaints resulting in the original signal installation.
 - e. Present and future developmental growth.
 - f. Known reasons for change in traffic patterns or volumes.
 - g. Capacity analysis for the alternate traffic control scheme most likely to be installed if the signal is removed.
 - h. Analysis of the cost of continued signal operation versus a one-time signal removal cost.
 - i. Discussion of traffic volume growth needed to warrant the signal.
2. Based on the traffic engineering study, the **District** shall decide whether to proceed with the removal process or defer signal removal. If the removal is deferred, the **District** shall document the reasons for deferral. The signalized location shall be reconsidered for removal every year until a signal warrant or other determination of permanent retention is satisfied.
3. If the **District** decides to proceed with the removal process, the following steps shall be taken:
 - a. Inform the local media, schools, governmental agencies and local emergency/safety forces of **ODOT's** intent to study the signalized location for removal.
 - b. Remove or reduce intersection sight distance restrictions, if needed.
 - c. Install the SIGNAL UNDER STUDY FOR REMOVAL (W24-H2b) sign next to the signal heads on each approach.
 - d. Check the controller cabinet wiring to ensure that the color of the flashing indications will agree with the alternate traffic control scheme.
 - e. Install the alternate traffic control devices, such as STOP signs and advance Warning Signs. Existing Stop Lines on the uncontrolled approaches should not be removed at this time.
 - f. Place the signal in flashing operation for ninety days, in conjunction **with item 3e above**.
4. If the signal is put in flashing operation for ninety days in anticipation of removal, the **District** shall monitor accident experience during the ninety-day flashing period:
 - a. If accidents of types susceptible to correction by traffic signal control have increased by more than two, the signalized location shall remain in flashing operation for an additional sixty-day period. If more than two such accidents occur in the second sixty-day period, the **District** should retain the signal in stop-and-go operation until the site conditions can be improved to reduce the accident frequency.
 - b. If accidents of types susceptible to correction by traffic signal control have not increased by more than two, continue with the removal process.
 - c. The **District** shall also monitor, investigate and respond to the concerns of the public during this period.
5. If the **District** decides to proceed with the removal process after considering the information gathered in **item 4**:
 - a. The signal heads shall be bagged or removed, and the traffic signal turned off for a sixty

442 PLAN NOTES**442-1 General**

Typical **Plan Notes** have been consolidated here for convenience in preparing plans. The number used for the **Plan Note** will be the same as the Section number. When a **Plan Note** revises the material or contractor requirements from that which is specified in the **CMS**, both the note and the bid item will be "as per plan". Where there are design instructions pertaining to a specific note, they are listed at the end of the note. These notes may be modified to further define the conditions of a project or maintaining agency.

In keeping with traditional format of **Plan Notes**, various format changes are used here that are not typical throughout the **TEM**, e.g., the terms Contractor and Engineer are capitalized.

442-2 Power Supply for Traffic Signals

Electric power shall be obtained from the _____ at the location indicated on the plans. Power supplied shall be ____ volts.

Designer Note: See **Sections 440-2 and 441-4**.

442-3 Reserved for Future Use**442-4 632 Removal of Traffic Signal Installation**

Traffic signal installations, including signal heads, cable, messenger wire, strain poles, cabinet, controller, etc., shall be removed in accordance with CMS 632.26 and as indicated on the plans. Removed items shall be reused as part of a new installation on the project or stored on the project for salvage by (name of agency receiving stored items) in accordance with the listing given herein.

(Items to be reused)

(Items to be stored)

In the event the items stored on the project for salvage by the local agency are not removed, the Contractor shall, when directed by the Engineer in writing, remove and dispose of the items at no additional cost to the project.

Designer Note: This note shall be included on projects where existing traffic signal installations are being removed. A listing of items to be reused and/or stored must be included. Pull boxes to be removed shall be itemized separately and paid for under Item 625 "Pull Box Removed".

442-5 632 Interconnect Cable, Misc.: (by Size), with Support Messenger, As Per Plan

The Contractor will be permitted to use either of two types of interconnect cable construction and installation under this item as follows:

1. Integral messenger type interconnect cable meeting the requirements of CMS 732.19. Under this method any sections of cable shown in the plans to be contained in controllers, cabinets, poles, conduits or supported on messenger wire installed for other purposes shall have the supporting messenger and jacket web neatly removed by the use of a tool specifically designed and sized for this purpose. Deviations from the cable routing shown in the plan, for the sole purpose of reducing the amount of messenger to be removed, will not be permitted. The cable shall be installed with approximately one twist for each 15 feet of span length.

2. Separate interconnect cable meeting the requirements of CMS 732.19 plus a 1/4 inch messenger wire and lashing meeting the requirements of CMS 732.18. Under this method the Contractor will install a separate 1/4 inch messenger to support the spans of interconnect cables in all locations where the plans show interconnect cable which is not otherwise supported by a signal messenger wire or other suitable support. Utilization of existing messenger wire, not provided by the project or designated therein as available for use, is prohibited. Deviation from the cable routing shown in the plans, for the purpose of reducing the need for separate messenger wire, will not be permitted.

In either case the number of splice locations shall be kept to a minimum.

Measurement will be based upon the number of feet of CMS Item 632, "Interconnect Cable, Misc.: (by size), with Support Messenger, As Per Plan" in place in accordance with the method described in CMS 632.29 and no separate payment will be provided for any separate messenger wire used to support interconnect cables.

Designer Note: This note may be used on projects with overhead interconnect cable, if acceptable to the maintaining agency.

442-6 632 Loop Detector Units, by Type, As Per Plan

In addition to the requirements of CMS Item 632 and CMS 732.07 or 732.08, loop detector units shall have the following requirements or features:

The output device shall be a relay, and all contacts shall be in the wiring harness.

The unit shall be self-tuning.

The unit's electrical connection plugs or wiring harness shall allow ready replacement with a single channel amplifier as described in CMS 732.07.

Each unit shall be labeled to correspond to its phase and direction.

Delay inhibit shall be connected on all detector harnesses for their respective phase greens.

Designer Note: This note should be included for projects which will be maintained by **Districts** that use **NEMA** TS-1 controller cabinets. Bid items are not used unless detector units are installed in an existing cabinet.

442-7 Reserved for Future Use

442-8 Reserved for Future Use

442-9 632 Loop Detector Lead-In Cable, Direct Burial

This work shall include furnishing and installing loop detector lead-in cable of the type required in CMS 732.19. Installation shall be by cable plow or vibratory cable plow to a minimum depth of 18 inches. All entries into pull boxes, conduit systems, foundation or other enclosures shall be free of sharp edges and be covered by insulated bushings. Following installation, the ground surface shall be restored to the original contour and surface condition.

Designer Note: This method may be considered in lieu of cable in conduit to reduce project costs. It is applicable to long underground runs in tree lawns or grassed roadsides where minimal interference with driveways or utilities is expected, and where disturbance of the area due to construction is not contemplated. If the cable is to be routed up a pole, a conduit riser (extending below ground with an insulated bushing) should be called for and detailed.

442-10 632 Combination Signal Support, Type TC-81.21 and Sign Support, TC- (with Light Pole Extension)

This support shall consist of a TC- _____ Design ____ pole with a TC-81.21 Design ____ signal arm and a TC- _____ Design ____ sign support arm (with light pole extension). All signal support items required by CMS Item 632 and all sign support items required by CMS Item 630 shall be included as part of this support.

Payment will be at the contract unit price and will be full compensation for all labor, materials, tools, equipment and other incidentals necessary for each support furnished, in place, complete and accepted.

Designer Note: This note shall be used when combination traffic signal supports and sign supports are desired. The blanks shall be filled in with appropriate **SCD** numbers and designs.

442-11 632 Combination Strain Pole, Type TC-81.10 and Sign Support, Type TC- (with Light Pole Extension)

This support shall consist of a TC- _____ Design ____ pole with a TC- _____ Design ____ sign support arm (with light pole extension). All signal support items required by CMS Item 632 and all sign support items required by CMS Item 630 shall be included as part of this support.

Payment will be at the contract unit price and will be full compensation for all labor, materials, tools, equipment and other incidentals necessary for each support furnished, in place, complete and accepted.

Designer Note: This note shall be used when combination traffic signal strain poles and sign supports are desired. The blanks shall be filled in with appropriate **SCD** numbers and designs. The following is a bid item example: Combination Strain Pole, Type TC-81.10 and Sign Support, Type TC-12.30 (with Light Pole Extension).

442-12 Strain Pole Foundation Elevations

Elevations shown in the plans for strain pole foundations are for computational purposes only. The actual elevation of the foundation shall be in accordance with SCD TC-21.20 provided the existing slope is less than 6:1.

At locations where the existing slope is 6:1 or greater, the buried depth of foundation, as shown in SCD TC-21.20 shall apply to the low side of the slope. The top of the foundation shall be set 2 inches above the existing surface on the high side of the slope. The additional depth of foundation necessary to meet these requirements shall be added to the formed top.

Designer Note: This note shall be used when strain pole foundations are located in slopes of 6:1 or greater.

442-13 632 Vehicular Signal Head, Color, Material, By Type, (with Backplate) As Per Plan

In addition to the requirements of CMS 632 and 732, the following requirements shall apply:

1. All upper signal support hardware and piping up to and including the wire inlet fitting shall be ferrous metal for signal displays of two or more sections.
2. The entrance fitting shall be of the tri-stud design with serrated rings in order to achieve positive locking.

Designer Note: This note should be included for projects which will be maintained by **ODOT**.

442-14 632 Power Service, As Per Plan

Power service shall be as per CMS Item 632 and SCD TC-83.10 with the following exceptions:

1. The meter base mounting height shall be no more than 5 feet high to the center of the meter base from the ground.
2. The Contractor shall supply the necessary meter bases.
3. All power services shall be metered. The meter shall have a lever operated bypass.

Disconnect switch enclosures furnished in accordance with CMS Item 632, Power Service, as per plan, shall include a padlock equal to Master no. 4BKA or Wilson Bohannon 660, with lock body of bronze or brass and keying shall be to the state master.

The Contractor shall contact the meter section of the power company for information regarding the meter base installation prior to ordering poles. The Contractor will be responsible for requesting and scheduling any inspections the power company may require for the power service hook up. The Contractor shall be responsible to contact the power company for the electrical service connection. Under no circumstances shall the Contractor splice power cable into the power company's circuits. The voltage supplied shall be nominally 120 volts. The Contractor is responsible for obtaining any necessary permits and the paying of all fees. The Contractor shall pay all power charges until the signal is accepted by the maintaining agency.

Designer Note: This note may be used when requested by the maintaining agency.

442-15 Guarantee

The Contractor shall guarantee that the traffic control system installed as part of this contract shall operate satisfactorily for a period of ____ days following completion of the 10-day performance test. In the event of unsatisfactory operation the Contractor shall correct faulty installations, make repairs and replace defective parts with new parts of equal or better quality. Equipment, material and labor costs incurred in correcting an unsatisfactory operation shall be borne by the Contractor.

The guarantee shall cover the following items of the traffic control system: controllers and associated equipment, detector units, interconnection items and master control equipment.

Customary manufacturer's guarantees for the foregoing items shall be turned over to the state or the maintaining agency following acceptance of the equipment.

The cost of guaranteeing the traffic control system will be incidental to and included in the contract unit price of the various items making up the system.

Designer Note: See *Section 441-11*.

442-16 633 Alternate Bid Item

633 Controller Unit, Type____, with Cabinet, Type ____

(Example of a standard bid item)

633 Controller Unit, Type ____, with Cabinet, Type ____ (Acme) - Alternate Bid

The controller shall be a Model (xx-99 as manufactured by Acme Signal Company, Santoy,

Ohio) and shall incorporate or be furnished with all the design features, auxiliary equipment, accessories, and prewired cabinet features as required in the standard bid item.

Payment will be at the contract unit price for each, in place, all connections made and wiring completed, tested and accepted.

(Example of an alternate bid item)

Designer Note: See **Section 441-12.**

442-17 632 Vehicular Signal Head, Color, Material, By Type, (with Backplate), As Per Plan

In addition to the requirements of CMS 632 and 732, the following requirements shall also apply:

Mounting Hardware: *(select items as needed)*

- [#. All signal heads shall be rigidly mounted to the mast arm with the (color) lens located in front of the mast arm.]
- [#. All upper signal support hardware and piping up to and including the wire inlet fitting shall be ferrous metal for signal displays of two or more sections.]
- [#. The entrance fitting shall be of the tri-stud design with serrated rings in order to achieve positive locking.]

The Department will measure "Vehicular Signal Head, Color, Material, By Type, (with Backplate), As Per Plan" by the number of complete units furnished and installed, and will include all support and mounting hardware, disconnect hangers, closure caps, dimmers, and lamps as specified.

Designer Note: Since maintaining agencies will use different combinations of signal sections, this note will allow the designer to choose the various options that will provide the maintaining agency with features that they prefer. Items that are enclosed in brackets [] should be carefully considered and retained or deleted based on maintaining agency preferences. Care should be taken not to include duplicate requirements for the same item. Some designer notes are in italics.

442-18 Reserved – Existing Note Deleted

The **Plan Note** for "632 Pedestrian Signal, (LED), (Countdown), Type A2, As Per Plan" has been deleted due to the fact that polycarbonate vehicular signal heads have been added to the CMS book.

442-19 632 Relamp Existing Signal Section with LED Lamp Unit, By Lens Type, As Per Plan

This item of work shall consist of replacing the 12 inch lens and incandescent lamp in an existing signal head section with a 12 inch LED lamp unit.

The light emitting diode (LED) signal lamp units shall meet the requirements of CMS 732.04-C. An LED signal lamp unit shall be furnished and installed for the type of signal lens specified in the bid item description.

[The existing reflector unit and lens shall be removed and returned to the maintaining agency. The existing incandescent lamp shall be disposed of by the contractor.]

The Department will measure "Relamp Existing Signal Head with LED Lamp Units, By Lens Type, As Per Plan" by the number of complete units furnished and installed, and will include all hardware and lamps as specified.

Designer Note: Since maintaining agencies will use different combinations of LED/incandescent lamp and aluminum/polycarbonate signal sections, this note will allow the designer to choose the various options that will provide the maintaining agency with features that they prefer. Items that are enclosed in brackets [] should be carefully considered and retained or deleted based on maintaining agency preferences. Care should be taken not to include duplicate requirements for the same item.

442-20 633 Controller Unit, Type 170E, with Cabinet, Type (332 or 336), As Per Plan

The 412C PROM module for the local controller shall be supplied without controller software to the ODOT District Office 14 days in advance of when the software is needed. The PROM modules shall be configured for Wapiti software and include a blank PROM module for program installation. ODOT will install the local controller software program. The Contractor shall pick up the PROM modules with the installed software from District. It shall be the Contractor's responsibility to use the returned PROM modules to program the signal controllers per the plans.

The Contractor shall not reassign the detector inputs in order to reduce the number of 2-channel detector units supplied, but shall use the standard CalTrans input file designations.

Designer Note: This note should be used at signalized intersections using Type 170E local controllers that are to be owned and maintained by **ODOT**.

442-21 633 Controller Unit, Type 2070L, with Cabinet, (By Type), As Per Plan

The controller unit shall be equipment manufactured in conformance to the California Department of Transportation (Caltrans) specifications titles "Transportation Electrical Equipment Specifications (TEES)." The controller unit, Model 2070L, shall be an Econolite Model 2070L, Build: 1.01.08.02b, Siemens Model 2070L, Build: 6.2.0.0.0.81, or approved equal.

The 2070L controller unit shall include the following:

1. Unit Chassis
2. 2070-1B CPU module
3. 2070-2A Field I/O Module
4. 2070-3B Front Panel
5. 2070-4A Power Supply
6. 2070-7A Serial Communication Module

The controller shall be supplied without traffic signal intersection control software. The controller shall be supplied with Microware Embedded OS-9 Release 1.3 or later with kernel edition #376 or later, as required by Caltrans TEES. For warranty purposes, a vendor-specific decal, as per ODOT CMS 733.02 shall be applied to each controller unit at time of delivery to the project.

The controller shall be shipped by the Contractor to the ODOT Signal Shop, 1606 West Broad Street, Columbus, Ohio 43223, either directly or via the ODOT District Office, a minimum of 14 days in advance of when the software is needed. ODOT will install the local intersection control software. The controller will then be performance tested by the ODOT Signal Shop. Every effort shall be made to have loading and performance testing completed by the ODOT Signal Shop within 2 weeks of receipt of an individual controller; larger groups of controllers submitted at the same time may take longer. Should any controller fail this performance test after being loaded with ODOT-licensed software, the software will be removed by the ODOT Signal Shop and the controller rejected. Rejected controllers will be returned, either directly to the Contractor or to the ODOT District Office. Controllers passing the performance test will be labeled by the ODOT Signal Shop with the OS Image Number, CPU serial number, Software Revision Number, and upload date. This label is not to be removed by the Contractor and serves as proof that the controller has been loaded, tested

and approved for initial installation on the project. Such proof does not alter the required 10-day Performance Test outlined in CMS Sections 632 and 633.

The Contractor shall not reassign the cabinet detector inputs in order to reduce the number of 2-channel detector units supplied, but shall use the standard Caltrans Input File designations.

Designer Note: This note should be used at signalized intersections using Type 2070L local controllers that are to be owned and maintained by **ODOT**.

442-22 633 Controller, Master, Traffic Responsive, As Per Plan

The 412B2 PROM module for the Type 170E master controller shall be supplied without controller software to the ODOT District Office 14 days in advance of when the software is needed. The PROM modules shall be configured for Wapiti software and include a blank PROM module for program installation. ODOT will install the master controller software program. The Contractor shall pick up the PROM modules with the installed software from District. It shall be the Contractor's responsibility to use the returned PROM modules to program the signal controllers per the plans.

Designer Note: This note should be used at signalized intersections using Type 170E master controllers that are to be owned and maintained by **ODOT**

442-23 633 Controller, Master, Traffic Responsive, As Per Plan

The Type 2070 master controller shall be supplied without controller software, but will be supplied with the operating system and CalTrans required software. The controller unit shall be delivered to the ODOT District Office 14 days in advance of when the software is needed. ODOT will install the master controller software program. The Contractor shall pick up the controller unit with the installed software from District. It shall be the Contractor's responsibility to program the Type 2070 signal controller per the plans.

Design Note: This note should be used at signalized intersections using Type 2070 master controllers that are to be owned and maintained by **ODOT**.

442-24 Reserved for Future Use

442-25 633 Preemption

This item of work shall consist of furnishing and installing preemption equipment in the locations and local controllers as shown in the plans. The preemption shall conform to ODOT Specification 633 and shall utilize communications to identify the presence of an emergency priority vehicle. It shall cause the traffic signal controller to select a pre-programmed preemption plan that will display and hold the desired signal phase for the direction of the emergency vehicle.

The communications medium shall employ either sound, light or radio detection techniques to determine and log the presence of the emergency vehicle. The system shall detect the presence of the vehicle through an emitting device located on the emergency vehicle. The system shall activate the preemption sequence by applying a signal to one of the controller's preempt discrete inputs. The system shall be completely compatible with the controller.

The equipment shall be shelf or rack mounted and easily removable and replaceable within the cabinet. The equipment shall be supplied completely wired in the controller cabinet and tested. The system shall be capable of preempting and receiving priority for each approach to the intersection. It shall be possible to detect the emergency vehicle up to 1200 feet from the intersection.

Each intersection shown in the plans shall be supplied with the following components, each

bid separately:

1. Preempt receiving unit.
2. Preempt detector cable.
3. Preempt phase selector assembly and interface wiring panel.
4. Confirmation light.

If a light activated system is specified, the Contractor shall inventory the City's existing emitters to determine compatibility with the proposed system. If existing emitters are found to be not compatible, then the City shall be supplied (at costs incidental to the system) with the emitters, transmitters, switches, wiring and all required vehicle equipment for the following emergency vehicles. The City shall be responsible for installing vehicle equipment. The model supplied shall be Opticom manufactured by Global Traffic Technologies LLC, Strobecom II manufactured by Tomar Electronics Inc., or approved equal.

If a radio activated system is specified, the Contractor shall supply the above emergency vehicles with emitters at cost incidental to the system. The model supplied shall be Opticom GPS manufactured by Global Traffic Technologies, LLC, Emtrac Priority Management System Model GPS manufactured by STC, Inc., or approved equal.

If a sound activated system is specified, the Contractor shall inventory the above emergency vehicles to determine compatibility of the sirens with the system. Each vehicle that is determined to be not compatible shall be supplied with new sirens at cost incidental to the system. The model supplied shall be Sonem 2000 manufactured by Traffic Systems LLC, Right-O-Way manufactured by Wapiti Microsystems, or approved equal.

If a light, radio, or sound activated system is not specified, then Contractor may supply any of the three types.

The City shall be supplied with software required to calibrate, log, and operate the system. The software shall be capable of operating under Windows 7, 32-bit operating system. Two (2) operating and instruction manuals shall be supplied with the software.

The Contractor shall thoroughly test the installed system. As a minimum, the Contractor shall verify that all connections are properly made to the controller cabinets. The Contractor shall check that the range setting is proper for each intersection. The Contractor shall determine that all phase selectors are selecting the proper phase and timing accurately. The Contractor shall verify that all vehicle emitters are being properly detected.

If the proposed preempt system is not compatible with the existing system, the Contractor shall provide training for up to fifteen (15) persons in the operation of the system. It shall be provided within 48 hours of the installation of the system. It shall consist of hands-on instruction for a minimum of sixteen (16) hours. The Contractor shall provide training for up to four (4) persons in the installation and maintenance of the system. It shall consist of a minimum of eight (8) hours of instruction. Training shall be supplied within seven (7) days of the installation of the system. All training shall be held in a City supplied location. Training shall be conducted by someone who has performed this within the last year and does it on a regular basis. The cost of training, including course material, travel subsistence and related costs, shall be entirely borne by the Contractor and shall be incidental to the preemption equipment.

Payment for Item 633 "Preemption" shall be made at the contract unit price for each preemption in place and fully operational as shown in the plans, except for those items bid separately.

Designer Note: This note may be used for generic preempt systems. The quantity in the plans should be one each for the system; not the number of intersections.

442-26 633 Preemption Receiving Unit

Receiving units shall consist of a lightweight, weatherproof and directional assembly. Each receiving unit shall be 360 degree adjustable. The receiving unit shall be capable of sending the proper electrical signal to the traffic signal controller via the preemption detector cable. Receiving units shall be supplied with mast arm mounting hardware as shown in the plans.

Furnish preemption receiving units with 60-month warranties or for the manufacturer's standard warranty whichever is greater. Ensure that the warranty period begins on the date of shipment to the project. Ensure that each unit has a permanent label or stamp indicating the date of shipment.

Payment for Item 633 "Preemption Receiving Unit" shall be at the contract unit for each receiving unit in place, completely installed at the location shown in the plans, wired, tested and accepted.

Designer Note: The note may be used when preemption is included for in the plans.

442-27 633 Preemption Detector Cable

This item shall consist of furnishing and installing preemption detector home run cable in the locations shown in the plans. It shall connect the preempt receiving units to the phase selectors in the local controller cabinet.

Preemption detector cable shall conform to ODOT Specification 632. Only one external splice shall be permitted between preemption receiver unit and controller cabinet. This splice shall meet the requirements of C&MS 632.23 using a waterproof epoxy splice kit. The cable shall be approved for both overhead and underground use. The jacket shall withstand exposure to sunlight and atmospheric temperatures and stresses reasonably expected in normal installations.

Payment for Item 633 "Preemption Detector Cable" shall be made at the contract unit price per foot for the cable furnished, in place, all connections made and wiring completed, tested and accepted.

Designer Note: This note may be used when preemption is included for in the plans.

442-28 633 Preempt Phase Selector

This item shall consist of furnishing and installing preempt phase selectors including wiring interface panels in the local controller cabinet and all other accessories that are necessary to make the preempt phase selectors completely functional and operational as shown in the plans. This item shall include the extra cabinet space necessary to be located in the local controller cabinets where indicated in the plans.

The phase selectors shall consist of a module or modules that will provide the necessary inputs to the controller. Phase selectors shall be supplied with sufficient quantities of channels to provide preemption for all approaches to the intersection separately. Power shall be obtained from the phase selector or phase selector power supply and not from the local controller timer.

The phase selectors shall have front panel indicators for active preempt channel status. It shall have test switches to activate all preempt channels.

Furnish preempt phase selectors with 60-month warranties or for the manufacturer's standard warranty whichever is greater. Ensure that the warranty period begins on the date of shipment to the project. Ensure that each unit has a permanent label or stamp indicating the

date of shipment.

Payment for Item 633 "Preempt Phase Selector" shall be made at the contract unit price for each phase selector in place, completely installed in the local controller shown in the plans, wired, tested and accepted.

Designer Note: This note may be used when preemption is included for in the plans.

442-29 633 Preempt Confirmation Light, LED

This item shall consist of furnishing and installing preempt confirmation lights including hardware and all other accessories that are necessary to make the preempt confirmation light completely functional and operational as shown in the plans.

A confirmation light shall be supplied for each intersection to indicate that the emergency vehicle has achieved control of the traffic signal.

The confirmation light shall be a vapor tight aluminum lighting fixture. It shall be supplied with a clear globe, LED lamp and mounting hardware to attach to the traffic signal mast arm. The confirmation light shall be powered by a load switch in the traffic signal controller. Signal cable conforming to 732.19 shall be used for confirmation lights. A minimum of 4-conductor cable shall be used with the green wire serving as the safety ground conductor.

Payment for Item 633 "Preempt Confirmation Light, LED" shall be made at the contract unit price for each light in place, completely installed in the location shown in the plans, wired, tested and accepted.

Designer Note: This note may be used when requested by the maintaining agency. The signal cable is a separate pay item.

442-30 Pull Box, 24" x 35" x 26"

Pull boxes shall have nominal opening dimensions of 24 inches by 35 inches. Materials shall conform to 725.06, 725.07 or 725.08. The word "Traffic" shall be integrally cast as part of the cover or securely fastened with corrosion resistant hardware. The supplied pull boxes shall support a 20,000 pound minimum vertical loading without permanent damage or deflection to the unit. Dispose of surplus material and restore disturbed facilities and surfaces.

The largest bend radius possible shall be maintained for the fiber optic cable.

All costs resulting from the above requirements shall be included in the unit price bid per each for Item 625 "Pull Box, 24" x 35" x 26".

Designer Note: The pull box cited in this note is bell shaped at the bottom to help maintain fiber optic cable minimum bend radii. Any pull box where a splice is required or a change in cable direction is made should use this larger pull box.

442-31 632 Pole Entrance Fitting

A pole entrance fitting shall be provided in accordance with the plan details to allow fiber optic cable entrance into both existing and proposed steel poles. In proposed poles the Contractor shall have the 2 inch entrance holes shown in the details pre-manufactured. Blind half couplings shall be welded into any new strain poles supplied as part of the project.

Existing strain poles shall require the Contractor to field locate the pole entrance hole and drill two pilot holes and use a hole saw to cut the 2 inch hole. All non-galvanized pole surfaces exposed after cutting the hole shall have three coats of zinc enriched paint applied.

No pole entrance fitting holes shall be located vertically within 24 inches of any other holes or blind half couplings.

All costs to provide a pole entrance including material, equipment and labor shall be included in the bid item price for each Item 632 "Pole Entrance Fitting".

Designer Note: The maintaining agency may opt to have the Contractor route drop cables down the outside of strain poles.

442-32 Grounding and Bonding

The requirements of the Construction and Material Specifications (CMS) and the TC series of Standard Construction Drawings are modified as follows:

1. All metallic parts containing electrical conductors shall be permanently joined to form an Effective Ground Fault Current Path back to the grounded conductor in the power service disconnect switch.
 - a. Provide an equipment grounding conductor in metallic conduits (725.04) in addition to the conductors specified and bond the conduit to this grounding conductor.
 - b. When an equipment grounding conductor is required in plastic conduit (725.05), the installation shall include a separate equipment grounding conductor in addition to the conductors specified.
 - c. Metallic conduit carrying the loop wires from in the pavement to the pull box splice location will only be bonded at the pull box end, and will not contain an equipment grounding conductor.
 - d. If multiple conduit runs begin and end at the same points, only one equipment grounding conductor is required.
 - e. If an equipment grounding conductor is needed in conduit between signalized intersections for underground interconnect cable, the grounding system for each signalized intersection will be separated about midway between the intersections.
 - f. The messenger wire at signalized intersections will be used as the conductive path from corner to corner if conduit is not provided under the roadway. When conduit connects the corners of an intersection, an equipment grounding conductor shall be used in the conduit.
2. Conduits.
 - a. The 725.04 conduit shall have grounding bushings installed at all termination points. The bushing material shall be compatible with galvanized steel conduit and the grounding lug material shall be compatible for use with copper wire. Threaded or compression type bushings may be used.
 - b. The 725.05 conduit shall have the inside and outside diameters of the conduit deburred at all termination points.
 - c. Both ends of metallic conduit shall be bonded to the equipment grounding conductor.
 - d. Metallic conduit may be bonded to metallic boxes through the use of conduit fittings UL approved for this type of connection, with the box bonded to the equipment grounding conductor.
3. Wire for grounding and bonding.
 - a. Use insulated, copper wire for the equipment grounding conductor. Bonding jumpers in boxes and enclosures may be bare or insulated copper wire. Wire size shall be as follows:
 - i. Use 4 AWG between the power service and supports, poles, pedestals, controller or flasher cabinets.
 - ii. Use a minimum 8 AWG between loop detector pull boxes and the first conduit that requires a larger size as specified in 3.a.i above.

- iii. Use a minimum 8 AWG between the “Prepare to Stop When Flashing” installation (including support) and the first conduit that requires a larger size as specified in 3.a.i above.
 - iv. The insulation shall be green or green with yellow stripe(s). For 4 AWG or larger, insulation may also be black with green tape/labels installed at all access points.
 - b. In a highway lighting system, the equipment grounding conductor shall be the same wire size as the duct cable or distribution cable circuit conductors, with the minimum conductor size of 4 AWG. Bonding jumpers will be minimum size 4 AWG.
4. Ground rod.
- a. A 3/4 inch Schedule 40 PVC conduit will be used in foundations and concrete walls for the grounding conductor (ground wire) raceway to the ground rod. Should metallic conduit be used, both ends of the conduit shall be bonded to the grounding conductor.
 - b. The typical grounding conductor (ground wire) shall be 4 AWG insulated, copper.
5. The green conductor in signal cables (conductor #4) shall not be used to supply power to a signal indication. It will be connected to the signal body as an equipment ground in aluminum heads and it will be unused in plastic heads. Unused conductors shall be grounded in the cabinet. Typical use of conductors is as follows:
- | Cond. no. | Color | Vehicle signal | Pedestrian signal |
|-----------|--------------------|------------------|-------------------|
| 1 | Black | green ball | #1 Walk |
| 2 | White | AC neutral | AC neutral |
| 3 | Red | red ball | #1 DW/FDW |
| 4 | Green | equipment ground | equipment ground |
| 5 | Orange | yellow ball | #2 DW/FDW |
| 6 | Blue | green arrow | #2 Walk |
| 7 | White/black stripe | yellow arrow | not used |
6. Power Service and Disconnect Switch.
- a. At the power service location, the grounding conductor (ground wire) from the disconnect switch neutral (AC-) bar to the ground rod shall be a continuous, unspliced conductor. If spliced, it shall be an exothermic weld butt splice.
 - b. The service neutral (AC-) shall only be connected to ground at the primary power service disconnect switch.
 - i. NEMA controller cabinets: If a power service disconnect switch is located before the controller cabinet, the neutral (AC-) and the grounding bars in the controller cabinet shall not be connected together as shown in NEMA TS-2, Figure 5-4.
 - ii. If secondary disconnect switches are connected after the primary disconnect switch, the neutral (AC-) shall only be grounded at the primary switch. Equipment grounding conductors shall be brought to the primary switch, but shall be grounded at both secondary and primary switches.
7. Payment – All materials and work required to complete the Effective Ground Fault Current Path system are incidental to the conductors installed by contract.

Designer Note: This note shall be used on all projects with electrical items (631, 632, 633). **Figures 498-39 through 498-42** provide examples of wire sizes for equipment grounding conductor.

442-33 Reserved – Existing Note Deleted

The **Plan Note** for “804 Fusion Splicer” has been deleted because the information is now in a fiber optic supplemental specification.

442-34 Reserved – Existing Note Deleted

The **Plan Note** for “804 Fusion Splicer” has been deleted because the information is now in a fiber optic supplemental specification.

442-35 Reserved – Existing Note Deleted

The **Plan Note** for “804 Cleave Tool” has been deleted because the information is now in a fiber optic supplemental specification.

442-36 Reserved – Existing Note Deleted

The **Plan Note** for “804 Optical Time Domain Reflectometer (OTDR)” has been deleted because the information is now in a fiber optic supplemental specification.

442-37 Reserved – Existing Note Deleted

The **Plan Note** for “804 Mechanical Splice Tool Kit” has been deleted because the information is now in a fiber optic supplemental specification.

442-38 Reserved – Existing Note Deleted

The **Plan Note** for “804 Fiber Optic Training” has been deleted because the information is now in a fiber optic supplemental specification.

442-39 633 Advance/Dilemma Zone Detection System

This item of work shall consist of furnishing and installing an Advance/Dilemma Zone Detection unit capable of intersection advance detection control utilizing above ground Digital Wave Radar Techniques. The unit shall be non-intrusive and shall detect vehicles from 50 feet up to 600 feet from the unit. The unit shall provide up to 8 detection zones simultaneously for intersection control. One unit shall be provided per approach, where specified in the plans, covering multiple lanes where advance detection is required. The detection unit shall include the following list of features and capabilities:

- The unit shall provide accurate presence-detection of both stopped and moving vehicles. The unit shall be mounted in a forward-fire, looking at either approaching or departing traffic and shall only detect vehicles in one direction of travel.
- The unit shall be tested to meet NEMA TS2 environmental standards and maintain accurate performance in the following operating conditions:
 - Rain up to 4 inches per hour
 - Freezing rain
 - Snow
 - Wind
 - Dust
 - Fog
 - Changing temperature
 - Changing lighting
- The radar design for each unit shall conform to the following:
 - Operating frequency: 10.5–10.55 GHz (X-band)
 - Matrix of a minimum of 16 radars
 - No manual tuning to circuitry
 - Transmits modulated signals generated digitally
 - No temperature-based compensation necessary
 - Bandwidth stable within 1%
 - Printed circuit board antennas
 - Antenna vertical 6 dB beam width (two-way pattern): 80 Degrees
 - Antenna horizontal 6 dB beam width (two-way pattern): 10.5 Degrees
 - Antenna two-way sidelobes: -40 dB

- Transmit bandwidth: 45 MHz
 - Un-windowed resolution: 11 feet
 - RF channels: 4
- The unit shall include a simple setup routine that shall automatically configure and calibrate the unit for proper operation during installation. The unit shall also be capable of being programmed and updated from a laptop computer or other portable programming device, such as a Pocket PC, via a local or remote ethernet connection using vendor supplied software. The software shall support TCP/IP connectivity, unit configuration back-up and restore, and virtual sensor connections. The graphical user interface shall operate on a Windows platform.
- The unit shall have one full-duplex RS2-232 and one half-duplex RS-485 communication ports and shall have the ability to upgrade firmware over any communication port.
- The unit shall be mounted directly to a pole or most arm, as recommended by the manufacturer. Cable(s) shall be provided as required and recommended by the manufacturer.
- Surge protection devices, as recommended by the manufacturer, shall be included both at the pole where the unit is located to protect the unit and in the traffic cabinet to protect the cabinet electronics.
- Power shall be provided from the traffic cabinet. The unit shall consume less than 10 watts and operate from a DC input between 9 VDC and 28 VDC. Complete and automatic recovery from a power failure shall be within 15 seconds after resumption of normal power.
- All required inputs cards shall be included in the traffic cabinet and shall be compatible with CalTrans, NEMA TS1 and NEMA TS2 detector racks. The cards shall provide true presence detector calls or contact closure to the traffic controller.
- The manufacturer's representative shall be on site during installation and testing and shall provide onsite training on the setup, operation and maintenance of the unit.
- The unit shall come with a 2-year manufacturer supplied warranty.

Payment for Item 633 Advance/Dilemma Zone Detection System shall be made at the contract unit price for each unit, complete and in place including all required cabinet hardware, mounting brackets, cables, conduit, connections tested and accepted, and any other necessary hardware to establish a fully functional detection system.

Designer Note: This note may be used when dilemma zone detection is included in the plans.

442-40 633 Uninterruptible Power Supply (UPS), Battery Replacement

In addition to the requirements of 733.09, provide four (4) batteries for each existing Uninterruptible Power Supply (UPS) cabinet location selected.

Batteries shall be provided from the Department's Qualified Product List.

Furnish batteries certified by the manufacturer to operate over a temperature range of -13 °F to +165 °F.

Place all batteries on battery heater mats in the enclosure.

Batteries shall be warranted for full replacement for two (2) years from date of purchase.

The Department will pay for Item 633 Uninterruptible Power Supply (UPS), Battery Replacement at the contract price bid for each UPS location where the four (4) existing batteries are replaced. Payment shall be full compensation for all labor, materials, tools, equipment, disposal and other incidentals necessary to replace the UPS batteries complete, in place, and accepted.

Designer Note: This note is required if the maintaining agency wishes to replace the batteries in an existing Uninterruptible Power Supply as part of a project.

442-41 633 Uninterruptible Power Supply, As Per Plan

In addition to the requirements of CMS 633 and 733, the Contractor shall furnish, install and test Uninterruptible Power Supply (UPS) status indicator lamps that allow maintenance personnel and law enforcement to quickly assess whether a traffic signal cabinet is being powered by a UPS. A 1-inch waterproof NEMA 4X or IP66 lamp with a domed RED lens shall be used to indicate the cabinet is operating under UPS backup power (the “backup” operating condition). This lamp shall be wired using minimum 20ga stranded, insulated hookup wire to the status relay outputs of the UPS. The wires shall be terminated by lugs at the display end and permanently labeled “BACKUP POWER STATUS DISPLAY,” with wire polarity indicated. This item includes programming the UPS status relay outputs to produce the lamp status displays. The status display shall be solid 100% duty cycle (not flashing). The lamp shall be placed in the UPS cabinet wall (not the roof) in such a manner as to be sealed from water intrusion and visible from a vehicle at the stop line in the closest lane of at least one approach to the signalized intersection. The operating voltage of the LED lamp shall be 120V AC.

Designer Note: This note is intended to allow maintaining agencies to include an indicator lamp for visual confirmation of UPS status if desired. Maintaining agencies may change or omit the recommended display, if desired, on either new or existing cabinets. The specified domed lens has better visibility than a flat lens, but is slightly more vulnerable to vandalism. A flat indicator lamp may be specified instead, if visibility is good and/or vandalism is a concern. If vandalism is a specific concern, external indicator lamps should not be used. The lamp may be placed on the cabinet roof instead of the wall, if desired. The operating voltage may be changed if required.

442-42 Reserved for Future Use

442-43 633 Stop Bar Detection Radar

This item of work shall consist of furnishing and installing a Stop Bar Detection unit capable of intersection detection control utilizing above ground Digital Wave Radar Techniques. The unit shall be non-intrusive and shall detect vehicles from 6 feet up to 140 feet for a 90 degree field of view from the unit. The unit shall provide real-time presence data for at least 10 lanes. The unit shall provide at least 16 detection zones simultaneously for intersection control. One unit shall be provided per approach, where specified in the plans, covering multiple lanes where stop bar detection is required. The detection unit shall include the following list of features and capabilities:

- The unit shall provide accurate presence-detection of moving vehicles. The unit shall be mounted in a forward-fire or side-fire position, looking at either approaching or departing traffic and shall only detect vehicles in one direction of travel.
- The unit shall be tested to meet NEMA TS2 environmental standards and maintain accurate performance in the following operating conditions:
 - o Rain up to 1 inches per hour
 - o Freezing rain
 - o Snow
 - o Wind
 - o Dust
 - o Fog
 - o Changing temperature
 - o Changing lighting
- The radar design for each unit shall conform to the following:
 - o Operating frequency: 24.0–24.25 GHz (K-band)
 - o Matrix of 16 radars
 - o No manual tuning to circuitry
 - o Transmits modulated signals generated digitally

- o No temperature-based compensation necessary
- o Bandwidth stable within 1%
- o Printed circuit board antennas
- o Antenna vertical 6 dB beam width (two-way pattern): 65 Degrees
- o Horizontal field of view: 90 Degrees
- o Antenna two-way sidelobes: -40 dB
- o Transmit bandwidth: 245 MHz
- o Un-windowed resolution: 2 feet
- o RF channels: 8
- o Self-test for verifying hardware functionality
- o Diagnostics mode for verifying system functionality
- The unit shall include a simple setup routine that shall automatically configure and calibrate the unit for proper operation during installation. The unit shall also be capable of being programmed and updated from a laptop computer or other portable programming device, such as a Pocket PC, via a local or remote ethernet connection using vendor supplied software. The software shall support TCP/IP connectivity, unit configuration back-up and restore, and Real-time traffic visualization for performance verification and traffic display. The graphical user interface shall operate on a Windows platform.
- The unit shall have two half-duplex RS-485 communication ports and shall have the ability to upgrade firmware over any communication port.
- The unit shall be mounted directly to a pole or mast arm, as recommended by the manufacturer. Cable(s) shall be provided as required and recommended by the manufacturer.
- Surge protection devices, as recommended by the manufacturer, shall be included both at the pole where the unit is located to protect the unit and in the traffic cabinet to protect the cabinet electronics.
- Power shall be provided from the traffic cabinet. The unit shall consume less than 10 Watts and operate from a DC input between 9 VDC and 28 VDC. Complete and automatic recovery from a power failure shall be within 15 seconds after resumption of normal power.
- All required inputs cards shall be included in the traffic cabinet and shall be compatible with CalTrans, NEMA TS1 and NEMA TS2 detector racks. The cards shall provide true presence detector calls or contact closure to the traffic controller.
- The manufacturer's representative shall be on site during installation and testing and shall provide onsite training on the setup, operation, and maintenance of the unit.
- The unit shall come with a 2-year manufacturer supplied warranty.

Payment for Item 633 Stop Bar Detection Radar shall be made at the contract unit price for each unit, complete and in place including all required cabinet hardware, mounting brackets, cables, conduit and connections tested and accepted.

Designer Note: This note may be used when stop line detection is included in the plans.

442-44 633 Controller Unit, Type 2070L, As Per Plan

The controller unit shall be equipment manufactured in conformance to the California Department of Transportation (Caltrans) specifications titles "Transportation Electrical Equipment Specifications (TEES)." The controller unit, Model 2070L, shall be model and build version listed on the ODOT QPL.

The 2070L controller unit shall include the following:

1. Unit Chassis
2. 2070-1B CPU module
3. 2070-2A Field I/O Module
4. 2070-3B Front Panel
5. 2070-4A Power Supply
6. 2070-7A Serial Communication Module

The controller shall be supplied without traffic signal intersection control software. The controller shall be supplied with Microware Embedded OS-9 Release 1.3 or later with kernel edition #376 or later, as required by Caltrans TEES. For warranty purposes, a vendor-specific decal, as per ODOT CMS 733.02 shall be applied to items 1 through 4 of the list above at time of delivery to the project.

The controller shall be shipped by the Contractor to the ODOT Signal Shop, 1606 West Broad Street, Columbus, Ohio 43223, either directly or via the ODOT District Office, a minimum of 14 days in advance of when the software is needed. ODOT will install the local intersection control software. The controller will then be performance tested by the ODOT Signal Shop. Every effort shall be made to have loading and performance testing completed by the ODOT Signal Shop within 2 weeks of receipt of an individual controller; larger groups of controllers submitted at the same time may take longer. Should any controller fail this performance test after being loaded with ODOT-licensed software, the software will be removed by the ODOT Signal Shop and the controller rejected. Rejected controllers will be returned, either directly to the Contractor or to the ODOT District Office. Controllers passing the performance test will be labeled by the ODOT Signal Shop with the OS Image Number, CPU serial number, Software Revision Number, and upload date. This label is not to be removed by the Contractor and serves as proof that the controller has been loaded, tested and approved for initial installation on the project. Such proof does not alter the required 10-day Performance Test outlined in CMS Sections 632 and 633.

The Contractor shall not reassign the cabinet detector inputs in order to reduce the number of 2-channel detector units supplied, but shall use the standard Caltrans Input File designations.

Designer Note: This note should be used at signalized intersections using Type 2070L local controllers that are to be owned and maintained by **ODOT**.

442-45 632 Signal Support, Mechanical Damper for TC-81.21 Mast Arm (Greater Than 59' in Length), As Per Plan

This item shall consist of the Contractor installing a tuned mechanical stockbridge or mass-spring type damper on a TC-81.21 mast arm signal support to reduce the possibility of harmonic vibrations caused by wind loads. A mechanical damper shall be applied to all mast arms over 59 feet in length. The installed damper shall be capable of reducing the loaded maximum vertical movement at the tip of the arm to 8 inches measured from the highest to the lowest point of deflection at wind speeds of 5-20 mph.

All attachment hardware connections shall be stainless steel. Stockbridge-type dampers shall have a stainless steel safety chain anchored to the mast arm to prevent weights from falling should they become separated from the rest of the assembly. The damper shall be attached to the arm within 8 feet of mast arm tip. Installation shall be per the manufacturer's guidelines. Static dampers such as horizontal flat sign mountings shall not be used. Acceptable devices include the following or approved equal:

1. Union Metal Alcoa Damper Device – DWG. NO. 2G-1817-C1
2. Valmont Structures Alcoa Device – DWG. NO. OH104242P1
3. Florida DOT Spring-Mass Damper – DRAWING INDEX NO. 17749

Payment for Item 632 "Signal Support, Mechanical Damper for TC-81.21 Mast Arm (Greater Than 59' in Length), As Per Plan" shall be made at the contract unit price per each complete and in place, and shall include all labor, materials, and equipment necessary to complete the work.

Designer Note: This note is required on all projects installing **TC-81.21** Mast Arms greater than 59 feet in length.

442-46 632 Signal Support, (By Type), As Per Plan

In addition to provisions of the ODOT CMS, furnish and install signal poles as specified in the plans.

The signal support designer shall provide drawings of a signal support with structural aspects of the design and materials in compliance with the 2001 AASHTO Standard Specifications, with 2006 Interim Revisions, for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. The signal support shall be ASTM A595 Grade A with a minimum yield strength of 50 ksi. The following design parameters shall be used:

1. Basic Wind Speed = 90 mph
2. Design Life = 25 years
3. Fatigue Category = III
4. Galloping: No
5. Truck Induced Gust: No

Submit, to the Engineer prior to incorporation: two copies of the signal support drawings and shop drawings, which identify and describe each manufactured signal support and signal support item which is being incorporated into the construction. The signal support drawings and shop drawings shall each be reviewed, sealed, stamped, and dated by two Ohio registered Professional Engineers.

Payment for Item 632 "Signal Support, (By Type), As Per Plan" shall be made at the contract unit price per each complete and in place, and shall include all signal support design, labor, materials, and equipment necessary to complete the work.

Designer Note: This note is required on all projects where non-standard signal supports are included in the plans.

442-47 632 Signalization, Misc.: Unlash and Relash Messenger Wire

The Contractor shall remove existing messenger wire lashing rods and reinstall them as necessary for the installation of any new cables on the existing intersection signal spans. The cables shall enter the existing strain pole through the pole cable entrance fitting and use the existing conduit system to get to the controller cabinet. The new cables shall be supported by a new cable support assembly at the top of the strain pole.

The new signal cables shall be bid by separate bid items.

Payment for Item 632 "Signalization Misc.: Unlash and Relash Messenger Wire" shall be made at the contract unit price per per foot and shall include all labor, materials, cable support assemblies and equipment to install new cables on existing signal span wire installations.

Designer Note: This note is intended for use on projects where unlash and relash messenger wire is required in the plans. Typical use would be for a traffic signal retrofit, where a new signal head and associated cables are to be added to the existing span.

442-48 632 Signalization, Misc.: FAA Type L-864 Obstruction Lighting, LED

This item consists of installation and testing of FAA L-864-compliant obstruction lighting for marking of structures over 150 feet. Location and wiring shall be as shown in the Bridge Plans. Each obstruction lamp shall utilize Light Emitting Diodes (LEDs). The obstruction lamp shall have a written minimum 5-year manufacturer warranty. The lamp shall be ETL verified to FAA Advisory Circular AC150/5345-43F, Type L-864 and shall be one of the following or approved equal:

1. Specialty Tower Lighting Model RB-LED
2. International Tower Lighting Model IFH-1710

3. Point Lighting Model PFB-37001
4. Pharos Marine Automatic Power Model FA-250LED L-864.

Each obstruction lamp shall have its own controller, housed in its own metal enclosure accessible by maintenance personnel standing at floor level. The controller shall operate at 120VAC, 60Hz and have its own dedicated circuit breaker in a nearby panelboard as detailed in the Bridge Plans. The controller shall produce the appropriate FAA-required flashing rate, and the obstruction lamp shall operate continuously twenty-four (24) hours per day, with no intervening photocell control. The controller shall provide at least one unused alarm status output in the form of a dry-contact or solid-state relay closure that responds to defective or inoperative obstruction lamp conditions. At least one relay with complete contacts (Normally Open, Normally Closed, and Common) shall be provided. Alarm relay contact ratings shall be at least 500 mA resistive at 120VAC/30VDC. The controller shall provide at least one visible alarm status indicator for lamp failure indication. This indicator shall be in the form of a panel-mounted red dome-type LED visible from the outside of the enclosure.

The controller enclosure shall utilize a vertically hinged, swing-open door, and be rated NEMA 3R, minimum. Enclosure shall include at least one commercial grade NEMA 5-15 receptacle to accommodate wireless communication equipment to be installed later by ODOT for alarm status monitoring. An integral shelf shall be provided for this equipment inside the enclosure, and shall provide an open, accessible space for equipment measuring at least twelve (12) inches wide, eight (8) inches deep, and six (6) inches in height.

The Contractor shall fully test the system and arrange for acceptance inspection of the Obstruction Lighting installation by ODOT District signal maintenance personnel after the system is operational. During acceptance inspection, the Contractor shall demonstrate the proper operation of all lamps and alarms. Contractor shall provide written manufacturer warranty and all operating manuals for obstruction lighting controller and lamp to ODOT District signal maintenance personnel at the time of inspection.

The Department shall measure LED FAA Type L-864 Obstruction Lighting by each individual obstruction light, complete and installed including any control devices and all wiring and conduits.

Designer Note: Although obstruction lighting is thought of as an incidental bridge item, this note appears in the **TEM** as a 632 Item because bridge lighting maintenance typically falls to **District** signal and lighting electricians. **FAA** regulations require daily visual monitoring of obstruction lighting by the operator (**ODOT**) if they are not equipped with automatic monitoring. Very fast notification and response times are required for repair of malfunctioning obstruction lights. The use of LED lighting significantly reduces **ODOT's** maintenance operations and provides much better reliability by eliminating the frequent outages and routine lamp changes associated with obstruction lights using older incandescent lamp technology. The use of cellular modems for automatic monitoring is recommended and is coordinated through the **Office of Traffic Engineering**.

442-49 632 Signalization, Misc.: Bridge-Mounted Marine Navigation Lighting, LED

This item consists of installation and testing of IALA/AISM-compliant, U.S. Coast Guard approved marine navigation lighting for marking of structures over navigable waters. Location and wiring shall be as shown in the Bridge Plans.

Each marine navigation lamp shall utilize Light Emitting Diodes (LEDs). The marine navigation lamp shall have a written minimum 5-year manufacturer warranty. The lamp shall meet the color, brightness (range), sectoring, and divergence requirements as shown in the Plans and approved by the applicable Coast Guard District. The lamp shall be manufactured by one of the following manufacturers or an approved equal:

1. Tideland Signal Corporation, Houston, TX
2. B&B Roadway, Russellville, AL

3. Pharos Marine Automatic Power, Houston TX

Each marine navigation lamp shall have its own controller/power supply, housed in its own metal enclosure accessible by maintenance personnel, as shown on the Bridge Plans. The controller shall operate at 120VAC, 60Hz and have its own dedicated circuit breaker in a nearby panelboard as detailed in the Bridge Plans. The marine navigation lamp shall operate continuously twenty-four (24) hours per day, with no intervening photocell control. The controller shall provide alarm status output in the form of a blue LED confirmation light visible to ODOT maintenance personnel from deck level to indicate defective or inoperative marine navigation lamp conditions.

The Contractor shall fully test the system and arrange for acceptance inspection of the Marine navigation Lighting installation by ODOT District signal maintenance personnel after the system is operational. During acceptance inspection, the Contractor shall demonstrate the proper operation of all lamps and alarms. Contractor shall provide written manufacturer warranty and all operating manuals for marine navigation lighting controller and lamp to ODOT District signal maintenance personnel at the time of inspection.

The Department shall measure Bridge-Mounted Marine Navigation Lighting by each individual marine navigation light, complete and installed including any control devices and all wiring and conduits.

Designer Note: Although marine navigation lighting is thought of as an incidental bridge item, this note appears in the **TEM** as a 632 Item because bridge lighting maintenance typically falls to **District** signal and lighting electricians. The use of LED lighting significantly reduces **ODOT's** maintenance operations and provides much better reliability by eliminating the frequent outages and routine lamp changes associated with marine navigation lights using older incandescent lamp technology.

442-50 633 Controller Unit, Type 170E, with Cabinet, By Type

In addition to the requirements of CMS 633 and 733, the following requirements shall also apply:

1. Controller units shall be equipment manufactured in conformance with the California Department of Transportation (CalTrans) specifications titled "Transportation Electrical Equipment Specifications." The manufacturer of the controller units shall be listed on the CalTrans QPL.
2. All circuit boards shall be vertically mounted. Ribbon cables, if used, shall terminate with properly rated and easily repairable connectors on each end. Ribbon cables shall not terminate onto plug-in modules.
3. The power supply shall be modular and easily removable from the chassis.
4. The unit shall contain separate input and output modules.
5. The controller unit shall include a Model 412C Program Module with the memory configuration for the software either shown in the plans or as provided by the maintaining agency.
6. All memory, microprocessor and ACIA devices shall be socket mounted. Sockets shall have machined beryllium copper contacts with gold plating.

Two controller unit manuals with schematics shall be supplied with each controller unit.

Controllers shall be warranted for a period of 60 months or for the manufacturer's standard warranty, whichever is greater. The warranty period shall begin on the date of shipment to the project. Each unit shall have a permanent label or stamp indicating the date of shipment.

Payment for Item 633 Controller Unit, Type 170E, with Cabinet, By Type shall be made at the contract unit price per each controller unit with software, all required auxiliary

equipment, loop detector units and a prewired cabinet, with all items completely wired and tested. Ground mounted cabinets will include anchor bolts and conduit ells for installation in the foundation. Pole mounted cabinets will include pole mounting hardware.

Designer Note: This note may be used when the maintaining agency wishes to use 170E type controllers.

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443 SPECIFICATIONS

ODOT specifications for the furnishing and installation of traffic signal equipment are contained in the following **CMS** sections, **Supplemental Specification** and **Supplements**.

625 and 725	Trench, conduit, ground rods and pull boxes
632 and 732	Traffic signal equipment
633 and 733	Traffic signal controllers

Supplemental Specifications 840 and 940 address Fiber Optic Cable and Components.

Supplement 1048 covers the prequalification procedure for loop detector sealant.

Supplement 1063 addresses signal construction personnel requirements.

Supplement 1076 covers the prequalification procedure for conflict monitors used with 2070 controllers.

Supplement 1094 defines the certification procedure for signal support and strain pole fabricators.

Supplement 1095 covers the prequalification procedure for Model 242 DC Isolators.

Supplement 1097 covers the prequalification procedure for LED vehicular and pedestrian signal lamps.

CMS sections, the **Supplemental Specification** and **Supplements** related to specific traffic signal items are referenced individually as they are discussed in this Manual.

Information on the **CMS** may be viewed on-line at

<http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Pages/2010CMS.aspx>

and information on **Supplemental Specifications** and **Supplements** may be viewed at

<http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Pages/ProposalNotesSupplementalSpecificationsandSupplements.aspx>.

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460 MAINTENANCE / OPERATIONS**460-1 General**

Because traffic signals by their very nature provide positive guidance to conflicting traffic movements, it is imperative that they be maintained in order for them to function reliably. The mean time before failure of a traffic signal installation can be dramatically reduced through proper maintenance practices. The consequence of poor maintenance practices are a reduction in safety to road users and an unnecessarily large exposure to liability claims. **District Roadway Services** personnel and signal maintenance contractors are required to perform maintenance on traffic signals according to a preset schedule.

460-2 Responsibilities

The **Office of Traffic Operations (OTO)** shall:

1. Staff and maintain a central repair facility for the purpose of repairing components of electrical traffic control devices.
2. Assist **Districts** in maintaining reasonable stock levels of all major electrical items, and their appurtenances, required for new installations and maintenance through the management of annual term contracts and spot purchase contracts.
3. Assist the **Districts**, through procedure manuals, training programs, inspections, and other methods, in providing quality maintenance.

The **OTO Signal Shop** shall:

1. Repair, check and make serviceable for installation all signal controllers, signal relays, detectors, flashers, conflict monitors and other associated items.
2. Provide the loop detectors and other miscellaneous parts to custom wire as per plan new controller cabinets purchased by the **Districts** or rewire/refurbish existing controller cabinets.
3. Periodically provide the **Districts** with technical information concerning old and new equipment, such as: a list of outdated equipment that will not be repaired by the **Signal Shop**, changes, problems, software updates and etc. for any equipment owned by **ODOT**, and other tips or tricks that may help the **District** personnel.
4. Distribute to the **Districts**, at least once per calendar year, a list of all equipment, parts, and services available from the **Signal Shop**.

Each **District** shall:

1. Maintain a stock of traffic control equipment and other spare parts sufficient for normal preventive maintenance and emergency field repairs.
2. Have a plan to support the extraordinary (i.e., severe storm damage) traffic control equipment needs of the **District**.
3. Evaluate, authorize and maintain records of all changes in the location or operation of electrical traffic control devices.
4. Transport defective controllers, detector relays, detectors, conflict monitors, etc., to the **OTO Signal Shop** (or approved contractor/vendor) for service, maintenance and repair, along with a **Signal Shop Order** and a tag indicating the exact type of malfunction. These units shall at all times be properly cushioned to prevent physical damage during shipping and handling.

5. Generate an “as built” drawing for each electrical traffic control device installation, including each new or upgraded intersection control beacon, school flasher or signal. The drawing shall be in MicroStation V8 or later format and shall include the following, if appropriate:
 - a. Geometrics of the intersection.
 - b. Materials list.
 - c. Layout and location of the detectors, poles, pull boxes, cable runs, span wire, signal and pedestrian heads, controller, power service, phase diagram, detector operation, date of installation, revision block, and any other information which shows the intended operation.
 - d. Changes which affect the geometrics of the intersection and/or the operation of the signal shall be added to the drawing as revisions.

These electronic files shall be accessible to the **Central Office** in a read-only mode. Signal drawings which exist in a raster or single element format and cannot be modified shall be digitized or converted by other means when revisions become necessary.

6. Perform appropriate engineering studies, as needed, upon which revisions in signal operations, e.g., phasing may be based. When such revisions are required, an engineering report and necessary supporting data shall be submitted for approval to the appropriate **District** staff person.

Some signalized intersections and/or signalized corridors may be eligible to apply for, and participate in, the Systematic Signal Timing & Phasing Program (SSTPP). See **Section 1213-6** for more information about this program.

460-3 **Preventive Maintenance**

460-3.1 **General**

ODOT-maintained traffic signal installations shall be inspected a minimum of one time annually. In addition to the annual traffic signal inspection, the following routine scheduled maintenance shall be performed by either **District Roadway Services** section personnel or a signal maintenance contractor.

460-3.2 **Traffic Control Signals and Intersection Control Beacons**

Every seven years, all LED traffic control signal lamps and intersection control beacons shall be replaced. A twelve-month compliance interval shall apply to this process such that no device shall be in service for more than eight years. The entire signal head should be replaced.

Incandescent lamps shall no longer be used.

Every twelve months the conflict monitor shall be tested with an automatic conflict monitor tester.

Conflict monitors that are over ten years old need to be removed from service.

460-3.3 **Other Electrical Traffic Control Devices**

For School Flashers, flashing and illuminated signs, and other electrical traffic control devices:

- Incandescent lamps shall no longer be used.
- Every seven years all LED lamps shall be replaced and the electrical cable and its connections in and near the signal head shall be checked.
- Every four years mercury vapor lamps shall be replaced, and all reflectors, lenses, tubes and /or lamps shall be cleaned.

460-3.4 Signal Support Inspection

All signal supports shall be inspected at a maximum five-year interval. New signal supports shall be inspected at the time of construction. Refer to **Section 421-2** for additional information on signal support inspections.

460-4 As Required Maintenance

The following maintenance shall be conducted as required:

At signalized intersections, and for School Flashers and Intersection Control Beacons (overhead flashers):

1. Replace premature failure of lamps. Clean all reflectors, lenses, tubes and/or lamps.
2. Repaint painted steel poles, controller housings and signal heads as necessary to maintain good appearance and protection.
3. If required by local conditions of smoke, smog, etc., clean all reflectors, tubes and/or lamps using a mild detergent.

At flashing signs, illuminated signs, and other electrical traffic control devices:

1. Replace premature failure of lamps. Clean all reflectors, lenses, tubes and/or lamps.
2. Maintain and replace all other items as required.

Maintain all signs and pavement markings directly associated with any of these devices.

460-5 Malfunction Response

Each **District** shall seek the cooperation of the **Ohio State Highway Patrol (OSHP)**, local law enforcement, and **ODOT** work crews in reporting outages and malfunction of electrical traffic control devices. The **District** shall provide directions for reporting malfunctions twenty-four hours a day.

Upon becoming aware of a traffic signal malfunction (i.e., single red or yellow outage, power outage, signal on flash, and other malfunctions or damage as deemed necessary), the **District** shall be reasonably prompt in responding at all times, including outside normal working hours. Other repairs, especially green outages, may be made when practicable.

The **District** shall establish procedures for addressing malfunction responses. At a minimum these shall include:

1. If necessary, notify the **OSHP** or other appropriate law enforcement agencies, and ask for immediate assistance with traffic control until operation can be restored to a safe condition.

2. Assure that the signal is examined by a signal electrician or other qualified individual to verify that the signal was not damaged by the outage.
3. When a response is made to a reported traffic signal malfunction, the nature and time of malfunctions and corrective action taken shall be recorded.
4. All maintenance of traffic operations shall follow the requirements of the **OMUTCD** and **Part 6** of this Manual.

460-6 Record Retention

The **District** shall be responsible for retaining records on all traffic signal maintenance, installations, upgrades, transfers, and removals. These records shall be retained for seven years and then reviewed by the **State Archives** for possible transfer. If the **State Archives** determines there is no historical value, they can be destroyed. These records shall include:

1. Date of lamp replacements and a description of all other signal maintenance and repairs preformed.
2. The record response to each reported traffic signal malfunction.
3. Documentation to reflect the history of the signals, shall also be maintained for each location. Copies of the original installation and each revision shall be retained either in paper or electronic form or both.

A current signal timing chart, current “as-built” plan, current programming chart for coordination if necessary, cabinet wiring diagram, and special function device diagrams in each controller housing and in the **District** office. If laptop computers are used instead of paper copies, a plan for updating all the signal electrician’s laptops shall be developed by the **District**.

460-7 Training

The **District** shall be responsible for training its personnel. The **Office of Training** and the **Office of Traffic Operations**, in cooperation with the **Districts**, will make the necessary classes and training available. The schedule for the training classes will depend on the needs of the **Districts**. The following are recommended classes and training for personnel responsible for the maintenance of electrical traffic control devices:

1. **International Municipal Signal Association (IMSA) Training:**
 - a. Work Zone Safety.
 - b. Traffic Signal Technician Level I.
 - c. Traffic Signal Technician Level II.
2. **Office of Traffic Operations Training:** Traffic Signal Maintenance.
3. **Electrical Safety Training**

460-8 Organizational Performance Index (OPI)

The **Traffic Signal Maintenance Organizational Performance Index (OPI)** is intended to establish a measurable performance of the **District’s** traffic signal maintenance. Through the **OPI** process, **Districts** will be identified that are adhering to **ODOT’s** traffic signal maintenance policies, and the condition of **ODOT** traffic signal installations will be quantified.

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The sign may be used in repetition, in conjunction with appropriate distance legends, or with other Warning Signs. Where used on high-speed facilities, the 48-inch size sign shall be used. Where speeds are 40 miles per hour or lower and volumes are moderately low, the 36-inch size may be used.

605-5.8 Flagger Sign (W20-7, W20-7a)

As noted in **OMUTCD Section 6F.31**, the Flagger symbol sign (W20-7) should be used before any point where a flagger is stationed to control traffic. The sign may be used in conjunction with other Warning Signs, such as BE PREPARED TO STOP (W3-4). The 48-inch size sign shall be used regardless of highway classification.

605-5.9 SURVEY CREW AHEAD Signs (W21-H6)

As noted in **OMUTCD Section 6F.38**, the SURVEY CREW AHEAD sign (W21-H6) should be used to warn of survey crews working in or next to the roadway.

605-5.10 Blasting Zone Signs (W22-1, W22-2, W22-3)

As noted in **OMUTCD Sections 6F.40 through 6F.43**, Blasting Zone signing shall be used in advance of a temporary traffic control zone where explosives are being used.

605-5.11 Construction Arrow Sign (W1-H16)

The Construction Arrow sign (W1-H16) (**see OMUTCD Section 6F.50.1**) should be used where it is necessary to guide traffic through construction areas, or where road work is in progress. This sign is often placed along lane shifts where it may be determined that traffic guidance is necessary. Examples of use of the Construction Arrow sign are presented in **OMUTCD Figures 6H-31, 6H-32 and 6H-36** and in **Traffic SCDs MT-102.10 and 102.20**.

605-5.12 SHOULDER CLOSED Signs (W21-5a, W21-5b)

SHOULDER WORK signs are addressed in **OMUTCD Section 6F.37**. On expressways and freeways, the RIGHT (LEFT) SHOULDER CLOSED sign (W21-5a) and RIGHT (LEFT) SHOULDER CLOSED AHEAD sign (W21-5b) should be used in advance of the point where the shoulder work occurs and should be preceded by a ROAD WORK AHEAD sign (W20-1).

Code No.	Route Type	Size Inches
W21-5a & W21-5b	Conventional	36 x 36
W21-5a & W21-5b	Expressway & Freeway	48 x 48

605-5.13 Shoulder Drop-Off Sign (W8-17)

OMUTCD Section 6F.44 indicates that the Shoulder Drop-Off sign (W8-17) “should be used when a shoulder drop-off, adjacent to the travel lane, exceeds 3 inches in depth for a continuous length along the roadway, based on engineering judgment.” However, **Traffic SCD MT-101.90** has been developed to address shoulder drop-off situations on **ODOT**-maintained freeways, expressways and other highways with speeds of 45 mph or greater and minimal driveways. If the guidance in the **SCD** is followed, there should be no need for the W8-17 sign.

Where the sign is appropriate, it shall be installed by the end of the day in which the drop-off is created.

Code No.	Route Type	Size Inches
W8-17	Conventional	36 x 36
W8-17	Expressway & Freeway	48 x 48

605-5.14 UNEVEN LANES Sign (W8-11)

The UNEVEN LANES sign (W8-11) is addressed in **OMUTCD Section 6F.45**. It should be used during operations that create a difference in elevation between adjacent lanes.

Code No.	Route Type	Size Inches
W8-11	Conventional	36 x 36
W8-11	Expressway & Freeway	48 x 48

605-5.15 NO CENTER LINE and NO EDGE LINE Signs (W8-12, W8-H12a)

NO CENTER LINE and NO EDGE LINE signs (W8-12 and W8-H12a) are addressed in **OMUTCD Section 6F.47**. They should be used when the work obliterates the center or edge line. These signs should be placed at the beginning of the zone and repeated at 2-mile intervals in long zones to remind the road users. They should also be used at major connections, traffic generators, and/or at appropriate intervals as determined by the project engineer, to advise road users entering within the zone. For acceptable temporary pavement marking standards see **Section 605-11.11**.

605-6 Special Warning Signs**605-6.1 General**

This Section is intended to address signs developed for use on **ODOT**-maintained highways that are not currently addressed in the **OMUTCD**. As noted in **OMUTCD Section 6F.51**, there may be a need for various Warning Signs that are not in **OMUTCD Part 6**. Some of these will be found in **OMUTCD Part 2** and others may be developed because of special conditions not yet addressed in the **OMUTCD**. These "special" Warning Signs may eventually be incorporated into the **OMUTCD**; however, if their use is limited they may not be incorporated into that manual. Special Warning Signs should conform to the general requirements of color, shape and alphabet size and series. The sign message should be brief, legible and clear.

605-6.2 Notice of Closure Signs (W20-H13, W20-H14)

Notice of Closure signs (W20-H13 and W20-H14) are intended to give advance notice to the road user of a scheduled road closure. The information provided on these signs includes the scheduled date of closure and the number of days of the scheduled closure. The W20-H13 also provides a telephone number for information and is the preferable sign. The selected sign should be erected at the point of closure except that more flexibility is acceptable in locating the signs on ramps. The sign should be erected at least one week in advance of a scheduled road or ramp closure and shall be erected on the right-hand side of the road or ramp, facing traffic. Additional details on placement of the Notice of Closure signs is provided in **Section 642-8 (Plan Note 642-8)**.

The first rumble strip pad should be placed before the advance warning devices. The last pad should be placed a minimum of 250 feet in advance of the traffic condition.

A RUMBLE STRIPS sign (W8-H15a) warning drivers of the onset of rumble strips may be placed in advance of any rumble strip installation.

Although the intent of the rumble strips is to alert the road user, the noise may also attract the attention of non-road users on adjacent property. This would be unacceptable in residential areas.

605-18 Screens

Screens (**see OMUTCD Section 6F.88**) are used to block the road users' view of activities that can be distracting. Screens might improve safety and vehicular traffic flow where volumes approach the roadway capacity because they discourage gawking and reduce headlight glare from oncoming vehicular traffic. They can also help contain the work area and reduce the accumulation of dust and debris on the pavement.

On **ODOT**-maintained highways a glare screen shall be used at all crossover locations unless a 50-inch portable barrier (PB) is provided. The upper portion of the 50-inch portable barrier (PB) serves as a glare screen (**see SCD RM-4.1** for details).

Paddle, or intermittent, type glare screens may be mounted on the top of 32-inch PB.

Where glare screen is provided, the glare screen shall be equipped with vertical stripes on the paddles as shown in **Traffic SCD MT-101.70**.

See **Section 642-21 (Plan Note 642-21)**, **L&D Manual Volume One, Section 604** and **Traffic SCD MT-95.70 or MT-95.71** for additional guidance.

The choice of 32-inch PB, with screen, or 50-inch is often left to the contractor. However, glare screen can be a maintenance problem. If PB will be in place over the winter during plowing operations, or if the PB is otherwise expected to be hit a lot, the 50-inch PB should be specified. Plowing over the top of a 50-inch PB is possible; however, it is not preferred.

605-19 Barrier Reflectors and Object Markers

Barrier reflectors shall be mounted on all portable barrier used for traffic control on **ODOT**-maintained highways, and barrier object markers shall be mounted on top of all portable barrier which does not have glare screen.

Barrier reflectors and object markers shall also be mounted on top of all permanent concrete barrier and guardrail located within 5 feet of the edge of the adjacent travel lane (**see Plan Notes 642-51 and 642-52 in Chapter 642**).

Maximum spacing for the barrier reflectors and object markers shall be 50 feet as shown in **Traffic SCD MT-101.70**. Where both barrier reflectors and object markers are provided on the same device, these items shall be staggered.

The minimum reflective surface area for the reflector portion of a barrier reflector should be 7 square inches, and the reflectors shall be mounted on the face of the barrier with the top of the reflector approximately 26 inches above the base.

Attachment of the reflector shall be by a suitable corrosion resistant fastener, bracket or adhesive. Barrier reflectors shall be the same color as the adjacent edge line. When adjacent to a reversible traffic direction lane, barrier reflectors shall be white on one side and yellow on the other side, such that regardless of the direction of travel of the road user, the yellow barrier reflectors will be visible to road user's left and white barrier reflectors will be visible to the road

user's right side.

Barrier object markers shall be 6 inches wide and at least 12 inches high. They shall have orange (fluorescent red-orange or fluorescent yellow-orange) retroreflective sheeting. If used with two-way traffic, two-way barrier object markers shall be used.

Spacing for barrier object markers shall be at 50-foot maximum centers midway between the face-mounted reflectors. When adjacent to a reversible traffic direction lane or between opposing traffic flows, they shall be mounted in pairs facing traffic from each direction.

See **Section 641-19** for more information about **Traffic SCD MT-101.70**.

605-20 Increased Barrier Delineation

605-20.1 General

On freeway and expressway projects, one of the alternate delineation methods for increased barrier delineation shown in **MT-101.70** shall be installed on all portable barrier and concrete permanent barrier located within 5 feet of the edge of the traveled lane under either of the following conditions: along tapers and transition areas; and along curves (outside only) with degree of curvature greater than or equal to 3 degrees.

605-20.2 Linear Delineation Panels

Linear delineation panels shall consist of panels of delineation, approximately 34 inches long and 6 inches wide and shall be "crimped." Panels shall be provided at the rate of one per section of portable barrier, or one panel every 10 feet on permanent portable barrier, spaced evenly along the length of the run. The panels shall be mounted such that the tops of the panels are 26 inches above the pavement. See **Plan Note 642-50** in **Chapter 642** for further details.

605-20.3 Triple Stacking of Barrier Reflectors

Triple stacking of barrier reflectors shall consist of attaching three barrier reflectors, aligned vertically, at locations where a single barrier reflector would be otherwise attached. There shall be no open space between the adjacent barrier reflectors. The top of the middle barrier reflector shall be located 26 inches above the pavement. See **Plan Note 642-50** in **Chapter 642** for further details.

605-21 Future and Experimental Devices

The **States**, **FHWA**, **AASHTO**, the **Transportation Research Board (TRB)**, and other organizations conduct research and experimentation on new traffic control and safety devices.

The **TEM** may be used to distribute information on experimental devices that have been approved for use, and on new devices that have yet to be incorporated into the **OMUTCD**.

641-10.7 Lighting

Typically lighting will not be required for signalized closings 1 lane or a 2-lane highway. However there may be some locations where the designer may find a special need to provide lighting. Examples of need for such lighting might be the existence of an intersection at the point of the lane closure, or poor geometrics or poor sight distance at the point of the lane closure.

The Plan Note for Work Zones Lighting System, found in **Section 642-39**, shall be included in the plans when lighting is required at the points of lane closure.

When lighting is called for, it shall be paid for as Work Zone Lighting System. Quantities shall be provided in the sub-summary for each phase of maintenance of traffic. If it is expected that lighting will be of the conventional type, the lighting shall be paid for per Each.

641-10.8 Field Reviews

A field review, by the designer, is required to verify the proposed locations of PB, drums, pavement markings, signal heads, signs and other features for each phase of the project. Each element shall be tentatively located according to the requirements of the **SCD** and plans to assure adequate visibility and to assure that the controls will be effective. Signal heads shall be visible no less than 215 feet in advance for 25 mile per hour approaches, 325 feet for 35 mile per hour; 460 feet for 45 mile per hour and 625 feet for 55 mile per hour approaches. Signs shall be visible at least 250 feet in advance. Reviews should consider the effects of summer foliage. Any existing traffic controls or other physical features which will detract from safe and efficient operation should be dealt with in the plans. The field check shall also verify that there will be adequate room to perform construction behind barriers or channelizing devices, and that available pavement widths will be sufficient to maintain traffic. The need for temporary pavement or pavement strengthening to carry maintained traffic shall be considered. Changes deemed necessary as a result of this field check shall be incorporated into the MOT Plans by providing details or descriptive notes in the plans. These may include revised locations for signs, signals, pavement markings, PB or other devices. They may also include requirements to use overhead-mounted signals or additional signals or other control devices and could include requirements to remove foliage on the right-of-way.

When actuated signals are necessary, **Plan Note 642-37 (Section 642-37)** should be included in the plans.

When overhead-mounted signals are necessary, **Plan Note 642-38 (Section 642-38)** should be included in the plans.

641-10.9 Bid Items

In an effort to obtain consistency in the bidding procedure the following pay items should be used, as required:

Item 615,	Pavement for Maintaining Traffic, Class _____	Sq. Yd.
Item 614,	Work Zone Edge Line, Class I	Mile
Item 614,	Work Zone Center Line, Class I	Mile
Item 614,	Work Zone Stop Line, Class I	Foot
Item 622,	Portable Concrete Barrier, _____	Foot
Item 614,	Barrier Reflector	Each
Item 614,	Object Marker, _____-way	Each
Item 614	Work Zone Lighting System	Each

All other items will be included in **Item 614 Maintaining Traffic**.

641-11 Flagger Closing One Lane of a Two-Lane Highway (MT-97.10, 97.11 and 97.12)

Traffic SCD MT-97.10 depicts a typical application using a flagger to close one lane of a two-lane highway for a stationary operation. The distance ("A") provided from the Flagger symbol sign (W20-7) to the flagger assumes light to moderate traffic with no substantial back-up, thus the distance allows for a typical back-up of cars plus adequate distance to slow from the approach speed to a stop at the end of the queue. Other locations with heavier traffic or a longer work area will increase the queue length build-up just before traffic is released. The designer should increase distance "A" by **Plan Note** when calculations show the need. Further, **MT-97.10**, allows the project engineer to increase sign spacing based on expected or actual field conditions at any time.

Traffic SCDs MT-97.11 and 97.12 were developed specifically for use during a paving operation on a two-lane road. Therefore, one shall be included with each two-lane resurfacing plan. **MT-97.11** should be used with all non-Federal two-lane resurfacing projects. **MT-97.12** shall be used with all Federal two-lane resurfacing projects.

MT-97.11 and 97.12 provide guidance for traffic going through a paving operation by the use of flaggers and traffic cones. They provide for the use of cones placed laterally across the lane being paved at roads intersecting the closure, and attempt to keep the work area length to a minimum and keep the advance signing and the flagger grouped together.

All items shown on these drawings will be included in the lump sum bid for **Item 614 Maintaining Traffic**.

641-12 Lane Closure at Entrance Ramp (MT-98.10 and 98.11)

Traffic SCDs MT-98.10 and 98.11 generally address lane closures in the vicinity of entrance ramps. **MT-98.10** applies primarily to major reconstruction work, where the work extends beyond the acceleration lane, upstream and downstream on the mainline and upstream on the ramp. **MT-98.11** applies to isolated work areas located primarily on the mainline, in the through lane adjacent to the acceleration lane of the entrance ramp.

Each of these **SCDs** includes separate details drawings. Work location determines which detail is used.

Traffic SCD MT-95.30, which pertains to lane closures on the mainline, shall be used as a companion drawing whenever **MT-98.10** or **98.11** is used.

The designer should exercise care when using **MT-95.30** in the area of an entrance ramp. The placement of signs for closing the right lane contained in **MT-95.30** may overlap an upstream ramp and confuse road users as to whether the ramp is open or closed. When this condition exists, the designer shall provide positive guidance for the road user. This may involve showing the exact placement of all signs and tapers noted in **MT-95.30** within both interchanges on a separate drawing, rather than relying on the **SCD**.

If the paved shoulder must be used to achieve minimum lane width, it may require that the shoulder be reconstructed or strengthened to accommodate the additional load. A separate sheet would be required in the plan detailing the shoulder work.

In order to work on an entire entrance-ramp, it will be necessary to use both detail drawings from the applicable **SCD**. Traffic operation under the detail shown on the second page of each of these drawings may be significantly restricted, and poorer operation can be anticipated. Therefore, the design and project implementation should attempt to do as much of the work as possible using the detail shown on the first page of each of these **SCDs**. This should minimize the time and traffic restrictions involved when the work area is as shown in the detail on the second page of the drawing. Consideration should be given to providing temporary pavement to locate the merge/shift area in the first detail shown at a point downstream, which will then allow for

the field and show the signs in the plans accordingly.

If existing supports are not available, breakaway supports or supports behind guardrail shall be individually designed.

Portable Changeable Message Signs (PCMSs) may also be used to supplement the flatsheet or extrusheet signs. If PCMSs are to be used, the designer shall specify the quantity of signs and provide the appropriate legends to be displayed.

641-17.3 Channelization Devices

Typically, the closure is identified by use of drums; however, PB is shown in **MT-99.50** for use when called for in the plans. A drop-off condition is an example of a situation that might constitute a need for PB (see **Subsection 605-5.13** and **MT-101.90**). The designer shall determine whether or not the additional protection provided by PB is necessary and shall provide the appropriate quantity.

Taper rates of drums shall be as called for in Table II in **MT-99.50**. These taper rates are intended to be similar to those shown in **OMUTCD Figure 6H-32**.

The flare rate of the PB shall also be as called for in Table II of **MT-99.50**. The flare rate may be applied at the exit gore; however, if the contractor will be working in the vicinity of the provided shift taper, the designer should consider specifying in the plans that the PB shall be located parallel to the edge line.

The drum/PB combination is intended to be similar to that shown in **MT-95.40** and in **OMUTCD Figure 6H-34**.

641-17.4 Multiple Lane Closures

If a freeway/expressway has three or more directional lanes and it is necessary to close more than one lane, insert a tangent section (equal in length to twice the taper) between the end of the first lane closure and the beginning of the second. Dual ground-mounted W4-2-28 signs (W9-H4-144 signs if using extrusheet signing) shall be placed along the tangent, in advance of the taper for the second lane closure, at approximately a distance equal to the length of the taper (**also see OMUTCD Figure 6H-37**). If additional lanes are closed, the same process shall be repeated.

If the signs shown as dashed at the ramps do not exist, the designer may require them or similar signs as a part of the work.

641-17.5 Portable Barriers and Impact Attenuators

1. The impact attenuator treatment will typically not require any additional grading of the median; however, foreslopes of 10:1 or flatter from the edge of the shoulder to the PB shall be required. This may require drainage changes.
2. The impact attenuator treatment should typically be more economical.
3. The offset "E" to the beginning of the PB may not always be sufficient (**see L&D Manual Volume One, Section 307**). If the roadway curves to the right, and the curvature exceeds 2.5 degrees (radius is less than 4100 feet), the offset shall be increased in accordance with **Table 697-7**.

The length of PB beyond the shoulder shall also be increased proportionately to maintain the flare rate relative to the edge of pavement, per Table II.

The designer, not the contractor, must determine when to use each type of end treatment

and note this in the MOT Plan.

641-17.6 Bid Items

For **MT-99.50**, all items will be included for payment under **Item 614 Maintaining Traffic**, except the following:

Item 630, Sign, Extrusheet	Square Foot
Item 630, Sign, Overlay	Square Foot
Item 630, Ground Mounted Supports, _____ Beam	Foot
Item 630, Breakaway Beam Connection	Each
Item 630, Ground Mounted Beam Support Foundation	Each
Item 614, Work Zone Edge Line, Class I (By Type)	Mile
Item 614, Work Zone Raised Pavement Marker	Each
Item 622, Portable Concrete Barrier, _____	Foot

641-18 Road Closure Using Type 3 Barricades (MT-101.60)

The type of closure shown in **Traffic SCD MT-101.60** will typically be used in two different situations:

1. The closure seals off a road from which through traffic has been detoured upstream. In this case, only local traffic is expected on the approach to the closure, although this traffic might still be appreciable if the detour begins some distance upstream. Any traffic approaching the closure must be adequately warned and given ample opportunity to stop. The minimum advance warning treatment is three signs. They are supplemented with Type A flasher warning lights. The signs will be dual installations on a four-lane divided road and the designer may insert a **Plan Note** requiring dual installations on other roads.
2. The closure is accompanied by some form of a runaround, directing traffic away from the barricade closure. The runaround may be any one of several types: it may be a true run-around as provided in **OMUTCD Figure 6H-7**; it may be a median crossover as provided in **Traffic SCD MT-95.70**; or, it may be a complete closure of a limited-access highway, requiring all of the traffic to exit upstream of the barricade closure, such as is shown on **Traffic SCD MT-99.50**.

All elements of the barricade closure, including any advance Warning Signs, will be included in the lump sum of **Item 614 Maintaining Traffic**.

641-19 Barrier and Impact Attenuator Delineation (MT-101.70)

Traffic SCD MT-101.70 shall be used when PB is specified in the plans. The drawing presents several methods for delineating PB as well as an impact attenuator nose cone delineation detail. Typically, PB is delineated using object markers and barrier reflectors at 50 foot intervals, with the object markers and the barrier reflectors offset at 25 feet. This method of delineation is applicable to 32-inch PB as well as to 50-inch PB. **Plan Note 642-26 (Section 642-26)** shall be included in the plans when this method of delineation is to be provided. (See **Sections 605-14.5 and 605-19** for more information on PB delineation.)

Where glare screen is provided, the use of object markers is not practical. In such cases, the traditional method for delineating the glare screen is to provide reflective sheeting stripes on glare screen panels. The stripes shall be placed in sets of three, on consecutive glare screen panels, at 50 foot intervals, center-to-center.

The delineation methods typically used are presented in the upper half of the detail drawing. In the bottom half of the drawing, two alternative delineation methods are presented for the purpose of providing an increased level of delineation of the side of the PB. For the top of the PB, only the typical methods of delineation, as discussed above, are presented.

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1213 OTHER TRAFFIC ENGINEERING STUDIES**1213-1 General**

This Chapter includes information about various other traffic engineering studies.

1213-2 Determining Curve Advisory Speeds**1213-2.1 General**

OMUTCD Section 2C.08 addresses Advisory Speed (W13-1P) plaques, when to use them (see **OMUTCD Table 2C-5**) and methods for determining the speed to be displayed. The most common method used to determine the speed shown on an Advisory Speed plaque is a Ball Bank Indicator (BBI)

1213-2.2 Ball Bank Indicator

The ball bank indicator (BBI) should be mounted in a passenger car and carefully calibrated per the manufacturer's specifications. Several test runs are made in determining the speed to use. For each test run, the driver should:

1. Appraise the curve under observation to determine the approximate safe speed that may be maintained throughout the curve.
2. Conduct the first test at a speed 10 miles per hour below the appraised speed.
3. Make each succeeding test at a speed 5 miles per hour greater than the last one.
4. Attain the trial run speed on each test at a distance of at least one-quarter mile from the beginning of the curve.
5. Maintain a course throughout the curve precisely in the center of the lane and at uniform speed.

Form 1296-11 is a sample form for use in recording the results of this curve study and determining the recommended advisory speed. A full-size copy of the Curve Study Sheet is available from the **Office of Traffic Operations'** website.

1213-2.3 Calculation Method to Determine Curve Advisory Speed

The advisory speed indications for horizontal curves may also be calculated by inserting the curve data into the following equation relating superelevation, pavement friction, radius of curvature and vehicle speed:

$$V_{mph} = \sqrt{(e + f)15R}$$

Where V = speed of vehicle in miles per hour
 e = superelevation in feet per foot of horizontal width
 f = transverse coefficient of friction
 R = radius of curvature in feet.

The recommended values of transverse coefficient of friction are as follows:

Operating Speed	Transverse Coefficient of Friction
30 mph	0.16
40 mph	0.15
50 mph	0.14
60 mph	0.13

1213-3 Delay Studies

This Section is reserved to address information available regarding delay studies. In the interim, contact **ORE** for such information if needed.

1213-4 Systematic Signal Timing & Phasing Program (SSTPP)

1213-4.1 General

The Systematic Signal Timing & Phasing Program (SSTPP) is funded by the **ODOT** Safety Program. Its purpose is to systematically update the timing and phasing of signal systems at approved candidate intersections and/or corridors. Requests can be submitted to the **Safety Program Manager** through the local **District** office. Applicants can contact the local **District Safety Coordinator**.

1213-4.2 Benefits

Safety Benefits - The following safety benefits can be realized by updated signal timing. The **Texas Transportation Institute (TTI)** cites the following crash reduction factors associated with improved signal timing and phasing:

- Properly timed addition of all red clearance interval = 25 % crash reduction factor
- Properly timed yellow clearance interval = 4-31 % crash reduction factor (all crashes)
- Adding protected/permitted left turn phase at existing signal = 40-60 % crash reduction factor (left-turn crashes)

Congestion Benefits - In addition to the safety benefits of good signal timing, a more obvious benefit is an improvement of mobility throughout the signalized corridor.

Ohio's Major New Program will go a long way to addressing congestion on **Ohio's** freeways. The Systematic Signal Timing & Phasing Program (SSTPP) is a complimentary program addressing congestion on surface street facilities. Numerous signal timing case studies have shown a reduction in stops of 10 to 20 percent, with a similar reduction in delays. As a result of reduced congestion, comparable decreases in fuel consumption and emissions are also realized. Case studies have shown that properly timed traffic signals reduce fuel consumption 10 to 15 percent when compared to poorly timed traffic signals. Most obvious to drivers is a significant decrease in travel times.

The tables shown in **Figure 1298-2** show examples of the benefits of improved signal timing and phasing that were realized through projects initiated in the **ODOT** Safety Program:

1213-4.3 Eligibility

The following intersections/corridors would be eligible for the SSTPP funding:

1. Intersections or corridors identified by **ODOT** as being high crash and relevant planned countermeasures will not be constructed within one year.
2. Intersections or corridors identified as being congested by **ODOT's** Congestion Model (**Office of Statewide Planning and Research**) and relevant planned countermeasures will not be constructed within one year.
3. Intersections or corridors identified by an **MPO** as being high crash or congested. See *Subsection 1213-4.4* for documentation requirements.
4. Intersections or corridors identified by a local government as being high crash or congested. See *Subsection 1213-4.4* for documentation requirements.

5. Corridors that span more than one local agency that could benefit from a unified signal system operation and were not previously operating as one system.
6. Others as recommended by the **ODOT District Safety Review Team (DSRT)**.

All potential corridors will be reviewed and approved by the **DSRT** then sent to the **Safety Program Manager** for final approval. **ODOT** maintains a pool of consultants that can conduct signal timing analysis and implement recommended improvements.

Every signalized intersection in a corridor that meets the above criteria would be eligible for funding, even if a specific signalized intersection does not meet the criteria.

The physical termini of traffic signal systems should not necessarily be defined by municipal boundaries. They should be logically determined based upon the operational characteristics of a corridor. Corporation limits should not be an artificial barrier to providing effective operations. Where it would be beneficial for a signal system, an attempt should be made to have multiple agencies enter into a joint operational agreement.

In the absence of an actual inter-agency agreement being adopted, every attempt should be made to coordinate signal operations across incorporated boundaries via time-based coordination. It is not necessary to have the cooperation of adjacent agencies to receive funding; however, it is required to attempt to cooperate with traffic operations when the signal system would benefit from having termini in multiple jurisdictions. If an agreement cannot be reached between agencies, an explanation shall be provided with the application for funding to the Safety Program.

1213-4.4 MPO & Local Documentation Requirements

MPO and Local project requests based upon safety and congestion (Eligibility Criteria 3, 4 and 5 in **Subsection 1213-4.3**) will need to provide documentation of need to the **DSRT**. The requesting agency will need to contact the **DSRT** about the extent of documentation for each funding request.

For safety related requests, the documentation may be as simple as noting how many crashes and crash types occur in the corridor, emphasizing those crash types related to signal timing. The requesting agency may provide the information from its own records or ask the **District** if an **ODOT** CAM tool analysis would be available to provide the information (CAM tool is an internal **ODOT** crash analysis program).

Congestion problems are more difficult to quantify because the effort will typically require much the same information that is required to re-time the signals (volumes, computer analysis, existing geometric information, etc.). Documentation for congestion can be as simple as pictures or video of the corridor operation or a field visit by the **DSRT**. Some corridors will be infamous for their congestion issues and will require very limited documentation. Alternatively, a congestion model run by the **MPO** could serve as the basis of documenting the project need.

The **DSRT** can provide specific guidance on need documentation for each funding request.

1213-4.5 Project Scope

Projects approved for funding will typically, but not always, be performed by **ODOT** utilizing existing Safety consultant task orders. The following describes a typical consultant scope of services. This scope may be altered by the **DSRT** as needed to meet the specific needs of each project.

Scope

This project will provide optimized traffic signal timings for (# of signals) in (location). Pre

and post travel time runs will be utilized to provide measures of effectiveness for the project. The following are the major tasks associated with this project.

Task 1: Equipment Inspection – A field inspection will be made to identify any detectors, pushbuttons or other appurtenances that are not operational that could affect system operation. Included shall be a confirmation that internal controller clocks are synchronized (system master and local clocks). A list of deficiencies will be provided to the maintaining agency identifying any problems. Prior to commencing any additional work, repairs must be made by the maintaining agency in order for the system to work as intended.

Task 2: Existing System Observation – The consultant shall make field observations of the existing signalized operation. These observations should include the identification of movements that experience cycle failure; turn-lane blockage; semi-truck issues; pedestrian operations; queue storage/spill back issues; lane utilization / volume balance issues; identification of very major midblock traffic generators/sinks; speed limits; school zones; vertical/horizontal alignments; and other issues that could affect traffic signal operations. These observations should be utilized to properly calibrate the model.

Task 3: Counts – 24-hour tube counts (or equivalent automated counting device) will be taken for one week (seven days) at (location). [Designer Note - tube count locations should be provided, and if more than one tube count is necessary, it should be noted how many and at what locations. Multiple tube count locations are based upon discretion considering system complexity, size and variations in volumes.]

Weekday 12-hour turning-movement counts (including percentage of trucks) shall be taken for each intersection. Weekday AM, midday PM peak and weekend/off-peak hour turning counts will be used to develop four individual weekday peak-hour timing plans. Tube counts will be used to identify the exact count hours. Tube counts will also be used to decide which weekday peak-hour plan is most appropriate for non-peak hours.

Weekend peak-hour timing counts/plans may be authorized if tube counts indicate the weekday timing plans would not be appropriate for use on the weekend. The consultant shall consider travel time runs as well as compare the weekend tube counts taken on the weekdays to make a recommendation to **ODOT** if weekend turning movement count/plans will be necessary. A typical application requiring the authorization to create separate weekend timing plans would be an arterial with large retail centers such as a mall.

In addition to identifying which weekday timing plan should be used in off-peak hours, the tube counts will be used to determine plan transition points and to determine if/when the system should be set to free operation.

Intersections that are currently operating in over-saturated conditions cannot be accurately counted (turning-movement counts) at the intersection due to the movements being over capacity (i.e., excessively long approach queues that experience cycle failure). The consultant shall notify **ODOT** if this condition exists and make a recommendation if additional counting should be undertaken to determine demand traffic. If authorized, the **demand approach traffic** (i.e., free-flow approach volume) shall be counted in addition to the turning-movement counts. The turning-movement counts will be used to derive movement percentages on the over-saturated approach (percentage of left, thru, and right). These percentages will then be applied to the demand (free-flow) approach traffic to obtain the demand turning-movement counts. An acceptable alternative method for obtaining counts at over-saturated intersections is to use modeled demand traffic.

The consultant should compare counts to the **Office of Technical Services** seasonal adjustment factors charts to determine if adjustments should be made based upon the time of year the counts are taken.

Paper copies and electronic files of all counts (turning movement and tube) shall be

provided to the **ODOT Office of Technical Services, Traffic Monitoring** as well as the maintaining agency. A map shall accompany the counts indicating the count locations.

Task 4: Measures of Effectiveness (existing timing) – The consultant shall perform travel time studies documenting existing conditions. Travel time studies shall not be performed until any necessary system repairs are made by the maintaining agency. Four sets of travel time studies shall be made, one for each of the AM, midday and PM peak periods as well as the peak weekend period identified from the tube traffic counts. Each travel time study shall have at least five bi-directional timing runs. All travel time studies shall be made using **ITE** recommendations and shall be accomplished through the use of a GPS based automated device.

Task 5: Signal Warrants – Signal Warrants shall be performed on all signalized intersections.

Any unwarranted signals that the local maintaining agency is unwilling to remove shall be assessed to determine if their retention significantly affects mobility in the project corridor. The consultant will use the optimized timing model - with and without the unwarranted signal modeled to make a recommendation to **ODOT**. Based upon the mobility assessment and the crash history associated with the unwarranted signal, **ODOT** will address each unwarranted signal on a case by case basis with the maintaining agency. A signal need only meet one of the **OMUTCD** prescribed signal warrants to be eligible for funding.

Task 6: Timing Parameters – Minimum green times shall be per local agency policy, or in the absence of a policy shall be per **ODOT** recommendations outlined in the Traffic Signal module of the **Traffic Academy**.

Vehicle clearance intervals (Y+AR) shall be calculated per **ITE** recommendations (contained in the **TEM**). Pedestrian clearance intervals shall be calculated using 3.5 feet/sec crossing speed, and shall be calculated to get the pedestrian to the opposite curb. Walk times should typically be 4 to 7 seconds depending on demand. Where applicable, authorization may be given to update railroad preemption clearance intervals.

Peak-hour factors for each intersection/timing plan shall be calculated based upon traffic volumes. Right turn on red will be allowed in the model when the condition is actually allowable in the field.

[One critical intersection should always be forced to have an offset of zero in all timing plans. This will allow the critical intersection to always be at the proper offset when timing plan changes are implemented.]

Task 7: Modeling –

Field Work - shall be performed to gather necessary model parameters including basic geometrics, lane use, turn-lane storage length, intersection widths (all-red calculation), pedestrian crossing widths, lane widths, intersection spacing, etc.

Model Creation - shall consist of the physical creation of the **Synchro 7.0** timing model using already gathered volume information and field work information.

Model Check/Calibration - shall consist, when necessary, of making vehicle and driver parameter changes to ensure the model accurately represents real world conditions.

Bandwidth Check - The offsets, cycle length and splits provided by **Synchro** will be input into a bandwidth optimization program to check arterial progression. The offsets will be adjusted as necessary to improve arterial operations. **Synchro** is based upon minimizing total delay and does not always provide the best progression in cases where side-street delay is a major consideration. This process should be iterative (back and

forth between **Synchro** and the bandwidth program **Tru-Traffic**) in an effort to maximize arterial operations without harshly impacting side-street and non-coordinated phase operations. **Simtraffic** should be used to determine the effects of manually changing the **Synchro** file results. Attention should be especially paid to turn-lane blockage and cycle failure for non-coordinated phases/approaches.

Timing Table Creation - shall consist of making easily readable timing tables for use in the field (or via download) to program controllers with optimized timing plans. Included shall be cycle lengths, splits, offsets, local timing parameters (min, max, recalls, yellow, all red, ped timing, memory settings, etc.). Also included shall be plan transition times (time when a plan is scheduled to begin).

[The implementation of a new timing plan (plan transition time) should normally occur at least a half hour prior to when it is needed. The implementation of a new timing plan can cause a lack of coordination for two to four cycle lengths, so this disruption should be completed prior to the onset of peak hours.]

Task 8: Field Timing Plan Implementation – Local agencies will be given the option to program the proposed optimized timings or have the consultant do it on their behalf. The consultant shall have qualified personnel, or partner with individuals with these qualifications, to implement the optimized timing plans in the field (or via download) should the local agency request it. The name and qualifications/resume of personnel actually implementing the timing changes shall be provided to **ODOT** for approval. The consultant shall coordinate implementation of the timing plan to accommodate the local maintaining agency if they wish to be represented in the field for the programming.

Task 9: Field Observation and Timing Adjustments – The consultant shall make field observations of implemented optimized signal timings. Adjustments will be made accordingly. Any changes shall be accurately reflected as the final timings in the Operational Report.

Task 10: Measures of Effectiveness (optimized timing) – The consultant shall perform travel time studies documenting optimized conditions. Four sets of travel time studies shall be made, one for each of the AM, midday and PM peak periods as well as the off-peak/peak weekend period. Each travel time study shall have at least five bi-directional timing runs. All travel time studies shall be made using **ITE** recommendations and shall be accomplished through the use of an automated device.

The optimized travel time runs shall be performed as nearly as practical on the same days and times as the existing condition runs. All travel time studies shall be made using **ITE** recommendations and shall be accomplished through the use of a GPS based automated device.

Task 11: Deliverables –

Geometric and Operations Report: The timing programmed into the controller shall be the best possible optimized timing. In instances where this optimized timing cannot provide a Level of Service (LOS) of “D” or better, a “geometric and operations report” shall be produced for that intersection. This shall be a very short report providing geometric improvements (e.g., addition of turn lanes) and/or operational improvements (e.g., addition of a protected turn phase) that would be required to improve the operation to an intersection LOS of “D” or better.

The purpose of the “geometric and operations report” is to document potential low/medium cost improvements that would improve capacity, safety and mobility. This report would be the documentation necessary for locals to request future funding for relatively low-cost improvements such as phase additions or turn lanes.

For the “geometric and operations report,” the consultant will base improvements both on current-day volumes and 20-year traffic. Twenty-year traffic will not be certified traffic. It will be the current-day traffic expanded to 20-year traffic using a reasonable growth factor for the project area. The idea is that the local could potentially make improvements using local money based upon current-day traffic; however, if State or Federal funding is used, they will need to utilize 20-year traffic. Use of estimated 20-year design traffic is just meant to give an idea of the possible scope for a future improvement project. Should a project request be made and subsequently approved certified traffic would be required as necessary in the Project Development Process (PDP). The “geometric and operations report” shall be provided to the maintaining agency(s), the **ODOT DSRT** chairman, the **ODOT Office of Traffic Operations** Administrator, and the **ODOT Office of Systems Planning and Analysis** Administrator.

Operational Report - This report will provide the optimized signal timing plans (with field adjustments accurately reflected); traffic counts; signal warrants (and any supporting documentation to retain an unwarranted signal); and **Synchro** reports for each intersection that shows lane use, timing, LOS, etc. Also included will be the MOE/travel time study findings. A commentary should also be provided as necessary noting any unsignalized intersections that could potentially benefit from being signalized. This should be based upon observation of the optimized signal timing model, as well as field observations. The scope of this work is simply to note the possible locations. If they want to, the maintaining agency can follow up on this outside of the signal timing project. The “operational report” shall be provided to the maintaining agency(s), the **ODOT DSRT** chairman, the **ODOT Office of Traffic Operations** Administrator, and the **ODOT Office of Systems Planning and Analysis** Administrator.

Software - The consultant shall provide one copy of the **Synchro/Simtraffic** to the local maintaining agency for their future use. Included shall be copies of the syn files with the optimized signal timing.

Task 12: Meetings – The consultant shall attend a pre-meeting with **ODOT** and the local maintaining agency and post-implementation meeting. After the pre-meeting the consultant shall submit a project schedule to both **ODOT** and the maintaining agency for approval.

1213-5 Road Safety Audits (RSAs)

1213-5.1 General

A Road Safety Audit (RSA) can be an effective tool to reduce injuries and fatalities on **Ohio's** roadways. An RSA is a formal performance examination of an existing or future road or intersection by an independent and multi-disciplinary team that includes representatives of EMS, Engineering, Education and Enforcement (the 4 E's) as appropriate. For planned roads, the RSA should be conducted at the earliest stage possible (planning or preliminary design), when all roadway design options and alternatives are being explored. RSAs can be used on any size project from minor intersection and roadway retrofits to mega-projects.

1213-5.2 Purpose

The aim of an RSA is to answer the following questions:

- What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

The RSA is not meant to be a replacement for traditional safety studies; rather, it is another tool that can be utilized for improving safety. An RSA may be used in addition to or in lieu of a

traditional safety study. When used in lieu of a traditional study, prior approval must be provided by the **District Safety Review Team (DSRT)** as well as the **ODOT Safety Program Manager** if the location is listed on the annual safety work plan. Results (countermeasures) identified in an RSA would be eligible for Safety funding through the normal funding application process.

ODOT, like most **State DOTs**, has established traditional safety review processes. However, a road safety audit and a traditional safety review are different processes. It is important to understand the difference between the road safety reviews that are commonly performed and newer road safety audits. The main differences between the two are shown below:

Differences between an RSA and a Traditional Safety Review	
Road Safety Audit	Traditional Safety Review
Performed by a team independent of the project.	The safety review team is usually not completely independent of the design team.
Performed by a multi-disciplinary team that includes people inside and outside of ODOT .	Typically performed by ODOT safety staff and reviewed by an internal multi-disciplinary team.
Always generates a formal RSA report.	Always results in a formal report, but typically requires more data collection, such as detailed existing conditions, traffic volume and capacity analysis.
A formal response report is an essential element of an RSA.	Often does not generate a formal response report.

Additional information regarding RSAs can be found on-line at <http://safety.fhwa.dot.gov/rsa/>.

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1296 FORMS INDEX

1296-1 Speed Zone Request for Narrow and Low-Volume Rural Roads

Form 1296-1 is used to document geometric and roadway characteristics when submitting a Speed Zone request for a road with an ADT of 400 or less or a width of 16 feet or less. This form is described in detail in **Section 1203-2.6**.

1296-2 Speed Zone Warrant Sheet

Form 1296-2 is used for a full-scale Speed Zone Warrant analysis. The procedure for using this form is described in **Section 1203-3.4**.

1296-3 Sample Speed Study Data Sheet

Form 1296-3 may be used to record data used in the Speed Zone Warrant Analysis (*see Section 1203-3.2*). See **Table 1297-2** for determination of Intersection Class and Building Type.

1296-4 Completed Sample Speed Study Data Sheet

Form 1296-4 is a sample of a completed version of *Form 1296-3*.

1296-5 Speed Check Form

Form 1296-5 is used to record speed information to determine the 85th-percentile and pace speeds (*see Section 1203-3.3*).

1296-6a Speed Limit Revision

Form 1296-6a is used to establish a revised speed limit (*see Section 1203-2*). Note that the established limit becomes effective when appropriate signs giving notice thereof are erected.

1296-6b Work Zone Speed Limit Revision

Form 1296-6b is used to establish a Work Zone Speed Zone (*see Section 1203-2.9*). Note that the established limit becomes effective when appropriate signs giving notice thereof are erected.

1296-7a Withdrawal of Issued Speed Limit Revision

Form 1296-7a is used to withdraw a revised speed limit (*see Section 1203-4*).

1296-7b Withdrawal of Issued Work Zone Speed Limit Revision

Form 1296-7b is used to withdraw a Work Zone Speed Zone (*see Section 1203-4*).

1296-8 Field Report on Parking Practices

Form 1296-8 is used to request a No-Parking Zone. The procedure for using this form is described in **Section 1204**.

1296-9 Establishment of No-Parking Restrictions

Form 1296-9 is used to establish a No-Parking Restriction (*see Section 1204-2*). Note that the restriction becomes effective when appropriate signs giving notice thereof are erected.

1296-10 Withdrawal of Issued No-Parking Restrictions

Form 1296-10 is used to withdraw an established No-Parking Restriction (*see Section 1204-4*).

1296-11 Curve Study Sheet

Form 1296-11 is used in the Ball Banking Study described in **Section 1213-2** to determine the recommended maximum speed to use on the Advisory Speed plate.

1296-12 Reserved – Deleted the Existing Form**1296-13 Reserved – Deleted the Existing Form****1296-14 Freeway Speed Zone Evaluation Sheet**

Form 1296-14 is used to document a request for a change in the speed limit on a freeway (*see Section 1203-2.8*).

1296-15 Speed Zone Request for Unimproved Highways and Residential and Commercial Subdivision Streets

Form 1296-15 is used to document a request for a reduction of the speed limit on unimproved **County** highways and residential and commercial subdivision streets (*see Section 1203-2.7*). The form may also be used by **Townships** to document Speed Zones they establish based on **ORC Division 4511.21(K)**.

1296-16 Work Zone Speed Zone (WZSZ) Justification Report

Form 1296-16 is a sample form for documentation of speed zone requests for temporary traffic control zones (*see Section 1203-2.9*).

1296-17 WZSZ Evaluation Sheet for High-Speed (≥ 55 mph) Multi-Lane Highways

Form 1296-17 is used for work zone speed zone analysis for freeways, expressways and multi-lane highways with an existing speed of 55 mph or higher. The procedure for using this form is described in **Section 1203-2.9**.

1296-18 WZSZ Tracking Report

Form 1296-18 is used to document and log the date, time, location and other detailed information regarding implementation of work zone speed zones.

1296-19 Sample OSHP Concurrence Sheet

Form 1296-19 is a sample of a form used to submit Speed Zone and Parking Control Zone requests to the **Ohio State Highway Patrol (OSHP)** for concurrence (*see Sections 1203-2 and 1204-2*).

Form 1296-10. Withdrawal of Issued No-Parking Restrictions

STATE OF OHIO
DEPARTMENT OF TRANSPORTATIONWITHDRAWAL OF ISSUED
NO-PARKING RESTRICTIONS

No. _____

District: _____

County: _____

State Route No.: _____ Section: _____

Under Authority of Section 4511.10 - 4511.68 of the Ohio Revised Code, the following described No-Parking restriction(s) approved by the Director of Transportation on _____, has been determined, on the basis of a traffic and engineering investigation, to be unreasonable and approval of the same is hereby withdrawn.

LOCATION OF NO-PARKING LIMITS

From	To	Along

Signs relating to the parking prohibition shall be immediately removed.

Date: _____

Director of Transportation

Immediately after removal of the No-Parking signs, return the attached copy of this No-Parking Restriction Withdrawal form to the ODOT District Deputy Director or his designee, with the following certification properly executed.

I hereby certify that appropriate signs, giving notice of the above No-Parking restriction were removed

on _____ Signed _____

Title _____

Form 1296-11. Curve Study Sheet

STATE OF OHIO
DEPARTMENT OF TRANSPORTATION

CURVE STUDY

COUNTY: _____

ROUTE: _____

SLM: _____

TANGENT DISTANCE BETWEEN CURVES _____ FEET
(REVERSE CURVE IF LESS THAN 600 FEET)

DATE: _____

REVIEWED BY: _____

DIRECTION: _____		LENGTH: _____				DIRECTION: _____		LENGTH: _____			
BALL BANK CRITERIA	TEST SPEED	BALL BANK ANGLE				BALL BANK CRITERIA	TEST SPEED	BALL BANK ANGLE			
		# 1	# 2	# 3	AVG			# 1	# 2	# 3	AVG
≤12°	55 MPH					≤12°	55 MPH				
	50 MPH						50 MPH				
	45 MPH						45 MPH				
	40 MPH						40 MPH				
	35 MPH						35 MPH				
>12° ≤14°	30 MPH					>12° ≤14°	30 MPH				
	25 MPH						25 MPH				
>14° ≤16°	20 MPH					>14° ≤16°	20 MPH				
	15 MPH						15 MPH				
	10 MPH						10 MPH				
RECOMMENDED ADVISORY SPEED						RECOMMENDED ADVISORY SPEED					
REMARKS: _____											

DIRECTION: _____		LENGTH: _____				DIRECTION: _____		LENGTH: _____			
BALL BANK CRITERIA	TEST SPEED	BALL BANK ANGLE				BALL BANK CRITERIA	TEST SPEED	BALL BANK ANGLE			
		# 1	# 2	# 3	AVG			# 1	# 2	# 3	AVG
≤12°	55 MPH					≤12°	55 MPH				
	50 MPH						50 MPH				
	45 MPH						45 MPH				
	40 MPH						40 MPH				
	35 MPH						35 MPH				
>12° ≤14°	30 MPH					>12° ≤14°	30 MPH				
	25 MPH						25 MPH				
>14° ≤16°	20 MPH					>14° ≤16°	20 MPH				
	15 MPH						15 MPH				
	10 MPH						10 MPH				
RECOMMENDED ADVISORY SPEED						RECOMMENDED ADVISORY SPEED					
REMARKS: _____											

Form 1296-12. Reserved – Existing Form Deleted

Form 1296-13. Reserved – Existing Form Deleted

1298 FIGURES INDEX**1298-1a Work Zone Speed Zoning Process – for a Construction Project in the Design Phase**

Figure 1298-1a provides a flowchart illustrating the work zone speed zoning process described in **Section 1203-2.9** for construction projects with the process starting during the design phase of the job, including design build and design build MOT projects.

1298-1b Work Zone Speed Zoning Process – for a Construction Project During Construction

Figure 1298-1b provides a flowchart illustrating the work zone speed zoning process described in **Section 1203-2.9** for construction projects where the request originates during the construction phase of the job.

1298-1c Work Zone Speed Zoning Process – for Operations/Maintenance Work

Figure 1298-1c provides a flowchart illustrating the work zone speed zoning process described in **Section 1203-2.9** for ODOT operations/maintenance jobs.

1298-2 Examples of Signal Timing and Phasing Improvements

Figure 1298-2 provides illustrations of the benefits of improved signal timing and phasing that were realized through projects initiated in the ODOT Safety Program described in **Section 1213-4**.

1298-3 Examples of Type A Roadway Characteristics for Speed Zoning

Figure 1298-3 provides aerial view examples to help illustrate the Type A category of roadway characteristics used in **Form 1296-1 (see Section 1203-2.6)**.

1298-4 Examples of Type B Roadway Characteristics for Speed Zoning

Figure 1298-4 provides aerial view examples to help illustrate the Type B category of roadway characteristics used in **Form 1296-1 (see Section 1203-2.6)**.

1298-5 Examples of Type C Roadway Characteristics for Speed Zoning

Figure 1298-5 provides aerial view examples to help illustrate the Type C category of roadway characteristics used in **Form 1296-1 (see Section 1203-2.6)**.

1298-6 Sample Non-Freeway Safety Study Table of Contents

Figure 1298-6 shows a sample Table of Contents for a Safety Study, as discussed in **Section 1211-2**.

1298-7 Sample Non-Freeway Safety Study Title Page

Figure 1298-7 shows a sample Title Page for a Safety Study, as discussed in **Section 1211-3**.

1298-8 Sample Condition Diagram - Section

Figure 1298-8 shows a sample condition diagram for a section, as discussed in **Section 1211-5.1**.

1298-9 Sample Condition Diagram - Intersection

Figure 1298-9 shows a sample condition diagram for an intersection, as discussed in **Section 1211-5.1**.

1298-10 Sample Collision Diagram - Intersection

Figure 1298-7 shows a sample collision diagram for an intersection, as discussed in **Section 1211-6**.

1298-11 Sample Collision Diagram - Section

Figure 1298-11 shows a sample collision diagram for a section, as discussed in **Section 1211-6**.

1298-12 Sample Collision Diagram - Intersection

Figure 1298-12 shows a sample collision diagram for an intersection, as discussed in **Section 1211-6**.

1298-13 Sample Crash Analysis

Figure 1298-13 shows a sample crash analysis, as discussed in **Section 1211-7**.

1298-14 Sample Rate of Return Worksheet

Figure 1298-14 shows a sample rate of return worksheet, as discussed in **Section 1211-10**.

1298-15 Sample Photos for Safety Study

Figure 1298-15 shows sample photos for a safety study, as discussed in **Section 1211-12**.

1298-16 Sample Photos for Safety Study

Figure 1298-16 shows sample photos for a safety study, as discussed in **Section 1211-12**.

1298-17 Sample Freeway Safety Study Title Page

Figure 1298-17 shows a sample title page for a Freeway safety study, as discussed in **Section 1212-3**.

1298-18 Sample Freeway Safety Study Table of Contents

Figure 1298-18 shows a sample Table of Contents for a Freeway safety study, as discussed in **Section 1212-2**.

1298-19 Sample Schematic with HSP Rankings

Figure 1298-19 shows a sample Schematic for a Freeway safety study, as discussed in **Section 1212-5.1**.

1298-20 Sample Freeway Safety Study Area Schematic

Figure 1298-20 shows a sample area schematic for a Freeway safety study, as discussed in **Section 1212-6.2**.

**Figure 1298-1c. Work Zone Speed Zoning Process –
for Operations / Maintenance Work**

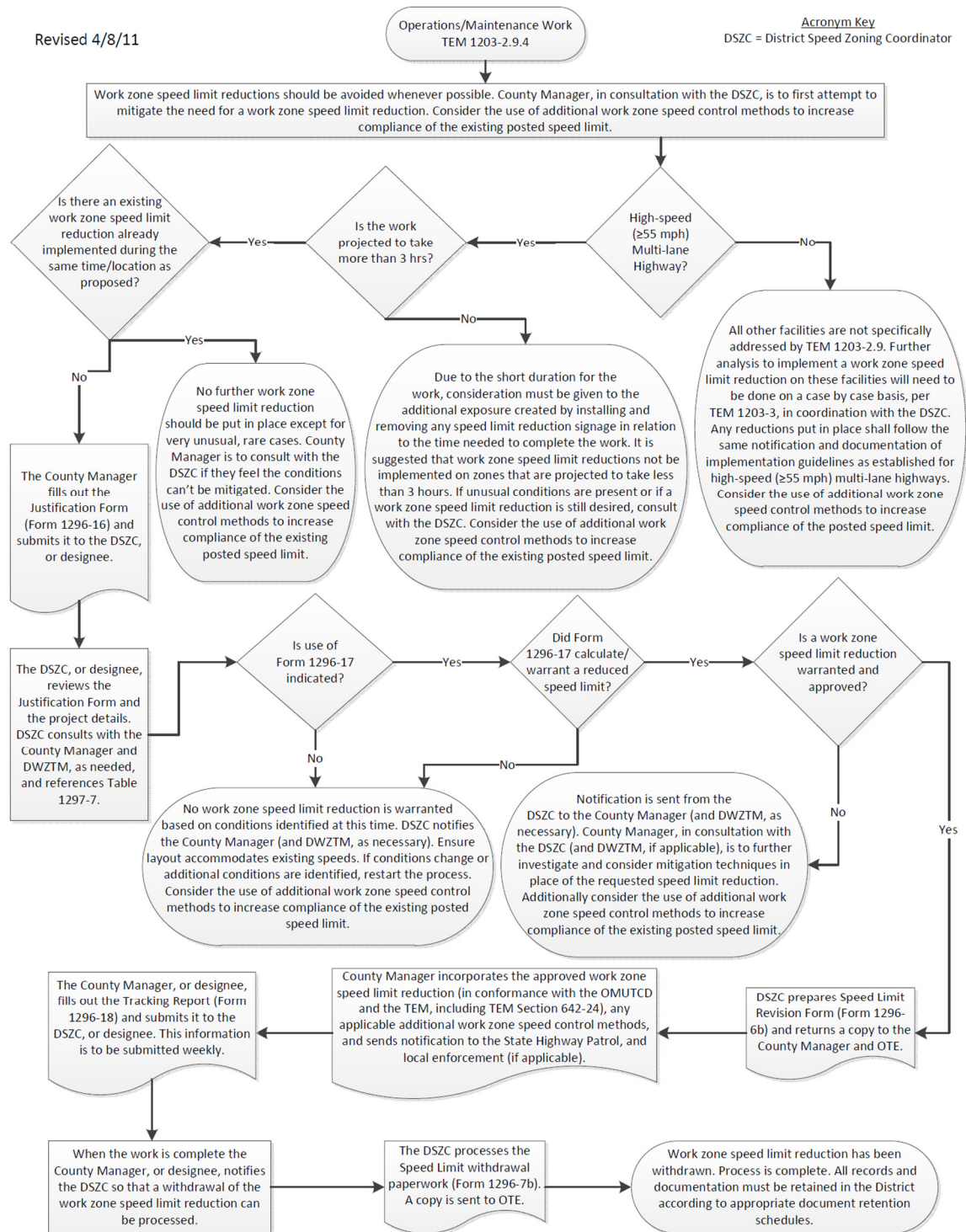


Figure 1298-2. Examples of Signal Timing and Phasing Improvements

(See *Section 1213-4* for related text.)

S.R. 32 Network MOE's - PC Travel Time Study Results			
AM Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	357.6	340.6	-5%
Average Speed (mph)	29.4	31.1	6%
Total Delay (hr)	127.6	109.6	-14%
Number of Stops	2.4	1.9	-21%
Mid-Day Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	332.5	319.9	-4%
Average Speed (mph)	32.8	33.7	3%
Total Delay (hr)	103.7	89.7	-14%
Number of Stops	1.9	1.7	-11%
PM Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	544.8	269.6	-51%
Average Speed (mph)	22.6	38.8	72%
Total Delay (hr)	317.6	43.0	-86%
Number of Stops	8.2	1.8	-78%
Off-Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	435.4	318.7	-27%
Average Speed (mph)	27.6	37.5	36%
Total Delay (hr)	171.2	64.6	-62%
Number of Stops	4.0	1.9	-53%

S.R. 28 Network MOE's - PC Travel Time Study Results			
AM Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	143.8	125.1	-13%
Average Speed (mph)	22.6	28.2	25%
Total Delay (hr)	71.4	51.4	-28%
Number of Stops	1.8	0.9	-50%
Mid-Day Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	170.4	131.5	-23%
Average Speed (mph)	19.5	28.8	48%
Total Delay (hr)	97.0	57.5	-41%
Number of Stops	2.2	1.3	-41%
PM Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	243.2	169.5	-30%
Average Speed (mph)	15.2	26.0	71%
Total Delay (hr)	164.0	87.1	-47%
Number of Stops	3.8	1.7	-55%
Off-Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	206.8	166.6	-19%
Average Speed (mph)	18.6	22.0	18%
Total Delay (hr)	127.2	85.1	-33%
Number of Stops	2.6	2.1	-19%

U.S. 27 Network MOE's - PC Travel Time Study Results			
AM Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	842.6	781.2	-7%
Average Speed (mph)	26.9	29.0	8%
Total Delay (hr)	325.8	266.4	-18%
Number of Stops	7.4	7.0	-5%
Mid-Day Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	991.2	1039.6	5%
Average Speed (mph)	23.2	22.2	-4%
Total Delay (hr)	469.0	518.0	10%
Number of Stops	9.4	10.0	6%
PM Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	1281.0	1126.8	-12%
Average Speed (mph)	18.2	20.5	13%
Total Delay (hr)	756.4	601.2	-21%
Number of Stops	17.4	11.2	-36%
Off-Peak Hour			
Measures of Effectiveness	Before Conditions	After Conditions	% Change
Travel Time	1493.0	1281.0	-14%
Average Speed (mph)	15.4	18.0	17%
Total Delay (hr)	972.8	761.8	-22%
Number of Stops	22.8	15.4	-32%

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Part 14 - MISCELLANEOUS

1400 GENERAL

This Part of the **TEM** serves as a collection of miscellaneous information not addressed in the other Chapters. For example, training provided by the **Office of Roadway Engineering (ORE)** and the **Office of Traffic Operations (OTO)** are addressed, as well as standards, policies and guidelines related to the use of rumble strips and other devices on **ODOT**-maintained highways.

TEM Part 1 addresses general information about specifications for traffic control devices and materials, and addresses various procedures addressing the review and approval of new products, and the purchase of traffic control related materials and equipment.

1401 TRAINING AVAILABLE

1401-1 General

There are various training opportunities available within **ODOT** in the traffic engineering field. In addition to the **ORE** Traffic Academy (*see Section 1401-2*), **ORE** and **OTO** provide additional courses related to various aspects of traffic control design and application. At this time, **OTO** offers courses in Traffic Signal Maintenance and in Overhead Sign Supports.

Also, the intranet web page for the **Office of Training: Employee Development & Enrichment** provides a link to the **ODOT** Training Course Catalog which contains courses for the Highway Technician (HT) Series. **ODOT** employees should consult their local **Training Coordinator** for additional information on these courses.

Courses presented by the [Ohio LTAP \(Local Technical Assistance Program\) Center](#) are also available for **ODOT** personnel sometimes, depending on space availability.

1401-2 Traffic Academy

The [Traffic Academy](#) provides training for consultants. It is also open to **ODOT** employees who wish to attend. Successful completion of the appropriate course is an **ODOT** requirement for consultant pre-qualification.

Detail information about the Traffic Academy and copies of some of the manuals used are available on-line at: www.dot.state.oh.us/Divisions/Engineering/Roadway/TrafficAcademy/.

1401-3 Overhead Sign Supports

Purpose: This course provides basic information regarding the inspection and repair of overhead sign supports.

- Designed For: Persons responsible for the inspection, maintenance and/or repair of overhead sign supports.
- Prerequisites: None
- Course Time: Varies
- Course Size: 4 Minimum, 12 Maximum
- Location: District or Central Office
- Program Manager: Jim Roth, Office of Traffic Operations (614) 752-0438

1401-4 NEMA Traffic Signal Maintenance

The **NEMA** Signal Maintenance Course is provided to the **Districts** upon request, on a first come first served basis by the **OTO Signals and ITS Section**. The course objectives are to help Signal Electricians, Project Engineers and Highway Technicians understand the operation, installation and maintenance of traffic signals.

This course is held only in Central Office at the Sign and Signal Shops, 1606 West Broad St. The class is restricted to six employees at a time because of limited classroom and equipment availability.

Course topics include:

- Understanding the terminology of traffic signals.
- Understanding traffic signal construction plans.
- Understanding **NEMA** traffic signal cabinet diagrams.
- Recognizing **NEMA** TS-1 and TS-2 traffic signal equipment.
- Basic programming of traffic signal equipment, including the use of laptops.
- Basic electrical safety and safe maintenance of traffic signals in the field.
- Trouble shooting malfunctioning traffic signals.

To schedule a class or get additional information, please contact the **OTO Signals and ITS Section**.

1401-5 2070 Traffic Signal Maintenance

The 2070 Signal Maintenance Course is provided to the **Districts** upon request, on a first come first served basis by the **OTO Signals and ITS Section**. The course objectives are to help Signal Electricians, Project Engineers and Highway Technicians understand the operation, installation and maintenance of 2070 traffic signal operation.

This course is held only in Central Office at the Sign and Signal Shops, 1606 West Broad St. The class is restricted to six employees at a time because on limited classroom and equipment availability.

Course topics include:

- Understanding the terminology of 2070 traffic signals.
- Understanding 2070 traffic signal cabinet diagrams.
- Recognizing 2070 traffic signal equipment.
- Basic programming of 2070 traffic signal equipment, including the use of laptops.
- Basic electrical safety and safe maintenance of traffic signals in the field.
- Trouble shooting malfunctioning traffic signals.

To schedule a class or get additional information, please contact the **OTO Signals and ITS Section**.

1401-6 Strain Pole Design (SWISS Software)

The SWISS course provides training for consultants in the design of strain poles. It is also open to **ODOT** employees. The course objective is to provide assistance in the use of the computer program for the design of span wire signal supports. The SWISS software is available on-line at: <http://www.dot.state.oh.us/Divisions/Engineering/Roadway/TrafficControl/>.

This course is held only in Central Office at the Sign and Signal Shops, 1606 West Broad Street. The class size is restricted to twelve people.

To schedule a class or get additional information, please contact the **ORE Traffic Control Design Section**.

1415 RUMBLE STRIPS (INCLUDING STRIPES) IN THE ROADWAY**1415-1 General**

As defined in **OMUTCD Section 1A.13** a rumble strip is “a series of intermittent, narrow, transverse areas of rough-textured, slightly raised, or depressed road surface that extend across the travel lane to alert road users to unusual traffic conditions or are located along the shoulder, along the roadway center line or within islands formed by pavement markings to alert road users that they are leaving the travel lanes.” Rumble strips within the roadway are addressed in this **TEM** Chapter.

ODOT standards, details and specifications for the use of longitudinal shoulder rumble strips are addressed in the **L & D Manual Volume One, Section 605, SCD BP-9.1** and **CMS Item 618**.

Permanent rumble strips shall be milled. They may be applied at any time to new or existing asphalt and concrete surfaces in good condition. However, they are not recommended for installation on bridge decks, crosswalks, within intersections, or within areas of abrupt vertical or horizontal alignment changes. They are also not recommended when the pavement or pavement overlay is less than 1.75 inches in depth. The grooves for in-lane rumble strips should not extend to within 2 inches of a concrete pavement joint.

The decision to install rumble strips should include careful consideration of the effect of the noise produced by rumble strips on any nearby residents.

Although self-cleaning to a limited extent, rumble strips should be inspected periodically to determine if debris needs to be removed or if they need to be re-milled.

Rumble strips should not be installed without the recommendation of the **District Safety Review Team** and the approval of the **District Deputy Director**. They should be re-evaluated when conditions change, and paved over or removed when no longer needed.

The term “rumble stripes” refers to rumble strips that are in-line with longitudinal pavement markings (*see Section 1415-3*). Additional information on rumble strips and stripes in the roadway may be found in **TEM Section 605.17 and Chapter 805, PIS 206410 (Rumble Stripes)** and **OMUTCD Section 6F.84**.

1415-2 Transverse Rumble Strips**1415-2.1 General**

Transverse rumble strips are used to alert drivers in advance of the need to stop or slow down, or of unexpected abrupt geometric changes. They consist of parallel 4-inch grooves cut at 1-foot intervals.

Transverse rumble strips extend nearly across the full width of the lane of travel, normally starting 4 inches from the center line and stopping 18 inches short of the right edge line.

When shoulders are 2.5 feet or less in width, or non-existent, on roadways which are dedicated bicycle routes or have considerable bicycle traffic, consideration should be given to increasing the clear distance on the right side of the roadway to provide a total clear path for the bicyclists (including any existing shoulder) of 4 feet.

A transverse rumble strip installation is typically made up of three groups/pads of rumble strips with each group placed about 250 feet apart. Each group is typically composed of fifteen 4-inch strips/grooves. A sample drawing is available from the **Office of Roadway** upon request.

Transverse rumble strips should be preceded by a RUMBLE STRIPS sign (W8-H15a).

If the color of a transverse rumble strip used within a travel lane is not the color of the pavement, the color of the rumble strip shall be white.

1415-2.2 Intersections

Transverse rumble strips should be considered for use in advance of intersections where there is a documented problem involving angle and/or rear-end crashes related to red light or STOP sign violations only after all other countermeasures have been tried and proven ineffective.

Possible locations include isolated high-speed or expressway signalized intersections and intersections with inadequate stopping sight distance.

If used, rumble strips should be installed on the approach(es) with the crash problem. They are usually installed on a stop approach at a STOP sign controlled intersection, but may also be installed on the mainline, or on a signalized approach when the crash problem is related to that particular approach.

For highways with a speed limit less than 50 mph, the last rumble strip should be at least 200 feet from the Stop Line, or if none, from the point where the road user should stop. If the speed limit is 50 mph or greater, the last rumble strip should be at least 300 feet from the stopping point.

1415-2.3 Grade Crossings

As noted in **Chapter 805**, rumble strips may be used at railroad grade crossings after other appropriate standard traffic control devices have been considered. The rumble strip installation is generally the same as for other intersections stop approaches; however, only two rumble strip pads, or groupings, are used. Contact the **Office of Roadway Engineering** for the detail drawing for this installation.

1415-2.4 Freeways and Expressways

Transverse rumble strips may be installed in the travel lanes in advance of toll booths both to alert drivers of the need to reduce speed before entering the toll booth area and to mitigate highway hypnosis.

They may be installed in the exit lane for loop ramps or other curved ramps where significant speed reductions are necessary when there is a documented problem involving run-off-the-road and/or rear-end crashes, but only after all other countermeasures have been tried and proven ineffective. They shall only be installed in the exit lane when the minimum braking distance for the necessary speed reduction exists beyond the final rumble strip.

Transverse rumble strips are not recommended inside lane-drop areas after the LANE ENDS sign. They may be installed to alert road users that the freeway or expressway is ending and that they must reduce speed when there is a documented problem involving crashes of the type susceptible to rumble strip treatment, but only after all other countermeasures have been tried and proven ineffective.

They shall only be installed with the recommendation of the **District Safety Review Team** and approval of the **District Deputy Director**.

1415-2.5 Other Applications

Transverse rumble strips may be considered for use in advance of locations where there is a documented problem involving crashes of the type susceptible to rumble strip treatment only after all other countermeasures have been tried and proven ineffective.

The use of rumble strip installations should be kept at a minimum, but may provide a solution to problems of excessive speed or of inattention resulting in crashes at narrow or one-lane bridges, at locations with abrupt changes in vertical or horizontal alignment, and at major commercial driveways with inadequate stopping distance because of horizontal or vertical alignment.

1415-3 Rumble Stripes

1415-3.1 General

Rumble stripes are longitudinal rumble strips that supplement the related longitudinal pavement markings. They are used to reduce highway hypnosis and to alert sleepy, fatigued, impaired, or inattentive drivers that they are leaving the roadway (edge line) or crossing the center or lane line. They provide increased guidance at night or in adverse weather (heavy rain, snow, fog and blowing dust) by defining roadway limits. Additional detail design information is available in **Traffic PIS 206410 (Rumble Stripes)**

Rumble stripes may be continuous or installed in a 60-foot cycle to permit crossing of the center line or edge line by motorcyclists and bicyclists.

These longitudinal rumble strips should be preceded by a RUMBLE STRIPS sign (W8-H15a).

1415-3.2 Center or Lane Line Rumble Stripes

Center line rumble stripes are installed primarily to reduce head-on and side-swipe crashes on two-lane highways. Lane line rumble stripes are installed primarily to reduce side-swipe crashes. Center or lane line rumble stripes should be considered for use in roadway sections where there is a documented problem involving head-on and side-swipe crashes only after all other countermeasures have been tried and proven ineffective. Since they offer a relatively low-cost, low-maintenance countermeasure to prevent these types of crashes, they may also be installed in other roadway sections where there is a high potential for head-on and side-swipe crashes.

Gaps shall be left at intersections, driveways and over structures as detailed in **Traffic PIS 206410, Rumble Stripes**.

Since center line rumble stripes extend through the center line pavement marking, the pavement markings should be reapplied following installation. When using paint, it should be applied twice, once in each direction of travel.

Center line rumble strips/strips shall only be installed with the recommendation of the **District Safety Review Team** and the approval of the **District Deputy Director**.

1415-3.3 Edge Line Rumble Stripes

Edge line rumble stripes provide increased wet/night visibility of the edge line pavement markings, and the corresponding audio and vibratory impacts which result when a vehicle's tires pass over the rumble strips.

Edge line rumble stripes should be installed on **ODOT**-maintained roadways meeting all of the following criteria:

1. 2-foot or greater paved shoulder.
2. Pavement Condition Rating (PCR) of 80 or greater, and shoulder condition suitable for rumble stripe treatment.
3. 11-foot minimum lane width.
4. 2-lane routes outside built-up areas, such as business, residential or urban districts (defined in **ORC 4511.01**).
5. Speed limit greater than 45 miles per hour.

Discretion may be used for roadways where the following conditions or roadway users are encountered:

1. Areas of Amish buggy travel.
2. Areas of high driveway density outside built-up areas.

Gaps shall be left at intersections, driveways and over structures as detailed in **Traffic PIS 206410, Rumble Stripes**.

Rumble stripes shall be discontinued 650 feet in advance of built-up areas, including municipal corporation limits and urban area boundaries. Also, when leaving built-up areas leave a 650 foot gap before starting rumble stripes.

Any roadway or roadway section which has been designated by the **Office of Statewide Planning** or a **Metropolitan Planning Organization** as a bike route and has a paved shoulder width of less than 3 feet should not be considered for edge line rumble stripes unless an existing crash problem is exhibited.

1415-4 Rumble Strips in Temporary Traffic Control Zones

For information on the use of rumble strips for Temporary Traffic Control, see **TEM Section 605-17**.

1416 OTHER DEVICES

1416-1 Driveway Mirrors

Driveway mirrors (usually convex in shape) are sometimes used to help indicate to a driver the presence or absence of a moving or stationary vehicle and/or pedestrian. However, for the following reasons **ODOT** does not install these devices on **ODOT**-maintained highways:

- It takes some time for drivers to understand and interpret the information provided by these mirrors. A convex shaped mirror results in distortion of the image, speed and distance of any object. The degree of distortion depends on the radius of curvature and size of the convex mirror; the larger the radius of curvature the less distortion and vice versa. The image appears to be smaller, further away and traveling at a slower speed in a mirror with a smaller radius of curvature. A convex mirror with a small radius of curvature will also provide too much detail in a small area which will hamper the motorist's ability to discriminate detail.
- During low light levels, mirrors do not clearly distinguish cars with no lights on. In particular, dark colored vehicles may be difficult to detect in these mirrors in low light conditions such as dawn, dusk or overcast.
- These mirrors are fairly expensive, require routine cleaning and are subject to vandalism.

If property owners want to install and maintain one of these mirrors on their own, they should be advised of the concerns mentioned above, and if the mirror will be on the State right-of-way, they will need to get a permit.

Since the burden of responsibility for the location and subsequent safe use of residential driveways rests with the property owner, not **ODOT**, before installing one of these mirrors, the property owner should consider other alternatives, such as relocating the drive. However, in most instances, the property owner will decide that installing a mirror is the preferred alternative. Therefore, also consider advising a property owner considering installation of a driveway mirror that:

- Secure mounting is required to minimize misalignment from high winds, vibrations, etc.
- Fairly large (e.g., 3 x 2 foot), flat, rectangular mirrors produce realistic images.
- For a mirror to function properly, it may need to be mounted fairly high.
- The use of a Plexiglas or metal mirror can minimize damage from vandalism.
- More than one mirror may be needed for proper coverage.