



# Roadway

design & construction

# specifications

2023



## ROADWAY DESIGN & CONSTRUCTION SPECIFICATIONS, Jan 2023

The following are changes to the above *Roadway Design & Construction Specifications, Revised Jan 2023, (Roadway Manual)*

- Chapter 1.00
  - Section 1.01.1: ADA Compliance
  - Section 1.01.2: Applicability
  - Section 1.02: Authority and Promulgation of Specifications
  - Section 1.05: Reference to interpretation of descriptive headings
  - Section 1.06.1: Associations Update
- Chapter 2.00
  - Section 2.01: Revised to update contact information and pre-submittal process
  - Section 2.02.1: Updated to include reference to subdivision plat checklist and real property instrument packets, traffic impact study guidelines, and minor formatting & numbering updates; made note of certain encroachments not permitted into easements or ROW
  - Section 2.02.2: Minor process term updates regarding pre-submittals
  - Section 2.02.4: Submittal document clarification
  - Section 2.02.6.03: Added easement dedications and/or vacations, and subdivision plats
  - Section 2.02.8: Updated process for expired approved plans
  - Section 2.03: Revised to include electronic submittal process
  - Section 2.03.4.02: Scale expanded for larger projects
  - Table 2.03.5.1: Added Preliminary Drainage Plan & Report
  - Table 2.03.5.1: Added “or designee” for signature on certain plans
  - Figure 2.03.5.02.1: Updated to reflect separate Aurora Water Utilities and Drainage Divisions
  - Section 2.03.5.10: Added verbiage on copyright restrictions
  - Section 2.03.6.15: Included verbiage to include specific private improvements
  - Section 2.03.6.17: Updated street lighting developer/owner responsibility and City of Aurora acceptance, along with other street light requirements
  - Section 2.03.6.22: Added SUE required note
  - Section 2.03.6.23: Addressed drainage and utility easement conflict
  - Section 2.03.6.24: Added phasing plan required note
  - Section 2.03.6.25: Added Critical Traffic Control Areas and TCP required note
  - Section 2.03.6.26: Added civil plan approval for associated infrastructure required note
  - Section 2.03.6.27: Added downstream water rights holders required note
  - Section 2.03.7: Added EDN language
  - Section 2.03.9: Variance section added; Includes variances to Roadway Manual and also Aurora Water – Water, Sanitary Sewer & Storm Drainage Infrastructure Standards & Specifications
  - Section 2.03.10: Phasing Plan requirement added
  - Section 2.04.1: Master Drainage must be approved prior to submittal of PD and prior to civil pre-submittal meeting.
  - Section 2.04.2: PD approved prior to submittal of final drainage and civil
  - Section 2.04.3: Removal of reference to hard copies and prior to subdivision plat approval
  - Section 2.04.5: Updated entity acronym
  - Section 2.05.4: Removed electronic stipulation of the seal
  - Section 2.06.1.04: Added street lights, small cell, and utility cabinets & clear zone dimension requirement
  - Figure 2.06.1.05.1: Revised to reflect new crossing and curb ramp standards

- Section 2.06.1.15: Added ADT with Clear Zone requirement to sections
- Section 2.06.1.26: Added sight triangles
- Section 2.06.3.06: Added curb cut requirements for future access
- Section 2.07.2.08: Added requirement to depict existing contours
- Section 2.07.2.09: Added requirement for private (metro district or HOA) storm drain facilities to be located within a tract, not on residential lots
- Section 2.07.4: Update to reflect structural section revisions
- Section 2.08.1.06: 2% minimum slope for all non-paved surfaces.
- Section 2.08.1.09: Update for hand rail requirements
- Section 2.08.2.03: Update to no more than 2 lots permitted to drain through common swale. Reference to Section 4 added.
- Section 2.08.2.07: TOF must be 6” higher than swale high point
- Section 2.10.1: Update to bicycle master plan
- Section 2.12: Update to Street Lighting submittal requirements
- Section 2.08.2.10: Added slope percentages to flow arrows.
- Section 2.13 **NEW**: Private Light Section
- Chapter 3.00
  - Section 3.00: Minor language updates
  - Section 3.01: Changes to media requirements; no hard copies
  - Section 3.04: Updates to revision methods
- Chapter 4.00
  - Section 4.02.3: Mid-block curb ramp clarification
  - Section 4.02.6: Require railing for all 30” or greater drops
  - Section 4.02.6: Section changed to “Reserved; Modified and relocated to Section 4.02.7.06 - pedestrian/bicyclist railing per Building Code
  - Section 4.02.7: Updated structural calculations, design, and submittal requirements
  - Section 4.02.9: Numbering slightly updated.
  - Section 4.02.9 & 4.02.9.01: Code citations updated.
  - Section 4.02.9.5: Removed, subsequent section numbering updated
  - Section 4.03.3: Inlet required to be 5’ from curb ramp
  - Section 4.03.3: Inlet required when storm within 300’
  - Section 4.03.3: Inlets & storm required at “T” intersection when TOF lower than intersection.
  - Section 4.03.6: Sidewalk chase drain required when more than one sump is discharging to a sideyard swale; Exception language added.
  - Section 4.04.1.05 – Minor text updates to clarify measurement requirements
  - Section 4.04.1.06 – Text updates to require turn-around turning movements for fire apparatus on dead end streets; minor signage updates; Language added about alley exceptions.
  - Section 4.04.2.06: Alleys to contain 100yr flood event, recommend but not required 6” freeboard to garage slab; Exceptions by Aurora Water.
  - Section 4.04.2.08.6: Added “drainage easements”
  - Section 4.05.3.04: New language added.
  - Section 4.05.4: Private street slope requirements
  - Section 4.05.6: Clarified street warping to end at PCR and extend away from intersection
  - Section 4.07.7.02.5.03: Clarification on measurement point
  - Section 4.10: Revised Street and Pedestrian Light design requirements
  - Section 4.11 **NEW**: Roadside Design and Clear Zone
- Chapter 5.00,
  - Section 5.01.2.01: Updated language to “Edge drains WILL be required...”
  - Section 5.01.2.02: Included TOD & Urban Centers in geotechnical requirement
  - Section 5.05.1.05: Nomographs removed from this section.
  - Table 5.06.1.1: Chemical stabilization depth clarified
  - Table 5.08.1: AC & Aggregate base asphalt thicknesses increased to 6.0”
  - Tables 5.08: Change Note 5 to allow ½” SMA on case by case basis

- Section 5.08.5: **NEW** Temporary Pavement Section language.
  - Section 5.09.2.01: New language added.
  - Section 5.12: Added language about minimizing swell potential
- Chapter 7.00
  - Section 7.11.2: New language added
  - Section 7.12.3: New section added
- Chapter 20.00
  - Table 20.06.4.02: New note callout
- Chapter 23.00,
  - Table 23.02.1: New Type 5 added to table; New note callouts added
  - Section 23.3: Removed AASHTO T-190 or T-205, replaced with T310
- Chapter 24.00:
  - Section 24.04: Prohibition of use of RAS in asphalt mix designs
  - Section 24.09.2.01: Clarification of truck load covering
  - Table 24.04.1.2: Deleted ST Column
  - Table 24.05.4.02.4: Clarified SMA maximum particle size
  - Section 24.16.3.04: Changed to AASHTO Re:Source or CDOT
  - Table 24.17.7.1: Correcting table QA & QC notes
- Chapter 27.00,
  - Section 27.01.3.05.1: Revised language to include TCP needed when 1+ hour required
- Chapter 36.00,
  - Section 36.10.4, 36.10.5, & 36.11: Mill depth set to 3.0"
- Chapter 50.00,
  - Section 50.06 **NEW**: Traffic Calming section
  - Section 50.07 **NEW**: Fiber Optic Communications section
- Standard Details S1.0 thru S1.12: Added Clear Zone requirement
- Standard Details S1.10: Updated 25' clear minimum paved surface to 26'
- Standard Detail S3.1: Included concrete on both side of chase through tree lawn
- Standard Details S9.0 through S9.16 include updates ADA Ramp Details
- Standard Details 15.1-15.3: Modified to S15.1 to "Reserved"; removed S15.2 and S15.3; See updated Lighting Details section
- Traffic Detail TE-2: New Pole foundation detail
- Standard Detail S12.2: Changed steel to concrete cast in place.
- Traffic Detail TE-2.1: New Pedestrian Pushbutton Bollard and Foundation Detail
- Traffic Detail TE-8.1: Revised table to include Home Runs
- Traffic Detail TE-CO: Revised Wiring Schedule
- Traffic Detail TE-0.1 to TE-0.4: Updated Traffic Signal Design and Construction Standard Notes
- Traffic Detail TE-0.4: Equipment to be return to Traffic Operations on rebuilds
- Traffic Detail TE-0.4: Ground rod to be treated to prevent corrosion
- Lighting Details: **NEW**

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## **SECTION 1.00 INTRODUCTION**

### **1.01 Scope**

This volume, entitled Roadway Design and Construction Specifications (Specifications) sets forth the minimum acceptable criteria for public and private roadway facilities, parking lots, and related infrastructure within the City of Aurora. Deviations or variances from these standards, may be considered upon formal written request; however, it shall be the responsibility of the applicant to demonstrate to the satisfaction of the City Engineer the proposed variance meets or exceeds the minimum acceptable criteria. Any proposed waiver of a City Code provision may only be made according to the procedures set forth in the City Code. Policies and technical criteria not specifically addressed in this document shall follow the provisions of the latest editions, or as noted in the Specifications, of the Roadside Design Guide, the American Association of State Highway and Transportation Officials' "A Policy on Geometric Design of Highways and Streets", and the "Standard Specifications for Road and Bridge Construction" of the Colorado Department of Transportation.

#### **1.01.1 ADA Compliance**

All private and public right of way constructed, or reconstructed improvements are required to comply with the Americans with Disabilities Act (ADA) which has been adopted through these Specifications. ADA compliant features, as well as a fully ADA compliant path of travel, are required for all development and/or redevelopment of a property.

#### **1.01.2 Applicability**

These Specifications shall apply to all projects within the City submitted for Site Plan approval (major or minor) as of the Effective Date.

Projects that have been submitted and accepted by the City for the first Site Plan review and are actively being pursued for approval (i.e. have been resubmitted within the past six months) may be permitted to use the prior adopted Specifications (2016, and subsequent erratum).

### **1.02 Authority**

The Specifications are adopted rules and regulations and the City Engineer has the authority to promulgate such rules and regulations under the provisions of City Code. Portions of the Aurora City Code most often consulted in this volume include: Streets, Sidewalks, and other Public Places,

Chapter 126; Traffic and Vehicles, Chapter 134; Utilities, Chapter 138 including Storm Drainage, Article VII; and Zoning, Chapter 146.

### **1.03 Revisions**

Revisions to these Specifications may be adopted annually and as often as needed. It is the responsibility of the Consultant/Contractor/Developer to obtain the latest revisions from the City.

### **1.04 Review and Approval**

City staff will review all submittals for general compliance with these Specifications. However, approval by the City does not relieve the owner, engineer, or designer from the responsibility of ensuring their calculations, plans, specifications, construction and as-built drawings are correct and in compliance with these Design and Construction Specifications.

### **1.05 Interpretation**

In the interpretation and application of the provisions of the Design and Construction Specifications, the following shall govern:

These Specifications shall be regarded as the **minimum requirements** needed for the protection of the health, safety, and welfare of Aurora and its residents, and shall be liberally construed to further such purposes.

Whenever these Specifications and any other law, ordinance, resolution, rule, or regulation of any kind contain any restrictions covering any of the same subject matter, whichever standards produce higher quality shall govern.

These Specifications shall not abrogate or annul any permits issued before their effective date; any construction plans approved before their effective date; or any final plat documents that have been recommended for approval by the Planning Commission prior to the effective date of these standards.

The descriptive headings of the sections of this Manual are inserted for convenience only and shall not control or affect the meaning or construction of any regulations herein.

## 1.06 Definitions and Terms

Wherever in these Specifications or on the submitted drawings the following terms, acronyms, or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

### 1.06.1 Associations

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AI	Asphalt Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
CDOT	Colorado Department of Transportation
COA	City of Aurora
CRSI	Concrete Reinforcing Steel Institute
FHWA	Federal Highway Administration, U.S. Department of Transportation
MHFD	Mile High Flood District (formerly known as Urban Drainage and Flood Control District)
MUTCD	Manual on Uniform Traffic Control Devices
PCA	Portland Cement Association
I. B. C.	International Building Code

### 1.06.2 Other Abbreviations

A.C.	Asphaltic Concrete
B.F.E.	Base Flood Elevation
C & G	Curb and Gutter
CIP	Cast Iron Pipe
COI	Curb Opening Inlet
CSP	Corrugated Steel Pipe
HBP	Hot Bituminous Pavement
HDPE	High Density Polyethylene Pipe
MH	Manhole

NRCP	Nonreinforced Concrete Pipe
PCC	Portland Cement Concrete
PCR	Point of Curb Return
PVC	Polyvinyl Chloride Pipe
RCP	Reinforced Concrete Pipe
R.O.W.	Right-of-Way
S_ _ _ _	COA Standard Detail

### 1.06.3 Definitions

CITY shall mean the City of Aurora, Colorado, a home rule municipal corporation of the Counties of Adams, Arapahoe, and Douglas.

CITY CODE shall mean the duly adopted City Code of the City of Aurora, Colorado, as amended.

CONTRACTOR shall mean a person, company, corporation or entity licensed and bonded as a contractor in the City in accordance with the City Code.

DESIGNATED PRIVATE CONSTRUCTION WORK includes: private sewer systems, water and sewer service lines to buildings, grading, drainage structures, retaining walls, parking lots, private streets and walks, fire lanes, driveways, and associated construction.

ENGINEER shall mean the City Engineer, the Director of Aurora Water, the Director of Public Works, or other authorized representative acting on behalf of the City.

EXPRESSIONS Wherever the words, "as directed", "as required", "as permitted", or words of like meaning are used, it shall be understood that the direction, requirements, or permission of the City's Project Manager is intended. Similarly, the words "approved", "acceptable", "satisfactory" shall refer to approval by the City's Project Manager.

Whenever the words "these Specifications" are used it shall be understood that reference is made to the City of Aurora's "Roadway Design and Construction Specifications" and "Water, Sanitary Sewer, & Storm Drainage Infrastructure Standards and Specifications" including all parts, supplements, and revisions pertaining thereto.

OBSERVER shall mean the authorized representative of the Project Manager assigned to observe the work

PROJECT MANAGER shall mean the authorized representative of the City who provides overall technical coordination and monitoring of work. However, for private projects the term shall be synonymous with Public Improvement Inspector.

PUBLIC IMPROVEMENTS shall mean any improvement the City is authorized to provide under its charter or ordinance passed pursuant to such charter or under the constitution and laws of this state, including, but not limited to physical facilities, whether publicly owned and maintained or not, that are required for the benefit, welfare, or service of more than a single property and include, but not be limited to, the construction, reconstruction, and improvement of the following: streets and avenues, major and minor arterials, collector streets and avenues, service and frontage roads, fire lanes, bike paths, parkways, alleys, passenger facilities, monuments and range boxes, sanitary sewer mains, including laterals to more than a single building service, storm sewers, inlets, concrete drain pans, underdrains, retention and detention facilities, including necessary structures, channel facilities; street lighting, traffic signals, medians, facilities for storm water quality Best Management Practices, water mains, hydrants and valves, meters, tree plantings and landscaping, irrigation facilities, and repairs and replacements thereof necessitated pursuant to the issuance of a City of Aurora building permit or other authorization for use of the land.

SUBCONTRACTOR Any person, company, corporation or entity licensed and bonded as a contractor in the City in accordance with the City Code which has a direct or indirect contract with the Contractor or other Subcontractor and furnishes and/or performs on-site labor and/or furnishes materials used in connection with the performance of the work.

SURETY shall mean the entity which bonds and guarantees the Contractor's satisfactory performance of the work as described in these specifications. (Bonded)

TESTING AGENCY Any individual or other person or entity which is qualified and licensed to perform the required sampling, analysis, testing, and professional recommendation service.

TRAFFIC MANAGER shall mean the Traffic Manager for the City, or his / her representative.

**Section 2.00 Submittal Requirements and Procedures.....1**

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## SECTION 2.00 SUBMITTAL REQUIREMENTS AND PROCEDURES

### 2.01 General

The procedures outlined herein apply to consulting engineers and developers seeking approval of civil construction plans and reports. Observing these guidelines will assist in timely review. Building permits will not be issued until all related civil construction plans are approved. The overall process for planning and implementing construction projects in the City of Aurora is described in the [Development Handbook](#) and may be found on the City's website.

Before the civil construction plans will be accepted for review the consulting engineer must email Chris Eravelly ([ceravell@auroragov.org](mailto:ceravell@auroragov.org)) or call 303-739-7457 to schedule a Pre-submittal Review Date and Time with the Engineering Control staff and staff from other departments and/or divisions. Prior to the pre-submittal date the consultant may obtain a copy of the [Pre-submittal Check List](#) from the City's website to make sure their submittal is complete.

### 2.02 Drawing Submittal Procedures

#### 2.02.1 Minimum Requirements for Approval

- 2.02.1.01** The City Engineer is responsible to ensure compliance with the Subdivision Plat Review Checklist, as may be administratively amended from time to time to promote public safety, health, and well-being, through the Real Property Services Division. The consultant may obtain a copy from the Real Property Services Division to make sure their submittal is complete.
- 2.02.1.02** In addition to the subdivision plat and/or site plan, adequate detail drawings of all necessary public improvements and of any private construction work not already covered by City specifications shall be submitted for review and approval. For City projects where the City specifications do not cover the work, specifications shall be submitted for review and approval.
- 2.02.1.03** The City requests the submitter refer to the CAD Data Submittal Standard, Civil 3D Template, and the Batch Standards Checker Tool when submitting the civil plans for approval by the City. Guidance can be found on the CAD Data Submittal Standard at <https://auroragov.org/cadtogisstandards>.
- 2.02.1.04** Approvals will be required for the entire water distribution system (including fire protection facilities), sanitary sewer, storm drainage system (including drainage reports, erosion control plans and reports, storm water quality plans, inspection and maintenance plans for water quality facilities, etc.), pavement design reports, grading plans, roadway design, and survey

control plans before issuance of a permit for any phase of development will be approved by the Public Works Department and the Water Department.

The only exception is when the Erosion and Sediment Control Plans and Report are approved; a Stormwater Quality Permit may be obtained to begin grading operations prior to the remaining civil plans being approved. However, should the approval of the final grading and/or drainage plan necessitate changes to the Erosion and Sediment and Control Plan, the developer is responsible for those changes to the plans and the necessary changes in the field.

**2.02.1.05** The project's associated Traffic Impact Study (TIS) shall conform with current Traffic Impact Study Guidelines latest edition. The consultant may obtain a copy of the guidelines from the City's website or Traffic division to make sure their submittal is complete.

**2.02.1.06** Small Cell and/or Fiber projects have (or will have) Standard Operating Procedures, in addition to this Manual, that outline the requirements for those projects. Use the most current version of the Standard Operating Procedures, if available. The applicant/consultant may obtain a copy of these procedures from the City's website or by contacting the Real Property Division.

**2.02.1.07** Submittal packets are available for other real property instruments, including Easements Dedication/Release, License Agreements, and Revocable Licenses. The applicant may obtain a copy of the packets from the City's website or from the Real Property Services Division to make sure their submittal is complete.

***Per City Code, certain encroachments (including overhangs, balconies, staircases, walls, etc.) may not be permitted in easements or right of way.***

## **2.02.2 Submittals**

**2.02.2.01** Aurora uses an electronic submittal process for the review of civil plans. The applicant will begin the submittal process by providing documents to the City for a Pre-Submittal Review Date and Time. The applicant will need to provide City staff with their contact information, including a valid email address, in order to be able to access the online submittal system; pre-application meeting notes, if available; site plan; and plat. This pre-submittal review is not a formal

review. It is only to check to see if the critical items required, as noted on the pre-submittal checklist, are included and the plans are complete enough for a formal review submittal.

**2.02.2.02** After the Pre-Submittal Review and the applicant confirms they are ready to proceed with the online review process, the Engineering staff will create an online project folder. Once this project folder is created the applicant will receive an email with instructions on how to access the online system. Information provided to the applicant includes a link, user/login name, and a temporary password. The applicant will click the hyperlink in the email and log onto the online system. At this point the applicant may now upload their civil plans and associated documents, including the Pre-Submittal Review's marked up set. There is also an online help guide to assist the applicant with the online submittal process. Once the plans are uploaded and accepted by Civil Plan Submittal an invoice will be emailed to the applicant. The deadline for payment is provided on the invoice. The applicant may choose to pay this invoice online or in person at the Cashier's Office. **DO NOT MAIL INVOICE PAYMENTS TO THE CITY. This will only delay your review and/or approval.** The fee structure associated with the civil plans review may be found on the City's website in the [Development Handbook](#).

**2.02.2.03** See Section 5.00 PAVEMENT DESIGN for pavement design requirements and for limits of paving required for arterial roadways. For concrete paving on City streets a jointing plan must be submitted. See Section 2.05 for the report format requirements. The pavement design report shall be electronically uploaded similarly to the civil plan submittal process, except the consultant shall contact the Civil Plan Submittal at 303-739-7335 to have a project folder created. No pre-submittal meeting is required.

**2.02.2.04** See "[Rules and Regulations Regarding Stormwater \(Quality\) Discharges Associated with Construction Activities](#)" for erosion and sediment control plans and reports and storm water quality plans submittal requirements. An Inspection and Maintenance Plan (I & M Plan) is required for all permanent water quality facilities. The information required for the I & M Plan may be found in the [City of Aurora Storm Drainage Design & Construction Criteria](#) manual and is located on the City's website. The I & M Plan shall be electronically loaded up with the civil plans and reports.

**2.02.2.05** Developers are cautioned that information submitted to the Building Division or other departments is not automatically forwarded to the Engineering Services

Division. Separate submittals are required for civil construction plans and building plans.

**2.02.3 Review Priority** As each civil plan set is submitted it is placed into the City’s queue of civil plans to be reviewed. In a sense it is a “first come, first served” process with the time of review schedule added to the process. Package submittals include plans as defined in Section 2.02.1 MINIMUM REQUIREMENTS FOR APPROVAL. Piecemeal submittals are those missing one or more of the items listed in Section 2.02.1 MINIMUM REQUIREMENTS FOR APPROVAL. Additional engineering information beyond those items described herein may be required, as needed, and is generally identified at the Pre-submittal Meeting.

**2.02.4 Review Time** The civil construction submittal (plans & reports) shall be reviewed in accordance with a schedule established when the plans are submitted. This schedule is based on the number of civil plan sheets in the submittal package. A typical project receives three reviews: the first review being the longest, the second not as long and the third review the shortest. Typically the third review should be for approval. The City is committed to meeting the review schedule established for a project, thereby, a development project is relatively assured of a known time frame for approval. Please note the schedule assumes a time frame for the consultant to respond to comments. It is the responsibility of the developer to confirm with their consultant for their time required to respond to the City’s comments. See the [Development Handbook](#) distributed by the Office of Development Assistance for the model review schedule. If the consultant does not respond to all review comments or made significant changes to the plans & reports by the time the third review is submitted, it is possible the submittal will not be approved. If this happens beyond three reviews, there will be subsequent reviews fees charged for the additional review of the project.

**2.02.5 Returned Plans and Reports** When City staff have completed their review an email will be sent to the applicant advising them their civil plans submittal is ready for revision. The electronic portal will then be open for the consultant to download the City’s review comments. This portal will remain open until the consultant uploads the subsequent submittal for review/approval.

### **2.02.6 Resubmittals**

**2.02.6.01** Once the consultant has downloaded the review comments from the electronic portal and after making all the revisions requested the applicant must upload their documents in the same manner as the initial submittal. If the applicant added comments/responses to the first review set, this set of plans must be

uploaded as well so the plan reviewers may see those comments. Plans with unaddressed comments, or significant plan changes, may be subject to additional review fees if the plans cannot be approved with the third submittal.

**2.02.6.02** When an email is sent after the second submittal review to the applicant, the email will indicate to make the necessary revisions and, then, upload the signature set for approval. This will require the applicant to upload two sets of civil plans and associated documents. The first set is the digitally signed and sealed by the professional engineer of record for the project and is “locked” by professional engineer. This pdf file shall be secured by the professional engineer of record in a manner approved by the State Board of Licensure for Architects, Professional Engineers, and Professional land Surveyors. This first set must also have any owner’s signatures, as required. These signatures do not need to be electronic. The second set does not require the owner’s signatures. The second set will be a facsimile of the professional engineer’s signed and sealed plans and reports set. Every plan sheet and the cover sheet, or signature page, of every report of the facsimile set shall have the following note added and be signed by the engineer of record.

**“This electronic plan (*or, report*) is a facsimile of the signed and sealed pdf plan (*or, report*).**

\_\_\_\_\_  
**(Original Signature)**

\_\_\_\_\_  
**(Date)”**

Once the plans and reports are approved, they will become the property of the City and remain on file in the office of the City Engineer. These approved plans cannot be modified without written permission of the Engineer of Record (see Section 3.04). Once the plans are approved the applicant will be notified by email the plans are approved and can be accessed online per the hyperlink contained within the email for 30 days.

**2.02.6.03 Approvals** The length of time for approvals typically ranges from five to ten working days depending on the number of sheets in the plan set. Extremely large plan sets are likely to take much longer than ten working days. **Right-of-ways, easement dedications and/or vacations and dedications by separate document, and license agreements must be executed prior to the Civil Plan approval. Subdivision plat must be executed prior to civil plan approval.** Adhere to the City’s Subdivision Plat checklist .

**2.02.6.04 Time Between Submittals** The City’s overall schedule for plan approval is set up for the consultant to turn the plans around in one business week. However, if the consultant decides to take more time to address the review comments, that is their prerogative. The consultant and the developer need to be aware this will affect the time to approve the civil plans. A word of caution: should the time between submittals exceed a year this will be cause for stopping the review process and requiring the review process to start over, including new review fees.

**2.02.7 Review Status** The current status of plans and reports in the review process may be obtained by calling the Civil Plan Submittal, 303-739-7335. Please limit calls to those **absolutely necessary**, however, as excessive phone calls only serve to lengthen the time required reviewing plans. Another way to check plans status is to go to “<http://aurora4biz.org/ProjectStatus/>” and look up the project electronically.

**2.02.8 Updating Expired, Approved Civil Plans** Once a set of civil plans are approved, they are valid for one year from the date they are approved (this includes all documents associated with the civil plans, Drainage Report, Drainage Letter, Stormwater Management Plan and Structural Design Calculations). If no permits or main extension agreements are executed within that one year, the civil plans approval will expire.

It is possible to extend the approval of a set of civil plans for one year at a time, on a case by case basis, and requires written approval from City Engineer. Updating plans may be done up to four times. This will extend the approval status of the civil plans for five years. This matches the five-year vesting for site plans and contextual site plans. However, in no case will the updating of plans exceed the five-year vesting timeline for the site plans or contextual site plans. This updating process must be done yearly before the plans expire. Please note that even if within the 5-year extension window, the approval to extend the expiration of a civil plan set and associated documents may not be granted, at the discretion of the City Engineer and in coordination with other City departments.

To do this, the engineer of record must write a letter to the Public Works, Engineering Supervisor(s) for Development Review requesting the plans be updated. (An Authorization to Revise Plan form shall be included in the case of a different engineer.) The letter shall include the Professional Engineer stamp and the six-digit Engineering Drawing Number (EDN). Once this letter is received a review folder is created and routed to all departments that previously approved the plans against the current set of criteria to see if the plans meet current criteria. The plans may be

approved for one more year. The revision or alterations to the plans must be reviewed separately, via a revision folder, prior to approving the updated plans.

## **2.03 Civil Construction Plan Requirements**

**2.03.1** All civil construction plans and drainage reports shall be prepared by, or under the direct supervision of, a Professional Engineer, licensed in the State of Colorado, and shall be reviewed for the minimum requirements set forth herein and in the City Code. The submitter should be aware that whenever unusual or serious problems are anticipated in conjunction with a proposed development, additional information and analysis beyond the minimum requirements of these specifications will be required.

**2.03.2** The City is not responsible for the accuracy or adequacy of the design, dimensions and elevations on the plans (which shall be confirmed and correlated at the job site). The City, through the approval of the development plan or drainage report, assumes no responsibility for the completeness and/or accuracy of the development plan or drainage report.

**2.03.3 Cover Sheet** A cover sheet shall be included with all plans and reports, unless the information indicated below can be placed on one sheet.

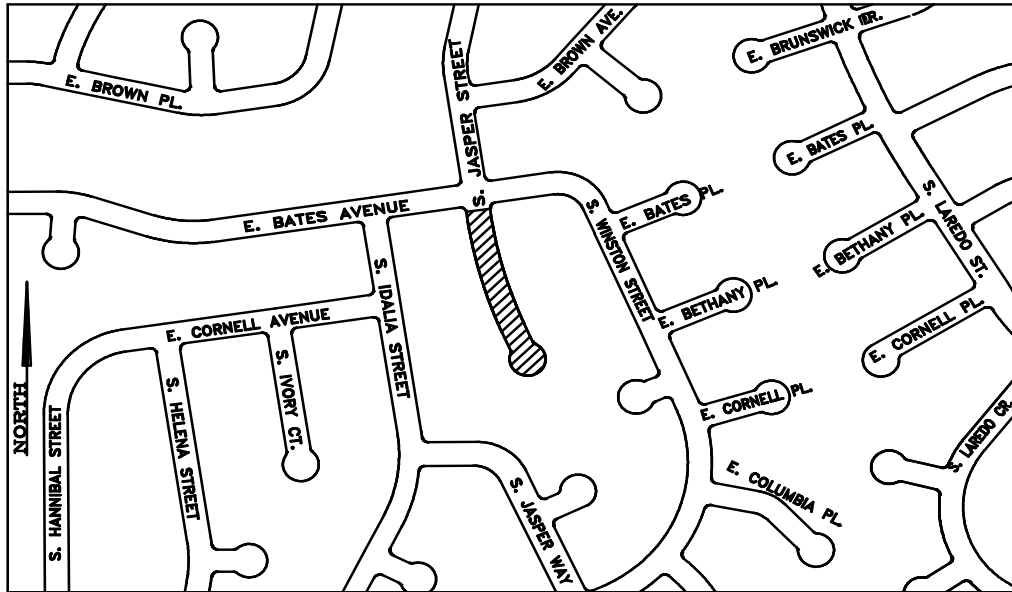
**2.03.4.01 Vicinity Map** Minimum scale is 1" = 2000' showing the location and name of all arterial roadways within one mile of the proposed development and all other roadways in the vicinity of the proposed development. The project area shall be indicated by shading. This map is required on the cover sheet or first sheet of all submittals. The map is also required in all drainage reports.

**2.03.4.02 Key Map** Minimum scale is 1" = 500' showing the location and name of all roadways within and adjacent to the proposed development and all non-existing future roadways. This map should be oriented with the north arrow pointing to the top of the drawing. Large projects may use a minimum scale of 1" = 1,000', at the discretion of the engineering reviewer.

This map shall appear in the upper right-hand corner on every sheet showing proposed roadway, water distribution, sanitary sewer, storm drainage, or grading improvements, with the roadway or area to which the design pertains shaded as shown on the following example. If the proposed improvements are shown on a single plan sheet, no key map is required.



Figure 2.03.4.1



EXAMPLE KEY MAP

**2.03.5 Civil Construction Plans and Detail Sheets** All civil construction plans and detail sheets shall conform to the following criteria and show the following information. Additional specific requirements are discussed later in these specifications.

**2.03.5.01 Title Block** A title block is required on every report, plan sheet and cover sheet submitted. The subdivision name and filing number; site plan name and its City file number (if applicable); the type of improvement; name of Developer/Owner, name of contact, address (including zip code), telephone number of the Development/Owner contact, the name of the Consultant; name of contact, address (including zip code) and telephone number of contact; and sheet number (consecutive, beginning with the cover sheet) shall be included in the title block. If the plans or reports do not relate to a specific subdivision, the name of the street or channel, as well as the limits of the project, shall be clearly indicated. The title block shall be located in the extreme lower right-hand corner of each sheet. See Section 2.05 for title information needed on **Pavement Design Reports**.

### 2.03.5.02 Approval Block

**2.03.5.02.1** An approval block is required on the cover sheet of the civil construction plans, the first page of every drainage report, the first page of every pavement design report, the first page of every inspection and maintenance plan document submitted for review and approval. See Table 2.03.5.1 for the required signatures in the approval block relative to the type of plan sheets included in the civil construction plans. The height of the approval block shall be adjusted according to the number of signatures required.

**Table 2.03.5.1  
Required Signatures**

<b>TYPE PLAN</b>	<b>SIGNATURES REQUIRED</b>
Water distribution and water system report	City Engineer Aurora Water – Utilities Department Fire Department
Sanitary sewer system and Sanitary sewer report	City Engineer Aurora Water – Utilities Department
Storm drainage system and drainage report Master Drainage Report Final Drainage Report	City Engineer Aurora Water – Utilities Division Aurora Water – Drainage Division
Preliminary Drainage Plan And Preliminary Drainage Report	City Engineer Aurora Water – Drainage Division
Roadway and grading	City Engineer
Roadway modifying existing or new raised median construction within the public R.O.W.	City Engineer
Access proposed onto the public R.O.W. without an approved site plan	City Engineer
Erosion and sediment control plan and report	City Engineer Aurora Water – Drainage Division
Traffic construction control	City Engineer or Designee
Signing and striping plans	City Engineer or Designee
Pavement design report	City Engineer
All plans on a case-by-case basis	Parks, Recreation and Open Space
Traffic Signal Plans	Traffic Manager or Designee
Street Light Plans	City Engineer

	<b>Approved For One Year From This Date</b>	
0.7"		
3.5" (6 SIGNATURES)	<b>City Engineer</b>	<b>Date</b>
3.0" (5 SIGNATURES)	<b>Parks, Recreation and Open Space</b>	<b>Date</b>
2.5" (4 SIGNATURES)	<b>Aurora Water - Utilities Division</b>	<b>Date</b>
2.0" (3 SIGNATURES)	<b>Aurora Water - Drainage Division</b>	<b>Date</b>
1.5" (2 SIGNATURES)	<b>Fire Department</b>	<b>Date</b>
	<b>Traffic Manager</b>	<b>Date</b>
	4.5"	

## **APPROVAL BLOCK**

**Figure 2.03.5.02.1**

**2.03.5.02.3** The approval block shall be located in the lower right-hand corner of the plan sheet just above the title block only. THE APPROVAL BLOCK SHALL INCLUDE ONLY THOSE SIGNATURES NEEDED FOR THE TYPE OF PLAN SHEETS SUBMITTED. An example approval block is provided above.

**2.03.5.03 Scale** The minimum scales are listed below. Larger scales may be required where necessary to clearly show details. Use a standard engineering scale. All plan drawings shall have the proper bar scale legibly shown on the plan sheet.

**2.03.5.03.1** All plan and profile plans

Horizontal 1" = 50'

Vertical 1" = 5'

**2.03.5.03.2** Master drainage plans may use scales as small as 1" = 200', 1" = 100' or larger is preferred.

**2.03.5.03.3** Preliminary and final drainage plans; utility plans:

Single family detached 1"=50'

Multifamily 1"=30'

Commercial and Industrial:

Building footprint less than 500,000 ft<sup>2</sup> 1"=30'

Building footprint greater than 500,000 ft<sup>2</sup> 1"=50'

**2.03.5.03.4** Master and preliminary drainage plans may use scales as small as 1" = 500' for off-site drainage basins.

**2.03.5.03.5** If multiple sheets are used for the drainage study then one drawing must be a part of the plans to show the whole project. This allows relating the individual sheets to the entire project.

**2.03.5.04 North Arrow** North shall point towards either the top or the right-hand margin of the sheet only.

**2.03.5.05 Date of Plan** The original date of the plan and any subsequent revision.

**2.03.5.06 Seal and Signature** The seal and signature of the Professional Engineer, licensed in the state of Colorado, under whose supervision the plans were prepared is required. Locate and date the seal and signature generally in the lower right-hand corner of the drawing, or within the drawing's title block. See Section 2.02.6.02 for additional information regarding electronic signatures for electronic submittals.

**2.03.5.07 Benchmark**

**2.03.5.07.1** The benchmark number, description and elevation shall be placed on each sheet showing any form of vertical design, including elevations based on City datum. Go to this link [Benchmarks](#) for the available information on the City's website.

Example: Benchmark No. \_\_\_ chiseled square, "□", at back of walk, southeast corner of Montview Blvd. and Galena St. Elevation 5338.19. Looped to C.O.A. Benchmark. #F-11, chiseled square, "□", concrete based of signal light actuator pole, southeast corner of Montview Blvd. and Havana St. City of Aurora Datum = 5334.03.  
NAVD 1988

**2.03.5.07.2 Projects shall be prepared using the NAVD 1988 vertical datum and the NAD 83 / 92 HARN horizontal control system (see Section 2.11).**

**2.03.5.08 Underground Utilities** The type, size, location, and the number of all underground utilities shall be shown. Field verified elevations and locations are required on all development plans for existing underground utilities which will potentially affect the proposed design or construction. It will be the responsibility of the Contractor to verify the existence and location of all existing underground utilities along his route of work prior to commencing any construction.

**2.03.5.09 Private Improvements**

**2.03.5.09.1** Private improvements, such as roadways, sidewalks, driveways, utilities, etc., shall be clearly shown and labeled as such on each sheet of the development plans. See required notes in Section 2.03.6.

**2.03.5.09.2** When a request is made for the City to assume maintenance of any private improvement, it shall be the responsibility of the person(s) making the request to prove the private improvement was in fact constructed in accordance with the current Roadway Design and Construction Specifications. The City will review these requests under normal review procedures. Private improvements built according to City specifications and standards may be accepted at the City's discretion. Private improvements not constructed in accordance with the applicable Design and Construction Standards and Specifications will not be accepted for maintenance by the City.

**2.03.5.10 Copyright Notes** Copyright notes nor notes restricting reproduction shall **not** be placed on the signature sets or any reports submitted for approval. The City must be able to make copies of the approved plans and reports at any time without written authorization from the plan's or report's author.

**2.03.6 Required Notes** These notes shall appear on the cover sheet. If a cover sheet has not been used, they shall be put on sheet 2, if space is not available.

- 2.03.6.01** City of Aurora plan review is only for general conformance with City of Aurora design criteria and the City Code. The City is not responsible for the accuracy and adequacy of the design, dimensions, and elevations which shall be confirmed and correlated at the job site. The City of Aurora, through the approval of this document, assumes no responsibility for the completeness and/or accuracy of this document.
- 2.03.6.02** All roadway construction shall conform to City of Aurora "*Roadway Design & Construction Specifications*," latest edition.
- 2.03.6.03** All water distribution, sanitary sewer, and storm drainage construction shall conform to City of Aurora "*Standards and Specifications Regarding Water, Sanitary Sewer and Storm Drainage Infrastructure*," latest revision
- 2.03.6.04** All materials and workmanship shall be subject to inspection by the City. The City reserves the right to accept or reject any materials and workmanship that does not conform to the City standards and specifications.
- 2.03.6.05** The Contractor shall notify the City Public Improvement Inspections Division, 303-739-7420, 24 hours prior to the beginning of construction.
- 2.03.6.06** Location of existing utilities shall be verified by the Contractor prior to actual construction. For information, contact Utility Notification Center of Colorado, 1-800-922-1987 or 811.
- 2.03.6.07** The Contractor shall have one signed copy of the plans (approved by the City of Aurora), one copy of the appropriate standards and specifications at the job site at all times, and a copy of any permits and extension agreements needed at the job site at all times.
- 2.03.6.08** It is the Consultant's responsibility to accurately show existing conditions, both on-site, and off-site, on the construction plans. Any modifications needed due to conflicts, omissions, or changed conditions either on-site or off-site, which arise in the field, will be entirely the Developer's responsibility. The cost to rectify any adverse situation to meet the City standards and specifications and the City Code shall be borne solely by the Developer.
- 2.03.6.09** The owner/developer must obtain the written permission of the adjacent property owner(s) prior to any off-site grading or construction.
- 2.03.6.10** Concrete shall not be placed until the forms have been inspected by Public Improvements Inspections.

- 2.03.6.11** Paving of public streets shall not start until a soil report and pavement design is approved by the City Engineer, proof rolling, and subgrade and trench compaction tests taken by the developer's Geotech are approved by Public Improvements Inspections/Materials Lab.
- 2.03.6.12** Standard City of Aurora curb ramps shall be constructed at all curb returns, at all "T" intersections and at all curbside kiosks or clusters, unless otherwise modified by these plans.
- 2.03.6.13** All stationing is based on centerline of roadways unless otherwise noted.
- 2.03.6.14** All elevations are \_\_\_\_\_ (indicate top of curb or flow line) unless otherwise noted.
- 2.03.6.15** The City of Aurora shall not be liable for the maintenance of \_\_\_\_\_. (Insert name of specific private improvement(s), or 'Any Private Improvements' if unknown.) These facilities may not meet City standards and shall remain in private maintenance by \_\_\_\_\_ (*insert name of entity to be responsible for the maintenance*) in perpetuity. These private facilities include, if provided, the private underdrain system placed within the public right-of-way.
- 2.03.6.16** The contractor/developer is responsible for contacting CDOT to ensure all work on or adjacent to state highways or CDOT R.O.W. meets CDOT requirements.
- 2.03.6.17** The public streetlight or pedestrian light installation within the public right-of-way shall be designed, funded, and constructed by the developer/owner. Ownership and maintenance of the public street/pedestrian lights shall be the responsibility of the City of Aurora once they have been accepted. Streetlight and/or pedestrian photometrics plans shall be prepared and submitted to the City for review and approval and shall become a part of the approved civil construction plans for the project. An electrical plan showing site location of lights, electrical one line and grounding details shall be submitting to the Permit Center for review by the Building Department. The owner is responsible for obtaining an address for the meter(s) from the Planning Department. A Building Permit for the meter and a Public Inspections Permit for the street lights are required. It is the developer's/owner's responsibility to contact Xcel Energy to initiate and obtain electrical service for any new development/redevelopment during the plan review process.

- 2.03.6.18** The Owner/Contractor must obtain a C.D.P.S. storm water discharge permit from the Colorado Department of Public Health and Environment, if required.
- 2.03.6.19** The Owner/Contractor is responsible for coordinating with the Army Corp of Engineers for wetland mitigation or work within the Waters of the U.S., if required. It is the responsibility of the Owner/Contractor to provide a copy of the Army Corp of Engineer's requirements to the City of Aurora. If there are no requirements by the Army Corp of Engineers, then a written notification from the Army Corp of Engineers shall be submitted to the City of Aurora stating such. City approval of the construction plans is subject to the Owner/Contractor obtaining a 404 permit, if applicable. A copy of this permit shall be submitted to the City of Aurora prior to any permits being issued.
- 2.03.6.20** All signage and striping shall be in accordance with the Manual on Uniform Traffic Control Devices, unless otherwise noted by the City of Aurora.
- 2.03.6.21** Private underdrain systems for groundwater discharges from foundation drains shall be owned and maintained by the HOA/Metro District (*select one*).
- 2.03.6.22** Project shall comply with Utility Engineering Investigation and Documenting requirements per CRS 9-1.5-101 et seq., as amended, when the project includes excavation. By stamping the plan the engineer of record is certifying the plan meets the standards established by the American Society of Civil Engineers' ASCE 38 Standard, latest publication, for defining the accuracy of a facility or utility. Project shall comply with Aurora Water Standards and Specifications, latest edition, when the project includes excavation, including but not limited to installation of electronically traceable markers or being traceable by approved electronic methods for all subsurface utilities
- 2.03.6.23** In locations where utility easements overlap drainage easements, only subsurface utilities shall be permitted within the portion of the utility easement that overlaps the drainage easement. Installation of above ground utilities within a drainage easement requires prior written approval by the Aurora Water Engineering Services Manager, or designee.
- 2.03.6.24** Proposed project phasing shall be included in the civil plans. The phasing plan shall include a descriptive narrative for each phase along with plan view.



**2.03.6.25** Critical Traffic Control Areas, as identified by the Traffic Manager during Civil Plan review, are circumstances that develop resulting from temporary modifications to the roadway network. Critical Traffic Control Areas can include, but are not limited to:

- lane closures resulting in reduction in vehicles capacity greater than 50%,
- proximity to intersections, access drives, rail lines,
- locations with higher multimodal movements, or
- other special circumstances

When identified, the contractor shall submit Traffic Control Plans (TCPs) to the City through the Public Improvement Permit Application process for the City's review as soon as possible or a minimum of four weeks in advance of construction. In addition, as part of the Public Improvement Permit and TCP, the contractor may be required to provide advance notice (minimum two weeks) to nearby impacted users. Notifications by the contractor may be required to neighboring residences, businesses, or impacted operations of emergency response entities (law enforcement, fire, and medical), transit, delivery companies, etc., as determined by the Traffic Manager at time of the TCP review

**2.03.6.26** The civil plans for the associated infrastructure (roadway as shown in the Infrastructure Site Plans) must be approved prior to issuance of adjacent building permits. Construction shown on civil plans for the associated infrastructure must be initially accepted by the City prior to issuance of Temporary Certificate of Occupancy/Certificate of Occupancy (TCO/CO) per the Public Improvement Plan (PIP).

**2.03.6.27** Ensure that the provisions of CRS 37-92-602, as amended by Senate Bill 15-212, regarding notification of downstream water rights holders are upheld.

**2.03.7 Engineering Drawing Number** Where applicable label adjacent subdivision names and their City of Aurora six digit Engineering Drawing Number (EDN). EDN and other existing project information can be found on the Aurora Property Info map on the city's website.

**2.03.8 Details** The plans shall include adequate details of special structures not covered by City of Aurora Standard Details. Do **not** include City Standard Details in the plans, but reference them by detail number, only.

**2.03.9 Variances** The civil plans shall include a variance table(s) within the first three sheets of the civil plans. The table format shall include: a heading 'Variances to the City of Aurora Roadway Design and Construction Specifications Manual' and/or

'Variances to the Aurora Water – Water, Sanitary Sewer & Storm Drainage Infrastructure Standards & Specifications', year of adopted code, reference section, brief reason, and requested variance, and shall include variances to standards details. Requested variances must be included in the first submittal of the civil plan set, and updated for each subsequent review. Variances that are not included may delay review and approval of the project. Final approval of the variance is with Civil Plan approval. If there are no variances the table shall be provided with the note no variances. Variance to the Storm Drainage Manual shall be included in the Drainage Report.

**2.03.10 Phasing Plan** Projects that are proposed to be phased must include a Phasing Plan. A plan sheet shall be provided showing the proposed phasing. In addition to the plan, a narrative shall be provided on the plan sheet addressing; all private (including tracts) and public improvements, life safety requirements including two points of access and looped water supply where required, and items required to be completed prior to first Certificate of Occupancy for each phase.

## **2.04 Storm Drainage Plans and Reports**

In accordance with the requirements set forth in Chapter 2.00, the City of Aurora "[\*Storm Drainage Design and Technical Criteria\*](#)" manual, and "[\*Standards and Specifications Regarding Water, Sanitary Sewer and Storm Drainage Infrastructure\*](#)," latest editions, the following information shall be shown on all storm drainage plans or included in all drainage reports submitted for approval.

**2.04.1 Master Drainage Study** A Master Drainage Study Plan and Report is required prior to approval of any planned community zoned district or master plan in excess of 80 acres or any phased commercial/industrial development in excess of 10 acres. The study shall be coordinated with all applicable drainage master plans and prepared according to the City of Aurora "Storm Drainage Design and Technical Criteria" manual. Master Drainage Study shall be approved prior to submittal of Preliminary Drainage Report and Plans.

**2.04.2 Preliminary Drainage Plan and Report/Letter** A Preliminary Drainage Plan and Report/Letter must be approved prior to approval of any subdivision plat or site plan. The Preliminary Drainage Plan and Report/Letter must be approved by the City Engineer and the Water Department prior to Planning Commission action. The Preliminary Drainage Plan and Report/Letter shall be prepared according to the City of Aurora "Storm Drainage Design and Technical Criteria" manual, latest edition. Preliminary Drainage Plan and Report/Letter shall be approved prior to submittal of civil plans and reports submittal.

**2.04.3 Final Drainage Plan and Report/Letter** The Final Drainage Plan and Report/Letter shall be a detailed study and analysis of the proposed development. It shall include detailed calculations for all runoff, as well as for all drainage structures, of facilities within the proposed development. The Final Drainage Plan and Report must be approved by the City Engineer and the Water Department prior to the issuance of any building permits within the proposed development. The Final Drainage Plan and Report/Letter must be submitted for review and approval with the construction plans for the entire development and will be reviewed concurrently with said construction plans. The digital report shall be sized to an 8-1/2" x 11" format. Plans and calculations comprising the Final Drainage Plan and Report/Letter shall be prepared in accordance with the City of Aurora "Storm Drainage Design and Technical Criteria" manual.

**2.04.4 Title of Storm Drainage Plan and Report** All drawings and reports shall include in the title the subdivision name, subdivision filing number, and the lot and block number where applicable.

**2.04.5 Channel Plans and Profiles** Where streams or channels are MHFD maintenance eligible the following note shall be added to the general notes. "The MHFD shall be contacted for a channel pre-construction meeting and to establish routine inspection for required elements of the channel, i.e., toe protection, grade control structures, etc."

## **2.05 Pavement Design Report Format**

**2.05.1 General** The report shall be submitted in a digital format in an 8 1/2" x 11" or 11"x17" format. At a minimum the report shall contain the following information and in the order enumerated: a title page with the City approval block; a vicinity map; the geotechnical investigation portion of the report (see Section 5.04); the pavement design portion of the report (see Section 5.05). See the submittal checklist after Figure 2.05.2.07.1.

**2.05.2 Title Page with City Approval Block** The title page shall be on the very first page of the report. A sample of the title page is included in Figure 2.05.2.07.1. The following information shall be shown on the title page:

**2.05.2.01** Title of the report: Geotechnical and Pavement Design Report.

**2.05.2.02** Subdivision Name and Filing Number. Also, include the Lot and Block numbers if the report does not apply to the entire filing. If the report does not relate to a specific subdivision, the name of the proposed development shall be listed or the street and the limits of construction.

- 2.05.2.03** City of Aurora Engineering Drawing Number of approved civil plans, if available.
- 2.05.2.04** Name of Consultant, full address (including zip code), telephone number, fax number of the Consultant, name of contact person, and email address of the contact person.
- 2.05.2.05** Name of the owner, full address (including zip code), telephone number, fax number, name of contact person, and email address of the contact person.
- 2.05.2.06** A 2 inch to 2 ½ inch blank space for the City reviewing engineer’s comments.
- 2.05.2.07** A City approval block, in the dimensions shown on the Sample Title Page.

*See next page for “Sample Title Page”*

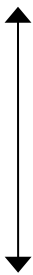
(NOTE: leave 1 1/2" – 2" space from top of page to report title)

**SAMPLE OF TITLE PAGE AND APPROVAL BLOCK**

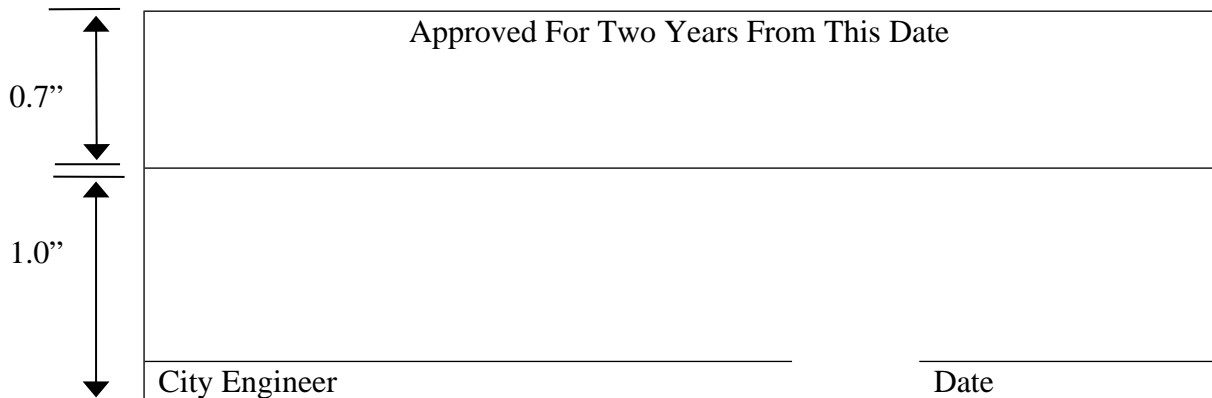
Geotechnical and Pavement Design Report  
Subdivision Name, Filing No. \_\_\_\_\_, Lot \_\_\_\_\_, Block \_\_\_\_\_  
Aurora Engineering Drawing Number (EDN): \_\_\_\_\_

Prepared By:  
Firm/Consultant's Name  
Full Address, Including Zip Code  
Phone: \_\_\_\_\_ Fax: \_\_\_\_\_  
Contact Name: \_\_\_\_\_

Prepared For:  
Owner's Name  
Full Address, Including Zip Code  
Phone: \_\_\_\_\_ Fax: \_\_\_\_\_  
Contact Name: \_\_\_\_\_



2" – 2 1/2" (Leave space for Reviewing Engineer's comments)



**Figure 2.05.2.07.1**

## **SUBMITTAL CHECKLIST for PAVEMENT GEOTECHNICAL DOCUMENTS**

**Geotechnical and Pavement Design Reports submitted with incomplete information on the title page shall not be accepted. If civil plans are approved, review time for all Geotech submittals is 10 working days.**

### **GEOTECHNICAL AND PAVEMENT DESIGN REPORT [1 copy]**

- The report (with digital and facsimile signature) must be submitted ONLINE. Please contact the Engineer on Duty at 303-739-7335 to request creation of a PA folder to upload your documents.
- The report shall have the stamp and original signature of, and be dated by a Colorado licensed Professional Engineer [Geotech].
- The report shall be pdf formatted at 8 ½" x 11" [please no PDF/A formatting].
- Title of the report: Geotechnical and Pavement Design Report
- Subtitle of the report: Subdivision Name and Filing Number (include the Lot and Block numbers if the report does not apply to the entire filing.)
- COA Engineering Drawing Number [EDN] If civil plans are approved.
- Name of Applicant, full address (including zip code), telephone number and fax number, name of contact person. [Applicant is the designated contact for all purposes.]
- Name of Geotech, full address (including zip code), telephone number and fax number, name of contact person.
- Name of the Owner, full address (including zip code), telephone number and fax number, name of contact person.
- A 2" to 2 ½" blank space for the City reviewing engineer's comments.
- A City approval block, in the dimensions shown on the Sample Title Page.

### **REQUEST FOR ALTERNATE PAVEMENT THICKNESS [Requires accompanying Geotechnical Report]**

- The request must be submitted ONLINE. Please contact the Engineer on Duty at 303-739-7335 to request creation of a PA folder to upload you documents.
- This letter is required to be signed by the owner of the property and it does not need to be a digital signature.
- Show the name of the subdivision, filing number, lot, and block, as well as street address (if applicable).
- Name of Applicant, full address (including zip code), telephone number, fax number, email address, and name of contact person. [Applicant is the designated contact for all purposes.]
- Name of the Owner, full address (including zip code), telephone number, fax number, name of contact person, and email address.

**2.05.3 Vicinity Map** The vicinity map shall follow the title page. Minimum scale is 1" = 2000' showing the location and name of all arterial roadways within one mile of the proposed development and all other roadways in the vicinity of the proposed development. The project area shall be indicated by shading.

**2.05.4 Seal and Signature** The geotechnical and pavement design report shall be sealed, signed, and dated by a Geotech licensed as a Professional Engineer in the State of Colorado in accordance with Section 2.03.5.06.

The seal, signature and date shall be affixed on the title or signature page of the "locked" report. The facsimile note shall also be affixed on the title or signature page of the "unlocked" report.

## **2.06 Roadway Plans**

In addition to the requirements set forth in Section 2.03 CIVIL CONSTRUCTION PLAN REQUIREMENTS, the following information shall be shown on all plans submitted for review and approval of roadways, fire lanes, private streets or drives, and parking lots. See Sections 4.05.4, 4.05.8, 4.05.9, 4.10.6.01 for additional information regarding intersections.

For residential developments only, private street designs shall be completed to the same degree of detail as the design of public local streets. A private street is a privately owned street, roadway, or way providing through access to and from the public street system or providing access to an area of parking spaces. The street width, sidewalks, tree lawn, and other features shall be the same for private streets as the requirements for the equivalent public street. Parking lot driveways or internal circulation driveways with perpendicular parking for multifamily, commercial, or industrial sites shall not be required to conform to standards for public streets, except all signage related to traffic shall be in conformance with the current [Manual on Uniform Traffic Control Devices](#) (MUTCD). The private streets shall be owned and maintained by either the homeowners/business association or the metropolitan district set up for the development.

**2.06.1 Plan** The plan view shall include, but not be limited to, the following.

**2.06.1.01** Show property and/or R.O.W. lines, easements and/or tracts. Type and dimension of easement or tract shall be clearly labeled. R.O.W. and street widths shall be dimensioned. Label lot and blocks. Show sidewalks.

**2.06.1.02** Survey lines and stations shall be based on centerline stationing only. Use continuous stationing for each street progressing from left to right and shall be coordinated with the profile. Stationing shall be equated to and from flow line stationing at bubbles, horizontal radius curves, and other departures from normal roadway cross sections, i.e., the pavement cross slope is not 2%, and at

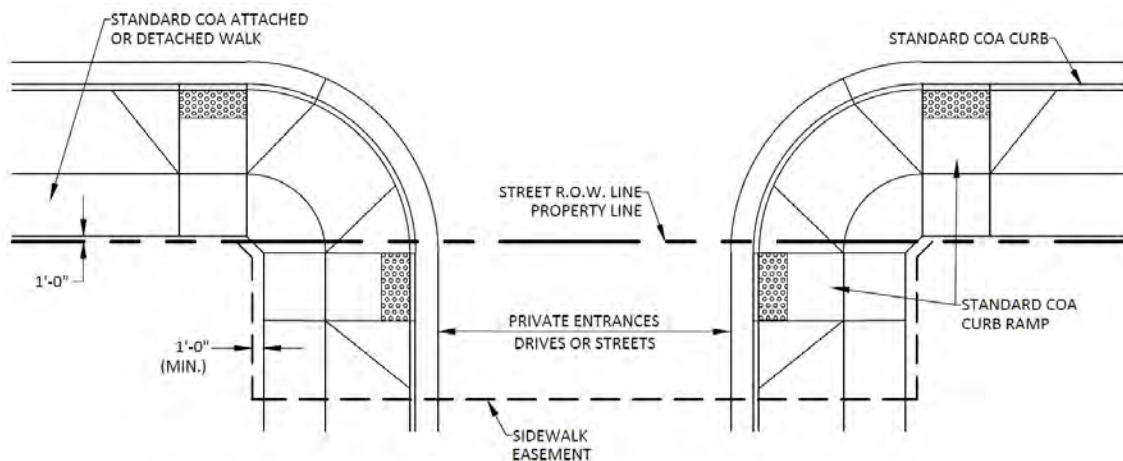
least 200' from all intersections. Stationing shall be equated to flow line stationing at cul-de-sacs. Also, if the roadway is horizontally curved, whenever the grade is less than 1%, separate flow line profiles are required as the basis for design.

**2.06.1.03** Show roadways and roadway names. Label the roadway classification.

**2.06.1.04** Show existing and proposed utilities and structures, including, but not limited to: water valves, fire hydrants, sanitary sewer manholes, storm drainage facilities (i.e., inlets, manholes, etc.), telephone, gas, electric, ditches or swales, curbs and gutters, pavement limits, bridges or culverts, guardrails, existing and proposed street lights, small cell tower, utility cabinets, etc. Plans shall provide a dimension from edge of travel lane to obstruction showing compliance with clear zone.

**2.06.1.05** Where curb returns are installed at private access streets or drives sidewalk easements shall be dedicated as shown in Figure 2.06.1.05.1. In situations where this type of access is anticipated to warrant a traffic signal in the future an additional traffic signal easement shall be included for the placement of the traffic signal poles and associated equipment. Coordinate with the Traffic Manager for this easement. If the plat has already been recorded these easements shall be done by separate document before the civil plans are approved.

**Figure 2.06.1.05.1  
Sidewalk Easement Geometry at Private Drives or Streets**



THE FOLLOWING NOTE SHALL BE ADDED TO ALL PLATS WHERE SIDEWALK EASEMENTS ARE REQUIRED:

NON-EXCLUSIVE SIDEWALK EASEMENTS ARE HEREBY GRANTED TO THE CITY OF AURORA FOR THE PURPOSE OF MAINTAINING, RECONSTRUCTING, CONTROLLING AND USING SUCH SIDEWALKS TOGETHER WITH THE RIGHT OF INGRESS AND EGRESS. PROVIDED THAT THE CITY SHALL NOT INTERFERE WITH ANY OTHER STRUCTURES OR IMPROVEMENTS.



- 2.06.1.06** Station and critical elevation (flow line, invert of pipe, etc.) of all utility or drainage appurtenances, existing and proposed. This includes the roadway edge drain. See Standard Detail S1.19 for more information.
- 2.06.1.07** Flow direction arrows, particularly at intersections
- 2.06.1.08** Match lines and associated sheet numbers.
- 2.06.1.09** Station and elevation of all curb return PCR's; horizontal P.C.s P.T.s, P.C.C.s, etc.; high or low point of all vertical curves, existing and proposed
- 2.06.1.10** Curb returns radii, existing and proposed
- 2.06.1.11** Mid-block curb ramp locations at "T" intersections including centerline stationing and flow line elevation at the center of the ramp
- 2.06.1.12** Complete horizontal curve data: (R,  $\Delta$ , L, PC Sta.)
- 2.06.1.13** Centerline stations of all non-single family residential driveways and all intersecting roadways
- 2.06.1.14** Survey line ties to section corners or quarter corners, if not already accomplished on the plat or the survey control plan.
- 2.06.1.15** Show typical roadway cross-section for all roadways, existing and/or proposed, within and adjacent to the proposed development. These cross sections shall appear on the cover sheet, or on the first sheet of the submittal showing the roadway design. They shall indicate type of roadway(s); profile grade design point (centerline, flow line, top of curb, lip of gutter, etc.); roadway width, street name, R.O.W.; type of curb, roadway edge drain, gutter, fire hydrant location, and walk; pavement cross slope, etc. The typical section shall identify the ADT and corresponding clear zone.
- 2.06.1.16** Basis of plan view and profile elevations shall be the same, i.e., flow line and flow line, top of curb and top of curb, etc.
- 2.06.1.17** Show all permanent asphalt patching a minimum of 24 inches wide.
- 2.06.1.18** Where the widening of an existing street occurs, provide existing spot elevations along the edge of the existing pavement, at the centerline of the existing roadway/crown line and the existing lip of pan or flow line of the existing curb and gutter at a maximum of 50-foot stations. This allows for the checking of proposed pavement cross-slopes.

- 2.06.1.19** Show existing and proposed range boxes. Proposed locations are determined by the plat. Add note on the plans the contractor is responsible for installing the proposed range boxes.
- 2.06.1.20** For concrete paving on City Streets a jointing plan must be submitted. Where an existing intersection is partially constructed with concrete pavement and when the adjacent property next to the unconstructed portion of the intersection develops, the remaining portion of the intersection shall be completed with concrete in accordance with Section 5.00 of this manual.
- 2.06.1.21** Show irrigation control sleeving locations for medians where required.
- 2.06.1.22** Show any proposed construction phasing. It must be coordinated with any main extension agreements associated with the utilities as well as any planning documents.
- 2.06.1.23** Where Motor Courts and/or Loop Lanes are used show the AASHTO “P” turning movements (vehicle tracking templates) are in conformance with Section 4.04.2.08.3 and Section 4.04.2.09.4, respectively.
- 2.06.1.24** For any intersection with double turn lanes or non-standard geometry, a detail of the intersection with the appropriate design vehicle tracking templates shall be shown on the plans.
- 2.06.1.25** Where arterial roads are superelevated, roadway edge drains shall be shown behind the median curb and gutter in conjunction with the edge drains along the outside curb and gutter. See Standard Detail S1.19 for additional information.
- 2.06.1.26** Sight triangles, as outlined in 4.04.2.10, shall be shown
- 2.06.2 Profile** The profile shall include, but not be limited to, the following.
- 2.06.2.01** Show original ground (dashed) and each design grade (heavy, solid). Both grades shall be plainly labeled.
- 2.06.2.02** For 6" vertical curb and gutter, or mountable curb and gutter, all design elevations shall be top of curb, lip of gutter, or flow line (preferred). For combination curb, gutter, and walk, all design elevations shall be back of walk, or lip of gutter, or flow line (preferred). The basis for as-built information shall be the same as the design (both flow line or both top of curb, etc.) when possible.

- 2.06.2.03** Stationing shall be set up to go from left to right and be continuous for the entire portion of the roadway shown in the plan view, with the centerline station of all non-single family residential driveways and all intersecting roadways clearly labeled.
- 2.06.2.04** Show all existing curbs, gutters, sidewalks, and asphalt grades at center line and edge of asphalt adjacent to the proposed design. Basis for existing grades shall be as-built elevations or survey data at the intervals not to exceed 50' for a minimum of 100'. Previously approved designs are not an acceptable means of establishing existing grades.
- 2.06.2.05** Existing utilities. See Section 2.03.5.08, UNDERGROUND UTILITIES.
- 2.06.2.06** Station and elevation of all P.C.R.s, horizontal P.C.s, P.T.s, P.C.C.s, etc., existing and proposed (optional).
- 2.06.2.07** Station and elevation of all vertical grade breaks, existing (as-built) and proposed. The use of grade breaks with proposed construction is discouraged. Where street widening occurs with curb and gutter, multiple grade breaks to match the existing profile is not acceptable. Utilize asphalt overlays to best fit a curb line profile and to provide a smooth transition back to the existing pavement.
- 2.06.2.08** Distance and slope (percentage) between grade breaks and VPI's.
- 2.06.2.09** Show vertical curves, when necessary, with VPI, VPC, and VPT, high or low point (if applicable) stations and elevations. All vertical curves shall be labeled with length of curve in feet (L) and  $K (= L/A)$  where A = algebraic difference in grades in percent. See Tables 4.05.1.1 and 4.05.1.2. All vertical curves shall be symmetrical.
- 2.06.2.10** Curb return profiles may be required at certain curb returns. If curb return profiles are required, the Consultant will be informed at the time of the initial review and instructions furnished.
- 2.06.2.11** Separate flow line (or top of curb) profiles are required as the basis for design at "bubbles," cul-de-sacs, horizontal curves when the vertical grade is less than 1%, any departure from normal roadway cross sections, i.e., the pavement cross slope is not 2%, and for at least 200' from all intersections.
- 2.06.2.12** Show construction phasing. This phasing of construction must be coordinated with the main extension agreements executed through the Water Department.

**2.06.2.13** Water or sanitary sewer line profiles shall **not** be placed on street plan and profile sheets.

**2.06.3** Roundabout plans shall include the following:

**2.06.3.01** Layout details at a 1" = 20' for the roundabout including the splitter islands, crosswalks, and bicycle ramps, if provided. Flowline profiles shall be provided:

**2.06.3.01.01** Along the curb and gutter flow line of the truck apron curb.

**2.06.3.01.02** Along the curb and gutter flow line for the splitter islands and along the inscribed circle, or roundabout circumference.

**2.06.3.01.03** Along the curb and gutter flow lines for both sides of right turn by-pass lanes.

**2.06.3.02** Profiles of alignments identified above shall be used for construction layout.

**2.06.3.03** Layout details for any crosswalks and bicycle ramps, if utilized<sup>1</sup>.

**2.06.3.04** Elevation at low points, high points, island noses, and 25-foot intervals within the circulatory roadway<sup>1</sup>.

**2.06.3.05** Half-sections at 25-foot intervals along the splitter islands when the roadway begins to separate. The half-sections may be "restitched" for the final cross-section sheets, if provided.

**2.06.3.06** Curb cuts shown on roadway plans for access to the future development of the adjacent parcels and will remain closed until construction of the site is initiated with approved civil and site plans for the development of the parcels. It will be the developer's sole responsibility and at their sole cost to remove and reconstruct the curb cuts (including crossspan, gutter, sidewalk, landscaping, curb ramps, etc.) if it is determined during the site plan and civil process that the curb cuts must be modified or in different locations. The curb cut including but not limited to the handicap ramps, radii, and cross pan will remain the developer's responsibility to maintain until the adjacent planning area is developed. The developer acknowledges the risk of constructing the curb cut without approved site or civils plans for the adjacent site.

## **2.07 Water Distribution, Sanitary Sewer, and Storm Sewer Plans**

In addition to the requirements set forth in Section 2.03, CIVIL CONSTRUCTION PLAN REQUIREMENTS, the following information shall be shown on all Water Distribution, Sanitary Sewer and Storm Sewer plans submitted for review and approval.

**2.07.1 Overall Utility Plan** An overall utility plan of the proposed development, including all off-site construction areas shall be submitted for review and approval, and shall include, but not be limited to, the following.

**2.07.1.01** Show property and/or R.O.W. lines, easements and/or tracts. Type and dimension of easement or tract shall be clearly labeled existing and proposed for both on-site and off-site. Property lines and R.O.W. lines shall be dimensioned. Label lots, blocks and tracts.

**2.07.1.02** Label roadway widths and roadway names.

**2.07.1.03** Show and label existing water distribution facilities including, but not limited to, size and location, valves, fire hydrants, blow offs, pressure zones, etc.

**2.07.1.04** Show and label existing sanitary sewer facilities including, but not limited to, size, slope, location, hydraulic capacity, and all pertinent information regarding which trunk lines will ultimately receive the wastewater collected by the proposed system.

**2.07.1.05** Show and label existing storm sewer facilities including, but not limited to, size, slope, pipe type, location, and inlet size, and whether public or private.

**2.07.1.06** Proposed construction including manholes (with a rim elevation), valve boxes, fire hydrants (with a bottom of bottom flange elevation that is 2" – 6" above final finished grade), water meters (with rim elevation on the meter pit), mains, service lines (including line lengths and sizes), inlets and appurtenances shall be shown and clearly labeled.

**2.07.1.07** Proposed outfall point(s) for wastewater from the development.

**2.07.1.08** Fixture unit table and meter sizing table in accordance with the "*Standards and Specifications Regarding Water, Sanitary Sewer and Storm Drainage Infrastructure*", latest edition.

**2.07.1.09** For commercial, industrial, or multi-family projects show dimensioned striping for all handicap-parking stalls.

**2.07.1.10** Show any proposed phasing of utilities. This phasing of construction must be coordinated with the main extension agreements executed through the Water Department and the street plan and profiles.

**2.07.2 Plan and Profile** A Plan and Profile is required on water mains larger than 12" in diameter, all public and private storm sewer and sanitary sewer mains. The Plan view shall include, but not be limited to, the following.

**2.07.2.01** Show property and/or R.O.W. lines, easements and/or tracts. Type and dimension of easement or tract shall be clearly labeled. Property lines and R.O.W. lines shall be dimensioned. Label lot, blocks and tracts.

**2.07.2.02** Label roadways and roadway names.

**2.07.2.03** Existing utilities and structures including, but not limited to: water valves, fire hydrants, sanitary sewer manholes, storm drainage facilities, telephone, gas, electric, ditches or swales, curbs and gutters, cross pans, pavement limits, bridges or culverts, guardrails, etc.

**2.07.2.04** All water mains, storm sewer, sanitary sewer laterals, mains, or trunk lines shall be tied to the centerline of the City R.O.W., to the centerline of a City easement, to government land corners, or to government landlines.

**2.07.2.05** Show flow direction arrows at sanitary and storm sewer manholes.

**2.07.2.06** Show match lines and sheet numbers.

**2.07.2.07** Label existing and proposed utilities as public or private, as the case may be.

**2.07.2.08** Show existing contours (dashed) at an interval of two feet or less, proposed contours (solid) at an interval of two feet or less. Contours to be labeled on the Storm Sewer plan view.

**2.07.2.09** Private (metropolitan district or HOA owned and maintained) storm drain surface facilities (inlets, flared end sections, manholes, channels, swales) exceeding Section 2.08.2.03 are not permitted on private residential lots and shall be located within a tract. Private storm drain subsurface utilities on residential lots are permitted provided there is a private easement.

**2.07.3 Profile** The profile shall include, but not be limited to, the following.

- 2.07.3.01** Show original ground (dashed) at each design grade (heavy, solid). Both grades shall be plainly labeled, existing and proposed.
- 2.07.3.02** All design elevations shall be invert of pipe. Top of pipe is acceptable for existing utilities.
- 2.07.3.03** Stationing shall be continuous for the entire length of the utility. Street centerline stationing and offsets of roadway shall be the basis for stationing whenever possible.
- 2.07.3.04** Existing and proposed utilities, particularly where crossed, with as-built or proposed elevations and stations and clearance between utilities (See Section 2.03.5.08, UNDERGROUND UTILITIES.)
- 2.07.3.05** Station and elevation of grade breaks, existing (as-built) and proposed.
- 2.07.3.06** Distance and grade or slope between grade breaks
- 2.07.3.07** Show size, type, and structural class of pipe, including ASTM or AWWA specifications on all proposed utility construction.
- 2.07.3.08** Indicate bedding classification to be used.
- 2.07.3.09** Show storm sewer design flows for each pipe segment. For storm sewers designed for 100-year flow, show and label the 100-year HGL. For storm sewers designed for the minor storm event, show and label the minor storm HGL. This applies for both private and public storm sewer systems.

**2.07.4 Details** The plans shall include adequate details of miscellaneous structures. Structural calculations shall be provided for the special structures. Refer to Section 4.02.7 for structural design, calculation, and submittal requirements.

## **2.08 Grading Plans**

In addition to the requirements set forth in **Section 2.03, CIVIL CONSTRUCTION PLAN REQUIREMENTS**, the following information shall be shown on all grading plans submitted for review and approval. The grading plan is the key document for construction of surface improvements. The grading plan must be consistent with any approved site plan and landscape plan. Grading plans are required for all types of development.

### **2.08.1 Final Grading Plan (for Commercial, Industrial, and Multifamily Sites)**

The plan shall include, but not be limited to, the following.

- 2.08.1.01** Show and identify; property and/or R.O.W. lines, easements and/or tracts. Type and dimension of easements or tract shall be clearly labeled. Include Lot and Block numbers.
- 2.08.1.02** Show existing contours (dashed) at a contour interval of two feet or less, proposed contours (solid) at a contour interval of two feet or less. Contour elevations shall be labeled and proposed contours shall be tied into existing contours. Existing grades are normally expected to extend at least 50 feet beyond property line and beyond flow line of any street adjoining the site.
- 2.08.1.03** Show building footprints and finished floor or top of foundation elevation of all structures. Plans for residential construction shall show finish floor elevations and the basement/walkout/garden level finish floor elevation and type of foundation, i.e., walkout, garden level, crawl space, or full basement. If finish floor elevations are labeled, add a note to each grading plan sheet stating the approximate distance from finish floor to top of foundation.
- 2.08.1.04** Identify curb and gutter type (spill or catch). On private property, provide a detail of any curb and gutter that is not an Aurora Standard Detail.
- 2.08.1.05** Indicate spot elevations at all angle points on curb and gutter. Flow direction arrows may be used to prescribe grading details of paved or landscaped surfaces in lieu of additional spot elevations provided the plan clearly communicates the required grading without ambiguity.
- 2.08.1.06** Minimum 0.50% slope on all concrete surfaces, minimum 1% slope on all asphalt surfaces, minimum 2% slope on all grass-lined swales, landscape areas and all non-paved areas.
- 2.08.1.06.1** Fine grading around structures shall be constructed per good engineering standards and in accordance with the geotechnical report and the approved final drainage study.
- 2.08.1.06.2** The slope away from the building shall have a minimum grade of five (5) percent for the first ten feet or to the property line, whichever occurs first, then a minimum of two (2) percent until the slope reaches the swale around the building. If physical obstructions or lot lines prohibit the ten feet of horizontal distance, a five (5) percent slope shall be provided to an approved alternative method of diverting storm runoff away from the foundation. Swales used for this purpose shall be sloped a minimum of two (2) percent. In no condition shall the bottom of the swale at its highest point be less than



six inches below the grade at the foundation of any adjacent structure. Impervious surfaces within ten feet of the building foundation shall be sloped a minimum of two (2) percent away from the building.

**2.08.1.06.2.01** *Office, Industrial, and Retail Commercial Projects Exception:* The slopes away from the building shall be per the recommendation of the soils engineer and per good engineering judgment.

**2.08.1.06.3** The swale around a building shall have a minimum slope of two (2) percent (2.5 percent preferred), unless otherwise recommended by a licensed professional engineer in the State of Colorado and approved. Where the swale is intended to be constructed straddling the property line, both halves of the swale must be constructed at the time the first building is completed. Where one side of the swale is considerably steeper than the other, the velocity effect of the water drainage off the steep side shall be taken into account, so as to prevent the water carrying over the other side. Swales having sharp change in direction shall be constructed with adequate turn radius and depth to prevent overflow. Where there is a large difference in elevation between one rear lot and the lot immediately behind, it may be desirable to place a lot line at either the top or bottom of the swale. In this case, with prior approval of the city, the drainage swale running parallel to the bottom of the slope may be allowed on one lot. Obstructions of swales, such as fences, berms, and walls, shall not be allowed within the swale unless adequate provisions have been made to allow passage of drainage.

**2.08.1.06.3.01** In regard to townhouse, condominium, and apartment projects swales shall be piped (or sidewalk chases) under walks and through curb heads so as not to carry drainage collected in swales over the top of sidewalks and over the top of curbs. Sidewalks shall not be constructed in the bottom of the swale, unless otherwise specified in the approved final drainage study. Where sidewalks and swales parallel, the depth of flow in the swale for the design storm shall not exceed the top of the sidewalk.

**2.08.1.06.4** The finish grade from the top of foundation or the bottom of the exterior siding material, whichever is more restrictive, shall be in accordance with the International Residential Code and International Building Code, as adopted by City Code Sections 22-181 and 22-131, respectively, unless the siding manufacturer's recommendations are more restrictive. Where there is no guidance provide a minimum of six (6) inches from the bottom of the siding to the finish grade.

- 2.08.1.07** Show and label other surface drainage facilities and appurtenances, such as sidewalk chases, overflow weirs, rip rap placement, etc. The grading plan shall show all surface improvements visible at the surface or affecting drainage of the site.
- 2.08.1.08** Maximum slopes shall be 3:1 unless approved by Public Works and Planning Departments. The maximum landscaped grades within public right-of-ways shall be 4:1 unless otherwise approved by Public Works.
- 2.08.1.09** Show and label all retaining walls, top of wall and bottom of wall elevations. Where walls exceed 30-inches in height pedestrian hand rails shall be installed within pedestrian areas or areas where pedestrian access is possible. See Section 4.02.7.06 for more information.
- 2.08.1.10** An Elevation Certificate shall be required for any non-residential parcel hydraulically connected, touching or included in a floodplain in the predevelopment or post development condition, where a non-residential building site with a proposed lowest floor elevation (including basement, crawl space or enclosure floor) that is not shown on the plan as being greater than two feet higher than the base flood elevation. The current Elevation Certificate form established by FEMA shall be used. The Elevation Certificate shall be stamped and signed by an Engineer or Surveyor licensed in the State of Colorado. The Elevation Certificate shall be submitted to the Engineering Division for review and concurrence **prior to issuance of a Certificate of Occupancy**. The Elevation Certificate shall demonstrate the lowest floor elevation is greater than one-foot above the base flood elevation. The Grading Plan shall note by a prominent asterisk (or other appropriate method) each lot or building site for which an Elevation Certificate shall be provided. The following note shall be added to each sheet of the grading and drainage plans that indicate an Elevation Certificate is required:
- No Certificate of Occupancy shall be issued until an Elevation Certificate has been submitted to and approved by the Engineering Division. The Developer/Contractor is encouraged to verify the adequacy of lot grades and the elevation of concrete forms prior to pouring a foundation. It is recommended the Elevation Certificate be submitted at least a week in advance of a request for a Certificate of Occupancy.**
- 2.08.1.11** A building permit and a floodplain development permit shall not be issued for the construction of a new, non-residential structure or addition to an existing, non-residential structure on a property removed from the floodplain by the

issuance of a FEMA Letter of Map Revision Based on Fill (LOMR-F), unless such new structure or addition has the lowest floor (including basement or crawl space), electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities (including ductwork), are elevated to at least one foot above the BFE that is current or existed prior to the placement of fill, whichever is greater, or together with attendant utility and sanitary facilities be designed so the structure or addition is watertight to at least one foot above the BFE that is current or existed prior to the placement of fill, whichever is greater, with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

**2.08.2 Area Grading** In addition to the above requirements, the following information shall be shown on single-family detached area grading plans. An area grading plan is required for any plan proposing construction of one or more residential lots.

**2.08.2.01** Spot elevations at all lot corners and flow direction arrows with slope percentages showing side and rear-lot swales and off-site or cross-lot drainage shall be included. At a minimum, spot elevations shall be shown at rear yard high points, ridgelines, and other locations necessary to define the grading and runoff flow path.

**2.08.2.02** Existing and proposed spot elevations shall be shown at all lot corners.

**2.08.2.03** Two or more lots are not allowed to drain through adjacent/common swale. Refer to Section 4.03.6 for criteria.

**2.08.2.04** For single family only, a building footprint envelope consistent with zoning standards may be used where the actual footprint is not known.

**2.08.2.05** Lot grading designation (Type A, Type B, etc.), walkouts (W.O.), garden levels (G.L.), and transition lots (T) shall be shown on each lot.

**2.08.2.06** For any residential lot in or adjacent to a regulated flood plain, provide the base flood elevation (B.F.E.) appropriate for any proposed structure, lowest lot elevation shall be one foot above B.F.E., lowest floor including basement or crawl space shall be two feet above B.F.E., or any other grade requirement related to the flood plain regulations.

**2.08.2.07** Show finished floor elevation(s) including lowest finished floor for walkouts and garden levels. Add a note to each area grading plan sheet stating the approximate distance from finish floor to top of foundation. The top of

foundation must be a minimum of six inches higher than the high point in the swale.

- 2.08.2.08** Show all retaining walls. The party responsible for the inspection and maintenance of these walls must be noted on the plans. This information must also be provided on the site plan or contextual site plan. See Section 4.02.7 for additional structural submittal requirements.
- 2.08.2.09** Show all inlets and fire hydrants on the streets so driveways will not be placed on top of the inlets or fire hydrants.
- 2.08.2.10** Where developments have relatively steep street grades the area grading plans shall identify those lots with potential side yard retaining walls. The side yard retaining walls shall be a minimum of two-feet from the side lot line to the face of the retaining wall. Basement egress windows shall not conflict with retaining walls. For small lots egress windows may not be permitted adjacent to retaining walls if the minimum two-feet to the side yard line from the face of the wall is not provided. This will minimize the need to change area grading plans when plot plans are submitted for approval. Coordinate with the setback requirements as they may vary depending on the street grade.
- 2.08.2.11** Where developments have relatively steep backyard slopes the area grading plan shall identify those lots with potential rear yard retaining walls. The retaining walls shall not inhibit drainage runoff from the lot or from offsite lots. Where possible the retaining walls shall not be placed within the rear utility easements. This will minimize the need to change the area grading plans when plot plans are submitted for approval.
- 2.08.2.12** **An Elevation Certificate** shall be required for any residential lot or parcel hydraulically connected, touching, or included in a floodplain in the predevelopment or post development condition where a residential structure with a proposed lowest floor elevation (including basement, crawl space or enclosure floor) is not shown on the plan as being greater than four-feet higher than the base flood elevation. If the proposed residential structure is placed on an area of fill within the predevelopment condition's floodplain, an Elevation Certificate shall be required. The current Elevation Certificate form established by FEMA shall be used. The Elevation Certificate shall be completed by an Engineer or Surveyor licensed in the State of Colorado. The Elevation Certificate shall be submitted to the Engineering Division for review and concurrence **prior to issuance of a Certificate of Occupancy.** The Elevation Certificate shall demonstrate the lowest point on the lot or parcel is one-foot or

higher above the base flood elevation and the lowest floor is two-feet or higher than the base flood elevation. See Section 2.08.2.13 for additional requirements. The Area Grading Plan shall note by a prominent asterisk (or other appropriate method) each lot or residential building site for which an Elevation Certificate shall be provided.

The following note shall be added to each sheet of the plans that indicate an Elevation Certificate is required:

**No Certificate of Occupancy shall be issued until an Elevation Certificate has been submitted to and approved by the Engineering Division. The Developer/Contractor is encouraged to verify the adequacy of lot grades and the elevation of concrete forms prior to pouring a foundation. It is recommended the Elevation Certificate be submitted at least a week in advance of a request for a Certificate of Occupancy.**

**2.08.2.13** A building permit and a floodplain development permit shall not be issued for the construction of a new, residential structure or addition to an existing, residential structure on a property removed from the floodplain by the issuance of a FEMA Letter of Map Revision Based on Fill (LOMR-F), unless such new structure or addition has the lowest floor (including basement or crawl space), electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities (including ductwork), are elevated to at least two feet above the BFE that is current or existed prior to the placement of fill, whichever is greater. Where a new addition to an existing residential structure is proposed, the NFIP requirements for substantial completion still apply.

**2.08.3 Erosion Control/Overlot Grading** In most cases the erosion control plan may be combined with the overlot grading plan. However, they may be submitted separately. If an erosion control and overlot grading plan is submitted separately from the rest of the civil construction package in order to obtain a storm water quality permit, only the erosion control plan is approved. The final grading plan is approved when the final drainage study is approved. Refer to the *"Rules and Regulations Regarding Stormwater Discharges Associated with Construction Activities"*, latest edition, for storm water quality control plan, and erosion and sediment control plan requirements.

**2.08.4 Over Excavation** Where over excavation and backfill within building envelopes will be performed, the erosion control plans shall show the following:

**2.08.4.01** The extent of the over excavation.

**2.08.4.02** Temporary stockpile locations resulting from the over excavation.

**2.08.4.03** The following notes shall be added:

**2.08.4.03.01** The Contractor shall not leave any 1:1 slopes open for any extended period of time. Excavations shall be backfilled if construction is delayed more than three weeks.

**2.08.4.03.02** A Colorado licensed Professional Engineer must be onsite to observe the excavation, evaluate slope stability, and determine when shoring and/or side sloping of the excavation is required.

**2.08.4.03.03** Due to the depth of the over excavation, the excavated area must be surrounded with a six-foot high chain link fence. It must be securely closed during non-working hours to prevent unauthorized access.

## **2.09 Combining Plans**

The plans described above may be combined, at the discretion of the consulting engineer, provided they are clear and adequately communicate the required information. The Public Works Engineering Control Division plans review staff shall make the final determination for approval or disapproval for the clarity and adequacy. Combining water line and/or sanitary sewer line information with other plans will not be allowed (see Section 2.06.2.13).

## **2.10 Signing and Striping Plans**

**2.10.1** Signing and striping plans (interim and final, if necessary) shall be submitted for all streets, including those streets designed to accommodate striped bike lanes. See the Aurora [Bicycle and Pedestrian Master Plan](#), dated February 17, 2012. Signing and striping plans shall include, but not be limited to, all appropriate and applicable regulatory, warning, and guide signs and striping materials in accordance with the current [Manual on Uniform Traffic Control Devices](#) (MUTCD) and City standards and specifications. Said plans shall also include street name signs on ALL public and private streets as appropriate and applicable.

**2.10.2** For TOD and Urban Centers signing and striping plans shall be submitted showing the striping for the parking and other striping requirements such as the Fire Department's truck set-up areas, bike lanes, etc.

**2.10.2.01** Bike lanes shall extend through curb extensions at TOD and Urban Centers intersections up to the cross-walks, if provided, in accordance with MUTCD standards. The bike lane width shall be a minimum of five-feet, not including the gutter pan width.

**2.10.3** Roundabout signing shall include proper regulatory control, advance warning, and directional guidance for the roadway users. The signs shall be located so the information needed are easily seen and in advance of the condition. Signs shall not be located where there will be conflict with vehicle turning movements and the swept path of vehicles. Since the signing and striping for a roundabout can get complicated a larger scale drawing for the roundabout signing and striping may be required. It may be necessary to have two separate drawings to avoid clutter and overlapping information between signs and striping. See Section 4.09.6 for additional information.

## **2.11 Survey Control Drawing**

**2.11.1** For all work within public right-of-way a survey control drawing shall be included in the civil plan submittal and shall contain the following:

**2.11.1.01** Title block in the center top of page with: “Survey Control Drawing”, Project Name, Project Location, (Section, Township, Range, Principal Meridian, City, County, and State) and entity performing the work.

**2.11.1.02** North arrow and scale with bar scale.

**2.11.1.03** Legend.

**2.11.1.04** Basis of Bearing.

**2.11.1.05** Project control must be tied to a minimum of two points in the City of Aurora GIS Horizontal Control with Colorado State Plane Coordinate (Grid), Central Zone, NAD 83/92. All Section and Quarter Section corners (the Public Land Survey System) are part of the city of Aurora GIS Horizontal Control Network.

**2.11.1.06** All coordinates and distances are to be in US Survey Feet. The conversion factor is: one meter equals 3937/1200 feet.

**2.11.1.07** If State Plane Coordinates are used and converted to Project Coordinates (Ground) include the Grid Factor (sea level factor combined with scale factor). Show the Grid Factor to nine decimal places. If Project Coordinates (Ground) were truncated, note what number was subtracted from the north and east coordinates. Project coordinates are to be shown to four decimal places.

**2.11.1.08** Include a table titled “Project Control Coordinates” listing the City of Aurora State Plane Coordinates (Grid) compared to the Project coordinates (Ground) on the same section and/or quarter section corners. In the table include all control points used for the project and found or set property pins noting the

point numbers, the coordinates (four decimal places), elevations (two decimal places), and description sufficiently detailed to allow others to locate and identify the monuments. Clearly identify the COA State Plane Coordinates (Grid) are NAD 83/92 and whether the Project Coordinates are modified to Ground, were truncated, or are assumed.

**2.11.1.09** Use City of Aurora Bench Marks from the City of Aurora Vertical Control based on NAVD 88. Elevations shall be shown to two decimal places. Include a note listing the Bench Mark name, a complete description, and elevation (three decimal places for the COA Bench Mark), and clearly identify NAVD 88 is the basis for all elevations.

**2.11.1.10** Any Public Land Survey System corner that was occupied and has been remonumented must be noted and a Colorado State Monument Record must be filed with the state, per Colorado Revised Statutes, “38-53-104, Filing of monument record required”.

**2.11.1.11** Existing right-of-way shall be shown with adjoining subdivision names. Proposed right-of-way shall be shown for informational purposes.

**2.11.1.12** The Survey Control Drawing shall be signed and sealed by the Professional Land Surveyor, licensed in the State of Colorado, under whose supervision the drawing was prepared. Signature and date shall be written over the PLS seal.

**2.11.1.13** All project control shall be shown on the construction plans to show the relationship of the project control to the construction site.

**2.11.1.14** If applicable include notes similar to the following:

**2.11.1.14.01** This survey is not a complete boundary and is prepared as a Survey Control Drawing only.

**2.11.1.14.02** Notice: According to Colorado law you must commence any legal action based upon any defect in this survey within three years after you first discover such defect. In no event may any action based upon any defect in this survey be commenced more than ten years from the date of the certification shown.

**2.11.1.14.03** A surveyor’s statement that the Survey Control Drawing shown on these sheets was performed under the supervision of a Professional Land Surveyor licensed in the State of Colorado and was in responsible charge.



**2.11.2** See the City’s [website](#) for a list of requirements.

**2.11.3** Any questions concerning the Survey Control Drawing please call the City of Aurora Chief Surveyor, 303-326-8015.

## **2.12 Street Lighting Plan**

In addition to the requirements set forth in Section 2.03, CIVIL CONSTRUCTION PLAN REQUIREMENTS, a Street Lighting Plan is required, and the following information shall be shown on all Street Lighting Plans submitted for review and approval for all public streets.

### **2.12.0 Lighting on Site Plan**

Conceptual lighting locations for public right of way shall be shown on site plan during the planning phase.

**2.12.0.1** The following criteria and note for each proposed roadway or portion of a roadway with differing criteria within a plat/development shall be identified, reviewed, and approved by the Public Works Department as part of the Planning Review Process (site plan) prior to performing lighting design and submitting the street lighting plan.

- Roadway Classification (typical section name)
- Adjacent Land Use Category (i.e., TOD), as applicable
- Number of lanes
- Back-to-back curb width
- Pedestrian Activity Level
- Pavement Type: R3, for all lighting calculations

\*Note: Site Plan criteria may be subject to change during the design process, and if the Site Plan and Civil Plan criteria are different, the civil plan shall be the final street lighting design criteria.

### **2.12.1 Final Street Lighting Plan**

During the Civil Plan submittal process, the street light plan shall include the minimum amount of information required in Sections 2.12.1.01 through 2.12.1.08 and shall be drawn at a scale of 1 inch equals 60 feet (min).

For infill or minor redevelopment projects, or City street lighting projects, the street lighting information may be placed on a plan prepared using the city’s ortho-rectified imagery as base mapping and adjusted from grid to ground using the conversion

factors established in COA Horizontal Control map, unless street widening is required for the infill or redevelopment project. Then, ortho rectified imagery cannot be used.

If the development or redevelopment is bordering or across the street from another development (that has not been initiated), is an interim condition, or is a half section of roadway, the final lighting plan shall include an ultimate build condition as well as an interim construction condition. Calculations shall be included for the ultimate build condition. Clear designation of the lighting to be constructed in the interim condition shall be shown on plans.

If there is an interim condition adjacent to the development or redevelopment or completion of a half section of roadway, the final lighting design and plan shall incorporate the lighting from the adjacent development approved civil plan (include reference to EDN, if available), including the original proposed lighting or as-built condition lighting, into the design.

The plan shall include the following:

- 2.12.1.01** Show property and/or R.O.W. lines, easements and/or tracts, and lot lines. All streets shall be labeled. Type and dimension of easements or tract shall be clearly labeled. Include Lot and Block numbers and adjoining subdivision names.
- 2.12.1.02** Show building footprints/envelopes for all non-residential structures, if known. If unknown, show set back lines.
- 2.12.1.03** Identify topography (include curb, gutter and sidewalks, fences, landscaping, private driveways, underground and overhead utilities, fire hydrants, and inlet locations). If ortho rectified imagery is utilized, all topography shall be highlighted by line work on the plan. Underground utilities shall be field located and surveyed to establish accurate alignment of proposed conduit.
- 2.12.1.04** Show any existing street lights and label as existing. Include luminaire light source type, style and finish color of poles and luminaires. Indicate the mounting height of the luminaire and reach length of the pole arm, if applicable.
- 2.12.1.05** Show any proposed trees or landscaping installations in the R.O.W. that may have future impacts to street light placement.
- 2.12.1.06** Show location of proposed meters/control centers. Such meters/control centers shall be dimensioned from street centerline and/or nearest lot line or ROW

corner, label with size, height, required offsets from curb or sidewalk, and indicate required height above ground or finished grade.

**2.12.1.07** Location of electric utility (Xcel Energy) power source.

**2.12.1.08** Proposed electrical infrastructure required to provide electrical feed to the street lights.

**2.12.1.08.1** Conduit: dimension from street centerline. Label conduit with diameter of conduit and the number, size and type of wire contained. Empty conduits shall have pull wires installed.

**2.12.1.08.2** Pull Boxes: show location in relation to the pole. Include size and type of pull box in electrical Legend on cover sheet.

**2.12.1.08.3** Meters/control centers: Provide electrical service size, voltage, anticipated electrical load, wiring diagram, and materials of construction.

**2.12.1.08.4** Notes indicating limits of electrical work under authority of COA Building department review and permitting.

**2.12.1.09** Lighting plans shall include a Luminaire Schedule. This schedule will include, at a minimum, the following information for all proposed lighting on the project:

- Type
- Description
- Initial Absolute Lumens output
- Manufacturer and model number
- Voltage and wattage
- Finish and/or color
- Luminaire Mounting Height

**2.12.1.10** Lighting plans shall include a Legend which gives the symbol and description of the various components of the lighting and electrical system.

**2.12.1.11** Show all street light luminaire and pole locations on the plan with a symbol and type identifier which matches the Luminaire Schedule. Provide longitudinal and setback location dimensions for each pole. Roadway alignment stationing is the preferred method for longitudinal position.

For private parking lots and drives the private lighting shall be shown on the grading or utility plans and be in conformance with the site plan or contextual site plan.

**2.12.1.12** Provide street light foundation details or reference to an approved standard.

**2.12.1.13** Show a Calculation Summary table which includes the following criteria, at a minimum, for each proposed roadway or portion of a roadway with differing criteria.

Roadway Classification (typical section name)

Adjacent Land Use Category (i.e. TOD), as applicable

Number of lanes

Back-to-back curb width

Pedestrian Activity Level

Pavement Type: R3, for all lighting calculations

Target lighting values

Calculated lighting values

**2.12.1.14** The Street lighting plans shall bear the seal and signature of a Professional Electrical Engineer licensed in the State of Colorado.

## **2.13 Street Lighting Plan Private**

**2.13.1** Private street lights shall be shown and identified on the private roadway civil plans. Private street lights shall be identified as private and the civil plans shall include a note stating ownership and maintenance responsibilities.

**2.13.2** A photometric plan shall be submitted with the civil plans for private street lights. Private street lights shall meet the location and average luminance requirements as outlined in Section 4.10. Electrical plans for private street lights shall not be submitted with the civil plans for review. Electrical plans for private streetlights shall be included in the Master Electrical Plan submitted to the Building Department for review.

**2.13.3** The following note shall be added to the private street roadway plans and the photometric plan:

**Private street lights will remain privately owned and maintained in perpetuity.**

**2.13.4** Private Street lights and Private infrastructure is NOT permitted to connect to a public streetlight infrastructure nor public meter.

**SECTION 3.00 PLAN AND DRAFTING STANDARDS .....1**

- 3.00 Acceptance of Submittals.....1
- 3.01 Media requirements.....1
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## SECTION 3.00 PLAN AND DRAFTING STANDARDS

### 3.00 Acceptance of Submittals

All submittals shall be in electronic format. Paper or hard copies will not be accepted. See Section 2.02.2 for additional information regarding the submittal process.

The City of Aurora requires that all plans submitted for city approval must adhere to new CAD Data Submittal Standards. Guidance can be found on the [CAD Data Submittal Standards](#) web page.

### 3.01 Media requirements

Scanned Professional Seals and signatures applied to the plans shall be legible. Plans with illegible Professional Seals or signatures may be rejected.

### 3.02 Drafting Standards

The following shall apply to all plans submitted for approval.

#### 3.02.1 Text

- Minimum lettering size shall be 0.08” high (can only be used to annotate existing features on the plans). Otherwise, minimum text height shall be .10”.
- Where text is less than 0.10 inch high, text shall be all capitals.
- All text shall be black. Professional signatures may be other dark colors provided they are legible after scanning.
- Recommended fonts are “Arial”, “Times New Roman”, “Calibri”, “Simplex”, or “Leroy”, and may include italicized or bold text.
- Pen weights shall not exceed the pen weights recommended for the text heights in the chart below:

Text Height (in.)	Pen Weight (in.)
.08	.008
.10	.010
.12	.010
.14	.014
.175	.018
.20	.024

### **3.02.2 Line work**

- Minimum line thickness shall be 0.006 inch.
- All line work shall be black.

### **3.02.3 Color and Shading**

- Color may be used but must contrast against the background of the plans.
- Solid hatches shall be shaded between 20% and 40%.
- Hatches shall not obscure text or line work.

### **3.02.4 Photography Used In Plans**

Photography added to the plans shall be transparent so the image does not substantially degrade when printed. Such images shall not obscure any line work or text added to them.

### **3.02.5 Plan Sheet Size**

- The size of the plans shall be either ARCH D (24 inches X 36 inches) or ANSI D (22 inches by 34 inches).
- Each sheet shall have a two-inch margin on the left edge and a one-half-inch (minimum) margin on all other sides.

## **3.03 Plan Set Indexing**

Engineering's policy for indexing plans is to index them by subdivision name and filing number. The subdivision name and filing number shall be clearly shown in the Title Block on each page of the plans.

It is the intent of the Engineering Division to provide the same Engineering Drawing number for all civil construction plans associated with a development. Frequently the set of full construction plans is broken into several sets for review and approval. Ultimately, the plans will be approved and filed together for records purposes. Each submittal shall include a cover sheet with a sheet index on it. The full construction plans shall also have a sheet index on a cover sheet that includes all sheets in the set, regardless of whether or not they were submitted together or in smaller sets.

All sheets in the plan set shall be numbered consecutively from the cover sheet (sheet 1) to the last sheet (usually the final drainage plans). If the consultant prefers a sheet designation different



than the numerical system the City requires, those numbers may also be shown in a separate column of the index.

### **3.04 Revisions**

Before any revisions to approved plans are allowed, a stamped and signed 'Authorization to Revise Approved Plans' form describing the edits must be submitted to Civil Plan Submittal - Technical Services. If the original Engineer of Record is not capable of approving the revision, then an alternative method for revising may be allowed per City Engineer. All revision sheets need to be stamped and signed by a licensed professional engineer.

The Engineering Division requires sheet replacement as the means of revising a sheet of electronically submitted approved plans with an electronic copy of the signed and sealed Authorization to Revise Approved Plans form. At such time the City requires replacement, the fee for plan revisions shall apply for the replacement. A sheet with the Engineer of Record's seal and signature, locked by the Engineer of Record, shall be submitted for each sheet revised in the approved set. Also, a facsimile sheet of each signed and sealed revised sheet shall be submitted.

Only revised sheets are required to be submitted via the revisions folder.

<b>Section 4.00</b>	<b>Roadway Design and Technical Criteria</b>	<b>1</b>
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## SECTION 4.00 ROADWAY DESIGN AND TECHNICAL CRITERIA

### 4.01 General

This section sets forth the minimum design and technical criteria and specifications to be used in the preparation of all roadway plans, including private streets, drives, parking lots, and fire lanes.

### 4.02 Sidewalks, Curb and Gutter, Driveways, Railings, and Retaining Walls

**4.02.1 Typical Roadway Sections** Typical roadway sections are summarized in Section 4.08 and shown in standard details S1.1, et seq. All public roadways shall be constructed according to typical roadway sections S1.1 to S1.19, unless specifically modified by action of the City Engineer.

**4.02.2 Curb and Gutter** Mountable curb and gutter shall be used on all local Type 1 and 2 streets. All other streets, including those within the Urban Centers and TODs, shall use 6" vertical curb and gutter.

**4.02.3 Curb Ramps** Americans with Disabilities Act requires curb ramps be installed at all pedestrian crosswalks for all new construction or reconstruction of curb and sidewalk. Curb ramps shall be shown at all curb returns, "T" intersections, at mid-block pedestrian crossing within Urban Centers or TOD's and any other location of public necessity. Curb ramps shall be provided within an acceptable distance of residential mail kiosks or clustered mailboxes, as approved by the City Engineer. Curb ramps must be shown (located) on the drawings. Curb ramp types shall be called out on the drawings by the specific standard detail S9.1, et seq. Mid-block curb ramps in residential subdivisions shall not be located at the lot property lines where property swales drain to the back of walk. Residential driveway placement shall not interfere with the location of the proposed ramps at mid-block. Uncontrolled mid-block pedestrian crossings within Urban Centers or TOD's shall not be used on multiple lane roadways. At "T" intersections the curb ramp located at the top of the "T" shall be located across from one of the two other ramp locations, typically to the right side of the top of the "T".

**4.02.4 Curb Cuts for Driveways** Flared curb cuts, Standard Detail S7.4, are not permitted for commercial/industrial or residential driveways where traffic movements would be substantial. When the number of parking spaces exceeds 20, curb returns are required. Inlets and cross pans are required as noted in Section 4.03,

DRAINAGE. See Section 6.53, Storm Drainage Design & Technical Criteria manual for exceptions when storm sewer is available.

**4.02.5 Guardrails** The design, location, and necessity of guardrails or impact attenuation for bridge and roadside obstruction situations, as well as design of the same, shall be in accordance with AASHTO's, "[\*Roadside Design Guide\*](#)," latest edition.

**4.02.6 Reserved.**

**4.02.7 Structural Calculations and Design (Retaining Walls, Bridges, Misc. Structures)**

**4.02.7.01 Permit Requirements** Permits are required for all retaining walls, bridges, and miscellaneous structures and shall be obtained from the City's permit center prior to commencing construction.

**4.02.7.02 Structural Calculations Report** Structural calculation reports for bridges, retaining walls, and miscellaneous structures, including associated foundations, shall be submitted with the first civil plan submittal to the Public Works Engineering Division. The design calculations and details shall be in accordance with the appropriate code requirements (outlined in sections 4.02.7.03, 4.02.8, and 4.02.9) and shall be signed, sealed, and dated by a licensed engineer in the State of Colorado. Signature set submittals shall include a locked/PE stamped and unlocked/facsimile stamp report (refer to Section 2.02.6.02). Structural reports shall be titled with the Subdivision name and Structure Identification number (if the structure will become a City asset), and shall also include the project geotechnical foundation report in an appendix.

**4.02.7.03 Retaining Walls** Retaining walls shall be required whenever slopes exceed 3 feet of run to 1 foot in rise (3:1). Refer to Section 1807.2 of the International Building Code, as adopted in City Code Section 22-131, for additional design criteria. Slopes to be revegetated and to be maintained by Aurora shall not exceed 4 feet of run to 1 foot of rise (4:1).

**4.02.7.03.1** Retaining walls for residential and commercial development projects excluding walls supporting roadway infrastructure shall be designed and constructed in accordance with the current edition of the International Building Code (IBC) including city amendments.

**4.02.7.03.2** Retaining walls supporting roadway infrastructure projects (private roadways, local, collector, arterials, or fire lane easements) shall be designed and constructed in accordance with the current edition of the AASHTO LRFD Bridge Design Specifications as modified by the CDOT Bridge Design Manual including city amendments.

**4.02.7.03.3 Submittal Requirements**

**4.02.7.03.3.1** To determine if a retaining wall requires structural calculations, use the table below. All wall heights refer to the exposed height measured from the top of the wall to the finished grade in front of the wall.

Table 4.02.7.03 <b>STRUCTURAL CALCULATIONS REQUIRED:</b>	<b>STRUCUTRAL CALCULATIONS <u>NOT</u> REQUIRED</b>
Individual retaining walls over 4 feet in height	Retaining walls 4 feet or less with no surcharge* load
Terraced retaining walls spaced less than twice the height of the lower wall apart with a total vertical height greater than 4 feet	
All retaining walls 4 feet or less in height where any part of the wall or foundation is supporting a surcharge* load or is within the 100-year water surface elevation.	
All retaining walls where any part of the wall or foundation intrudes on a line projected at 3:1 (H:V) slope from an easement line, right-of-way line, edge of fire lane, or edge of public building.	

\* “Surcharge” refers to any gravity load applied above the retained soil or any lateral load which contributes to overturning. Surcharge loads include but are not limited to vehicle loading (including maintenance vehicles), sloped embankments, building foundations, railing design loads, wind pressure, and water/hydrostatic pressure. Loads shall be applied in accordance with the applicable design code.

**4.02.7.03.3.2** For retaining walls not requiring calculations, details shall be included in the civil plans with the first submittal.

**4.02.7.03.3.3** Civil plans shall include wall typical sections dimensioning the maximum exposed height of the wall(s), type of material, whether walls are private or public, and owner responsible for maintenance. Structural drawings shall include necessary detailing required for wall construction. Structural reinforcing shall be properly called out and dimensioned on plans.

**4.02.7.03.3.4** Structural calculations for retaining walls shall include stability checks for bearing, overturning, sliding resistance, and global stability (if applicable) as well as material and reinforcement strength and serviceability design. Calculations shall include references and or back-up calculations for all design loads and parameters used.

**4.02.7.03.3.5** The design of retaining walls, wing walls, and miscellaneous structures that are unattached and not considered part of a building shall be submitted with the civil construction plans to the Public Works, Engineering Services Division. The design for walls attached to and part of a building or for walls that the building is structurally dependent upon shall be submitted to the Public Works, Building Division for review.

#### **4.02.7.04 Retaining Wall Heights**

**4.02.7.04.1** Detention, and/or water quality ponds shall not have retaining walls exceeding 42 inches, with a maximum total height of 8 feet, and shall have a sloped egress from the pond. Retaining wall requirements must meet this Manual as well as the *Storm Drainage and Design Technical Criteria*, and meet the submittal requirements of this Manual.

**4.02.7.04.2** Residential Development:

**4.02.7.04.2.01** Maximum 48 inch height adjacent to rear lot lines.

**4.02.7.04.2.02** Maximum 30 inch height adjacent to side lot lines.

**4.02.7.04.2.03** Maximum 30 inch height in front yard and side yard for corner lots.

**4.02.7.04.2.04** Maximum 48 inch height in all common areas including all multi-family areas.

**4.02.7.04.2.05** Terraced retaining walls are not permitted within the side yards of single-family detached homes.

**4.02.7.04.2.06** Retaining walls across residential lot lines are strongly discouraged and approved on a case-by-case basis by the City Engineer. Retaining walls within residential developments shall be located in a Tract that is owned and maintained by the Metropolitan District (or Homeowners Association, if no Metropolitan District).

Retaining walls that cross lot lines require a private easement, processed and executed through the County, allowing the Metropolitan District (or Homeowners Association, if no Metropolitan District) access to maintain the private wall. The site plan and civil plans shall identify the private wall(s) that are owned and maintained by the Metropolitan District (or Homeowners Association if no Metropolitan District).

**4.02.7.04.3** All other retaining wall heights shall not exceed eight feet except when approved by variance by the Public Works Engineering Division. Walls shall be terraced until the required amount of slope has been taken up. Slopes between walls shall not exceed four feet of run to one foot of rise (4:1).

**4.02.7.04.4** Slopes in front of and between walls shall not exceed 4 feet of run to 1 foot of rise (4:1). Slopes behind walls shall not exceed 3 feet of run to one foot of rise (3:1).

#### **4.02.7.05 *Design Requirements***

**4.02.7.05.1** Recommended types of retaining walls include reinforced concrete, structural masonry, and Mechanically Stabilized Earth (MSE) walls. Timber and boulder wall construction is not permitted.

**4.02.7.05.2** Minimum factors of safety and design loading used in structural calculations shall meet the requirements of the applicable code.

**4.02.7.05.3** Backfill material behind retaining walls shall be well-drained to prevent the accumulation of water. Weep holes or a drainage system shall also be provided behind the wall stem to prevent water pressure. If designer elects



not to have a drainage system, the wall shall be designed utilizing hydrostatic pressure.

**4.02.7.05.4** Retaining walls shall have the bottom of the footing a minimum of 3 feet below finished grade at front face to prevent frost heave. MSE structures are not subject to the minimum depth requirements for frost heave as they are considered earth structures.

**4.02.7.05.5** CDOT standard details for wing walls and head walls are acceptable for use without additional structural calculations. When the design parameters shown on CDOT's details are exceeded, structural calculations shall be required and submitted with first civil plan submittal. Plans shall include any applicable CDOT details. Details not provided in the City standards must also be included in the civil plans.

**4.02.7.05.6** Runoff shall not be permitted to pass freely over the wall; rather, a wall coping, drain system, or a properly designed ditch shall be used to carry runoff water along the wall to be properly deposited.

**4.02.7.05.7** If the horizontal distance between terraced walls is less than twice the height of the lower wall (even if the individual walls are less than 4 feet high) then:

- The entire terraced wall height shall be considered to act as one single wall and shall be designed as one wall to support the total retained height, or
- Each terrace of the wall can be designed individually (including any effects of the upper wall on the lower wall).

**4.02.7.05.8** Global stability is required for: individual walls with an exposed height greater than 8 feet; terraced walls with a total exposed height exceeding 4 feet when the horizontal distance between walls is less than twice the height of the lower wall.

**4.02.7.05.9** When scour potential is identified in front of a retaining wall, the passive resistance shall be neglected for the depth of scour and shall not contribute to sliding resistance in the stability calculations for the wall. Wall foundations shall be located below the scour elevation.

**4.02.7.05.10** Walls located within ponds (any portion of wall or footing within the 100-year water surface elevation) shall be designed considering saturated soil conditions and shall include hydrostatic pressure. Selected wall types shall be suitable for waterway applications.

#### **4.02.7.06 Safety Measures**

**4.02.7.06.1** Railings are required on any walls in excess of 30 inches. In areas directly adjacent to sidewalks, trails, bike paths, etc. are required to meet the current Building Code. Terraced walls with heights of individual walls over 30" shall restrict access between the walls either with a railing or fence. All railings including guardrail, bicycle railing, or pedestrian railing shall conform to the geometry and design loading requirements of the latest edition of the applicable code. Wall typical sections shall show the railing and shall show how the railing is supported. Railing may be integral with the wall or may have a separate foundation just for the railing. The designer is responsible for determining the appropriate railing details.

In areas of bicyclists the height of the railing shall be increased to of 54". The civil plans shall include a detail of the railing. For low water crossings a 54" pedestrian and bicyclist railing is required, if this differs from Parks Recreation and Opens space or UDFCD the more conservative requirements shall apply.

#### **4.02.7.07 Clearance Requirements**

**4.02.7.07.1** The Engineer must consider ROW and property line limits for placement of the footings and determine if temporary easements are needed for excavation. Any private wall footings, straps, soil anchors, or other wall elements including tie-backs shall not be located within the public right-of-way. Private walls are discourage within utility easements, however may be granted by variance by the City Engineer on a case-by-case basis. Walls within utility easements require an executed License Agreement prior to civil plan approval.

**4.02.7.07.2** There shall be a minimum of 2 feet of clear distance from a retaining wall to a property line. Additional width may be required at the top of the wall to collect drainage. At the base of the wall, for every 1-foot increase in vertical height of the wall over 2 feet an additional 1 foot of clear distance

to the property line should be added (up to a wall height of 6 feet exposed). Walls in excess of 6 feet (or terraced walls with total height of all terraced walls greater than 6 feet) shall provide a minimum clear distance of 12 feet when owned and maintained by the City or a minimum clear distance of 4 feet for private developments, measured from the front face of the wall to the property line or adjacent structures, to allow for maintenance. No part of the wall shall extend beyond the property lot line including footings or soil mesh reinforcing.

#### **4.02.7.08 *Miscellaneous Structures***

- 4.02.7.08.1** Miscellaneous structures in this section shall include but are not limited to drainage structures, overhead signs, and pole foundations.
- 4.02.7.08.2** Miscellaneous structures within the public right-of-way or supporting roadway infrastructure or fire lane shall be designed and constructed in accordance with the current edition of the AASHTO LRFD Bridge Design Specifications as modified by the CDOT Bridge Design Manual including city amendments.
- 4.02.7.08.3** Miscellaneous structures not within the public right-of-way shall be designed and constructed in accordance with the current edition of the International Building Code (IBC) including city amendments.
- 4.02.7.08.4** CDOT M standard plans for drainage structures are acceptable for use without additional structural calculations if the site conditions do not exceed CDOT's design parameters. Plans shall include any applicable CDOT details. Details not provided in the City standards must also be included in the civil plans.
- 4.02.7.08.5** When City standards are not available, CDOT S standard plans for sign structures and foundations are acceptable for use without additional structural calculations if the site conditions do not exceed CDOT's design parameters. Plans shall include any applicable CDOT details. Details not provided in the City standards must also be included in the civil plans.
- 4.02.7.08.6** Structural calculations are required for miscellaneous structures that do not conform to City or CDOT standard plans or exceed the City's or CDOT's

design parameters including steel grates, plates, and anchorages. Structural calculations are required with first submittal of civil plans.

**4.02.7.08.7** Structural calculations are not required for miscellaneous structure walls that meet the criteria of section 4.02.7.03 of this specification or baffle blocks 2 feet or less in height.

**4.02.7.08.8** For miscellaneous structures not requiring calculations, details shall be included in the civil plans and submitted with the first civil plan submittal to the Public Works Engineering Division for review. The construction details shall be in accordance with the appropriate code requirements.

#### **4.02.7.09 Bridge Structures**

**4.02.7.09.1** Bridges in this section are defined as a structure that spans over a road, railway, river, or other obstacle to provide passage for pedestrians, vehicles, and other moving loads from one side to the other.

**4.02.7.09.2** For the purposes of this manual for the City, a major bridge structure is defined using the CDOT Bridge Design Manual as “Bridges and culverts carrying vehicular traffic with a total length greater than 20 ft. measured along the centerline of the roadway between the inside face of abutments, inside faces of the outermost walls of culverts, or spring lines of arches. Major Structures also include culverts with multiple pipes where the clear distance between the centerlines of the exterior pipes, plus the radius of each of the exterior pipes, is greater than 20 ft.”

**Bridge structures as defined above shall be identified as a bridge in CAD files submitted to the City.**

**4.02.7.09.3** For the purposes of this manual for the City, a minor bridge structure is defined using the CDOT Bridge Design Manual as “Bridges, culverts, or a group of culverts carrying vehicular traffic that have a total length greater than or equal to 4 ft. and less than or equal to 20 ft. measured along the centerline of the roadway between the inside face of abutments, inside

faces of the outermost walls of culverts, or spring lines of arches” Bridge structures as defined above shall be identified as a bridge in CAD files submitted to the City.

**4.02.7.09.4** All vehicular bridge structures within or over public right-of-way, supporting roadway infrastructure, or that are publicly owned and maintained shall be designed and constructed in accordance with the current edition of the AASHTO LRFD Bridge Design Specifications as modified by the CDOT Bridge Design Manual, the CDOT Standard Specifications for Road and Bridge Construction, and as amended by these City Roadway Design & Construction Specifications. Associated required bridge plan sheets are required to be included with first civil plan submittal.

**4.02.7.09.5** All pedestrian bridge structures within or over public right-of-way, supporting public pedestrian infrastructure and/or open to the public, or that are publicly owned and maintained shall be designed and constructed in accordance with the current edition of the AASHTO LRFD Bridge Design Specifications as modified by the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges, the CDOT Bridge Design Manual, the CDOT Standard Specifications for Road and Bridge Construction, and as amended by these City Roadway Design & Construction Specifications. Associated required bridge plan sheets are required to be included with first civil plan submittal.

**4.02.7.09.6** Prior to first submittal of civil plans for all bridges within or over public right-of-way, supporting roadway infrastructure, or that are publicly owned and maintained, the design engineer shall contact Public Works, Engineering Division to have a Structure Identification Number assigned.

#### **4.02.7.10 Submittal Requirements**

Structural calculations reports and construction details are required with the first submittal of civil plans for all major bridge structures and for all bridges within or over public right-of-way, supporting public infrastructure, or that are publicly owned or maintained. Structural calculations shall conform to the CDOT Bridge Design Manual and construction details shall be prepared in accordance with the CDOT Bridge Detailing Manual.

**4.02.7.10.1** Prefabricated Structural calculations and construction details shall be submitted to city prior to fabrication.

**4.02.7.10.2** The construction of all major bridge structures and for all bridges within or over public right-of-way, supporting public infrastructure, or that are publicly owned or maintained shall be certified by an engineer licensed in the State of Colorado. The certification shall be submitted to the Public Works, Engineering Division upon completion of construction and prior to initial acceptance of public improvements. In no case shall the structure be opened to the public prior to submittal of certification. Please use the form provided on the website at the following link to submit the certification.

**4.02.8 Sidewalks** Sidewalks associated with streets shall have a cross-slope of two percent down toward the street. Other non-accessible, private walks' cross-slope shall have a preferred cross-slope of two percent, but, may on a case-by-case basis range between two-percent to five-percent. There shall be a minimum two-foot recovery zone along sidewalks before there is a significant change of slope.

**4.02.8.01** Detached sidewalk/bicycle path shall be required along both sides of all state highways. Adjacent development shall be responsible for the sidewalk/bicycle path installation. Generally, these sidewalks shall be a minimum of ten-feet wide and may be wider if these walks are associated with regional or sub-regional trail systems. There shall be two-foot wide recovery zones on either side of the walk before there is a grade break to grade to existing ground. The recovery zone shall have the same cross-slope of the walk. The walks shall be set back a minimum of ten-feet from the highway's curb and gutter or edge of pavement.

**4.02.8.01** Private sidewalks shall be constructed from concrete or materials matching other pavements in the development.

**4.02.9 Driveways** All driveways abutting paved public rights-of-ways shall be surfaced with concrete, asphalt, or brick or stone pavers, with exceptions as noted in City Code Section 146-4.6.5.C.

**4.02.9.01** The maximum permissible grade for single family residential driveways is 14 percent. Where grades are in excess of ten percent there shall be an accompanying pedestrian walk from the street sidewalk to the main entry with

steps to keep the walk below ten percent. Those portions of driveways supplying access to required parking shall not exceed eight percent slope per City Code. See also Section 4.05.4 below for additional requirements.

- 4.02.9.02** The subgrade shall be compacted to the same requirements as the local streets. See Section 20.06.8.
- 4.02.9.03** Driveway thicknesses shall be in accordance with Standard Details S7.4 and S7.5.
- 4.02.9.04** Brick and/or stone pavers shall be at least four-inches thick. The brick and/or stone pavers shall be laid within a containment system that will not allow movement from the anticipated wheel loads. This may be in the form of concrete border edging, mortared brick and/or stone pavers, etc.
- 4.02.9.05** For those areas of the City still with unpaved streets, other surfacing material allowed are recycled asphalt roto-millings or granular road base (Type 2A per Section 23, Table 23.02.1, or equivalent).
- 4.02.9.06** Relative to single family residences the off-street parking spaces, pads and driveways shall be kept a minimum of two feet from any property line for drainage purposes, unless otherwise approved in writing by the City of Aurora Public Works Department and Planning & Development Services Department. The addition to existing driveways located adjacent to side property lines shall not impede drainage.
- 4.02.9.07** A driveway permit is required for all single family residential driveways, pads or parking spaces, except for new single family home construction or where the existing driveways, pads or parking spaces are being replaced with the same material and where the material type, location, size and slope does not change.

## 4.03 Drainage

- 4.03.1 Design Standards** The drainage system for all private site development, as well as all public rights-of-way, shall be designed in accordance with City of Aurora, "[Storm Drainage Design and Technical Criteria Manual](#)," latest edition. A final drainage report or letter shall be submitted with all civil construction plans submitted for review and shall be considered part of the civil construction plans. The major

function of a roadway is the safe conveyance of traffic. Drainage is a secondary function of a roadway, and the safe conveyance of traffic shall at all times take precedence over drainage.

**4.03.2 Cross Pans** Cross pans shall be constructed in accordance with the standard details. Cross pans are **not** allowed **across** collector or arterial roadways, nor are they allowed on roadways with storm sewer systems.

The use of cross pans at intersecting streets where the through street grade exceeds 4.5% at the cross pan or in new construction of local streets will be considered only after all other alternatives have been exhausted.

**4.03.3 Inlets** Inlets shall be located to intercept flow at the point curb capacity for a minor storm (major storm in Urban Centers and TOD's) is exceeded as indicated on an approved drainage plan. Inlets also shall be located due to nuisance drainage, icing, or other conditions. Refer to Figures 2, 3, 4A, and 4B in the City of Aurora "Storm Drainage Design & Technical Criteria Manual" for inlet and curb capacity, respectively. Inlets shall also be installed to intercept cross-pavement flows at point of transition in superelevation. See Section 4.05.3.06. Inlets are not allowed in the curb return and shall be located five feet from the point of curb returns' tangent points (Urban Centers and TOD's, zero to three feet from the point of curb returns) and edge of curb ramp. See Section 4.05.9 for minimum grades around curb returns for turning runoff. Inlets shall also be located within the parallel and diagonal parking areas of Urban Centers and TOD's. Top, back of curb elevation and street centerline station at the centerline of the inlet and station offset shall be shown on the plans.

At a street intersection, with existing or proposed storm drain within 300' from the centerline of the intersection, where two streets slope down to the intersection an inlet shall be placed on the through street, uphill of the intersection to collect flows prior to the intersection, and on the intersecting street, uphill of the intersection to collect flows prior to the intersection. The inlets shall be placed uphill of warping when warping is present or at a location 5' from the curb return.

At T-intersections intersections when flows are transported down the leg of the T to the intersection and lots are located opposite, along the top of the T, with top of foundations lower than the intersection, inlets and storm drain systems are required to collect 100 year flows and prevent 100 year flows from bypassing the intersection to the lots below (the use of additional inlets at the top of the T may also be required). Lots with top of foundations higher than the intersection may also require inlets, on



the leg of the T, unless it can be shown that 100 year street flow depths are not exceeded at the top of the T (should 100 year flows bypass the intersection).

All inlets within the public right-of-way, or to be maintained by the City, shall be the curb opening Type R modified, constructed in accordance with the standard details S12.1 et seq. The following note shall apply to all inlets in a sump condition located within the public right-of-way:

**"Contractor shall maintain a minimum of 0.5% grade at flow line into inlet."**

This note shall appear on all applicable street plan and profile plans.

**4.03.4 Minimum Pipe Diameter** The minimum pipe diameter allowed within the public R.O.W. or to be maintained by the City of Aurora is 18 inches.

**4.03.5 Temporary Erosion Control** In addition to the requirements identified in the City of Aurora "Rules and Regulations Regarding Stormwater Discharges Associated with Construction Activities", latest edition, temporary erosion control is required at the ends of all roadways not completed due to the project phasing, subdivision boundaries, etc. Prevention of erosion at the roadway terminus shall be by methods approved by the City Engineer and the Aurora Water Department, and shall be the responsibility of the Developer.

**4.03.6 Sidewalk Chases** Within multi-family, commercial, or industrial developments storm water from concentrated points of discharge from a storm event shall not be allowed to flow over internal, private sidewalks and perimeter, public sidewalks, but shall drain to the roadway by the use of chase sections.

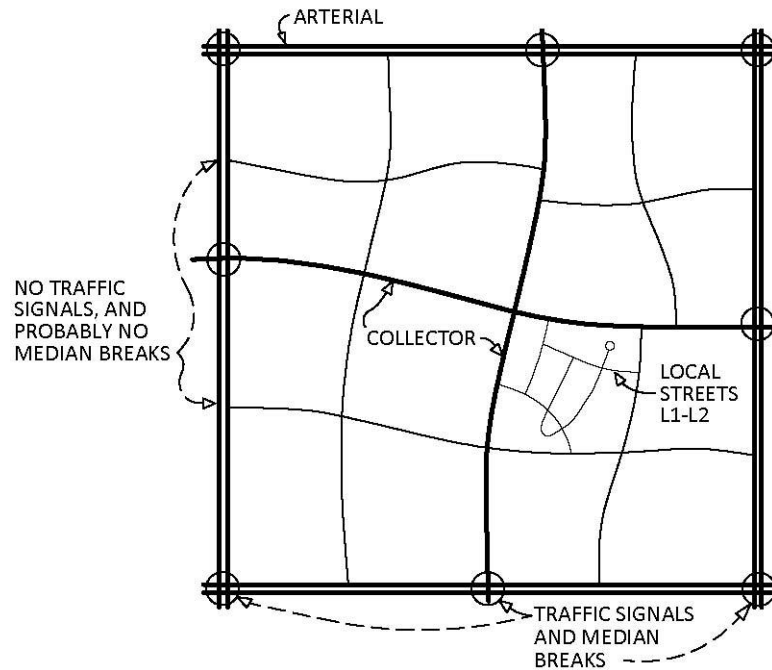
Within single-family developments side yard points of discharge from a storm event are allowed to flow over the public sidewalk where there are less than two lots draining through an adjacent/common side yard swale. A chase drain is required when two or more lots drain to an adjacent swale, or the drainage basin area to the swale is larger than the drainage area tributary from the two adjacent lots. Exceptions may be granted on a case by case basis by the City Engineer.

The builder will be required to install a chase if more than one single family home sump pump is directed to a side yard swale. Chase sections shall not be located within a curb cut, driveway, curb ramp or curb return. Station, width, and invert elevations of sidewalk chases shall be shown on the plans. Sidewalk chase sections shall be constructed in accordance with standard details S3.1 et seq.

## 4.04 Horizontal Alignment

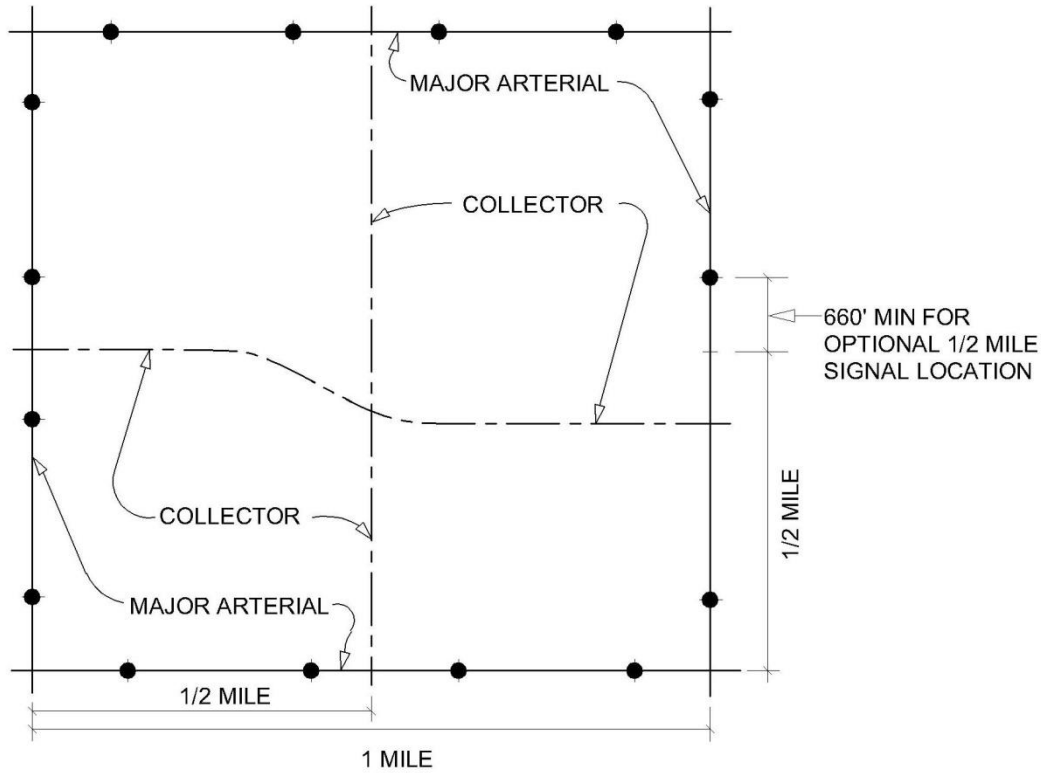
### 4.04.1 Street layout

**4.04.1.01** Arterials shall be located at approximately one mile intervals, both in an east-west direction and a north-south direction. (See Figure 4.04.1.01.1.)



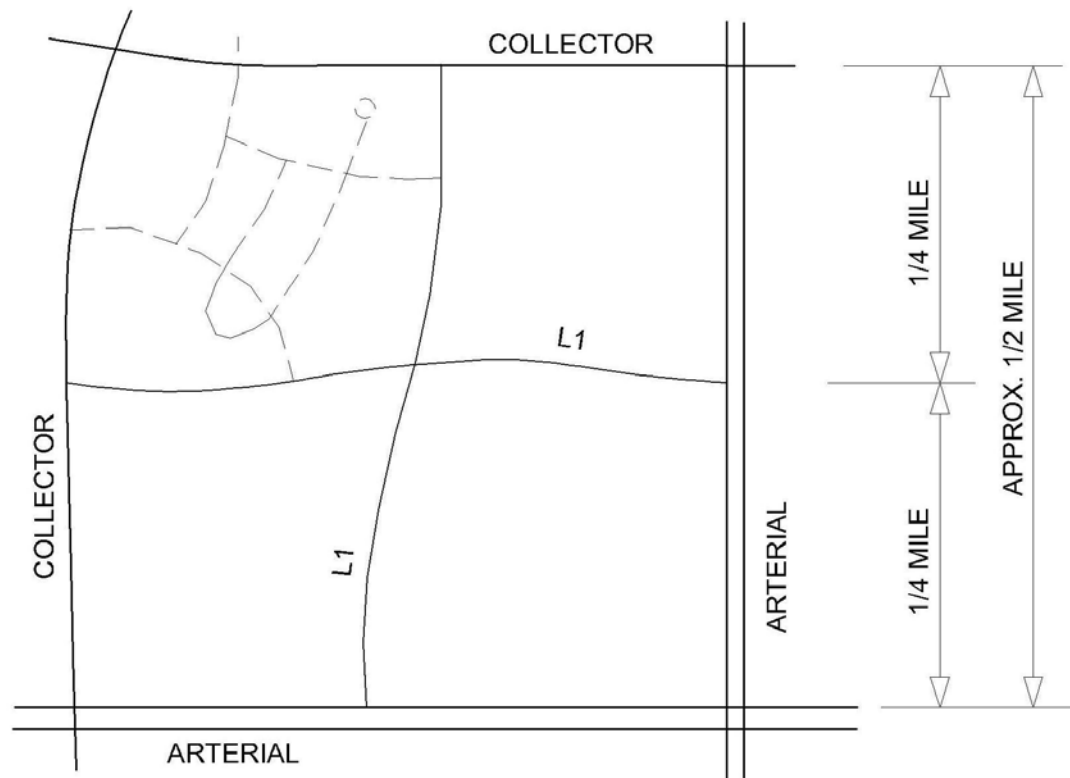
**Figure 4.04.1.01.1**  
**General Arterial Street Layout**

**4.04.1.02** Within each one mile segment, collectors shall divide the segment east-west and north-south at approximately the half-mile points (or within 660 feet on either side of the half-mile points) into four approximately quarter-mile square (160 acre) areas. Generally, it is expected the collectors will align and connect across arterials to distribute traffic and to provide continuity on bicycle routes, which are generally located on collectors. (See Figure 4.04.1.02.1.)



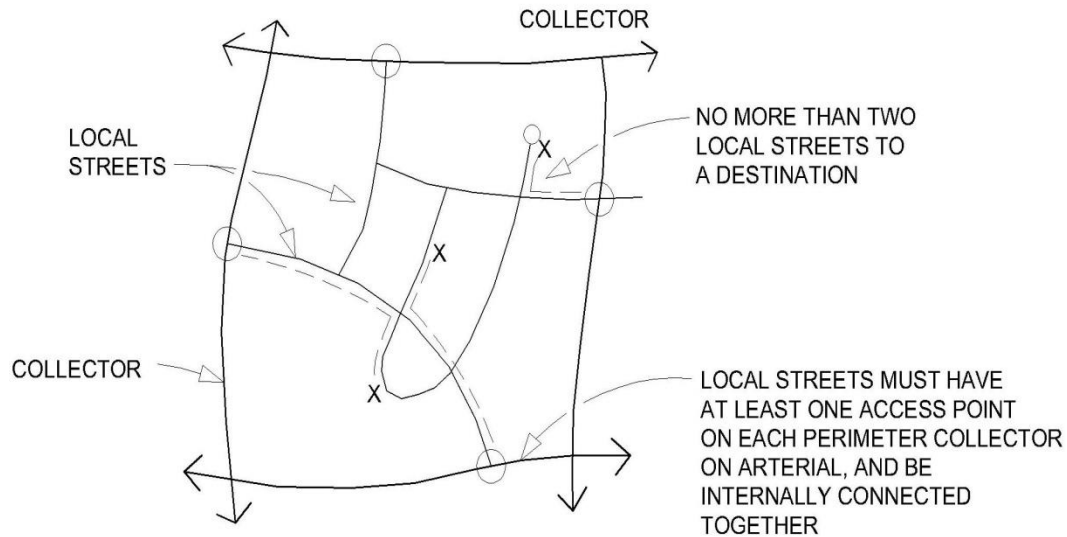
**Figure 4.04.1.02.1  
General Collector Street Layout**

**4.04.1.03** Within each approximately 160 acre segment, at least one continuous local Type 1 street shall connect an arterial and a collector, in both the north-south and the east-west directions. The locations of the continuous local Type 1 Street should define four areas of roughly similar size (approximately 40 acres). (See Figure 4.04.1.03.1.)



**Figure 4.04.1.03.1  
General Type 1 Local Street Layout**

**4.04.1.04** For each approximately 40-acre area, at least one street giving access to its interior shall be provided on every perimeter street of the area unless (1) such a connection to an arterial would create undesirable turning movements or present other traffic safety hazards; Or (2) the connection would be impractical because of topography or other physical obstructions such as intervening open space, a golf course, a ravine, or existing adjoining development. Such access streets shall connect across continuous local Type 1 streets and should connect across collectors, depending upon land use relationships. In no case shall local streets be required to connect to an arterial street at intervals of less than one-quarter mile. (See Figure 4.04.1.04.1.)



**Figure 4.04.1.04.1**  
**General Local Street Layout in Approximate 40 Acre Area**

**4.04.1.05** No cul-de-sac shall be longer than 500 feet unless a secondary emergency access is approved by the fire marshal. The secondary emergency access shall contain a connecting pedestrian path and comply with all life safety requirements. Cul-de-sac length shall be measured along street centerline from the flowline of the intersecting street to the center of the cul-de-sac bubble. If the cul-de-sac street is off-set or curved, the max length shall be no longer than 500 feet, and shall be measured with a gradual radius (greater than 120') from the street centerline at the start of the cul-de-sac to center of cul-de-sac.

**4.04.1.06** Dead end streets (public or private) shall have a turnaround at the end within a minimum property line radius of 58 feet and a minimum flow line radius of 48 feet. If the dead end street is greater than 150 feet, and does not have a cul-de-sac that meets these requirements, turning movements will be required to be submitted for the City's evaluation and approval. If two or more curb cuts with hard paved driveways are provided, then the minimum property line radius shall be 45 feet and the minimum flow line radius shall be 35 feet. Hammerhead turnarounds, where permitted by the City Engineer, shall be posted at all times for "No Parking – Tow Away Zone". This section does not apply to alleys, unless the alley includes a fire lane easement, then the determination would be at the discretion of the City Engineer in coordination with Fire/Life Safety Examiner.

## 4.04.2 Classifications

### 4.04.2.01 Local Streets

**4.04.2.01.1 Local street type 1** Neighborhood streets connecting with collectors or arterials. This category also includes through streets generally located midway between collectors and arterials. Intersections with arterials shall be flared and include an entry island. Between an arterial intersection and the first interior intersection, single-family detached, two family and single-family attached duplex dwellings shall not be allowed to front the local street where projected future traffic volumes at full build-out and 20 years are in excess of 2,000 vehicles per day. Corner lots at local/arterial intersections shall be designed to minimize conflicts between driveways and street entry islands and local traffic.

**4.04.2.01.2 Local street type 2** Destination streets that do not connect with collectors or arterials and that have fewer than 40 homes fronting the street with no opportunity for cut through traffic. For cul-de-sacs less than 250 feet in length, the sidewalk may be attached and the right-of-way width reduced in accordance with the roadway design and construction specifications.

**4.04.2.01.3 Local street type 3** A local street within a primarily commercial or industrial area.

### 4.04.2.02 Collector Streets

**4.04.2.02.1 Two-lane collector** Any street that connects at both ends with an arterial, generally located midway between parallel arterials. Single-family residences may not front or have driveways onto a collector street, except in designated urban centers and as noted in 4.04.2.02.4.

**4.04.2.02.2 Alternative two-lane collector** Any two-lane collector with no on-street parking or loading permitted. This section may be used where there is no access for a minimum of 1,000 feet measured from intersection flow lines. At intersections the collector shall be as described in 4.04.2.02.1 for a minimum distance of 125 feet plus tapers as measured from flow line of the intersection street. Single-family residences may not front or have

driveways onto a collector street, except in designated urban centers and as noted in 4.04.2.02.4.

**4.04.2.02.3 Three-lane collector** A street that connects through neighborhoods and that connects arterials to arterials or arterials to collectors. Single-family residences may not front or have driveways onto a collector street, except in designated urban centers and as noted in 4.04.2.02.4.

**4.04.2.02.4 Exceptions** Single-family detached, two family and single-family attached duplex dwellings may front on a collector street with projected future traffic volumes at full build-out and 20 year projection of 4,000 vehicles per day or less if a minimum of two of the following mitigation measures are provided:

**4.04.2.02.4.01** An increase in minimum front yard setbacks for residences by five feet.

**4.04.2.02.4.02** Driveway turn-arounds.

**4.04.2.02.4.03** Noise attenuation windows for all front elevation windows and side elevation windows within 15 feet of the front elevation plane.

**4.04.2.02.4.04** A landscaped and bermed median at least 14 feet in width.

**4.04.2.02.4.05** Alley-loaded garages.

**4.04.2.02.5 Exceptions within designated urban centers and TODs** Single-family detached, two family, and single-family attached duplex dwellings may front on a collector street with projected future traffic volumes at full build-out and 20 year projection of 4,000 vehicles per day, or less, only if the design mitigates the impact of high traffic volumes. The following mitigation measures are mandatory:

- Minimum front yard setback of 17 feet to porch or façade; and
- Alley loaded garages; and
- Noise attenuation in conformance with Section 146-810(B); and
- A landscaped median or residential frontage opposite a public or private park.

In addition to the above mandatory mitigation measures, at least one of the

following mitigation measures must be provided:

- On street parking and bike lane is provided; or
- Notification of property owners with the purchase of the single family homes the traffic volumes will increase; or
- Other mitigation measure approved by the Public Works Director and the Planning and Development Services Director.

#### **4.04.2.03 Arterial Streets**

##### **4.04.2.03.01 Six-lane arterial**

##### **4.04.2.03.02 Four-lane arterial**

**4.04.2.04 Low density rural street or avenue** This street may be allowed only where development of 30 or more acres is planned for single-family detached dwellings with a maximum density of two dwelling units per acre with no lot size smaller than four-tenths of an acre.

**4.04.2.05 Private streets** The street width, sidewalks, tree lawn, and other features shall be the same as the requirements for the equivalent public street. Parking lot driveways or internal circulation driveways with perpendicular parking for multi-family, commercial, or industrial sites shall not be required to conform to standards for private streets.

**4.04.2.06 Alleys** Alleys shall be paved in concrete. The pavement section shall be in conformance with SECTION 5, PAVEMENT DESIGN. The alley must contain the 100 year storm event, unless there are specific constraints that prohibit meeting this criteria, as approved by the Engineering Services Manager in Aurora Water. Freeboard is recommended, but not required, of six inches.

**4.04.2.06.1 Residential** Alley shall be 16-feet wide.

**4.04.2.06.2 Commercial and industrial** Alley shall be 20-feet wide.

**4.04.2.07** Where street cross-sections either narrow or widen on either side of an intersection the transition of traffic shall occur past the intersection. This transition should start one hundred feet past the curb return. See Section 4.09.4 for signing and striping requirements.



#### **4.04.2.08 Motor Courts**

- 4.04.2.08.1** Motor Courts shall be no longer than 150 feet and shall be at least 23 feet in width.
- 4.04.2.08.2** Motor Court drive lanes less than 30 feet wide shall be surfaced with concrete. Drive lanes 30 feet, or greater, in width may be constructed with asphalt, if provided with full concrete curbs and gutters. See City Code Section 146-1108(A)3 for parking requirements.
- 4.04.2.08.3** The Motor Court design shall permit a passenger vehicle to back out of an individual driveway and turn 90 degrees in either direction without any portion of the vehicle: (a) leaving the individual driveway from which the vehicle is exiting or the shared drive lane, or (b) entering on or over the individual driveways of any other residence. The AASHTO turning template for a “P” design vehicle shall be used to confirm this standard is met.
- 4.04.2.08.4** Each motor court with a shared drive lane longer than 100 feet from the public street shall have a fire hydrant to the shared drive lane at a point determined by the Fire Department.
- 4.04.2.08.5** City utility meter pits shall be located on the motor court side of the dwelling units.
- 4.04.2.08.6** Public access easements, fire lane easements, drainage easements, and/or utility easements shall be dedicated for Motor Courts as needed.

#### **4.04.2.09 Loop Lanes**

- 4.04.2.09.1** The width of the Loop Lane shall be 18 feet wide for one-way travel. For two-way travel the Loop Lane shall be 23 feet wide. Loop Lanes shall be private and dedicated as a public access easement, firelane easement, and/or utility easement, if needed.
- 4.04.2.09.2** No portion of the Loop Lane shall extend more than 250 feet measured from centerline of public street to which it gives access.
- 4.04.2.09.3** The Loop Lane shall meet private pavement requirements, Section 5.01

**4.04.2.09.4** The Loop Lane design shall permit a passenger vehicle to back out of an individual driveway and turn 90 degrees in either direction without any portion of the vehicle: (a) leaving the individual driveway from which the vehicle is exiting or the loop lane, or (b) entering on or over the individual driveways of any other residence. The AASHTO turning template for “P” design vehicle shall be used to confirm these standards are met.

**4.04.2.09.5** Each Loop Lane with a shared driveway longer than 100 feet from the public street shall have a fire hydrant adjacent to the shared driveway at a point determined by the Fire Department.

#### **4.04.2.10 Sight Triangles**

**4.04.2.10.1 Obstruction prohibited.** No person shall place or maintain any structures, fences, landscaping, or any other objects within any sight triangle area described in Section 4.04.2.10.2 that obstruct or obscure sight visibility through such structures, fencing, landscaping, or other objects in the vertical plane above the sight triangle area between a height of 36 inches and 84 inches above the roadway surface. The following are exceptions to these restrictions:

**4.04.2.10.1.01** Landscaping, structures, or fences that protrude no more than 24 inches above the adjacent roadway surface may be permitted within the sight triangle area.

**4.04.2.10.1.02** Landscaping, structures, fences, or any other objects that obstruct or obscure sight visibility less than or equal to 25 percent through such structures, fences, landscaping, or other objects in the vertical plane above the sight triangle area between a height of 24 inches and 36 inches above the roadway surface. See Figure 4.04.2.10.1.02.1.

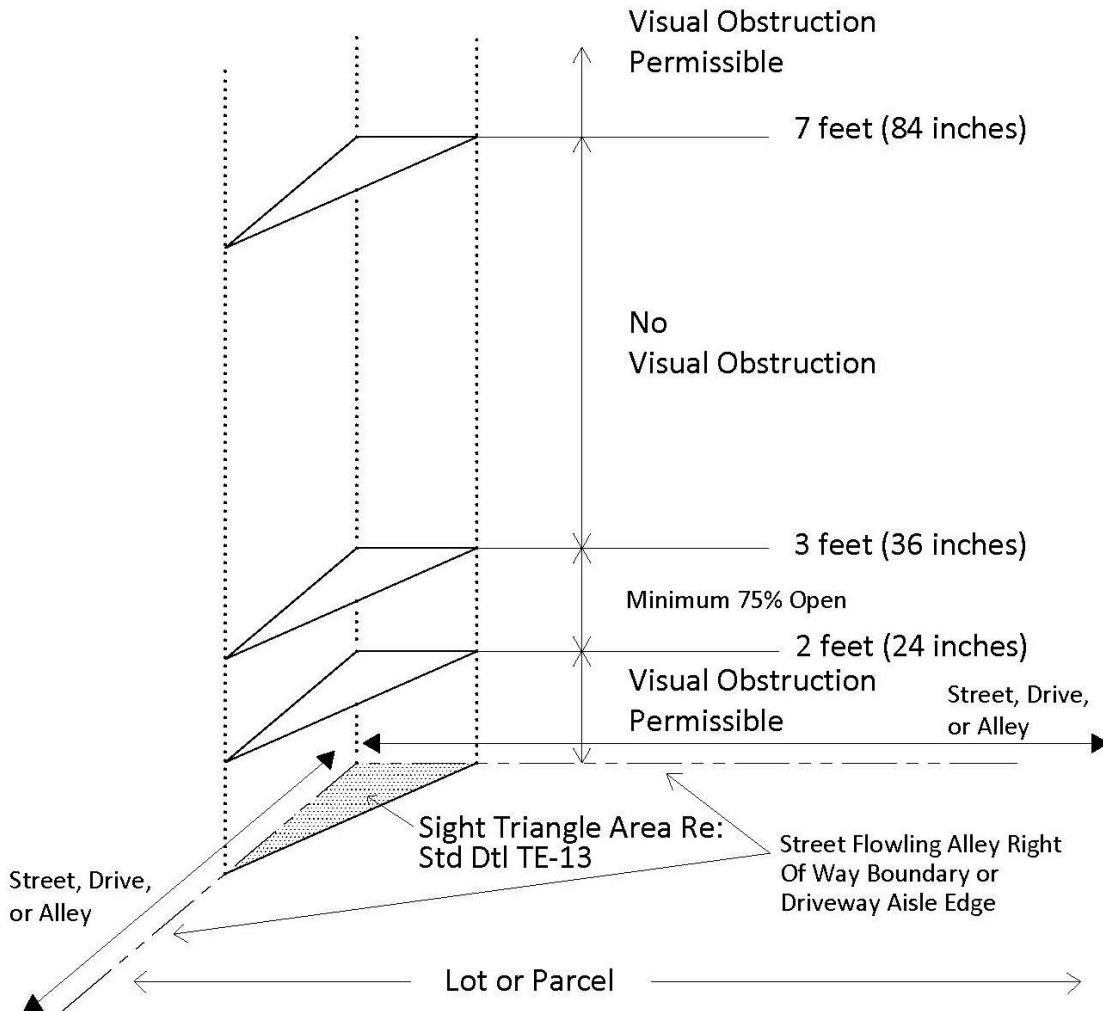
**4.04.2.10.1.03** Trees may be planted and maintained within the sight triangle area if all branches are trimmed to maintain a clear vision for a vertical height of 84 inches above the roadway surface. The location of the trees planted, based on the tree species' expected mature height and size, shall not obstruct sight visibility by more than 25 percent of the sight triangle area.

**4.04.2.10.2 Sight triangle area.** For purposes of this section, the sight triangle area is:

**4.04.2.10.2.01** The sight triangle shall be based on the criteria found in Detail TE-13, Roadway Design & Construction Specifications, latest edition; or

**4.04.2.10.2.02** The area formed at a corner intersection of an alley and a public or private street whose two sides are 15 feet, measured along the right-of-way line of the alley and the flow line of the street, and whose third side is a line connecting the two sides; or

**4.04.2.10.2.03** The area formed at the intersection of a public or private street and a non-residential driveway aisle, whose two sides are 15 feet, measured along the flow line of the street and the edge of the driveway aisle, and whose third side is a line connecting the two sides;



**Figure 4.04.2.10.1.02.1  
Three Dimensional Sight Triangle**

**4.04.3 Design Speed** Design speed shall be as shown in Table 4.04.4.1.

**4.04.4 Horizontal Curves** The minimum centerline radius for horizontal curves shall be as shown in Table 4.04.4.1. Variances from the requirements of Table 4.04.4.1 for local streets only will be considered on a case-by-case basis.

**Table 4.04.4.1  
Horizontal Alignment Controls, Including Urban Centers and TODs**

STREET CLASSIFICATION	DESIGN SPEED MPH	MINIMUM RADIUS***	STREET CLASSIFICATION	DESIGN SPEED	MINIMUM RADIUS
ARTERIALS	50	930'	Boulevard 4 or 6 Lanes	50	930'
LOW DENSITY RURAL	45	720'	Multiway Boulevard – 4 or 6 Through Lanes	50*	930'
COLLECTOR 3-LANE	35	425'	Main Street 2 Lanes with Median / Center Turn Lane	35 30	375' 250'
COLLECTOR 2-LANE	35	425'	Main Street – Median 4 Lanes	40 35	575' 425'
LOCAL TYPE I	30	250'	Main Street – 2 Lanes with Parallel Parking	30	250'
LOCAL TYPE 2**	25	150'	Main Street – 2 Lanes with Diagonal Parking	30	250'
LOCAL TYPE 3	35	375'	One Way Couplet 2 Lanes	35 30	425' 250'
			Local Urban 2 Lanes	30	250'
			Residential Parkway 2 Lanes	30	250'
			Neighborhood 2 Lanes	30	250'

\*The posted speed limit for the access road for the Multiway Boulevard will be 25.

\*\*Local Type 2 streets on dead-end cul-de-sacs shall use Local Type 2 criteria except minimum road centerline radius may be reduced to 100' with curve widening. See Section 4.04.5.04.

\*\*\*Arterial Roads and for some selected 4-Lane Collectors and Low Density Rural Roads, when the minimum street radii are used these roads shall also be superelevated. See Section 4.05.3.

#### 4.04.5 Intersections

**4.04.5.01 Turning Radius** All roadways shall intersect at 90 degrees  $\pm$  5 degrees. For the minimum allowable intersection turning radius on cross streets intersecting arterial streets, see Standard Detail S2.4.

**4.04.5.02** For any intersection with double turn lanes or non-standard geometry, the design shall provide an analysis of turning radii using an appropriate design vehicle. Consult with the Engineering staff to discuss criteria prior to performing the analysis.

**4.04.5.03 Curb Return and Property Line Radii** Minimum curb return and property line radii shall be as shown in Table 4.04.5.02.

**Table 4.04.5.02  
Curb Return Flow Line and Property Line Radii at Intersections\*\*\***

	Local	Collector	Arterial
Driveway 20 or less spaces*	15	20	25
Driveway 21 or more spaces	15	20	25
Alleys**	--	--	--
Local or private street	15	20	25
Collector	--	20	25
Low Density Rural	20	20	25
Arterials	--	--	25

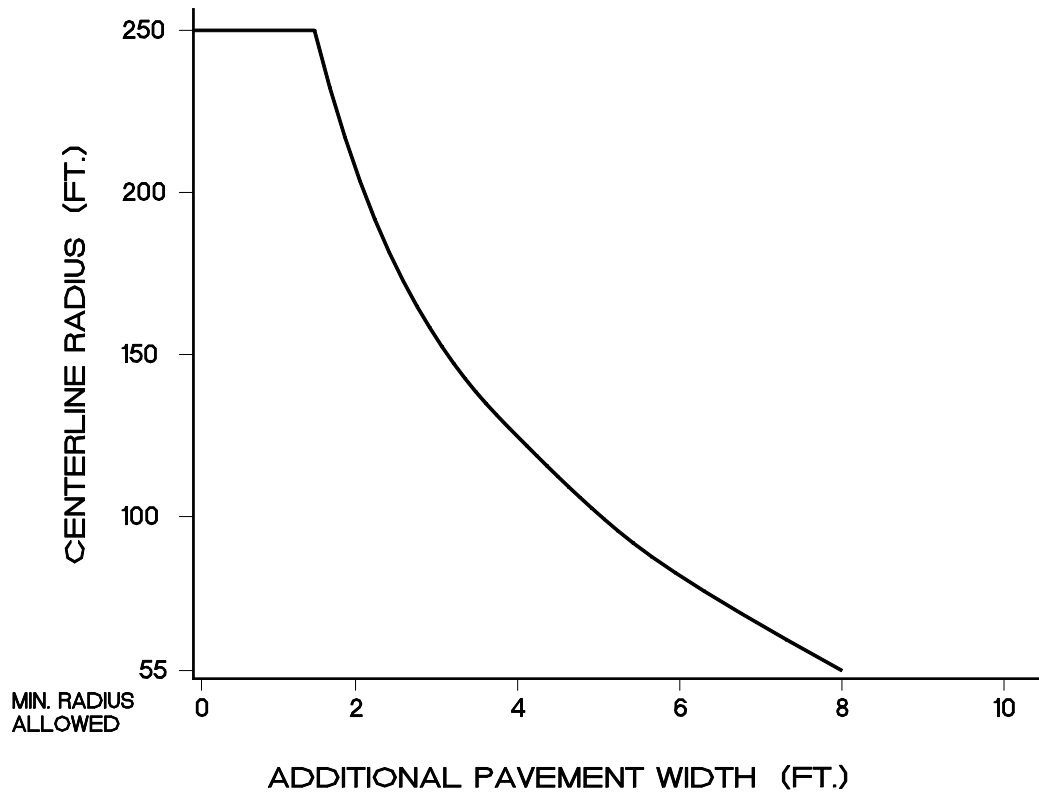
\* Curb cuts may be used in lieu of curb returns if the requirements of Section 4.02.4 are satisfied.

\*\* Alleys shall be constructed with curb cuts per Std. Detail S7.4.

\*\*\*Larger minimum radii may be required by the City Engineer where there is a significant volume of truck or bus traffic.

**4.04.5.04 Pavement Widening for Short Radii** All curves in local and private streets with radii from 55' to 250' shall be designed using Figure 4.04.5.04.1 to increase pavement width. Centerline radii less than 33' shall not be permitted. For radii between 33' and 55' see Figure 4.07.10.1. Additional right-of-way may be required for curve widening.

**Figure 4.04.5.04.1  
Required Widening at Private Street and Local Intersections/Curves**



Notes

1. No pavement widening required for a radius greater than 250'.
2. Transitions and other criteria described in 4.07.10 References: "*A Policy on Geometric Design of Highways and Streets*," 2011, 6th Edition and City of Aurora standard fire truck dimensions.
3. Private street and local intersection  $90^\circ \pm 5^\circ$ .
4. Curve widening may occur on the inside of the curve, preferred, or on the outside of the curve.

**4.04.6 Roundabouts**

**4.04.6.01** The design of a roundabout is an iterative process where the design objectives must be considered and balanced within the site-specific constraints. For general planning of new residential developments the City may require roundabouts along corridors where excessive speeding may be an issue, or in conjunction with adjacent land uses, like schools. NCHRP 772 – Evaluating

the Performance of Corridors with Roundabouts<sup>1</sup> may be a helpful reference to determine the suitability of roundabouts in corridors. These roundabouts will be considered as a substitute for other types of intersection traffic control, i.e., two-way or four-way stops or for traffic signal locations, if deemed potentially warranted in the future. Generally, roundabouts shall be limited to one or two approach lanes and a maximum of five legs to the roundabout. The fifth approach leg may be approved by the City Engineer as long as it can be shown the fifth leg will not significantly degrade the operation or safety of the roundabout. Roundabouts with more than two approach or circulating roadway lanes will be considered on a case-by-case basis.

**4.04.6.02** There will be a two-step process for the roundabout design: a schematic preliminary design and associated traffic analysis submitted with the Department of Planning and Development Services' entitlement process (See the [Traffic Impact Study Guidelines](#) for more information); and the final construction level design submitted with the civil construction plans. The preliminary design will be prepared to a 30 percent completion, but the horizontal, geometric layout will be 100 percent complete at this preliminary stage.

**4.04.6.03** The traffic analysis and considerations for a preliminary roundabout design shall include the following:

**4.04.6.03.01** Three fundamental elements must be developed in the preliminary design concept stage: the optimal inscribed circle size (ICD) plus approach medians (splitter islands); the optimal circle position; and the optimal alignment and arrangement of the approach legs. Attending to these geometric elements correctly for the site context and traffic volumes will ensure space for the design vehicle, adequate sight of the roundabout, control of entry speeds and accommodation of vulnerable road users.

In cases where a roundabout is under consideration for retrofitting an existing intersection, an initial estimate of the footprint required for a roundabout needs to be determined. This may affect the feasibility of a

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<sup>1</sup> National Cooperative Highway Research Program (NCHRP) 772 Evaluating the Performance of Corridors with Roundabouts

roundabout at any given location. At this planning level the following questions should be explored:

1. Is sufficient space available to accommodate an appropriately sized roundabout?
2. If right-of-way acquisition is required, how will the acquisition process impact the schedule and the project budget?
3. Are there physical constraints that may affect the performance of the roundabout, e.g., speed control or sight distance?

Due to the need to accommodate large trucks through the intersection, roundabouts typically require more space than conventional intersections. However, this may be offset by the space saved compared with turning lane requirements with alternative intersection forms. The key indicator of the required space is the inscribed circle diameter (ICD). See NCHRP, Chapter 6.3<sup>2</sup> for additional guidance on selecting circle size and alignment of approach roadways.

**4.04.6.03.02** Provide daily volumes, vehicle classifications, and AM/PM peak hour turning movements for existing, site build out and a 20 year projection. When large traffic generators, like schools, shopping centers, etc., are present the peak hour for local traffic with the large traffic generator fully developed shall be used. If the traffic flow estimates for the build condition plus ten years does not exceed the capacity of single lane entries, then a staged expansion of the layout may be justified. In such cases, the City Engineer will be consulted prior to the layout being developed.

**4.04.6.03.03** Identify the location and type of the proposed roundabout, including approach roadway widths, design vehicle, speeds and classifications for the intersecting roadways, sight distance, the preliminary approach grades, free-flow (non-yielding) right turn bypass lanes when warranted by turning movement volumes. If significant conflicting pedestrian crossings are anticipated, free-flow right turn bypass lanes will not be allowed.

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<sup>2</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition



Where multilane roundabouts are considered, a lane configuration sketch is required to identify the need for exclusive turn lanes and designs where the number of lanes differs by approach.

- 4.04.6.03.04** Provide preliminary dimensions of the roundabout, including the inscribed circle and circulating roadway, number of lanes for each approach and departure, pedestrian and bicycle facilities through the roundabout, existing right-of-way boundaries and the proposed right-of-way line work.
- 4.04.6.03.05** Define the preliminary fastest paths and their corresponding radii and speeds. See Section 4.04.6.04.15 for guidelines on designing and checking for entry speed on roundabout approaches.
- 4.04.6.03.06** Provide sufficient design to accommodate a WB-67 truck and show the swept paths. There may be some intersections where the design will need to accommodate oversized and overweight vehicles (OSOW) and change the design vehicle requirement. Site observation and a desktop-level screening of potential nearby origins and destinations for OSOWs should be performed prior to the preliminary design to confirm the design vehicle to be used.
- 4.04.6.03.07** Show and label sight lines and sight triangles relative to vertical and horizontal alignment for the approach legs, pedestrian crosswalks, and through the roundabout. Do this in accordance with the National Cooperative Highway Research Program (NCHRP) Report 672, Section 6.7 Performance Checks<sup>3</sup>.
- 4.04.6.03.08** Use ARCADY<sup>4</sup> or HCM to analyze the level of service for the roundabout and compare it to other alternative intersection designs. The roundabout shall provide a minimum LOS C or better.
- 4.04.6.03.09** Identify any impacts on nearby intersections, driveways, bus stop locations, and/or traffic signals caused by queuing at the roundabout. Also note the type of control at nearby intersections.

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<sup>3</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition

<sup>4</sup> [www.trl.co.uk](http://www.trl.co.uk)

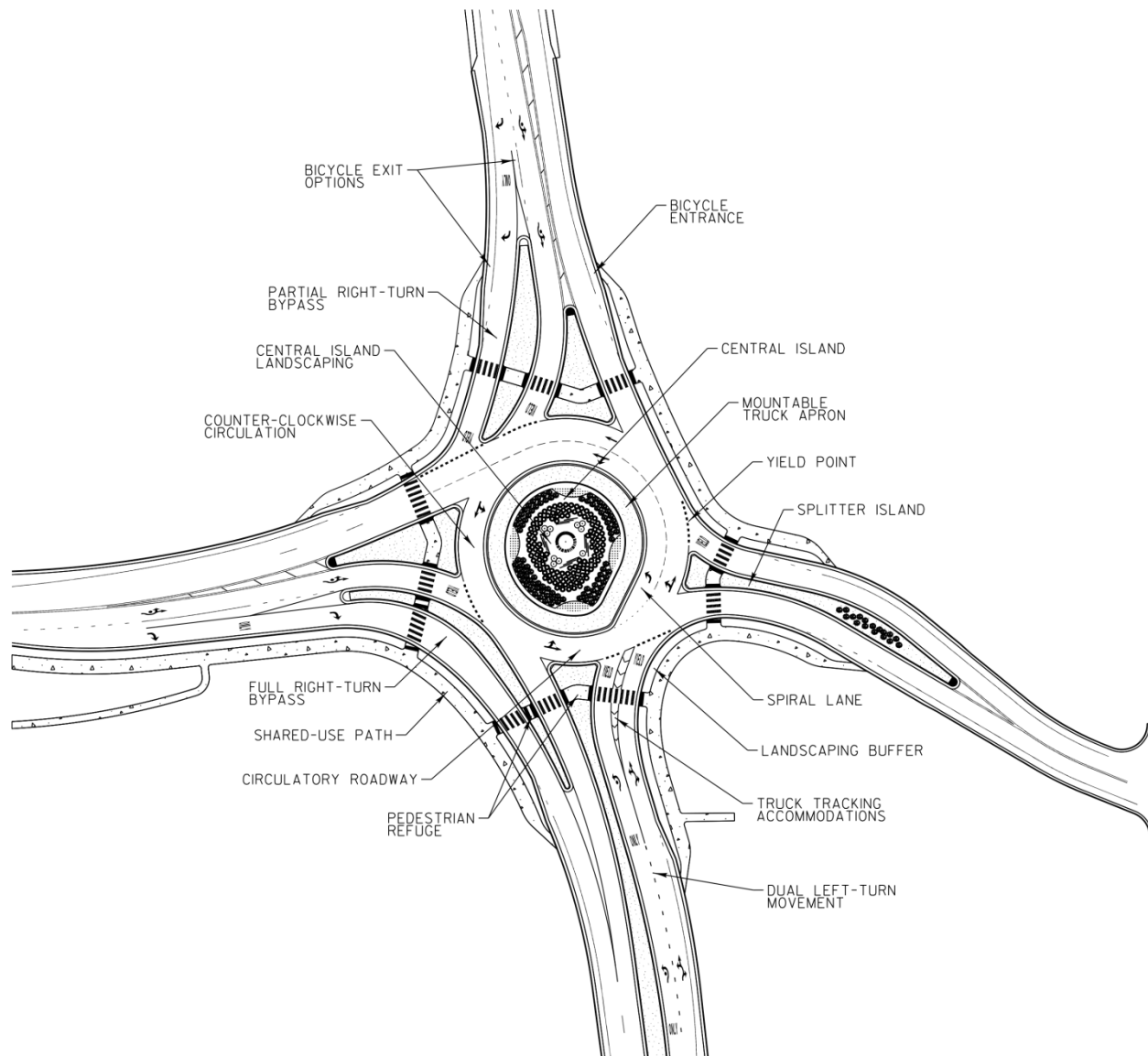
**4.04.6.03.10** Identify potential construction or phasing issues and proposed mitigation measures if the roundabout is replacing an existing standard intersection.

**4.04.6.03.11** Show and label the auto turn tracking templates for the design vehicle identified in Section 4.04.6.04.01 through the roundabout for all turn/through movements.

**4.04.6.04** Design guidelines shall be as follows:

**4.04.6.04.01** Single lane roundabouts shall be designed to allow single passenger cars, pickups, and single unit (SU) trucks (B-40, BUS-45) to proceed without requiring the use of a truck apron. For two lane roundabouts the design shall generally accommodate a WB-50 vehicle without the use of a truck apron. All roundabouts shall be designed to a WB-67 vehicle, except as noted in Section 4.04.6.03.06 above. Two lane roundabouts shall be designed to allow a WB-50 and/or the largest fire truck to track in lanes on approach, entry, circulating, and exiting. For left turning movements of a WB-50, this assumes the truck will use the left lane and the truck apron for over tracking. For the largest fire truck the left turning truck must stay on the travel way. The equivalent turning template for a City of Aurora fire truck is the BUS-45.

**4.04.6.04.02** The approach roadway may be single lane, single lane with a transition to add a left-only or right-only turn movement, single lane with a by-pass or partial by-pass right turn lane, or two lanes without added lanes or an added by-pass or partial by-pass right turn lane. Figure 4.04.6.04.02.1 shows an example with a combination of exclusive and bypass lanes. A lane schematic must be developed in advance of this. It shall be developed according to AM and PM lane by lane traffic demands, in some cases allowing for staged expansion from single lane entries to two lane entries. On the diagram an exclusive left-turn lane is shown developed using a spiral design to ensure no lane changes are required for the correct lane choice to exit without crossing lanes. The configuration used will be based on the intersection's projected traffic movements as provided in the schematic design submittal discussed in Section 4.04.6.02.



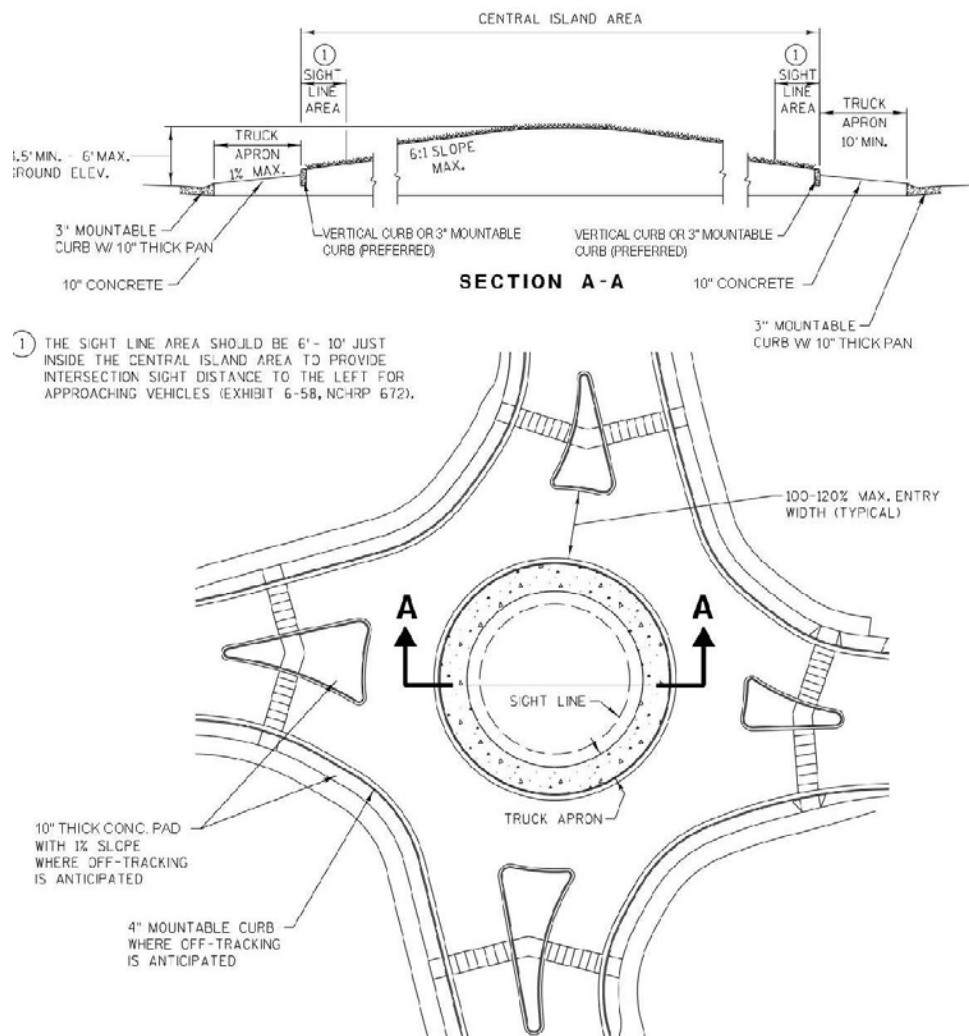
**Figure 4.04.6.04.02.1<sup>5</sup>**  
**Example of Exclusive and Bypass Lanes**

**4.04.6.04.03** Where intersections have high right turn lane traffic volumes the designer needs to consider the use of right turn bypass lanes or partial right turn bypass lanes. The use of these bypass lanes may increase the capacity of a single lane roundabout and not require a multiple lane roundabout. However, the use of a full bypass right turn lane will likely increase the speed of this traffic movement resulting in potential conflicts with bicyclists and pedestrians, especially pedestrians with sight impairments. The exiting

<sup>5</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Figure 30.15

traffic from a right turn bypass lane shall transition in accordance with Section 4.04.6.04.10. The use of the partial right turn bypass lane provides a yield control where traffic is slowed and provides better accommodation of bicyclists and pedestrians.

**4.04.6.04.04** The central island of the roundabout shall be a raised and non-traversable area encircled by the roundabout's circulatory roadway and truck apron, if required. The center or highest point within the central island shall not exceed six feet and have a maximum slope of 6:1 with a minimum slope of four percent. Figure 4.04.6.04.04.1 illustrates the combination of elements described above.



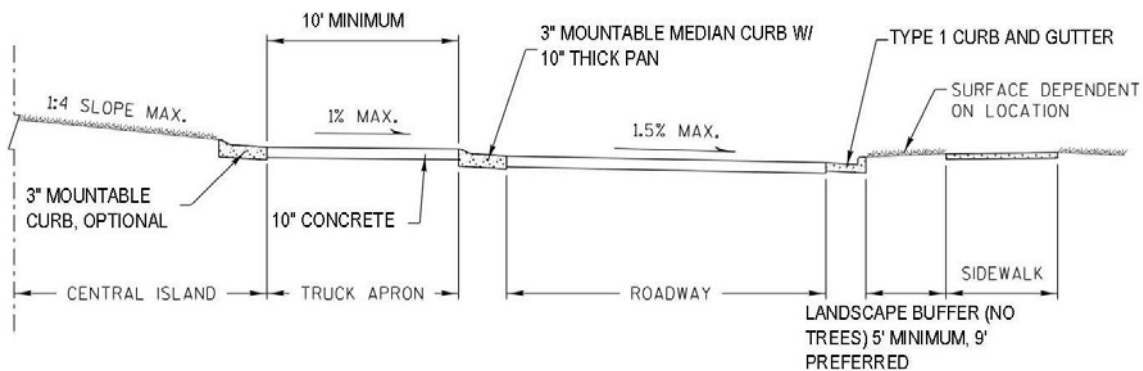
**Figure 4.04.6.04.04.1<sup>6</sup>**  
**Example of Raised Central Roundabout Island**

<sup>6</sup> Wisconsin Department of Transportation, Roundabout Guide, March 2013, Update, Figure 40.1 (modified)

**4.04.6.04.05** Circulatory roadway width is the width between the outer edge of the inscribed diameter, curb flowline, and the central island curb flowline. Typical width for a single-lane roundabout ranges between 18-feet to 20-feet. However, care must be taken so drivers will not think there is room for two lanes of travel. For a two-lane roundabout the width ranges from 26-feet to 32-feet. However, the circulatory roadway width is dependent on the design vehicle. See Section 4.04.6.04.01.

**4.04.6.04.06** Curbing shall be six-inch vertical curb within the roundabout and on the approaches for low-speed approaches. High-speed approaches, usually present in rural settings, shall require a transition section where the shoulders shall narrow and vertical curb is introduced. This gives the approaching driver a visual notice a roundabout is ahead and requires a decrease in speed.

**4.04.6.04.07** The cross-slope of the circulatory roadway for single lane roundabouts shall be in the range of one percent to one and one-half percent, sloped away from the truck apron. For two lane roundabouts the circulatory roadway shall have a 1.5 percent cross slope away from the truck apron as shown on Figure 4.04.6.04.07.1.



**Figure 4.04.6.04.07.1**  
**Example of Circulatory Roadway Cross-section**

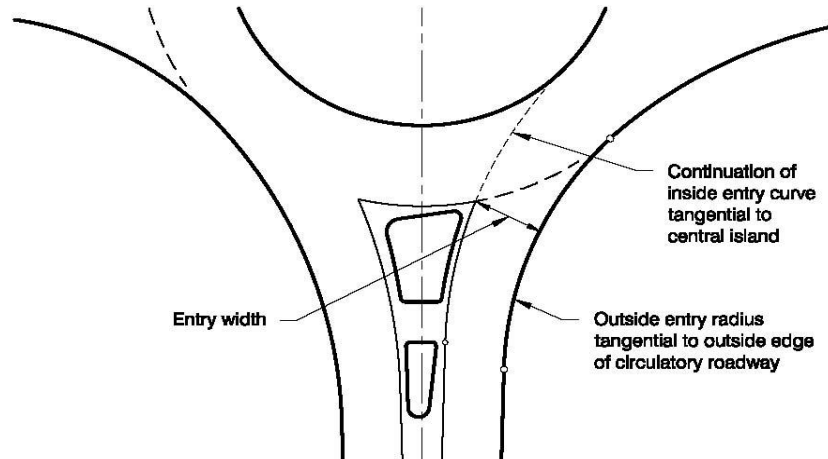
**4.04.6.04.08** Traversable truck aprons are used to accommodate large vehicles while maintaining relatively smaller roundabout dimensions. Accordingly, the width of the truck apron shall be determined by the WB-67 vehicle path around the roundabout.

Truck aprons shall be of contrasting color to the circulatory roadway. The concrete shall **not** be stamped. The outside radius of the truck apron shall

be delineated with a mountable, spill, median curb with a three-inch height and a rolled profile.

#### **4.04.6.04.09 Entry Widths**

**4.04.6.04.09.1** The entry width is measured perpendicularly from the outside curb face to the point of intersection of the continuation of the inside entry curve tangential to the central island and the inscribed circle diameter. See Figure 4.04.6.04.09.1.1.



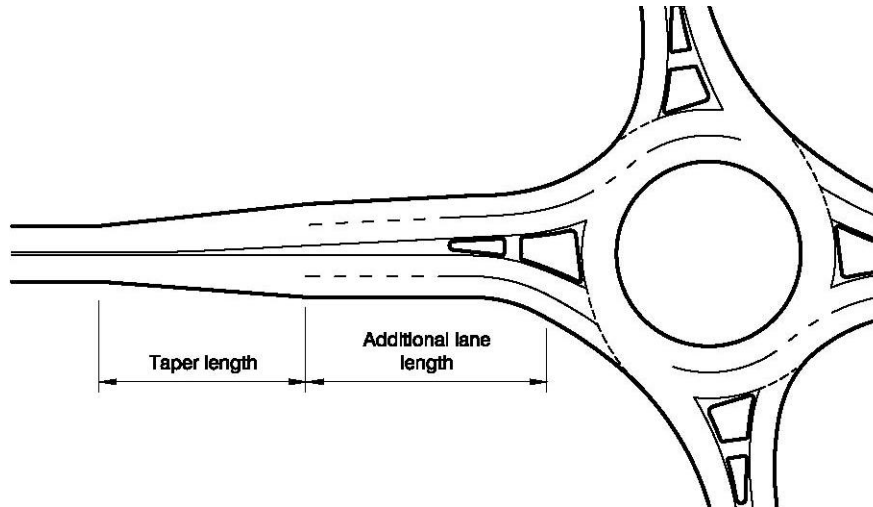
**Figure 4.04.6.04.09.1.1<sup>7</sup>**  
**Entry Width Measurement**

The entry width is dependent on the design vehicle. The width for a single-lane roundabout is a minimum of 19 feet with upwards of 22 feet, flowline to flowline, required to accommodate a WB-67 truck at entries. For a two lane roundabout the entry width will range from 28 feet to 30 feet, flowline to flowline, to allow a WB-50 truck to track in lane. Pavement marking of a striped gore area between lanes will restrict lanes to 12 feet.

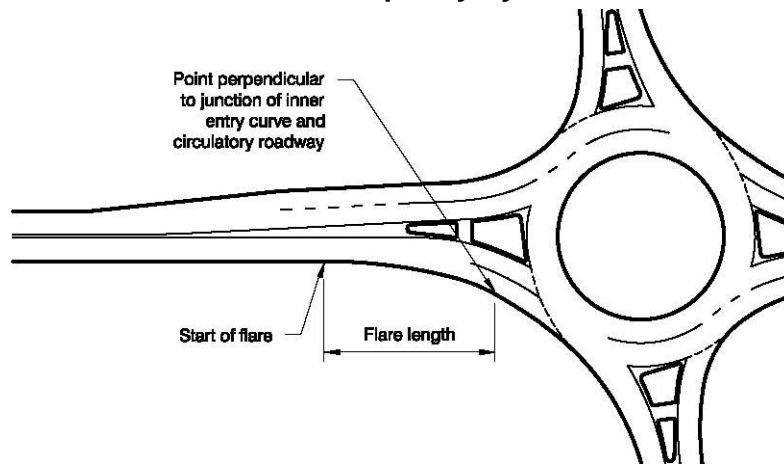
**4.04.6.04.09.2** Where extra entry capacity is warranted flaring an entry from one lane to two lanes will increase entry capacity with minimal midblock widening. See Figures 4.04.6.04.09.2.1 and 4.04.6.04.09.2.2 for two alternatives.

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<sup>7</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition



**Figure 4.04.6.04.09.2.1<sup>8</sup>**  
**Increased Roundabout Capacity by an Additional Lane**



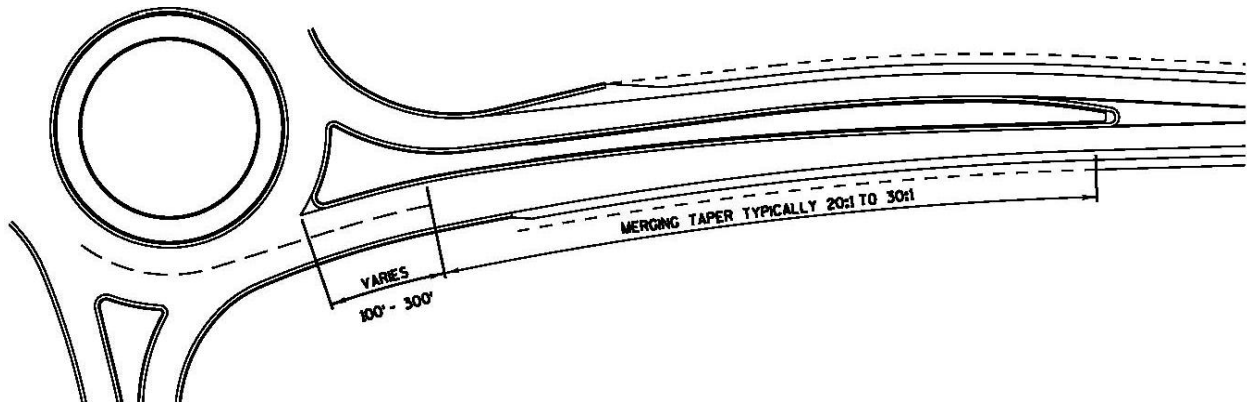
**Figure 4.04.6.04.09.2.2<sup>8</sup>**  
**Increased Roundabout Capacity by an Additional Lane**

**4.04.6.04.10** For the single lane roundabout where the entry lanes were flared to two lanes, the exit tapering from the two lanes back to one lane allows for additional capacity while minimizing the midblock widening. The exit speeds are much slower and eliminates the need for a long parallel section downstream of an exit. The design exit tapers are based on the exiting speed, not the fastest path speed, which usually is within the range of 15 mph to 25 mph. This results in a taper between 20:1 and 30:1. The length of the full width lanes beyond the circulatory roadway may vary between 100 feet and 300 feet. This distance is dependent on traffic volumes,

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<sup>8</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition

potential upstream lane choice, and factors unique to the roundabout site. See Figure 4.04.6.04.10.1.



**Figure 4.04.6.04.10.1<sup>9</sup>**  
**Exit Tapering from Two Lanes Back to One**

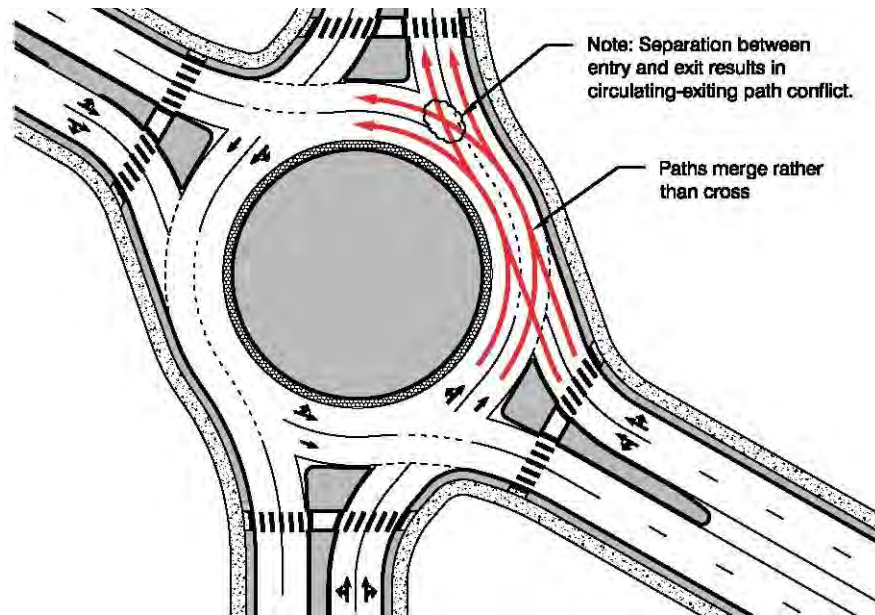
**4.04.6.04.11** Exit curvature for multilane roundabouts requires attention to the exit path trajectories of both lanes to minimize conflicts from the multiple lanes. If proper entry lane assignments are not identified, then there will likely be conflicts between exiting and circulating traffic. Care must also be taken to minimize vehicle path overlap from too much curvature of the exit geometry. The exit curvature radii needs to be established to minimize traffic on the inside lane to exit through the outside lane on a more comfortable turning radius.

Entries and exits need to be separated by roughly equal angles. Do not allow too much separation from the entries and subsequent exits. Large separations tend to allow for entering traffic to be alongside circulating traffic that might be exiting. See Figure 4.04.6.04.11.1 for an illustration of this conflict.

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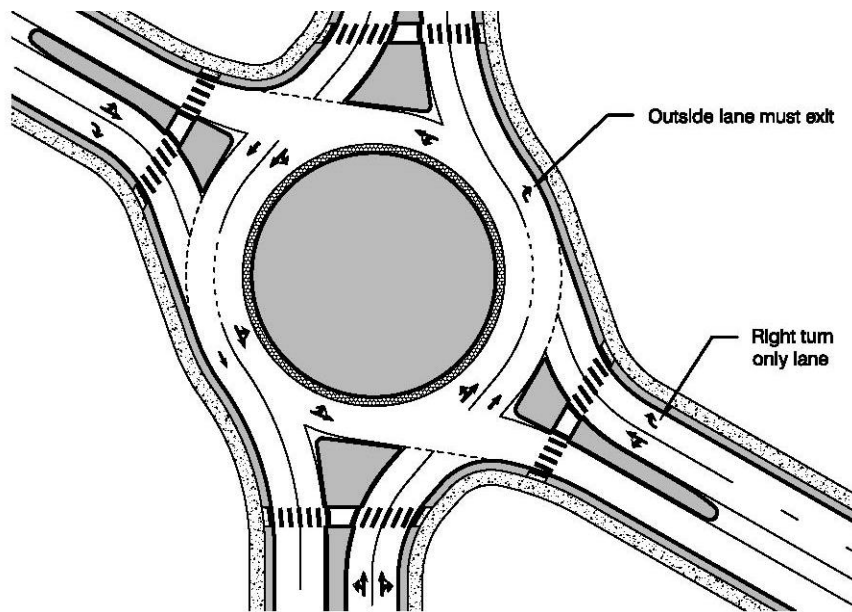
<sup>9</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Figure 30.22





**Figure 4.04.6.04.11.1<sup>10</sup> - Flow Conflicts Example**

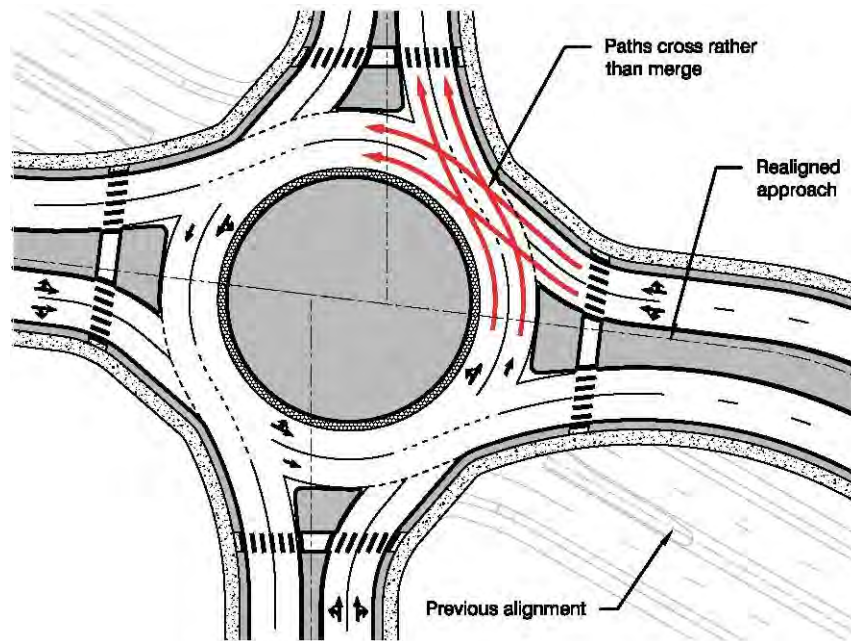
If the alignment of approach roadways can be altered a possible alternative to the above figure is shown in Figure 4.04.6.04.11.2. A better alternative is shown in Figure 4.04.6.04.11.3 where the traffic flow paths are crossing rather than merging and weaving.



**Figure 4.04.6.04.11.02<sup>11</sup> - Alternative to Flow Conflicts Example**

<sup>10</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Exhibit 6-33

<sup>11</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Exhibit 6-34

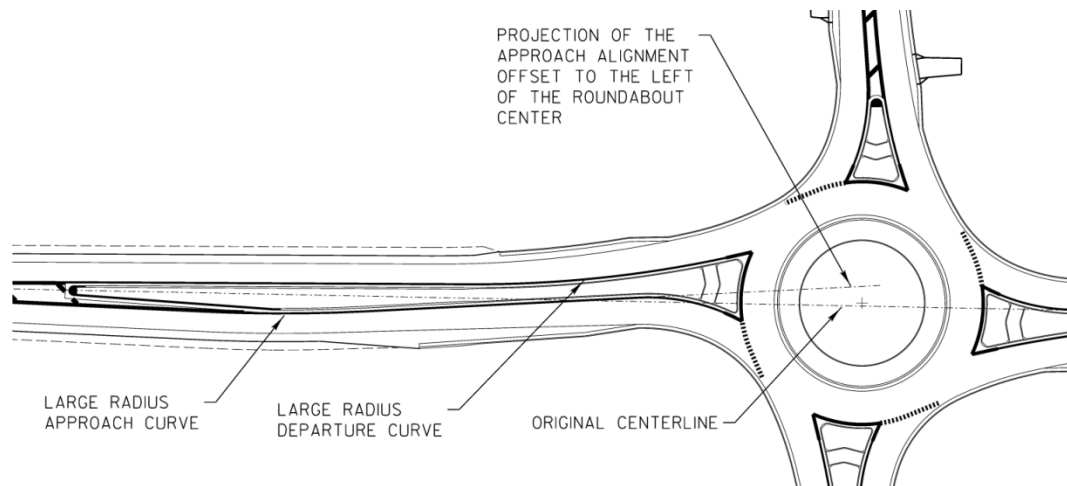


**Figure 4.04.6.04.11.3<sup>12</sup>**  
**Better Alternative to Flow Conflicts Example**

**4.04.6.04.12** It is desirable to have the entry path deflection in a roundabout approach design so drivers may be made aware of the roundabout and decelerate to the appropriate entry speed. Deflection can be accomplished by offsetting the approach alignment to the left of the roundabout center, flattening the exit curvature to the maximum extent possible, and/or realigning the entry lanes through the use of a subtle series of reverse curves as shown on Figure 4.04.6.04.12.1. Choose approach curves that progressively slows the approaching driver and do not apply super-elevation downstream of the approach median bull-nose. Approach alignments to the center or slightly right of center will **not** be acceptable.

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<sup>12</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Exhibit 6-35



**Figure 4.04.6.04.12.1<sup>13</sup>**  
**Entry Path Alignment Encouraging Slower Speed Entry**

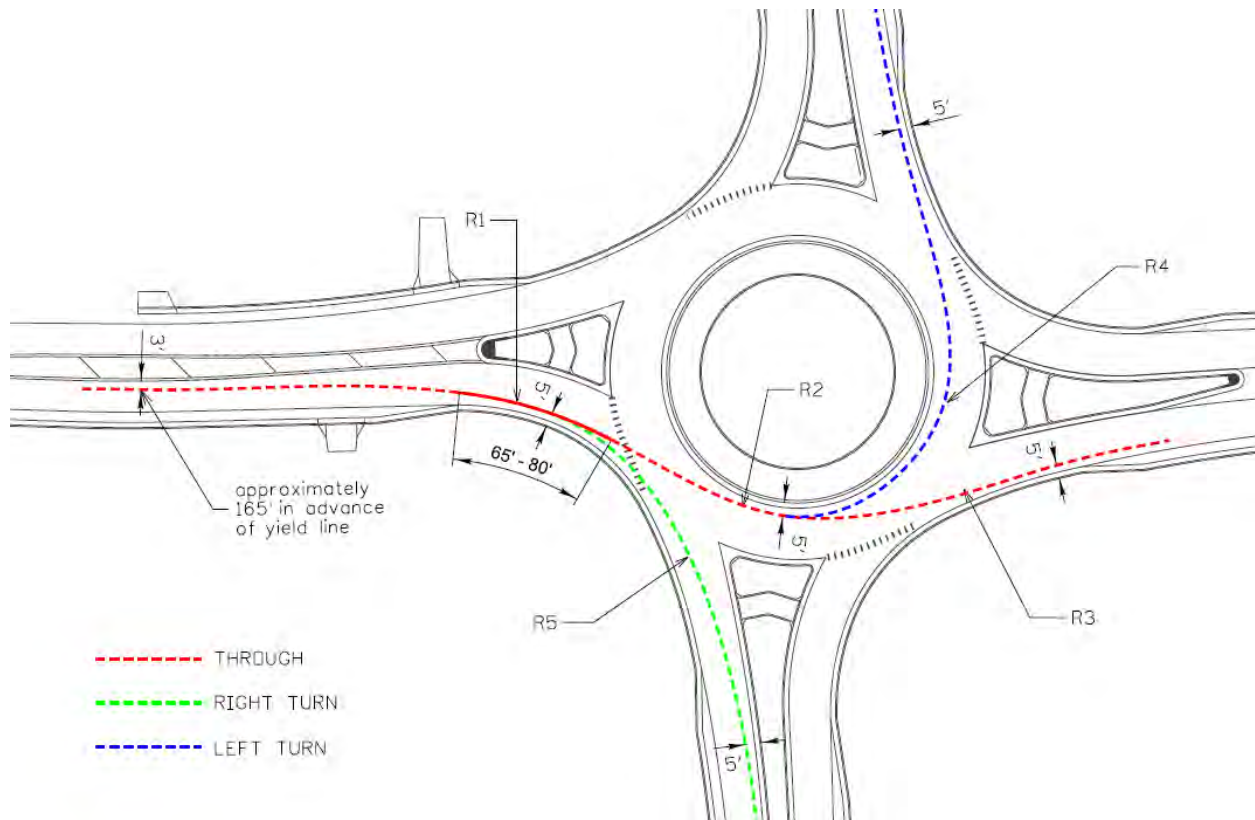
**4.04.6.04.13** To aid speed reduction on approaches with a posted speed of 40 mph or higher, splitter islands shall have the length of approximately the deceleration distance per Figure 2-25, ASSHTO 2011 A Policy on Geometric Design<sup>14</sup>, or a minimum of 200 feet. For lower speed urban conditions, the minimum splitter island length is 50 feet.

**4.04.6.04.14** The design speed of a roundabout is defined by the theoretical speed drivers could achieve through the roundabout if taking the smoothest, fastest path through the roundabout without regard to lane line striping.

**4.04.6.04.15** The theoretical design speed of each movement is determined by drawing the fastest path allowed by the geometrical design. Figure 4.04.6.04.15.1 illustrates the three major movements through a single-lane roundabout and the five corresponding critical path radii required to be checked for each approach. All of these paths are represented by spline curves and shall be drawn at a starting point not less than 165 feet in advance of the yield line with an offset of five feet from curbs or three feet from stripes if there is no curb. The five critical radii are best fit to said curves and are measured over a distance of 65 feet to 80 feet.

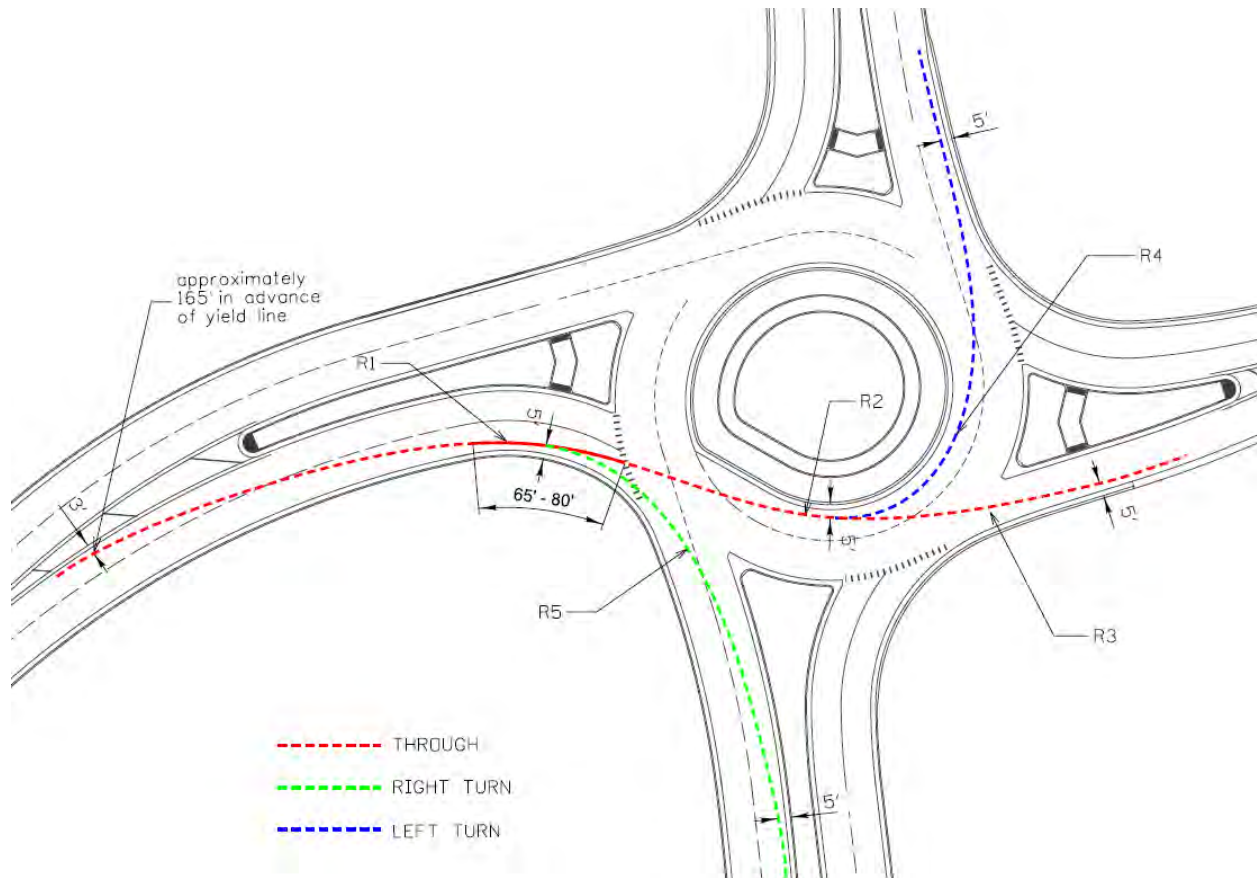
<sup>13</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Figure 30.2

<sup>14</sup> American Association of State Highway and Transportation Officials, *A Policy on Geometric Design*, 2011, 6<sup>th</sup> Edition, Figure 2-25



**Figure 4.04.6.04.15.1**  
**Single Lane Roundabout Fastest Paths Example**

For multilane roundabouts, there are two paths of interest: the fastest paths if vehicles stay in the correct lanes, and the fastest paths if they do not. Figure 4.04.6.04.15.02 illustrates the three major movements through a two-lane roundabout if the vehicles do not obey lane striping. The in-lane speeds are also of value in analyzing fastest-paths of multilane roundabouts.



**Figure 4.04.6.04.15.2**  
**Two Lane Roundabout Fastest Paths Example**

Table 4.04.6.04.15.01 summarizes the descriptions of the critical radii as well as the corresponding range of speeds the design should aim to achieve. Vehicle speed estimation is in accordance with NCHRP 672, Section 6.7.1.2 Equations 6-1 and 6-2<sup>15</sup> (Equations 4.04.10.04.03.01 and 4.04.10.04.03.02 below). Equation 6-3 may be used to estimate actual entry speed, but it will not govern the design.

$R_1$  equals the minimum entry path radius with a speed range of 20-25 mph for a single lane roundabout and 25-30 mph for a multilane roundabout. This radius is measured over a distance of 65 feet to 80 feet near the yield line, but not more than 165 feet in advance of the yield line.  $R_2$  equals the circulating path radius with a speed range of 15-25 mph for any type of roundabout.  $R_3$  equals the exit path radius with a speed range of  $R_2$  plus the

<sup>15</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition

acceleration over the path to the exit crosswalk location.  $R_4$  equals the left turn path radius with a speed range of 10-22 mph for any type of roundabout.  $R_5$  equals the right turn path radius with a speed range of 15-20 mph for any type of roundabout.

The relationship between vehicle speed and the horizontal curvature can be determined in the following equations corresponding to superelevation values of +0.02 and -0.02 for two percent cross-slopes.

$$V = 3.4415R^{0.3861}, \text{ for } e = +0.02 \quad \text{Equation 4.04.10.04.03.01}$$

$$V = 3.4614R^{0.3673}, \text{ for } e = -0.02 \quad \text{Equation 4.04.10.04.03.02}$$

where

$V$  = predicted speed, mph;

$R$  = radius of curvature, ft.; and

$e$  = superelevation, ft. /ft.

**Table 4.04.6.04.15.01 Roundabout Critical Radii<sup>16</sup>**

Critical Radius	Description	Range of Speeds
Entry Path Radius, $R_1$	The minimum radius on the fastest through path prior to the yield line. This is not the same as Entry Radius.	Single Lane 20 to 25 mph Multilane 25 to 30 mph Multilane in-lane 20 to 22 mph
Circulating Path Radius, $R_2$	The minimum radius on the fastest through path around the central island.	15 to 25 mph
Exit Path Radius, $R_3^*$	The minimum radius on the fastest through path into the exit.	$R_2$ + Acceleration over the path to the exit crosswalk Desirable < 25 mph
Left Turn Path Radius, $R_4$	The minimum radius on the path of the conflicting left-turn movement.	10 to 20 mph
Right Turn Path Radius, $R_5$	The minimum radius on the fastest path of a right-turning vehicle.	15 to 22 mph

\* Where pedestrian crossing traffic on exits is expected to be moderate to high slower exit speeds are desirable. Increased exit curvature will facilitate lower exit speeds. However, in multi-lane design excessive exit curvature may create exit path overlap, an added safety concern.

<sup>16</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Table 30.2 (modified)

**4.04.6.04.16** The design of roundabout approaches and circulating roadways shall account for Stopping Sight Distance. This is the distance along a roadway required for a driver to perceive and react to an object in the roadway and to brake to a complete stop before reaching the object. Stopping sight distance of the entry to the roundabout shall be provided at every point within a roundabout and on each entering and exiting approach and from an entry to the next exit crosswalk<sup>17</sup>. See Figures 4.04.6.04.16.1 through 4.04.6.04.16.3 and Table 4.04.6.04.16.01.

Approach stopping sight distance shall be as calculated in Equation 4.04.6.04.16.01 and measured from the approach to the entry point of the roundabout as a minimum and, preferably, from the approach to the upstream side of the crosswalk, if provided, as shown in Figure 4.04.6.04.16.1. Show and label sight distance for pedestrian crosswalks and sight for circulating traffic.

$$d = (1.468)(t)(V) + 1.087(V^2) \div a \quad \text{Equation 4.04.6.04.16.01}^{18}$$

Where:

d = stopping sight distance, ft.;

t = perception – brake reaction time, assumed to be 2.5 s;

V = initial speed, mph; and

a = driver deceleration, assumed to be 11.2 ft. /s<sup>2</sup>.

**Table 4.04.6.04.16.01<sup>19</sup>**  
**Stopping Sight Distance**

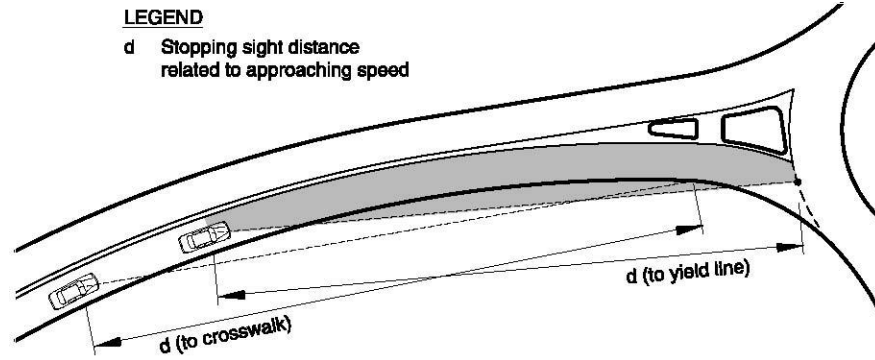
Speed (km/h)	Computed Distance* (m)	Speed (mph)	Computed Distance* (ft)
10	8.1	10	46.4
20	18.5	15	77.0
30	31.2	20	112.4
40	46.2	25	152.7
50	63.4	30	197.8
60	83.0	35	247.8
70	104.9	40	302.7
80	129.0	45	362.5
90	155.5	50	427.2
100	184.2	55	496.7

\* Assumes 2.5 s perception–braking time, 3.4 m/s<sup>2</sup> (11.2 ft/s<sup>2</sup>) driver deceleration

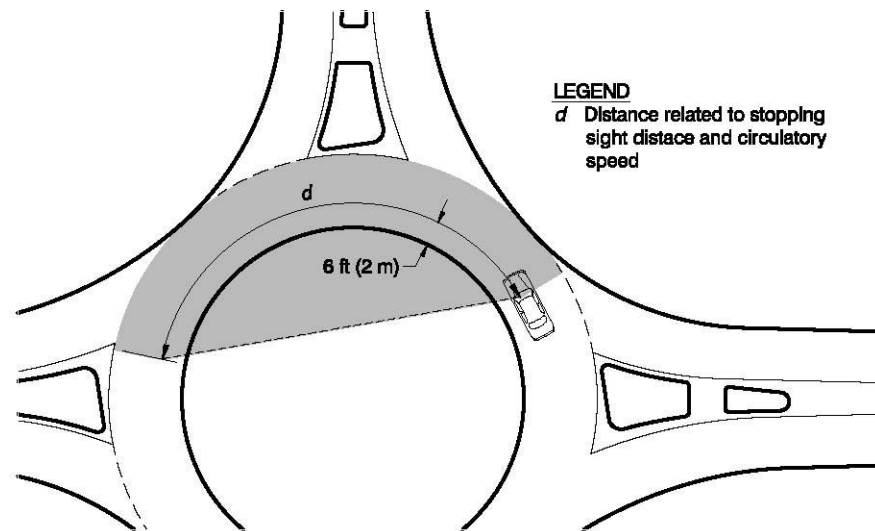
<sup>17</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition

<sup>18</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Equation 6-5

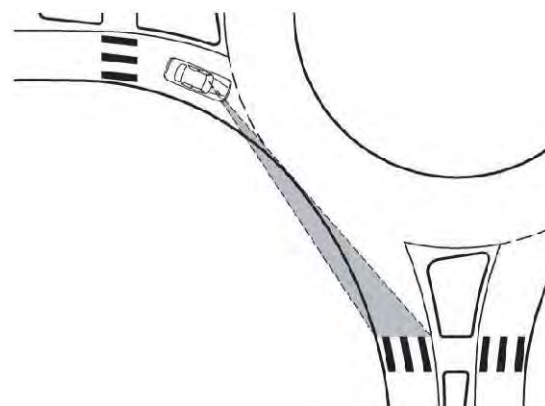
<sup>19</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Exhibit 6-54



**Figure 4.04.6.04.16.1<sup>20</sup> - Stopping Sight Distance at Entry**



**Figure 4.04.6.04.16.2<sup>20</sup> – Stopping Sight Distance within Roundabout**



**Figure 4.04.6.04.16.3<sup>20</sup> – Stopping Sight Distance at Exit**

<sup>20</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Exhibits 6-55 through 6-57



**4.04.6.04.17** Intersection Sight Distance (ISD) is the distance required for a driver without the right-of-way to perceive and react to the presence of conflicting vehicles. The following equations determine the theoretical ISD.

$$d_1 = (1.468)(V_{major, entering})(t_c) \quad \text{Equation 4.04.6.04.17.01}^{21}$$

$$d_2 = (1.468)(V_{major, circulating})(t_c) \quad \text{Equation 4.04.6.04.17.02}^{21}$$

where

$d_1$  = length of entering leg of sight triangle, ft.;

$d_2$  = length of circulating leg of sight triangle, ft.;

$V_{major}$  = design speed of conflicting movement, mph, discussed below;  
and

$T_c$  = critical headway for entering the major road, s, equal to 5.0 s.

Two conflicting traffic streams should be checked at each entry:

1. *Entering stream*, which is composed of vehicles from the immediate upstream entry. The speed for this movement can be approximated by taking the average of the theoretical entering ( $R_1$ ) speed and the circulating ( $R_2$ ) speed.
2. *Circulating stream*, which is composed of vehicles that enter the roundabout prior to the immediate upstream entry. This speed can be approximated by taking the speed of left-turning vehicles (path with radius  $R_4$ ).

**Table 4.04.6.04.17.01<sup>22</sup>**  
**Intersection Sight Distance**

Conflicting Approach Speed (mph)	Computed Distance (ft.)
10	73.4
15	110.1
20	146.8
25	183.5
30	220.2

Note: Computed distances are based on a critical headway of 5.0 s.

The critical headway for entering the major road is based on the amount of time required for a vehicle to safely enter the conflicting stream. The critical headway value of 5.0 s ... is based upon the critical headway required for passenger cars<sup>23</sup>. Figures 4.04.6.04.17.1 and 4.04.6.04.17.2 s

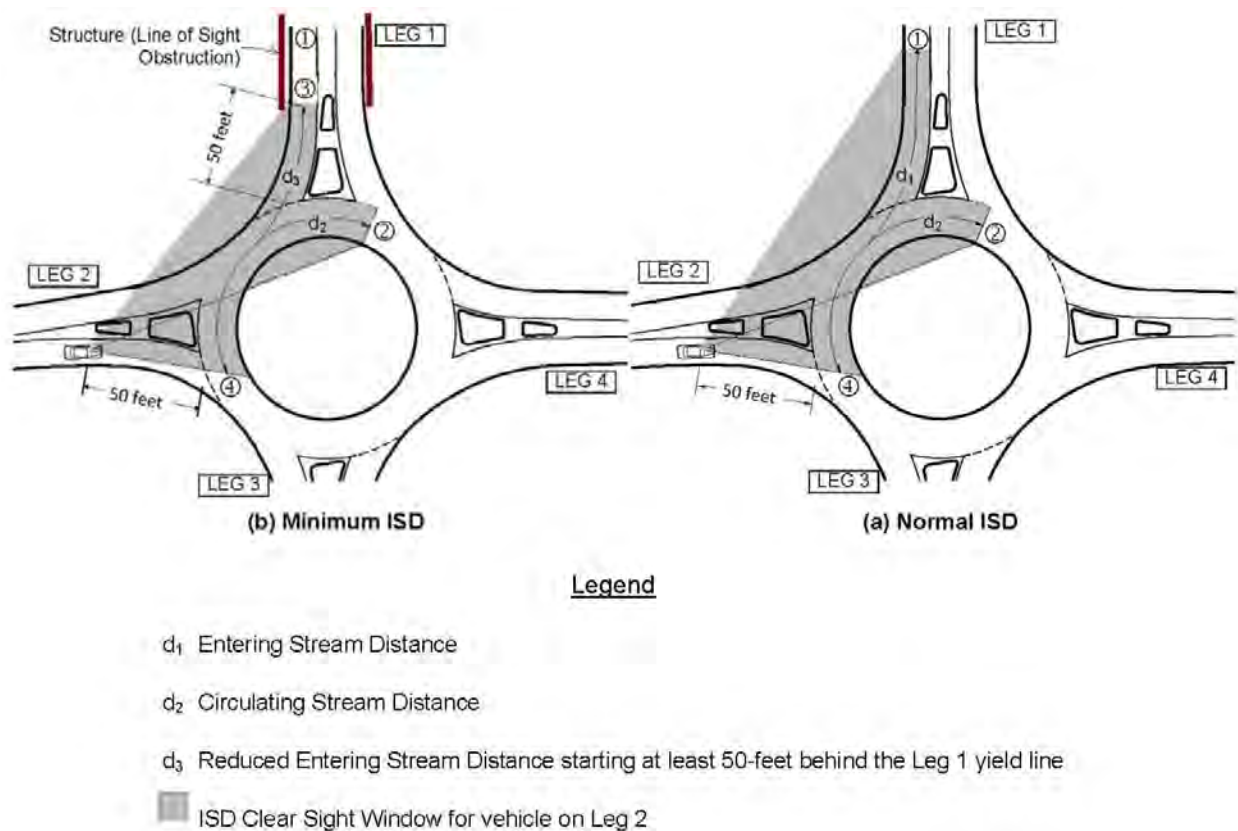
<sup>21</sup> North American Roundabout Workshop, Roundabout Design Details, presented by GHD, April 15, 2014, Seattle.

<sup>22</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Exhibit 6-59

<sup>23</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26

how examples of combined intersection sight and stopping sight distance check diagrams with a design that has a sight restriction, requiring the use of the minimum sight to the left.

Designer experience and judgment is needed to balance the impacts where ISD is severely restricted or where excessive ISD is available. More sight distance is **not** better when it comes to ISD for roundabouts<sup>24</sup>. In most cases it is best to provide no more than the minimum required ISD on each approach<sup>25</sup>. Where there is excessive sight distance the use of landscaping or other obstructions to restrict the sight distance to the acceptable ISD.

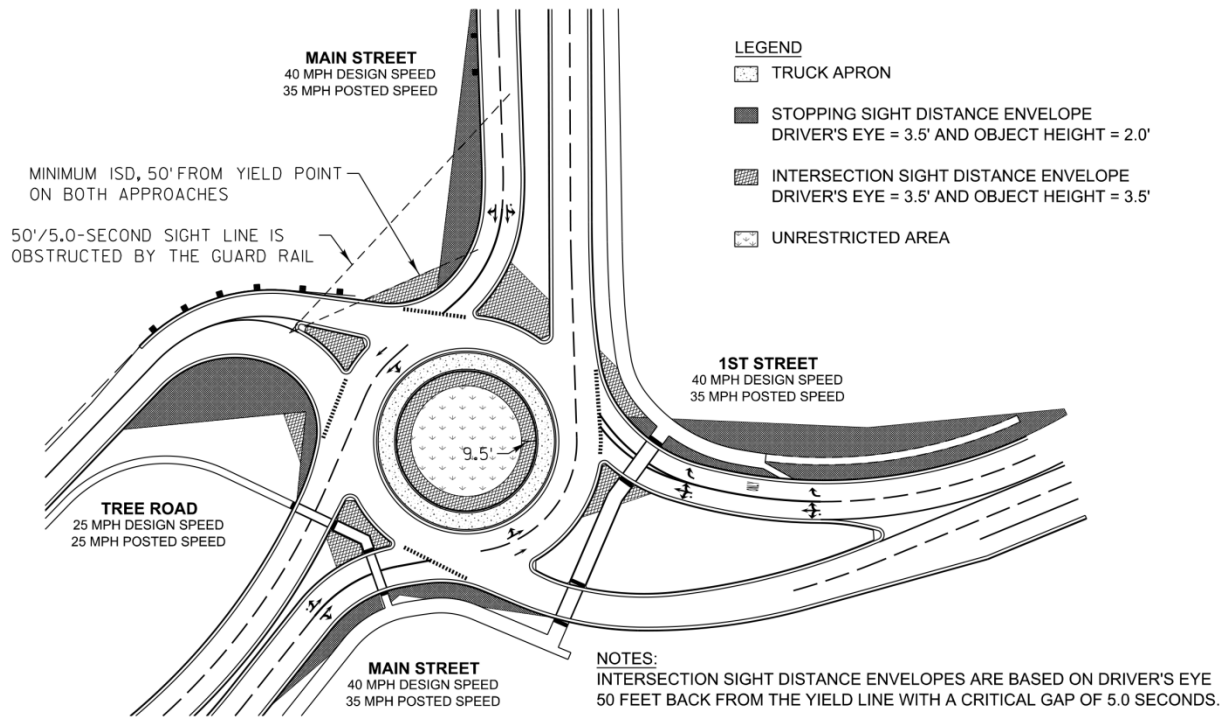


**Figure 4.04.6.04.17.126**  
**Combined Intersection and Stopping Sight Distance – Single Lane**

<sup>24</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Paragraph 30.5.15

<sup>25</sup> North American Roundabout Workshop, Roundabout Design Details, presented by GHD, April 15, 2014, Seattle

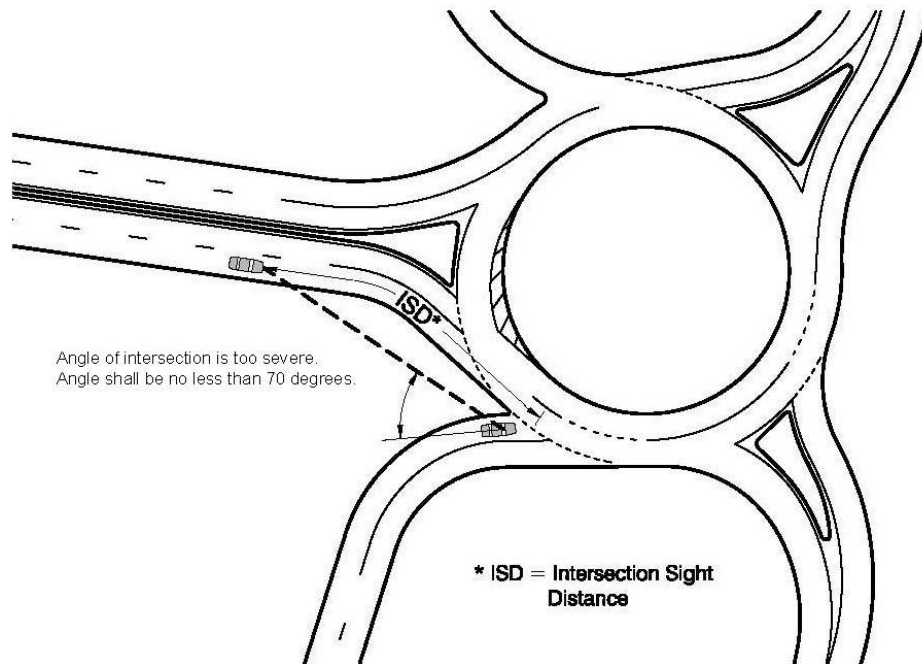
<sup>26</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Figure 30.14



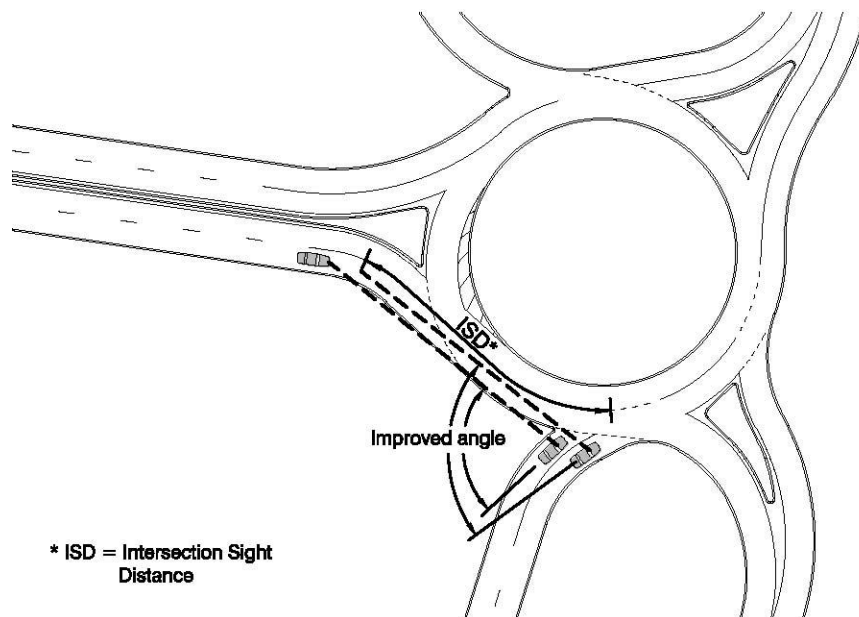
**Figure 4.04.6.04.17.2**  
**Combined Intersection and Stopping Sight Distance – Two Lane**

**4.04.6.04.18** The intersection angle between consecutive entries must not be overly acute in order to allow drivers to comfortably turn their heads to the left to view oncoming traffic from the immediate upstream entry. Based on guidance for designing for older drivers and pedestrians, the recommended angle for visibility to the left at entry is  $90^\circ \pm 15^\circ$ . The designer is cautioned not to provide generous sight to the left as this can contribute to failure to yield conflicts and collisions<sup>27</sup>. In no case should the sight angles be less than  $70^\circ$ . See Figures 4.04.6.04.18.1 and 4.04.6.04.18.2.

<sup>27</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition



**Figure 4.04.6.04.18.1<sup>28</sup> - Example of Poor Sight Angle**



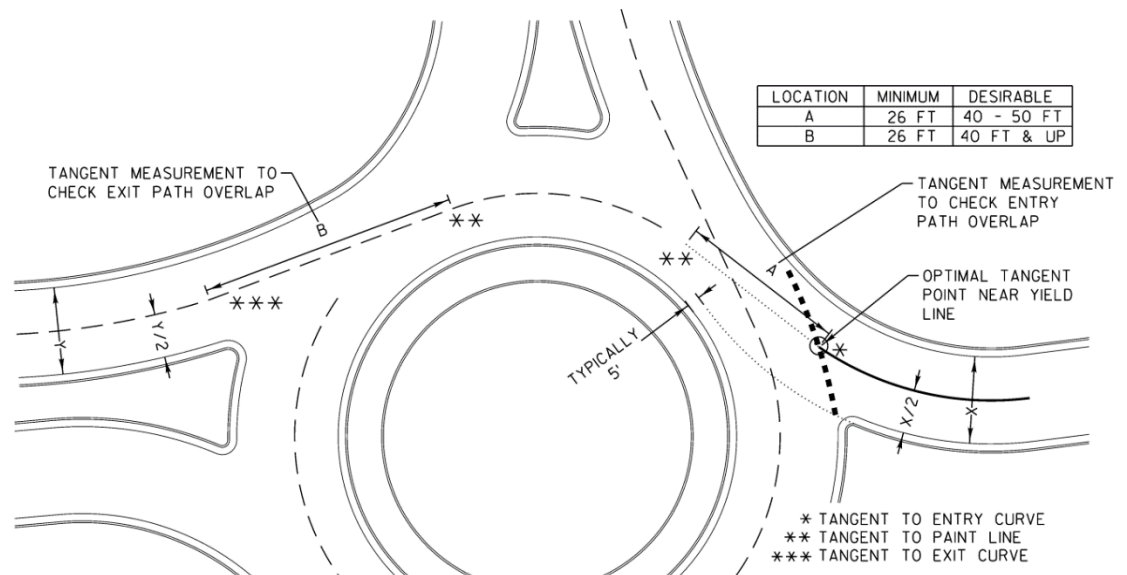
**Figure 4.04.6.04.18.2<sup>28</sup> – Example of Improved Sight Angle**

**4.04.6.04.19** In multilane roundabouts, path overlap occurs when the natural paths of vehicles in adjacent lanes overlap or cross one another. It occurs most

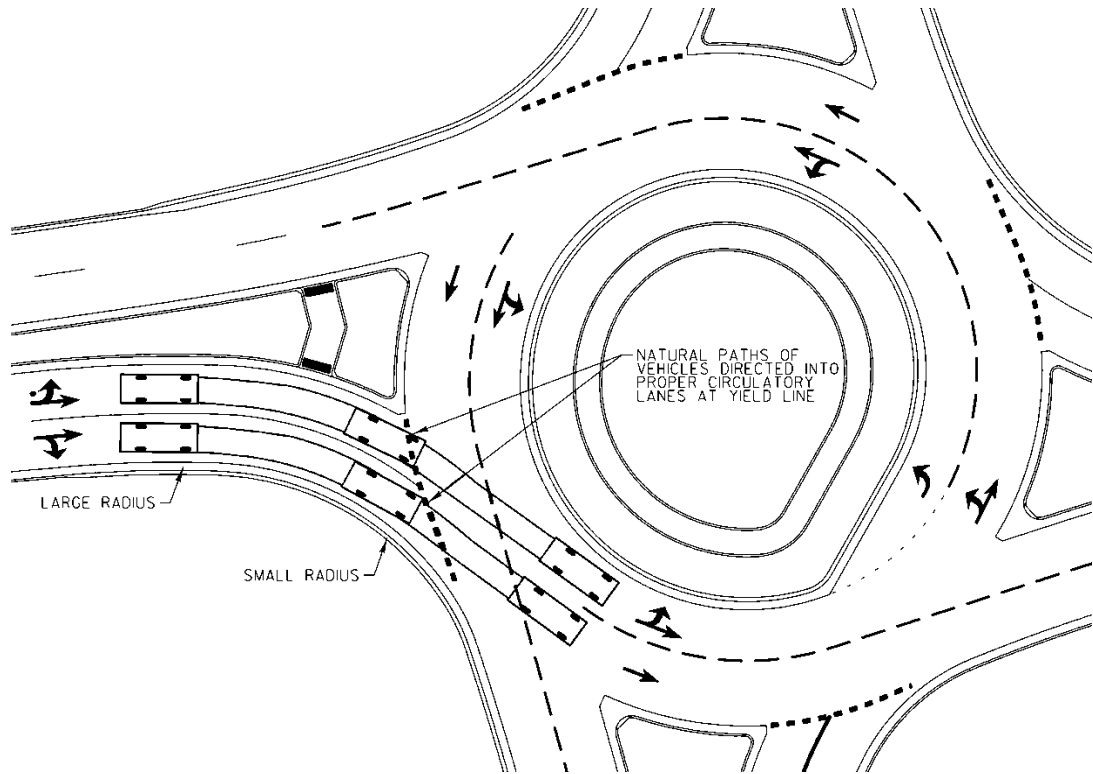
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<sup>28</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition

commonly at entries, where the geometry of the right-hand lane tends to lead vehicles into the left-hand circulatory lane. However, vehicle path overlap can also occur at exits, where the exit geometry or pavement marking of the exit tends to lead vehicles from the left-hand lane into the right-hand exit lane. To avoid path overlap, the desirable tangent length of 40 feet to 50 feet, or two car lengths, for the entry path tangent and 40 feet and greater for the exit path tangent. The minimum tangent length to avoid entry and exit path overlap is 26 feet, or one car length. As a rule of thumb, path overlap can be avoided if there is approximately five feet between the face of the central island curb and the extension of the face of the splitter island curb with the radius of that curve face extension in the range of 100 feet, see Figure 4.04.6.04.19.1. The result of proper entry design is shown in Figure 4.04.6.04.19.2.

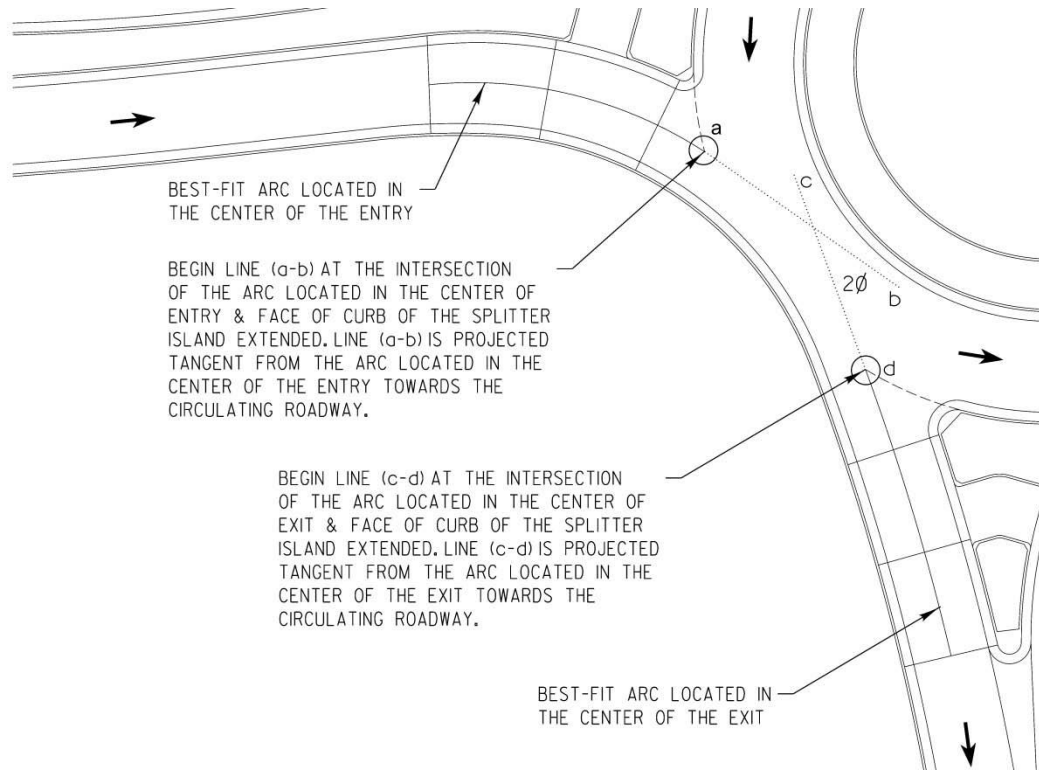


**Figure 4.04.6.04.19.1<sup>29</sup>**  
**Tangent Lengths at Entry and Exit to Minimize Path Overlap**

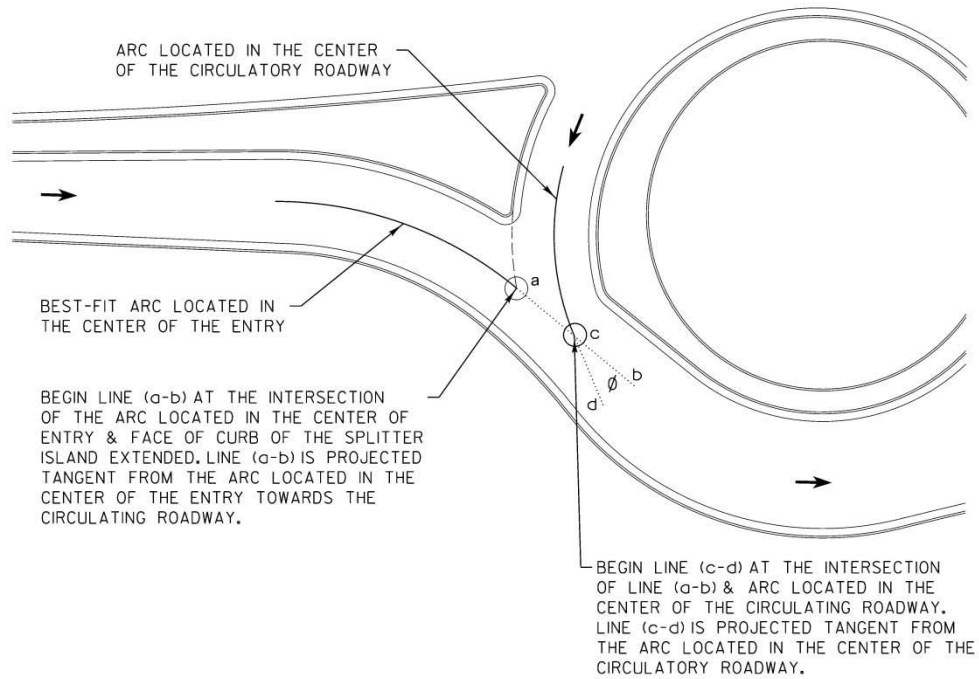


**Figure 4.04.6.04.19.2<sup>30</sup>**  
**Example of Proper Tangent Length Minimizing Path Overlap**

**4.04.6.04.20** The entry angle Phi ( $\phi$ ) is not a design input, but it affects both the capacity and intersection sight to the left. The typical range for the Phi angle is between 20 and 30-degrees with 25-degrees or greater being optimal. Designers may find it difficult to attain the Phi angle values in the desirable range, but provided the fast path speeds are relatively low, the Phi angle criteria may be waived by the City Engineer. There are two methods for measuring the Phi angle. They are described below in Figures 4.04.6.04.20.1 and 4.04.6.04.20.2.

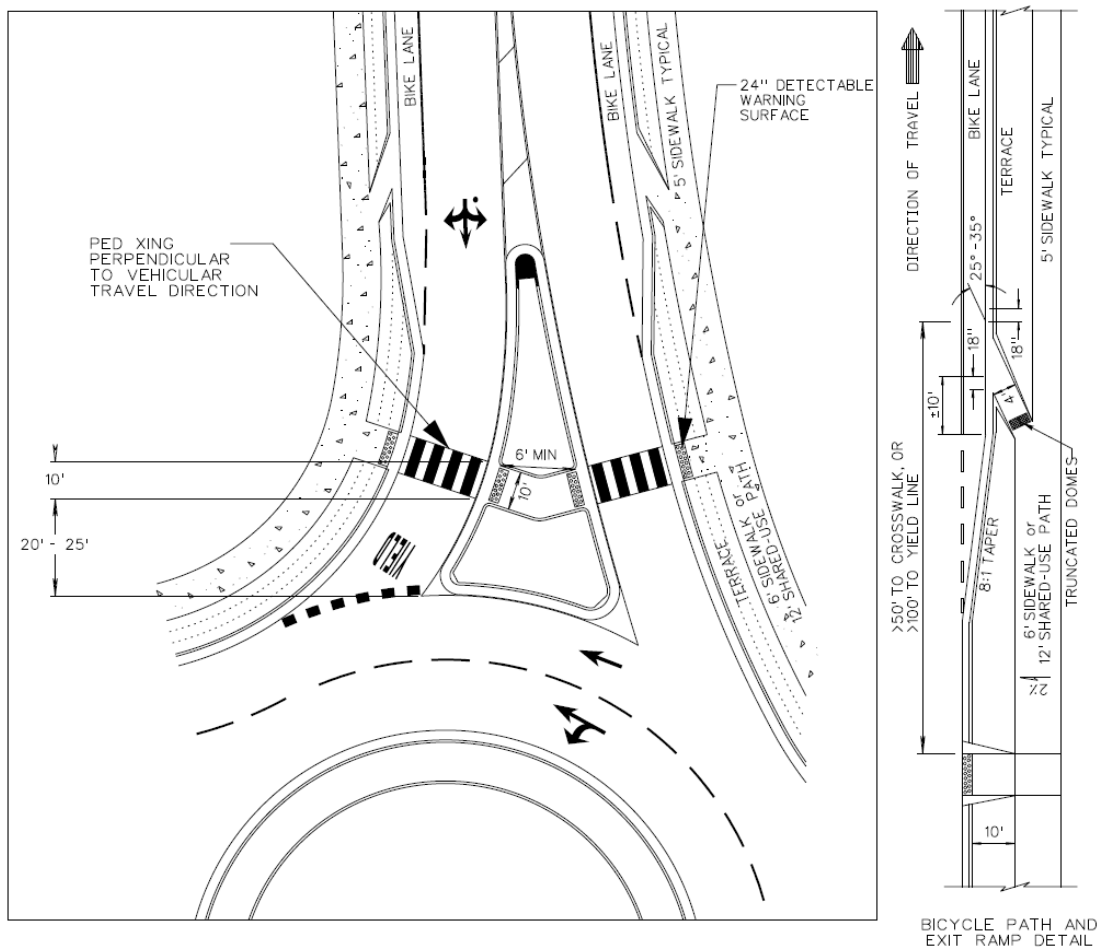


**Figure 4.04.6.04.20.1<sup>31</sup> - Entry Angle Phi, Alternate One**



**Figure 4.04.6.04.20.2<sup>31</sup> – Entry Angle Phi, Alternate Two**

**4.04.6.04.21** All roundabouts shall be designed to allow pedestrian crossings whenever sidewalks are existing or planned. The angled crosswalk provides shorter perpendicular crossing paths and discourages bicyclists from crossing without stopping in the refuge area. The minimum crossing length of the refuge area shall be six feet with eight feet preferred (face of splitter island curb to face of splitter island curb). The width of the crosswalk in the splitter island shall be ten feet. The crosswalk shall be located one car length upstream of the yield line to the roundabout (20 to 25 feet). See Figure 4.04.6.04.21.1 below. For roundabouts with multiple lanes and larger splitter islands, staggered crossings may be used. Where a staggered configuration is implemented, the crosswalk shall be located two car lengths downstream from the yield point on the exit leg. See Figure 4.04.6.04.21.2.



**Figure 4.04.6.04.21.1**  
**Angled Pedestrian Crossing and Bicycle Ramp Detail, Single Lane**

**4.04.6.04.22** Pedestrian traffic shall be accommodated by constructing a minimum six-foot wide sidewalk around the circulatory roadway. The sidewalk shall be



detached ten-feet from the circulatory roadway. Where roundabouts provide bicycle ramp access to the sidewalks the minimum width of the sidewalk shall be 12-feet. See Figures 4.04.6.04.21.01 and 4.04.6.04.21.02 above.

**4.04.6.04.23** Bicycle ramp exits and entrances shall be located at least 100 feet upstream of the yield line on the entry leg of the roundabout and downstream of the circulatory roadway on the exit leg. If right turn by-pass lanes are provided, then these distances must be increased to clear these right turn lanes. See Figures 4.04.6.04.21.01 and 4.04.6.04.21.02 above for diagrammatic drawings of pedestrian and bike facility details.

**4.04.6.04.24** The design of underground utilities shall take into consideration where water valves, manhole lids, etc., are placed relative to wheel paths. Maintenance safety issues shall also be considered. Underground utilities shall not be placed under the central island due to potential installation of landscaping and/or art features.

**4.04.6.04.25** Landscaping is an important part of the design as it provides visual awareness of the roundabout. Landscape designs must consider pedestrian and vehicle safety without causing sight distance problems. All landscaping shall be coordinated with Public Works and the Planning and Development Services Department. Landscaping around the outside of the central island shall be low in height in accordance with sightline requirements. Landscaping and/or art features shall be high enough to screen traffic on the other side of the roundabout and prevent a “see through” problem.

**4.04.7 Railroad Crossings** All railroad crossings on arterial streets shall be approved “rubberized” crossings for vehicular and pedestrian traffic.

**4.04.8 Barricades** Whenever roadways terminate due to project phasing, subdivision boundaries, etc., barricades are required. A note shall be placed on the plans directing the Contractor to construct permanent Type III and/or Type IV barricades (as specified in the MUTCD) across the roadway terminus. A note shall also be placed on the site plan or contextual site plan and civil plans indicating the developer, metro district, or HOA will be responsible for the maintenance of these barricades.

**4.04.9 Median Turn Bay** When ½ of an arterial street with a raised median is constructed, the construction shall include required turn bays on the half being

constructed. The turn bays' curb and gutter shall be constructed through and including the solid concrete nose.

#### **4.04.10 Urban Centers and TOD's Intersection and Mid-Block Approach Design**

**Matrix** Table 4.04.10.01 provides information regarding intersection and mid-block design criteria. All markings (pavement striping) and signing relative to cross-walks shall be in conformance with the Manual on Uniform Traffic Control Devices. Also reference Section 126-36.5 of the City Code for additional information.

**Table 4.04.10.01  
Urban Centers and TODs  
Curb Return Flow Line Radii at Intersections**

	Boulevard – Four or Six Lanes	Multi-way Boulevard – Four or Six Through Lanes	Main Street – Four Lanes with Median	Main Street – Two Lanes with Median/Center Turn Lane	Main Street – Two Lanes with Median/Center Turn Lane (Mid-Block)	Main Street – Two Lanes with Parallel Parking	Main Street – Two Lanes with Parallel Parking (Mid-Block)	Main Street – Two Lanes with Diagonal Parking	Main Street – Two Lanes with Diagonal Parking (Mid-Block)	One-Way Couplet – Two Lanes	Residential Parkway – Two Lanes	Residential Parkway – Two Lanes (Mid-Block)	Neighborhood/Local Urban – Two Lanes
Curb Extensions	No	Yes (Access street only)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Partial
Corner Radii	25'	20'	20'	20'	20'	20'	20'	20'	20'	20'	20'	20'	20'
Exclusive Left Turn Lanes Allowed	Yes	Yes (Thru street only)	Yes <sup>1</sup>	Yes <sup>1</sup>	Yes <sup>1</sup>	No	No	No	No	Yes <sup>1</sup>	No	No	No
Exclusive Right Turn Lanes Allowed	Yes	No	No	No	No	No	No	No	No	No	No	No	No
Standard Markings <sup>2</sup>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High Visibility Markings <sup>3</sup>	No	No	No	No	Yes	No	Yes	No	Yes	No	No	Yes	No
Colored Paving	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Pavers	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Pedestrian Refuge Islands	Yes	Yes	Yes	Yes	Yes	NA	NA	NA	NA	NA	Yes	Yes	NA

<sup>1</sup> When intersects with boulevards or existing major arterials.

<sup>2</sup> This marking shall only be used when nonstandard pavement or pavement color is used within the cross walk and when traffic signals are present.

<sup>3</sup> This marking shall only be used when standard pavement and color are used and when traffic signals are present.

## 4.05 Vertical Alignment

Design controls for vertical alignment are shown in Tables 4.05.1.1 and 4.05.1.2. The values in these tables are based on the 2011, 6<sup>th</sup> Edition of AASHTO's "A Policy on Geometric Design of Highways and Streets".

**4.05.1 Permissible Roadway Grades** Designers are encouraged to avoid grades less than 0.8% to minimize maintenance and icing problems. The minimum allowable grade for any roadway or alley is 0.5%. The maximum allowable grade for any roadway is shown in Table 4.05.1.1 and 4.05.1.2. The maximum grade for an alley is subject to the approval of the City Engineer, but shall not exceed eight percent.

**Table 4.05.1.1  
Alignment Controls**

	DESIGN SPEED MPH	MAXIMUM GRADE	K FACTOR		SSD
			CREST	SAG	
ARTERIALS	50	6%	90	100	425'
LOW DENSITY RURAL	45	*6%	70	80	360'
COLLECTOR 3-LANE	35	*5%	30	50	250'
COLLECTOR 2-LANE	35	*5%	30	50	250'
LOCAL TYPE 1	30	*5%	20	40	200'
LOCAL TYPE 2	25	*5%	15	30	155'
LOCAL TYPE 3	35	*5%	30	50	250'

\* 8% may be allowed by the City Engineer where an alternate access route, at 6% or less, exists.

**Table 4.05.1.2  
Urban Centers and TODs Alignment Controls**

	DESIGN SPEED MPH	MAXIMUM GRADE	K FACTOR		SSD
			CREST	SAG	
Boulevard 4 or 6 Lanes	50	6%	90	100	425'
Multiway Boulevard 4 or 6 Through Lanes	50*	6%	90	100	425'
Main Street 2 Lanes with Median / Center Turn Lane	35	5%	30	50	250'
	30	5%	20	40	200'
Main Street - Median 4 Lanes	40	5%	45	65	305'
	35	5%	30	50	250'
Main Street - 2 Lanes with Parallel Parking	30	5%	20	40	200'
Main Street - 2 Lanes with Diagonal Parking	30	5%	20	40	200'
One Way Couplet 2 Lanes	35	5%	30	50	250'
	30	5%	20	40	200'
Local Urban 2 Lanes	30	5%	20	40	200'
Residential Parkway 2 Lanes	30	5%	20	40	200'
Neighborhood 2-Lanes	30	5%	20	40	200'

\*The posted speed limit for the access road for the Multiway Boulevard will be 25.

**4.05.2 Roundabouts** The following are basic criteria for the vertical control through roundabouts.

- 4.05.2.01** Roundabouts shall be constructed on relatively flat or rolling terrain with an approach grade preferably less than three percent, but not greater than five percent.
- 4.05.2.02** Entry grade profiles for 65 feet from the outer edge of the circulatory roadway shall not exceed three percent with two percent being the desirable maximum. Exit grades shall be similar to the entry grades, but shall not exceed four percent. Vertical break-over grades greater than three percent should be avoided within 200 feet of the entry yield line location. A maximum cross slope of two percent may be used in the roadway area. A note shall be included in the plans that the vertical and horizontal design shall not be adjusted in the field without the City Engineer's approval.
- 4.05.2.03** The design of the approach roadway shall, where needed, locate low points with associated Type R inlets located upstream of crosswalks.
- 4.05.2.04** Where approach downgrades are steeper than four percent, the Stopping Sight Distance in accordance with AASHTO Section 3.2.2, Equation 3-3, *A Policy on Geometric Design of Highways and Streets*, 2011, 6<sup>th</sup> Edition, shall be reviewed relative to the Stopping Sight Distance from Section 4.04.6.04.16 of this manual. The more restrictive shall apply.
- 4.05.2.05** Care shall be taken with the vertical profiles to ensure adequate sight distance, both horizontally and vertically, is provided for the intersection and entry.
- 4.05.2.06** Profiles of alignments identified in Section 2.06.3.01 shall be used for construction layout. It is ideal from a drivability and safety perspective to design and construct the circular component of the roundabout in one plane with one low point and one high point around the inscribed circle. The approach and exit roadways shall then match into the roundabout grade similar to side streets at a standard intersection<sup>32</sup>.

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<sup>32</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Paragraph 30.6 (modified)

**4.05.2.06** The center or highest point within the central island shall not exceed six-feet and have a maximum slope of 6:1 with a minimum slope of four percent. This will reduce or eliminate the possibility of experiencing headlight glare at night and driver distraction by other vehicles on the circulating roadway.

**4.05.2.07** The truck apron cross-slope shall be one percent down toward the circulatory roadway.

**4.05.3 Superelevation** Superelevation may be required for arterial roadways, selected collector roadways (usually three-lane collector roadways) and low density rural roadways. Horizontal curve radius and superelevation shall be in accordance with Table 4.05.3.1.

Superelevation shall not be used on local roadways. The following procedure is an outline for the correct application of superelevation. Runout lengths are not used in the design of superelevations.

**Table 4.05.3.1  
Superelevations for Horizontal Curvature Runoff Length  
Arterials, Boulevards, Multi-way Boulevards, Selected Collector Streets,  
And Low Density Rural Roadways**

R	e	L		
		2-lane	4-lane	6-lane
7220'	NC	0	0	0
4940'	RC	50'	75'	100'
4280'	.022	55'	80'	110'
3690'	.024	60'	90'	125'
3130'	.026	65'	95'	140'
2660'	.028	70'	105'	150'
2290'	.03	75'	110'	160'
1980'	.032	80'	115'	155'
1720'	.034	85'	125'	165'
1480'	.036	90'	130'	175'
1260'	.038	95'	140'	185'
930'	.040	100'	150'	195'
<b>LOW DENSITY RURAL ROADWAYS and 4-LANE COLLECTORS</b>				
7220'	NC	0	--	--
4940'	.02	50'	75'	--
2290'	.03	75'	110'	--
930'	.04	100'	150'	--

D = Degree of Curve

R = Radius of Curve

e = Rate of superelevation

L = Minimum Length of Superelevation Runoff

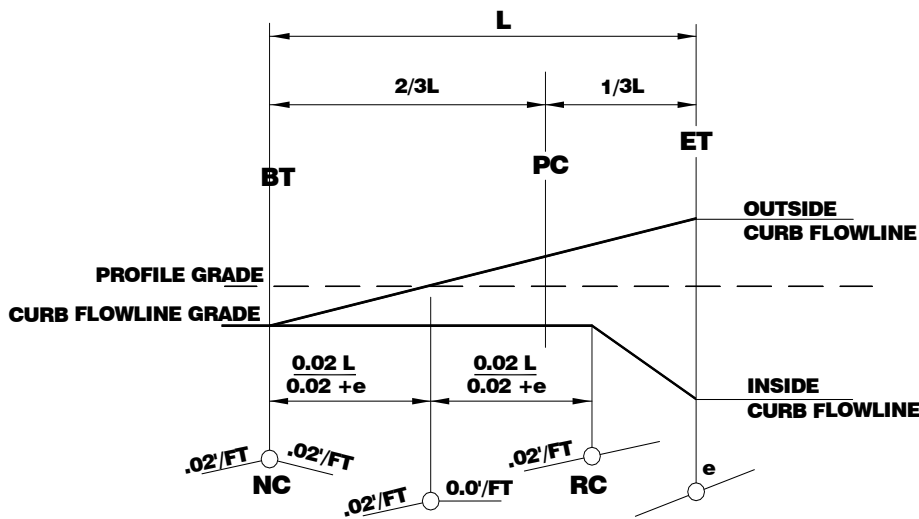
NC = Normal Crown Section

RC = Reverse Crown

Adapted from, "A Policy on Geometric Design of Highways and Streets," The American Association of State Highway and Transportation Officials, 2011 Edition, Table 3-8.

- 4.05.3.01** Establish horizontal centerline radius, degree of curvature and centerline design grade. The method of attaining superelevations shall be rotation about the centerline design profile.
- 4.05.3.02** See Table 4.05.3.1 to determine rate of superelevation and length of superelevation runoff required for the degree of curvature. On arterials and collectors, the 6-lane, 4-lane, and 2-lane column shall be used respectively.
- 4.05.3.03** Use the information obtained from Table 4.05.3.1 to construct a "super diagram." See Figure 4.05.3.03.1. Intervals at which pavement cross slopes are shown shall not exceed 25 feet. The exterior curb elevation and centerline or median curb elevations shall also be shown.

**FIGURE 4.05.3.03.1  
SUPERELEVATION DIAGRAM EXAMPLE**



**SUPERELEVATION DIAGRAM**

**e = MAXIMUM RATE OF SUPERELEVATION IN FEET (PER FOOT OF WIDTH) FOR THE GIVEN DEGREE OF CURVE AND DESIGN SPEED.**

- BT** BEGINNING OF TRANSITION
- ET** ENDING OF TRANSITION
- NC** NORMAL CROWN SECTION
- PC** POINT OF CURVATURE
- RC** REMOVE ADVERSE CROWN, SUPERELEVATE AT NORMAL CROWN SLOPE

- 4.05.3.04** The superelevation runoff shall be about the horizontal P.C. or P.T. of the curve at a two-thirds to one-third (2/3-1/3) ratio, with approximately two-thirds (2/3) of the total length required for the superelevated runoff being achieved prior to

the P.C. or after the P.T. of the curve. Superelevation runouts shall not be continued into intersection and shall end at the PCR prior to intersection, unless otherwise approved by the City Engineer. If a variance is granted by City Engineer cross sections are required in the plans for the superelevated roadway. A minimum of three cross sections are required of the superelevated roadway each cross section shall be extended fifty feet past a line parallel to the superelevated roadway back of curb. Cross Sections shall be provided at interesting centerlines and for each intersecting flowlines.

**4.05.3.05** As part of the construction plans, submit 3-line profiles and super diagrams of the centerline and both outside curb profile elevations shall be radial to the centerline. Scale for a 3-line profile is 1" = 50' or larger horizontally, 1" = 1' vertically.

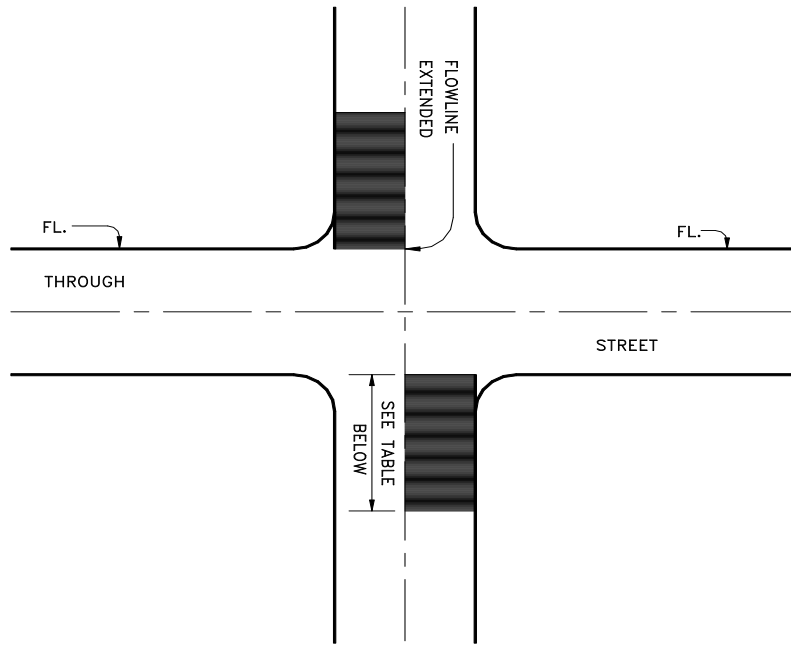
**4.05.3.06** Station, elevation, and rate of superelevation shall be shown on the plan at each transition point. Special consideration shall be given to potential icing problems when superelevation runoff occurs near sump conditions. Storm sewer inlets shall be placed at or near points where the pavement cross-slope is flat to capture nuisance flows before these flows will cross the pavement.

**4.05.3.07** Where there are reverse curves requiring superelevation a tangent length between the curves shall be provided. Its length shall accommodate the runoff lengths of both superelevations.

**4.05.4 Permissible Grades Approaching Intersections** The maximum approach grade of intersecting streets with a through street or approaching a stopped condition shall be 3% for the distances shown in the table in Figure 4.05.4.1. At intersecting arterials, the maximum permissible grade shall be 2% for 200' either side of the flow line of the intersecting street. Private street, private driveway, parking lot drive, and fire lane grades, other than single family residential, may be 4% maximum when sloping down toward the public street and up to 6% maximum when sloping up toward the public street. The maximum slope for single family driveways is 14%. In all cases where driveways are steeper than 10%, there shall be an accompanying pedestrian walk to the main entry with steps as needed to allow a maximum slope of 10% on the walk.



**Figure 4.05.4.1**  
**Permissible Intersection Grade**



See the table on the next page for the continuation of this figure.

Figure 4.05.4.1 (Continued)

Required Minimum Length of Approach Grade at Intersections

*	LOCAL	COLLECTOR	ARTERIAL, BOULEVARD	MULTI-WAY BOULEVARD	MAIN STREET TWO LANES w/ MEDIAN	MAIN STREET FOUR LANES w/ MEDIAN	MAIN STREET TWO LANES	ONE WAY COUPLET	LOCAL URBAN	RESIDENTIAL PARKWAY	NEIGHBORHOOD
Private Driveways	65' (4% DN) (6% UP)	65' (4% DN) (6% UP)	75' (4% DN) (6% UP)	75' (4% DN) (6% UP)	65' (4% DN) (6% UP)	65' (4% DN) (6% UP)	65' (4% DN) (6% UP)	65' (4% DN) (6% UP)	65' (4% DN) (6% UP)	65' (4% DN) (6% UP)	65' (4% DN) (6% UP)
Private Streets	95'	100'	125'	--	--	--	--	--	--	--	--
Local	95'	100'	125'	125'	100'	100'	--	--	--	--	--
Collector	--	120'	200'	200'	120'	120'	--	--	--	--	--
Low Density Rural	--	120'	200'	--	--	--	--	--	--	--	--
Arterial, Boulevard	--	--	200' (2.0%)	200' (2.0%)	200' (2.0%)	--	--	--	--	--	--
Multi-way Boulevard	--	--	200' (2.0%)	200' (2.0%)	--	--	--	--	--	--	--
Main Street Two Lanes w/ Median	--	120'	200'	200'	120'	120'	--	--	--	--	--
Main Street Four Lanes w/ Median	--	120'	200'	200'	--	120'	--	--	--	--	--
Main Street Two Lanes	--	--	--	125'	100'	100'	95'	95'	95'	95'	95'
One Way Couplet	--	--	125'	125'	120'	120'	95'	95'	--	95'	--
Local Urban	--	--	125'	125'	100'	100'	95'	95'	95'	95'	95'
Residential Parkway	--	--	125'	125'	100'	100'	--	--	--	--	--
Neighborhood	--	--	125'	125'	100'	100'	95'	95'	95'	95'	95'

\* This figure and table refer to Section 4.05.4.

**4.05.5 Changing Grades** Continuous grade changes or "roller-coastering" shall not be permitted. The use of grade breaks, in lieu of vertical curves, is not encouraged.

However, if a grade break is necessary and the algebraic differences in grade (A) does not exceed 0.4%; the grade break will be permitted, except at intersections where algebraic differences in grade of 0.8% will be permitted to facilitate the warping of the side street to meet the through street.

**4.05.6 Cross Slopes** Except at intersections, or where superelevation is required, new roadways shall be level from top of curb to top of curb with a 2% crown as measured from centerline to lip of curb, or lip of median curb to lip of outside curb on roadways with raised center islands. The cross slope of a street intersecting a street of higher classification, or through street, shall be warped to match the grade on the higher classification street or through street. In no case shall the pavement cross slope at intersections exceed the grade of the through street. Maximum pavement cross slope is 4% at intersections, as measured across the PCR's of the intersecting street. The rate of change in pavement cross slope to match the through street shall not exceed 1% every 25 feet horizontally on a local roadway, 1% every 37.5 feet horizontally on a collector roadway, or 1% every 56.5 feet horizontally on arterial roadways. Street warping shall be complete at the PCR's (of the warped street) and shall extend to the point of beginning away from the intersection. Separate flow line profiles shall be shown until a standard cross section is obtained (see Section 2.06.2.11). Do not show a centerline profile within the area that the separate flow line profiles are shown. See Section 4.05.8 for through street grade precedents. Quarter crowning may be accepted on a case-by-case basis with approval from the City Engineer.

**4.05.7 Vertical Curves** All vertical curves shall be symmetrical. Vertical curves shall meet the design criteria found in Tables 4.05.1.1 and 4.05.1.2. The minimum flowline grade within a sag (sump) vertical curve is 0.50%. This grade can be achieved due to the three inch depression at the throat of the Type R inlet. The lip of gutter shall be consistent with the vertical curve grades (the gutter pan will have more than the two inch drop from lip to flowline where the minimum 0.5% slope is maintained in the sump curve). All vertical curves shall be labeled, in the profile, with length of curve (L) and  $K (=L/A)$ , High/Low Pts., PI, P.V.C. and P.V.T. stations and elevations. See Tables 4.05.1.1 and 4.05.1.2.

Requirements of the above policy are established by the City Code and the source of the above policy is, "*A Policy on Geometric Design of Highways and Streets*," The American Association of State Highway Officials, 2011, 6th edition.

**4.05.8 Intersections** In addition to the requirements set forth in Sections 4.04.5 and 4.05.5, the following criteria shall apply at intersections.

**4.05.8.01** The grade of the "through" street shall take precedence at intersections. At intersections of roadways with the same classification, the more important roadway, as determined by the Traffic Manager, or his/her representative, shall have this precedence.

**4.05.8.02** Key factors determining the elevation of the curb return on the side street and the amount of warp needed on a side street transitioning to a through street are:

**4.05.8.02.1** For permissible approach grade, see Section 4.05.4.

**4.05.8.02.2** For pavement cross slope at the P.C.R.'s on the side street and permissible warp in pavement cross slope, see Section 4.05.6.

**4.05.8.02.3** Vertical curve criteria, per Section 4.05.7

**4.05.8.02.4** Vertical controls, per Sections 4.05.7, 4.05.10, and 4.05.11

**4.05.8.03** The elevation at the P.C.R. on the through street is set by the grade of the through street in conjunction with pavement cross slope.

In retrofit situations, pavement cross slopes (from the existing crown or edge of existing asphalt to the lip of gutter) between 1% and 4% may be approved. Where existing streets are widened the cross slope requirements of above apply. Cross slope grade breaks must provide a safe driving condition. The plan or profile of the street shall include existing spot elevations located at the existing curb and gutter lip, crown line (centerline) and the existing edge of asphalt at a maximum of 50-foot spacing. This provides data for verification of existing/proposed cross slopes.

**4.05.8.04** Carrying the crown of the side street into the through street is not permitted.

**4.05.8.05** Tipping an inlet for the benefit of drainage is not permitted.

**4.05.8.06** At arterial-arterial; boulevard-boulevard; multi-way boulevard-multi-way boulevard intersections, a more detailed drawing of the entire intersection's drivability shall be submitted. See Section 4.05.6 for rates of pavement warp allowed.

Pavement cross slopes in the plan view shall be shown until a normal cross section is obtained on each side of the intersection, in addition to standard requirements of a roadway plan. Also show spot elevations in the intersection, on the plan view, on a 15-foot grid. Show this information on separate plan sheets at minimum scales of 1"=20' horizontally.

**4.05.9 Curb Returns** Minimum grade around curb returns, when turning water, shall be 1.27%. Label high point elevation and distance from P.C.R. Label station and elevation of upstream flow line intersection when a cross pan is required. Maximum fall around a curb return generally equals steepest grade ( $\geq 2\%$ ) coming into or out of a return multiplied by the length of the return, plus .2 of a foot. This maximum fall shall apply to inside curbs on streets with knuckles for pavement widening requirements. The longitudinal sidewalk grade within this inside curb shall not exceed five percent.

**4.05.10 Connection with Existing Roadways** Connections with existing roadways shall be smooth transitions. If the algebraic difference in grade (A) exceeds 0.40% a vertical curve shall be used to transition the grade following the criteria in Section 4.05.7. Show the existing centerline and/or flow line elevations for 200-feet at 50-foot maximum intervals, unless conditions warrant additional information. Transverse slopes for connection with existing roadways may be between one percent (0.5 percent for concrete pavements) and four percent as long as a smooth, drivable surface is achieved in the longitudinal direction.

The following note shall appear on all street construction plans where the proposed design is matching an existing street along an existing edge of asphalt:

**"Cores showing adequacy of pavement in accordance with an approved soils report and pavement design are required prior to issuance of street permits. If the developer cannot prove adequacy he shall be responsible for the removal of existing pavement and replacement with the properly designed pavement. A minimum of 24-feet of pavement or one-half of the street section, whichever is less, is the required replacement. Any construction beyond centerline of the street in order to match existing grades and to make a safe, drivable surface will also be the developer's responsibility."**

**4.05.11 Offsite Design and Construction** The design grade and existing ground of all roadways that dead end due to project phasing, subdivision boundaries, etc., shall be continued in the proposed plan and profile for at least 500 feet or to its intersection

with an arterial roadway. This limit shall be extended to 1,000 feet when arterial roadways are being designed. If the roadway adjacent to the proposed development is not fully improved, the developer is responsible for the design and construction of an asphalt transition beyond the project phasing, subdivision boundaries, etc., of City approved thickness and a 4' wide Type 2 (Table 23.1) aggregate base shoulder for the safe conveyance of traffic from the improved section to the existing roadway. The following formula shall be applied to the taper or lane change necessary for this transition:

$$L = WS$$

Where:

L = length of transition in feet

W = width of offset in feet

S = speed limit or 85<sup>th</sup> percentile speed (whichever is greater)  
for speeds greater than 40 mph.

$$L = WS^2/60$$

Where:

L = length of transition in feet

W = width of offset in feet

S = speed limit or 85<sup>th</sup> percentile speed (whichever is greater)  
for speeds less than or equal to 40 mph.

For temporary transitions, 15:1 may be used as approved by the City Engineer.

The Traffic Engineer should be consulted for any unusual transition conditions. Grade breaks within the transition greater than 1% are not allowed when matching existing streets.

The cost of pavement transitions shall be borne by the Developer.

## **4.06 Streetscape Design and Specifications**

Contact Planning, Design, and Construction Division of the Parks, Recreation and Open Space Department, 303-739-7160 for all median construction landscape requirements, including maintenance obligations.

## **4.07 Specification for Fire Lanes, Private Streets or Drives, and Parking Lots**

**4.07.1 General** This section provides design and construction requirements, in addition to those listed elsewhere in this document, and specifically address private streets, driveways, parking lots, and fire lanes.

**4.07.1.01** Fire lane widths shall be as provided in City Code Section 66-32 and shall be designated on all plats, site plans, and civil plans. Where fire lanes turn the inside radius shall be 29-feet and the outside radius shall be 52-feet. Where the fire lane width is 26-feet wide the inside radius shall be 26-feet and outside radius of 52-feet.

**4.07.1.02** Fire lanes shall be paved full width with asphalt, concrete, or hidden pavement structures. When hidden pavement structures are used the fire lane must be marked in some way so the Fire Department, if they need to, will know where the fire lane is located.

**4.07.1.03** A fire lane shall not be considered by the City for acceptance as a public street, unless it meets all current public street standards.

**4.07.1.04** See Sections 4.04.1.05 and 4.04.1.06 for additional fire lane information.

**4.07.2 Pavement Design** Pavement design for fire lanes, private streets or drives, and parking lots shall be in conformance with Section 5.00 PAVEMENT DESIGN.

**4.07.3 Drainage Report** Preliminary and final drainage reports are required. See Section 2.04, STORM DRAINAGE PLANS AND REPORTS.

**4.07.4 Pavement Cross Slopes** All asphalt surfaces shall have a minimum grade of 1.00%. If grades are less than 1.00%, the pavement shall be concrete. Inverted crowns used for driveways, fire lanes, or parking lots shall have a swale "V" design with 1.00% minimum positive slope along the flow line. Drainage pans shall continue to an inlet or other acceptable outfall and will not drain to an asphalt surface. If the pan slope is between 0.5% and 1.0%, a concrete drainage pan shall be installed. The pan shall have a minimum width of 4 feet, and shall be a minimum 6 inch thick in parking lot areas, a minimum of 10 inch thick in fire lanes, and driveways. The center depression of the pan shall be ¼ inch per foot of pan width (total) minimum. Where bituminous paving adjoins the pan, paving must be 1/8 inch to 3/8 inch higher than the elevation of the lip of pan. Reinforcing shall be as required by standard

detail S4.1. If drainage is appropriately provided and the perpendicular parking spaces and adjoining private street form a continuous crowned section, the drainage pans may be omitted.

**4.07.5 Transitions** Transitions in private street width shall be smooth and shall not pose a hazard to traffic (refer to Section 4.05.11, OFFSITE DESIGN AND CONSTRUCTION). Transitions shall not encroach on the limits of the existing private street width. Horizontal alignment and pavement widening in curves shall conform to Section 4.04, HORIZONTAL ALIGNMENT.

**4.07.6 Curbs** Vertical or mountable curb and gutter shall border all private streets. Refer to the City approved site or contextual site plan.

**4.07.7 Parking Area and Parking Lots** Island noses for landscaping, utility access, or pedestrian access may be located within areas of perpendicular parking stalls but no island may project within 18 feet of centerline of a private street. Curb radii shall be a minimum of 18 inches, except at locations allowing drive-through access. All parking areas shall be surfaced with concrete, asphalt, brick pavers, or stone pavers.

#### **4.07.7.01 Accessible Parking**

**4.07.7.01.1** Accessible parking shall be provided within TODs and Urban Centers streets with diagonal parking. There shall be two universal spaces per each side of the street, per block, where there is diagonal parking. One of the universal spaces shall be van accessible. Additional accessible parking shall be provided at locations designated on the approved site plans or parking plans

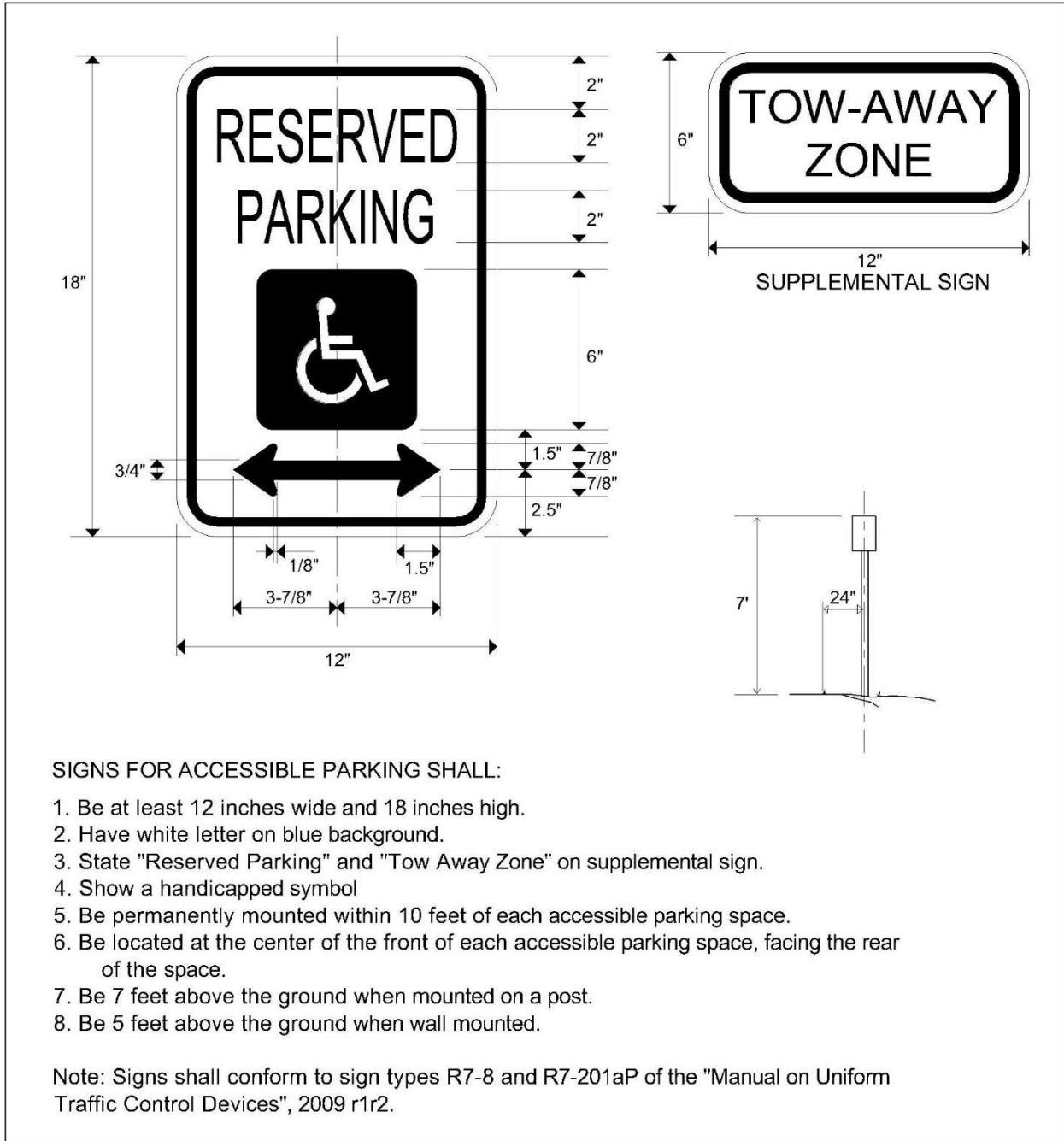
**4.07.7.01.2** Accessible parking spaces shall be a minimum of nine feet wide. Access aisles adjacent to accessible spaces shall be a minimum of five feet wide. Two accessible parking spaces may share a common access aisle. One space in every eight accessible spaces, but not less than one, shall be served by an access aisle at least eight feet wide, and shall be designated “Van Accessible”.

**4.07.7.01.3** Parking access aisles next to accessible spaces shall be part of the accessible route to the building or facility entrance. Curb cuts or curb ramps shall be required for all new construction and reconstruction. Accessible spaces



serving a particular building shall be located on the shortest accessible route of travel from parking to an accessible entrance.

- 4.07.7.01.4** Accessible parking spaces shall be marked and maintained with striping or other surface painting to distinguish accessible spaces from other parking spaces. Accessible parking spaces shall also be posted with an above grade sign at each accessible space incorporating the international symbol of accessibility and the following language: “Reserved Parking, Tow Away Zone.” Such sign shall adhere to the provisions of Section 2B.46: Parking, Standing, and Stopping Signs of the [Manual on Uniform Traffic Control Devices, 2009 Edition](#).



**Figure 4.07.7.01.4.1 – Signage for Accessible Parking**

**4.07.7.01.5** The resultant grade in any direction within accessible parking areas shall not exceed two percent.

**4.07.7.02 Parcel / Parking Access**

**4.07.7.02.1** Only the minimum number of curb cuts necessary to serve the subject parcel/parking lot shall be permitted.

- 4.07.7.02.2** Access drives shall be oriented substantially at right angles (90 degrees) to the street.
- 4.07.7.02.3** Higher density residential access driveway widths shall not be less than 20 feet nor more than 30 feet, unless there are medians in the driveways.
- 4.07.7.02.4** Access to parking lots along arterials shall be from the local side street wherever possible, except between commercial parking areas bordered by residential property.
- 4.07.7.02.5** Access drives shall be located as follows and is based on centerline to centerline measurement:
- 4.07.7.02.5.01** Access points shall be no closer than 300 feet to arterial intersections. Depending on site characteristics access control may be required.
  - 4.07.7.02.5.02** Access points shall be no closer than 150 feet to collector or local intersections. Depending on site characteristics access control may be required.
  - 4.07.7.02.5.03** Edge of access point (curb or pavement edge) shall be no closer than ten feet to any adjacent property line, unless they are shared accesses.
  - 4.07.7.02.5.04** Residential driveways shall be located as far from street intersections as possible, 75-feet preferred with the distance measured from the intersecting street's flowline. See Section 4.04.2.01.1 for additional requirements.
  - 4.07.7.02.5.05** Access points shall align with other access points/streets across from the cross street, unless otherwise allowed by the Engineer.
  - 4.07.7.02.5.06** If adherence to the above criteria would leave a parcel with no access, then the Director of Planning, or their designee, and the City Engineer may vary the requirements to provide a single point of access on a case-by-case basis.
- 4.07.7.02.6** If a gating system is proposed to be installed at a site access point, the gate access shall be set back from the flow line of the street at least 35 feet or one design vehicle length, whichever is larger, and be approved by Fire and Life Safety. Gating systems located within close proximity to public right-of-way (ROW) shall be assessed by the City of Aurora Traffic Manager, or designee, and may require a traffic analysis to determine the appropriate distance of the gating system to the street flow line. Where a gating system

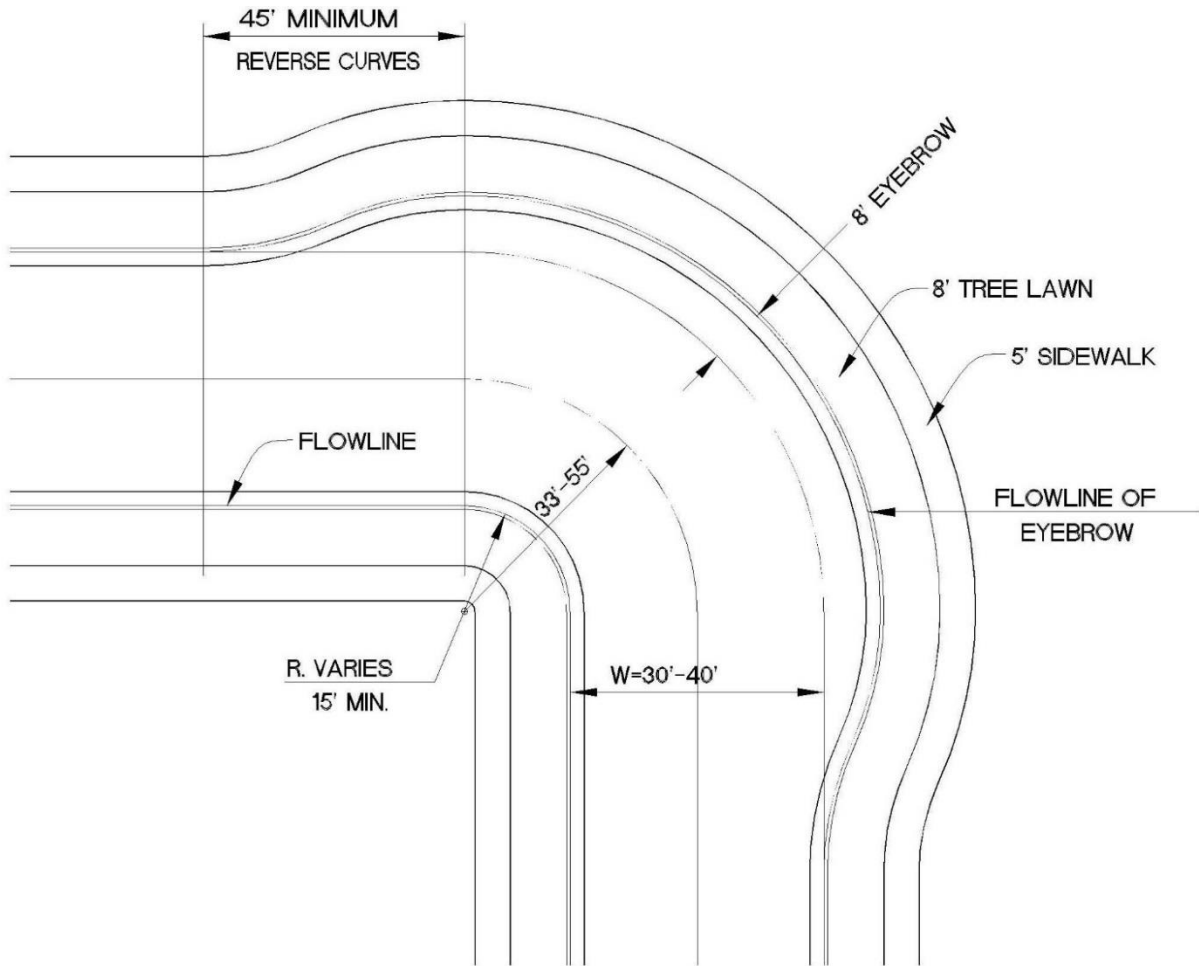
crosses a dedicated or designated firelane please reference Section 503.6 *Security Gates*, 2015 International Fire Code (IFC) as adopted by the City. The installation of security gates across a firelane access road shall be approved by the fire chief, or designee.

**4.07.7.02.7** A minimum paved access of 25 feet in length shall be provided from the flowline of the street curb and gutter into the site. See Section 4.05.4 for the allowable access grades approaching the public street.

**4.07.8 Access Ramps** Wheelchair access shall be provided along designated pedestrian paths from each area of parking to adjacent buildings and connecting sidewalks. Ramps shall have a minimum width of 48 inches, a maximum slope of 1 vertical on 12 horizontal, approach areas, and turning areas as provided for in the Uniform Federal Accessibility Standards.

**4.07.9 Permissible Grades** The maximum permissible longitudinal grade for fire lanes is 10%. The maximum transverse grade for a fire lane is four percent with a resultant maximum slope of ten percent.

**4.07.10 Pavement Widening at Curves on Private and Public Local Streets** At an intersection of two private or public local streets with a centerline radius from 33' to 55' Figure 4.07.10.1 shall be used. The width of pavement around horizontal curves shall be widened in accordance with Section 4.04.5.04 PAVEMENT WIDENING FOR SHORT RADII. Pavement widening transitions should generally occur over a roadway length of between 100 feet and 200 feet before the points of curvature and tangency. The adequacy of the geometric design will be based on the ability of the designed section to envelope a template based on the coincident passage of a fire truck and standard passenger car at a speed of 10 mph in accordance with AASHTO procedures. The geometric design may be based on a variety of methods including, but not limited to, (1) three point curves, (2) spiral curves, or (3) straight-line transitions.



**WIDENING DETAIL FOR PRIVATE AND LOCAL STREET INTERSECTIONS**

NOTE: RADII LESS THAN 33 FEET NOT ALLOWED.  
FOR RADII GREATER THAN 55 FEET, SEE FIGURE 4.04.5.04

**Figure 4.07.10.1**

**Private Street Pavement Widening on Horizontal Curve Less than 55' R**

## 4.08 Roadway Specifications

Following is a summary of the minimum roadway construction requirements (see standard detail S1.1 et seq.).

**Table 4.08.1  
Roadway Specifications**

Roadway Type	Minimum Dedicated Right-of-Way Width	Minimum Roadway Width Flow line to Flow line	Landscaping Strip/Tree Lawn	Type of Sidewalk, Curb, and Gutter
Local Type I	64'	34'	8'	Mountable curb, gutter, and 5.5' detached walk
Local Type II	60'	30'	8'	Mountable curb, gutter, and 5.5' detached walk
Local Type II Alternate	44'	30'	None	Mountable curb, gutter, and 5.5' attached walk
Local Type III	68'	40'	7.5'	6" vertical curb and gutter, and 5.5' detached walk
Three Lane Collector	80'	50'	8'	6" vertical curb and gutter, and 6' detached walk
Two Lane Collector	80'	50'	8'	6" vertical curb and gutter, and 6' detached walk
Two Lane Collector Alternate	66'	36'	8'	6" vertical curb and gutter, and 6' detached walk
Low Density Rural	60'	24'	None	4' gravel shoulder each side
Six Lane Arterial	144'	102'(2-38' roadways; 26' min. raised median)	10'	6" vertical curb and gutter and 10' detached walk
Four Lane Arterial Raised Median	114'	76' (2-31' roadways; 14' min. raised median)	10'	6" vertical curb and gutter, and 8' detached walk
Four Lane Arterial Painted Median	114'	76'	10'	6" vertical curb and gutter, and 8' detached walk
Four Lane Arterial Painted Median, Separated Bike Lane	109'	66'	7'	6" vertical curb and gutter, 8' separated bike lane, and 6' detached walk
Residential Alley	16'	16'	N/A	N/A
Local Commercial and Industrial Alleys	20'	20'	N/A	N/A
Fire Lanes Commercial	N/A	23'	N/A	N/A
Fire Lanes Residential	N/A	23'	N/A	N/A

Private streets or drives see Section 2.06 Roadway Plans

**Table 4.08.2  
Urban Centers and TOD's Roadway Specifications**

<b>Roadway Type</b>	<b>Minimum Dedicated Right-of-Way Width</b>	<b>Minimum Roadway Width Flow line to Flow line</b>	<b>Landscaping Strip/Tree Lawn</b>	<b>Type of Sidewalk, Curb, and Gutter</b>
Boulevard	146'	106' (2-39' roadways; 28' min. raised median)	9.5'	6" vertical curb and gutter and 10' detached walk
Multi-way Boulevard w/ parallel parking	166'	134' (2-8' parking lanes; 2-14' local lanes; 2-26' thru lanes; 2-11' min. & 1-16' min. raised median)	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
Multi-way Boulevard w/ diagonal parking	182'	150' (2-16' parking lanes; 2-14' local lanes; 2-26' thru lanes; 2-11' min. & 1-16' min. raised median)	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
Main Street – 4 Lanes w/ Median / Center Turn Lane	120'	88' (2-35' roadways; 16' min. raised median)	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
Main Street – 2 Lanes w/ Median / Center Turn Lane	98'	62' (2-25' roadways; 16' min. raised median)	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
Main Street – 2 Lanes w/ Parallel Parking	80'	48'	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
Main Street – 2 Lanes w/ Diagonal Parking	90'	58'	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
One Way Couplet	74'	42'	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
Local Urban – 2 Lanes	66'	34'	NA	6" vertical curb and gutter and 16' attached walk (hardscape)
Residential Parkway – 2 Lanes	106'	78' (2-25' roadways; 28' min. raised median)	7.5'	6" vertical curb and gutter, and 6' detached walk
Neighborhood – 2 Lanes	62'	34'	7.5'	6" vertical curb and gutter, and 6' detached walk
Alleys	20'	20'	NA	NA
Fire Lanes	NA	23'	NA	NA

## 4.09 Signing and Striping

- 4.09.1** All private roadways within the City upon which building numbering and addressing are dependent shall be named and marked with signs that have white retroreflective legend on a blue background composed of initial upper-case letters at least six-inches in height and lower case letters at least four and one-half inches in height. Supplementary lettering to indicate the type of street (such as Street (St), Avenue (Ave), or Road (Rd)), or the section of the City (such as East (E), South (S)) may be in smaller lettering, composed of initial upper-case letters at least three-inches in height and lower-case letters at least two and one-quarter inches in height. The street name signs shall be placed at all intersections of private roadways with other private roadways and all intersections of private roadways with dedicated public streets and shall be erected and maintained by the private property owner, HOA, or metro district.
- 4.09.2** A private roadway identification sign shall be a ground-mounted sign of a type approved by the City Traffic Manager and of a size appropriate to accommodate the requirements of Section 2.10.1, securely fastened to a post/pole that places the bottom of the sign not less than seven feet above the ground as near as practicable to the edge of the private roadway being identified without interfering with any pedestrian or cyclist facility.
- 4.09.3** All private roadway signage shall conform to the current edition of the MUTCD indicating location, size, and message (i.e., Stop sign, speed limit, etc.).
- 4.09.4** Where street cross-sections either narrow or widen on either side of an intersection the transition of traffic shall occur past the intersection. The transition should start one-hundred feet past the curb return. Appropriate warning signs with applicable striping is required for these transitions. Where multiple lanes must be dropped, or added, additional signing and striping requirements may be required.
- 4.09.5** Bike lanes shall extend through curb extensions at TOD and Urban Centers intersections up to the cross-walks, if provided, in accordance with MUTCD standards. The bike lane width shall be a minimum of five-feet, not including the gutter pan width when adjacent to curb and gutter. Otherwise, the minimum width is six-feet.
- 4.09.6** Roundabout signing shall include proper regulatory control, advance warning, and directional guidance for the roadway users. The signs shall be located so the



information needed are easily seen and in advance of the condition. Signs shall not be located where there will be conflict with vehicle turning movements and the swept path of vehicles. Since the signing and striping for a roundabout can get complicated a larger scale drawing for the roundabout signing and striping may be required.

**4.09.6.01** A number of regulatory signs are appropriate for roundabouts and are described below and shown in Figure 4.09.6.01.1.

**4.09.6.01.01** A YIELD sign, R1-2, shall be installed on the right side of all roundabout approaches. For all multilane roundabouts and single-lane roundabouts where the yield point is not clearly visible due to sight restrictions, a supplemental YIELD sign shall be also be placed on the left side of the approach (in the splitter island). Attention should be given to ensure the left side YIELD sign and right side YIELD sign are mounted at the same height.

Under all YIELD signs mounted on the right side, install a TO TRAFFIC FROM LEFT sign, R1-2bP. Under all YIELD signs mounted on the left side a ONE WAY sign, R-2, shall be installed to reinforce the direction of circulating traffic. During the first six months of operation of the roundabout, 18-inch x 18-inch orange flags may be installed on top of the YIELD signs to emphasize the yielding required at a roundabout.<sup>33</sup>

**4.09.6.01.02** The ROUNDABOUT DIRECTIONAL ARROW, R6-4b – series of 4 chevrons, shall be used in the central island opposite the entrances in combination with the ONE WAY sign R6-1. The mounting height to the bottom of the R64b sign is four feet, measured from the surface of the truck apron to the bottom of sign. Specify the four foot mounting height from the surface of the truck apron on the plans.<sup>33</sup>

**4.09.6.01.03** Install a ONE WAY sign, R6-1, in the central island opposite each entrance and mounted above the ROUNDABOUT DIRECTIONAL ARROW R6-4b sign to emphasize the direction of travel within the circulatory roadway<sup>33</sup>.

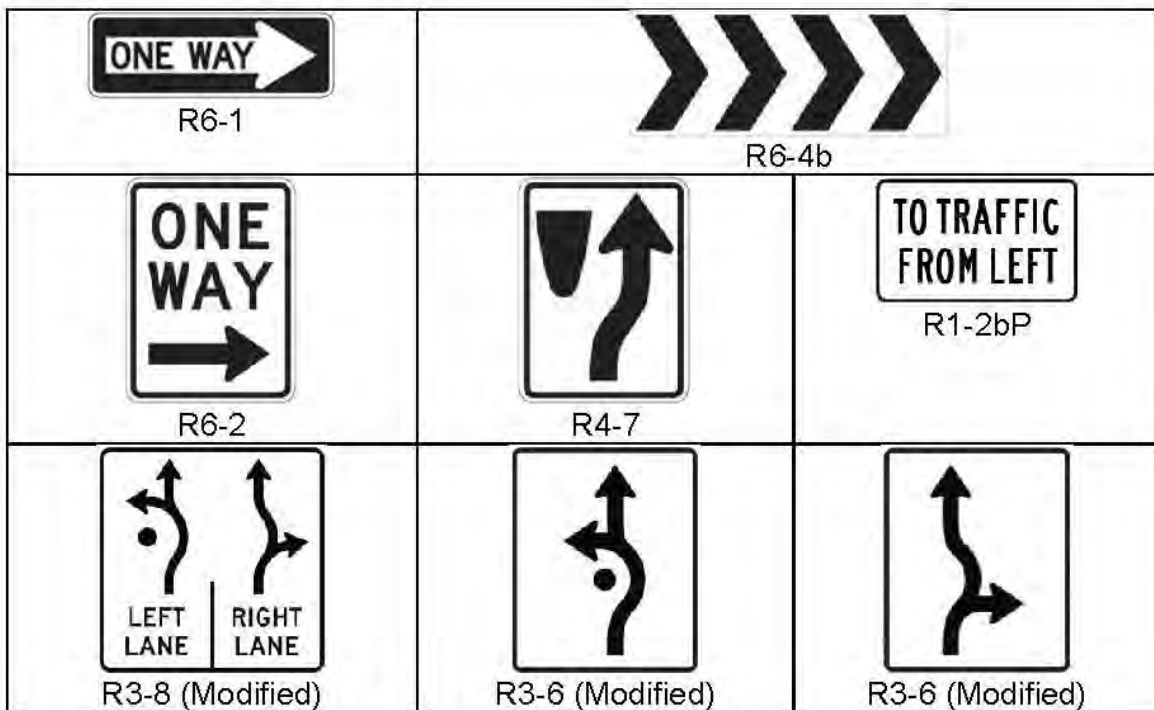
**4.09.6.01.04** Install a KEEP RIGHT sign R4-7 at the nose of raised curb splitter islands. Attention should be given to the location of the KEEP RIGHT sign and light poles on the right side to ensure conflicts do not occur with larger width

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<sup>33</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Paragraph 35.1 (modified)

vehicles. This is especially critical with single-lane entry roundabouts. The single DOWN ARROW, W12-1 – Modified, may be used in place of the R4-7 on approaches exiting commercial access points, low-volume approaches, or where splitter islands are otherwise small and the typical R4-7 may obscure visibility. The single DOWN ARROW is less desirable for consistency, driver expectancy, and enforceability, but, when used, may be mounted two feet to the bottom of the sign

Lane control signs, such as the R3-8 series of signs, and lane use pavement markings shall not be used for single-lane entries. Consult the City Traffic Manager for sign placement for multilane entries or if overhead lane control signs, R3-5/6 Series, should be installed. Roundabout operation will dictate which R3-5/6 or R3-8 signs are installed<sup>34</sup>. If overhead signs are used, one sign should be used per lane, centered over the lane. An advanced street name sign may also be mounted adjacent to the lane control signs. Arrow styles shall match the pavement markings used (e.g., conventional arrow markings shall not be used with fishhook arrows on the lane control signs).



**Figure 4.09.6.01.1<sup>34</sup> - Roundabout Regulatory Signage**

<sup>34</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Figure 35.1 (Modified)

**4.09.6.02** A selection of appropriate warning signs are described below and shown in Figure 4.09.6.02.1. The amount of warning a motorist needs is related to site-specific intersection conditions and the vehicular speeds on approach roadways. Overuse may result in drivers ignoring the upcoming condition. The applicable sections of the MUTCD govern the specific placement of warning signs<sup>35</sup>.

**4.09.6.02.01** CIRCULAR INTERSECTION sign, W2-6, should be installed on each approach in advance of the roundabout, if the approach speed is 40 mph, or greater, or if the YIELD sign is not readily visible for a sufficient distance per Table 4.09.6.02.01, Minimum Visibility Distance<sup>36</sup>. Below the W2-6 sign, an advisory speed plate, W13-1, may be required. Rural roundabouts have a typical advisory speed of 20 mph, urban roundabouts have a typical advisory speed of 15 mph. Check with the City Traffic Manager before assigning an advisory speed. The speed given on the advisory speed plate should be no greater than the design speed of the circulatory roadway. Advisory speeds are posted in multiples of 5 mph and should not exceed 20 mph<sup>3</sup>.

**Table 4.09.6.02.01<sup>36</sup>**  
**Minimum Visibility Distance**

Posted or 85 <sup>th</sup> Percentile Speed (MPH)	Minimum Visibility Distance (feet)
25	280
30	335
35	390
40	445
45	500
50	555
55	610

**4.09.6.02.02** The usage of crossing warning signs is optional per the 2009 MUTCD. The designer is encouraged to coordinate the usage of these signs with the City Traffic Manager. Locate pedestrian crossing signs in such a way to not obstruct the approaching driver’s view of the YIELD sign or pedestrians standing at the crosswalk<sup>35</sup>. Crossing warning signs at roundabouts should

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<sup>35</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Paragraph 35.1 (modified)

<sup>36</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Table 35.1

be used sparingly, as too many signs may overload the approach information system and diminish the value of any one sign. Crossing warning signs should be used when visibility of the crossing is obscured or when higher volumes of non-motorized users are expected, (e.g., near a school, park, marked bicycle trail, etc.), where approach speeds are at least 40 mph, or in transitional areas where pedestrians or cyclists were previously not expected. When a crossing sign is installed, it shall be accompanied by the appropriate downward diagonal-pointing arrow. The PEDESTRIAN CROSSING sign, W11-2, should be used, unless other user conditions warrant. Other acceptable signs include:

- TRAIL, W11-15
- BICYCLE, W11-1
- SCHOOL, S1-1.

If a school crossing is present, additional speed zone signs may be required. Coordinate additional signs with the City Traffic Manager. In locations where sight of the crossing is restricted or approach speeds are at least 40 mph, a crossing warning sign may also be installed in advance of the crossing with an AHEAD, W16-9P, supplemental plaque, instead of the downward diagonal arrow.



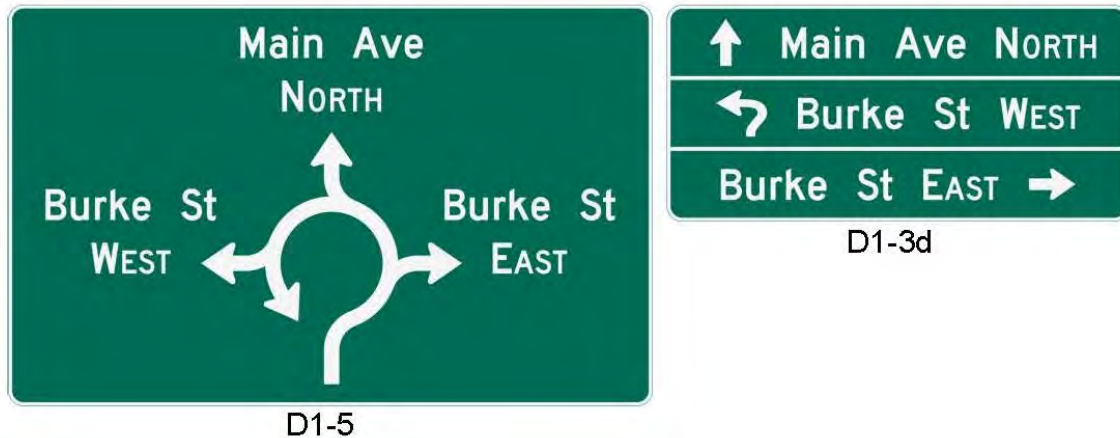
**Figure 4.09.6.02.1  
Roundabout Warning Signage**

**4.09.6.02.04** A bicycle sign may be needed to designate the exit to the bike path (D11-1a and M7-2, federal sign plate).

**4.09.6.03** Guide signs provide drivers with needed navigational information. They are particularly needed at roundabouts since circular travel may disorient unfamiliar drivers. A number of guide signs are appropriate for roundabouts and are described below<sup>37</sup>.

<sup>37</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Paragraph 35.1 (modified)

**4.09.6.03.01** Intersection destination/direction style signs in all single-lane approach roundabouts for rural locations and in urban/suburban areas should be considered. For more significant intersections diagrammatic style guide signs shall be used when required. See Figure 4.09.6.03.01.1 for an example<sup>38</sup>. The destination message shall be comprised of mixed-case letters, with a capital letter height of at least six-inches. Eight-inch capital letter height is recommended, especially on approaches with speeds higher than 45 mph.



**Figure 4.09.6.03.01.1<sup>38</sup> – Roundabout Destination Signage**

**4.09.6.03.02** Exit, directional signs shall be installed on all roundabout exits. Each roundabout will have its own unique characteristics, so the type of exit, directional sign, if used, will be similar to Figure 4.09.6.03.02.1. The message shall be comprised of mixed-case letters, with a capital letter height of at least six-inches.



D1-1d

**Figure 4.09.6.03.02.1<sup>38</sup> – Roundabout Directional Signage**

**4.09.6.04** All roundabout pavement markings shall be in conformance with the MUTCD and as further described herein. Approach and departure pavement markings

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<sup>38</sup> Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition, Including Revisions 1 and 2 Figure 2D-8 (modified)

consist of lane lines, edge lines, lane-use arrows, other pavement word and symbol markings, yield-point/dotted edge lines, and crosswalk markings<sup>39</sup>.

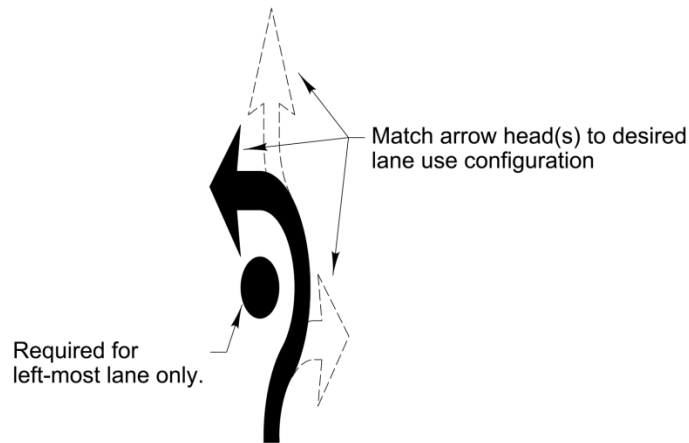
- 4.09.6.04.01** Double yellow centerline markings representing a two-direction no-passing zone shall be used on undivided roadways on the approach to the splitter islands. Immediately before the splitter island the double yellow centerline markings shall split into two double yellow markings, creating a taper to the raised splitter island<sup>10</sup>. Yellow edge lines may be used along the left side of the approach when speeds are greater than 40 mph. Yellow edge lines shall not be used around the central island.
- 4.09.6.04.02** White edge line markings shall be used along the right side of the approach and departure roadways adjacent to the outside curb. White edge line markings shall be used along the right side of approach and departure roadways adjacent to right-turn bypass islands to enhance driver recognition of the changing roadway<sup>39</sup>.
- 4.09.6.04.03** Solid white lane lines shall be used on multilane approaches and departures. On flared approaches to roundabouts, the lane lines in the flared section shall extend back from the circulatory roadway to the point where the paved entry width is 20 feet, flowline to flowline<sup>39</sup>.
- 4.09.6.04.04** Coordinate with the City Traffic Manager regarding the placement of crosswalk markings. The crosswalk is ten-feet by two-foot bars in the zebra formation parallel to the expected wheel paths to minimize wear and loss of traction.
- 4.09.6.04.05** A “strong” dotted white line (otherwise referred to as the “Dotted Edge line” or “Yield Point”) shall be used on all approaches and partial bypass lanes. The line should be at least 18-inches wide, with a two-foot line and two-foot gap.<sup>40</sup> See Figures 4.09.6.04.08.1 and 4.09.6.04.08.2 for how this line is used.
- 4.09.6.04.06** Lane-use arrows shall be used on all multi-lane roundabouts. Arrows should not be used on single-lane roundabouts. The lane-use arrows shall

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<sup>39</sup> National Cooperative Highway Research Program, Report 672, Roundabouts: An Informational Guide, Second Edition, Section 7.3 (modified)

<sup>40</sup> Wisconsin Department of Transportation, *Facilities Development Manual*, Chapter 11, Section 26, Subject 35.2 (modified)

be “Fish-hook Arrows” with the optional dot included for the left-most lane only (see Figure 4.09.6.04.06.1). Lane use arrows shall be placed approximately 25-feet upstream of any pedestrian crossings and at least one more set of arrows 50 to 100-feet. See Figure 4.09.6.04.08.2 for how these markings shall be used.



**Figure 4.09.6.04.06.1<sup>41</sup>**  
**Fish-hook Lane Use Arrow**

Arrows used within the circulatory roadway shall be conventional arrows, per the [2009 MUTCD](#). No dot shall be used with a lane arrow in the circulatory lanes. Arrows should not be used on single-lane circulatory roadway sections.

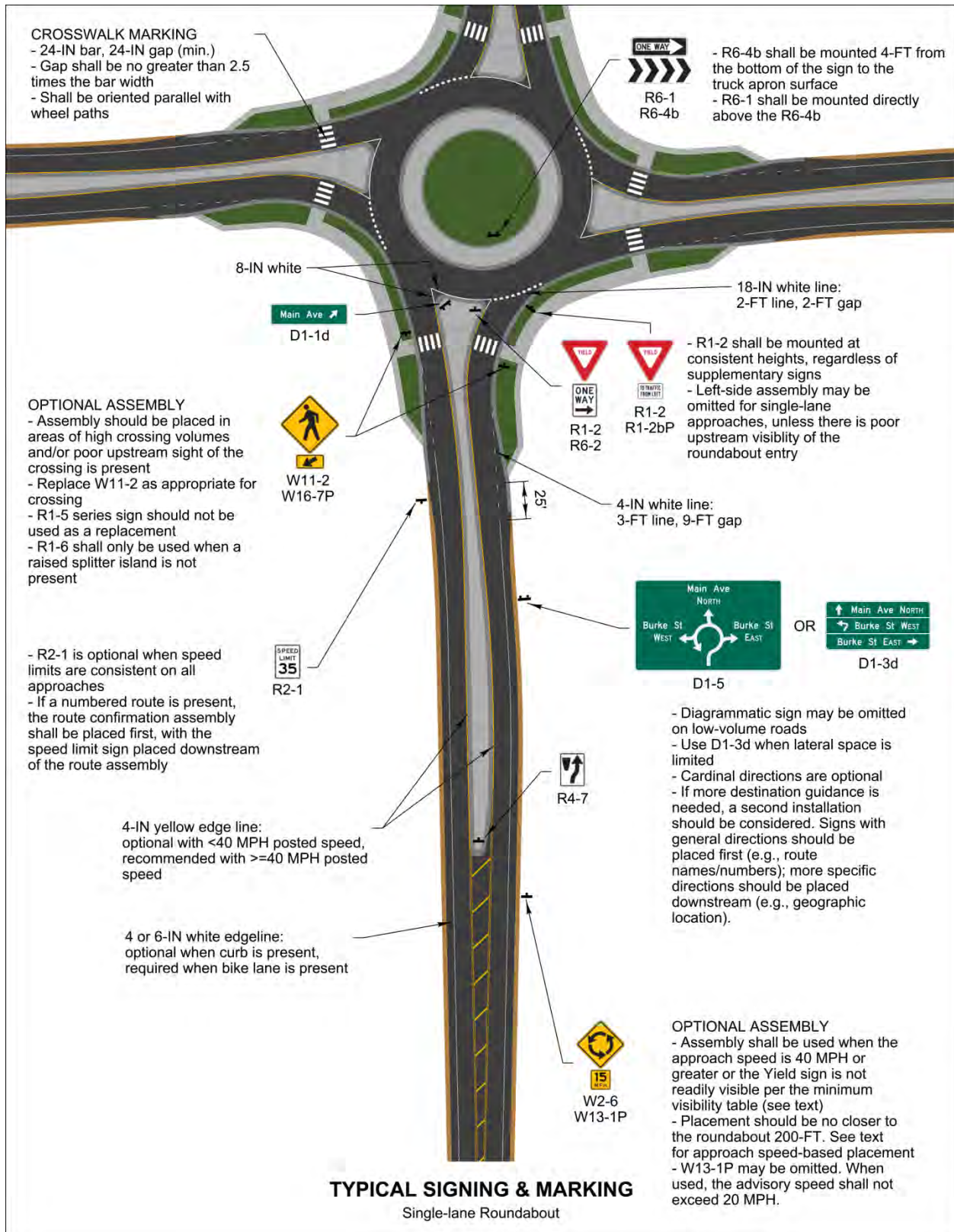
**4.09.6.04.07** Lane lines within the roundabout shall be a “strong” dotted line, starting at the splitter island and continuing through the exit to the crosswalk, if present. See Figure 4.09.6.04.08.2 for how these markings shall be used.

**4.09.6.04.08** Solid white edge lines should be used along the splitter islands and to mark the gore point of the exits. See Figures 4.09.6.04.08.1 and 4.09.6.04.03 for how these markings shall be used.

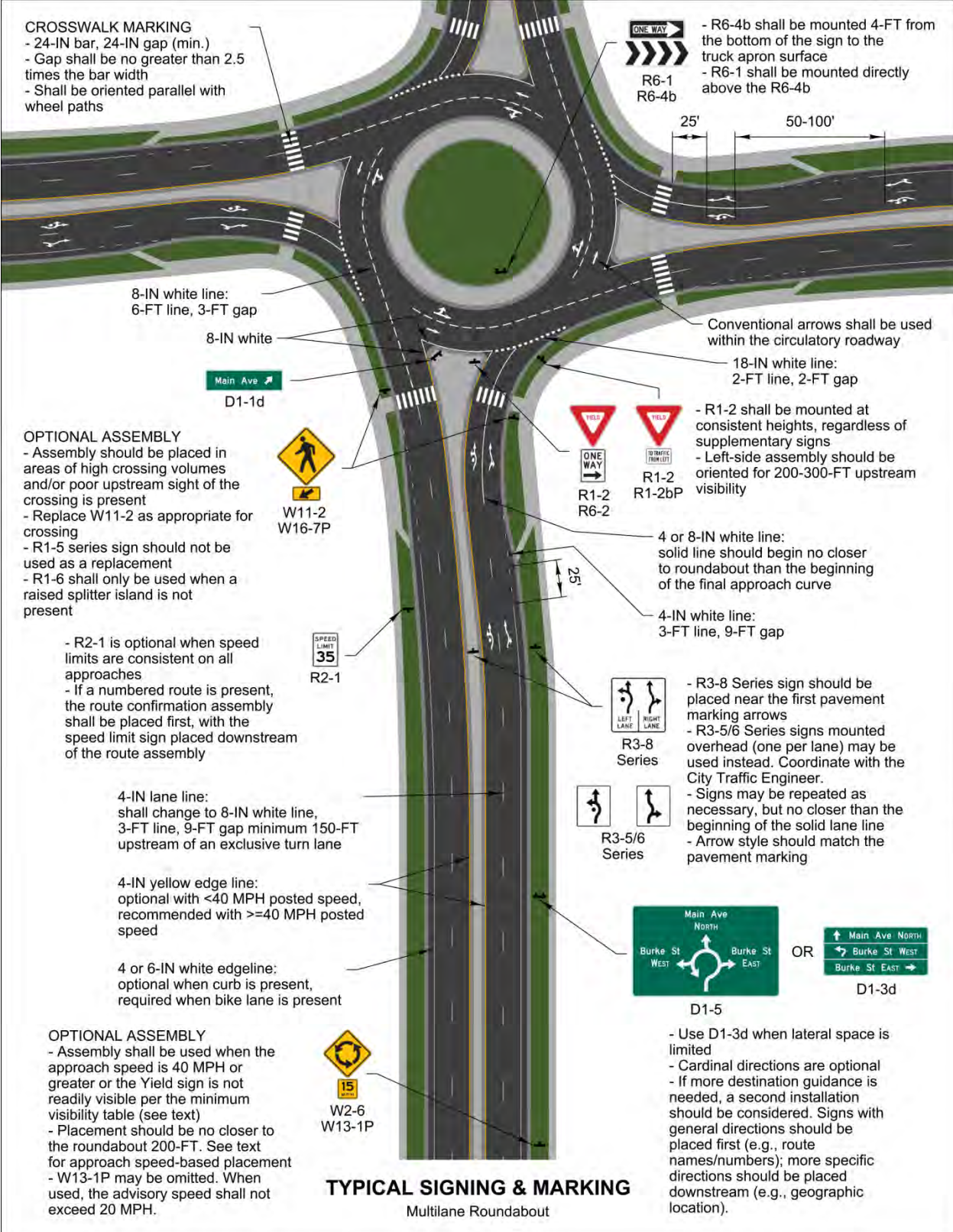
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<sup>41</sup> Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition, Figure 3C-2





**Figure 4.09.6.04.08.1**  
**Single Lane Roundabout Signage and Lane Markings**



**Figure 4.09.6.04.08.2**  
**Two Lane Roundabout Signage and Lane Marking**

## 4.10 Street and Pedestrian Lights

**4.10.1 General** Street and pedestrian lighting shall be installed and connected through via underground circuits to metered electric service pedestal(s) on all public and private streets in the City. All property owners abutting these streets shall, at their sole expense, pay for the cost of design and installations. The installation of street and pedestrian lighting facilities will be required as a prerequisite to the issuance of certificates of occupancy for any structure constructed along said streets.

The design guidance for roadway and pedestrian lighting given in this section relies on and references the Illuminating Engineering Society of North America's (IESNA) *Recommended Practice: Lighting Roadway and Parking Facilities, ANSI / IESNA RP-8-21*, except as noted in these standards. The IESNA is the leading technical authority on illumination and RP-8 is the nationally recognized guideline document for roadway illumination. The City of Aurora reserves the right to approve variances from these guidelines as long as variances meet the general intent of these guidelines. Proposed variances shall be submitted to the City Engineer with documentation of reason and justification for such variance.

Reference the L-series details for the Public Lighting Construction Standards for the City of Aurora.

### 4.10.2 Electrical Service Requirements

It is the property owner's or land developer's responsibility to contact Xcel Energy to initiate and obtain electrical service for any new development/redevelopment during the plan review process. The property owner or developer shall employ the services of an experienced roadway lighting designer for the design and provide a copy of the approved site plan and/or civil plan which will be used for the proposed street/pedestrian light design and cost estimate (when applicable).

It is the responsibility of the property owner or developer to transfer the meter service to the City upon final acceptance of the public improvements. The developer/owner is responsible for paying all services charges until the service is transferred to the City.

Private lights shall be wired to a separate meter to billed to the property owner or developer.

### **4.10.3 Solar Powered Street and Pedestrian Lights**

The property owner or land developer may propose the installation of solar powered street and pedestrian lights. The property owner or land developer shall contact Public Works Department, Engineering Services Division at the start of the land development process to discuss the availability and use of solar powered street lights.

### **4.10.4 Street and Pedestrian Lighting Design and Placement Requirements**

The City of Aurora requires at least one street light at every public street intersection. Major street intersections may need two or four street lights. See Standard Detail S15.1 and S15.2.

#### **4.10.4.01 Street Intersection Requirements**

**4.10.4.01.01** Four street lights are required, one at each corner for the following intersections:

1. 6-Lane Arterial at 6-Lane Arterial
2. 6-Lane Arterial at 4-Lane Arterial
3. 4-Lane Arterial at 4-Lane Arterial

**4.10.4.01.02** Two street lights are required, one at each right approach on the minor street, for the following intersections:

1. 6-Lane Arterial at 3-Lane Collector
2. 6-Lane Arterial at 2-Lane Collector or Local
3. 4-Lane Arterial at 2-Lane Collector or Local
4. 3-Lane Collector at 2-Lane Collector or Local
5. 2-Lane Collector at 2-Lane Collector or Local
6. Couplet at any other street

**4.10.4.01.03** One street light is required for the following intersection:

1. Local at Local
2. Local and public access drive with medium pedestrian activity

**4.10.4.01.04** Rural street (temporary or permanent) lighting is on a case-by-case basis. Coordinate with Public Works, Engineering Division.

#### **4.10.4.02 Miscellaneous Offset and Minimum Distance Requirements:**

**4.10.4.02.01** In residential areas, street lights to be located on lot lines.

**4.10.4.02.02** On arterials, when median width is less than 10 feet, move street lights to the outside edges of R.O.W., generally adjacent to curb & gutter.

#### **4.10.4.03 Roundabout Requirements:**

**4.10.4.03.01** Roundabout lighting shall fully illuminate the roundabout. Marked pedestrian crossings shall be illuminated. Light poles shall be located around the perimeter of the roundabout, but not within any clear zones. Optimal pole location accounts for vertical illuminance and positive contrast for pedestrians in a crosswalk. Ideally poles should be placed on the approach side of the crosswalk to give positive contrast to a pedestrian in the crosswalk. Transition lighting shall also be provided if there is no, or inadequate, lighting on the approaches.

**4.10.4.03.02** Refer to *ANSI / IESNA RP-8-21, Chapter 12 – Intersections, Roundabouts and Crosswalks*, for illuminance criteria and guidance on the placement of light poles associated with roundabouts.

**4.10.4.03.03** Roundabout street/pedestrian lights are required to be on a separate, larger scaled plan.

**4.10.4.03.04** See Standard Detail S15.3 for the requirements for pedestrian lighting locations.

#### **4.10.4.03 Street Lighting Infill Requirements between Intersections**

Lighting in the public right of way for roads and streets within the City shall address the visibility needs and safety of all users. Roadway lighting levels shall be based on the guidance and lighting criteria values, as follows:

- Street Luminance: *Recommended Practice: Lighting Roadway and Parking Facilities, ANSI / IESNA RP-8-21*
- Pedestrian Illuminance: *Recommended Practice: Lighting Roadway and Parking Facilities, ANSI / IESNA RP-8-21*
- Street Illuminance: *AASHTO Roadway Lighting Design Guide, 7<sup>th</sup> Edition.*

The amount of light a specific roadway requires may vary depending on local conditions, vehicular volume, roadway geometry, pedestrian activity, time of day/year, or other factors specific to the location. The standard allows some

discretion on the part of the designer with approval from the authority having jurisdiction to use professional judgement in the application of fixed roadway lighting equipment.

Type R3 pavement shall be used for all street lighting calculations regardless of the type of pavement that is proposed to be installed.

A total Light Loss Factor (LLF) of 0.85 shall be applied to all luminaires for all photometric calculations.

### **Luminance Method – Generally applies to Arterials & Collectors**

The Luminance method is the preferred method for calculating light levels of the proposed lighting for all street classifications except Local Streets, Neighborhood – 2 Lane Streets, and Residential Parkways in the City. Luminance is preferred because it predicts the roadway surface brightness from the view angle of the driver and accounts for the roadway surface material. The resulting values are given in the units  $\text{cd}/\text{m}^2$ . For curved sections of roadway, reduce the “straight line” centerline space by a factor of 0.85.

Luminance for streets shall be calculated as defined in *IESNA RP-8-21*, Chapter 3 – Calculations, Section 3.3 – Calculation of Roadway Pavement Luminance. Calculating general surface luminance using planar or other types of surfaces is not acceptable. The Street Lighting Plan shall show a representative luminance calculation grid with observer location indication for each proposed roadway classification/category within the plat/development.

### **Illuminance Method – Generally applies to Locals, Neighborhood – 2 Lanes and Residential Parkway, Sidewalks, and Bikeways**

The Illuminance method is the preferred method for calculating light levels of the proposed lighting for all Local Street, Neighborhood – 2 Lanes, and Residential Parkway classifications in the City. Illuminance is preferred because of the typically close-spaced intersections/corners along such streets. The resulting values are given in footcandles (fc).

The Illuminance method is also used for calculating average light levels on sidewalks or bikeways. The resulting values are given in footcandles (fc).

Typical light pole spacing will vary with roadway width, number of lanes, and pedestrian activity level. Developers are to employ the services of an experienced roadway lighting designer to perform the calculations necessary to determine the spacing based on the requirements of the project.

#### **4.10.4.04 Street Lighting Requirements for Residential Redevelopment**

In areas with existing surrounding development constructed generally on all sides of the project (i.e. infill), multi-family residential projects and single-family residential projects with 2 or more platted properties are required to evaluate the existing street light and provide one or more infill street lights, as determined by City Engineer.

##### **4.10.4.04.01 Pedestrian Lighting Criteria**

The criteria are based on pedestrian activity level, which is generally prescribed by adjacent land use and destinations. The classifications for pedestrian activity are low, medium, and high.

##### ***Pedestrian Activity Classifications***

The City's pedestrian lighting is based on the following pedestrian activity classifications: high, medium, and low.

**High** – The high classification is generally used in the following areas including, but not limited to, downtown retail areas, theaters, concert halls or event venues, stadiums, hospitals, campuses, TOD, urban and City center, malls.

**Medium** – The medium classification is generally used in the following areas including, but not limited to, downtown office areas, libraries, recreation centers, places of worship, apartments or multi-family residences, industrial, parks, and streets with transit or bus stops.

**Low** – The low classification is generally used in the following areas including, but not limited to, single family residential, and rural or semi-rural areas. (Use the medium classification in the vicinity of bus stops in low density areas.)

**Bus or Transit Stops** – Provide a light directly adjacent to bus or transit stops regardless of pedestrian activity classification.

If there is a concern or question about the pedestrian activity area classifications, reach out to the Public Works, Engineering Division.

Refer to relevant agency criteria for light level requirements in the public realm of Transportation Oriented Developments.

**Table 4.10.4.04.01  
Pedestrian Walkway Lighting Criteria**

Pedestrian Walkways*			
Pedestrian Activity Classification	Avg. Horizontal <sup>1</sup> Illuminance ( $E_{avg}$ )(fc)	Min. Vertical Illuminance ( $E_{Vmin}$ )(fc)	Uniformity ( $E_{avg}/E_{min}$ )
High	0.9	0.5	5.0
Medium	0.5	0.2	5.0
Low	0.2	0.1	10

\*Based on RP-8-21, Table 11-2, Recommended Design Criteria for Walkways within Road Right of Way

$E_{avg}$  = minimum maintained average horizontal illuminance at pavement

$E_{min}$  = minimum horizontal illuminance

$E_{Vmin}$  = minimum vertical illuminance at 5' (1.5m) above the pavement

<sup>1</sup> For Walkways 10' wide or less, all values are calculated along the centerline of the walkway. Calculation points shall not be greater than 10' apart.



**4.10.4.04.02** Local Streets, Neighborhood – 2 Lane Streets, and Residential Parkways.

**Table 4.10.4.04.02**

Roadway			Sidewalks
Pedestrian Activity	Avg. Illuminance (fc)	Uniformity ( $E_{avg}/E_{min}$ )	Avg. Illuminance (fc)
High	0.9	6.0	0.9
Medium	0.7	6.0	0.5
Low ( $\geq 30$ mph)	0.4	6.0	0.2*
Low ( $< 30$ mph)*	Meet the Illuminance requirements in this table for Low ( $\geq 30$ mph),  OR  Use the following typical spacing: Follow intersection lighting requirements (Section 4.10.4.01), and: <ul style="list-style-type: none"> <li>• For blocks 600' long or less, provide one mid-block light,</li> <li>• For blocks greater than 600' long, provide additional lights, equidistant between intersection lights</li> </ul> Maximum street light spacing is 300' per side of street from the intersection.		

\*Illumination of Sidewalks is required for all classifications except for Local – Low Pedestrian Activity, or at the discretion of the City Engineer

**4.10.4.04.03** Collectors, 2-Lane Main Streets, and Couplets.

**Table 4.10.4.04.03**

Roadway			Sidewalks
Pedestrian Activity	Avg. Luminance ( $cd/m^2$ )	Uniformity ( $L_{avg}/L_{min}$ )	Avg. Illuminance (fc)
High	0.8	3.0	0.9
Medium	0.6	3.5	0.5
Low	0.4	4.0	0.2

**4.10.4.04.04** 6- and 4-Lane Arterials, Boulevards, and Multiway Boulevards, and 4-Lane Main Streets.

**Table 4.10.4.04.04**

Roadway			Sidewalks
Pedestrian Activity	Avg. Luminance (cd/m <sup>2</sup> )	Uniformity (L <sub>avg</sub> /L <sub>min</sub> )	Avg. Illuminance (fc)
High	1.2	3.0	0.9
Medium	0.9	3.0	0.5
Low	0.6	3.5	0.2

**4.10.4.04.05** Street lighting interval spacing may vary depending on utilities located both below and above ground, driveway locations, landscaping (tree canopy conflicts) and street lengths, widths, and alignments. Significant deviation from these criteria should be coordinated with Public Works, Engineering Division.

**4.10.4.05 Street Light Assembly Specifications**

The City has pre-approved street light assemblies specified in this section. Any deviation from the street light assemblies will require the property owner, metropolitan district, and/or HOA to install, maintain, and operate the street lighting. **Private street lighting design is required to meet the City’s photometric criteria.**

**Luminaire Specifications**

**4.10.4.05.1** Luminaires shall utilize integral LED modules, packages, or arrays designed and intended for use in outdoor applications, Screw-based LED bulbs or other LED retro-fit kits or products will not be accepted.

**4.10.4.05.2** Where the street or pedestrian lighting will be owned and maintained by the City and for private lighting, the luminaires shall be suitable for outdoor use and conform to the following general requirements:

**4.10.4.05.3** Transmissive optical components shall be applied in accordance with the original equipment manufacturer’s (OEM) design guidelines to ensure suitability for the environment (e.g., electromagnetic, thermal, mechanical, chemical).

- 4.10.4.05.4** Luminaire shall be listed for use in wet locations by a U.S. Occupational Safety Health Administration (OSHA) Nationally Recognized Testing Laboratory (NRTL).
- 4.10.4.05.5** Luminaire shall be designed for ease of component replacement and end-of-life disassembly.
- 4.10.4.05.6** LED light source(s) and driver(s) shall be Restriction of Hazardous Substances (RoHS) compliant.
- 4.10.4.05.7** Luminaires shall be tested in accordance with International Illumination Engineering Society of North America's (IESNA) LM-79-08 (or latest) *Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products*.
- 4.10.4.05.8** Nominal luminaire input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading.
- 4.10.4.05.9** Allowable A/C operating voltages for luminaires shall be 120 V, 208V, or 240V at 60 Hz. and shall operate normally for input voltage fluctuations of plus or minus 10 percent.
- 4.10.4.05.10** All internal components shall be assembled and pre-wired using modular electrical connections.
- 4.10.4.05.11** Luminaire shall have an external label per the American National Standards Institute (ANSI) C136.15 and an interior label per ANSI C136.22.
- 4.10.4.05.12** The following shall be in accordance with corresponding sections of ANSI C136.37:
  - Wiring and grounding
  - Terminal blocks for incoming AC lines (electrical mains wires)
  - Latching and hinging
  - Mounting provisions
- 4.10.4.05.13** Painted or finished luminaire surfaces exposed to the environment shall exceed a rating of six per the American Society for Testing and Materials (ASTM) D1654 after 1000 hours of testing per ASTM B117. The coating shall exhibit no greater than 30% reduction of gloss per ASTM D523, after 500 hours of QUV testing at ASTM G154 Cycle 6.
- 4.10.4.05.14** Luminaire shall be rated to start and operate in ambient temperature of -40°C (-40°F) to +40°C (+104°F).
- 4.10.4.05.15** Maximum rated case temperature of driver and other internal components shall not be exceeded when luminaire is operated in the ambient temperature range specified.

- 4.10.4.05.16** Mechanical design of protruding external surfaces (e.g. heat sink fins) shall facilitate hose-down cleaning and discourage debris accumulation.
- 4.10.4.05.17** Liquids or other moving parts shall be clearly indicated in submittals, shall be consistent with product testing, and shall be subject to review by the City.
- 4.10.4.05.18** Luminaire shall be fully pre-wired and shall incorporate an ANSI C136.41 compliant 7-pin receptacle. The driver shall be dimmable and compatible with 0-10V or DALI control signals. Control wires shall be connected to the receptacle pads as specified in ANSI C136.41; connection of the two remaining pads shall be as directed by the City.
- 4.10.4.05.19** Luminaire shall meet the performance requirements specified in ANSI C136.2-2015 for electrical immunity, using the “Enhanced” (10kV/5kA) combination wave test level.
- 4.10.4.05.20** Manufacturer shall indicate on luminaire submittal form whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire.
- 4.10.4.05.21** Luminaire shall comply with FCC 47 CFR Part 15 interference criteria for Class A (non-residential) digital devices.
- 4.10.4.05.22** Luminaire shall comply with section 5.2.5 (luminaires rated for outdoor use) of ANSI C82.77 at full input power and across specified voltage range.
- 4.10.4.05.23** Color Rendering Index (CRI) of the LED source shall not be less than 70.
- 4.10.4.05.24** Nominal Correlated Color Temperature (CCT) of the LED source shall be  $3000\text{K} \pm 120$ .
- 4.10.4.05.25** Luminaire shall be capable of  $\pm 5$  degrees of tilt, minimum, for leveling adjustment.
- 4.10.4.05.26** Luminaire shall be provided with the capability for optional, field installed backlight control.
- 4.10.4.05.27** Luminaire cooling system shall consist of a passive heat sink. Mechanical design of protruding external surfaces (heat sink fins) shall facilitate hose-down cleaning and discourage debris accumulation. Circulating liquids, fans, diaphragms or other moving parts shall not be permitted.
- 4.10.4.05.28** Luminaires shall be tested in accordance with IESNA TM-15-11 (or latest) *Luminaire Classification System for Outdoor Luminaires*. Luminaires shall have a ‘U0’ rating for Uplight except in Neighborhoods. In Neighborhoods, the maximum ‘U’ rating shall be ‘U1’. In other applications, roadway luminaires shall not exceed the following Glare ratings:

Less than 5,000 lumens:	G = 1
5,001 to 12,000 lumens:	G = 2
12,001 to 22,00 lumens:	G = 3
Greater than 22,000 lumens:	G = 4

#### **4.10.4.06 Pole Specifications**

Light poles shall be suitable for the intended application and conform to the following general requirements:

- 4.10.4.06.1** The pole shaft shall be a round, one-piece assembly conforming to ASTM A595 Grade A or A572 Grade 55. Tapered shafts shall have a constant linear taper of 0.14in/ft.
- 4.10.4.06.2** Pole shall be sufficient to support the luminaire and arm in 100MPH wind with a 1.3 Gust Factor.
- 4.10.4.06.3** Poles shall be set plumb on the light standard foundation using leveling nuts. Refer to pole manufacturer's specification information for bolt circle diameter and other dimensional information.
- 4.10.4.06.4** A reinforced handhole shall be provided and shall include cover and cover attachment hardware.
- 4.10.4.06.5** Anchor bolts shall conform to ASTM F1554 Grade 55 and be provided with two hex nuts and two flat washers.
- 4.10.4.06.6** Defects and scratches on painted, powder-coated, or anodized poles shall be primed and painted with a color-matched paint.
- 4.10.4.06.7** Stainless steel mounting hardware shall be used to mount luminaires, arms, access doors, and other hardware to the poles. Apply an approved zinc-based anti-seize compound to all mounting hardware prior to assembly.
- 4.10.4.06.8** Pole shall include an external tag per City of Aurora requirements. Tag to be furnished by the City of Aurora and affixed to pole by installing contractor.

#### 4.10.4.07 Acceptable Manufacturers

The City has Pre-Approved Pedestrian and Street Lighting Assemblies that are required to be used for City lighting and may be found on the City’s website.

**Table 4.10.4.07.01  
Typical Street Light Standards**

Street Type	Symbol
Pedestrian Lighting in TODs, Urban Centers, and High Pedestrian Traffic areas.	● PL-1
Local, Neighborhood, Residential Parkway	● SL-1
2-Lane Main Street, Single Lane Roundabout	● SL-2
2-Lane and 3-Lane Collector, 4-Lane Main Street, Couplet, Two-lane Roundabout	● SL-3
Arterial, Boulevard, Multiway Boulevard, > Two-lane Roundabout	● SL-4

<sup>1</sup> Generally used for four-lane arterial or equivalent Urban Center or TOD street.

<sup>2</sup> Generally used for six-lane arterial or equivalent Urban Center or TOD street.

<sup>3</sup> The color of the street light equipment shall be noted on the site plan and the civil plans.

<sup>4</sup> For infill projects located within commercial/industrial areas for local streets the pole and fixture may match existing street light and fixture within the surrounding area as long as the matching light pole and fixture also match the City’s requirements.

**4.10.4.07.1** TYPE ‘PL-1’ shall be a “decorative” luminaire on a 14-foot (max.) aluminum or steel pole with 8” base diameter. Assemblies utilizing two luminaires at 180-degrees apart are acceptable. Color of all lighting assembly components (ie. Pole, base cover, luminaire, bracket arm, etc.) must match.

<u>Short-Arm Luminaire Requirements</u>	
Minimum Initial Absolute Lumens:	9,000
IES Light Distribution:	Type III
Backlight/Uplight/Glare (BUG) Max Rating:	Bx-U0-G2 *
Luminaire Mounting Height:	14 feet
Finish Color:	Grey or Black

Post-Top Mount Style: shall be a “decorative” luminaire on a 14-foot, 4.5” round straight aluminum pole with 8” base diameter. Color of all lighting assembly components (pole, base cover, luminaire, etc.) must match.

<u>Post-Top Luminaire Requirements</u>	
Minimum Initial Absolute Lumens:	6,000
IES Light Distribution:	Type IV
Backlight/Uplight/Glare (BUG) Max Rating:	Bx-U0-G2 *
Luminaire Mounting Height:	14 feet
Finish Color:	Natural Aluminum Paint

**4.10.4.07.2** TYPE ‘SL-1’ shall be an LED post-top lantern-style luminaire or rectilinear luminaire with a short luminaire arm. Luminaires shall be mounted on a round tapered galvanized steel or architectural-grade composite fiberglass pole. Color of all lighting assembly components (i.e. pole, base cover, luminaire, bracket arm, etc.) must match. Assemblies utilizing two luminaires at 180-degrees apart are acceptable.

<u>Luminaire Requirements</u>	
Minimum Absolute Lumens:	6,000
IES Light Distribution:	Type III
Backlight/Uplight/Glare (BUG) Max Rating:	Bx-U0-G2 *
Mounting Height:	20 feet
Finish Color:	Grey or Black

\* Maximum Uplight rating is U1 in Neighborhood locations only.

**4.10.4.07.3** TYPE ‘SL-2’ shall be an LED cobra head-style luminaire mounted on a 4-foot tapered upswept single-tube luminaire arm with 2-inch nominal pipe size (NPS) tenon. Luminaire and arm shall be mounted on a round tapered galvanized steel pole. Assemblies utilizing two luminaires at 180-degrees apart are acceptable.

<u>Luminaire Requirements</u>	
Minimum Absolute Lumens:	6,000
IES Light Distribution:	Type II or III, Medium

Backlight/Uplight/Glare (BUG) Max Rating:	Bx-U0-G2
Mounting Height:	25 feet
Finish Color:	Grey

**4.10.4.07.4** TYPE ‘SL-3’ shall be an LED cobra head-style luminaire mounted on a 4-foot tapered single-tube upswept luminaire arm with 2-inch nominal pipe size (NPS) tenon. Luminaire and arm shall be mounted on a round tapered galvanized steel pole. Assemblies utilizing two luminaires at 180-degrees apart are acceptable.

<u>Luminaire Requirements</u>	
Minimum Absolute Lumens:	14,000
IES Light Distribution:	Type II or III, Medium
Backlight/Uplight/Glare (BUG) Max Rating:	Bx-U0-G2
Mounting Height:	30 feet
Finish Color:	Grey

**4.10.4.07.5** TYPE ‘SL-4’ shall be an LED cobra head-style luminaire mounted on an 8-foot tapered single-tube upswept luminaire arm with 2-inch nominal pipe size (NPS) tenon. Luminaire and arm shall be mounted on a round tapered galvanized steel pole. Assemblies utilizing two luminaires at 180-degrees apart are acceptable.

<u>Luminaire Requirements</u>	
Minimum Absolute Lumens:	25,000
IES Light Distribution:	Type II or III, Medium
Backlight/Uplight/Glare (BUG) Max Rating:	Bx-U0-G2
Mounting Height:	30 feet
Finish Color:	Grey

#### **4.10.4.08 Lighting Control Centers**

Lighting Control Centers shall be an all-in-one commercial pedestal and shall include a load center, a panelboard, contactors, a 120V GFCI maintenance receptacle, a meter housing, a photoelectric control, a grounding rod system, a



NEMA 4 enclosure with all related components, and connections to the utility power supply.

- 4.10.4.08.1** Service Pedestals shall be metal conforming to ANSI C47.12.28, *Pad Mounted Enclosure Integrity Standard* and shall be the nominal size and dimensions shown in the Contract.
- 4.10.4.08.2** NEMA 4 construction and shall be UL listed as “Enclosed Industrial Control Equipment” (UL508). Cabinets shall be vandal resistant dead-front enclosures.
- 4.10.4.08.3** The external finish of the cabinet shall be industrial grade, polyurethane powder paint of 1.7 mil minimum thickness. The internal finish of the cabinet shall be industrial grade, polyurethane powder paint of 1.7 mil minimum thickness or bare aluminum.
- 4.10.4.08.4** All external fasteners, rivets, screws and bolts shall be stainless steel. Fasteners, except sealing screws, shall not be removable by external access. Hinges shall be stainless steel continuous piano hinge type hinges.
- 4.10.4.08.5** External nameplates shall be permanently attached to the cabinet. A stainless steel handle shall be provided on the front exterior of each cabinet door or hood. Cabinet shall be equipped with a three point catch and lock. These locks shall be furnished with two keys for each cabinet, and all locks shall be master keyed Type I police lock. When final acceptance of the project is made, the Engineer will distribute the keys to the agencies responsible for maintenance of the system.
- 4.10.4.08.6** The cabinet shall have separate isolated sections for metering equipment (if required), utility termination, and City equipment. All sections must be sealed and pad-lockable.
- 4.10.4.08.7** The metering section shall have a hinged swing back hood with hold-open arm and an integral hinged polycarbonate sealable window for visual access to meters. The meter shall have a lever bypass and internal locking tab on meter cover.
- 4.10.4.08.8** The utility termination section shall be sealed and securable with a padlock. The section shall have a lift off cover with a stainless steel handle and padlock hasp. Sufficient clearance shall be provided for a 4-inch diameter

conduit for utility cables. Utility landing lugs shall be UL Listed and equipped with “finger-safe” thermoplastic covers and shall accommodate 6 - #350 kcmil conductors.

**4.10.4.08.9** The City compartment door shall be sealed and securable with a padlock. The compartment door shall be anchorable in an open position. There shall be a print pocket on the inside of the door. The print pocket shall hold all wiring schematics and instructions in a clear weatherproof sleeve with a side opening. Required UL labeling shall be located on the inside of the City door. Distribution and control equipment shall be behind an internal dead-front door with a quarter-turn securing latch and be hinged to open more than 90 degrees. The dead-front door shall be hinged on the same side as the City section door.

**4.10.4.08.10** Metered Electrical Pedestals shall be mounted on a concrete (Class B) pad. Pedestal mounting bolts shall not be visible or accessible externally. Pad mounting shall include concrete pad mounting base, anchor bolt kit and hardware.

**4.10.4.08.11** Metered Electrical Service Pedestals shall be rated for 600 VAC and installed with protection against damage from greater currents. The pedestals shall be grounded with grounding rods in conformance with the National Electric Code. The following equipment is for a typical installation and may or may not be required as shown on the plans:

- (1) Meter Sockets (100 amp minimum).
- (2) Main circuit breaker that is installed in a circuit load center as sized on the plans.
- (3) Circuit load center with an all-copper bus for City loads as shown on the plans.
- (4) Circuit breakers.
- (5) Ground Fault Circuit Interrupter receptacle (20 amp, 120 VAC).
- (6) Multiple-pole Lighting Contactors.
- (7) Test Switch.
- (8) Photoelectronic Control Relay.
- (9) Mounting pans or false backs for circuit breakers, contactors, relays, switches, transformers, and other types of electrical equipment mounted inside the cabinet.

**4.10.4.08.12** The internal wiring of cabinets shall be assembled by a UL listed facility. Cabinets shall conform to one or more of the following standards where

appropriate: UL 50, Cabinets and Boxes; UL 67, Panel Boards and UL 869A, Service Equipment.

- 4.10.4.08.13** Circuit breakers and equipment shall be labeled with an engraved permanent label on the dead-front panel to indicate the circuit controlled.
- 4.10.4.08.14** Multiple-pole Lighting Contactors shall be “lighting” type, specifically rated for the type of lighting load specified. The contactors shall have a 600 Volt rating. All multiple-pole light contactors shall be unenclosed, single phase with the number of poles specified on plans; they shall be open type lighting contactors with the rating shown or specified. Contactors shall be constructed for surface mounting on a false back or bracket within a weatherproof cabinet. The contactor coil shall operate on 120 Volt for 240 Volt circuits and 240 Volt, 208 Volt, and 277 Volt for 480 Volt circuits. Contact material shall be designed for lighting ballast loads and require no maintenance such as filing, burnishing, or dressing at any time the contactor is in service.
- 4.10.4.08.15** A 120VAC rated test switch shall be installed in the control cabinets if shown. The test switch shall be a heavy-duty single pole switch or circuit breaker rated at 20 amps and shall be installed in the control cabinet as a roadway lighting test switch. The switch shall be wired to shunt the photoelectric control relay power contactor and energize the lighting circuit contactors.
- 4.10.4.08.16** All components of the photoelectric control relays shall be housed in a weatherproof, locking, non-rusting container. The photoelectric control relay shall attach to a three pole locking receptacle by a twisting motion.
- 4.10.4.08.17** The photoelectronic control shall have a built in surge protective device for protection from induced high voltage and overcurrents. The photoelectric control relay shall meet or exceed the requirements of ANSI C136.10. The photoelectric control shall be factory set to turn on lights when ambient light falls to 1.4 footcandle plus or minus 0.2 footcandle when operated at 120 VAC. When operated at 240 VAC, turn on shall not change more than plus or minus 0.3 footcandle from the 120 VAC value. The maximum off to on ratio shall be 1.5:1. The photoelectric control shall be a cadmium sulfide photoelectric control encapsulated for humidity protection, or a silicon junction type photo transistor. The photoelectric control shall be designed

for normal operation at a dual voltage of 105 V and 285 V. Power consumption shall be less than 1 watt. At the designated voltage, the photoelectric control shall be capable of controlling a minimum load of 1000 watts. Minimum operating temperature range shall be from -40 °F to 150 °F. A time delay control circuit shall prevent false turn offs by transient lighting conditions. The unit shall include a failsafe circuit for the lighting load such that the lighting systems remain energized if any functional failure of the photoelectric control circuit occurs.

**4.10.4.08.18** “Arc-Flash Hazard Warning” labels shall be furnished and installed by the electrical contractor per the National Electric Code-2014 NEC 110.6 and the NFPA 70E-2015, and all other labels required by NFPA 70 on all new panels.

**4.10.4.08.19** The Meter Pedestal shall be properly grounded. If the ground rod does not measure below 10 ohms, Contractor shall furnish and install a second ground rod. Both ground rods shall be 8’-0” (min.) apart. If two grounds are installed, resistance must be less than 25 ohms. If 25 ohms cannot be achieved with two ground rods, notify the City Engineer.

#### **4.10.4.09 Testing and Inspection**

Prior to final acceptance, the Contractor shall demonstrate to the Engineer’s satisfaction that all electrical and lighting equipment installations are in proper working condition. Temporary power and all cable connections required for testing shall be provided by the Contractor.

The Contractor shall operate the lighting system from sunset to sunrise for ten consecutive days. Light sources, drivers, and photoelectric or I/P addressable control devices that fail shall be replaced immediately. However, replacement of these items will not require a restart of the test.

The Contractor shall perform grounding tests at lighting control center to show ground resistance of 25 ohms or less. Contractor shall submit test report to the City for review and acceptance prior to approval.

Inspection shall be scheduled and coordinated with Inspections and Operations. All critical punchlist items shall have been addressed and confirmed corrected and the street lighting to be 100% complete prior to final acceptance. The City

will not assume ownership, maintenance, and operation of the new street light until such time as the punchlist has been verified complete. A minimum one-year warranty shall be provided for all new street light installation work. Any deviation from the above must be approved by the Engineer.

#### **4.10.4.10 As-built Drawings**

Contractor shall supply accurate as-built drawings of the project to the City of Aurora. Drawings shall include, but not limited to, conduit location, lighting control center location, and utility point of service, and pole location (latitude and longitude) along the roadway. Coordinate additional pole GIS information with the City of Aurora Public Works Department. Final acceptance of work will be withheld until such data has been presented to the City of Aurora.

#### **4.10.4.11 City Approval of Street and Pedestrian Lighting Equipment**

Unless design and selected fixtures meet the City standards, selected street lighting luminaire, type of lamp and lumen output, mounting height, pole type, and color for installation on all public streets or city rights-of-way shall require variance approval from the City Engineer. Follow the variance process in Section 2.03.9.

If a developer desires to install special street and/or pedestrian lights and fixtures (not in the City of Aurora's Standards), then the metropolitan district or the homeowner's association must own and maintain those lights. There must be a funding source, from the metropolitan district or homeowner's association, for the power supply and the general maintenance of the street lights.

### **4.11 Roadside Design & Clear Zone**

#### **4.11.1 General**

Proposed roadside improvements within ROW shall conform to the appropriate design guide and requirements. Design guides include *AASHTO Roadside Design Guide* (current edition) (AASHTO RSDG), *Geometric Design of Low Volume Roads*, *FHWA Noteworthy Practices: Roadside Tree and Utility Pole Management* and the specific City requirements of this section. Variances from the above referenced requirements require coordination with Traffic division and require approval from the City Engineer.

Regardless of the cause, and within reason, the roadside environment including the objects placed in the ROW should not present a severe hazard to the occupants of errant vehicles. The remaining portions of this section address the latter, and assumes that despite its efforts, vehicles will likely depart the roadway.

#### 4.11.2 Terminology

**Clear Zone** – an unobstructed, relatively flat area beyond the edge of through traveled way that allows a motorist to stop safely or regain control of a vehicle that leaves the traveled way.

**Edge of Through Traveled Way** – The reference point from which clear zone should be measured, representing the effective edge of an adjacent through lane carrying through traffic.

**Obstacle** – a broad category of physical items installed in the roadside environment, including rigid and crashworthy objects.

**Rigid Object** – Objects that cannot be classified as breakaway, and shall not be placed in the clear zone.

**Breakaway** – design properties of an obstacle whereby an obstacle is designed to behave in such a way when struck by an errant vehicle to make the object crashworthy.

**Crashworthy** – a characteristic of roadside obstacles that can be struck by an errant vehicle, relative low severity impacts to the safety of the occupants of errant vehicles.

**Traversable** – a characteristic of roadside obstacles that can be driven over without causing a motorist to lose additional control of an errant vehicle.

#### 4.11.3 Applicability

Roadside design requirements apply to all non-traversable terrain and obstacles greater than 2.0 feet in height in the public ROW, the location of which are not critical for transportation safety reasons. Roadside design principles should also be applied by adjacent private property owners to areas outside of ROW that exist within the clear zone, as defined in this section. Examples of typical objects subject to roadside design standards include but are not necessarily limited to:

- traffic sign supports
- roadside cabinets
- utility poles

- street light poles
- wireless access towers
- irrigation equipment
- fire hydrants
- mail boxes
- other objects determined by the City Engineer
- Landscaping elements such as trees and boulders

Exempt infrastructure includes but is not necessarily limited to:

- traffic signal supports, due to their contribution to roadway safety through traffic control
- other existing objects, unless otherwise determined by the City Engineer

#### **4.11.4 Lateral Offsets**

##### ***4.11.4.01 Minimum (Operational) Lateral Offset***

Under no circumstances shall a non-traversable obstacle be installed within 3.0' of the face of curb near intersections or on the outside of curved roadway sections. In all other sections of roadways with curb, no non-traversable obstacles shall be installed within 1.5' of the face of curb.

The minimum lateral offset applies to breakaway and rigid objects alike, and does not necessarily satisfy requirements to provide a clear zone free of unshielded rigid objects.

##### ***4.11.4.02 Edge of Through Traveled Way***

Edges of through traveled way are respective reference points from which the clear zones for roadside and median areas are measured, and are defined as the edges of the adjacent through lane. The curb face is often mistakenly automatically assumed as the edge of through traveled way.

Other traversable roadway surfaces listed below are not considered 'through traveled lanes' and are considered to be in the clear zone.

- Parking lanes
- Bike lanes
- Aux lanes, at the discretion of the City Engineer.

- Gutter pans, where the curb-adjacent lane's remaining travelled way width is at minimum 12', and there is a clear edge of pavement (not monolithic).

When changes to the roadway due to widening, lane marking re-configurations, or similar projects that impact the location of the edge of through traveled way are proposed, the designer shall also identify the existing and proposed edge of traveled way and evaluate the resulting impacts to the clear zone and existing obstacles in the roadside environment.

#### **4.11.4.03 Curbs**

Vertical curbs are present at most non-rural roadways, and are not considered a barrier due to lack of significant re-direct capability, by neither AASHTO RSDG nor the City.

Refer to **Section 0** regarding curb and the edge of through traveled way.

### **4.11.5 Clear Zone Determination**

Obstacles identified in **Section 4.11.2** shall be located outside of the clear zone as defined in the design guides in Section 4.11.1 and the following subsections. Objects that do not exceed 18 inches in height or are crashworthy may be installed in the ROW.

#### **4.11.5.01 Design ADT**

For the sole purposes of clear zone determination, design ADT shall be as shown on the plans.

#### **4.11.5.02 Design Speed**

For the sole purposes of clear zone determination, design speed shall be as shown in **Table 4.04.4.1**. In scenarios where an existing roadway does not fit the proposed roadway classifications in **Table 4.04.4.1**, the City Engineer will determine the design speed.

Refer also to **Section 4.11.7.2.2.1.3** for information about design speed and guard rail design.

#### **4.11.5.03 Base Clear Zone**

The most conservative clear zone lateral offset distance suggested in the RSDG shall be used unless otherwise reduced, as described in **Section 4.11.5.4**.

#### **4.11.5.04 Reduced Clear Zone**

The 4.11.5.03 Base Clear Zone defined in **Section 4.11.5.3** may be reduced if requested in writing by the engineer, and approved in writing by the City Engineer. Use **Error!**



**Reference source not found.**” may be considered when at least one of the following cases apply. The magnitude of the approved reduction may be based on the number of cases that do apply:

- The proposed obstacle is located along the inside edge of a curved section of roadway,
- For Arterial roadway classifications, the proposed obstacle is not located in the roadside of arterials on DRCOG’s High Injury Network<sup>42</sup>.
- The proposed obstacle is not downstream of driveways or intersections
- Nearby sight triangle restrictions compete with Base Clear Zone width
- Frequent and consistent occupancy of on-street parking approaching the site can be documented for times when free-flow speeds and high traffic volumes exist<sup>43</sup>
- Typical justifications to reduce the clear zone dimensions, that are typically not considered acceptable, include:
  - On-street parking is available
  - Other existing roadside obstacles exist nearby

#### **4.11.6 Prioritized Design Strategies**

Under certain conditions, adequate ROW width may not be available to satisfy clear zone requirements. In such instances, design alternatives shall be considered, and using the following process. Refer to the following sections for prioritized design alternatives that include such scenarios.

##### **4.11.6.01 Do Not Install Obstacle In Roadside Environment**

Do not install the obstacle along the roadside in the public right of way, or remove the obstacle, if practical and permissible.

##### **4.11.6.02 Re-Design Obstacle as Traversable**

Redesign the obstacle so that it can be safely traversed by an errant vehicle (for example, install the obstacle underground).

##### **4.11.6.03 Reset Rigid Object Out of Clear Zone, within ROW**

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<sup>42</sup> High Injury Network interactive map is linked from The Denver Regional Council of Government’s (DRCOG’s) Regional Vision Zero website, <https://drcog.org/planning-great-region/transportation-planning/traffic-safety/regional-vision-zero> or directly at, <https://drcog.maps.arcgis.com/apps/webappviewer/index.html?id=28b1fdcc3b3e45069497370402ec64c2>

<sup>43</sup> On-street parking is transient by nature, and is not seen as a strong argument for reduction of the base clear zone lateral offset.

Relocate the rigid object laterally from the roadway to a point outside of the clear zone, and within existing ROW.

**4.11.6.04 *Re-Design Obstacle as Breakaway, within Clear Zone***

Redesign the obstacle as crashworthy by equipping with an appropriate breakaway device per **Section 4.11.7.2.1**.

**4.11.6.05 *Shield Errant Vehicles from Rigid Object within Clear Zone***

Shield any rigid objects proposed within the clear zone with a longitudinal traffic barrier designed for redirection and/or crash impact attenuation. The operations and maintenance of counter measure devices installed within the ROW shall be the responsibility of the owner of the shielded rigid object.

<b>SECTION 5.00</b>	<b>PAVEMENT DESIGN .....</b>	<b>1</b>
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## SECTION 5.00 PAVEMENT DESIGN

### 5.01 Pavement Design

**5.01.1 General** The "AASHTO Guide for Design of Pavement Structures," (AASHTO Guide) and "Pavement Design Standards and Construction Specifications" for Metropolitan Government Pavement Engineers Council, (Latest editions), are the basis for this design specification.

#### 5.01.2 Scope

**5.01.2.01** Placement of pavement within public right-of-way or public access easements maintained by Aurora requires a geotechnical investigation and pavement design report (hereafter called "geotechnical and pavement design report" or "report") approved prior to issuance of a permit to perform the work. **All new street and public access easements maintained by Aurora shall be paved with a composite Asphaltic Concrete and Aggregate Base Course section or Portland Cement Concrete section.** Edge drains will be required for the composite sections (See Standard Detail S1.19), unless the geotechnical and pavement design report indicates the subgrade soil's permeability is greater than 10 feet per day. Where edge drains are installed the base course material shall conform to Type 6 (See Section 23.02, Table 23.02.1). The edge drain shall outfall into an adjacent storm sewer inlet. Edge drains shall be installed 100 feet either side of low points (sump inlets) in streets or upstream from on-grade Type R Inlets, unless geotechnical analysis requires additional protection. For work within an existing paved street, the City Engineer or authorized representative may approve the use of a pavement cross section based on the existing pavement condition or a previously approved pavement design report.

**5.01.2.02** Placement of pavement for new or existing private parking lots, fire lanes, driveways and private streets shall equal or exceed the **default sections** listed in Tables 5.01.2.03.1 through 5.01.2.03.4 below, unless a site specific pavement design is approved. **A geotechnical and pavement design report is not required for paving of new or existing private parking lots, fire lanes, driveways, and private streets (other than TODs and Urban Centers).**

The civil plans shall have the default pavement thicknesses labeled on the plans and a note indicating the type of soils within the project. A paving permit for these private infrastructure is not required.

[A Private Development Pavement Certification shall be required to be submitted prior to issuing a Certificate of Occupancy \(see example after the end of Section 5.12.7\).](#)

**Table 5.01.2.03.1  
PRIVATE PAVEMENT DEFAULT SECTIONS<sup>1</sup>  
PRIVATE STREET OR DRIVE**

	Single-Family Residential	Multifamily Residential	Commercial and Business	Industrial
<b>Minimum ESAL (X10<sup>6</sup>)</b>	0.06	0.07	0.2	0.7
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.5"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	4.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "C" <sup>2</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "D" <sup>2</sup> A-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.0"	5.0"	5.5"	6.5"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	4.0" + 6.0"	4.0" + 8.0'
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "E" <sup>2</sup> A-7-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.5"	6.0"	7.0"	8.5"
AC and Aggregate Base	4.0" + 6.0"	4.0" + 8.0'	5.0" + 8.0"	5.0" + 12.5"
PCC	6.0"	6.0"	6.0"	6.0"

Note 1 Based on ACPA Software StreetPave 12

Note 2 For swelling soils see Table 5.06.1.1 for subgrade preparation requirements.

**Table 5.01.2.03.2  
PRIVATE PAVEMENT DEFAULT SECTIONS<sup>1</sup>  
FIRE LANE**

	Single-Family Residential	Multifamily Residential	Commercial & Business	Industrial
<b>Minimum ESAL (X10<sup>6</sup>)</b>	--	0.07	0.2	0.2
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>				
Full Depth Asphalt	--	5.0"	5.0"	5.0"
AC and Aggregate Base	--	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	--	6.0"	6.0"	6.0"
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>				
Full Depth Asphalt	--	5.0"	5.0"	5.0"
AC and Aggregate Base	--	3.5" + 6.0"	3.5" + 6.0"	4.0" + 6.0"
PCC	--	6.0"	6.0"	6.0"
<b>SOIL GROUP "C" <sup>2</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	--	5.0"	5.0"	5.0"
AC and Aggregate Base	--	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	--	6.0"	6.0"	6.0"
<b>SOIL GROUP "D" <sup>2</sup> A-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	--	5.0"	5.5"	5.5"
AC and Aggregate Base	--	3.5" + 6.0"	4.0" + 6.0"	4.0" + 8.0"
PCC	--	6.0"	6.0"	6.0"
<b>SOIL GROUP "E" <sup>2</sup> A-7-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	--	6.0"	7.0"	7.0"
AC and Aggregate Base	--	4.0" + 8.0"	5.0" + 8.0"	5.0" + 8.0"
PCC	--	6.0"	6.0"	6.0"

Note 1 Based on ACPA Software StreetPave 12

Note 2 For swelling soils see Table 5.06.1.1 for subgrade preparation requirements.

**Table 5.01.2.03.3  
PRIVATE PAVEMENT DEFAULT SECTIONS<sup>1</sup>  
PARKING, CARS ONLY**

	Single-Family Residential	Multifamily Residential	Commercial & Business	Industrial
<b>Minimum ESAL (X10<sup>6</sup>)</b>	0.04	0.04	0.04	0.04
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	4.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "C" <sup>2</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "D" <sup>2</sup> A-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "E" <sup>2</sup> A-7-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.5"	5.5"	5.5"	5.5"
AC and Aggregate Base	4.0" + 6.0"	4.0" + 6.0"	4.0" + 6.0"	4.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"

Note 1 Based on ACPA Software StreetPave 12

Note 2 For swelling soils see Table 5.06.1.1 for subgrade preparation requirements.



**Table 5.01.2.03.4  
PRIVATE PAVEMENT DEFAULT SECTIONS<sup>1</sup>  
PARKING, ALL OTHER**

	Single-Family Residential	Multifamily Residential	Commercial & Business	Industrial
<b>Minimum ESAL (X10<sup>6</sup>)</b>	0.04	0.04	0.07	0.07
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	4.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "C" <sup>2</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "D" <sup>2</sup> A-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.0"	5.0"	5.0"	5.0"
AC and Aggregate Base	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"	3.5" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "E" <sup>2</sup> A-7-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	5.5"	5.5"	6.0"	6.0"
AC and Aggregate Base	4.0" + 6.0"	4.0" + 6.0"	4.0" + 6.0"	4.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"

Note 1 Based on ACPA Software StreetPave 12

Note 2 For swelling soils see Table 5.06.1.1 for subgrade preparation requirements.

### 5.01.3 TOD and Urban Centers

**5.01.3.01** Transit oriented developments (TODs) and urban centers have different pavement requirements than other zoning districts. This difference is due to the fact the disruption to the surrounding daily activities within these denser developments warrants a higher standard of care to minimize the frequency of such disruptions. These types of developments are defined in Article 126-36.5 of the City Code. See Section 2.00 and 4.00 for additional information. TOD's and urban centers are set up to contain three context zones: Edge, Transition and Core.

**5.01.3.01.1** Edge Zones may use flexible pavement utilizing the modified ESAL values shown in Table 5.07.1.2. Concrete pavements may also be used in this zone. See Section 5.09.2 for required uses of concrete pavements.

**5.01.3.01.2** Core and Transition Zones are required to use concrete pavement utilizing the modified ESAL values shown in Table 5.07.1.2. Concrete paving, upon request, maybe approved by the City Engineer on a case by case basis.

**5.01.4** Additive overlays (i.e., maintenance overlays on top of an existing pavement’s finished grade) will not be allowed. In order to maintain consistency of the street grade for purposes, including pedestrian accessibility and surface drainage, rotomilling will be required to the depth of overlay proposed.

### **5.01.5 Definitions**

**5.01.5.01**  $W_{18}$  - 18 Kip Equivalent Single Axle Loads for the design period in the design lane. (ESAL)

**5.01.5.02**  $M_R$  - Effective Roadbed Soil Resilient Modulus as correlated from Hveem Stabilometer (R-Value) AASHTO Test Method T 190 for soil groups classified as A-1, A-2-5, A-2-7, A-3, A-4, and A-5, or Unconfined Compressive Strength Test (remold), UCC, AASHTO Test Method T 208 for soil groups classified as A-6, A-7, A-2-4, and A-2-6. In the event that Unconfined Compressive Strength tests results for A-2-4 and A-2-6 soils are not reproducible, R-value testing shall be performed.

**5.01.5.03**  $K$  - Effective Modulus of Subgrade Reaction.  $M_R$  is input and adjustments made for the effects of subbase, rigid foundation near the surface, and potential loss of support due to erosion, as applicable.

## **5.02 Report Submittal and Review**

**5.02.1** Aurora uses an electronic submittal process for the review and approval of the pavement design report. The geotechnical consultant shall contact Aurora Public Works at 303-739-7335 to request an electronic folder be created so the pavement design report can be submitted electronically. Once this folder is created the applicant will receive an email with instructions on how to access the online system. Information provided to the applicant includes a link, user/login name, and a temporary password. The applicant will click the hyperlink in the email and log onto the online system. At this point the applicant may now upload the “locked” and “unlocked” pavement design

reports. There is also an online help guide to assist the applicant with the online submittal process. Once the report has been uploaded and the review fee paid, the report will be reviewed. The “locked” report shall have an electronic stamp and signature of, and be dated by a Colorado licensed Professional Engineer competent in the field of Geotechnical Engineering (herein called “Geotech”). The “unlocked” report will be a facsimile of the professional engineer’s signed and sealed report. The cover of the “unlocked” report shall have the following note added and signed by the professional engineer.

“This electronic report is a facsimile of the signed and sealed pdf report.

\_\_\_\_\_

(Original Signature)

\_\_\_\_\_

(Date)”

See the general checklist on the next page for assistance in preparing a report.

## SUBMITTAL CHECKLIST for PAVEMENT GEOTECHNICAL DOCUMENTS

**Geotechnical and Pavement Design Reports submitted with incomplete information on the title page shall not be accepted. If civil plans are approved, review time for all Geotech submittals is 10 working days.**

### **GEOTECHNICAL AND PAVEMENT DESIGN REPORT [1 copy] \$310 FEE**

- The report (with digital and facsimile signature) must be submitted ONLINE. Please contact the Engineer on Duty at 303-739-7335 [or email engineering@auroragov.org](mailto:engineering@auroragov.org) to request creation of a PA folder to upload your documents.
- The report shall have the stamp and original signature of, and be dated by a Colorado licensed Professional Engineer [Geotech].
- The report shall be pdf formatted at 8 1/2" x 11" [please no PDF/A formatting].
- Title of the report: Geotechnical and Pavement Design Report
- Subtitle of the report: Subdivision Name and Filing Number (include the Lot and Block numbers if the report does not apply to the entire filing.)
- COA Engineering Drawing Number [EDN] if civil plans are approved.
- Name of Applicant, full address (including zip code), telephone number, email address, name of contact person. [Applicant is the designated contact for all purposes.]
- Name of Geotech, full address (including zip code), telephone number, email address, name of contact person.
- Name of the Owner, full address (including zip code), telephone number, email address, name of contact person.
- A 2" to 2 1/2" blank space for the City reviewing engineer's comments.
- A City approval block, in the dimensions shown on the Sample Title Page.

### **REQUEST FOR ALTERNATE PAVEMENT THICKNESS [Requires accompanying Geotechnical Report] \$310 FEE**

- The request must be submitted ONLINE. Please contact the Engineer on Duty at 303-739-7335 [or email engineering@auroragov.org](mailto:engineering@auroragov.org) to request creation of a PA folder to upload you documents.
- This letter is required to be signed by the owner of the property and it does not need to be a digital signature.
- Show the name of the subdivision, filing number, lot, and block, as well as street address (if applicable).
- Name of Applicant, full address (including zip code), telephone number, email address, and name of contact person. [Applicant is the designated contact for all purposes.]
- Name of the Owner, full address (including zip code), telephone number, name of contact person, and email address.

**5.02.2** Satisfactory reports will be approved and signed by the City Engineer. Approval is for two years only and may be revoked by the City Engineer in the event of regrading, placement of fill, extended revegetation, prolonged ponding or other disturbance to the site. Approved pavement design sections from the approved report will be noted in the appropriate space on each applicable sheet of the civil design plans to ensure the appropriate pavement section is clearly documented. In the event the pavement design is not completed and approved at the time of the civil plan approval the approved pavement sections will be noted on each applicable sheet later as a “no review fee cost” plan revision requested by the engineer and processed by Engineering Services. **For private parking lots, driveways, fire lanes and private streets, other than TODs and urban centers, the correct default pavement section will be noted by the engineer submitting the plans in the typical cross-sections or on the grading plans for parking lots, unless an alternate pavement section based on an approved design is provided.**

**5.02.3** Contingent upon previously approved civil plans, the review will generally be completed within ten (10) working days for the first review, and within five (5) working days for any subsequent review. The submitter will be notified by email if the submittal is not approved. Unsatisfactory reports, with appropriate comments, will be available for downloading from the City’s electronic portal. Also, the submitter will be notified by email when the submittal is approved. With the approval of the report the applicant will be able to download the approved report from the City’s electronic portal up to 30 days after the report is approved.

### **5.03 Report Format**

See Section 2.05 for the report format.

### **5.04 Geotechnical Investigation**

**5.04.1** The geotechnical investigation portion of the report shall contain the following minimum information:

**5.04.1.01** The streets shall be cut to rough construction grade at the time of the borings, a map with location and depth of test holes located to within 5 feet horizontally and 1 foot vertically, as located by a Professional Land Surveyor licensed in the State of Colorado is required.

**5.04.1.02** Ground water elevations, if encountered

**5.04.1.03** Drill logs with subgrade elevations

- 5.04.1.04** Grading analysis curves, AASHTO T 27 (each sample of A-1 to A-4 soils)
  - 5.04.1.05** Atterberg limits, AASHTO T 89 and T 90 (each soil type in each boring)
  - 5.04.1.06** Soil classification, AASHTO M 145 and ASTM D 2487
  - 5.04.1.07** Moisture-density curves, AASHTO T 99 or AASHTO T 180
  - 5.04.1.08** Natural Moisture/Density, AASHTO T 265 and T 204 (each drive sample)
  - 5.04.1.09** Permeability of fine grain soils, ASTM D 5856
  - 5.04.1.10** Percent passing No. 200, AASHTO T 11 (each soil type in each boring)
  - 5.04.1.11** Sulfate Tests, AASHTO T 290 (1 test per 1,000' of A-6 and A-7 soils)
  - 5.04.1.12** Swell Tests, ASTM D 4546 at 200 psf (except soil types A-1 to A-4) One test per five borings or fraction thereof
  - 5.04.1.13** Effective Resilient Modulus of Roadbed Soils,  $M_R$ , for design of flexible pavements and Effective Modulus of Subgrade Reaction,  $K$ , for design of rigid pavements
  - 5.04.1.14** Depth from finished subgrade of bore hole or test pit shall be four-foot minimum, with every fourth one (minimum of one) at nine feet.
  - 5.04.1.15** All borings shall be sampled using a "California" style thin-wall type of sampler AASHTO T 206
  - 5.04.1.16** Boring logs shall include boring number, number of blows per foot, moisture conditions, free water, and anomalous conditions
  - 5.04.1.17** A map showing location or limits of different soil types
- 5.04.2** In addition, the Geotech shall investigate and recommend solutions to problems of:
- 5.04.2.01** Swell potential of cohesive soils
  - 5.04.2.02** Frost heave in silty soils
  - 5.04.2.03** Potential ground water problems
  - 5.04.2.04** Presence of sulfates
  - 5.04.2.05** Any other matter that may adversely affect the design and life of the pavement.
- 5.04.2** Soil samples shall be taken based on the proposed subgrade elevation. All borings shall be taken at 250 foot maximum intervals along local and collector streets, private

streets, and fire lanes and 200 foot maximum along arterials. One boring shall be made for each 15,000 square feet of parking lot. A minimum of one boring is required in all parking lots. If more than one soil type is encountered in the boring, they shall be logged and tested separately. The pavement shall be designed for the soil exhibiting the lowest subgrade support values.

## **5.05 Pavement Design Portion of the Report**

**5.05.1 Flexible Pavement** The report shall include the following minimum information.

**5.05.1.01** Map showing location of each different pavement section and soil type

**5.05.1.02** Design calculations for each pavement section

**5.05.1.03** Swell potential discussion

**5.05.1.04** Discussion of any unusual design or construction problems or requirements

**5.05.1.05** Related information indicated in Section 5.04

**5.05.2 Rigid Pavement** The report shall contain the following information.

**5.05.2.01** Map showing locations of each different pavement section and soil types

**5.05.2.02** Discussion of any unusual design or construction problems or requirements

**5.05.2.03** Design calculations for each pavement section.

**5.05.2.04** Swell potential discussion

**5.05.2.05** Discussion of any unusual design or construction problems or requirements

**5.05.2.06** Related information indicated in Section 5.04

## **5.06 Subgrade Characteristics**

**5.06.1 Swell Potential** All soil groups, excluding A-1 through A-4, shall be tested to determine swell or settlement potential. Tests shall be run on the "California Spoon" samples in accordance with ASTM D 4546 at a surcharge of 200 psf. The swell tests shall be plotted and the percent swell/settlement and swell pressure (psf) shall be determined and reported. Test results which are suspected of being too high or too low for the soil type shall not be considered in the design of the pavement, but shall be

reported. In the field these soils not consistent with the remainder of the site's soils shall be removed by over excavation. The project's geotechnical engineer shall define the limits of the over excavation in the field. Any deletion of data shall be justified in the report.

As a minimum, the report shall stipulate the following: the required depth of moisture treatment of the subgrade and shall be determined by the highest percentage of swell as recorded as a whole number as indicated in Table 5.06.1.1 below:

Moisture treatment shall achieve a moisture content and compaction as specified in Section 20.06.8 COMPACTION.

Soils with >5% swell shall also require swell mitigation per Section 22.00, CHEMICAL AND MECHANICAL STABILIZED SUBGRADE, in addition to moisture treatment.

See section 20.06.4.02 Minimizing Swell Potential.



## 5.06.2 Resilient Modulus

**5.06.2.01** For soil types, A-1, A-3, A-2-5, A-2-7, A-4, and A-5 Resilient Modulus,  $M_R$  shall be determined by R-Value conversion. R-Value shall be determined in accordance with AASHTO T 190. The following formula based on Colorado Department of Transportation, "Roadway Design Manual" shall be utilized to convert Hveem "R" to  $M_R$ .

$$M_R = (.75) 10^Z; \text{ where } Z = 0.0142R + 3.4098 \quad \text{Equation 5.06.2.1}$$

**5.06.2.02** For soil types A-2-4 and A-2-6:  $M_R = 1.67 q_u$

For soil type A-6:  $M_R = 1.61 q_u$

For soil type A-7-6:  $M_R = 2.35 q_u$

For Claystone:  $M_R = 1.26 q_u$

Where  $q_u$  = Unconfined Compressive Strength (remolded at 2% over OMC and 95% of MDD) in psf, AASHTO T 208; and where  $M_R$  is in psi

For fine-grained soils with a soaked CBR between 5 and 10, use the following equation to correlate CBR to resilient modulus ( $M_r$ ):

$$\text{Design } M_r \text{ (psi)} = 1,500 \times \text{CBR} \quad \text{Equation 5.06.2.2}$$

For non-fine-grained soils with a soaked CBR greater than 10, use the following equation:

$$M_r = 3,000 \times \text{CBR}^{0.65} \quad \text{Equation 5.06.2.3}$$

The above values may be multiplied by a coefficient of 1.33, if one of the following applies: an edge drain system is provided; subgrade permeability is greater than 10 ft. per day; it is a Low Density Rural roadway section with drainage ditches; or the subgrade is gneiss or granite in nature.

Remarks - Note unusual conditions or other data that would be considered necessary to properly interpret the results.

**5.06.2.03 Effective Modulus of Subgrade Reaction** For rigid pavement design, laboratory soil resilient Modulus MUST be converted to Modulus of Subgrade Reaction based on the formula:  $k = M_R/19.4$  or Figure 3.3 or 3.4 of the AASHTO Guide. Figure 3.6 of the AASHTO Guide must also be applied with  $LS = 2.5$  to obtain the Effective Modulus of Subgrade Reaction,  $k$ , before entering this value into the appropriate rigid pavement design nomograph, N-5.3 or N-5.4, or computer program.

## 5.07 Traffic - Equivalent Single Axle Loads (ESAL)

**5.07.1** ESAL is defined as total number of equivalent 18,000 lb. single axle load applications for the design lane. Local streets shall use a 20-year design period. Collectors and Arterials shall use a 30-year design period. The design period for pavements within the Core and Transition Zones of TOD's and Urban Centers is 30-years. Calculated ESALs must be equal to or greater than the Minimum ESALs listed in Tables 5.07.1.1 and 5.07.1.2 below. For Collector and Arterial streets the ESALs shall be weighted by a factor of 1.5 on the right lane due to the Regional Transportation District's bus routes. The intersections of Collector and Arterial streets shall increase the ESALs by a factor of 1.5. See Section 5.09.2.01 for additional requirements for pavement sections. The City Engineer may increase the minimum ESAL at any location, if, in his opinion, traffic conditions warrant.

**Table 5.07.1.1**  
**Minimum ESAL (X10<sup>6</sup>)\***

	Single-Family Residential	Multifamily Residential	Commercial and Business	Industrial
Arterials	2.2	2.2	3	4
2 and 3-Lane Collector	1.5	1.5	2.2	2.2
Low Density Rural	0.07	--	--	--
Local Street	0.06	0.07	0.2	0.7
Private Street or Drive	0.06	0.07	0.2	0.7
Fire Lane	--	0.07	0.2	0.2
Parking, Cars Only	0.04	0.04	0.04	0.04
Parking, All Other	0.04	0.04	0.07	0.07

\* To deviate to less than the minimum indicated ESAL an axle-load analysis must be approved by the City Engineer.

**Table 5.07.1.2**  
**Minimum ESAL (X10<sup>6</sup>)\* (Urban Centers and TODs)**

Inside TOD	Single-Family Residential	Multifamily Residential	Commercial and Business	Industrial
<b>Edge Zone</b>				
Boulevard - 6 Lanes	3.3	3.3	4.5	--
Multiway Boulevard; Median/Center Turn Lane - 3-Lane	2.25	2.25	3.3	--
Main Street; Median/Center Turn Lane - 3-Lane	2.25	2.25	3.3	--
Main Street; Median/Center Turn Lane - 2-Lane	0.3	0.3	0.6	--
Couplet - 2 Lanes	0.3	0.3	0.6	--
<b>Transition Zone</b>				--
Main Street; Median/Center Turn Lane - 3-Lane	--	2.25	3.3	--
Main Street; Median/Center Turn Lane - 2-Lane	--	0.3	0.6	--
Main Street; Parallel Parking - 2-Lane	--	0.3	0.6	--
Main Street; Angled Parking - 2-Lane	--	0.3	0.6	--
Couplet - 2 Lanes	--	0.3	0.6	--
Local Urban - 2 Lanes	--	0.3	0.6	--
Residential Parkway - 2 Lanes	--	0.3	0.6	--
Neighborhood - 2 Lanes	--			--
<b>**Core Zone - Concrete Only</b>				--
Main Street; Parallel Parking - 2-Lane	--	0.3	0.45	--
Main Street; Angled Parking - 2-Lane	--	0.3	0.45	--
Local Urban - 2 Lanes	--	0.3	0.45	--
Residential Parkway - 2 Lanes	--	0.3	0.45	--

\*To deviate to less than the minimum indicated ESAL an axle-load analysis must be approved by the City Engineer.

\*\*Rigid ESALs Used in the Core Zone

**5.07.2** Roadway zoning classifications are based on the projected land use of the areas served by the subject segment of roadway. Residential roadways service only areas with a minimum of 80% residential zoned property. Commercial and Industrial classifications service areas with 20% or more of the land to be used as Commercial or Industrial. If less than 80% of the area served is residential, the Classification will be either Commercial or Industrial. If any of the non-residential area served is Industrial, the classification will be Industrial. If none of the non-residential area served is Industrial, the Classification will be Commercial. Any classification with a calculated ESAL of  $1.4 \times 10^6$  or more will be considered to be an arterial.

Pavement design traffic studies are a method of determining 20/30-year design ESALs (30-year design ESALs within Core Zones of TOD's and Urban Centers). ESAL calculations in traffic studies shall be based on the AASHTO "Guide for Design of Pavement Structures," latest edition. The traffic study, when required, shall be submitted with the pavement design and subject to review and acceptance.

**5.07.2.01 Parking Areas** For parking areas, traffic loads from Table 5.07.1.1 may be assumed Suburban areas, Urban Centers, and TODs.

**5.07.2.02 Residential** If a traffic study for a residential roadway is not available, traffic loads can be determined using Equation 5.07.2.02.1:

$$ESAL_{20} = 62,000 + 80 R \quad \text{Equation 5.07.2.02.1}$$

Where:

R = number of residential density units serviced by the street

**5.07.2.03 Commercial** For roadways where any individual commercial site is 10 acres or more, traffic loading shall be determined by an approved traffic study only. For commercial roadways with sites less than 10 acres, traffic loading can be calculated using Equation 5.07.2.03.1:

$$ESAL_{30} = 93,000 + 120 R + 390,000 C_A \quad \text{Equation 5.07.2.03.1}$$

Where:

$C_A$  = Commercial Acres serviced by the street

**5.07.2.04 Industrial** For roadways where any individual industrial site is 10 acres or more, traffic loading shall be determined by an approved traffic study only. The City may require a traffic study for any industrial roadway. For industrial roadways with sites less than 10 acres, traffic can be calculated using equation 5.07.2.04.1.

$$ESAL_{30} = 390,000 C_A + 600,000 I_A$$

Equation 5.07.2.04.1

Where:

$I_A$  = Industrial Acres serviced by the street.

## **5.08 Minimum Pavement Sections and Private Pavement Alternate Sections**

If the calculated pavement sections, outside of TOD and Urban Center developments, indicate thinner sections than the Minimum Pavement Sections listed in Table 5.08.1 through 5.08.4 below, the Minimum Pavement Sections shall govern. The City Engineer may increase the minimum pavement section at any location if, in his opinion, conditions warrant. All asphalt roadways will be paved with a minimum of two (2) lifts, regardless of minimal thickness.

**Table 5.08.1  
MINIMUM PAVEMENT SECTIONS<sup>3</sup>  
ARTERIALS<sup>5</sup>**

	Single-Family Residential	Multifamily Residential	Commercial & Business	Industrial	Bus Lane <sup>1</sup>
<b>Minimum ESAL (X10<sup>6</sup>)</b>	2.2	2.2	3	4	5.6
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>					
Full Depth Asphalt <sup>4,6</sup>	6.0"	6.0"	6.5"	6.5"	8.5"
AC & Aggregate Base <sup>2</sup>	6.0" + 6.0"	6.0" + 6.0"	6.0" + 6.5"	6.0" + 7.5"	6.0" + 10.0"
PCC	6.0"	6.0"	7.0"	7.0"	9.0"
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>					
Full Depth Asphalt <sup>4,6</sup>	7.0"	7.0"	7.0"	7.5"	9.5"
AC & Aggregate Base <sup>2</sup>	6.0" + 8.0"	6.0" + 8.0"	6.0" + 9.0"	6.0" + 10.0"	7.0" + 11.0"
PCC	6.0"	6.0"	7.0"	7.0"	9.0"
<b>SOIL GROUP "C"<sup>4</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>					
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC & Aggregate Base <sup>2</sup>	6.0" + 6.0"	6.0" + 6.0"	6.0" + 6.0"	6.0" + 6.0"	6.0" + 10.0"
PCC	6.0"	6.0"	6.0"	7.0"	9.0"
<b>SOIL GROUP "D"<sup>4</sup> A-6 (Q<sub>U</sub>)</b>					
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC & Aggregate Base <sup>2</sup>	6.0" + 11.0"	6.0" + 11.0"	6.0" + 12.0"	6.0" + 12.0"	8.0" + 12.0"
PCC	7.0"	7.0"	8.0"	8.0"	9.0"
<b>SOIL GROUP "E"<sup>4</sup> A-7-6 (Q<sub>U</sub>)</b>					
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC & Aggregate Base <sup>2</sup>	7.0" + 12.0"	7.0" + 12.0"	8.0" + 11.0"	8.5" + 11.0"	9.0" + 20.0"
PCC	7.0"	7.0"	8.0"	8.0"	10.0"

Note 1 This extra depth pavement to be in the outside lane only. The City reserves the right to review location and length of bus stops with RTD and change the size and location of the extra-depth pavement. The curb and gutter pan shall be eleven inches thick with three #4 rebars longitudinally within the pan. The curb and gutter shall be poured monolithically with the bus pad. The bus stop pad shall be reinforced with # 4 rebars at 12" each way.

Note 2 HMA shall not exceed nine inches of full depth where full depth is allowed by the City Engineer. When the maximum HMA thickness structural coefficient is less than the Required Structural Number (SN), multiply the remaining SN coefficient by a factor of 1.52 in order to determine the required thickness of aggregate base course.

Note 3 All pavement depth requirements were based on ACPA Software StreetPave 12

Note 4 For swelling soils see Table 5.06.1.1 for subgrade preparation.

Note 5 All arterial streets shall have a top lift of three-inches of ¾-inch SMA over the HMA or ½-inch SMA upon approval by City Engineer on a case-by-case basis

Note 6 Full Depth Asphalt only allowed by the City Engineer on a case-by-case basis.

**Table 5.08.2  
MINIMUM PAVEMENT SECTIONS<sup>3</sup>  
COLLECTORS**

	Single-Family Residential	Multifamily Residential	Commercial & Business	Industrial	Bus Lane <sup>1</sup>
<b>Minimum ESAL (X10<sup>6</sup>)</b>	1.5	1.5	2.2	2.2	3.1
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>					
Full Depth Asphalt <sup>5</sup>	5.5"	5.5"	6.0"	6.0"	7.5"
AC and Aggregate Base	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 10.5"
PCC	6.0"	6.0"	6.0"	6.0"	8.0"
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>					
Full Depth Asphalt <sup>5</sup>	6.5"	7.0"	7.0"	7.0"	8.5"
AC and Aggregate Base	5.0" + 7.0"	5.0" + 7.0"	5.0" + 8.0"	5.0" + 8.0"	6.0" + 11.0"
PCC	6.0"	6.0"	6.0"	6.0"	8.0"
<b>SOIL GROUP "C" <sup>4</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>					
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 8.0"
PCC	6.0"	6.0"	6.0"	6.0"	8.0"
<b>SOIL GROUP "D" <sup>4</sup> A-6 (Q<sub>U</sub>)</b>					
Full Depth Asphalt <sup>2</sup>	Not Allowed	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	5.0" + 9.5"	5.0" + 10.0"	5.0" + 11.0"	5.0" + 11.0"	7.0" + 12.0"
PCC	6.0"	6.0"	8.0"	8.0"	9.0"
<b>SOIL GROUP "E" <sup>4</sup> A-7-6 (Q<sub>U</sub>)</b>					
Full Depth Asphalt <sup>2</sup>	Not Allowed	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	7.0" + 12.0"	7.0" + 12.0"	7.0" + 12.0"	7.0" + 12.0"	9.0" + 15.0"
PCC	7.0"	7.0"	8.0"	8.0"	9.0"

Note 1 This extra depth pavement to be in the outside lane only. The City reserves the right to review location and length of bus stops with RTD and change the size and location of the extra-depth pavement. The curb and gutter pan shall be eleven inches thick with three #4 rebars longitudinally within the pan. The curb and gutter shall be poured monolithically with the bus pad. The bus stop pad shall be reinforced with # 4 rebars at 12" each way.

Note 2 HMA shall not exceed nine inches of full depth where full depth is allowed by the City Engineer. When the maximum HMA thickness structural coefficient is less than the Required Structural Number (SN), multiply the remaining SN coefficient by a factor of 1.52 in order to determine the required thickness of aggregate base course.

Note 3 All pavement depth requirements were based on ACPA Software StreetPave 12

Note 4 For swelling soils see Table 5.06.1.1 for subgrade preparation.

Note 5 Full Depth Asphalt only allowed by the City Engineer on a case-by-case basis.

**Table 5.08.3  
MINIMUM PAVEMENT SECTIONS<sup>1</sup>  
LOW DENSITY RURAL**

	Single-Family Residential	Multifamily Residential	Commercial & Business	Industrial
<b>Minimum ESAL (X10<sup>6</sup>)</b>	0.07	--	--	--
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>				
AC and Aggregate Base	5.0" + 6.0"	--	--	--
PCC	6.0"	--	--	--
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>				
AC and Aggregate Base	5.0" + 6.0"	--	--	--
PCC	6.0"	--	--	--
<b>SOIL GROUP "C" <sup>2</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>				
AC and Aggregate Base	5.0" + 6.0"	--	--	--
PCC	6.0"	--	--	--
<b>SOIL GROUP "D" <sup>2</sup> A-6 (Q<sub>U</sub>)</b>				
AC and Aggregate Base	5.0" + 6.0"	--	--	--
PCC	6.0"	--	--	--
<b>SOIL GROUP "E" <sup>2</sup> A-7-6 (Q<sub>U</sub>)</b>				
AC and Aggregate Base	5.0" + 6.0"	--	--	--
PCC	6.0"	--	--	--

Note 1 Based on ACPA Software StreetPave 12

Note 2 For swelling soils see Table 5.06.1.1 for subgrade preparation.



**Table 5.08.4  
MINIMUM PAVEMENT SECTIONS<sup>1</sup>  
LOCAL STREETS**

	Single-Family Residential	Multifamily Residential	Commercial & Business	Industrial
<b>Minimum ESAL (X10<sup>6</sup>)</b>	0.06	0.07	0.2	0.7
<b>SOIL GROUP "A" A-1 thru A-5 (R-Value)</b>				
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "B" A-2 thru A-5 (CBR)</b>				
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "C" <sup>2</sup> A-2-4 &amp; A-2-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "D" <sup>2</sup> A-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	5.0" + 6.0"	5.0" + 6.0"	5.0" + 6.0"	5.0" + 7.0"
PCC	6.0"	6.0"	6.0"	6.0"
<b>SOIL GROUP "E" <sup>2</sup> A-7-6 (Q<sub>U</sub>)</b>				
Full Depth Asphalt	Not Allowed	Not Allowed	Not Allowed	Not Allowed
AC and Aggregate Base	5.0" + 6.0"	5.0" + 6.0"	5.0" + 8.0"	5.0" + 12.0"
PCC	6.0"	6.0"	6.0"	6.0"

Note 1 Based on ACPA Software StreetPave 12

Note 2 For swelling soils see Table 5.06.1.1 for subgrade preparation.

**5.08.5 Temporary Pavement Sections** Temporary Pavement Sections should meet all other requirements and minimum thicknesses for a permanent roadway of the same roadway classification.

## 5.09 Pavement Materials

**5.09.1** Asphalt Cement Concrete (AC) shall be plant mix hot bituminous pavement (also referred to as HBP). Use of other than AC, PCC, or gravel base requires submittal of appropriate test data for approval. Materials and construction shall comply with Section 24.00, BITUMINOUS PAVEMENT MATERIALS, Section 31.00,

CONCRETE PAVEMENT, or Section 23, STREET CONSTRUCTION AGGREGATES.

Both sides of the street must be of the same material.

Minimum lengths for any one type of pavement material shall be as specified in Table 5.09.2.01 below.

**5.09.2** Where arterial/arterial, boulevard/boulevard, multi-way boulevard/multi-way boulevard intersections are already partially paved with PCC the remaining portions of the intersection shall be PCC beginning 250' behind each PCR and extending through the entire intersection when the intersection is completed.

**5.09.2.01** Where new arterial/arterial, boulevard/boulevard, multi-way boulevard/multi-way boulevard intersections are paved with a composite Asphaltic Concrete and Aggregate Base Course section with the top lift being Stone Matrix Asphalt (SMA) the Aggregate Base Course through the intersection (100-feet beyond the PCR on all legs of the intersection) shall be thickened to allow for the Asphaltic Concrete section to remain uniform from the street section through the intersection. Edge drains will be required with outlets to storm sewer inlets, unless the geotechnical and pavement design report indicates the existing subgrade soil's permeability is greater than 10 feet per day.

**Table 5.09.2.01.1  
DIFFERENT PAVING MATERIALS**

STREET TYPE	MINIMUM LENGTH
Arterial, Boulevard, Multi-way Boulevard	1/4 mile
Collector, Main Street – 4 and 2 Lane w/ Median, Residential Parkway	one block, if longer than 500'
Local access, Main Street – 2 Lane, One Way Couplet, Local Urban, Neighborhood	one block, if longer than 300'
Cul-de-sac*	300'
Parking Lot	no restrictions

\*Must be same material as intersecting street if less than 300' long.

**5.09.3** Alternate paving materials are (see Section 5.01.3 for requirements regarding TOD and Urban Center developments):

**5.09.3.01** Aggregate base courses (ABC) plus AC or PCC

**5.09.3.02** Chemically treated or stabilized subgrade plus ABC and AC or PCC

**5.09.3.03** Other material as approved by the City Engineer

## 5.10 Pavement Design Procedure

The following is the method for design with the structural number using the nomographs in this specification. The design process may alternatively involve various software packages whose use is not explained here. All designs must be clearly justified to the satisfaction of the City Engineer by the signing engineer in the pavement design report. See Sections 5.10.4 and 5.12.7 for further discussion.

### 5.10.1 Flexible Pavement

**5.10.1.01** Determine the street classification, zoning, and ESAL.

**5.10.1.02** Choose Nomograph N5.1 or N5.2 depending on street classification.

**5.10.1.03** Using  $M_R$  and ESAL, determine SN.

**5.10.1.04** Using the strength coefficients from Table 5.10.1.04.1 for the base and subbase layers, calculate the thickness of the various pavement layers by the following formula. Keep in mind the Minimum Pavement Sections (Tables 5.08.1 through 5.08.4) govern when thinner sections are indicated.

$$SN = a_1(D_1) + a_2(D_2) + \dots + a_n(D_n) \quad \text{Equation 5.10.1.04.1}$$

Where:

$a_1, a_2, a_n$  = strength coefficients

$D_1, D_2, D_n$  = thickness of pavement layers

**Table 5.10.1.04.1  
STRENGTH COEFFICIENTS**

COMPONENTS	COEFFICIENT (a)
Stone Matrix Asphalt (SMA)	0.44
Hot Bituminous Pavement	0.44
Existing Bituminous Pavement	0.30
Hot Mix Asphalt Grading Fines ( ST & Sx)	0.34
Plant Mix Bituminous Base	0.34
Verification of testing required for items listed below:	
100% RAP with R-Value $\geq 90$	0.19
100% RAP with R-Value $< 90$	0.15
Aggregate Base Course with R-Value $> 83$	0.15
Aggregate Base Course with R-Value $> 77, < 83$	0.12
Aggregate Base Course with R-Value $> 69, < 77$	0.11

Aggregate Base Course with R-Value >59, < 69	0.10
Treated Subgrade* unconfined 7 day Strength ≥425psi	0.15
Treated Subgrade* unconfined 7 day Strength 350-424 psi	0.14
Treated Subgrade* unconfined 7 day Strength 275-349 psi	0.13
Treated Subgrade* unconfined 7 day Strength 200-274 psi	0.12
Treated Subgrade* unconfined 7 day Strength 125-199 psi	0.11

\* In accordance with Section 22 and Table 5.06.1.1

**5.10.2** In TOD and Urban Centers where there is a flexible pavement section greater than nine inches warranted, a composite section of flexible pavement shall be used. Following the AASHTO guide Section 3.1.4, a drainage coefficient for base and subbase layers shall be used in conjunction with the current structural number calculation. Equation 5.10.1.04 is modified as follows to incorporate the drainage coefficient.

$$SN = a_1(D_1) + a_2(D_2)m_2 + \dots + a_n(D_n)m_n \quad \text{Equation 5.10.2.1}$$

Where:

$a_1, a_2, a_n$  = strength coefficients

$D_1, D_2, D_n$  = thickness of pavement layers

$m_x$  = Drainage coefficient

It is up to the design engineer to identify what level or quality of drainage is achieved under a specific set of drainage conditions, Below are the general definitions corresponding to different drainage levels from the pavement structure:

Quality of Drainage <sup>1</sup>	Water Removed Within
Excellent	2 hours
Good	1 day
Fair	1 week
Poor	1 month
Very poor	Water will not drain

<sup>1</sup> Test for the quality of drainage: use ASTM D4750 Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well). Borehole shall be extended a minimum of five-feet below the proposed street grade.

Drainage Coefficients are from AASHTO Table 2.4 and are presented below.

#### AASHTO Table 2.4 <sup>1</sup>

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<sup>1</sup> American Association of State and Highway Transportation Officials, AASHTO Guide for Design of Pavement Structures, Washington D.C., 1993.

Recommended $m_x$ Values for modifying Structural Layer Coefficients of Untreated Base and Subbase Materials in Flexible Pavements				
	Percent of Time Pavement Structure is exposed to Moisture Levels Approaching Saturation			
Quality of Drainage	Less than 1%	1 -5%	5 – 25%	Greater than 25%
Excellent	1.40 – 1.35	1.35 – 1.30	1.30 – 1.20	1.20
Good	1.35 – 1.25	1.25 – 1.15	1.15 – 1.00	1.00
Fair	1.25 – 1.15	1.15 – 1.05	1.00 – 0.80	0.80
Poor	1.15 – 1.05	1.05 – 0.80	0.80 – 0.60	0.60
Very Poor	1.05 – 0.95	0.95 – 0.75	0.75 – 0.40	0.40

### **5.10.3 Rigid Pavement (Portland Cement Concrete, PCC)**

**5.10.3.01** Determine ESAL for the design period.

**5.10.3.02** Determine effective K-value of subgrade soils.

**5.10.3.03** Use Nomograph in Figure N5.3 or N5.4, depending on street classification.

**5.10.3.04** Submit a jointing plan conforming to Standard Detail S19.1, et seq. See Section 2.06.1.20.

**5.10.4** Alternatives to the use of the above-mentioned nomographs may be presented for approval as follows: computer printouts presenting results in accordance with the equations shown on the respective nomographs and the AASHTO Guide will be allowed for review. The printout must reiterate all design parameters. The report must justify to the satisfaction of the City Engineer any deviation from the design parameters specified herein.

**5.10.5** Factors for Design of Pavement Structures utilizing 1993 AASHTO "Guide for Design of Pavement Structures" and "1998 Design for Rigid Pavement" (AASHTO Guide).

#### **5.10.5.01 Reliability (R)**

**5.10.5.01.1** 95% for arterials, boulevards, multi-way boulevards, all fire lanes, all commercial and industrial roadways

**5.10.5.01.2** 90% for local roadways, main streets (2-lane, 2 and 3-lanes with medians), one way couplet streets, local urban streets, neighborhood streets, residential parkways and collector roadways and parking lots other than commercial and industrial. Except local roadways and private drives where the area to be served by the roadway is 90% or more developed, R = 85% may be used (this does not include the TOD and Urban Center street sections).

#### **5.10.5.02 Overall Standard Deviation ( $S_o$ )**

**5.10.5.02.1** 0.45 for flexible pavements

**5.10.5.02.2** 0.35 for rigid pavements

### 5.10.5.03 Design Serviceability Loss

<u>Flexible</u>	<u>Rigid</u>	
2.2	2.5	Local roadways, main street (2- lane, 2 and 3-lanes with medians), one way couplet streets, local urban streets, neighborhood streets, residential parkways and collector roadways, other than commercial and industrial, private drives, and parking lots
1.7	2.0	Arterials, boulevard, multi-way boulevard, fire lanes, all commercial and industrial roadways

### 5.10.5.04 Concrete Elastic Modulus ( $E_c$ )

3.6 x 10<sup>6</sup> psi

### 5.10.5.05 Mean Concrete Modulus of Rupture ( $S'_c$ )

600 psi

### 5.10.5.06 Load Transfer Coefficient ( $J$ )

If monolithic or tied curb and gutter are placed on both sides of the pavement use 3.6, otherwise use 4.2.

### 5.10.5.07 Drainage Coefficient ( $C_d$ )

1.0

### 5.10.5.08 Loss of Support ( $LS$ )

2.5 for use in Figure 3.6, located at the end of this section, to correct the Effective Modulus of Subgrade Reaction,  $K$ , for Potential Loss of Support.

## 5.11 Miscellaneous

**5.11.1 Field Copies** It is to the submitter's benefit to provide the Contractor with an approved copy of the Pavement Design Report to reduce confusion and delays in the field.

**5.11.2 Jointing Details** Pavement Design Report submittals for Rigid Pavement alternates shall include approved jointing details. See Standard Details S19.1 et seq. and Section 31.10.

## 5.12 Forms, Nomographs

**5.12.1 Default and Alternate Sections Certification** To assure the quality of construction, a Licensed Professional Engineer, in the State of Colorado, competent in the field of geotechnical engineering (Consultant), shall provide construction observation and materials testing services for all private development paving projects. This Consultant shall be knowledgeable in civil work construction, street and roadway construction, utility construction, material sampling and testing, and shall be familiar with the most recent edition of the City of Aurora “**ROADWAY DESIGN & CONSTRUCTION SPECIFICATIONS**”, and the design of the project.

Construction observation and materials testing shall be under the direct supervision of the Consultant and shall be in conformance with Section 32 Materials Testing and the project specifications. Periodic construction observation and materials testing services shall be performed daily when significant work is in progress. These services shall be sufficient in scope to determine the quality and adequacy of the construction. The Consultant shall ensure compliance with the City of Aurora, “**ROADWAY DESIGN & CONSTRUCTION SPECIFICATIONS**”. Before a Certificate of Occupancy or an Initial Acceptance of the work can be issued, the Consultant shall prepare a written statement and shall submit it to the Public Improvement Inspections Supervisor at 15151 East Alameda Parkway, Suite 3200, Aurora, Colorado 80012. A boiler plate letter is attached at the end of this Chapter.

**5.12.2 Nomograph N-5.1** Flexible Pavement Design Chart for Arterials and all Commercial and Industrial sites.

**5.12.3 Nomograph N-5.2** Flexible Pavement Design Chart for Local and Collector Streets except Commercial and Industrial sites.

**5.12.4 Nomograph N-5.3** Rigid Pavement Design Chart for Arterials and all Commercial and Industrial sites.

**5.12.5 Nomograph N-5.4** Rigid Pavement Design Chart for Local and Collector Streets except Commercial and Industrial sites.

**5.12.6 Sample of the Title page and Approval Block** The preparer of the report must follow the format indicated in Section 2.05.2.07. Geotechnical and Pavement Design Reports submitted with incomplete information on the title page shall not be accepted.



**5.12.7** The use of roadway design software may be utilized to provide accurate and reproducible results. All data entry and output results sheet must accompany the report. Software can include, but not limited to, Darwin, AASHTO M-E, MGPEC Pavement Design, PreRoad 3.5, Weslea for Windows Ver. 3.0, or other programs acceptable to the City Engineer.

**PRIVATE DEVELOPMENT PAVEMENT CERTIFICATION**

\_\_\_\_\_ (date)

Supervisor of Public Improvements Inspections  
City of Aurora, Public Works  
15151 E. Alameda Pkwy, Suite 3200  
Aurora, CO 80012

**RE:** Statement of Construction Observation and Materials Testing

Mr. vonClausburg:

**Permit#** \_\_\_\_\_ **Plat Name** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ **(Name and Address of Project)**

Our firm was retained to provide construction observation and materials testing services for the above subject project. Services were performed daily during the construction of the private infrastructure (parking lots, drives, and private streets).

Copies of observation logs and materials testing reports are available upon request. It is our Professional opinion our construction observation and testing services were adequate to show construction was in compliance with the City of Aurora Roadway Design & Construction Specifications, latest edition.

Respectfully submitted,  
(Signature of P.E.)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ (Name and Address of Company)

\_\_\_\_\_  
(Printed Name of P.E.)  
(Seal Over Signature)

**REQUEST FOR ALTERNATE PAVEMENT THICKNESS**

\_\_\_\_\_ (Date)

City Engineer  
City of Aurora, Public Works Department  
15151 E. Alameda Parkway, Ste. 3200  
Aurora, CO 80012

Subject: \_\_\_\_\_  
(Project or Subdivision Name)

Dear Sir:

\_\_\_\_\_ requests that the following pavement sections be approved for the  
(Company/Property Owner)

above-referenced \_\_\_\_\_ project: \_\_\_\_\_,  
(Zoning/Use) (Subdivision Name and Filing Number)

Lot, block: \_\_\_\_\_

All new paving within \_\_\_\_\_ shall be \_\_\_\_\_ full depth  
(parking area or private street) (thickness)  
asphalt/concrete (*choose pavement type*) (or  
\_\_\_\_\_ asphalt and \_\_\_\_\_ base course), per \_\_\_\_\_  
(thickness) (thickness) (Geotechnical Firm)

All new paving within fire lanes shall be \_\_\_\_\_ full depth asphalt/concrete (*choose one*)  
(thickness)  
(or \_\_\_\_\_ asphalt and \_\_\_\_\_ base course), per \_\_\_\_\_  
(thickness) (thickness) (Geotechnical Firm)

Report # \_\_\_\_\_ dated \_\_\_\_\_.

As Owner of this Property, \_\_\_\_\_, is aware  
(Company/Property Owner)  
this pavement design does not meet the criteria established by the City of Aurora for this application.

The attached soils report references the characteristics of the soil and recommends the above section.

In addition, \_\_\_\_\_ shall hold the City of Aurora harmless for the  
(Company/Property Owner)  
performance and maintenance of this design.

Sincerely,

\_\_\_\_\_  
(Authorized Signature) Date

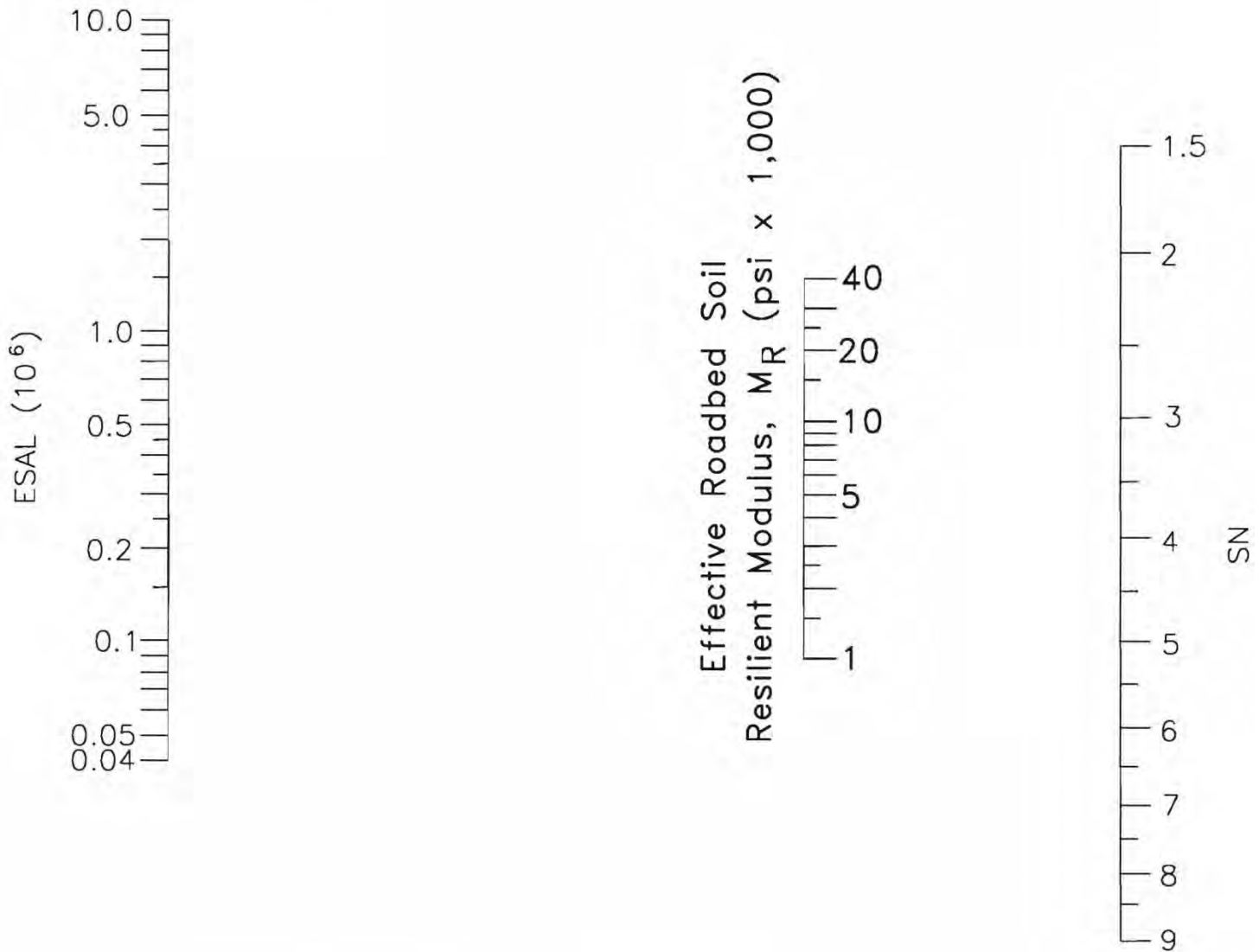
\_\_\_\_\_  
(Reviewing Engineer) Date

\_\_\_\_\_  
(Print Authorized Signatory's Name)

\_\_\_\_\_  
(City Engineer) Date

# ARTERIALS ALL COMMERCIAL & INDUSTRIAL

## Design chart for flexible pavements



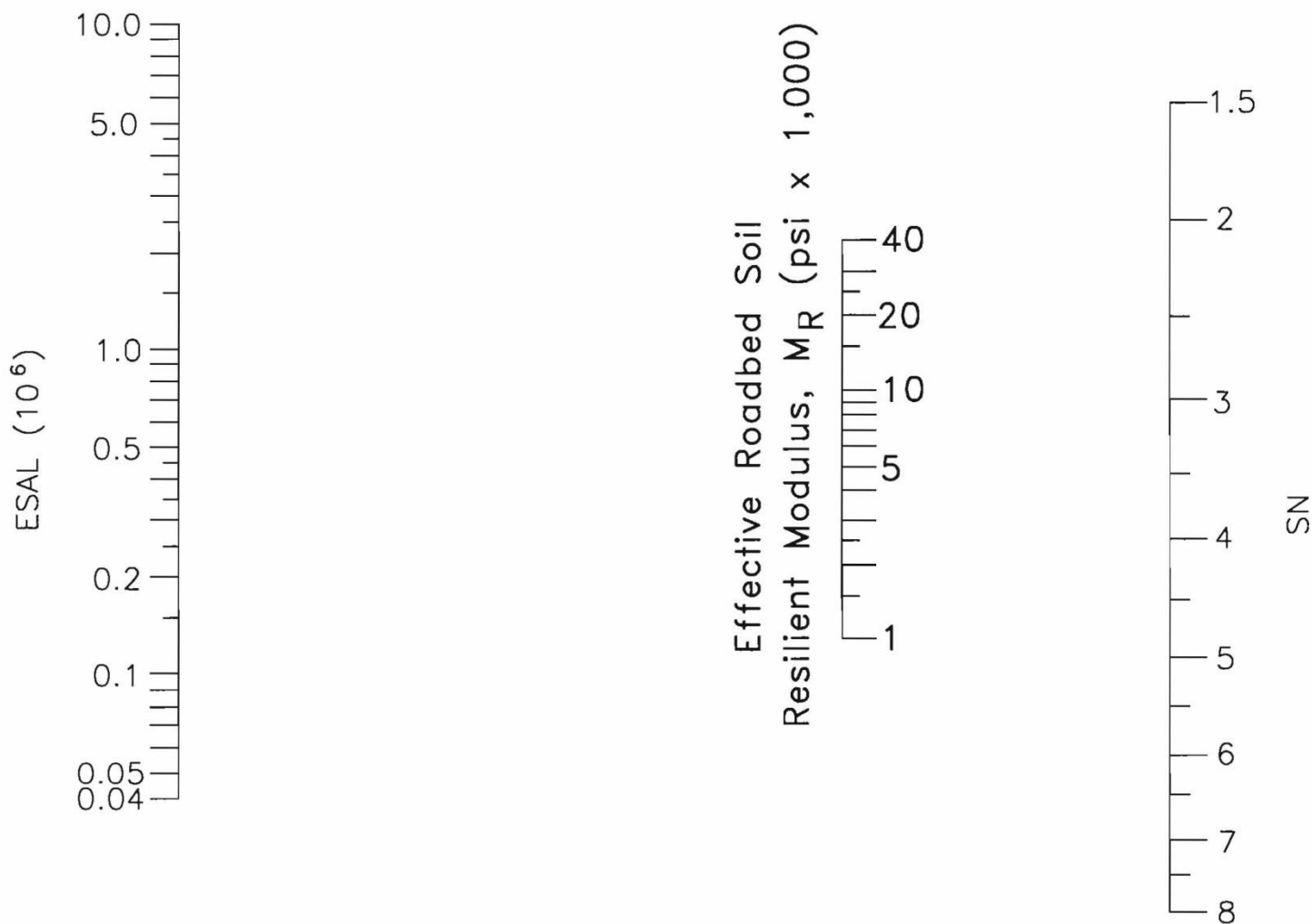
NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_0 + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10} \left[ \frac{\Delta PSI}{4.2 - 1.5} \right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$

**N - 5.1**

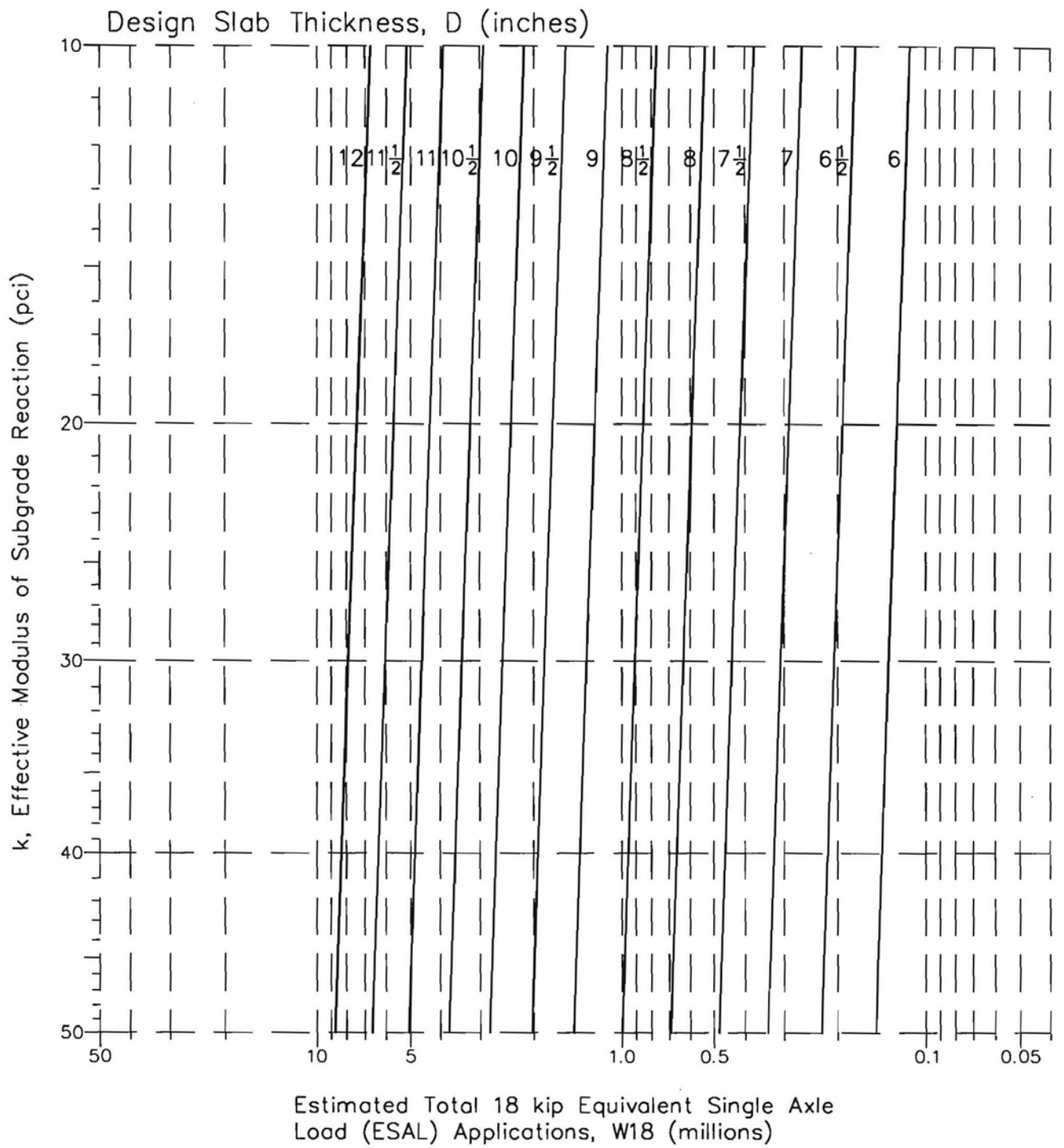
# LOCAL & COLLECTOR EXCEPT COMMERCIAL & INDUSTRIAL

## Design chart for flexible pavements



N - 5.2

ARTERIALS  
ALL COMMERCIAL & INDUSTRIAL  
Design chart for rigid pavements

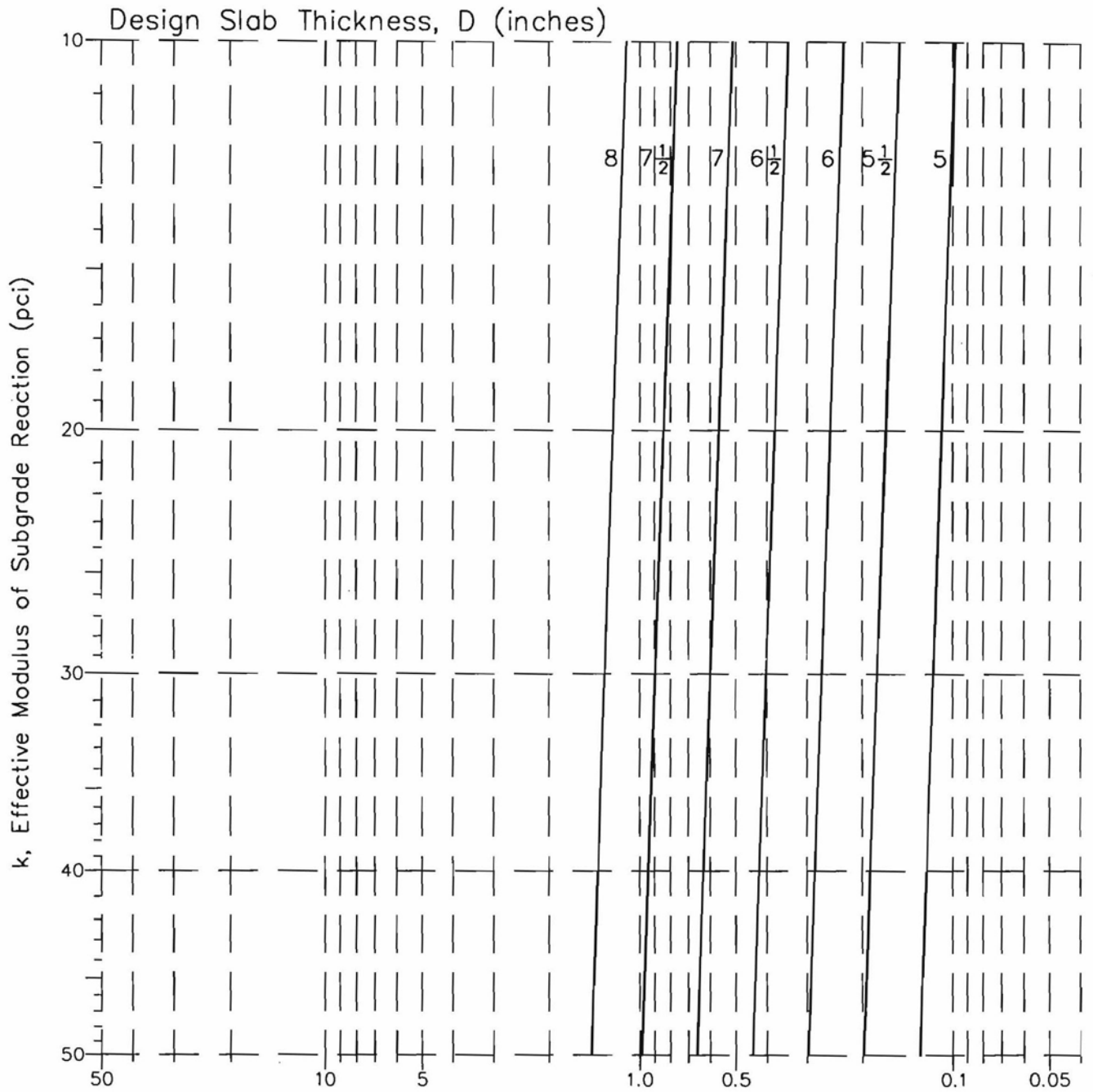


Determine thickness by reading the nearest line to the left of your data point.

N - 5.3

LOCAL AND COLLECTOR  
EXCEPT COMMERCIAL OR INDUSTRIAL

Design chart for rigid pavements



Estimated Total 18 kip Equivalent Single Axle  
Load (ESAL) Applications, W18 (millions)

Determine thickness by reading the nearest line to the left of your data point.

N - 5.4

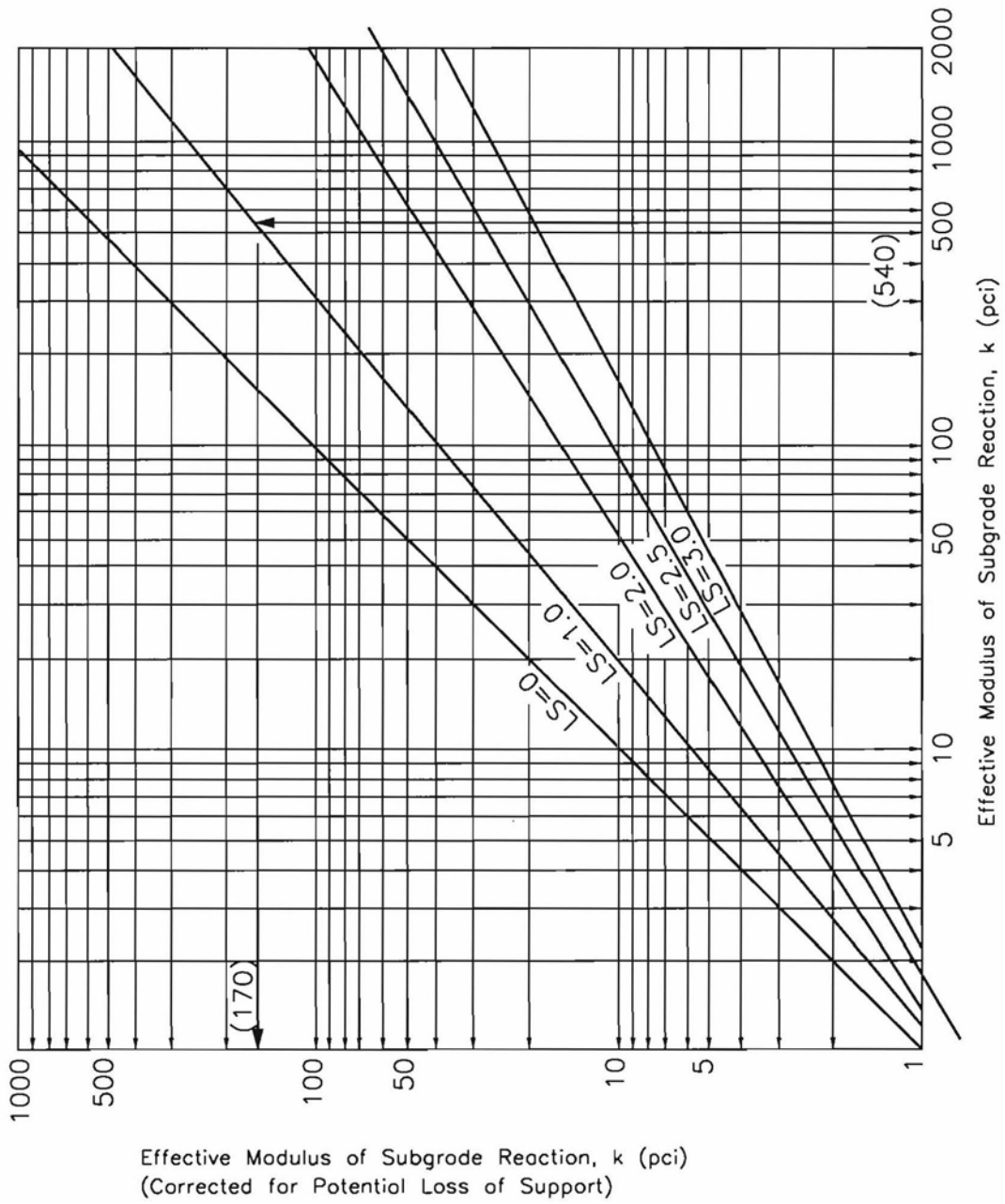


Fig. 3.6 Correction of effective modulus of subgrade reaction for potential loss of subbase support (6).



**SECTION 7.00 CONSTRUCTION REQUIREMENTS .....1**

- 7.01 Scope .....1
- 7.02 Licenses .....2
- 7.03 Permits .....2
- 7.04 Work Hours .....3
- 7.05 Authority of the Project Manager .....4
- 7.06 Authority of the Public Improvement Observer .....4
- 7.07 Construction Observations .....4
- 7.08 Defective Materials and Work .....4
- 7.09 Protests .....5
- 7.10 Inspection Facilities .....5
- 7.11 Initial Acceptance .....5
- 7.12 Warranty Period .....6



## SECTION 7.00 CONSTRUCTION REQUIREMENTS

### 7.01 Scope

This section specifies the requirements for permits, licenses, and construction observation required for public improvement construction work and designated private construction work. Requirements stated in this section shall be supplemented by, and be in compliance with, any additional requirements or conditions required by City Codes, specifications, or administrative requirements.

#### City Offices

Aurora Municipal Center  
15151 East Alameda Parkway.  
Aurora, Colorado 80012

<u>City Contacts</u>	<u>Room</u>	<u>Phone</u>
Building – Permits, Licenses and Certificates	2400	303-739-7420
Cashier's Office	1300	303-739-7064
Contractor Business Licenses	1100	303-739-7057
Contractor License	2400	303-739-7420
Dry Utility Inspections - Utility Company Permits	2400	303-739-7420
Public Improvements Permits, Fees and Inspections	2400	303-739-7420
Life Safety Inspection	2400	303-739-7420
Traffic Services	3200	303-739-7300
Water and Sewers - Extension Agreements	3600	303-739-7375

13636 East Ellsworth Ave., Aurora, Colorado 80012

<u>City Contacts</u>	<u>Phone</u>
Survey	303-326-8015

15750 East 32nd Ave., Aurora, Colorado 80011

City Contacts

Phone

Materials Testing Laboratory

303-326-8270

## **7.02 Licenses**

**7.02.1** Any company, contractor, or firm engaging in construction work of public improvements shall have a contractor's right-of-way license.

Permits and licenses for public utility companies shall be required unless otherwise indicated in their franchise agreement. Utility company contractors shall comply with the applicable licensing and bonding requirements. Contractors Licenses shall be obtained from the Building Division.

**7.02.2** Public improvement construction work shall be supervised by an individual who has a Supervisor Certificate which is applicable to the type of work being performed. Supervisor Certificates shall be obtained from the Building Division.

**7.02.3** Contractors engaging in the maintenance or construction of private water and sewer lines shall have either a Class D5 Excavators License (Drain Layers and Caisson Drillers License) or a Plumbers License. Such licenses are valid only for work on private property and can be obtained from the Building Division.

**7.02.4** A Contractor Business License is required and shall be obtained from the Business Licensing Division on the first floor of the Aurora Municipal Center.

## **7.03 Permits**

**7.03.1** Permits are required for the following.

- Any public improvement construction or any other work in the public right of way;
- The construction or repair of any private utilities, including storm drainage, sanitary sewer, water service lines, fire suppression lines, and dry utilities located within public right-of-way.

**7.03.2** Permits shall be obtained before any work is authorized or allowed. Permits will be issued only to a contractor actually performing the work and licensed and bonded for the type of work. For City contracts, permits may be issued to a general contractor

only when such contractor and his subcontractors are in compliance with licensing and bonding requirements.

**7.03.3** Permits are issued only after:

- the Public Works Engineering Division has approved the plans for the specific improvements to be constructed and
- all applicable permit fees have been paid.

Permits for public streets are issued after pavement design reports are submitted to and approved by the Public Works Engineering Division. Additionally, paving permits require prior acceptance or approval of any newly-constructed utilities which are under the proposed paving. This acceptance or approval requires the submittal and approval of the applicable utility compaction test reports. Compaction test reports shall be submitted to the City Materials Testing Laboratory for review and acceptance.

Permits for private driveways are required.

**7.03.4** A complete set of approved drawings, specifications, and a valid permit shall be on the job site and available to the construction observer at all times.

## **7.04 Work Hours**

**7.04.1** Work between sundown and sunrise may be authorized by the Project Manager if adequate lighting is available and noise will not disturb nearby residents or businesses. See Section 94-107 of City Code.

**7.04.2** When Public Improvement Observers or other City personnel are required to work overtime or on legal holidays (New Year's Day, Martin Luther King, Jr. Day, Presidents' Day, Memorial Day, Independence Day, Labor Day, Veterans' Day, Thanksgiving Day, the day after Thanksgiving, and Christmas Day), it shall be at the Contractor's expense. Public Improvement Observers normally work an eight-hour day from 7:30 a.m. to 4:00 p.m. Monday through Friday. Other days or hours will be considered overtime and will be at the Contractor's expense. A minimum charge of four hours will be charged for any overtime work requested and performed on weekends and legal holidays. The Contractor's payment for all overtime work shall be made by check to the City of Aurora or paid online.

## **7.05 Authority of the Project Manager**

The Project Manager is designated by the City Manager to exercise all authority on behalf of the City to ascertain that all construction of facilities is equal to or better than the minimum construction requirements set forth in the project specifications. The Project Manager shall be represented by a Public Improvement Observer who will observe work performed under a permit issued for construction, including all materials to be incorporated in the work, excavation, bedding, backfill, and all construction methods and practices. The Project Manager shall have the sole authority to issue, in writing, deviations from the provisions of the project specifications or changes to previously-approved drawings.

## **7.06 Authority of the Public Improvement Observer**

Public Improvement Observers are assigned by the Project Manager to assist the Contractor in complying with the approved project specifications. Observers have the authority to reject inferior materials or defective workmanship and to suspend work not in accordance with the City "Roadway Design and Construction Specifications" until such time as corrections are made and approved. The Public Improvement Observers are not authorized to alter any provisions or to issue instructions contrary to the project specifications, or to make any changes to approved drawings.

## **7.07 Construction Observations**

- 7.07.1** The Contractor shall obtain the Observer's approval of any material before placement and before beginning any work.
- 7.07.2** The Contractor shall call for observation giving 24-hours minimum notice. Observation may be requested from the Public Improvements Permits Office at 303-739-7420. For utility company observation, please call Public Works Department at 303-739-7420.
- 7.07.3** In the event any of the work or material fails to meet any of the requirements of the specifications, written notice of the rejection shall be given to the Contractor, and work shall be halted until corrective action is taken.
- 7.07.4** Periodic construction observation is only an aid to the Contractor and in no way reflects any responsibility on the part of the City for quality or quantity control, and in no way implies acceptance of the work, or any part thereof, by the City.

## **7.08 Defective Materials and Work**

Whenever materials and/or work are found to be defective, the Contractor, at his expense, shall promptly remove such defective materials and construction from the job site and replace all

defective portions to the satisfaction of the Project Manager. Work performed or covered without observation is subject to rejection. In the event the Contractor fails to remove the defective items from a City project job site within ten days of written notice, the Project Manager may arrange for such removal at the expense of the Contractor.

## **7.09 Protests**

If the Contractor considers any work demanded of him by the Observer to be outside the requirements of the approved specifications, he will immediately ask for a written decision or instruction and shall proceed to perform the work to conform with the Observer's ruling. If the Contractor considers such instructions unsatisfactory, he will, within 24 hours after their receipt, file a written protest with the Project Manager for a City project and the Public Improvement Inspections Supervisor for private projects stating his objections and the reasons therefore. Unless protests or objections are made in the manner specified and within the time limits stated herein, the Contractor hereby waives all grounds for protests.

## **7.10 Inspection Facilities**

The Contractor shall furnish all reasonable facilities and shall assist the Observer as necessary for the proper inspection of materials to be used and workmanship involved in the construction.

## **7.11 Initial Acceptance**

When the final clean-up has been performed, the Contractor will notify the Observer all work has been completed and schedule an inspection. The observer will perform all necessary inspections and notify the Contractor of any noted defects. Until the NOTICE OF INITIAL ACCEPTANCE is issued, the Project Manager may direct the newly-constructed public improvements be barricaded to prevent public use of the improvements.

The NOTICE OF INITIAL ACCEPTANCE OR SUBSTANTIAL COMPLETENESS begins the warranty period and will be issued when the following items are completed.

- 7.11.1** All major work elements have been accepted by the Observer.
- 7.11.2** For City of Aurora capital or maintenance projects a "Release and Indemnification" statement has been delivered to the Project Manager.
- 7.11.3** Compaction and Materials Testing Reports, in compliance with the applicable specifications and the requirements of Section 32.00, MATERIALS TESTING, have been delivered to and approved by the City's Materials Testing Laboratory.

## **7.12 Warranty Period**

The warranty period is for one year from the date of initial acceptance or substantial completion, unless otherwise specified or mutually agreed upon in writing.

- 7.12.1** A final inspection will be performed by Public Improvements Inspections on, or about, the expiration of the one-year warranty period. The Public Improvements Inspection Division of the Public Works Department will schedule a final inspection of the warranty work with the contractor.
- 7.12.2** The Public Improvements Inspection Division shall inform the contractor of any necessary repairs in writing. The contractor shall schedule an onsite meeting with the Public Improvements Inspector to discuss the required warranty repairs 24 hours prior to beginning the warranty repairs. After the completion of the repairs and a final inspection by the Public Improvements Inspector a written notice shall be issued to the contractor the completed work/project is acceptable to the City. No work/project shall be considered accepted by the City until all necessary repairs are complete and a letter of final acceptance has been issued.
- 7.12.3** Warranty repairs shall be completed within 30 days of the date of written notification of required repairs, dependent on weather and work/project complexity.



**SECTION 20.00 EARTHWORK.....1**

- 20.01 Scope .....1
- 20.02 Clearing and Grubbing .....1
- 20.03 Topsoil.....2
- 20.04 Watering .....3
- 20.05 Removal of Structures and Obstructions .....4
- 20.06 Excavation and Embankment .....6
- 20.07 Reset Structures, Fences, and Guardrail.....14
- 20.08 Tracking Mud on City Streets.....15



## SECTION 20.00 EARTHWORK

### 20.01 Scope

The intent of this section is to specify materials, methods, and standards to be used in the construction of embankments or excavations for roads, drainage channels, structures, or other purposes as indicated on the drawings or contract documents. The work shall include excavation, embankment, grading, compaction, clearing and grubbing, removal of topsoil, trees, stumps, vegetation, removal and/or resetting of minor obstructions, subgrade preparation, and any other work incidental for the construction of excavations and embankments. All workmanship and materials shall be in accordance with the requirements of these specifications, and in conformity with the lines, grades, quantities, and the typical cross section shown on the plans or as directed by the Project Manager. When used in these specifications, AASHTO shall refer to the American Association of State Highway and Transportation Officials, ASTM shall refer to the American Society for Testing and Materials, and CDOT shall refer to the Colorado Department of Transportation.

### 20.02 Clearing and Grubbing

**20.02.1 General** This work shall consist of clearing, grubbing, removing, and disposing of all vegetation and debris within the limits of project and such other areas as may be indicated on the plans or required by the work, except such objects as are designated to remain or are to be removed in accordance with other sections of these specifications. This work shall also include the preservation from injury or defacement of all vegetation and objects designated to remain.

**20.02.2 Construction** The Project Manager will establish construction lines and designate all trees, shrubs, plants, and other objects to remain. The Contractor shall preserve all objects designated to remain.

All surface objects and all trees, stumps, roots, and other protruding obstructions not designated to remain shall be cleared and/or grubbed, including mowing, as required, except non-perishable solid objects which will be a minimum of two feet below subgrade. Perishable objects shall be removed to a depth of three feet below the existing ground or subgrade, whichever is lower.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed, shall be backfilled with suitable materials and compacted in accordance with these specifications. Materials and debris shall be disposed of in a manner acceptable to the Project Manager. Burning will not be permitted.

The Contractor shall make all necessary arrangements for obtaining suitable disposal locations. If disposal will be at other than established dump sites, the Project Manager may require the Contractor to furnish, in writing, permission from the property owner on whose property the materials and debris are placed. Branches on trees or shrubs shall be removed as directed or as specified. Branches of trees extending over the roadbed shall be trimmed to give a clear height of 20 feet above the roadway surface. All trimming shall be done by skilled workmen and in accordance with good tree surgery practices.

The Contractor shall scalp areas where excavation or embankment will be made, except mowed sod need not be removed where the embankment to be constructed is four feet or more in height below subgrade elevation. Scalping shall include the removal of materials such as brush, roots, sod, grass, residue of agricultural crops, sawdust, and other vegetable matter from the surface of the ground.

Hedges shall be pulled or grubbed in such a manner as to assure complete and permanent removal. Scattered hedge or shrubs not classified as hedge shall be removed as specified for hedge. Sod not required to be removed shall be thoroughly disked before construction of embankment.

## **20.03 Topsoil**

**20.03.1 General** This work shall consist of excavating suitable topsoil from stockpiles, approved pits, or from the natural groundcover on designated portions of the project. It shall include the placing of topsoil upon constructed cut and fill slopes after grading operations are completed. All work shall be in accordance with these specifications and in reasonably close conformity with the lines and thickness shown on the plans or as directed.

**20.03.2 Materials** Topsoil shall consist of loose, friable loam reasonably free of admixtures of subsoil, refuse, stumps, roots, rocks, brush, weeds, or other material which would be detrimental to the proper development of vegetative growth.

**20.03.3 Construction** Materials selected for topsoil and lying within the limits of the project shall be excavated and stockpiled along the project at locations designated. Excavated topsoil shall be placed directly upon constructed cut and fill slopes without the use of stockpiles whenever conditions and the progress of construction will permit.

Topsoil shall not be placed until the areas to be covered have been properly prepared and grading operations in the area have been completed.

Topsoil shall be placed and spread at locations and to the thickness shown on the plans and shall be keyed to the underlying materials by the use of harrows, rollers, or other equipment suitable for the purpose.

Water shall be applied to the topsoil at the locations and in the amounts designated. Water shall be applied in a fine spray by nozzles or spray bars in such manner it will not wash or erode the topsoil areas.

## **20.04 Watering**

**20.04.1 General** This work shall consist of wetting, water for landscaping, and the application of dust palliatives to soils and aggregates in accordance with these specifications and in conformity with the plans.

**20.04.2 Materials** All water used shall be free of any mineral salts or contaminating material which might result in expansion of materials after placement. In case the water source proposed for use by the Contractor is not of known quality and chemical content, samples of the water shall be submitted for tests and shall be approved prior to use. When water will be metered for measurement, the Contractor shall use an approved metering device.

### **20.04.3 Construction**

**20.04.3.01 Wetting** Sprinkling equipment shall be of a type which insures uniform and controlled distribution of water without ponding or washing. Water added during finishing operations shall be uniformly applied by spraying across the full width of the course by means of controllable pressures and spray bars or nozzles.

**20.04.3.02 Dust Palliative** The Contractor shall be required to furnish and apply a dust palliative on portions of the project and on haul roads at the locations and in the amounts as may be called for on the plans or as directed. Dust palliative may consist of water or a dilution of water and emulsified asphalt, or other approved substance. Dust palliative shall be of the type and proportions called for on the plans, or as directed. Spreading of water or water mixture shall be done with acceptable sprinkling equipment.

**20.04.3.03 Landscaping** The Contractor shall be required to furnish water for seeding, mulching, planting, transplanting, sodding, soil sterilization, and any other landscaping work, when called for on the plans or when designated.

## 20.05 Removal of Structures and Obstructions

**20.05.1 General** This work shall consist of the removal, wholly or in part, and satisfactory disposal of all foundations, fences, signs, structures, sidewalk, curbing, old pavements, traffic signal materials, abandoned pipelines, and any other obstructions not designated or permitted to remain, except for the obstructions to be removed and disposed of under other items in the contract. It shall also include the salvaging of designated materials and backfilling the resulting trenches, holes, and pits.

When the proposal does not include pay items for removal of structures and obstructions as set out in this section, such work shall be performed under Section 20.06, EXCAVATION AND EMBANKMENT. This work shall also include sawing or cutting concrete or asphalt in reasonably close conformity with the dimensions and details on the plans or as directed, to create planes of weakness in order to facilitate controlled breaking for removal.

**20.05.2 Construction** The Contractor shall raze, remove, and dispose of all foundations, signs, structures, fences, old pavements, abandoned pipelines, traffic signal materials, and other obstructions, any portion of which are within the project limits except utilities and those for which other provisions have been made for removal.

Traffic signals and related materials shall include all attachment hardware and other included materials such as, but not limited to, mast arms, span wire, and internal wiring.

Concrete adhering to sign posts shall be removed. Pedestals and bases shall be removed to one foot below the surrounding ground or subgrade.

Where portions of structures will be removed, the remaining portions shall be prepared to fit new construction. The work shall be done in accordance with plan details, and in such manner that materials to be left in place shall be protected from damage. All damage to portions of structure to remain in place shall be repaired by the Contractor at his expense. Reinforcing steel projecting from the remaining structure shall be cleaned and aligned to provide bond with new extension. Dowels as required by plans shall be securely grouted with approved grout. Removal of sign panel shall include all work necessary to remove the panel and its attachment hardware from the existing installation.

Where culverts or sewers will be left in place and plugged, the ends shall be filled with Class III concrete. Culvert and sewer ends shall be sufficiently filled to prevent future settlement of embankments.

Materials used in detour structures for the project, which are supplied by the Contractor, shall be considered to be the property of the Contractor. After the detour is abandoned, he shall completely remove the detour structure and shall dispose of materials as specified.

**20.05.3 Removal of Bridges, Culverts, and Other Drainage Structures** Bridges, culverts, and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic.

Unless otherwise directed, the substructures of existing structures shall be removed down to one foot below natural stream bottom or ground surface. Where such portions of existing structures lie wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure. Steel, precast concrete, and wood bridges as specified, shall be carefully dismantled without unnecessary damage. Steel members to be salvaged shall be match marked with waterproof paint.

**20.05.4 Removal of Pipe** Unless otherwise provided, all pipe shall be carefully removed, cleaned, and every precaution taken to avoid breaking or damaging the pipe. Pipes to be re-laid shall be removed and stored when necessary so there will be no loss or damage before relaying.

In removing manholes, catch basins, and inlets, any live sewers connected with them shall be properly reconnected, and satisfactory bypass service shall be maintained during such operations.

**20.05.5 Removal of Pavements, Sidewalks, Curbs, Etc.** Portland cement concrete (PCC) or asphaltic concrete to remain shall be cut in a straight, true line with a vertical face. PCC or asphaltic concrete may be cut with a cutting wheel, saw, or broken to the directed point of removal. The Contractor shall be responsible for the cost of removal and replacement of all excess breaks.

If the Contractor cannot maintain a straight, true break line by other means, the Project Manager shall order sawing.

The sawing shall be done carefully, and all damages to PCC or asphaltic concrete to remain in place, due to Contractor's operations, shall be repaired by the Contractor at his expense. The minimum depth of saw cut in concrete shall be two inches or one-quarter depth of pavement, whichever is greater.

**20.05.6 Salvage** All salvageable material shown on the plans shall be removed, without unnecessary damage, in sections or pieces which may be readily transported, and shall be stored by the Contractor in locations designated by the Project Manager, or as specified on the plans. The Contractor shall be required to replace any materials lost from storage or damaged by negligence or by use of improper methods.

**20.05.7 Disposal** The Contractor shall make all necessary arrangements for obtaining suitable disposal locations and the cost involved shall be included in the work. If disposal will be at other than established dump sites, the Project Manager may require the Contractor to furnish written permission from the property owner on whose property the materials are placed. Broken concrete or asphalt shall not be disposed in the City, except as provided in Section 20.06.6 when approved by the Project Manager.

**20.05.8 Backfill** Except in areas to be excavated, all cavities left by structure removal shall be backfilled with suitable material and compacted in accordance with these specifications. Jetting or ponding will not be allowed.

## **20.06 Excavation and Embankment**

**20.06.1 General** This work shall consist of excavation, disposal, shaping, or compaction of all material encountered within the limits of the work, including excavation for ditches and channels, and not being removed under some other item, necessary for the construction of the project in accordance with the specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the plans or as staked by the Project Manager or Project Surveyor.

**20.06.2 Excavation** All excavation shall be classified as rock excavation, unclassified excavation, or borrow, as hereafter described.

**20.06.2.01 Rock Excavation** Rock excavation shall consist of igneous, metamorphic, and sedimentary rock which cannot be excavated without blasting and all boulders or other detached stones each having a volume of two cubic yards or more, as determined by physical or visual measurements.

**20.06.2.02 Unclassified Excavation** Unclassified excavation shall consist of the excavation of all materials of whatever character is required for the work, obtained within the right-of-way, or designated sites close to the project area, including surface boulders and excavation for ditches and channels.



**20.06.2.03 Borrow** Borrow shall consist of approved material obtained from outside the right-of-way, required for the construction of embankment or other portions of the work.

**20.06.3 Embankment Material** Embankment material shall consist of approved material acquired from excavations, hauled and placed in embankments in reasonably close conformity with the line, grades, thickness, and typical cross sections shown on the plans or established.

The type of relative compaction required shall be as called for on the plans or as designed.

When the source of embankment materials is not designated on the plans, approval of the source will be contingent on the material having a resistance value of at least 15 or as shown on the plans when tested by the Hveem Stabilometer, and a maximum dry density of not less than 95 pounds per cubic foot.

#### **20.06.4 Construction**

**20.06.4.01 General** The excavation and embankments shall be finished to reasonably smooth and uniform surfaces. Variation from the subgrade plan shall not be more than 0.08 feet for soil, nor more than 0.50 feet for rock. Materials shall not be wasted without permission of the Project Manager. Excavation operations shall be conducted so the material outside of the limits of slopes will not be disturbed. Prior to beginning grading operations in any area, all necessary clearing and grubbing and topsoil in that area shall have been performed in accordance with Section 20.02, CLEARING AND GRUBBING, and SECTION 20.03, TOPSOIL.

The Contractor shall notify the Project Manager with sufficient time before beginning excavation so the necessary cross sections may be taken. The Contractor shall not excavate beyond the dimensions and elevations established, and material shall not be removed prior to the staking and cross sectioning of the site.

When the Contractor's excavating operations encounter remains of prehistoric people's dwelling sites or artifacts of historical or archaeological significance, the operations shall be temporarily discontinued. The Project Manager will contact archaeological authorities to determine the disposition thereof. When directed, the Contractor shall excavate the site in such manner as to preserve

the artifacts encountered and shall remove them for delivery to the custody of the proper state authorities. Such excavation will be considered and paid for as extra work.

The Contractor shall at all times take precautions for the protection of culverts, irrigation crossings, mail boxes, driveway approaches, valve boxes, manholes, survey monuments, underground or overhead utility lines, and all other public or private installations that may be encountered during construction. The Contractor shall be responsible for the repair of any installations damaged due to his work. Manholes and valve boxes shall be observed by the Project Manager for displacements and introduction of foreign matter. It shall be the Contractor's responsibility to correct any displacement and to remove any foreign matter resulting from his work.

**20.06.4.02 Minimizing Swell Potential** For all soil groups, excluding A-1 through A-4, the required depth of moisture treatment of the subgrade shall be determined by the highest percentage of swell (ASTM D 4546 at a surcharge of 200 lbs./s.f.) as indicated in the table below.

**Table 20.06.4.02  
Moisture Treatment Requirements**

Swell Potential <sup>1</sup>	Depth of Subgrade Moisture Treatment <sup>2</sup>	Depth of Chemical Stabilization <sup>4</sup>
< 3% swell	moisture treat to a depth of 1'	---
> 3% < 5% swell <sup>3</sup>	moisture treat to a depth of 2.5' or	---
	moisture treat to a depth of 1.5' below the chemical stabilization	Stabilization treat to a depth of 1' <sup>4</sup>
> 5% swell <sup>3</sup>	moisture treat to a depth of 1.5' below the chemical stabilization	Stabilization treat to a depth of 1' <sup>4</sup>

<sup>1</sup> Indicated highest percentage of swell as recorded to the nearest whole number.

<sup>2</sup> From the top of finished subgrade, moisture treatment **shall not** go deeper than 30 inches without written direction from the engineer.

<sup>3</sup> The moisture content for the subgrade moisture treatment shall be + 2 to + 4 percent optimum moisture content.

<sup>4</sup> Chemical stabilization shall be completed after moisture treatment and the total treated depth shall be 2.5 feet (1' chemical +1.5' moisture treatment) followed by a chemical treatment of the upper 1.0' below top of subgrade.

**NOTE:** From the top of finished grade, moisture treatment **shall not** go deeper than 30 inches without written direction from the Engineer.

Moisture treatment shall achieve a moisture content in accordance with Table 20.06.8 Compaction and Moisture for Various Soil Types.

Soils with >5% swell shall also require swell mitigation per Section 22, CHEMICAL AND MECHANICAL STABILIZED SUBGRADE, in addition to moisture treatment.

## **20.06.5 Excavation**

**20.06.5.01 Rock** Unless otherwise specified, rock shall be excavated to a minimum depth of three feet below subgrade within the limits of the roadbed and the excavation backfilled with material designated on the plans or from an approved source.

**20.06.5.02 Unclassified** Where material encountered within the limits of the work is considered unsuitable by the Project Manager, such material shall be excavated as directed by the Project Manager and replaced with suitable material. All excess or unsuitable excavated material, including rock and boulders, that cannot be used in embankments may be placed on the fill-side slopes in a satisfactory manner or otherwise disposed of as approved by the Project Manager.

Wherever shown on the plans, or considered necessary, intercepting ditches shall be made above the top of cut slopes and carried to outlets near the ends of the cuts. In order to blend the intersection of cut slopes with the slope of the adjacent natural ground surfaces in a uniform manner, the tops of all cut slopes shall be flattened and rounded.

Excess quantities of excavation not necessary for the construction of the embankments, unless otherwise specified on the plans or in the special conditions, shall become the property of the Contractor and shall be disposed of as specified in Section 20.05.7. The Project Manager may allow disposal by widening and flattening fill slopes, if right-of-way conditions permit and if no damage results.

**20.06.5.03 Borrow** Borrow material should not be placed until after the excavation has been placed in the fill. If the Contractor places more borrow than is required and thereby causes a waste of excavation, the amount of such waste will be deducted from the borrow volume. Borrow areas shall be finished so water will not collect or stand therein, unless otherwise specified. The Project Manager shall be notified 14 days in advance of opening any material sources to allow time for testing.

**20.06.6 Embankment** Embankment construction shall consist of constructing roadway embankments, including preparation of the areas upon which they are to be placed; the construction of dikes; the placing and compacting of approved material within project areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits, and other depressions within the project area. Only approved materials shall be used in the construction of embankment and backfills.

Free-running water shall be drained from the material before the material is placed. Rocks, broken concrete, or other solid materials more than six inches in greatest dimension shall not be placed in embankment areas less than one foot deep measured from the subgrade. Materials less than 150 pounds per cubic foot, but not less than 95 pounds per cubic foot, may be placed in fills over one foot deep provided there remains one foot minimum cover measured from the subgrade and with the approval of the Project Manager.

If embankment can be deposited on only one side of abutments, wing walls, piers, or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of or excessive pressure against the structure. The fill adjacent to the end bent of a bridge or to a box culvert shall not be placed higher than the bottom of the back wall of the bent or floor slab of the box until the superstructure is in place. When embankment will be placed on both sides of a concrete wall or box-type structure, operations shall be conducted so the embankment is always at approximately the same elevation on both sides of the structure.

Roadway embankment of earth material shall be placed in horizontal layers not exceeding eight inches (loose measurement) and shall be compacted as specified before the next layer is placed. Effective spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous leveling and manipulating will be required to assure uniform density. Water shall be uniformly added or removed if necessary, in order to obtain the required density and moisture content.

Placing of occasional boulders of sizes larger than the maximum layer thickness may be authorized by the Project Manager. Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of earth.

Cross hauling or other action as appropriate will be ordered when necessary to insure the best available material is placed in critical areas of embankments, including the top two feet of all embankments.

Frozen materials shall not be used in the construction of embankments.

During the construction of the roadway, the roadbed shall be maintained in such condition it will be well drained at all times.

**20.06.7 Benching** Embankment material to be placed and compacted adjacent to existing embankment or existing slopes steeper than 5:1 shall be continuously benched as the new embankment material is placed up in layers. Each bench shall be keyed a minimum of three feet into the existing ground and shall begin at the intersection of existing ground and the vertical sides of the previous cut. The configuration of the benches shall be as shown on the plans or at least four feet in height. Materials from the benching shall be compacted with the embankment material. Placement of embankment materials shall begin at the low point of slopes. Materials which have been loosened shall be recompacted with the embankment materials.

Any deviation of grade tolerances in excess of 0.08 feet in cross section and 0.08 feet in 16 feet measured longitudinally shall be corrected by loosening, adding or removing the material, reshaping, moisture conditioning, and re-compacting. Deviations in excess of this tolerance shall be corrected by the Contractor, at the Contractor's expense, in a manner satisfactory to the Project Manager.

**20.06.8 Compaction** All material in embankments shall be compacted to the specified relative compaction. The moisture content of the soil at the time of compaction shall be as specified.

Within the areas indicated on the plans and to the designated depth below subgrade, for the full width of roadway in all cut sections, earth shall be thoroughly scarified and the moisture content increased or reduced, as necessary, to bring the moisture to the content specified. This scarified layer shall then be compacted to the relative compaction specified. The remainder of the area up to subgrade elevation shall be constructed of suitable material placed at the moisture content specified and compacted to the percent relative compaction specified. Maximum dry density of all soil types encountered, or to be used, will be determined in accordance with AASHTO T99 or AASHTO T180. The percent of relative compaction and

moisture content shall be as shown in the following table for the various classes of soil and type of compaction.

**Table 20.06.8  
COMPACTION AND MOISTURE FOR VARIOUS SOIL TYPES**

Soil Classification (AASHTO M 145)	AASHTO T99 Minimum Relative Compaction (Percent)	AASHTO T180 Minimum Relative Compaction (Percent)	Moisture % of Optimum
A-6 & A-7	95	--	0, +2
A-1 through A-5	--	95	-2, +2

Base or subbase shall not be placed upon the subgrade or any previously placed layer of the pavement section until compaction tests are taken and approved by the Project Manager. Testing shall include, but not be limited to, trenches for water, sanitary, storm, telephone, gas, electric, and around manholes, valve boxes, and inlets. If the subgrade or base does not have the specified density and moisture content at the time of placing the next pavement layer, the Project Manager shall require scarifying, wetting or drying, and re-rolling. If the specified compaction cannot be obtained, a new pavement design shall be determined and approved by the City Engineer. The compaction requirements of this section shall apply under curb, gutter, and sidewalk.

If more than 24 hours has elapsed between the time compaction tests are taken and the time the next layer in the pavement section is placed, the area shall be retested. Additional testing will not be required if a prime coat is applied within the 24-hour period, provided the prime coat is in good condition and not over two weeks old and has not been exposed to the elements.

Compaction tests shall be taken under the direct supervision of a Geotechnical Engineer, licensed as a Professional Engineer in the State of Colorado. The Geotechnical Engineer shall take sufficient compaction tests to assure himself the street is ready for surfacing, as the case may be, and shall so state on his compaction report. Compaction testing exposed to the elements will only be valid for a 24-hour

period without protection from the elements and will require retesting. Compaction reports shall be signed, sealed, and dated by the Geotechnical Engineer.

**20.06.9 Proof Rolling** Proof rolling with a heavy rubber-tired roller is required. Proof rolling shall be done after specified compaction has been obtained. Areas found to be weak and those areas which fail a proof roll shall be ripped, scarified, wetted or dried if necessary, and re-compacted to the requirements for density and moisture at the Contractor's expense. The proof roller shall be a pneumatic-tired vehicle with tire pressure of at least 100 psi capable of applying ground loads of not less than 18,000 pounds per axle, provided by the Contractor. Complete coverage of the proof roller will be required. Rollers shall be operated between two and six miles per hour.

**20.06.10 Subgrade, Base Course, and Pavement Surface Grade Checks** The Project Manager shall check elevations, unless otherwise specified, for subgrade, base course, and pavement surfaces to ensure each layer's elevation is within  $\pm \frac{1}{2}$  inch. The total thickness of each roadway structural material shall not differ from the specified thickness by more than  $\frac{1}{2}$  inch. Using the Contractor's established grade hub stakes (blue tops) set outside the pavement box and at break lines, the Project Manager shall check elevations within the roadbed limits using a string line drawn taut between these hub stakes to ensure the grade stakes indicate the referenced vertical cut or fill measurement conforms to the specified finish grade. The Project Manager shall check elevations longitudinally every 50 feet and transversely every 12.5 feet on a grid system, with all break points included, and the center of each lane and shoulder. The Project Manager may direct additional grade stakes in areas with rapid changes in grade so the intermediate longitudinal checks may be made. GPS rovers shall not be used as they are not accurate enough to measure within the specified tolerances.

When finishing to blue tops the Project Manager shall look at the laydown grade to be verify the grade between the blue tops does not have an incorrect grade break. This condition shall be checked quickly by means of a string line. The Contractor shall make adjustments or corrections, as needed, during the grade check.

The subgrade shall be thoroughly compacted, as specified, and shall conform to the required cross section and grade. Subbase and base materials shall not be used to correct irregularities in the subgrade.

## 20.07 Reset Structures, Fences, and Guardrail

**20.07.1 General** This item shall consist of removing, relaying, resetting, or adjusting structures, fences, guardrail, signs, pipe, end sections, traffic signals, and related materials. All designated items shall be carefully removed and every precaution taken to avoid damage. Coordinate relocation of permanent traffic devices with the Traffic Services Division. The Contractor will be required to replace or repair any material damaged due to his operations at his own expense. The work shall include the backfilling of any resulting trenches, holes, or pits with suitable material and compacted in accordance with these specifications.

**20.07.2 Construction** Pipe to be re-laid and structures to be reset shall be thoroughly cleaned. Removal sites shall be neatly backfilled with suitable material and compacted in accordance with these specifications.

Materials in good condition from removed structures or fences may be used in the rebuilding operations. All removed material not reused shall be salvaged or disposed of as directed by the Project Manager, or as designated in the plans.

Where fences are to be rebuilt or reset, it will be the Contractor's responsibility to supply and install any new materials required to restore the fence to acceptable condition. Unless otherwise stated in the Special Conditions, the Contractor may reuse any existing salvageable material. The quality of construction of the reset fence shall equal or exceed that of the existing fence.

Unserviceable material from structures shall be replaced with new material of dimensions similar to those used in building the original structure. Replacement parts and new materials, including concrete footings, necessary to restore these structures to service at new locations, shall be provided and installed by the Contractor as part of this item.

All new materials and replacement parts shall be of similar quality to those used in the original structure or as specified. Gates designated or noted on plans to be reset shall be removed and restored for service at the new locations indicated.

Mailboxes, complete with supporting structures, shall be removed and temporarily reset at points near their original location to be easily accessible for mail delivery service. Immediately upon completion of surfacing operations, the boxes shall again be reset to a height of 42 inches to 48 inches at the locations designated. A supporting structure may contain one or more mailboxes. Prior to the removal and



resetting of mailboxes the necessary approvals shall be obtained from the U.S. Post Office.

Resetting of all traffic control signs and traffic signaling devices will conform to Section 50.00 and be coordinated with the Traffic Services Division.

Adjusting structures shall include, but not be limited to, manhole rings and covers, inlet gratings and frames, water valve boxes, water meters, gate posts, and other structures and facilities. Construction operations shall include any raising, lowering, moving, removing masonry or concrete, adding brickwork, masonry or concrete, and resetting grates, frames or rings and covers to fit the new construction. At no time shall manholes and valve boxes be covered up or buried. Valve boxes and manholes shall be maintained fully accessible at all times for emergency and maintenance operations by City personnel. Work on water services shall be subject to observation and testing by the owners. Damage to any fire hydrant or any part of the system due to Contractor's operations shall be repaired at the Contractor's expense.

## **20.08 Tracking Mud on City Streets**

Pursuant to Sections 138-440 and 138-442 of the Aurora Municipal Code, the Stormwater Permittee shall locate, install, and maintain all erosion control and water quality BMPs as indicated in the approved Erosion and Sediment Control Plan. The Stormwater Permittee shall take appropriate preventive measures to prevent dirt and mud from being tracked or deposited onto paved sections via multiple BMPs. All sediment, mud, and construction debris tracked, deposited, or accumulated on paved sections, in the flowlines, private property, and/or public rights-of-way of the City as a result of the construction project shall be cleaned up daily. Daily clean up shall be required on all paved sections with mud tracked on them due to construction.

**SECTION 21.00 STRUCTURE EXCAVATION AND BACKFILL .....1**

21.01 General .....1

21.02 Materials.....1

21.03 Construction .....1



## **SECTION 21.00 STRUCTURE EXCAVATION AND BACKFILL**

### **21.01 General**

This work shall consist of the excavation and disposal of excess material so developed, backfill, and filter material required for the construction of major structures, all in accordance with these specifications and in reasonably close conformity with the lines, grades, and typical cross section shown on the plans or established. All excavation and backfill for structures below the designed slope or subgrade line as shown on the plans shall be included under this item. Unless otherwise specified, structure excavation shall include all pumping, bailing, draining, sheeting, bracing, and incidentals required for proper execution of the work.

### **21.02 Materials**

Structure backfill shall be composed of materials from excavations, borrow pits, or other sources. Type of material shall be COA Type 4 (structural) per Table 23.02.1 or as specified on the plans. The material installed in place will be tested for acceptance. Filter material shall be as shown on the plans or as designated. The material installed in place will be tested for acceptance.

### **21.03 Construction**

**21.03.1 Structure Excavation and Backfill** Poor foundation material shall be removed, as directed by the Project Manager, below the normal designated elevation and paid for as structure excavation. Suitable surplus excavated material shall be used in the construction of embankments, and all unsuitable material shall be wasted. Material removed below designed elevation shall be replaced with approved material.

Where rock, hardpan, or other unyielding material is encountered, it shall be removed below the designed grade for a minimum depth of 12". The extra-depth excavation shall be backfilled with approved material.

Backfilling shall consist of placing materials in horizontal, uniform layers brought up uniformly on all sides of the structure. The thickness of each layer of backfill shall not exceed 6" before compacting to the required density. Structure backfill shall be compacted to the density specified in Section 20.06, EXCAVATION AND EMBANKMENT, or as shown on the plans.

The excessive use of water during backfilling operations will not be permitted.

Compaction equipment or methods that produce horizontal or vertical earth pressures, which may cause excessive displacement or may damage structures, shall not be used.

Backfill material shall not be deposited against the back of concrete abutments, concrete retaining walls, or the outside walls of cast-in-place concrete structures until the concrete has developed a strength of not less than 2500 pounds per square inch in compression.

Unless otherwise indicated in the plans or directed, all sheeting and bracing used in making structure excavation shall be removed by the Contractor prior to backfilling.

**21.03.2 Filter Material** Filter material shall be placed behind bridge abutments, wing walls, and retaining walls as shown on the plans. When shown on the plans, wall-drain outlets shall be backed with sacked filter material.

Filter material shall be placed in horizontal layers along with and by the same methods specified for structure backfill.

**SECTION 22.00 CHEMICAL AND MECHANICAL STABILIZED**

**SUBGRADE.....1**

22.00 Description ..... 1

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## SECTION 22.00 CHEMICAL AND MECHANICAL STABILIZED SUBGRADE

### 22.00 Description

This work consists of the contractor constructing one or more courses of a mixture of subgrade soil, approved stabilizing agent and water in substantial conformity with the design line, grades, thicknesses, and typical cross sections shown on the approved plans and the approved pavement thickness design.

**22.00.1 PURPOSE** The purpose of the work shall be to provide a structural section on which paving materials can be placed and to meet design specifications, while at the same time, protecting the underlying moisture-treated subgrade soils. This specification can also be applied to achieve a stabilized paving platform without structural benefits.

### 22.01 Materials

**22.01.1 Stabilizing Agents** The pre-approved stabilizing agents are listed in Table 22.01.1.1. Various combinations of these materials may also be used, subject to a suitable mix design. Other agents may be used with prior written approval of the Project Manager.

**TABLE 22.01.1.1**

<b>PRE-APPROVED STABILIZING AGENTS</b>		
<b>Agents</b>	<b>Must conform to requirements of</b>	
Lime	ASTM	C 977, C110
Fly Ash (C and F)	ASTM	C 618
Cement Kiln Dust	ASTM	D 5050
Portland Cement	ASTM	C 114

High-calcium quicklime shall conform to the requirements of ASTM C 977 and rate of slaking test shall produce a temperature rise of 20° C in 30 seconds and 35° C in 3 minutes per ASTM C110. Dolomitic quicklime, magnesia quicklime with magnesium oxide contents in excess of 4 percent or carbonated hydrated lime, shall not be used. High-calcium quicklime must be applied in a slurry.

Fly ash may consist of Class C or Class F. Class F fly ash shall only be allowed in conjunction with lime or other stabilizing agents.

All stabilizing agents shall come from the same source as used in the design. If the source is changed, a new design must be submitted for the Project Manager's



approval. Each lot of stabilizing agent furnished shall have the supplier's certificate of compliance.

**22.01.2 Water** Water used for mixing or curing should be from a potable source. In the event potable water is not used, non-potable water shall be tested in accordance with and meet the requirements of AASHTO T 26.

**22.01.3 Subgrade** The subgrade to be stabilized shall be free of roots, sod, weeds, wood, construction debris, ice, snow, or other frozen materials, deleterious matter, and stones larger than 3 inches. Material in the stabilized zone shall have a soluble sulfate content of less than 0.2 percent as per CPL 2103, Method B. If the subgrade soils have a soluble sulfate content exceeding 0.2 percent, the mix design shall be addressed to the specific methodology used to prevent adverse effects of sulfate reactions (e.g. heaving subgrade, cracked pavement). See Section 22.05.1.3 HIGH SULFATE TREATMENT for more high sulfate guidance.

**High Sulfate Treatment** Where sulfates are over 0.2 percent the ENGINEER must address the method of treatment.

Note: When a double treatment of lime is required, the first 50 percent of the agent shall be placed, moisture treated and allowed to mellow or cure for up to three weeks, as determined by the engineer. The last half of the lime shall then be applied.

**22.01.4 Sealant** Emulsified asphalt is the only pre-approved sealant; no other sealant may be utilized without prior written approval of the Project Manager. Emulsified asphalt used for a bituminous seal shall conform to requirements in Table 22.01.4.1 below.

**TABLE 22.01.4.1**

<b>PRE-APPROVED SEALANTS</b>			
<b>Sealant</b>	<b>Type</b>	<b>Requirements</b>	
Emulsified Asphalt	SS-1	ASTM	D 977
Emulsified Asphalt	SS-1h	ASTM	D 977
Emulsified Asphalt	CSS-1	ASTM	D 2397
Emulsified Asphalt	CSS-1h	ASTM	D 2397

## **22.02 Equipment**

All equipment shall be subject to approval by the AGENCY. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled.

**22.02.1 Dry Application Equipment** Equipment for spreading dry stabilizing agent shall be of an approved screw-type spreader box, mixer, or other semi-enclosed equipment which is equipped with a metering device. Spreading of stabilizing agents by aggregate spreaders or motor- graders will not be allowed.

**22.02.2 Slurry Application Equipment** A distributor or truck applicator shall be used and be capable of continuous agitation to keep the slurry mixture uniform. The applicator shall be capable of uniformly metering the stabilizing agent during application.

**22.02.3 Mixing Equipment** Mixing equipment shall be of sufficient size to adequately mix the stabilizing agent into the soil and to pulverize the mixture according to the requirements of Section 22.05. The size of the mixer shall be adequate to mix and pulverize the mixture to a minimum depth of 12 inches in a single pass. Blades, discs, and similar equipment are not allowed without prior written approval of the Project Manager.

**22.02.4 Compaction Equipment** Compaction equipment shall be in good working order and of sufficient size and effective force to achieve the required compactive effort as prescribed in Section 22.06.

## **22.03 Construction Submittals**

At least 15 days prior to commencing stabilization work, the Contractor shall furnish the following information to the Project Manager:

**22.03.1** The source and supplier of stabilizing agent and certifications, including purity of stabilizing agent, from the manufacturer's testing agency indicating that the stabilizing agent meets the appropriate requirements.

**22.03.2** Description of the proposed construction equipment, construction methods, expected production rates and planned sequence of construction.

**22.03.3** A mix design giving the percentage of stabilizing agent, source of the agent, properties and any special considerations.

**22.03.4** Water Soluble Sulfate test results.

For each day's work, the Contractor shall furnish the following information to the Project Manager by the following day:

**22.03.5** Certified truck weight tickets of stabilizing agent, delivered or used at the site.

**22.03.6** A summary of the amount of stabilizing agent used each day, areas stabilized and first mixed, areas second mixed and compacted, and areas with curing completed.

**22.03.7** Prior to paving, final in place soil properties per Table 22.11.1.

## 22.04 Stabilized Mix Design

Mix designs shall be performed under the supervision of and signed by a Professional Engineer licensed in the State of Colorado. Laboratories shall be accredited by AASHTO.

Mix design shall comply with the following requirements in Table 22.04.1 below:

**TABLE 22.04.1**

<b>STABILIZATION MIX DESIGN REQUIREMENTS</b>			
<b>Stabilization Agent</b>	<b>Minimum pH</b> Notes 1 & 2	<b>Maximum Swell Potential (%)</b> Note 3	<b>Minimum Unconfined Compressive Strength (psi)</b> Note 4
Lime	12.0	1.0	160
Fly Ash	N/A	1.0	160
Cement Kiln Dust	N/A	1.0	160
Portland Cement	N/A	1.0	160
Lime-Fly Ash	12.3	1.0	160

Notes:

1. When lime is used, the pH should be no less than 12.0 as measured after completion of initial mixing with stabilizing agent and at ambient temperature.
2. Testing of pH is to be done in accordance with Eades-Grim pH test method (ASTM D 6276).
3. Swell Potential to be less than 1.0 percent at 200 psf, ASTM D 4546.
4. Minimum of 160 psi ( $M_R > 34,800$  psi, where  $M_R = 10,000 + 124q_U$ ) in five (5) days of moist curing at 100°F (38°C). Testing is in accordance with ASTM D 1633 Method A for pozzolanic agents and ASTM D 5102 Procedure B for Hydrated Lime.
5. When lime is used, Plasticity Index is to be reported from initial to final construction to all interested parties and shall not be used for acceptance purposes. The design stabilizing agent percentage as determined by the designer shall be increased by 0.5 percent in the field to account for waste, inert materials, and construction variability.

## 22.05 Processing Materials

It is the primary requirement of this specification to secure a completed subgrade structural section containing a uniform stabilized mixture. The mixture is to have a uniform density and moisture content, free from loose or segregated areas, well bound for its full depth, well cured, and with a surface suitable for placing subsequent courses.

It shall be the responsibility of the Contractor to regulate the sequence of their work, to use the proper amount of stabilizing agent, maintain the work, and rework the courses, as necessary, to meet the requirements.

**22.05.1 Application** The subgrade shall not be treated when the ambient air temperature falls below freezing or the subgrade material is below 40° F, or when weather predictions suggest that subgrade material temperature may fall below 40° F within 24 hours, unless prior written approval of the Project Manager has been issued. Prior to beginning any treatment, the subgrade shall also be constructed and finished to a smooth and uniform surface that is in conformity to the grade and typical section specified. Variation from the subgrade plan elevation specified shall not be more than ± 0.08 ft. The in-place density shall be at least 95% of maximum dry density as determined by ASTM D 698, Standard Proctor Density, and within 0 to 3% of optimum moisture content.

Stabilizing agent shall be applied at the minimum rate specified by the mix design for the depth of stabilized subgrade shown on the plans. The rate shall be determined from a design using the on-site soils and shall meet the requirements found in Section 22.04. Rate of application shall be verified using area/quantity calculations or testing of stabilized subgrade. Stabilizing agent shall be spread only on that area where the first mixing operations can be completed during the same working day. Lime slurry shall not be left exposed to the air for more than four hours without initial mixing.

The Project Manager reserves the right to require variation of the rate of application of stabilizing agent from the mix design application rates during the progress of construction as necessary to maintain the desired characteristics of the stabilized subgrade. Chemical stabilization shall not be used to eliminate or control frost.

Stabilizing agent shall be applied using the following methods:

**22.05.1.1 Slurry Placement** The distribution of stabilizing agent shall be attained by successive applications over a measured section of subgrade until the proper amount of agent has been spread. The amount spread shall be the amount required for mixing to the specified depth, which will result in the percentage determined in the design. When quicklime is used in place of hydrated lime the amount of quicklime used will be determined by the certified lime purity for each load supplied as follows:

$$\text{Quicklime delivered } X \% \text{ purity} * 1.32 = A \quad \text{Equation 22.05.1.1.1}$$

$$\text{Quicklime delivered } *X \% \text{ inert material} = B \quad \text{Equation 22.05.1.1.2}$$

A + B = total hydrated lime available

Equation 22.05.1.1.3

**22.05.1.2 Dry Placement** This method only can be used for Fly Ash, cement kiln dust, and Portland cement.

The amount of stabilizing agent spread shall be the amount required for mixing to the specified depth, which will result in the percentage specified by the design.

The stabilizing agent shall be distributed in such a manner that scattering by wind will be minimal. Agents shall not be applied when wind conditions, in the opinion of the Project Manager, are detrimental to a proper application. The blended material shall be sprinkled or watered until moisture content is as specified in subgrade stabilization design.

The combination of stabilizing agent, soil and water shall be called the “mixture.” After spreading of stabilizing agent and during mixing, water shall be added to hydrate the agent and to reduce dusting.

## **22.05.2 Mixing**

**22.05.2.01** No stabilization shall take place when precipitation may cause damage to the subgrade, as determined by the Project Manager. Mixing shall be continuous. The full depth of the treated subgrade material shall be mixed with an approved mixing machine to the specified depth below the bottom of the pavement structure and curb. The mixing machine shall make a sufficient number of passes to adequately achieve 100 percent of the material passing the one-inch sieve and 60 percent passing the 1/4-inch sieve. Water shall be added to the subgrade during mixing to provide a moisture content of at least 3 percent above the optimum moisture of the mixture or as specified in subgrade stabilization design.

**22.05.2.02** Mixing and remixing will be performed, as necessary, to assist the stabilizing agent-soil reaction and produce a homogeneous mixture. Mixing and remixing shall continue until the combination of stabilizing agent and subgrade material is free of streaks or pockets of stabilizing agent.

## **22.05.3 Mellowing (Lime or Lime/Fly Ash Only)**

The water content of the subgrade mixture shall be maintained at a moisture content above the optimum moisture content for a minimum of two days and until the subgrade stabilization design criteria is met. Remixing will be done as necessary to assist the reaction, as determined by the Project Manager. Application of moisture shall be performed as necessary during the mellowing period; the material shall maintain a moisture content of at least 3 percent above the optimum moisture content. The stabilized material shall not be subjected to traffic. If during the mellowing period the material is not in a semi-loose state, the chemical reaction process may slow down and, therefore, require additional time and/or mixing as determined by the Project Manager.

**22.05.4 Final Mixing (Lime or Lime/Fly Ash Only)**

**22.05.4.01** Final mixing of the treated subgrade shall not occur if the temperature of the soil to be stabilized is below 40°F. The treated subgrade shall be maintained at a temperature of 40° F or above until the treated material has been compacted.

**22.05.4.02** The material shall be uniformly mixed by an approved method to meet the following requirements when tested dry by laboratory sieves:

Sieve Size	Minimum Percent Passing
1-inch sieve	100
No. 4 sieve	60

**22.06 Compaction**

**22.06.1** Compaction of the mixture, for the full depth of the stabilized subgrade shown on the plans, shall begin as soon as practical after final mixing. Stabilized subgrade with cementitious stabilization agent shall be completed within 90 minutes of the time cementitious stabilization agent or water is applied. The field density of the compacted mixture shall be at least 95 percent of the maximum dry density of laboratory specimens prepared from samples taken from the treated subgrade material immediately prior to compacting. The specimens shall be compacted and tested in accordance with ASTM D 698 or ASTM D 558, as specified in subgrade stabilization design. The in-place field density shall be determined in accordance with ASTM D 1556, ASTM D 2167 or ASTM D 2922. The moisture content of the mixture shall be between 0 to 3 percent above the optimum moisture content. The optimum moisture content shall be determined in accordance with ASTM D 698 or ASTM D 558, as specified in subgrade stabilization design.

- 22.06.2** Initial compaction shall be done by means of a sheep foot or segmented wheel roller. Final compaction shall be by means of a smooth wheel or pneumatic tired roller. Areas inaccessible to a mechanical roller shall be compacted to the required density by other means suitable to the Project Manager.
- 22.06.3** All irregularities, depressions, or weak spots which develop, as determined by the Project Manager, shall be corrected immediately by scarifying the areas affected, adding or removing materials as required, and reshaping and recompacting by moisture conditioning and rolling. Adding additional stabilized material to an initial cured section, resulting in lamination and potential slip plane, is not allowed. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed thereon or the work is accepted. Should the material, due to any reason or cause, lose the required stability, density, and finish before the next course or pavement is placed, it shall be corrected and refinished at the sole expense of the Contractor, as directed by the Project Manager.

## **22.07 Finishing and Curing**

- 22.07.1** After the final layer of stabilized subgrade has been compacted, the shape of the surface shall be maintained by blading. The surface shall be smooth and conform to the required lines, sections, and grades, in accordance with the plans and thoroughly cured, or to within a minimum of 0.1 foot above the finished subgrade elevation to allow for trimming to final grade prior to placement of surface coarse. The completed section shall then be finished by rolling with suitable pneumatic tired equipment with sufficiently light effort to prevent hairline cracking.
- 22.07.2** Curing may be accomplished by periodic water application to maintain moisture content preventing sloughing or cracking in the surface of the stabilized subgrade to a depth no greater than 0.1 foot, or by the utilization of a bituminous seal. When bituminous seal (Section 22.01.4) is utilized, the minimum application will be at the rate of 0.12 gallons per square yard, as directed by the Project Manager
- 22.07.3** The completed section shall be cured for a minimum of five days before further courses are added or any traffic is permitted, unless otherwise permitted by the Project Manager. The moisture cured duration may be reduced if a non-yielding surface is obtained to support construction traffic and either the next layer of stabilized soils are placed or the pavement layer is constructed, as approved by the Project Manager.

**22.07.4** If the surface of the finished layer is above the approved plan elevation tolerance specified in this section, the excess material shall be trimmed, removed, and disposed of. Any low areas will be replaced with the subsequent surface courses. No loose material shall be left in place after trimming. After trimming the stabilized subgrade surface shall be rolled again with a steel wheel or pneumatic tired roller to seal the surface.

## **22.08 Tolerances**

**22.08.1 Thickness** Stabilized zone thickness shall be verified by the use of phenolphthalein and shall be performed at intervals of approximately every 500 feet in each lane. When the measurement of the thickness is deficient by more than one inch from the plan thickness, two additional locations shall be measured randomly within the deficient area and used in determining the average thickness. When the average thickness is deficient by more than one inch, the entire area shall be reprocessed to meet the design parameters or the roadway design section must be re-evaluated to the satisfaction of the Project Manager.

**22.08.2 Grade** Prior to placement of surface course, any deviation in excess of 1/2 inch in cross-section and 1/2 inch in 10 feet measured longitudinally shall be corrected. Variations in excess of this tolerance shall be corrected by the Contractor, at the Contractor's expense, in a manner satisfactory to the Project Manager. Thickness requirements shall be met in areas corrected for grade.

**22.08.3 Strength** The stabilized subgrade must develop a laboratory compressive strength of at least 160 psi at 5 days in accordance with Table 22.04. Samples shall be molded from stabilized soil within 1.5 hours of final mixing with the material compacted per ASTM D 558 or ASTM D 698, as specified in subgrade stabilization design, at the field moisture content.

## **22.09 Conformity with Plans and Specifications**

When thickness and/or strength criteria fail to meet design parameters, even after all possible attempts have been made to correct said deviations, remediation will be required as listed in Table 22.09.1 below. Evaluation of the roadway pavement section will be made by the Geotechnical Engineer for the project with written approval of the Project Manager. The pavement structural section shall be adjusted to compensate for any deficiency in the stabilized subgrade thickness and strength, at the Contractor's expense. Placement of subsequent surface course will not occur until



the stabilized subgrade has been accepted in writing by both the Geotechnical Engineer and the Project Manager.

**TABLE 22.09.1  
CONFORMITY WITH PLANS AND SPECIFICATIONS**

<b>Deficiency</b>	<b>Remediation</b>
< 25% of design thickness	Evaluate roadway design section
> 25% of design thickness	Remove and replace
< 25% of required strength	Evaluate roadway design section
> 25% of required strength	Remove and replace

## 22.10 Measurement

**22.10.1** The area of stabilized subgrade shall be measured by the plan quantities completed, in place, and accepted.

**22.10.2** The quantity of stabilizing agent accepted and used shall be measured by the ton of fly ash, Portland cement, cement kiln dust, or hydrated lime used (or the calculated dry hydrated lime content of the lime slurry). The load tickets for the stabilizing agent shall be provided to the Project Manager.

## 22.11 Testing and Inspection

Testing and inspection shall be performed in accordance with Table 22.11.1.

**TABLE 22.11.1**

<b>SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING</b>		
<b>Test Type</b>	<b>Test Standard</b>	<b>Minimum Frequency of Tests</b>
Sampling	AASHTO T 87	One per 1,000 square yards
Sample Preparation	ASTM D 3551	
Maximum Dry Density and Optimum Moisture Content	ASTM D 698 (Lime) ASTM D558 (Cement)	As directed by Project Manager (minimum one per soil type)
In Place Soil Density	ASTM D 1556 ASTM D 2167 ASTM D 6938	One test for each 200 lane feet (not less than one test per day)
In Place Moisture Content	ASTM D 2216 ASTM D 6938	
Ph	ASTM D 6276	One test per 1,000 square yards
Swell	ASTM D 4546 Method B	As directed by Project Manager minimum one test per 1,000 square yards
Unconfined Compressive Strength (Lime)	ASTM D 5102 (Procedure B)	One set of four cylinders per 1,000 square yards. Sealed and moist cured at 100° F for 5 days.
Compressive Strength Cementitious Agents	ASTM D 1633 (Method A)	One set of four cylinders per 1,000 square yards. Sealed and moist cured at 100° F for 5 days.
Atterberg Limits	AASHTO T 89 & T 90	One test per 1,000 square yards
Stabilization Thickness	As directed by Project Manager	One test every 500 feet per lane

## 22.12 Mechanical Stabilized Subgrade

Item includes mechanically stabilized subgrade of base/subbase course and/or subgrade improvement in the construction of paved or unpaved roadways. Design details for geogrid reinforcement, such as geogrid type, fill thickness, pavement cross-section and associated details, shall be as shown on the contract drawings. The purpose of the work shall be to provide a stabilized paving platform section on which paving materials can be placed. This Item shall not be used to retain moisture in subgrades, unless retaining moisture in the section can be assured. This specification shall be used for a construction platform and not as a means of mitigating swell. See Section 20.06.10 Subgrade, Base Course, and Pavement Surface Grade Checks.

### 22.12.01 Definitions

- 22.12.01.1 *Mechanically Reinforced:*** Placement of a geogrid immediately over a soft subgrade soil in order to improve the bearing capacity and mitigate deformation of the subgrade soil. The goal of this application may be to reduce deeper excavation requirements, improve construction efficiency, reduce the amount of aggregate subbase/base material required, provide a stiff working platform for pavement construction, or combination of these.
- 22.12.01.2 *Geogrid:*** A biaxial polymeric grid formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth to function primarily as reinforcement.
- 22.12.01.3 *Multi-Layer Geogrid:*** A geogrid product consisting of multiple layers of grid which are not integrally connected throughout.
- 22.12.01.4 *Extruded Geogrid:*** A geogrid product formed by extrusion of a polypropylene or polypropylene/polyethylene copolymer sheet followed by its perforation with a precise arrangement of holes and subsequent stretching, or drawing, into the finished product.
- 22.12.01.5 *Woven Geogrid:*** A geogrid product formed by weaving discrete strips of polymer into a network. These geogrids usually require a protective coating to protect the polymer from pre-mature degradation.
- 22.12.01.6 *Minimum Average Roll Value (MARV):*** Value based on testing and determined in accordance with ASTM D4759-92.

- 22.12.01.7 True Initial Modulus in Use:** The ratio of tensile strength to corresponding zero strain. The tensile strength is measured via ASTM D6637 at a strain rate of 10 percent per minute. Values shown are MARVs. For multi-layer geogrid products, rib tensile testing shall be performed on the multi-layer configurations, as prescribed by ASTM D6637.
- 22.12.01.8 Junction Strength:** Breaking tensile strength of junctions when tested in accordance with GRI-GG2 as modified by AASHTO Standard Specification for Highway Bridges, 1997 Interim, using a single rib having the greater of 3 junctions or a minimum 8 inch machine direction sample and tested at a strain rate of 10 percent per minute based on this gauge length. Values shown are MARVs. For multi-layer geogrid products, junction strength testing shall be performed across junctions from each layer of grid individually, and results shall not be assumed as additive from single layers to multiple layers.
- 22.12.01.9 Flexural Stiffness (also known as Flexural Rigidity):** Resistance to bending force measured via ASTM D1388-96, Option A, using specimen dimensions of 864 millimeters in length by 1 aperture in width. Values shown are MARVs. For multi-layer geogrid products, flexural stiffness testing shall be performed directly on the multi-layer configuration without using any connecting elements other than those used continuously throughout the actual product, and results shall not be assumed as additive from testing performed on a single layer of the multi-layer product.
- 22.12.01.10 Aperture Stability Modulus (also known as Torsional Rigidity or Torsional Stiffness):** Resistance to in-plane rotational movement measured by applying a 20 kg-cm (2.0 m-N) moment to the central junction of a 9-inch by 9-inch specimen restrained at its perimeter. Values shown are MARVs. For multi-layer geogrid products, torsional stiffness testing shall be performed on each layer of grid individually, and results shall not be assumed as additive from single layers to multiple layers.
- 22.12.01.11 Granular Fill Material:** The preferred gradation for base reinforcement application is well-graded crushed aggregate fill with a maximum particle size (100 percent passing) of 1 ½ inches, and less than 10% fines (passing the #200 sieve). Recycled concrete may be used only with polypropylene geogrids in accordance with FHWA 2001.

**22.12.02 Manufacturers** All manufacturers shall be considered provided they meet the submittal process and properties as per Section 22.12.08 and per Table 22.12.03.1.1, respectively.

**22.12.03 Geogrid Material Properties**

**22.12.03.1 Structural Soil Reinforcement Geogrid:** The geogrid shall be integrally formed and deployed as a single layer having the following characteristics according to Table 22.12.03.1.1. (ALL VALUES ARE MINIMUM AVERAGE ROLL VALUES, UNLESS A RANGE OR CHARACTERISTIC IS INDICATED):

**TABLE 22.12.03.1.1 – GEOGRID STRUCTURAL PROPERTIES**

Property	Test Method	Units	Type 1	Type 2
Aperture Stability Modulus at 20 cm-kg (2.0 m-N)	Kinney (2001)	m-N/deg	0.32	0.65
Rib Shape	Observation	N/A	Rectangular or Square	Rectangular or Square
Rib Thickness	Calipered	In	0.03	0.05
Nominal Aperture Size	I.D. Calipered	In	1.0 to 1.5	1.0 to 1.5
Junction Strength	GRI-GG2-2000 <sup>1</sup>	ratio	NOTE 1	NOTE 1
Flexural Rigidity	ASTM D1388-96 <sup>2</sup>	Mg-cm	250,000	750,000
Minimum Tensile Strength @ 2% Strain:	ASTM D6637-01 <sup>4</sup>			
- MD <sup>3</sup>		Lb/ft	280	410
- CMD <sup>3</sup>		Lb/ft	450	620
Minimum Tensile Strength @ 5% Strain:	ASTM D6637-01 <sup>4</sup>			
- MD <sup>3</sup>		Lb/ft	580	810
- CMD <sup>3</sup>		Lb/ft	920	1,340

NOTES:

1. The ratio of Junction Strength/Ultimate Tensile Strength must meet or exceed 75%.
2. Resistance to bending force measured via ASTM D-5732-95, using specimens of width two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs (as a “ladder”), and of length sufficiently long to enable measurement of the overhang dimension.
3. MD = machine direction (along roll length); CMD = cross-machine direction (across roll width).
4. True resistance to elongation when initially subjected to a load determined in accordance with ASTM D6637 without deforming test materials under load before measuring such resistance or employing “secant” or “offset” tangent methods of measurement so as to overstate tensile properties.

**22.12.03.2** Geotextile materials shall not be considered as an alternate to geogrid materials for subgrade improvement or base/sub-base reinforcement applications. A geotextile may be used in the cross-section to provide separation, filtration or

drainage; however, no structural contribution shall be attributed to the geotextile.

#### **22.12.04 Execution**

**22.12.04.1 Examination** The Contractor shall check the geogrid upon delivery to verify that the proper material has been received. The geogrid shall be inspected by the Contractor to be free of flaws or damage occurring during manufacturing, shipping, or handling.

#### **22.12.04.2 Delivery, Storage, and Handling**

**22.12.04.2.01 Storage and Protection** Prevent excessive mud, wet concrete, epoxy, or other deleterious materials from coming in contact with and affixing to the geogrid materials.

Store at temperatures above -20 degrees F (-29 degrees C).

Rolled materials may be laid flat or stood on end.

Geogrid materials shall not be left directly exposed to sunlight for a period longer than the period recommended by the manufacturer (as per ASTM D4355).

**22.12.04.2.02 Preparation** The subgrade soil elevation shall be prepared at the proper elevation and alignment as directed by the engineer or as indicated on the construction drawings.

**22.12.04.2.03 Installation** The geogrid shall be installed in accordance with the installation guidelines provided by the manufacturer or as directed by the Project Engineer.

The geogrid may be temporarily secured in place with ties, staples, pins, sand bags or backfill as required by fill properties, fill placement procedures or weather conditions or as directed by the Project Engineer.

#### **22.12.05 Granular Fill**

**22.12.05.1 Compaction** Standard compaction methods shall be used unless the soils are very soft. In these cases, static instead of vibratory compaction is prudent, particularly over silty subgrades. Compaction is achieved using a light roller.

Keeping fill moisture content near optimum will make compaction more efficient. Water spray is most effective with sand fill. Compact aggregate fill to project specifications, after it has been graded smooth and before it is subject to accumulated traffic.

**22.12.05.2 Vehicle Operation over Geogrids** A minimum loose fill thickness of six inches is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles shall be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid. When underlying substrate is trafficable with minimal rutting, rubber-tired equipment may pass over the geogrid reinforcement at slow speeds (less than 10 mph) when integrally-formed geogrids are used. This shall not be allowed with coated geogrids and sharp turning movements shall be avoided.

**22.12.06 Inspection** The owner or owner's representative may randomly inspect geogrid before, during and after (using test pits) installation.

Any damaged or defective geogrid (i.e. frayed coating, separated junctions, separated layers, tears, etc.) will be repaired/replaced in accordance with Manufactures recommendations.

**22.12.07 Repair** Any roll of geogrid damaged before, during and after installation shall be replaced by the contractor at no additional cost to the owner.

Proper replacement shall consist of replacing the affected area adding three feet of geogrid to either side of the affected area.

## **22.12.08 SUBMITTALS**

### **22.12.08.1 Submittal Procedure – 15 days prior to bid letting.**

**22.12.08.1.01** Submit geogrid product sample approximately 4 inches by 7 inches or larger three days prior to installation.

**22.12.08.1.02** Submit geogrid product data sheet, certification, and/or independent full scale laboratory testing from the manufacturer that the geogrid product supplied meets the requirements of Table 22.12.03.1.

**22.12.08.1.03** Submit manufacturer's installation instructions and general recommendations.

**22.12.08.1.04** A list of five comparable projects that are similar in terms of size and application, within the state of Colorado, and where the results of using

the specific geogrid material can be verified after a minimum of one year of service life.

**22.12.08.1.05** Additional information as requested by the engineer to fully evaluate the product.

**22.12.09 Quality Assurance** Prior to the installation of the geogrid, the contractor shall arrange a preconstruction meeting at the site with the geogrid material supplier and, where applicable, the geogrid installer. The Project Manager shall be notified at least three days in advance of the time of the meeting. A representative of the geogrid supplier shall be available on an “as needed” basis during construction.

**22.12.10 Construction Platform Design** Construction platform design shall be performed under supervision of and signed by a Professional Engineer licensed in the State of Colorado. The recommended procedure shall be derived by the Giroud-Han, Method (ASCE, August 2004).

Appropriate partial safety factors shall be applied to results obtained using geogrids having properties or characteristics outside the range of rigorous model validation (Giroud and Han, 2004). This method has been endorsed by numerous Department of Transportations and Government Agencies such as the Federal Highway Administration and Army Corps of Engineers.

For general guidance purposes only, Tables 22.12.10.1 and 22.12.10.2 present a guide for estimating subgrade soil strength and minimum construction platform recommendations based on a range of subgrade strengths, respectively. A piping ratio analysis (D15fill/D85subgrade) shall be performed to determine the need of a separation fabric. If the piping ratio is less than 5 then no separation fabric is required. If the piping ratio is greater than 5 then a separation fabric is required below the geogrid. The Project Engineer shall approve final determination of construction platform.

**TABLE 22.12.10.1**  
**GUIDE for Estimating Subgrade Strengths (Fine Grained Soils)**

Estimate Consistency by:		Tested By:				Correlates to:			
Feel	Equipment/Visual	Standard Penetration Test (blows/ft.)	Dynamic Penetrometer (mm/blows)			Shear $C_u$ (kPa)	Strength (tsf)	R-Value	CBR
			SC, SM, SP	CL	CH				
Very Soft	Man standing sinks >3"	<2	-	-	-	<12	<0.125	-	<0.4
Soft	Man walking sinks 2-3"	2-4	-	-	-	12-24	0.125-0.25	<0.36	0.4-0.8
Medium	Man Walking sinks 1"	4-8	-	>66	-	24-48	0.25-0.5	0.36-2.5	0.8-1.6
Stiff	Pickup Truck ruts 1/2-1"	8-15	>100	66-46	-	48-96	0.5-1.0	2.5-22.8	1.6-3.2
Very Stiff	Loaded Dump truck ruts 1-3"	15-30	100-56	46-33	>109	96-193	1.0-2.0	22.8-15.5	3.2-22.4
Hard	Insignificant rutting by loaded dump truck	>30	56-27	33-23	109-54	>193	>2.0	>15.5	>22.4

Reference: After Portland Cement Association, E.I Dupont Literature and McCarthy, David F. "Essentials of Soil Mechanics and Foundation, 1977, and Tensar 1998, Webster, Personal Communication 2001, "DCP vs. Correlations".

AASHTO. 1993 Guide for Design of Pavement Structures," Van Till et. Al. NCHRP 128

**TABLE 22.12.10.2**

Recommended Aggregate Fill Thickness Feel / CBR Value with Geogrid Mechanical Reinforcement				
Soil Strength <sup>1</sup>	CBR	Aggregate Fill Thickness (in.) <sup>2</sup>		
Feel	approx.	Type 1 Geogrid <sup>3</sup>	Type 2 Geogrid <sup>3</sup>	Unreinforced
Very Soft	< 0.4	37"	34"	52"
Soft	0.6	30"	26"	42"
Medium	1.2	20"	16"	29"
Stiff	2.5	14"	9"	22"
Very Stiff	4	12"	6"	20"

Notes:

1. Soil Strength is based in Table 22.12.10.1. The soil strength used is general for these purposes.
2. Results of aggregate fill thickness were derived using the published Giroud-Han (2004) Methodology. Average values for fill thickness are used. Aggregate fill was assumed to have a minimum R-value of 30.
3. Type 1 and Type 2 geogrid structural properties used were a minimum as derived from Table 22.12.03.1.



**SECTION 23.00 STREET CONSTRUCTION AGGREGATES.....1**

23.01 Scope .....1

23.02 Materials.....1

23.03 Construction Requirements for Base Course Material .....2



## SECTION 23.00 STREET CONSTRUCTION AGGREGATES

### 23.01 Scope

This specification specifies materials and methods to be used for the construction of aggregate bases and subbases for streets, parking lots, walks, drainage ways, and other work requiring the use of aggregates. The work covered shall include general requirements applicable to aggregate base course. All workmanship and materials shall be in accordance with the specifications, and in conformity with the lines, grades, depths, quantity requirements, and the typical cross section shown on the plans, or as directed by the Project Manager. See Section 20.06.10 Subgrade, Base Course, and Pavement Surface Grade Checks.

### 23.02 Materials

Aggregates shall be crushed stone, crushed slag, crushed gravel, or natural gravel which conforms to the requirements of AASHTO M 147 as herein supplemented. Aggregate shall meet the grading requirements specified below. The type used shall be specified on the plans or special provisions. The maximum liquid limit (LL) shall be as shown in Table 23.02.1.

**Table 23.02.1  
CLASSIFICATION TABLE FOR AGGREGATES**

	Type 1 (Course-Graded)	Type 2 (Normal)	Type 2A (Normal)	Type 3 (Non-Permeable)	Type 4 (Structural)	Type 5** (Permeable Base)***
Use	Subbase	Base	Base	As Specified	As Specified	Base
Sieve	Percentage by Weight Passing Square Mesh Sieve					
6"	100	--	--	--	--	--
2"	95-100	--	--	100	100	--
1 1/2"	--	--	100	--	--	--
1"	--	100	90-100	--	--	100
3/4"	--	--	60-90	--	--	90-100
1/2"	--	--	--	--	--	35-65
3/8"	40-85	50-85	45-75	--	--	20-45
No. 4	30-60	35-65	30-60	75-100	30-100	18-40
No. 8	--	--	--	--	--	5-25
No. 10	--	25-50	20-50	--	--	--
No. 50	--	--	--	--	--	0-7
No. 40	--	15-30	10-30	60 MAX.	60 MAX.	--
No. 200*	3-15	3-15	3-12	15-40	5-20	0-2
LL (max.)	35	25	25	35	35	--
* Percent passing No. 200 determined by Wash Test (ASTM C 117). Fraction passing No. 200 shall not be greater than 2/3 of the fraction passing No. 40. ** Must be used when edge drains are installed at the edge of streets, unless otherwise approved by the City Engineer. *** Use of a lean Asphalt or Cementitious application may be advisable for binding the aggregate together.						

For Type 2 and 2A aggregate base course, the plasticity index (PI) shall not exceed 15 when the aggregate is tested in accordance with AASHTO T 89 and T 90, respectively. The liquid limit of the Type 2 and 2A material shall not exceed 30. The R value, AASHTO T 96, is a minimum of 78 at 300 psi with less than 10 point difference between 100 psi and 300 psi exudation. Los Angeles abrasion shall not exceed 45%.

At least two weeks in advance of the beginning of placing any aggregates, the Contractor shall submit suitable samples of the proposed material to an approved Materials Testing Laboratory for tests to determine the compliance with the requirements of this specification. The results of all tests shall be submitted to the Project Manager for approval prior to the placement of any aggregate material. Tests shall be at the Contractor's expense.

Under certain conditions, the Project Manager may allow the substitution of Type 1 aggregate for Type 2 or Type 2A aggregate. The Project Manager will consider the substitution if the liquid limit of the Type 1 material does not exceed 30, the R Value, AASHTO T 96, is a minimum of 78, at least 300 psi with less than a 10 point difference between 100 psi and 300 psi exudation pressure. The depth is at least 2 times the maximum size of the coarse aggregate. If Type 1 material is used, it shall be overlaid with a minimum of 4" of Type 2 or Type 2A material.

### **23.03 Construction Requirements for Base Course Material**

**23.03.1 Placing** The base course material shall be placed on the previously prepared subgrade at the locations and in the proper quantities to conform to the typical cross sections as shown on the plans and as directed by the Project Manager. The material shall be placed without segregation. Any segregated areas shall be removed and replaced with uniformly graded material at the Contractor's expense. Blue tops shall be used on all new construction.

The base material may be placed in lifts of up to 6", providing that after compaction, uniform density is obtained throughout the entire depth of the lift. If the required depth exceeds 6", it shall be placed in two or more lifts of approximately equal thickness. If uniform density cannot be obtained by 6" lifts, the maximum lift shall not exceed 4" in final thickness.

**23.03.2 Compaction** Rolling will be continued until the base material has been compacted to not less than 95% of maximum density as determined by AASHTO T 180, Method D (Modified Proctor). Water shall be uniformly applied as necessary during compaction to obtain moisture content within 1% of optimum and to aid in

consolidation. The surface of each layer shall be maintained during the compaction operations in such a manner that a uniform texture is produced and the aggregates are firmly keyed.

The finished base course surface shall be smooth and free of ruts and irregularities and true to grade and crowned as shown on the plans or as directed by the Project Manager. The final surface shall be finished with a smoothness tolerance of 1/4" measured vertically from the surface to a ten-foot straightedge laid parallel to the survey line or 3/8" perpendicular to the survey line. The Project Manager shall make allowance for rounding at the crown line. The base course shall be maintained in this condition by watering, drying, rolling, or blading, as necessary or as the Project Manager may direct, until the surfacing is placed.

In-place field density determination shall be made in accordance with AASHTO T310. AASHTO T191 or T205 (AASHTO T224 may be required to correct for oversize particles) are allowed alternates and should be used to correlate the nuclear density gage at the request of the project manager or City Engineer.

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## SECTION 24.00 BITUMINOUS PAVEMENT MATERIALS

### 24.01 Overview

**24.01.1** This work shall consist of providing a bituminous mixture to be placed in one or more lifts over a prepared aggregate base or underlying subgrade as shown on the plans, or as directed by the Project Manager. See Section 20.06.10 Subgrade, Base Course, and Pavement Surface Grade Checks for additional subgrade requirements. The Contractor shall be responsible for Quality Control (QC) of the bituminous mixture; including the design, and control of the quality of the material incorporated into the project. The Project Manager will be responsible for Quality Assurance (QA); including testing, to assure the quality of the material incorporated into the project meet design parameters. For private projects the Contractor shall be responsible for QA as mentioned above and submit copies of the test reports to the Materials Lab for review and acceptance. The following specifications include general requirements applicable to all types of plant mixed asphaltic pavements. The work consists of one or more lifts of an asphalt mixture constructed on a prepared subgrade foundation. The work shall meet the requirements within the contract documents and in conformity with the lines, grades, thickness, and design cross sections as shown on the plans or established by the City Engineer’s representative.

**24.01.2** This specification will provide a pavement with adequate thickness and quality to provide a serviceable life of at least 20 years for Local Streets and 30 years for Collector/Arterial Streets and streets within TODs and Urban Centers.

### 24.02 Definition of Terms

Wherever the following abbreviations are used in the specifications or other Contract documents, the intent and meaning will be interpreted as shown below:

Definition of Abbreviations	
ASHTO	American Association of State Highway & Transportation Officials
ASTM	American Society for Testing & Materials
HMA	Hot Mixed Asphalt
LabCAT	Laboratory for the Certification of Asphalt Technicians
RAP	Reclaimed Asphalt Pavement
RAS	Reclaimed Asphalt Shingles
SMA	Stone Matrix Asphalt



## **24.03 Contractor Process Control**

**24.03.1** At least 30 days prior to placing any mixture on the project, the Contractor shall submit a mix design for acceptance.

**24.03.2** The Contractor shall assume full responsibility for controlling all operations and processes so the requirements of the Specifications are met at all times. The Contractor shall perform any tests necessary at the plant and on site for process control purposes and maintain a log of all process control testing. The Project Manager's representative will use both Quality Assurance (QA) and Quality Control (QC) test results in the decision to acceptance of payment requests.

**24.03.3** Prior to use on the project the Contractor shall submit a quality control plan addressing production, sampling, testing, qualifications of testing personnel, timing, and methods for making adjustments to assure compliance with the specifications. The Contractor shall provide a process or schedule for making corrections for material placed but does not meet specifications as well as obtain a follow up sample immediately after corrective actions are taken to assess the adequacy of the corrections. In the event the follow-up process control sample also fails to meet Specification requirements, the Contractor shall cease production of the asphalt mixture until the problem is adequately resolved to the satisfaction of the Project Manager.

## **24.04 Materials**

Asphalt mixtures will consist of various aggregates, filler, hydrated lime, and asphalt binder. If stated in the contract document, Asphalt mixtures may contain Reclaimed Asphalt Pavement (RAP), as well as a variety of binders and additives. Use of Recycled Asphalt Shingles (RAS) in asphalt mix designs is prohibited for all paving operations on City projects or within the City right-of-way.

### **24.04.1 Aggregate**

**24.04.1.01** Aggregate shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. The material shall not contain clay balls, vegetable matter, rounded aggregate, or other deleterious substances, and shall meet the following requirements:

**TABLE 24.04.1.1  
AGGREGATE PROPERTIES**

Aggregate Test Property	Coarse: Retained on #4	Fine: Passing the #4
Fine Aggregate Angularity, CP-L 5113 Method A or AASHTO T 304 (Does not apply to RAP or RAS aggregates)		45% Min
Two Fractured Faces, ASTM D 5821 Top and Middle Lifts Bottom Lifts SMA Mixtures	80% Min. 70% Min. 100% required	
LA Abrasion, AASHTO T 96	45% Max.	
Flat and Elongated (Ratio 5:1) %, AASHTO M 283	10% Max.	
Sand Equivalent. AASHTO-T 176		45% Min.
Micro Deval AASHTO T 327	18% Max for individual materials 20% Max. for combined sample	

**TABLE 24.04.1.2  
DENSE GRADED ASPHALT MATERIAL GRADATION RANGE  
(Percent by Weight Passing Square Mesh Sieves, AASHTO T 11 & T 27)**

Mixture Grading	SX (1/2" nominal)	S (3/4" nominal)	G (1" nominal)*
Traffic Loading,	Low to Medium 0 to 300,000 Top Lift only	Medium To High >300,000	All Loading Lower lifts
Sieve Size	Control Points	Control Points	Control Points
1 1/2"			100
1"		100	90-100
3/4"	100	90-100	@
1/2"	90-100	@	@
3/8"	@	@	@
#4	@	@	@
#8	28-58	23-49	19-45
#16	@	@	@
#30	@	@	@
#50	@	@	@
#200**	2.0-8.0	2.0-7.0	1.0-7.0

\* The G gradation shall be used in the lower lifts for all pavement sections.

\*\* These limits shall include the required 1% of lime by weight.

@ These sieve sizes used only to determine the final Job Mix Formula (JMF) in accordance with 24.15.

**24.04.1.02** Voids in Mineral Aggregate (VMA) shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (AASHTO T-166) and Aggregate (T 84 & T 85), and calculated according to AASHTO PP 19. All mixes shall meet the minimum VMA specified in Table 24.04.4.02.4:

**TABLE 24.04.1.3  
SMA AGGREGATE GRADATION RANGE PROPERTIES  
(Percent by Weight Passing Square Mesh Sieves, AASHTO T 11 & T 27)**

Sieve Size	Stone Mastic Grading Designation for Top Layer section for Traffic Loading in High Range greater than 3.0 Million ESALs (Percent by Weight Passing Square Mesh Sieves)	
	½" Nominal	¾" Nominal
25 mm (1")		100
19.0 mm (3/4")	100	90-100
12.5 mm (1/2")	90-100	50-88
9.5 mm (3/8")	50-80	25-60
4.75 mm (#4)	20-30	20-28
2.36mm (#8)	16-24	16-24
1.18mm (#16)	@	@
600 µm (#30)	@	@
300 µm (#50)	@	@
150 µm (#100)	@	@
75 µm (#200)	8-11	8-11

@ These sieve sizes used only to determine the final Job Mix Formula (JMF) in accordance with 24.15

**24.04.2 Reclaimed Asphalt Pavement (RAP)**

**24.04.2.01** RAP material may be used only where specifically allowed, but shall **not** be in the top lift. The material shall be of uniform quality and gradation with a maximum size no greater than the nominal aggregate size of the mix. Grading G shall not contain more than 35% RAP based on weight. All other gradations may contain up to 25% or as specified in the construction documents. The allowable percentage of RAP or recycled materials allowed will be listed in the construction documents and may vary by pavement layer. When RAP content is greater than 15%, the binder shall be 1 level softer than for virgin mixes. Alternatively, the binder can be shown to meet the required performance grade using AASHTO T 315.

**24.04.2.02** HMA mixtures containing RAP shall meet the same gradation requirements as a virgin HMA mix. The Project Manager may determine the allowable percentage of RAP to be utilized in the top lift of any asphalt pavement. A maximum of 25% RAP in mixture grading S may be allowed in layers below the top lift or a maximum of 35% RAP in mixture grading G. RAP or RAS are not allowed in Stone Mastic Asphalt Mixtures.

**24.04.2.03** The reclaimed asphalt pavement shall meet all the requirements for Asphalt Pavements, as contained herein. The Contractor shall have an approved mix design for HMA with RAP prior to placement and shall include the asphaltic binder and virgin aggregate to be used to meet the requirements contained herein.

**24.04.2.04** The Contractor shall maintain separate stockpiles for each type of RAP material. All processed material shall be free of foreign materials and segregation shall be minimized. Any RAP material that cannot be readily broken down in the mixing process, and/or affects the paving operation, shall be processed prior to mixing with the virgin material.

**24.04.2.05** Fine Aggregate Angularity requirements shall not apply to RAP aggregate. RAP shall not contain clay balls, vegetable matter, or other deleterious substances.

**24.04.2.06** Verification testing for asphalt content and gradation will be performed on RAP at the frequencies listed in Section 24.04.2.08. The Project Manager may request the asphalt supplier to provide testing results on RAP mixtures daily. The asphalt supplier shall provide results of tests for properties listed in this specification.

**24.04.2.07** When the use of RAP is allowed, the following additional conditions shall apply:

The aggregate obtained from the processed RAP shall be 100% passing the 1 inch sieve. The aggregate and binder obtained from the processed RAP shall be uniform in all the measured parameters to the mix design submitted in accordance with the following:

**Table 24.04.2.1  
RAP AGGREGATE UNIFORMITY TOLERANCES**

Element	Uniformity*
Binder Content	0.5
% Passing ¾"	4.0
% Passing ½"	4.0
% Passing 3/8"	4.0
% Passing #4	4.0
% Passing #8	4.0
% Passing #30	3.0
% Passing #200	1.5

\* Uniformity is the Maximum allowable Standard Deviation of test results of processed RAP.

**24.04.2.08** Quality Control (QC) Plan for RAP details how the RAP will be processed and controlled shall be developed and followed by the asphalt producer/Contractor and shall address the following:

**24.04.2.08.1** A schematic diagram and narrative that explains their RAP processing techniques required for crushing, screening, rejecting, and stockpile operation for normal plant operation,

**24.04.2.08.2** The control of RAP Asphalt Binder Content with a minimum testing frequency of 1/1,000 tons of processed RAP material (minimum 3 tests) for most recent production of the mix,

**24.04.2.08.3** The control of RAP Gradation (AASHTO T-30) with a minimum testing frequency of 1/1,000 tons of processed RAP material (minimum 3 tests) for most recent production of the mix,

**24.04.2.08.4** Process control charts shall be maintained for binder content and each screen when RAP material is added to the stockpile. Separate control charts for each RAP stockpile shall be maintained. These charts shall be displayed and shall be provided upon request.

**24.04.2.09** The Contractor shall determine the total binder replacement by the binder in the RAP and the percentage of virgin binder in the HMA pursuant to AASHTO PP 53 methods and the following equation: **Eq. 24.04.3.1**

$$\text{Total Binder Replacement} = ((A \times B) \times 100/E)$$

Where: A = RAP% binder Content\*

B = RAP% in Mix\*

E = Total Effective Binder Content\*

\* In decimal format

**24.04.2.10** The Total Binder Replacement by the binder in the RAP shall not exceed 30% of the effective binder content of either the mix design or the production mix.

**24.04.2.11** HMA with RAP shall be tested in accordance with the above section. Project verification testing for asphalt content and gradation will be performed at the frequency noted in the above section.

**24.04.2.12** The Contractor shall supply a Performance Graded Binder which meets the AASHTO specifications for one temperature grade lower for both the high and low end than that specified in the contract when RAS is included in the mix. For example, if the Contract originally specified a PG 64-22, the Contractor shall supply a binder meeting the AASHTO specifications for a PG 58-28, subject to the Project Manager's approval. The Contractor shall provide a field verification test of the binder after production per mix design each production season.

### **24.04.3 Mineral Filler**

**24.04.3.01** Mineral filler for use with Stone Matrix Asphalt (SMA) pavement may consist of limestone dust or any other material filler that will meet the requirements of this subsection and have a maximum Plasticity Index (AASHTO T 90) of less than or equal to 4.0 %.

**24.04.3.02** The mineral filler for SMA shall be stored in a separate silo and added automatically in the correct proportion. The mineral filler addition equipment shall be electronically or mechanically interlocked to the aggregate feed sensors so the proper amount of mineral filler is added whenever SMA is produced.

**24.04.3.03** The SMA mineral filler shall be added at the same time the asphalt cement is added to the aggregate.

**24.04.3.04** The Contractor shall submit hydrometer analysis (AASHTO T 88) for the gradation of mineral filler used in the SMA mixture.

#### **24.04.4 Performance Graded Asphalt Binders**

**24.04.4.01** The Contractor shall provide to the Project Manager acceptable 'Certifications of Compliance' of each applicable asphalt binder grade from the supplier. Should testing or certificate show nonconformance with the specifications, the asphalt binder may be rejected. When production begins, the Contractor shall, upon request, provide a one quart can of each specified asphalt binder for analysis. Additionally, the Contractor shall provide the refinery test results that pertain to the asphalt binders used during production.

**24.04.4.02** Asphalt binder shall meet the requirements of the Superpave Performance-Graded Binders (PG) as presented in Table 24.04.4.02.1.

**TABLE 24.04.4.02.1  
PROPERTIES OF PERFORMANCE GRADED BINDERS**

<b>Usage for each Binder Grade</b>	<b>PG 58-28***</b>	<b>PG 64-22</b>	<b>PG 76-28</b>
Traffic Loading, Total 18 kip ESALs Over Design Life****	Low Volume (0-300,000)	>300,000 to <3.0 Million	>3.0 Million
Superpave Compactor Design Gyration Recommended Usage	N <sub>design</sub> = 50	N <sub>design</sub> = 75	N <sub>design</sub> = 100
<b>Property of Binder Grade</b>	<b>PG 58-28</b>	<b>PG 64-22</b>	<b>PG 76-28</b>
Flash Point Temperature, °C, AASHTO T 48	230 Min.	230 Min.	230 Min.
Viscosity at 135 °C, Pas, ASTM D 4402	3 Max.	3 Max.	3 Max.
Dynamic Shear, Temperature °C, where C'/Sin δ @ 10 rad/sec. ≥ 1.00 Kpa, AASHTO TP 5	58 ° C	64 ° C	76 ° C
<b><i>Rolling Thin Film Oven Residue Properties, AASHTO T 240</i></b>			
Mass Loss, %, AASHTO T 240	1.00 Max.	1.00 Max.	1.00 Max.
Dynamic Shear, Temperature °C, where G'/Sin δ @ 10 rad/sec. ≥ 2.20 Kpa, AASHTO TP 5	58 ° C	64 ° C	76 ° C
Elastic Recovery <sup>1</sup> , 25°C, % Min.*	N/A	N/A	50 Min.
<b><i>Pressure Aging Vessel Residue Properties, Aging Temperature 100 °C AASHTO PP1</i></b>			
Dynamic Shear, Temperature °C, where G'/Sin δ @ 10 rad/sec. ≤ 5,000 Kpa, AASHTO TP 5	19 ° C	25 ° C	28 ° C
Creep Stiffness, @ 60 sec. Test Temperature in °C, AASHTO TP 1	-18 ° C	-12 ° C	-18 ° C
S, Mpa, AASHTO TP 1	300 Max.	300 Max.	300 Max.
m-value, AASHTO TP 1	0.300 Min.	0.300 Min.	0.300 Min.
**Direct Tension Temperature in °C, @ 1.0 mm/min., Where Failure Strain >1.0%, AASHTO TP 3	-18 ° C	-12 ° C	-18 ° C

\* Elastic Recovery by Task Force 31, Appendix B Method

\*\* Direct tension measurements are required when needed to show conformance to AASHTO MP.1

\*\*\* This binder shall only be used in private streets or private parking lots.

\*\*\*\* See Section 24.01.2 for design life parameters.

### 24.04.5 Additives

**24.04.5.01** Hydrated Lime shall be added at the rate of 1% by dry weight of the aggregate and shall be included in the amount of material passing the No. 200 sieve.



Hydrated lime for aggregate pretreatment shall conform to the requirements of ASTM C 207, Type N. In addition, the residue retained on a No. 200 sieve shall not exceed 10% when determined in accordance with ASTM C 110. Drying of the test residue in an atmosphere free from carbon dioxide will not be required.

**24.04.5.02** The Project Manager shall approve use of any other additives used in the production of asphalt mixtures.

**24.04.6 Tack Coat** The emulsified asphalt for Tack Coat shall meet the specification for emulsified asphalt, consisting of CSS-1h or SS-1h and conform to AASHTO M208 or M140, respectively.

## **24.05 Design and Production Requirements**

**24.05.1** There shall be no substitutions of materials allowed during production. All substitutions will require checkpoint verification and if the checkpoint differs from the Job Mix Formula (JMF) a new mix design will be required. Upon request of the Project Manager, the binder grade may be changed by one available binder grade level down without requiring a new mix design.

**24.05.2** The Project Manager shall indicate on “**Mixture Design Requirements for Hot Mix Asphalt Pavements**” form provided in the project specification documents the criteria concerning mix design method, traffic level, binder type, mixture grading, and maximum amount of RAP allowed. This information form is provided on [MGPEC Form](#) “**Mixture Design Requirements for Hot Mix Asphalt Pavements**”, or other Contract bidding documents.

**24.05.3** Grading G (1-inch nominal aggregate) shall only be designed using the 150 mm Superpave molds. Hveem Stability and Lottman test are not required for Grading G mixtures. Grading ST, SX, and S shall be designed using 100 mm Superpave molds.

### **24.05.4 Design Method for Superpave Mixture**

**24.05.4.01** A JMF design shall be submitted for each mixture required, at least seven (7) days prior to construction. The JMF design shall be determined using AASHTO T-312 for the Superpave Method of Mixture Design.

**24.05.4.02** Mixture design and field control testing shall meet the criteria in Table 24.05.4.02.1, Superpave Mixture Properties for Dense Graded Asphalt

Mixtures. Mixture design and field control testing of SMA shall meet the following requirements of Table 24.05.4.02.2, Superpave Mixture Properties for Open Graded SMA.

**TABLE 24.05.4.02.1  
SUPERPAVE MIXTURE PROPERTIES FOR DENSE GRADED ASPHALT MIXTURES**

Property or Test	Traffic Levels		
Traffic Loading, Total 18 kip ESALs Over Design Life (20 to 30 Years)	Low (0-300,000)	Medium >300,000 to ≤3.0 Million	High >3.0 Million
Design Gyration, N <sup>design</sup> (Air Void: 3.5% to 4.5%) (See Note 1,2)	50	75	100
Air Voids in Total Mix (VTM) AASHTO T-312 (See Note 1)	3.5-4.5	3.5-4.5	3.5-4.5
Hveem Stability AASHTO T-246 (Grading S & SX only) (See Note 3)	N/A	28 Min.	30 Min.
Voids Filled with Asphalt, MS-2	70-80	65-78	65-75
Lottman, Tensile Strength Ratio, % Retained, AASHTO T-283, Method B	80 Min.	80 Min.	80 Min.
AASHTO T-283 Dry Tensile Strength, psi	30 Min.	30 Min.	30 Min.
Voids in Mineral Aggregates (VMA) %. AASHTO PP 19 (See notes 2,3,4)	A minimum VMA criterion applies to the mix design only (Table 24.05.4.02.4). The minimum VMA criteria shall be linearly interpolated based on actual air voids. See 24.15 for production tolerances		

Note 1: Target Optimum asphalt binder content of mix: Choose target % as close to 4.0 air voids as possible. VTM is also referred to as Pax in CPL 5115, and % Gmmx in AASHTO T 312

Note2: Maximum Theoretical Specific Gravity of mix is to be determined by AASHTO T 209.

Note 3: Refer to Section 24.15 for production tolerances.

Note 4: VMA shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (AASHTO T 166) and Aggregate (AASHTO T 84 & T 85), and calculated according to AASHTO PP 19. All mixes shall meet the minimum VMA specified in Table 24.03.1.3.

**Table 24.05.4.02.2  
Superpave Mixture Properties for Open Graded SMA**

Property	Test Method	Value for SMA
Lab compaction (Gyrations) N <sub>Design</sub>	AASHTO T-312	100
Air Voids, percent at: N <sub>Design</sub> (See Note 1)	AASHTO T-312	3.0 – 4.0
Hveem Stability	AASHTO T-312 100 Gyrations	30 Min.
Accelerated Moisture Susceptibility, tensile strength Ratio, (Lottman)	AASHTO T 283, Method B	80 Min.
Dry Split Tensile Strength, psi	AASHTO T 283, Method B	30 Min.
Grade of Asphalt Binder	n/a	PG 76-28
Voids in the Mineral Aggregate (VMA) %, minimum	AASHTO R 46	17 (3/4" SMA) 17.5 (1/2" SMA) (See Note 2)
Drain down at Production Temperature	AASHTO T305	0.3 maximum
% VCA <sub>MIX</sub> (Voids in the Coarse Aggregate)	AASHTO R 46	Less than VCA <sub>DRC</sub> (Dry-Rodded condition)

Note 1: Select target Job Mix Optimum Binder Content for SMA grading at 3.0% to 4.0% air voids

Note 2: The formula for VMA can be developed as follows based on the weight volume relationship. Bulk specific gravity from aggregate being used for calculating VMA.

$$VMA = 100 - \{(G_{mb} \times P_s) / G_{sb}\}$$

Equation 24.05.4.1

Where:

G<sub>mb</sub> = Bulk specific gravity of compacted mix,

G<sub>sb</sub> = Most recent bulk specific gravity of aggregate,

P<sub>s</sub> = Aggregate, percent by total weight of mix.

**TABLE 24.05.4.02.3  
SUPERPAVE SMA LABORATORY  
MIXING AND COMPACTION TEMPERATURES**

Superpave Binder Grade	Laboratory Mixing Temperature, °C (°F)	Laboratory Compaction Temperature, °C (°F)
PG 76-28	163 (325)	149 (300)

**TABLE 24.05.4.02.4  
MINIMUM VOIDS IN MINERAL AGGREGATE (VMA) for  
Dense Graded & Open Graded (SMA), %**

Nominal Maximum* Particle Size	Air Voids ++		
	3.5%	4.0%	4.5%
1"	12.2	12.7	13.2
¾"	13.2	13.7	14.2
½"	14.2	14.7	15.2
¾" SMA	17.0	17.0	17.0
½" SMA	17.5	17.5	17.5

\* Nominal Maximum Particle Size is defined as one sieve size larger than the first sieve to retain more than 10%, but shall not exceed the 100% passing size. The Nominal Maximum Particle Size can vary during mix production even when the 100% passing size is constant.

++ Minimum VMA criteria apply to the mix design only. The minimum VMA criteria shall be linearly interpolated based on actual air voids. See Section 24.15 for tolerances.

## 24.06 Mixture Design Submittals

The Contractor shall submit all mix designs, Certificates of Compliance, and laboratory data to the Project Manager for approval at least 7 calendar days before the scheduled start of construction. The mix design (Proposed Design Job Mix) must be approved by the Project Manager prior to the start of construction.

### 24.06.1 General Requirements

**24.06.1.01** Designs shall be developed and performed in a materials laboratory that meets the requirements set forth by AASHTO AASHTO Re:Source or satisfies the annual CDOT Round Robin verification for all required testing procedures and be under the direct supervision of and be stamped and signed by a Professional Engineer licensed in the State of Colorado and practicing in this field. In addition, the Contractor shall submit, as part of the mixture design, laboratory data documents to verify the following:

**24.06.1.01.1** Gradation, specific gravity, source and description of individual aggregates and the final blend.

**24.06.1.01.2** Aggregate physical properties.

**24.06.1.01.3** Source and Grade of the Performance Graded Binder.

**24.06.1.01.4** Proposed Design Job Mix: aggregate and additive blending, final gradation shown on 0.45 power graph, optimum asphalt content.

**24.06.1.01.5** Mixing and compaction temperatures used.

**24.06.1.01.6** Mixture properties shall be determined with a minimum of four asphalt contents and interpolated at optimum and graphs showing mixture properties versus asphalt content.

**24.06.1.02** Contractor shall obtain approval of all mix designs for any Asphaltic Pavement Material (HMA or SMA) by the Project Manager prior to start of construction. The Project Manager reserves the right to verify the asphalt supplier's mix design for each Asphaltic Material grading utilizing materials actually produced and stockpiled. The asphalt supplier shall provide, at no cost, a sufficient quantity of each aggregate, mineral filler, RAP, and additive for the required laboratory tests, as well as all Certificates of Conformance/Compliance at any time on any material used. The asphalt supplier shall provide copies of quality control testing results during the production of asphaltic mixtures used within one (1)-business day from the sampling date.

**24.06.2 Change in Source or Grade:** Should a change in the source of any material used in the production of asphaltic pavement material (Aggregate, Mineral filler, Lime, or Performance Graded Asphalt Binder) occur, a one point verification test (at optimum asphalt content) of the mix must be performed to verify the applicable criteria in Section 24.05.4.02 (Dense Graded Asphalt Mix), Table 24.05.4.02.2, (SMA), and Table 24.05.4.02.4 (VMA) is still met. If this testing shows noncompliance, the Contractor shall establish a new Job Mix Design and obtain approval by the Project Manager before the new Asphaltic Material is used.

**24.06.3 Mix Production Verification** Production verification shall occur prior to the start of the project. Technicians with current LabCAT Level C certification shall verify the volumetric properties of the mix. Certified technicians shall maintain current Certification to verify the volumetric properties of the mix. Volumetric properties for mix verification testing shall be within the following tolerances compared to the Proposed Design Job Mix. The mix verification test reports shall be submitted to the Project Manager prior to start of paving operations.

**TABLE 24.06.3.1  
MIX DESIGN VERIFICATION TOLERANCES**

Air Voids	+/- 1.2%
VMA	+/- 1.2%
Asphalt Binder Content	+/-0.3%
Stability	Applicable minimum

The tolerances in this table are for mix design verification only. See section 24.15 for production tolerances.

Project Verification Testing for asphalt content and gradation shall be performed at the frequencies listed in TABLE 24.15.1.

**24.06.4 Job Mix Formula Tolerances**

**24.06.4.01** Job Mix Formula Tolerances for production test results that deviate from the design job mix by more than shown in the following table are subject to this section:

**TABLE 24.06.4.1  
JOB MIX FORMULA TOLERANCES**

Mixture Grading	ST (3/8" Nominal)		SX (1/2" nominal)		S (3/4" nominal)		G (1" nominal)	
Traffic Loading,	Repair Segregation Bike path Sidewalk		Low To Medium 0 to 300,000		Medium To High >300,000		Lower lifts	
Sieve Size	Control Points	Tolerance	Control Points	Tolerance	Control Points	Tolerance	Control Points	Tolerance
1 1/2"							100	+ 1%
1"					100	+ 1%	Design	± 6%
3/4"			100	+ 1%	Design	± 6%	Design	± 6%
1/2"	100	+ 1%	Design	± 6%	Design	± 6%	Design	± 6%
3/8"	Design	± 6%	Design	± 6%	Design	± 6%	Design	± 6%
#4	Design	± 5%	Design	± 5%	Design	± 5%	Design	± 5%
#8	Design	± 5%	Design	± 5%	Design	± 5%	Design	± 5%
#16	Design	± 4%	Design	± 4%	Design	± 4%	Design	± 4%
#30	Design	± 4%	Design	± 4%	Design	± 4%	Design	± 4%
#50	Design	± 4%	Design	± 4%	Design	± 4%	Design	± 4%
#200	Design	± 2%	Design	± 2%	Design	± 2%	Design	± 2%
Air Voids	Design	3.0-5.0%	Design	3.0-5.0%	Design	3.0-5.0%	Design	3.0-5.0%
VMA	Design	± 1.2%	Design	± 1.2%	Design	± 1.2%	Design	± 1.2%
Hveem Stability	See Table 24.05.4.02.1		See Table 24.05.4.02.1		See Table 24.05.4.02.1		See Table 24.05.4.02.1	
Asphalt Content	Design	± 0.3%	Design	± 0.3%	Design	± 0.3%	Design	± 0.3%

There is 1.0 percent tolerance for the maximum sieve size.

Mixes with passing No. 200 sieve material produced over 7.0 percent are allowed only when the above Air Voids and VMA tolerances are still met.

Hveem Stability must meet the minimum value specified in table

When calculating VMA, use the most current aggregate specific gravity  $G_{sb}$ .

**24.06.4.02** When disagreements concerning determination of specification compliance occur, only valid tests from both the Project Manager and Contractor will be considered. The Project Manager shall determine validity. Generally, valid tests are those in which sampling and testing have been performed according to referenced procedures and the results are within stated precision statements. When disagreements occur with asphalt content and gradation tests results, solvent extracted aggregate testing shall take precedence over burn off oven

extracted aggregate, which shall take precedence over cold feed belt testing.

#### **24.06.4 Pre-paving Meeting**

**24.06.4.01** Project Manager may require a pre-paving meeting of all parties directly involved in supply, haul, lay down, inspection, quality control, and quality assurance of asphalt pavement. Traffic control, haul direction, sequence of paving and construction (joint) plan will be reviewed and discussed at the pre-paving meeting, see Sections 24.11 and 24.12 for joint requirements. Form #24.1 provided at the end of this section is an example of a pre-paving meeting agenda. Areas of responsibility and contact names and numbers **shall** be shared.

**24.06.4.02** The pre-paving meeting shall be scheduled a minimum of seven (7) days prior to the start of paving operations. Two (2) weeks prior to the pre-paving meeting, the Contractor shall submit a mix design for all proposed asphaltic materials specified in the project specifications. The mix design shall meet the appropriate materials specification requirements.

### **24.07 Manufacture**

#### **24.07.1 Preparation of Aggregates**

**24.07.1.01** Heating and drying of the aggregates shall be accomplished without damaging the aggregate. Hydrated lime shall be added to achieve complete and uniform coating of the aggregate in accordance with one of the following methods:

**24.07.1.01.1** Lime Slurry Added to Surface Saturated Dry Aggregate: The hydrated lime shall be added to the aggregate in the form of slurry and, then, thoroughly mixed in an approved pugmill. The slurry shall contain a minimum of 70 percent water by weight.

**24.07.1.01.2** Hydrated Lime Added to Wet Aggregate: The hydrated lime shall be added to wet aggregate (a minimum of three percent above saturated surface dry) and, then, thoroughly mixed in an approved pugmill. The lime-aggregate mixture may be fed directly into the hot plant after mixing, or, it may be stockpiled for not more than 90 days before introduction into the plant for mixing with the asphalt binder. The hydrated lime may be added to different sized aggregates and stockpiled by adding 75 percent of the lime to the aggregate passing the No. 4 sieve and 25 percent to the aggregate



retained on the No. 4 sieve.

**24.07.1.02** A minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all Dense Graded and Open Graded Asphalt mixtures.

## 24.07.2 Mixing

**24.07.2.01** The dried aggregates and asphalt binder shall be combined in the mixer in the quantities required to meet the design job mix. The materials shall be mixed until the aggregate is completely and uniformly coated, and the asphalt binder is uniformly distributed throughout the aggregate. Baghouse fines may be fed back to the mixing plant in a uniform and continuous manner to maintain uniformity in the mixture.

**24.07.2.02** The minimum temperature of HMA or SMA mixtures when discharged from the mixer shall be according to refinery recommendations or as shown in the following table:

**TABLE 24.07.2.1  
MIXTURE DISCHARGE TEMPERATURES**

HMA and SMA Asphalt Grade	Minimum Discharge Temperature	Maximum Discharge Temperature
PG 58-28	275° F	310° F
PG 64-22	290° F	325° F
PG 76-28*	318° F	326° F

\* Contractor or Binder supplier must supply production temperature as required by their product

**24.07.2.03** HMA mix shall be produced at the lowest temperature within the specified temperature range that produces a workable mix and provides for uniform coating of aggregates (95 percent minimum in accordance with AASHTO T 195), and that allows the required compaction to be achieved.

**24.07.2.04** Asphaltic mixtures may be stored provided any and all characteristics of the mixture are not altered by storage. Unsuitable mixture shall be removed and disposed of at the Contractor's expense.

**24.07.2.05** When placing hot mix asphalt over bridge decks covered by waterproofing membrane, the minimum temperature of the mixture, when rolling operations begin, shall be 250 ° F. The job mix temperature may be increased up to an additional 30 ° F to obtain this temperature.

**24.07.2.06** Mineral filler for SMA shall be stored in a separate silo and added automatically in the correct proportion.

**24.07.2.07** The SMA mineral filler shall be added at the same point and time the asphalt binder is added.

## 24.08 Tack Coat

The emulsified asphalt, for Tack Coat emulsion, shall meet the specification for emulsified asphalt, consisting of CSS-1h or SS-1h and conform to AASHTO M208 or M140, respectively.

Prior to placement of HMA and SMA, a tack coat shall be applied to all existing concrete and asphalt surfaces. The material shall be in accordance with Section 24.08. The emulsified asphalt shall be applied per Table 24.08.1. The surface prior to receiving the tack coat shall be dry and clean. All dust, debris, and foreign matter shall be removed. Tack coat shall be applied uniformly by distributor. Prior to paving all water shall have evaporated from the tack coat. The time required between the application of the tack coat and the application of the asphalt may require 20 minutes or greater to achieve a set. Areas where the tack becomes contaminated during construction shall be cleaned and tack coat shall be reapplied and allowed to cure before paving resumes.

**TABLE 24.08.1  
Tack Coat Application Rates**

Pavement Condition	Application Rate (gal/yd <sup>2</sup> )		
	Residual	Undiluted	Diluted (1:1)
New HMA	0.03 - 0.04	0.05 - 0.07	0.10 - 0.13
Oxidized HMA	0.04 - 0.06	0.07 - 0.10	0.13 - 0.20
Milled Surface (HMA)	0.06 - 0.08	0.10 - 0.13	0.20 - 0.27
Milled Surface (PCC)	0.06 - 0.08	0.10 - 0.13	0.20 - 0.27
Portland Cement Concrete (PCCP)	0.04 - 0.06	0.07 - 0.10	0.13 - 0.20

Per NCHRP Report 712

## 24.09 Equipment

### 24.09.1 Mixing Plant

**24.09.1.01** The mixing plant shall be capable of producing a uniform material, have adequate capacity, and be maintained in good mechanical condition. Defective parts shall be replaced or repaired immediately if they adversely affect the proper functioning of the plant or plant units, or adversely affect the quality of the HMA or SMA.

**24.09.1.02** The mixing plant shall meet all air quality requirements in the "Colorado Air Quality Control Act," Title 25, Article 7, CRS, and regulations promulgated there under for dust, smoke, or other contaminants and shall be controlled at the plant and project site. All acceptable safety equipment required by OSHA to accommodate sampling and testing shall be available.

### 24.09.2 Hauling Equipment

**24.09.2.01** Trucks used for hauling HMA or SMA material shall have tight, clean, smooth beds or functional and maintained conveyor belt bottom that is thinly coated with a minimum amount of paraffin oil, lime solution, or other approved release agent. **Petroleum distillates such as kerosene or fuel oil shall not be permitted.** Each truck shall have a cover of canvas or other suitable material to protect the mixture from the weather and excessive temperature loss or cooled layers of mix in the truck.

**24.09.2.02** Each truck shall be completely covered (non-porous tarps preferred) to completely protect the mix during transport at all times. The Project Manager can reject any mix transported through adverse weather, shows an excess or deficiency of asphalt cement, damage due to burning or overheating when it arrives on the jobsite uncovered

**24.09.3 Material Transfer Vehicle (MTV)** shall be required for placement of SMA. A MTV shall be a self-propelled storage unit capable of receiving material from trucks, storing the material and transferring the material from the unit to a paver hopper insert via a conveyor system. The required paver hopper insert and unit shall have a combined minimum storage capacity of 15 tons. Prior to placing the asphalt material on the roadway surface, the storage unit or paver hopper insert must be able to remix the material in order to produce a uniform, non-segregated mix, having a uniform temperature.

#### **24.09.4 Bituminous Pavers**

**24.09.4.01** Self-propelled pavers shall be provided for full lane width paving capable of spreading and finishing the HMA or SMA material in full lane widths applicable to the typical section and thicknesses shown in the Contract documents and shall be equipped with:

**24.09.4.01.1** Anti-segregation devices.

**24.09.4.01.2** A vibratory screed assembly capable of being heated.

**24.09.4.02** Pavers used for shoulders, patching and similar construction, not requiring fine grade control, shall be capable of spreading and finishing courses of Asphalt material in the required widths and depths as shown in the Contract without segregation.

**24.09.4.03** The paver's receiving hopper shall have sufficient capacity for a uniform spreading operation and shall have an automatic distribution system that will place and spread the mixture uniformly in front of the screed.

**24.09.4.04** The paver shall be capable of operating at forward speeds consistent with uniform and continuous laying of the mixture. Stop and go operations of the paver shall be avoided. The screed or strike-off assembly shall produce the specified finished surface without tearing, shoving, or gouging the mixture. Self-propelled pavers shall be equipped with automatic screed controls with sensors capable of detecting grade from an outside reference line, and maintaining the screed at the specified longitudinal grade and transverse slope. The sensors may be contact or non-contact type devices. The sensor shall be constructed to operate from either or both sides of the paver and shall be capable of working with the following devices when they are required for the situation:

**24.09.4.04.1** Grade control device at least 30 feet in length.

**24.09.4.04.2** Joint matching device.

**24.09.4.04.3** Adequate length of control line and stakes, if no other type of geometric control is present.

**24.09.4.04.4** A straight edge at least 10 feet in length shall be available to verify the crown on the screed, at the request of the Project Manager.

**24.09.4.05** The controls shall be capable of maintaining the screed at the specified transverse slope within plus or minus 0.1 percent. Automatic mode should be used where possible. If the automatic controls fail or malfunction, the equipment may be operated manually for the remainder of the normal working day, provided specified results are obtained.

**24.09.4.06** If the Contractor fails to obtain and maintain the specified surface tolerances, the paving operations shall be suspended until satisfactory corrections, repairs, or equipment replacements are made. Placement of HMA or SMA on a waterproofed bridge deck shall be accomplished with equipment that will not damage the membrane or protective covering.

## 24.10 Placement

**24.10.1** Bituminous pavement shall be placed on approved, properly constructed surfaces that are free from loose material, water, frost, snow, or ice. SMA or HMA and tack coat shall be placed in accordance with the temperature limitations of Table 24.10.1.1 and only when weather conditions permit the pavement to be properly placed, finished, and compacted in accordance with the project specifications. Placement temperature shall be increased by 5 °F for each 10 miles per hour wind velocity to a maximum increased placement temperature of 70 °F as measured at the laydown location. In-place density for Asphaltic Pavement Material shall be  $94 \pm 2$  percent of the Asphalt Mix maximum specific gravity as measured according to Maximum Theoretical Value (Rice) (AASHTO T 209). Compaction test results shall be reported to the nearest tenth of a percent and under no circumstance shall results for in-place density or percent compaction be rounded to the nearest whole number.

**TABLE 24.10.1.1  
MINIMUM AIR and SURFACE TEMPERATURES  
LIMITATIONS for MIX PLACEMENT (HMA and SMA)**

Compaction Layer Thickness	Top Layer of Pavement*		Lower Layers *	
	PG 58-28 PG 64-22	PG 76-28	PG 58-28 PG 64-22	PG 76-28
<2 inches (not recommended)**	60 °F	75 °F	N/A	N/A
2 inches to <3 inches	50 °F	65 °F	40 °F	50 °F
≥ 3 inches	50 °F	50 °F	40 °F	40 °F

G mix only	N/A	N/A	38 °F	38 °F
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\* Air and surface (subgrade, base, or previously placed AC lift) temperatures are to be taken in the shade where applicable.

\*\* Less than a two-inch layer shall not be allowed in public right-of-way, unless authorized by the City Engineer.

**24.10.2** The temperature limitations for PG 76-28 in Table 24.10.1.1 shall **not** be waived. Air and surface temperatures are important and become more critical when modified binders are used.

**24.10.3** The temperature of the HMA or SMA mixture immediately behind the screed shall be sufficient to allow for proper compaction of the layer and at least 245° F for PG 58-28 or PG 64-22 binder and between 297° F and 305° F for SMA using PG 76-28 binder. The breakdown compaction should be completed as quickly as possible after placement occurs and before the mixture temperature drops 20°F from placement temperature. Mix that is too cold or damaged by weather will be rejected.

**24.10.4** The mixture shall be placed on an approved surface, spread and struck off to obtain the required grade and elevation after compaction. The minimum lift thickness shall be **at least three times (preferably four times) the nominal particle size**. The uncompacted mixture should be placed approximately 10-25 percent thicker than the existing surrounding mat to account for compaction based on the materials being placed.

**24.10.5** Redistribution of the mixture using hand tools is only permitted when necessary around utilities and in areas inaccessible to equipment. Casting or raking that causes any segregation will not be permitted.

**24.10.6** In areas where the use of mechanical spreading and finishing equipment is impractical; the mixture shall be carefully dumped, uniformly spread, raked, screeded, and luted by using hand tools to the required compacted thickness plus approximately 25 percent based on the materials being placed. Carefully move or minimally work the HMA or SMA mix with the use of rakes, lutes, or shovels to avoid segregation. Mixtures made with modified asphalt binder require more rapid completion of handwork areas than for normal mixtures.

**24.10.7** Hauling and placement sequences shall be coordinated so the paver is in constant motion. Bituminous pavers shall be used to distribute the mixture over the entire width or over such partial width as may be practical. Echelon paving is encouraged.

Excessive starting and stopping shall not be allowed. A construction joint shall be placed any time the paver stops, or when the screed drops enough to cause a surface dip in violation of Section 24.15.1, surface tolerances; or when the mat temperature falls below what is allowed in Section 24.14.1.

**24.10.8** Placement of HMA on a waterproofed bridge deck shall be accomplished with equipment that will not damage the membrane or protective covering. Use of a vibratory roller will not be allowed to obtain compaction when placement of bituminous pavement on bridge deck utilizing a waterproof membrane.

#### **24.10.9 SMA Pre-Placement**

**24.10.9.01** Before proceeding with SMA placement, the Contractor shall demonstrate the ability to produce and place a satisfactory mix. The actual work may proceed when a full lane width demonstration control strip, having a minimum length of 1,000 feet has been successfully placed. The Contractor shall determine properties VMA, Voids, in-place density, and Marshall Stability of the project produced mix used in the demonstration control strip and provide the results to the Project Manager. **No other SMA production or placement will be allowed until densities are determined.** If the material in the demonstration control strip is not in close conformity with the specifications, the demonstration control strip will be removed and replaced at the Contractors expense. The Project Manager will designate the location of the control strip.

**24.10.9.02** The Contractor shall submit a plan for a Roller Pass Study (RPS) to the Project Manager for acceptance. Upon acceptance by the Project Manager, the Contractor shall perform a RPS. The plan for the RPS shall include, but is not limited to the following:

**24.10.9.02.1** Number, size, and type of rollers.

**24.10.9.02.2** Amplitude, frequency, size and speed of vibratory rollers.

**24.10.9.02.3** Temperature of mixture being compacted.

**24.10.9.02.4** Roller patterns.

**24.10.9.03** For SMA the in-place density shall be determined through the completion of a Roller Pass Study (RPS) to be conducted during placement of the required 1,000 feet demonstration control strip. The RPS will determine the necessary roller

compaction process needed to produce a minimum pavement density of  $95 \pm 2$  percent of Theoretical Maximum Density (Rice).

**24.10.9.04** Density will be determined daily using the same method as during the RPS for each day of production to confirm pavement density. If a daily density check shows density below 93 percent of Rice, the Contractor shall stop production and the Contractor will again complete a RPS to establish the necessary compaction process. All subsequent daily checks that identify locations having density below 93 percent of Rice shall be removed and replaced at the Contractor's expense. A new RPS shall be completed and approved prior to resuming production.

#### **24.10.10 SMA Placement**

**24.10.10.01** SMA mixture shall be transported and placed with the use of a MTV, see Section 24.09.3, on the roadway without drain-down or flushing. All flushed areas shall be removed immediately. If there are more than 50 square feet of flushed areas within the pavement, operations shall be discontinued until the source of the flushing has been found and corrected. The Project Manager will designate the depth and area of all flushed areas requiring removal and replacement. All costs associated with the removal and replacement of the flushed areas shall be at the Contractor's expense.

**24.10.10.02** SMA Pavement shall be placed and compacted in accordance with the temperatures listed in Table 24.10.1.1 or as revised by the Project Manager.

**24.10.10.03** The relative compaction for all Asphaltic Pavement Material shall be measured based on cores in accordance with AASHTO T 166, Method B, unless the material being placed is on a structure (bridge deck) in which case the Project Manager may allow nuclear gauge measurements to be used.

**24.10.10.04** When cores are used, the Contractor shall provide all labor and equipment for the coring and repair of the core holes. When nuclear density gauges are used, the tests shall be performed in accordance with ASTM D 2950 and AASHTO T 230.

**24.10.10.05** In-place density for HMA shall be  $94 \pm 2$  percent of the HMA Mix maximum specific gravity and for SMA density in-place density shall be  $95 \pm 2$  percent of SMA maximum specific gravity as measured according to Maximum



Theoretical Value (Rice) (AASHTO T 209).

## 24.11 Longitudinal Joints

**24.11.1** Longitudinal joints in all pavement layers shall offset the joint in the layer immediately below by a minimum of six (6) inches. The joint in any pavement layer shall not fall in or between wheel paths. Joints in the top layer of new pavement shall be located on lane lines unless otherwise shown on the plans. Longitudinal joints shall be minimized with wide paving pulls. The paver shall be equipped with heated adjustable screed plates with augers and the ability to provide initial compaction. Hydraulic screed extensions that just strike off the mixture are not acceptable for echelon paving. Joints shall be parallel to the flow of traffic and shall not cross any centerline, lane line, or edge line. Prior to the pre-paving meeting the Contractor shall submit a joint plan and pavement marking plan showing locations and the methods to establish the paving control lines. **The plan must be acceptable to the Project Manager** prior to paving. The Contractor shall use a continuous string line to delineate longitudinal joints during paving. When applicable, string lines shall be removed at the end of each day's paving.

**24.11.2** All paving shall be placed parallel to the roadway centerline and as straight as possible. All joints shall receive a coat of tack prior to placement of adjacent paving.

**24.11.3** When placing a layer of pavement against a previously compacted layer in an adjacent lane of pavement the edge of new layer shall not overlap the compacted layer by more than 1.5 inches. Overlap or excess thickness shall not be cast onto the new un-compacted layer but shall be pulled away from the joint and removed. The hot edge shall be bumped in a vertical smooth line consistent with the previous longitudinal edge. A minimal amount of raking will be allowed around manholes and other utilities. Longitudinal joints shall be rolled from the hot side and overlap the cold joint by approximately six (6) inches.

## 24.12 Transverse Joints

**24.12.1** Prior to paving, the Contractor shall submit a joint plan showing locations and the methods to be used to construct transverse joints. **The plan must be acceptable to the Project Manager** prior to paving. In areas where the use of mechanical spreading and finishing equipment is impracticable, the mixture shall be carefully dumped, spread, raked, screeded, and luted by hand tools to meet the elevation of the adjacent pavement. Placing of the HMA or SMA shall be continuous with a minimum of

transverse joints, and rollers shall not pass over the unprotected end of a freshly laid mixture. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. Tack coat material shall be applied to contact surfaces of all joints before additional mixture is placed against the previously compacted material.

**24.12.2** Transverse joints shall be located so they will be constructed with a full head of mix in front of the screed. When butt joints are constructed, runoff boards shall be used to support the roller on the downstream side of the joint. All tapered sections, rounded edges, and segregated areas shall be removed to achieve a vertical face at the butt joint before paving is restarted. When a temporary tapered joint is required for temporary traffic access, the ramp shall be removed back to a full depth section before paving is restarted.

**24.12.3** When paving operations resume the screed of the paver shall be placed on thin strips of material on the completed pavement. The strips should be of sufficient thickness so the adequate grade and compaction can be achieved on starting the paving operation. The screed should be nulled (angle removed) when starting from blocks and set in an up angle of attack. Proper head of mix shall be introduced into the paver prior to starting. The new compacted (downstream) side of the joint may be up to 3/16 inches higher than the old (upstream) side. Raking of this joint shall not create a bump in the transverse joint. The surface tolerance at the transverse joint must be verified by the Contractor with a 10 foot straight edge before the paver is more than 50 feet from the joint. If the surface tolerance is not within the 3/16 of an inch, the Contractor shall stop the paver and make corrections to the joint before proceeding.

## **24.13 Segregation**

**24.13.1** Segregated areas may be determined visually, by density or gradation. The extent of the segregation will be determined visually. The Contractor will remove and replace or repair segregated areas at their expense to the satisfaction of the Project Manager.

**24.13.2** The asphalt mixture shall be transported and placed on the roadway without segregation. All segregated areas shall be removed immediately and replaced with specification material before the initial rolling. If more than 50 square feet of segregated pavement is removed and replaced in any continuous 500 linear feet of paver width paving shall be discontinued until the source of the segregation has been determined and corrected.

## 24.14 Compaction

- 24.14.1** The temperature of the HMA or SMA mixture immediately behind the screed shall be sufficient to allow for proper compaction of the HMA layer and at least 245° F for PG 58-28 or PG 64-22 binder and between 297° F and for SMA 305° F for PG 76-28 binder. The breakdown compaction should be completed as quickly as possible after placement occurs and before the mixture temperature drops 20°F from placement temperature.
- 24.14.2** The HMA or SMA shall be compacted by rolling. Both steel wheel and pneumatic tire rollers will be required. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density and surface texture while the mixture is in a workable condition. Compaction shall begin immediately after the mixture is placed and continued until the required density is obtained. Final compaction shall be obtained using steel wheel rollers.
- 24.14.3** Pavement operations shall be suspended when density requirements are not met and the surface temperature falls below 165° F, or when there is obvious surface distress or breakage; further compaction effort shall not be applied unless approved. If the mixture contains polymer modified asphalt cement (PG 76-28) and the surface temperature falls below 230° F, further compaction effort shall not be applied unless approved by the Project Manager.
- 24.14.4** The minimum compaction temperatures may be adjusted according to the asphalt binder supplier recommendations. Adjusted minimum compaction temperatures must be shown on the approved mix design or on other asphalt binder supplier documents and be available on the job site.
- 24.14.5** All roller marks shall be removed with the finish rolling. Use of vibratory rollers with the vibrator on shall not be permitted during surface course final rolling and shall not be permitted on bridge decks covered with waterproofing membrane.
- 24.14.6** The Contractor shall establish a rolling pattern or procedure during the beginning of paving operations in accordance with Section 24.10.9.02 and shall achieve the required compaction and surface tolerances. This procedure may be re-evaluated by the Contractor and Project Manager throughout the paving operations.
- 24.14.7** All HMA paving shall be compacted to  $94.0 \pm 2$  percent, and for SMA paving shall be compacted to  $95.0 \pm 2$  percent of Maximum Theoretical (Rice) Density,

(AASHTO T 209: Maximum Specific Gravity of Bituminous Paving Mixtures) as determined by ASTM D 2950. Rice values shall be used in calculating Relative Compaction according to AASHTO T 166. Rice value(s) will be based on a three (3) production day's average. The Contractor shall provide the producer's Rice value, which shall be used for production until the actual day's Rice value is determined by the testing firm of record for the project as approved by the Project Manager.

**24.14.8** All joints shall be compacted to minimum of 92.0 percent of Rice, taken six (6) inches on each side of joint, every 200 Linear Feet. Rice values shall be used in calculating Relative Compaction according to AASHTO T 166, cores if needed will be used to verify compaction results.

**24.14.9** The Contractor shall core the pavement, as required by the Project Manager; for field density tests in accordance with AASHTO T 230, Method B, or for field calibration of nuclear density equipment in accordance with the ASTM D 2950. At a minimum, cores for nuclear density equipment calibration shall be taken at the beginning of placement of each pavement layer or change of mixture materials or gradation. Untested areas during placement will also require cores to verify compaction.

**24.14.10** Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers. Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, shall be immediately removed and replaced with uncontaminated hot mixture and compacted to conform to the surrounding area at the expense of the Contractor.

**24.14.11** Compaction requirements for SMA are covered in Section 24.10.1. Rollers shall not be used in a vibratory mode on SMA unless they are first used successfully in the demonstration control strip. Pneumatic wheel rollers shall not be used on SMA Mix.

## **24.15 Production Tolerances**

### **24.15.1 Top lift Surface Tolerances**

**24.15.1.01** Surface variation between any two contacts shall not exceed 3/16 of an inch in 10 feet for full lane width paving. For patching surface tolerances, the variation shall not exceed 3/8 of an inch in 10 feet. All humps or depressions exceeding

the specified tolerance shall be corrected by removing defective work and replacing it with new material or by overlaying (patching) as directed by the Project Manager. The final pavement surface shall not vary from the specified cross section thickness by more than one (1) inch at any point. Irregularities exceeding the specified tolerance shall be corrected at the Contractor's expense. Transverse measurements for variations shall exclude breaks in the crown sections. Roadway smoothness testing will not be measured or paid for separately, but shall be included in the work.

**24.15.1.02** The final surface pavement adjacent to concrete gutter shall be finished from 1/8-inch to 3/8-inches above the lip of the gutter into which it drains. Any surface pavement above the lip more than 3/8 of an inch shall be removed and replaced to the specified height. Any pavement surface below the lip of the gutter shall be corrected as directed by the Project Manager. This provision does not apply to "tipped" or standard median gutter but does apply to median "catch" gutters used on super-elevated roadways.

**24.15.1.03** Prior to placing the surface course, the Contractor shall adjust all manholes, valve boxes, and survey range boxes so they are from 1/8 to 1/2 of an inch below finish grade after the final surface course is placed. The Contractor shall notify the Project Manager of the timing of adjustments to all manholes and valve boxes so the adjustments may be observed. The Contractor shall remove any foreign matter introduced into all manholes and valve boxes during construction. It shall also be the Contractor's responsibility to insure proper compaction around all manholes and valve boxes after they have been raised. If manholes and/or valve boxes are covered during paving operations, they shall have location stakes, or markings on the curb, outside the area of work indicating distance to these facilities. Once the paving operations are complete the manholes and/or valve boxes shall be brought to finish asphalt grade as specified. Valve boxes and manholes shall be maintained fully accessible at all times for emergency and maintenance operation by City personnel. The cost of adjusting valve boxes, manholes, and survey range boxes shall be included in the work, unless otherwise specified in the Special Conditions or Proposal. The Contractor shall be responsible for any cost incurred by the City to provide access to the covered manholes or valve boxes. Valve boxes, manholes, and survey range boxes shall be clean when work is completed. Manhole rings shall be adjusted to match the slope of the roadway. Final adjustment of all utility access points shall be completed within seven (7) days of from the time the

roadway pavement was placed.

**TABLE 24.15.2.1  
JOB MIX FORMULA TOLERANCES**

Mixture Grading	ST (3/8" Nominal)		SX (1/2" nominal)		S (3/4" nominal)		G (1" nominal)	
Traffic Loading,	Repair Segregation Bike path Sidewalk		Low To Medium 0 to 300,000		Medium To High >300,000		Lower lifts	
Sieve Size	Control Points	Tolerance	Control Points	Tolerance	Control Points	Tolerance	Control Points	Tolerance
1 1/2"							100	+ 1%
1"					100	+ 1%	Design	± 6%
3/4"			100	+ 1%	Design	± 6%	Design	± 6%
1/2"	100	+ 1%	Design	± 6%	Design	± 6%	Design	± 6%
3/8"	Design	± 6%	Design	± 6%	Design	± 6%	Design	± 6%
#4	Design	± 5%	Design	± 5%	Design	± 5%	Design	± 5%
#8	Design	± 5%	Design	± 5%	Design	± 5%	Design	± 5%
#16	Design	± 4%	Design	± 4%	Design	± 4%	Design	± 4%
#30	Design	± 4%	Design	± 4%	Design	± 4%	Design	± 4%
#50	Design	± 4%	Design	± 4%	Design	± 4%	Design	± 4%
#200	Design	± 2%	Design	± 2%	Design	± 2%	Design	± 2%
Air Voids	Design	3.0-5.0%	Design	3.0-5.0%	Design	3.0-5.0%	Design	3.0-5.0%
VMA	Design	± 1.2%	Design	± 1.2%	Design	± 1.2%	Design	± 1.2%
Hveem Stability	See Table 24.05.4.02.1		See Table 24.05.4.02.1		See Table 24.05.4.02.1		See Table 24.05.4.02.1	
Asphalt Content	Design	± 0.3%	Design	± 0.3%	Design	± 0.3%	Design	± 0.3%

There is 1.0 percent tolerance for the maximum sieve size.

Mixes with passing No. 200 sieve material produced over 7.0 percent are allowed only when the above Air Voids and VMA tolerances are still met.

Hveem Stability must meet the minimum value specified in table

When calculating VMA, use the most current aggregate specific gravity  $G_{sb}$ .

**24.15.2.02** When disagreements concerning determination of specification compliance occur, only valid tests from both the Project Manager and Contractor will be considered. The Project Manager shall determine validity. Generally, valid tests are those in which sampling and testing have been performed according to referenced procedures and the results are within stated precision statements. When disagreements occur with asphalt content and gradation tests results, solvent extracted aggregate testing shall take precedence over burn off oven

extracted aggregate, which shall take precedence over cold feed belt testing.

## **24.16 Conformity with Plans and Specifications**

### **24.16.1 General**

- 24.16.1.01** All work performed and all materials furnished shall conform to the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown or stated in the contract documents.
- 24.16.1.02** When tolerances are not specified, the Contractor shall perform the work in a manner consistent with reasonable and customary manufacturing and construction practices.
- 24.16.1.03** When the Project Manager finds the materials furnished, the work performed, or the finished product does not conform to the contract, but that reasonably acceptable work has been produced, the Project Manager shall determine the extent of the work to be accepted and remain in place.
- 24.16.1.04** When the Project Manager determines the material furnished, work performed, or the finished product is not in conformity with the contract and has resulted in inferior or unsatisfactory product, the finished product or materials shall be removed and replaced or otherwise corrected by, and at the expense of, the Contractor.
- 24.16.1.05** Materials shall be sampled and tested by a qualified testing laboratory in accordance with the sampling, testing schedules, and procedures contained in the Section 24.17 Testing and Inspection. The approximate maximum quantity represented by each sample shall be as set forth in the testing schedule. An additional number of samples, in relation to the quantity of materials represented, may be selected and tested at the Project Manager's discretion. The quantity represented by five consecutive random samples shall constitute a lot, whenever production schedules and material continuity permits. When it is necessary to represent short production runs, significant material changes, or other unusual characteristics of the work, the Project Manager may establish a lot consisting of the quantity represented by any number of consecutive random samples from one to seven inclusive. Testing results determined to have sampling or testing errors, as determined by the Project Manager, shall not be used.



## **24.16.2 Use of Cores to Determine Acceptable Asphalt Thickness**

**24.16.2.01** All cores shall be no more than 0.25-inch deficient than the required thickness shown on plans or pavement design report for full payment or acceptance. A minimum of 90 percent of all the pavement thickness cores must equal or exceed the required thickness shown on plans or pavement design report for full payment or acceptance. Any deficient pavement thickness shall be remedied by the Contractor at the Contractor's expense to the satisfaction of the Project Manager.

## **24.16.3 Verification of Thickness and Remedial Action:**

**24.16.3.01** When the Project Manager determines deficient thickness exists, the Contractor may define the deficient section boundaries by any means acceptable, and then verify the boundaries to the satisfaction of the Project Manager at the boundary, or by direct measurement when cutting the pavement.

**24.16.3.02** When the Project Manger determines the top lift shall not be cored, the Contractor shall be required to use non-destructive survey techniques to determine top lift thickness. This shall be combined with core information taken from lower lifts to determine total pavement thickness.

**24.16.3.03** The Contractor will be responsible for the coring of the Bituminous Pavement and notifying the Project Manager of the coring operations, so Project Manager may be present to observe. Duplicate cores shall be required. The Contractor shall retain one set and the Project Manager shall receive the other set for comparison testing.

**24.16.3.04** Referee: In the event the Contractor elects to question the acceptance test results for either asphalt binder content, laboratory air voids, density, thickness, gradation, or a combination thereof for a Lot, the Contractor may make a written request for additional testing of that lot to the Project Manager. Any request for referee testing must describe the Contractor's reasons for questioning the validity of the original acceptance results and must clearly describe which set of acceptance tests are in question. The Contractor shall engage an independent laboratory (at their own expense) who is accredited by AASHTO Re:Source or CDOT in all of the acceptance test methods. The independent laboratory shall be acceptable to the Project Manager and shall perform a complete new set of acceptance tests (as required to represent the area or set of tests in question).

The results of these determinations shall be binding on both the Contractor and the Project Manager.

**24.16.3.05** These tests may include asphalt binder content, aggregate gradation, Gyrotory unit weight, maximum theoretical unit weight, laboratory air voids, and in-place air voids (compaction). Samples for referee testing shall come from representative samples obtained from the completed pavement.

**24.16.3.06** The number of samples taken shall be the same as specified. The independent laboratory shall compile the test results and transmit them to both the Project Manager and the Contractor. The independent laboratory shall include a report signed by an Engineer licensed in the State of Colorado, who is experienced in asphalt concrete testing and mix design development. The signed report shall give an opinion the material evaluated either does or does not comply with project specifications, will clearly describe any deficiencies, and the results will be binding between all parties.

#### **24.16.4 Price Reductions on Thickness**

**24.16.4.01** Price reductions shall not be allowed for Thickness deficiencies on any projects to be accepted. Remedial action is required of the Contractor to the satisfaction of the Project Manager to meet the design thickness requirements. Extended warranty will no be an acceptable alternate to remedial action.

### **24.17 Testing and Inspection**

**24.17.1** If any materials furnished or work performed fails to fulfill the specification requirements, such deficiencies shall be reported to the Project Manager and the Contractor immediately. Written field reports of all tests taken and observation results shall be given to the Contractor and Project Manager, and developer **within 3 business days** after samples were obtained or density testing performed. Reports of in place density using Rice values from samples taken during construction or other test results that cannot be reported within 3 days of construction shall be provided to the Project Manager no later than one week following the testing.

**24.17.2** Reports of all tests taken, including failing tests, shall be reported to the Project Manager, the Developer, and the Contractor no later than one (1) week following the sampling.

**24.17.3** Density test results shall be reported to the inspector/observer at the time the testing

occurs and in writing. Failing Test results must reported to the Project Manager representative and Contractor **immediately**.

- 24.17.4** Testing of HMA and SMA Pavement shall be performed in accordance with Tables 24.17.7.1 and 24.17.7.2, respectively. The tests shall be performed under the general supervision of and signed by a Professional Engineer licensed in the State of Colorado. Laboratories shall be accredited by AASHTO Re:Source or CDOT for the material being tested. Technicians taking samples and conducting compaction tests must have a LabCAT Level A certification, or equivalent. Technicians conducting tests of asphalt content and gradation must have a LabCAT Level B certification, or equivalent. Technicians performing volumetric testing must have a LabCAT Level C certification, or equivalent.
- 24.17.5** The Contractor shall provide assistance at all facilities and at the job site to inspectors whose duties shall include checking temperatures of mix in the truck and on the pavement, segregation, rolling patterns, and other construction means and methods that affect the performance of the pavement system. The Contractor shall provide assistance in sampling and testing at all facilities and at the job site.
- 24.17.6** The HMA or SMA mix design must be approved by the Project Manager before any pavement is placed on the project. In addition, the Contractor shall provide field control testing during production of the SMA mix and for the demonstration control strip. The Contractor shall perform the following tests and provide the results to the Project Manager.
- 24.17.7** If a Superpave SMA mix design is used, the Contractor shall perform the tests identified in Tables 24.17.7.1 and 24.17.7.2 and provide the results to the Project Manager during production:

**TABLE 24.17.7.1  
SCHEDULE FOR MINIMUM QUALITY CONTROL & QUALITY ASSURANCE  
MATERIALS SAMPLING AND TESTING FOR ALL BITUMINOUS PAVING  
MIXTURES**

<b>Test</b>	<b>Standard*</b>	<b>Minimum Frequency Quality Control</b>	<b>Minimum Frequency Quality Assurance</b>
Sampling	AASHTO T168, ASTM D 979 and ASTM D3665	One per 1,000 tons or fraction thereof (not less than one test per day)	One per 2,000 tons or fraction thereof (not less than one test per day)
Density	AASHTO T 166, T 238, T 230	One test for each 250 lineal feet per Lane	One test for each 500 lineal feet per Lane
Thickness (Core)	ASTM D3549	One test for each 1,000 lineal feet per Lane,	One test for each 2,000 lineal feet per Lane,
Air Voids & VMA	AASHTO T 166 & AASHTO PP 19	One per 1,000 tons or fraction thereof (not less than one test per day)	One per 5,000 tons or fraction thereof (not less than one test per day)
Gradation	AASHTO T 27, T 11	One per 1,000 tons or fraction thereof (not less than one test per day)	One per 2,000 tons or fraction thereof (not less than one test per day)
Hveem/Marshall Stability As Applicable	AASHTO T 245, AASHTO T 246	One per 2,000 tons or fraction thereof (not less than one test per day)	One per 10,000 tons of each mix production (not less than one test per project)
Asphalt (AC) Content	AASHTO T 164 or other methods agreed upon between Project Manager and Contractor	One per 1,000 tons or fraction thereof (not less than one test per day)	One per 2,000 tons or fraction thereof (not less than one test per day)
Maximum Theoretical Specific Gravity (Rice)	AASHTO T 209	One per 1,000 tons or fraction thereof (not less than one test per day)	One per 2,000 tons or fraction thereof (not less than one test per day)
Lottman Stripping, TSR & Dry Density	AASHTO T 283	As requested by the Project Manager	As requested by the Project Manager
Micro Deval	AASHTO T 327	One per 5000 tons or 1 per project minimum	As requested by the Project Manager
Determining the Rheological Properties of Asphalt Binder	AASHTO TP5	One per 20,000 tons produced or 1 per project minimum per RAP mix design used.	As requested by the Project Manager

\* Project Manager may determine the method used (CP vs. AASHTO)

Contractor shall provide plant split samples to the appropriate testing Project Manager.

**TABLE 24.17.7.2**  
**SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING**  
**FOR SMA PAVEMENT**

Superpave Mix Property	Frequency
Drain down (AASHTO T 305)	1/1,000 tons or fraction thereof
Percent Voids in the total mix @ $N_{design}$	1/1,000 tons or fraction thereof
VMA (Percent Voids in the Mineral Aggregate) @ $N_{design}$	1/1,000 tons or fraction thereof
Lottman, AASHTO T 283, Method B	1/5,000 tons or fraction thereof
Dry Tensile Strength, AASHTO T 283	1/5,000 tons or fraction thereof
Percent AC & Aggregate Gradation AASHTO T 308	1/1,000 tons or fraction thereof

Agency: \_\_\_\_\_  
Date: \_\_\_\_\_

Project Number: \_\_\_\_\_  
Project Name: \_\_\_\_\_

<b>Form # 24.1</b>	<b>• Mixture Design Requirements for Hot Mix Asphalt Pavements (HMA)</b>
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• Project Special Provision Sheet for Hot Mix Asphalt Pavements (HMA)

This MGPEC Form #9 is a **mandatory part of the bid documents**, and shall be filled out by the AGENCY for each mix specified. The Contractor shall include a copy of this form with each Mix Design submittal after the contract is awarded.

Street Classification: \_\_\_\_\_ (examples: Residential, Collector, Arterial, Industrial, Parking Lot or actual name for Project)

Construction Application:  Top Lift     Intermediate Lift(s)     Bottom Lift  
 Patching     Other \_\_\_\_\_

Aggregate Gradation:     Grading ST (1.5" or less lifts, 3/8" NMPS)  
                                   Grading SX (2.5" or less lifts)  
                                   Grading S (2.5+ to 3.5" lifts)  
                                   Grading G\*1 (3.5" or thicker lifts)  
SMA (Top lift only)     3/8"     1/2"     3/4"

\*1Note = Grading G depends on approved texture of mix, Grading G lower lift(s) only.

RAP Quantity, Maximum:     0%     20%     25%     35% Grading G only

Notes: - A quality control plan for RAP will be required when RAP is used  
- Top lift Maximum RAP content allowed is 20%

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Superpave Gyrotory Mix Design Compaction Level, Recommended usage and Recommend binder(s):

Design Level	Recommended Traffic Levels	Recommended PG Binder(s)
<input type="checkbox"/> N <sub>design</sub> =50	Low volume	<input type="checkbox"/> PG 58-28 or <input type="checkbox"/> PG 64-22
<input type="checkbox"/> N <sub>design</sub> =75	0 to <3 million ESALs	<input type="checkbox"/> PG 64-22 or <input type="checkbox"/> PG 58-28
<input type="checkbox"/> N <sub>design</sub> =100	3 million to <30 million ESALs	<input type="checkbox"/> PG 64-22 or <input type="checkbox"/> PG 76-28

Notes: - The binders are shown in order they should be considered.  
- Polymer modified PG Binders are typically used in the top lift only  
- PG 58-28 Binder recommended for residential developments with less than 2 million ESAL's

- Target job Mix Optimum Asphalt Content Selection, Choose target % as close to 4.0 as possible (3.5% to 4.5% air voids per MGPEC 2008)
- Target Job Mix optimum Binder content for SMA grading at 3.0% to 4.0% air voids

\*\*Warm mix asphalt (WMA) is allowed as an alternate to hot mix asphalt provided that all material requirements and specification standards are met and as approved by the Agency.

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A completed MGPEC Form #9 shall supplement the MGPEC Construction Specifications defining the contract specific requirements of Item 9: Hot Mix Asphalt Pavement (HMA). Refer to the Specifications for details.

**SECTION 25.00 ASPHALT PLANING.....1**

25.01 Scope .....1

25.02 General.....1

25.03 Stockpile of Material .....1

25.04 Equipment .....1

25.05 Construction Methods .....2





## **SECTION 25.00 ASPHALT PLANING**

### **25.01 Scope**

This specification specifies equipment and methods to be used for the cold planing of existing pavement surfaces to the specified depth and the removal and disposal of the planed material.

### **25.02 General**

The Contractor shall provide a planed and finished surface free from gouges, soot, oil film, and other imperfections. The completed planed surface shall have a uniform textured appearance. The existing asphalt shall be planed to the depth specified  $\pm 1/4$  inch with a two percent crown, unless otherwise specified.

The planing depth shall be measured at the existing outside edge of the gutter pan on both sides of the roadway to establish a new elevation prior to overlaying. Additional planing depth may be required near the roadway centerline to achieve the desired roadway cross section.

### **25.03 Stockpile of Material**

Stockpiling of planed materials or cuttings shall not be permitted on the project site. All planed materials shall be delivered and stockpiled as directed by the Project Manager and shall become the property of the City, unless otherwise specified or directed.

### **25.04 Equipment**

A cold planing machine shall be used by the Contractor to perform the planing operation. The equipment shall be sufficient to maintain adequate depth of cut and slope within specified tolerance. The equipment shall be capable of accurately and automatically establishing a finish profile grade along each edge of the machine within  $1/4$  inch of the specified depth.

The planing machine shall be equipped with an integral loading mechanism to immediately remove the bulk of the materials being cut from the surface of the roadway and discharge into a truck. The machine shall be equipped with a means to control the dust created by the cutting action and shall meet all local, state, and federal air pollution laws.

The Contractor shall provide adequate backup equipment (mechanical street sweepers, loaders, water truck, etc.) and personnel to insure all cuttings are cleaned up and removed from the roadway daily.

## **25.05 Construction Methods**

- 25.05.1** The Project Manager may require the pavement planing operation be referenced from an independent grade control at his discretion.
- 25.05.2** In any area where the pavement has not been planed full width, leaving a vertical edge greater than one inch in the longitudinal or transverse direction, this edge shall be sloped at a maximum rate of one inch depth per one foot horizontal.
- 25.05.3** The planing machine shall be removed when approaching manholes, inlets, valve boxes, and other obstructions that have not been lowered. Asphalt around these obstructions shall be removed by other means to the required depth prior to placement of the overlay. If overlay operations are not performed immediately after planing, the Project Manager may require the installation and removal of a temporary HBP transition. However, overlay must be completed within seven days of the planing operation. Allowable transition taper shall be not greater than 1/4 inch vertical rise per one foot horizontal. Such tapers shall be removed to the required depth prior to the placement of the overlay. Where traffic must utilize the planed roadway prior to completion of the overlay, the Project Manager may require the installation and removal of temporary HBP transitions around appurtenances and obstructions and painted lane striping.
- 25.05.4** Curbs, gutters, drainage structures, and other surfaces shall be cleaned of debris at the completion of the project and before opening to traffic.
- 25.05.5** The Contractor shall prevent the spread of dust and debris during the performance of the work. Where equipment comes into contact with tree branches or other plant material, the Contractor shall exercise caution to avoid damage to trees, shrubs, and other plant material. All trimming shall be performed as directed by the Project Manager.

**SECTION 27.00 SURFACE TREATMENTS.....1**

27.01 General .....1

27.02 Slurry Seal .....7

27.03 Chip Seal .....19

27.04 Cape Seal .....27

27.05 Hot Chip Seal.....29

27.06 Crack Seal .....33



## SECTION 27.00 SURFACE TREATMENTS

### 27.01 General

**27.01.1 PURPOSE** Surface treatments referred to and used per this section are to be applied to asphalt concrete pavements only. The purpose of these treatments is to seal major and minor cracks in the pavement surface thereby preventing water infiltration into the pavement structure and subgrade thus prolonging the pavement life.

When surface treatments are applied by contract, Contractor shall be responsible for full compliance with all portions of these specifications unless otherwise noted.

Specifications contained in this section shall supplement specifications in Section 24.00 BITUMINOUS PAVEMENT MATERIALS.

**27.01.2 DEFINITIONS** The surface treatments referred to in this section are generally defined below:

SLURRY SEAL – A minimal surface treatment consisting of bituminous emulsion and fine aggregate material.

CHIP SEAL – A surface treatment consisting of bituminous emulsion and aggregate material sized at least ¼ inch usually covered with a fog seal.

CAPE SEAL – A surface treatment consisting of a chip seal treatment covered by a slurry seal treatment.

HOT CHIP SEAL – A surface treatment consisting of a chip seal treatment covered by a hot chip seal application.

CRACK SEAL – A surface treatment consisting of bituminous sealant and possibly aggregate used to fill and seal larger surface cracks.

**27.01.3 GENERAL CONSTRUCTION REQUIREMENTS** The following construction requirements shall apply to construction of all surface treatments within this section, unless otherwise specified or directed by the Project Manager. Modifications or additions to these requirements may be contained within the specification for each treatment.

#### 27.01.3.01 Surface Preparation

**27.01.3.01.1 General** Immediately prior to applying any surface treatment, the street surface and gutters shall be cleaned of all loose material, silt spots, oil spots, vegetation, and other objectionable material for the full width of the

area to be treated. Dust and other material in depressions or other places not removed by mechanical sweepers shall be swept with hand brooms or removed by use of flushers. The Project Manager may require washing of the pavement where other methods of cleaning do not provide an acceptable surface. Material removed from the surface shall not be mixed with the cover aggregate. Bituminous material shall not be spread until the area to receive a surface treatment application has been cleaned to the satisfaction and approval of the Project Manager.

All vegetation shall be removed from the area to receive a surface treatment prior to placement of any surface treatment. This work shall be performed within two weeks of the surface treatment. All dead or remaining vegetation shall be removed prior to sweeping of the area and application of surface treatment. Vegetation may be removed by burning when in the opinion of the Project Manager such burning causes no safety hazard or air pollution nuisance.

#### **27.01.3.02 Manholes, Valve Boxes and Survey Monuments, etc.**

**27.01.3.02.1 Protection and Cleaning** Manholes, valve boxes, survey monuments, inlets, etc., shall be protected and covered in a suitable manner prior to application of any surface treatment. This covering shall be removed immediately after the surface treatment is applied or as specified for each surface treatment or as directed by the Project Manager. All covering material shall be disposed of in a lawful manner. All manholes, valve boxes, survey monuments, inlets, etc., shall be cleaned to the satisfaction of the Project Manager when work is completed.

**27.01.3.02.2 Locates** All manholes, valve boxes, and survey monuments within the project area shall be located prior to construction to the satisfaction of the Project Manager. All appropriate utilities and representatives shall be contacted and met as necessary to fully identify and locate all such items within the work area. Work shall not commence until all such items have been located to the satisfaction of the Project Manager. When surface treatment work is performed by contract, Contractor shall comply with this section at no additional cost to the City.

### **27.01.3.03 Quality Control**

**27.01.3.03.1 Materials** Samples of the aggregate and asphalt emulsion used in surface treatments shall be obtained at the Project Manager's discretion. Gradation and sand equivalent tests may be run on the aggregate and consistency and residual asphalt content tests on the emulsion. Samples of material may be taken directly from the mixing and/or application unit(s). Test results will be compared to specifications. Initial tests will be run at the expense of the City. For surface treatment work that is performed by contract, Contractor shall assist the Project Manager in obtaining samples of the aggregate and asphalt emulsion used in the project at the Project Manager's discretion.

Each load of emulsified asphalt shall be accompanied by a certification of Analysis and Compliance. Emulsions shall show no separation after mixing.

The Project Manager may use the recorders and measuring facilities of the unit to determine application rates, asphalt emulsion content, mineral filler, and additive.

**27.01.3.03.2 Noncompliance** If any two (2) consecutive tests fail on any stockpile material, the job shall be stopped. If any two (2) successive tests on the approved material from the same machine fail, the use of that machine shall be suspended. When surface treatment work is performed by contract, it shall be Contractor's responsibility, at their own expense, to prove to the Project Manager's satisfaction that the material problems have been corrected and that the machine is operating within manufacturer specifications.

**27.01.3.04 STORAGE SITE REQUIREMENTS** Job materials and equipment may be stockpiled and stored at locations near the job site. A list of sites to be used for this purpose and written permission from the property owner shall be submitted to the Project Manager for approval at least ten (10) days prior to any use. The proposed truck route for ingress and egress to such sites shall also be submitted to the Project Manager for approval. Using such job-site storage requires the following:

**27.01.3.04.1** Obtaining written permission from the property owner, which shall include a brief description of the area of the property to be used, the length

of time the property will be used for this purpose, any access restrictions (i.e. times of day), and the name and phone number of the property owner. A copy of the written permission shall be submitted to the Project Manager at least one week prior to delivery of material to the site.

**27.01.3.04.2** Keeping stockpiles and equipment confined to the approved area.

**27.01.3.04.3** Providing security for job materials and equipment and for public safety at the site.

**27.01.3.04.4** Keeping all access roads clean and in good condition.

**27.01.3.04.5** Returning site to original condition.

When surface treatment work is performed by contract, the Contractor shall be responsible for compliance with all requirements of this section. The Contractor shall hold the City of Aurora and all its employees and representatives harmless from any injury or damage to property occurring as a result of Contractor's operations on property used for this purpose.

#### **27.01.3.05 Traffic Control**

**27.01.3.05.1 General** Traffic shall be directed through the project with signs, barricades, flag persons or pilot cars as necessary to protect the work and safety of the public. Traffic Control Plan will be required should traffic be affected for more than 1+ hours.

Roadway traffic shall be maintained safely, adequately, and continuously on all portions of existing roads, detours, and cross roads affected by surface treatment work in accordance with the provisions of Section 50.00 Traffic Control. Whenever traffic signal power lines and/or loop detection lines are located within the limits of a proposed construction area, the Traffic Engineer shall be contacted a minimum of 48 hours in advance to have the lines located to insure continuity of the signal.

When surface treatment work is performed by contract, Contractor shall be responsible for all traffic control in the construction area and compliance with all requirements of this section.

**27.01.3.05.2 Street Closures** Traffic may be detoured if detours are properly erected and maintained, as approved by the Traffic Engineer. All detours must be



requested with the proper permits, as they apply to street closures and traffic detours. This includes but is not limited to, proper notification to all authorities that may be affected by any street closure, such as Fire and Rescue, Law Enforcement Agencies and Ambulance Services. A detailed Traffic Control Plan, showing the detour route is required. When streets are approved for closing, they shall not be closed prior to 7:00 a.m. or after 5:00 p.m. unless otherwise approved by the Project Manager and Traffic Engineer. Residents on streets to be closed shall be notified a minimum of two working days in advance with written notices (English & Spanish) distributed to each residence or business. Street signs advising of the closing shall be placed a minimum of 24 hours in advance of the operation. When surface treatment work is performed by contract, this shall be the responsibility of the Contractor.

**27.01.3.05.3 Temporary Pavement Markers** Temporary raised pavement markers shall be placed at the direction of the Project Observer, and shall be placed prior to the surface treatment operation. Tabs shall be placed at 40' intervals on straight sections. At all turn lane tapers and curved markings, the tabs shall be placed at 25' intervals. After the treatment has been placed and prior to any covering operation, the paper over the reflective tabs shall be removed from every other tab placed. After all cover operations are completed, all adhesive tabs shall be exposed. Any temporary markings shall conform to the existing City striping plans.

**27.01.3.05.4 Traffic Control Devices** All "Traffic Control" devices must meet the Manual of Uniform Traffic Control Devices (MUTCD) specifications and guidelines, and be approved by the Project Manager. Traffic control devices shall include cones, barricades and any such means as approved or required by the Traffic Engineer. When flaggers are required, they shall have no other duty than to direct traffic. Sufficient flaggers for traffic control shall be provided as directed by the Traffic Engineer.

Any and all traffic control devices shall be clean, in good working order and properly placed according to the approved traffic control plan prior to and during daily operations. If, in the opinion of the Project Manager and/or the Traffic Engineer, the traffic control measures are in anyway inadequate, operations shall be stopped until proper traffic control measures are in place.

When surface treatment work is performed by contract, Contractor shall furnish, place and maintain all traffic control devices at Contractor's expense and shall be responsible for compliance with the requirements of this section.

### **27.01.3.06 Notification**

**27.01.3.06.1 Notification Requirements** All notices and signs required in this section shall be distributed and posted at a minimum of 48 hours in advance of the surface treatment operation. This includes, but is not limited to, notification forms, no parking and tow away signs and other means as deemed necessary by the Project Manager. If work does not occur on the specified day, new notification shall be distributed 48 hours in advance of the work. Car towing operations will only be authorized by the City after 24 hours of the above advance notice and posting of no parking signs.

**27.01.3.06.2 Notification Forms** Forms for resident and business notification shall be submitted to the Project Manager for approval prior to the start of construction and shall contain the following information at a minimum in both Spanish and English:

Name, address and telephone number of the Contractor

Description of the work (chip seal, slurry seal, etc.)

Dates of the work (range of dates)

Parking and/or access alternatives

A contact person and local phone number for citizens' questions (24hour availability). If work is performed by contract, this contact person shall be supplied by Contractor.

A local telephone number must be located on the flyer and this telephone shall be manned 24/7 until the contract is completed. The Project Manager shall approve all notices prior to distribution.

**27.01.3.06.3 Signs** Signage for the purpose of public notification of impending work shall be furnished. These areas will be identified prior to the start of construction and as designated by the Project Manager. Public notification signs shall be affixed at locations approved by the Project Manager at each end of the proposed construction areas. Signs shall be posted a minimum

of FIVE WORKING DAYS in advance of the surface treatment. All signs shall be approved by the Traffic Engineer.

Signs shall be constructed of 0.100 gauge aluminum, alodine coated in accordance with ASTM-B209, 48"x 48" minimum with black lettering on an orange background. Signs shall be mounted and anchored using a suitable assembly. Details of the proposed signs and mounting apparatus shall be submitted to the Project Manager for review and approval.

Signs shall contain the following information at a minimum, type of operation, the scheduled week of work, and the phrase "ALTERNATE ROUTES ARE ADVISED".

Any missing or defaced signs shall be replaced within 24 hours.

"NO PARKING" signs shall be placed a minimum of 24 hours in advance of any surface treatment operations on all streets to be treated.

"Fresh Oil" signs shall be posted in sufficient number and proper locations to adequately notify the public of such fresh oil.

Any other signs as required by the Traffic Engineer shall be placed.

When surface treatment work is performed by contract, Contractor shall supply and maintain all signs at Contractor's expense.

**27.01.3.07 Limitations on Work Times** Work on all arterial, collector, and cross streets shall not be allowed between the hours of 6:00 to 8:30 a.m. and 3:30 to 7:00 p.m. with exception of weekend work, Saturday and Sunday, or as directed by the Project Manager.

Limitations on work due to weather shall be as specified for each surface treatment type or as directed by Project Manager.

## **27.02 Slurry Seal**

**27.02.1 SCOPE** The bituminous slurry seal surface shall consist of properly proportioned and mixed mineral aggregate, asphalt emulsion, and water, spread evenly on the surface, as specified herein and as directed by the Project Manager. The slurry, when cured, shall have a homogenous appearance, fill all cracks, adhere firmly to the existing asphalt surface, and provide a skid-resistant texture. The scope of this

work consists of constructing a bituminous slurry seal surface on a prepared surface in accordance with these specifications and as shown on the plans or directed by the Project Manager.

Slurry mixes are divided into Type I, Type II, and Type III. Each type has unique emulsion and gradation requirements. Application of each type shall be specified by Project Manager. General uses are:

**TABLE 27.02.1.1  
SLURRY MIX TYPES AND ASSOCIATED USES**

Type I	Parking Areas, Rural and low volume Residential Streets
Type II	Residential and Low Volume Collectors Streets
Type III	High Volume Collector and Arterial Streets

**27.02.2 MATERIAL REQUIREMENTS**

**27.02.2.01 Asphalt Emulsion** CQS-1hL (Cationic Quick Setting Emulsified Asphalt with 1% Latex Polymer). CQS-1hL shall be an emulsified blend of asphalt, water, styrene-butadiene rubber (SBR) latex and emulsifiers. The emulsion shall be pump able and suitable for use in slurry seal mixing and spreading equipment and suitable for application through a distributor truck. The emulsion shall contain a minimum of one percent (1.0%) up to three percent (3.0%) by weight of styrene-butadiene rubber (SBR) polymer solids based on weight of residual asphalt. The percentage of polymer used will be determined by the type of application and traffic volume. The polymer shall be added as SBR latex by high shear mixing by co-milling or post-milling. The emulsified asphalt shall conform to the following requirements:

**27.02.2.01.1 Tests on Emulsion**

**TABLE 27.02.2.01.1.1  
SLURRY SEAL EMULSION TEST REQUIREMENTS**

	Min	Max	Test Method
Viscosity, Saybolt Furol, 77°F, s		50	ASTM D88
Storage stability test, 24-h, % <sup>A</sup>		1	ASTM D244 (§ 82 to 88)
Particle charge test		positive	ASTM D244 (§ 28 to 33)
Sieve test, % <sup>A</sup>		0.1	ASTM D244 (§ 58 to 63)
Distillation <sup>B</sup> :	60		20
Residue, %			ASTM D244 (§ 11 to 15)
Polymer Content, %			(Supplier Certification)

**27.02.2.01.2 Tests on Residue** The following test shall be completed on emulsion residue from oven evaporation test (ASTM D244 § 21 to 27) B:

**TABLE 27.02.2.01.2.1  
SLURRY SEAL RESIDUE TEST REQUIREMENTS**

	<b>Min</b>	<b>Max</b>	<b>Test Method</b>
Penetration, 77°F, 100g, 5s	40	90	ASTM D5
Penetration, 77°F, 100g, 5s	40		ASTM D113
Solubility in trichloroethylene, %	97.5		ASTM D113
Solubility in trichloroethylene, %	40		ASTM D113

A. This test requirement on representative samples is waived if successful application of the material has been achieved in the field.

B. Distillation to 500°F (D244 §11 to 15) shall be the reference method for percent distillate and percent residue. Residue by evaporation at 325°F (D244 §21 to 27) shall be the reference method to obtain material for tests on residue. Residue from distillation shall not be used for tests on residue due to polymer degradation at 500°F.

**27.02.2.01.3 Emulsion Storage** Suitable storage facilities and containers for the asphalt emulsion shall be provided and shall be equipped to prevent water from entering the emulsion. If necessary, suitable heat shall be provided to prevent freezing.

**27.02.2.02 Aggregate** The mineral aggregate shall be washed, hard, durable, clean rock and free from coatings or deleterious material, and clay balls. All of the aggregate shall be crushed gray granite with 100% fractured faces. The aggregate shall have a loss of no greater than 20% when tested with the LA Abrasion procedure as defined by ASTM C131, grade C or D. Only one type of aggregate shall be used and shall conform to the following gradations. The aggregate shall be gray in color.

Oversized granular material and or the presence of clay balls will require the project to be stopped. The total aggregate, including mineral filler, shall be tested and conform to the following requirements:

**TABLE 27.02.2.02.1  
AGGREGATE SPECIFICATIONS**

Aggregate Sampling		ASTM D75
Unit Weight of Aggregate; 0-5% moisture by Rodding Procedure		ASTM C29
Gradation		ASTM C136 & ASTM C117
Resistance to Degradation	ASTM C131	20% maximum loss
Soundness of Aggregate	ASTM C88	15% maximum loss
Sand Equivalent Value	ASTM C2419 <sup>A</sup>	60 minimum

A. The reference method for preparation of the sample shall be as follows: The aggregate shall be oven dried at 140°F to a constant weight and allowed to cool to room temperature. Two percent (2.0%) of water based on weight of the aggregate shall be mixed with the aggregate and the aggregate-water mixture shall be sealed in a moisture proof and water proof container for a minimum of 24 hours. Complete using ASTM D2419 Procedure B.

**27.02.2.02.1 Aggregate Gradation** Requirements for target mix design based on the Slurry Type specified.

**TABLE 27.02.2.02.1.1  
SLURRY SEAL AGGREGATE GRADATION**

	TYPE I	TYPE II	TYPE III	
SIEVE SIZE	% PASSING	% PASSING	% PASSING	Stockpile Tolerances
3/8"	100	100	100	0
1/4"	100	100	90-100	0
No.4	100	90-100	70-90	+/- 4%
No.8	90-100	65-90	45-70	+/- 4%
No.16	65-90	45-70	28-50	+/- 4%
No.30	40-65	30-50	19-34	+/- 4%
No.50	25-42	18-36	12-25	+/- 4%
No.100	15-30	10-24	7-18	+/- 3%
No.200*	10-20	5-15	5-15	+/- 2%

\*Materials finer than No. 200 sieve will be determined by washing.

Aggregates used on the job site shall be within the specifications and within the stockpile tolerance of the aggregate used in the mix design.

**27.02.2.02.2 Mineral Filler** Mineral fillers, such as Portland cement, limestone dust, lime, and fly ash shall be considered as part of the blended aggregate, and shall be used in the amount required. They shall meet the gradation requirements of ASTM D242. Mineral fillers shall be used for one or more of the following reasons only: to improve the gradation of the aggregate; to control the time of break of the emulsion; to provide improved stability and workability of the slurry; or to increase the durability of the cured slurry. (Use only materials as specified in the mix design)

**27.02.2.02.3 Stockpiling of Aggregate** Precautions shall be taken to insure that stockpiles are carefully mixed just prior to use to insure uniform distribution of the moisture, and that they do not become contaminated with over-sized seed rock, clay, silt, or excessive amounts of moisture. The stockpile shall be kept in areas that drain readily. Segregation of the aggregate will not be permitted. If oversize material is present, screening through a 1/4" screen will be required prior to delivery to the slurry machine.

**27.02.2.03 Water** All water used in making the slurry shall be potable and free of dissolved materials that may affect the mix characteristics or finished characteristics of the product. The effect of moisture content on the specific

weight of the aggregate, and the moisture content of the aggregate being used, shall be taken into account in calibrating the machine to deliver asphalt in the correct proportion.

**27.02.2.04 Additives** Additives may be used to accelerate or retard the break-set of the slurry seal or to improve the resulting finished surface. The use of the additives in the slurry mix (or individual materials) shall be made initially in quantities predetermined by the mix design with adjustments if required, after approval by the Engineer.

**27.02.2.05 Laboratory Testing** Sources of all materials shall be selected and identified. All materials shall be pre-tested by a qualified laboratory as to their suitability for use in slurry and conformance with project specifications. For materials placed by contract, Contractor shall be responsible for compliance with this section at Contractor's expense.

**27.02.2.06 Laboratory Report** The laboratory report shall show the results of tests performed on the individual materials, comparing their values to those required by this specification. The report shall provide the following information:

**TABLE 27.02.2.06.1  
REQUIRED LABORATORY REPORT INFORMATION**

Wet Track Abrasion Test - 6 day soak*	75g/ft <sup>2</sup> max	ISSA T100
Sand Adhesion by Loaded Wheel Tester	50g/ft <sup>2</sup> max	ISSA T109
Asphalt Content (based on dry aggregate)	7.5% - 13.5%	ISSA A105
Determination of Emulsion Content by Graphical Method		ISSA T111

**\*1 hour soak test not allowed as a substitute**

**27.02.2.07 Mix Design Submittals**

**27.02.2.07.1 General** Before work commences, a mix design, signed and stamped by a Professional Engineer licensed to practice Civil Engineering, covering the specific materials to be used shall be submitted to the Project Manager. This design shall be prepared by an independent laboratory qualified in slurry seal mix design and testing. Once the materials are selected, no substitution will be permitted, unless first tested and approved by the laboratory preparing the mix design. The report shall include the laboratory testing results and laboratory reports per Sections 27.02.2.05 and 27.02.2.06.

**27.02.2.07.2 Mix Design** The qualified laboratory shall develop the job mix design and present certified test results to the Project Manager. Compatibility of the aggregate and emulsion shall be verified by the mix design. All component materials used in the mix design shall be representative of the material proposed for use on the project.

**27.02.2.07.2.01 Specifications** The Project Manager shall review the design mix and all materials and methods prior to use. The component materials shall be within the following limits.

**TABLE 27.02.2.07.2.01.1  
COMPONENT MATERIAL MIX LIMITS**

Residual Asphalt	Type I: 10 - 16% Type II: 7.5 - 13.5% Type III: 6.5 - 12% (Based on dry weight of aggregate)
Mineral Filler	0% to 3% by dry weight of aggregate
Additive	As required to provide the specified properties
Water	As required to produce proper mix consistency. (Total mix liquids should not exceed the loose aggregate voids. ISSA T106 shall be used to check optimum liquids.)

**27.02.2.07.2.02 Trial Mix Characteristics** A sufficient number of variations of the mix design shall be shown to provide the applicator with an indication of the effects of changing filler rate, additive rate, etc.

**TABLE 27.02.2.07.2.02.1  
TRIAL MIX CHARACTERISTICS**

Mix Characteristics	No excess free liquids in mix No excessively dry or stiff mix	ISSA T113/3.5
Mix Time at 77°F	180 seconds minimum	ISSA T113/3.6
Mix Time at 100°F	120 seconds minimum	ISSA T113/3.6
Set Time at 77°F		
Displacement	30 minutes maximum	ISSA T113/3.7
Clear blot	30 minutes maximum	ISSA T113/3.8

**Cured Trial Mix Evaluation (24hr-77°F cured mix from ISSA T113/3.6 - 30 second mix)**

A sufficient number of variations shall be shown to provide the applicator with an indication of the effects of changing filler rate, additive rate, etc.



**TABLE 27.02.2.07.2.02.2  
CURED TRIAL MIX EVALUATION REQUIREMENTS**

Surface Examination	No tackiness No shininess	ISSA T113/4.1
Fines Flotation	No fines flotation	ISSA T113/4.2
Internal Adhesion	95% minimum coating, all size particles securely held in mix, asphalt/aggregate segregation	ISSA T113/4.3

**Wet Stripping Test modified to a 10 minute boiling period (ISSA T114)  
(24hr 77°F cured mix from ISSA T113/3.6 - 30 second mix)**

A sufficient number of variations shall be shown to provide the applicator with an indication of the effects of changing filler rate, additive rate, etc.

**TABLE 27.02.2.07.2.02.3  
WET STRIPPING REQUIREMENTS**

Coated aggregate	ISSA T114	95% minimum coating
Integrity		report: solid, broken, crumbly, etc.
Cohesion Values at 77°F	ISSA T139	30 min 12 minimum 60 min (report this value) 2 hr. (report this value) 4 hr. (report this value) 24 hr. solid spin (26 in-lb)

**27.02.2.07.3 Job Mix Recommendation and Comments** The laboratory shall calculate the minimum slurry application rate for large stone embedment based on measured maximum aggregate size retained on #4 sieve and bulk dry density by rodding procedure.

The laboratory shall report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effect). The laboratory report must clearly show the proportions of aggregate, mineral filler (min. and max.), water (min. and max.), additive(s) (usage), and asphalt based on the dry aggregate weight.

A complete laboratory analysis and test report accompanied by abraded and unabraded slurry test samples shall be submitted to the Project Manager a minimum of two weeks prior to use. The Project Manager shall be allowed to observe all testing.

## 27.02.3 CONSTRUCTION REQUIREMENTS

**27.02.3.01 Public Notice** Public notification shall comply with Section 27.01.3.06. When slurry seal work is performed by contract, Contractor shall be responsible for compliance with all requirements for public notification.

**27.02.3.02 Work Limitations** In addition to the limitations in Section 27.01.3.07, slurry shall not be applied when any of the following weather conditions exist:

- When there is any danger the finished product will freeze before it cures completely.
- When the pavement and/or air temperature is 55°F or below.
- When precipitation is possible prior to complete cure of the mix.
- In the period following precipitation while puddles of water remain on the surface to be coated.

*Slurries that cure by evaporation shall not be placed during periods of abnormally high humidity, or when precipitation may fall within a few hours of placement.*

### 27.02.3.03 Equipment

**27.02.3.03.1 General** All equipment, tools, and machines used in the performance of this work shall be maintained in satisfactory working order at all times. Any equipment found to be defective and potentially affecting the quality of the slurry application shall be replaced.

**27.02.3.03.2 Slurry Mixing Equipment** The slurry mixing machine shall be a double shafted continuous flow mixing unit, capable of delivering accurate predetermined proportions of aggregate, water, and asphalt emulsion to a revolving spiraled multi-blade mixer tank, and of discharging the thoroughly-mixed product on a continuous basis. The aggregate shall be pre-wetted immediately prior to mixing with the emulsion. The mixing unit shall be capable of thoroughly blending all ingredients together without violent action. The mixing machine shall be equipped with suitable means of accurately metering each individual material being fed into the mixer. The units shall be equipped with approved devices so that the machine can be accurately calibrated and the quantities of materials used during any one period estimated. The mixing machine shall be equipped with a water pressure system, and fog type spray bar adequate

for completely fogging the surface with up to 0.055 gallons per square yard (depending on conditions and as directed by the Project Manager), immediately ahead of the spreading equipment. The machine shall be capable of mixing materials at preset proportions regardless of the speed of the machine engine, and without changing machine settings.

**27.02.3.03.3 Proportioning Devices** Individual volume or weight controls for proportioning each material to be added to the mix, i.e., aggregate, mineral filler, emulsified asphalt, and water shall be provided and properly marked. These proportioning devices are usually revolution counters, gate valves, or similar devices and are used in material calibration and regulating of materials output.

**27.02.3.03.4 Slurry Spreading Equipment** The spreader box shall be equipped to prevent loss of slurry seal from all sides and with a flexible rear strike-off. It shall have mechanical mixing augers in both the front and rear of the box. It shall be capable of producing a uniform surface along its full width. It shall have suitable means for side tracking to compensate for deviations in pavement geometry. Any type of drag used shall be approved by the Engineer and kept in a completely flexible condition at all times. The box shall be kept clean and buildup of asphalt and aggregate shall not be permitted.

**27.02.3.03.5 Surface Preparation Equipment** Suitable Power brooms, power blowers, air compressors, and hand brooms for cleaning the base surface and cracks therein shall be supplied.

**27.02.3.03.6 Auxiliary Equipment** Hand squeegees, shovels, and other equipment necessary to perform this work shall be provided in suitable condition.

#### **27.02.3.04 Surface Preparation**

**27.02.3.04.1 Tack Coat** A tack coat will be required when the surface is extremely dry and raveled, concrete, brick, or as otherwise determined by the Project Manager.

When a tack coat is required, the tack coat shall consist of two part emulsion, to two parts water. The emulsion to be used shall be the same emulsion used for the specific surface treatment. Tack coat emulsion shall be applied with an asphalt distributor capable of applying the tack coat

evenly across the pavement surface at a rate of 0.05 to 0.10 gallons per square yard. The application rate shall range between 0.05 and 0.10 gallons of the diluted emulsion per square yard of surface area. Tack shall be evenly distributed across the pavement surface. The tack coat shall be allowed to break prior to application of the surface treatment.

The distributor, when not spreading, shall be parked so that the spray bar or mechanism will not drip bituminous materials onto the surface of the street, gutters or private property. During all applications, the surface of adjacent structures shall be protected in such a manner as to prevent their being spattered or marred. Any areas inaccessible to the distributor shall be sprayed by hand. All sidewalks, gutters or other surfaces where spatter is excessive, in the opinion of the Project Manager, shall be immediately cleaned to the satisfaction of the Project Manager.

**27.02.3.05 Application of Materials**

**27.02.3.05.1 Composition** The amount of asphalt emulsion to be blended with the aggregate shall be determined in the laboratory, subject to final adjustment in the field to allow for absorption by the existing surface. The amount of water added must be controlled accurately to insure production of product that can be readily applied, yet remain a completely stable slurry.

**TABLE 27.02.3.05.1.1  
MATERIAL APPLICATION RATES**

SLURRY MIX TYPE	LOCATION	APPLICATION RATE
Type I	Parking Areas, Rural and low volume Residential Streets	8-12 lb/yd <sup>2</sup>
Type II	Residential and Low Volume Collector Streets	16-20 lb/yd <sup>2</sup>
Type III	High Volume Collector and Arterial Streets	20-30 lb/yd <sup>2</sup>

Proper water content shall be determined by an appropriate consistency test on freshly made slurry using ISSA T 106 procedures.

**27.02.3.05.1.01 Mix Stability** The slurry mixture shall be sufficiently stable during the entire mixing/spreading period so that premature breaking of the material in the spreader box does not occur. The mixture shall be homogenous during and following mixing and spreading; it shall be free of excess water or emulsion and free of segregation of the emulsion and aggregate fines from the

coarse aggregate. Total time of mixing, from introduction of emulsion to spreading shall be two minutes or less.

**27.02.3.05.1.02 Quantities** For estimating purposes, the following proportions and application rates are assumed:

Dry Aggregate Spread Rate	18 - 20 lb./SY
% Mineral Filler *	1.00%
% Asphalt Content *	8.0%

\* By dry weight of aggregate

A test strip of 60 square yards shall be placed in the area designated by the Project Manager. The test section shall be placed using the same equipment and methods to be used on the job. Slurry mixtures placed in test strips shall conform to design mix with minor variations to obtain crack filling, bond to pavement, and desired skid resistant texture. In the event the materials do not meet the requirements for fluidity, non-segregation, or surface texture, a new job mix shall be formulated and tested. Work shall not proceed before approval of a design mix, application rates, and acceptance of the test strip.

### **27.02.3.05.2 Application of Slurry Mix**

**27.02.3.05.2.01 General** The surface shall be fogged with water directly preceding the spreader if required. The slurry mixture shall be of the desired consistency as it leaves the mixer, and no additional elements shall be added. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that complete coverage is obtained. No lumping, balling, or unmixed aggregates shall be permitted. No segregation of the emulsion and aggregate fines from the coarse aggregate will be permitted. If the coarse aggregate settles to the bottom of the mix, the slurry will be removed from the surface. No excessive breaking of the emulsion will be allowed in the spreader box. No streaks, as caused by oversized aggregate, will be left in the finished pavement. Rippling of the finished surface is undesirable and shall be minimized.

**27.02.3.05.2.02 Joints** No excessive build-up or unsightly appearance shall be permitted on longitudinal or transverse joints. Burlap drags or other type drags may be required at the discretion of the Project Manager. When drags are used, they must be kept relatively clean and free of excessive build-up. Joints shall be straight and have a neat appearance.

**27.02.3.05.2.03 Hand Work** Approved squeegees shall be used to spread slurry in areas not accessible to the slurry mixer. Every effort shall be made to minimize segregation during hand work. Material shall be placed as close to final position as practicable to reduce the amount of hand work. Care shall be exercised as to leave a pleasing appearance.

**27.02.3.05.2.04 Lines** Care shall be taken to insure straight lines along curbs, shoulders, and joints. No runoff on these areas will be permitted. Lines at intersections will be kept straight to provide a good appearance. At no point shall the limits of the slurry mix be spread greater than two inches beyond the lip of curb.

**27.02.3.05.2.05 Curing** Slurry surfacing shall be completed within a time frame to allow opening of the roadway, parking lot, or other resurfaced area within normal working hours, while providing sufficient cure time. The goal is a 4 hour break time for traffic.

**27.02.3.05.2.06 Machine Speed** In order to minimize rippling, slurry machines shall not be permitted to travel in excess of 220 ft/min. This speed may be further reduced by the Project Manager if excessive rippling of the surface, due to machine speed, occurs.

**27.02.3.05.2.07 Rolling** Slurry Seal shall be rolled by a self-propelled, 10-ton pneumatic roller with a tire pressure of 50 PSI (3.4 ATMS), equipped with a water spray system. The surface areas shall be subjected to a minimum of two (2) full coverage passes by the roller. Rolling shall not commence until the slurry has cured enough so that it will not pick up on the tires of the roller.

**27.02.3.06 Manholes, Valve Boxes and Survey Monuments** All shall be protected as specified in Section 27.01.3.02.

**27.02.3.07 Quality Control** In addition to the requirements of Section 27.01.3.03, samples of materials and of the finished slurry surface shall be furnished as directed by the Project Manager during progress of the work at no expense to the City. Test reports shall be required as additional materials arrive. The Project Manager will conduct testing as required during the project.

**27.02.3.08 Storage Site Requirements** On or near job site storage may be approved by the Project Manager. Selected sites and permissions to use said sites shall comply with Section 27.01.3.04.

**27.02.3.09 Traffic Control** All traffic control shall conform to Section 27.01.3.05.

## 27.03 Chip Seal

**27.03.1 SCOPE** This item shall consist of furnishing all labor, materials, and equipment necessary to complete, in place, the application of polymerized emulsified asphalt and a cover coat of aggregate to street surfaces.

### 27.03.2 MATERIAL REQUIREMENTS

**27.03.2.01 Asphalt Emulsion** Polymerized cationic rapid set emulsified asphalt (CRS-2P), or equivalent, shall be an emulsified blend of polymerized asphalt, water, emulsifiers, and polymer. The asphalt cement shall be polymer modified prior to emulsification and shall contain a minimum of 3% styrene-butadiene-styrene (SBS) block copolymer by weight of asphalt cement. The emulsion, standing undisturbed for a minimum of 24 hours, shall show no milky white separation, but shall be smooth and homogeneous throughout. The emulsion shall be pump able and suitable for application through a distributor truck. The CRS-2P shall conform to the following specifications.

#### 27.03.2.01.1 Tests on Emulsion

**TABLE 27.03.2.01.1.1  
CHIP SEAL EMULSION TEST REQUIREMENTS**

Emulsion Test	Minimum	Maximum	Test Method
Viscosity, Saybolt Furol, 122° F,s	80	400	ASTM D88
Storage Stability Test, 24-h,%(a)		1	ASTM D244
Demulsibility, 36 ML, 0.8% dioctyl sodium Sulfosuccinate, % (c)	40		ASTM D244
Particle Charge Test	Positive		ASTM D244
Sieve Test, %(a)		0.1	ASTM D244
Distillation: (b)			ASTM D244
Oil Distillate, by Volume of Emulsion, %		3	ASTM D244
Residue, %	60		ASTM D244

- a) This test requirement on representative samples is waived if successful application of the material has been achieved in the field.
- b) Residue by evaporation at 325 °F shall be the reference method to obtain material for tests on residue. Residue from distillation shall not be used for tests on residue due to polymer degradation at 500 °F.

**27.03.2.01.2 Tests on Residue**

**TABLE 27.03.2.01.2.1  
CHIP SEAL RESIDUE TEST REQUIREMENTS**

<b>Residue Test</b>			
Penetration, 77°F, 100g, 5s	70	150	ASTM D5
Ductility, 77°F, 5 cm/min, cm	75		ASTM D113
Ductility, 39.5°F, 5 cm/min, cm	25		ASTM D113
Solubility in Trichloroethylene, %	97.5		ASTM D2042
Toughness, in-lb	70		ASTM D5801
Tenacity, in-lb	45		ASTM D5801
Elastic Recovery, 77° F, 10cm,1h,%	80		ASTM D5976

- a) This test requirement on representative samples is waived if successful application of the material has been achieved in the field.
- b) Residue by evaporation at 325 °F shall be the reference method to obtain material for tests on residue. Residue from distillation shall not be used for tests on residue due to polymer degradation at 500 °F.
- c) The Demulsibility test shall be made within 30 days from the date of shipment
- d) Distillation shall be determined by AASHTO test T 59, oven evaporation method.
- e) The asphalt cement shall be polymerized prior to emulsification.
- f) Contractor shall supply samples for testing upon request of the City.
- g) The material shall be accepted at the distributor.

A one-quart sample of the final emulsion shall be submitted upon request. The source of the base asphalt, polymer, additives, and supplier shall be stated on the sample and shall not change during the course of construction.

**27.03.2.01.3 Emulsion Storage** Suitable storage facilities and containers for the asphalt emulsion shall be provided and shall be equipped to prevent water from entering the emulsion. If necessary, suitable heat shall be provided to prevent freezing.

**27.03.2.02 Aggregate Cover Coat Material (Chip Seal)** The chip, or aggregate cover coat, shall be washed, hard, durable, clean rock and free from coatings or deleterious material and clay balls. The presence of oversized material and/or clay balls shall be grounds for the project to be stopped. All of the aggregate shall be crushed gray granite with 100% fractured faces. The aggregate shall have a loss of no greater than 20% when tested with the LA Abrasion procedure as defined by ASTM C131, grade C or D. Only one type of aggregate shall be used and shall conform to the following gradations. The aggregate shall be gray in color.



**27.03.2.02.1 Gradation** The total cover aggregate shall be tested and conform to the following gradation:

**TABLE 27.03.2.02.1.1  
CHIP SEAL AGGREGATE GRADATION**

<b>Sieve Size</b>	<b>½" Chip Seal</b>	<b>3/8" Chip Seal</b>	<b>¼" Chip Seal</b>
¾"	100	100	100
5/8"	100	100	100
½"	95-100	100	100
3/8"	0-60	95-100	100
¼"	0-10	0-35	95-100
No. 8	0-3	0-3	0-3
No. 200	0-1.2	0-1.2	0-1.2

**27.03.2.02.2 Bituminous Film** When tested in accordance with (ASTM D 1664), the aggregate shall have a retained bituminous film above 95%. Aggregates that do not meet this requirement may be used for surface treatments and seal coats provided a satisfactory chemical additive or wetting agent is used to provide a water-resistant film. Use of chemical additives or wetting agents is subject to prior approval by the Project Manager.

**27.03.2.02.3 Moisture Content** The cover coat material shall be moistened with water to eliminate or reduce any dust coating of the aggregate. This will eliminate surface tension between the aggregate and the emulsified oil which improves the bond. The moisture content of the cover aggregate at the time of application shall not exceed 2% of the weight of dry aggregate.

**27.03.2.02.4 Stockpiling of Aggregate** Precautions shall be taken to insure that stockpiles are carefully mixed just prior to use to insure uniform distribution of the moisture, and that they do not become contaminated with over-sized seed rock, clay, silt, or excessive amounts of moisture. The stockpile shall be kept in areas that drain readily. If oversize material is present, screening will be required prior to delivery to the spreader.

**27.03.2.03 Laboratory Testing** Sources of all materials shall be selected and identified. All materials shall be pre-tested by a qualified laboratory as to their suitability for use in chip seal and conformance with project specifications. For materials placed by contract, Contractor shall be responsible for compliance with this section at Contractor's expense.

**27.03.2.04 Laboratory Report** The laboratory report shall show the results of tests performed on the individual materials, comparing their values to those required by this specification.

**27.03.3 CONSTRUCTION REQUIREMENTS**

**27.03.3.01 Public Notice** Public notification shall comply with Section 27.01.3.06. When chip seal work is performed by contract, Contractor shall be responsible for compliance with all requirements for public notification.

**27.03.3.02 Work Limitations** In addition to the work limitations specified in Section 27.01.3.07, no construction of a chip seal application shall occur when either the ambient or pavement surface temperature fall below the table below or when the pavement is moist or when the weather is or may be detrimental. Detrimental weather is defined as rain showers, cool temperatures, moist pavements, threat of rain showers, or other environmental factors which could affect the performance of the chip seal. Emulsion application rate shall be adjusted accordingly, depending on current temperatures within the material application specifications.

**TABLE 27.03.3.02.1  
CHIP SEAL TEMPERATURE LIMITATIONS**

TEMPERATURE	½" Chip seal	3/8" Chip seal	¼" Chip seal
Surface Temperature (minimum)	≥65°F	≥65°F	≥60°F
Ambient Temperature (daily high)	≥70°F	≥70°F	≥65°F

**27.03.3.03 EQUIPMENT**

**27.03.3.03.1 General** The size and condition of all equipment shall be approved prior to construction. Should any equipment be unsatisfactory for whatever cause, the equipment shall be removed and replaced without delay or cost. The equipment shall conform to the following minimum requirements.

**27.03.3.03.2 Bituminous Distributor:** A minimum of two (2) like distributors shall be used. The distributors shall be self-powered and capable of providing a uniform application rate of emulsion varying from .05-1.00 gallons per square yard over a variable width up to twenty feet in a single pass. The uniformity of the distributors shall not vary by more than two-hundredths (0.02) gallons per square yard. The distributors shall be equipped with a variable power unit for the pump and full circulation spray bars, which are adjustable laterally and vertically. The nozzle angle and bar height shall

be set to provide one hundred percent of double coverage in a single pass. Where multiple passes are required to complete the full width, the four inches adjacent to the second pass may be left with fifty percent coverage so that the next pass will complete the full application rate specified. Distributors shall be self-powered and include computerized application controls, a tachometer, pressure gauges, accurate volume devices, calibrated tank, and a thermometer for measuring temperatures of the emulsion in the tank. Necessary precautionary measures shall be taken to prevent diesel fuel or other cleaning solvents from contaminating bituminous material.

**27.03.3.03.3 Aggregate Spreader** The aggregate spreader shall be self-propelled and supported by at least four tires on two axles capable of providing a uniform application rate of aggregate from five to fifty pounds per square yard over a variable width up to twenty feet in a single pass. The uniformity of this machine shall not vary by more than one pound per square yard. The aggregate spreader shall be equipped with the means of applying the cover coat material to the surface with computerized application controls so that the required amount of material will be deposited uniformly over the full width of the bituminous material. A computerized rate control aggregate spreader shall be required. Other types of aggregate spreaders may be used provided they accomplish equivalent results and are previously approved.

**27.03.3.03.4 Rollers** A minimum of two (2) rubber-tired rollers shall be used on the project unless otherwise requested by the Project Manager. The pneumatic tired rollers shall be self-propelled and the gross load adjustable to apply 200 to 350 pounds per inch of rolling width, as directed. Tire pressures or contact pressures may be specified for the pneumatic tire rollers. Tire pressures on each roller shall not vary more than plus or minus 2.0 psi. The wheels on the rollers shall be equipped with adjustable scrapers, which shall be used when necessary to clean the wheel surface. Depending on the speed of the chip seal operation and the width of coverage, additional rollers may be required. At no time shall the rollers travel more than ten miles per hour. The rollers shall be maintained in good condition and be operated by experienced roller operators.

**27.03.3.03.5 Sweepers** A rotary broom or other approved sweeping or blowing equipment meeting applicable U.S. Environmental Protection Agency Standards shall be used to windrow excess material to be picked up. A minimum of two (2) vacuum designed sweepers having only negative air pressure at the road surface capable of removing excess aggregate and debris material shall be used on this project. The body hoppers of the vacuum sweepers shall have a minimum capacity of ten cubic yards, and the negative air pressure at the intake shall be rated at forty six inches of negative water pressure. Sweepers shall meet applicable U.S. Environmental Protection Agency Standards. No mechanical pick-up brooms will be allowed on the project.

**27.03.3.04 SURFACE PREPARATION** All surface preparations and cleaning shall be covered in Accordance with Section 27.01.3.01.

**27.03.3.05 APPLICATION OF MATERIALS**

**27.03.3.05.1 General** The specific emulsion and cover aggregate application rate shall be determined using factors such as surface temperature, traffic volume, existing road condition, and time of year. The application rate may be modified at any time during the course of the construction upon approval by the Project Manager. The following table provides general application rates.

**TABLE 27.03.3.05.1.1  
CHIP SEAL MATERIAL APPLICATION RATES**

<b>Material</b>	<b>1/2" Chip</b>	<b>3/8" Chip</b>	<b>1/4" Chip</b>
<b>CRS-2P-Chipseal</b>	0.40-0.45 Gal/SY	0.35-0.40 Gal/SY	0.29-0.33 Gal/SY
<b>CRS-2P-Fogseal</b>	0.12 Gal/SY min	0.11 Gal/SY min	0.10 Gal/SY min
<b>Aggregate</b>	24lbs./SY min	22lbs/SY min	20lbs/SY min

**Test Section** - A 200 square yard test section shall be placed to determine actual application rates of aggregates and emulsion.

**27.03.3.05.2 Emulsion Application** Bituminous material shall be applied by means of a pressure distributor in a uniform, continuous spread over the section to be treated and within the temperature range of 125 -185° F. The quantity of bituminous material to be used per square yard shall be as specified. The distributor shall be moving forward at the proper application speed at the time the spray bar is opened. If the cut-off is not positive, the use of paper may be required at the end of each spread. The

paper shall be disposed of in a lawful manner. Any skipped areas or deficiencies shall be corrected. Junctions of spreads shall be carefully made to assure a smooth riding surface.

The length of spread of bituminous material shall not be in excess of that which trucks loaded with cover coat material can immediately cover.

The spread of bituminous material shall not be more than four (4) inches wider than the width covered with aggregate from the spreading device and shall not spread onto the concrete gutter pan. Under no circumstances shall operations proceed in such a manner that the bituminous material be allowed to chill, set up, dry or otherwise impair retention of the cover coat. Application rate shall be sufficient to prevent streaked appearance in the final surface.

The distributor, when not spreading, shall be parked so that the spray bar or mechanism does not drip bituminous materials onto the surface of the street, gutters or private property. During all applications, the surface of adjacent structures shall be protected in such a manner as to prevent their being spattered or marred. Any areas inaccessible to the distributor shall be sprayed by hand. All sidewalks, gutters or other surfaces where spatter is excessive, in the opinion of the Project Manager, shall be immediately cleaned to the satisfaction of the Project Manager.

**27.03.3.05.3 Aggregate Application** Immediately following the application of bituminous material, aggregate cover material shall be spread in quantities as designated. Spreading shall be accomplished in such a manner that the tires of the trucks or aggregate spreader at no time contact the uncovered and newly applied bituminous material. The aggregate shall not be applied in such a thickness as to cause blanketing.

If directed by the Project Manager, the cover coat material shall be moistened with water, not to exceed 2% by weight, to eliminate or reduce the dust coating of the aggregate; however, excess dust will be a cause for rejection of the aggregate. Immediately after the cover coat is spread, any deficient areas shall be covered by additional material.

**27.03.3.05.4 Armor Coat (Fog Seal) Application** Three days after the application of the chip seal, or as directed by the Project Manager, all excess

aggregate shall be swept from the roadway and adjacent areas and then a fog seal of diluted CRS-2P applied to all areas chip sealed. The CRS-2P emulsion shall be diluted 40 percent with water. The application rate shall comply with the minimums in the table above or as deemed necessary by the Project Manager.

**27.03.3.06 Rolling** Rolling shall begin with a minimum of two self-propelled, pneumatic-tired rollers. Rolling shall proceed in a longitudinal direction, beginning at the outer edges of application and working toward the center. Each pass shall overlap the previous pass by one-half of the width of the front wheel or roll. There shall be a minimum of three (3) passes with the pneumatic-tired rollers over the entire surface prior to moving ahead. One pass will be considered the number of trips to cover the entire surface from one side of the street to the other and for the length being worked. The first rolling of the aggregate shall be made before the asphalt emulsion breaks (roller shall complete the first rolling within approximately two and one-half (2 ½) minutes of the emulsion spray application). In no event shall traffic be allowed on the treated surface until all rolling has been completed.

**27.03.3.07 Sweeping** After the application of the cover coat material excess material shall be removed from the entire surface, sidewalks and adjacent streets by means of approved brooms and or street sweepers within 24 hours. Excess aggregate that is clean may be stockpiled and re-used in subsequent locations at the discretion of the Project Manager. The Project Manager may reject aggregate that has been previously applied by visual observation of the stockpile.

**27.03.3.08 Manholes, Valve Boxes and Survey Monuments** Locating, protecting and cleaning for manholes, valve boxes, survey monuments, etc. shall conform to Section 27.01.3.02.

**27.03.3.09 Quality Control** In addition to the requirements of Section 27.01.3.03, samples of materials and of the finished chip seal surface shall be furnished as directed by the Project Manager during progress of the work at no expense to the City. Test reports shall be required as additional materials arrive. The Project Manager will conduct testing as required during the project.

**27.03.3.10 STORAGE SITE REQUIREMENTS** On or near job site storage may be approved by the Project Manager. Selected sites and permissions to use said sites shall comply with Section 27.01.3.04.

**27.03.3.11 TRAFFIC CONTROL** In addition to the requirements of Section 27.01, 4x4 warning signs shall be provided, posted and maintained for a period of seven (7) days at the beginning of chip sealed streets and at 1,500 foot intervals in both directions. The signs shall warn drivers to slow down, loose gravel and shall be lighted. Temporary Raised Pavement Markers shall be installed as needed and shall conform to the requirements in Section 27.01.3.05.

## 27.04 Cape Seal

**27.04.1 SCOPE** This item shall consist of all labor, equipment, material, supplies, raised markers, signage, traffic control, and other incidentals necessary to provide a Cape Seal satisfactory to the Project Manager. The work shall consist of placing a standard chip seal followed by an application of an additional cover coat of standard slurry seal.

Chip seal and slurry seal layers of a cape seal application shall be paired as indicated in the following table, unless otherwise approved by the Project Manager.

**TABLE 27.04.1.1  
CHIP SEAL AND SLURRY SEAL LAYERS  
for  
CAPE SEAL APPLICATION**

Chip Seal Type	Slurry Seal Type
1/4" Aggregate	Type I
3/8" Aggregate	Type I or Type II
1/2" Aggregate	Type II or Type III

### 27.04.2 MATERIAL REQUIREMENTS

**27.04.2.01 Tack Coat** A tack coat may be required by the Project Manager between the existing surface and the chip seal layer or between the chip seal layer and the slurry seal layer, or both. If a tack coat is required, the material, equipment and application shall conform to Section 27.01.

**27.04.2.02 Chip Seal Layer** Materials used in the chip seal layer of a cape seal application shall comply with all requirements of Section 27.03.2.

**27.04.2.03 Slurry Seal Layer** Materials used in the slurry seal layer of a cape seal application shall comply with all requirements for Section 27.02.2.

**27.04.3 CONSTRUCTION REQUIREMENTS**

**27.04.3.01 Work Limitations** In addition to the work limitations specified in Section 27.01.3.07, no construction of a cape seal application shall occur when either the ambient or pavement surface temperature fall below the table below or when the pavement is moist or when the weather is or may be detrimental. Detrimental weather is defined as rain showers, cool temperatures, moist pavements, threat of rain showers, or other environmental factors which could affect the performance of the cape seal. Emulsion application rate shall be adjusted accordingly depending on current temperatures within the material application specifications.

**TABLE 27.04.3.01.1  
CAPE SEAL TEMPERATURE LIMITATIONS**

TEMPERATURE	1/2" Cape Seal	3/8" Cape Seal	1/4" Cape Seal
Surface Temperature (minimum)	≥ 65°F	≥ 65°F	≥ 60°F
Ambient Temperature (daily high)	≥ 70°F	≥ 70°F	≥ 65°F

**27.04.3.02 Chip Seal Layer** Construction of the chip seal layer of a cape seal application shall comply with all requirements of Section 27.03.3 with the following exceptions:

**FOG SEAL** – Application of a fog seal coat to the chip seal layer of a cape seal application is not required.

**MATERIAL APPLICATION RATES** – Material application rates shall be as specified below in Section 27.04.3.04.

**27.04.3.03 Slurry Seal Layer** Construction of the slurry seal layer of a cape seal application shall comply with all requirements of Section 27.02.3.

**APPLICATION OF SLURRY MIX** – In addition to the requirements of Section 27.02.3, the slurry seal layer shall be applied within two weeks of completion of the chip seal layer application. The chip seal surface shall be broomed prior to application of the slurry seal layer in accordance with Section 27.03.3.

**MATERIAL APPLICATION RATES** – Material application rates shall be as specified below in Section 27.04.3.04.

**WEATHER LIMITATIONS** – Weather limitations shall be as specified in Section 27.04.3.01.



**27.04.3.04 Material Application Rates** Specific emulsion and aggregate application rates shall be determined using factors such as surface temperature, traffic volume, existing road and weather conditions, and time of year. Application rates may be altered at any time during the course of the work with approval of the Project Manager. General application rates are as follows:

**TABLE 27.04.3.04.1  
CAPE SEAL MATERIAL APPLICATION RATES**

<b>Material</b>	<b>1/2" Chip seal</b>	<b>3/8" Chip seal</b>	<b>1/4" Chip seal</b>
CRS-2P Chip seal Emulsion	0.40-0.45 Gal/SY	0.35-0.40 Gal/SY	0.29-0.33 Gal/SY
Cover Aggregate	24lbs./SY min	22lbs/SY min	20lbs/SY min
Type I Slurry	N/A	8-12 lb/SY	8-12 lb/SY
Type II Slurry	16-20 lb/SY	16-20 lb/SY	N/A
Type III Slurry	20-30 lb/SY	N/A	N/A

## **27.05 Hot Chip Seal**

**27.05.1 SCOPE** This work shall furnish all labor, equipment, material, supplies, raised markers, signage, traffic control, and other incidentals necessary to provide a Hot Chip Seal satisfactory to the Project Manager. The work shall consist of placing a standard chip seal followed by an application of an additional cover coat material (hot chip) placed by an asphalt paver.

### **27.05.2 MATERIAL REQUIREMENTS**

**27.05.2.01 Chip Seal Layer** Materials used in the chip seal layer of a hot chip seal application shall comply with all requirements of Section 27.03.2.

**27.05.2.02 Fog Seal** A fog seal will be required by the Project Manager between the chip seal layer and the hot chip seal layer.

**27.05.2.03 Hot Chip Layer** The aggregate of the hot chip seal layer of a hot chip application shall consist of washed, hard, durable, clean rock and free from coatings or deleterious material and clay balls. The presence of oversized material and/or clay balls shall be grounds for the project to be stopped. All of the aggregate shall be crushed gray granite with 100% fractured faces. The aggregate shall have a loss of no greater than 20% when tested with the LA Abrasion procedure as defined by ASTM C131, grade C or D. Only one type of aggregate shall be used and shall conform to the gradations below.

The hot chip seal layer shall conform to the following gradations based on percent passing. A mix design shall be submitted for approval that conforms to the following:

**TABLE 27.05.2.03.1  
HOT CHIP SEAL AGGREGATE GRADATION**

Sieve Size	1/2" Cover Coat Material	3/8" Cover Coat Material
3/4"	100 %	100 %
1/2"	90-100 %	100 %
3/8"	60-90 %	100 %
1/4"	N/A	25-60 %
No. 4	25-35 %	25-35 %
No. 8	15-25 %	15.25 %
No. 200	3-8 %	3-8 %
Asphalt Content (PG 64-22)	5.0 % to 5.5%	5.5% to 6.0%

Mix Design submittals shall conform to Section 24.04 of City of Aurora Roadway Design & Construction Specifications.

**27.05.3 CONSTRUCTION REQUIREMENTS**

**27.05.3.01 Work Limitations** In addition to the work limitations specified in Section 27.01.3.07, no construction of a hot seal application shall occur when either the ambient or pavement surface temperature fall below the table below or when the pavement is moist or when the weather is or may be detrimental. Detrimental weather is defined as rain showers, cool temperatures, moist pavements, threat of rain showers, or other environmental factors which could affect the performance of the hot chip seal. Emulsion application rate shall be adjusted accordingly depending on current temperatures within the material application specifications.

**TABLE 27.05.3.01.1  
HOT CHIP SEAL TEMPERATURE LIMITATIONS**

TEMPERATURE	1/2" Hot Chip	3/8" Hot Chip
Surface Temperature (minimum)	50°F	50°F
Ambient Temperature (daily high)	60°F	60°F

**27.05.3.02 Chip Seal Layer** Construction of the chip seal layer of a hot chip application shall comply with all requirements of Section 27.03.3 with the following exceptions:

**MATERIAL APPLICATION RATES** – Material application rates shall be as specified below in Section 27.05.3.04.

**WEATHER LIMITATIONS** – Weather limitations shall be as specified in Section 27.05.3.01.

### **27.05.3.03 CONSTRUCTION REQUIREMENTS**

**27.05.3.03.1 Public Notice** All notification measures shall comply with Section 27.01.3.06.

**27.05.3.03.2 Quantities of Materials** Application rates of hot chip layer materials used in a hot chip seal application shall be as specified below in Section 27.05.3.04.

**27.05.3.03.3 Work Limitations** In addition to the requirements of Section 27.01.3.07, hot chip layer material shall not be applied on a wet surface, or when the air temperature is below 50° F or the pavement temperature is below 50° F, unless otherwise specified, or when weather conditions would prevent the proper construction of the hot chip layer.

#### **27.05.3.03.4 EQUIPMENT**

**27.05.3.03.4.01 General** The size and condition of all equipment shall be approved prior to construction. All equipment deemed unsatisfactory by the Project Manager, for whatever cause, shall be removed and replaced without delay or cost. The equipment shall conform to the following minimum requirements.

**27.05.3.03.4.02 Asphalt Paver** The hot chip seal shall be placed by a type of paver used for the placement of hot asphalt material. The paver shall be self-contained, power propelled units provided with an adjustable activated screed, heated and capable of spreading and finishing course material on variable widths of surface up to 18 feet.

**27.05.3.03.4.03 Rollers** A minimum of two steel wheel rollers will be used to seat the Hot Chip seal. The steel drum rollers shall be double drum rollers with a loaded rate of five tons. At no time shall the rollers travel more than ten miles per hour.

**27.05.3.03.4.04 Sweepers** A minimum of two vacuum designed sweepers having only negative air pressure at the road surface capable of removing excess aggregate and debris material shall be used on this project. The body hoppers of the vacuum sweepers shall be a minimum capacity of ten cubic yards, and the negative air pressure at the intake shall be rated at forty six inches of

negative water pressure. Sweepers shall meet applicable U.S. Environmental Protection Agency Standards. No mechanical pick-up brooms will be allowed on the project.

**27.05.3.03.5 Surface Preparation** The street shall be swept and cleaned before hot chip seal applications. The surface and gutter shall be cleaned and all debris removed for the full width to be treated immediately prior to application of the bituminous material. Dust and other material in depressions or other places not removed by mechanical sweepers shall be swept with hand brooms or removed by use of flushers. The Project Manager may require washing of the pavement where other methods of cleaning do not provide an acceptable surface. Material removed from the surface shall not be mixed with the cover aggregate. Bituminous material shall not be spread until the area to receive chip seal application has been cleaned to the satisfaction and approval of the Project Manager.

All vegetation shall be removed from the surface to be sealed prior to any hot chip seal placement. Vegetation shall be removed no earlier than two weeks prior to application of the hot chip seal layer. Any dead or remaining vegetation shall be removed before sweeping and applying the hot chip seal layer. Vegetation may be removed by burning when in the opinion of the Project Manager such burning causes no safety hazard or air pollution nuisance.

**27.05.3.03.6 Application of Hot Chip Seal Layer** The hot chip seal layer shall be applied within two weeks of the chip seal layer application and after the loose material has been swept up. The hot chip seal material shall have a minimum temperature of 275 °F. The hot chip seal shall be applied over the entire chip seal surface and struck off to the established grade and proper elevation. Application rate of this material shall be as specified in Section 27.05.3.04

A minimum of two steel wheel rollers making two or more passes shall follow immediately to seat and cool the material.

**27.05.3.03.7 QUALITY CONTROL** The hot chip seal layer of a hot chip seal application shall conform to testing and inspection requirements of Section 24.15.

**27.05.3.03.8 MANHOLES, VALVE BOXES AND SURVEY MONUMENTS**

Manholes, valve boxes and survey monuments in the area of the hot chip seal layer shall be protected and cleaned in Accordance with Section 27.01.3.02.

**27.05.3.03.9 TRAFFIC CONTROL** All traffic control for application of the hot chip seal layer of a hot chip seal application shall comply with Section 27.01.3.05.

**27.05.3.04 Application of Materials** Specific emulsion and aggregate application rates shall be determined using factors such as surface temperature, traffic volume, existing road and weather conditions, and time of year. Application rates may be altered at any time during the course of the work with approval of the Project Manager. General application rates are as follows:

**TABLE 27.05.3.04.1  
HOT CHIP SEAL MATERIAL APPLICATION RATES**

<b>Material</b>	<b>1/2" Chip seal</b>	<b>3/8" Chip seal</b>
CRS-2P Chip seal	.30-.40 Gal/SY	.28-.34 Gal/SY
Cover Coat Aggregate	22 – 28 lbs/SY	20 - 26 lbs/SY
Hot Chip seal	85 lbs/SY Minimum	75 lbs/SY Minimum

**27.06 Crack Seal**

**27.06.1 SCOPE** The intent of this specification is to specify materials and methods used for crack filling existing pavement surfaces throughout the City of Aurora. This work shall furnish all labor, equipment, material, supplies, raised markers, signage, traffic control, and other incidentals necessary to provide and place crack seal material satisfactory to the Project Manager. All work and materials shall be in accordance with the requirements of these specifications.

**27.06.2 MATERIAL REQUIREMENTS** Hot poured crack sealant shall conform to the requirements of ASTM D3405. Crack sealant material shall be supplied pre-blended, pre-reacted, and prepackaged. If supplied in solid form the sealant material shall be cast in a plastic or other dissolvable liner having the capability of becoming part of the crack sealing liquid. The sealant shall be delivered in the manufacturer’s original sealed container. Each container shall be legibly marked with the manufacturer’s name, the trade name of the sealer, the manufacturer’s batch or lot number, the application temperature range, the recommended application temperature, and the safe heating temperature. Each container or

portion of shall be saved and matched to the daily check-out log. These records shall be provided to the Project Manager.

### **27.06.3 CONSTRUCTION REQUIREMENTS**

**27.06.3.01 Public Notice** Signage for the purpose of public notification of impending work shall be furnished at all entrances to the work area the morning in advance of crack seal operations. Signs shall remain in place until removal is approved by the Project Manager. All signs shall conform to Section 27.01.3.06.

**27.06.3.02 Work Limitations** Crack fill materials shall not be placed during periods of adverse weather conditions or at times when the materials will not adhere to the cracked surface as directed by the manufacturer. Crack fill materials shall not be placed during such times or when directed by the Project Manager.

**27.06.3.03 Equipment** The equipment for heating the material shall be an indirect heating type double boiler using oil or other heat transfer medium and shall be capable of constant agitation. The heating equipment shall be capable of controlling the sealant material temperature within the manufacturer's recommended temperature range and shall be equipped with a calibrated thermometer capable of  $\pm 5$  °F accuracy from 200°F to 600 °F. This thermometer shall be located so the Project Observer can safely check the temperature of the sealant material. The machine shall be equipped with level indicators or other device that can accurately measure the quantity of material in the crack filling machine at any one time. All crack filling equipment shall be maintained in safe and working condition at all times. If, in the opinion of the Project Observer, the crack filling machine is not suitable for use and the above indicators are not operational, the Project Observer may require the equipment be removed from the jobsite and replaced with fully operational equipment.

**27.06.3.04 Surface Preparation** Cracks shall be cleaned and dried for the entire crack depth as much as practicable using such methods as brushing and air-blowing as required to provide a crack free from all debris, dust, loose material and moisture.

### **27.06.3.05 Application of Material**

**27.06.3.05.1 General** Crack fill material shall be heated and placed in accordance with manufacturer's recommendations. All cracks greater than one-quarter inch including transverse and longitudinal cracks shall be filled. These Cracks shall be filled with hot poured joint and crack sealant flush with the pavement surface. Immediately following the filling of the crack, excess sealant shall be leveled off at the wearing surface by squeegee, a shoe attached to the applicator wand, or other suitable means approved by the Project Manager. The squeegeed material shall be centered on the cracks and shall not exceed 3 inches in width or 1/16 inch in depth. Areas of alligator cracking shall not be sealed.

**27.06.3.05.2 Application of Crack Fill Material** Cleaned cracks shall be filled with sealant from the bottom to the surface and level in a manner, which does not result in sealant bridging or entrapped air pockets. With deep cracks, settlement of the sealant may occur and a second layer of sealant material shall be applied. Crack filler shall be placed in such a manner as to minimize overfilling of the cracks. Suitable equipment, such as squeegees, shall be used to remove excess crack filling material from the roadway surface.

A liquid specifically designed to prevent tracking of freshly applied crack seal material, such as "Glenzoil 20 Plus" or other suitable surface treatment as approved by the Project Manager, shall be applied to all cracks filled.

**27.06.3.06 TRAFFIC CONTROL** All necessary precautions shall be observed when placing crack filler material. All necessary traffic control devices and warning signs shall be supplied as required by the Traffic Engineer. Minimum requirements shall include, but not be limited to, an arrow board mounted on a truck or other approved vehicle following the material placement personnel and a chase vehicle following no greater than 50 feet behind the arrow board. Proper safety clothing for all of their employees on the project shall be provided in accordance with the Manual on Uniform Traffic Control Devices, including, but not limited to, safety vests, warning signs and barricades. Materials shall not be placed until these requirements are met.

Arrow boards pulled behind a mobile vehicle are required on all arterial streets in conjunction with a flagger walking with the sealing unit. Flaggers shall have no other duty than to direct traffic. Sufficient flaggers for traffic control shall be provided as directed by the Traffic Engineer.



**SECTION 29.00 THERMOPLASTIC PAVEMENT MARKINGS .....1**

29.00 Description.....1

29.01 Material.....1

29.02 Physical Properties .....1

29.03 Application .....2



# SECTION 29.00 THERMOPLASTIC PAVEMENT MARKINGS

## 29.00 Description

This work shall consist of furnishing and installing thermoplastic pavement markings to specified street segments after all street construction or designated street resurfacing is completed.

## 29.01 Material

The material manufacturer shall have the option of formulating the material according to their own specifications; however, the solid resin shall comprise a minimum of 8% by weight of the entire material formulation which shall only consist of 100% percent maleic-modified glycerol ester of resin. The physical and chemical properties contained in this specification shall apply regardless of the type of formulation used. The material upon heating to the application temperature shall not exude fumes that are toxic, or injurious to persons or property.

Glass beads (Pre-Mix) shall be free from air inclusions:

Refractive Index	1.50 Minimum
Spheres, %	80 Minimum
AASHTO M247 Type I	

The beads used in the formulation shall be smooth, clear and free from air inclusions and scratches that might affect their function as a reflecting media.

## 29.02 Physical Properties

**29.02.1 Specific Gravity** The specific gravity of the thermoplastic traffic line material shall not be less than 1.95 nor more than 2.15.

**29.02.2 Composition** The pigment, beads and filler shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements according to Table 29.02.2.1.

**TABLE 29.02.2.1 COMPOSITION**

<b>Component</b>	<b>By Weight</b>
Binder	18.0% Min.
Glass Beads	35.0% Min.
Titanium Dioxide	8.0% Min.
Calcium Carbonate & Inert Filler	SEE NOTE

NOTE: Amount of calcium carbonate and inert fillers shall be at the option of the manufacturer, providing all other requirements of the specification are met. The total silica used in the formulation shall be in the form of spherical glass traffic beads.

The binder shall consist of a mixture of synthetic resins, at least one of which is solid at room temperature, and high boiling point plasticizers. At least one-third of the binder composition shall be the solid maleic-modified glycerol ester of resin and shall be no less than 8% by weight of the entire material formulation. The binder shall not contain petroleum based hydrocarbon resins or similar derivatives.

**29.02.3 Other Ingredients** The other ingredients shall meet the following requirements:

**29.02.3.1** Titanium Dioxide: ASTM D 476-Type 2

**29.02.3.2 Color** - The thermoplastic material after heating for four hours at 218 C (425 F) and cooled to 25 C (77 F) shall meet the following:

**29.02.3.2.1 White:** Daylight reflectance (45 to 0 deg.). 75% Min.

**29.02.3.2.2 Drying Time** - When applied at a temperature range of 211 +/- 7 C (412 +/- 12.5 F) and thickness of 2.28mm (.090 in.) the material shall set to bear traffic in not more than two minutes when the air temperature is 10 C (50 F) and not more than 15 minutes when the air temperature is 32 C (90 F).

**29.02.3.2.3 Bond Strength** - After heating the thermoplastic material for four hours at 218C (425 F), the bond strength to Portland concrete shall exceed 180 psi (1.24 MPa).

**29.02.3.2.4 Impact Resistance** - After heating the thermoplastic material for four hours at 218 C (425 F) and tested, the impact resistance shall be a minimum of 10 inch pounds.

**29.02.3.2.5 Softening Point** - After heating the thermoplastic material for four hours at 218 C (425 F) and testing in accordance with ASTM D36, the materials shall have a softening point of 102.5 +/- 9.5 C (215 +/- 15 F).

**29.02.3.2.6 Yellowness Index** - The white thermoplastic material shall not exceed a yellowness index of 0.15.

## **29.03 Application**

The thermoplastic material shall be applied to the pavement by an extrusion method.

The finished lines shall have well defined edges and be free of waviness. All of the equipment necessary to the preheating and application of the material shall be so designed that the temperature of the material can be controlled within the limits defined by the material manufacturer.

The minimum thickness of thermoplastic lines as viewed from a lateral cross section shall be not less than .080 inch at the edges nor more than .100 inch at the center.

The pavement surface shall be clean and dry (no moisture within 48 hours) and at a minimum temperature of 50 degrees F.

Drop on flotation type glass beads shall be applied to the thermoplastic line immediately after extrusion at a rate consistent with manufacturer recommendations.

**SECTION 30.00 CONCRETE WORK .....1**

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## SECTION 30.00 CONCRETE WORK

### 30.01 Scope

This section covers all concrete work to include, but not limited to, footings, structure walls, slab, beams, thrust blocks, curb and gutter, sidewalk, inlets, manhole, drainage works and structures. Cementitious material used shall be in conformance with requirements for Sulfate Exposure of:  $0.10 \leq \text{SO}_4^{2-} < 0.20$ .

### 30.02 Materials

**30.02.1 Cement** All cement used in concrete work shall be Portland cement conforming to all requirements of ASTM C150. Portland cement shall be Type II "low alkali" cement and shall conform to ASTM C 150. Type IP(MS) or IP(HS), with Class C fly ash, conforming to ASTM C-595, shall not be substituted for cement. Type II or Type IIA shall be used. High-early strength, Type III (or IIIA), may be used in concrete for anchors and thrust blocks at the Contractor's option. Use of other types requires the approval of the Project Manager.

**30.02.2 Fly Ash** Fly ash may be substituted for cement in all classes of concrete up to an amount not exceeding 25% by weight. The fly ash shall conform to AASHTO M 295, Class C or Class F. All chemical requirements of ASTM C 618 Table 1-A shall apply, with the exception as modified below.

**Table 30.02.2.1**

**Chemical Requirements Modifications to ASTM C 618, Table 1-A**

Loss on ignition	2.5% maximum
Pozzolanic activity index with Portland cement, at 28 days, percent of control	85% minimum
Autoclave expansion or contraction	0.5% maximum

Class C fly ash will not be permitted where sulfate resistant cement is required. The fly ash shall be limited to a maximum of 20 percent by weight of cementitious material, when used with Portland cement. Class C fly ash shall not be used with Type IP cement.

The use of fly ash shall not cause any deviation from air content requirements of the specifications.

**30.02.3 Admixtures** The use of calcium chloride in the production of Portland cement concrete is prohibited. Admixtures for air entrainment, water reducers, or other uses shall be in a liquid state and conform to the requirements of ASTM C 260 or C494.



Air-entraining admixtures shall conform to AASHTO M 154, latest edition. Water-reducing and set-controlling admixtures shall conform to AASHTO M 194 according to the following types: Type A, Water Reducing; Type B, Retarding; Type D, Water Reducing and Retarding; and Type E, Water Reducing and Accelerating. Written approval of the Project Manager shall be obtained prior to the use of any admixture except air-entrained admixtures. Application of admixtures shall be as per manufacturer's specifications. Any and all admixtures used in the production of the concrete mix and design of the concrete shall be compatible with each other.

**30.02.4 Water** The water used for concrete shall be clean and free from sand, oil, acid, alkali, organic matter, or other deleterious substances and shall conform to specification ASTM C1602. Water from public supplies, or which has been proven to be suitable for drinking, is satisfactory.

**30.02.5 Fine Aggregate**

**30.02.5.01 Composition** Fine aggregate shall be washed, hard, durable and uncoated particles of natural or manufactured sand or a combination thereof. It shall be free from frozen material, salt, alkali, vegetable matter, or other objectionable material.

**30.02.5.02 Grading** Fine aggregate shall be well graded and conform to the following:

**TABLE 30.02.5.02.1  
FINE AGGREGATE GRADING**

Sieve	Percent by Weight
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	26-60
No. 50	10-30
No 100	2-10

Fine aggregate for Portland cement concrete (PCC) shall conform to the requirements of AASHTO M 6. The minimum sand equivalent, as tested in accordance with ASTM D 2419 shall be 80 unless otherwise specified. The fineness modulus shall not be less than 2.3 nor greater than 3.3 unless otherwise approved.

Aggregate shall be tested and considered innocuous if it complies with the following:

- ASTM C1260 14-day expansion less than or equal to 0.10%, or
- ASTM C1293 1-year expansion less than or equal to 0.040%

For aggregates that do not meet these criteria, mitigation measures shall be demonstrated in accordance with:

- ASTM C1567 14-day expansion less than or equal to 0.10%\*, or
- ASTM C1293 2-year expansion less than or equal to 0.040%\*
- Tested with submitted concrete mix design cement, supplementary cementitious materials, and aggregate(s)

Alternative mitigation measures will be considered case by case.

Sulfate soundness loss by weight (ASTM C-88) shall not exceed 10% (Sodium Sulfate,) or 15% (Magnesium Sulfate.)

For organic impurities, reference ASTM C-33.

**30.02.5.03 Deleterious Substances** The maximum percentage of deleterious substances shall not exceed the following values.

**TABLE 30.02.5.03.1  
FINE AGGREGATE DELETERIOUS SUBSTANCES**

	AASHTO	Specification
Material finer than 200 mesh sieve	T 11	3% by weight
Shale <sup>a</sup>	Petrographic analyses	1% by weight
Coal and lignite <sup>a</sup>	T 113	0.25% by weight
Clay lumps and friable particles	T 112	3% by weight
Alkali reactivity	ASTM C 1260 Using Water bath	< 0.1% @ 16 days

<sup>a</sup> If the aggregate has a specific gravity less than 2.40

The sum of the percentages of the above deleterious substances shall not exceed 5% by weight.

Sulfate soundness loss by weight (ASTM C-88) shall not exceed 12% (Sodium Sulfate,) or 18% (Magnesium Sulfate) All fine aggregate shall be free from injurious amounts of alkali and organic impurities.

### 30.02.6 Coarse Aggregate

**30.02.6.01 Composition** Coarse aggregate shall be washed and shall consist of crushed limestone, trap rock, granite, washed gravel, or other approved inert materials

or combinations thereof having clean, hard, strong, durable pieces, free from frozen material, salt, alkali, vegetable matter, or other objectionable material either free or as an adherent coating (AASHTO M 80).

**30.02.6.02 Deleterious Substances** The maximum percentage of deleterious substances shall not exceed the following values.

**TABLE 30.02.6.02.1  
COARSE AGGREGATE DELETERIOUS SUBSTANCES**

	ASTM	Specification
Material finer than 200 mesh sieve	C-117	1% by weight
Lightweight fragments (specific gravity < 2.4)	C-123	5% by weight
Coal and lignite (specific gravity < 2.0)	C-123	0.5% by weight
Clay lumps and friable particles	C-142	3% by weight
Sulfate soundness loss by weight	ASTM C-88	shall not exceed 12% (Sodium Sulfate,) or 18% (Magnesium Sulfate.)
Alkali reactivity **	ASTM C 1260 Using Water bath	< 0.1% @ 14 days

The sum of the percentages of the above deleterious substances shall not exceed 5% by weight.

\* Tested with submitted concrete mix design cement, supplementary cementitious materials, and aggregate(s)

\*\* Aggregate shall be tested and considered innocuous if it complies with the following:

- ASTM C1260 14-day expansion less than or equal to 0.10%, or
- ASTM C1293 1-year expansion less than or equal to 0.040%

For aggregates that do not meet these criteria, mitigation measures shall be demonstrated in accordance with:

- ASTM C1567 14-day expansion less than or equal to 0.10%\*, or
- ASTM C1293 2-year expansion less than or equal to 0.040%\*

**30.02.6.03 Grading** Coarse aggregate shall be well graded between the limits specified and shall conform to the following requirements. Grading No. 57 or 67 shall be used when the concrete section thickness is six (6)-inches or less, unless otherwise specified.

**TABLE 30.02.6.03.1  
GRADING COARSE AGGREGATE**

Nominal Maximum Size of Aggregate (in inches)/No.	Percentages by weight Passing Standard Laboratory Sieve Having Square Openings						
	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8
1 1/2" No. 467	95 to 100	--	35 to 70	--	10 to 30	0 to 5	--
1" No. 57	--	95 to 100	--	25 to 60	--	0 to 10	0 to 5
3/4" No. 67	--	100	90 to 100	--	20 to 55	0 to 10	0 to 5

**30.02.6.04 Other Requirements** When tested in accordance with ASTM C131/C535 (based on nominal maximum aggregate size.), the percentage of wear shall not exceed 45%.

**30.02.6.05 Combined Aggregate Blend** Combined aggregate blends will be allowed upon approval of the Project Manager.

**30.02.7 Proportioning of Portland Cement Concrete (PCC)** The following criteria are for general use concrete. Jobsite and exposure conditions may require modifications to these general criteria. Other concrete mixtures may be appropriate when application and jobsite conditions dictate.

The proportions of materials to be used for mix design trial and field placement shall produce an applicably appropriate PCC that achieves 4500-psi design compressive strength in 28 days with a maximum water to cementitious ratio of 0.45 meeting F3, S1, W0 and C2 exposure conditions as defined by ACI 318, unless otherwise specified.

**TABLE 30.02.7.1  
EXPOSURE CATEGORY AND CLASS**

CATEGORY	CONDITION
F3	Concrete exposed to freezing-and-thawing cycles with frequent exposure to water and exposure to deicing chemicals
S1	$0.10 \leq SO_4^{2-} < 0.20$ Sulfate Exposure
W0	Concrete dry in service or concrete in contact with water low permeability not required
C2	Concrete exposed to moisture and an external source from deicing chemicals

### 30.02.8 Reinforcement

**30.02.8.01 Bars** Reinforcing steel bars shall conform to the requirements of the STANDARD SPECIFICATION FOR DEFORMED AND PLAIN BILLET-

STEEL BARS FOR CONCRETE REINFORCEMENT of the ASTM. Bars shall be new billet steel conforming to AASHTO M 31 of the grade shown on the plans.

**30.02.8.02 Welded Wire Fabric** Wire fabric for concrete reinforcement shall conform to the requirements of AASHTO M 55. The use of wire mesh from "rolls" is not allowed.

**30.02.8.03 Synthetic Fibers**

Synthetic fibers shall conform to ASTM C 1116, Type III.

Microsynthetic fibers shall provide a minimum cracking reduction ratio (CRR) of 40 percent when tested in accordance with ASTM C 1579.

Macrosynthetic fibers shall provide a minimum equivalent flexural strength ratio ( $R_{e,3}$ ) of 30% percent when tested in accordance with ASTM C 1609.

**30.02.9 Joint Materials** Joint materials shall conform to AASHTO specifications according to type as follows.

- Concrete joint sealer, hot-poured elastic M 324
- Silicone joint sealant shall be a rapid cure, self-leveling, cold applied, single or two-component silicone sealant ASTM C 719, C793
- Preformed expansion joint fillers (bituminous type) M 213
- Preformed sponge rubber and cork expansion joint fillers M 153
- Preformed expansion joint fillers – non-extruding and resilient bituminous M 33

**30.02.10 Curing Compound or Combination Cure / Sealer** Allowable curing compound types and specification shall vary depending upon when an expected snow or freeze condition may occur, or when de-icing materials will be soon used.

**30.02.10.1 For PCC placed between April 1 through September 14:**

For normal PCCP, related flatwork, sidewalks, and vertical surfaces, white-pigmented curing compound conforming to ASTM C-309 Type 2, (white pigmented dye) shall be used unless another method conforming to ACI 308, Section 2, is approved by the Project Manager in writing. For colored concrete, products must meet ASTM C-309 Type 1 (clear) or 1-D (fugitive dye).

### **30.02.10.2 For PCC placed between September 15 and March 31:**

A combination cure-sealer shall be used for PCCP and other related flatwork, sidewalks, and vertical surfaces placed during these dates, or when the Project Manager predicts an event where they expect to receive snow, freezing conditions and/or the need for use of de-icing materials within 28 days after concrete is placed. Provide adequate texture to surfaces prior to applying the cure-seal, as the solvent-based product has a high gloss finish and can pose visual distractions to drivers at nighttime if applied to smooth concrete surfaces.

The combination cure-seal products for PCCP, related flatwork, sidewalks, and vertical surfaces must meet ASTM C-1315 Type II, Class B (pigmented, some yellowing allowed). For colored concrete, products must meet ASTM C-1315 Type I, Class A (clear, non-yellowing). The compound must be an acrylic copolymer type, non-freezing solvent based, with a minimum of 25% solids content. Compound must be VOC compliant in accordance with EPA 40 CFR Part 59. The final gloss appearance will serve as proof of application.

The contractor shall use a sealer that when applied according to manufactures recommendations will not adversely affect the skid resistance of the pavement. The use of cure-Sealer shall not be a substitute for best cold weather curing practices according to ACI 308.

## **30.03 Concrete Proportioning**

**30.03.1** The proportions of materials to be used shall produce a workable concrete having a slump of one inch to four inches, water cement ratio of less than 0.45, with air content and minimum 28-day compressive strength as indicated in Section 30.03.3. Minimum cement content shall be 550 lbs. (six sacks) per cubic yard with a maximum water/cement ratio = 0.45. Where "Water Tight" concrete is specified or used as pavement, the water/cement ratio shall not exceed 0.40.

**30.03.2** An approved air-entraining agent (AASHTO M 154) shall be used in all concrete except Class III.

**30.03.3** The class of concrete specified shall conform to the following:

**TABLE 30.03.3.1**  
**CLASS OF CONCRETE SPECIFICATIONS**

	Maximum Size Coarse Aggregate	(f' <sub>cr</sub> ) Laboratory Minimum 28-day Strength (PSI)	Field Minimum 28-day Strength (PSI)	Entrained Air, %
Class I	3/4"	5,200	4,500	6% ± 1.5
Class IA	1"	5,200	4,500	6% ± 1.5
Class IB	1 1/2"	5,200	4,500	5.5% ± 1.5
Class P	1"	5,200	4,500	6% ± 1.5
Class PA	1 1/2"	5,200	4,500	5.5% ± 1.5
Class PB	2"	5,200	4,500	4% ± 1.5
Class PC	3"	5,200	4,500	4.5% ± 1.5

**30.03.4 Minimum Class of Concrete** Class I or Class 1A will be used in sidewalk, curb and gutter, slope paving, curb cuts, cross pans, driveways, retaining walls, storm drainage structures, slabs, and structural members. For sections greater than 6 inches thick, Class IB concrete may be used.

**30.03.5 Mix Design** The Contractor shall submit design mix proportions, laboratory trial mix, and aggregate data for each class of concrete being placed on the project. The test data shall show the mix design proportions, slump, air content, unit weight, water/cement ratio, and 28-day compressive strength results, as tested under laboratory conditions. The design mix proportions must produce at least 100% of the required 28-day laboratory compressive strengths. Each design shall establish the mix proportions and sources of all ingredients. Aggregate test data shall include gradations - #200, sand equivalent, fineness modulus, specific gravities, absorptions, and LA Abrasion test results. The Contractor shall be responsible for the design mix proportions and all subsequent adjustments necessary to produce the specified concrete.

The Contractor shall submit a new design mix based on the above requirements when a change occurs in the mix proportions, source or type of cement, fly ash, or aggregate, or failure of field tests to meet specifications.

Review of the design mix by the Project Manager does not constitute acceptance of the concrete. In accordance with ACI 301 and 318, standard supplier design mixes may be approved in lieu of the above. Submittal of appropriate test data will be required. Acceptance will be based solely on test results of the concrete placed on the project.

**30.03.6 Enforcement of Strength Requirements** Strength requirements shall be in accordance with ACI 214, Section 4.2. The strength level of the concrete will be considered satisfactory so long as the averages of all sets of three consecutive strength test results equal or exceed the specified strength,  $f'c$ , and no individual strength test result falls below the specified strength  $f'c$  by more than 500 psi. Should the strength level be unsatisfactory, the Project Manager shall have the right to require changes in mix proportions to apply on the remainder of the work. In the event of failure of test specimens for any portion of the work, the Project Manager may require that portion of the structure be removed and replaced at the Contractor's expense.

### **30.04 Mixing Concrete**

All concrete shall be thoroughly mixed in a batch mixer of an approved type and capacity for a period of not less than two minutes after all the materials, including water, have been placed in the drum. During the period of mixing, the drum shall be operated at the speed specified by the manufacturer of the equipment. The entire contents of the mixer shall be discharged before recharge, and the mixer shall be cleaned frequently. The concrete shall be mixed only in such quantities as are required for immediate use. No retempering of concrete shall be permitted. Hand-mixed concrete shall not be permitted except by written approval of the Project Manager.

### **30.05 Ready-Mixed Concrete**

At the option of the Contractor, ready-mixed concrete may be used in lieu of concrete mixed at the job. The use of ready-mix concrete in no way relieves the Contractor of sole responsibility for proportioning, mixing, delivering, or placing concrete as specified. Ready-mixed concrete shall conform to all the requirements of these specifications and AASHTO M 157. The Project Manager shall have free access to the mixing plant at all times. Ready-mixed concrete shall be continuously mixed or agitated from the time the water is added until the time of use. The concrete shall be completely discharged from the truck mixer or truck agitator as soon as possible, but shall be rejected when the concrete temperature is greater than 90 °F. Retempered concrete shall not be allowed. The organization supplying ready-mixed concrete shall have sufficient plant and transportation facilities to assure continuous delivery of concrete at the required rate. When requested by the Project Manager, the Contractor shall collect delivery or batch tickets from the ready-mix driver for all concrete used on the project and turn them over to the Project Manager. Batch tickets shall provide the following information: weight and type of cement, weights of fine and coarse aggregates, weight (or gallons) of water, including surface water on fine and coarse aggregates, quantity (cu. yds.) of batch, times of batching and discharging of the concrete, name of batch plant, name of Contractor, type, name and amount of admixture, date, mix identification, and truck number.



## 30.06 Placing Concrete

**30.06.1 Placing** Before depositing concrete, debris shall be removed from the space to be occupied by the concrete, and the forms, including any existing concrete surfaces, shall be thoroughly wetted. Concrete shall not be placed until all forms and reinforcing steel have been observed by the Project Manager. Concrete shall be handled from the mixer to the place of final deposit as rapidly as possible by methods which prevent separation or loss of ingredients. To avoid rehandling, it shall be deposited in the forms as nearly as practical in its final position. It shall be deposited in continuous layers, the thickness of which generally shall not exceed 12 inches. Concrete shall be placed in a manner that will avoid segregation and shall not be dropped freely more than five feet. If segregation occurs, the Project Manager may require the concrete to be removed and replaced at the Contractor's expense. Concrete shall be placed in one continuous operation, except where keyed construction joints are shown on the plans or as approved by the Project Manager. Delays in excess of 45 minutes may require removal and replacement of that pour, as determined by the Project Manager. Concrete will not be placed until the subgrade compaction requirements have been met.

**30.06.2 Vibrating** Concrete shall be thoroughly consolidated. All machine placed concrete shall be consolidated by internal vibration using mechanical vibrating equipment. Concrete in floor slabs, sidewalks, or curb and gutter placed against a form, shall be vibrated. Care shall be taken in vibrating concrete to vibrate only enough to bring a continuous film of mortar to the surface. Vibration shall stop before any segregation of the concrete occurs. Mechanical vibrators shall be an approved type as specified in ACI 309, Chapter 3. Vibrators shall not be used to move or spread the concrete. Any evidence of lack of consolidation or over consolidation shall be regarded as sufficient reason for requiring the removal of the section involved and its replacement with new concrete at the Contractor's expense. The Contractor shall be responsible for any defects in the quality and appearance of completed work.

The rate of vibration shall be not less than 5,000 vibrations per minute for surface vibrators and 9,000 vibrations per minute for internal vibrators. The amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete more than 1 foot from the vibrating element. The Contractor shall furnish a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

Vibrators shall not rest on new pavements or side forms. Power to the vibrators shall be so connected that vibration will cease when the forward or backward motion of the machine is stopped.

**30.06.3 Workability** The consistency of concrete shall be kept uniform for each class of work and shall be checked by means of slump tests or Kelly ball tests. Concrete shall at all times be of such consistency that it can be worked into corners and angles of the forms and around joints, dowels, and tie-bars, by the construction methods used without excessive spading, segregation, or undue accumulation of water or laitance on the surface. If by accident, intention, or error in mixing, any concrete fails to conform to the proportions of the approved mix design; such concrete shall not be incorporated in the work, but shall be discarded off the project site as waste material at the Contractor's expense. **NO WATER MAY BE ADDED AT THE JOB SITE WITHOUT THE PERMISSION OF THE PROJECT MANAGER.** If permission is obtained and water is added at the job site, slump, air entrainment testing and water cement ration shall be calculated prior to placement. Following the addition of water to achieve the right consistency and within specification requirements, no additional water shall be allowed and test cylinders shall be cast.

**30.06.4 Testing** Testing of Concrete shall be performed in accordance with Section 32.00. Water Cement Ratios shall be calculated on each load tested. Android and iPhone apps are available on line.

ACI certified technicians shall perform testing. The Project Manager shall determine who is responsible for performing QA testing, and the contractor shall be responsible for QC testing.

As stated in ASTM C-94:

Section 17.6.1 – If the measured slump or slump flow, or air content, or both is greater than the specified upper limit, a check test shall be made immediately on a new test sample. In the event the check test fails, the concrete shall be considered to have failed the requirements of the specification.

Section 17.6.2. – If the measured slump or slump flow, or air content, or both is less than the lower limit, permit adjustments in accordance with Section 12.7 or Section 8.3 or both, as appropriate, and obtain a new sample. If the sample of the adjusted concrete fails, a check test shall be made immediately on a new sample of the adjusted concrete. In the event the check test fails, the concrete shall be considered to have failed the requirements of the specification.

The contractor shall provide and maintain onsite facilities that will allow for the initial curing of test specimens to meet the requirements of ASTM C31.

### 30.07 Forms

Forms shall conform to the shape, lines, and dimensions, as shown on the plans. Approved flexible forms shall be used for construction where the radius is 150 feet or less. Unexposed surfaces shall have forms of No. 2 common (or better) lumber. Forms shall not be disturbed until the concrete has adequately hardened. The Contractor or his superintendent shall be present at the time forms are removed and shall be responsible for the safety of this operation at all times. In no case shall the minimum time between placing concrete and removal of forms be less than the following.

**TABLE 30.07.1**

**TIME BETWEEN PLACING CONCRETE AND REMOVAL OF FORMS**

	Time
Curb and gutter	4 hours
Side forms for footings and slabs	12 hours
Side forms for walls, beams, and Columns	24 hours
Forms under structural beams and slabs requiring shoring	7 days or when concrete has reached 2/3 of 28-day field design strength as indicated by compressive strength tests on field-cured specimens

### 30.08 Reinforcing Steel

**30.08.1 Shop Drawings** Before fabrication of the reinforcement, the Contractor shall prepare or have prepared complete bending, fabrication, and setting drawings and bar lists covering all required reinforcement steel. Such drawings and bar lists shall be submitted to the Project Manager for his review of general conformity to specified requirements. The review of the shop drawings by the Project Manager in no way relieves the Contractor of sole responsibility for correct placement of reinforcing steel.

**30.08.2 Placing** Reinforcing steel, before being placed, shall be thoroughly cleaned of coatings that will destroy or reduce bond. A light coating of rust may be allowed by the Project Manager. Reinforcement shall be carefully formed to the dimensions indicated on the plans. It shall not be bent or straightened in a manner that will injure the material. **THE USE OF HEAT IN BENDING BARS SHALL NOT BE PERMITTED.** Bars with kinks or bends not shown on the plans shall not be used. Reinforcing steel shall be accurately placed and secured against displacement by

using annealed iron wire of not less than No. 18 gauge, or suitable clips, at intersections, and where necessary, reinforcing steel shall be supported by metal chairs or spacers, precast mortar blocks, or metal hangers. Reinforcing bars shall not be spliced at points of maximum stress. Splices, where permitted, shall be as specified in ACI 318. All reinforcing steel shall be placed in the position and at the spacings shown on the plans with the tolerances specified in ACI 301, Section 3.3.

**30.08.3 Cover** The minimum clear cover for reinforcing steel shall be as specified in ACI 301, Section 3.3, and as shown below, unless otherwise shown on the plans.

**TABLE 30.08.3.1  
MINIMUM COVER FOR REINFORCING STEEL**

Bottom bars on soil-bearing foundations and slabs	3 inches
Bars adjacent to surfaces exposed to weather on earth backfill	
Bars $\frac{3}{4}$ inch in diameter or larger	2 inches
Bars $\frac{5}{8}$ inch in diameter or smaller	1 1/2 inches
Interior surfaces: slabs, walls, joists with 1 $\frac{3}{8}$ inch diameter or smaller bars	3/4 inch

**30.08.4 Placing Welded Wire Fabric** Wire fabric in curb cuts shall be placed as shown in the plans and details. The fabric shall be fully supported on precast mortar blocks or other approved supports prior to placing the concrete. The use of welded-wire fabric from "rolls" is not allowed.

## 30.09 Joints

**30.09.1 Expansion Joints** Expansion joints in combination curb and walk, vertical curb and gutter, channels, or any other place that is designed or can be expected to carry water shall be recessed  $\frac{1}{2}$  inch and shall be sealed with an approved *one-component, moisture-curing, non-priming, gun-grade, elastomeric polyurethane joint sealant meeting the requirements of ASTM C920, Type S, Grade NS, Class 25, Use NT and M. It shall be applied in accordance with the manufacturer's instructions* within seven days of the placement of the concrete. Expansion joints shall be provided at the following locations:

- at each end of curb return
- at both edges of the driveway
- between back of sidewalk and driveway slab or service walk
- between new concrete and existing masonry buildings
- as shown on the drawings

- as directed by the Project Manager
- between new and existing concrete
- ½ inch joints every 200 feet of sidewalk

**30.09.2 Contraction Joints** Transverse joints shall be placed at maximum intervals of ten feet to control random cracking. The joints shall be formed, sawed, or tooled to a minimum depth of ¼ of the total thickness. If divider plates are used, the maximum depth of plates shall not be greater than ½ the total thickness. Joints shall be spaced as follows:

- Not more than ten feet nor less than five feet apart in curb and gutter
- Not more than five feet nor less than three feet apart in sidewalk
- In driveways at least two joints equally spaced at not greater than ten-foot intervals, as applicable
- Joints will be placed at ten-foot intervals for the eight-foot and ten-foot bike paths, unless otherwise authorized by the Project Manager, and shall be saw cut to a depth of ¼ depth of the concrete section.
- As directed by the Project Manager

**30.09.3 Finished Tool Joints** The finished joints shall be placed with a jointer having a width no greater than 5/16 inch and depth not less than ¾ inch. A maximum joint width at the finished surface shall be no greater than 5/16 inch. Tool joints shall be spaced as follows:

- Not more than ten feet nor less than five feet apart in curb and gutter
- Not more than five feet nor less than three feet apart in sidewalk
- In driveways at least two joints equally spaced at not greater than ten-foot intervals, as applicable
- Joints will be placed at ten-foot intervals for the eight-foot and ten-foot bike paths unless otherwise authorized by the Project Manager
- As directed by the Project Manager

## 30.10 Pumping Concrete

Methods, materials, and equipment to be used in placing concrete by pumping shall conform to ACI 304. A separate mix design will be required in accordance with paragraph 30.03.5.

## 30.11 Cold Weather Protection

When concrete is placed with ambient temperatures below 40°F, the Contractor shall provide satisfactory methods and means to protect the mix from injury by freezing. The aggregates, or water, or both, shall be heated in order to place the concrete at temperatures between 50°F and

90°F. Placing of concrete may be started in the morning if the Contractor desires, but shall be discontinued at 3:00 p.m. of the same day if freezing weather threatens. The concrete or aggregates shall be protected during transit, mixing, and before and after placing, as directed by the Project Manager, to retain all heat possible in the concrete mix. After the concrete has been placed, the Contractor shall provide sufficient protection such as blankets, canvas, framework, heating apparatus, etc., to enclose and protect the structure and maintain the temperature of the concrete at not less than 50°F until at least 60% of the 28-day field strength has been attained. Except as provided above, cold weather concreting shall be in accordance with ACI 306. If in the opinion of the Project Manager, the protection provided is inadequate, concreting shall cease until conditions or procedures are satisfactory to the Project Manager.

### **30.12 Hot Weather Concreting**

Except by written authorization, concrete shall not be placed if the temperature of the plastic concrete cannot be maintained at 90°F or lower. The placement of concrete in hot weather shall comply with ACI 305.

### **30.13 Curing Concrete**

White-pigmented curing compound conforming to Section 30.02.10 shall be used unless another method conforming to ACI 308, Chapter 2, is approved by the Project Manager in writing. All concrete, regardless of temperature, weather, or season, shall be protected from premature drying for a period of not less than seven days. Where concrete is being protected from freezing, the time period for water curing shall be one day less than that of the frost protection. The application rate of curing compound shall be as per manufacturer's recommendation (not greater than 150 sq. ft./gal.). Curing will not be required longer than 72 hours if high-early strength concrete is used. It shall be the Contractor's responsibility to protect the concrete being cured from the elements, traffic, and vandalism. Those surfaces covered by forms shall be similarly treated after the forms are removed. Inadequate protection by the Contractor shall be cause for suspension of concreting operations and replacement of the affected concrete at no expense to the City.

Curing and Cure-Sealing compound, meeting requirements of Section 30.02.10, shall be applied to freshly placed concrete as soon as the surface water has dissipated and/or immediately upon removal of formwork. Apply compound at uniform coverage rate in accordance with manufacturer's instructions with a low-pressure sprayer. If using preform pavement markings, apply pavement markings first, cover pavement marking, and then apply sealer. Do not dilute curing and sealing compound. Protect horizontal surfaces from traffic until curing and sealing compound has cured.

## 30.14 Finishing

**30.14.1 General** Exposed faces of curbs and sidewalks shall be finished to true line and grade as shown on the plans. The surface shall be floated to a smooth but not slippery finish. Sidewalk and curb shall be broomed and edged, unless otherwise directed by the Project Manager. The use of steel trowels is strictly prohibited in the finishing processes, unless approved by the Project Manager. After completion of brooming and before concrete has taken its initial set, all edges in contact with the forms shall be tooled with an edger having a 3/8 inch radius.

No dusting or topping of the surface, or sprinkling with water, to facilitate finishing shall be permitted. Colloidal silica finishing aid products shall only be applied to cast-in-place concrete to facilitate as a finishing agent. Colloidal silica finishing aid products shall only be used as directed by the manufacturer.

### 30.14.2 Types of Finish

**30.14.2.01** Class 1 - Ordinary Surface Finish. Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed. On all surfaces, the cavities produced by form ties honeycomb spots, broken corners or edges, and other defects, shall be thoroughly cleaned, moistened with water, and carefully pointed and trued with a mortar consisting of cement and fine aggregate, and the surface left sound, smooth, even, and uniform in color. Mortar used in pointing shall be not more than 30 minutes old. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges. All concrete surfaces shall be given a Class 1 finish. Additional finish classes may be specified by the plans for designated surfaces.

**30.14.2.02** Class 2 - Broom Finish. All curb and gutter, sidewalk, and cross pan unless otherwise specified.

**30.14.2.03** Class 3 - CDOT Class 5, Masonry Coating Finish.

**30.14.2.04** Class 4 - Special. See plans and special provisions.

**30.14.3 Markings** Concrete used in curb and gutter, sidewalk, curb cuts, driveways, inlets, bicycle paths, retaining walls, and slope paving, shall have the name of the Contractor and the year of construction impressed therein using letters not less than one inch

high and 3/8 inch deep. Impressions shall be made in concrete at the beginning and end of each pour and in each driveway. Structures shall have the year constructed impressed therein using letters three inches high and 1/2 inch deep. The Contractor shall place the date stamp at the end of his work at the point where it joins existing work. If only a portion of sidewalk, or curb & gutter is being constructed, the new slab shall be marked at one end.

**30.14.4 Final Surface Test** All work shall be true to line and grade as established by the Project Manager. Prior to acceptance of the work, the Contractor shall test the surfaces with a 10-foot straightedge. Any areas higher than 1/4 inch, but not higher than 1/2 inch, above the correct surface thus indicated, shall be ground to the correct surface by the Contractor at his expense. When the deviation exceeds the foregoing limits, the Contractor shall remove and replace that portion of the work at his expense, as directed by the Project Manager. Protection of freshly placed concrete shall be provided by the Contractor. The Contractor shall erect and maintain suitable barricades and employ watchmen as may be necessary to exclude (pedestrian or vehicular) traffic from the newly constructed concrete until it has sufficiently cured and will not be affected by the traffic. The Contractor shall have sufficient materials available to protect the unhardened concrete against damage by rain or hail. When rain is imminent, the unhardened concrete shall be immediately covered with tarps, plastic sheeting, or other suitable material, and planks or forms shall be placed along the edge of the work to hold the protective materials in place. Concrete pavement damaged by rail or hail will be removed and replaced as directed, at no additional cost, by the Project Manager.

**30.14.5 Protection of Pavement during Inclement Weather** The contractor shall protect newly placed PCCP from any detrimental precipitation and weather. The contractor may choose to proceed with PCCP placement during marginal weather. Concrete damaged due to deteriorating weather conditions shall be repaired, or removed and replaced, as determined by the Project Manager, at the contractor's expense.

- 30.14.5.1** Placing PCCP shall be stopped and newly placed PCCP to be covered before:
- The quantity of rainfall or snow is sufficient to cause a flow or wash the surface.
  - The surface quality of the surface from hail is sufficient to cause defects on the surface.
  - The quantity of precipitation or foreign substances shall impact the strength or durability



- The quantity of wind could cause surface drying leading to cracking.

**30.14.5.1.01** The contractor must protect pavement from damage due to the above mentioned causes. Failure to properly protect concrete may constitute cause for removal and replacement of defective pavement. Plastic film is preferred for surface and edge protection to limit water intrusion or surface drying.

**30.14.5.1.02** Rain damage varies considerably depending on rainfall intensity, duration, and protective measures taken by the contractor. Covering and side forms placed by the contractor afford sufficient protection to unhardened concrete in some cases. In other cases, surface and edges may erode to such a degree that removal and replacement of the slab is the only solution. If the concrete is still plastic and is damaged by rain, the damaged surface may be dug out and replaced with fresh concrete. It is not acceptable to refinish the damaged surface without first removing the damaged concrete.

**30.14.6 Damage Analysis** All flatwork, where the Project Manager suspects might be damaged, shall be assessed for suitability by mutual agreement with the contractor. Contractor shall provide the Project Manager with approved experts in assessment, and shall replace or repair any damaged flatwork at the contractor's expense, as approved by the Project Manager.

In the event the contractor does not agree with removal and replacement, the contractor may elect, at his own expense, to send cores to an experienced petrographer for analysis of the concrete's water-cement ratio, air content, air-void spacing factor, and general appearance using ASTM C 856. The number of cores and the core locations shall be approved by the Project Manager prior to submittal. A petrographic examination of cores taken from the concrete does provide helpful information to determine the extent of the damage. A petrographer can indicate how deep any damage extends and provide recommendations for effective repair, such as diamond grinding. If a general petrographic evaluation does not answer all of the questions on the concrete's durability to the satisfaction of the Project Manager, a more detailed analysis of the air-void system using ASTM D 457 shall be performed. Surface scaling tests should also be conducted in accordance with ASTM C 672. Rain damaged concrete shall be removed if it is determined by the Project Manager to be non-durable in terms of abrasion, skid resistance, or freezing & thawing.

**30.14.7 Repairs** If, after stripping of forms, any concrete is found to be not formed as shown on the drawings, or is out of alignment or level, or shows a defective surface, it shall be considered as not conforming to these specifications. The defective area shall be removed and replaced by the Contractor at his expense unless the Project Manager gives written permission to patch the defective area. Patching, if allowed, shall be done as described in the following paragraphs.

Ridges and bulges shall be removed by grinding. Honeycombed and other defective concrete that does not affect the integrity of the structure shall be chipped out and the vacated areas shall be filled in a manner acceptable to the Project Manager. The repaired area shall be patched with a non-shrink, nonmetallic grout, with a minimum compressive strength of 4,500 psi in 28 days. All repair areas shall be treated with an epoxy bonding agent before the repair filling is placed.

Bolt-holes, tie-rod holes, and minor imperfections as approved by the Project Manager shall be filled with dry-patching mortar composed of one part Portland cement to two parts of regular concrete sand (volume measurement), and only enough water so that after the ingredients are mixed thoroughly the mortar will stick together upon being molded. Mortar repairs shall be placed in layers and thoroughly compacted by suitable tools. Care shall be taken in filling rod and bolt holes so that the entire depth of the hole is completely filled with compacted mortar. The mortar mix proportions described above are approximate.

An approved mix shall be prepared to insure that the grout has a 28-day compressive strength equal to that of the area to which it is placed. All costs for mix design and testing shall be paid by the Contractor. Those areas with excessive deficiencies, as determined by the Project Manager, shall be removed and replaced at the Contractor's expense.

## **30.15 Miscellaneous**

**30.15.1 Backfilling** When side forms are removed and the concrete has gained sufficient strength (minimum compressive strength of 2,500 psi), the space adjoining the concrete shall be promptly backfilled with suitable material, properly compacted, and brought flush with the surface of the concrete and adjoining ground surface. In embankments the compacted backfill shall be level with the top of the concrete for at least two feet and then sloped as shown on the drawings or as directed by the Project Manager.

**30.15.2 Repairing Existing Pavement** Existing pavement which is damaged or removed during construction shall be repaired to the satisfaction of the Project Manager by the Contractor at the Contractor's expense.

**30.15.3 Repairs of Existing Sidewalks** Where repairs are made in existing sidewalks, all edges of the old sidewalk allowed to remain shall be saw cut to a minimum depth of two inches. No rough edges will be permitted where new construction joins old. Unless directed by the Project Manager, no section less than five feet in length shall be placed or left in place. Where new sidewalk construction abuts existing sidewalks, the work shall be accomplished so no abrupt change in grade results.

**30.15.4 Removal of Existing Concrete** Removal and replacement of existing concrete features (curb and gutter, sidewalk, curb cuts, cross pans, etc.) beyond the limits shown on the plans, or required by the Project Manager, shall be at the Contractor's expense.

**30.15.5 Opening to Traffic** Walks shall not be opened to pedestrian traffic for at least 24 hours after placement. Curb cuts, curb and gutter, and cross pans shall not be opened to vehicular traffic for at least seven days after placement or until concrete has attained two-thirds of 28-day field strength. The Contractor shall maintain suitable barricades and signage in accordance with MUTCD and the approved traffic control plan.

**30.15.6** Insufficient thickness and compressive strength shall be subject to removal and replacement, at the direction of the Project Manager, if the deficiency is greater than 0.60 inches. Strengths less than 85 percent of the design strength shall be removed and replaced.

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## SECTION 31.00 CONCRETE PAVEMENT

### 31.01 Scope

The work covered by this section consists of furnishing all labor, equipment, and materials and in performing all operations in connection with the construction of air-entrained Portland cement concrete pavement for streets, alleys, and parking lots. Section 30.00, CONCRETE WORK shall apply, except where a conflict between CONCRETE WORK and CONCRETE PAVEMENT exists. In such a case, the specifications for CONCRETE PAVEMENT shall govern.

### 31.02 Materials

Concrete shall be composed of Portland cement, air-entraining agent, aggregates, and water. Other admixtures to be used shall first be reviewed by the Project Manager prior to use. These materials shall be furnished only from sources of supply reviewed by the Project Manager before shipments are started. Such sources shall be able to produce materials of the quality and in the quantity required.

**31.02.1 Portland Cement** The use of other than Type II cement shall be reviewed by the Project Manager prior to use. Cement shall conform to the requirements of AASHTO M 85 for Portland cement Type I, Type II, Type III, Type IV, or Type V, or for air-entraining Portland cement Type IA, Type IIA, or Type IIIA. Cement which for any reason has become partially set or which contains lumps of caked cement shall be rejected. Either packaged or bulk cement may be used. Fly ash may be used as specified in Section 30.00, CONCRETE WORK.

**31.02.2 Aggregates** All aggregates for concrete shall meet ASTM C-33. Aggregates shall be so handled that moisture content and gradation are reasonably uniform and do not change appreciably from batch to batch or hour to hour. No aggregates shall be used which have become contaminated or intermixed. Frozen aggregates or aggregates containing frozen lumps shall be thawed before use.

#### 31.02.3 Joints

**31.02.3.01 Expansion Joints** See Section 30.02.9 and S19.1 et seq.

**31.02.3.02 Pre-Molded Joint Material** Pre-molded parting strips, when called for on the plans, shall be 1/16" to 3/16" thick and of the width shown on the plans. They shall consist of strips which have been formed from layers of felt or shredded felt, cane, wood, or other suitable fibers, securely bound together and uniformly impregnated with a suitable binder. They shall not permanently

deform by ordinary handling during hot weather, or become hard and brittle in cold weather.

**31.02.3.02 Joint Sealant** All joints shall be sealed with an approved *one-component, moisture-curing, non-priming, gun-grade, and elastomeric polyurethane joint sealant meeting the requirements of ASTM C920, Type S, Grade NS, Class 25, Use NT and M. It shall be applied in accordance with the manufacturer's instructions* within seven days of the placement of the concrete and Standard Detail S19.1 et seq.

#### **31.02.4 Curing Compound or Combination Cure/Sealer**

Allowable curing compound types and specification shall vary depending upon when an expected snow or freeze condition may occur, or when de-icing materials will be soon used.

##### **31.02.4.01 For PCC placed between April 1 through September 14:**

For normal PCCP, related flatwork, sidewalks, and vertical surfaces, white-pigmented curing compound conforming to ASTM C-309 Type 2, (white pigmented dye) shall be used unless another method conforming to ACI 308, Section 2, is approved by the Project Manager in writing. For colored concrete, products must meet ASTM C-309 Type 1 (clear) or 1-D (fugitive dye).

##### **31.02.4.02 For PCC placed between September 15 and March 31:**

A combination cure-sealer shall be used for PCCP and other related flatwork, sidewalks, and vertical surfaces placed during these dates, or when the Project Manager receives a weather forecast indicating snow, freezing conditions is imminent and/or the need for use of de-icing materials within 28 days after concrete is placed. Provide adequate texture to surfaces prior to applying the cure-seal, as the solvent based product has a high gloss finish and can pose visual distractions to drivers at night time if applied to smooth concrete surfaces.

The combination cure-seal products for PCCP, related flatwork, sidewalks, and vertical surfaces must meet ASTM C-1315 Type II, Class B (pigmented, some yellowing allowed). For colored concrete, products must meet ASTM C-1315 Type I, Class A (clear, non-yellowing). The compound must be an acrylic copolymer type, non-freezing solvent based, with a minimum of 25% solids

content. Compound must be VOC compliant in accordance with EPA 40 CFR Part 59. The final gloss appearance will serve as proof of application.

The contractor shall use a sealer that when applied according to manufactures recommendations will not adversely affect the skid resistance of the pavement. The use of cure-Sealer shall not be a substitute for best cold weather curing practices according to ACI 308.

#### **31.02.4.03 Application**

The Contractor shall be responsible to protect the concrete being cured from the elements, traffic, and vandalism. Those surfaces covered by forms shall be similarly treated after the forms are removed. Inadequate protection by the Contractor shall be cause for suspension of concreting operations and replacement of the affected concrete at the Contractor's expense.

The Contractor shall examine concrete surfaces that are to receive curing and sealing compound. The Contractor shall notify the Project Manager if surfaces are not acceptable. Unacceptable conditions include, but are not limited to, cracked, curled, or spalled concrete surfaces. The Contractor shall not begin surface preparation or application until unacceptable conditions are corrected.

Clean surface of substances that might interfere with penetration or performance of concrete curing and sealing compound. Remove oil, existing curing compounds, laitance, and other substances that could prevent adhesion or penetration of concrete sealers. If necessary, the Contractor shall clean surface with a concrete cleaner. Protect adjoining work, including sealant bond surfaces, from spillage or blow-over of concrete sealer. Cover adjoining and nearby surfaces comprised of aluminum and glass if there is the possibility of concrete sealer being deposited on surfaces. Cover live plants and grass.

Curing and Cure-Sealing compound should be applied to freshly placed concrete as soon as the surface water has dissipated and/or immediately upon removal of formwork. Apply compound at uniform coverage rate in accordance with manufacturer's instructions with a low-pressure sprayer. If using preform pavement markings, apply pavement markings first, cover pavement marking, and then apply sealer. Do not dilute curing and sealing compound. Protect horizontal surfaces from traffic until curing and sealing compound has cured.



### 31.03 Batching

Measurement and batching of cement, fine and coarse aggregates shall be by weight on scales accurate to within 0.5%. Bulk cement and cement from fractional sacks shall be weighed.

**31.03.1 Proportioning Concrete** The concrete shall have a minimum 28-day compressive laboratory design strength of 5,200 psi (4500 psi field) and a design laboratory modulus of rupture of 700 psi in 28 days (600 psi field). Proportions of cement, water, and aggregate shall be determined in accordance with ACI Standard 318. Mixes shall comply with the following table.

**Table 31.03.1.1  
PROPORTIONS FOR NORMAL WEIGHT CONCRETE\***

Nominal Size of Coarse Aggregate* (inches)	Minimum Cement Content (lb./cu. yds.)	Water/Cement Ratio** (lb./lb. maximum)	Total Air Content (% by volume) ± 1%
3		0.40	4.5%
2		0.40	4%
1 ½	610	0.40	5.5%
1	610	0.40	6%

\* Per ACI 318

\*\* ACI 318 Table 19.3.1.1-Exposure category and class

**Table 31.03.1.2  
Exposure Category and Class**

Category	Condition
F3	Concrete exposed to freezing-and-thawing cycles with frequent exposure to water and exposure to deicing chemicals
S1	$0.10 \leq SO_4^{2-} < 0.20$ Sulfate Exposure
W0	Concrete dry in service or concrete in contact with water low permeability not required
C2	Concrete exposed to moisture and an external source from deicing chemicals

The entrained air shall be obtained either by using air-entraining cement or an air-entraining agent. Mix design, including lab test results showing compliance with compressive strength and modulus of rupture requirements, shall be submitted to the Project Manager for review ten days before paving begins. The maximum size of aggregate shall not exceed 1/4 of the slab thickness. The maximum water content shall include the surface water on the aggregate.

**31.03.2 Consistency** For workability, the slump for the concrete shall be 1/2 inch to 2 inches (internal vibration) and 1-1/2 inch to 3 inches (surface vibration).

**31.03.3 Ready-Mixed Concrete** Ready-mixed concrete shall be proportioned, mixed, and transported in accordance with AASHTO M 157. Concrete shall be placed in accordance with Section 30.00, CONCRETE WORK.

**31.03.4 Job-Mixed Concrete** Job-mixed concrete shall be mixed in a drum mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified time, and capable of discharging the material without segregation. The entire contents of the drum shall be discharged before recharging. Each mixer shall have attached in a prominent place, a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of drum or mixing blades. The volume of the mixed materials per batch shall not exceed the manufacturer's guaranteed capacity (110% of rated capacity) of the mixer.

**31.03.5 Time of Mixing** The mixing of each batch shall continue for not less than one minute after all materials, except water, are in the mixer. All mixing water shall be introduced into the drum before 1/4 of the mixing time has elapsed. The mixer shall rotate at the rate recommended by its manufacturer. The mixer shall be provided with a batch timing device which shall be subject to inspection and adjustment by the Project Manager at any time.

## **31.04 Measuring Air Content**

The air content of freshly-mixed concrete shall be checked by an independent agency as often as necessary (at least twice daily) to insure uniform air content in conformance with ACI and ASTM specifications. Concrete with air content above or below the amount specified in Section 31.03.1 shall be corrected by adjustments in the mix design or quantities of air-entraining admixture being used.

## **31.05 Forms**

**31.05.1 General** Forms may be made of wood or metal and shall have a depth equal to or greater than the prescribed edge thickness of the pavement. Each section of form shall be straight and free from bends or warps.

The maximum deviation of the top surface shall not exceed 1/8 inch in ten feet, or the inside face not more than 1/4 inch in 10 feet. The method of connection between sections shall be such that the joint thus formed is tight and free from movement in any direction.

Forms shall be of such cross section and strength and so secured as to resist the pressure of the concrete when placed and the impact and vibration of any equipment which they support without springing or settlement.

Approved flexible forms shall be used for construction where the radius is 150 feet or less.

All roadway paving over 50 feet in length shall be accomplished using a self-propelled, string controlled slip form paver. Screeds or forms shall not be the primary means of placing and controlling concrete paving, except when permitted by the City Engineer.

**31.05.2 Setting Forms** The subgrade under the forms shall be compacted and shaped so that the form when set will be uniformly supported for its entire length at the specified elevation. See Section 20.06.10 Subgrade, Base Course, and Pavement Surface Grade Checks. The supply of forms shall be sufficient to permit their remaining in place for at least 12 hours after the concrete has been placed. All forms shall be cleaned and oiled each time they are used.

**31.05.3 Grade and Alignment** The alignment and grade elevations of the forms shall be checked by the Contractor immediately ahead of concrete placement and necessary corrections will be made. Any forms that have been disturbed or subgrade that has become unstable shall be corrected, and forms reset and rechecked. Any variations in grade and alignment shall be reviewed by the Project Manager prior to placing the concrete.

## **31.06 Placing Concrete**

The concrete shall be mixed in quantities required for immediate use and shall be deposited on the subgrade to the required depth and width of the construction lane in successive batches and in a continuous operation without the use of intermediate forms or bulkheads. The concrete shall be placed as uniformly as possible in order to minimize segregation. While being placed, the concrete shall be vibrated to prevent the formation of voids or honeycomb pockets. The concrete shall be especially well consolidated against the forms and along all cold joints. Care shall be taken in the distribution of the concrete to deposit a sufficient volume along the outside form lines so that the curb section can be consolidated and finished simultaneously with the slab. At the start of a day's run, or whenever placing concrete adjacent to existing concrete, the surface of the existing concrete shall be thoroughly wetted immediately prior to placing the new concrete. No concrete shall be placed around manholes or other structures until they have been brought to the required grade and

alignment and expansion joints have been installed. Placement of concrete will cease when rain is threatening. The Contractor shall provide protection of freshly poured concrete. The Contractor shall erect and maintain suitable barricades and employ watchmen as may be necessary to exclude (pedestrian or vehicular) traffic from the newly constructed concrete pavement until it has sufficiently cured that it will not be affected by the traffic. The Contractor shall have sufficient materials available to protect the unhardened concrete against damage by rain or hail. When rain is imminent, the unhardened concrete shall be immediately covered with tarps, plastic sheeting, or other suitable material, and planks or forms shall be placed along the edge of the work to hold the protective materials in place. Concrete pavement damaged by rain or hail will be removed and replaced as directed, at no additional cost, by the Project Manager.

**31.06.1 Cold Weather Concreting** Except by specific written authorization, concreting shall cease when descending air temperature in the shade and away from artificial heat falls below 40°F. It shall not be resumed until the ascending air temperature in the shade and away from artificial heat rises to 35°F.

When concreting is permitted during cold weather, the temperature of the mix shall be not less than 60°F, not more than 80°F, at the time of placing. Aggregates or water or both may be heated, but the water shall not be hotter than 175°F and aggregates shall not be hotter than 150°F. Before concreting is started, ice, snow, and frost must be removed from forms, rebar, and subgrade.

When concrete is being placed in cold weather and the temperature may be expected to drop below 35°F, a supply of straw, insulated curing blankets, or other suitable material shall be provided along the line of work. Prior to any time when the air temperature may be expected to reach the freezing point during the day or night, the material so provided shall be spread over the concrete to a sufficient depth to prevent freezing of the concrete. Concrete shall be protected from freezing temperatures until it is at least five days old. Concrete injured by frost action shall be removed and replaced at the Contractor's expense. Additional cement, Type A or Type E mixtures (AASHTO M 194) may be used to accelerate setting in cold weather subject to the review of the Project Manager. The use of calcium chloride additives shall NOT be allowed.

**31.06.2 Hot Weather Concreting** Concrete shall not be placed if the temperature of the concrete exceeds 90°F. To facilitate the placement of concrete in hot weather, the aggregates or water or both may be cooled.

## 31.07 Consolidating and Finishing

**31.07.1 General** The pavement shall be struck off and consolidated with a mechanical finishing machine. Hand finishing shall be allowed only on irregular or confined areas when approved by the Project Manager. The use of steel trowels for finishing concrete pavement surfaces is strictly prohibited. When a mechanical finishing machine is used, the concrete shall be struck off at such a height that after consolidating and final finishing, it shall be at the elevation as shown on the plans, with not more than ¼ inch variation when measured with a ten-foot straight-edge.

The finishing machine shall be provided with a screed which shall consolidate the concrete by pressure and vibration. Minimum vibratory requirements are that the eccentric diameter be 1-7/8 inch, a frequency of 7,000 to 9,000 vibrations per minute and be spaced a maximum of 18 inches mounted longitudinally. The concrete shall be brought to a true and even surface, free from rock pockets. The edge of the screeds along the curb line may be notched out to allow for sufficient concrete to form the integral curb.

Hand-finishing tools shall be kept available for use in case the finishing machine breaks down. Paving progress shall immediately cease until the finishing machine has been repaired. When hand finishing is used, the pavement shall be struck off and consolidated by a hand mechanical vibrating device to the elevation as shown on the plans, with not more than ¼ inch variation when measured with a ten-foot straightedge. When the forward motion of the vibrating device is stopped, the vibrator shall be shut off; it shall not be allowed to idle on the concrete. Delays in excess of 15 minutes in vibrating and tamping shall be cause for stopping paving until finishing operations have caught up with the paving. No finishing aides shall be used without the approval of the Project Manager. Colloidal silica finishing products shall only be applied to cast-in-place concrete. These products shall only be used as directed by the manufacturer to aid in finishing.

**31.07.2 Scraping and Straight-Edging** The pavement shall be scraped with a straightedge ten-foot long (minimum), equipped with a handle to permit it to be operated from the edge of the pavement. The straight-edge shall be operated so that any excess water and laitance are removed from the surface of the pavement. Prior to the concrete taking its initial set, irregularities shall be corrected by adding or removing concrete. All disturbed places shall be floated with a wooden or metal float not less than three feet long and not less than six inches wide and again straight-edged. The pavement surface shall have no depression where water will stand.

The use of the long-handled float shall be confined to a minimum. It may be used with the straightedge to correct surface texture, but shall not be used to float the entire surface of the pavement.

**31.07.3 Edging** Before final finishing is completed and before the concrete has taken its initial set, the edges of the slab and curb shall be carefully finished with an edger, having a 3/8 inch radius.

**31.07.4 Final Surface Finish** A burlap drag shall be used as the final finishing method for concrete pavement. The drag shall be at least three feet in length and wide enough to cover the entire pavement width. It shall be kept clean and saturated during use. It shall be laid on the surface of the pavement and dragged. The curb shall have the same final finish as the pavement. The finish surface of the concrete pavement and curb shall have a uniform gritty texture, free from excessive harshness, and true to the grades and cross section shown on the plans. The Project Manager may require changes in the final surface texture.

## **31.08 Integral Curb**

When integral curbs are required along the edges of all street paving, depressed curbs shall be provided at all driveway entrances and at such other locations as designated by the Project Manager.

The integral curb shall be constructed with, or immediately following, the finishing operation. Special care shall be taken so that the curb construction does not lag the pavement construction and form a “cold joint.”

In placing curb concrete, sufficient consolidation shall be done to secure an adequate bond with the paving slab and eliminate all voids in the curb.

The finished surface of the curb and gutter shall be checked by the use of a ten-foot straight-edge and corrected if necessary.

## **31.09 Curing**

**31.09.1 General** Concrete shall be cured by protecting it against loss of moisture, rapid temperature change, rain, flowing water, and mechanical injury for a period of not less than five days from the beginning of the curing operation. Curing shall conform to Section 30.13 and Section 31.02.4.

## 31.10 Joints

**31.10.1 General** Longitudinal and transverse joints shall be per detail S19.1, et seq. and the recommendations of the Portland Cement Association and the American Concrete Paving Association. In the event of a discrepancy, the more stringent requirements shall apply.

**31.10.2 Expansion Joints** Expansion joints shall be provided as shown on the plans, around manholes, valve boxes, inlets, other structures, and as directed by the Project Manager. Expansion joints shall conform to the specification in Section 30.02.9. They shall extend the entire width of the pavement and from the subgrade to ½ inch below the surface of the pavement.

Under no circumstances shall any concrete be left above the expansion material or across the joint at any point. Any concrete spanning the ends of the joint next to the forms shall be carefully cut away after the forms are removed. Before the pavement is opened to traffic, the groove above the filler shall be cleaned and sealed with specified joint sealing material.

**31.10.3 Sawed Joints** Sawing of the joints shall begin as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling. Any procedure for sawing joints that result in premature and uncontrolled cracking or raveling shall be revised immediately by adjusting the time interval between the placing of the concrete and cutting of the joints. The sawing of any joint shall be omitted if a crack occurs at or near the joint location before the time of sawing. Sawing shall be discontinued if a crack develops ahead of the saw. If necessary, the sawing operations shall be carried out both day and night, regardless of weather conditions. A standby saw shall be available in the event of breakdown.

**31.10.4 Construction Joints** Construction joints shall be placed whenever the placing of concrete is suspended for more than 30 minutes.

**31.10.5 Plastic-Parting Strip Joint** The joint material shall be inserted with a mechanical device that places the material in a continuous strip, except where intervening structures break the continuity of paving. Splices in the joint material will be permitted providing they are effective in maintaining the continuity of the joint material.

**31.10.6 Joint Sealing** Joints shall be filled to a level such that, upon cooling, the sealer shall be slightly below the concrete surface about 1/8 inch (1/4 inch maximum). Any excess material should be removed from the pavement surface before opening to traffic.

**TABLE 31.10.6.1  
SUGGESTED LOCATION OF LONGITUDINAL JOINTS  
(TYPE E OR L - SEE S19.2 AND S19.3)**

ROADWAY CLASSIFICATION	LOCATION OF LONGITUDINAL JOINT
Local Type 1	BOC, 7', 11', 11', 7', BOC
Local Type 3	BOC, 9.5', 11', 11', 9.5', BOC
Two-Lane Collector	BOC, 12.5', 11', 11', 12.5', BOC
Four-Lane Collector	BOC 6.5', 11', 11', 11', 11', 6.5', BOC
Four-Lane Arterial	BOC <sup>1</sup> , 7.5', 12', 12', 14', 12', 12', 7.5', BOC <sup>1</sup>
Six-Lane Arterial	BOC <sup>1</sup> , 14.5', 12', 13.5', BOC <sup>1</sup> BOC <sup>1</sup> , 13.5', 12', 14.5', BOC <sup>1</sup>

<sup>1</sup> Monolithic C & G are not allowed without an approved revised joint pattern.

Note: Location of joints may vary due to local conditions, traffic, bike paths, etc.

BOC = Back of Curb

### 31.11 Structures

All manholes, catch basins, or structures of a permanent nature encountered in areas to be paved shall be raised or lowered to the elevation of the surface of the new pavement and the specified expansion material placed around each structure for the full depth of the slab.

### 31.12 Protection and Opening to Traffic

The Contractor shall protect the pavement against all damage prior to final acceptance of the work. Traffic shall be excluded from the pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old, or has attained a flexural strength of 550 psi when tested in accordance with AASHTO T 23 or T 97. The pavement shall not be used at any time within this period for transporting or operating equipment. As a construction expedient, the subgrade planer, concrete finishing machine, and similar equipment may be permitted to ride upon the edges of previously constructed slabs provided the concrete is more than 72 hours old and the equipment have rubber-tired wheels to run on the finished slab. The pavement shall be cleaned and tabbed for lane stripes (or painted) immediately before opening to traffic.



## 31.13 Slip Form Paving

**31.13.1 General** When the concrete pavement exceeds 50 lineal feet the Contractor shall use a slip-form paver and the construction methods described in the preceding section of the specifications shall not be applicable. All reference in the preceding sections of this specification referring to forms shall be deleted. Use of a vibrating screed is not allowed.

**31.13.2 Grade** After the grade or base has been placed and compacted to required density, the grade and areas which are to support the paving machine shall be cut to the proper elevation by means of a fine-grading machine. The fine-grading machine shall be of sufficient weight, and shall be either self-propelled or towed by sufficient power, to trim the compacted material without gouging or tearing the surface. The machine shall have cutting edges or surface shavers controlled from an independent control reference wire by means of an automatic control device. The machine may accomplish the fine grading by means of successive passes with each pass controlled from the independent reference line through the automatic control. Motor graders shall not be used for shaping of the base except for small areas or areas of irregular shape where the use of a fine grade would be impracticable. If the density of the base is disturbed by the grading operations, it shall be corrected by additional compaction before concrete is placed. If any traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately ahead of the placing of the concrete.

**31.13.3 Placing Concrete** All concrete shall be placed with a self-propelled, string-controlled paving machine with internal vibrators designed to spread, consolidate, screed, and float-finish the freshly-placed concrete in one complete pass of the machine in such manner that a minimum of hand finish will be necessary to provide a dense and homogenous pavement in conformance with the plans and specifications. The machine shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Such vibrations shall be accomplished with vibrating tubes or arms working in the concrete, and vibrating pan operating on the surface of the concrete. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The forms shall trail behind the paver for a distance such that no appreciable slumping of the concrete will occur.

The concrete shall be held at a uniform consistency, having a slump of not more than 2 inches. The slip-form paver shall be operated with as nearly a continuous forward movement as possible, and all operations of mixing, delivering, and spreading concrete shall be so coordinated as to provide uniform progress with stopping and

starting of the paver held to a minimum. If for any reason it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

### **31.14 Subgrade Preparation**

See Section 20.06.9 and 20.06.10 for requirements before proceeding with the following requirements. The subgrade shall be in a moist condition at the time the concrete is placed. It shall be thoroughly wetted a sufficient time in advance of the placing of the concrete to insure that there will be no puddles or pockets of mud when the concrete is placed but shall not be allowed to dry out before the concrete is placed.

Immediately prior to placing the concrete, the subgrade and forms shall be tested for conformity with the cross section shown on the plans by means of an approved template or string line method. Forms shall be checked for grade. If necessary, material shall be removed or added, as required, to bring all portions of the subgrade to the correct elevation. It shall then be thoroughly compacted and again tested with the template.

Concrete shall not be placed on any portion of the subgrade which has not been tested for density, correct grade, and cross section. The subgrade shall be cleared of any loose material. All soft and yielding material and other portions of the subgrade which will not compact readily when rolled or tamped shall be removed as directed and replaced with structurally suitable material, placed and compacted as specified.

Prior to placing concrete, the testing agency shall submit to the Project Manager a report under the seal of a Professional Engineer stating the forms are to proper grade, the subgrade is at proper depth and cross slope, and the subgrade is properly prepared and compacted.

### **31.15 Testing and Acceptance**

**31.15.1 Test Specimens** The Contractor shall furnish the concrete necessary for casting test beams and cylinders, as well as supplying an area for curing safely along with required power for said curing. One set of 4 beams and 6 cylinders shall be made for each 300 cubic yards, or fraction thereof, of pavement placed, but not less than two sets of beams and cylinders for any one day's work, plus any additional beams or cylinders ordered by the Project Manager. The beams and cylinders shall be cured by the method specified in AASHTO T 23. A qualified independent testing agency, meeting requirements of Section 32.05, shall furnish the molds and test the specimens. Each specimen shall be marked with the date, time, location, batch, and

any other pertinent information. Testing for Portland Cement Concrete Pavement by qualified independent testing agency shall be performed in accordance with Section 32.00 following Section 32.03.4 for sampling, testing, frequency, and reporting of results.

**31.15.2 Thickness** The Project Manager may require core tests for determining actual thickness and for outlining areas of deficient thickness. Cores shall be taken as directed. The length of the thickness deficiency will be taken as half way between the core showing the deficiency and the nearest acceptable core.

The Contractor, at his expense, may take additional cores to further define the area of thickness deficiency. The area so determined will not be taken as less than one full panel, as defined by transverse joints and the width of one pass of the paver. It will include the curb and sidewalk if poured integrally with the paving. The Project Manager shall determine whether the deficient concrete panels shall be removed and replaced by the Contractor at the Contractor's expense.

**31.15.3 Strength Tests** Unless otherwise approved by the Project Manager, beams shall have a minimum field modulus of rupture at 28 days of 600 psi when tested in accordance with AASHTO T 177.

**31.15.4 Final Surface Test** Prior to acceptance of the pavement, the Project Manager may require the Contractor to test the surface of the finished pavement with a ten-foot straight-edge. Any areas higher than 1/4 inch, but not higher than 3/8 inch above the correct surface (as indicated by such test) shall be ground to the required surface by the Contractor at his expense. When the deviation exceeds 3/8 inch, the pavement shall be removed and replaced by the Contractor at his expense. Final surface testing may be completed using a profilograph, with the written permission of the Project Manager.

## **31.16 Opening Pavement to Traffic**

No traffic or contractor's equipment shall be permitted on the pavement until the strength requirement has been reached. Criteria shall be at least 2,500 psi for PCCP over eight inches thick, and the design field strength (4,000psi) for PCCP less than or equal to eight inches thick. See Section 31.17 for using the maturity method to predict opening strength.

## 31.17 Developing Strength-Maturity Relationship

The maturity method utilizes the principle that directly relates the strength of concrete to the cumulative temperature history of the concrete. Using this principle, the Project Manager and Contractor can quickly and reliably estimate the field strength of concrete based on the *maturity index* (equivalent age or time-temperature factor) rather than by beam or cylinder tests in the field or the laboratory. The maturity as applied to a concrete mix is specific to that particular mix. When the mix design is changed, the Contractor may need to develop a new maturity relationship, or *maturity curve* in accordance with ASTM Standard Specification 2461.

**31.17.1** The development of a maturity-strength relationship requires three steps. These include:

**31.17.1.01** Developing the maturity-strength curve in the laboratory or in the field,

**31.17.1.02** Estimating the in-place strength in the field, and

**31.17.1.03** Verifying the strength-maturity relationship in the field.

This procedure utilizes the Nurse-Saul method for developing strength-maturity curves, as described in ASTM C 1074. The Nurse-Saul method uses a specific datum temperature (usually  $-10^{\circ}\text{C}$ , but may be determined experimentally) to calculate the time-temperature factor (TTF) and to relate this to the measured concrete flexural or compressive strength at the particular TTF value. The general form of the Nurse-Saul method is shown in Equation 31.17.1.03.1.

$$TTF = \sum(T_a - T_0)\Delta t \quad \text{Equation 31.17.1.03.1}$$

where

TTF = the time-temperature factor at age  $t$ , degree-days or degree-hours,

$\Delta t$  = time interval, days or hours,

$T_a$  = average concrete temperature during time interval,  $\Delta t$ ,  $^{\circ}\text{C}$ , and

$T_0$  = datum temperature,  $-10^{\circ}\text{C}$ .

This test method describes the procedure for developing maturity-strength relationships to estimate concrete strength using the maturity method. This method uses either beams for flexural strength or cylinders for compressive strength. While the majority of this procedure uses dual units, measure and record all temperatures relating to the computation of maturity in degrees centigrade ( $^{\circ}\text{C}$ ).

#### **31.17.1.04 Definitions**

**31.17.1.04.1 Temperature Sensor** The device on a maturity meter or data logger that is inserted into the concrete and provides a measure of temperature.

**31.17.1.04.2 Data Logger** A commercially available device that record temperature measurements from a temperature sensor at various intervals

**31.17.1.04.3 Maturity Meter** A commercially available device that includes a temperature sensor, data logger, and conducts maturity calculations automatically.

**31.17.1.04.4 Maturity Index** The cumulative area under the time-temperature curve developed as concrete cures. The units of maturity index are in degree-hours (C-hr). For the purposes of this procedure, the maturity index called the time-temperature factor (TTF).

**31.17.1.04.5 Maturity Curve** The relationship between the time-temperature factor and the strength of the concrete.

**31.17.1.04.6 Verification Test** At various intervals during construction, the maturity curve is verified by casting additional specimens and comparing the TTF-strength relationship with the original maturity curve for a particular mix.

#### **31.17.1.05 APPARATUS**

**31.17.1.05.1 Maturity Meter or Temperature Sensor and Data Logger** A maturity meter, for the sole purpose of recording concrete maturity, or a temperature sensor and data logger combination, accurate to  $\pm 1^{\circ}\text{C}$ , and capable of recording data at a time interval of 1 hour or less. For high-early strength or accelerated opening mixes, provide a device capable of recording data at a time interval of 15 minutes or less.

Calibrate maturity meters yearly to ensure proper operation and temperature sensing.

Verify proper operation of maturity meters and temperature sensors every 30 days during normal plant production. Perform verification by comparing the temperature recorded by the maturity meter or temperature sensor to a known temperature, as provided by a calibrated thermometer. Use at least

three temperature points (e.g. 40°F, 75°F, and 110°F [5°C, 25°C and 45°C]) in the sensor verification.

**31.17.1.05.2 Beam Specimen Molds** Developing a maturity relationship with beams, a minimum of 15 beam specimen molds are required. Use beam molds six inches by six inches (150 mm x 150 mm) in cross section, and with an overall length allowing for a span length in the testing apparatus of at least 3 times the depth.

**31.17.1.05.3 Cylinder Specimen Molds** Developing a maturity relationship with cylinders, a minimum of 17 cylinders specimen molds are required. Use cylinder molds four inches by eight inches (100 x 200 mm). If the aggregate has a maximum size greater than 1¼ inches (31.5 mm), use 6 inch x 12 inch (150 x 300 mm) molds.

**31.17.1.05.4 Flexural Strength Test Apparatus** The apparatus for testing beam strength in flexure shall conform to the requirements in Testing Beams for Flexural Strength) of the AASHTO T-97

**31.17.1.05.5 Compressive Strength Test Apparatus** The apparatus for testing compressive strength shall conform to the requirements in AASHTO T-22 (Compressive Strength of Cylindrical Concrete Specimens).

#### **31.17.1.06 PREPARATION OF SPECIMENS**

**31.17.1.06.1** Prepare specimens according to ASTM C39 (cylinders) or AASHTO T97 (beams). The preferred method is to cast, cure, store, and test specimens in the field at the beginning of the construction project. Ensure that concrete temperatures in the specimens do not drop below 50°F (10°C). If air temperatures are expected to drop below 40°F (4°C), place the specimens on foam board or plywood to insulate them from the cold ground. Place insulation on and around the specimens.

If prepared in the laboratory, ensure that concrete used in making the specimens is identical in mixture proportions, quantities and material manufacturers to those specified on the Approved Mix Design.

**31.17.1.06.2** Test and record air content, temperature, and slump of the fresh concrete on the form provided by the Maturity Meters' manufacturer.

**31.17.1.06.3** For beams, prepare 15 specimens according to the appropriate standard listed e sensors in at least two of the specimens. Place all sensors so that they are approximately 3 in. (75 mm) from any surface and in one of the outside thirds (i.e. within 6 in. (150 mm) from the end of the beam). Save the specimens with the temperature sensors for testing last.

For cylinders, prepare 17 specimens according to the appropriate standard listed in Section 31.17.1.06.1 above. Use a minimum of one cubic yard of concrete. Embed temperature sensors in the center of two of the specimens, record the data and do not test for strength.

**31.17.06.4** Protect the concrete specimens according to ASTM C39 (cylinders) or AASHTO T97 (beams).

**31.17.07 Procedure**

**31.17.07.1 Develop Strength-Maturity Relationship** Perform strength tests according to AASHTOT 97(beams) or AASHTO T-22 (compressive) for the type of concrete at the ages specified in the table below.

**Table 31.17.07.1.1**

<b>Chronological Testing Ages of Strength Specimens</b>	
<b>Type of Concrete</b>	<b>Testing Ages *</b>
Concrete pavement Normal Strength Concrete	Determined by the Contractor <sup>1</sup> 1, 2, 3, 7 and 28 days
High-Early (HE) Concrete	12 hours, 1, 2, 7 and 28 days
Ultra-High-Early (UHE) Concrete	3, 4 and 8 hours, 1 and 14 days
* The Contractor may adjust the testing ages if approved by the Engineer, in conjunction with the Concrete Engineer.	
<sup>1</sup> Test at least two (2) sets of strength specimens before the anticipated opening strength.	

Test three specimens at each age and compute the average strength.

If a low test is the result of an obviously defective specimen, discard the result from the average but record its value and the reason for discarding it in the data entry form.

At each test age, determine the average maturity index (TTF) at the time the specimens are tested, by averaging the values obtained from the two maturity meters or data loggers. If using a maturity meter, read the maturity index directly from the meter. If using a temperature sensor and data logger, calculate the maturity index using the time-temperature history from the logger, and Equation 31.17.1.03.1 of this procedure. Average the two maturity index values and report this in the appropriate location on the *Concrete Maturity-Strength Development* form.

The *Concrete Maturity-Strength Development* form is a Microsoft Excel® spreadsheet that plots the average flexural strength vs. the average maturity index for each test age, and determines the best-fit logarithmic curve using the form.

$$S = S_u e^{-\left(\frac{\tau}{TTF}\right)^\alpha} \quad \text{Equation 31.17.1.07.1}$$

Where:

- S = flexural strength (modulus of rupture) or compressive strength, psi
- TTF = the time-temperature factor at age t, degree-days or degree-hours,
- S<sub>u</sub> = ultimate expected flexural strength, psi
- τ, α = time and shape coefficients.

Use the resulting fitted curve maturity-strength relationship for estimating the in-place strength of concrete cured under any conditions including those in the lab or in the field.

Obtain the *Concrete Maturity-Strength Development* form for these calculations from the Concrete Engineering website <http://www.dot.state.mn.us/materials/concrete.html>.

For pavements, determine the opening strength criteria for concrete pavements in accordance with Section 31.16, “Opening Pavement to Traffic.”

Enter all collected and recorded data in the *Concrete Maturity-Strength Development* form.



### **31.17.07.2 Estimate In-Place Concrete Strength**

To estimate the in-place concrete strength in the field, place a temperature sensor in the concrete at a rate specified in AASHTOT-97 Standard Specification.

Record the identification number(s) of the maturity meters or data loggers on the *Maturity - Field Data* form.

Protect any protruding wires from construction equipment. Initiate data collection and recording according to the manufacturer's instructions. Use a datum temperature value of -10°C.

At regular intervals, check the recorded maturity index (or temperature history and compute the maturity index). Record the temperature readings and calculate the maturity values on the *Maturity - Field Data* form to estimate the strength of the in-place concrete.

### **31.17.07.3 Verify Strength-Maturity Relationship**

At intervals, cast and cure three specimens and insert a temperature sensor in at least one of them. If using cylinders, cast an additional cylinder for inserting the temperature sensor only. Test all three specimens as described in this standard as close to the maturity index (TTF) for the opening, loading or form removal strength criteria as possible. Compute the average strength as described in using the *Concrete Maturity-Strength Verification* form.

Plot the average strength and maturity index on the *Concrete Maturity-Strength Verification* form and check that it falls on or near the curve.

Report the results of the validation testing on the *Concrete Maturity-Strength Verification* form and submit the form to the Project Manager in the field.

**SECTION 32.00 MATERIALS TESTING .....1**

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## **SECTION 32.00 MATERIALS TESTING**

### **32.01 Scope**

The requirements of this section shall apply to all testing agencies and required materials testing services for soils, asphalt, and concrete.

### **32.02 Responsibilities of the Testing Agency**

**32.02.1 General** All materials and operations shall be tested in accordance with these specifications and as directed by the Project Manager. Agencies testing soil and rock shall meet the requirements of ASTM D 3740. Agencies testing asphalt or concrete shall meet the requirements of ASTM D 3666 or D 1077, respectively. All testing agencies shall meet the requirements of ASTM E 329.

A trained and properly qualified representative of the testing agency shall observe, sample, and test the materials and work on the project, as required by these specifications and as directed by the Project Manager. If any materials furnished or the work performed by the Contractor fails to fulfill the specification requirements, such deficiencies shall be reported to the Project Manager and the Contractor, immediately. Preliminary written field reports of all tests and observation results shall be given to the Contractor or Developer immediately after they are performed. Field reports shall be made available to the Project Manager by the testing agency. Final reports shall be forwarded to the Project Manager no later than one week following the testing. Results of all tests taken, including failing tests, shall be reported.

Reports shall bear the seal and signature of a Professional Engineer licensed in the State of Colorado and competent in the required testing practice. All test reports shall show the horizontal location where the test was performed or where the work or batch represented by the test was placed. Test reports shall include all information specified in the AASHTO or ASTM test procedure used. Improperly completed reports will not be accepted. A Certificate of Occupancy, or initial acceptance, will not be issued until all final reports indicating compliance with these specifications are reviewed and placed on file by the City. The testing agency personnel are not authorized to stop work, to revoke, alter, relax, enlarge, or release any requirements of the specifications, or to approve, accept, or reject any portion of the work.

## 32.03 Testing

**32.03.1 General** All testing methods and procedures performed by the testing agency personnel shall be in accordance with the applicable AASHTO and ASTM requirements and procedures (see Tables 32.03.1 – 32.03.6). Test reports shall include the AASHTO and ASTM test designations of all tests taken. All testing and retesting services shall be at the expense of the Contractor or Developer, except on City contracts. Initial testing on City contracts shall be at the City's expense; all retesting due to failing tests shall be at the Contractor's expense.

When changes in materials or proportions are encountered during construction, or when the work fails to pass tests or fails to meet the specifications, additional tests shall be taken as directed by the Project Manager. Failure of the Contractor or Developer to furnish satisfactory test data shall be sufficient cause for rejection of the work in question.

### 32.03.2 Soil Testing

**32.03.2.01** All testing shall be according to AASHTO or ASTM as designated in Table 32.03.1 and Table 32.03.2.

**32.03.2.02** When density and moisture content are determined by a nuclear device, a sand cone density test shall be taken daily or at the discretion of the Project Manager or the City. If the results of the sand cone tests do not agree with the nuclear tests, use of that nuclear device shall be immediately discontinued until the cause of the disagreement is determined and corrected.

**32.03.2.03** A moisture-density determination shall be taken for each soil type encountered. For A-6 and A-7 soils, AASHTO T 99 shall apply. All other soils use AASHTO T 180.

**Table 32.03.1  
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING FOR EMBANKMENT**

	AASHTO	ASTM	Minimum Frequency of Tests
<b>SOILS</b>			
Sampling	T 86	D 420	One test per soil type
Soil Classification	M 145	D 3282	One test per soil type
Liquid Limit	T 89		One test per soil type
Plastic Limit	T 90		One test per soil type
Material Finer than 75um Sieve	T 11 T 88		One test per soil type
Moisture Density (Proctor)	T 99 T 180	D 698 D 1557	One test per soil type
In-Place Density			
Nuclear	T 238 T 239	D 2922 D 3017	One test for each 200 lane feet per layer or every 200 cu. yds. (not less than one test per day)
Sand Cone	T 191	D 1556	One test for every tenth nuclear method in-place density test

**Table 32.03.2  
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING FOR  
AGGREGATE BASE COURSE**

	AASHTO	ASTM	Minimum Frequency Of Tests
<b>AGGREGATE BASE COURSE</b>			
Sampling	T 2	D 75	One test per every 1,000 tons or fraction thereof
Moisture Density	T 180	D 1557	One test per every 1,000 tons or fraction thereof
Atterberg limits	T 89 & T 90		One test per every 1,000 tons or fraction thereof
Gradation	T 27 & T 11		One test per every 1,000 tons or fraction thereof
In-place density	T 238 & T 239		One test for each 200 lane feet per layer or every 200 cu. yds.
Thickness			One test for each 200 lane feet per layer or every 200 cu. yds.
Resilient Modulus	T 294		Upon request

**Table 32.03.3**  
**SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING**  
**FOR BITUMINOUS PAVING MIXTURES**

	AASHTO	ASTM	Minimum Frequency of Tests
<b>ASPHALT</b>			
Sampling	T 168	D 979 D 3665	One test per every 1,000 tons or fraction thereof (not less than one test per day)
Hveem properties	T 245 T 247 T 166	D 1559 D 1561	One test per every 1,000 tons or fraction thereof (not less than one test per day)
In-place density		D 1188 D 2950	One test for each 250 linear lane feet per layer of in-place HBP
Asphalt content	T 164 T 269 TP 53	D 2172 D 3203 PS 90	One test per every 1,000 tons or fraction thereof (not less than one test per day)
Maximum Specific Gravity of HBP	T 209	D 2041	One test per every 1,000 tons or fraction thereof (not less than one test per day)
Air voids and VMA <sup>1</sup>	T 269	D 3203	One test per every 1,000 tons or fraction thereof (not less than one test per day)
Thickness		D 3549	One test for each 250 linear lane feet
Aggregate Gradation	T 27	C 136	One test per every 1,000 tons or fraction thereof (not less than one test per day)

<sup>1</sup> If production test result calculations for VMA indicate results are not within the mix design specification limits, the testing agencies are required to verify the bulk specific gravity from the asphalt supplier prior to the publication of the test results.

**Table 32.03.4**  
**SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING**  
**FOR PORTLAND CEMENT CONCRETE**

	AASHTO	ASTM	Minimum Frequency of Tests
<b>CONCRETE</b>			
Sampling	T 141	C 172	One set per 50 cu. yds. One set per 100 cu. yds. (paving)
Compressive strength		C 39	One set per 50 cu. yds. One set per 300 cu. yds. (paving)
Temperature		C 1064	One test per 50 cu. yds.
Unit Weight	T 121	C 138	One set per 25 cu. yds. One set per 50 cu. yds. (paving)
Slump	T 119	C 143	One set per 25 cu. yds. One set per 50 cu. yds. (paving)
Water to Cementitious Material Ratio			Per each load tested. APPS available for Android and Apple
Air content	T 196 T 121	C 173 C 138	One set per 25 cu. yds. One set per 50 cu. yds. (paving)
Thickness		C 174	One test per 500 linear lane feet (paving)

**Table 32.03.5**  
**SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING**  
**FOR SLURRY SEAL**

	AASHTO	ASTM	Minimum Frequency of Tests
Residue after distillation	T 59		One test for each 5,000 sq. yds. or fraction thereof (not less than one test per day)
Extraction and Gradation	T 164 T 30		One test for each 5,000 sq. yds. or fraction thereof (not less than one test per day)
Application Rate			One test for each 5,000 sq. yds. or fraction thereof (not less than one test per day)

**Table 32.03.6**  
**SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING**  
**FOR STABILIZED SUBGRADE**

Test Type	Test Standard	Minimum Frequency of Tests
Sampling	AASHTO T 87	Per 1,000 square yards
Maximum Dry Density and Optimum Moisture Content	ASTM D 3551	As directed by Project Manager (minimum one per soil type)
In Place Soil Density	ASTM D 1556 ASTM D 2167 ASTM D 2922	One test for each 200 lane feet (not less than 1 test per day)
In Place Moisture Content	ASTM D 2216 ASTM D 3017	
pH	ASTM C 110 ASTM C 977 APPENDIX	One test per 1,000 square yards
Swell	ASTM D 4546 Method B	As directed by Project Manager
Unconfined Compressive Strength (Lime)	ASTM D 5102 (Procedure B)	One set of 4 cylinders per 1,000 square yards. Sealed and moist cured at 100°F for 5 days.
Compressive Strength Cementitious Agents	ASTM D 1633 (Method A)	One set of 4 cylinders per 1,000 square yards. Sealed and moist cured at 100°F for 5 days.
Atterberg Limits	AASHTO T 89 & T 90	One test per 1,000 square yards
Thickness	As directed by Project Manager	One test every 500 feet per lane
Percentage of Agent	AASHTO T 232 See Section 22.11	One test per 1,000 square yards

**32.03.2.04** In addition to the requirements of Section 32.03, all reports shall include elevation or depth below finish grade at which the test was taken. Results shall report densities (maximum dry and relative) to nearest 0.1 lb/cu. ft., moisture content (optimum and in place) to nearest 0.1%, and compaction (relative and required) to nearest 0.1%. The most recent adjusted manufacturer's calibration



curve must be available upon request. The manufacturer's calibration curve shall be adjusted as required by ASTM D 2950.

### **32.03.3 Asphalt Testing**

**32.03.3.01** All testing shall be according to AASHTO or ASTM as designated in Table 32.03.3.

**32.03.3.02 *In-Place Density*:** A minimum of one test for each 250 linear lane feet per layer of in-place HBP or fraction thereof.

**32.03.3.03 *Aggregate Gradation*** A minimum of one test per 1,000 tons or fraction thereof.

**32.03.3.04** In addition to the requirements of Section 32.03, all reports shall include densities to the nearest 0.1 lb. per cu. ft. and compaction to the nearest 0.1%. If a nuclear device is used, the report shall contain the method used (i.e., back scatter, direct transmission, etc.)

**32.03.3.05** In-place pavement thickness shall be determined as follows: The pavement shall be cored at 500 foot intervals or fraction thereof, in each 12 foot lane (nominal), with a minimum of three cores in any area. The Project Manager may require additional cores to define deficient areas.

### **32.03.4 Concrete Tests**

**32.03.4.01** All testing shall be according to AASHTO or ASTM as designated in Table 32.03.4.

**32.03.4.02** Sampling and testing shall be required on all concrete work including curb, sidewalk, pans, pavement, slope paving, retaining walls, inlets, manholes, or any other structures.

**32.03.4.03** Maximum time between sampling and casting cylinders shall not exceed 45 minutes. If the concrete cannot be taken to the laboratory and cylinders cast within 45 minutes, the cylinders shall be cast in the field. Cylinders shall be transported to the laboratory within 24 hours of casting, but after the concrete has hardened (see AASHTO T 23).

**32.03.4.04** Concrete cylinders shall be broken according to the following table.

**Table 32.03.7  
CONCRETE CYLINDER BREAKS**

NUMBER OF CYLINDERS	BREAK INTERVAL (days)
FIELD CURED SERIES (4-Cylinders)	
2	7
2	14*
LABORATORY CURED SERIES (6 Cylinders)	
2	7
2	28
2	45*

\* Or as directed by the Project Manager

One laboratory cured series shall be taken for each 50 cubic yards of concrete placed or fraction thereof.

**32.03.4.05** Slump AASHTO: T 119. Air: AASHTO T 196 or T 121. Test shall be taken for each 25 cubic yards of concrete placed or fraction thereof. A minimum of three slump and air tests shall be taken per day or as directed by the Project Manager. Slump and air tests shall be taken with each cylinder series.

**32.03.4.06** If samples of fresh concrete have not been obtained and tested, a minimum of three cores shall be taken per AASHTO T 24 and broken. Air content, ASTM C 451, and cement content, AASHTO T 178, shall also be determined. Concrete in the portion of the structure from which the core was taken will be considered adequate if the average strength of the cores is equal to a minimum of 80% of the specified strength (f 'c) and if the strength of no single core is less than 75% of f 'c. All core holes shall be completely filled with a concrete meeting the same mix design criteria.

**32.03.4.07** In addition to the requirements of Section 32.03, all reports shall include the type of structure; cylinders; data on obtaining, transporting, storing, curing, time between sampling and casting cylinders; supplier, batch ticket I.D., finisher and contractor.

## **32.04 Responsibilities of the Contractor or Developer**

**32.04.1 General** The Contractor or Developer shall provide at his expense the required testing services, except on City contracts. Initial testing on City contracts shall be at the City's expense. All retesting shall be at the Contractor's expense. The use of a

testing agency's services does not relieve the Contractor or Developer of the responsibility to furnish the required materials and to perform the required construction in full compliance with these specifications. Passing test results do not constitute acceptance of the work or materials represented by the test. The Contractor is responsible for quality control of his work.

**32.04.2 Testing Agency Access and Assistance** The Contractor or Developer shall allow the testing agency access to the job site at all times; furnish any labor required to assist the testing agency in obtaining and handling samples at the source of material and at the project; provide and maintain, for the sole use of the testing agency, adequate facilities for safe storage and proper curing of concrete test specimens the project site as required by AASHTO T 23.

**32.04.3 Mix Designs** When requested by the Project Manager, the Contractor or Developer shall furnish asphalt mix designs or concrete mix designs meeting the requirements of these specifications. Concrete mix designs shall be performed according to the most recent provisions of ACI-211 or ACI-304. A separate mix design shall be provided if pumped concrete is used.

## **32.05 Personnel Qualifications**

**32.05.1** The person responsible for the quality control testing shall be a Licensed Professional Engineer in the State of Colorado and practicing in this field.

**32.05.2** Technician shall be certified as a Level II or higher NICET in the specific area where they perform tests, i.e., soils, concrete, asphalt.

**32.05.3** The technician taking samples and performing tests must possess one or more of the following qualifications.

- Technicians taking samples and conducting compaction tests must have a Level A certification from LabCAT or equivalent.
- Technicians conducting tests of asphalt content and gradation must have a Level B certification from LabCAT or equivalent.
- Technicians determining asphalt mixture volumetric and strength characteristics must have a Level C certification from LabCAT or equivalent.
- Technicians taking concrete samples and conducting field tests must have a Concrete Field Testing Technician - Grade I certification from ACI or equivalent.
- Technicians conducting tests of Portland cement concrete for compressive strength and flexural strength and to determine mixture design characteristics shall possess a certification from Concrete Laboratory Testing Technician - Level 1 or equivalent.

**SECTION 33.00 CONTROLLED LOW STRENGTH MATERIALS (CLSM)**

- BACKFILL.....1**
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- 33.02 Mix Design .....3
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## **SECTION 33.00 CONTROLLED LOW STRENGTH MATERIALS (CLSM) BACKFILL**

### **33.01 Scope**

This work shall consist of the excavation and rapid backfill of trenches for the installation or repair of utility and underground substructures, temporary paving patching materials, and the replacement of permanent paving surfaces. The work requires the use of removable, controlled low-strength materials (CLSM) for the backfill material, as an alternative to traditional compacted soil, for trenches and cuts too small for traditional soil compaction and safe human entry for testing it. Temporary pavement materials may also be utilized, prior to permanent pavement repairs are made.

#### **33.01.1 Description of Removable, Flowable, Backfill Materials or CLSM**

**33.01.1.01** The term CLSM used in this ITEM shall mean the same as Removable CLSM or flowable backfill. This material is covered in detail due to the many time saving and engineering benefits of this type of backfill material. CLSM does not need compacting from the contractor, nor moisture density compaction testing. Only a few physical tests of the CLSM properties are needed to assure durability and future removability with light excavating equipment. A low strength is desired so that surrounding utilities or structures will not be damaged if the CLSM must be removed in the future. Air entrainment is required to prevent damage and displacement of trench patches due to freeze-thaw damage.

**33.01.1.02** In addition, the CLSM may be used for other specialized applications apart from trench or street cut backfill. These include filling voids due to pipe abandonment or undercutting of excavation in caving or normal soils. CLSM offers quick restoration of the trench or improving other subgrade condition for roadway or structure support in a rapid time frame without need or traditional soil backfill testing requirements or when a quick strength is needed to support upper layers. These benefits may outweigh the extra costs vs. using traditional compaction and testing methods.

**33.01.1.03** Other specialized applications include: backfilling behind retaining walls and abutments, filling void areas including pipe abandonment, annular spaces, undercut areas and other approved void filling applications. Other suitable

applications include structural support for utilities, replacement of unstable subgrade during pavement repairs.

**33.01.1.04** Utility types that can utilize CLSM include: conduits or pipes for electrical, communications, fiber optic, traffic signal or other small utilities, gas and water lines, sanitary and storm sewer lines, and other types of utility under existing pavements or ground surfaces to be later built upon or improved.

### **33.01.2 Objectives for Required Use of CLSM**

**33.01.2.01** The objectives of requiring the use of the CLSM specified below instead of reusing excavated soils, is to provide a self-leveling, frost heave-resistant, non-settling, controlled low-strength material (defined by American Concrete Institute in ACI 229 as a CLSM), that does not require compactive effort and compaction testing. Traditional use of soil or aggregate materials for backfill will require Project Manager or Public Improvement Observer's approval and testing.

### **33.01.3 Requirements for CLSM – Flow-Fill or Flash-fill**

**33.01.3.01** This ITEM further specifies two distinct CLSM material products: The Flash-fill products will allow trench backfill, temporary or permanent pavement restoration and traffic access to occur more quickly than Flow-Fill. The terms 'CLSM' in this ITEM shall mean either or both.

**33.01.3.02** A **high slump** is required to aid in the self-leveling and void filling objective. The visual consistency may appear to range in appearance from thin batter or mud, to thick water. It must be foremost removable with light machinery in the future, and also quickly stable to support paving operations and traffic quickly.

**33.01.3.03** **Minimum air contents** are required in the top four feet of CLSM fill to limit permanent frost heave. This air content requirement should be used for the entire depth, to aid in the ability to remove or excavate CLSM in the future. The air content spec may be forbidden for some utility agencies, such as for thrust blocks or as pipe bedding normally used for lateral support of pressurized pipes.

**33.01.3.04** A **Removability Modulus (RE)** is specified at a maximum 1.5, and is based on compressive strength and unit weight of the CLSM Backfill. Refer to Section 33.04.01.

## **33.02 Mix Design**

**33.02.1** A mix design shall be prepared in a testing laboratory by a Colorado Registered Professional Engineer competent in the field of materials engineering. In lieu of a mix design, documentation of field test data may be submitted. Samples of the mix, with its formula, shall be made available to the City for testing prior to construction. City reviewed mixes may be considered prequalified for subsequent usage. The Contractor shall have an approved mix design for Flow Fill or Flash Fill prior to placement. Flowability and strength requirements when tested in accordance with ASTM D 4832, shall be as list in Section 30.03

## **33.03 Materials and Production**

### **33.03.1 Flow-Fill**

**33.03.1.01** shall consist of a controlled low-strength, self-leveling concrete material composed of various combinations of cement, fly ash, aggregates, water, chemical admixtures and/or cellular foam for air-entrainment. It shall have a minimum air content of 6.0% but may be increased to a range from 15% to 25%, when tested in accordance with ASTM C231, to provide suitable resistance to frost-heave. Generally, a contractor may place Flow-Fill in approximate 3 feet thick layers, allow bleed water to rise and divert away from placement before another layer may be added.

**33.03.1.02** Flow-Fill shall have typical design compressive strengths of 30 to 150 psi at 28 days, when tested in accordance with ASTM D4832. However, the Flow-Fill shall be limited to a maximum Removability Modulus (RE, as described in Section 33.03.2.02) of 1.5, which may require the lower strengths towards the 50 psi minimum, and/or higher air contents over 15%.

**33.03.1.03** The mix shall result in a product having a flow in the range of 6 to 8 inches, when tested in accordance with ASTM D6103. Flows of less than 6 inches will not be permitted for placement, since the flowability to avoid settlement is impaired, and strengths may increase.



**33.03.1.04** The contractor shall submit a mix design for approval by a representative of the City Engineer, prior to placement. The mix design shall be supported by laboratory test data verifying compliance with air content, slump, strength and removability (RE) requirements.

**Table 33.03.1.1  
Flow Fill Properties and Specifications**

Flow-Fill Property	Flow-Fill Specification
Air Content, ASTM C231	6% Minimum
Compressive Strength, ASTM D4832	50psi – 150psi at 28 days
Slump, ASTM C143	7" – 10"
Removability Modulus, RE	1.5 Maximum

**33.03.2 Flash-Fill**

**33.03.2.01** Flash-fill shall consist of a controlled low-strength, self-leveling cementitious material composed of various combinations of fly ash, water, chemical admixtures, and/or cellular foam for air-entrainment. No aggregate or sand is usually needed. It may have a minimum air content of 6.0% if testing shows this air content provides suitable resistance to frost-heave but shall be increased to a range from 15% to 25%, when tested in accordance with ASTM C231, or by volumetric calculations shown below in Section 33.04.02, to provide suitable resistance to frost-heave when no testing is available. Higher air limits may be allowed by a representative of the City Engineer for special circumstances.

**33.03.2.02** Flash-Fill may have typical design compressive strengths of 100 to 300 psi at 28 days, when tested in accordance with ASTM D4832. Higher strengths may be permitted, but the flash-fill shall be limited to a maximum Removability Modulus (RE) of 1.5, which may require lower strengths and/or higher air contents.

**33.03.2.03** The mix shall result in a product having fluidity as measured by ASTM D6103 with typical spreads of 8 to 12 inches, or greater. Flow of spreads of less than 8 inches will not be permitted for placement, since the flowability to avoid settlement is impaired and the strength may increase.

**33.03.2.04** The contractor shall submit a mix design for approval by a representative City Engineer, prior to placement. The mix design shall be supported by

laboratory test data verifying compliance with air content, slump, strength and removability (RE) requirements.

**Table 33.03.2.1  
Flash Fill Properties and Specifications**

<b>Flash-Fill Property</b>	<b>Flash-Fill Specification</b>
Air Content, ASTM C231, or by Section 33.04.2 volumetric calculations (recommended)	15% Minimum
Compressive Strength, ASTM D4832	100psi – 300psi at 28 days
Slump, ASTM C143 (may set too fast)	8" – 11"
Spread, ASTM D6103 (recommended)	8" – 12", or greater
Removability Modulus, RE	1.5 Maximum

### **33.03.3 Cement**

**33.03.3.01** Cement shall meet the standard chemical requirements of Type II or Type IP, ASTM C150, or ASTM C595, respectively.

### **33.03.4 Fly Ash**

**33.03.4.01** Fly ash shall meet the requirements of ASTM C633 or AASHTO M 295, Type C or Type F. Fly ash not meeting the requirements of ASTM C633 or AASHTO M 295 may be used if prior testing indicates acceptable, consistent results for strength and air content.

### **33.03.5 Water**

**33.03.5.01** Potable water or reasonably clean and free of chemicals injurious to the final product are to be used.

### **33.03.6 Chemical Admixtures**

**33.03.6.01** Air-entraining admixtures shall conform to ASTM C260 requirements; other chemical admixtures shall conform to ASTM C494 requirements.

### **33.03.7 Foaming Agents**

**33.03.7.01** Foaming agents shall conform to ASTM C869 and C796, or as approved by the engineer.

### 33.03.8 Suitability of Flowable Backfill Constituents

**33.03.8.01** Flowable Backfill materials may not contain any material deemed toxic or hazardous. Material Safety Data Sheets (MSDS) must be available for any cement, fly-ash or admixture component of the mixture upon request. Flowable Backfill shall be compatible with bedding materials, electrochemically and otherwise if used as a metal pipe backfill application.

### 33.03.9 Aggregates

**33.03.9.01** Aggregates including rock, coarse aggregate, and/or fine aggregate, shall conform to the following gradations of Table 33.03.9.01.1:

**TABLE 33.03.9.01.1  
Flowable Backfill Aggregate Gradation**

Sieve Size	% Passing
1 inch (25 mm)	100
No. 200	0 to 10

**33.03.9.02** When coarse aggregate is used, 100 percent shall pass the 1-inch sieve, and it shall comprise of not more than 40 percent of the total aggregate content. Other aggregate products such as aggregate base, crushed rock, pea gravel, or reject sand will have no more than 20 percent passing the No. 200 sieve and be free of organic material and other deleterious substances may be accepted when the CLSM is flowable, workable, and can be produced without segregation of the aggregate.

## 33.04 Limits

### 33.04.1 Removability Modulus

**33.04.1.01** The Removability Modulus\*, RE, is a value calculated by:

$$RE = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6} \quad \text{Equation 33.04.1.1}$$

Where:

W = in-situ unit weight (pcf)

C = 28-day compressive strength (psi)

\* RE was developed and is used by Hamilton County, Ohio; per the NCHRP #597 CLSM Report. A lower RE means the CLSM will be easier to excavate or remove.

**Table 33.04.1.01.1  
REMOVABILITY MODULUS**

Compressive strength, psi [ C ]	Unit Weight, pcf [W]										
	50	60	70	80	90	100	110	120	130	140	150
25	0.18	0.24	0.30	0.37	0.44	0.52	0.60	0.68	0.77	0.86	0.96
50	0.26	0.34	0.43	0.53	0.63	0.74	0.85	0.97	1.09	1.22	1.35
75	0.32	0.42	0.53	0.64	0.77	0.90	1.04	1.18	1.33	1.49	1.65
100	0.37	0.48	0.61	0.74	0.89	1.04	1.20	1.37	1.54	1.72	1.91
125	0.41	0.54	0.68	0.83	0.99	1.16	1.34	1.53	1.72	1.93	2.14
150	0.45	0.59	0.75	0.91	1.09	1.27	1.47	1.67	1.89	2.11	2.34
175	0.49	0.64	0.81	0.98	1.17	1.38	1.59	1.81	2.04	2.28	2.53
200	0.52	0.68	0.86	1.05	1.26	1.47	1.70	1.93	2.18	2.44	2.70
Less than or equal to 1.50 indicates Removable							1.70	Shading indicates Not Readily Removable			

### 33.04.2 Air Content Volumetric Calculation

**33.04.2.01** Air content can be calculated as follows (using wet densities before and after foaming):

$$\text{Air Content} = \frac{(\text{Unit Weight No Air-Entrained} - \text{Unit Weight Air-Entrained}) \times 100\%}{\text{Unit Weight No Air-Entrained}}$$

Equation 33.04.2.01.1

### 33.04.3 Flow consistency of CLSMs using ASTM D6103

**33.04.3.01** ASTM D6103 utilizes a moistened 3” diameter, 6” high open-ended cylinder, filled with the Flash Fill. When the cone is lifted, the resulting “pancake” is measured at its longest and shortest dimensions and averaged.

**33.04.3.02** CLSM backfill shall be produced from a job mix formula as specified above.

## 33.05 Placement

**33.05.1** Use of Pre-Qualified Flash-fill or Flow-Fill will only be allowed with the permission of the Materials Testing Laboratory, or the Project Manager, or the Public Improvements Observer for backfilling of utility trenches. In no case will Flash-fill or Flow-Fill be allowed to come in contact with or within one foot of any utility line.

- 33.05.2** Before depositing flowable backfill, debris shall be removed from the space to be occupied by the CLSM backfill. CLSM backfill shall be held low enough from the pavement surface to allow adequate trench patching depth per Detail S10.2. Vibratory or other compaction equipment shall be used **only** when necessary to fill inaccessible voids.
- 33.05.3** This work shall consist of the excavation and rapid backfill of trenches for the accommodation of Utility substructures, and the replacement of paving surfaces. The work requires the use of removable, CLSM for the backfill material, as an alternative to traditional compacted soil. This is specified herein for specialized backfill situations.
- 33.05.4** CLSM backfill should be discharged directly from the truck into the space to be filled, or by other methods approved by a representative City Observer. The mix may be placed part depth or full depth as conditions at the site dictate. When used as backfill in the pipe zone, care should be taken to prevent flotation or misalignment of the pipe by means of straps, soil anchors, or other approved means of restraint. Material may be placed in stages with initially less flowability, to prevent movement or flotation of pipe.
- 33.05.5** Compaction of CLSM backfill will not be required. The maximum layer thickness shall be 3 feet at one time. Additional layers shall not be placed until the backfill has lost sufficient moisture to be walked on without indenting more than 2 inches. Any damage resulting from placing flow fill in layers that are too thick or from not allowing sufficient time between placement of each layer shall be repaired at the contractor's expense.
- 33.05.6** Placement of pavement materials or allowing vehicular traffic shall not be allowed until the flowable backfill has achieved a penetration resistance of at least 50 psi using a hand-held penetrometer, in accordance with ASTM C 403. This penetration resistance shall be considered achieved when a person weighing at least 150 pounds, by use of their body weight as an axial load, cannot penetrate the flowable backfill with the square cut end of a No. 4 steel reinforcing bar.

## **33.06 Excess Excavation**

**33.06.1** Use of Flash fill or flow fill will only be allowed with the permission of the Materials Testing Laboratory, or the Project Manager, or the Public Improvements Observer for backfilling of utility trenches. In no case will Flash fill or flow fill be allowed to come in contact with or within one foot of a metal utility line. All excess excavation material will become property of the Contractor and shall be removed from the job site be at the expense of the Contractor.

**SECTION 34.00 RELATED CONSTRUCTION AND SPECIFICATIONS ...1**

34.01 Utility Construction .....1

34.02 Storm Drainage Specifications .....1

34.03 Minimum Storm Drainage Pipe Size .....1

34.04 Trenchless Technology .....1





## **SECTION 34.00 RELATED CONSTRUCTION AND SPECIFICATIONS**

### **34.01 Utility Construction**

All utility construction within the city shall conform to the requirements in the "[City of Aurora Standards and Specifications Regarding Water, Sanitary Sewer and Storm Drainage Infrastructure](#)," latest edition. The above utility standards and specifications shall by reference be a part in whole of these standards and specifications and may be [downloaded](#) from the City's website. Where utilities are to cross concrete pavements, saw cuts shall be at existing joints so whole panels shall be removed, unless otherwise approved by the City Engineer. No new joints shall be made.

### **34.02 Storm Drainage Specifications**

All design criteria and regulations governing storm drainage and storm water within the city shall conform to the requirements in the "[City of Aurora Storm Drainage Design & Technical Criteria](#)," latest edition. The above storm drainage standards and specifications shall by reference be a part in whole of these standards and specifications and may be [downloaded](#) from the City's website.

**34.02.1** Storm sewers placed in arterial roadways within the C.O.A. right-of-way shall be either RCP, Class III or higher. Other alternate pipe materials will not be considered for use in arterial roadways.

### **34.03 Minimum Storm Drainage Pipe Size**

The minimum diameter of storm pipe allowed within public right-of-way shall be 18 inches.

### **34.04 Trenchless Technology**

Trenchless technology refers to subsurface, horizontal excavation used as an alternative to trenching for installation of utility lines. Pipes, conduits, sleeves, cables, and wires will be collectively referred to as utility lines in this section. This section applies primarily to directional boring. It also applies to pneumatic missiling, micro-tunneling, augering and pipe ramming, or jacking. Utility companies, Contractors, and others using trenchless technology in City rights-of-way or other City properties such as parks, drainage ways, parking lots, etc., shall be licensed and bonded with the City. A utility construction permit shall also be required. For information, refer to Section 7, CONSTRUCTION REQUIREMENTS, and Section 36.0, ROAD CUTS.

**34.04.1 Location of Existing Utilities** Prior to construction, all existing underground utilities shall be physically located. It is advised to obtain design locates when

planning bore alignments. It may not be allowable to waive clearance and depth requirements solely due to unknown conflicts if design locates were not performed.

All underground utilities shall be marked on the surface five feet on both sides of the proposed bore alignment by the utility owners. Contact the Utility Notification Center of Colorado at 1-800-922-1987 for locating service and a listing of tier 2 utilities. Contact the City of Aurora Water Department for water, sanitary and storm sewer locates; the Public Works Department for traffic signal locates; and the Parks Department for irrigation system locates. Contact adjacent property owners for locating private water service lines, sanitary service lines, and sprinkler systems. Depth determination of existing utilities shall be done by carefully potholing.

**34.04.2 Size and Alignment of Bores** Bore hole diameter and the amount of void space remaining around the utility line shall be minimized to prevent surface subsidence. Alignment and depth of bores shall be designed to accommodate the many different underground utilities which use relatively narrow corridors and cross each other.

**34.04.2.01 Size of Bores** Bore hole diameter shall not exceed 1-1/2 times the utility line diameter for smaller utilities less than seven inches in diameter. For larger utility lines and multiple lines using the same bore hole, approval of construction methods and bore diameter by the City Engineer shall be required.

**34.04.2.02 Alignment and Depth of Bores** Bore hole alignment shall be parallel for longitudinal street bores and perpendicular for street crossings. A bore hole shall not meander more than one foot to either side of the approved proposed alignment. A bore hole shall not encroach within one foot, horizontal or vertical, of another utility facility. The minimum depth of private utility lines (gas, electric, communication) shall be 30 inches.

### **34.04.3 Drilling Operations**

**34.04.3.01 Water** Water used for the drilling operation shall not be obtained from City fire hydrants without a meter. A meter shall be obtained from the City's Water Shop at 13645 E. Ellsworth Avenue (phone 303-326-8120) to be used on hydrants. The Water Department personnel at the Water Shop will provide direction on use and proper methods for filling tanks so as not to cause a cross connection that could contaminate the City's water supply.

**34.04.3.02 Emergencies** The Fire Department shall be notified immediately (phone 911) whenever gas or electric lines are damaged by the drill. The utility owner and the City observer shall be notified whenever any utility line is damaged. Failure to make these notifications may be cause to revoke license and permit.

**34.04.3.03 Mud Containment and Clean Up** Drilling mud shall be ponded or contained in a manner which does not allow it to flow onto sidewalks, into traveled lanes, or down the gutter across driveways and cross pans. It is prohibited to allow mud to be tracked onto City streets. It is also prohibited to wash drilling mud into, or allow it to flow into storm sewer inlets. Citations will be issued for these violations. The City observer may temporarily allow the Contractor to pond mud in the gutter with the use of hay bales or sand bags as long as it is barricaded and does not impede traffic. In the event drilling mud should leak from the bore hole to the surface, the area shall be barricaded from vehicular and pedestrian travel immediately before resuming drilling operation. Complete clean up of drilling mud with hydro-vacuuming equipment is required at the end of each day.

**34.04.4 Restoration and Miscellaneous** Pavement, sidewalk, other items of infrastructure, and landscaping damaged during construction shall be replaced or repaired.

**34.04.4.01** Surface improvements undermined from adjacent bore/splice pits more than one foot horizontally shall be replaced or repaired.

**34.04.4.02** Structures raised by more than 1/4 inch due to pressure from drilling mud, e.g., humped pavement or faulted sidewalk stones, shall be replaced or repaired.

**34.04.4.03** Bore holes greater than three inches in diameter and are abandoned without conduit shall be filled with an approved grout or flowable backfill material.

**34.04.4.04** Conduit wasted between the bore hole collar at grade and the splice pit at depth shall be removed, not abandoned in place.

**34.04.4.05** Lids and covers on hand holes, pull/splice/junction boxes, and other below-grade utility vaults shall be adjusted to grade prior to backfilling. Buried facilities with concealed covers are prohibited.

**34.04.4.06 Asphalt Pavement Repairs** See Section 36.00 for requirements.

**SECTION 35.00 RIPRAP AND FILTER BLANKET.....1**

35.01 Riprap.....1

35.02 Construction Requirements.....1



## SECTION 35.00 RIPRAP AND FILTER BLANKET

### 35.01 Riprap

All materials and construction methods shall conform to Urban Storm Drainage Criteria Manual (USDCM), Volume 1, "Management, Hydrology and Hydraulics, Chapter 8, Open Channels." Per USDCM, Figure 8-34 – "Riprap and soil riprap placement and gradation (part 1 of 3)"

### 35.02 Construction Requirements

Slopes to be protected by riprap, soil riprap, or void-filled riprap shall be free of brush, trees, stumps, and other objectionable material and be dressed to a smooth surface. All soft or spongy material shall be removed to the depth shown on the plans, or as directed by the Project Manager, and replaced with approved material. All slopes and embankments not in the right-of-way of roadways shall be compacted at optimum moisture to a minimum 90% of the maximum density as determined by AASHTO Test T 99 or T 180, depending on the soil type. All slopes and embankments in the right-of-way of roadways shall be compacted in accordance with the latest revision of Section 20.06, Excavation and Embankment.

**35.02.1 Dumped Riprap** Stone for riprap shall be placed on the prepared slope or area in a manner which will produce a reasonably well-graded mass of stone with the minimum practicable percentage of voids. The entire mass of stone shall be placed so as to be in conformance with the lines, grades, and thickness shown on the plans. Riprap shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying material. Placing of riprap in layers, or by dumping into chutes, or by similar methods likely to cause segregation will not be permitted.

The larger stones shall be well distributed and the entire mass of stone shall conform to the gradation specified in Section 35.01, Riprap. All material going into riprap protection shall be so placed and distributed so there will be no large accumulations of either the larger or smaller sizes of stones.

Unless otherwise authorized by the Project Manager, the riprap protection shall be placed in conjunction with the construction of the embankment with only sufficient lag in construction of the riprap protection as may be necessary to allow for proper construction of the portion of the embankment protected, and to prevent mixture of embankment and riprap. The Contractor shall maintain the riprap protection until accepted; any material displaced by any cause shall be replaced to the lines and grades shown on the plans at no additional cost to the City.

**35.02.2 Hand-Placed Riprap** Hand-placed riprap shall conform to all the requirements of Section 35.02.1, Dumped Riprap. Hand-placed riprap shall be required when the depth of riprap is less than two times the nominal stone size, or when required in the special conditions.

After the riprap has been dumped, hand placing or rearranging of individual stones by mechanical equipment shall be required to the extent necessary to secure a uniform surface and the specified depth of riprap.

**35.02.3 Soil Riprap or Void-filled Riprap** Soil riprap or void-filled riprap shall conform to the requirements of UDFCD’s, Volume 1, "Management, Hydrology and Hydraulics”, Chapter 8, “Open Channels”, Section 8.2.

**35.02.4 Grouted Riprap** Grouted riprap shall not be used.

**35.02.5 Grouted Boulders** Grouted boulders shall conform to the requirements of Urban Drainage and Flood Control District’s requirements under Volume 2, “Structures, Storage and Recreation”, Chapter 9, “Hydraulic Structures”, Section 2.6.4. The boulders shall be placed on the prepared grade to the dimensions shown on the plans. The boulders shall be thoroughly moistened before grouting.

Grout shall not be placed when the temperature is below 35°F or at 35°F and falling. It shall be protected from freezing and cured as specified in Section 30.00, CONCRETE WORK.

**35.02.6 Filter Blanket** Filter fabric is not a complete substitute for granular bedding. Per USDCM Figure 8-34, “Riprap and soil riprap placement and gradation (part 3 of 3)”, granular bedding shall be required as follows.

**TABLE 35.02.6.1  
THICKNESS REQUIREMENTS FOR GRANULAR BEDDING**

Riprap Designation	Minimum Bedding Thickness (Inches)		
	Fine Grained Soils*		Course Grained Soils**
	Type I	Type II	Type II
VL, L	4	4	6
M	4	4	6
H	4	6	8
VH	4	6	8

\* May substitute one 12-inch layer of Type II bedding. Substitution of one layer of Type II bedding shall not be permitted at drop structures. Use of a combination of filter fabric and Type II bedding at drop structures is acceptable.

\*\* 50% or more by weight retained on the #40 sieve

When required, a filter blanket shall be placed on the prepared slope or area to the full specified thickness of each layer in one operation, using methods which will not cause segregation. The surface of the finished layer should be reasonably even and free from mounds or windrows. Additional layers of filter material, when required, shall be placed in the same manner, using methods which will not cause mixture of the material in the different layers.



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## **SECTION 36.00 ROAD CUTS**

### **36.01 Scope**

This section is designed to help the contractor, engineer, project manager, HOA, or utility company to understand what restorations will be required if a new or existing street, or Right-of-Way in the City of Aurora is cut. The Public Works Director is authorized under the Aurora City Code and the Colorado Revised Statutes (“C.R.S.”) 38-5.5-106 to set standards for public roadways in the City of Aurora. The following standards are adopted to maintain the esthetics, ride quality, structural integrity, safety and life cycle of new and existing City of Aurora Roadways.

### **36.02 License**

All contractors working in the City of Aurora’s public right-of-way are required to be licensed and bonded by the City of Aurora.

### **36.03 Permits**

All contractors working in the City of Aurora’s public right-of-way, including Landscapers and HOAs (excludes work that does not require excavation or construction of above grade facilities), are required to obtain a permit from the Public Improvement Inspections Permit Counter, Suite 2400, prior to any site construction. For all work other than city projects, the contractor doing the work is responsible for pulling the permit, unless otherwise specified by state law, license agreement, or franchise agreement (Comcast, Xcel Energy). Emergency repairs of utilities to restore a service disruption may begin without a permit as long as the city is notified of the extent of the work, and a permit is obtained the next working day. Permits for irrigation line installation and repair shall be based on waterline trench fees for lines three-inch and larger and on service line installation on lines less than three-inches in diameter.

### **36.04 Notification and Inspection Requirements**

The contractor is required to notify and request inspection a minimum of 24 hours before beginning work. Failure to call for inspection is grounds for rejection, removal and replacement of work. Inspections are to be scheduled through the Public Improvement Inspections Permit Counter at 303-739-7420. Inspectors’ work hours are Monday through Friday 7:30 AM to 4:00 PM. Inspection work outside of these hours or on weekends or on holidays, will be billed as overtime at the current overtime rate. When inspectors are on standby outside of normal working hours, the Contractor will be billed at overtime rates. There is a minimum charge of 4

hours for weekends and holidays. Work on weekends or holidays must be requested by close of business two business days before the weekend or holiday.

### **36.05 Road Cut Definition**

A road cut is defined as any excavation, break, removal, hole, or displacement of a roadway surface caused by or resulting from: physical removal, mechanical removal, subsurface investigations, or changes in subgrade moisture attributable to construction activities, construction traffic, or utility related movement such as breaks, settlement or heaving.

### **36.06 Disturbed Roadway Definition**

A disturbed roadway is defined as any roadway, or roadway surface that is displaced, cut, heaved, settled, cracked, or eroded as a result of construction related activities, including, but not limited to, repairs or failures of utilities. Road surfaces include but are not limited to dirt, gravel, millings, asphalt, and concrete.

### **36.07 Requirements and Exceptions**

All road cuts or other roadway disturbances within the City of Aurora's public right-of-way shall be repaired or restored according to the standards specified in this Section 36.00. There might be additional requirements specified elsewhere in the Roadway Design and Construction Specifications.

Any exceptions to these standards for road cut restorations must be approved in writing by the City Engineer or his/her assignee.

### **36.08 Small Trench Cut in an Existing Roadway**

This section is generally reserved for small road cuts from utility locates, water line repairs, sewer line repairs, electrical line repairs, gas main, phone lines, fiber optic lines, cable lines, or service line repairs with damage to asphalt pavement areas less than 500 square feet. Unless pre-approved, all small trenches must be closed and temporarily resurfaced by the end of the workday. Trenches in existing roadways shall be backfilled with compacted native materials or with a pre-approved controlled low-strength material (CLSM) backfill, and the surface restored to use by the end of the workday through the use of hot patch asphalt, cold-mix asphalt or steel plate. (Plating is not allowed between October 15 and April 15.)

Final surface restoration shall be completed within 48 hours of temporary surface placement, excluding curing of concrete. For roadways where concrete is involved, high early strength concrete may be required. For damaged or disturbed concrete pavements, sidewalks, curbs,

gutters, cross pans, fillets, handicap ramps, etc., the entire panel must be removed and replaced, unless a variance is granted by the City Engineer or his/her assignee.

If more than 500 square feet of existing roadway is disturbed (from single street cuts on arterial or collector streets to multiple street cuts on local streets) within a single block, the construction area shall be milled and overlaid by the end of the project or as directed by the City Engineer. The mill and overlay shall encompass all of the disturbed asphalt areas in a generally rectangular shape. See Subsection 36.10 for additional requirements. Standard trench patching shall be required immediately following the initial road cut(s). Should the disturbed pavements be limited to a small or single area, the City Engineer or the Public Improvement Inspections Supervisor may reduce the required mill and overlay pavement areas.

### **36.09 Trenches Crossing a Roadway**

Unless otherwise approved in writing by the City Engineer, all trenches crossing a roadway shall be perpendicular to the direction of travel. The sides of the trench shall be saw cut smooth a minimum of two-feet from the edge of the trench. The road surface shall be replaced in accordance with Standard Detail S10, matching the existing pavement grade and maintaining proper drainage. In concrete roads, the pavement thickness shall be the same as existing, but the panel must be doweled into the existing pavement as shown in the standard details. Unless otherwise approved, all cuts in asphalt road surfaces that are less than three-years old shall be milled and overlaid with approved materials a minimum of ten-feet on both sides of the trench for local roadways and a minimum of 25-feet on both sides of the trench for collector and arterial roadways.

### **36.10 Trenches within a Roadway**

**36.10.1** Longitudinal trenches within a roadway shall be straight and will generally be a consistent distance from either the centerline of the road or flow line, as specified. Meandering will not be allowed. All pavements shall be saw cut a minimum of two-feet beyond the edge of the trench prior to patching. If the distance between the edge of the trench and the lip of gutter, cross pan, or edge of pavement is less than six feet, all pavement to the lip of gutter, cross pan or edge of pavement shall be removed and replaced. At a minimum, removed asphalt pavements shall be in accordance with Standard Detail S10.

**36.10.2** Pavements within arterials and collectors shall have the final repairs completed within 24 hours of the completion of the work requiring a road cut, unless the City Engineer grants an exception in writing. All permanent repairs and temporary

patches shall restore the pavement to existing or **better conditions** than existed prior to construction. Temporary patches in arterial and collector roadways shall be completed by the end of each working day.

**36.10.3** Final repairs of pavements within local streets shall be completed within five days of the completion of the work requiring a road cut, unless the City Engineer grants an exception in writing. At no time will more than 800 feet of trench be allowed to be un-restored or temporarily patched. All patches shall restore the pavement to existing or **better condition** than existed prior to construction.

**36.10.4** In collector and arterial roadways whose surface is **more than three-years old**, a minimum 12-foot wide mill and overlay to a depth of three inches is required for the length of the trench before the end of construction. Where the trench straddles two or more traffic lanes, both lanes shall be milled and overlaid to a depth of three inches for the length of the trench before the end of construction or as specified by the City Engineer or his/her assignee.

**36.10.4.1** Local streets shall be patched in accordance with Standard Detail S10.1 and S10.2. Where multiple trench cuts occur in the street, the construction area shall be milled and overlaid by the end of the project or as directed by the City Engineer. The mill and overlay shall encompass all of the disturbed asphalt areas in a generally rectangular shape.

**36.10.5** In collector and arterial roadways whose surface is **less than 3-years old**, the half of the roadway disturbed by construction shall be milled and overlaid to a depth of three inches for the length of the trench before the end of construction or as specified by the City Engineer or his/her assignee. This restoration section shall extend from the centerline of the roadway to the lip of the gutter or pan. Should the road surface on both sides of the centerline be damaged as a result of construction activities, the entire surface of the roadway shall be milled and overlaid as directed by the City Engineer or his/her assignee.

**36.10.5.1** Local streets shall be patched in accordance with Standard Detail S10.1 and S10.2. Where multiple trench cuts occur in the street, the construction area shall be milled and overlaid by the end of the project or as directed by the City Engineer. The mill and overlay shall encompass all of the disturbed asphalt areas in a generally rectangular shape.

**36.10.6** At no time will more than 800 feet of road be disturbed and unavailable for the public use, unless approved in writing by the City Engineer.

**36.10.7** All final road restorations shall be completed within 24 hours for arterials and 4-lane collectors, 48 hours for 2-lane collectors and 5 days for locals. Failure of the contractor to perform the required restorations on time may result in the work being done through the city with the project owner/contractor responsible for all costs. Failure to remit payment for those charges within 30 days of written notice may incur additional finance charges, project acceptance delays, and collection fees.

### **36.11 Potholes for Locates or Subsurface Investigations in Asphalt Pavements**

Unless otherwise approved in writing by the City Engineer, potholes for utility locates shall be done by means of a 3 to 6-inch diameter core drill through the existing roadway surface. Cuts in asphalt roadways with a surface disturbance less than one-square foot shall be repaired using pre-approved pavement materials with an infrared surface treatment. Should there be more than five surface cuts, including any previous cuts, or a single disturbed area greater than one-square foot, or should the area require extensive repair, the entire disturbed area shall be milled to a depth of three inches and re-paved per City Standards. Paving shall be a minimum of 50 feet in length and a minimum of 12 feet in width or as directed by the Public Improvement Inspections observer.

All small subsurface excavations shall be backfilled using a pre-approved controlled low-strength materials (CLSM) backfill. The use of sand, soil, pea gravel, bedding material, or any other material not pre-approved for this type of application by the Aurora Materials Testing Laboratory, or cannot flow to fill the entire void, will not be allowed.

### **36.12 Potholes For Locates or Subsurface Investigations in Concrete Pavements**

Unless otherwise approved by the City Engineer in writing, potholes for utility locates shall be done by means of a 3 to 6 inch diameter core drill through the concrete surface. Cores larger than six inches in diameter or open excavations shall be repaired as directed by the Public Improvement Inspections observer. Cores in concrete pavement shall be plugged using a pre-approved fast setting pavement concrete. More than five cuts in a concrete pavement, including any previous cuts, or a single disturbed area greater than one square foot, shall require the entire panel to be removed and replaced.

For sidewalks, curbs, gutters, fillets, handicap ramps and other small concrete placements, the Public Improvement Inspections observer shall determine the extent of replacement if only one small core is performed. Should the concrete section/panel have more than one core, including any previous core, the entire section/panel shall be removed and replaced unless otherwise directed in writing by the City Engineer or his/her assignee.

All small subsurface excavations shall be backfilled using a pre-approved controlled low-strength materials (CLSM) backfill. The use of sand, soil, pea gravel, bedding material, or any other material not pre-approved by the Aurora Materials Testing Laboratory or cannot flow to fill the entire void to prevent settlement and provide proper load bearing character, will not be allowed.

### **36.13 Amount of Unpaved Roadway Trench**

Unless otherwise approved by the City Engineer in writing, at no time shall more than 800-feet of a trench or trenches be without final restoration and useable by the public. Situations other than a temporary surface patch, approved by the Public Improvement Inspections observer, due to weather or the need to gain access for final tie in work must be approved in writing by the City Engineer or his/her assignee prior to the road surface being cut. Before paving, the contractor or the project owner shall demonstrate passing compaction density tests by the use of written field test notes from the Geotech doing the testing and passing a proof roll as specified in Section 20.06.9 of the City of Aurora Roadway Specifications. Official testing on the roadway surface and subsurface conditions shall be delivered to the Aurora Materials Testing Laboratory within seven days of installation and restoration.

### **36.14 Trenchless Technology – Bores and Missiles**

Trenchless construction for dry utilities using missiles, rams, unguided bores, or any other type of limited control device is not allowed in the City of Aurora right-of-way. Only machines with fully controlled boring head are permitted.

The individual contractor shall warranty the work for a period of 10 years for heave or settlement. In areas where the exact depth and location of sewer mains or services is not known, the contractor shall pothole to determine the depth or shall have a TV video survey done of the sewer line or service, prior to construction. The contractor shall again video survey the sewer line or service after construction is complete to demonstrate the lines have not been damaged. A videotape of the before and after conditions shall be submitted to the city within 30 days of completing boring operations.



### **36.15 Traffic Signal Restoration**

Any and all damage, to traffic signal poles, lines, loop detectors, or any other components of the traffic signal shall be immediately reported to the Public Improvement Inspections observer. Unless otherwise approved by the City Traffic Manager, all repairs shall be made immediately. If additional active traffic control is required due to the damage caused by construction activity, it shall be at the expense of the contractor who damaged the facility.

### **36.16 Traffic Signage and Pavement Markings Restoration**

Unless otherwise specified by the City Traffic Manager, all signage and striping shall be restored to existing or better condition within 24 hours. Missing or damaged markings and signs that may pose a serious risk to the traveling public shall be repaired or restored immediately.

### **36.17 Public Safety**

The contractor is responsible for maintaining a clean, neat and safe work site at all times. The safety of the public is the first and foremost concern of the City. The contractor shall take all steps to protect the health, life, property and safety of the public, City staff and contracting staff. To that end, the following shall be adhered to when working in a City roadway:

1. Traffic control plans shall be submitted to the Permit Center and approved by the City Traffic Engineering Division at the time a permit is requested. Prior to any work in the City roadway, the approved plan shall be implemented.
2. Any and all holes in City right-of-way shall be backfilled at the end of the working day. If the work is scheduled to extend beyond a single day, the construction area may be kept open with approval of the City Traffic Manager. If allowed to remain open, the construction area shall be secured from public access through the use of construction fences, concrete barricades, or lighted barricades (panel, barrel or sawhorse). No work will be allowed in arterial roadways between the hours of 6:00 a.m. and 8:30 a.m., and 3:30 p.m. to 6:30 p.m. Traffic control setup shall not begin before 8:30 a.m. and must be removed by 3:30 p.m. along collectors and arterials.
3. All trenches in excess of two-feet deep, in or adjacent to an active roadway shall be secured from the traveling public by the use of temporary concrete barricades.
4. Work hours shall be in accordance with Section 126-136(3) of the City Code. Work hours will typically be limited to 7:00 AM to 5:00 PM for heavy construction unless work is being done on an emergency basis to restore lost utility service to existing customers or done within a busy collector or arterial where the Traffic Manager has imposed restrictions on work hours.
5. At no time will an excavation remain open over a weekend without the express written approval of the City Engineer or Traffic Manager.

6. At no time will an excavation be allowed to remain open endangering the public, contractors or City staff.

### **36.18 Minimum Pavement Standards**

All pavement materials, construction methods, construction practices and materials testing shall be in conformance with the Roadway Design & Construction Specifications, latest edition.

### **36.19 Smoothness Criteria**

Unless otherwise specified, surface variation of pavement repairs shall not deviate by more than 3/16-inch in 10 feet. Settlement adjacent to newly repaired road cuts shall be considered damage incidental to the road cut and must be included in the approved repair. In the event the proper smoothness or matching of existing pavement cannot be maintained due to existing roadway wear or condition, the damaged pavement section shall be repaired or removed and replaced as directed by the Public Improvement Inspections observer.

### **36.20 Warranty Period**

Unless otherwise approved by the City Engineer in writing, all repairs shall be warranted against defects in material, workmanship or settlement for a minimum of one year from the date of initial acceptance in accordance with Section 7.12 of the Roadway Design & Construction Specifications. Repairs to property associated with utility repair, maintenance or installation shall be for a minimum of two years per Section 126-513 of the City Code.

### **36.21 Landscaping and Irrigation Within and Outside Public Right-of-Way**

Unless otherwise specified by a franchise agreement or license agreement, all construction related work in public right-of-way shall be required to be permitted. Damages to the right-of-way or City owned facilities, such as, but not limited to, signs, street lights, traffic signal wiring, conduits, walkways, bike paths, retaining walls, inlets, or curb and gutters, shall be the responsibility of the Contractor or HOA associated with the work to repair such damage.

Any damages to landscaping outside of the public right-of-way caused by the work shall be repaired to as good as or better than the original condition.

**SECTION 40.00 SEEDING .....1**

- 40.01 Scope .....1
- 40.02 Materials.....1
- 40.03 Construction Requirements.....1
- 40.04 Permissible Planting Times .....3
- 40.05 Maintenance.....3
- 40.06 Seed Germination Inspection.....3



## SECTION 40.00 SEEDING

### 40.01 Scope

Seeding shall consist of furnishing and drilling-in, placing, or sowing seed at locations shown on the plans, or as designated, in conformity with the requirements of these specifications.

### 40.02 Materials

**40.02.1 Seed** All seed shall be furnished in bags or containers clearly labeled to show the name and address of the supplier, the seed name, the lot number, net weight, the percent of weed seed content, and the guaranteed percentage of purity and germination. All brands furnished shall be free from such noxious seeds as Russian or Canadian thistle, European bindweed, Johnson grass and leafy spurge. The Contractor shall furnish to the Project Manager signed statements certifying that the seed furnished is from a lot that has been tested by a recognized laboratory for seed testing within six months prior to the date of delivery. Seed which has become wet, moldy, or otherwise damaged in transit or in storage will not be acceptable.

Seed and seed labels shall conform to all current state and federal regulations and will be subject to the testing provision of the Association of Official Seed Analysis.

If seed available on the market does not meet the minimum purity and germination percentages specified, the Contractor must compensate for a lesser percentage of purity and germination by furnishing sufficient additional seed to equal the specified product. Product comparison shall be made on the basis of pure live seed in pounds. Seed shall conform to the mixtures indicated in the Standard Detail SM in the *City of Aurora Rules and Regulations Regarding Stormwater Discharges Associated with Construction Activities*, latest edition.

**40.02.2 Fertilizer and Organic Matter** Treble super phosphate (18-46-0) will be used on all soil to be seeded. The rate of application shall be 250 lbs./acre. Organic matter is defined as compost, peat moss, and aged manure mixtures, or any combination of the above materials. The rate of application shall be 4 cu. yd. per 1000 sq. ft. to be seeded.

### 40.03 Construction Requirements

Preparatory to seeding, all irregularities in the ground surface, except the saucers for trees and shrubs, shall be removed. The surface shall then be brought to the desired line and grade.

Fertilizer and organic matter shall be used wherever there is not any suitable topsoil that can be moved back in place after the earthwork is complete. The organic matter and fertilizer shall be applied uniformly to the soil and rototilled or disked 6" into the soil to be seeded. Necessary measures shall be taken to prevent the formation of low places and pockets where water will stand. Immediately prior to seeding, the ground surface shall be lightly tilled or hand worked into an even and loose seed bed having no lumps or stones over 3". The seedbed shall be well settled and firm, but friable enough so seed can be placed at the seeding depth required, and be reasonably free of weeds.

Seeding may be accomplished by means of mechanical power-drawn drills followed by packer wheels, broadcast-type seeders, or another method if approved by the Project Manager.

Mechanical power-drawn drills shall have depth bands set to maintain a planting depth of at least 1/4". All seed sown by broadcast-type seeders shall be "raked in" or otherwise covered with soil to a depth of at least 1/4" and rolled to obtain a firm seed bed. Water shall be applied when necessary.

Seed shall not be drilled or sown during windy weather or when the ground is frozen or otherwise untillable. When a seed drill is used, it shall be set to space the rows not more than 7" apart. Hand method of broadcasting seed will be permitted only on small areas not accessible to the machine method.

Seed of different sizes for mixtures to be drilled shall be sown from at least two separate hoppers adjusted or set to provide the coverage of the planted mixtures specified.

To protect newly-seeded areas mulch shall be applied. Mulch shall be applied at a rate of 2 1/2 tons per acre and shall be attached by an approved method suitable for the type of mulch used. Mulch shall be spread uniformly, in a continuous blanket, after seeding is complete. Mulch shall be clean, weed and seed free, long stemmed grass or hay, or long stemmed straw of oats, wheat or rye. At least 50% of mulch, by weight, shall be ten inches or longer. Mulch shall be spread by hand or blower-type mulch spreader. Mulching shall be started on the windward side of relatively flat areas or on the upper part of a steep slope and continued uniformly until the area is covered. The mulch shall not be bunched. Immediately following spreading, the mulch shall be anchored to the soil by a v-type wheel land packer or a scalloped-disk land packer designed to force mulch into the soil surface a minimum of 3 inches. All seeded areas shall be mulched after seeding on the same day as the seeding.

If observation indicates that strips wider than the specified space between the planted rows have been left, or other areas skipped, the Project Manager may require immediate resowing of seed in such areas at the Contractor's expense.

#### **40.04 Permissible Planting Times**

Normally, grass seeding shall be accomplished in one or another of two planting seasons within a specified time. Seeding shall be performed between September 1 and October 1, or March 1 and June 15. Any deviation from these dates must be with written consent of the Project Manager.

#### **40.05 Maintenance**

The Contractor shall be responsible for maintaining and watering seeded areas for a period of six weeks after the time of seeding. Areas in which there is not a satisfactory stand at the expiration of the first four weeks of this period shall be reseeded. Sprinkling of the seeded areas shall be carefully done in such manner as to avoid standing water surface wash, or scour. Areas seeded and so maintained shall be protected against damage by vehicle and pedestrian traffic by the use of barriers and appropriate warning signs.

#### **40.06 Seed Germination Inspection**

The warranty period for the seed mix shall begin at the time of final completion and extend for the duration of forty-five (45) days. During this time, when germination is complete and plants are visible, the engineer will perform a germination inspection. At this time, any areas which are thin, weak, dead, or more than five (5%) percent in weeds, shall be rototilled and reseeded. All washouts shall be reseeded immediately after the germination inspection. No partial acceptances shall be made.

**SECTION 41.00 SODDING .....1**

41.01 Scope .....1

41.02 Materials.....1

41.03 Construction .....1

41.04 Guarantee .....1

41.05 Inspections .....2





## **SECTION 41.00 SODDING**

### **41.01 Scope**

The Contractor shall provide all labor, equipment, and material necessary to furnish and install all sod as required by the drawings and specifications.

### **41.02 Materials**

**41.02.1 Sod** Sod shall be a blended bluegrass sod or a bluegrass alternate mix and shall match existing sod. Sod shall be free from diseases and weeds, have a healthy appearance, have a soil mat of uniform depth, and be between one inch to two inches.

**41.02.2 Fertilizer and Organic Matter** Treble super phosphate will be used on the soil to be sodded. The rate of application shall be 10 pounds per 1000 sq. ft.

Organic matter shall be defined as compost, peat moss, aged manures, aged sawdust, or any combination of the above materials. The rate of application shall be 10 pounds per 1000 sq. ft.

### **41.03 Construction**

Preparatory to sodding, the top six inches of the surface shall be tilled and brought to the desired line and grade. Fertilizer and organic matter shall be used wherever there is not any suitable topsoil that can be moved back in place after the earthwork is complete. Fertilizer and organic matter shall then be applied uniformly at the rate specified and be rototilled or disked six inches into the soil. The Contractor shall lightly sprinkle the sod bed just prior to laying the sod. Sod shall be laid together tightly with no gaps and rolled to a smooth and even surface free of bumps and depressions. Immediately after installation, the sod shall be thoroughly watered. Settled sod areas shall be pulled, regraded, and re-laid.

### **41.04 Guarantee**

The Contractor shall guarantee the life and good health of the sod installed by him for a period of 45 days from the date of approval of the work. Any areas deemed by the Project Manager to be thin, weak, or dead shall be resodded at the Contractor's expense, according to these specifications, prior to the end of the guarantee period. During the guarantee period, the Contractor shall be responsible for any required erosion control, mowing, weeding, and watering of the sod bed.

## **41.05 Inspections**

When the Contractor is prepared for one of the required inspections, he shall give the Project Manager 24-hour notice for the Project Manager to visit the site and perform the inspection. This does not preclude the right of the Project Manager to make informal construction observation at any time during the work of this section. The required inspections for which the Contractor must notify the Project Manager are as follows.

**41.05.1 Sodding Inspection** When sodding operations are complete, the Contractor shall notify the Project Manager and request a "sodding inspection" for approval in order to begin the guarantee period. Any areas deemed by the Project Manager to be thin, weak, or dead shall be replaced at this time. No partial acceptances shall be made. The Contractor shall request another "sodding inspection" from the Project Manager after replacing the sod.

**41.05.2 End-of-Guarantee Inspection** Three days prior to the end of the guarantee period, the Contractor shall notify the Project Manager and request an "end-of-guarantee inspection." The Project Manager shall inspect the sod for coverage and health at this time. Any areas deemed by the Project Manager to be thin, weak, or dead shall be replaced at this time. No partial acceptances shall be made.

**SECTION 42.00 INTERIM MEDIAN COVER MATERIAL .....1**

42.01 General .....1

42.02 Materials.....1

42.03 Construction Requirements.....1



## SECTION 42.00 INTERIM MEDIAN COVER MATERIAL

### 42.01 General

This work shall consist of furnishing the materials, site preparation and material placement required for the installation of the median cover material specified, all in accordance with these Specifications and in reasonably close conformity with the lines, grades, and typical cross section shown on the plans. This work shall only be done where permanent landscaping of the median shall not be constructed.

### 42.02 Materials

**42.02.1 Pre-Emergent** The pre-emergent shall be Oryzalin (Surflan AS), (3, 5 dinitro-N4, N4-Dipropylsulfanilamide) at an application rate of four quarts per acre.

**42.02.2 Weed Suppression Fabric** The weed suppression fabric shall be MIRAFI 140NS fabric or an equivalent approved by the Project Manager.

**42.02.3 Rock for Median Cover** Rock for median cover shall consist of washed river rock. The percentage of wear, when tested in accordance with AASHTO T96, shall be no more than 70 percent. The grading requirements shall be as follows:

Passing 1-1/2" sieve	100%
Passing 3/4" sieve	0-5%

**42.02.4 Concrete for Median Cover** Class I concrete shall be used in accordance with Section 30.00, CONCRETE WORK. All other requirements for concrete construction contained in CONCRETE WORK shall apply, unless stated otherwise in this Specification.

### 42.03 Construction Requirements

#### 42.03.1 Median Cover Material, Rock

**42.03.1.01 General** Median cover operations shall not be started until the underlying surface has been compacted and treated with pre-emergent. The fabric and rock shall be placed immediately after the soil surface has been treated. When completed, the median cover will be a consistent depth of three inches.

**42.03.1.02 Pre-Emergent Application** All surface vegetation shall be removed from the area to be treated not more than three days before the pre-emergent application.

Prior to the pre-emergent application, the median shall be leveled and compacted to 95% density according to AASHTO T99 or T180, depending on the soil type, with the moisture content per Table 20.06.8. The pre-emergent shall be applied according to the methods and precautions recommended by the manufacturer.

The Contractor shall comply with all Colorado statutes and all local ordinances or codes pertaining to the use and application of fungicides, insecticides, herbicides, or other agricultural chemicals.

Care shall be exercised to prevent the drift of powder, spray, or vapor which may damage crops, gardens, shrubs, or trees in the vicinity of the areas being treated. Chemicals shall not be used where they may contaminate water used for irrigation or drinking purposes.

The Contractor will be held responsible for any damage to plant growth outside treatment areas attributable to carelessness or improper application of the pre-emergent.

#### **42.03.2 Median Cover Material, Concrete**

**42.03.2.01 General** Concrete median cover material shall be installed adjacent to the median turn bay as shown on Standard Detail S2.1 or as specified on the plans. Prior to installation, the median shall be graded and compacted to 95% density according to AASHTO T99 or T180, depending on the soil type.

**SECTION 43.00 CHAIN LINK FENCE.....1**

43.01 Scope .....1

43.02 Materials.....1

43.03 Workmanship .....2





## SECTION 43.00 CHAIN LINK FENCE

### 43.01 Scope

This section covers all work necessary for complete installation of chain link fence, in-place and ready for use.

### 43.02 Materials

**43.02.1 General** All materials shall be products of recognized, reputable manufacture conforming to these Specifications. Materials shall carry a tag identifying the manufacturer and, in the case of fabric and barbed wire, the class of zinc coating. Used or rerolled materials, materials with a regalvanized finish, and open-seam posts are not allowed. After fabrication, all materials shall be hot-dip galvanized to a minimum zinc coating of 2.0 ounces per square foot of surface.

**43.02.2 Fabric** No. 9 gauge wire conforming to ASTM A-392, woven in a two- inch diamond mesh pattern, selvages twisted and barged. Galvanizing shall be Class 2. Fabric shall also be polyvinyl chloride (PVC) coated in accordance with ASTM F-668. Colors for PVC coatings shall be in accordance with ASTM F-934. See City Code Section 146-1731, 146-1741 – 1743 for additional requirements.

**43.02.3 Posts** Standard lengths for setting in concrete in the ground unless Special Conditions indicate otherwise.

**43.02.3.01 Line Post:** 2-inch Inside Diameter Standard Pipe, 3.65 pounds per linear foot.

**43.02.3.02 End, Corner, Line Brace Post and Line Post, and Line Post Sleeve:** 2-1/2 inch I.D. Standard Pipe, 5.79 pounds per linear foot.

**43.02.3.03 Gate Posts:** Up to 6 feet wide, 2-1/2 inch I.D. Standard Pipe, 5.79 pounds per linear foot. 6 to 13 feet wide, 3-1/2 inch I.D., 9.11 pounds per linear foot.

**43.02.4 Top Rail** 1-1/4 inch I.D. Standard Pipe, 2.27 pounds per linear foot.

**43.02.5 Bottom Reinforcing Wire** Coil spring wire 0.177 inch minimum diameter. Tied to fabric at a maximum spacing of 24 inches with approved tie clips.

**43.02.6 Fabric Ties** No. 9 gauge wire ties at a maximum spacing of one per foot of post height.

**43.02.7 Fittings** Malleable steel, cast iron, or pressed steel to include extension arms for barbed wire, stretcher bars and clamps, clips, tension rods, brace rods, hardware, fabric bands, and fastenings. Supports for barbed wire shall be 45 degree bracket type supports. Bracket supports for line posts shall be of pressed steel attached to malleable iron bases with rivets; those for corner posts shall be malleable iron throughout.

**43.02.8 Gates** Fabricate frames of standard weight pipe 1-1/2 inch inside diameter, weight 2.72 pounds per linear foot. Provide gates with all necessary malleable iron fittings, braces, sag rods, hinges, and single or plunger-bar-type latches as required, and semi-automatic outer latches to secure gates in open position. Arrange latches and plunger bars for locking with padlocks. Brace gate diagonally with adjustable rods to prevent sagging in conformance with the manufacturer's standard practice and as approved by the Project Manager.

### **43.03 Workmanship**

**43.03.1 Installation** Erect fencing in straight lines between angle points by competent workmen experienced in this type of construction. Erect in accordance with the manufacturer's recommendations as approved and in accordance with these Specifications. Post holes shall be a minimum depth of three feet below finished grade and shall be 10 inches in diameter. Space posts not more than 10 feet on centers and in true lines. Set posts plumb and to a depth of 2 feet - 9 inches. Fill remainder of the hole with concrete to extend around the posts to a point two inches above finished grade. The top surface shall have a crown watershed finish. Concrete shall be City of Aurora Class III. After concrete has set, install accessories; fasten chain link fabric to end posts with stretcher bars and clamps and line posts and top rail with wire or bands at approximately 14 inch centers. Brace gate posts diagonally to adjacent line posts to insure stability. Hang gates and adjust all hardware so the gates operate satisfactorily from open or closed position.

**43.03.2 Cleanup** Upon completion of the fence installation, clean up all waste material resulting from the construction. Spread excavated earth from post holes on the adjacent area and grade smooth.

**SECTION 44.00 UTILITY LOCATION GUIDELINES .....1**  
44.01 Guidelines .....1

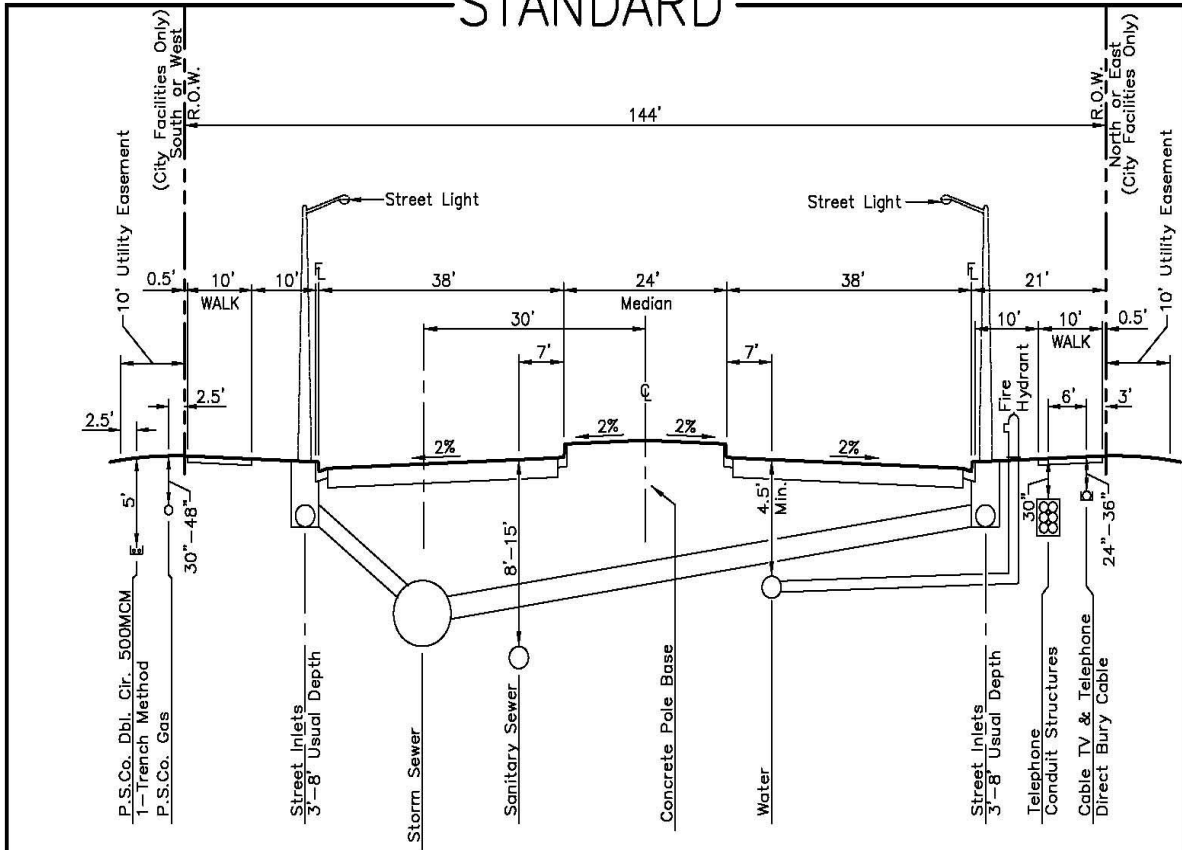


## **SECTION 44.00 UTILITY LOCATION GUIDELINES**

### **44.01 Guidelines**

Proposed streetscapes shown in Figures 44.1 and 44.2 are conceptual only and are recommendations for planning purposes. Exact locations should be coordinated with the appropriate utility owners.

# STANDARD



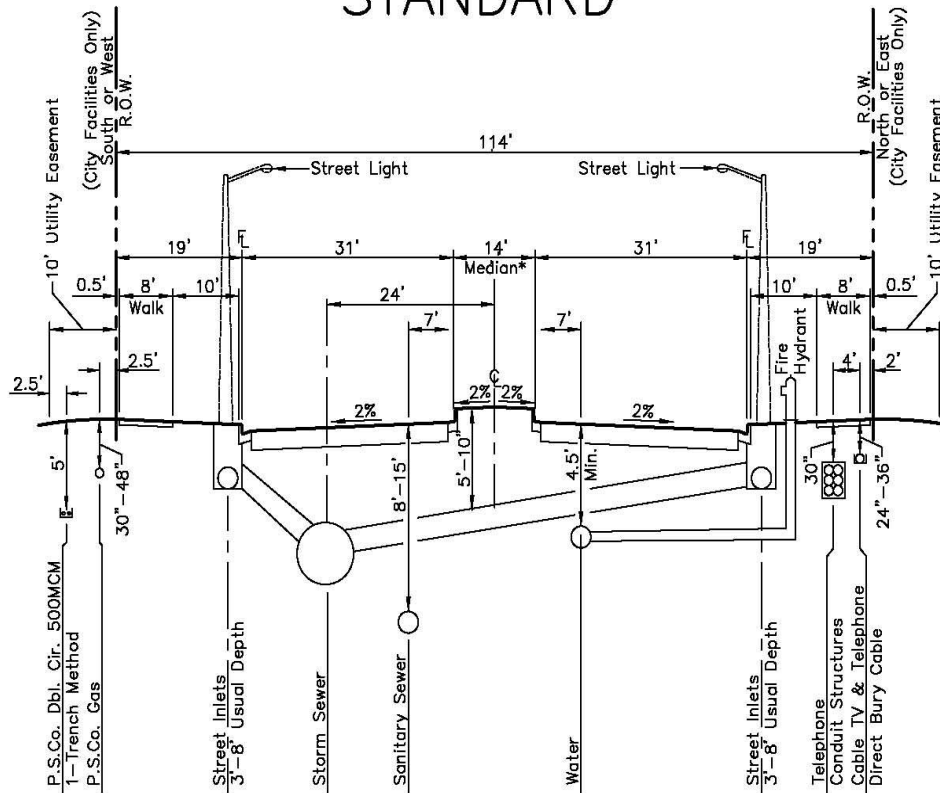
\*MEDIAN MAY BE RAISED OR IT MAY BE PAINTED (AND NOT RAISED).

**NOTES:**

1. PROPOSED STREETScape CONCEPTS REQUIRE GAS LINES IN EASEMENT BEHIND SIDEWALK. THE ALTERNATIVE IS TO INSTALL AT THE FRONT EDGE OF WALK.
2. LOCATIONS PRESUPPOSE FULL STREET R.O.W. AT TIME OF UTILITY INSTALLATION.
3. IN INSTANCES WHERE OVERHEAD LINES WILL BE CONSTRUCTED, LOCATION OF POLES SHALL BE BEHIND WALKS IN R.O.W.
4. FIRE HYDRANTS ARE SPACED AT APPROXIMATELY 250' INTERVALS, ALTERNATING SIDES OF THE ARTERIAL. SEE STANDARD 208-1 FOR DETAILS.
5. STORM SEWERS IN THE STREET ARE USUALLY LARGE DIAMETERS (36" OR GREATER). SMALL DIAMETER STORM SEWERS WILL USUALLY BE PLACED IN LINE WITH INLETS.
6. ELECTRIC FEEDERS REQUIRE A MINIMUM OF 5' OF SEPARATION FROM ALL OTHER UTILITIES BECAUSE OF HEAT. IF THE DOUBLE TRENCH METHOD IS USED (COMMON NEAR SUBSTATIONS) THE TRENCHES ARE SEPARATED BY 3 FEET.
7. JOINT TRENCHES FOR TELEPHONE, CABLE TV, AND ELECTRIC DISTRIBUTION ARE PREFERRED. ALL UNDERGROUND CABLE AND CONDUIT STRUCTURES REQUIRE ABOVE GROUND CABINETS VARYING IN SIZE FROM 12" ROUND CABINETS TO 8'X8' CABINETS. POCKET EASEMENTS WILL BE NECESSARY TO ACCOMMODATE LARGE ABOVE GROUND STRUCTURES.
8. STREET LIGHTS ARE REQUIRED ALONG ALL PUBLIC STREETS IN AND ADJACENT TO NEW DEVELOPMENTS. MOST STREET LIGHTS ARE LOCATED BEHIND THE CURB FOR DETACHED SIDEWALKS OR BEHIND THE SIDEWALK WHEN SIDEWALKS ARE ATTACHED.

## FIGURE 44-1 SIX LANE ARTERIAL

# STANDARD



\*MEDIAN MAY BE RAISED OR IT MAY BE PAINTED (AND NOT RAISED).

**NOTES:**

1. PROPOSED STREETScape CONCEPTS REQUIRE GAS LINES IN EASEMENT BEHIND SIDEWALK. THE ALTERNATIVE IS TO INSTALL AT THE FRONT EDGE OF WALK.
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5. STORM SEWERS IN THE STREET ARE USUALLY LARGE DIAMETERS (36" OR GREATER). SMALL DIAMETER STORM SEWERS WILL USUALLY BE PLACED IN LINE WITH INLETS.
6. ELECTRIC FEEDERS REQUIRE A MINIMUM OF 5' OF SEPARATION FROM ALL OTHER UTILITIES BECAUSE OF HEAT. IF THE DOUBLE TRENCH METHOD IS USED (COMMON NEAR SUBSTATIONS) THE TRENCHES ARE SEPARATED BY 3 FEET.
7. JOINT TRENCHES FOR TELEPHONE, CABLE TV, AND ELECTRIC DISTRIBUTION ARE PREFERRED. ALL UNDERGROUND CABLE AND CONDUIT STRUCTURES REQUIRE ABOVE GROUND CABINETS VARYING IN SIZE FROM 12" ROUND CABINETS TO 8'X8' CABINETS. POCKET EASEMENTS WILL BE NECESSARY TO ACCOMMODATE LARGE ABOVE GROUND STRUCTURES.
8. STREET LIGHTS ARE REQUIRED ALONG ALL PUBLIC STREETS IN AND ADJACENT TO NEW DEVELOPMENTS. MAST STREET LIGHTS ARE LOCATED BEHIND THE CURB FOR DETACHED SIDEWALKS OR BEHIND THE SIDEWALK WHEN SIDEWALKS ARE ATTACHED.

**FIGURE 44-2  
FOUR LANE ARTERIAL**



**SECTION 50.00 TRAFFIC CONTROL.....1**

- 50.01 Description .....1
- 50.02 Prior to Construction .....1
- 50.03 During Construction .....1
- 50.04 After Construction .....3
- 50.05 Traffic Signals .....4
- 50.06 Traffic Calming .....4
- 50.07 Fiber Optic Communications.....4



## **SECTION 50.00 TRAFFIC CONTROL**

### **50.01 Description**

Traffic Control shall consist of furnishing and maintaining all barricades, signs, traffic control devices, detours, temporary pavement, or personnel to conduct traffic safely through the construction site, the conformity with these specifications and the Manual on Uniform Traffic Control Devices (MUTCD), latest edition, and the Colorado Supplement thereto. Traffic control shall include accommodating the needs of bicyclists and pedestrians at sites.

### **50.02 Prior to Construction**

**50.02.1** The Contractor shall contact Traffic Operations Division at least 48 hours before starting work on any arterial street, or within 400 ft. of a traffic signal, to secure locations of any underground facilities. The Contractor shall be responsible for the cost of repair to any such facilities damaged by his construction. Phone Numbers are: Traffic Operations Division 303-326-8200, Signal Locates 303-326-8200, Fax 303-326-8238.

**50.02.2** Unless provided in the plans, the Contractor shall submit a traffic control plan to Traffic Engineering through the Permit Center process for review and approval at least five business days before the start of work. Failure to provide a traffic control plan or obtain permission from Traffic Engineering may result in immediate work stoppage. If the Contractor desires to revise an approved traffic control plan, the revision proposal shall be submitted to Traffic Engineering through the Permit Center process for review.

**50.02.3** Unless otherwise indicated on the plans, when construction is likely to interfere with or damage an official traffic control sign or device, the Contractor shall notify Traffic Operations Division 48 hours in advance to have the sign or device retrieved or relocated. Once construction has been completed, Traffic Operations Division shall require two business days' notice for resetting the signs or devices prior to opening the project to traffic. The Contractor will be responsible for any repairs or replacement of any sign or device missing or damaged.

### **50.03 During Construction**

**50.03.1** The Contractor shall not interfere with traffic between the hours of 5:00 p.m. - 7:00 a.m. for local streets and 3:30 p.m. – 8:30 a.m. for collector/arterial streets on weekdays or at any time on weekends or holidays without permission from Traffic Engineering.

**50.03.2** The Contractor shall provide a traffic control person, other than the Project Superintendent, when called for in the plans or in the special conditions, or when determined necessary by Traffic Engineering. The Traffic Control Person shall

- Have traffic control as their primary duty;
- Carry a valid Traffic Control Supervisor certificate and a valid Flagging certificate (recognized by the Colorado Department of Transportation);
- Be on the job site at all times during working hours. Check all traffic control devices before and after the a.m. and p.m. rush hours, and periodically throughout the remainder of the day and night;
- Verify all traffic control devices are in accordance with the Manual on Uniform Traffic Control Devices, including the Colorado Supplement, and all traffic control devices are properly positioned and operating according to the approved traffic control plans, or as directed by Traffic Engineering;
- Maintain two-way traffic on existing pavement unless otherwise authorized by Traffic Engineering;
- Be on call 24 hours per day and provide home and emergency phone numbers to Traffic Engineering;

**50.03.3** When traffic control is required within a signalized intersection involving an arterial, there shall be a minimum of two off-duty uniformed City of Aurora police officers required. On all other signalized intersections, only one off-duty uniformed City of Aurora police officer shall be required, unless otherwise specified by Traffic Engineering. Requests for officers may be made through the Secondary Employment Office of the Aurora Police Department at 303-739-6269 or 303-739-6268, at least five days before needed. The Contractor shall specify dates, hours, and the number of officers required. Cost of officers shall be at the Contractor's expense.

**50.03.4** The Contractor shall not allow construction equipment, personal vehicles, or construction materials to remain on or near the traveled lanes or at any location that may interfere with the safe movement of traffic.

**50.03.5** The cut or fill resulting from construction adjacent to traffic lanes shall be temporarily sloped and shall have vertical hazard delineators with steady-burn lights at the intervals specified on the traffic control plan, immediately behind grading and removal operations, in order to safeguard the traveling public. Any cut or fill two inches or greater in depth within five feet of a travel lane shall require vertical panels for edge-line delineation.

- 50.03.6** The Contractor shall provide access, acceptable to the property owners, to existing driveways of businesses and homes in the project area.
- 50.03.7** The Contractor shall remove all dirt, mud, and debris from the travel lanes daily.
- 50.03.8** Construction traffic control signs or devices not in use shall be removed from the view of the traveling public and must never impede a pedestrian walkway (sidewalk). Laying the sign down in a horizontal position or turning the sign parallel is not permitted on the sidewalk. For locations that do not have sufficient right-of-way available to store the sign(s) or device(s), they must be picked up or moved to an approved storage area. Signs placed in the medians must be dismantled or laid down. Turning of the sign(s) is not permitted. Sign(s) or device(s) left out facing traffic after work hours shall be confiscated. The Contractor shall be responsible for the cost of removing the sign(s) or device(s), at a minimum charge of \$35.00 per sign or device, and shall be responsible for picking up the confiscated material.
- 50.03.9 Directional Arrow Boards** Any four or six-lane arterial street lane closure that exceeds one hour will require one directional arrow board per lane direction closed. Requirements on all other streets will be determined by the Traffic Manager
- 50.03.10 Open Pits and Trenches** Open pits and trenches shall not be allowed on city streets or sidewalks without advance approval from Traffic Engineering. They will be backfilled daily or they may be covered with steel plates. Note: steel plates (3/4 inch thick minimum) may not be used once the temperature reaches the freezing zone or any time in the winter.
- 50.03.11** Installation and removal of temporary signing and striping shall be the responsibility of the Contractor.

## **50.04 After Construction**

- 50.04.1** The Developer/Contractor shall be responsible for all final street marking and signing as shown on the signing and striping plans. The signing and striping shall be in place prior to opening the project area to traffic. The Developer/Contractor shall notify Public Improvements Inspections at least two business days prior to opening the project area to traffic to inspect the signing and striping for completeness. Any deficiencies shall be corrected before opening the project area to traffic.

Installation and removal of any existing or temporary striping and signing shall be the responsibility of the Contractor.

## **50.05 Traffic Signals**

When a construction project includes the relocation of any traffic signal equipment or construction of a new signalized intersection, the work shall be done by a qualified signal contractor in conformance with City standards, approved plans, and to the satisfaction of Traffic Engineering, Operations, and Public Improvement Inspections.

## **50.06 Traffic Calming**

**50.06.1** The City of Aurora encourages traffic calming to reduce vehicular travel speeds, reduce severity of collisions, and improve safety for pedestrians and cyclists. Traffic calming measures shall be installed at the discretion of the City Traffic Engineer for roadways that contain some or all of the following characteristics:

- 1) Design speed is less than or equal to 35 miles per hour
- 2) Direct frontage to residential land uses
- 3) A collector or local roadway that provides connectivity between other local and collector roadways and adjacent arterials
- 4) Roadways with wide pavement sections or minimal horizontal deflections over several blocks

The City of Aurora may require traffic calming measures to be designed and installed on local and collector roadways including, but not limited to, the following:

- 1) Speed cushions
- 2) Dynamic speed limit feedback signs
- 3) Compact or urban roundabouts
- 4) Curb extensions
- 5) Chicanes
- 6) Enhanced-visibility or pedestrian-activated beacons at crosswalks

## **50.07 Fiber Optic Communications**

Underground infrastructure for future fiber optic communications to traffic signals shall be installed in the following instances:

- New and modified traffic signals
- New roadways
- Roadway widening projects

- Site plans
- Utility permit applications

Underground infrastructure consists of Electrical Conduit, Pull Boxes, Fiber Optic Splice Closures, Fiber Optic Delineators, and Fiber Optic cable.

In all cases listed in this section, Electrical Conduit and Pull Boxes infrastructure shall be installed per the requirements below.

In some cases, the City Traffic Engineer may also require that fiber optic media shall also be installed, per the requirements below. For example, installation of fiber optic media may be required with new or modified traffic signals or other ITS devices.

#### Electrical Conduit Requirements

- Conduit crossing roadways shall be bored
- Conduit shall be 3" nominal diameter
- Conduit material shall be Schedule 80 HDPE where bored, or Schedule 40 PVC otherwise. No metal conduit will be accepted.
- A # 14 AWG stranded copper conductor shall be placed for underground locating purposes.
- A nylon pull tape with a minimum 1,250 lb tensile strength shall be installed in all new conduit

#### Pull Box Requirements

- Pull boxes shall be 30"x48"x24", with two-piece interlocking lids
- Pull box spacing shall be 750 feet maximum
- Each pull box shall include a dome delineator

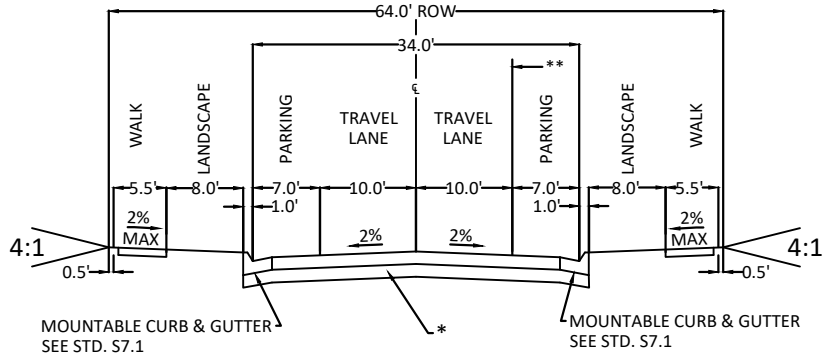
#### Fiber Optic Requirements

- Fiber optic backbone cable shall be 432-strand single mode fiber optic (SMFO)
- Fiber optic lateral cables to traffic signal cabinets shall be 12-strand SMFO, unless otherwise directed by the City Traffic Engineer

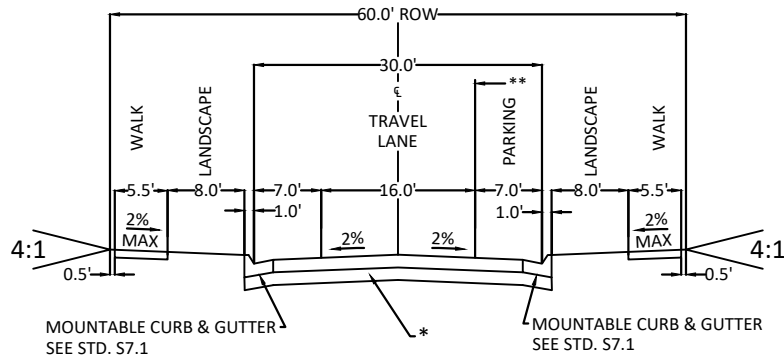
#### Fiber Optic Termination Panel

- A 12 Termination Panel

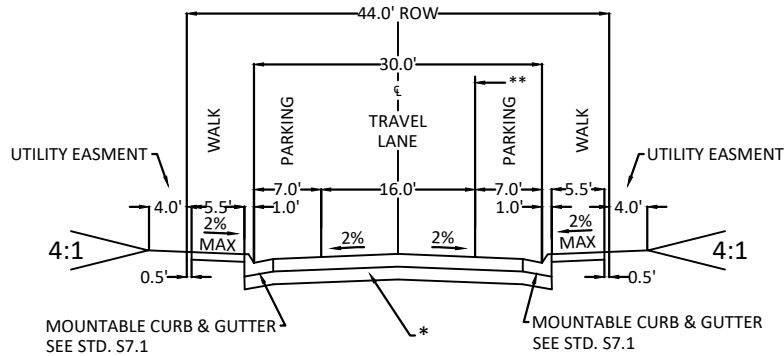
# STANDARD



**LOCAL STREET TYPE 1**



**LOCAL STREET TYPE 2**



**LOCAL STREET TYPE 2 ALTERNATE**  
RESIDENTIAL CUL-DE-SAC LESS THAN 250' IN LENGTH ONLY

- \* Composite pavement section. Extend base course to the bottom back of curb. Edge trench drain shall be required to drain base course. See detail S1.19.
- \*\* Indicate clear zone based on design speed and ADT.

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City of Aurora, Colorado

*Heidi B. Bannister*  
CITY ENGINEER

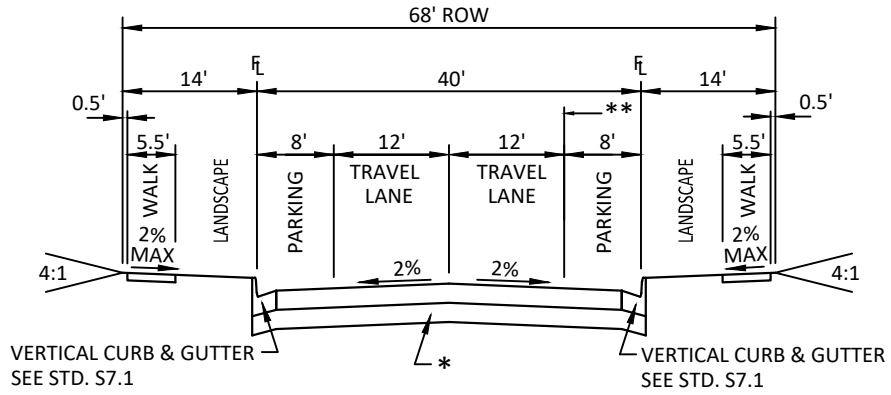
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**LOCAL ROADWAY  
CLASSIFICATIONS AND  
TYPICAL CROSS SECTIONS**

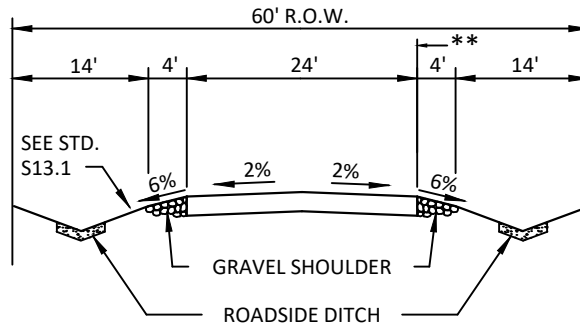
**S1.1**



# STANDARD



## LOCAL TYPE 3



NOTE:  
AT CUL-DE-SACS WITH 5  
LOTS OR LESS, DRAINAGE  
DITCHES MAY BE REDUCED  
TO FIT TYPICAL SECTION  
INTO A 50' R.O.W.

## LOW DENSITY RURAL

- \* Composite pavement section. Extend base course to bottom back of curb. Edge trench drain shall be required to drain base course. See detail S1.19.
- \*\* Indicate clear zone based on design speed and ADT.

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City of Aurora, Colorado

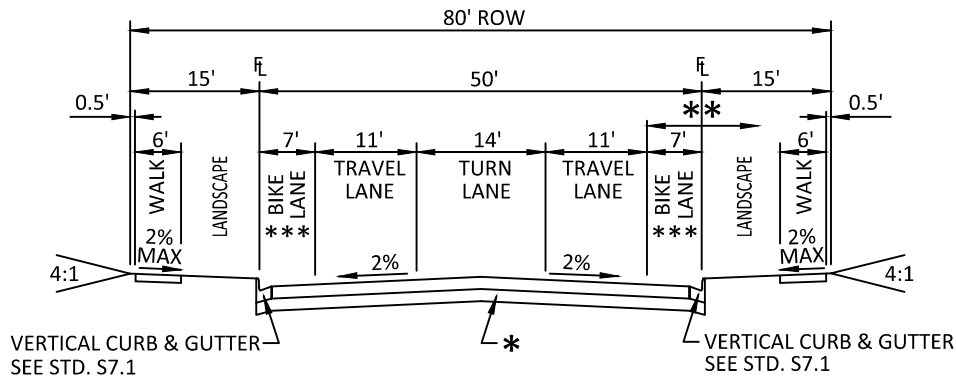
*Heley B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

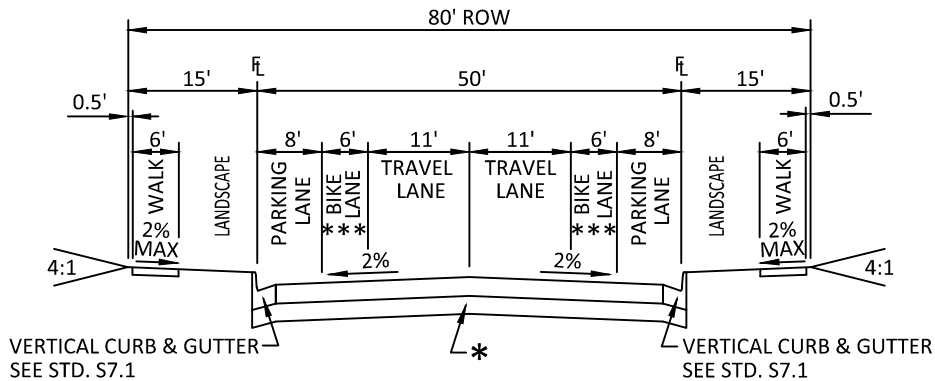
LOCAL ROADWAY  
CLASSIFICATIONS AND  
TYPICAL CROSS SECTIONS

S1.2

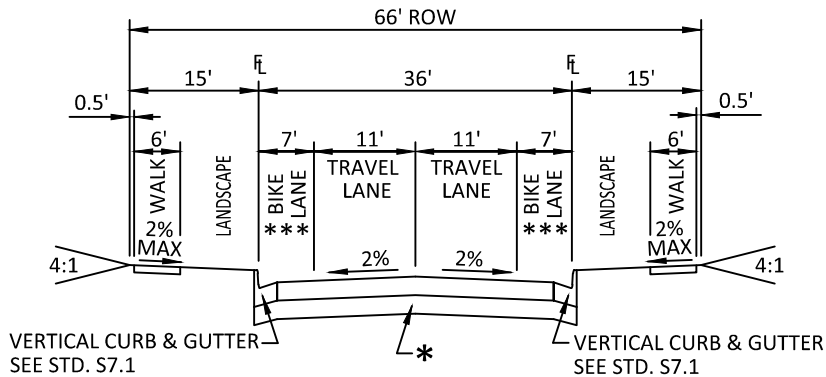
# STANDARD



**THREE LANE COLLECTOR**



**TWO LANE COLLECTOR**



**ALTERNATIVE TWO LANE COLLECTOR**

\* Composite pavement section. Extend base course to bottom back of curb. Edge trench drain shall be required to drain base course. See Detail S1.19.

\*\* Indicate clear zone based on design speed and ADT.

\*\*\* Bike lanes on-street may not be appropriate for all collector sections. Coordinate with Public Works engineering review staff during Master Plan or Site Plan phase prior to submittal to determine, if bike lanes should be omitted from the section.

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City of Aurora, Colorado

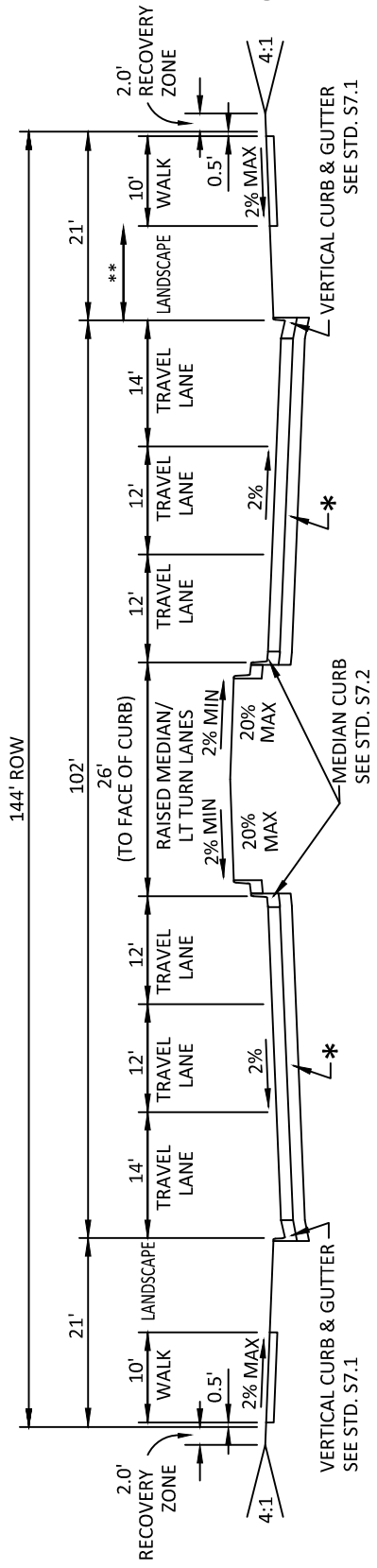
*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

**COLLECTOR ROADWAY  
CLASSIFICATIONS AND  
TYPICAL CROSS SECTIONS**

**S1.3**

# STANDARD



## SIX LANE ARTERIAL

MEDIAN TURN LANE WIDTH = 11'

\* Composite pavement section. Extend base course to bottom back of curb. Edge trench drain shall be required to drain base course. See Detail S1.19.  
 \*\* Indicate clear zone based on design speed and ADT.

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City of Aurora, Colorado

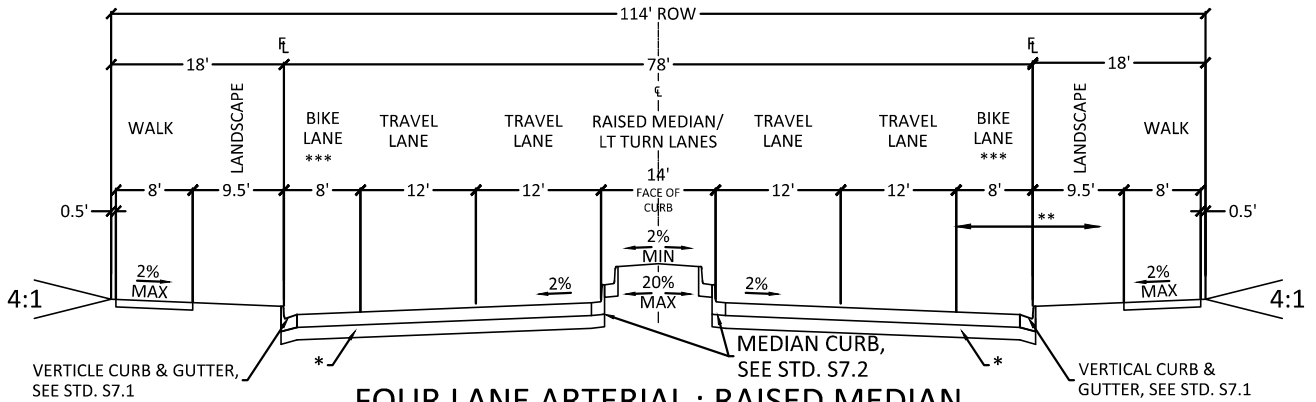
*Helen B. Anderson*  
 CITY ENGINEER

01/31/2023  
 DATE

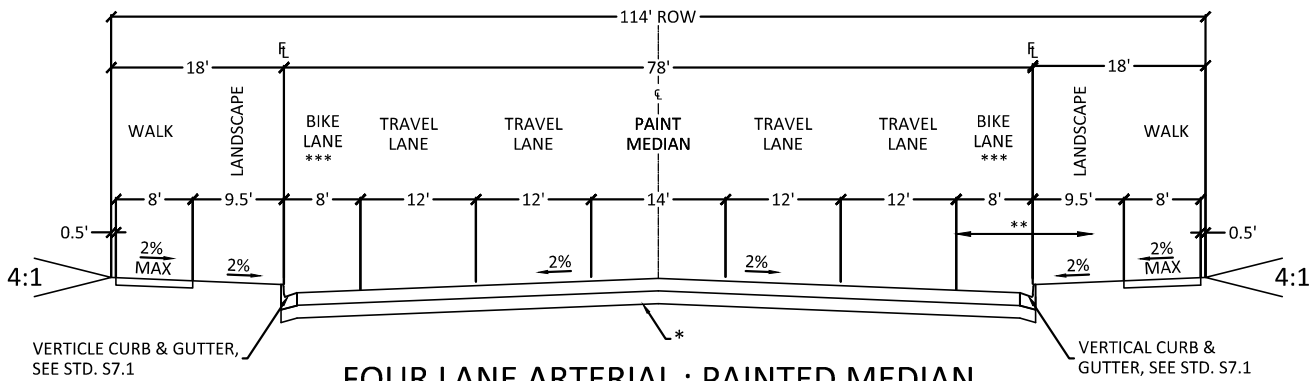
ARTERIAL ROADWAY  
 CLASSIFICATIONS AND  
 TYPICAL CROSS SECTIONS

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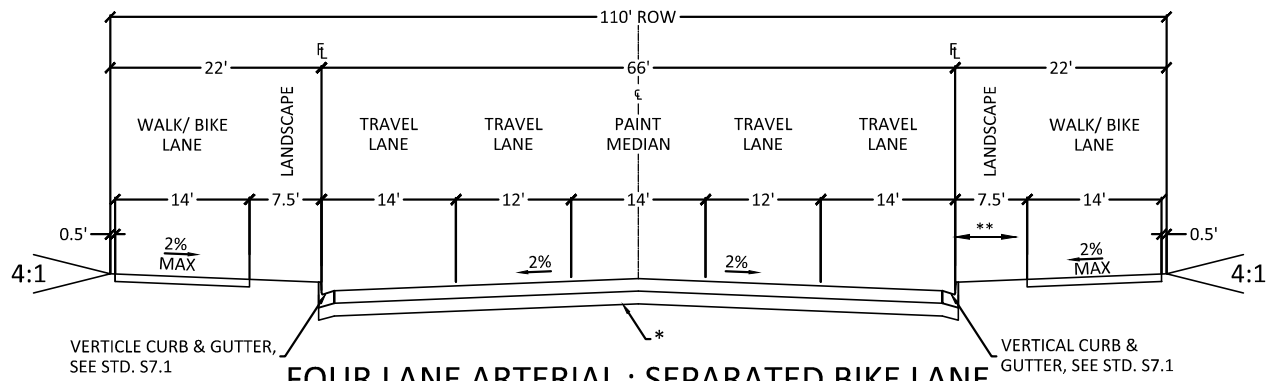
# STANDARD



**FOUR LANE ARTERIAL : RAISED MEDIAN**  
 MEDIAN TURN LANE WIDTH = 10'



**FOUR LANE ARTERIAL : PAINTED MEDIAN**  
 MEDIAN TURN LANE WIDTH = 10'




**FOUR LANE ARTERIAL : SEPARATED BIKE LANE**  
 MEDIAN TURN LANE WIDTH = 10'

\* Composite pavement section. Extend base course to the bottom back of curb. Edge trench drain shall be required to drain base course. See Detail S1.19.  
 \*\* Indicate clear zone based on design speed and ADT.

\*\*\* Bike lanes on-street are not preferred, and are required to be approved by the City Engineer. Walk width may be required to be increased, at the discretion of the City Engineer.

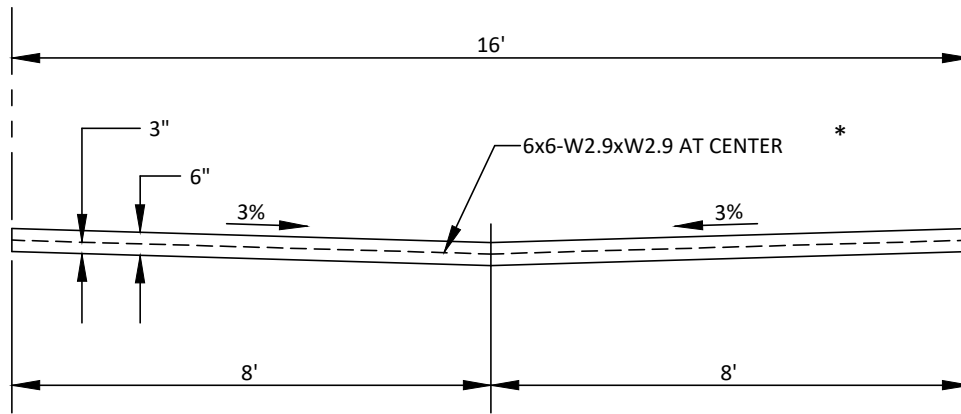
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City of Aurora, Colorado  
  
 CITY ENGINEER  
 01/31/2023  
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**ARTERIAL ROADWAY  
 CLASSIFICATIONS AND  
 TYPICAL CROSS SECTIONS**

**S 1.5**

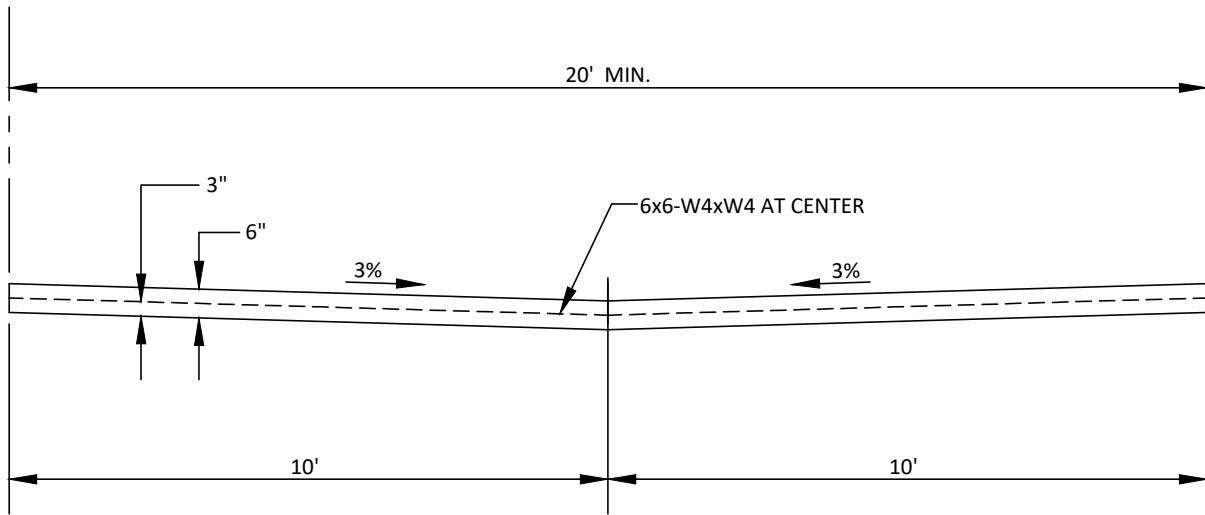
# STANDARD



## TYPICAL ALLEY CROSS SECTION

RESIDENTIAL : CONCRETE

\* POLYPROPYLENE FIBERMESH 1-1/2 LBS. PER CU. YD.-3/4" LONG FIBERS IN PLACE OF WIRE MESH ON RESIDENTIAL ALLEYS ONLY.



## TYPICAL ALLEY CROSS SECTION

COMMERCIAL OR INDUSTRIAL: CONCRETE

NOTES:

1. SEE S19.1 FOR JOINT SAWING PATTERN.
2. ALL REINFORCEMENT STEEL SHALL BE IN SHEETS. LAP ALL JOINTS A MINIMUM OF 6".
3. ALL NEW ALLEYS ARE PRIVATE AND WILL BE OWNED AND MAINTAINED BY THE OWNER, HOA, OR METRO DISTRICT.
4. ONLY ALLEYS WITH CURRENTLY DEDICATED R.O.W. WILL BE PUBLIC AND OWNED AND MAINTAINED BY THE CITY OF AURORA.

City of Aurora, Colorado

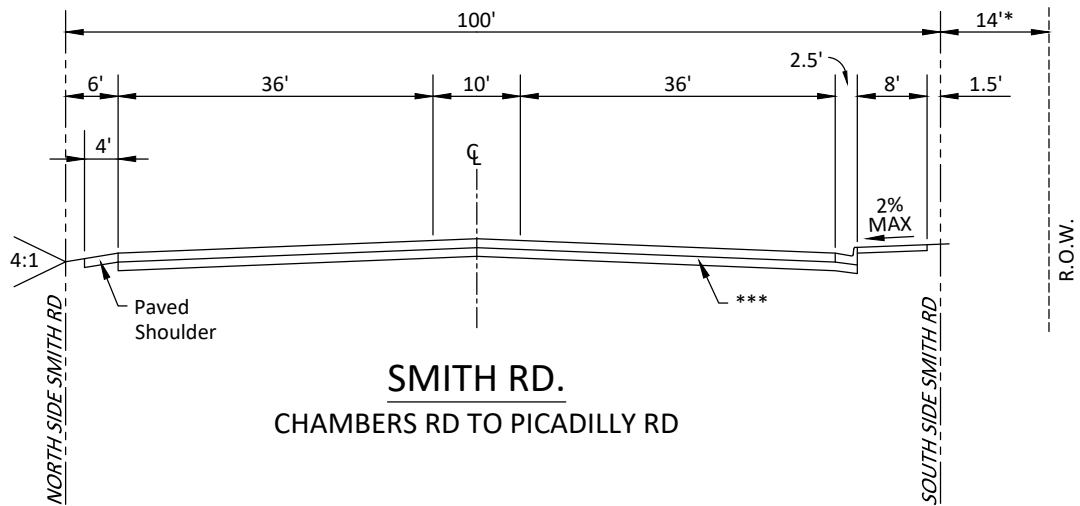
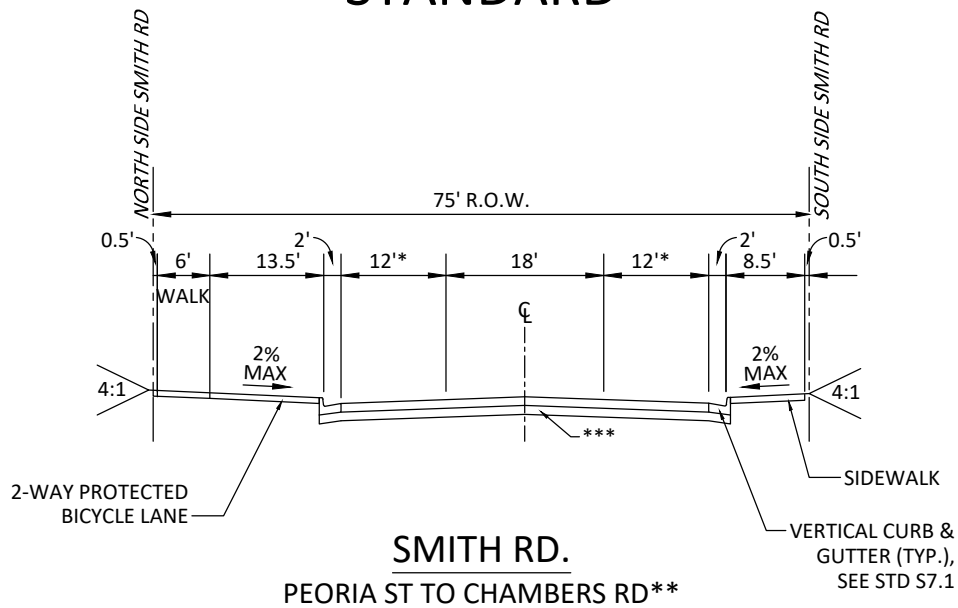
*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

ALLEY ROADWAY  
CLASSIFICATIONS AND  
TYPICAL CROSS SECTIONS

S1.6

# STANDARD



## SMITH RD. EAST OF PICADILLY RD\*\*

USE 4-LANE ARTERIAL: PAINTED MEDIAN STD EXCEPT NO WALK AND CURB AND GUTTER ON THE NORTHERLY SIDE OF THE STREET WHERE ADJACENT TO RAILROAD. SECTION WHOLLY CONTAINED IN THE 100' R.O.W. FROM UPPR. ADD 4' PAVED SHOULDER THEN GRADE 4:1 TO EXISTING GRADE.

- \* 14' ACCEL/DECEL LANE MAY BE REQUIRED BASED ON TRAFFIC STUDY
- \*\* AT STREET INTERSECTIONS THE CROSS SECTION MAY BE MODIFIED TO ACCOMMODATE TRAFFIC OPERATIONS.
- \*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

City of Aurora, Colorado

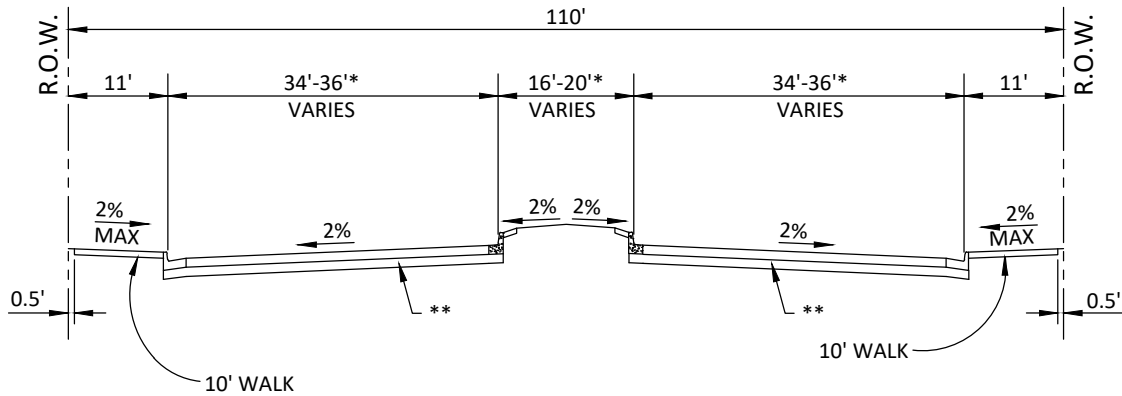
*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

SMITH ROAD TYPICAL  
CROSS SECTIONS

S1.7

# STANDARD



## SPECIAL ARTERIAL AT AIRPORT BOULEVARD ALAMEDA AVENUE TO 40TH AVENUE

*ALAMEDA AVENUE TO COLFAX AVENUE	34' - 20' - 34'
COLFAX AVENUE TO SMITH ROAD	36' - 16' - 36'
SMITH ROAD TO 32ND AVENUE	34' - 20' - 34'
32ND AVENUE TO I-70	36' - 16' - 36'
I-70 TO 40TH AVENUE	36' -VARIES- 36'

1. CONTACT PARKS, RECREATION & OPEN SPACE DEPARTMENT FOR LANDSCAPE/HARDSCAPE MEDIAN REQ'TS.

\*\* Composite pavement section. Extend base course to bottom back of curb. Edge trench drain shall be required to drain base course. See Detail S1.19.

City of Aurora, Colorado

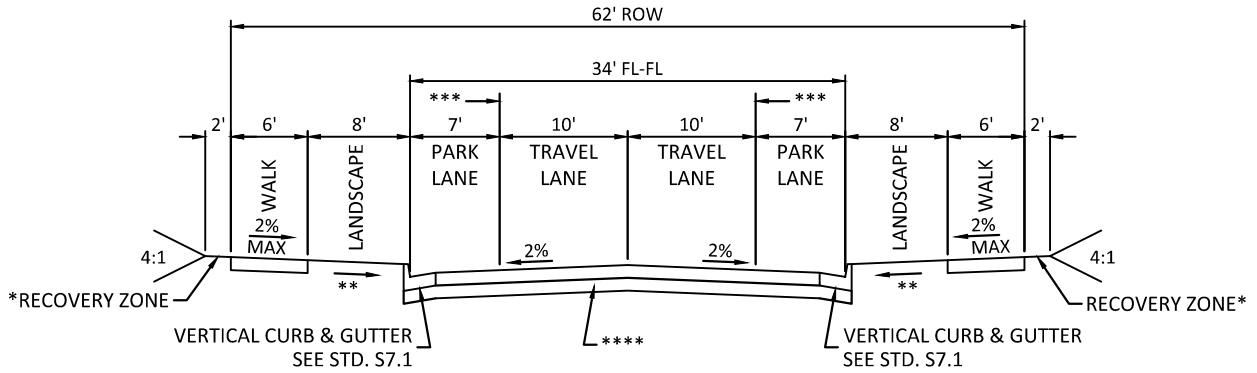
*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

AIRPORT BOULEVARD  
TYPICAL CROSS SECTIONS

S1.8

# STANDARD



## NEIGHBORHOOD - 2 LANES

\*MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCROACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

\*\*GENERALLY, THE LANDSCAPED TREE LAWN SHALL HAVE A TRANSVERSE SLOPE OF 2%. HOWEVER, ON A CASE BY CASE BASIS THIS TRANSVERSE SLOPE MAY BE INCREASED TO A MAXIMUM OF 4:1 WITH PRIOR APPROVAL FROM THE CITY ENGINEER.

\*\*\* INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

**NOTE:**

26' CLEAR MINIMUM PAVED SURFACE SHALL BE PROVIDED EVERY 150' OF ROAD LENGTH FOR EMERGENCY VEHICLE SETUP, SEE STD. S23.1

q:\2022-roadway specs\dwgs\s1-9.dwg 18 January 2023

City of Aurora, Colorado

*Heley B. Johnson*  
CITY ENGINEER

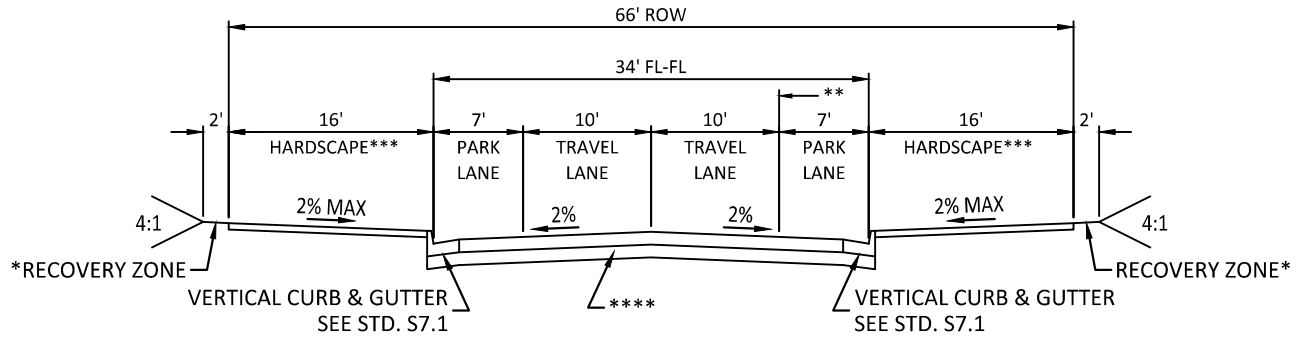
01/31/2023  
DATE

URBAN CENTER & TOD TRANSITION  
ZONE ROADWAY CLASSIFICATIONS  
AND TYPICAL CROSS SECTIONS

S1.9



# STANDARD



## LOCAL URBAN - 2 LANES

- \* MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCROACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.
- \*\* INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.
- \*\*\* HARDSCAPE DESIGN MAY INCLUDE LANDSCAPING AND STREET FURNITURE BUT MUST INCLUDE AN ACCESSIBLE WAY OF NOT LESS THAN 6 FEET.
- \*\*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASED COURSE. SEE DETAIL S1.19.

NOTE:  
26' CLEAR MINIMUM PAVED SURFACE SHALL BE PROVIDED EVERY 150' OF ROAD LENGTH FOR EMERGENCY VEHICLE SETUP, SEE STD. S23.1

City of Aurora, Colorado

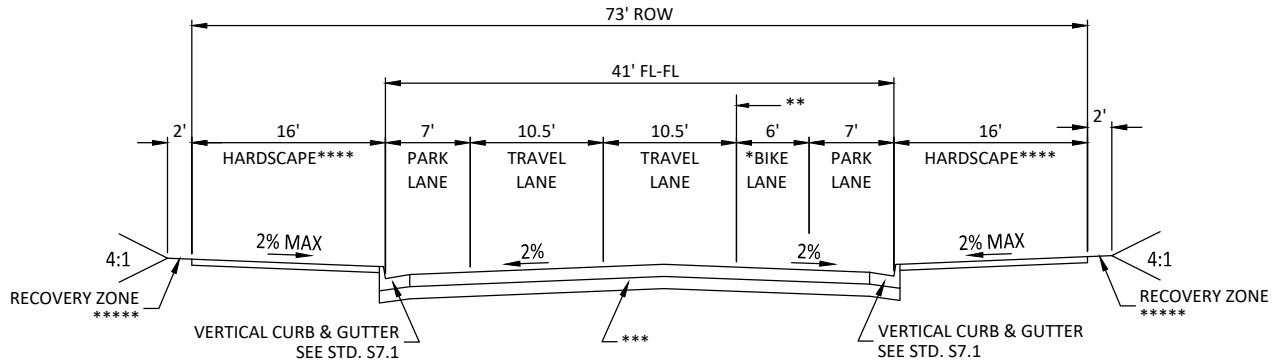
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CITY ENGINEER

01/31/2023  
DATE

URBAN CENTER & TOD  
TRANSITION OR CORE ZONE  
ROADWAY CLASSIFICATIONS  
AND TYPICAL CROSS SECTIONS

S1.10

# STANDARD



## ONE WAY COUPLET - 2 LANES

\* BIKE LANE SHALL BE ON RIGHT HAND SIDE OF TRAFFIC FLOW.

\*\* INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

\*\*\*\* HARDSCAPE DESIGN MAY INCLUDE LANDSCAPING AND STREET FURNITURE BUT MUST INCLUDE AN ACCESSIBLE WAY OF NOT LESS THAN 6 FEET.

\*\*\*\*\* MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCROACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

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City of Aurora, Colorado

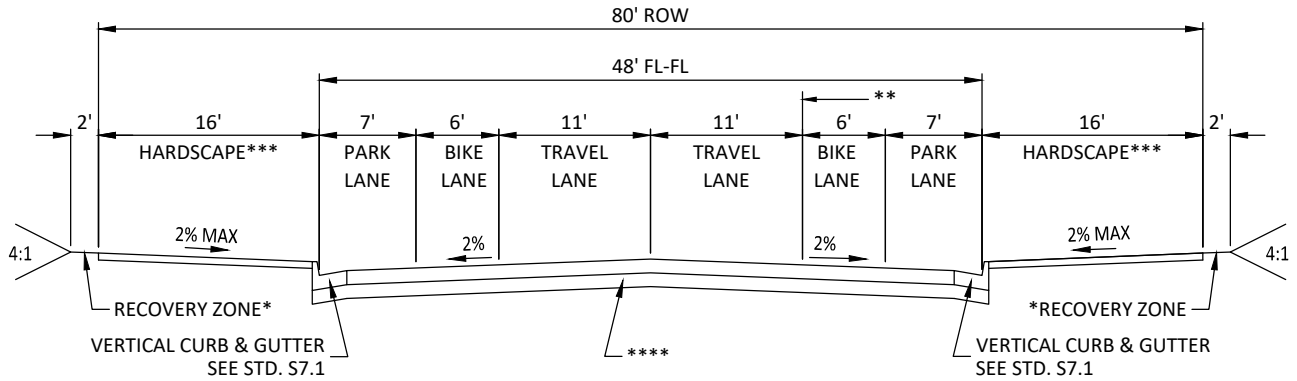
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CITY ENGINEER

01/31/2023  
DATE

URBAN CENTER & TOD  
TRANSITION OR EDGE ZONE  
ROADWAY CLASSIFICATIONS  
AND TYPICAL CROSS SECTIONS

S1.11

# STANDARD



## MAIN STREET - PARALLEL PARKING - 2 LANES

\*MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCROACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

\*\* INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\* HARDSCAPE DESIGN MAY INCLUDE LANDSCAPING AND STREET FURNITURE BUT MUST INCLUDE AN ACCESSIBLE WAY OF NOT LESS THAN 6 FEET.

\*\*\*\*COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19

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City of Aurora, Colorado

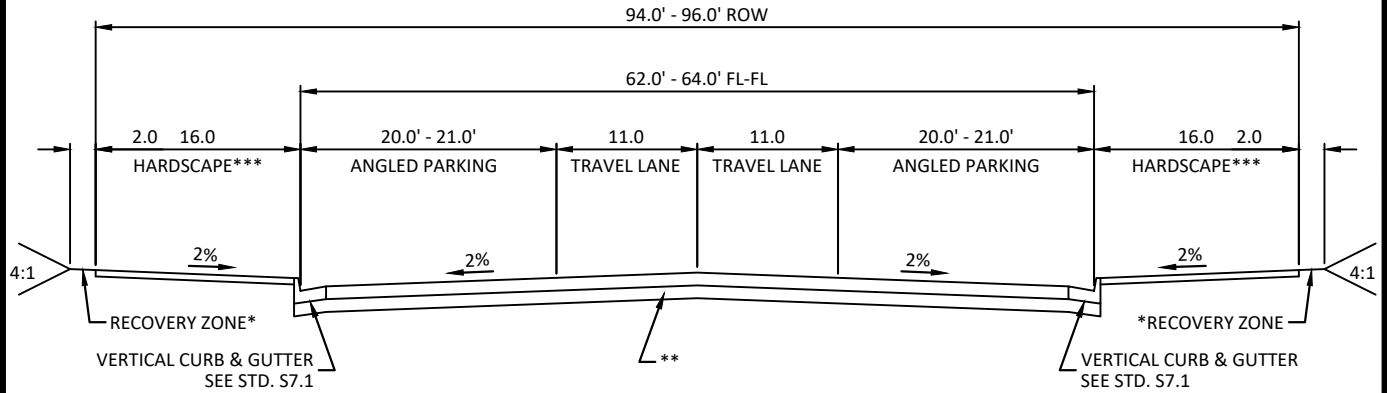
*Helen B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

URBAN CENTER & TOD  
TRANSITION OR CORE ZONE  
ROADWAY CLASSIFICATIONS  
AND TYPICAL CROSS SECTIONS

S1.12

# STANDARD

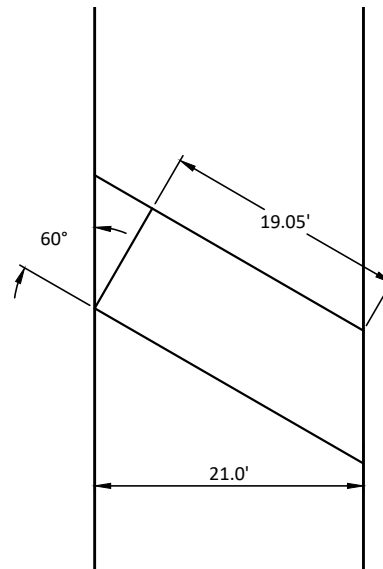
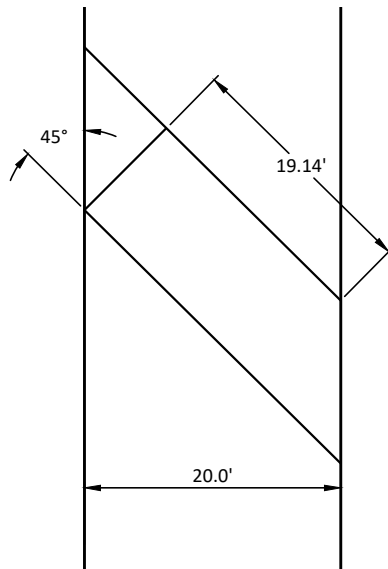


## MAIN STREET - ANGLED PARKING - 2 LANES

\*MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCROACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

\*\*\* HARDSCAPE DESIGN MAY INCLUDE LANDSCAPING AND STREET FURNITURE BUT MUST INCLUDE AN ACCESSIBLE WAY OF NOT LESS THAN 6 FEET.



City of Aurora, Colorado

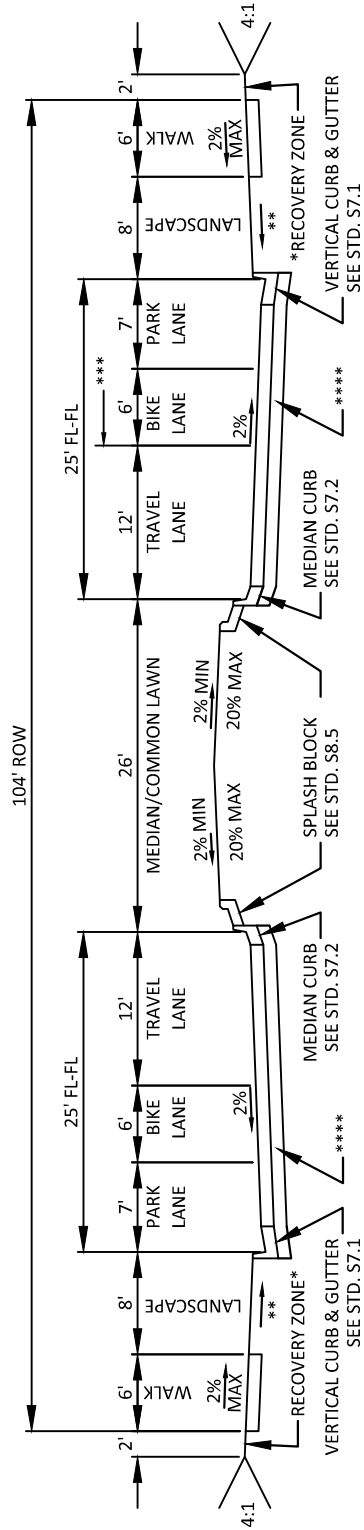
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CITY ENGINEER

01/31/2023  
DATE

URBAN CENTER & TOD  
TRANSITION OR CORE ZONE  
ROADWAY CLASSIFICATIONS  
AND TYPICAL CROSS SECTIONS

S1.13

# STANDARD



## RESIDENTIAL PARKWAY - 2 LANES

\* MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCR OACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

\*\* GENERALLY, THE LANDSCAPED TREE LAWN SHALL HAVE A TRANSVERSE SLOPE OF 2% . HOWEVER, ON A CASE BY CASE BASIS THIS TRANSVERSE SLOPE MAY BE INCREASED TO A MAXIMUM OF 4:1 WITH PRIOR APPROVAL FROM THE CITY ENGINEER.

\*\*\* INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

NOTE:  
26' CLEAR MINIMUM PAVED SURFACE SHALL BE PROVIDED EVERY 150' OF ROAD LENGTH, SEE STD. S23.1.

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City of Aurora, Colorado

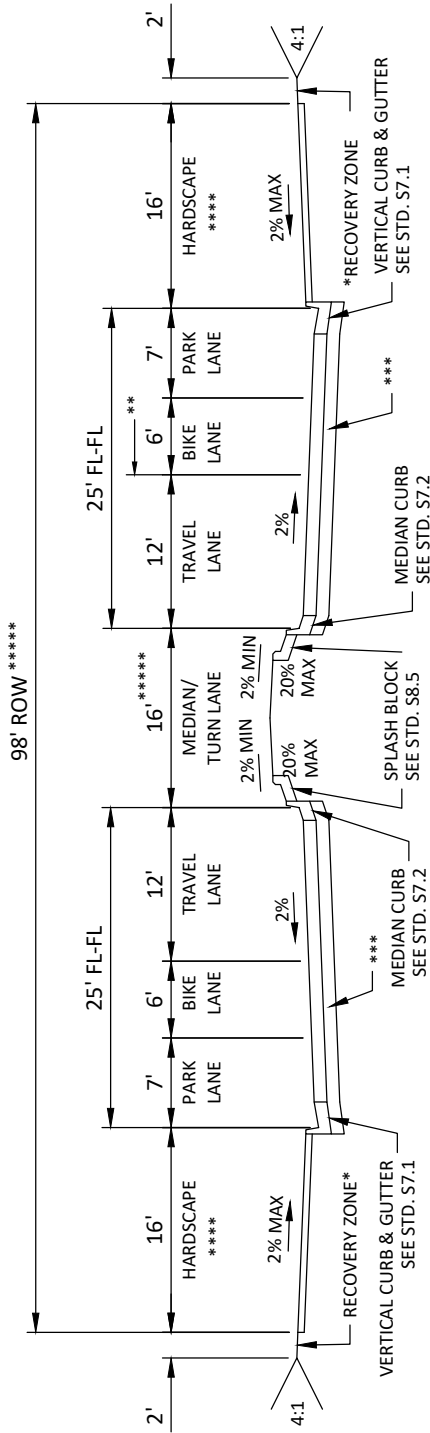
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CITY ENGINEER

01/31/2023  
DATE

URBAN CENTER & TOD  
TRANSITION OR CORE ZONE  
ROADWAY CLASSIFICATIONS  
AND TYPICAL CROSS SECTIONS

S1.14

# STANDARD



## MAIN STREET - MEDIAN - 2 LANES

MEDIAN TURN LANE WIDTH = 10.0'

\* MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCR OACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

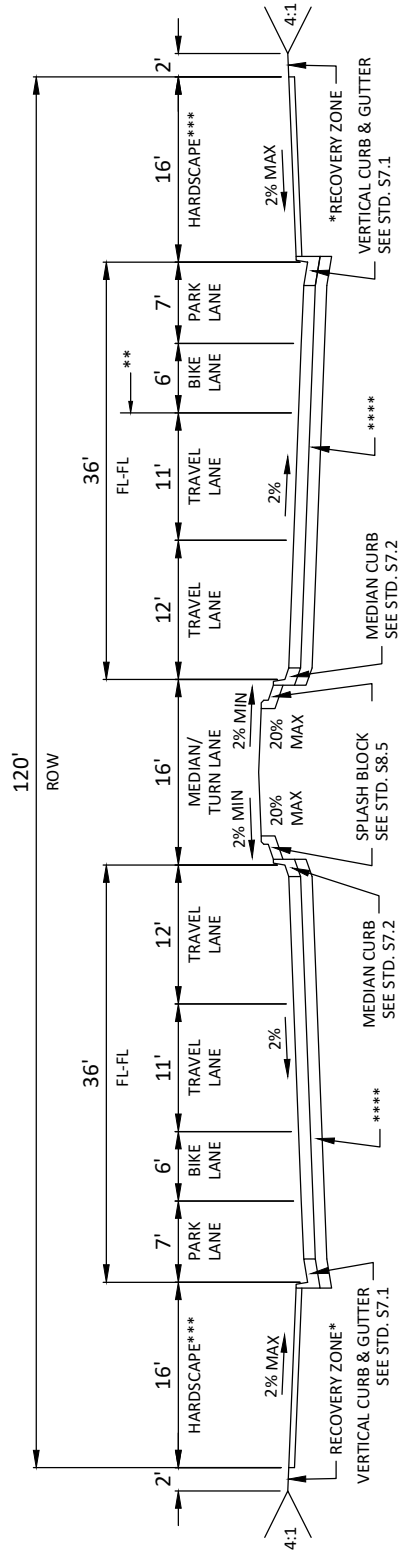
\*\* INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

\*\*\*\* HARDSCAPE DESIGN MAY INCLUDE LANDSCAPING AND STREET FURNITURE BUT MUST INCLUDE AN ACCESSIBLE WAY OF NOT LESS THAN 6 FEET.

\*\*\*\*\* ALTERNATE SECTION. PAINTED MEDIAN IN LIEU OF RAISED MEDIAN. MEDIAN WIDTH SHALL BE 14 FEET AND THE RIGHT-OF-WAY WIDTH SHALL BE 96 FEET.

# STANDARD



## MAIN STREET - MEDIAN - 4 LANES

MEDIAN TURN LANE WIDTH = 10.0'

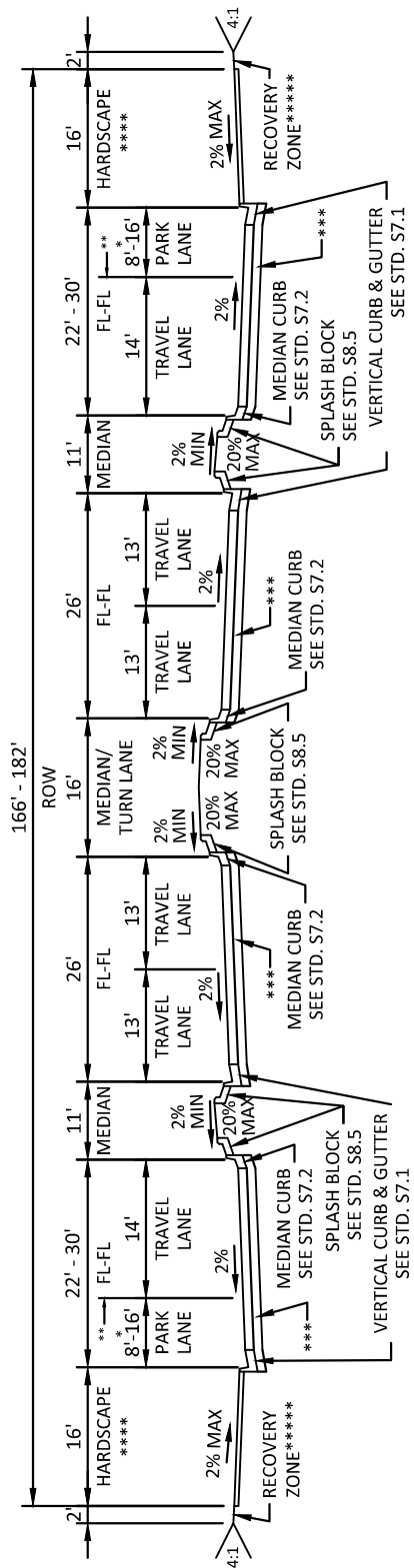
\*MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCRATCH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

\*\*INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\*HARDSCAPE DESIGN MAY INCLUDE LANDSCAPING AND STREET FURNITURE BUT MUST INCLUDE AN ACCESSIBLE WAY OF NOT LESS THAN 6 FEET.

\*\*\*\*COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

# STANDARD



## MULTIWAY BOULEVARD - 4 LANES

MEDIAN TURN LANE WIDTH = 10.0'

\* 8' DIMENSION IS FOR PARALLEL PARKING 16' DIMENSION IS FOR ANGLED PARKING

\*\* INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

\*\*\*\* HARDSCAPE DESIGN MAY INCLUDE LANDSCAPING AND STREET FURNITURE BUT MUST INCLUDE AN ACCESSIBLE WAY OF NOT LESS THAN 6 FEET.

\*\*\*\*\* MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCOACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

NOTE:

26' CLEAR MINIMUM PAVED SURFACE SHALL BE PROVIDED EVERY 150' OF ROAD LENGTH, SEE STD. S23.1. WHEN PARALLEL PARKING OPTION IS USED, 24' FLOWLINE TO FLOWLINE IS ALLOWED FOR THIS SECTION.

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City of Aurora, Colorado

*Healy B. Johnson*  
CITY ENGINEER

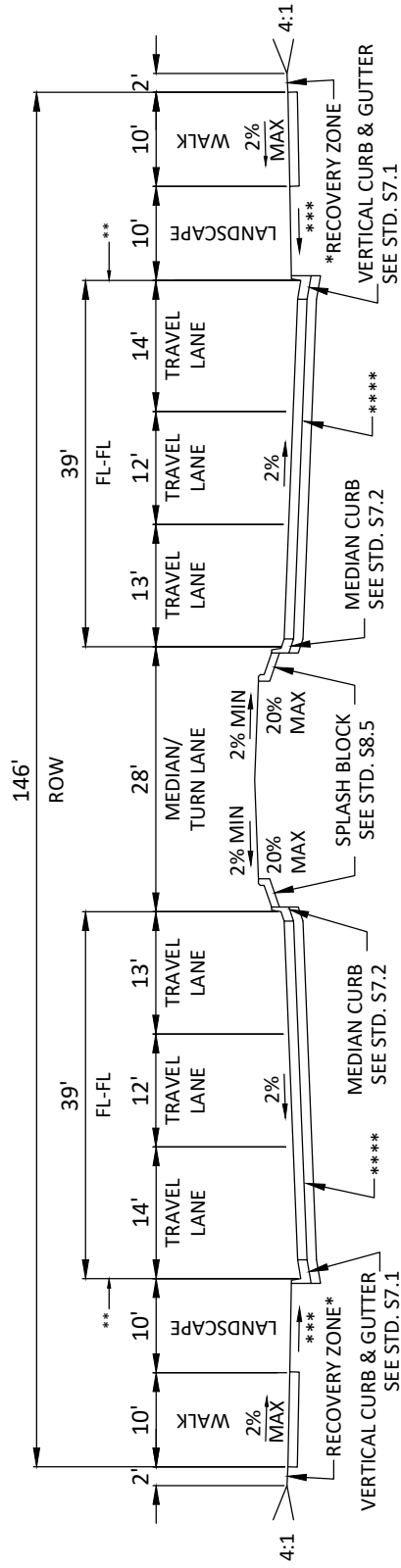
01/31/2023  
DATE

URBAN CENTER & TOD EDGE  
ZONE ROADWAY  
CLASSIFICATIONS AND TYPICAL  
CROSS SECTIONS

S1.17



# STANDARD



## BOULEVARD - 6 LANES

MEDIAN TURN LANE WIDTH = 11.0'

\*MAY BE REDUCED OR ELIMINATED WHERE PRIVATE IMPROVEMENTS ENCR OACH WITHIN THIS ZONE. BUILDING FOUNDATIONS SHALL NOT EXTEND INTO PUBLIC RIGHT-OF-WAY.

\*\*INDICATE CLEAR ZONE BASED ON DESIGN SPEED AND ADT.

\*\*\*GENERALLY, THE LANDSCAPED TREE LAWN SHALL HAVE A TRANSVERSE SLOPE OF 2%. HOWEVER, ON A CASE BY CASE BASIS THIS TRANSVERSE SLOPE MAY BE INCREASED TO A MAXIMUM OF 4:1 WITH PRIOR APPROVAL FROM THE CITY ENGINEER.

\*\*\*\* COMPOSITE PAVEMENT SECTION. EXTEND BASE COURSE TO BOTTOM BACK OF CURB. EDGE TRENCH DRAIN SHALL BE REQUIRED TO DRAIN BASE COURSE. SEE DETAIL S1.19.

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City of Aurora, Colorado

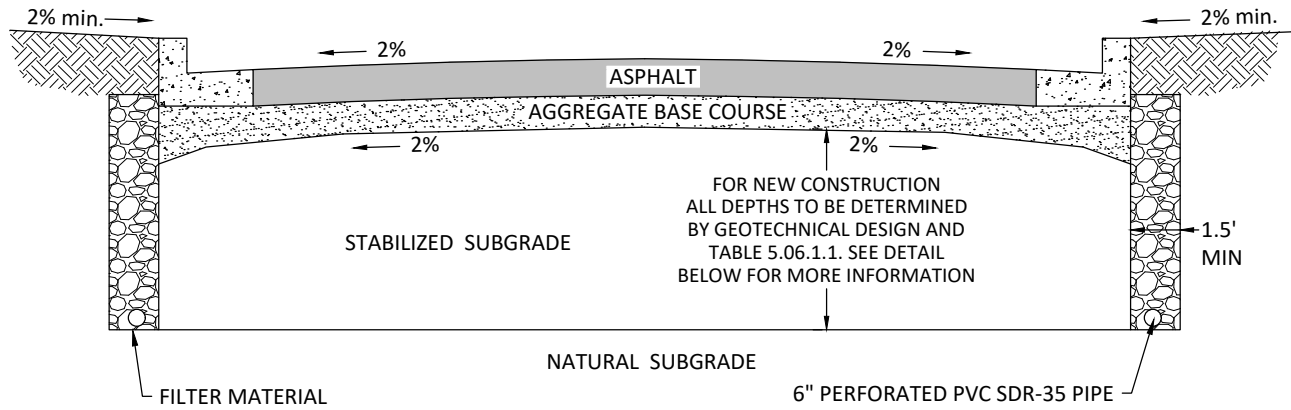
*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

URBAN CENTER & TOD EDGE  
ZONE ROADWAY  
CLASSIFICATIONS AND TYPICAL  
CROSS SECTIONS

S1.18

# STANDARD

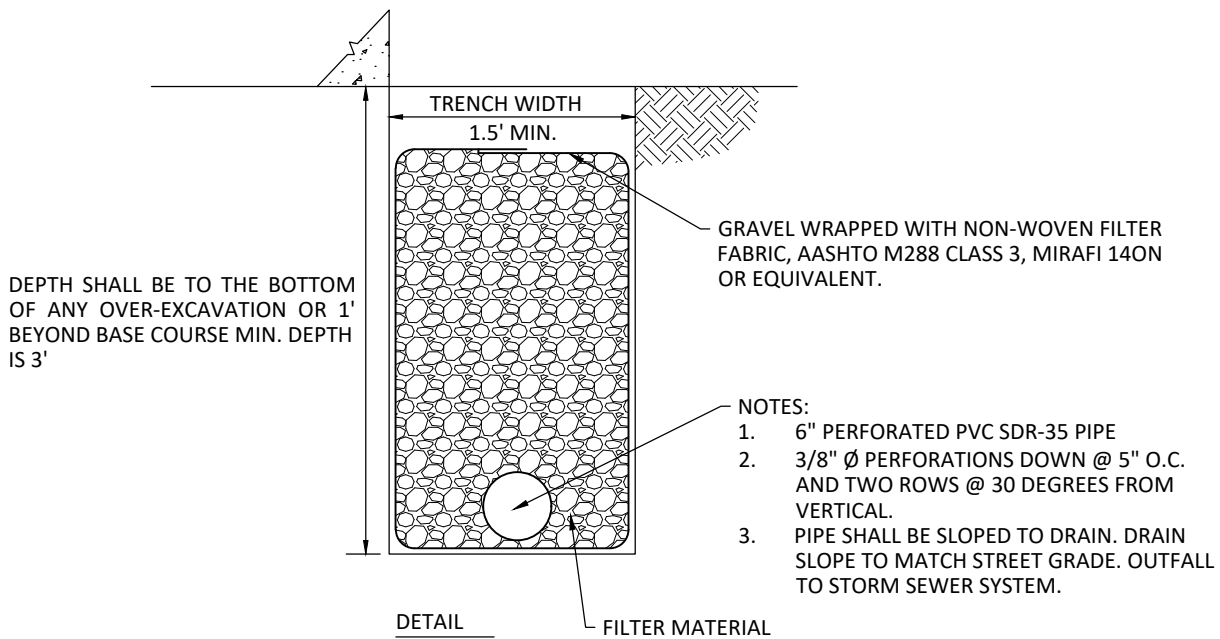


**NOTES:**

1. FOR RETROFITTING EXISTING ROADWAYS, DEPTH OF DRAIN PIPE MAY VARY BASED ON EXISTING STREET STRUCTURE AND/OR SOIL CONDITIONS.
2. 6" SOLID WALL PVC SDR 35 PIPE SHALL BE USED FOR ALL CLEANOUTS AND LATERAL CONNECTIONS UNDER THE ROADWAY.
3. CLEANOUTS SHALL BE INSTALLED EVERY 250' OR AT CHANGES IN PIPE SIZE OR DIRECTION. AND SHALL BE PROTECTED WITH A CAST IRON CLEAN OUT BOX SUCH AS A CASTINGS INC CO-8030 C.I.
4. EDGE DRAINS SHALL BE INSTALLED 100 FEET EITHER SIDE OF SUMP INLETS IN STREETS OR UP STREAM FROM ONGRADE TYPE 'R' INLETS, UNLESS PAVEMENT DESIGN REPORT RECOMMENDS ADDITIONAL LENGTH.

**FILTER MATERIAL GRADATION**

Sieve Size	Mass Percent Passing Square Mesh Sieves
19.0 mm (3/4")	100
4.75mm (No. 4)	60 - 100
300 µm (No. 50)	10 - 30
150 µm (No. 100)	0 - 10
75 µm (No. 200)	0 - 3



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City of Aurora, Colorado

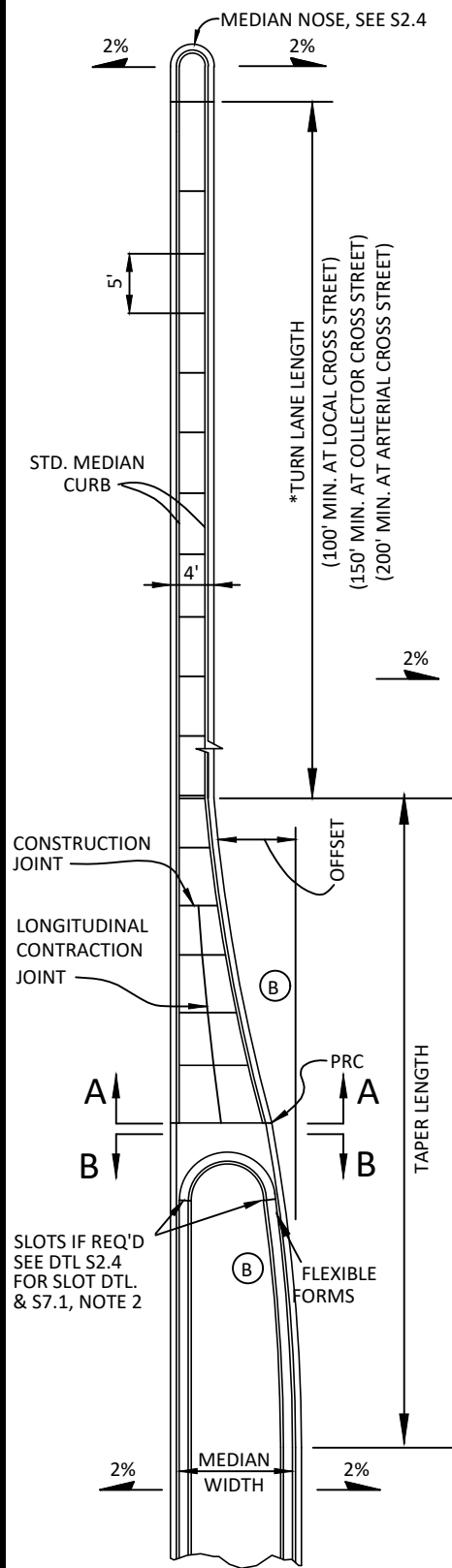
*Heidi Blahnik*  
CITY ENGINEER

01/31/2023  
DATE

**ROADWAY EDGE DRAIN**

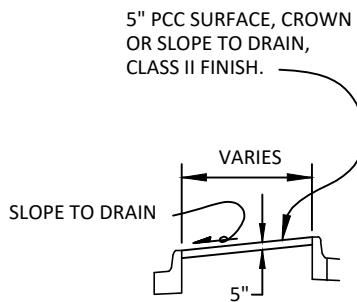
**S1.19**

# STANDARD

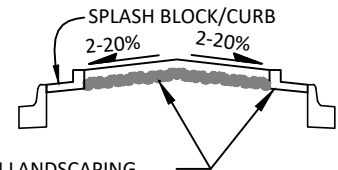


## CURVE DATA

	(B)	
MEDIAN WIDTH	14'	26'
$\Delta$	10°28'31"	14°15'00"
R	300'	357.51'
L	54.85'	88.92'
T	27.50'	44.69'
TAPER LENGTH	109.1'	176'
OFFSET	10'	22'



**MEDIAN FINISH DETAIL  
SECTION A-A**



MEDIAN LANDSCAPING  
CONTACT PARKS, RECREATION & OPEN  
SPACE DEPT. FOR CONCRETE COLORING,  
MEDIAN COVER SPLASH BLOCK REQUIREMENTS  
& CONCRETE THICKNESS REQ'TS RELATED TO  
MAINTENANCE EQUIPMENT ACCESS.

**MEDIAN FINISH DETAIL  
SECTION B-B**

ALL 5" PCC SHALL HAVE CONTRACTION JOINTS 5' MAXIMUM (SEE S7.3) AND EXPANSION JOINTS AT 50' MAXIMUM. MEDIAN CURB JOINTS AND CONTRACTION JOINTS SHALL BE COLLINEAR AND PERPENDICULAR TO THE ROADWAY CENTER LINE. CONCRETE WIDER THAN 5' SHALL HAVE LONGITUDINAL CONTRACTION JOINTS EVERY 5'. SPACING SHALL BE SYMMETRICALLY CENTERED ON THE MEDIAN.

NOTE: FOR ANY TYPE OF CONSTRUCTION WITHIN AN EXISTING MEDIAN, THE CONTRACTOR SHALL REPLACE THE MEDIAN COVER MATERIAL WITH 5" PCC SURFACE FROM MEDIAN NOSE TO THE SPLASH BLOCK RETURN.

\* AS SHOWN ON THE DRAWINGS AND DETERMINED BY THE TRAFFIC ENGINEER PRIOR TO CONSTRUCTION.

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CITY ENGINEER

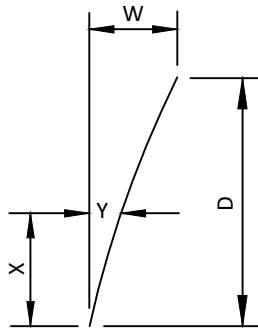
01/31/2023  
DATE

14' & 26' RAISED MEDIANS  
TURNING LANE &  
TRANSITION

1 of 10

S2.1

# STANDARD

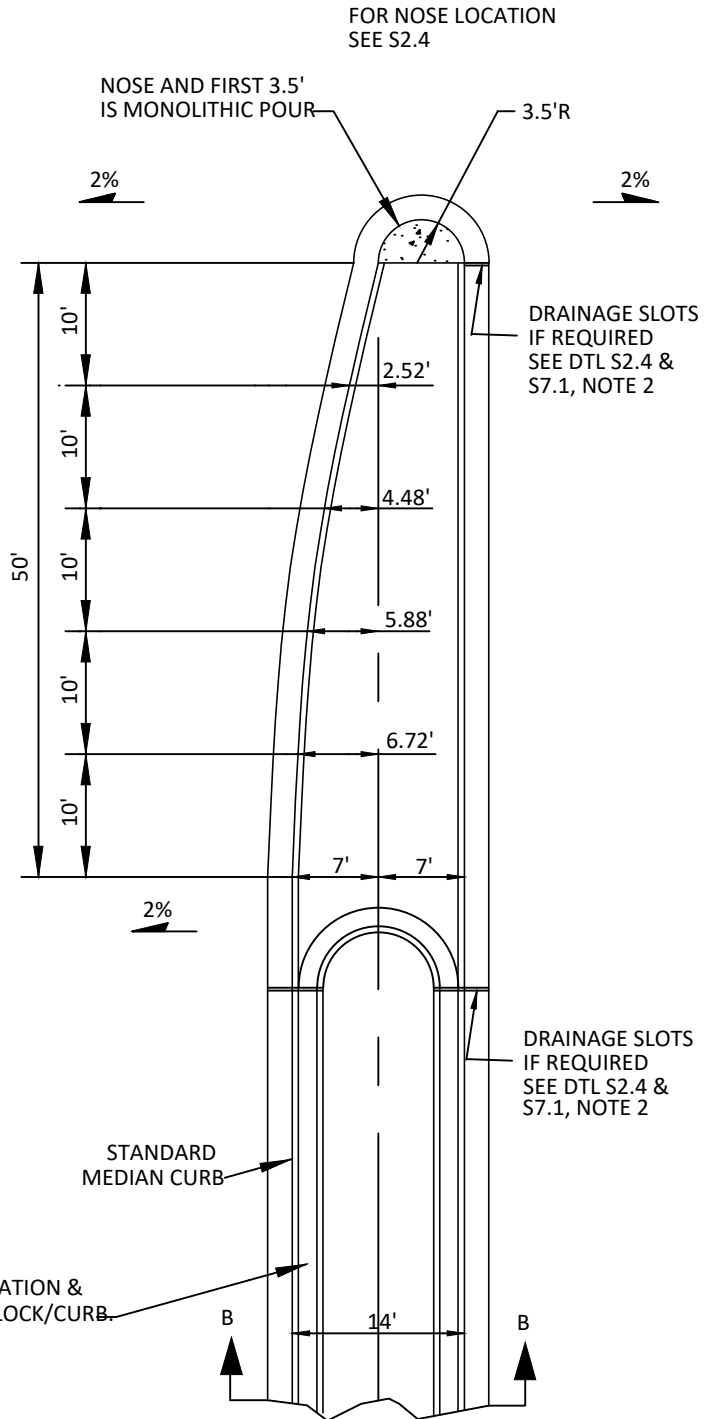


$$Y = \frac{WX^2}{D^2}$$

D = LENGTH OF FLARE (FEET)  
 W = MAXIMUM OFFSET (FEET)  
 X = DISTANCE ALONG BASELINE (FEET)  
 Y = OFFSET FROM BASELINE (FEET)

NOTE:  
 PARABOLIC FLARE & MEDIAN NOSE TO BE  
 CONSTRUCTED WITH FLEXIBLE FORMS.

COORDINATE WITH PARKS, RECREATION &  
 OPEN SPACE DEPT. FOR SPLASH BLOCK/CURB.



FOR SECTION B-B SEE S2.1

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 CITY ENGINEER

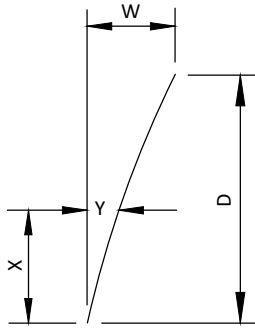
01/31/2023  
 DATE

14' RAISED MEDIAN  
 PARABOLIC FLARE AT TEE  
 INTERSECTION

2 of 10

S2.2

# STANDARD

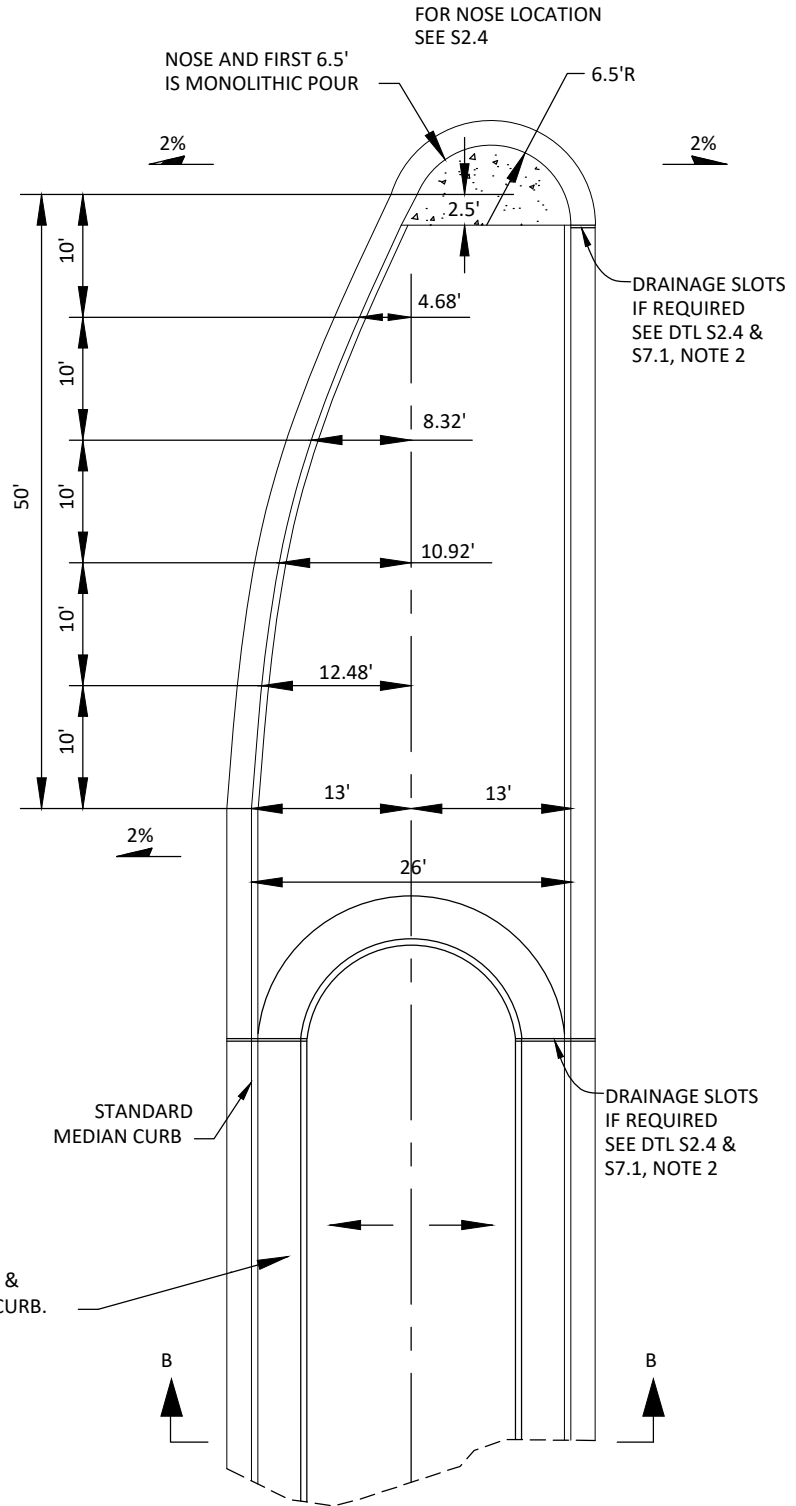


$$Y = \frac{WX^2}{D^2}$$

D = LENGTH OF FLARE (FEET)  
 W = MAXIMUM OFFSET (FEET)  
 X = DISTANCE ALONG BASELINE (FEET)  
 Y = OFFSET FROM BASELINE (FEET)

NOTE:  
 PARABOLIC FLARE & MEDIAN NOSE TO BE  
 CONSTRUCTED WITH FLEXIBLE FORMS.

COORDINATE WITH PARKS, RECREATION &  
 OPEN SPACE DEPT. FOR SPLASH BLOCK/CURB.



FOR SECTION B-B SEE S2.1

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City of Aurora, Colorado

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 CITY ENGINEER

01/31/2023  
 DATE

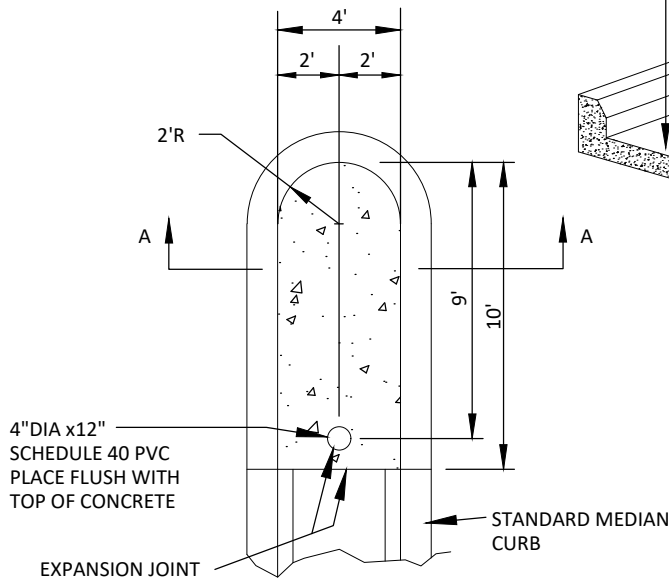
26' RAISED MEDIAN  
 PARABOLIC FLARE AT TEE  
 INTERSECTION

3 of 10

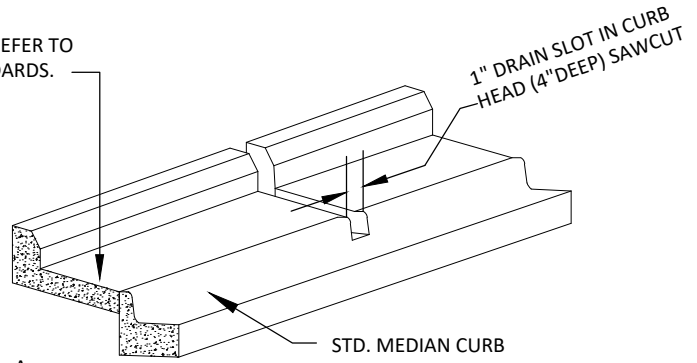
S2.3

# STANDARD

SPLASHBLOCK/CURB. REFER TO PARKS, RECREATION & OPEN SPACE DEPT. STANDARDS.



**NOSE DETAIL**



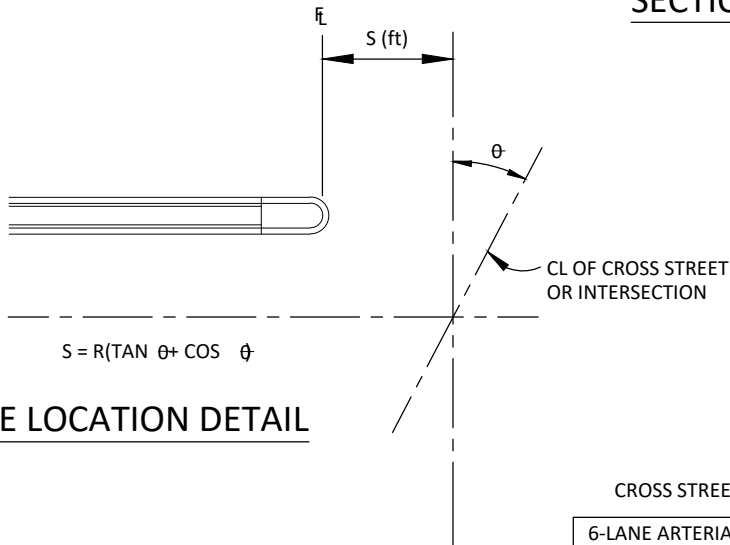
**DRAINAGE SLOT DETAIL**

SEE DETAIL S7.1, NOTE 2 FOR SLOT LOCATION.



NOSE AND FIRST TEN FEET IS MONOLITHIC POUR

**SECTION A-A**



**NOSE LOCATION DETAIL**

CROSS STREET	MINIMUM INTERSECTION TURNING R=RADIUS (FEET)
6-LANE ARTERIAL	77
4-LANE ARTERIAL	62
4-LANE COLLECTOR	47
2-LANE COLLECTOR	42
LOCAL	39

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City of Aurora, Colorado

*Heley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

**RAISED MEDIAN NOSE &  
NOSE LOCATION DETAILS**

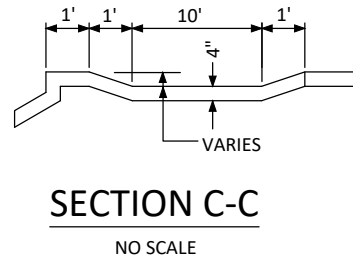
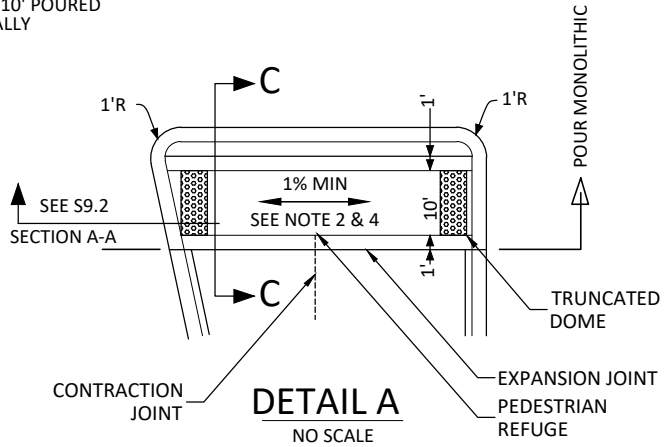
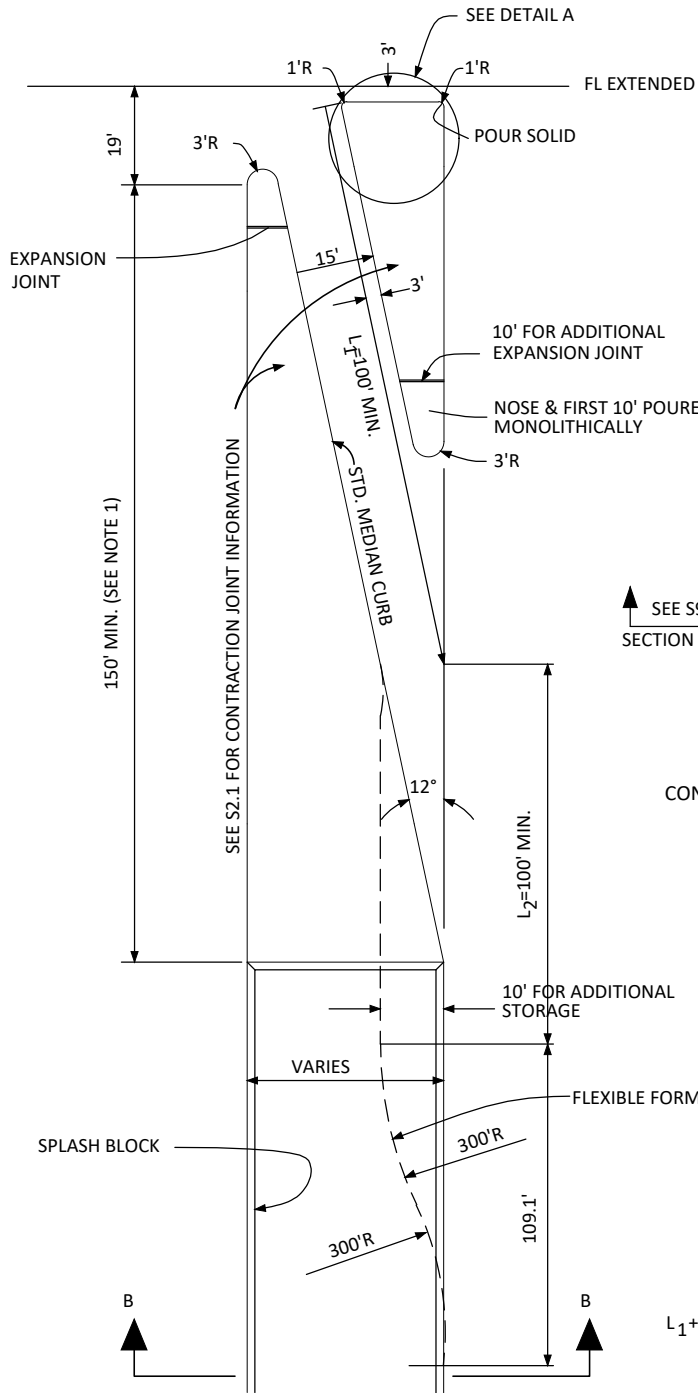
4 of 10

**S2.4**

# STANDARD

## NOTES:

1. IF THE 12° MAXIMUM ANGLE IS EXCEEDED WHEN USING THE 150' LENGTH, A NEW LENGTH SHALL BE USED BASED ON THE 12° MAXIMUM ANGLE.
2. CONSTRUCTION PLANS SHALL INCLUDE COMPLETE DETAILS FOR THE MEDIAN.
3. REFER TO CITY OF AURORA DETAIL S9.4 FOR TRUNCATED DOME DETAILS AND SECTION INFORMATION.
4. 1% MINIMUM LONGITUDINAL SLOPES, 2% MAXIMUM SLOPES IN ANY DIRECTION. SEE NOTE 3.
5. PEDESTRIAN RAMP SHALL MEET ADA REQUIREMENTS.



L<sub>1</sub> + L<sub>2</sub> = LENGTH OF TURN LANE SHOWN ON PLANS OR SET BY TRAFFIC ENGINEER PRIOR TO CONSTRUCTION.

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City of Aurora, Colorado

*Heley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

BUCKLEY ROAD  
RAISED MEDIAN

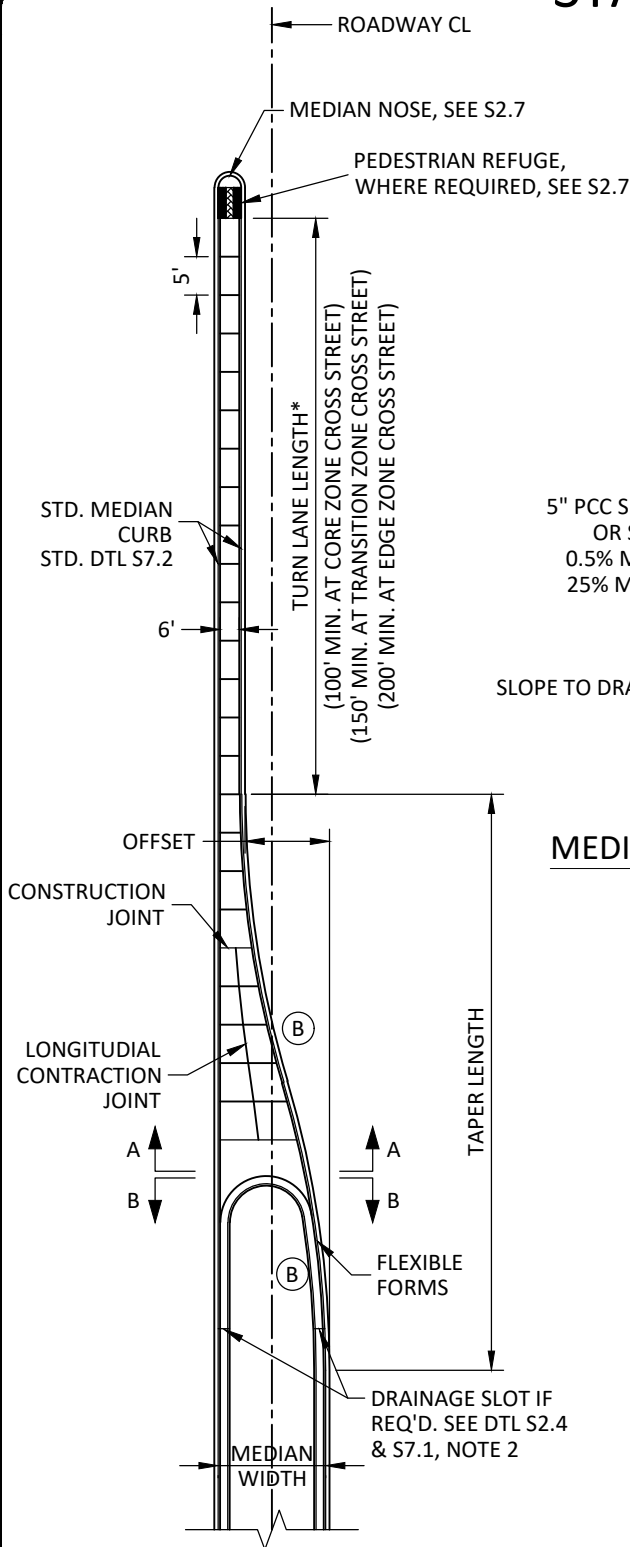
5 of 10

S2.5

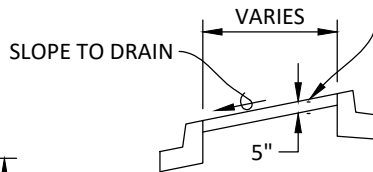
# STANDARD

## CURVE DATA

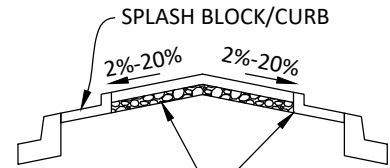
MEDIAN WIDTH	28'
$\Delta$	13°12'35"
R	415.73'
L	95.85'
T	48.14'
TAPER LENGTH	190'
OFFSET	22'



5" PCC SURFACE, CROWN OR SLOPE TO DRAIN, 0.5% MINIMUM SLOPE, 25% MAXIMUM SLOPE, CLASS II FINISH



**MEDIAN FINISH DETAIL**  
SECTION A-A



MEDIAN LANDSCAPING CONTACT PARKS, RECREATION & OPEN SPACE DEPT. FOR CONCRETE COLORING, MEDIAN COVER, SPLASH BLOCK REQUIREMENTS & CONCRETE THICKNESS REQ'TS RELATED TO MAINTENANCE EQUIPMENT ACCESS.

**MEDIAN FINISH DETAIL**  
SECTION B-B

ALL 5" PCC SHALL HAVE CONTRACTION JOINTS AT 5' MAXIMUM SPACING (SEE S7.3) AND EXPANSION JOINTS AT 50' MAXIMUM SPACING. MEDIAN CURB JOINTS AND CONTRACTION JOINTS SHALL BE COLINEAR AND PERPENDICULAR TO THE ROADWAY CENTER LINE. CONCRETE WIDER THAN 5' SHALL HAVE LONGITUDINAL CONTRACTION JOINTS EVERY 5'. SPACING SHALL BE SYMMETRICALLY CENTERED ON THE MEDIAN.

NOTE: FOR ANY TYPE OF CONSTRUCTION WITHIN AN EXISTING MEDIAN, THE CONTRACTOR SHALL REPLACE THE MEDIAN COVER MATERIAL WITH 5" PCC SURFACE FROM MEDIAN NOSE TO THE SPLASH BLOCK RETURN.

NOTE: THE NEED FOR A PEDESTRIAN REFUGE WILL VARY DEPENDING ON INTERSECTION TRAFFIC CONTROL. CONTACT THE CITY TRAFFIC MANAGER OR DESIGNEE TO CONFIRM LAYOUT.

\* AS SHOWN ON THE DRAWINGS AND DETERMINED BY THE TRAFFIC ENGINEER PRIOR TO CONSTRUCTION.

\\aurora\files\dept\public works\pwo\draft\standard\roadway\series details\s2-6.dwg, 28 November 2016

City of Aurora, Colorado

*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

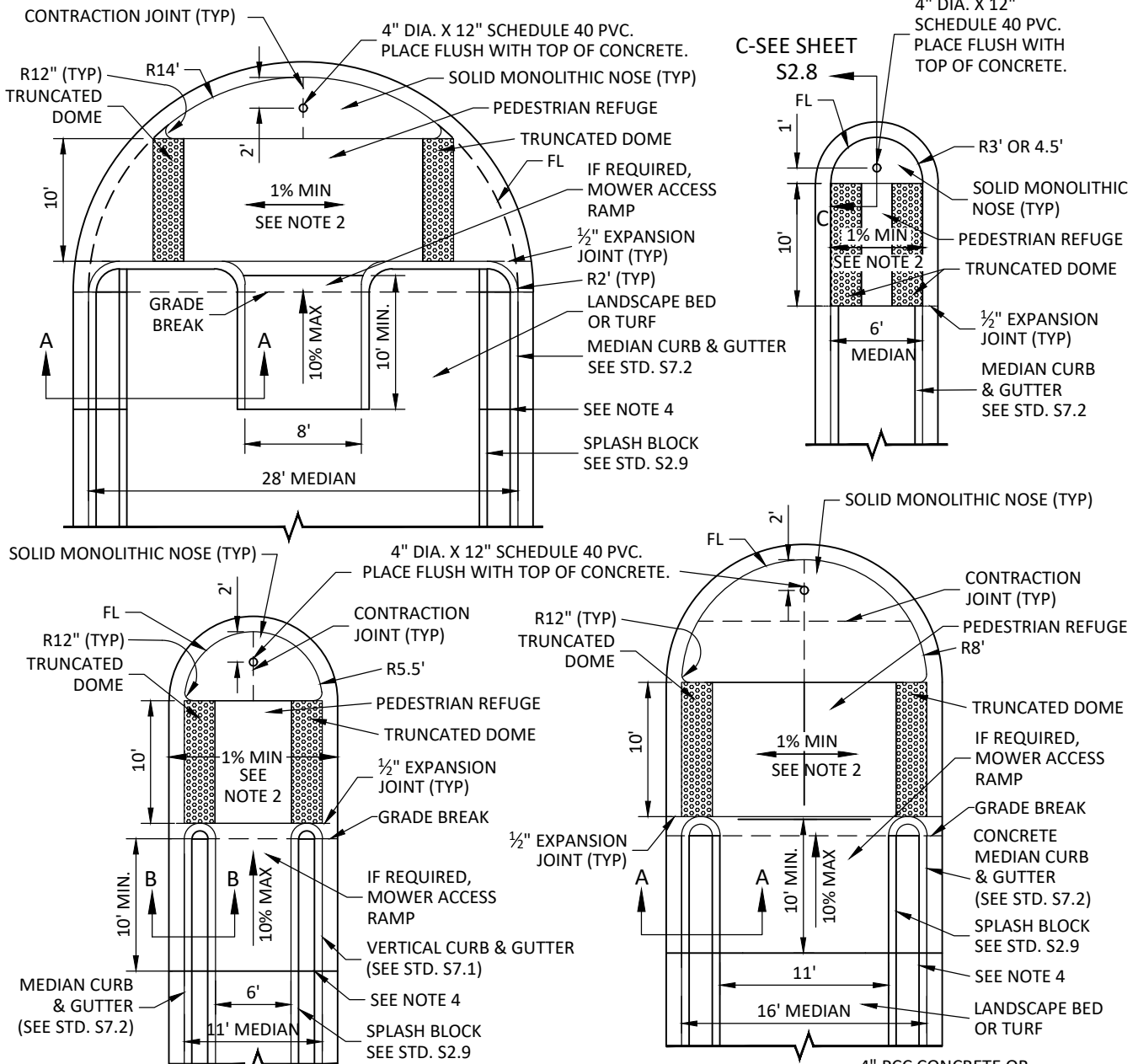
URBAN CENTER & TOD  
28' RAISED MEDIANS  
TURNING LANE

6 of 10

S2.6



# STANDARD



- NOTES:**
1. REFER TO CITY OF AURORA DETAIL S9.4 FOR TRUNCATED DOME DETAILS AND SECTION INFORMATION.
  2. 1% MINIMUM LONGITUDINAL SLOPES, 2% MAXIMUM SLOPES IN ANY DIRECTION. SEE NOTE 3.
  3. PEDESTRIAN RAMPS SHALL MEET ADA REQUIREMENTS.
  4. BEGIN TRANSITION OF FULL-HEIGHT SPLASHBLOCK TO ZERO-HEIGHT SPLASH BLOCK. MATCH SLOPE OF MOWER ACCESS RAMP.
  5. THE NEED FOR A PEDESTRIAN REFUGE WILL VARY DEPENDING ON INTERSECTION TRAFFIC CONTROL. CONTACT THE CITY TRAFFIC MANAGER OR DESIGNEE TO CONFIRM LAYOUT.

\\aurora\files\dept\public works\pww\draft\standard\roadways-series details\s2-7.dwg, 28 November 2016

City of Aurora, Colorado

*Heley B. Johnson*

CITY ENGINEER

01/31/2023

DATE

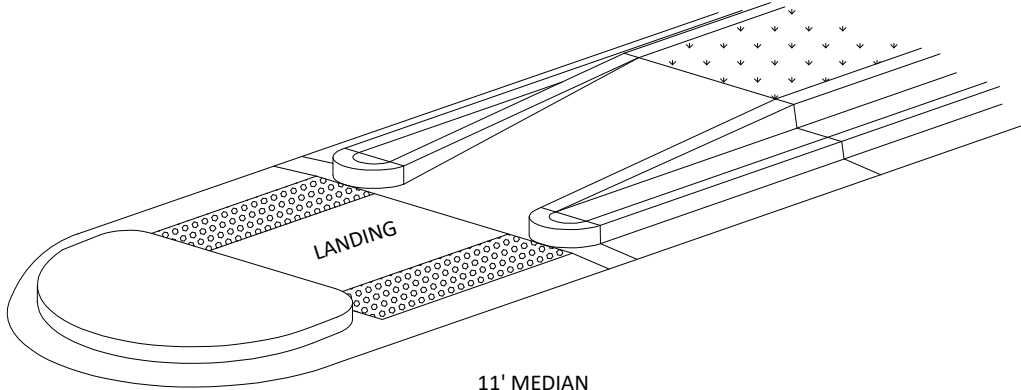
URBAN CENTER & TOD

PEDESTRIAN REFUGE

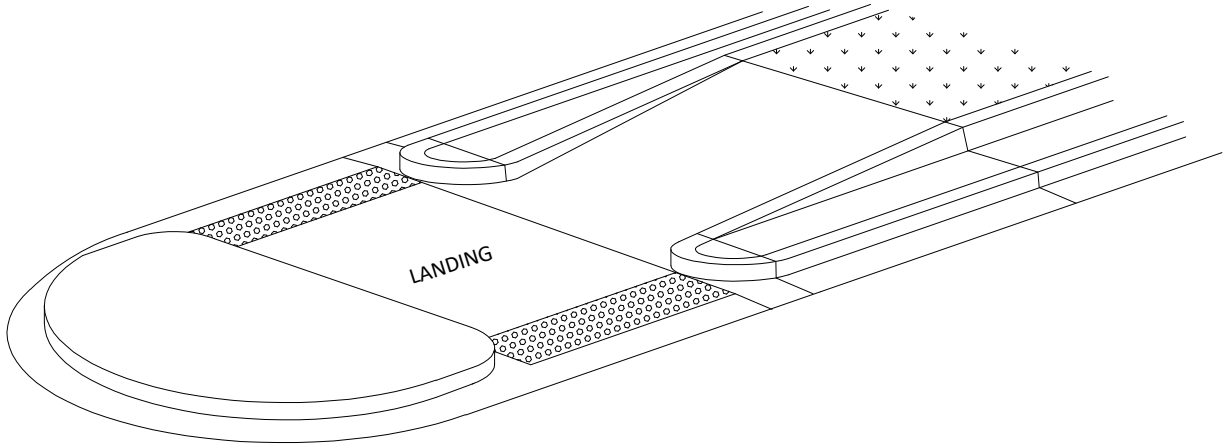
7 of 10

S2.7

# STANDARD



11' MEDIAN  
PEDESTRIAN REFUGE  
WITH MOWER ACCESS



16' MEDIAN  
PEDESTRIAN REFUGE  
WITH MOWER ACCESS

THE NEED FOR A PEDESTRIAN REFUGE WILL VARY DEPENDING ON INTERSECTION TRAFFIC CONTROL. CONTACT THE CITY TRAFFIC MANAGER OR DESIGNEE TO CONFIRM LAYOUT.

SEE NOTE 2 ON S2.7

City of Aurora, Colorado

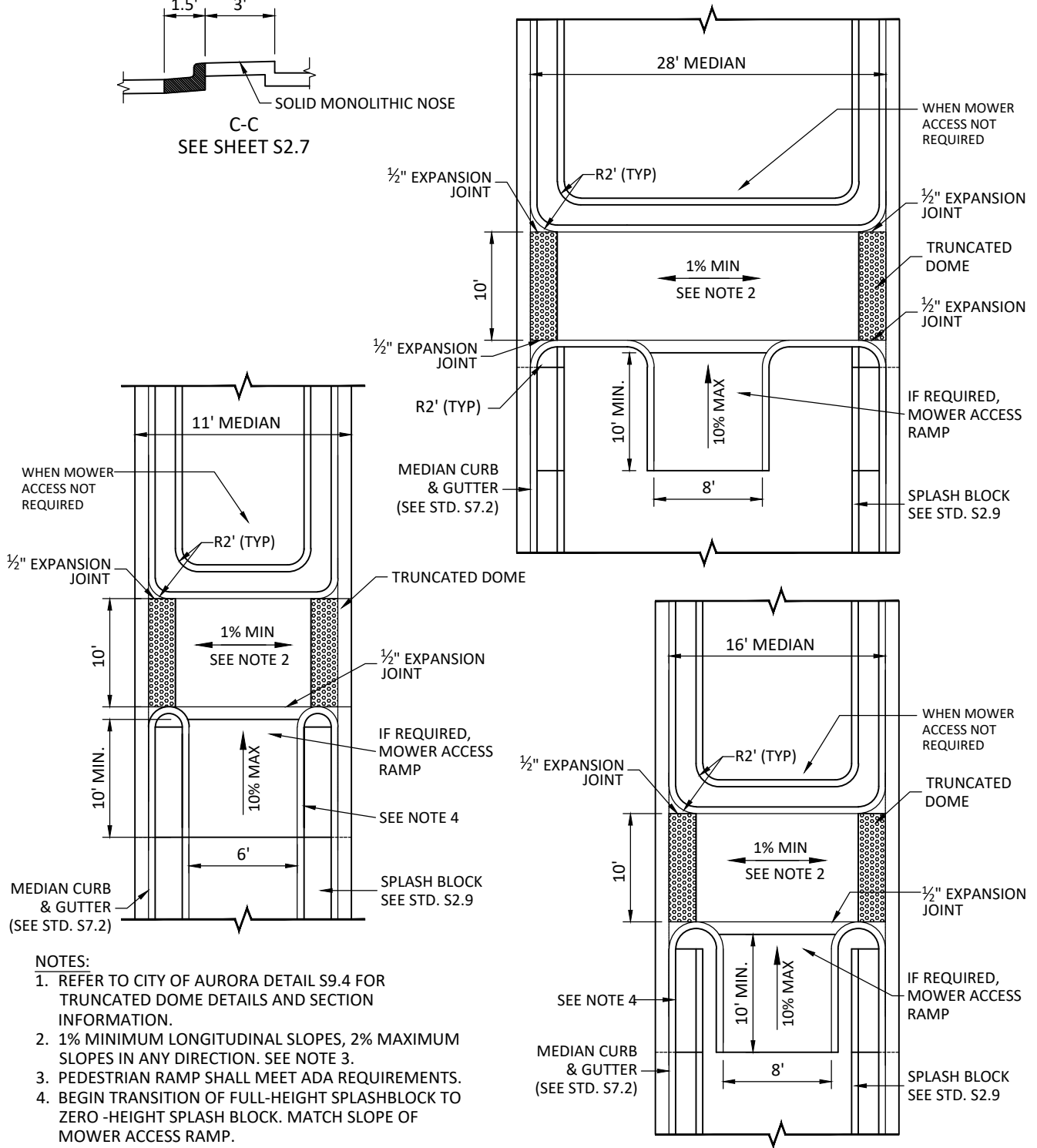
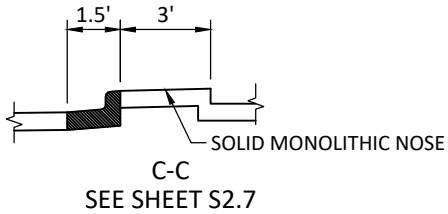
*Haley B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

URBAN CENTER & TOD  
PEDESTRIAN REFUGE  
PERSPECTIVE

7 of 10  
S2.7a

# STANDARD



**NOTES:**

1. REFER TO CITY OF AURORA DETAIL S9.4 FOR TRUNCATED DOME DETAILS AND SECTION INFORMATION.
2. 1% MINIMUM LONGITUDINAL SLOPES, 2% MAXIMUM SLOPES IN ANY DIRECTION. SEE NOTE 3.
3. PEDESTRIAN RAMP SHALL MEET ADA REQUIREMENTS.
4. BEGIN TRANSITION OF FULL-HEIGHT SPLASHBLOCK TO ZERO -HEIGHT SPLASHBLOCK. MATCH SLOPE OF MOWER ACCESS RAMP.
5. PROVIDE IRRIGATION SLEEVING AS NEEDED.

City of Aurora, Colorado

URBAN CENTER & TOD  
PEDESTRIAN REFUGE  
MIDBLOCK

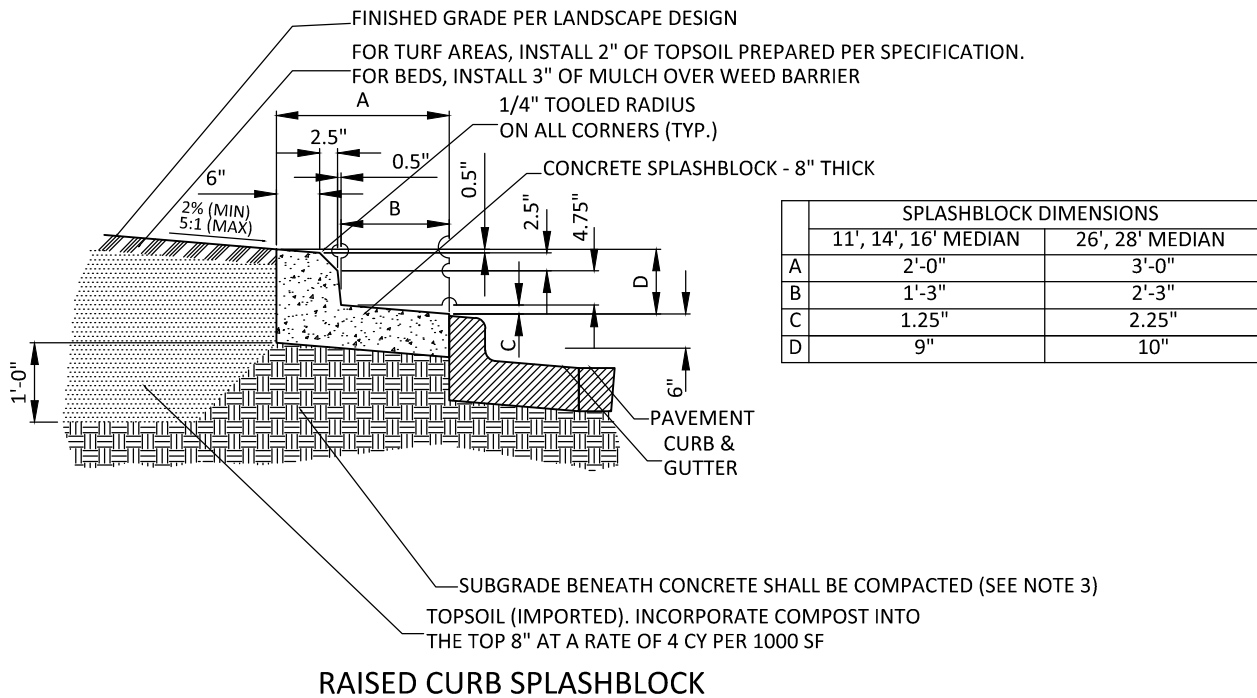
8 of 10

S2.8

*Healy B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



**NOTES:**

1. ALL CONCRETE TO BE FIBER-REINFORCED, 4000lb MIX WITH INTEGRAL COLOR. FIBER MESH TO BE ADDED TO CONCRETE MIX AT A RATE OF 1.5 LBS PER CUBIC YARD. FOR OMAHA TAN COLOR, ADD 1 LB OF #5084 PER 94 LBS OF CEMENT.
2. CONTRACTOR SHALL RAISE ALL EXISTING VALVE BOXES AND UTILITY FACILITIES TO AN APPROPRIATE RELATIONSHIP WITH THE NEW FINISH GRADES.
3. SEE SECTION 20.06.8 IN THE ROADWAY DESIGN AND CONSTRUCTION SPECIFICATIONS TO DETERMINE IF STANDARD PROCTOR OR MODIFIED PROCTOR SHOULD BE USED FOR DENSITY MEASUREMENTS AND REQUIRED COMPACTION REQUIREMENTS.
4. SEE DETAIL S2.4 FOR SLOTTED DRAIN DETAIL AND DETAIL S7.1, NOTE 2 FOR SLOTTED DRAIN LOCATIONS.

City of Aurora, Colorado

URBAN CENTER & TOD  
 RAISED CURB  
 SPLASHBLOCK

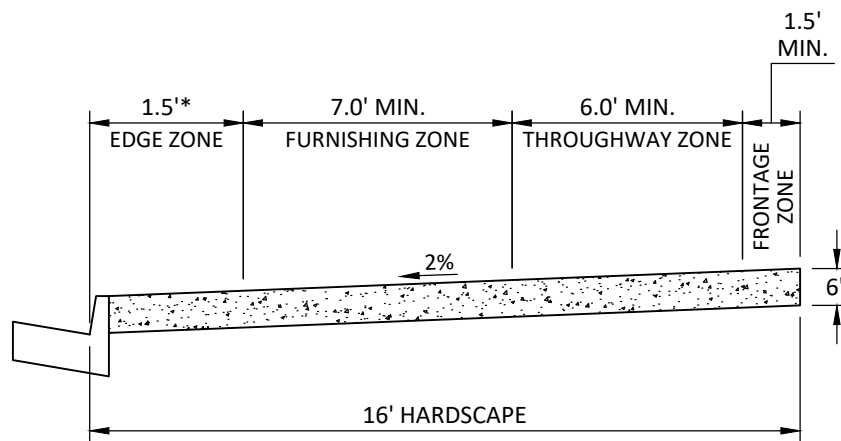
9 of 10

S2.9

*Heley B. Johnson*  
 CITY ENGINEER

01/31/2023  
 DATE

# STANDARD



\*MAY BE WIDENED TO FOUR FEET AT TRANSIT STOPS WITH COMPARABLE DIMENSION REDUCTION IN THE FURNISHING ZONE.

## 16' HARDSCAPE TYPICAL SECTION

1. IF NO SPECIAL CONCRETE PATTERNS ARE PROVIDED WITH THE ADJACENT DEVELOPEMENT, PROVIDE A LONGITUDINAL JOINT AT EIGHT FEET FROM THE RIGHT-OF-WAY LINE.

City of Aurora, Colorado

URBAN CENTER & TOD 16'  
HARDSCAPE TYPICAL  
CROSS SECTION

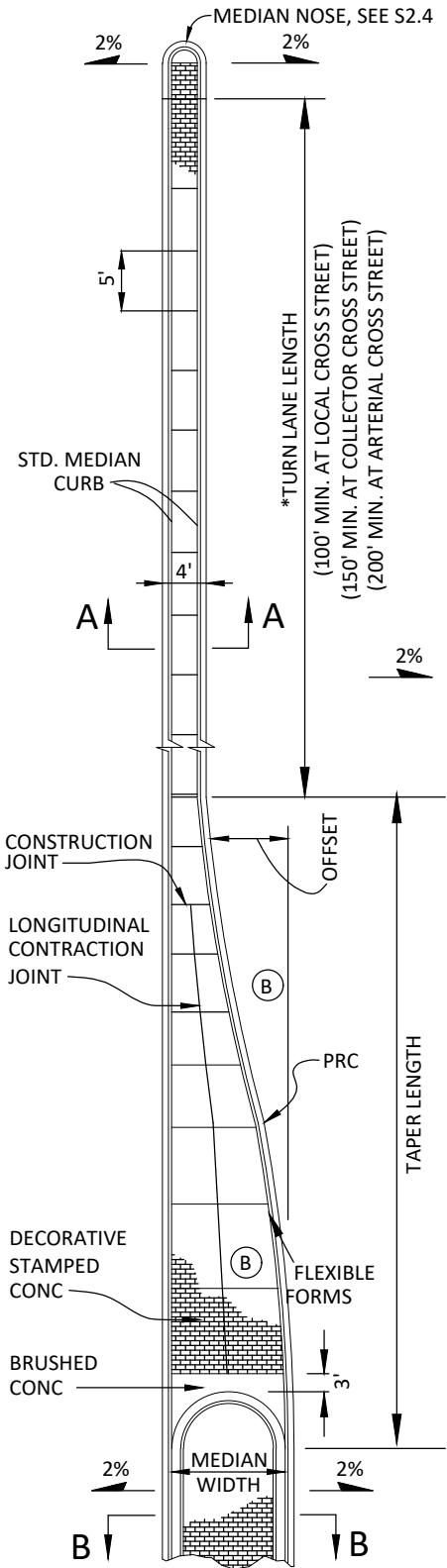
10 of 10

S2.10

*Heley B. Anderson*  
CITY ENGINEER

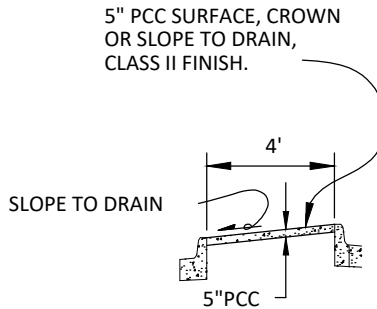
01/31/2023  
DATE

# STANDARD

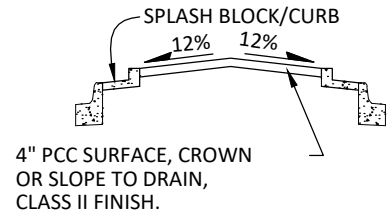


## CURVE DATA

	B	
MEDIAN WIDTH	14'	26'
$\Delta$	10°28'31"	14°15'00"
R	300'	357.51'
L	54.85'	88.92'
T	27.50'	44.69'
TAPER LENGTH	109.1'	176'
OFFSET	10'	22'



**MEDIAN FINISH DETAIL SECTION A-A**



**MEDIAN FINISH DETAIL SECTION B-B**

ALL 5" PCC SHALL HAVE CONTRACTION JOINTS 5' MAXIMUM (SEE S7.3) AND EXPANSION JOINTS AT 50' MAXIMUM. MEDIAN CURB JOINTS AND CONTRACTION JOINTS SHALL BE COLINEAR AND PERPENDICULAR TO THE ROADWAY CENTER LINE. CONCRETE WIDER THAN 5' SHALL HAVE LONGITUDINAL CONTRACTION JOINTS EVERY 5'. SPACING SHALL BE SYMMETRICALLY CENTERED ON THE MEDIAN.

NOTE: FOR ANY TYPE OF CONSTRUCTION WITHIN AN EXISTING MEDIAN, THE CONTRACTOR SHALL REPLACE THE MEDIAN COVER MATERIAL WITH 5" PCC SURFACE FROM MEDIAN NOSE TO THE SPLASH BLOCK RETURN.

\* AS SHOWN ON THE DRAWINGS AND DETERMINED BY THE TRAFFIC ENGINEER PRIOR TO CONSTRUCTION.

City of Aurora, Colorado

**HAVANA ST RAISED  
MEDIAN TURNING LANE &  
TRANSITION**

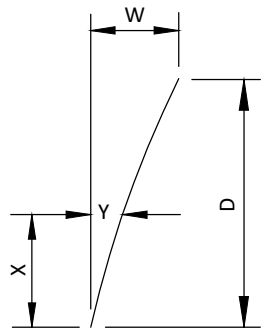
**S2.11**

*Healy B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD

FOR NOSE LOCATION  
SEE S2.4

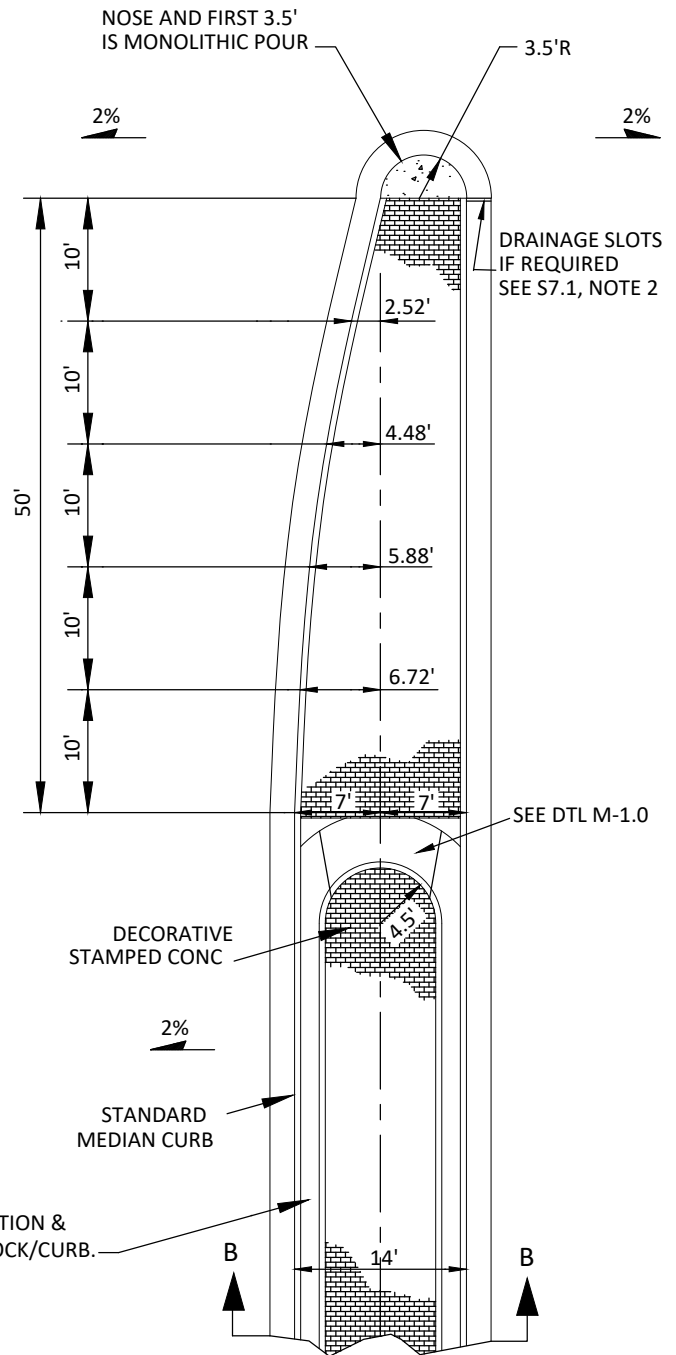


$$Y = \frac{WX^2}{D^2}$$

D = LENGTH OF FLARE (FEET)  
W = MAXIMUM OFFSET (FEET)  
X = DISTANCE ALONG BASELINE (FEET)  
Y = OFFSET FROM BASELINE (FEET)

NOTE:  
PARABOLIC FLARE & MEDIAN NOSE TO BE  
CONSTRUCTED WITH FLEXIBLE FORMS.

COORDINATE WITH PARKS, RECREATION &  
OPEN SPACE DEPT. FOR SPLASH BLOCK/CURB.



FOR SECTION B-B SEE S2.1

City of Aurora, Colorado

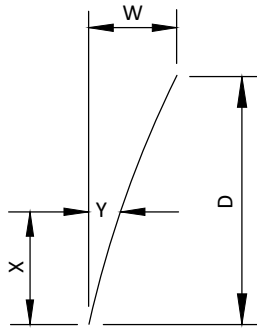
*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

HAVANA ST ~ 14' RAISED  
MEDIAN PARABOLIC FLARE  
AT TEE INTERSECTION

S2.12

# STANDARD

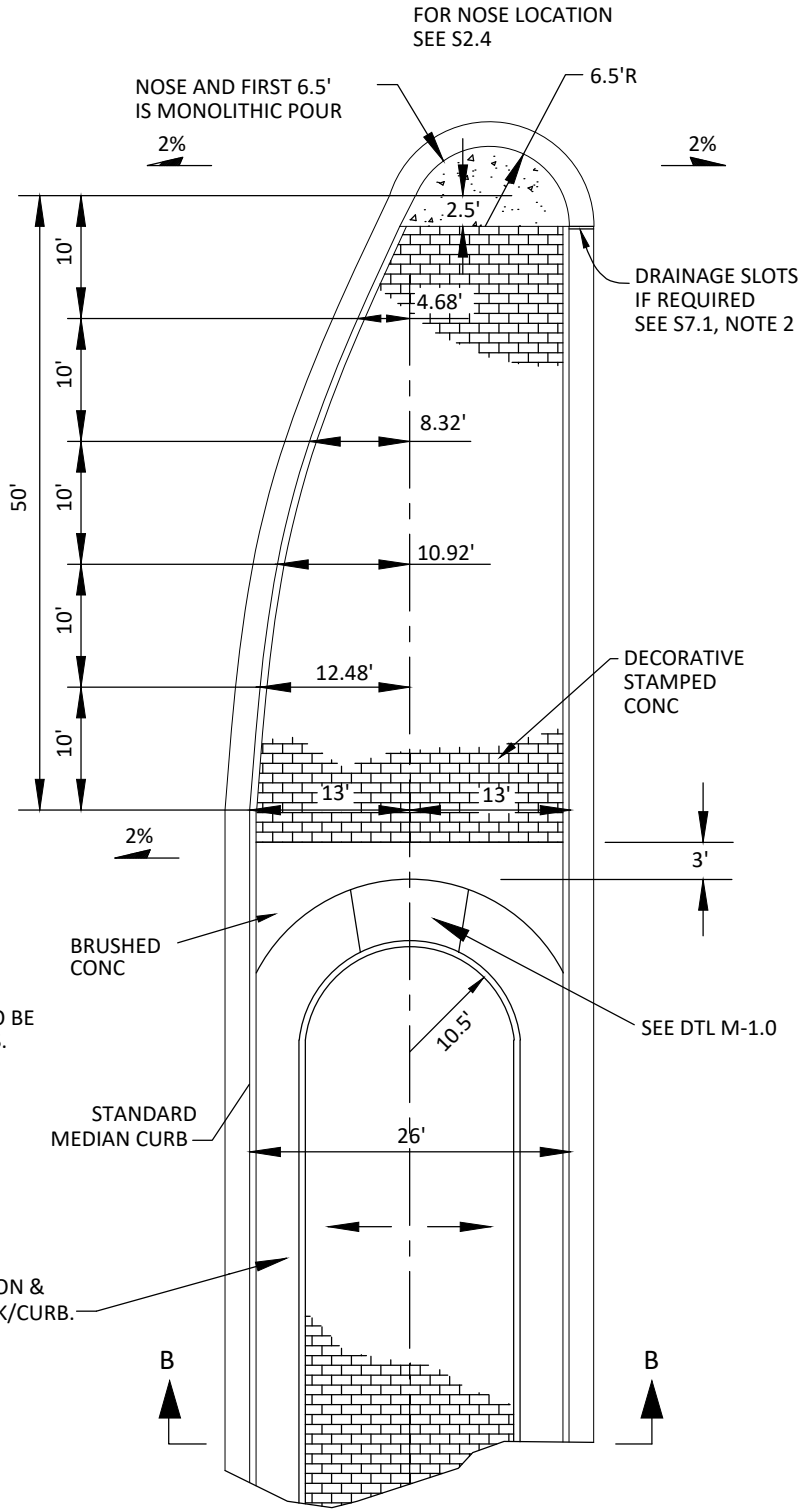


$$Y = \frac{WX^2}{D^2}$$

D = LENGTH OF FLARE (FEET)  
 W = MAXIMUM OFFSET (FEET)  
 X = DISTANCE ALONG BASELINE (FEET)  
 Y = OFFSET FROM BASELINE (FEET)

NOTE:  
 PARABOLIC FLARE & MEDIAN NOSE TO BE  
 CONSTRUCTED WITH FLEXIBLE FORMS.

COORDINATE WITH PARKS, RECREATION &  
 OPEN SPACE DEPT. FOR SPLASH BLOCK/CURB.



FOR SECTION B-B SEE S2.1

City of Aurora, Colorado

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 CITY ENGINEER

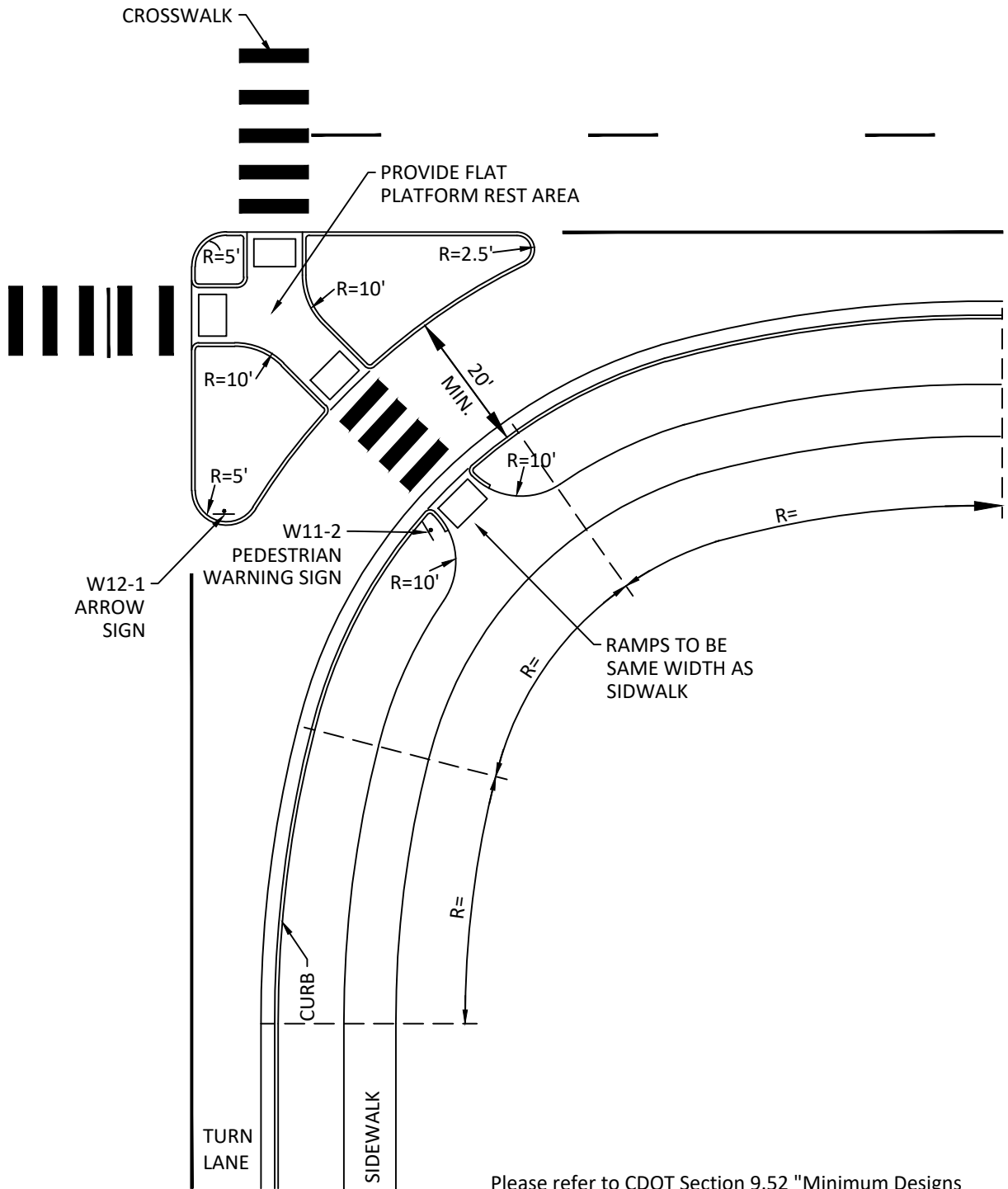
01/31/2023  
 DATE

HAVANA ST ~ 26' RAISED  
 MEDIAN PARABOLIC FLARE  
 AT TEE INTERSECTION

S2.13



# STANDARD



Please refer to CDOT Section 9.52 "Minimum Designs for Sharpest Turns" of the CDOT Roadway Design Guide 2018

NOTE: Three centered curve for the outside curb flowline transition based on field conditions.

City of Aurora, Colorado

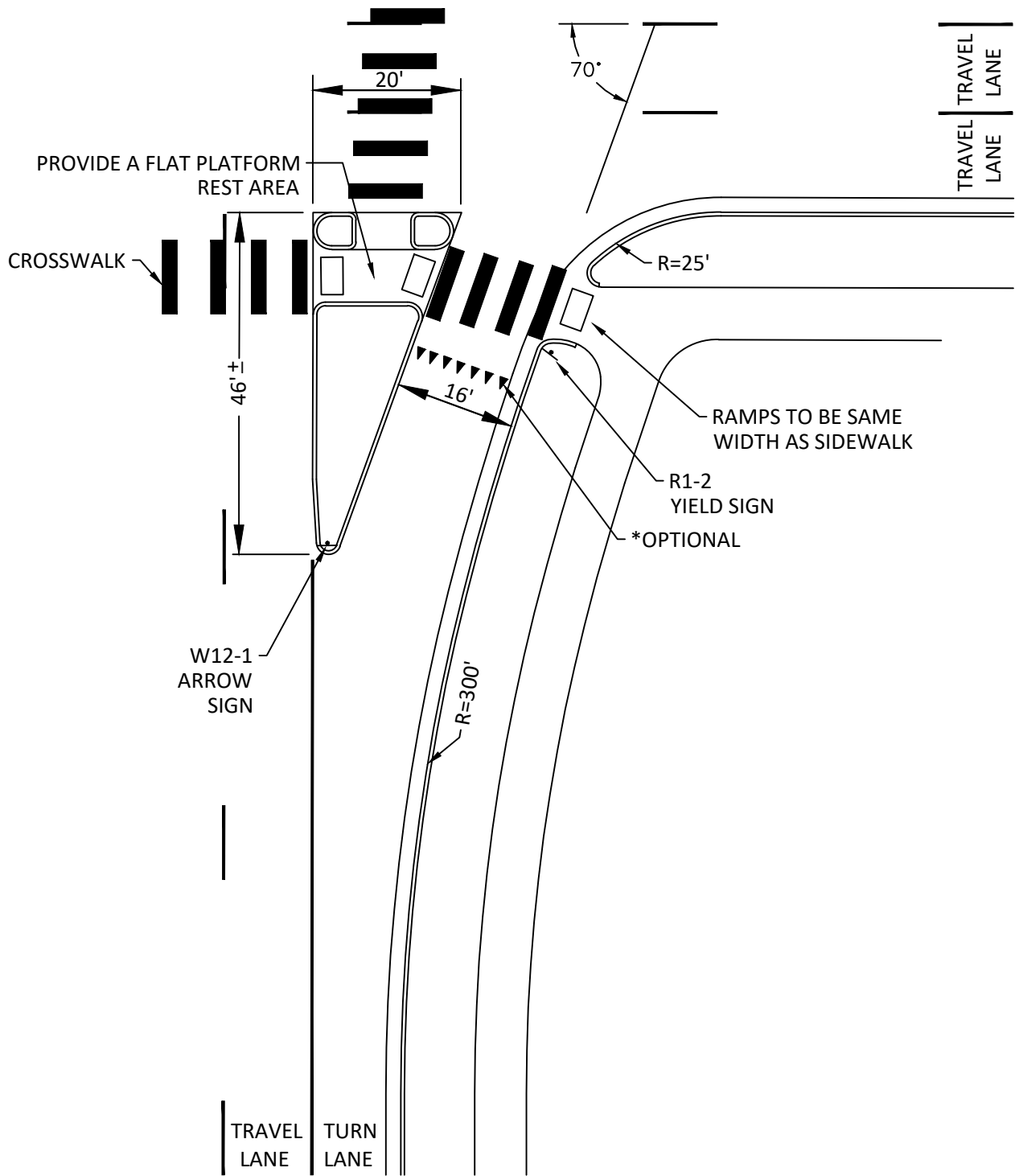
RT TURN LANE TO A  
CONTINUOUS LANE W/  
PED. REFUGE

S2.14

*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



City of Aurora, Colorado

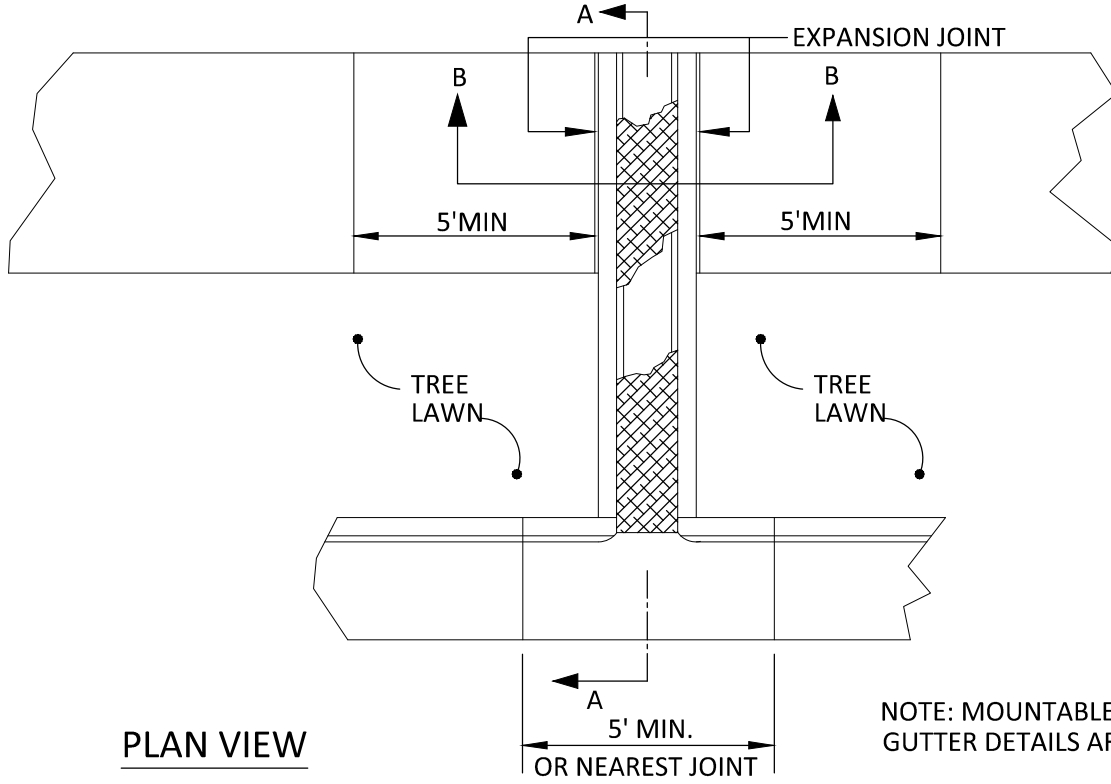
PEDESTRIAN REFUGE  
ISLAND / RIGHT TURN  
LANE

S2.15

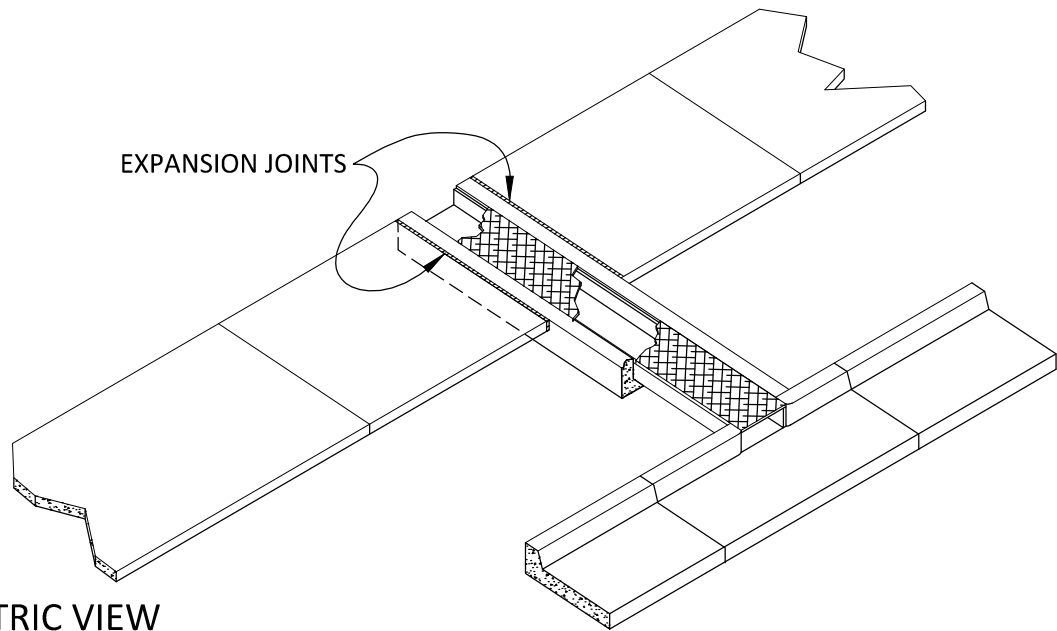
*Helen Blomquist*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



PLAN VIEW



ISOMETRIC VIEW

City of Aurora, Colorado

1 of 4

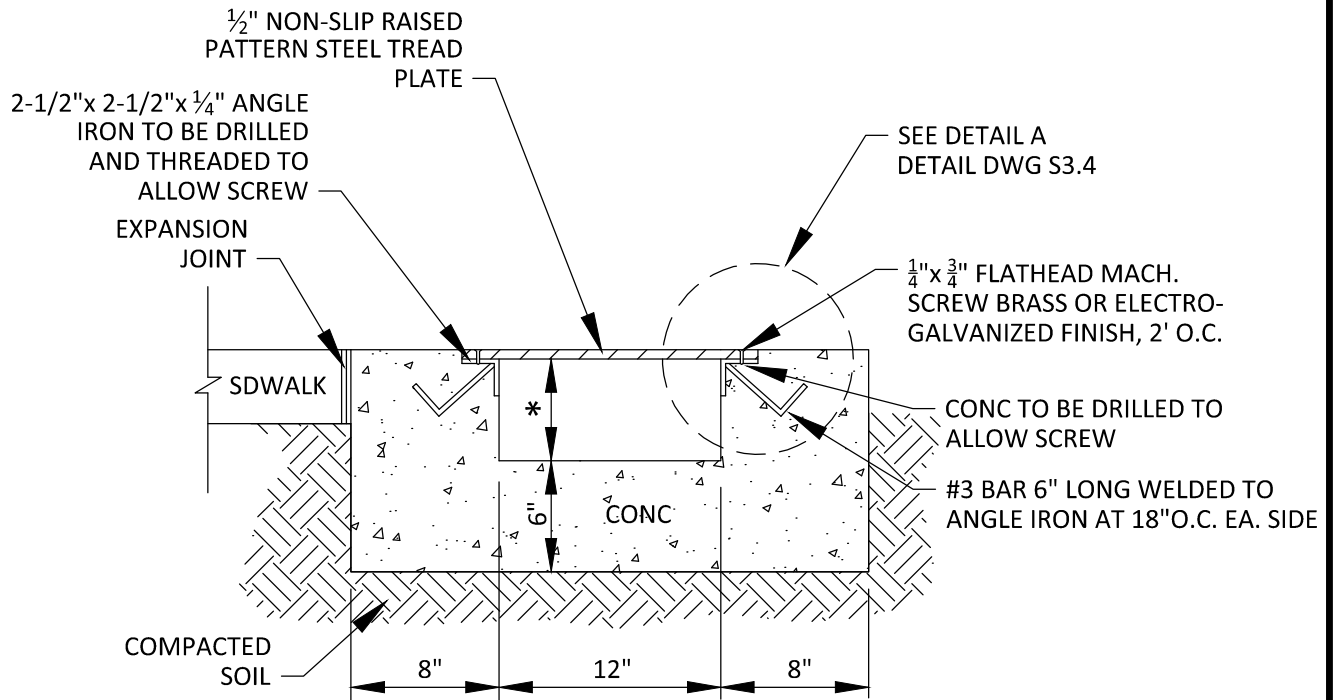
SIDEWALK CHASES

S3.1

*Heather B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



Section B-B

\* Varies for type of curb & gutter,  
See DTL S3.4

q:\2022-roadway specs\dwgs\s3-2.dwg 25 January 2023

City of Aurora, Colorado

2 of 4

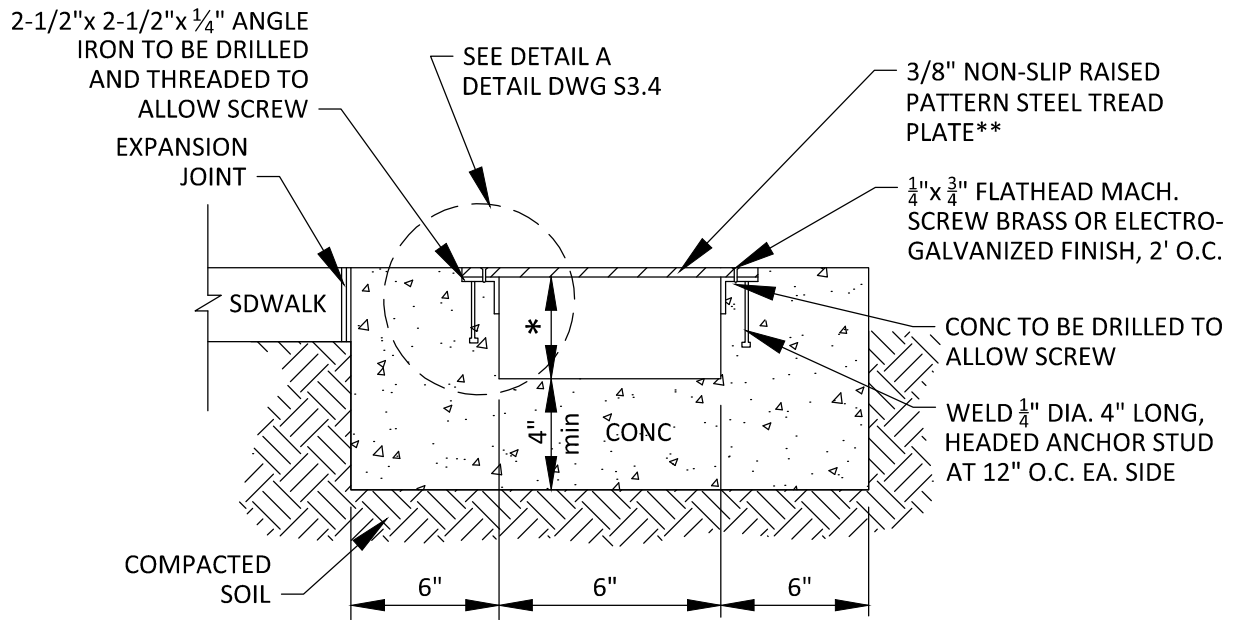
*Helen B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

SIDEWALK CHASES  
INDUSTRIAL/COMMERCIAL  
OR COLLECTOR/ARTERIAL

S3.2

# STANDARD



Section B-B

\* Varies for type of curb & gutter,  
See DTL S3.4

q:\2022-roadway\_specs\dwgs\s3-3.dwg 25 January 2023

City of Aurora, Colorado

3 of 4

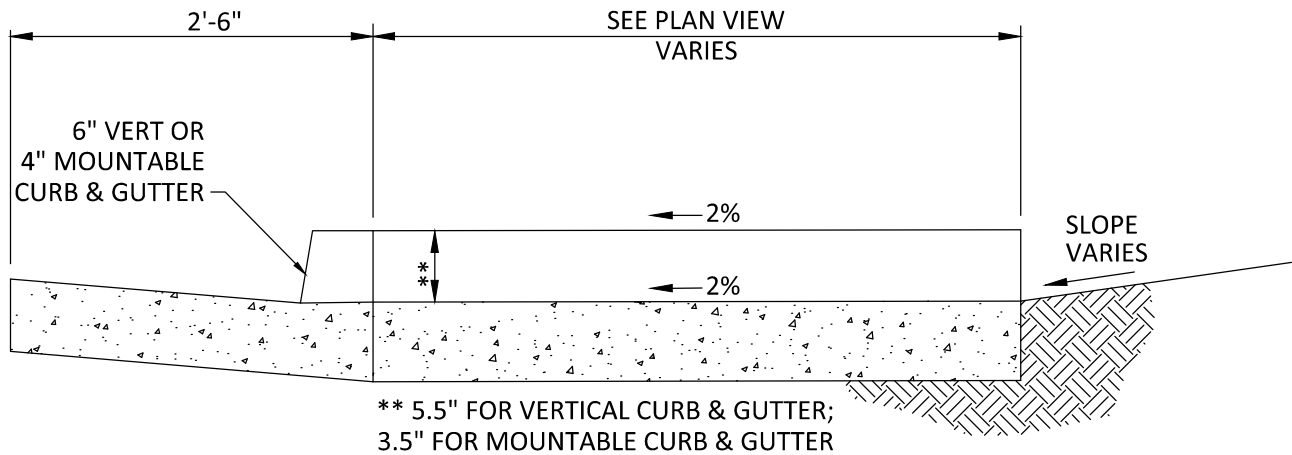
*Heley B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

SIDEWALK CHASES  
RESIDENTIAL / LOCAL STREET

S3.3

# STANDARD

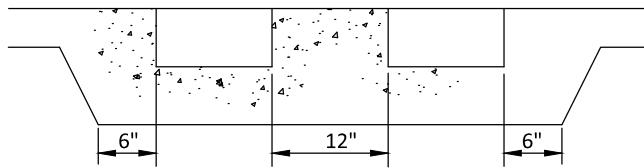
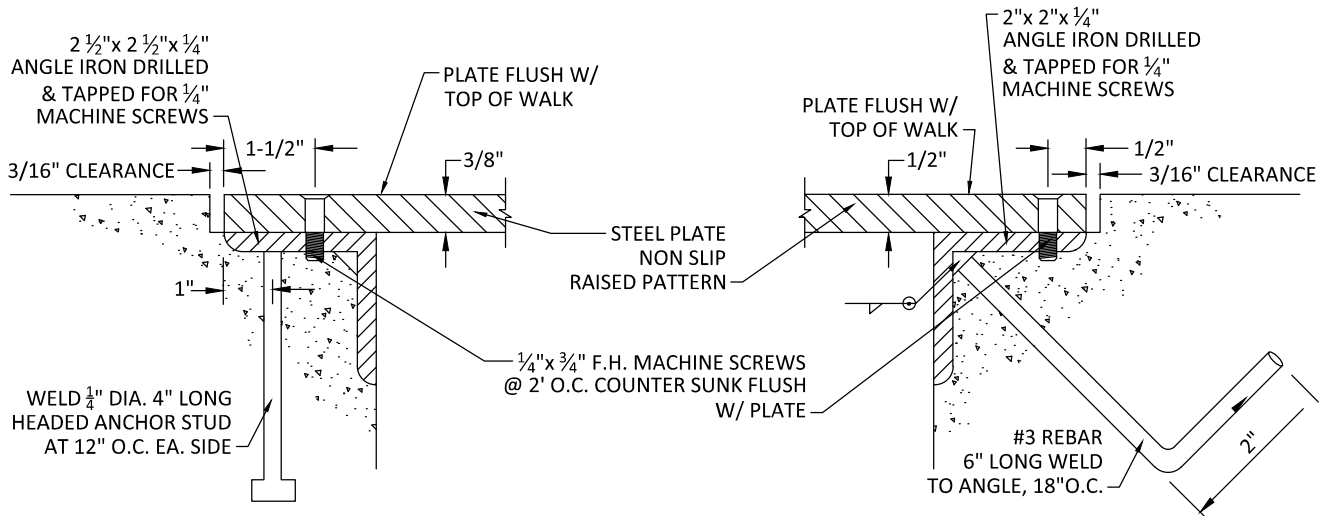


\*\* 5.5" FOR VERTICAL CURB & GUTTER;  
3.5" FOR MOUNTABLE CURB & GUTTER

FOR RESIDENTIAL/LOCAL STREET  
APPLICATIONS - S3.3

## DETAIL A

FOR INDUSTRIAL / COMMERCIAL  
APPLICATIONS - S3.2



## MULTIPLE CHASE

WHEN OPENINGS LARGER  
THAN 12" ARE REQUIRED

City of Aurora, Colorado

4 of 4

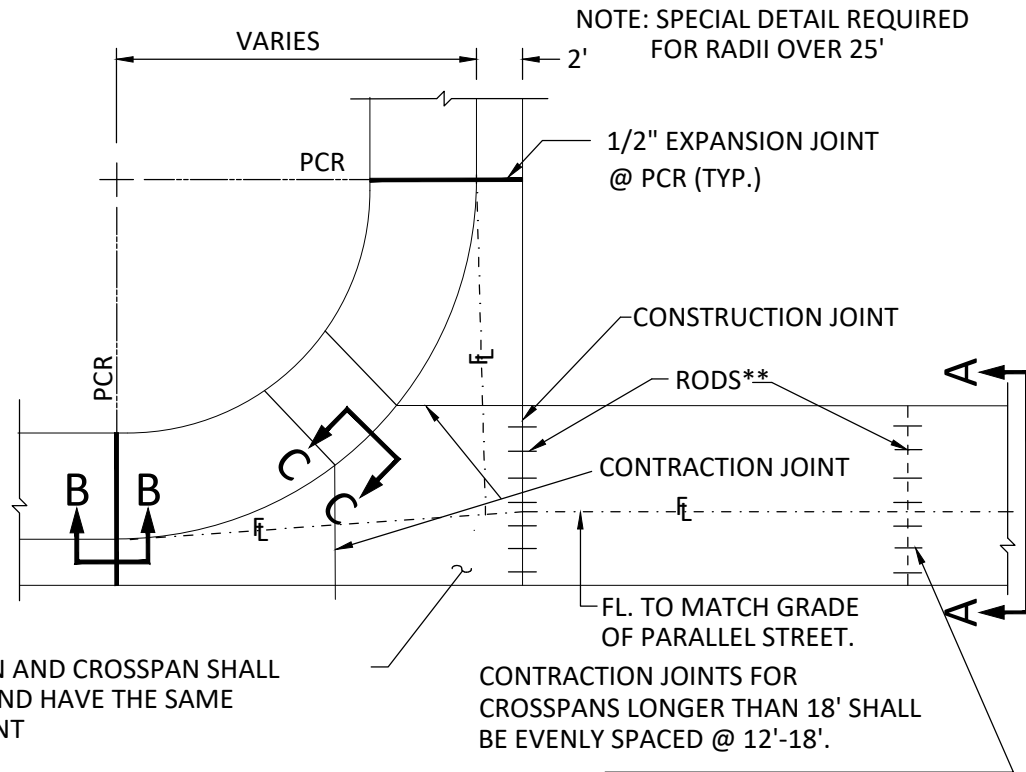
*Helen B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

SIDEWALK CHASES

S3.4

# STANDARD



GUTTER APRON AND CROSSPAN SHALL BE 10" THICK AND HAVE THE SAME REINFORCEMENT

CONTRACTION JOINTS FOR CROSSPANS LONGER THAN 18' SHALL BE EVENLY SPACED @ 12'-18'.

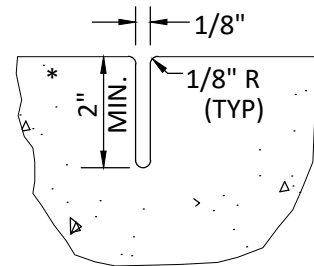
## PLAN

\*\* #6X18" SMOOTH RODS ON 12" CENTERS WITH ONE END GREASED SHALL BE USED.

PAN LENGTH (LIP TO LIP)	REPLACE WITH GRADE 60 REBAR HAVING AN AREA OF
36'	0.10 SQ. IN./FT. (#4@18"E.W.)
45'	0.13 SQ. IN./FT. (#4@18"E.W.)
64'	0.20 SQ. IN./FT. (#4@12"E.W.)
84'	0.26 SQ. IN./FT. (#4@9"E.W.)

**NOTE**  
GUTTER APRONS AND PANS SHALL BE REINFORCED AS SHOWN IN THE TABLE ABOVE.

SECTIONS A-A, B-B & C-C ARE ON STD S4.2



## CONTRACTION OR WEAKENED PLANE JOINT

\* D/4 IF TEMPLATES ARE NOT USED

City of Aurora, Colorado

1 of 2

CROSSPAN TYPE 1

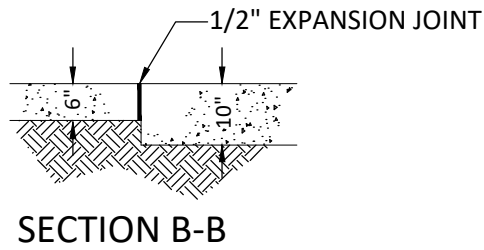
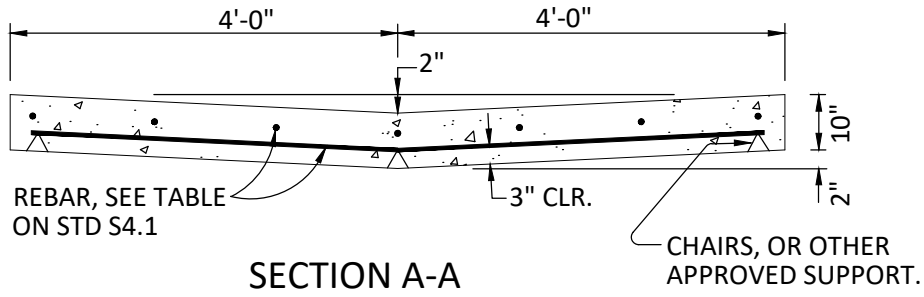
S4.1

*Heley B. Johnson*  
CITY ENGINEER

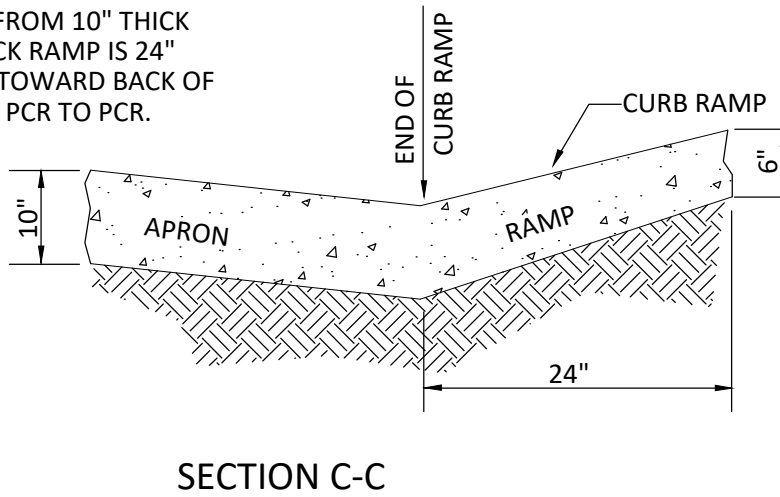
01/31/2023  
DATE

# STANDARD

CROWN SHALL BE TRANSITIONED  
OUT OF THE STREET.



THE TRANSITION FROM 10" THICK  
APRON TO 6" THICK RAMP IS 24"  
FROM FLOWLINE TOWARD BACK OF  
RAMP AND FROM PCR TO PCR.



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City of Aurora, Colorado

2 of 2

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CITY ENGINEER

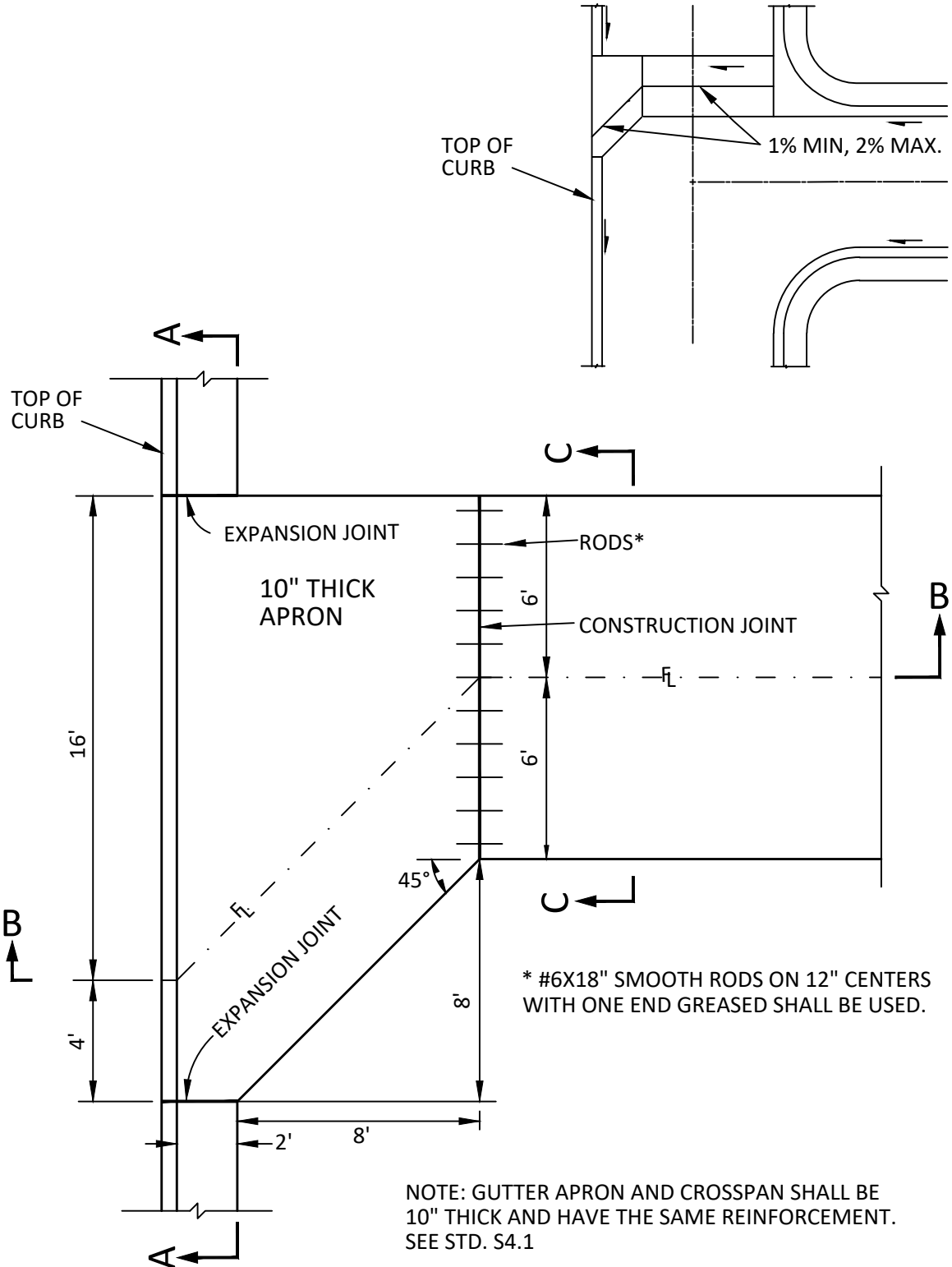
01/31/2023  
DATE

CROSSPAN TYPE 1

S4.2



# STANDARD



City of Aurora, Colorado

**CROSSPAN TYPE 2 AT TEE INTERSECTION REQUIRES APPROVAL BY CITY ENGINEER**

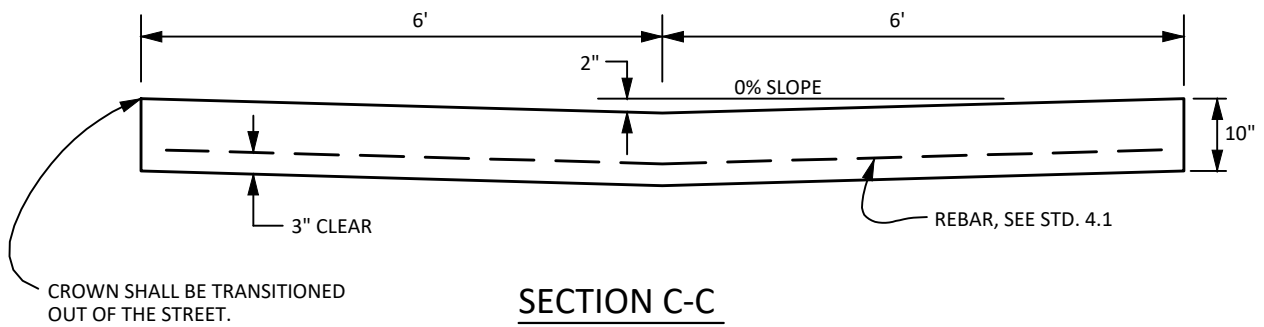
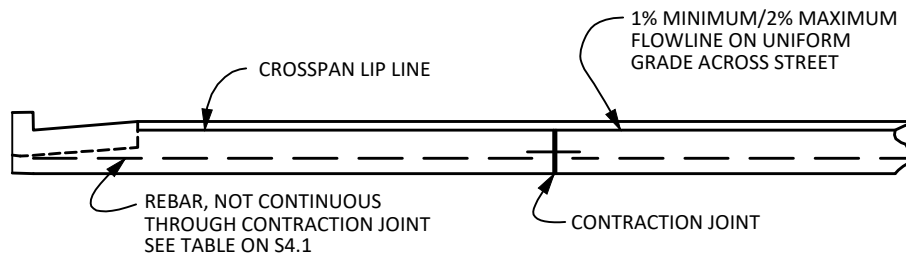
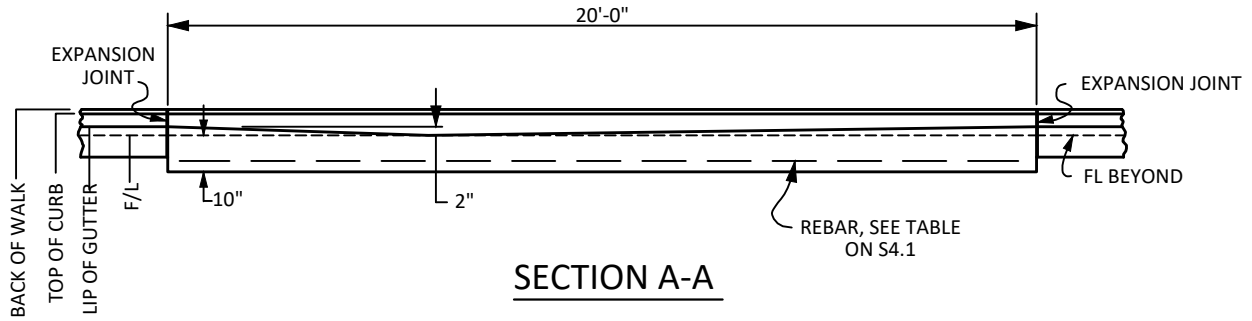
1 of 2  
**S5.1**

*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

n:\pww\draft\standard\roadway\s-series details\s5-1.dwg 10 November 2021

# STANDARD



q:\2022\roadway specs\dwgs\s5-2.dwg, 10 November 2021

City of Aurora, Colorado

*Helen Blomquist*  
CITY ENGINEER

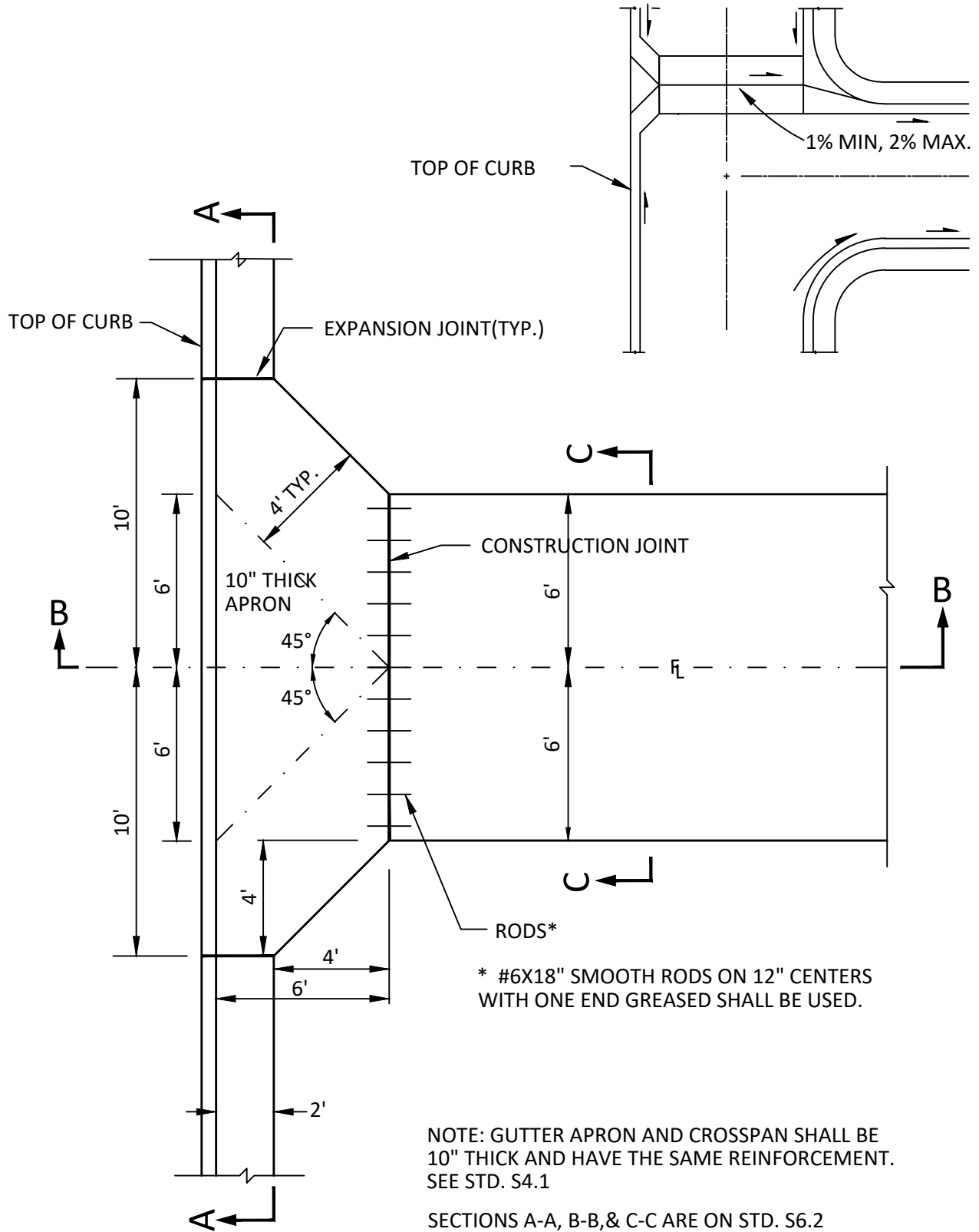
01/31/2023  
DATE

CROSSPAN TYPE 2  
AT TEE INTERSECTION

2 of 2

S5.2

# STANDARD



q:\2022\roadway specs\dwgs\s6-1.dwg, 10 November 2021

City of Aurora, Colorado

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CITY ENGINEER

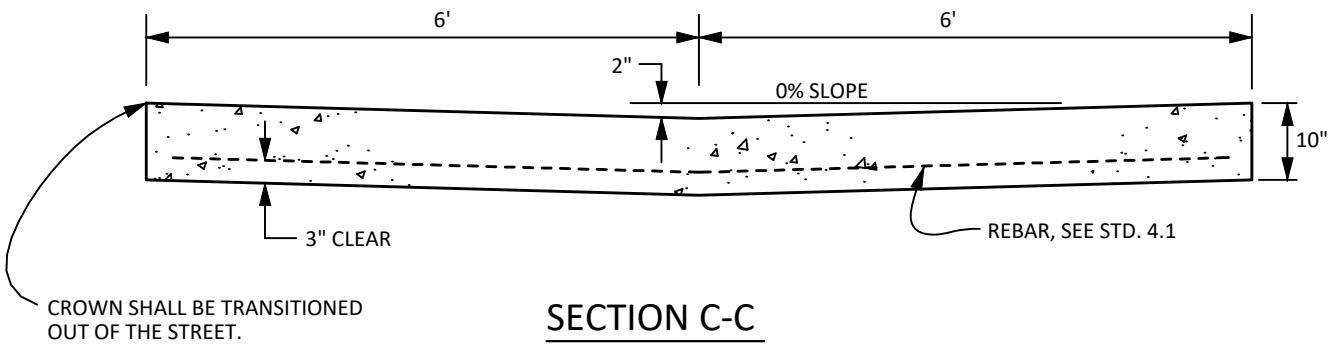
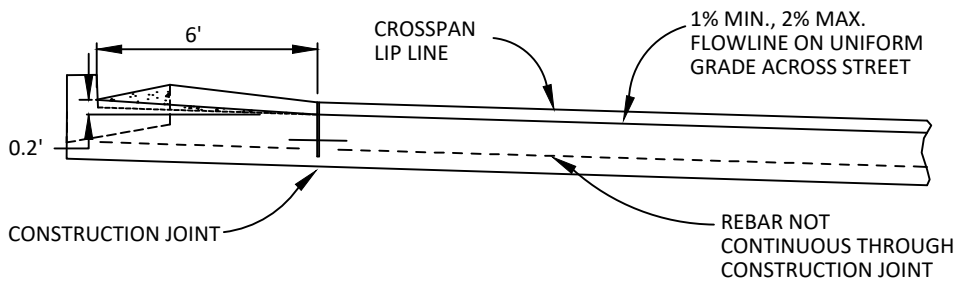
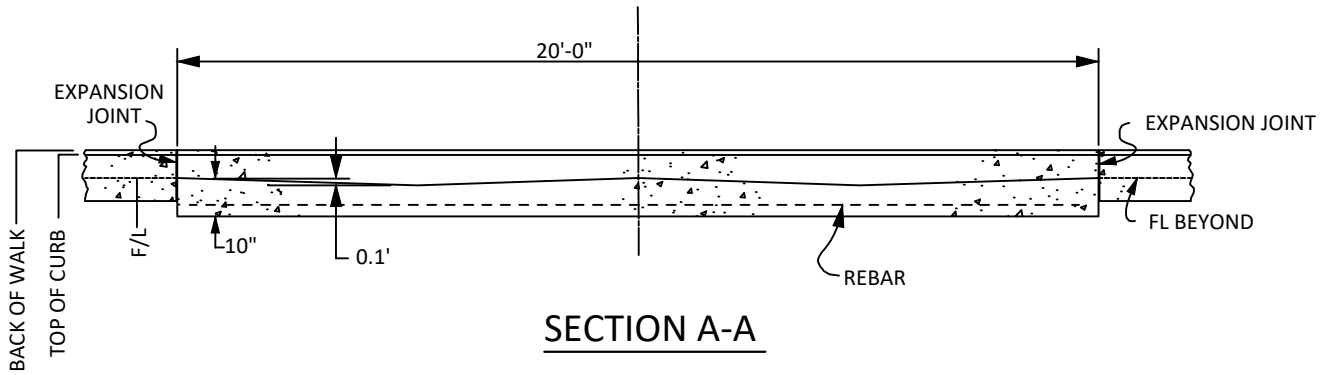
01/31/2023  
DATE

**CROSSPAN TYPE 3 AT TEE  
INTERSECTION REQUIRES  
APPROVAL BY CITY ENGINEER**

1 of 2

**S6.1**

# STANDARD



q:\2022 roadway specs\dwgs\s6-2.dwg, 10 November 2021

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*Heidi B. Hansen*  
CITY ENGINEER

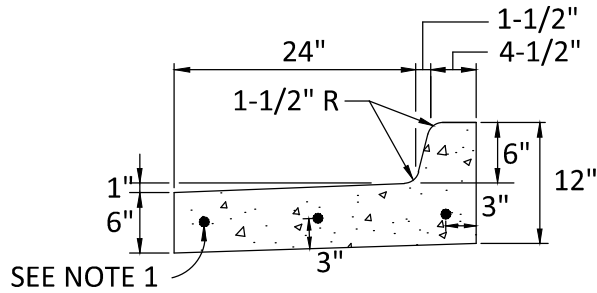
01/31/2023  
DATE

CROSSPAN TYPE 3  
AT TEE INTERSECTION

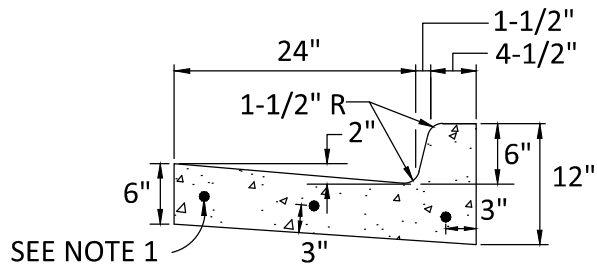
2 of 2

S6.2

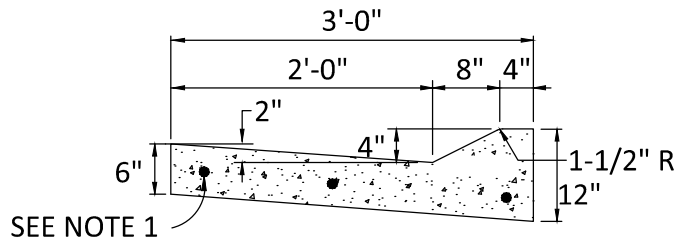
# STANDARD



**VERTICAL CURB & GUTTER  
(SPILL)**



**VERTICAL CURB & GUTTER  
(CATCH)**



**MOUNTABLE CURB AND GUTTER**

## NOTES

1. THREE NO. 4 REBARS SHALL BE USED IN ALL CURB RETURNS WITH 25' OR LARGER RADII. THE REBAR SHALL BE USED FROM BEGINNING TO END OF THE CURB RETURN.
2. AT EACH LOW POINT OF EACH MEDIAN CURB, A DRAINAGE SLOT SHALL BE INSTALLED - SEE DRAINAGE SLOT DETAIL ON S2.4.
3. SLIP FORM TEMPLATE FOR VERTICAL CURB AND GUTTER SHALL NOT BE ALLOWED FOR POURING STANDARD MEDIAN CURB.
4. WHERE CONCRETE PAVEMENT IS USED, PLANS SHOULD SHOW MONOLITHIC CURBS.

City of Aurora, Colorado

1 of 7

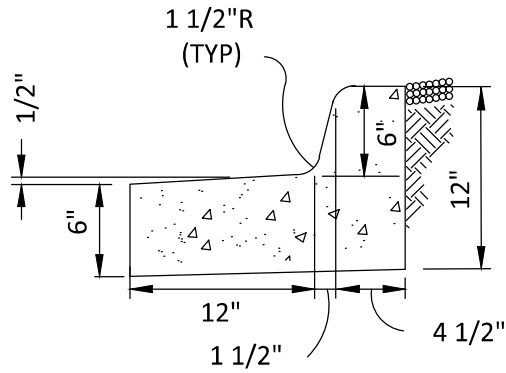
*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

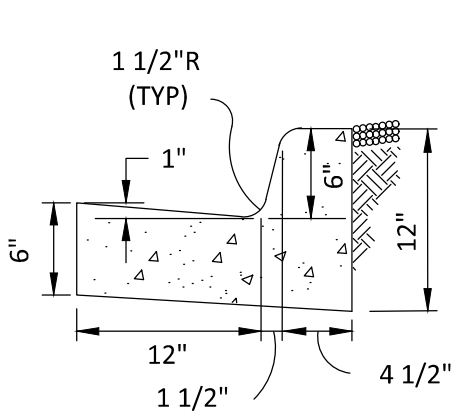
**CURB AND GUTTER**

**S7.1**

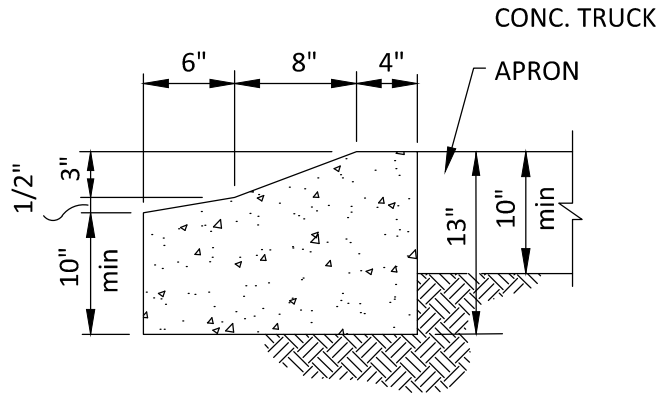
# STANDARD



STANDARD MEDIAN CURB



MEDIAN CATCH CURB



TRUCK APRON MEDIAN SPILL CURB

## NOTES

1. SEE S2.1-S2.3 FOR LOCATION OF REQUIRED SPLASH BLOCKS. CONTRACTION JOINTS IN SPLASH BLOCKS SHALL MATCH MEDIAN CURB JOINTING.
2. SEE S2.4 FOR DRAINAGE SLOTS AND MONOLITHIC NOSE.
3. SEE S7.1 FOR LOCATION OF DRAINAGE SLOTS.
4. WHERE CONCRETE PAVEMENT IS USED, PLANS SHOULD SHOW MONOLITHIC CURBS.

City of Aurora, Colorado

2 of 7

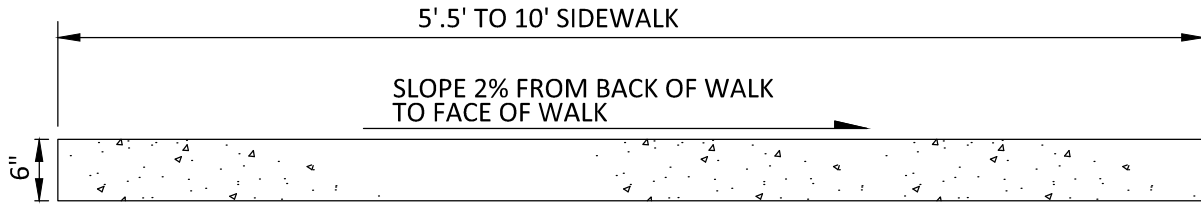
*Heather B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

STANDARD MEDIAN CURBS

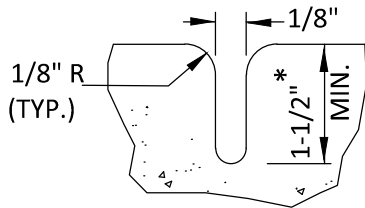
S7.2

# STANDARD



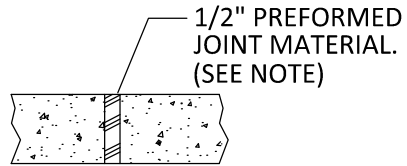
## SIDEWALK

NOTE: WHEN WALK IS ADJACENT TO A CURB CUT, MATCH THICKNESS AND REINFORCING WITH CURB CUT. (SEE S7.4)



\* 1.5" IF TEMPLATES ARE NOT USED

## CONTRACTION OR WEAKENED PLANE JOINT



## EXPANSION JOINT

NOTE: IN GUTTER FLOWLINES RECESS EXPANSION JOINT 1/2" AND SEAL WITH FLEXIBLE SEALANT.

SEE STD. S19.1 THRU S19.4 FOR TYP. CONC. PAVEMENT JOINT DETAILS

City of Aurora, Colorado

3 of 7

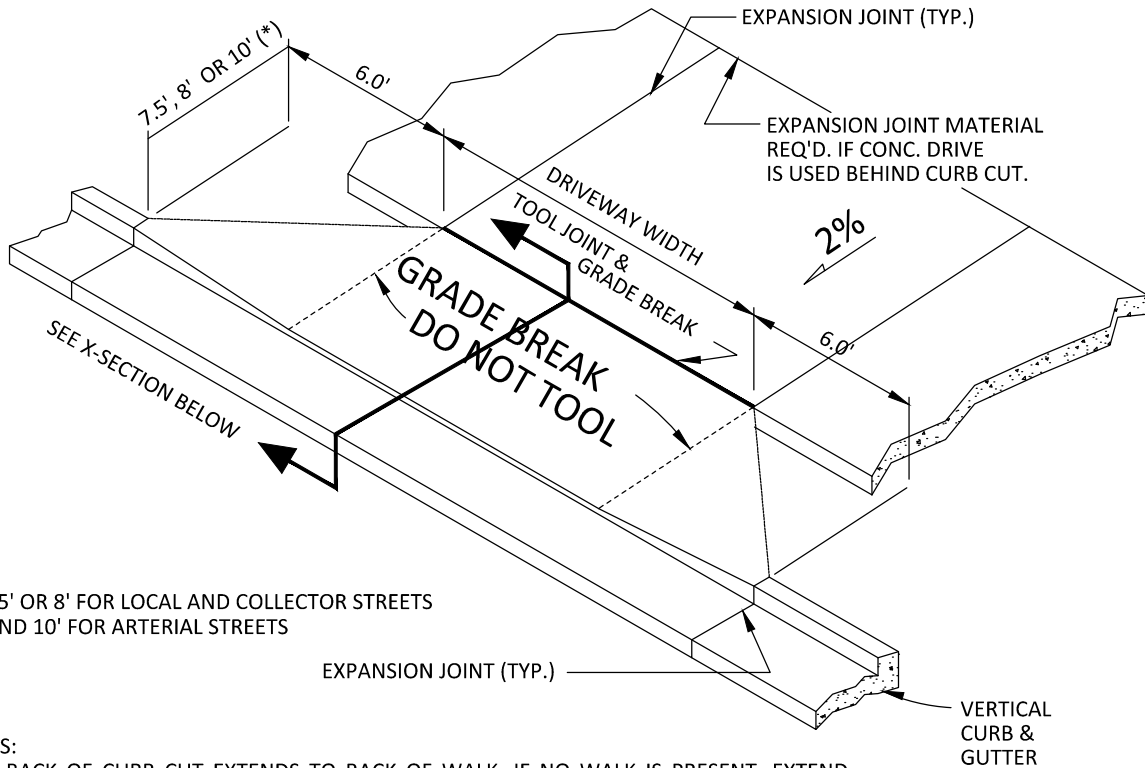
*Heidi Bakansen*  
CITY ENGINEER

01/31/2023  
DATE

SIDEWALK  
CONSTRUCTION JOINTS

S7.3

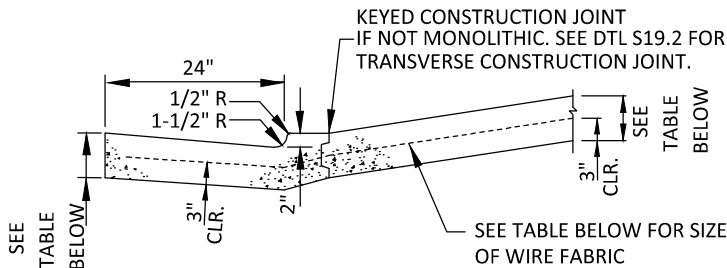
# STANDARD



\*7.5' OR 8' FOR LOCAL AND COLLECTOR STREETS  
AND 10' FOR ARTERIAL STREETS

**NOTES:**

1. BACK OF CURB CUT EXTENDS TO BACK OF WALK. IF NO WALK IS PRESENT, EXTEND BACK OF CURB CUT TO BACK OF FUTURE WALK (SEE S1.1 TO S1.5).
2. END OF CURB CUT SHALL NOT BE CONSTRUCTED WITHIN 5' OF A PROPERTY LINE OR 20' OF AN INTERSECTING STREET R.O.W. UNLESS APPROVED BY THE CITY ENGINEER.
3. CITY ENGINEER SHALL APPROVE LOCATION OF CURB CUT BEFORE CONSTRUCTION.
4. REBAR SHALL BE CONTINUOUS IN CURB CUT AND ADJACENT WALK EXCLUDING SINGLE FAMILY CURB CUTS.
5. WALK ACROSS DRIVEWAY SHALL BE SAME THICKNESS WITH SAME REINFORCEMENT AS CURB CUT.



## CROSS-SECTION THROUGH CURB CUT

\* APT. BLDGS. WITH LESS THAN 5 UNITS MAY USE 6" THICKNESS.

TYPE OF CUT	WIDTH OF DRIVEWAY	TOTAL WIDTH	MINIMUM THICKNESS	GRADE 60 REBAR
SINGLE FAMILY	12'-16'	22'-26'	6"	-----
MULTI FAMILY*	16'-25'	26'-35'	10"	#4 @ 18", E.W.
COMMERCIAL	30'-40'	40'-50'	10"	#4 @ 12", E.W.

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City of Aurora, Colorado

*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

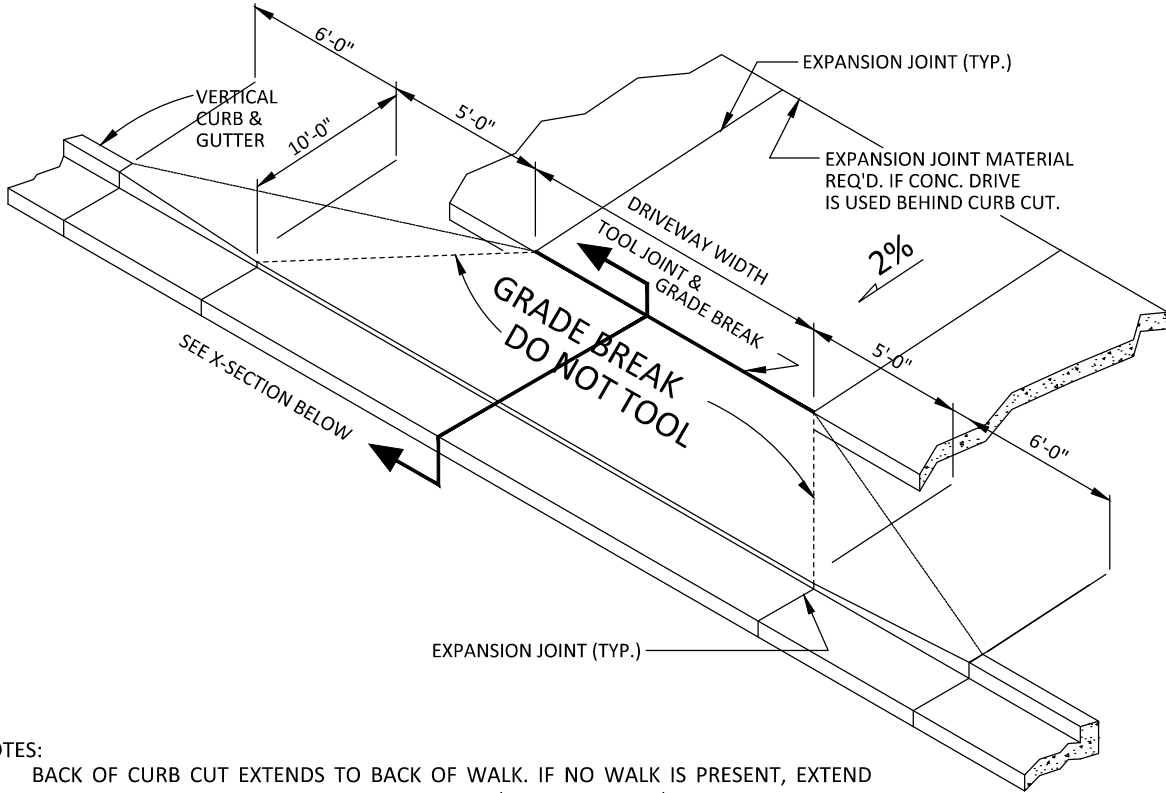
## CURB, GUTTER AND WALK CURB CUTS

4 of 7

S7.4

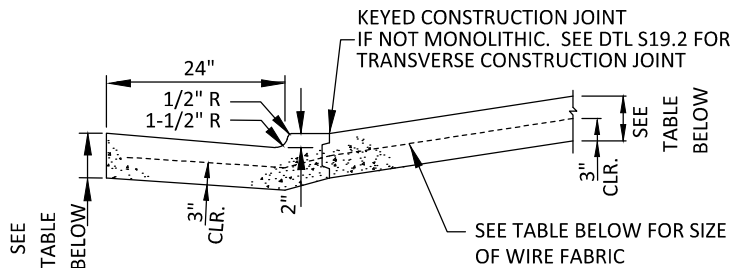


# STANDARD



**NOTES:**

1. BACK OF CURB CUT EXTENDS TO BACK OF WALK. IF NO WALK IS PRESENT, EXTEND BACK OF CURB CUT TO BACK OF FUTURE WALK (SEE S1.1 TO S1.5).
2. END OF CURB CUT SHALL NOT BE CONSTRUCTED WITHIN 5' OF A PROPERTY LINE OR 20' OF AN INTERSECTING STREET R.O.W. UNLESS APPROVED BY THE CITY ENGINEER.
3. CITY ENGINEER SHALL APPROVE LOCATION OF CURB CUT BEFORE CONSTRUCTION.
4. REBAR SHALL BE CONTINUOUS IN CURB CUT AND ADJACENT WALK EXCLUDING SINGLE FAMILY CURB CUTS.
5. WALK ACROSS DRIVEWAY SHALL BE SAME THICKNESS WITH SAME REINFORCEMENT AS CURB CUT.



## CROSS-SECTION THROUGH CURB CUT

TYPE OF CUT	WIDTH OF DRIVEWAY	TOTAL WIDTH	MINIMUM THICKNESS	GRADE 60 REBAR
MULTI FAMILY*	16'-25'	26'-35'	*10"	#4 @ 18", E.W.
COMMERCIAL	30'-40'	40'-50'	10"	#4 @ 12", E.W.

\*APARTMENT BUILDINGS WITH LESS THAN 5 UNITS MAY USE 6" THICKNESS WITH NO REINFORCING.

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City of Aurora, Colorado

*Haley B. Anderson*  
CITY ENGINEER

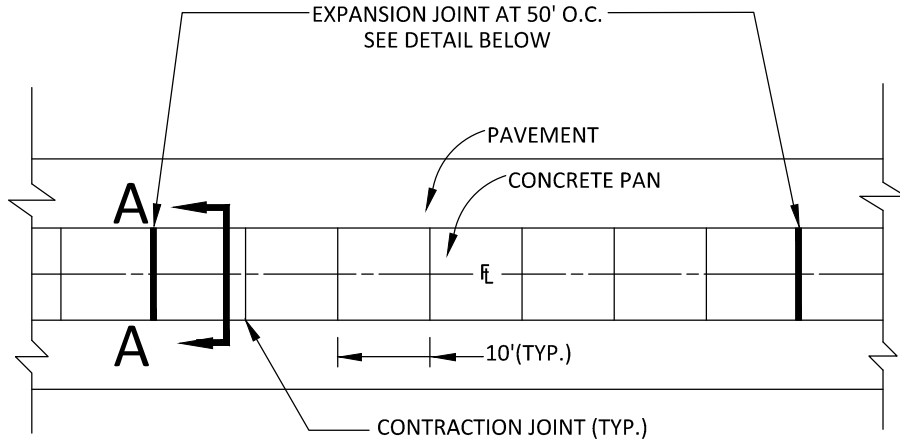
01/31/2023  
DATE

**ARTERIAL ROADWAY  
CURB, GUTTER AND WALK  
CURB CUTS**

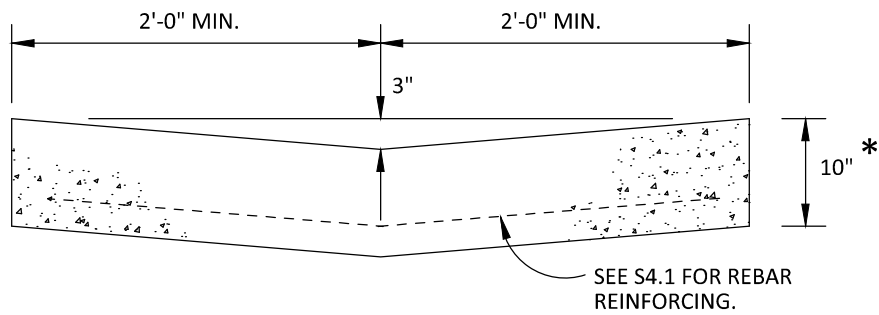
5 of 7

**S7.5**

# STANDARD

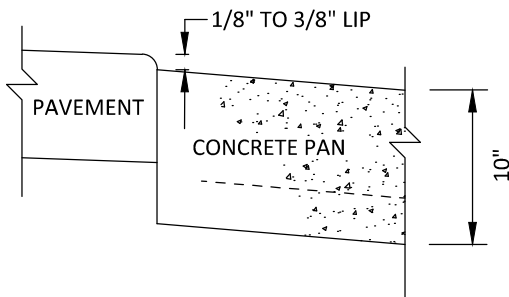


**PLAN VIEW**

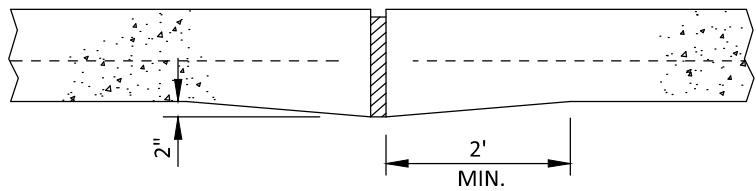


**SECTION A-A**

\*6" IN AREAS OUTSIDE OF FIRELANES AND TRASH TRUCK ACCESS ROUTES.



**DETAIL**



**EXPANSION JOINT**

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City of Aurora, Colorado

6 of 7

*Helen B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

PRIVATE LONGITUDINAL  
CONCRETE PAN

S7.6

# STANDARD

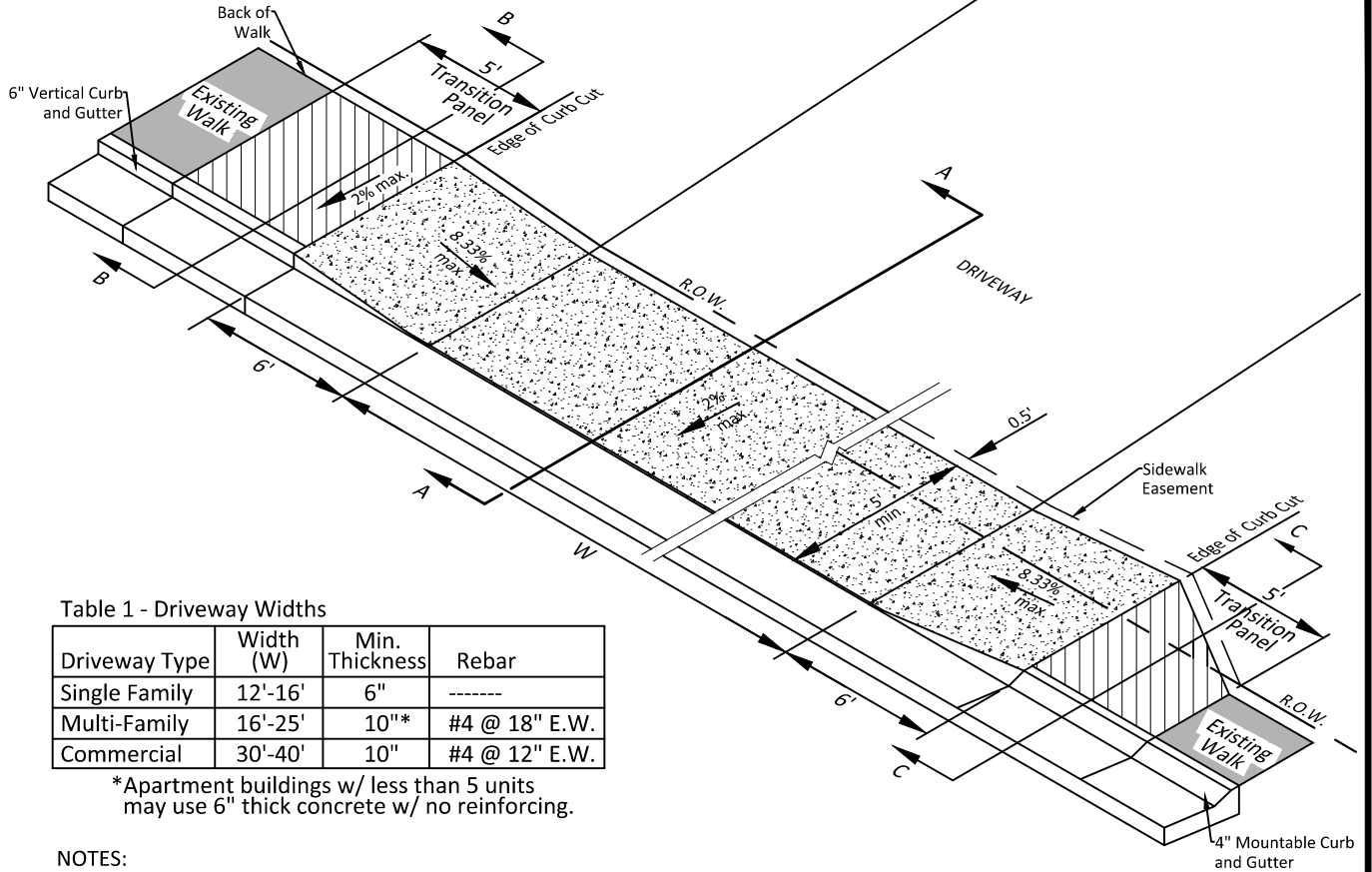


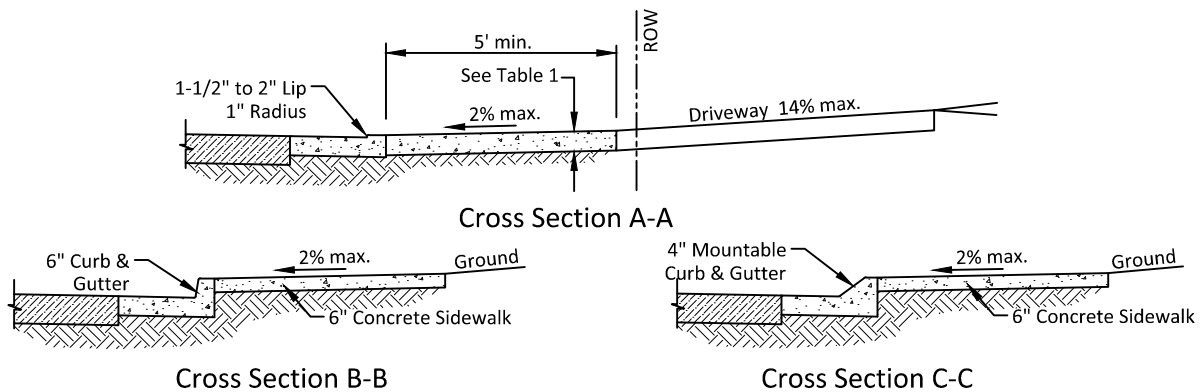
Table 1 - Driveway Widths

Driveway Type	Width (W)	Min. Thickness	Rebar
Single Family	12'-16'	6"	-----
Multi-Family	16'-25'	10"*	#4 @ 18" E.W.
Commercial	30'-40'	10"	#4 @ 12" E.W.

\*Apartment buildings w/ less than 5 units may use 6" thick concrete w/ no reinforcing.

NOTES:

1. BACK OF CURB CUT EXTENDS TO BACK OF WALK. (SEE STANDARD DETAIL S1.1 TO S1.5).
2. EDGE OF CURB CUT SHALL NOT BE CONSTRUCTED WITHIN 5' OF A PROPERTY LINE OR 20' OF AN INTERSECTING STREET R.O.W. UNLESS APPROVED BY THE CITY ENGINEER OR DESIGNEE.
3. CITY ENGINEER SHALL APPROVE LOCATION OF NEW CURB CUT BEFORE CONSTRUCTION.
4. REBAR SHALL BE CONTINUOUS IN CURB CUT AND ADJACENT WALK EXCLUDING SINGLE FAMILY CURB CUTS.
5. WALK ACROSS DRIVEWAY SHALL BE SAME THICKNESS WITH SAME REINFORCEMENT AS CURB CUT.
6. DRIVEWAY SHALL BE PAVED A MINIMUM OF 3' BEHIND SIDEWALK.
7. SIDEWALK AND/OR CONSTRUCTION EASEMENT MAY BE REQUIRED.
8. CONTRACTOR SHALL GRADE DRIVEWAY AT 14% MAX BEHIND SIDEWALK UNTIL ELEVATION EQUALS TOP OF CURB. IF 6" VERTICAL CURB THIS ELEVATION EQUALS FLOWLINE PLUS 6". IF 4" MOUNTABLE CURB THIS ELEVATION EQUALS FLOWLINE PLUS 4".
9. DRIVEWAYS SHALL BE INSTALLED IN ACCORDANCE WITH SECTION 4.07.9 OF THE COA ROADWAY DESIGN & TECHNICAL CRITERIA MANUAL.
10. 5' TRANSITION PANEL SHALL BE CONSTRUCTED AT EDGE OF CURB CUT. THIS WILL TRANSITION SIDEWALK WIDTH AND GRADES BACK TO EXISTING SIDEWALK WIDTHS AND CROSS SLOPES.



**Note: Both vertical and mountable curb and gutter shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.**

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City of Aurora, Colorado

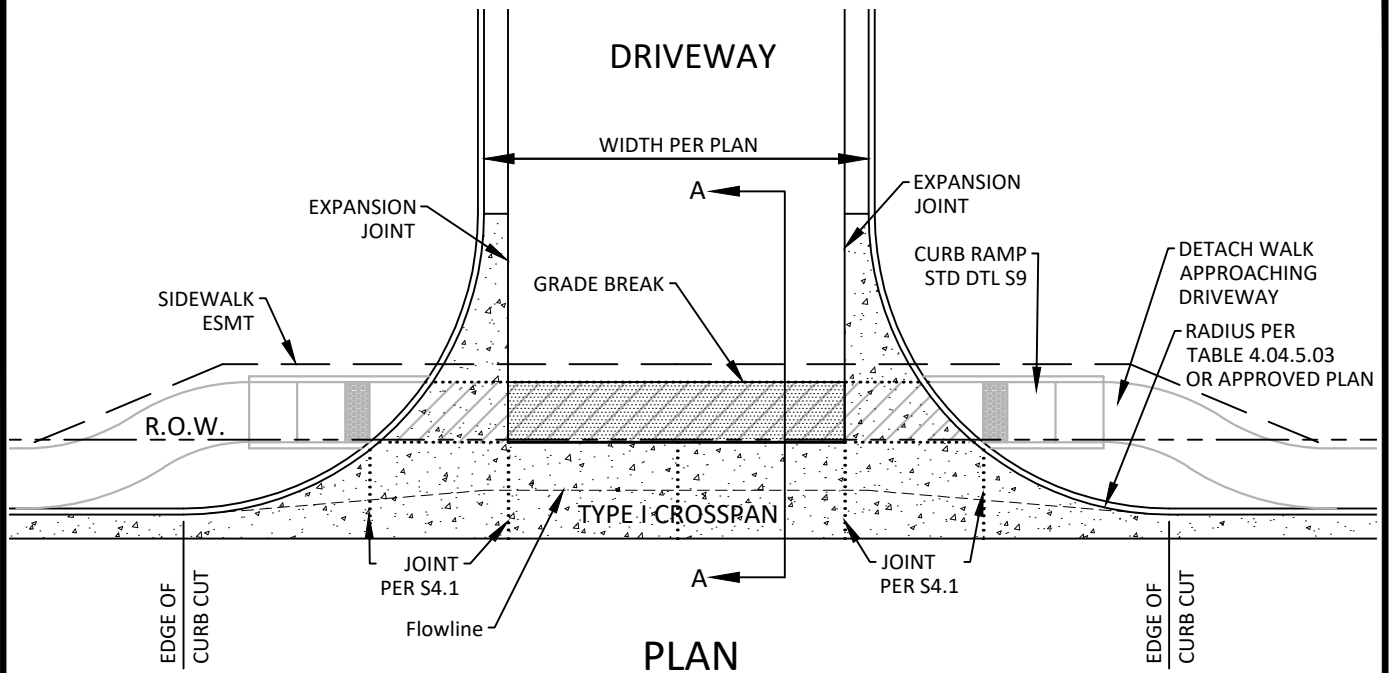
*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

**CURB CUT  
ATTACHED SIDEWALK  
(RETROFIT ONLY)**

7 of 7  
**S7.7**

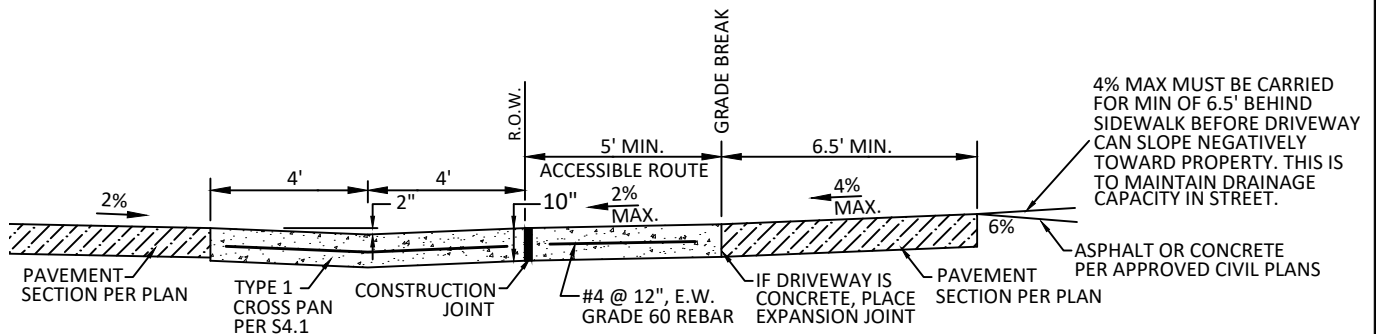
# STANDARD



- CONCRETE SIDEWALK BEHIND GUTTER PAN TO BE INSTALLED W/ EXPANSION JOINT WHERE ADJACENT TO CONCRETE
- ACCESSIBLE ROUTE THROUGH DRIVEWAY -2% MAX CROSS SLOPE
- CONCRETE CROSSPAN (TYPE I) TO BE POURED MONOLITHICALLY W/ CURB, GUTTER & RAMPS PER COA STD DTL S4.1

## Notes:

1. CONTRACTION JOINTS PER S19.1 THRU S19.4
2. DRIVEWAY LOCATIONS SHALL BE APPROVED BY THE CITY ENGINEER.
3. EDGE OF CURB CUT SHALL NOT BE CONSTRUCTED WITHIN 5' OF A PROPERTY LINE OR 20' OF AN INTERSECTING STREET R.O.W. UNLESS APPROVED BY THE DIRECTOR OF PUBLIC WORKS.
4. STOP SIGNS MAY BE REQUIRED WITH THIS TYPE OF DRIVEWAY APPROACH.
5. USE OF CONCRETE PAN AS REQUIRED PER APPROVED CIVIL PLAN.
6. DRIVEWAY SHALL CONTAIN AN ACCESSIBLE (2% MAX. CROSS SLOPE) ROUTE BETWEEN CURB RAMPS. WIDTH TO BE 5' MIN. OR EQUAL TO APPROACHING SIDEWALK, WHICH EVER IS GREATER. ACCESSIBLE ROUTE SHALL BE CONCRETE. NO PORTION OF ACCESSIBLE ROUTE SHALL BE LOCATED WITHIN GUTTER PAN.
7. SIDEWALK AND/OR CONSTRUCTION EASEMENT MAY BE REQUIRED.
8. REBAR SHALL BE CONTINUOUS IN CURB CUT AND ADJACENT WALK.
9. WALK ACROSS DRIVEWAY SHALL BE SAME THICKNESS WITH SAME REINFORCEMENT AS CURB CUT.
10. DRIVEWAY SHALL BE INSTALLED IN ACCORDANCE WITH SECTION 4.07.9 OF COA ROADWAY DESIGN AND TECHNICAL CRITERIA MANUAL.



CROSS SECTION A-A

NOT TO SCALE

City of Aurora, Colorado

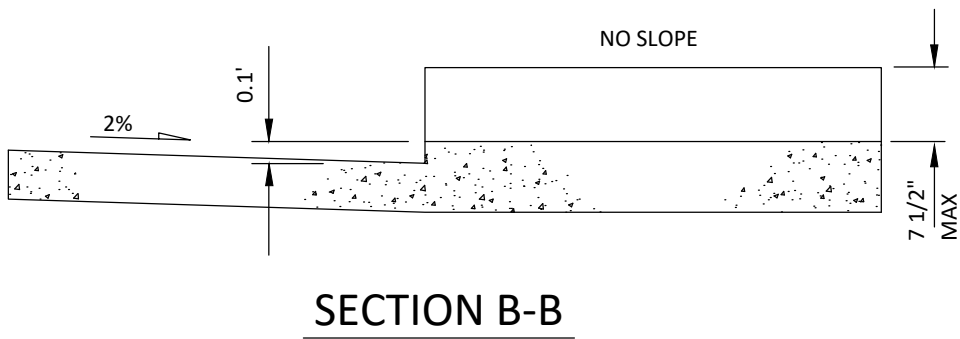
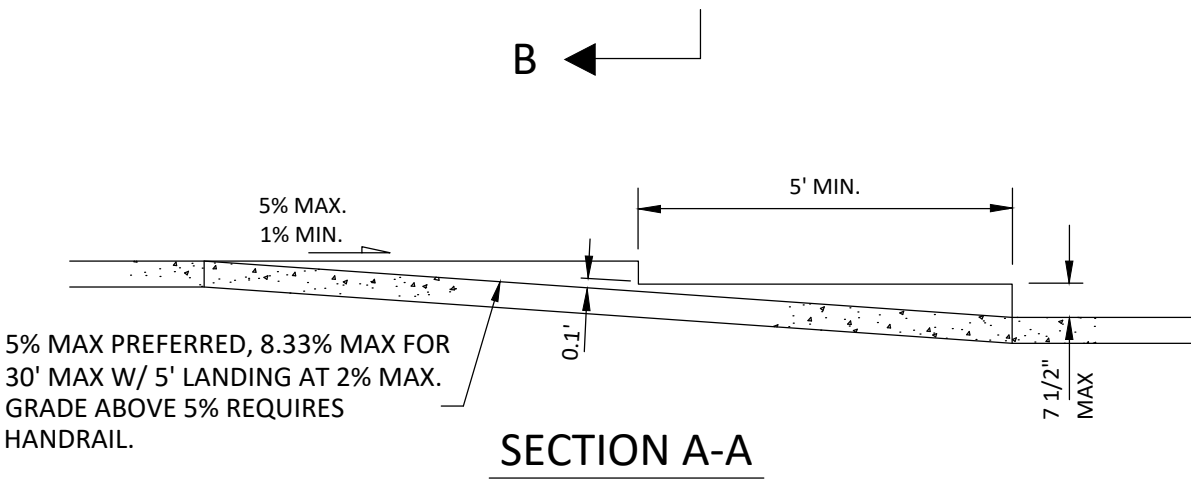
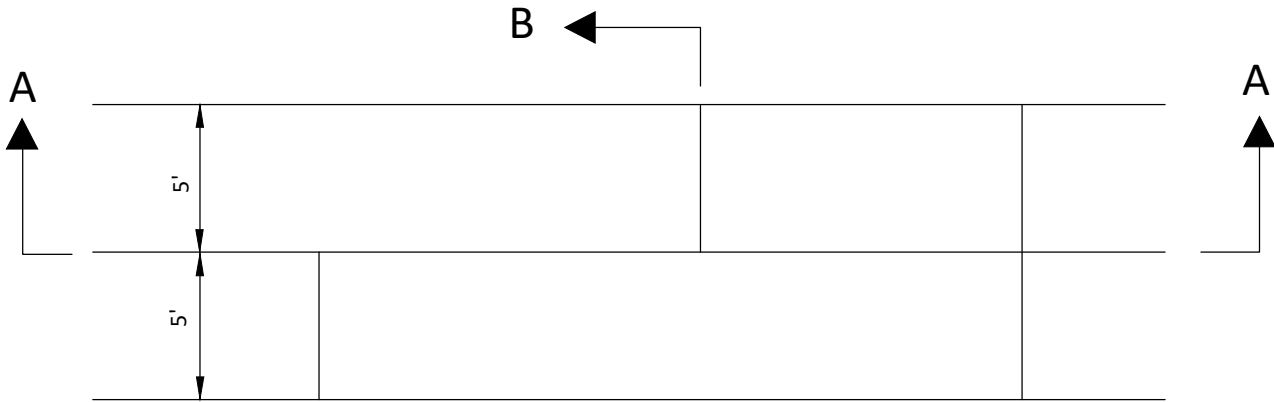
COMMERCIAL /  
INDUSTRIAL DRIVEWAY  
CURB RETURN

S7.8

*Helen B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



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City of Aurora, Colorado

*Heather B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

PEDESTRIAN WALKWAY  
RAMP AND STEP DETAILS

S8.1

# STANDARD

All ADA curb ramp designs shall be done in accordance with Section 4.02.3 of the "Roadway Design and Construction Specifications" of the City of Aurora, latest edition and as outlined below.

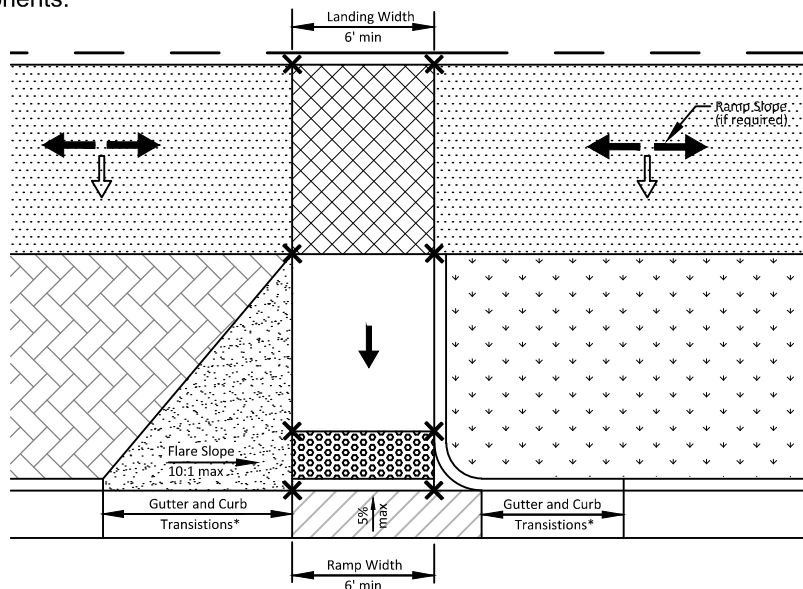
These curb ramp standards and the details that follow are general representations, not designed to cover every possible scenario, and many will require modifications to fit actual field conditions. Many applications will be retrofit situations where field conditions may vary. In all cases, the civil plans shall detail site-specific designs, with minimum detailing defined below. It is the responsibility of the design engineer to provide enough detail to construct a compliant ramp taking existing topographical and physical constraints into consideration. The details (S9.1 through S9.6) contained within this guidance show typical examples of the ramp types shown below.

**Definition of Ramp Types:**

- **Type 1 - Perpendicular Ramps:** a curb ramp that is aligned so the ramp (8.3% max) is generally perpendicular to the centerline of the roadway. This is the preferred ramp style in the City of Aurora and should be used in ALL new construction.
- **Type 2 - Parallel Ramps:** a curb ramp that has two ramps leading to the level landing at the bottom. The ramps (8.3% max) are oriented so the path of travel on the ramp is parallel to the vehicular path of the adjacent street.
- **Type 3 - Full Drop Transitions:** ramps that are gradually lowered to meet the grade of the street. These are designed as expanded "diagonal" ramps that extend almost entirely around the curb return. The running slope should be less than 5%. These ramps shall only be used in retrofit scenarios where Type 1 or Type 2 aren't practical.
- **Type 4 - Midblock Ramps:** curb ramps that do not occur on a corner of an intersection. An example would be a receiving ramp on the opposite side of a "T" intersection.
- **Type 5 - "Diagonal Ramp"** is a singular ramp, centered on the apex of the curb return which directs users into the center of the intersection. This is no longer part of the City standards and will not be permitted in new construction. In retrofit scenarios where obstructions or right-of-way limitations exist they may be approved on a case-by-case basis by the City Engineer.

**Combination Ramps:** any curb ramp that combines attributes of both a parallel ramp and a perpendicular ramp.

**Basic curb ramp components:**



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City of Aurora, Colorado

*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

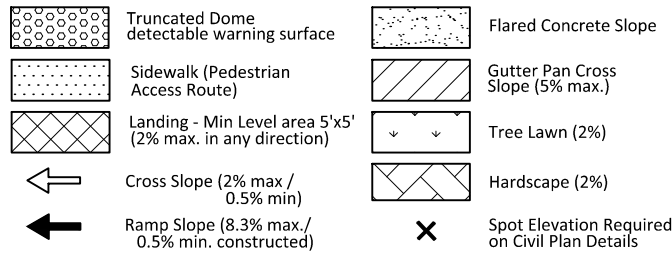
General Curb Requirements

1 of 3

S9.0

# STANDARD

As part of the ramp grading detail designers shall use standard hatching as set forth below to convey the intent of the various parts of the ramp:



All standard slopes shown in the guidance below are maximum or minimum constructed, *finished surface* slopes. Designers should use best judgement in designing ramps to allow for construction tolerances.

## RAMP DESIGN GUIDELINES:

- 1) Curb ramps shall be equal to the width of the approaching sidewalk/trail or 6-feet, whichever is greater. In retrofit designs, ramps may be reduced to a minimum of 4-feet as approved by the City Engineer.
- 2) Ramps, landings, approaches, and sidewalks shall have minimum slopes of 0.5% in any direction. Where practical, minimum slopes of 1.0% to 1.5% are preferred. All ramps must be graded to have positive drainage to the street. Under no circumstances shall street runoff drain through a curb ramp.
- 3) Landings shall be 2% (design of 1.8% recommended) maximum in *any* direction. Landings designed at gutter elevation should be avoided as much as practical as they increase ponding and sediment accumulation.
- 4) The longitudinal, finished surface running slope of ramps shall not exceed 8.33% (design of 7.5% recommended).
- 5) Ramp and sidewalk finished surface cross slopes shall not exceed 2% (design of 1.8% recommended).
- 6) The tops of ALL ramps must have a minimum landing area that is the same width as the approaching sidewalk by 5-feet long.
- 7) The cross section of the gutter shall be transitioned from 8.3% to 5% max gutter cross slope in front of the ramp. The transition from the standard gutter cross-section to an accessible slope of 5% shall occur a minimum of 2-feet and a maximum of 6-feet from the outer edges of the ramp.
- 8) The algebraic difference between grade breaks shall not exceed 11%. Exceptions may be granted at the discretion of the City Engineer (and list in variance table per Section 2.03.9) if the design is for a retrofit area or is determined to infeasible due to existing conditions, and then it must not exceed 13%.
- 9) Curb ramps shall be placed to align with the opposing receiving ramp to the maximum extent feasible. There should be a dedicated ramp for each crossing of an intersection. Where there is a "T" intersection with no pedestrian crossing of the through street, the standard details shall be modified to not include the directional ramp pointed towards the through street.
- 10) Grade breaks at the top and bottom of the ramp shall be perpendicular to the roadway centerline to the maximum extent feasible. Where this can't be achieved, grade breaks shall be radial to the curb return.
- 11) Curb ramps located at intersections with no stop control shall be permitted to have a cross slope equal to the longitudinal slope of the street and have the cross slope transition to the landing in accordance with detail S9.6. All other ADA requirements and conditions must be met.

City of Aurora, Colorado

General Curb Requirements

2 of 3

S9.0

*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD

- 12) Drainage structures shall not be placed within 5-feet of curb ramps and no closer than 5-feet from the PCR. Location of the ramp shall take precedence over location of drainage structures, traffic signal equipment, and other obstructions; except where existing structures are to remain, as approved by the City Engineer.
- 13) Detectable warning panels shall be installed on each curb ramp where the sidewalk transitions to the street and span the entire width of the ramp in accordance with detail S9.6. The detectable warning surface shall be placed a minimum of 6-inches, but not more than 8", from the flow line. Detectable warning panels placed within the City of Aurora Right-of-Way and/or on City of Aurora Property, shall be per the City of Aurora approved materials list.
- 14) The entire ramp area shall be poured monolithically, 6 inches thick from PCR to PCR and include the curb heads. In cases where it is not practical to complete in one pour, ramps sections shall be doweled together.
- 15) All radii shall be 2-foot, minimum and as shown on the approved plans.
- 16) A 1/2-inch expansion joint shall be required where the concrete ramp joins any structure, at both PCR's, top of ramps, and at connecting sidewalks.
- 17) Tree lawns shall slope toward the street in accordance with the Roadway Design and Construction Specifications Manual, latest edition.
- 18) All curb ramp joints and grade breaks shall be flush including the joint between the roadway surface and the gutter; there shall be no gutter lips at curb ramps.
- 19) Curb ramps (excluding flared sides) shall be wholly contained within the limits of the crosswalk and/or the pedestrian street crossing they serve.
- 20) Existing crosswalks and median bull noses may require modification to ensure an obstruction free route exists where the ramps are wholly contained within the crosswalk.
- 21) Pedestrian push buttons shall be installed within acceptable ADA reach requirements and in accordance with the MUTCD, latest edition, subject to the direction of the Traffic Engineer or designee.
- 22) The contractor shall verify removal limits of existing ramps and sidewalks are to nearest joint and sufficient to meet these guidelines, provide positive drainage, maintain existing drainage patterns, and avoid ponding.
- 23) In no case shall a curb ramp or full drop direct pedestrians into a cross pan.

City of Aurora, Colorado

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General Curb Requirements

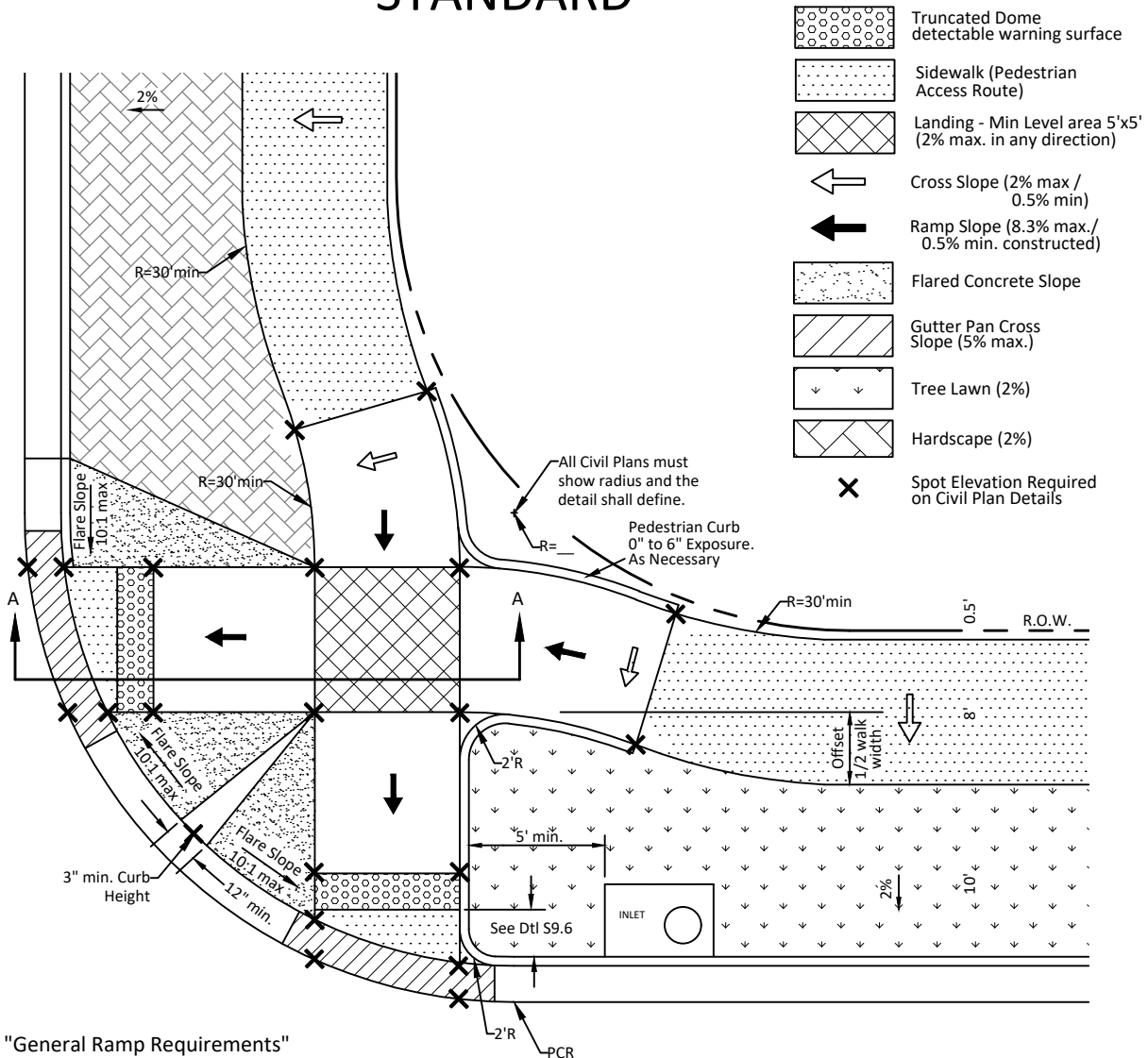
S9.0

  
CITY ENGINEER

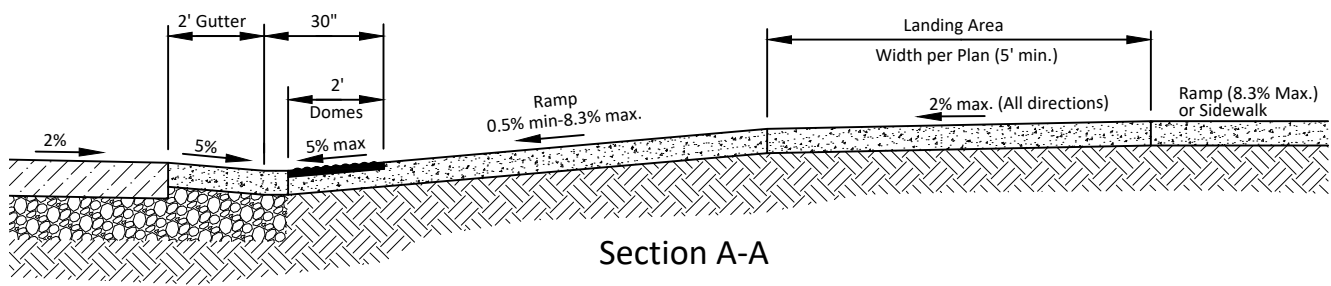
01/31/2023  
DATE



# STANDARD



Reference "General Ramp Requirements"  
COA Std Dtl D9.0 for design requirements.



Section A-A

**Note:**

1. Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
2. All ramps are to be in accordance with general notes on S9.0.
3. All slopes shown are constructed finished surface slope.
4. Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

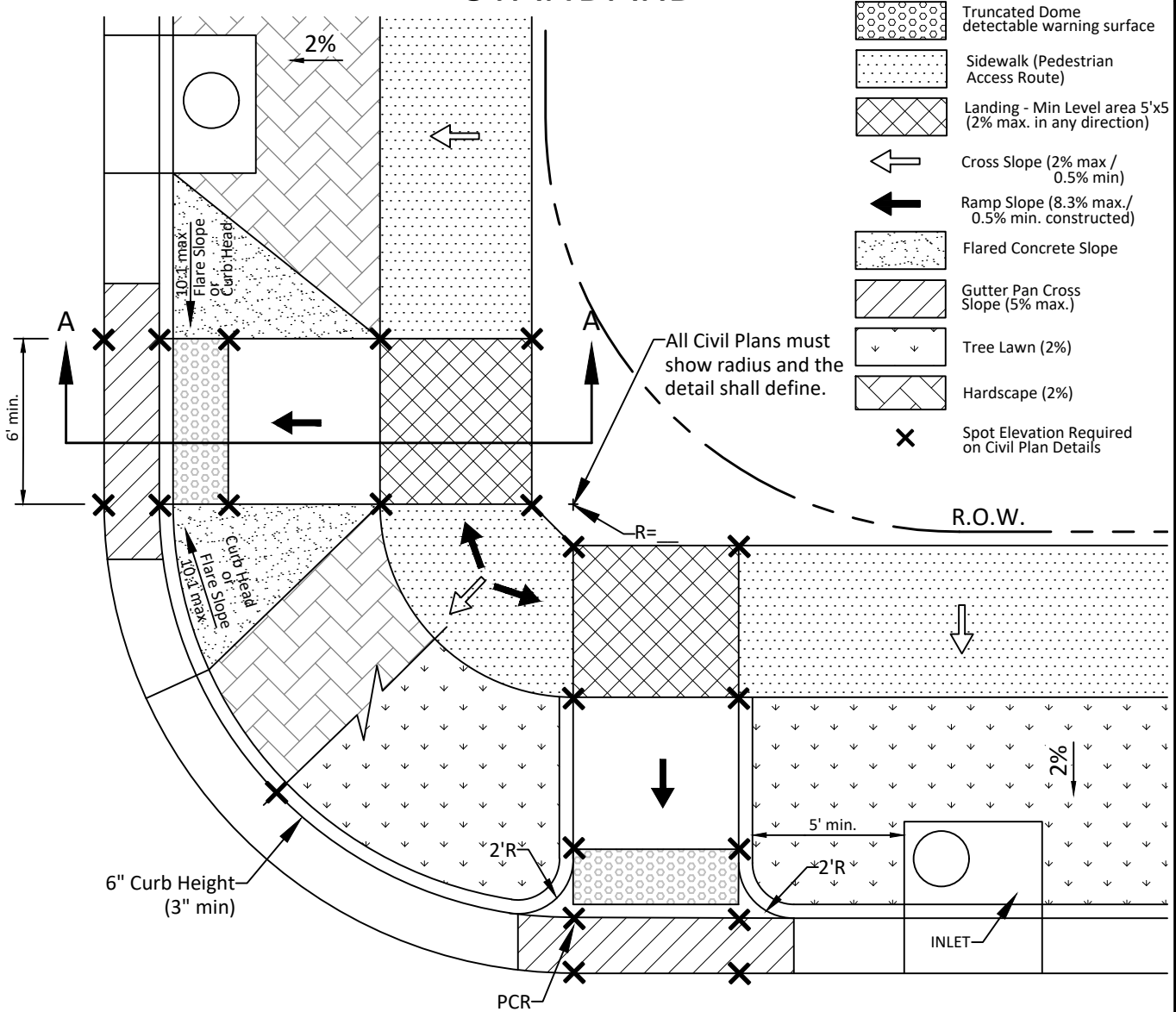
Type 1a  
Perpendicular  
(25' Radius)

1 of 4  
S9.1

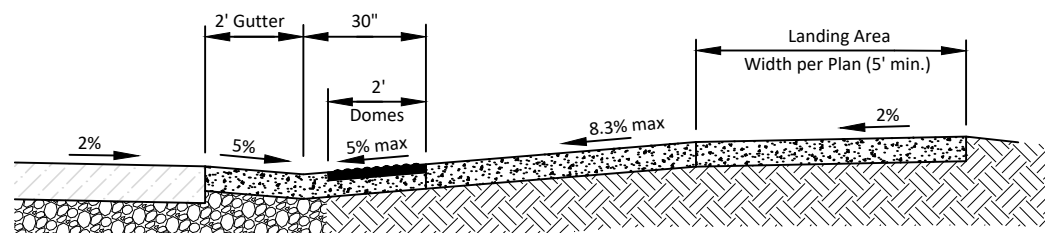
*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



- Truncated Dome detectable warning surface
- Sidewalk (Pedestrian Access Route)
- Landing - Min Level area 5'x5' (2% max. in any direction)
- Cross Slope (2% max / 0.5% min)
- Ramp Slope (8.3% max./ 0.5% min. constructed)
- Flared Concrete Slope
- Gutter Pan Cross Slope (5% max.)
- Tree Lawn (2%)
- Hardscape (2%)
- Spot Elevation Required on Civil Plan Details



Section A-A

Note:

1. Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
2. All ramps are to be in accordance with general notes on S9.0.
3. All slopes shown are constructed finished surface slope.
4. Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

Type 1b  
Perpendicular  
(≤ 20' Radius)

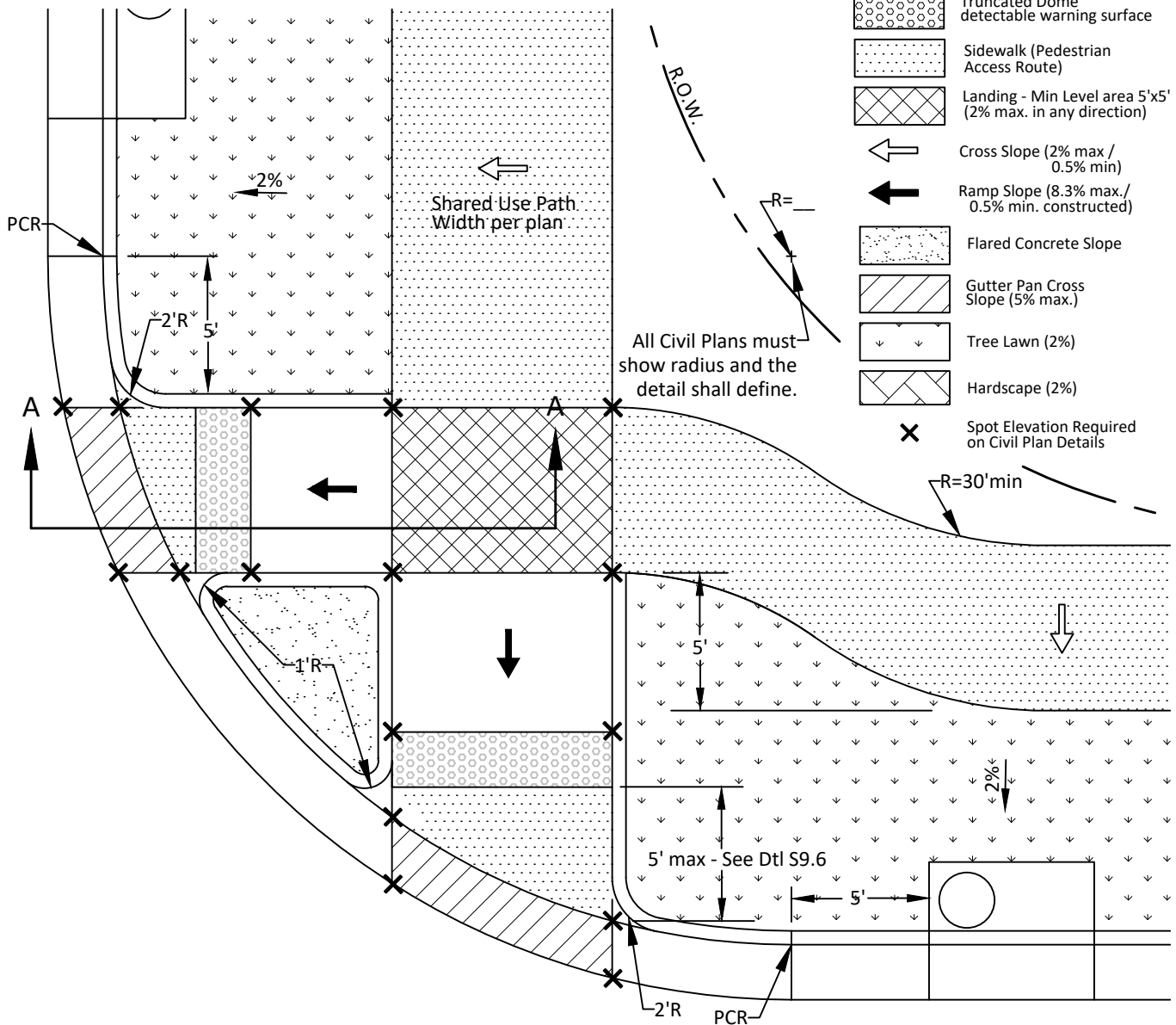
2 of 4  
S9.1

*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE



# STANDARD



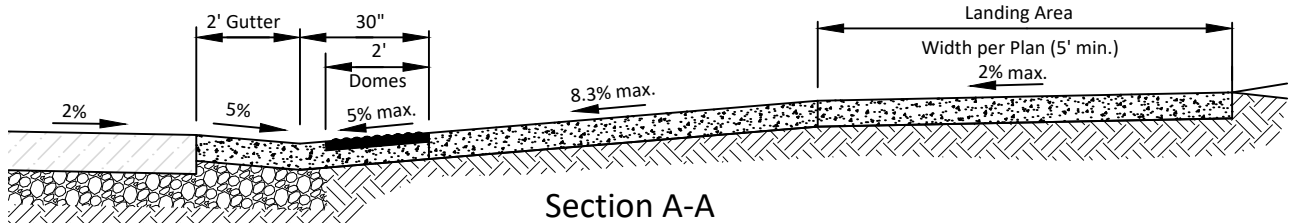
- Truncated Dome detectable warning surface
- Sidewalk (Pedestrian Access Route)
- Landing - Min Level area 5'x5' (2% max. in any direction)
- Cross Slope (2% max / 0.5% min)
- Ramp Slope (8.3% max./ 0.5% min. constructed)
- Flared Concrete Slope
- Gutter Pan Cross Slope (5% max.)
- Tree Lawn (2%)
- Hardscape (2%)
- Spot Elevation Required on Civil Plan Details

All Civil Plans must show radius and the detail shall define.

Shared Use Path Width per plan

R=30' min

5' max - See Dtl S9.6



Section A-A

Note:

1. Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
2. All ramps are to be in accordance with general notes on S9.0.
3. All slopes shown are constructed finished surface slope.
4. Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

Type 1d  
Shared Use Path  
at Collector / Arterial

4 of 4

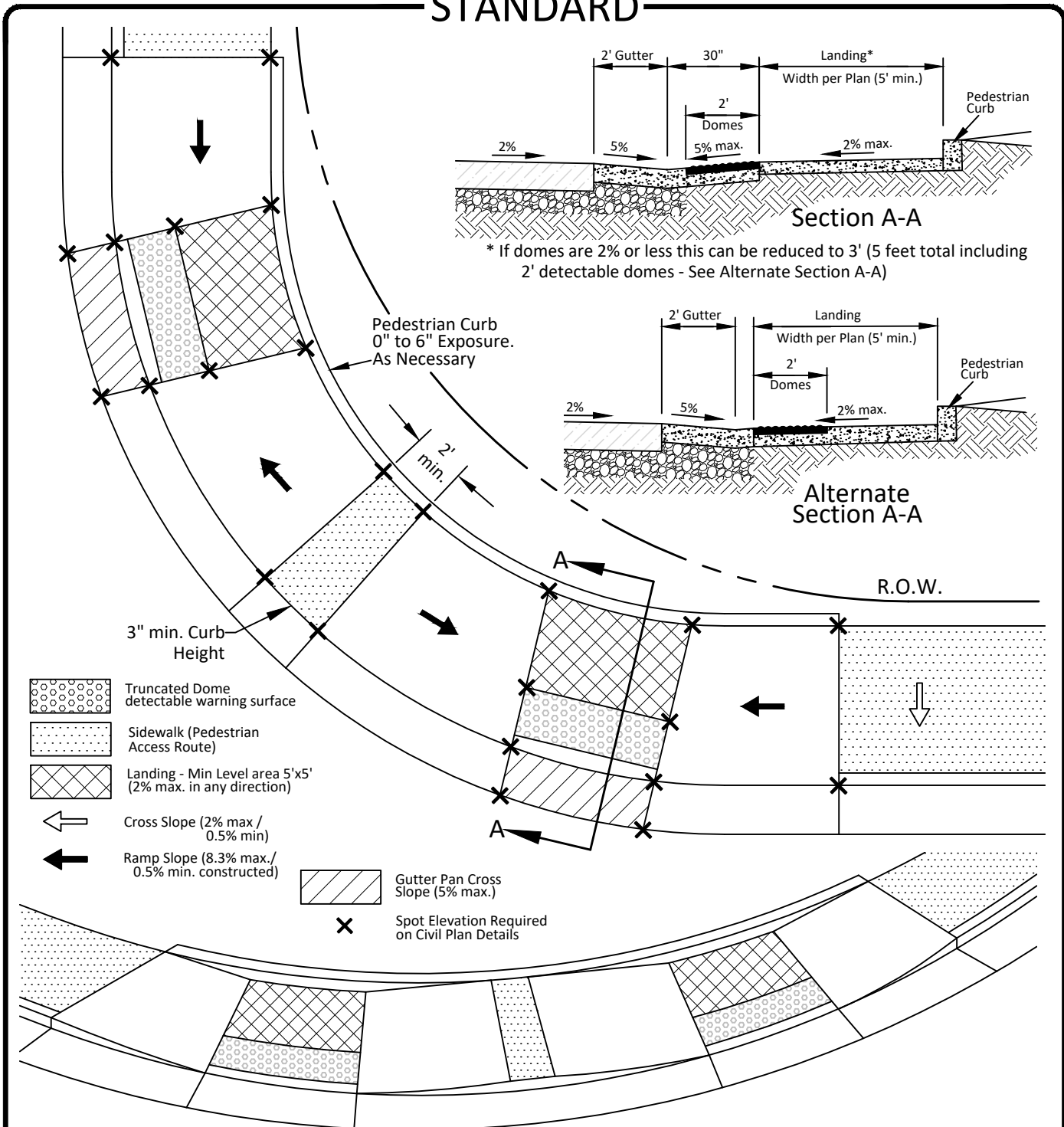
S9.1

*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

c:\2022-roadway specs\dwgs\s9-details.dwg 4 February 2022

# STANDARD



\* If domes are 2% or less this can be reduced to 3' (5 feet total including 2' detectable domes - See Alternate Section A-A)

**Note:**

1. Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
2. All ramps are to be in accordance with general notes on S9.0.
3. All slopes shown are constructed finished surface slope.
4. Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

Type 2  
Parallel

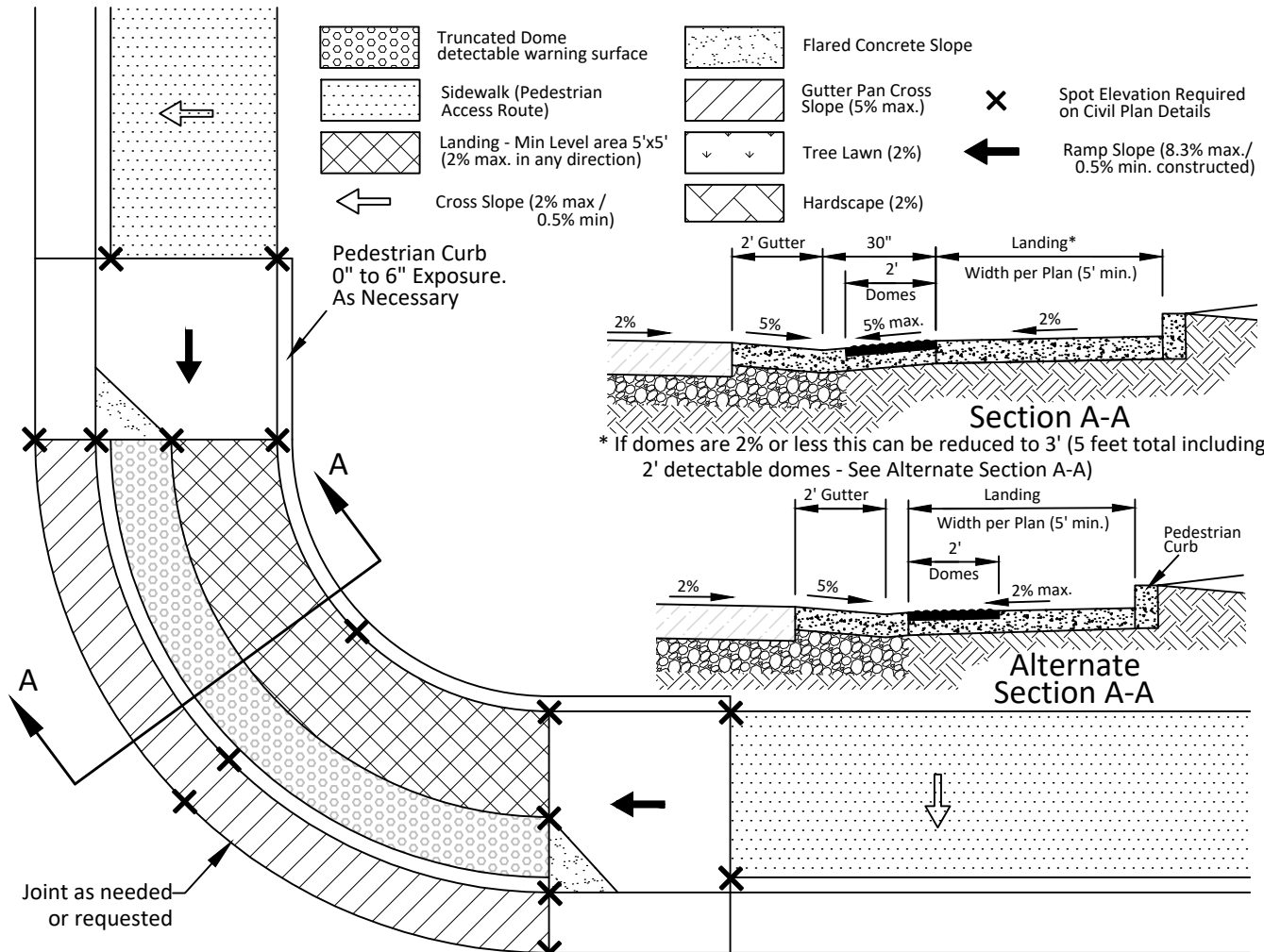
S9.2

*Helen B. Hansen*  
CITY ENGINEER

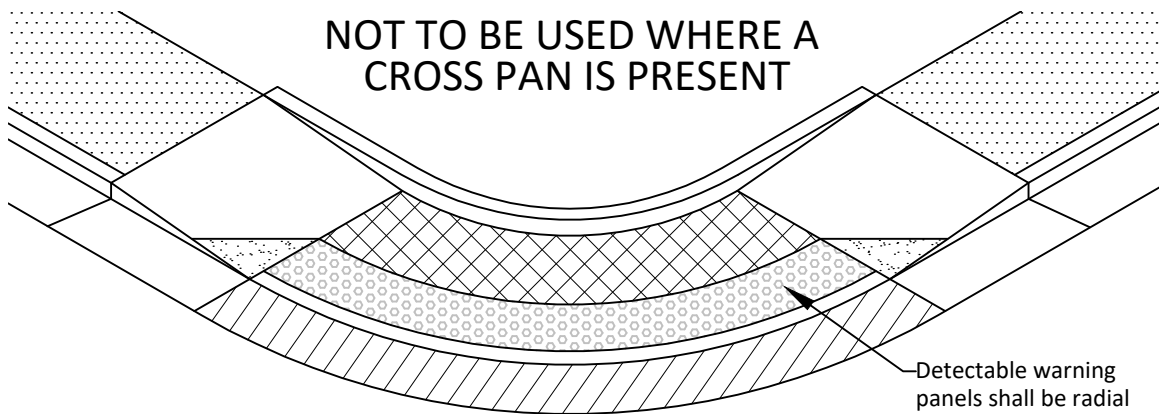
01/31/2023  
DATE

c:\2022-roadway specs\dwgs\s9-details.dwg 4 February 2022

# STANDARD



**NOT TO BE USED WHERE A CROSS PAN IS PRESENT**



**Note:**

- Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
- All ramps are to be in accordance with general notes on S9.0.
- All slopes shown are constructed finished surface slope.
- Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

*Helen B. Anderson*  
CITY ENGINEER

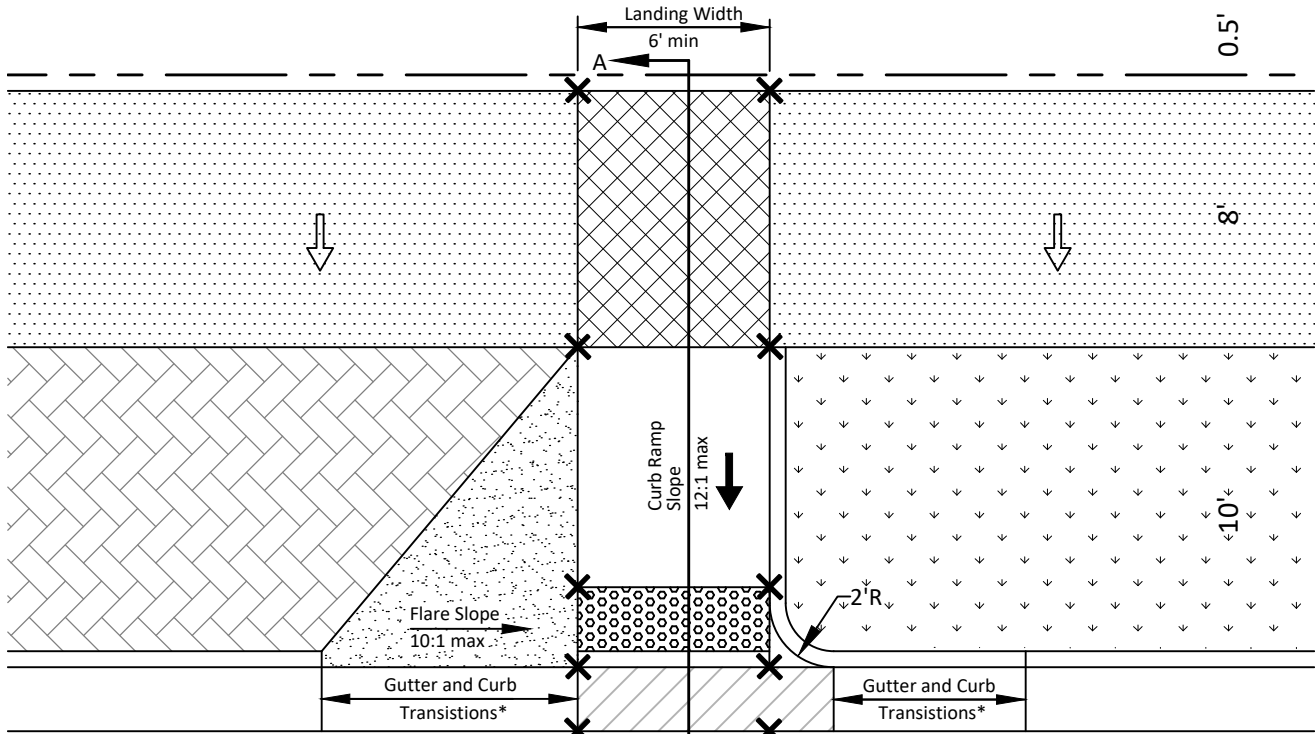
01/31/2023

DATE

Type 3  
Full Drop Ramp  
(Retrofit)

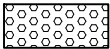
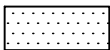




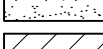
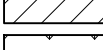

S9.3

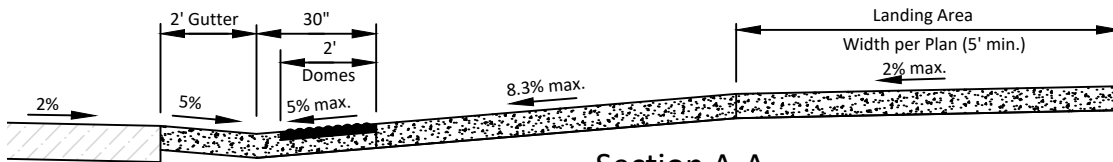
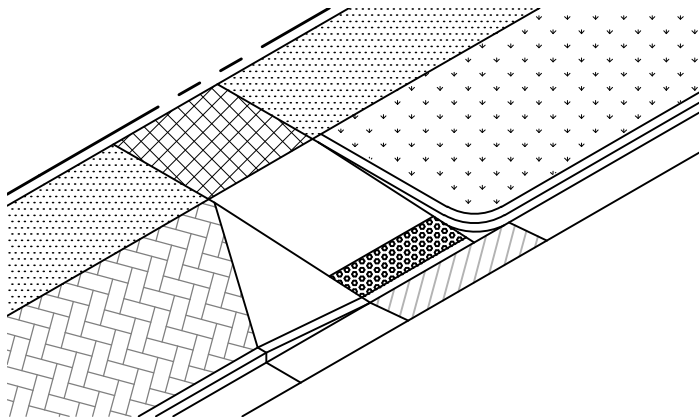
# STANDARD



✕ Spot Elevation Required on Civil Plan Details

Ramp Width  
6' min

-  Truncated Dome detectable warning surface
-  Sidewalk (Pedestrian Access Route)
-  Landing - Min Level area 5'x5' (2% max. in any direction)
-  Cross Slope (2% max / 0.5% min)
-  Ramp Slope (8.3% max / 0.5% min. constructed)
-  Flared Concrete Slope
-  Gutter Pan Cross Slope (5% max.)
-  Tree Lawn (2%)
-  Hardscape (2%)



Section A-A

Note:

1. Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
2. All ramps are to be in accordance with general notes on S9.0.
3. All slopes shown are constructed finished surface slope.
4. Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

Type 4  
Mid-Block Ramp  
(Perpendicular)

1 of 2

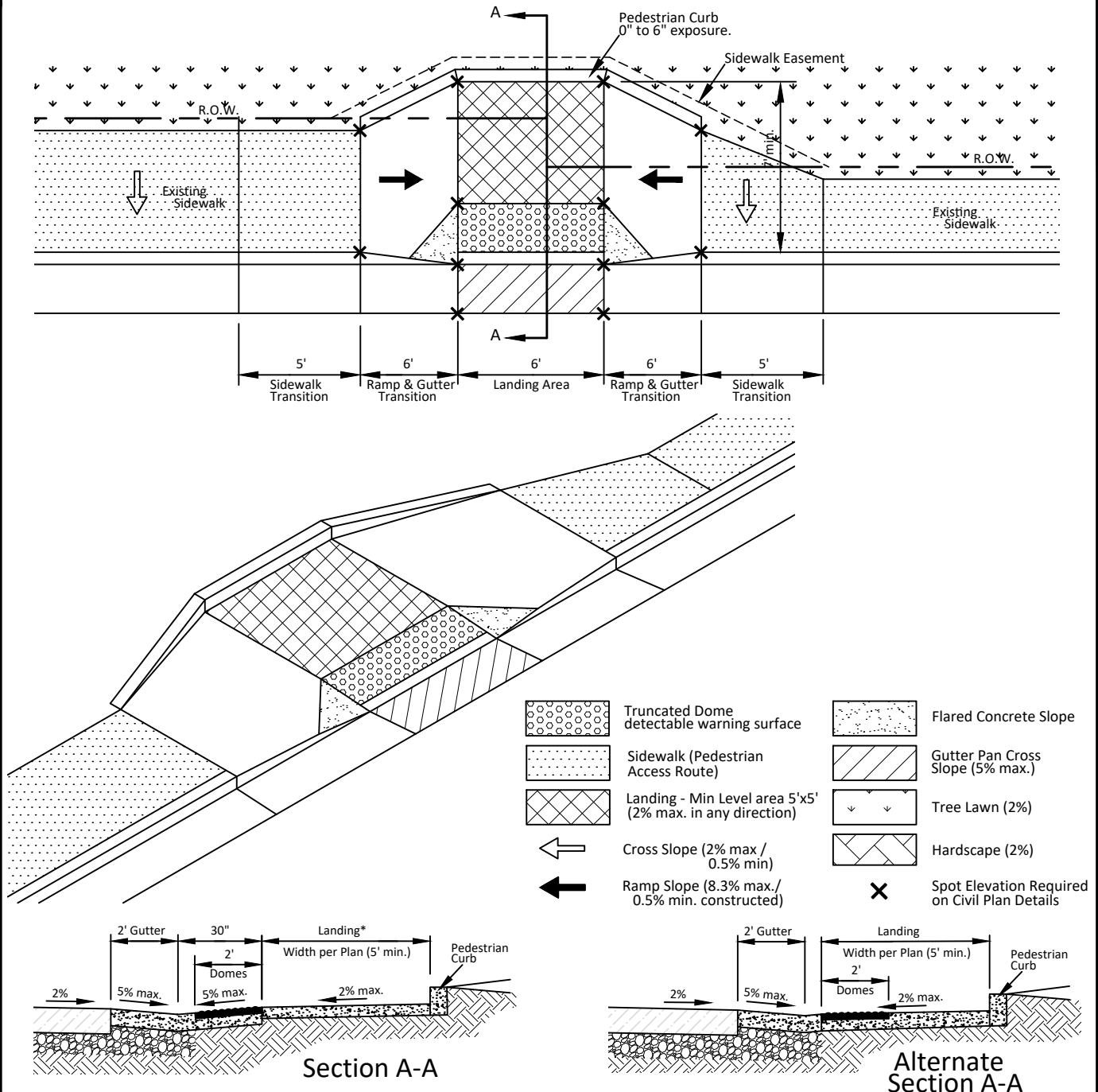
S9.4

*Heley B. Johnson*  
CITY ENGINEER

01/31/2023

DATE

# STANDARD



\* If domes are 2% or less this can be reduced to 3' (5 feet total including 2' detectable domes - See Alternate Section A-A)

**Note:**

- Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
- All ramps are to be in accordance with general notes on S9.0.
- All slopes shown are constructed finished surface slope.
- Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

Type 4a  
 Mid-Block  
 Parallel (Retrofit)

2 of 2  
 S9.4

*Heidi B. Anderson*  
 CITY ENGINEER

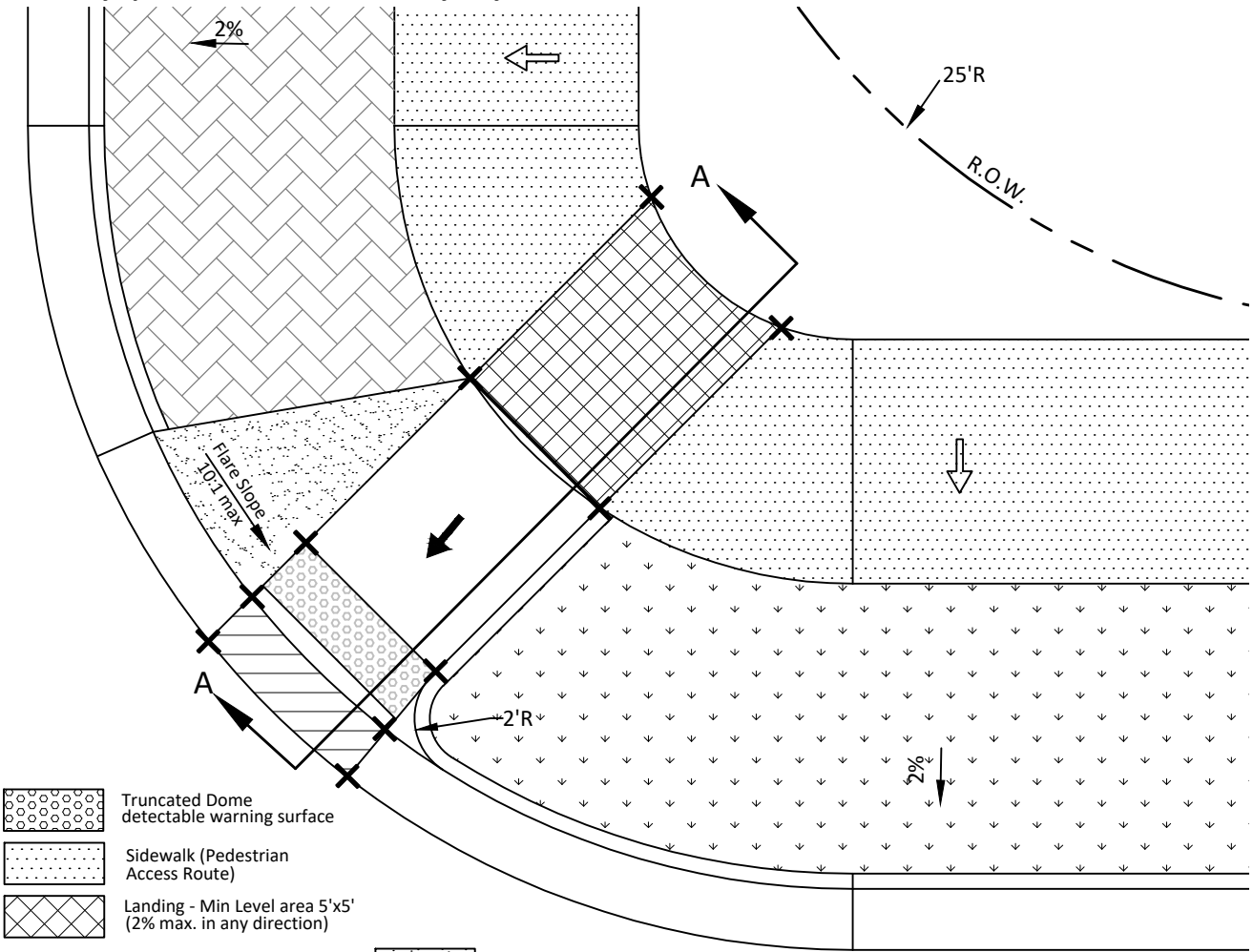
01/31/2023  
 DATE

c:\2022-roadway specs\dwgs\s9-details.dwg 4 February 2022

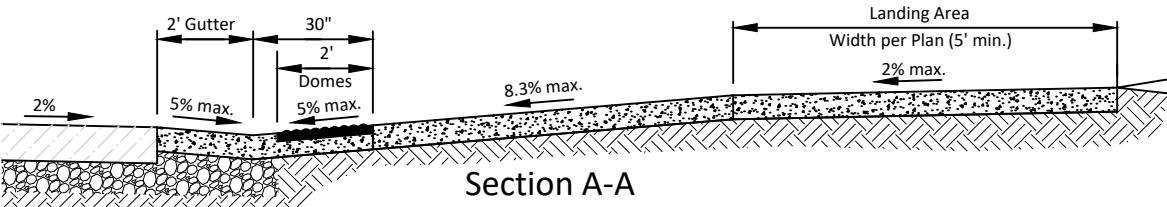


# STANDARD

Do not use this design unless constraints, such as drainage structures, vaults, etc. require it; paired ramps are always preferred or as directed by City staff.



- Truncated Dome detectable warning surface
- Sidewalk (Pedestrian Access Route)
- Landing - Min Level area 5'x5' (2% max. in any direction)
- Cross Slope (2% max / 0.5% min)
- Ramp Slope (8.3% max./ 0.5% min. constructed)
- Flared Concrete Slope
- Gutter Pan Cross Slope (5% max.)
- Tree Lawn (2%)
- Hardscape (2%)
- Spot Elevation Required on Civil Plan Details



Section A-A

Note:

1. Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
2. All ramps are to be in accordance with general notes on S9.0.
3. All slopes shown are constructed finished surface slope.
4. Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

Type 5  
Diagonal Ramp

1 of 2  
S9.5

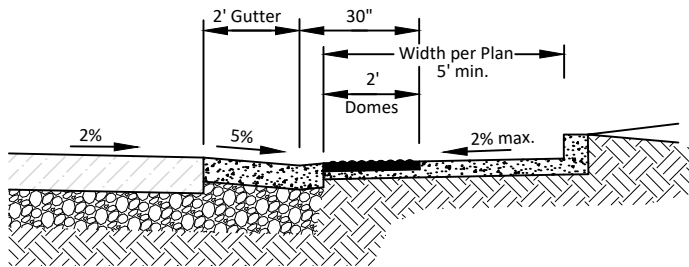
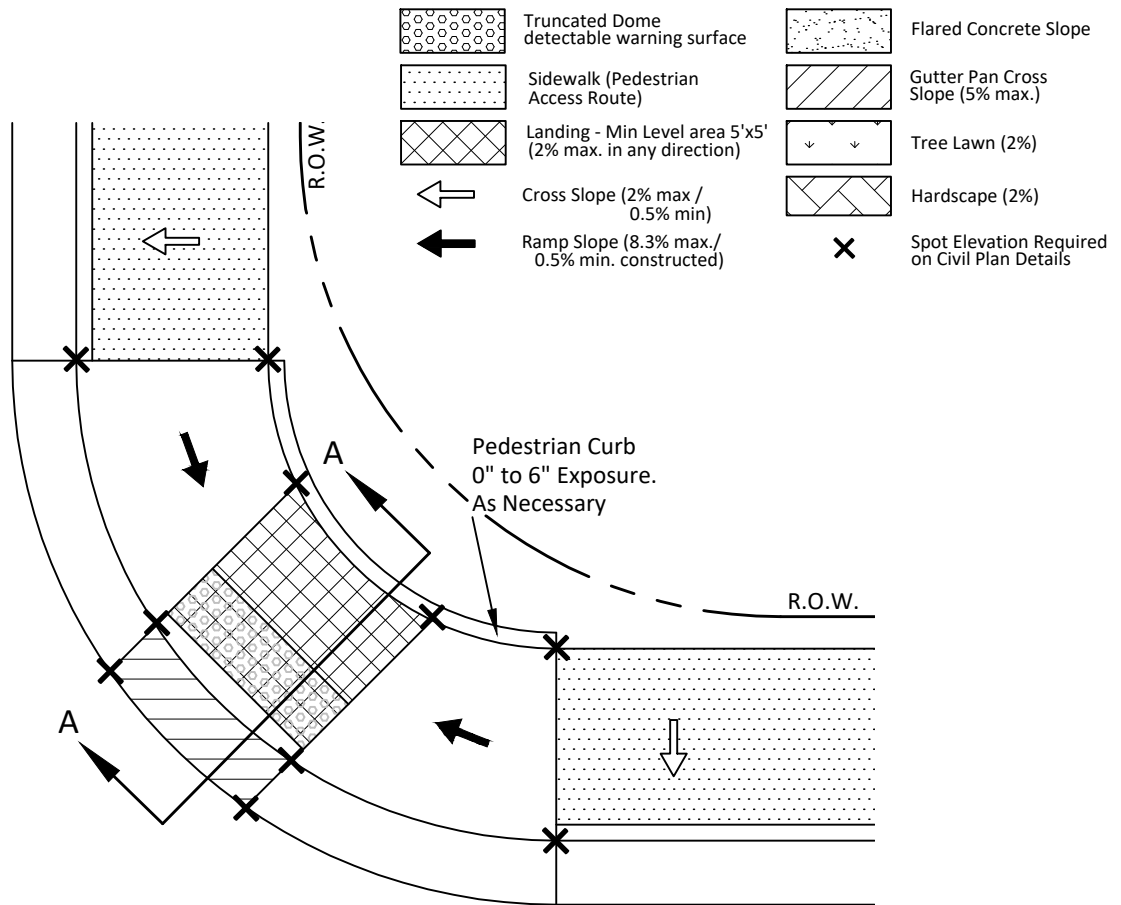
*Helen B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

c:\2022-roadway specs\dwgs\s9-details.dwg 4 February 2022

# STANDARD

**Do not use this design unless constraints, such as drainage structures, vaults, etc. require it; paired ramps are always preferred. Use only with City Engineer approval.**



Section A-A

**Note:**

1. Both tree lawn and hardscape shown for graphical representation. Use appropriate treatment per approved plans or as existing conditions require.
2. All ramps are to be in accordance with general notes on S9.0.
3. All slopes shown are constructed finished surface slope.
4. Sides of ramps must be flared where a walkable surface is adjacent to the ramp. If a tree lawn or some other non-walkable surface or obstruction exists adjacent to the ramp, a transition curb will be acceptable. The length of the flare must be 10-times the height of the curb, measured along the curb line.

City of Aurora, Colorado

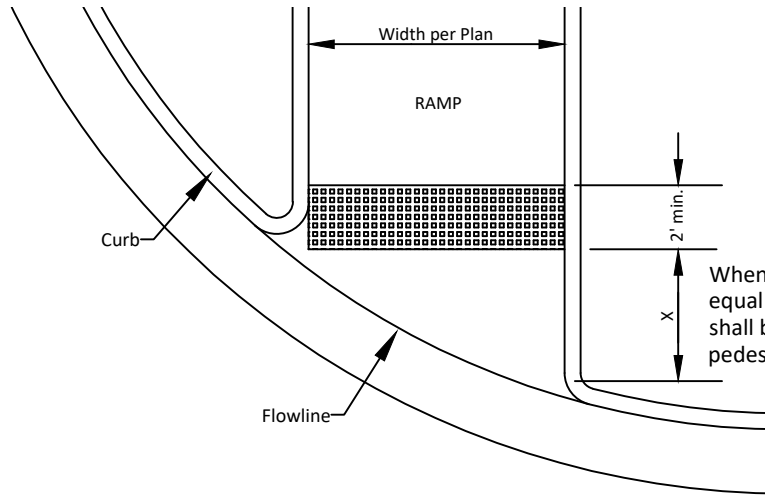
Type 5a  
Diagonal Ramp  
(Retrofit)

2 of 2  
**S9.5**

*Haley B. Anderson*  
CITY ENGINEER

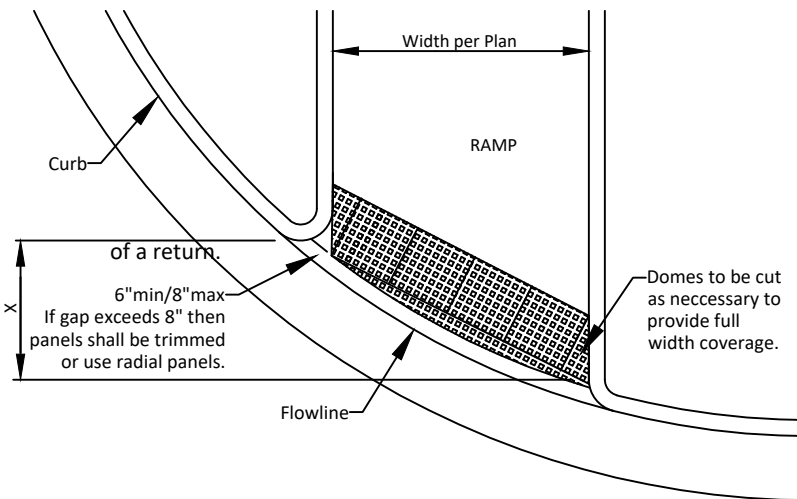
01/31/2023  
DATE

# STANDARD



When distance "X" is less than or equal to 5 feet, detectable warnings shall be placed perpendicular to the pedestrian travel.

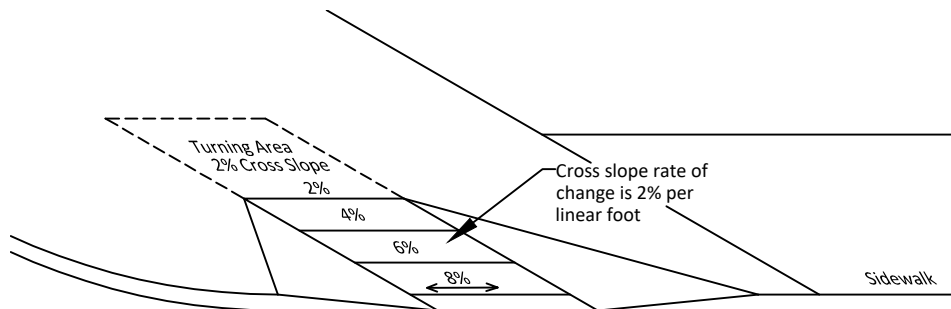
Note: If an attached walk approaches from side street then detectable warning shall be placed at the bottom of the ramp.



When distance "X" is greater than 5-feet or an attached sidewalk approaches from the side street, detectable warnings shall be located along projected curb line. Radial warning panels are preferred when placed within the radius

of a return.  
6" min/8" max  
If gap exceeds 8" then panels shall be trimmed or use radial panels.

Domes to be cut as necessary to provide full width coverage.



## Ramp Cross Slope Transition To Match Profile (Applicable to All Curb Ramp Types)

Curb ramp cross slopes and turning spaces shall be:

- A. 2% max. when a yield or stop sign present.
- B. Permitted to equal the roadway grade when there is no yield or stop control, when a traffic signal is present, or at a midblock crossing location.

City of Aurora, Colorado

*Haley B. Anderson*  
CITY ENGINEER

01/31/2023

DATE

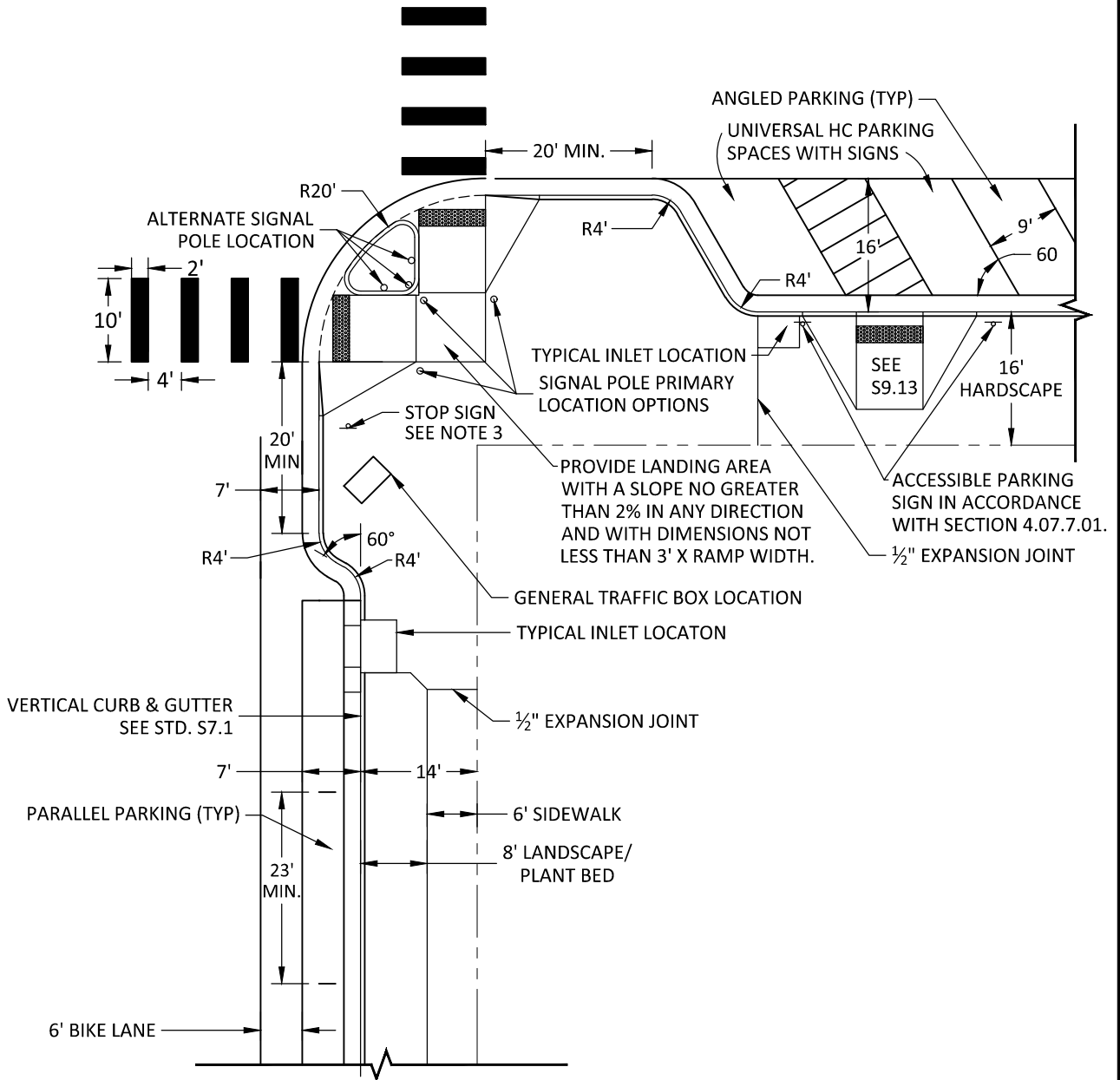
Detectable Warning  
Placement Guide &  
Transition Rate

S9.6

# STANDARD

**NOTES:**

1. IF COLORED PAVING IS NOT USED, THEN CONTINENTAL STRIPING MUST BE USED, SEE TE-12
2. STRIPING AND STOP SIGN LOCATION SHALL MEET CURRENT MUTCD STANDARDS.
3. PLACE SIGN POST WITHIN 4"Øx12", SCH. 40, PVC PIPE WITHIN SIDEWALK. PLACE PIPE FLUSH WITH TOP OF CONCRETE WALK.



n:\pwc\draft\standard\roadways-series details\s9-15.dwg 22 November 2017

City of Aurora, Colorado

*Heidi Blomquist*  
CITY ENGINEER

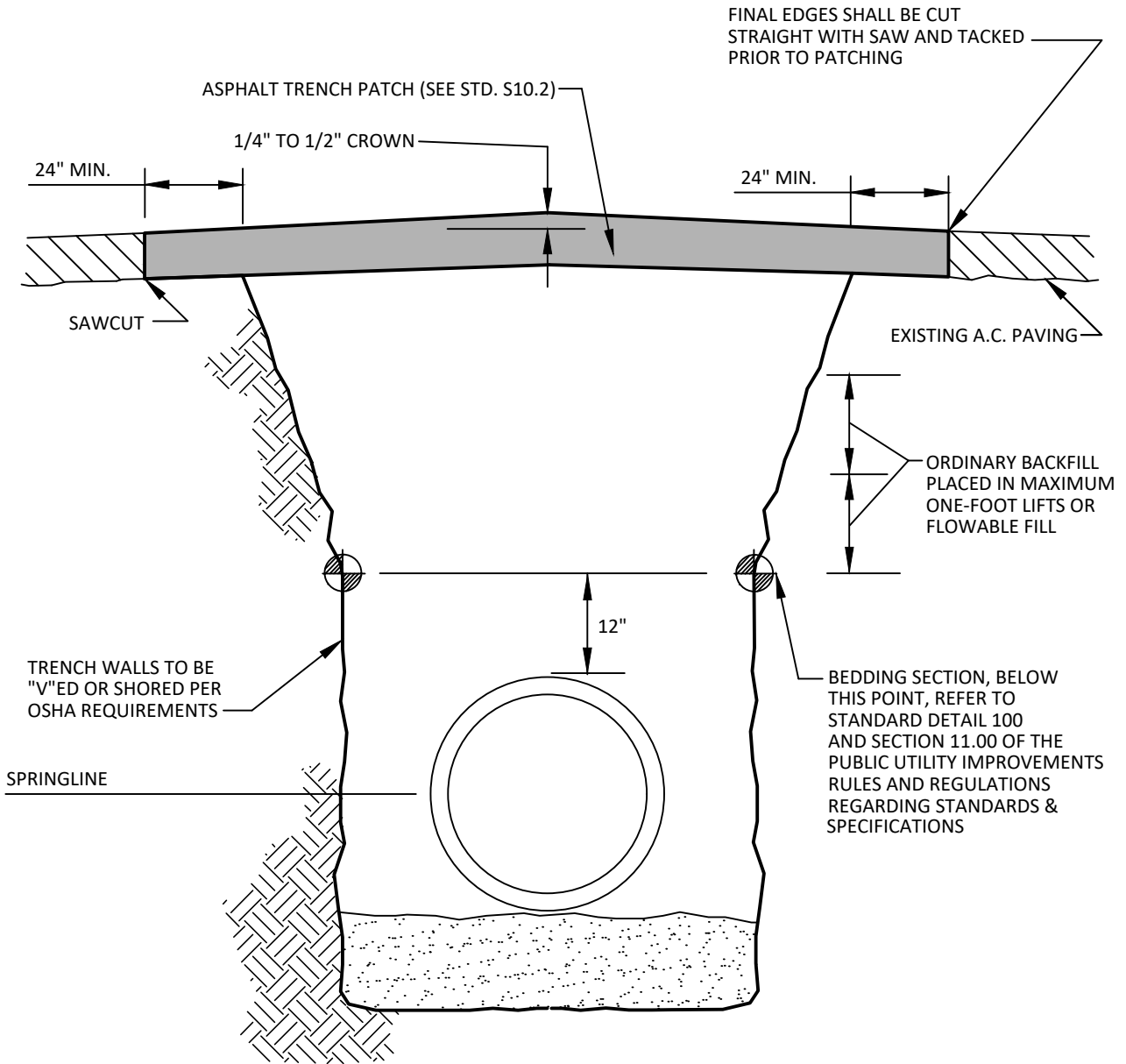
01/31/2023  
DATE

URBAN CENTER & TOD CURB  
EXTENSION ANGLED/PARALLEL  
PARKING

S9.15

# STANDARD

NOTE: CONTRACTORS PATCHING ASPHALT TRENCHES WITHIN 6' OF AN EXISTING PATCH OR LIP OF GUTTER SHALL REMOVE AND REPLACE EXISTING ASPHALT TO THE EDGE OF THE EXISTING PATCH OR LIP OF GUTTER.



SOIL CLASSIFICATION (AASHTO M145)	MIN. RELATIVE COMPACTION	STANDARD
A-1, A-3, A-2-4, A-2-5	95%	AASHTO T180*
ALL OTHERS	95%	AASHTO T99**

\*ASTM D1557  
\*\*ASTM D698

q:\2022\roadway specs\dwgs\s10-1.dwg 15 November 2021

City of Aurora, Colorado

1 of 2

*Heidi B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

**ASPHALT TRENCH  
PATCHING**

**S10.1**

# STANDARD

## STREET CLASSIFICATION

	THICKNESS
ARTERIAL	10 1/2"
COLLECTOR	9"
LOCAL	7"

- MAXIMUM LIFT DEPTH - 3", 4" FOR LOWER LIFTS WHEN USING "G" HMA.
- MINIMUM LIFT DEPTH - 3"
- TOP LIFT SHALL CONFORM TO SECTION 24.00 HOT MIX ASPHALT PAVEMENT.

NOTE:  
WHERE EXISTING PAVEMENTS ARE THICKER THAN THE DIMENSIONS IN THE ABOVE TABLE, THEN THE ASPHALT PATCH SHALL BE THE EXISTING ASPHALT THICKNESS PLUS ONE INCH.

City of Aurora, Colorado

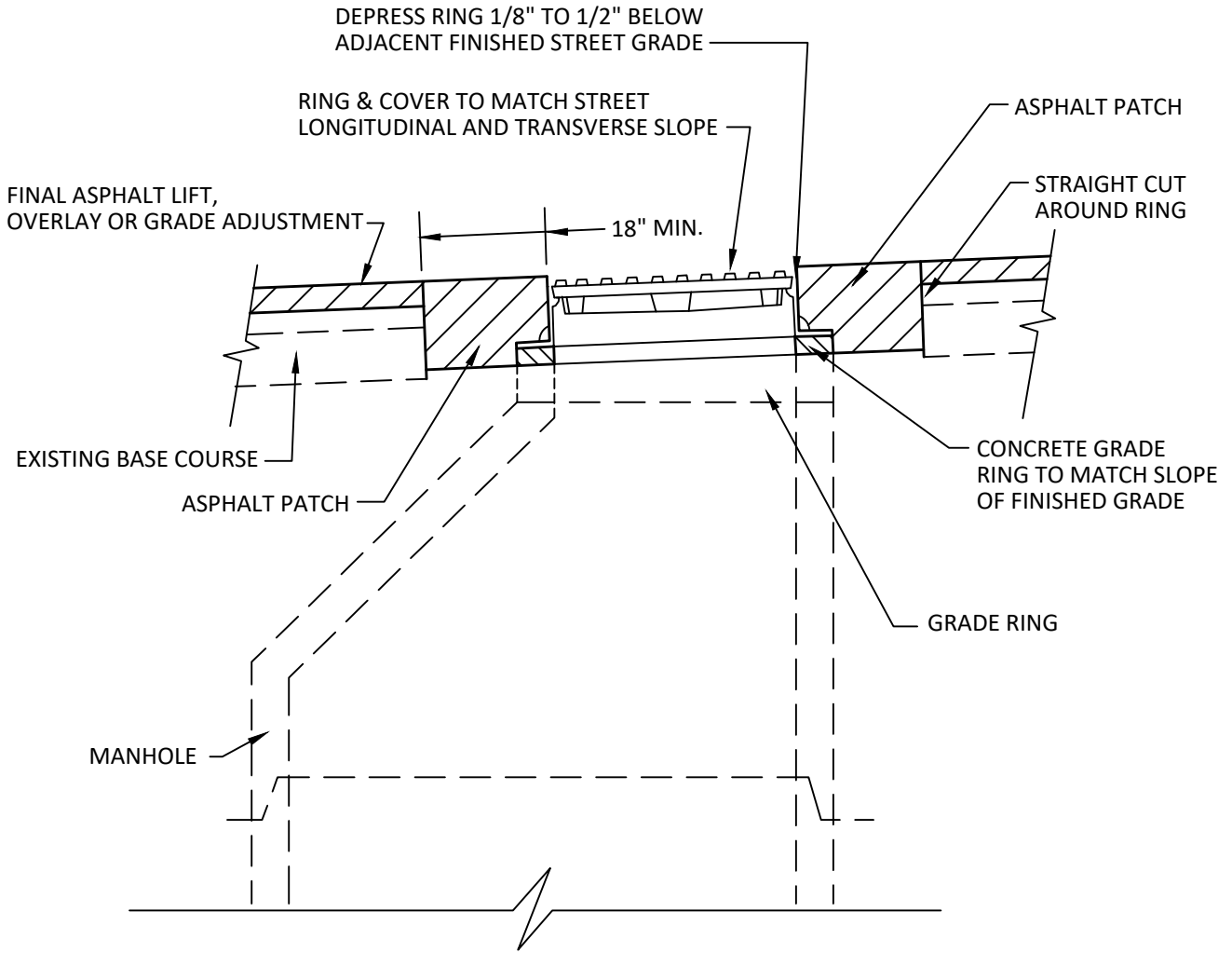
  
CITY ENGINEER

01/31/2023  
DATE

ASPHALT TRENCH PATCHING

S10.2

# STANDARD



q:\2022 roadway specs\dwgs\s11-1.dwg 15 November 2021

City of Aurora, Colorado

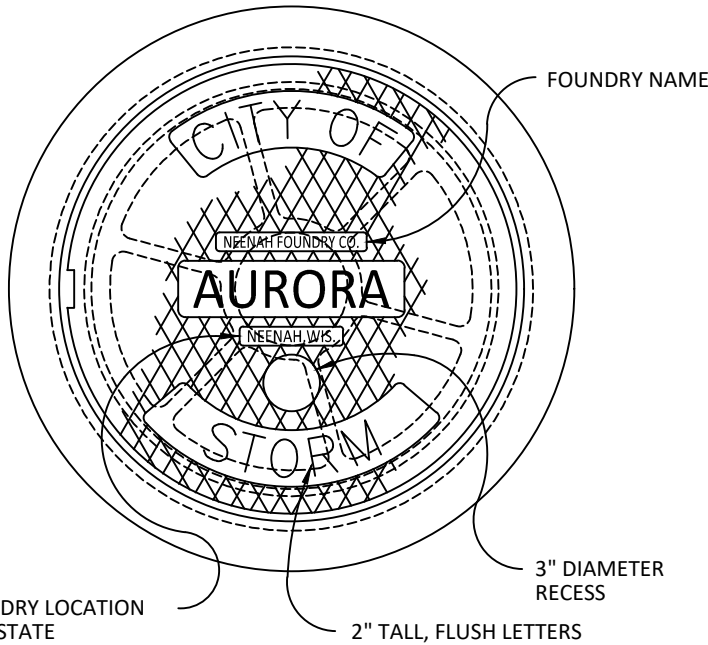
*Heidi B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

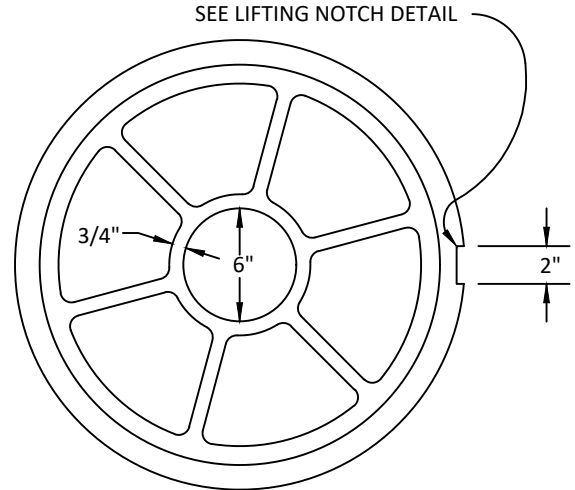
MANHOLE RING &  
COVER ADJUSTMENT

S11.1

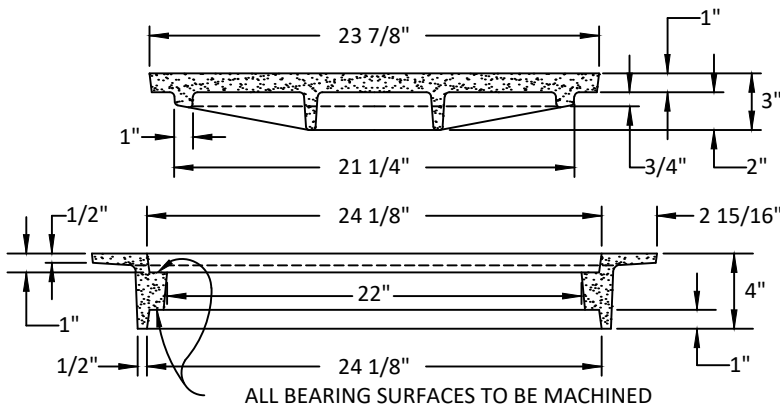
# STANDARD



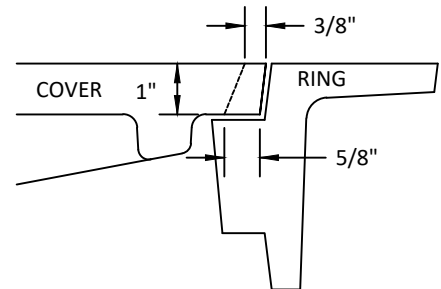
TOP VIEW



UNDERSIDE VIEW  
OF COVER



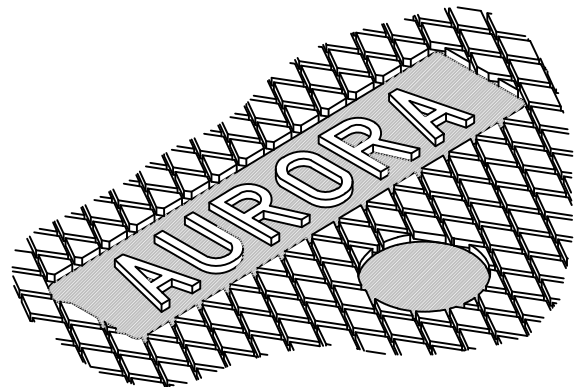
RING & COVER



DETAIL-LIFTING NOTCH

**NOTES:**

1. A.S.T.M. DESIGNATION A-48-83 CLASS 35B (UNPAINTED).
2. ALL BEARING SURFACES TO BE MACHINED.
3. LETTERING ON COVER AS REQUIRED (STORM).
4. TOTAL MINIMUM WEIGHT APPROXIMATELY 272 LBS.
5. AURORA STANDARD-NEENAH R-1706-1S, OR EQUAL.
6. LIFTING NOTCH SHALL NOT EXTEND PAST INSIDE FACE OF RING SEAT.
7. MINIMUM FRAME WEIGHT-114 LBS; MINIMUM LID WEIGHT-158 LBS.
9. SEE SECTION 12.00 OF THE PUBLIC UTILITIES IMPROVEMENTS RULES AND REGULATIONS REGARDING STANDARDS & SPECIFICATIONS.



DETAIL-COVER DESIGN

TYPE "C" DESIGN: 1" X 1" SCORED 1/32"± DEEP

City of Aurora, Colorado

1 of 11

24" TYPE 'R' INLET  
RING & COVER

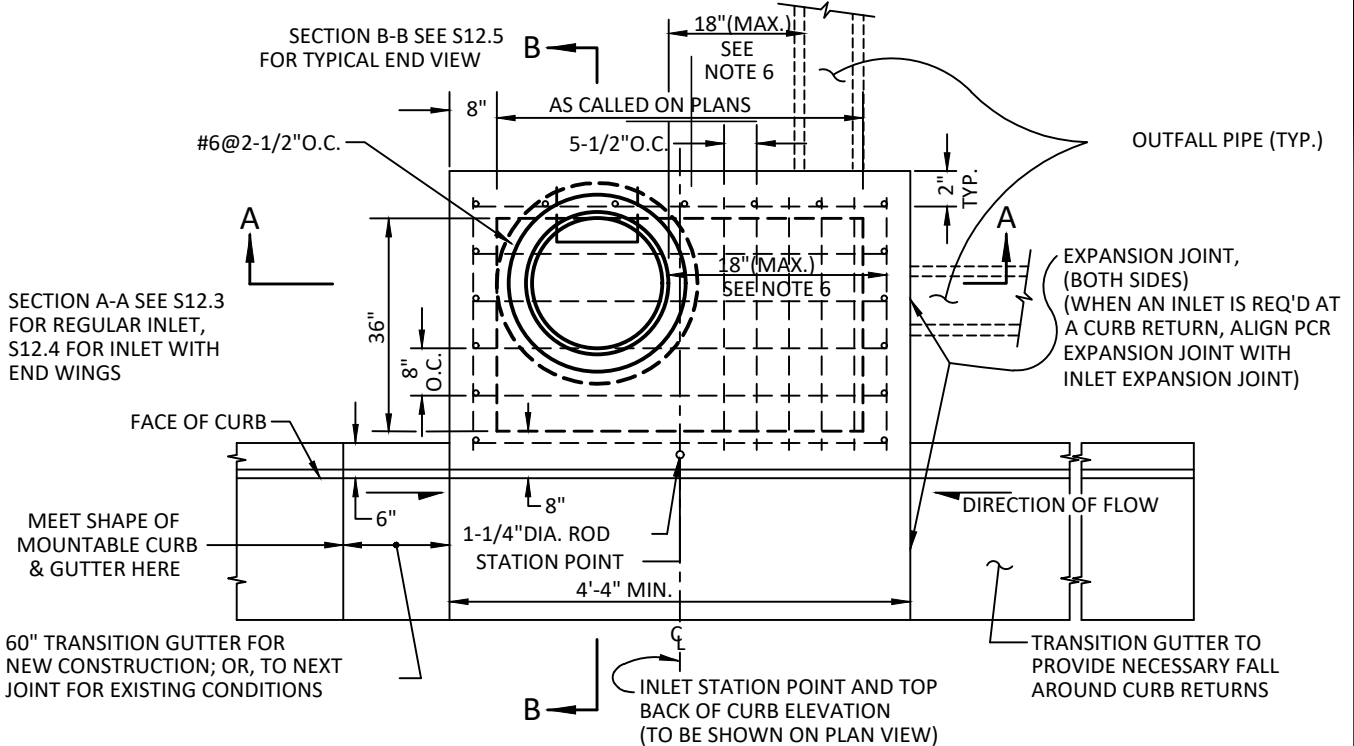
S12.1

*Heidi B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

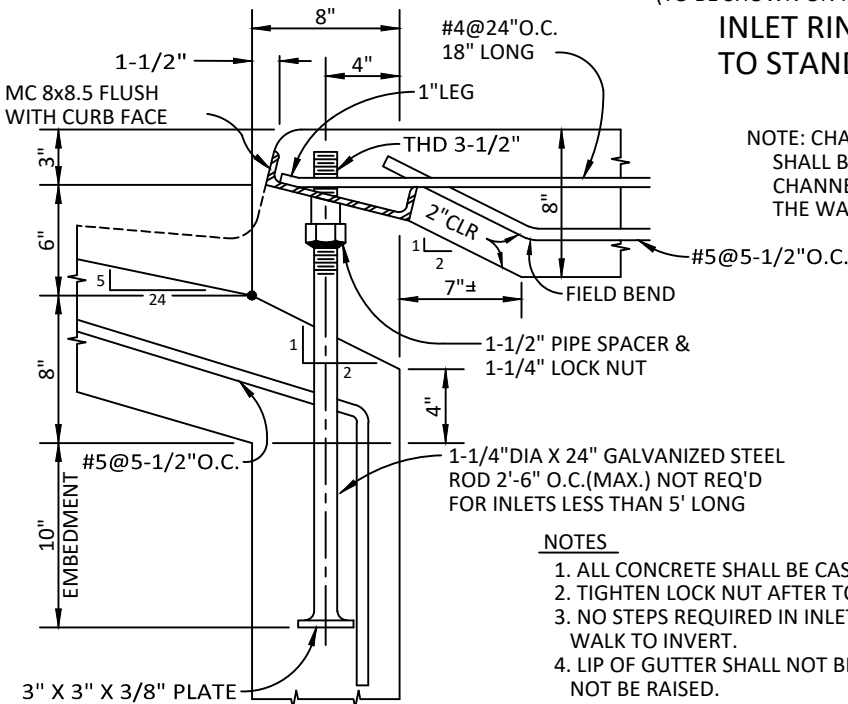


# STANDARD

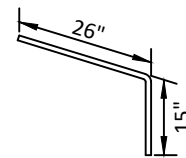


## INLET RING & COVER TO CONFORM TO STANDARD DETAIL S12.1

NOTE: CHANNEL AND ALL OTHER EXPOSED STEEL SHALL BE GALVANIZED (AASHTO M111). CHANNEL SHALL BE EXTENDED 5" INTO THE WALL ON EACH SIDE.



## BENDING DIAGRAM



## CURB FACE ASSEMBLY

### NOTES

1. ALL CONCRETE SHALL BE CAST IN PLACE.
2. TIGHTEN LOCK NUT AFTER TOP SLAB CURES.
3. NO STEPS REQUIRED IN INLETS LESS THAN 36" DEEP, TOP OF WALK TO INVERT.
4. LIP OF GUTTER SHALL NOT BE DIPPED, TOP OF BOX SHALL NOT BE RAISED.
5. SEE CDOT M STANDARDS FOR ALL INFORMATION NOT SHOWN ON THIS DRAWING.
6. EDGE OF ACCESS OPENING SHALL BE LOCATED NO MORE THAN 18" FROM THE INSIDE FACE OF THE OUTFALL PIPE.
7. FOR ON GRADE INLETS, THE DECK TOP SHALL MATCH THE STREET GRADE.

q:\2022-roadway specs\dwgs\s12-2.dwg 12 January 2022

City of Aurora, Colorado

2 of 11

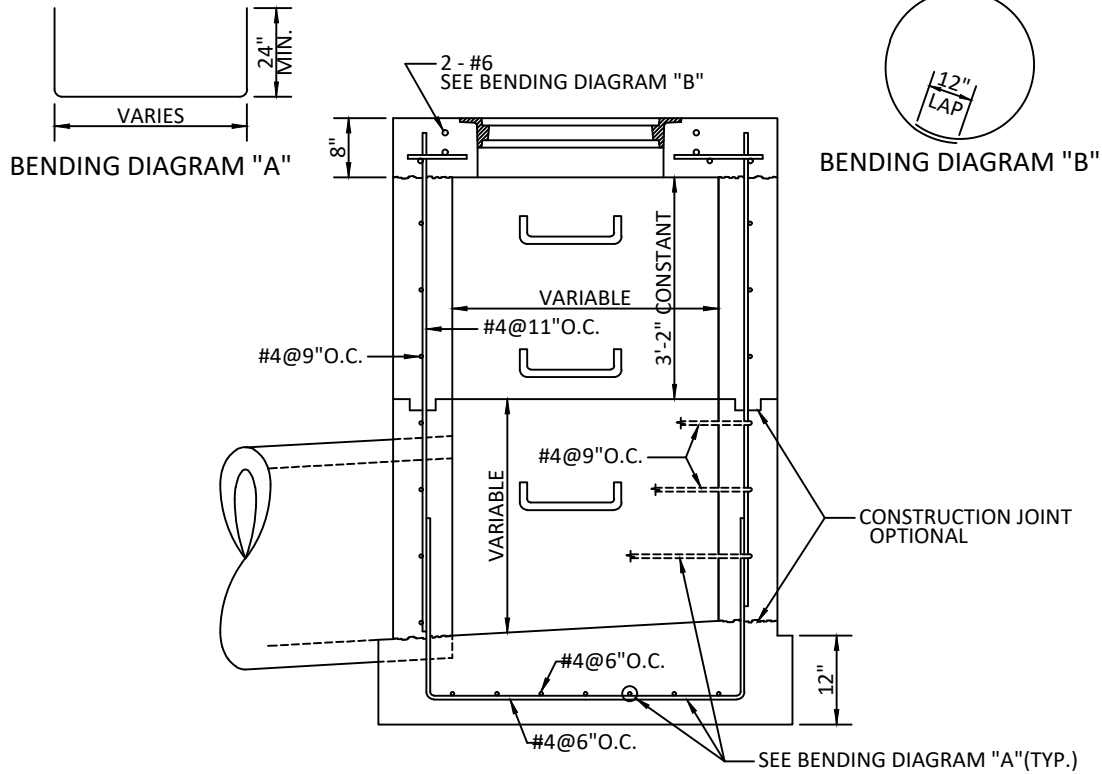
**CURB OPENING INLET  
TYPE 'R' MODIFIED**

**S12.2**

*Heaven B. Hansen*  
CITY ENGINEER

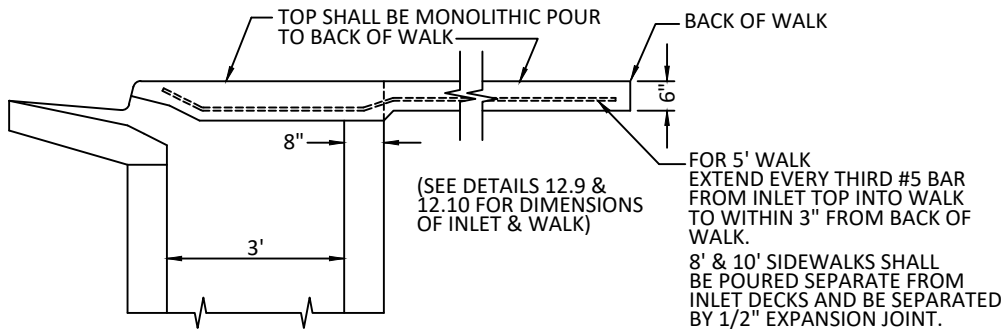
01/31/2023  
DATE

# STANDARD



**SECTION A-A  
REGULAR INLET  
NOT TO SCALE**

NOTE:  
ALL CONSTRUCTION JOINTS  
SHALL HAVE A 2" X 4" KEYWAY.



q:\2022\roadway specs\dwgs\12-3.dwg 15 November 2021

City of Aurora, Colorado

3 of 11

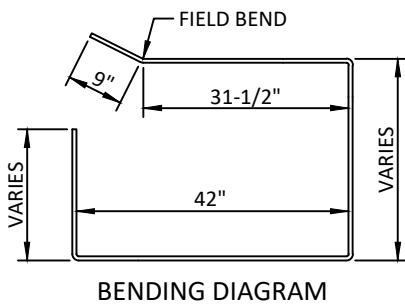
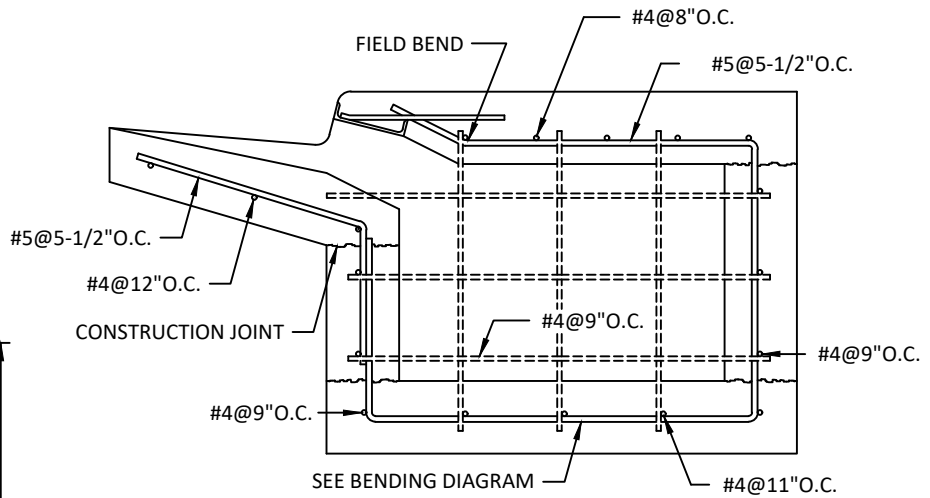
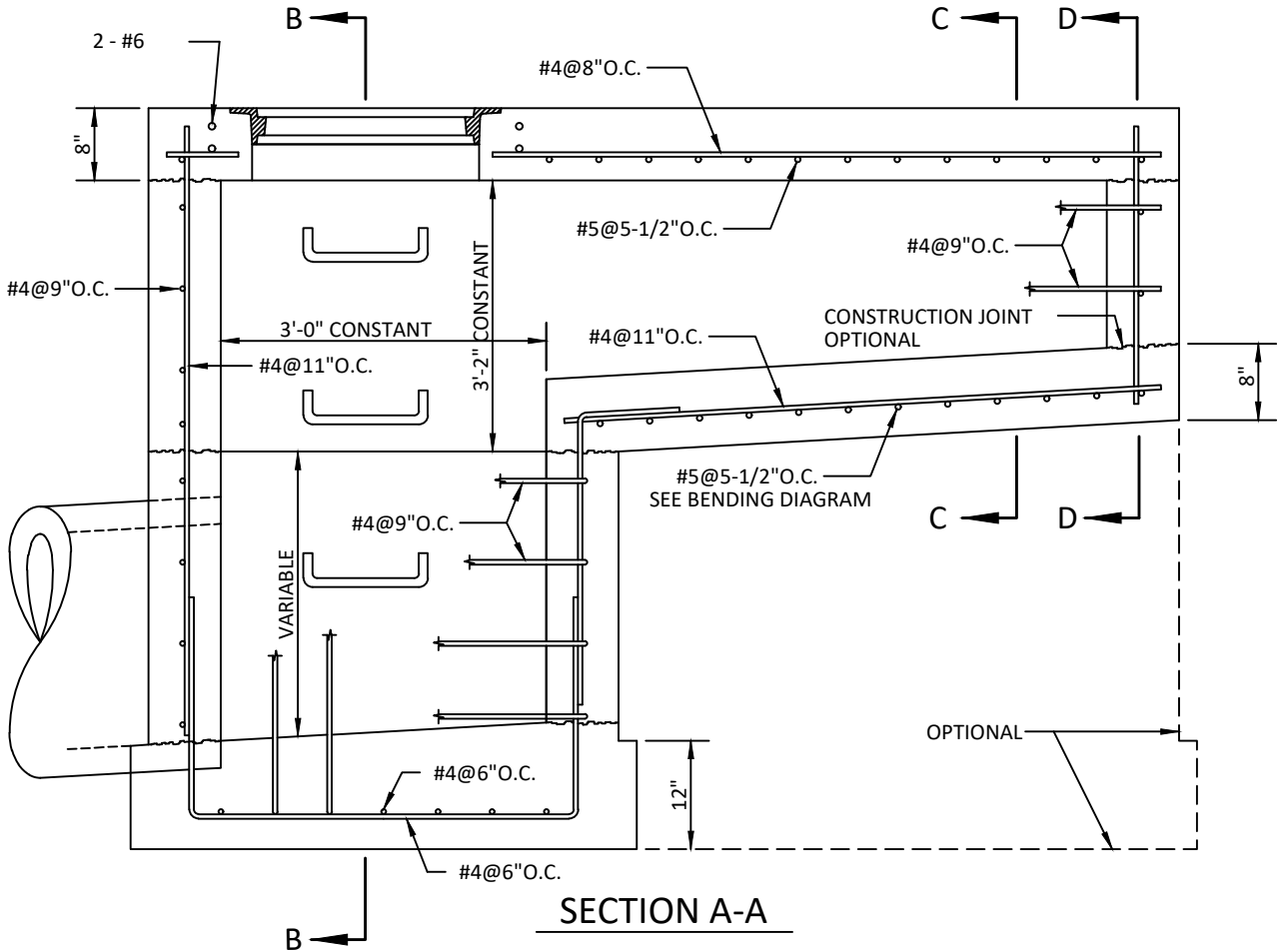
*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

**CURB OPENING INLET  
TYPE 'R' MODIFIED**

**S12.3**

# STANDARD



q:\2022 roadway specs\dwgs\s12-4.dwg 15 November 2021

City of Aurora, Colorado

4 of 11

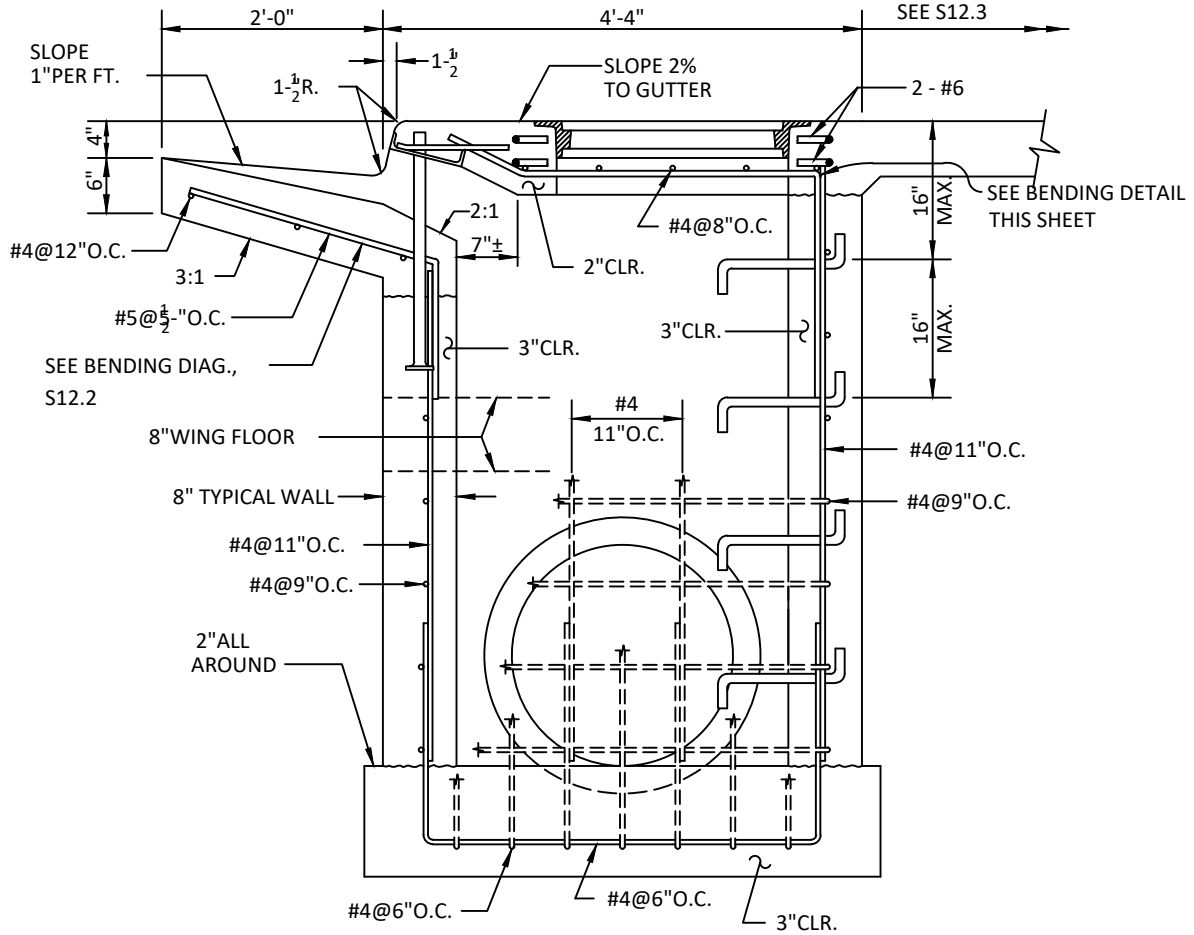
*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

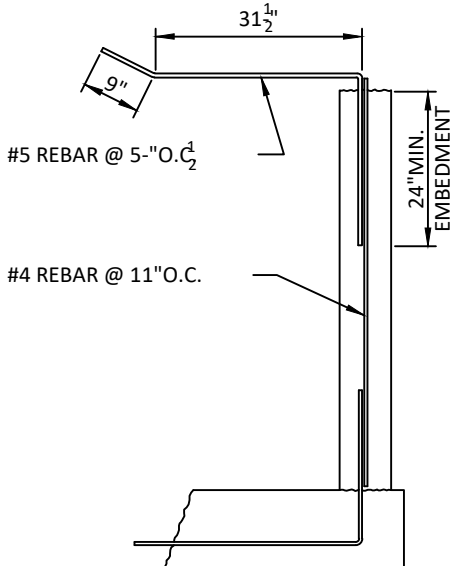
**CURB OPENING INLET  
TYPE 'R' MODIFIED**

**S12.4**

# STANDARD



**SECTION B-B  
TYPICAL END VIEW**



**BENDING DETAIL**

INLET RING AND COVER TO CONFORM TO STANDARD DETAIL S12.1

STEPS SHALL BE AS SPECIFIED IN DETAILS 105 AND 106 OF CITY OF AURORA PUBLIC UTILITY IMPROVEMENTS RULES AND REGULATIONS REGARDING STANDARDS AND SPECIFICATIONS: WATER, SANITARY, STORM SEWER.

ALL #4 REBAR SHALL BE GRADE 40.

ALL #5 AND LARGER REBAR SHALL BE GRADE 60.

q:\2022\roadway specs\dwgs\s12-5.dwg 15 November 2021

City of Aurora, Colorado

5 of 11

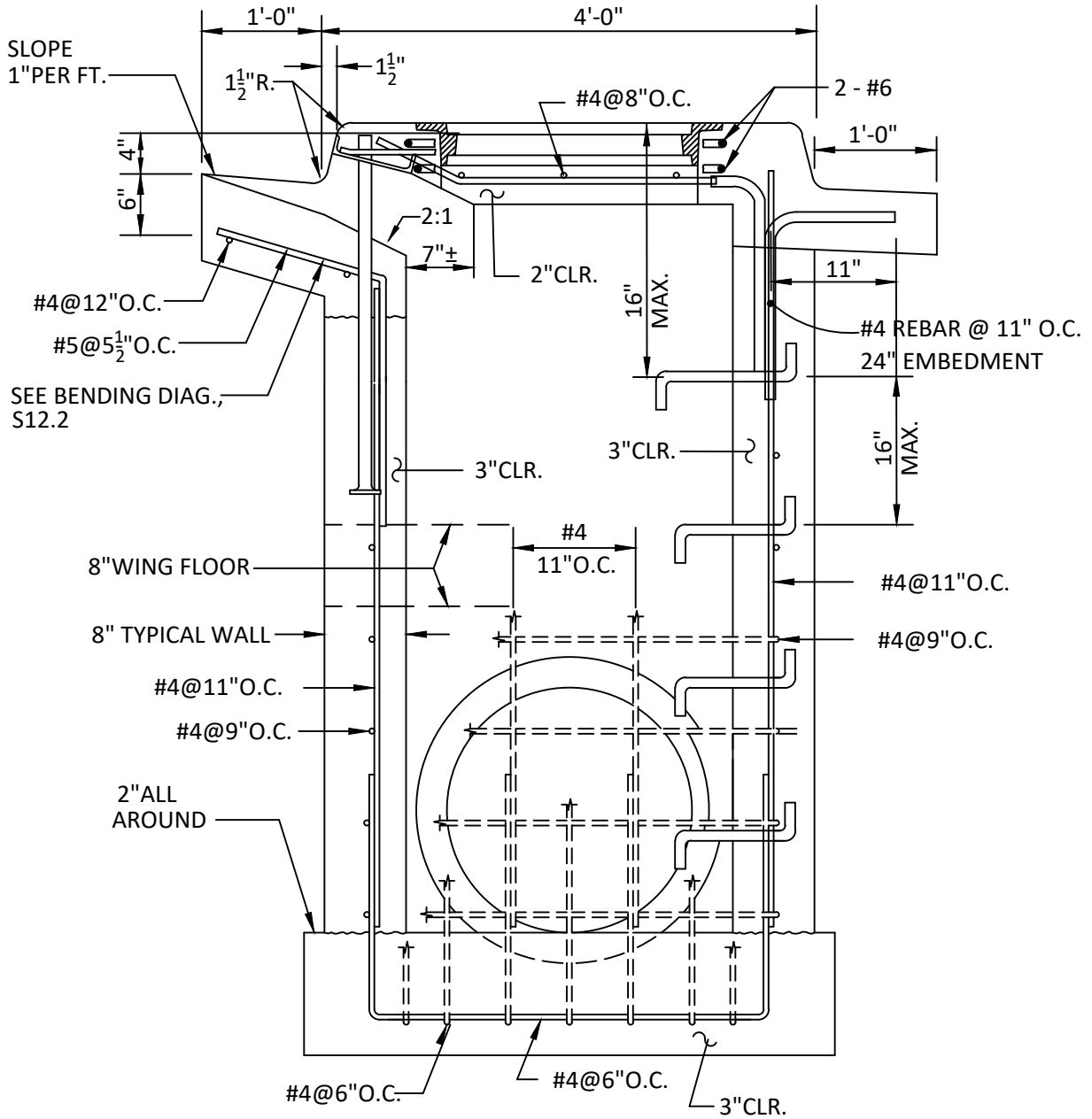
*Helen B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

**CURB OPENING INLET  
TYPE 'R' MODIFIED**

**S12.5**

# STANDARD



## TYPICAL END VIEW

REFER TO STANDARD S 12.5  
FOR REINFORCING INFORMATION  
AND NOTES

City of Aurora, Colorado

**MEDIAN ISLAND CURB  
OPENING INLET TYPE 'R'  
MODIFIED**

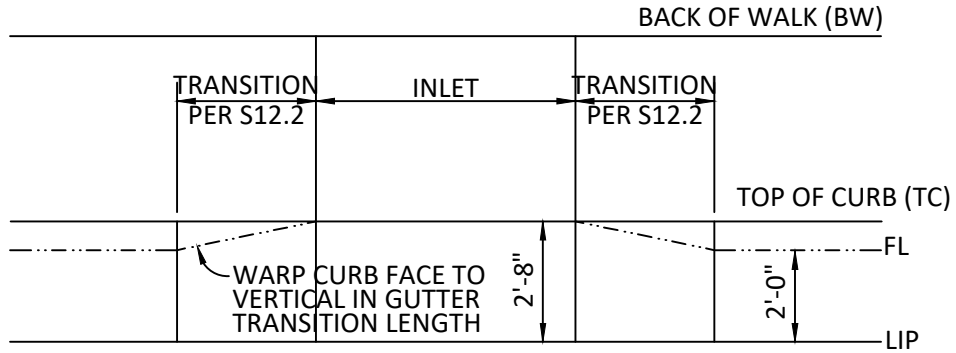
6 of 11

**S12.6**

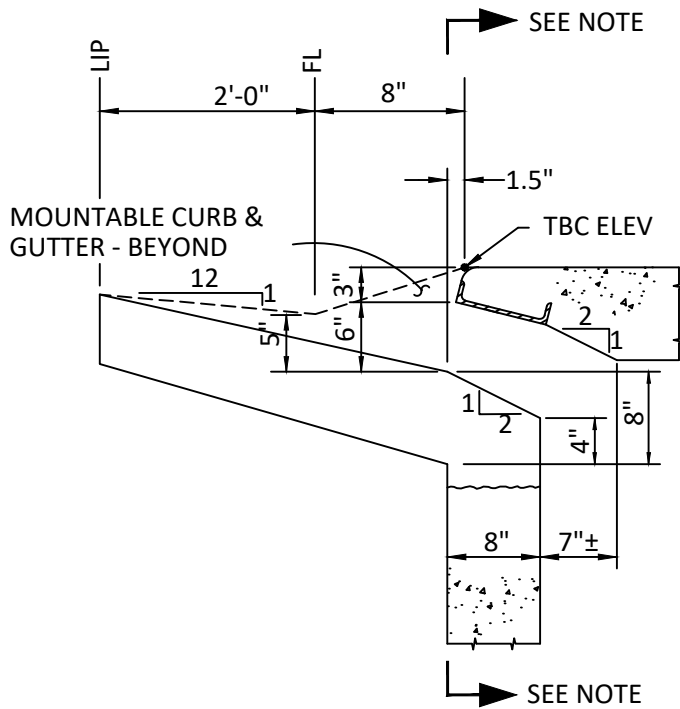
*Heley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD

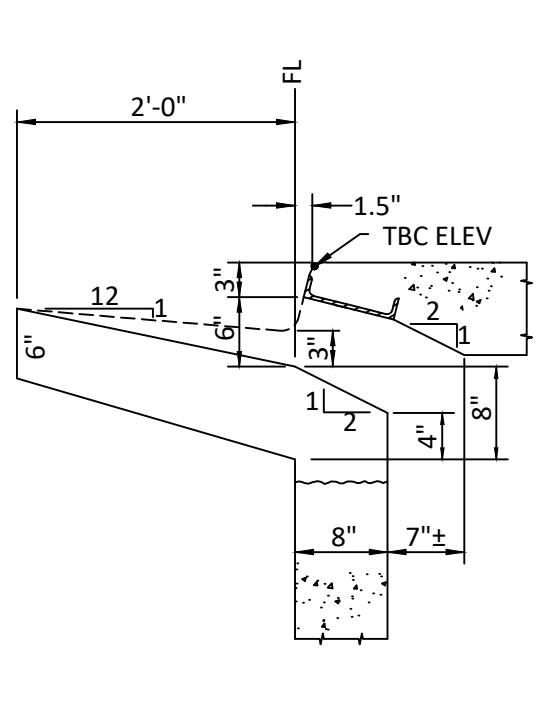


PLAN  
TRANSITION MOUNTABLE CURB & GUTTER TO CURB OPENING INLET



NOTE:  
ALL CONSTRUCTION THIS POINT BACK  
SHALL CONFORM TO S12.1-S12.5.

THROAT CONFIGURATION DETAIL  
CURB OPENING INLET WITH  
MOUNTABLE CURB & GUTTER



NOTE:  
REFER TO S12.1-S12.5 FOR COMPLETE  
CONSTRUCTION DETAILS.

THROAT CONFIGURATION DETAIL  
CURB OPENING INLET WITH  
VERTICAL CURB & GUTTER

q:\2022\roadway specs\dwgs\s12-7.dwg 15 November 2021

City of Aurora, Colorado

*Heley B. Johnson*  
CITY ENGINEER

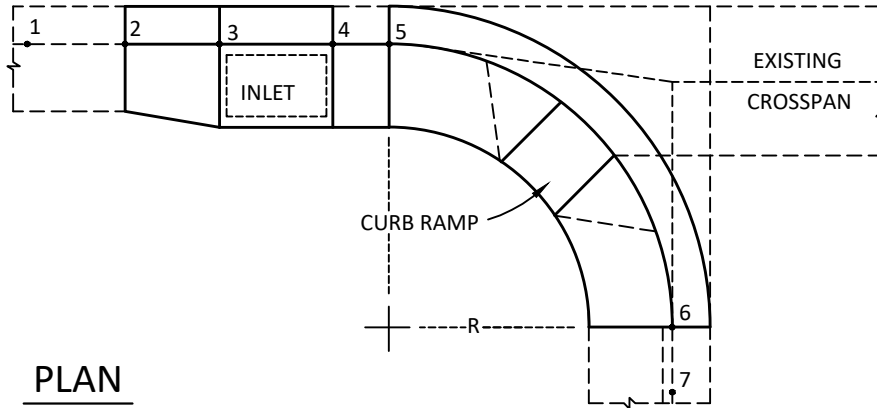
01/31/2023  
DATE

**CURB OPENING INLET  
TYPE R MODIFIED**

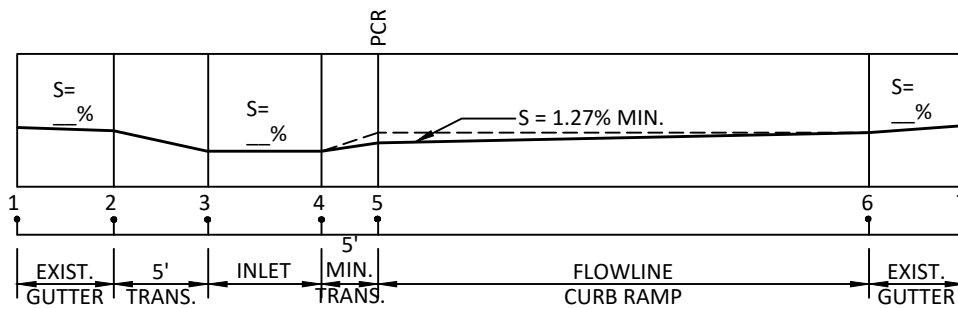
7 of 11

**S12.7**

# STANDARD



**PLAN**



**PROFILE**

## DETAIL FOR MINIMUM SLOPE OF FLOWLINE ALONG CURB

FROM - TO	SLOPE DESCRIPTION
1 - 2	EXISTING OR CORRECTED SLOPE OF THE FLOWLINE
2 - 3	VERTICAL TRANSITION OF THE FLOWLINE
3 - 4	THE SLOPE OF THE FLOWLINE SHALL BE PARALLEL WITH THE STREET
4 - 5	TRANSITION OF THE SLOPE UP TO THE INTERSECTION WITH 1.27% SLOPE
5 - 6	MINIMUM SLOPE OF 1.27% ALONG CURB FLOWLINE
6 - 7	EXISTING OR CORRECTED SLOPE OF THE FLOWLINE

NOTE: FOR RETROFITTING WHERE REPLACING PREVIOUS INLET WITH NEW INLET

City of Aurora, Colorado

**SPECIAL RETROFIT CURB  
OPENING INLET TYPE R  
MODIFIED**

8 of 11

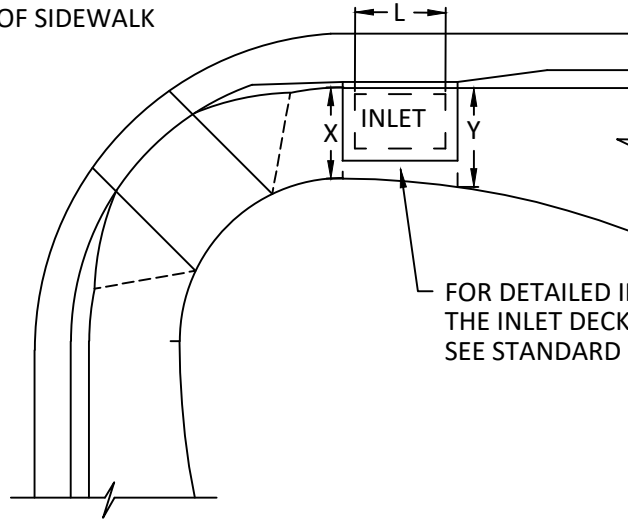
**S12.8**

*Heidi Blumhauer*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD

EXPANSION JOINTS SHALL  
EXTEND FROM THE SIDES OF  
INLETS TO BACK OF SIDEWALK

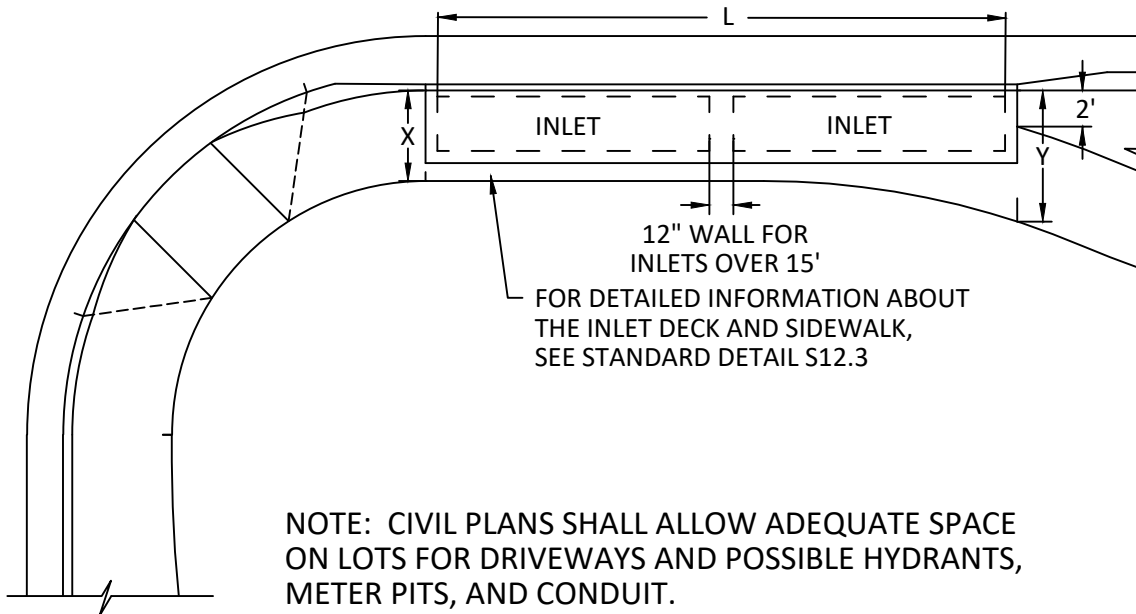


FOR DETAILED INFORMATION ABOUT  
THE INLET DECK AND SIDEWALK,  
SEE STANDARD DETAIL S12.3

## SIDEWALK DIMENSIONS AT INLET

FOR INLET LENGTH (L) UP TO 12' LOCALS, 15' COLLECTORS, AND 18' 6 LANE ARTERIALS

EXPANSION JOINTS SHALL  
EXTEND FROM THE SIDES OF  
INLETS TO BACK OF SIDEWALK



FOR DETAILED INFORMATION ABOUT  
THE INLET DECK AND SIDEWALK,  
SEE STANDARD DETAIL S12.3

NOTE: CIVIL PLANS SHALL ALLOW ADEQUATE SPACE  
ON LOTS FOR DRIVEWAYS AND POSSIBLE HYDRANTS,  
METER PITS, AND CONDUIT.

## SIDEWALK DIMENSIONS AT INLET

FOR INLET LENGTH (L) UP TO 30'

SCALE 1"=10'

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City of Aurora, Colorado

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CITY ENGINEER

01/31/2023  
DATE

**CURB RAMPS**  
**(INLET CONSTRUCTION)**  
(SEE DETAIL S12.10 FOR DIMENSIONS)

9 of 11

**S12.9**



# STANDARD

INLET LENGTH <b>L =</b>	X=5'	X=5'	X=8'	X=10'
	5' SIDEWALK **50' RADIUS LOCAL 1,2,3 (ALSO LOCAL @ COLLECTOR)	5' SIDEWALK **75' RADIUS COLLECTOR	8' SIDEWALK **100' RADIUS 4 LANE ARTERIAL	10' SIDEWALK **100' RADIUS 6 LANE ARTERIAL
	Y	Y	Y	Y
3'	5' 3"	5' 7"	8' 1"	10' 1"
5'	5' 5"	5' 8"	8' 3"	10' 3"
10'	6' 5"	6' 2"	8' 8"	10' 9"
15'	7' 3"	7' 1"	9' 6"	11' 6"
20'	7' 3"	7' 3"	10' 2"	12' 3"
30'	7' 3"	7' 3"	10' 2"	12' 3"

COLLECTOR @ 6 LANE ARTERIAL - WITH A 14' 6" RADIUS AT BACK OF WALK, X & Y EQUAL 10' FOR ANY LENGTH OF INLET.

\*\* = RADIUS AT BACK OF WALK (SEE DETAIL S9.8)

NOTES: 5' SIDEWALKS SHALL BE POURED MONOLITHICALLY WITH INLET DECK.  
8' AND 10' SIDEWALKS SHALL BE POURED SEPARATE FROM INLET DECKS AND SEPARATED BY 1/2" EXPANSION JOINT.

THESE STREET COMBINATIONS ARE BY FAR THE MOST COMMON. THERE ARE OTHER POSSIBLE STREET COMBINATIONS NOT PRESENTED HERE. IN THESE CASES, THE INLET AND WALK LAYOUT SHALL FOLLOW DETAIL S9.8.

## SIDEWALK DIMENSIONS AT INLET

City of Aurora, Colorado

  
CITY ENGINEER

01/31/2023  
DATE

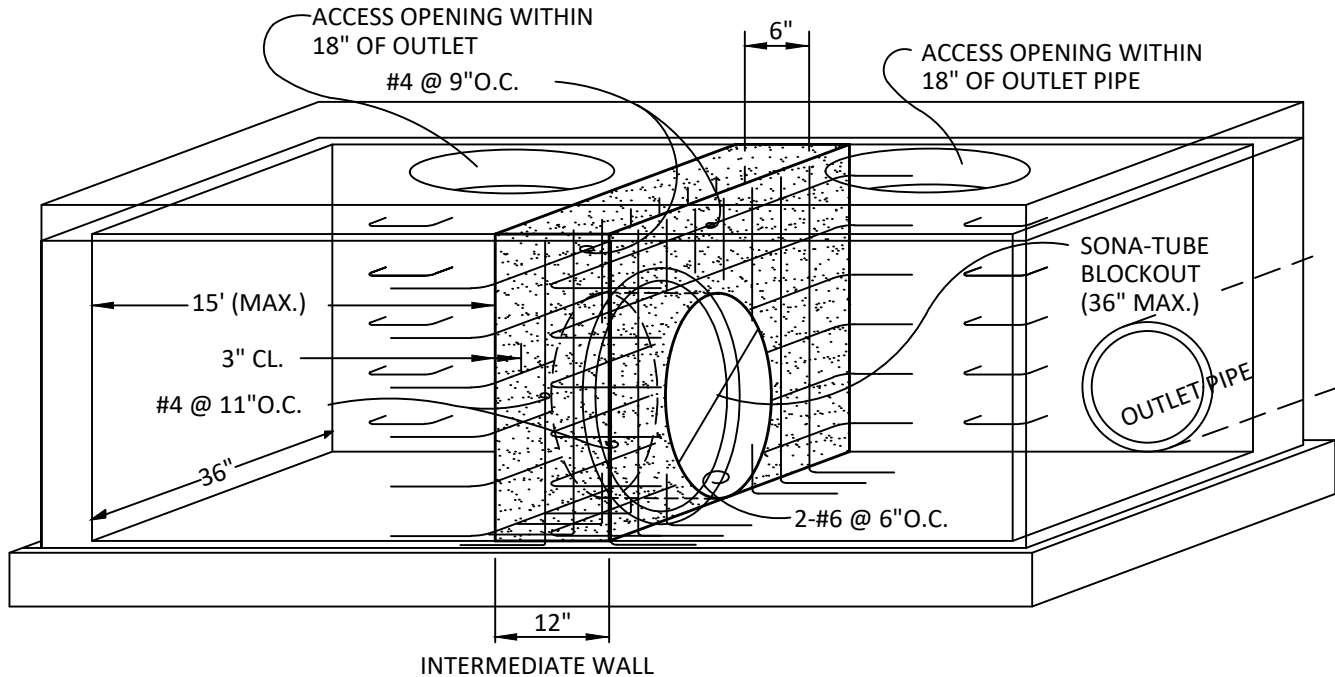
**CURB RAMPS  
(INLET CONSTRUCTION)**  
(SEE DETAIL S12.9 FOR USE OF THIS TABLE)

10 of 11

**S12.10**

# STANDARD

INLET DECK IS SHOWN WITHOUT CURB OPENING



## NOTES

1. PROVIDE A 1 1/2" DEEP CONTROL JOINT THROUGH THE INLET DECK AT EACH INTERMEDIATE WALL PER S7.3 OF THE "ROADWAY DESIGN & CONSTRUCTION SPECIFICATIONS". THE JOINT SHALL EXTEND FROM THE BACK OF THE DECK TO THE FACE OF THE GUTTER PAN.
2. INLET DECK REINFORCEMENT STEEL SHALL BE CONTINUOUS WITH SPLICE LENGTHS OF NO LESS THAN 18". INTERMEDIATE WALL STEEL SHALL TIE INTO THE OUTSIDE WALLS AND FLOOR PER STANDARD DETAILS.
3. ALL INTERMEDIATE WALL CONSTRUCTION SHALL CONFORM TO STANDARD CONSTRUCTION SPECIFICATION AS SHOWN IN STANDARD DETAILS #400, 1 THRU 7 UNLESS OTHERWISE NOTED.

City of Aurora, Colorado

11 of 11

**TYPE 'R' INLET**  
(GREATER THAN 15' IN LENGTH)

**S12.11**

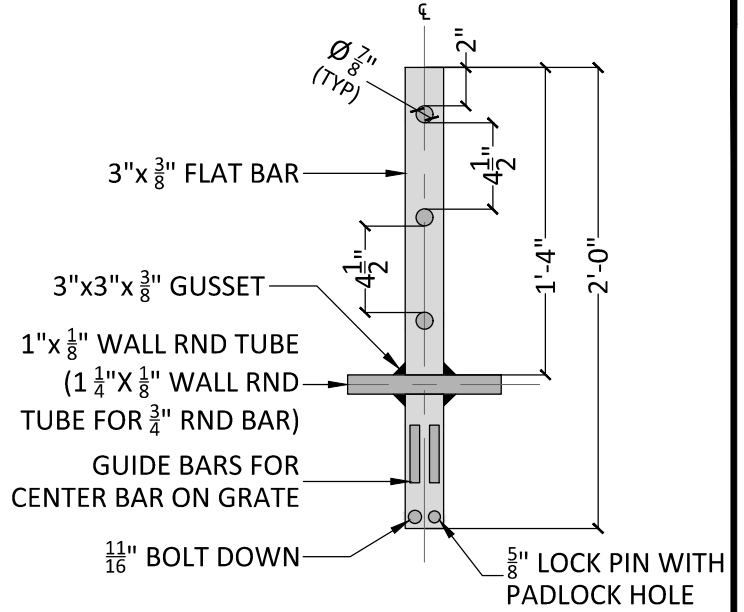
*Heley B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

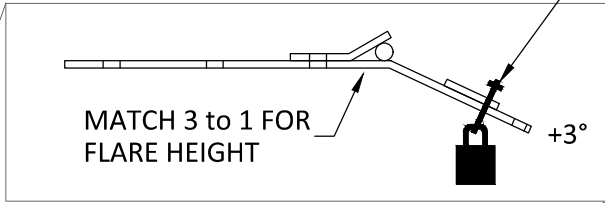
# STANDARD

**NOTES:**

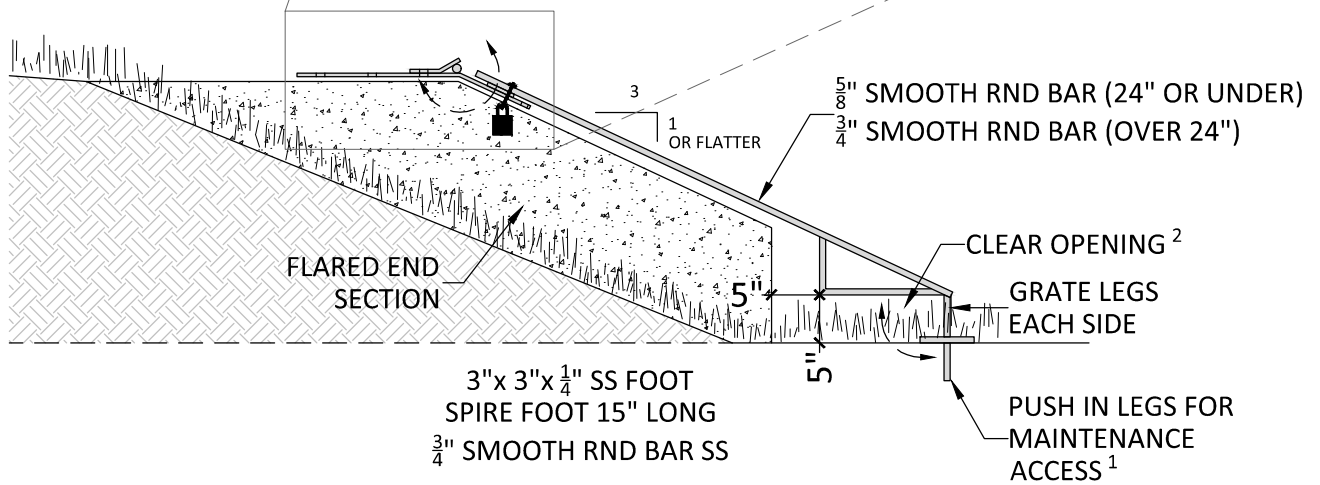
1. LEGS FOLD UP INTO GRATE WHEN NOT ACCESSING. LENGTH OF FOLD DOWN LEG EQUAL TO PIPE DIAMETER. CULVERTS 36" AND SMALLER PROVIDE ONE LEG IN CENTER OF GRATE; LARGER THAN 36" PROVIDE TWO LEGS APPROXIMATELY 6" IN FROM GRATE LEGS.
2. NO CLEAR OPENING SHALL EXCEED 5" ON ANY PART OF THE SAFETY GRATE, THE DISTANCE FROM LOWER HORIZONTAL BAR TO ANY PART OF THE GROUND, OR THE SIDE OF THE GRATE TO SIDE OF THE END SECTION.
3. PADLOCK SHALL BE 2396 LOCK/KEY
4. MATERIAL SHALL BE GALVANIZED STEEL
5. SEE UDFCD STORM DRAINAGE CRITERIA MANUAL FOR ADDITIONAL SAFETY GRATE REQUIREMENTS.
6. CIVIL PLANS SHALL INCLUDE COMPLETE DETAIL OF PROPOSED SAFETY GRATE



PAD LOCK FOR PRIVATE FACILITIES SHALL BE INSTALLED PRIOR TO CERTIFICATE OF OCCUPANCY



5/8" LOCK PIN WITH PADLOCK HOLE; PAD LOCK TO BE INSTALLED BY AURORA WATER UPON ACCEPTANCE OF PUBLIC UTILITIES;



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City of Aurora, Colorado

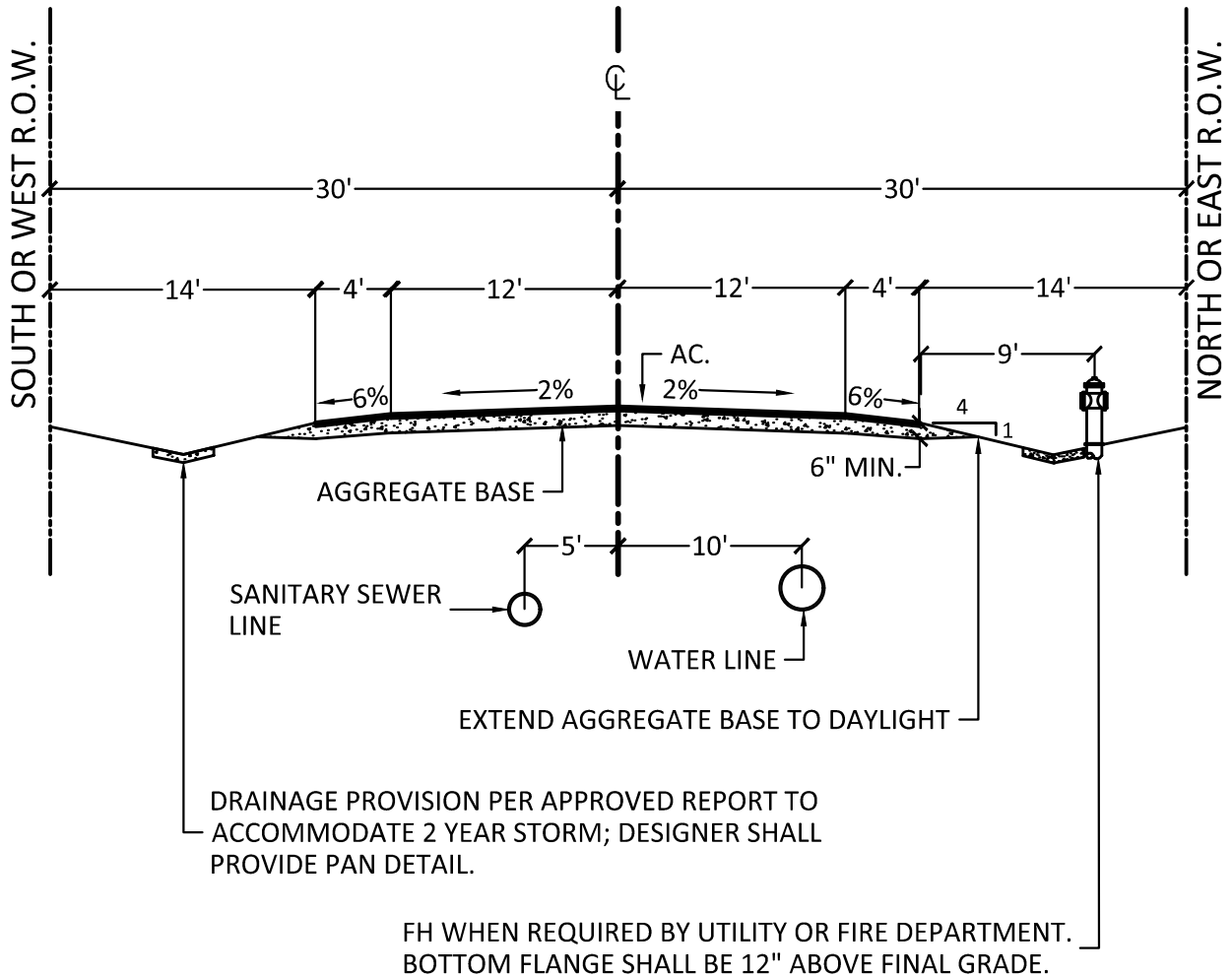
*Helen B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

**SAFETY GRATE HINGE  
DETAIL FOR END  
SECTIONS**

**S12.12**

# STANDARD



\* ACTUAL PAVEMENT SECTION DETERMINED BY APPROVED PAVEMENT DESIGN REPORT

LOW DENSITY, SINGLE FAMILY RESIDENTIAL, 30 ACRE MINIMUM DEVELOPMENT, MAXIMUM TWO DWELLING UNITS PER ACRE, MINIMUM LOT SIZE 0.4 ACRES [SECTION 4.04.2.04, ROADWAY DESIGN AND SPECIFICATIONS MANUAL]

SCALE 1"=10'

q:\2022-roadway specs\dwgs\s13.1.dwg 18 January 2023

City of Aurora, Colorado

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CITY ENGINEER

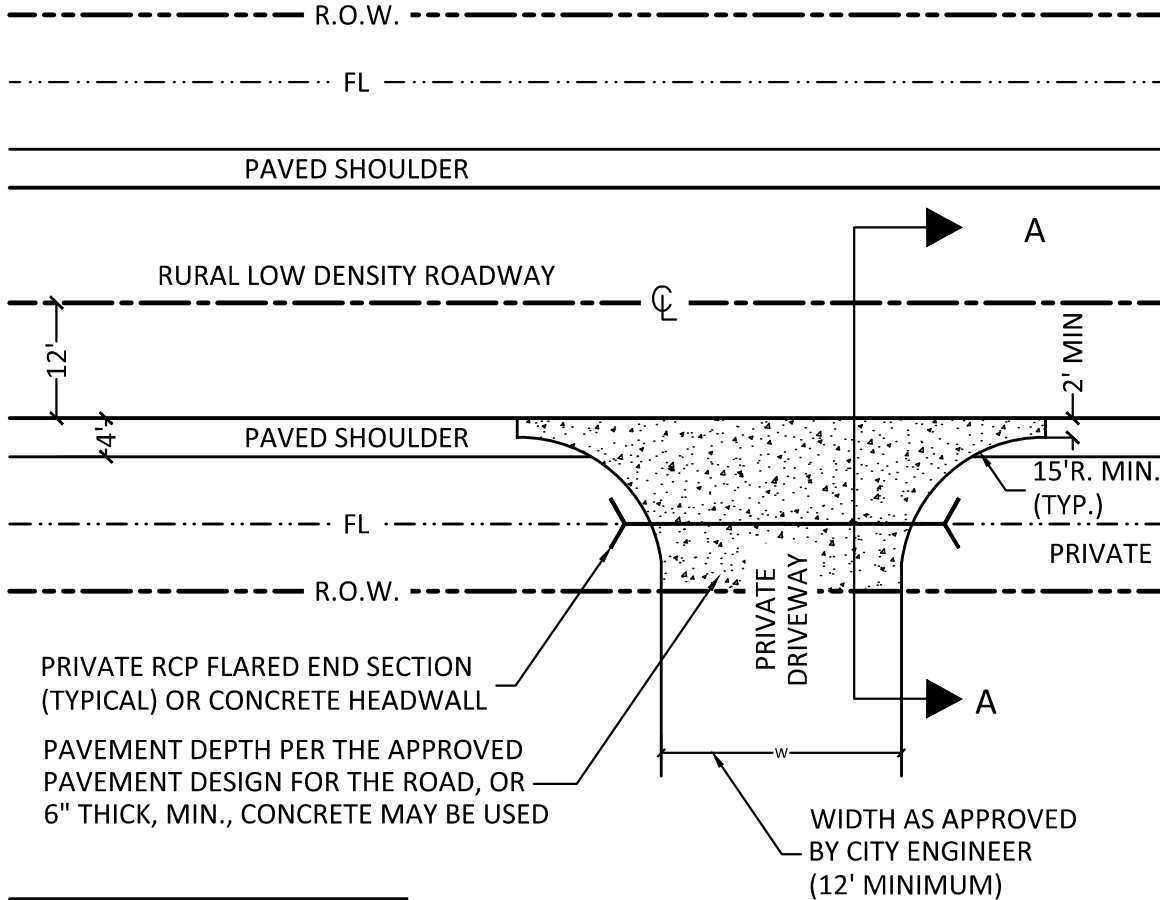
01/31/2023  
DATE

**RURAL  
LOW DENSITY  
ROADWAY**

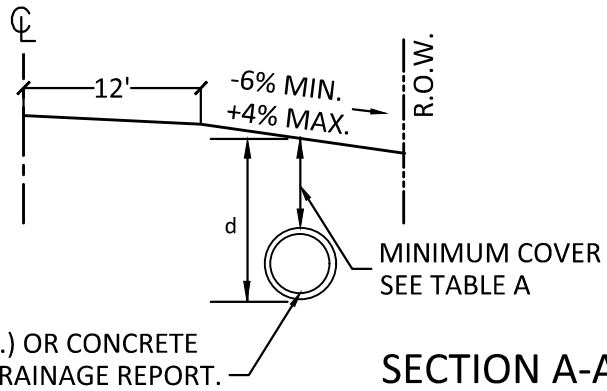
1 of 5

**S13.1**

# STANDARD



PIPE	MINIMUM COVER
RCP/NRCP	1.00'
CMP (16 GA.)	2.00'
HDPE (40 psi)	2.00'
PVC (46 psi)	2.00'



PRIVATE PIPE (18" MIN.) OR CONCRETE PAN PER APPROVED DRAINAGE REPORT.  
 PIPE LENGTH =  $W + 8d$ .

ALL PIPE SHALL COMPLY WITH APPLICABLE AASHTO STANDARDS. FOR PIPES LARGER THAN 18", SUBMIT MIN. COVER DEPTHS & PIPE THICKNESS FOR REVIEW

NOT TO SCALE

City of Aurora, Colorado

RURAL  
 LOW DENSITY  
 ROADWAY

2 of 5

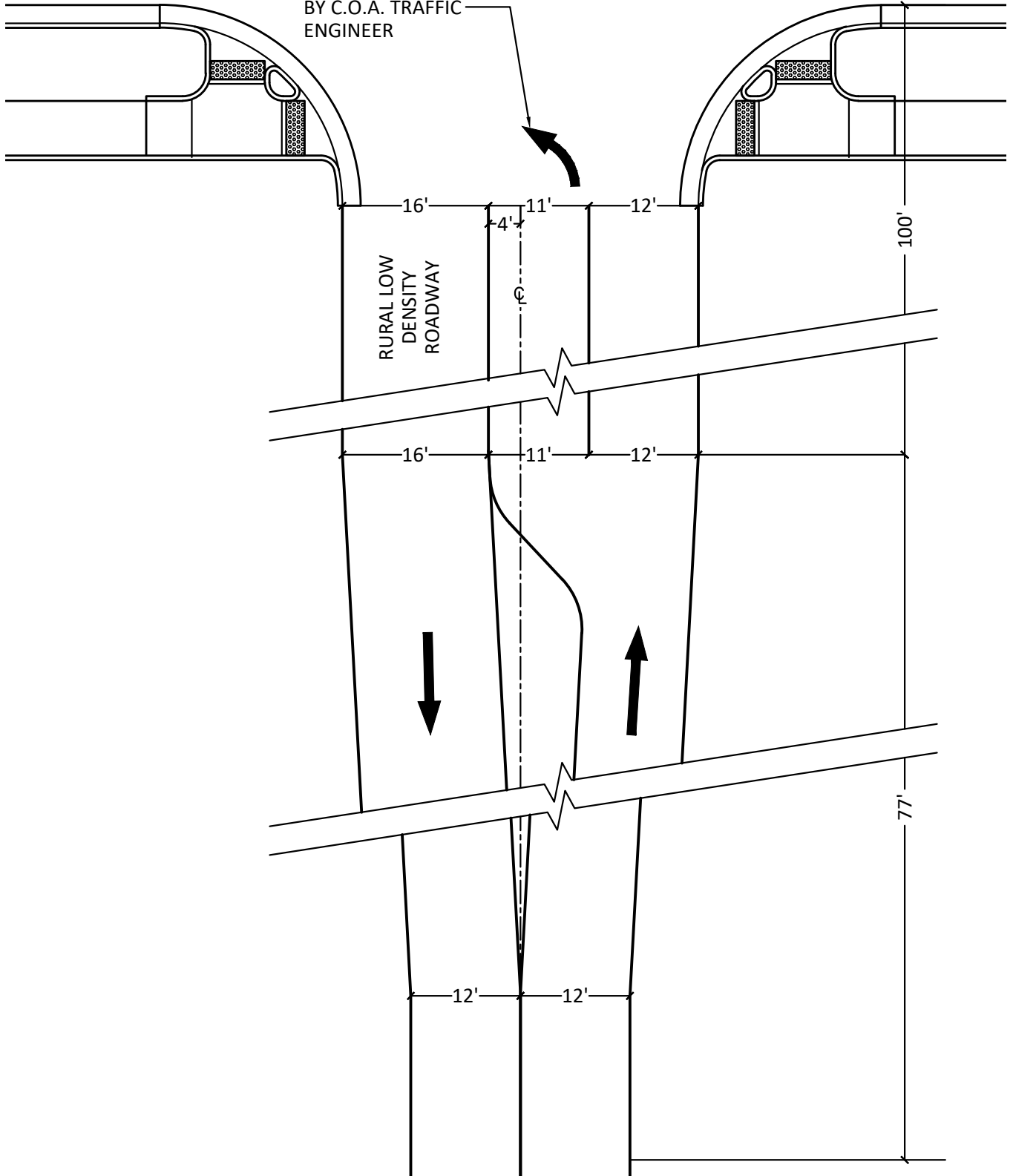
S13.2

*Heley B. Johnson*  
 CITY ENGINEER

01/31/2023  
 DATE

# STANDARD

WHEN REQUIRED  
BY C.O.A. TRAFFIC  
ENGINEER



City of Aurora, Colorado

RURAL  
LOW DENSITY  
ROADWAY

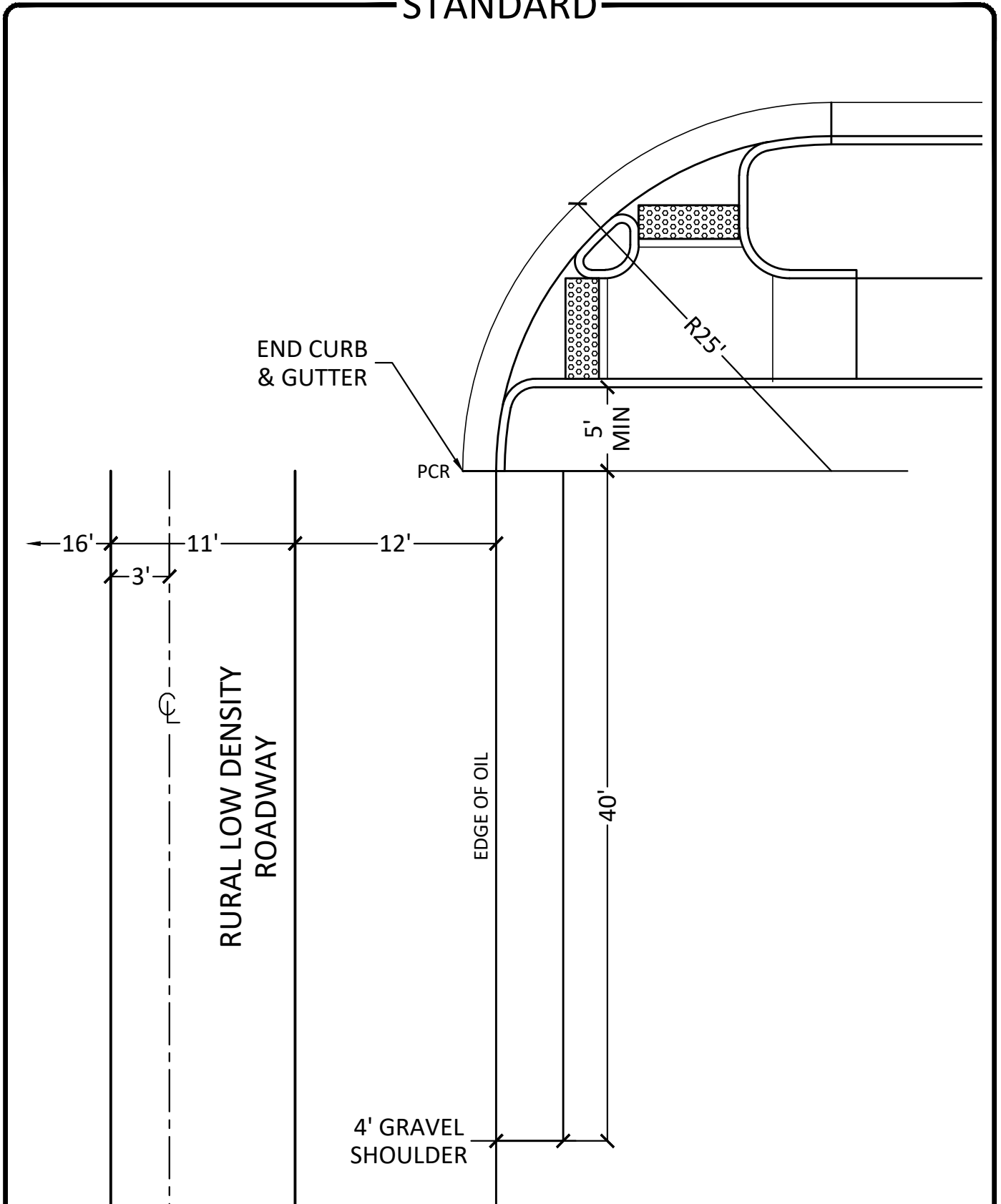
3 of 5

S13.3

*Helen B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

STANDARD



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City of Aurora, Colorado

*Helen B. Johnson*  
CITY ENGINEER

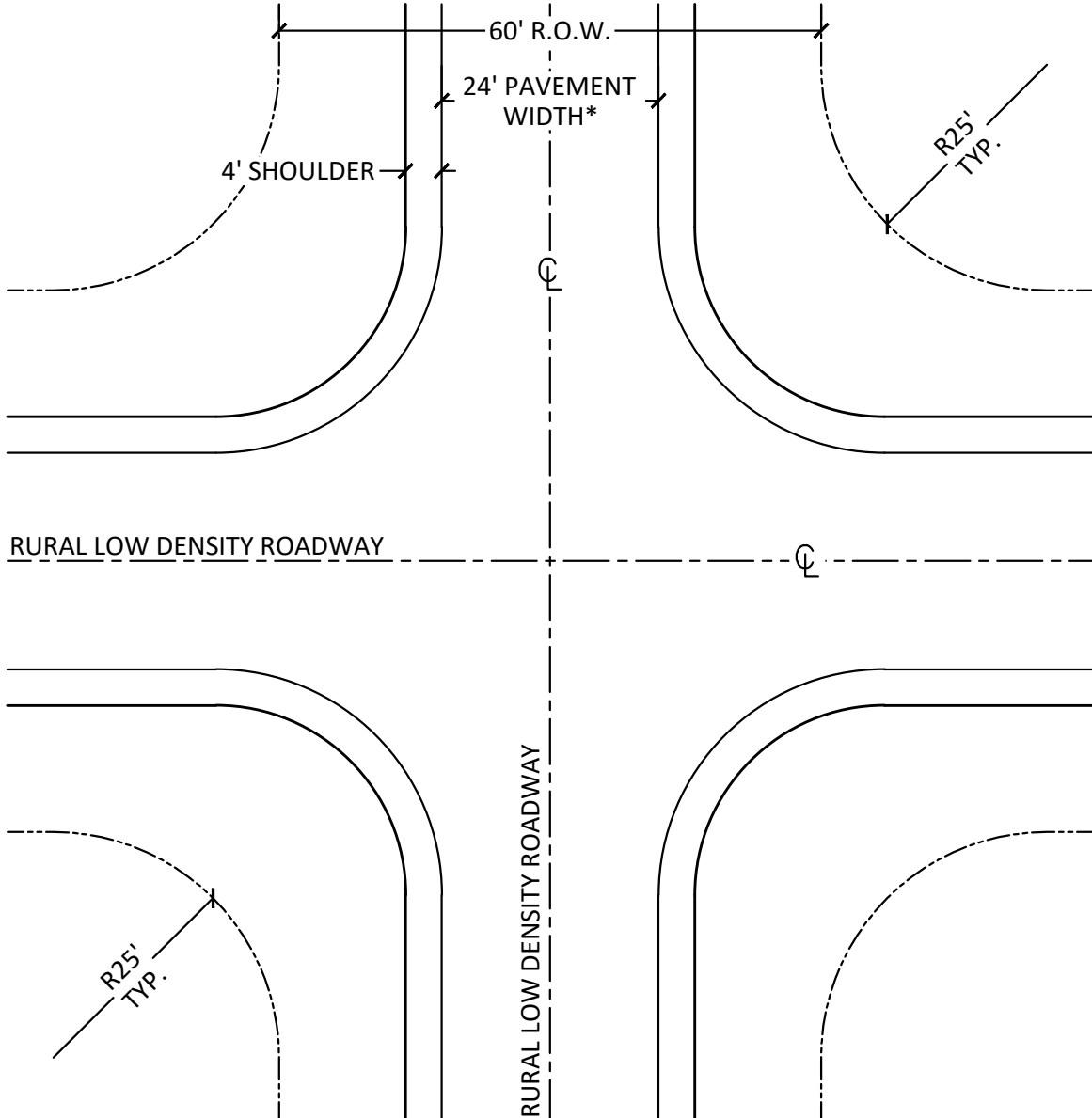
01/31/2023  
DATE

RURAL  
LOW DENSITY  
ROADWAY

4 of 5  
S13.4

# STANDARD

\* THIS WIDTH MAY WIDEN IF LEFT TURN LANE IS REQUIRED BY TRAFFIC ENGINEER



NOT TO SCALE

City of Aurora, Colorado

*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

RURAL  
LOW DENSITY  
ROADWAY

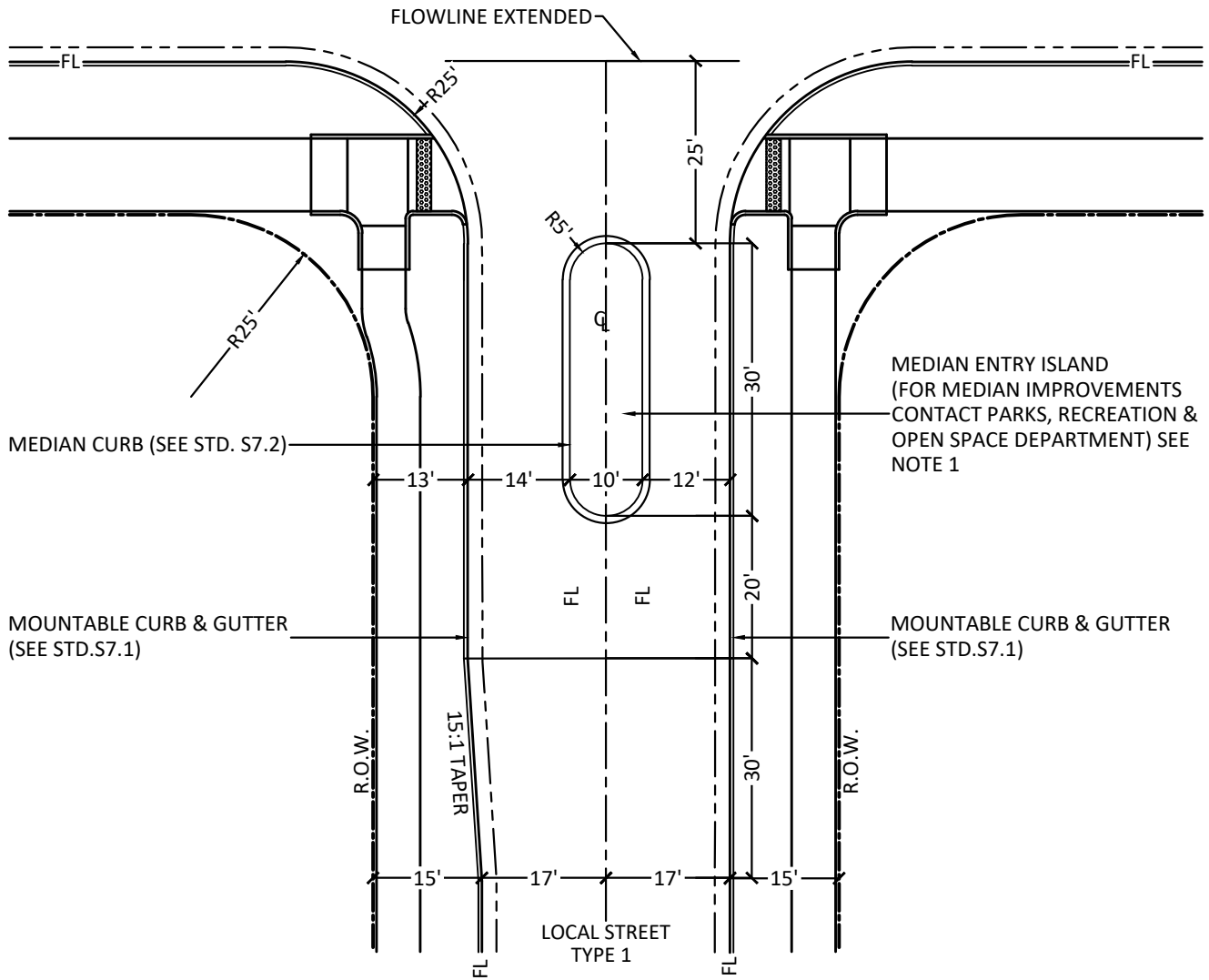
5 of 5

S13.5



# STANDARD

## ARTERIAL STREET INTERSECTION



MEDIAN ENTRY ISLAND  
(FOR MEDIAN IMPROVEMENTS  
CONTACT PARKS, RECREATION &  
OPEN SPACE DEPARTMENT) SEE  
NOTE 1

MEDIAN CURB (SEE STD. S7.2)

MOUNTABLE CURB & GUTTER  
(SEE STD.S7.1)

MOUNTABLE CURB & GUTTER  
(SEE STD.S7.1)

LOCAL STREET  
TYPE 1

**NOTE 1:**

THE INTERIOR OF THE MEDIAN ISLAND (BACK OF MEDIAN CURB TO BACK OF MEDIAN CURB) SHALL BE MAINTAINED BY THE HOA OR METROPOLITAN DISTRICT.

NOT TO SCALE

City of Aurora, Colorado

*Haley B. Anderson*  
CITY ENGINEER

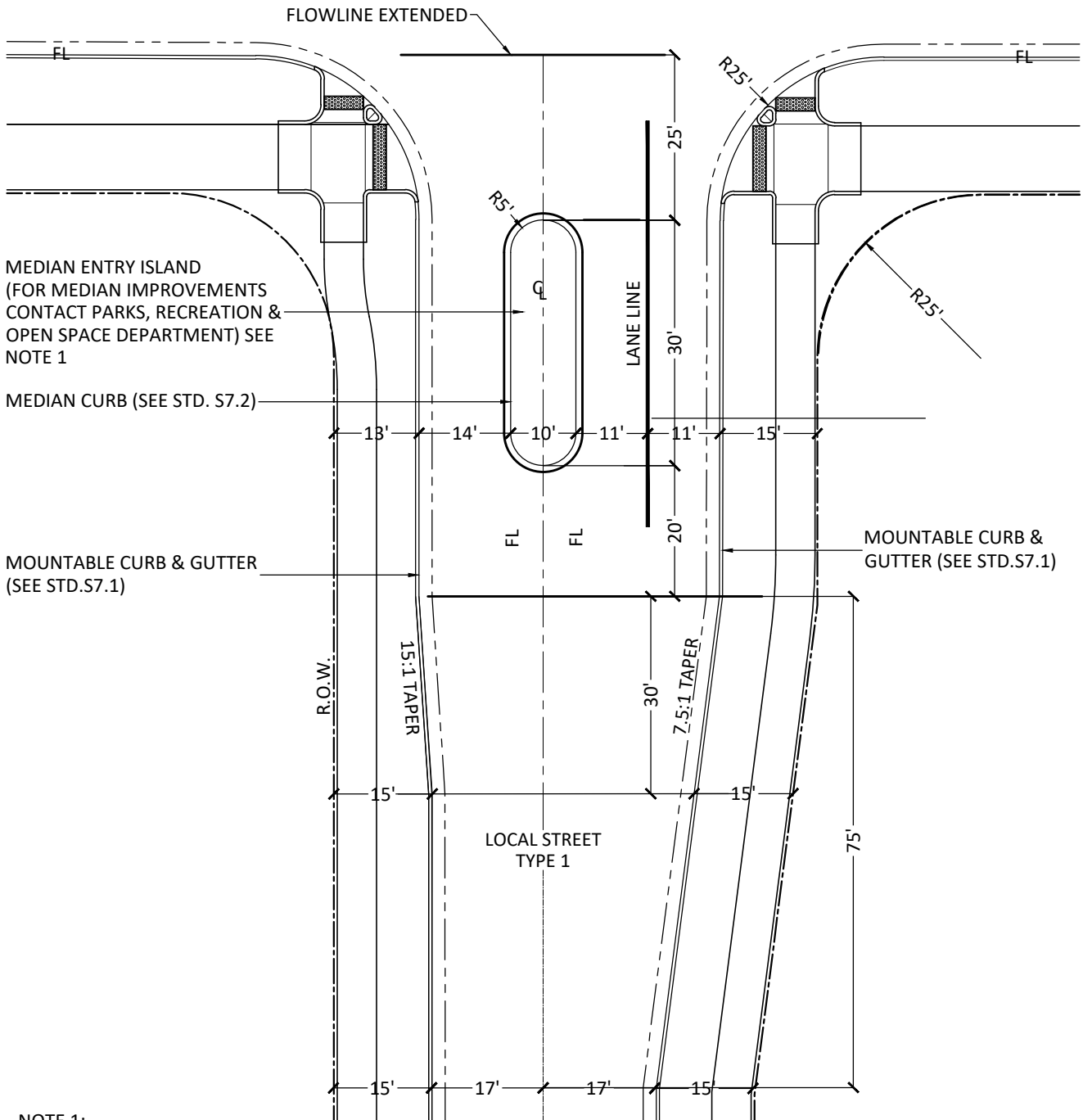
01/31/2023  
DATE

**INTERSECTION**  
**TYPE 1 LOCAL & ARTERIAL**  
(WITHOUT FULL INTERSECTION MOVEMENT)

**S14.1**

# STANDARD

## ARTERIAL STREET INTERSECTION



MEDIAN ENTRY ISLAND  
(FOR MEDIAN IMPROVEMENTS  
CONTACT PARKS, RECREATION &  
OPEN SPACE DEPARTMENT) SEE  
NOTE 1

MEDIAN CURB (SEE STD. S7.2)

MOUNTABLE CURB & GUTTER  
(SEE STD.S7.1)

MOUNTABLE CURB &  
GUTTER (SEE STD.S7.1)

LOCAL STREET  
TYPE 1

**NOTE 1:**

THE INTERIOR OF THE MEDIAN ISLAND (BACK OF MEDIAN CURB TO BACK OF MEDIAN CURB) SHALL BE MAINTAINED BY THE HOA OR METROPOLITAN DISTRICT.

NOT TO SCALE

City of Aurora, Colorado

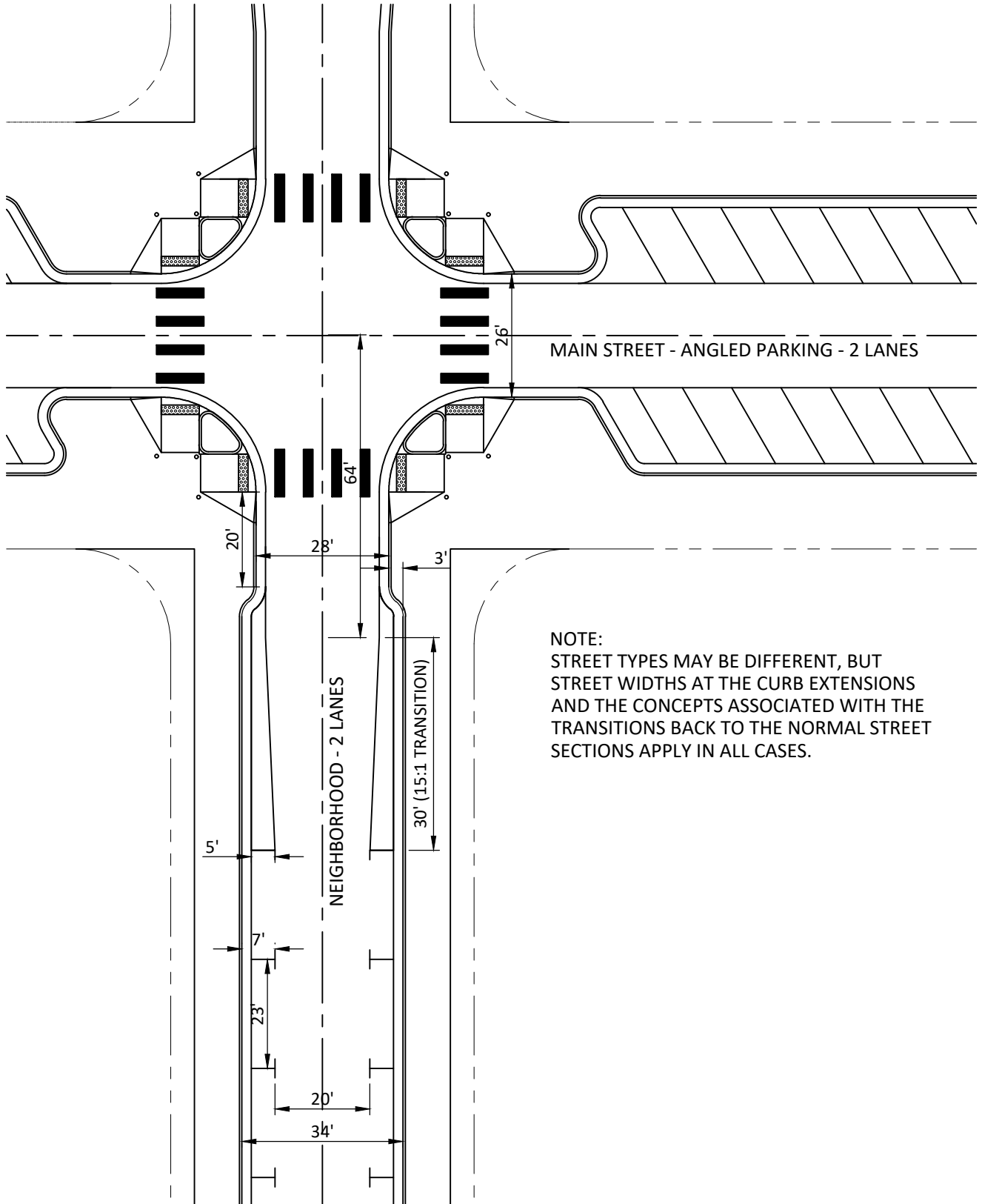
*Haley B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

**INTERSECTION**  
**TYPE 1 LOCAL & ARTERIAL**  
(WITH FULL INTERSECTION MOVEMENT)

**S14.2**

# STANDARD



NOTE:  
STREET TYPES MAY BE DIFFERENT, BUT  
STREET WIDTHS AT THE CURB EXTENSIONS  
AND THE CONCEPTS ASSOCIATED WITH THE  
TRANSITIONS BACK TO THE NORMAL STREET  
SECTIONS APPLY IN ALL CASES.

City of Aurora, Colorado

URBAN CENTER OR TOD  
INTERSECTION - TYPICAL

14.3

*Haley B. Hansen*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD

THIS DETAIL SECTION  
RESERVED FOR FUTURE  
UPDATES

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City of Aurora, Colorado

RESERVED

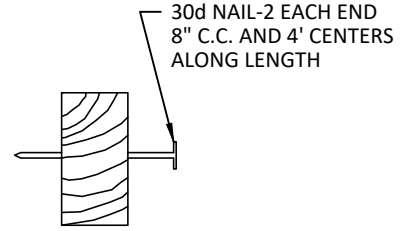
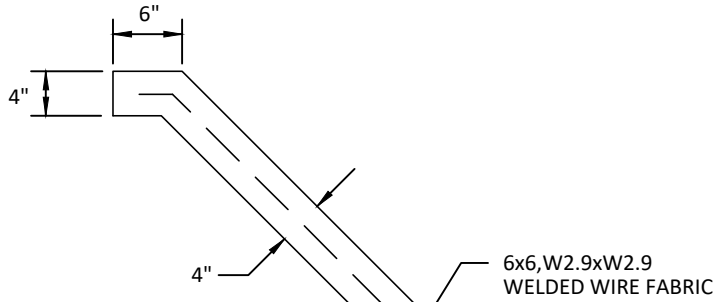
1 OF 1

S15.1

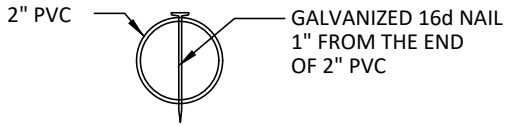
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CITY ENGINEER

\_\_\_\_\_  
DATE

# STANDARD

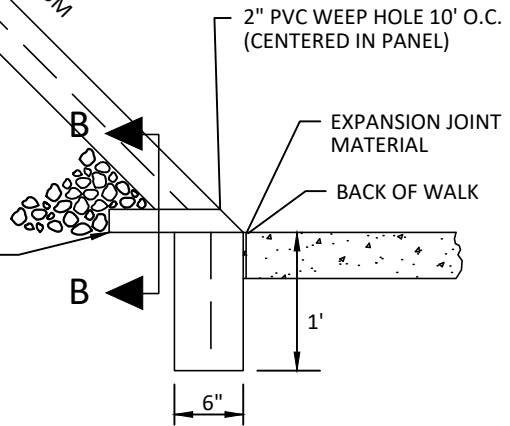


**HEADER ANCHOR**

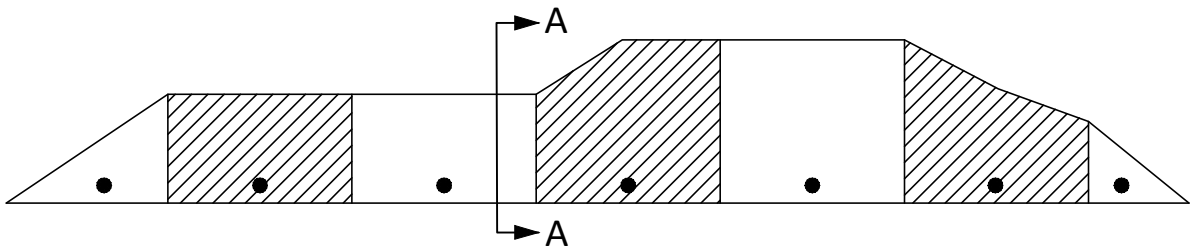


**SECTION B-B**

1.5 cf OF 1 1/2" CLEAN ROCK WRAPPED  
IN MIRAFI AROUND WEEP HOLE.  
EXTEND PIPE 4" INTO GRAVEL.



**SECTION A-A**



NOTE: FACE OF SLOPE PAVING TO BE ALTERNATING EXPOSED AGGREGATE FINISHED CONCRETE PANELS. INSTALL 2x4 (SELECT HEART OR BETTER GRADE) REDWOOD HEADERS BETWEEN 10' PANELS TO MATCH SIDEWALK JOINTS. HEADERS WILL REMAIN IN PLACE.

City of Aurora, Colorado

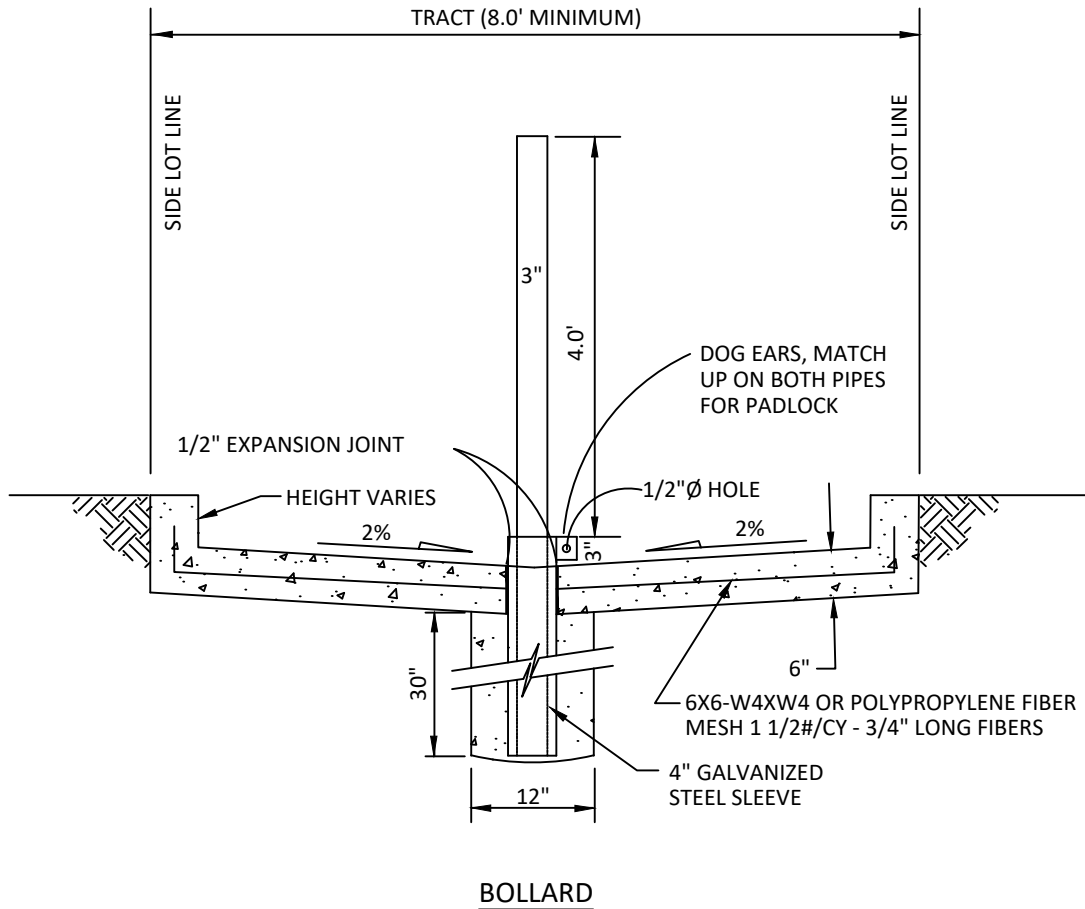
**SLOPE PAVING**

**S16.1**

*Helen Blomquist*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



1. AT NO TIME SHALL THE DISTANCE BETWEEN BOLLARDS BE GREATER THAN 5'.
2. ALL BOLLARDS, EXCEPT FOR REMOVABLE POST, SHALL BE FILLED WITH CONCRETE.
3. ALL BOLLARDS SHALL BE GALVANIZED STEEL.
4. BOLLARDS SHALL BE SET 5' TO 7' BACK OF SIDEWALK.
5. CHANNEL WIDTH = TRACT WIDTH (UNLESS OTHERWISE APPROVED.)

City of Aurora, Colorado

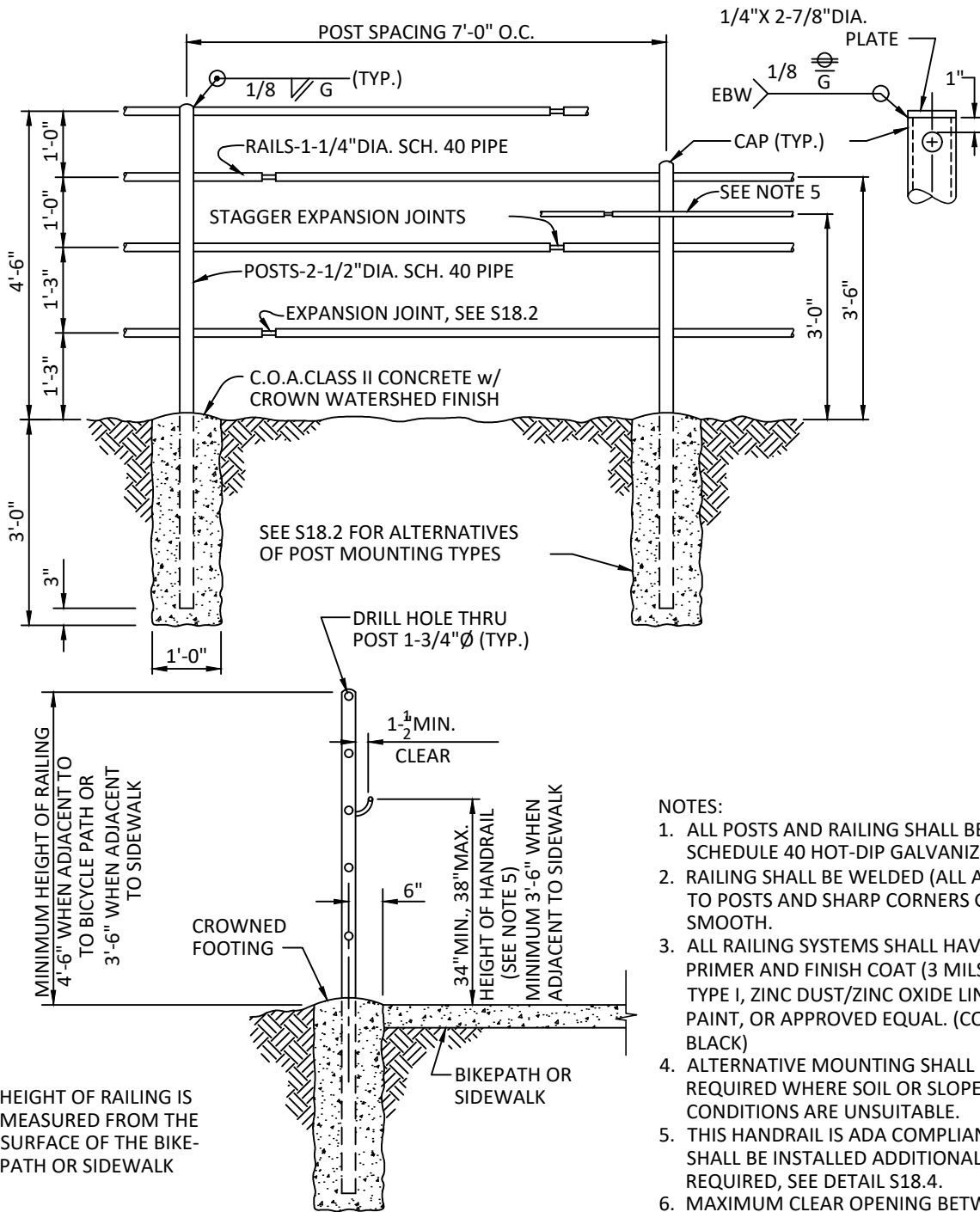
TYPICAL CONCRETE  
DRAINAGE PAN

S17.1

*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



HEIGHT OF RAILING IS MEASURED FROM THE SURFACE OF THE BIKE-PATH OR SIDEWALK

**NOTES:**

1. ALL POSTS AND RAILING SHALL BE SCHEDULE 40 HOT-DIP GALVANIZED PIPE.
2. RAILING SHALL BE WELDED (ALL AROUND) TO POSTS AND SHARP CORNERS GROUND SMOOTH.
3. ALL RAILING SYSTEMS SHALL HAVE A PRIMER AND FINISH COAT (3 MILS EACH) OF TYPE I, ZINC DUST/ZINC OXIDE LINSEED OIL PAINT, OR APPROVED EQUAL. (COLOR: BLACK)
4. ALTERNATIVE MOUNTING SHALL BE REQUIRED WHERE SOIL OR SLOPE CONDITIONS ARE UNSUITABLE.
5. THIS HANDRAIL IS ADA COMPLIANT & SHALL BE INSTALLED ADDITIONALLY WHEN REQUIRED, SEE DETAIL S18.4.
6. MAXIMUM CLEAR OPENING BETWEEN RAILS AND BETWEEN BOTTOM RAIL OR PATH IS 1'-3"

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CITY ENGINEER

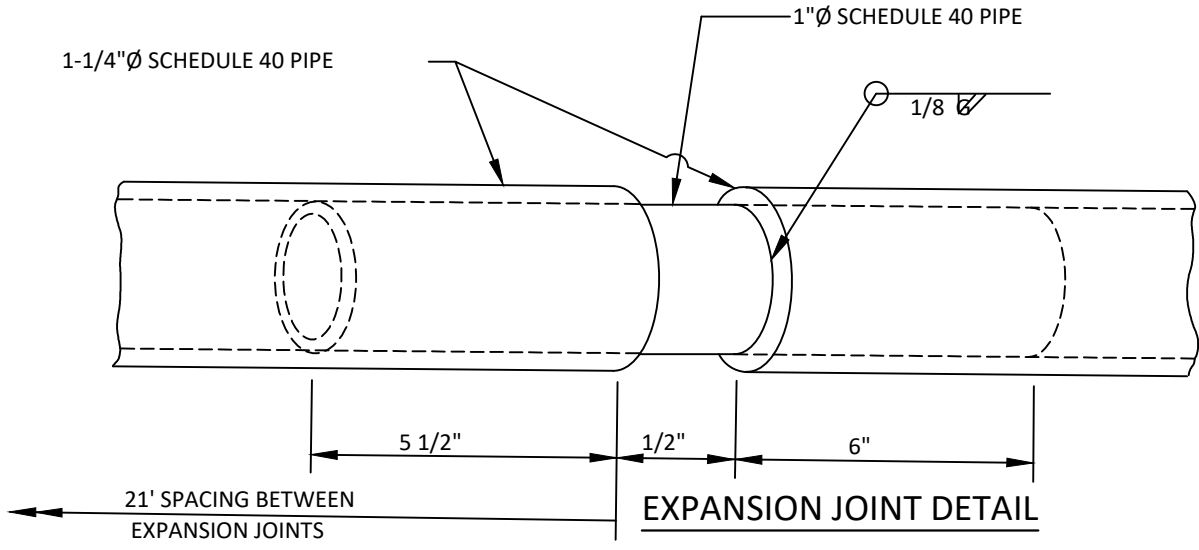
01/31/2023  
DATE

**PEDESTRIAN / BICYCLE  
RAILING**  
(ADA STANDARD)

1 of 4

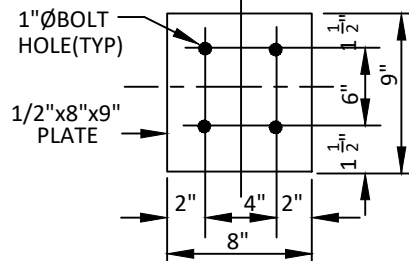
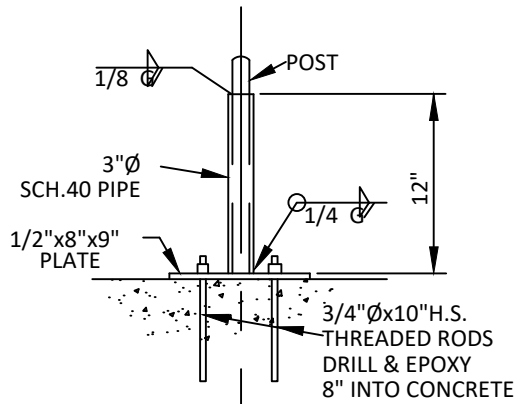
**S18.1**

# STANDARD

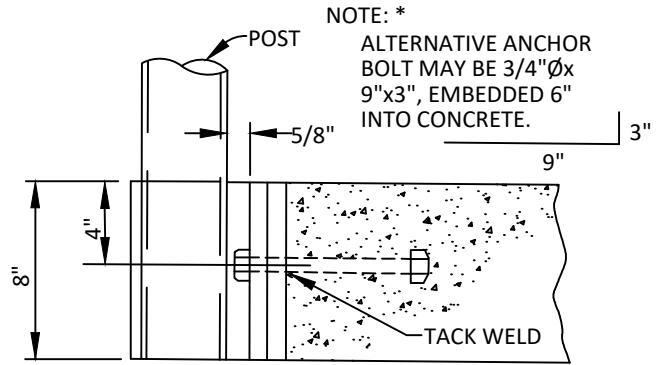


**NOTES:**

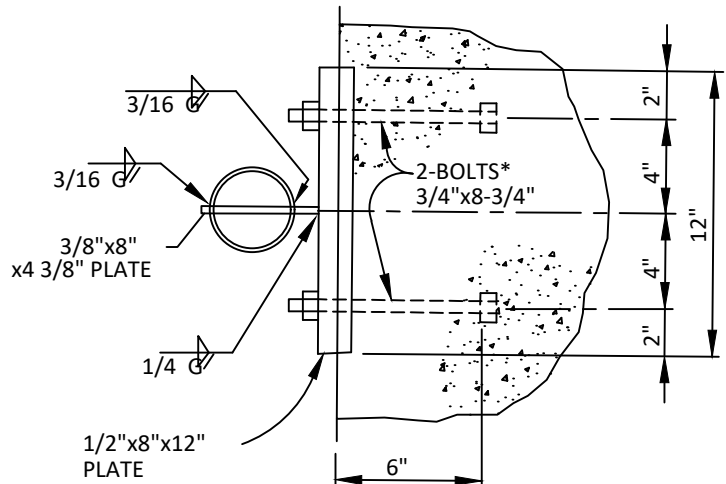
EXPANSION JOINTS TO BE WELDED TO ONE SIDE ONLY.



**TOP-MOUNTED BRACKET**



**SIDE-MOUNTED BRACKET**



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City of Aurora, Colorado

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**PEDESTRIAN / BICYCLE  
RAILING**

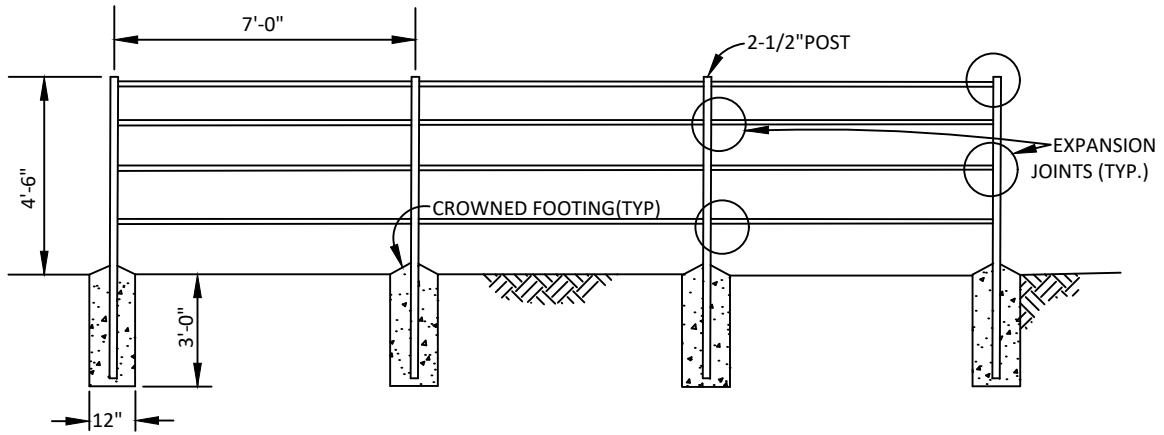
**S18.2**

*Heavenly*  
CITY ENGINEER

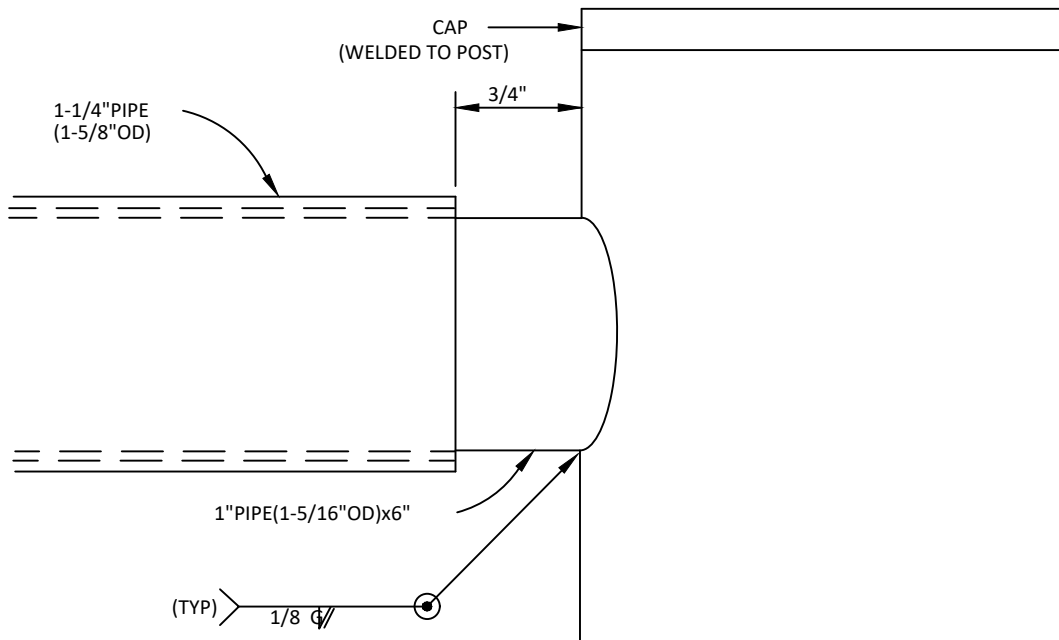
01/31/2023  
DATE



# STANDARD



ALTERNATE EXPANSION JOINT



EXPANSION JOINT DETAIL

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City of Aurora, Colorado

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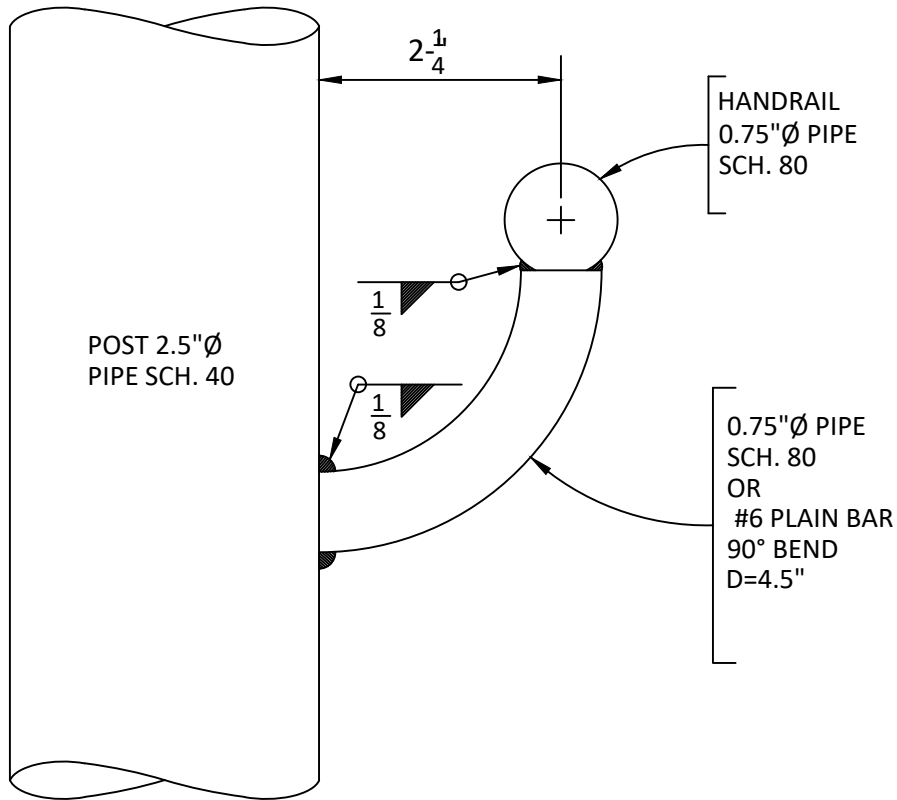
*Heidi Blomquist*  
CITY ENGINEER

01/31/2023  
DATE

PEDESTRIAN / BICYCLE  
CROSSING

S18.3

# STANDARD



**NOTES:**

1. THIS HANDRAIL IS REQUIRED BY THE AMERICANS WITH DISABILITIES ACT (ADA), 1990. IT SHALL BE INSTALLED ALONG PUBLIC WALKWAYS AT LOCATIONS WHERE THE GRADE EXCEEDS 5% (SLOPE 1:20) AT THE ENTRANCE TO A BUILDING. FOR ADDITIONAL DESIGN CRITERIA, REFER TO ADA HANDBOOK, DEC. 1991, ACCESSIBILITY GUIDELINES, APPENDIX B, PUBLISHED BY US GOVERNMENT PRINTING OFFICE.
2. ALSO, SEE SECTION 4.02.6.

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City of Aurora, Colorado

4 of 4

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01/31/2023  
DATE

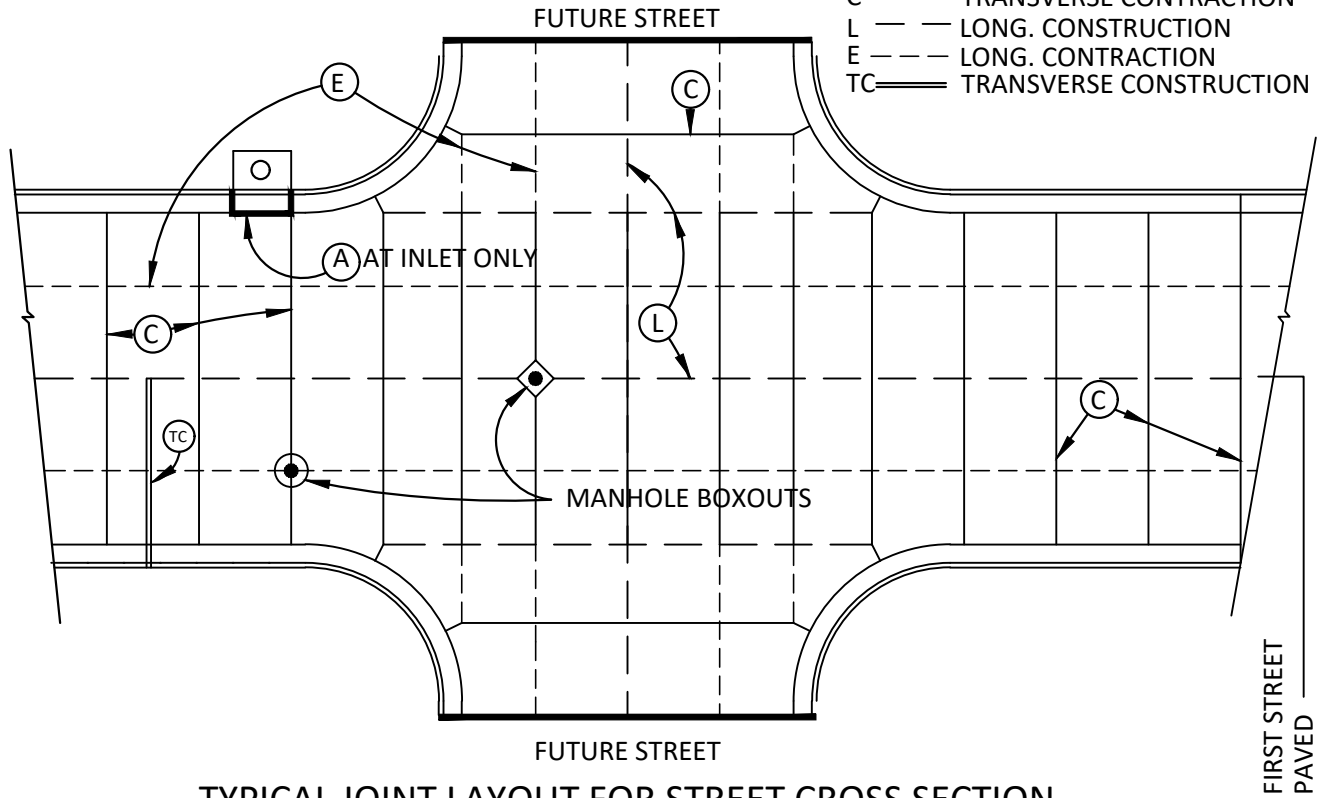
PEDESTRIAN / BICYCLE  
RAILING

S18.4

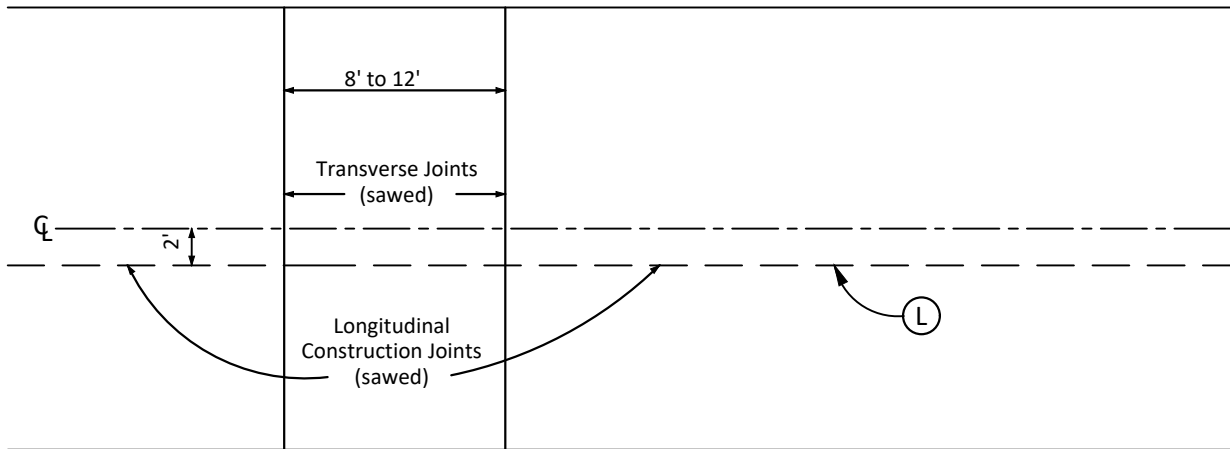
# STANDARD

## JOINT LEGEND

- A ——— EXPANSION
- C ——— TRANSVERSE CONTRACTION
- L ——— LONG. CONSTRUCTION
- E ——— LONG. CONTRACTION
- TC ——— TRANSVERSE CONSTRUCTION



TYPICAL JOINT LAYOUT FOR STREET CROSS SECTION



TYPICAL JOINT LAYOUT FOR ALLEY CROSS SECTION

City of Aurora, Colorado

1 of 4

## CONCRETE PAVEMENT JOINT DETAILS

S19.1

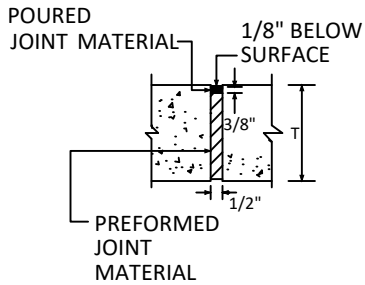
*Healy B. Hansen*  
CITY ENGINEER

01/31/2023

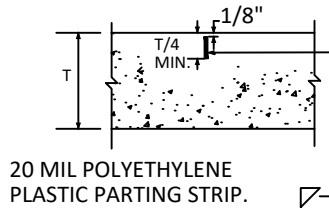
DATE

# STANDARD

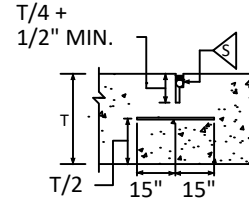
## (A) EXPANSION JOINT



## (C) TRANSVERSE CONTRACTION JOINT (TRANSVERSE WEAKENED PLANE JOINT)



## (E) LONGITUDINAL CONTRACTION JOINT (LONGITUDINAL WEAKENED PLANE JOINT)



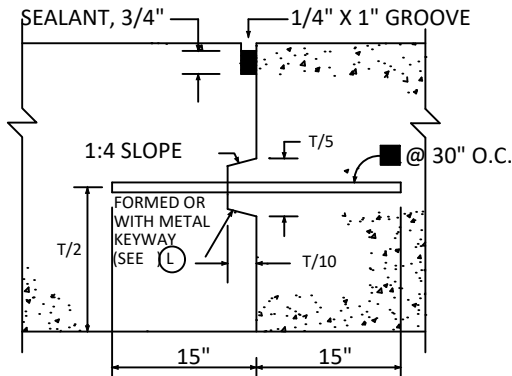
## (C) ALTERNATIVE TRANSVERSE CONTRACTION JOINT

( ALTERNATIVE TRANSVERSE WEAKENED PLANE JOINT )



## (TC) TRANSVERSE CONSTRUCTION JOINT

REQUIRED WHEN POUR HAS BEEN INTERRUPTED MORE THAN 30 MINUTES, PLACE THIS JOINT AT THE END OF A POUR. TO BE PLACED IN THE MIDDLE 1/3 OF THE TRANSVERSE CONTRACTION JOINT SPACING.



### GENERAL NOTES

■ — BARS SHALL BE DEFORMED REINFORCING BARS, GRADE 40 OR BETTER @ 30" O.C. UNLESS NOTED OTHERWISE. NO. 4 WHEN T=8" & NO. 5 WHEN T>8"

T — SEE PLANS FOR DIMENSION T, THICKNESS OF CONCRETE PAVEMENT.

THE COST OF ALL JOINTING BARS (JOINT MATERIAL, SAWING, ETC.) IS TO BE INCLUDED IN THE BID PRICE FOR CONCRETE PAVEMENT.

▽ — PLASTIC STRIP SHALL BE INSTALLED AT THE TIME OF PLACING OF THE CONCRETE AND SHALL BE LEFT IN PLACE. PLASTIC STRIP SHALL BE 1/8" BELOW THE SURFACE AND VERTICAL TO THE CONCRETE PAVEMENT BEFORE FINISHING AND TEXTURING. SPlicing SHALL BE WITH ENDS BUTTED.

CONSTRUCTION JOINT GROOVES SHALL BE ACCOMPLISHED BY FORMING, SAWING OR AS DIRECTED, TO THE DIMENSION SHOWN.

← S SEE S19.3

City of Aurora, Colorado

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## CONCRETE PAVEMENT JOINT DETAILS

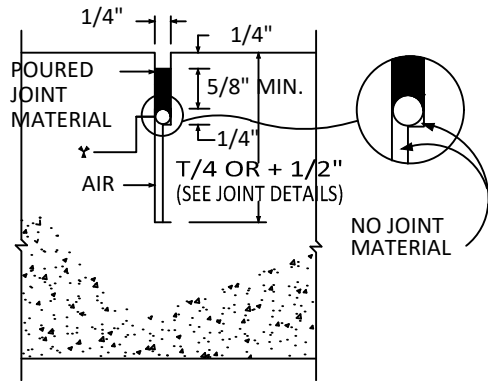
# S19.2

*Haley B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

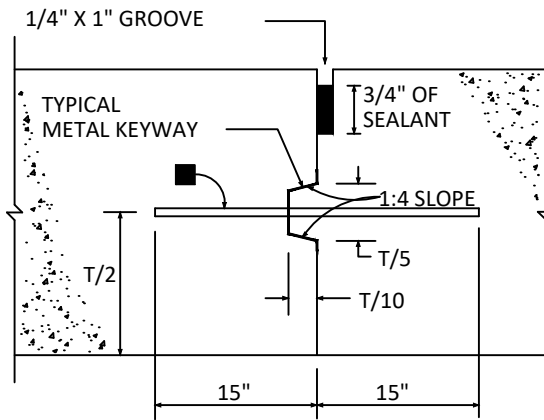
# STANDARD

## SAWED JOINT



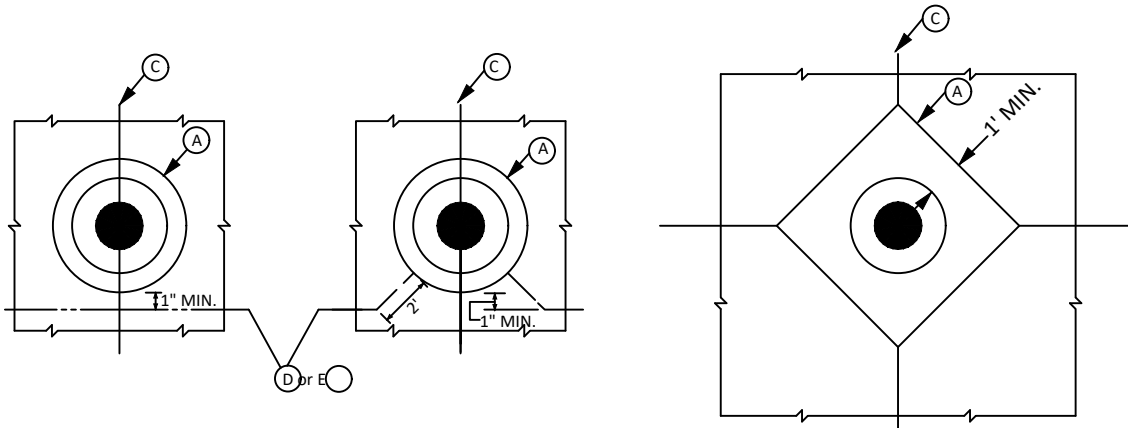
\* NYLON ROPE OR OPEN CELL POLYURETHANE STRAND

## LONGITUDINAL CONSTRUCTION JOINT



TO BE USED WHEN TRAFFIC LANE IS ADDED SEPARATELY OR FOR INTERSECTIONS, TAPERS OR SPEED CHANGE LANES.

ALTERNATE LONGITUDINAL CONSTRUCTION JOINT DESIGNS MAY BE USED IF APPROVED.



## MANHOLE BOXOUT

SEE GENERAL NOTES ON S19.2, SHEET 2 OF 4

City of Aurora, Colorado

3 of 4

*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

CONCRETE PAVEMENT  
JOINT DETAILS

S19.3

# STANDARD

## GENERAL NOTES:

1. THE TYPICAL JOINT LAYOUT SHOWN IS INTENDED TO BE USED AS A STANDARD. THE DEVELOPER/CONTRACTOR SHALL PREPARE A PAVEMENT JOINT LAYOUT FOR REVIEW BY THE PROJECT MANAGER PRIOR TO APPROVAL OF THE PAVEMENT DESIGN REPORT. FOR ALL CONCRETE ROADWAYS A COPY OF THE JOINT LAYOUT SHALL BE AVAILABLE AT THE CONSTRUCTION SITE DURING PAVING OPERATIONS.
2. LONGITUDINAL JOINTS SHALL COINCIDE WITH LANE MARKINGS, IF POSSIBLE. SEE TABLE 31.10.6.01. ALL LONGITUDINAL JOINTS SHALL BE TYPE "E" OR "L."
3. TRANSVERSE JOINTS SHALL EXTEND THROUGH THE CURB AND GUTTER OR CURB-GUTTER AND WALK (COMBINATION). AS GENERAL RULES: JOINT SPACING SHALL NOT EXCEED 2-1/2' PER INCH OF PAVEMENT THICKNESS (15' MAXIMUM, 12' PREFERRED); CONCRETE PANELS SHALL NOT HAVE TRANSVERSE JOINT SPACING EXCEEDING 1.25 TIMES THE LONGITUDINAL JOINTS SPACING. TRIANGULAR CORNERS (POINTS) OF LESS THAN 60° SHALL NOT BE ALLOWED.
4. IMMEDIATELY AFTER SAWING, JOINTS SHALL BE CLEANED OF CEMENT SLURRY WITH A PRESSURIZED WATER JET OR OTHER ACCEPTABLE METHOD. SAWED JOINTS SHALL BE DRY, CLEAN OF ALL SCALE, DIRT, DUST, CURING COMPOUND, AND OTHER FOREIGN MATTER. THE SIDEWALLS OF THE JOINT TO BE SEALED SHALL THEN BE THOROUGHLY SANDBLASTED AND BLOWN CLEAN OF LOOSE SAND BY HIGH PRESSURE AIR JUST PRIOR TO PLACING THE BACKER ROD AND THE POURED JOINT SEALANT.
5. THE CONTRACTOR SHALL, UNLESS OTHERWISE SHOWN ON THE PLANS, USE A BOXOUT AT MANHOLES AND SIMILAR ROADWAY APPURTENANCES. AN EXPANSION JOINT WILL BE REQUIRED BETWEEN CURB OPENING INLETS AND CONCRETE PAVEMENT.
6. PREFERRED TRANSVERSE JOINT LOCATIONS ARE: AT THE MIDPOINT OF ROUND BOXOUTS OR APPURTENANCES; OR AT THE CORNER OF RECTANGULAR BOXOUTS OR APPURTENANCES.
7. WHERE A LONGITUDINAL JOINT IS LOCATED ONE FOOT OR MORE CLEAR OF AN APPURTENANCE EDGE, A BOXOUT MAY BE USED. WITH LESS THAN THIS CLEARANCE, USE THE "TYPICAL 2' RADIAL JOINT" AS SHOWN IN THE DETAILS. USE OF SQUARE OR ROUND BOXOUT, OR BOND BREAKER, IS APPROPRIATE WHEN THE APPURTENANCE IS CENTERED ON A LONGITUDINAL JOINT.
8. THE FINAL FINISH REQUIREMENTS SHALL BE IN CONFORMANCE WITH SECTION 31.07.4, FOR STREET GRADES GREATER THAN 5% SEE CDOT SPECIFICATIONS SUBSECTION 412.12(D). TINED GROOVES WILL NOT BE REQUIRED WITHIN 2 FEET OF CURB FACES. STATION MARKING SHALL NOT BE REQUIRED.

City of Aurora, Colorado

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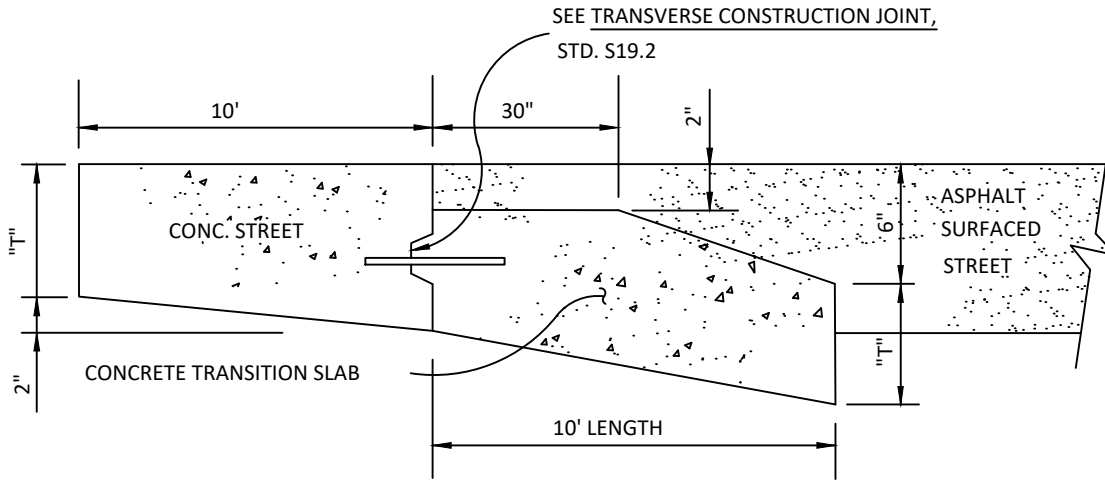
### CONCRETE PAVEMENT JOINT DETAILS

S19.4

  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



SEE PLANS FOR DIMENSION "T", THICKNESS OF CONCRETE PAVEMENT.

City of Aurora, Colorado

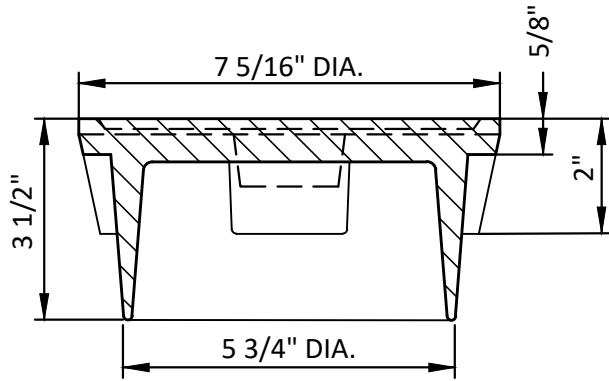
*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

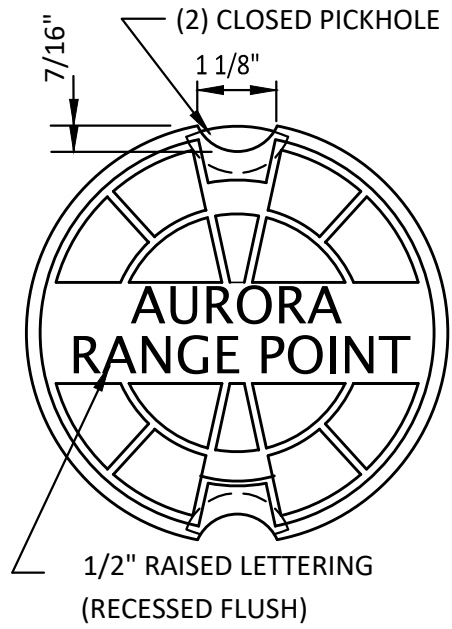
TRANSITION SECTION  
BETWEEN PORTLAND CEMENT  
CONCRETE AND ASPHALT  
PAVING SECTIONS

S20.1

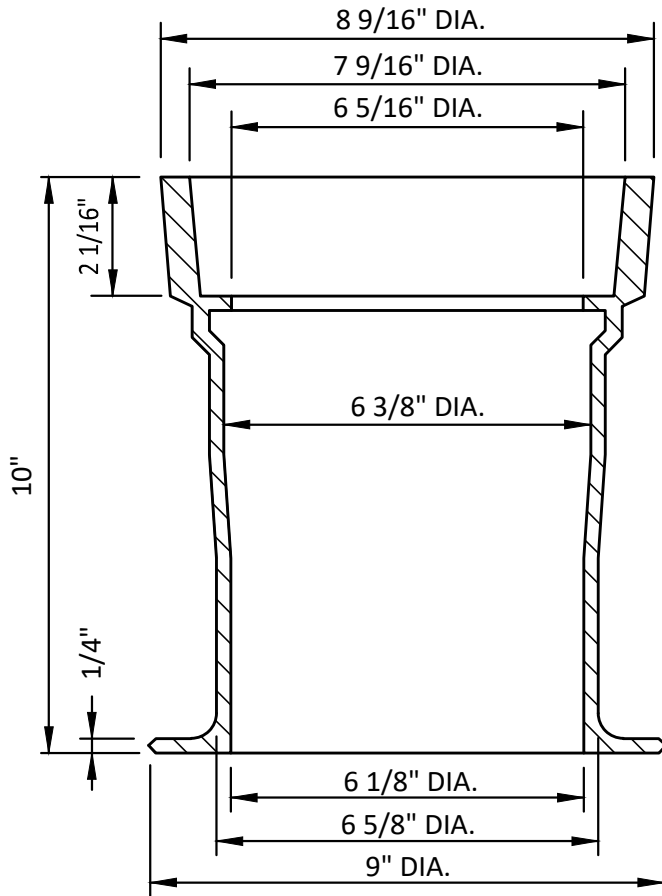
STANDARD



LID SIDE



LID TOP



BOX

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City of Aurora, Colorado

*Haley B. Hansen*  
CITY ENGINEER

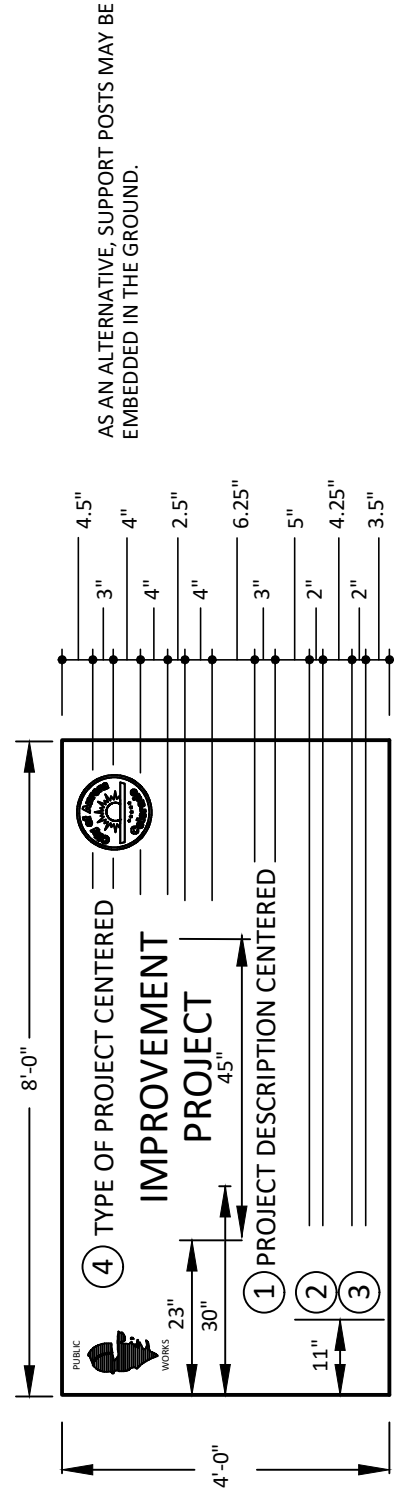
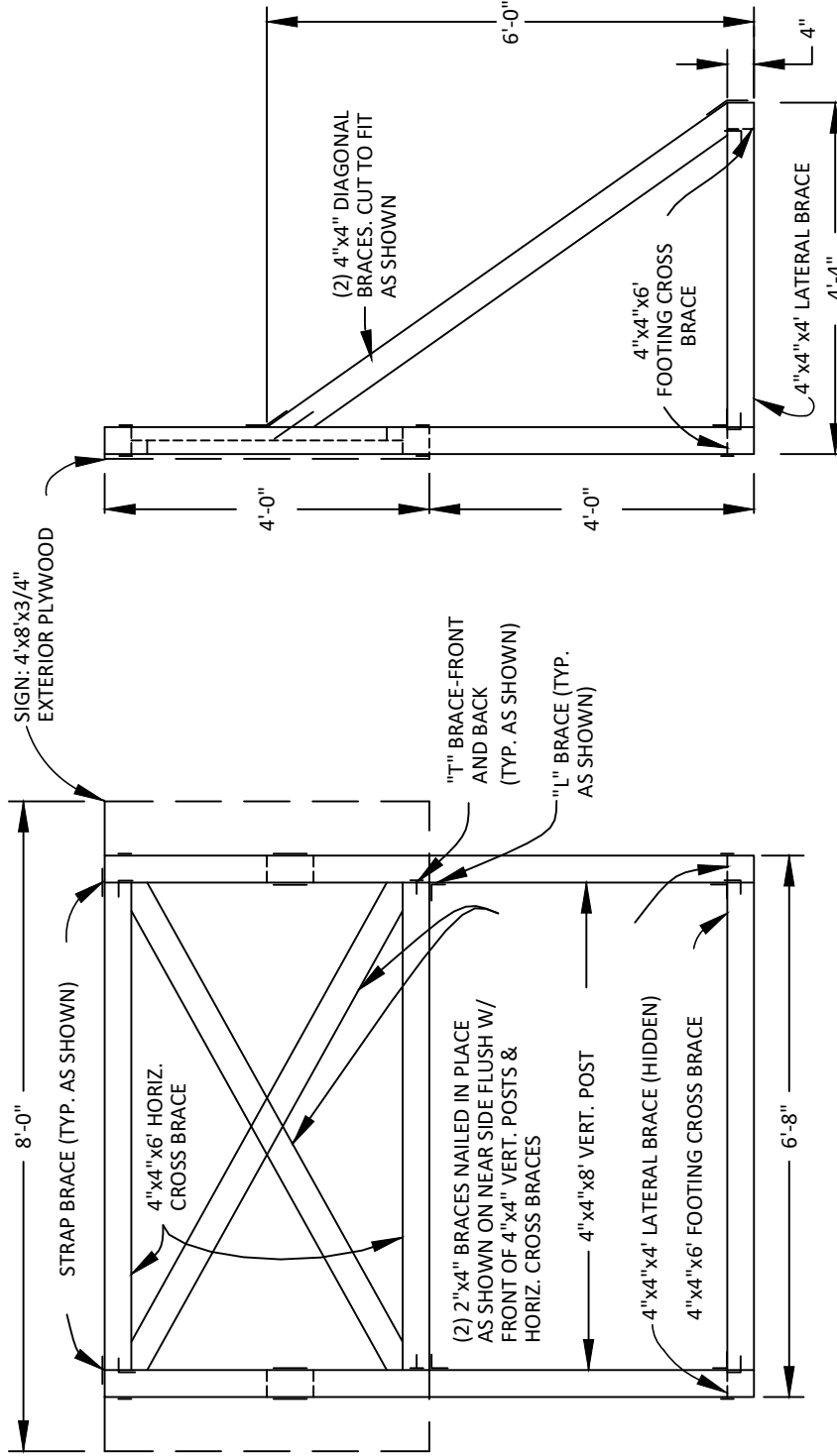
01/31/2023  
DATE

CITY OF AURORA RANGE  
BOX SPEC.'S

S21.1



# STANDARD



AS AN ALTERNATIVE, SUPPORT POSTS MAY BE EMBEDDED IN THE GROUND.

City of Aurora, Colorado

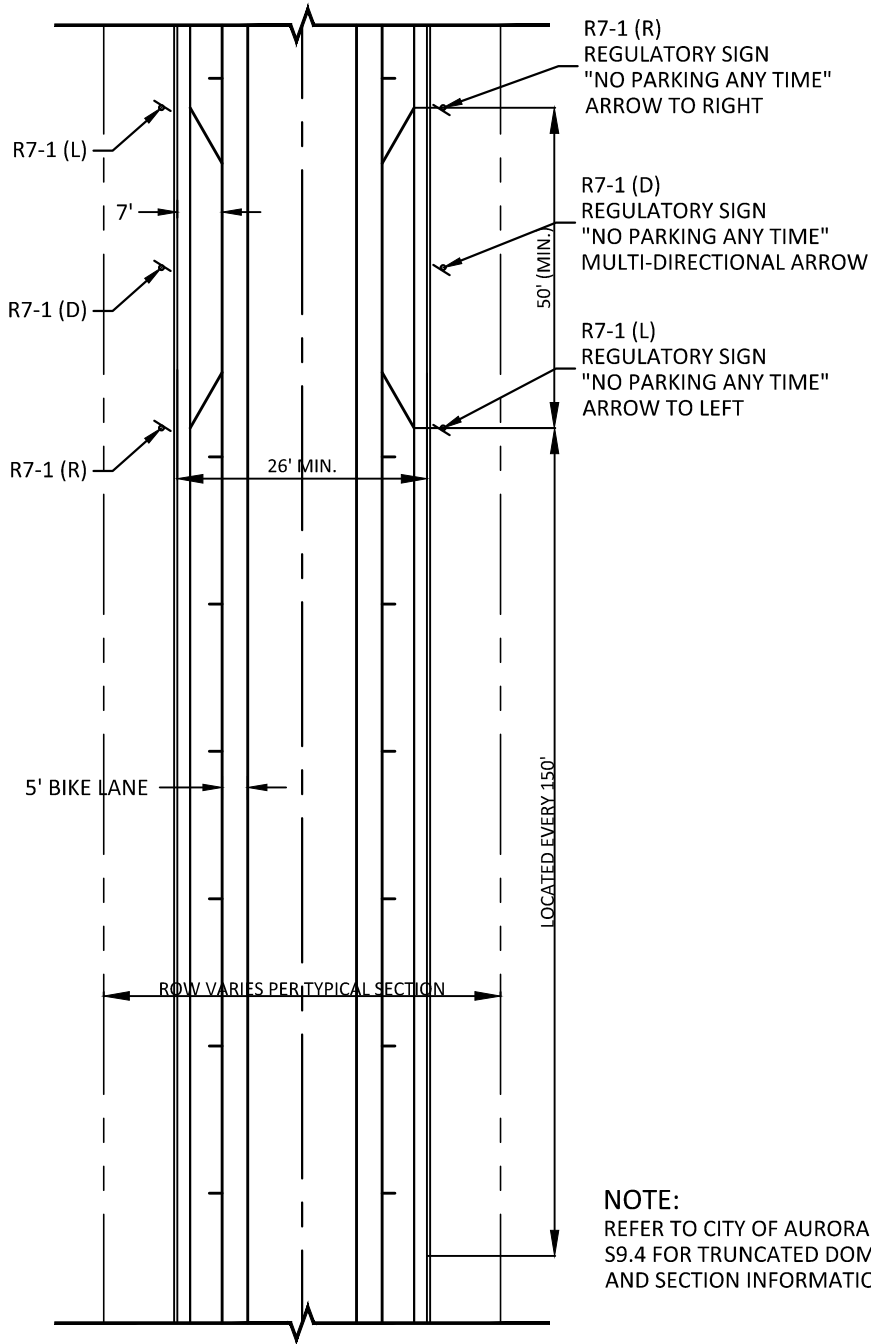
*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

PROJECT SIGN

S22.1

# STANDARD



**NOTE:**  
REFER TO CITY OF AURORA DETAIL S9.4 FOR TRUNCATED DOME DETAILS AND SECTION INFORMATION.

**NOTE:**

1. A MINIMUM WIDTH OF 26' PAVED SURFACE SHALL BE PROVIDED EVERY 150' ALONG STREETS. THIS MAY BE PROVIDED BY STRIPED OUT "NO PARKING" AREAS, DRIVEWAYS, CURB EXTENSIONS OR OTHER UNOBSTRUCTED DESIGN FEATURES.
2. IF PEDESTRIAN CROSSWALKS ARE LOCATED AT MIDBLOCK, PROVIDE HANDICAP RAMPS AND CROSSWALK IN ACCORDANCE WITH THE MUTCD. THE MIDBLOCK EMERGENCY SET UP MAY ALSO BE LOCATED AT THIS LOCATION.

City of Aurora, Colorado

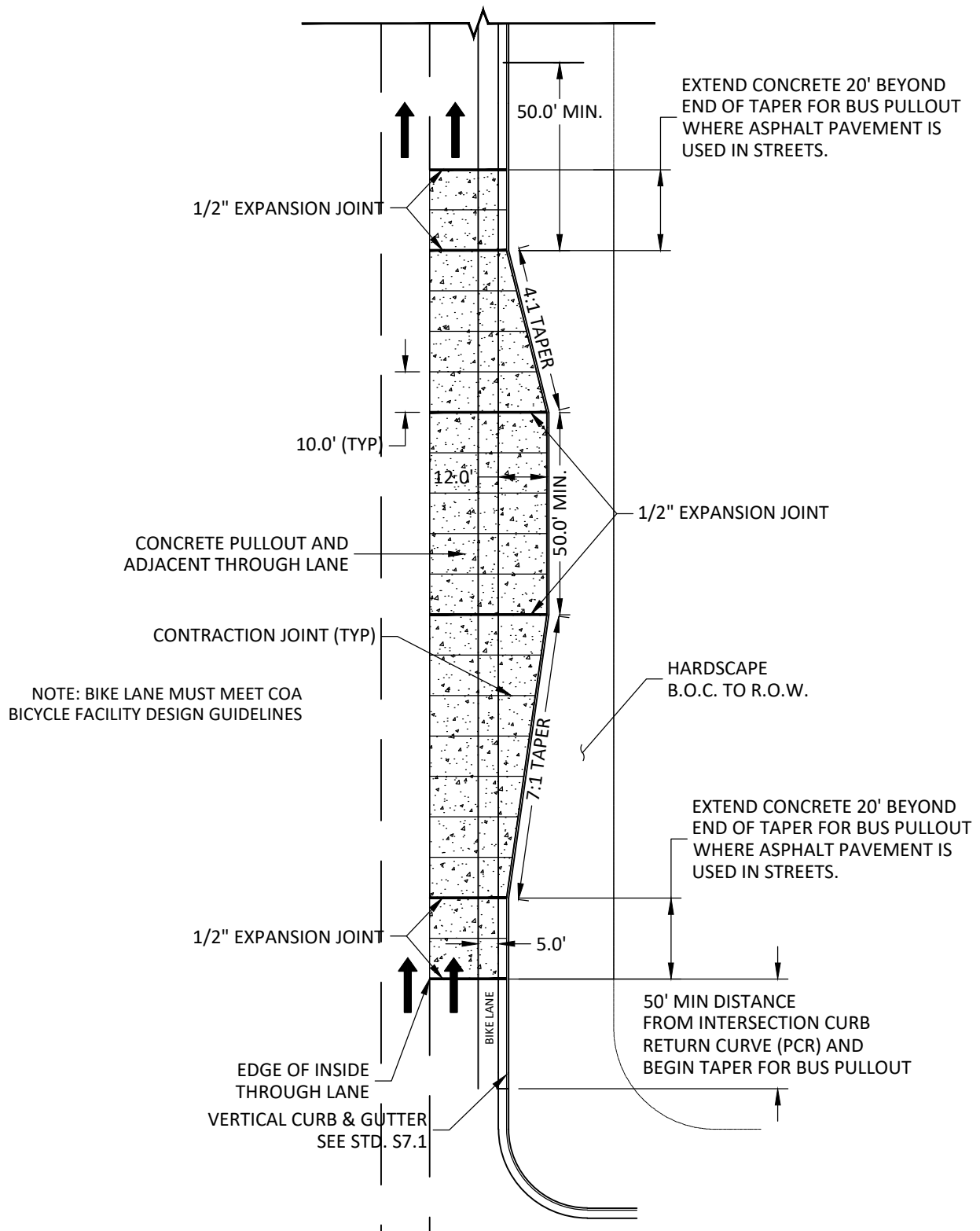
URBAN CENTER & TOD  
MIDBLOCK  
EMERGENCY SETUP

S23.1

*Heley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



City of Aurora, Colorado

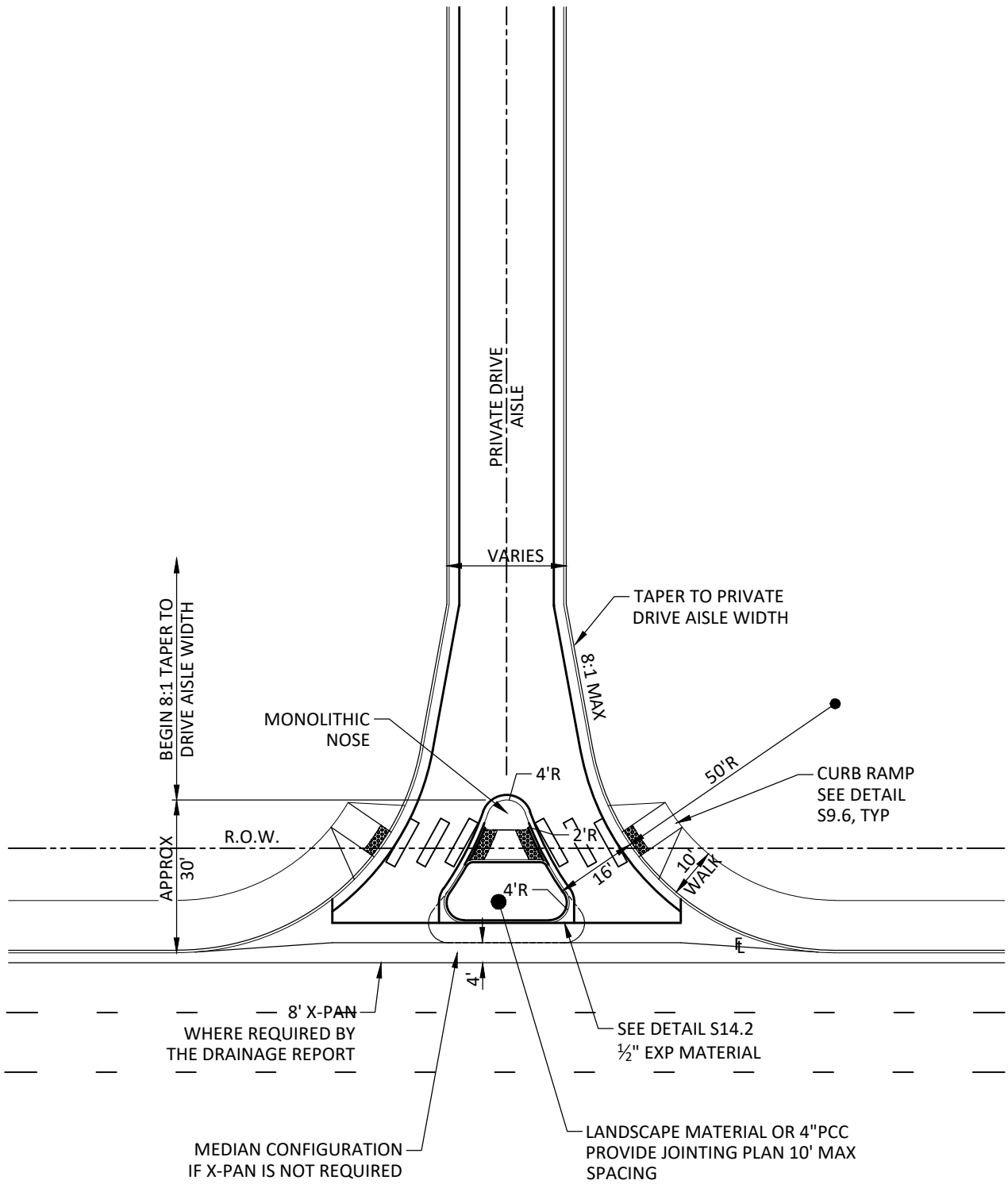
**BUS STOP INTERACTION  
WHERE REQUIRED IN TOD'S**

**S24.1**

*Heidi B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



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City of Aurora, Colorado

*Haley B. Johnson*  
CITY ENGINEER

01/31/2023  
DATE

**RESTRICTED ACCESS MEDIAN  
TO ARTERIAL STREET**

**S25.1**

# STANDARD

## PUBLIC LIGHT CONSTRUCTION STANDARDS CITY OF AURORA

All Public Lights maintained by the City of Aurora must be constructed in accordance with the details shown on sheets L1-1 through L10-1 as well as the following:

### A. Cabinets and Cabinet Foundations

1. All conduits shall be cut off with no more than 1/2 inch extending above concrete base.
2. Cabinet ground rod shall be a 5/8 inch 8 foot copper rod located in the home run pull box.
3. Ground wire shall be a #6 AWG solid copper.
4. All field wiring shall be tagged by direction.
5. All wiring shall be neat with adequate slack for rearrangements.
6. Cabinet base shall be level extending approximately 2 inches above and 18 inches below ground.
7. Cabinet shall be leveled so that the door opens freely without binding.
8. Cabinet shall be caulked around base with silicon caulk to make watertight.

### B. Pull boxes & Conduit

1. Pull boxes shall be set on a minimum of 8 inches of 3/4 inch crushed gravel for drainage.
2. Conduits in pull boxes shall be stubbed up a minimum of 4 inches above the gravel at a 90-degree angle from level and flush with each other. Conduit shall be cut off approximately 6 inches below the pull box lid.
3. Conduit shall be direct bore under existing roadway unless otherwise approved. Number & size to be per approved design plans. Typical depth shall be 36" unless otherwise approved by the Director of Public Works or Designee. All conduit to be Schedule 80 under roadway, schedule 40 elsewhere.
4. Pull box cover bolts shall be in place and the drain holes for bolts shall be opened.
5. Pull boxes shall be one inch above and parallel to the ground except when installed in concrete or as field determined.
6. Pull boxes installed in concrete shall be flush with finished concrete.
7. Wire in pull boxes shall not be tangled or twisted. Wire shall be neat with a maximum of a 1-foot loop and be tagged indicating direction and termination point.
8. A pull string shall be provided in all conduits. Any unused conduits shall be capped and have a locating line (metallic conductor) installed if the unused conduit does not parallel other populated conduit. Unused conduit installed through a separate bore shall have locating line installed, regardless of relation to other populated conduit.
9. No wire splices shall be allowed in pull boxes. All splices shall be in the pole.
10. Any necessary cuts to a pull box shall be done with a cutting tool without structural damage to the pull box.

### C. Wiring

1. Wiring in hand holes shall have 12 to 18 inches of slack that can be pulled out for inspection or rearrangements.
2. All new public light pole installations shall be installed with 14/2 conductor wire continuous from lighting control cabinet to handhole. For any street light modification involving changes to the wiring splices (between the main multiconductor feed from control cabinet to pole corner) in the handhole of the pole, if 14/2 conductor wire is not already present from control cabinet to handhole it shall be installed as part of the modification. All rewiring and exceptions are subject to review and approval by the Public Works Director or Designee.

City of Aurora, Colorado

PUBLIC LIGHT DESIGN &  
CONSTRUCTION  
STANDARD NOTES

1 of 1

L0.1

  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD





## PUBLIC LIGHT CONSTRUCTION STANDARDS CITY OF AURORA

All Public Lights maintained by the City of Aurora must be constructed in accordance with the details shown on sheets L1-1 through L10-1 as well as the following:

### D. Additional Notes

1. Any materials not provided by the City shall be submitted to the Public Works Director or Designee for review and approval prior to procurement of said materials.
2. For all new street light installations punchlist inspection shall be scheduled and coordinated with Inspections and Operations. All critical punchlist items shall have been addressed and confirmed corrected and the street lighting to be 100% complete prior to final acceptance. The City will not assume ownership, maintenance, and operation of the new street light until such time as the punchlist has been verified complete. A minimum one-year warranty shall be provided for all new street light installation work. Any deviation from the above must be approved by the Engineer.
3. Underground feeder cable shall be a minimum of 14/2 with ground THHN insulated color coded conductors with gray PVC jacket, unless larger size is dictated by code.

ALL HAND HOLE TERMINATIONS SHALL BE IDENTIFIED AS FOLLOWS:

	NORTH
	EAST
	SOUTH
	WEST

City of Aurora, Colorado

2 of 2

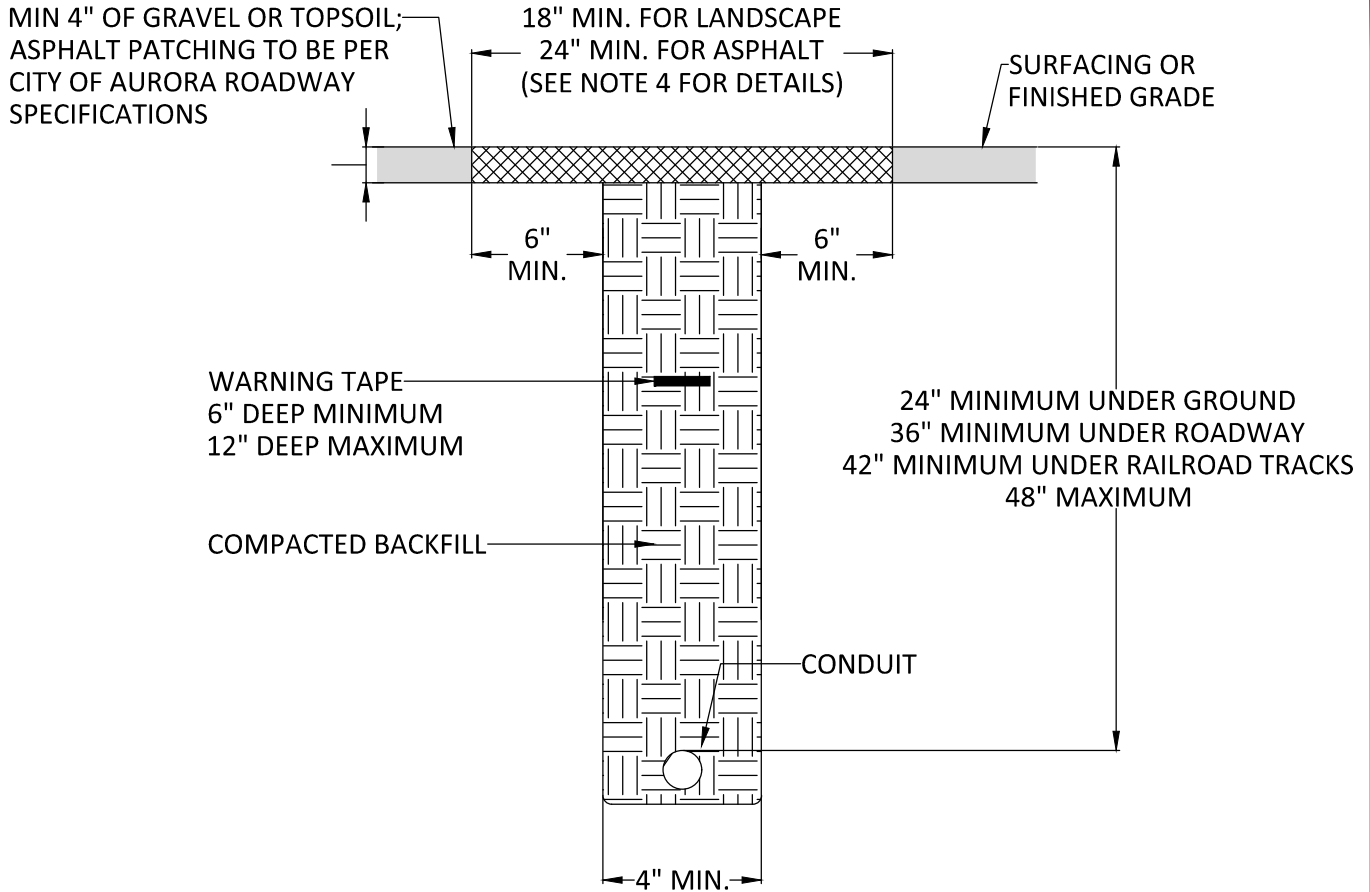
PUBLIC LIGHT DESIGN &  
CONSTRUCTION  
STANDARD NOTES

L0.2

  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



## DETAIL NOTES:

1. CONTRACTOR SHALL COORDINATE BORING, DRIVING, OR TRENCHING WITH OTHER UNDERGROUND UTILITIES. CONTRACTOR SHALL USE COMMON TRENCHES AT ALL ROAD CROSSINGS WHEREVER POSSIBLE.
2. WHENEVER POSSIBLE, CONDUIT OR CABLE SHALL BE INSTALLED BY BORING, DRIVING, OR ANY OTHER ACCEPTABLE MEANS UNDER CONCRETE UNITS. OPEN CUTTING SHALL BE USED ONLY UNDER SPECIAL CIRCUMSTANCES AND ONLY WITH APPROVAL OF PUBLIC WORKS.
3. MINIMUM WIDTH AND TYPE OF RESTORATION TO BE DETERMINED BY PW INSPECTOR, BASED ON CONTRACTOR'S PRE-ACTIVITY PHOTOS, TO MATCH PRE-EXISTING CONDITIONS.
4. SOD REPLACEMENT SHALL BE A MINIMUM OF 18" IN WIDTH. ASPHALT REPLACEMENT SHALL BE A MINIMUM OF 24" IN WIDTH. CONCRETE REPLACEMENT SHALL BE PER THE DEPARTMENT OF PUBLIC WORKS TRANSPORTATION STANDARD DETAILS.
5. ANY HARDSCAPE (CONCRETE OR PAVERS) SHALL BE REPLACED IN FULL PANELS OR PAVERS OF THE SAME TYPE, COLOR, AND SIZE AS BEFORE.
6. 1-#12 AWG LOCATE WIRE AND A NYLON OR POLYESTER PULL TAPE WITH 1,250 LBS TEST STRENGTH AND FOOTAGE MARKINGS IN ALL EMPTY CONDUITS.
7. ALL CONDUIT, LANDSCAPE RESTORATION, ASPHALT RESTORATION, AND CONCRETE RESTORATION MUST BE INSTALLED IN ACCORDANCE WITH THE DEPARTMENT OF PUBLIC WORKS TRANSPORTATION STANDARD DETAILS.
8. A PULL STRING SHALL BE PROVIDED IN ALL CONDUITS. ANY UNUSED CONDUITS SHALL BE CAPPED AND HAVE A LOCATING LINE (METALLIC CONDUCTOR) INSTALLED IF THE UNUSED CONDUIT DOES NOT PARALLEL OTHER POPULATED CONDUIT.

City of Aurora, Colorado

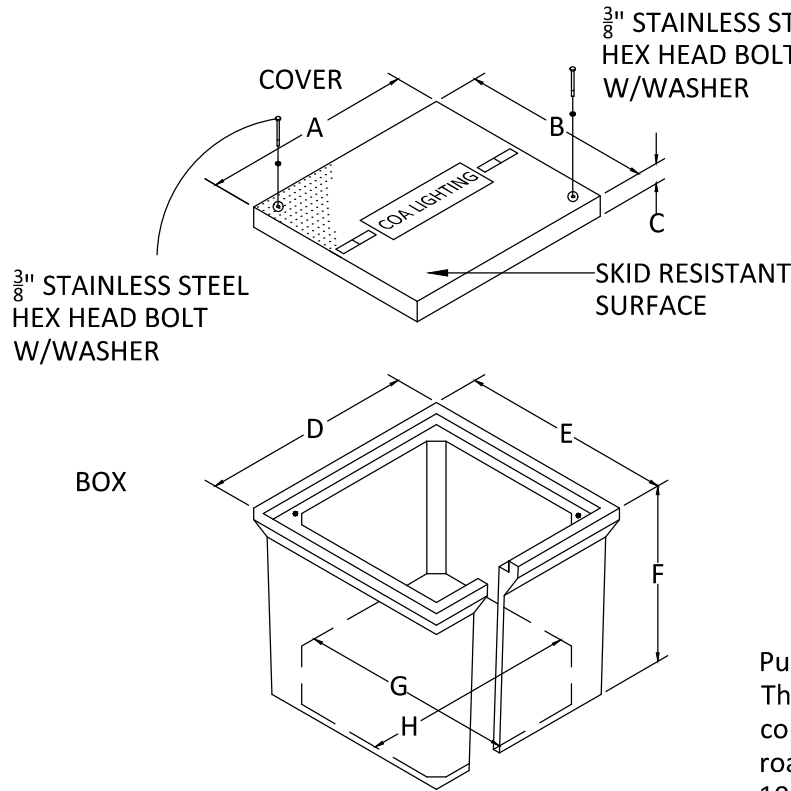
**TYPICAL CONDUIT  
BURIAL DETAIL**

**L1.1**

*Heley B. Hansen*  
CITY ENGINEER

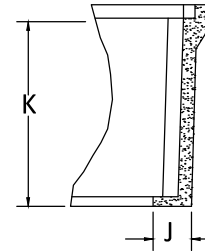
01/31/2023  
DATE

# STANDARD



## SPECIFICATIONS/DATA

PC and PG Style Assemblies



Pull boxes shall not be placed at each light. They shall be placed at direction changes, conduit size changes (i.e. both sides of the roadway), and on conduit runs exceeding 100 feet that do not have a light on them.

### COVER (COA LIGHTING)

DESCRIPTION	SIZE	DIMENSIONS (IN.)			WT. LBS
		A	B	C	
HEAVY DUTY (HA) LOCKING COVER	SMALL (PC)	12 7/8	12 7/8	3/4	12

### BOXES (STACKABLE)

DESCRIPTION	SIZE	DIMENSIONS (IN.)							WT. LBS
		D	E	F	G	H	J	K	
OPEN BOTTOM (BA)	SMALL (PC)	14 3/4	14 3/4	12	12	12	1	12	36

### SPECIFICATIONS:

Underground enclosures shall be Quazite as manufactured by Hubbell or approved equal. Covers shall be concrete gray color and rated for no less than 15,000 lbs over a 10"x10" area. Enclosures shall be concrete gray in color and rated for no less than 15,000 lbs (SM). Covers and enclosures shall be designed and tested to temperatures of -50°F. Covers shall have a minimum coefficient of friction of 0.5. Boxes shall be stackable for extra depth.

City of Aurora, Colorado

PULL BOX  
PRECAST FLUSH TOP

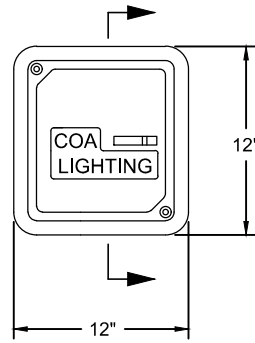
L2.1

*Heidi B. Hansen*  
CITY ENGINEER

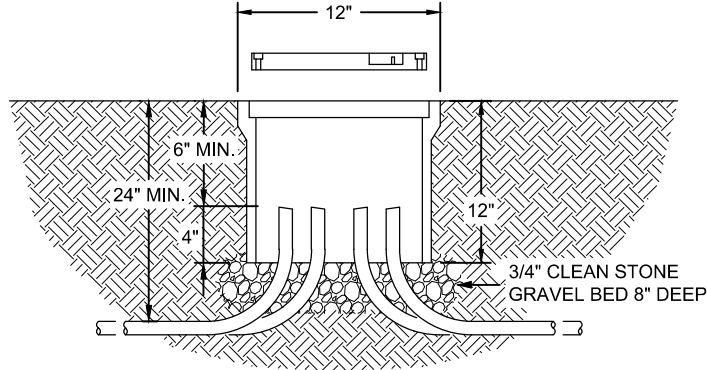
01/31/2023  
DATE



STANDARD



PLAN VIEW



SECTION A-A

TYPICAL PULL BOX

DETAIL NOTES:

- 1. ALL PULL BOXES SHALL BE INCIDENTAL TRAFFIC RATED TO TIER 15 MINIMUM.

City of Aurora, Colorado

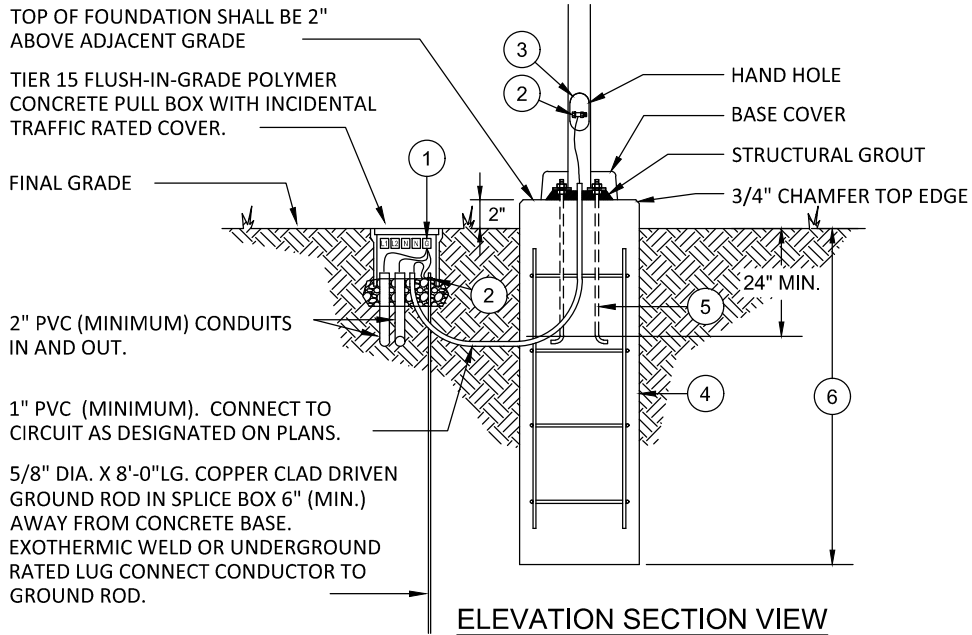
*Heidi Blankenship*  
CITY ENGINEER

01/31/2023  
DATE

TYPICAL IN-GRADE  
COMPOSITE PULL-BOX

L3.1

# STANDARD



## FOUNDATION DETAIL NOTES

1. BOND RACEWAY GROUND TO GROUND ROD IN PULL BOX.
2. BOND (1-#6 SOFT DRAWN BARE CU) TO GROUND ROD IN PULL BOX AND GROUNDING ROD IN POLE BASE HAND HOLE.
3. AT EACH POLE BASE HAND HOLE, PROVIDE A BREAKAWAY, WATERPROOF, IN-LINE FUSE HOLDER BY EATON OR APPROVED EQUAL WITH FNQ-R 15A FUSE FOR EACH HOT AND A BREAKAWAY, WATERPROOF CONNECTOR ON NEUTRAL (IF REQUIRED).
4. LIGHT STANDARD FOUNDATION EMBEDMENT DEPTH, DIMENSIONS AND REINFORCEMENT SHALL BE PER L10.1 OR AS DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO.
5. ANCHOR BOLT CIRCLE SHALL BE 12 INCH DIAMETER AND CENTERED ON FOUNDATION.
6. DEPTH OF FOUNDATION PER L10.1 OR AS DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO.

## GENERAL NOTE

FOUNDATION DETAILS ARE INCLUDED ONLY TO SHOW ELECTRICAL COMPONENTS. REFER TO L10.1 FOR STRUCTURAL REQUIREMENTS.

City of Aurora, Colorado

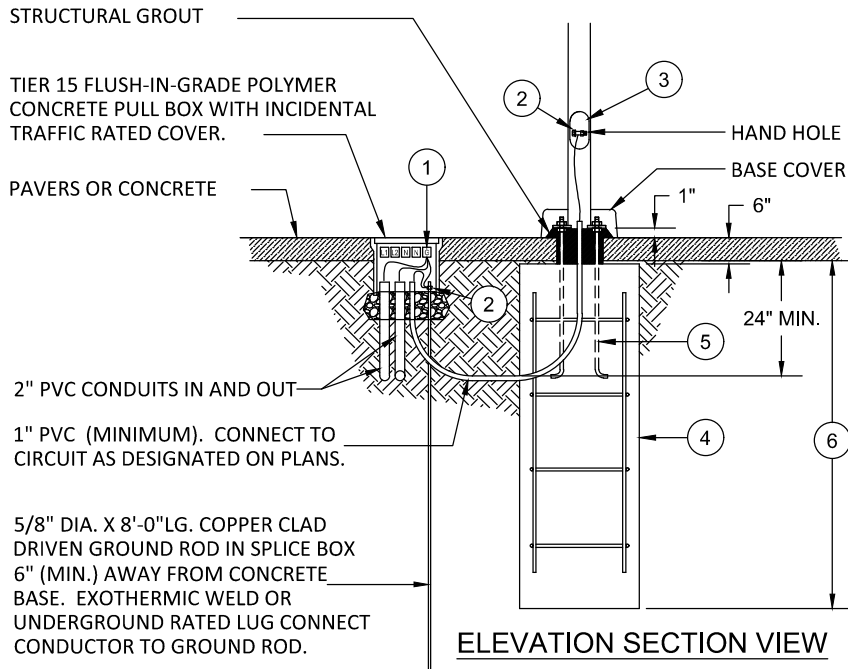
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CITY ENGINEER

01/31/2023  
DATE

TYPICAL STREET LIGHT  
STANDARD FOUNDATION  
ELECTRICAL DETAIL IN  
SOFTSCAPE

L4.1

# STANDARD



## FOUNDATION DETAIL NOTES

1. BOND RACEWAY GROUND TO GROUND ROD IN PULL BOX.
2. BOND (1-#6 SOFT DRAWN BARE CU) TO GROUND ROD IN PULL BOX AND GROUNDING ROD IN POLE BASE HAND HOLE.
3. AT EACH POLE BASE HAND HOLE, PROVIDE A BREAKAWAY, WATERPROOF, IN-LINE FUSE HOLDER BY EATON OR APPROVED EQUAL WITH FNQ-R 15A FUSE FOR EACH HOT AND A BREAKAWAY, WATERPROOF CONNECTOR ON NEUTRAL (IF REQUIRED).
4. LIGHT STANDARD FOUNDATION EMBEDMENT DEPTH, DIMENSIONS AND REINFORCEMENT SHALL BE PER L10.1 OR AS DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO.
5. ANCHOR BOLT CIRCLE SHALL BE 12 INCH DIAMETER AND CENTERED ON FOUNDATION.
6. DEPTH OF FOUNDATION PER L10.1 OR AS DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO.

## GENERAL NOTE

FOUNDATION DETAILS ARE INCLUDED ONLY TO SHOW ELECTRICAL COMPONENTS. REFER TO L10.1 FOR STRUCTURAL REQUIREMENTS.

City of Aurora, Colorado

*Haley B. Hansen*  
CITY ENGINEER

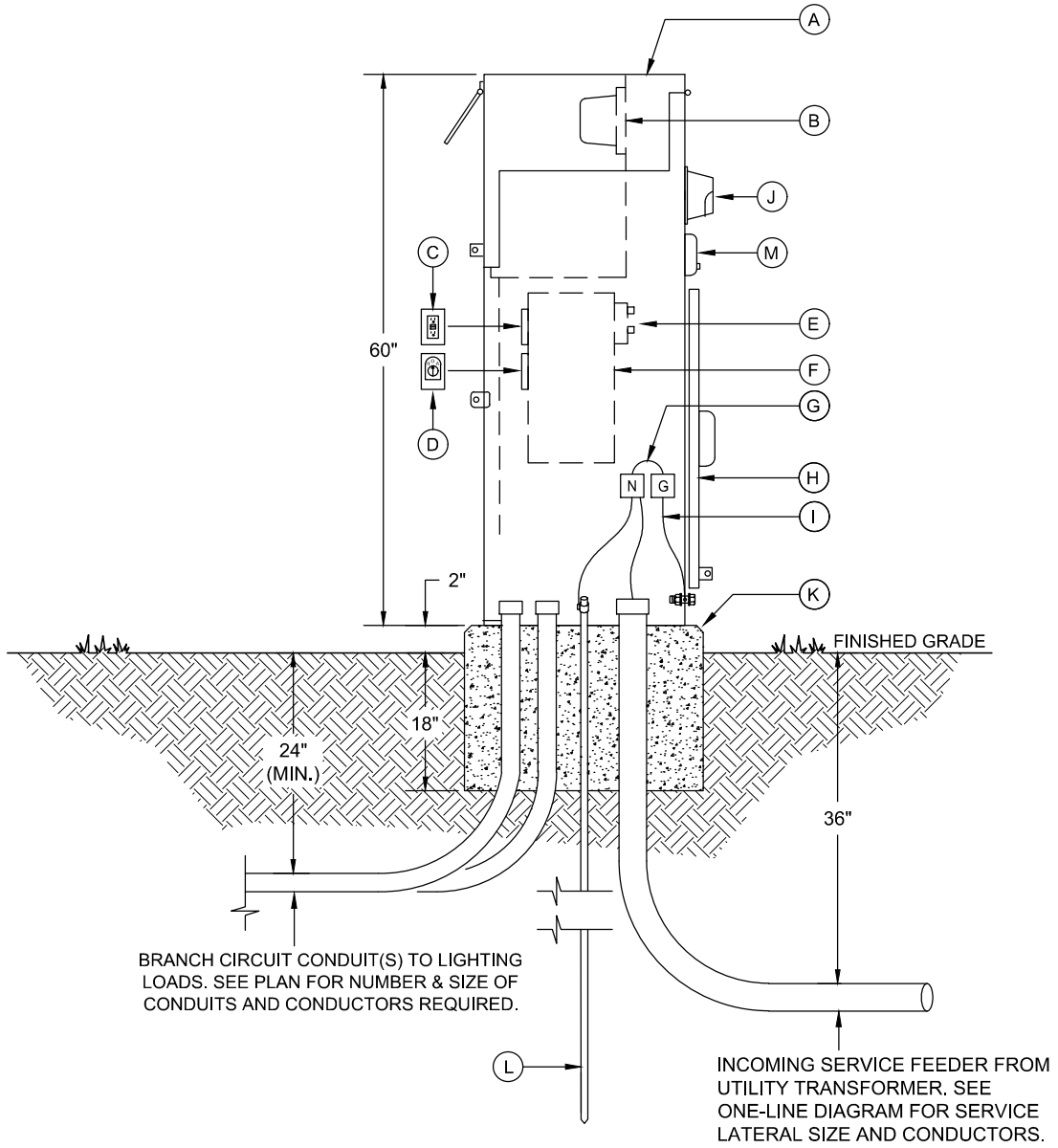
01/31/2023  
DATE

TYPICAL STREET LIGHT  
STANDARD FOUNDATION  
ELECTRICAL DETAIL IN  
HARDSCAPE

L5.1

# STANDARD

NOTE:  
REFER TO L6.2 FOR COMPONENT LIST.



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City of Aurora, Colorado

*Heidi B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

TYPICAL LIGHTING CONTROL  
CENTER CABINET DETAIL

1 of 2  
L6.1

# STANDARD

## CABINET COMPONENT LIST

- (A) FULLY HINGED METER/TEST SECTION LOCKABLE COVER WITH HOLD OPEN ARM TO KEEP COVER FROM BLOWING SHUT PER CITY OF AURORA SPECIFICATION. COMBINATION ALL-IN-ONE COMMERCIAL METER POWER PEDESTAL IN A NEMA 3R STAINLESS STEEL ENCLOSURE.
- (B) UTILITY METER INSIDE NEMA 3R ENCLOSURE. METER SHALL HAVE LEVER BYPASS AND INTERNAL LOCKING TAB ON METER COVER.
- (C) GFCI MAINTENANCE RECEPTACLE FLUSH MOUNTED IN PANEL DEAD FRONT INSIDE OF THE NEMA 3R ENCLOSURE.
- (D) HAND-OFF-AUTO SWITCH - 15A-2P, HOA SWITCH WITH LEGEND FLUSH MOUNTED IN PANEL DEAD FRONT INSIDE OF THE NEMA 3R ENCLOSURE.
- (E) UTILITY TERMINATION LANDING LUGS.
- (F) LOAD CENTERS WITH SERVICE MAIN AND BRANCH BREAKERS. ENGINEER SHALL PROVIDE PANEL SCHEDULE FOR BREAKERS REQUIRED.
- (G) PROVIDE NEUTRAL TO GROUND BONDING JUMPER.
- (H) LIFT OFF SERVICE COVER WITH PAD LOCK HASP.
- (I) CABINET GROUND BOND #6 BARE COPPER CONDUCTOR.
- (J) NEMA 3R 120V PHOTOELECTRIC CONTROL WITH 3-PRONG TWIST-LOCK RECEPTACLE BASE WIRED THROUGH THE H.O.A. SWITCH. THE PHOTOELECTRIC CONTROL SHALL BE MOUNTED ON THE NORTH SIDE ON ENCLOSURE TO MINIMIZE THE SUN'S INTERFERENCE.
- (K) REINFORCED CONCRETE (CLASS B) FOUNDATION PER STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO. MINIMUM 6" ABOVE GRADE, 3/4" CHAMFER ALL EXPOSED EDGES, 3" MINIMUM (6" MAXIMUM) OVERLAP ON ALL SIDES.
- (L) 3/4" X 8'-0" Lg. COPPER CLAD DRIVEN GROUND ROD. EXOTHERMIC WELD OR UNDERGROUND RATED LUG CONNECT CONDUCTOR TO GROUND ROD.
- (M) T-HANDLE, PULL-OUT FUSE HOLDER WITH FRN-R FUSES, METER DISCONNECT FOR METER PROTECTION (XCEL ENERGY SERVICE AREA), COLD SEQUENCE METER, WEATHERPROOF COVER WITH TAB LOCKABLE.

## TYPICAL CABINET REQUIREMENTS:

200AMP MCB,120/240V-1Ø-3W STAINLESS STEEL, NEMA 3R, METER/ POWER PEDESTAL WITH SEPARATE SEALABLE AND LOCKABLE CUSTOMER SECTION WITH:

1. LOAD CENTER (ENGINEER SHALL PROVIDE SCHEDULE FOR # OF CIRCUITS) FOR ALWAYS ON LOADS THAT INCLUDE:  
(APPLIES TO STREET LIGHTS AND PEDESTRIAN LIGHTS)
  - SERVICE ENTRANCE M.C.B. - ENGINEER TO PROVIDE SIZE ON THE PANEL SCHEDULE.
  - CONTROL POWER CIRCUIT BREAKER - ENGINEER TO PROVIDE SIZE ON THE PANEL SCHEDULE.
  - SWITCHED LOAD CENTER MAIN BREAKER - ENGINEER TO PROVIDE ON THE PANEL SCHEDULE.
  - BRANCH BREAKERS AS SHOWN - ENGINEER TO PROVIDE SIZE AND QUANTITY ON THE PANEL SCHEDULE.
  - CIRCUIT DIRECTORY TO DOCUMENT CONFIGURATION IN POCKET ON HINGED DOOR.
  - MAINTENANCE RECEPTACLE FLUSH MOUNTED IN DEAD FRONT INSIDE ENCLOSURE.
2. CONTROL CIRCUIT INCLUDING:  
(ONLY APPLIES TO PEDESTRIAN LIGHTS OR OTHER LIGHTS THAT DO NOT HAVE INDIVIDUAL ANSI 7-PIN RECEPTACLES.)
  - PHOTOCELL RECEPTACLE, MOUNTED EXTERNALLY ON NEMA-3R ENCLOSURE.
  - ONE HAND-OFF-AUTO (HOA) SWITCH FLUSH MOUNTED IN DEAD FRONT.
  - ONE LIGHTING CONTACTOR CONTROLLING ONE LOAD CENTER IN THIS SECTION.
  - ONE 12-CIRCUIT LOAD CENTER PHOTOCELL ON/OFF CONTROLLED.
  - A CIRCUIT DIRECTORY TO DOCUMENT CONFIGURATION IN POCKET ON HINGED DOOR.

City of Aurora, Colorado

TYPICAL LIGHTING CONTROL  
CENTER CABINET  
COMPONENT LIST

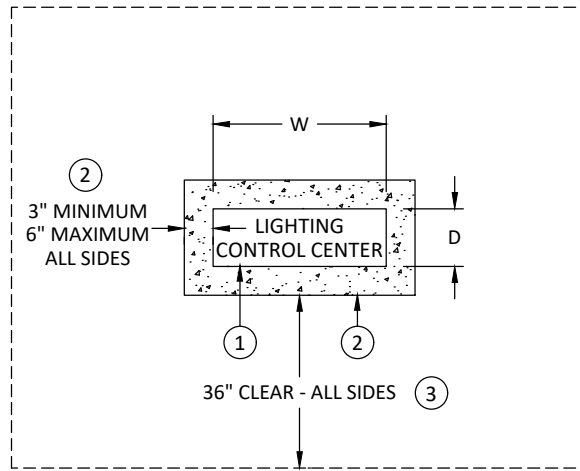
2 of 2

L6.2

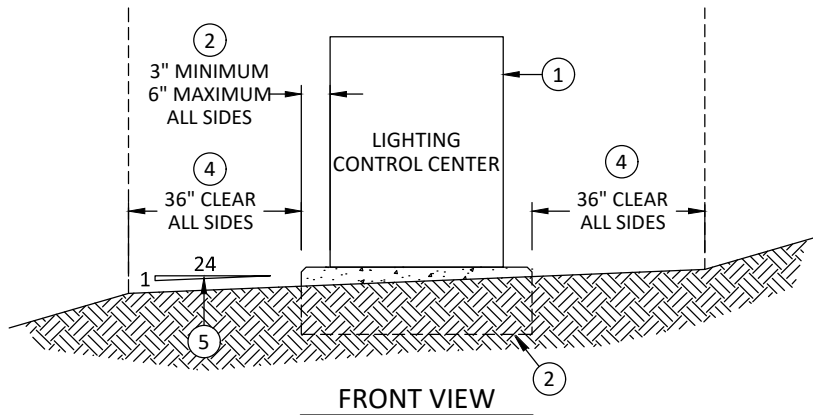
  
CITY ENGINEER

01/31/2023  
DATE

# STANDARD



PLAN VIEW



FRONT VIEW

## TYPICAL LIGHTING CONTROL CENTER DETAIL

### DETAIL NOTES

- ① PREBUILT NEMA 3R LIGHTING CONTROL CENTER CABINET (LCC). REFER TO LIGHTING CONTROL CENTER DETAILS FOR MORE INFORMATION.
- ② REINFORCED CONCRETE (CLASS B) FOUNDATION PAD, PER STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO, WITH 1" CHAMFER ON ALL EXPOSED EDGES. EDGE OF CONCRETE TO EXTEND 3" (MINIMUM) OR 6" (MAXIMUM) BEYOND EDGE OF CABINET.
- ③ THE LCC SHALL NOT BE LOCATED IN ANY INTERSECTION SIGHT TRIANGLES. PLACEMENT SHALL CONFORM TO ALLOWABLE ENCROACHMENTS IN THE PUBLIC ROW.
- ④ MINIMUM OF 36" CLEAR ZONE ON ALL SIDES OF CONCRETE PAD.
- ⑤ MAXIMUM OF 1:24 SLOPE IN CLEAR ZONE AREA.

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City of Aurora, Colorado

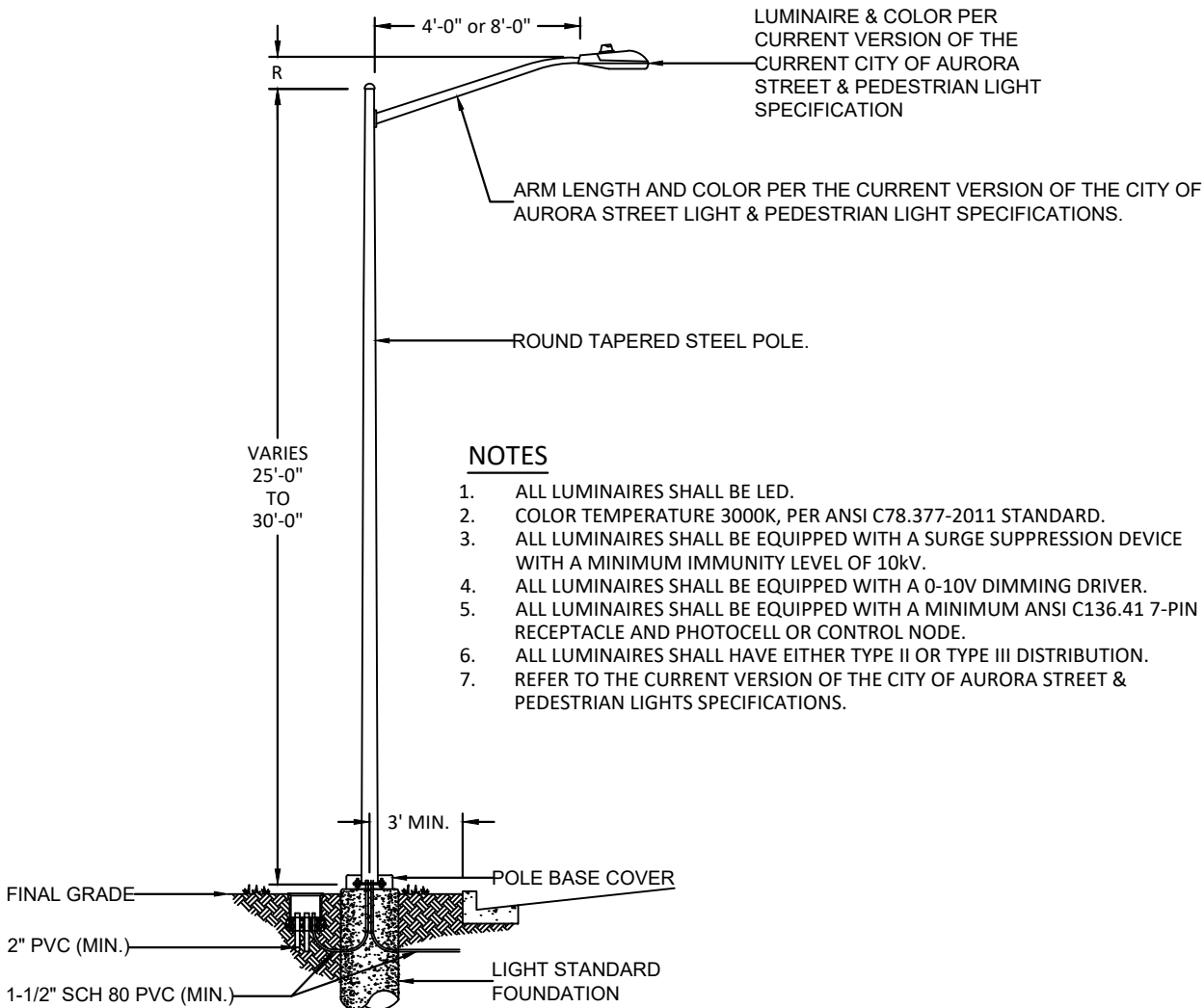
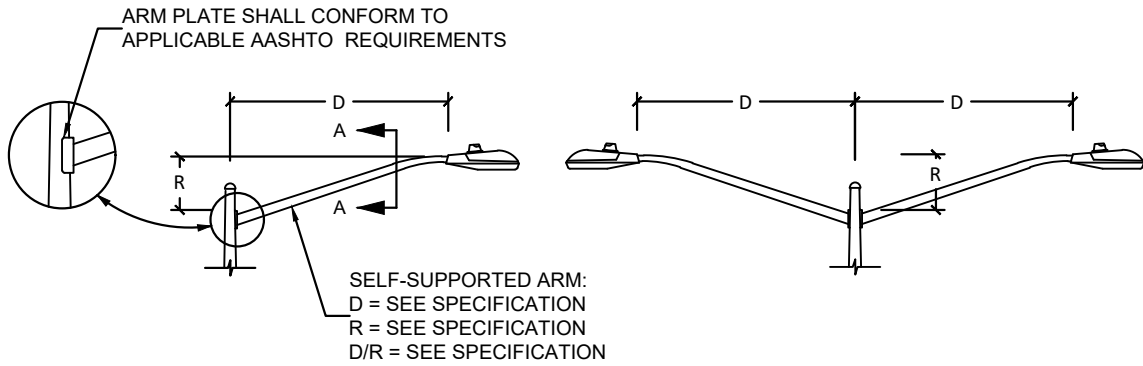
*Helen B. Anderson*  
CITY ENGINEER

01/31/2023  
DATE

TYPICAL LIGHTING  
CONTROL CENTER  
CABINET DETAIL

L7.1

# STANDARD



## NOTES

1. ALL LUMINAIRES SHALL BE LED.
2. COLOR TEMPERATURE 3000K, PER ANSI C78.377-2011 STANDARD.
3. ALL LUMINAIRES SHALL BE EQUIPPED WITH A SURGE SUPPRESSION DEVICE WITH A MINIMUM IMMUNITY LEVEL OF 10kV.
4. ALL LUMINAIRES SHALL BE EQUIPPED WITH A 0-10V DIMMING DRIVER.
5. ALL LUMINAIRES SHALL BE EQUIPPED WITH A MINIMUM ANSI C136.41 7-PIN RECEPTACLE AND PHOTOCCELL OR CONTROL NODE.
6. ALL LUMINAIRES SHALL HAVE EITHER TYPE II OR TYPE III DISTRIBUTION.
7. REFER TO THE CURRENT VERSION OF THE CITY OF AURORA STREET & PEDESTRIAN LIGHTS SPECIFICATIONS.

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City of Aurora, Colorado

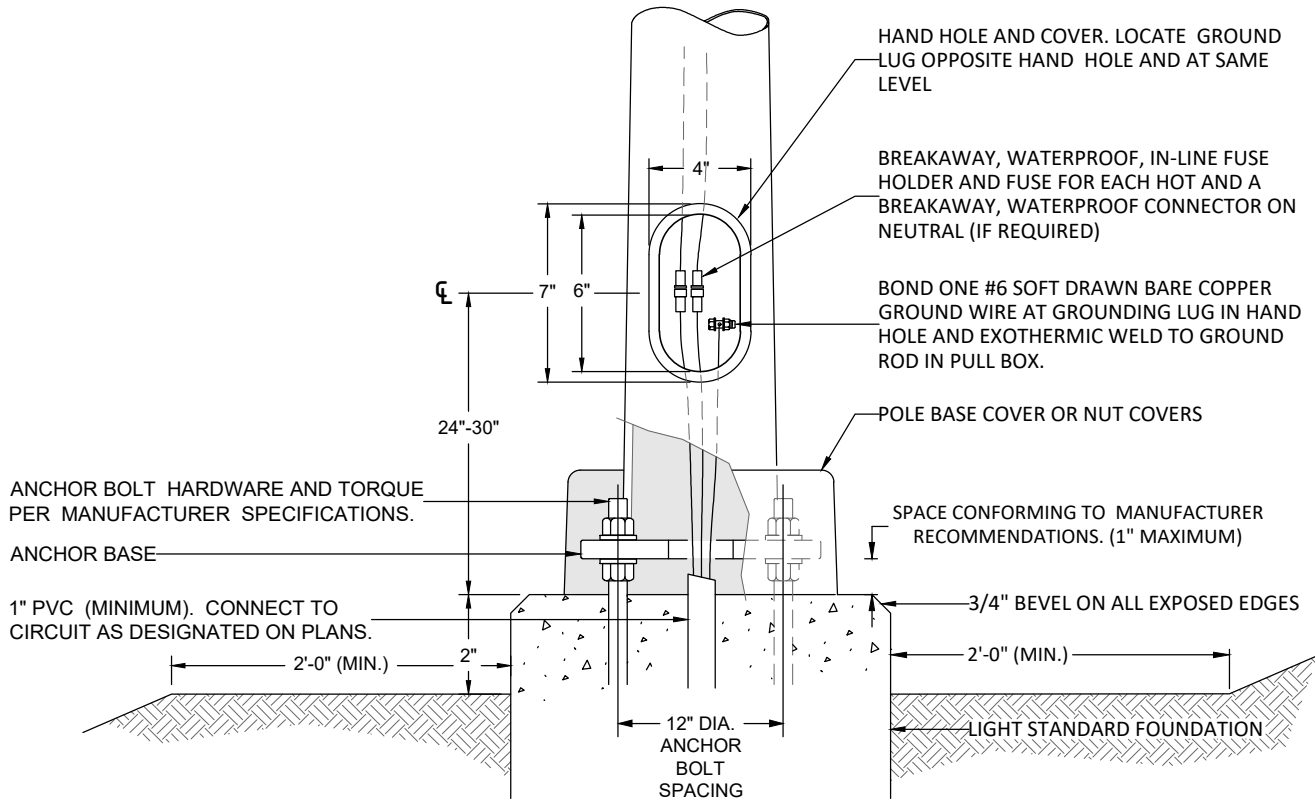
*Helen B. Johnson*  
 CITY ENGINEER

01/31/2023  
 DATE

TYPICAL LIGHT  
 STANDARD DETAIL

L8.1

# STANDARD




**TYPICAL NON-BREAKAWAY BASE DETAIL**  
 FOR USE ONLY OUTSIDE CLEAR ZONE OR IN PROTECTED INSTALLATIONS.

**NOTES**

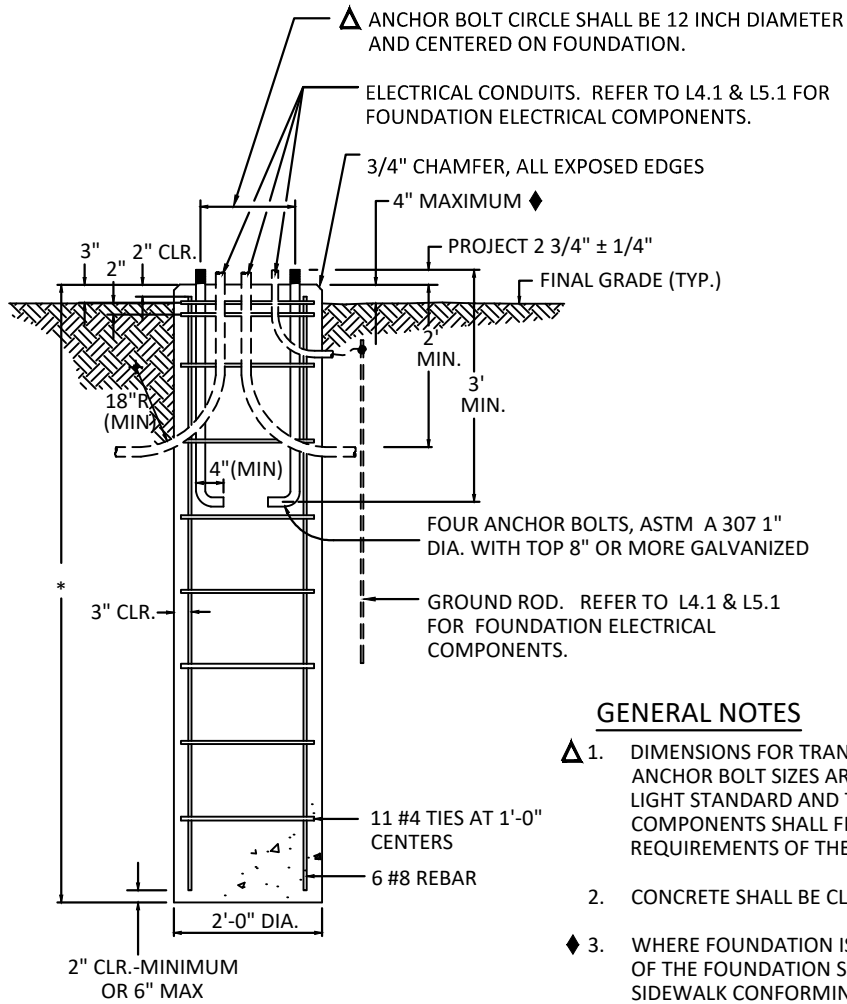
1. LIGHT STANDARD FOUNDATIONS SHALL BE PRECAST CONCRETE.
2. ALL CONDUCTORS SHALL BE SIZED IN CONFORMANCE WITH N.E.C. REQUIREMENTS 14/2 AWG CABLE MINIMUM.

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City of Aurora, Colorado   CITY ENGINEER	<b>TYPICAL NON-BREAKAWAY                  POLE BASE                  STANDARD DETAIL</b>	<b>L9.1</b>
01/31/2023 DATE		



# STANDARD



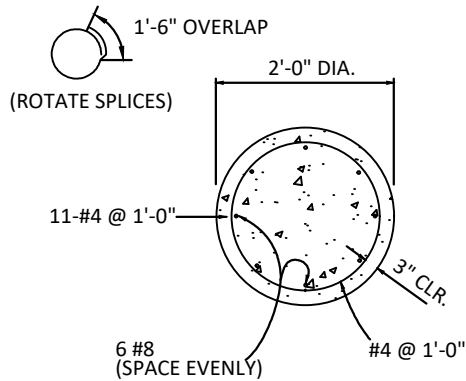
## GENERAL NOTES

1. DIMENSIONS FOR TRANSFORMER BASE, ANCHOR BASE AND ANCHOR BOLT SIZES ARE VARIABLE FOR THE HEIGHT OF THE LIGHT STANDARD AND THE MAST ARM CONFIGURATION. ALL COMPONENTS SHALL FIT AND SHALL ACCOMMODATE THE REQUIREMENTS OF THE LIGHT STANDARD SUPPLIED.
2. CONCRETE SHALL BE CLASS 1.
3. WHERE FOUNDATION IS LOCATED IN THE SIDEWALK, THE TOP OF THE FOUNDATION SHALL BE FLUSH WITH THE TOP OF THE SIDEWALK CONFORMING TO ADA REQUIREMENTS.
- \* 4. FOUNDATION DIMENSIONS PER FOUNDATION SCHEDULE BELOW. LIGHT STANDARDS HIGHER THAN 50'-0" OR WITH MULTIPLE LUMINAIRES OR BANNERS, OR VARYING SOIL OR WIND CONDITIONS, SHALL BE DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO AND SHOWN ON THE PLANS.

## \* FOUNDATION SCHEDULE

POLE HEIGHT	FOUNDATION DEPTH	FOUNDATION DIAMETER
< 20'	6'-0"	24"
20' - < 40'	7'-0"	24"
40' - 50'	11'-0"	24"
> 50'	P.S.E.	P.S.E.

P.S.E. (PER STRUCTURAL ENGINEER)



TYPICAL FOUNDATION SECTION

City of Aurora, Colorado

*Helen B. Johnson*  
CITY ENGINEER

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TYPICAL NON-BREAKAWAY  
POLE BASE  
STANDARD DETAIL

L10.1

## LIST OF TRAFFIC DETAILS

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FOUNDATION FOR SIGNAL POLE WITH BOLT DOWN BASE	2	TE-1
VEHICLE AND PEDESTRIAN POLE STANDARD	2	TE-2
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P-I CABINET FOUNDATION WITH FOOT PAD	1	TE-4
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METRO STREET NAME SIGN MOUNTING	1	TE-7
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# STANDARD

## TRAFFIC SIGNAL CONSTRUCTION STANDARDS CITY OF AURORA

All traffic signals maintained by the City of Aurora must be constructed in accordance with the details shown on sheets TE-1 through TE-13 as well as the following:

### A. CABINETS AND CABINET FOUNDATIONS

1. ALL CONDUITS SHALL BE CUT OFF WITH NO MORE THAN 1/2 INCH EXTENDING ABOVE CONCRETE BASE.
2. AC AND DC CONDUCTORS SHALL BE IN SEPARATE CONDUIT. COMMUNICATION LINES SHALL BE INCLUDED WITH THE DC CABLES. A SEPARATE 2 INCH CONDUIT SHALL BE USED FOR THE POWER FEED.
3. CABINET GROUND ROD SHALL BE A 5/8 INCH 8 FOOT COPPER ROD LOCATED IN THE HOME RUN PULL BOX.
4. GROUND WIRE SHALL BE A #6 AWG INSULATED STRANDED COPPER.
5. POWER WIRING SHALL BE #6 AWG COPPER STRANDED AND INSULATED, BLACK FOR THE HOT AND WHITE FOR THE NEUTRAL. WIRING SHALL BE LABELED INDICATING POINT OF SERVICE.
6. FIELD WIRING SHALL BE TERMINATED USING INSULATED SPADE CONNECTORS, WITH A MAXIMUM OF TWO (2) #14 AWG WIRES PER CONNECTOR.
7. ALL FIELD WIRING SHALL BE LABELED AND COLOR CODED BY PHASE AND DIRECTION. THIS INCLUDES SIGNAL, PUSHBUTTON, DETECTION, AND OPTICOM WIRING. COMMUNICATIONS LINE SHALL BE LABELED INDICATING THE LOCATION OF SERVICE (IF APPLICABLE) AND INTERCONNECT SHALL BE LABELED INDICATING DESTINATION.
8. ALL WIRING SHALL BE NEAT WITH ADEQUATE SLACK FOR REARRANGEMENTS.
9. CABINET BASE SHALL BE LEVEL EXTENDING APPROXIMATELY 18 INCHES ABOVE AND 18 INCHES BELOW GROUND.
10. CABINET SHALL BE LEVELED SO THAT THE DOOR OPENS FREELY WITHOUT BINDING.
11. CABINET SHALL BE CAULKED AROUND BASE WITH SILICON CAULK TO MAKE WATERTIGHT.
12. SURGE SUPPRESSORS FOR VEHICLE AND MULTI-MODAL VIDEO DETECTION SHALL BE INSTALLED IN A VERTICAL ORIENTATION WITH COAXIAL CABLE CONNECTED AT THE BOTTOM OF THE SUPPRESSOR.

### B. PULL BOXES & CONDUIT

1. PULL BOXES SHALL BE SET ON A MINIMUM OF 8 INCHES OF 3/4 INCH CRUSHED GRAVEL FOR DRAINAGE.
2. CONDUITS IN PULL BOXES SHALL BE STUBBED UP A MINIMUM OF 4 INCHES ABOVE THE GRAVEL AT A 90-DEGREE ANGLE FROM LEVEL AND FLUSH WITH EACH OTHER. CONDUIT SHALL BE CUT OFF APPROXIMATELY 6 INCHES BELOW THE PULL BOX LID.
3. CONDUIT SHALL BE DIRECT BORE UNDER EXISTING ROADWAY UNLESS OTHERWISE APPROVED. NUMBER & SIZE TO BE PER APPROVED DESIGN PLANS, TYP. 1 2" AND 2 3" FOR INTERSECTION LEGS. TYPICAL DEPTH SHALL BE 36" UNLESS OTHERWISE APPROVED BY THE TRAFFIC ENGINEER. ALL CONDUIT TO BE SCHEDULE 80.
4. PULL BOX COVER BOLTS SHALL BE IN PLACE AND THE DRAIN HOLES FOR BOLTS SHALL BE OPENED.
5. PULL BOXES SHALL BE ONE INCH ABOVE AND PARALLEL TO THE GROUND EXCEPT WHEN INSTALLED IN CONCRETE OR AS FIELD DETERMINED.
6. PULL BOXES INSTALLED IN CONCRETE SHALL BE FLUSH WITH FINISHED CONCRETE AND HAVE EXPANSION MATERIAL AROUND THE OUTSIDE OF PULL BOX.
7. WIRE IN PULL BOXES SHALL NOT BE TANGLED OR TWISTED. WIRE SHALL BE NEAT WITH A MAXIMUM OF A 1-FOOT LOOP AND BE TAGGED AND COLOR CODED, INDICATING DIRECTION AND TERMINATION POINT.
8. A PULL STRING SHALL BE PROVIDED IN ALL CONDUITS. ANY UNUSED CONDUITS SHALL BE CAPPED AND HAVE A LOCATING LINE (METALLIC CONDUCTOR) INSTALLED IF THE UNUSED CONDUIT DOES NOT PARALLEL OTHER POPULATED CONDUIT. UNUSED CONDUIT INSTALLED THROUGH A SEPARATE BORE SHALL HAVE LOCATING LINE INSTALLED, REGARDLESS OF RELATION TO OTHER POPULATED CONDUIT.
9. NO WIRE SPLICES SHALL BE ALLOWED IN PULL BOXES, EXCEPT FOR LOOPS, WHICH MUST BE SOLDERED AND SEALED WITH SHRINK TUBE. LOOPS SHALL BE TAGGED AND COLOR CODED WITH PHASE AND DIRECTION. (SEE TE-9.3)
10. ANY NECESSARY CUTS TO A PULL BOX SHALL BE DONE WITH A CUTTING TOOL WITHOUT STRUCTURAL DAMAGE TO THE PULL BOX.
11. AC AND DC CONDUCTORS SHALL BE IN SEPARATE CONDUITS.

(CONTINUED ON TE0.2)

City of Aurora, Colorado

  
TRAFFIC ENGINEER

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DATE

  
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TRAFFIC SIGNAL DESIGN  
& CONSTRUCTION  
STANDARD NOTES

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TE0.1

# STANDARD

## TRAFFIC SIGNAL CONSTRUCTION STANDARDS CITY OF AURORA

All traffic signals maintained by the City of Aurora must be constructed in accordance with the details shown on sheets TE-1 through TE-13 as well as the following:

### C. WIRING

1. EACH POLE SHALL HAVE ITS OWN SEPARATE HOME RUN, WITH A MINIMUM OF 25-CONDUCTOR IMSA SIGNAL CABLE. NO SPLICES SHALL BE ALLOWED BETWEEN THE CABINET AND THE DESTINATION POLE. WIRING SHALL BE TERMINATED IN ACCORDANCE WITH ATTACHED COLOR CODE (SEE TE-CO).
2. ALL SIGNAL WIRING IN POLE BASES SHALL BE IDENTIFIED WITH PHASE TAPING BY DIRECTION, PER CITY COLOR CODE.
3. EACH PUSH BUTTON SHALL BE FED WITH A SEPARATE BLACK 2 CONDUCTOR SHIELDED CABLE, CONTINUOUS FROM CABINET TO BUTTON.
4. A 4 CONDUCTOR IMSA SIGNAL CABLE SHALL SERVICE EACH PEDESTRIAN (WALK / DON'T WALK) HEAD.
5. ALL HOLES DRILLED IN SIGNAL POLES OR MAST ARMS FOR WIRING ACCESS, INCLUDING BUT NOT LIMITED TO PEDESTRIAN PUSH- BUTTONS; VEHICULAR DISPLAYS; PEDESTRIAN DISPLAYS; ILLUMINATED STREET NAME SIGNS; DETECTION DEVICES; ETC., SHALL BE DRILLED 1-1/4 INCHES IN DIAMETER AND HAVE A WELL-FITTING RUBBER GROMMET INSTALLED TO PROTECT SAID WIRING.
6. WIRING IN HAND HOLES SHALL HAVE 12 TO 18 INCHES OF SLACK THAT CAN BE PULLED OUT FOR INSPECTION OR REARRANGEMENTS.
7. EACH SIGNAL HEAD SHALL BE FED WITH A 7 CONDUCTOR IMSA SIGNAL CABLE.
8. STREET LIGHT WIRING SHALL BE INSTALLED PER CITY OF AURORA STANDARDS. STREETLIGHT FEED SHALL BE IN A SEPARATE 2" CONDUIT AND HAVE SEPARATE PULLBOXES ON EACH CORNER TO ISOLATE THE STREETLIGHT CIRCUIT AS MUCH AS POSSIBLE.
9. ILLUMINATED STREET NAME SIGNS SHALL BE SERVICED BY A 14/2 UF CABLE (WITH GROUND) WHICH MUST BE CONTINUOUS AND WITHOUT SPLICES FROM THE BASE OF THE SIGNAL POLE TO THE POWER SOURCE. THE POWER CABLE FROM THE ILLUMINATED STREET NAME SIGNS SHALL BE SPLICED TO THE 14/2 UF CABLE IN THE HAND HOLE AT THE BASE OF THE SIGNAL POLE. (SEE TE-5.2)
10. LOOP DETECTION LEAD IN ("HOMERUN") WIRE SHALL BE A 2-CONDUCTOR, #14 AWG STRANDED TINNED COPPER WIRE, POLYETHYLENE INSULATED TWISTED CONDUCTORS WITH 100% SHIELD COVERAGE AND STRANDED TINNED COPPER DRAIN WIRE. WIRE SHALL HAVE A CHROME PVC JACKET. WIRE SHALL BE BELDEN #8720 OR APPROVED EQUAL.
11. AC AND DC CONDUCTORS SHALL BE IN SEPARATE CONDUITS.
12. VIDEO DETECTION WIRING SHALL BE CONTINUOUS FROM CAMERA TO CONTROL CABINET. NO SPLICES SHALL BE ALLOWED.
13. ALL NEW TRAFFIC SIGNAL POLE INSTALLATIONS SHALL BE INSTALLED WITH 25 CONDUCTOR WIRE CONTINUOUS FROM CONTROL CABINET TO HANDHOLE. FOR ANY TRAFFIC SIGNAL MODIFICATION INVOLVING CHANGES TO THE WIRING SPLICES (BETWEEN THE MAIN MULTICONDUCTOR FEED FROM CONTROL CABINET TO POLE CORNER AND THE INDIVIDUAL MULTICONDUCTOR FEEDS FROM VEHICULAR AND PEDESTRIAN DISPLAYS DOWN THE MAST ARM AND POLE) IN THE HANDHOLE OF THE POLE, IF 25 CONDUCTOR WIRE IS NOT ALREADY PRESENT FROM CONTROL CABINET TO HANDHOLE IT SHALL BE INSTALLED AS PART OF THE MODIFICATION. ALL REWIRING AND EXCEPTIONS ARE SUBJECT TO REVIEW AND APPROVAL BY THE TRAFFIC ENGINEER.

### D. TRAFFIC SIGNAL POLES AND MASTARMS

1. TRAFFIC SIGNAL POLES SHALL MEET CURRENT CITY STANDARDS AND BE APPROVED BY THE TRAFFIC ENGINEER PRIOR TO PROCUREMENT.
2. MASTARM LENGTHS SHALL AT A MINIMUM REACH THE CENTER OF THE LEFT-TURN LANE FOR EACH APPROACH IN THE THE CASE OF SINGLE LEFT-TURN LANE; OR THE CENTER OF THE INSIDE LEFT-TURN LANE (ADJACENT TO CENTERLINE) IN THE CASE OF DUAL LEFT-TURN LANES. IN EITHER CASE, THE LENGTH OF THE MASTARM SHALL BE ROUNDED UP TO THE NEAREST 5 FOOT INCREMENT AND INDICATED ON THE SIGNAL PLAN AND QUANTITIES SHEET ACCORDINGLY.
3. SIGNAL POLE EXTENSIONS AND LUMINAIRE ARMS SHALL BE FURNISHED FOR ALL SIGNAL POLES AT AN INTERSECTION UNLESS THERE IS AN OVERHEAD OBSTRUCTION SUCH AS A POWERLINE AND DEVIATION IS

(CONTINUED ON TE0.3

City of Aurora, Colorado

  
TRAFFIC ENGINEER

1/26/2023  
DATE

  
CITY ENGINEER

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TRAFFIC SIGNAL DESIGN  
& CONSTRUCTION  
STANDARD NOTES

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TE0.2

# STANDARD

## TRAFFIC SIGNAL CONSTRUCTION STANDARDS CITY OF AURORA

All traffic signals maintained by the City of Aurora must be constructed in accordance with the details shown on sheets TE-1 through TE-13 as well as the following:

(TRAFFIC SIGNAL POLES AND MASTARMS CONTINUED)

4. APPROVED BY THE TRAFFIC ENGINEER.
5. A TYPICAL INTERSECTION SHALL CONSIST OF ONE POLE AND MASTARM FOR EACH APPROACH. MULTIPLE MASTARMS ON A SINGLE POLE SHALL NOT GENERALLY BE ALLOWED.

### E. INTERSECTION PHASING/SIGNAL HEADS/SIGNAGE

1. INTERSECTION PHASING SHALL HAVE PHASE Ø2 AS EITHER THE NORTHBOUND OR EASTBOUND THROUGH MOVEMENT, WHICHEVER IS THE MAJOR STREET. THROUGH MOVEMENTS ARE NUMBERED AS EVEN PHASES (Ø4, Ø6, Ø8) CLOCKWISE AROUND THE INTERSECTION FROM PHASE Ø2. LEFT-TURN PHASING (WHERE APPLICABLE) IS DENOTED BY ODD NUMBERED PHASES (Ø1, Ø3, Ø5, Ø7), WITH THE FOLLOWING PHASE PAIRS (Ø2 Ø5, Ø4 Ø7, Ø1 Ø6, Ø3 Ø8). UNUSUAL GEOMETRY OR OTHER CONDITIONS SHALL REQUIRE PHASE APPROVAL BY THE TRAFFIC ENGINEER. PHASING DIAGRAM SHALL BE SHOWN ON DESIGN PLANS.
2. SIGNAL HEADS SHALL BE PROVIDED ON BOTH LEFT AND RIGHT POLES FOR EACH DIRECTION TO SUPPLEMENT OVERHEAD SIGNAL HEADS. THE LEFT SIDE POLE HEAD SHALL MATCH THE LEFTMOST OVERHEAD SIGNAL HEAD AND THE RIGHT SIDE POLE HEAD SHALL MATCH THE RIGHTMOST OVERHEAD SIGNAL HEAD UNLESS OTHERWISE APPROVED BY THE TRAFFIC ENGINEER.
3. ONE SIGNAL HEAD PER LANE, CENTERED ON THE LANE, SHALL BE PROVIDED. DEDICATED RIGHT TURN LANES SHALL BE PROVIDED WITH A REGULATORY R3-5R 30"X36" OVERHEAD SIGN CENTERED ON THE LANE IN LIEU OF A SIGNAL HEAD. ANY DEVIATION SHALL BE APPROVED BY THE TRAFFIC ENGINEER.
4. CITY STANDARD FOR LEFT-TURN DISPLAYS SHALL BE THE FLASHING YELLOW ARROW (FYA) 3 SECTION DISPLAY FOR PERMISSIVE ONLY PHASING; FYA 4 SECTION DISPLAY FOR PROTECTED/PERMISSIVE PHASING, AND A 3 SECTION RA-YA-GA DISPLAY FOR FULL TIME PROTECTED ONLY PHASING UNLESS OTHERWISE APPROVED BY THE TRAFFIC ENGINEER. DETERMINATION OF THE APPROPRIATE DISPLAY SELECTION SHALL BE MADE BY THE TRAFFIC ENGINEER.
5. DEDICATED LEFT-TURN LANE(S) SHALL BE PROVIDED WITH A REGULATORY R3-5L 30"X36" OVERHEAD SIGN OR R3-5MOD 48"X30" (DUAL LEFT) SIGN PLACED TO THE RIGHT OF THE LEFT-TURN SIGNAL HEAD.
6. OVERHEAD SIGNAL HEADS SHALL BE INSTALLED WITH RETRO-REFLECTIVE BACKPLATES.
7. SIGNAL HEAD BACKPLATES SHALL BE INSTALLED WITH MANUFACTURER MOUNTING HARDWARE AND WASHERS.

### F. ADDITIONAL NOTES

1. ON DESIGN PLANS, THE LANE CONFIGURATION FOR EACH APPROACH (E.G. LEFT ONLY, THROUGH-THROUGH-THROUGH/RIGHT) SHALL BE SHOWN BY MEANS OF HOLLOW ARROWS AT THE EDGE OF THE APPROACH FURTHEST FROM THE INTERSECTION - THESE ARROWS ARE FOR INFORMATIONAL PURPOSES ONLY AND ARE NOT MEANT TO INDICATE PAVEMENT MARKINGS. ON THE DESIGN PLANS, THE MAJOR STREET SHALL BE SHOWN FOR 200' IN ADVANCE OF THE INTERSECTION AND THE MINOR STREET FOR 150' IN ADVANCE OF THE INTERSECTION FOR BOTH DIRECTIONS.
2. NECESSARY PAVEMENT MARKINGS SHALL BE SHOWN AS FILLED ARROWS IN THEIR APPROPRIATE LOCATIONS.
3. PEDESTRIAN MOVEMENTS SHALL BE PROVIDED FOR ALL FOUR DIRECTIONS OF AN INTERSECTION, ACCOMPANIED BY COUNTDOWN PEDESTRIAN HEADS, AUDIBLE PUSHBUTTONS AND CROSSWALKS UNLESS OTHERWISE APPROVED BY THE TRAFFIC ENGINEER.
4. FLASH PROGRAM OPERATIONS SHALL BE SHOWN ON ALL DESIGN PLANS.
5. ANY MATERIALS NOT PROVIDED BY THE CITY SHALL BE SUBMITTED TO THE TRAFFIC ENGINEER OR DESIGNATE FOR REVIEW AND APPROVAL PRIOR TO PROCUREMENT OF SAID MATERIALS.
6. THE CITY RESERVES THE RIGHT TO REQUIRE SUCCESSFUL DEMONSTRATION OF ANY PROPOSED NON-STANDARD OR UNUSUAL PHASING OR OPERATION AT ITS DISCRETION.
7. ONCE TRAFFIC SIGNAL CONTRACTOR HAS BEGUN WORK ON TRAFFIC SIGNAL CONSTRUCTION, ALL OPERATIONS & MAINTENANCE RESPONSIBILITIES FOR THE TRAFFIC SIGNAL AND INTERSECTION SHALL SHIFT TO THE

(CONTINUED ON TE0.4)

City of Aurora, Colorado

  
TRAFFIC ENGINEER

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TRAFFIC SIGNAL DESIGN  
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STANDARD NOTES

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TE0.3

# STANDARD

## TRAFFIC SIGNAL CONSTRUCTION STANDARDS

### CITY OF AURORA

All traffic signals maintained by the City of Aurora must be constructed in accordance with the details shown on sheets TE-1 through TE-13 as well as the following:

(ADDITIONAL NOTES CONTINUED)

CONTRACTOR UNTIL SUCH TIME AS ALL WORK IS COMPLETE AND HAS BEEN INSPECTED BY TRAFFIC ENGINEERING, TRAFFIC OPERATIONS, AND PUBLIC IMPROVEMENTS AND ACCEPTED IN WRITING BY TRAFFIC ENGINEERING OR OPERATIONS. ADDITIONALLY, THE CONTRACTOR SHALL PROVIDE A MINIMUM ONE-YEAR WARRANTY FOR ALL WORK.

8. FOR REBUILDS OR MODIFICATIONS TO EXISTING SIGNALS, DESIGN PLANS SHALL INCLUDE, AT A MINIMUM, ONE SHEET REFLECTING EXISTING CONDITIONS AND ONE SHEET REFLECTING PROPOSED CONDITIONS. ADDITIONAL SHEETS AND INFORMATION MAY ALSO BE REQUIRED AT THE TRAFFIC ENGINEER'S DISCRETION.
9. FOR NEW TRAFFIC SIGNAL CONSTRUCTION, THE SIGNAL SHALL BE PLACED INTO FLASHING OPERATION A MINIMUM OF 48 HOURS PRIOR TO THE ACTIVATION OF FULL OPERATION. BOTH FLASH AND FULL TURN-ONS SHALL OCCUR ON TUESDAYS AND THURSDAYS, RESPECTIVELY, ONLY ON NON-HOLIDAY WEEKS ONLY UNLESS OTHERWISE APPROVED BY THE TRAFFIC ENGINEER. FOR TRAFFIC SIGNAL REBUILDS OR MODIFICATIONS, CHANGEOVERS FROM OLD EQUIPMENT TO NEW EQUIPMENT SHALL ONLY OCCUR BETWEEN 8:30AM AND 3:30PM ON TUESDAY, WEDNESDAY, OR THURSDAY ONLY ON NON-HOLIDAY WEEKS ONLY UNLESS OTHERWISE APPROVED BY THE TRAFFIC ENGINEER.
10. ANY TRAFFIC SIGNAL OR PEDESTRIAN INDICATIONS THAT ARE UNDER CONSTRUCTION AND ARE NOT ACTIVE SHALL BE COVERED WITH ORANGE BAGS UNTIL SUCH TIME AS THEY ARE PLACED INTO SERVICE. ANY PEDESTRIAN PUSHBUTTONS THAT ARE UNDER CONSTRUCTION AND NOT ACTIVE SHALL HAVE THE ASSOCIATED SIGNAGE PLACED BLANK SIDE OUT AND THE BUTTONS COVERED UNTIL SUCH TIME AS THEY ARE PLACED INTO SERVICE. CROSSWALKS SHALL NOT BE MARKED AT NEW TRAFFIC SIGNAL INSTALLATIONS UNTIL SUCH TIME AS THE TRAFFIC SIGNAL IS PLACED INTO FULL OPERATION BUT SHALL THEN BE MARKED ON THE SAME DAY OR AS SOON AS POSSIBLE AFTERWARD. ANY DEVIATION FROM THE ABOVE MUST BE APPROVED BY THE TRAFFIC ENGINEER.
11. FOR ALL NEW TRAFFIC SIGNAL INSTALLATIONS PUNCH-LIST INSPECTION SHALL BE SCHEDULED AND COORDINATED WITH TRAFFIC ENGINEERING, INSPECTIONS, AND TRAFFIC OPERATIONS. ALL CRITICAL PUNCH-LIST ITEMS SHALL HAVE BEEN ADDRESSED AND CONFIRMED CORRECTED AND THE TRAFFIC SIGNAL TO BE 100% COMPLETE PRIOR TO FLASH TURN-ON. THE CITY WILL NOT ASSUME OWNERSHIP, MAINTENANCE, AND OPERATION OF THE NEW TRAFFIC SIGNAL UNTIL SUCH TIME AS THE PUNCH-LIST HAS BEEN VERIFIED COMPLETE, THE SIGNAL HAS BEEN PLACED INTO FULL OPERATION, AND THE SIGNAL HAS BEEN FORMALLY ACCEPTED IN WRITING BY TRAFFIC ENGINEERING OR TRAFFIC OPERATIONS. A MINIMUM ONE-YEAR WARRANTY SHALL BE PROVIDED FOR ALL NEW TRAFFIC SIGNAL INSTALLATION WORK. ANY DEVIATION FROM THE ABOVE MUST BE APPROVED BY THE TRAFFIC ENGINEER.
12. VIDEO DETECTION (CAMERA) PLACEMENT AND MOUNTING TYPE TO BE DETERMINED BY THE MANUFACTURER AND/OR VENDOR FOR OPTIMAL LOCATION AND PERFORMANCE OF THE PRODUCT, SUBJECT TO APPROVAL BY THE CITY OF AURORA. THIS WILL BE A VEHICLE LANE APPROACH SPECIFIC DETERMINATION.
13. ALL TRAFFIC SIGNAL CABINETS FURNISHED BY THE CONTRACTOR MUST BE PROGRAMMED AND TESTED BY CITY OF AURORA TRAFFIC OPERATIONS. PROGRAMMING SHALL INCLUDE CONFIGURATION OF EMERGENCY VEHICLE PRE-EMPTION (OPTICOM) DETECTOR CARDS AND THE MALFUNCTION MANAGEMENT UNIT JUMPER CARD. CABINET PROGRAMMING AND BURN IN REQUIRES A MINIMUM OF TWO (2) BUSINESS WEEKS. CABINET DROP OFF AND PICK UP SHALL BE SCHEDULED WITH TRAFFIC OPERATIONS A MINIMUM OF THREE (3) WEEKS BEFORE THE ANTICIPATED CABINET PICKUP DATE. THE CONTRACTOR SHALL SUBMIT A SIGNAL TIMING REQUEST TO TRAFFIC ENGINEERING A MINIMUM OF (4) WEEKS BEFORE THE ANTICIPATED CABINET PICKUP DATE. ALL SIGNAL TIMING, PROGRAMMING, AND TESTING SCHEDULES ARE SUBJECT TO REVIEW AND MODIFICATION BY THE TRAFFIC ENGINEER.
14. ALL PEDESTRIAN PEDESTAL POLES AND BOLLARDS SHALL HAVE PUSHBUTTONS AND PEDESTRIAN SIGNAGE INSTALLED ON A PUSHBUTTON STATION ADAPTER, ANY DEVIATION MUST BE APPROVED BY THE TRAFFIC ENGINEER.
15. TRAFFIC MATERIALS AND EQUIPMENT STANDARDS CAN BE FOUND IN SPECIAL CONDITIONS FOR TRAFFIC SIGNAL CONSTRUCTION DOCUMENTATION AVAILABLE FROM CITY OF AURORA PUBLIC WORKS TRAFFIC ENGINEERING.

(CONTINUED ON TE0.5)

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<p style="text-align: center;">City of Aurora, Colorado</p> <div style="display: flex; justify-content: space-between;"> <div style="text-align: left;">               TRAFFIC ENGINEER         </div> <div style="text-align: right;">             1/26/2023              DATE         </div> </div> <hr/> <div style="display: flex; justify-content: space-between;"> <div style="text-align: left;">               CITY ENGINEER         </div> <div style="text-align: right;">             01/31/2023              DATE         </div> </div>	<p><b>TRAFFIC SIGNAL DESIGN &amp; CONSTRUCTION STANDARD NOTES</b></p>	<p>4 of 5</p> <p><b>TE0.4</b></p>
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# STANDARD

## TRAFFIC SIGNAL CONSTRUCTION STANDARDS CITY OF AURORA

All traffic signals maintained by the City of Aurora must be constructed in accordance with the details shown on sheets TE-1 through TE-13 as well as the following:

PLEASE CALL 303.739.7300 FOR MORE INFORMATION.

16. FOR TRAFFIC SIGNAL REBUILDS ALL EXISTING EQUIPMENT INCLUDING TRAFFIC SIGNAL HEADS, REGULATORY SIGNAGE, VIDEO DETECTION EQUIPMENT, MOUNTING HARDWARE, AND WIRING SHALL BE RETURNED TO TRAFFIC OPERATIONS.
17. COPPER GROUND RODS INSTALLED IN CONCRETE SHALL BE TREATED TO PREVENT CORROSION.

### NOTES FOR TRAFFIC SIGNAL REBUILDS WHICH INCLUDE THE INSTALLATION OR REPLACEMENT OF ONE OR MORE TRAFFIC SIGNAL POLES:

1. THE CONTRACTOR SHALL REQUEST AND ATTEND AN ON-SITE PRE-CONSTRUCTION MEETING WITH THE CITY'S PROJECT MANAGER, TRAFFIC ENGINEERING, TRAFFIC OPERATIONS, THE CONTRACTOR'S FOREMAN, AND PRIME CONTRACTOR AS APPLICABLE BEFORE STARTING WORK.
2. THE CONTRACTOR SHALL CONDUCT A FIELD INVENTORY OF EXISTING EQUIPMENT PRIOR TO STARTING WORK AND TAKING OVER SIGNAL OPERATIONS AND MAINTENANCE. ANY EQUIPMENT NEEDED TO ACHIEVE THE INTENDED OPERATION SHALL BE FURNISHED BY THE CONTRACTOR.
3. IF EXISTING CONDUIT IS FOUND TO BE FULL OR BROKEN, IT SHALL BE FURNISHED AND REPLACED BY THE CONTRACTOR.
4. IF ANY EQUIPMENT THAT IS PLANNED TO BE RESET IS FOUND TO BE BROKEN OR IN POOR WORKING CONDITION, IT SHALL BE FURNISHED AND REPLACED BY THE CONTRACTOR.
5. EXISTING OPTICOM FUNCTIONALITY SHALL BE TESTED AND SHALL BE FURNISHED AND REPLACED BY THE CONTRACTOR IF NEEDED AS DETERMINED BY THE CITY TRAFFIC ENGINEER.
6. ALL DETECTION SHALL BE REPLACED BASED ON THE CITY'S CURRENT STANDARD. DETECTION MUST BE CONFIGURED AND OPERATIONAL AT THE TIME OF INSTALL.
7. ALL CONTROLLERS, CABINETS, MMU, AND UPS SHALL BE FURNISHED AND REPLACED BY THE CONTRACTOR UNLESS OTHERWISE APPROVED BY THE CITY TRAFFIC ENGINEER.
8. WHEN THE CONTRACTOR TAKES OVER MAINTENANCE AND OPERATIONS OF THE SIGNAL, THEY MUST HAVE A LEVEL II IMSA TECHNICIAN ON STAFF WITH WORKING KNOWLEDGE OF SIEMENS AND INTELIGHT CONTROLLERS.
9. THE CONTRACTOR MUST RESPOND TO ALL NON-URGENT COMPLAINTS OR REQUESTS FOR REPAIRS WITHIN 24 HOURS AND ALL EMERGENCY REQUESTS WITHIN 1 HOUR. IF A SIGNAL IS IN FLASH, THE CONTRACTOR MUST STAY ON SITE UNTIL IT IS OPERATIONAL.
10. FOR CITY PROJECTS ONLY: THE CONTRACTOR IS RESPONSIBLE TO PERFORM AN INVENTORY AND ASSESSMENT OF EXISTING INFRASTRUCTURE PRIOR TO THE COMMENCEMENT OF WORK. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE CITY PROJECT MANGER IN WRITING OF ANY UNFORESEEN CONDITIONS OR OMISSIONS FROM THE CONTRACT DOCUMENTS THAT RESULT IN NON-COMPLIANCE WITH THE REQUIREMENTS AS OUTLINED IN THESE NOTES.

(END)

City of Aurora, Colorado

  
TRAFFIC ENGINEER

1/26/2023  
DATE

  
CITY ENGINEER

01/31/2023  
DATE

TRAFFIC SIGNAL DESIGN  
& CONSTRUCTION  
STANDARD NOTES

5 of 5

TE0.5

# STANDARD





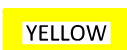





## MAIN STREET

#2 SOLID WHITE AC-RETURN	M.S. GREEN
#4 SOLID GREEN	M.S. YELLOW
#5 SOLID ORANGE	M.S. RED
#3 SOLID RED	M.S. L/T GREEN ARROW
#6 SOLID BLUE	M.S. L/T YELLOW ARROW
#11 BLUE W/BLACK STRIPE	M.S. WALK
#14 GREEN W/WHITE STRIPE	M.S. DON'T WALK
#13 RED W/WHITE STRIPE	M.S. R/T GREEN ARROW
#19 BLUE W/RED STRIPE	M.S. R/T YELLOW ARROW
#18 ORANGE W/RED STRIPE	M.S. L/T FLASHING YELLOW ARROW FYA
#21 ORANGE W/GREEN STRIPE	M.S. L/T RED ARROW
#20 RED W/GREEN STRIPE	

## SIDE STREET

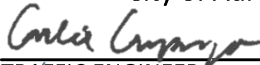

#9 GREEN W/BLACK STRIPE	S.S. GREEN
#10 ORANGE W/BLACK STRIPE	S.S. YELLOW
#8 RED W/BLACK STRIPE	S.S. RED
#1 SOLID BLACK	S.S. L/T GREEN ARROW
#12 BLACK W/WHITE STRIPE	S.S. L/T YELLOW ARROW
#15 BLUE W/WHITE STRIPE	S.S. WALK
#16 BLACK W/RED STRIPE	S.S. DON'T WALK
#7 WHITE W/BLACK STRIPE	S.S. L/T FYA
#17 WHITE W/RED STRIPE	S.S. L/T RED ARROW
#22 SECOND GREEN WIRE	S.S. R/T GREEN ARROW
#23 SECOND BLACK WIRE	S.S. R/T YELLOW ARROW
#24-25 SPARE CONDUCTORS	

NOTE: ALL HAND HOLE TERMINATIONS SHALL BE IDENTIFIED AS FOLLOWS:

	NORTH
	EAST
	SOUTH
	WEST
	IDENTIFIES A PED
 	IDENTIFIES A PUSH BUTTON
	IDENTIFIES A LEFT TURN
	IDENTIFIES A RIGHT TURN
	IDENTIFIES SPARE CONDUCTORS

FYA = FLASHING YELLOW ARROW  
 #XX - DESIGNATES WIRE # ON STANDARD IMSA SPEC., 25 CONDUCTOR CABLE. FOR REFERENCE ONLY.

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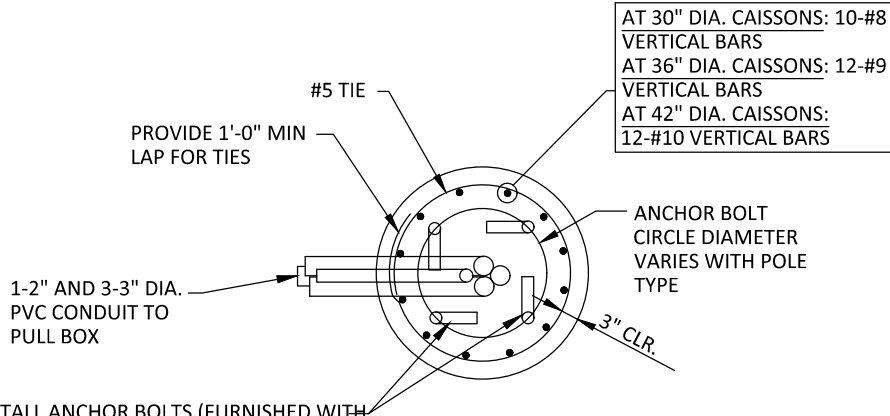
City of Aurora, Colorado  
  
 TRAFFIC ENGINEER 1/26/2023  
 DATE  
  
 CITY ENGINEER 01/31/2023  
 DATE

25 CONDUCTOR  
 CABLE WIRING AND  
 COLOR CODE

1 of 1  
 TE-CO



# STANDARD



INSTALL ANCHOR BOLTS (FURNISHED WITH POLE) PER MANUFACTURER'S TEMPLATE (FURNISHED WITH ORDER). ORIENT HOOKS SUCH THAT A CONCRETE PUMP HOSE CAN ACCESS THE BOTTOM OF THE EXCAVATION. ANCHOR BOLTS SHALL BE GALVANIZED AT THREADED ENDS IN ACCORDANCE WITH ASTM A-153.

## TRAFFIC SIGNAL FOUNDATION TOP VIEW

### GENERAL NOTES

1. THE STANDARD SIGNAL FOUNDATIONS SHOWN ON THIS DRAWING SHALL ONLY BE USED WITH SIGNAL PLANS APPROVED BY THE CITY OF AURORA.
2. ALL WORK SHALL BE CONDUCTED IN ACCORDANCE WITH CITY OF AURORA ROADWAY DESIGN AND CONSTRUCTION SPECIFICATIONS.
3. CAISSON CONCRETE SHALL BE CITY OF AURORA CLASS 1A,  $f'_c = 4000$  psi.
4. ALL REINFORCING STEEL SHALL BE PER AASHTO M31, GRADE 60,  $f_y = 60,000$  psi.
5. ANCHOR BOLTS SHALL BE ASTM F1554 MODIFIED TO 55 ksi YIELD STRENGTH. ANCHOR BOLTS SHALL BE FURNISHED BY SIGNAL POLE MANUFACTURER. BOLTS SHALL BE GALVANIZED AT THREADED ENDS IN ACCORDANCE WITH ASTM A153.
6. THE SIGNAL FOUNDATION DESIGN SHOWN ON THIS DRAWING ASSUMES THE MINIMUM SOIL CHARACTERISTICS AS WOULD BE TYPICALLY ENCOUNTERED IN AURORA WHICH ARE NOTED BELOW. IN THE EVENT THAT SOFT OR LOOSE SOIL CONDITIONS ARE ENCOUNTERED, A SITE SPECIFIC GEOTECHNICAL EVALUATION AND FOUNDATION DESIGN MAY BE NECESSARY.

#### ASSUMED GEOTECHNICAL DESIGN PARAMETERS:

SOIL DENSITY ( $\gamma_g$ ) = 110 pcf for Cohesive (Clay) Soils; 115 pcf for Non-Cohesive (Sandy) Soils  
 SOIL COHESION = 750 psf (for Cohesive Soils)  
 $E_{50} = 0.01$  in/in (for Cohesive Soils)  
 ANGLE OF INTERNAL FRICTION ( $\phi$ ) = 30° (for Non-Cohesive Soils)  
 HORIZONTAL MODULUS OF SUBGRADE REACTION ( $K_s$ ) = 90 pci (for Non-Cohesive Soils)

7. IF THE FOLLOWING SITUATIONS ARE ENCOUNTERED DURING DRILLING, CONTACT THE CITY OF AURORA ENGINEER:
  - (A) THE SOIL HAS A HIGH ORGANIC CONTENT OR CONSISTS OF SATURATED SILT OR CLAY
  - (B) THE SITE WILL NOT SUPPORT THE WEIGHT OF THE DRILLING RIG
  - (C) THE FOUNDATION SOILS ARE NOT HOMOGENEOUS
  - (D) FIRM BEDROCK IS ENCOUNTERED
  - (E) GROUNDWATER IS ENCOUNTERED

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City of Aurora, Colorado

*Carla Compton*  
 TRAFFIC ENGINEER

DATE

01/31/2023

*Alexander*  
 CITY ENGINEER

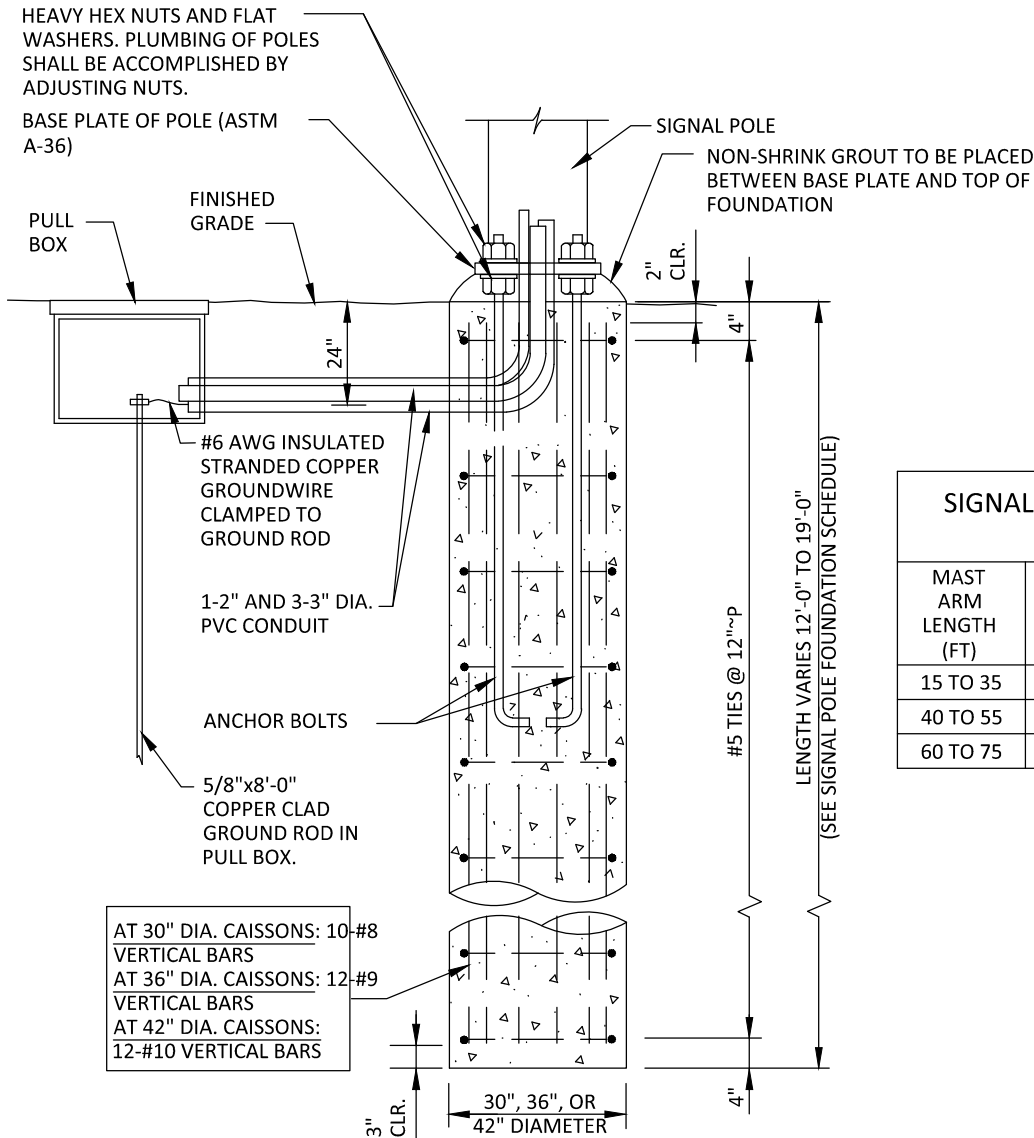
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FOUNDATION FOR  
 SIGNAL POLE WITH BASE

1 of 2

TE1.1

# STANDARD



TRAFFIC SIGNAL FOUNDATION ELEVATION

CONSTRUCTION NOTES

1. FOUNDATIONS SHOULD BE POURED 10 TO 20 DAYS PRIOR TO POLE INSTALLATION.
2. CAISSONS SHALL BE PLACED AGAINST UNDISTURBED EARTH.
3. CONCRETE SHALL BE VIBRATED.
4. A MINIMUM OF 3" CONCRETE COVER SHALL BE MAINTAINED AROUND THE STEEL CAGE. A MAXIMUM OF 4" OF COVER IS ALLOWED AT THE TOP OF THE CAGE.
5. LOOSE DIRT SHALL BE REMOVED FROM THE BOTTOM OF THE HOLE PRIOR TO POURING CONCRETE.
6. NO COLD JOINTS ARE ALLOWED IN CAISSONS. POUR CAISSONS CONTINUOUSLY TO FINISHED GRADE.
7. POLE FOUNDATION MAY ALTER IN DEPTH AND/OR DIAMETER, AS APPROVED BY THE CITY'S TRAFFIC ENGINEER. THE CITY SHALL APPROVE MODIFICATIONS NEEDED FOR THE CAISSONS DUE TO UNFORESEEN CONDITIONS.
8. BASE DIMENSIONS MAY VARY FROM THE STANDARD, BUT ONLY UPON APPROVAL BY THE CITY TRAFFIC ENGINEER.
9. THE BOLT CIRCLE DIAMETERS SHOWN REPRESENT THE MAXIMUM ANTICIPATED DIAMETERS REQUIRED AT THE SIGNAL POLE BASES FOR THE CORRESPONDING MAST ARM SPAN.

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City of Aurora, Colorado

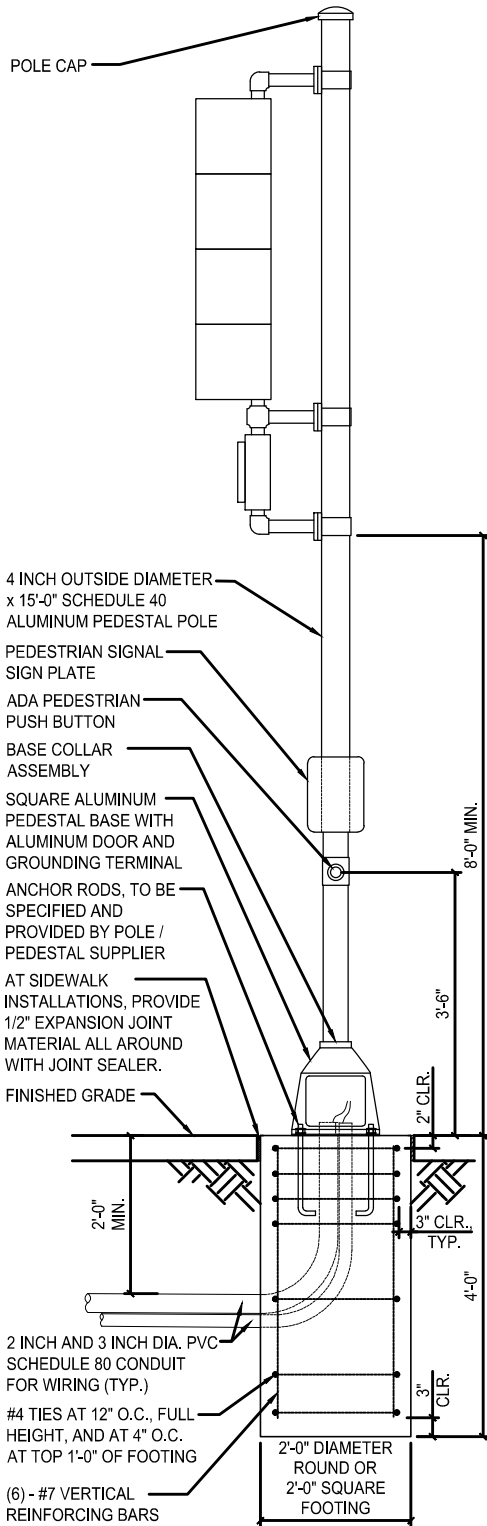
*Carla Compton* 1/26/2023  
 TRAFFIC ENGINEER DATE

*Heather Blahnik* 01/31/2023  
 CITY ENGINEER DATE

FOUNDATION FOR  
 SIGNAL POLE WITH BASE

2 of 2  
 TE1.2

# STANDARD



**PEDESTAL POLE ELEVATION**

## GENERAL NOTES

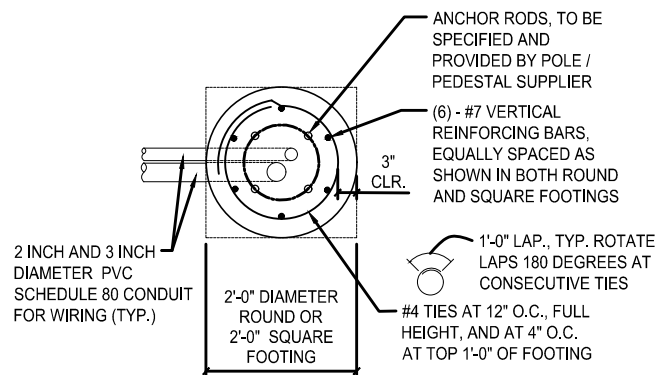
1. ALL WORK SHALL BE CONDUCTED IN ACCORDANCE WITH CITY OF AURORA ROADWAY DESIGN AND CONSTRUCTION SPECIFICATIONS.
2. FOOTING CONCRETE SHALL BE CITY OF AURORA CLASS 1A,  $f_c = 4,000$  psi AT 28 DAYS.
3. ALL REINFORCING STEEL SHALL BE PER AASHTO M31, GRADE 60,  $f_y = 60,000$  psi.
4. EXPANSION JOINT MATERIAL SHALL MEET AASHTO SPECIFICATION M213.
5. GROUND WIRE SHALL BE #8 AWG INSULATED SOLID COPPER
6. THE PEDESTAL FOUNDATION DESIGN SHOWN ON THIS DRAWING ASSUMES THE MINIMUM SOIL CHARACTERISTICS THAT WOULD TYPICALLY BE ENCOUNTERED IN THE CITY OF AURORA, WHICH ARE NOTED BELOW. IN THE EVENT THAT SOFT OR LOOSE SOIL CONDITIONS ARE ENCOUNTERED, CONTACT THE CITY TRAFFIC ENGINEER.

### ASSUMED GEOTECHNICAL DESIGN PARAMETERS:

SOIL DENSITY = 110 PCF FOR COHESIVE (CLAY) SOILS  
 115 PCF FOR NON-COHESIVE (SANDY) SOILS  
 SOIL COHESION = 750 PSF (COHESIVE SOILS)  
 $E_{50} = 0.01$  IN/IN (COHESIVE SOILS)  
 ANGLE OF INTERNAL FRICTION ( $\phi$ ) = 30 DEGREES (NON-COHESIVE SOILS)  
 HORIZONTAL MODULUS OF SUBGRADE REACTION ( $K_s$ ) = 90 PCI (NON-COHESIVE SOILS)

## CONSTRUCTION NOTES

1. FOOTING SHALL BE PLACED AGAINST UNDISTURBED EARTH.
2. CONCRETE SHALL BE VIBRATED.
3. A MINIMUM OF 3" CONCRETE COVER SHALL BE MAINTAINED AROUND THE STEEL CAGE. A MAXIMUM OF 4" OF COVER IS ALLOWED AT THE TOP OF THE CAGE.
4. LOOSE DIRT SHALL BE REMOVED FROM THE BOTTOM OF THE HOLE PRIOR TO POURING CONCRETE.
5. BASE DIMENSIONS MAY VARY FROM THE STANDARD, BUT ONLY UPON APPROVAL BY THE CITY TRAFFIC ENGINEER.
6. VERIFY THE BOLT CIRCLE DIAMETER SHOWN WITH THE PEDESTAL SUPPLIER PRIOR TO STARTING WORK.



**PEDESTAL POLE FOOTING SECTION**

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City of Aurora, Colorado

*Carla Lopez*  
 TRAFFIC ENGINEER  
*Alan B. Hansen*  
 CITY ENGINEER

1/26/2023

DATE

01/31/2023

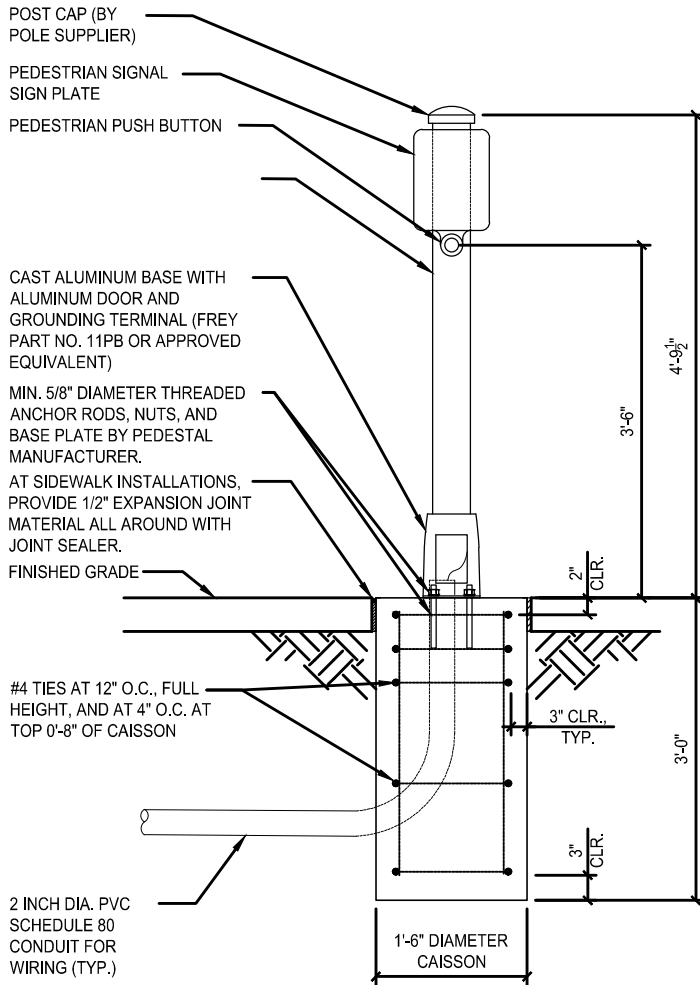
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VEHICLE AND  
 PEDESTRIAN POLE  
 STANDARD

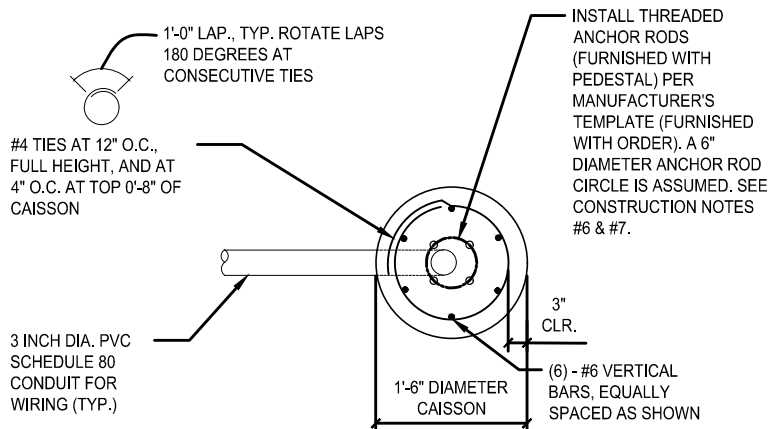
1 of 2

TE-2.0

# STANDARD



**PEDESTRIAN PUSHBUTTON BOLLARD FOUNDATION ELEVATION**



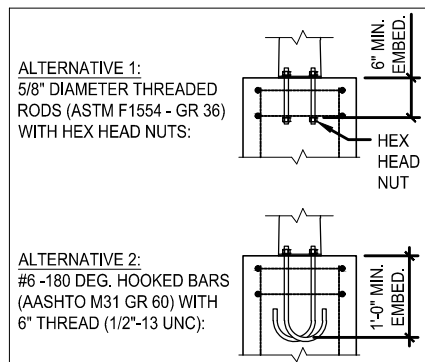
**PEDESTRIAN PUSHBUTTON BOLLARD FOUNDATION TOP VIEW**

## GENERAL NOTES

1. ALL WORK SHALL BE CONDUCTED IN ACCORDANCE WITH CITY OF AURORA ROADWAY DESIGN AND CONSTRUCTION SPECIFICATIONS.
2. CAISSON CONCRETE SHALL BE CITY OF AURORA CLASS 1A,  $f_c = 4,000$  psi AT 28 DAYS.
3. ALL REINFORCING STEEL SHALL BE PER AASHTO M31, GRADE 60,  $f_y = 60,000$  psi.
4. EXPANSION JOINT MATERIAL SHALL MEET AASHTO SPECIFICATION M213.
5. GROUND WIRE SHALL BE #8 AWG INSULATED SOLID COPPER
6. THE CROSSWALK PEDESTAL FOUNDATION SHOWN ON THIS DRAWING ASSUMES THE MINIMUM SOIL CHARACTERISTICS THAT WOULD TYPICALLY BE ENCOUNTERED IN AURORA, AS NOTED IN STANDARD DRAWING NO. TE-1.1. IN THE EVENT THAT SOFT OR LOOSE SOIL CONDITIONS ARE ENCOUNTERED, CONTACT THE CITY TRAFFIC ENGINEER.

## CONSTRUCTION NOTES

1. CAISSONS SHALL BE PLACED AGAINST UNDISTURBED EARTH.
2. CONCRETE SHALL BE VIBRATED.
3. A MINIMUM OF 3" CONCRETE COVER SHALL BE MAINTAINED AROUND THE STEEL CAGE. A MAXIMUM OF 4" OF COVER IS ALLOWED AT THE TOP OF THE CAGE.
4. LOOSE DIRT SHALL BE REMOVED FROM THE BOTTOM OF THE HOLE PRIOR TO POURING CONCRETE.
5. BASE DIMENSIONS MAY VARY FROM THE STANDARD, BUT ONLY UPON APPROVAL BY THE CITY TRAFFIC ENGINEER.
6. VERIFY THE BOLT CIRCLE DIAMETER SHOWN WITH THE PEDESTAL SUPPLIER PRIOR TO STARTING WORK. CAISSON DIAMETER MAY REQUIRE ADJUSTMENT IF LARGER BOLT CIRCLE IS PROVIDED.
7. ANCHOR THREADED RODS INTO FOUNDATION WITH 5" EMBEDMENT USING EPOXY ADHESIVE PER MANUFACTURER'S RECOMMENDATIONS. ACCEPTABLE EPOXY PRODUCTS INCLUDE:
  - 7.1. DEWALT AC200+
  - 7.2. SIMPSON SET-XP
  - 7.3. HILTI-HY 200-A
  - 7.4. APPROVED EQUIVALENT
8. THE FOLLOWING CAST-IN-PLACE ANCHORS MAY BE USED AS AN ALTERNATIVE TO POST-INSTALLED EPOXIED THREADED ANCHOR RODS SPECIFIED IN NOTE #7:



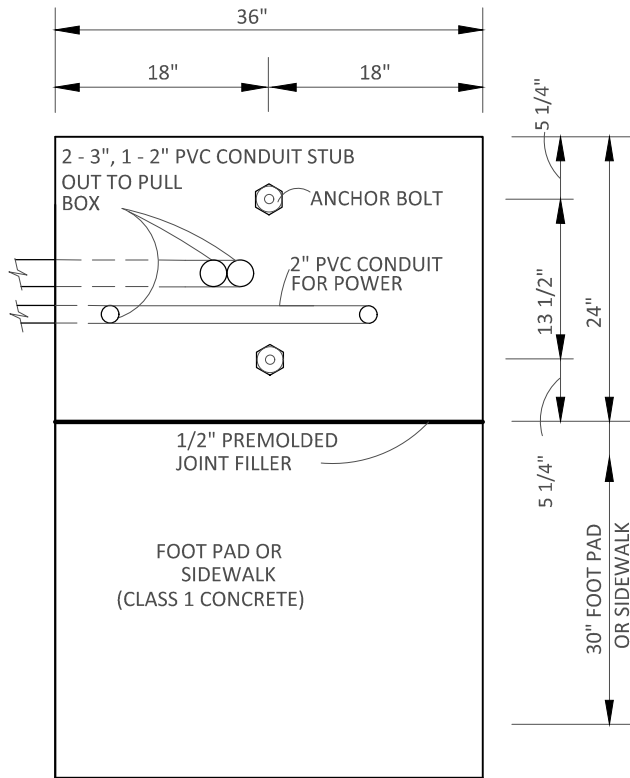
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City of Aurora, Colorado	
<i>Carla Compton</i>	1/26/2023
TRAFFIC ENGINEER	DATE
<i>Ally B. Johnson</i>	01/31/2023
CITY ENGINEER	DATE

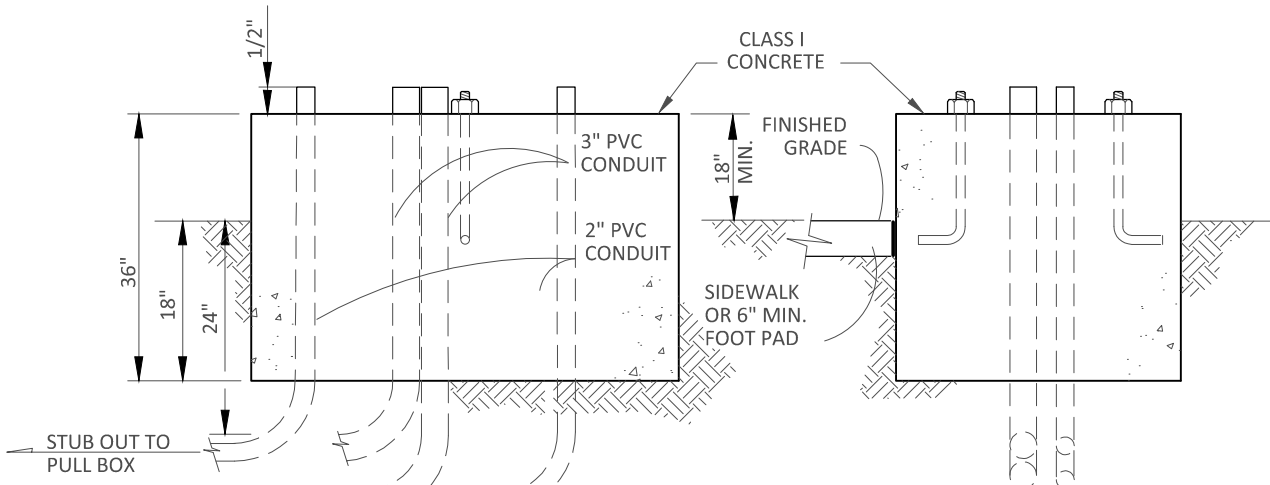
## PEDESTRIAN PUSHBUTTON BOLLARD AND FOUNDATION

2 of 2  
**TE-2.1**

# STANDARD



**TOP VIEW**



**FRONT VIEW**

**SIDE VIEW**

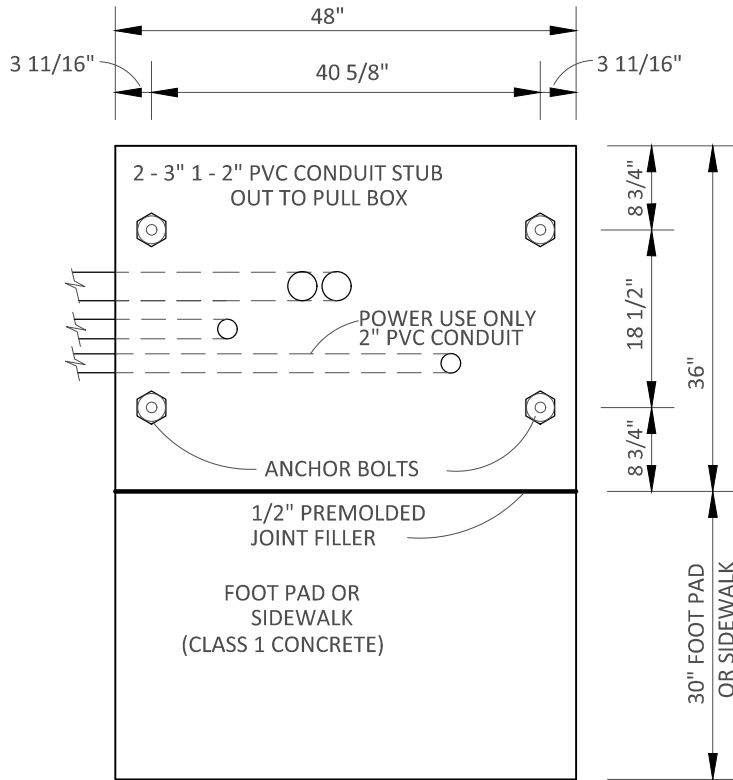
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City of Aurora, Colorado	
<i>Carla Compton</i>	1/26/2023
TRAFFIC ENGINEER	DATE
<i>Alexis Blankenship</i>	01/31/2023
CITY ENGINEER	DATE

**M-1 CABINET FOUNDATION  
WITH FOOT PAD  
(BACKUP POWER CABINET  
FOUNDATION)**

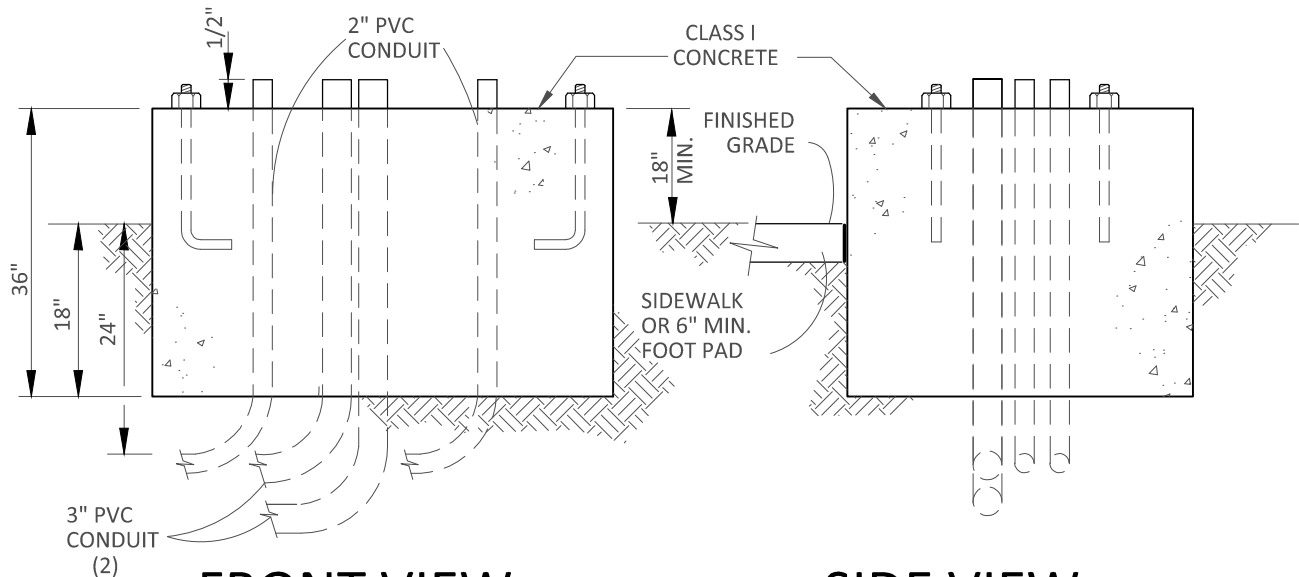
**TE-3**

# STANDARD



1) Foot pad may be eliminated per design or at Traffic Engineer's discretion.

## TOP VIEW



## FRONT VIEW

## SIDE VIEW

City of Aurora, Colorado

*Concetta Curran*  
TRAFFIC ENGINEER

*Alicia Blahnik*  
CITY ENGINEER

1/26/2023

DATE

01/31/2023

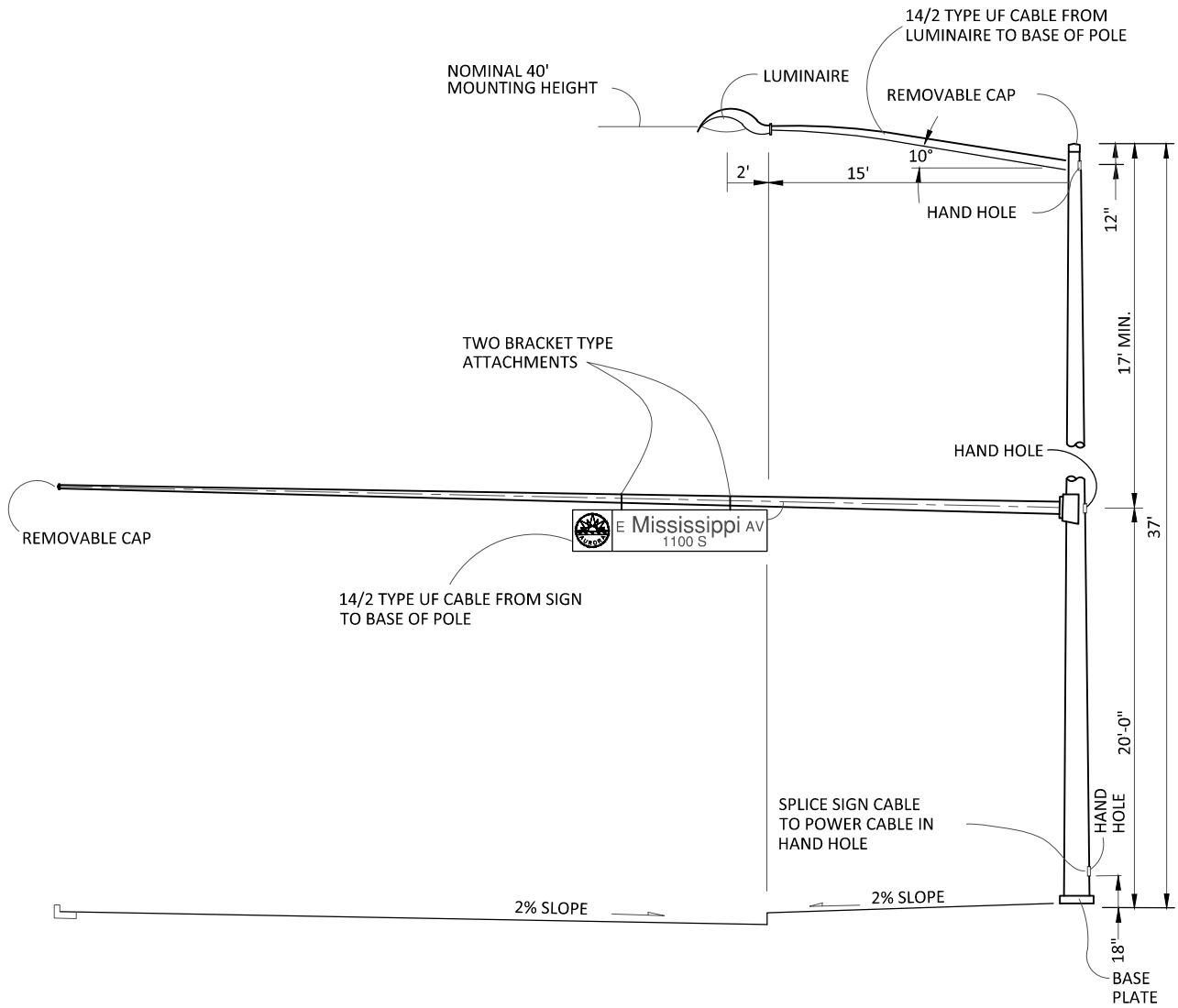
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P-1 CABINET FOUNDATION  
WITH FOOT PAD  
(STANDARD CONTROL CABINET  
FOUNDATION)

TE-4



# STANDARD



- NOTES: 1. ILLUMINATED STREET NAME SIGN CABLE IS SPLICED TO 14/2 UF POWER CABLE IN HAND HOLE AT EACH POLE AS SHOWN. IN ADDITION, THE POWER CABLE FROM EACH POLE IS BROUGHT BACK TO THE ELECTRIC P. O. S. AND FUSED AT THAT POINT.
2. STREET LIGHT AND POLE EXTENSION ARE STANDARD. IF SITE-SPECIFIC CONDITIONS PRECLUDE POLE EXTENSION, A REMOVABLE CAP SHALL BE INSTALLED ON TOP OF THE POLE.

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City of Aurora, Colorado

*Carla Lopez*  
TRAFFIC ENGINEER

*Alexander*  
CITY ENGINEER

1/26/2023  
DATE

01/31/2023  
DATE

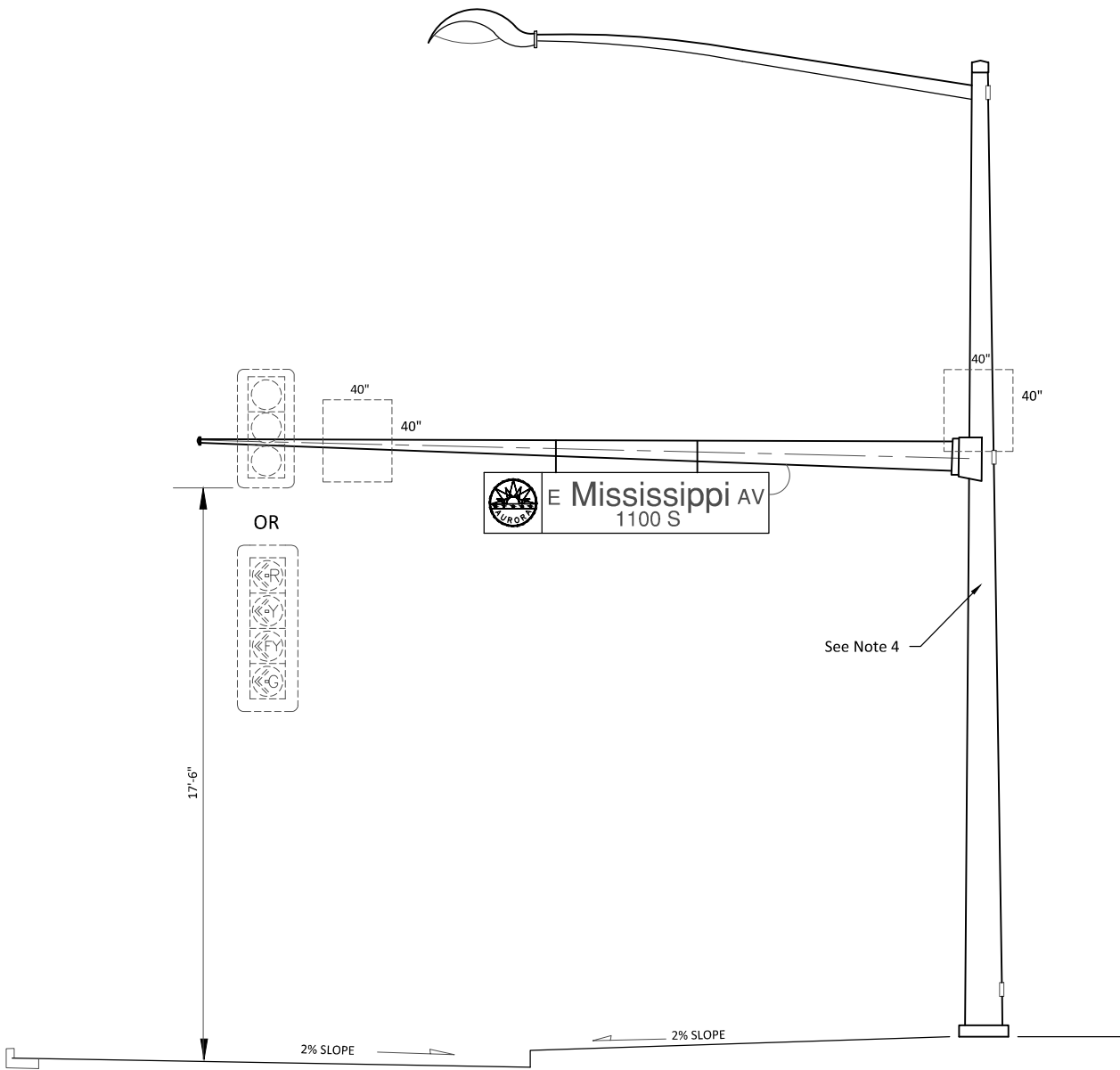
STREET LIGHT,  
STREET NAME SIGN,  
AND POLE

2 of 5

TE-5.2



# STANDARD



**Notes:**

1. Condition shown indicates maximum loading for mastarms from 15-25 feet in length. Actual length may vary by location
2. Reference current City of Aurora Traffic Signal Structure Specifications for specifics of loading surface areas and weights.
3. City standards requires heads to be centered on lanes with the exception of double left turn lanes, for which the head is centered on the lane line - lane widths and therefore head spacing may vary by location.
4. Although not shown on this detail, the typical installation will also include 2 each 3- or 4-section vehicle signal heads without backplate; 2 each pedestrian heads; and 2 each 9x12 pedestrian pushbutton frames and signage located on the pole below the mastarm plate -- see TE-6.1 for specifics.

c:\2022-roadway\_specs\dwgs\traf-dtl\te5-3.dwg 20 January 2023

City of Aurora, Colorado

*Carla C...*  
TRAFFIC ENGINEER

1/26/2023  
DATE

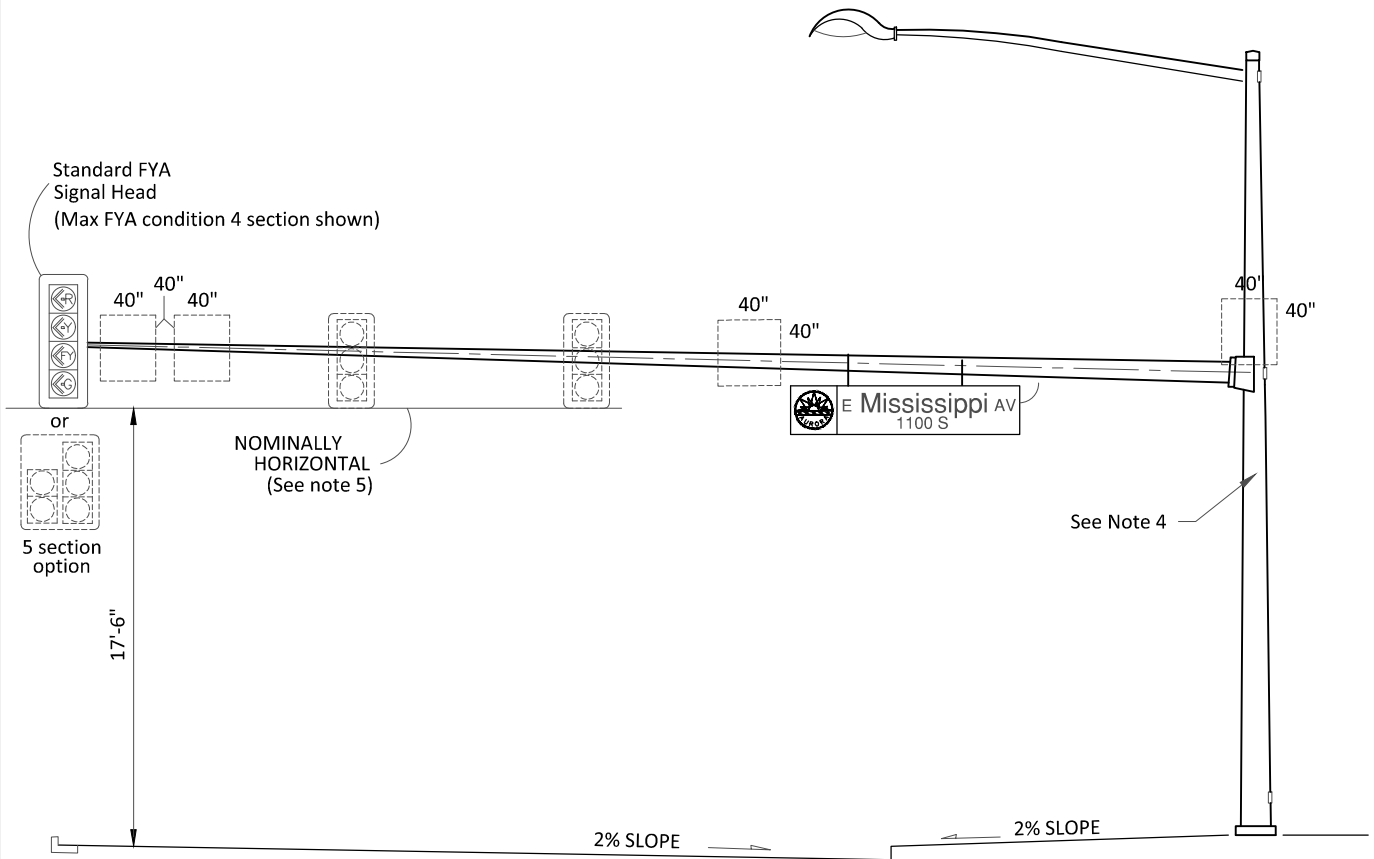
*Haley B...*  
CITY ENGINEER

01/31/2023  
DATE

**SIGNAL POLE  
WITH MAST ARM  
(15' - 25')**

3 of 5  
**TE-5.3**

# STANDARD



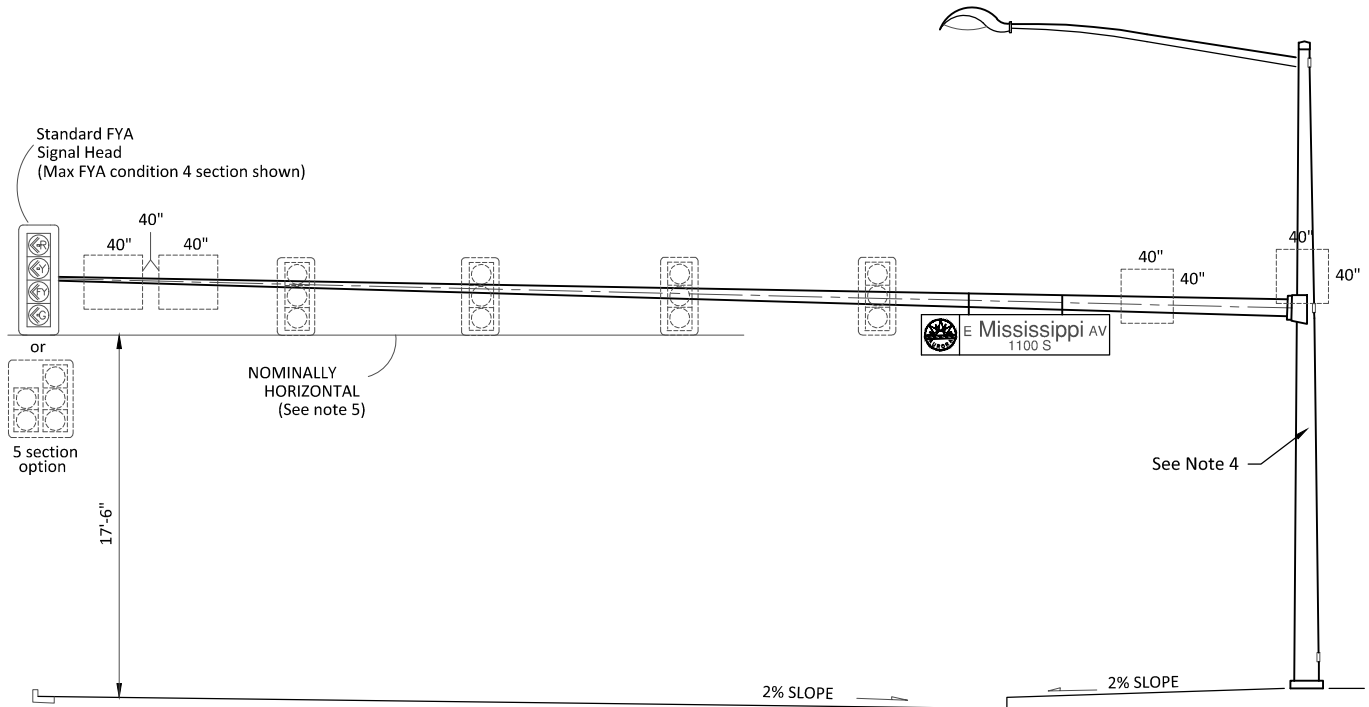
**Notes:**

1. Condition shown indicates maximum loading for mastarms from 30-50 feet in length. Actual length may vary by location
2. Reference current City of Aurora Traffic Signal Structure Specifications for specifics of loading surface areas and weights.
3. City standards requires heads to be centered on lanes with the exception of double left turn lanes, for which the head is centered on the lane line - lane widths and therefore head spacing may vary by location.
4. Although not shown on this detail, the typical installation will also include 2 each 3- or 4-section vehicle signal heads without backplate; 2 each pedestrian heads; and 2 each 9x12 pedestrian pushbutton frames and signage located on the pole below the mastarm plate -- see TE-6.1 for specifics.
5. The bottom of the backplate for each head shall be aligned with the bottom of the FYA (or 5-section option) baseplate unless field determined by the traffic engineer.

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<p>City of Aurora, Colorado</p> <p><i>Carla Compton</i> 1/26/2023 TRAFFIC ENGINEER DATE</p> <p><i>Helen B. Anderson</i> 01/31/2023 CITY ENGINEER DATE</p>	<p>SIGNAL POLE WITH MAST ARM (30' - 50')</p>	<p>4 of 5 TE-5.4</p>
---	--	--------------------------

# STANDARD



**Notes:**

1. Condition shown indicates maximum loading for mastarms from 55-75 feet in length. Actual length may vary by location
2. Reference current City of Aurora Traffic Signal Structure Specifications for specifics of loading surface areas and weights.
3. City standards requires heads to be centered on lanes with the exception of double left turn lanes, for which the head is centered on the lane line - lane widths and therefore head spacing may vary by location.
4. Although not shown on this detail, the typical installation will also include 2 each 3- or 4-section vehicle signal heads without backplate; 2 each pedestrian heads; and 2 each 9x12 pedestrian pushbutton frames and signage located on the pole below the mastarm plate -- see TE-6.1 for specifics.
5. The bottom of the backplate for each head shall be aligned with the bottom of the FYA (or 5-section option) baseplate unless field determined by the traffic engineer.

City of Aurora, Colorado

*Carla Cruz*  
TRAFFIC ENGINEER

1/26/2023

DATE

*Heather B. Hansen*  
CITY ENGINEER

01/31/2023

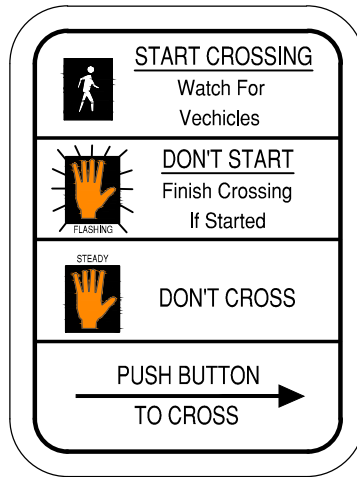
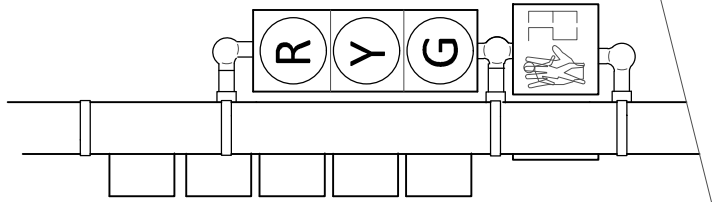
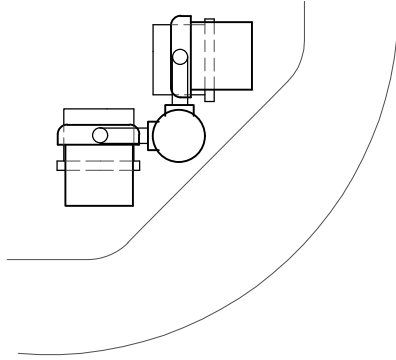
DATE

SIGNAL POLE  
WITH MAST ARM  
(55' - 75')

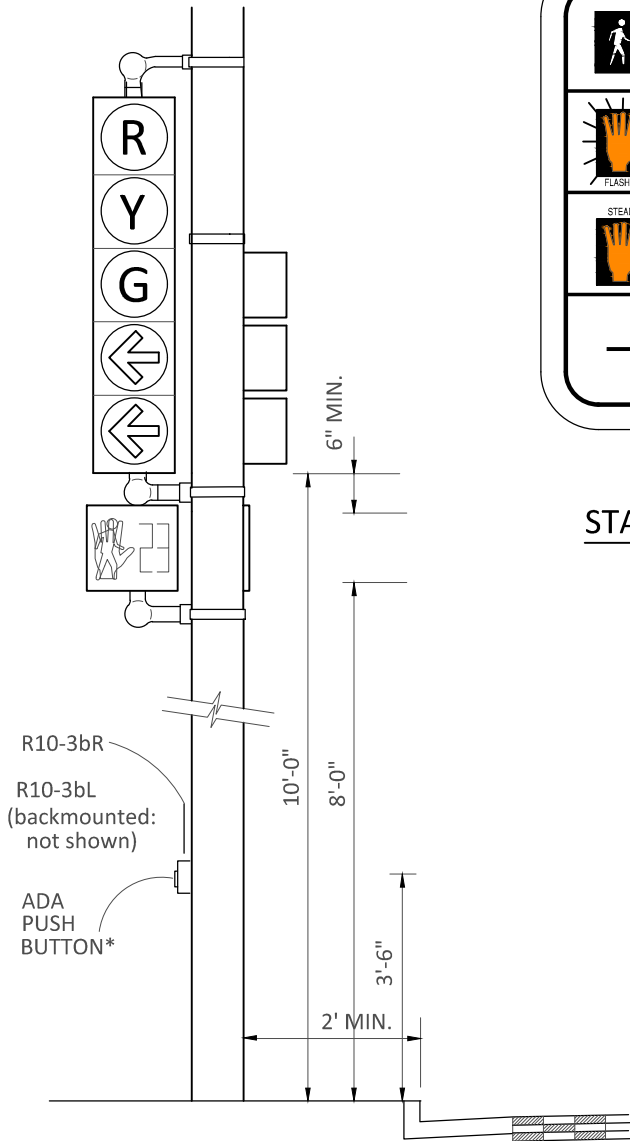
5 of 5

TE-5.5

# STANDARD

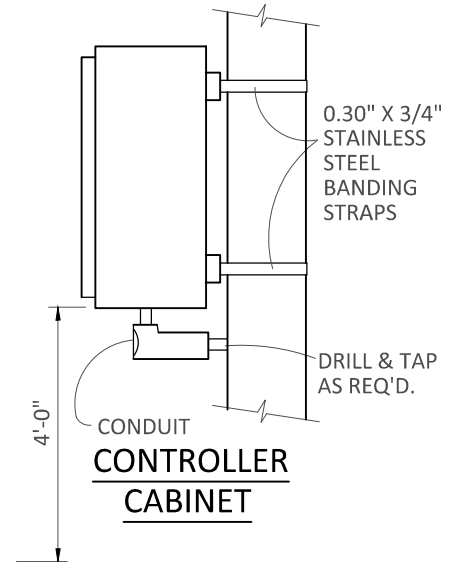


**R10-3b  
STANDARD SIGN**



R10-3bR  
R10-3bL  
(backmounted:  
not shown)  
ADA  
PUSH  
BUTTON\*

\* DRILL AND TAP FOR PUSH BUTTON MOUNTING  
(BANDING IS NOT ACCEPTABLE)



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City of Aurora, Colorado

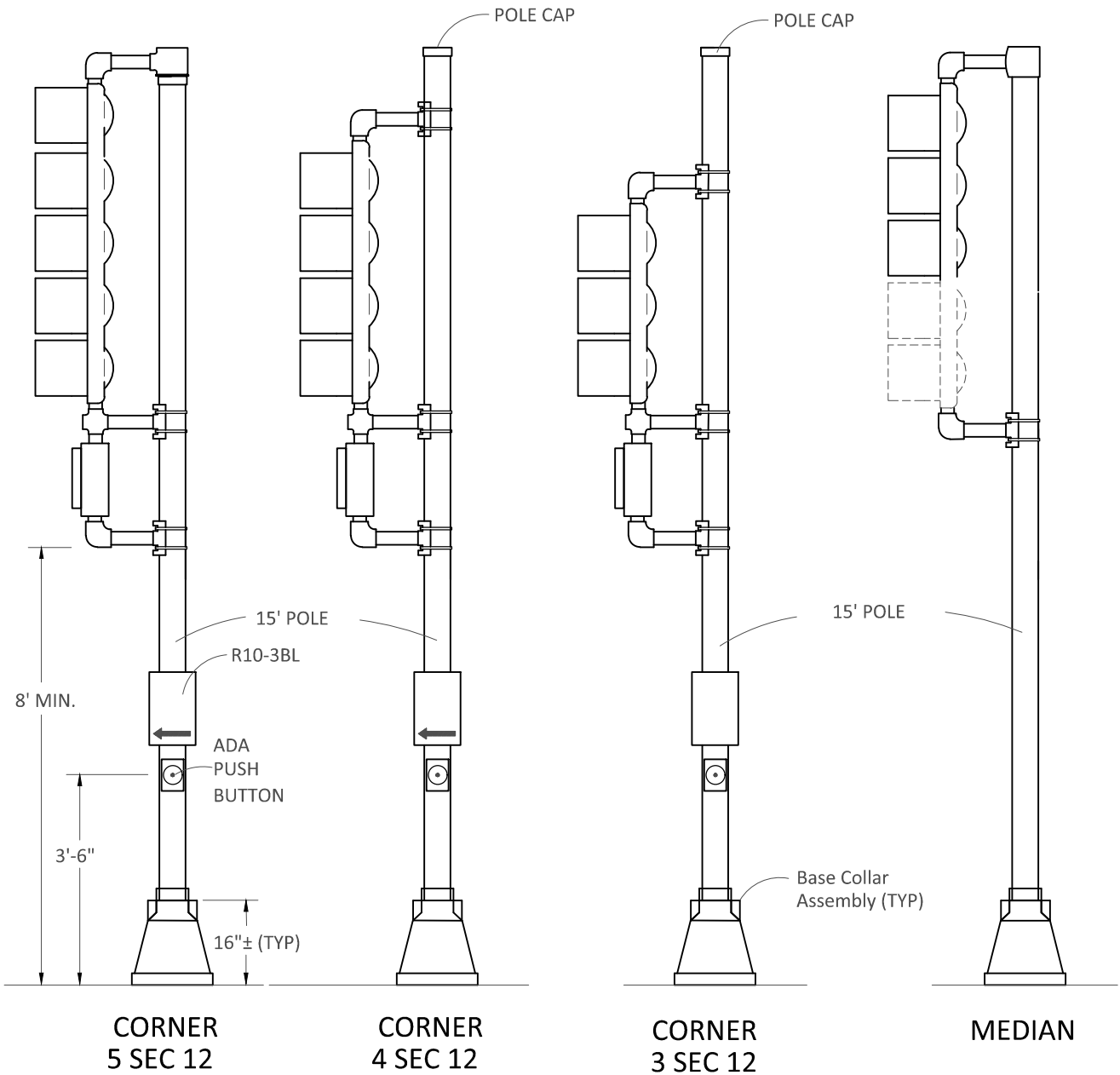
*Carla Compton*  
TRAFFIC ENGINEER  
*Alicia B. Hansen*  
CITY ENGINEER

1/26/2023  
DATE  
01/31/2023  
DATE

POLE MOUNTED  
VEHICULAR & PEDESTRIAN  
SIGNAL HEADS

1 of 2  
**TE-6.1**

# STANDARD



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City of Aurora, Colorado  
*Carla Lopez*  
 TRAFFIC ENGINEER  
 DATE 1/26/2023  
*Helen B. Hansen*  
 CITY ENGINEER  
 DATE 01/31/2023

POLE MOUNTED  
 VEHICULAR & PEDESTRIAN  
 SIGNAL HEADS



2 of 2  
 TE-6.2

STANDARD



SIGN MOUNTED USING SIGNFIX SX0220 UNIVERSAL CHANNEL CLAMP WITH SIGNFIX SX0073 MEDIUM CHANNEL EXTRUSION OR APPROVED EQUAL.

City of Aurora, Colorado

 TRAFFIC ENGINEER	1/26/2023 DATE
 CITY ENGINEER	01/31/2023 DATE

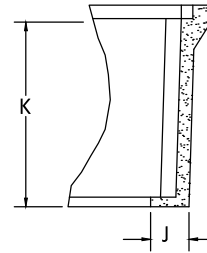
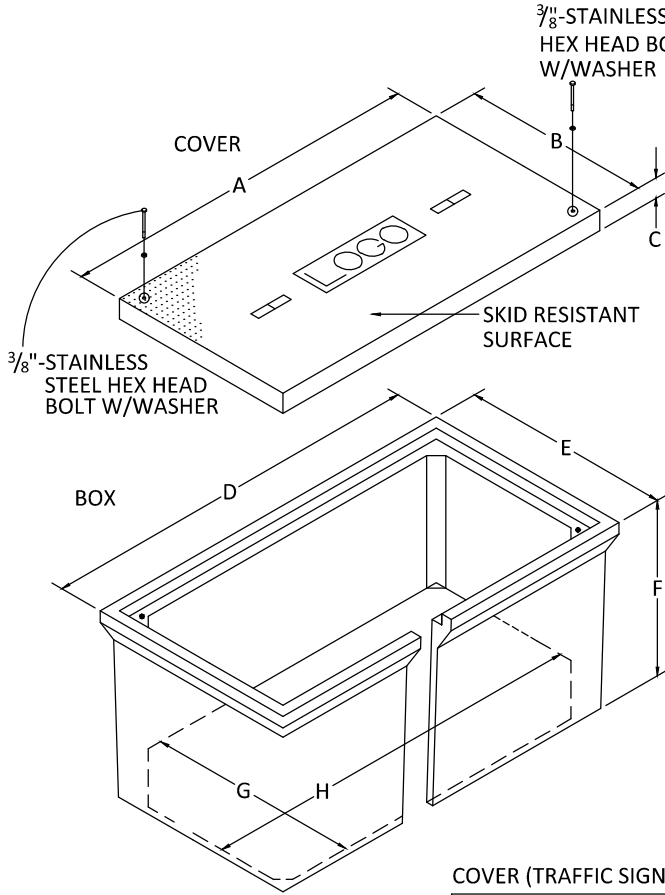
METRO STREET NAME  
SIGN MOUNTING

TE-7

# STANDARD

## SPECIFICATIONS/DATA

PC and PG Style Assemblies



COVER (TRAFFIC SIGNAL LOGO-CODE 46)

DESCRIPTION	SIZE	DIMENSIONS (IN.)			WT. LBS
		A	B	C	
HEAVY DUTY (HA) LOCKING COVER	SMALL (PC)	12 7/8	12 7/8	3/4	12
	MEDIUM (PG)	23 1/4	13 3/4	2	54
	LARGE (PG)	30 1/2	17 1/2	2	83
	HOME RUN	35 3/4	24	3	98

BOXES (STACKABLE)

DESCRIPTION	SIZE	DIMENSIONS (IN.)							WT. LBS
		D	E	F	G	H	J	K	
OPEN BOTTOM (BA)	SMALL (PC)	14 3/4	14 3/4	12	12	12	1	12	36
	MEDIUM (PG)	25	15 1/2	12	11 3/4	21 1/4	1 1/4	10	53
	LARGE (PG)	32 1/4	19 1/4	12	15 1/2	28 1/2	1 1/4	10	67
	HOME RUN	37 5/8	26	12			1 1/4	10	200

### Specifications

Underground enclosures shall be Quazite as manufactured by Hubbell or approved equal.  
 Covers shall be concrete gray color and rated for no less than 15,000 lbs over a 10"x10" area.  
 Enclosures shall be concrete gray in color and rated for no less than 15,000 lbs (SM) or 22,500 lbs (MED/LG). Both covers and enclosures shall be designed and tested to temperatures of -50°F. Covers shall have a minimum coefficient of friction of 0.5. Boxes shall be stackable for extra depth.

c:\2022-roadway specs\dwgs\traf-dtts\te8-1.dwg 20 January 2023

City of Aurora, Colorado

*Carla Cuyler*  
 TRAFFIC ENGINEER  
*Alexander*  
 CITY ENGINEER

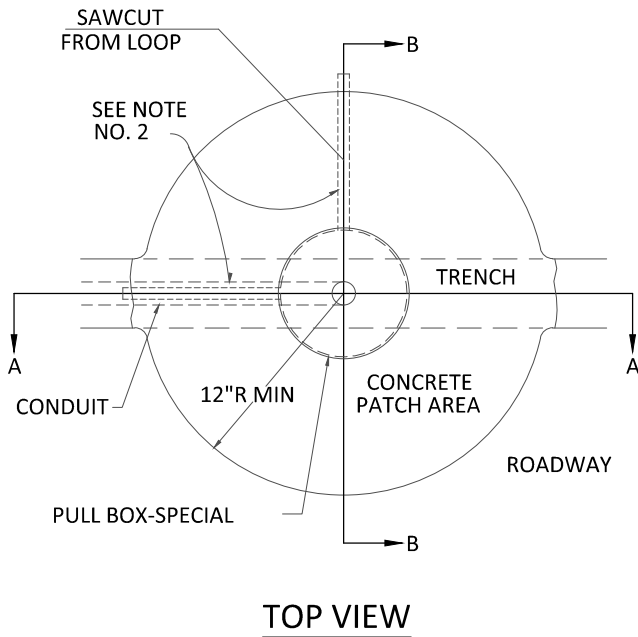
1/26/2023  
 DATE  
 01/31/2023  
 DATE

PULL BOX PRECAST  
 FLUSH TOP

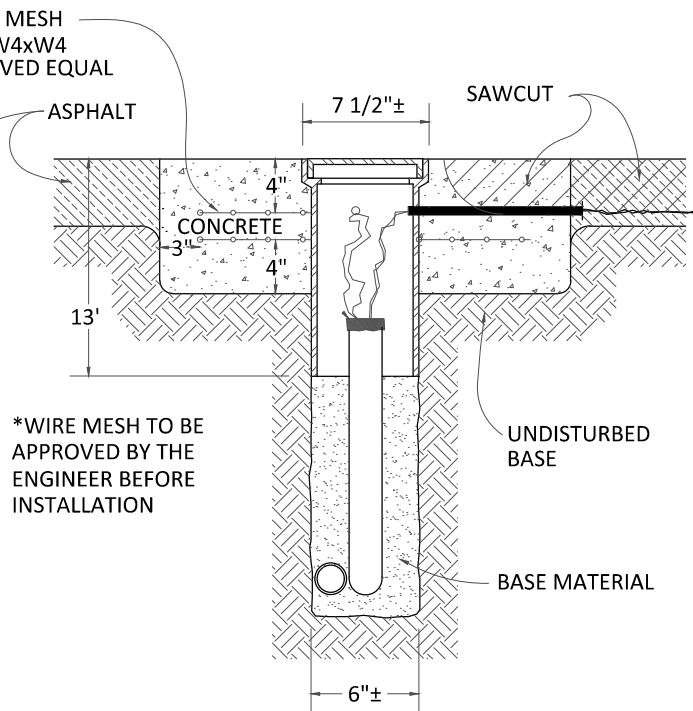
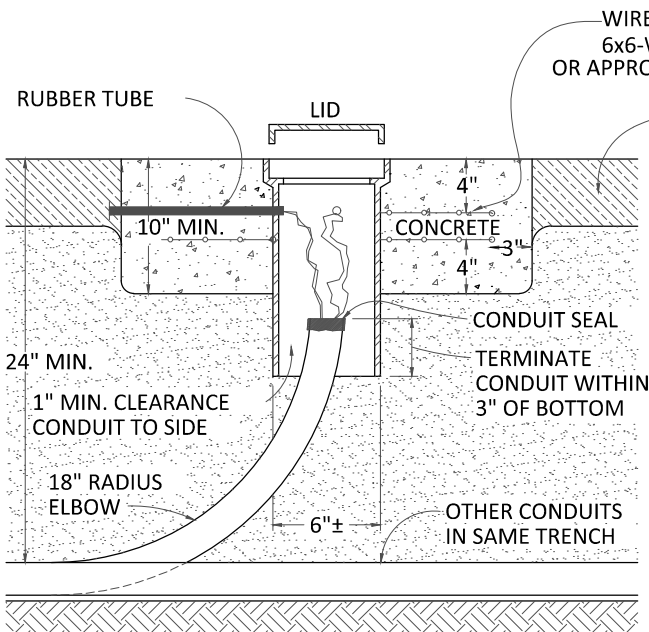
1 of 2  
 TE-8.1

# STANDARD

## GENERAL NOTES:



1. Pull Box-Special shall be a Water Valve Stem Type pull box made of steel. The pullbox shall have the capability of accepting riser rings for the future overlays. The lid shall have the word "TRAFFIC" printed on it and shall be of the same material as the box.
2. Pull boxes shall have 3/4" to 1" diameter holes drilled or torched 3" from the top to accept a rubber tube. The number of tubes shall be as shown on the plans or as directed by the engineer.
3. Care shall be taken during backfill compaction to prevent collapse of the tubes.
4. Connect loop lead-ins to home run cable in nearest pull box. (DO NOT splice in water valve box.)
5. Pull box is to be located in a area of the street not heavily traveled: if possible, as centered a minimum of 12" from the gutter pan.
6. A concrete ring (12" minimum radius and 10" minimum depth) shall be installed around the pull box. The rubber tube must extend beyond the concrete to the asphalt joint.
7. Final grade of lid to be 1/4" below asphalt.
8. Wire mesh to stop 3" inside concrete



\*WIRE MESH TO BE APPROVED BY THE ENGINEER BEFORE INSTALLATION

q:\2022-roadway-specs\dwgs\traf-dtts\te8-2.dwg - 20 January 2023

City of Aurora, Colorado	
<i>Carla Compton</i>	1/26/2023
TRAFFIC ENGINEER	DATE
<i>Alan Blahnik</i>	01/31/2023
CITY ENGINEER	DATE

**PULL BOX - SPECIAL  
WATER VALVE STEM TYPE**

2 of 2  
**TE-8.2**

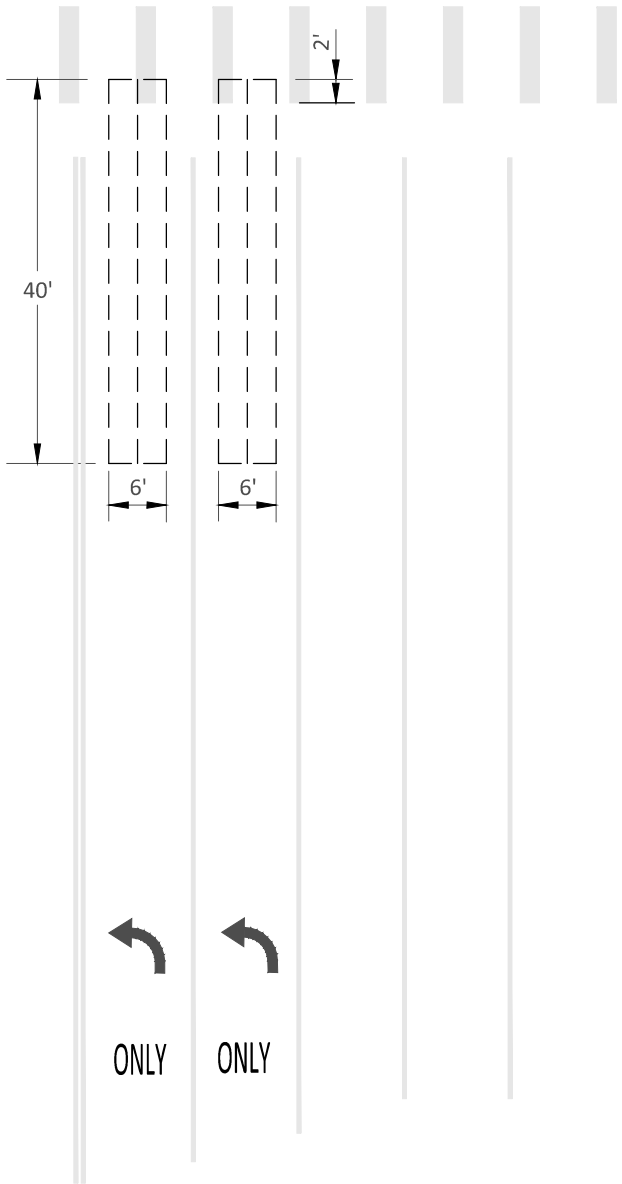




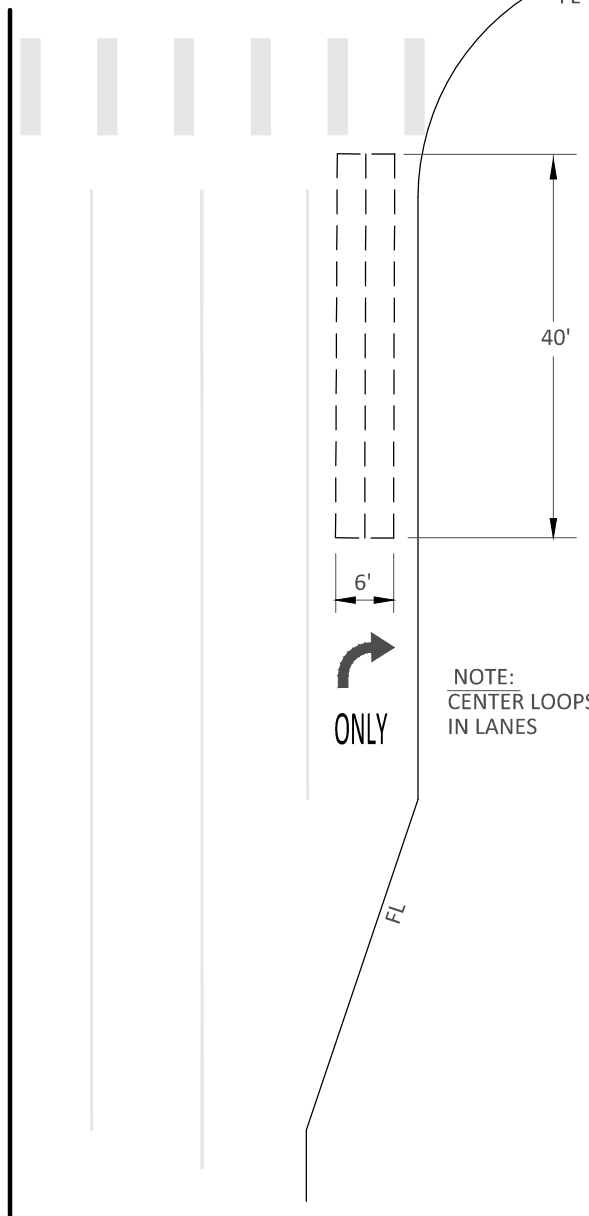
# STANDARD

NOTES:

1. DASHED LINES INDICATE ONLY LOCATION OF LOOP DETECTORS.
2. SEE TE-0.1, 0.2 AND TE-9.3 FOR LEAD IN CONNECTOR, LOOP LAYOUT, AND SAW CUT REQUIREMENTS.
3. APPROXIMATE LOCATION OF LEAD IN CONNECTOR'S HOME RUN PULL BOX SHALL BE DETERMINED BY TRAFFIC ENGINEER OR DESIGNEE.
4. MAJOR STREET THROUGH MOVEMENTS SHALL ONLY HAVE LOOP DETECTION AS PER PLAN, AT THE DISCRETION OF THE TRAFFIC ENGINEER.



DUAL LEFT TURN LANES



DEDICATED RIGHT TURN LANE

NOTE:  
CENTER LOOPS  
IN LANES

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City of Aurora, Colorado

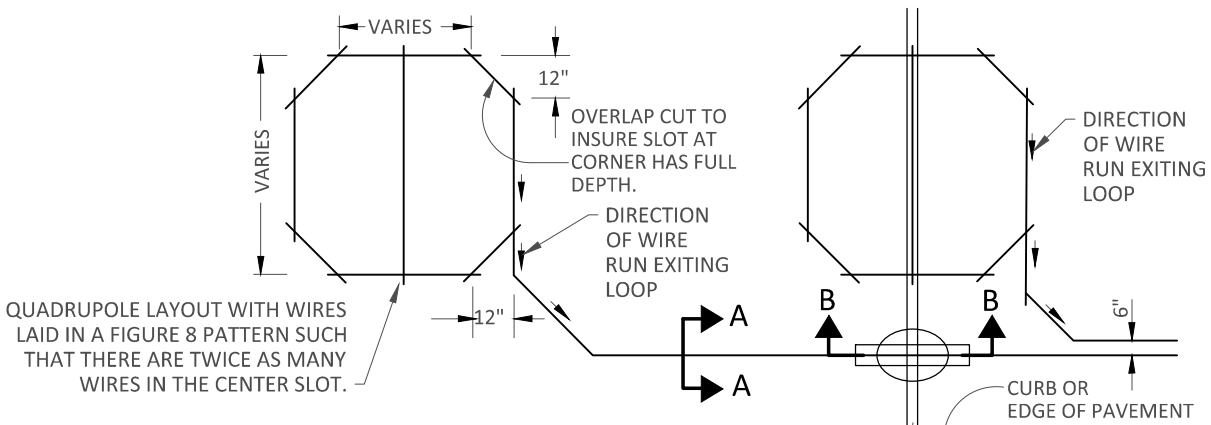
<i>Carla Lopez</i>	1/26/2023
TRAFFIC ENGINEER	DATE
<i>Haley Bohannon</i>	01/31/2023
CITY ENGINEER	DATE

LOOP DETECTORS  
(MAJOR STREET)

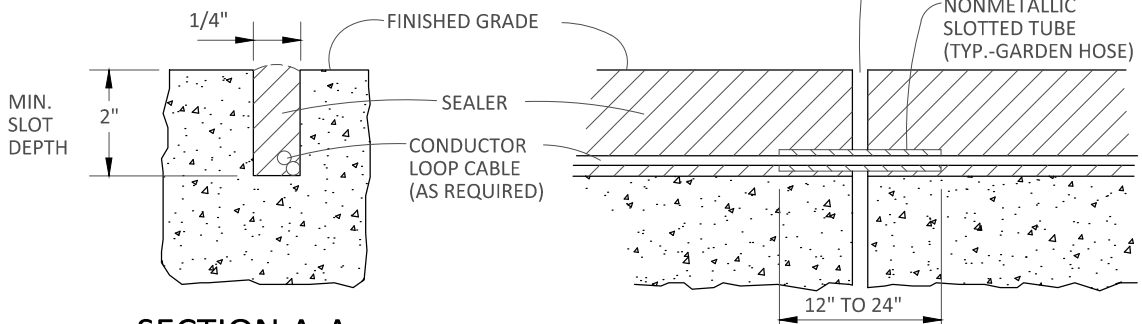
2 of 3

TE-9.2

# STANDARD



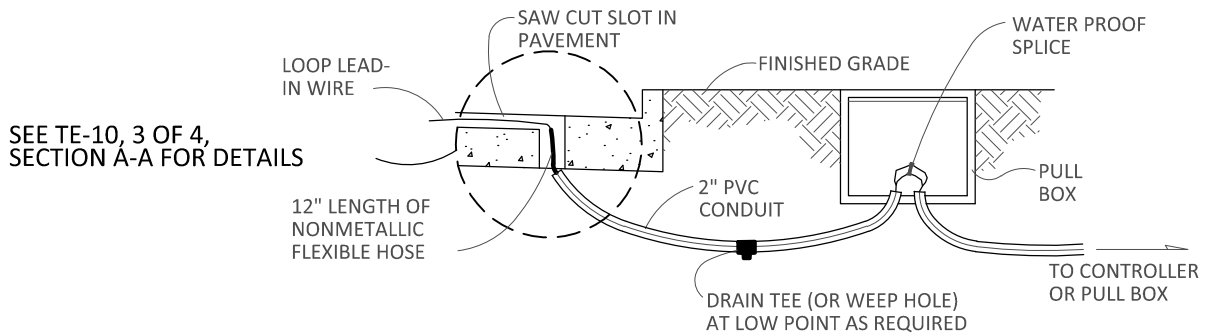
## TYPICAL SAW CUT DETAIL



SECTION A-A

SECTION B-B

NOTE: WIDEN SLOT AS REQUIRED FOR LENGTH OF TUBE



SEE TE-10, 3 OF 4, SECTION A-A FOR DETAILS

## LOOP DETECTOR LEAD-IN INSTALLATION

### NOTES:

1. PNEUMATICALLY REMOVE DIRT, DEBRIS AND WATER FROM SAW CUT.
2. WIRE TO BE 14-AWG STRANDED COPPER, XHHW INSULATED BLACK.
3. SEALANT TO BE PRECO/GOLD LABEL FLEX.
4. "HOMERUN" WIRE SHALL BE BELDEN TYPE 8720 OR AN APPROVED SUBSTITUTE.
5. GENTLY TAMP WIRE WITH BLUNT WOOD TOOL TO AVOID DAMAGE TO INSULATION. DO NOT USE SHARP OBJECT.
6. LOOP DETECTOR WIRE LEAD-IN SHALL BE TWISTED (ONE TWIST PER FOOT MIN.) FROM PULLBOX (WHERE SPLICED) TO CABINET.
7. ALL VEHICLE DETECTORS INSTALLED IN CONJUNCTION WITH ROADWAY IMPROVEMENT PROJECTS SHALL BE INSTALLED BEFORE THE FINAL LIFT OF ASPHALT.

City of Aurora, Colorado

*Conita Curran*  
TRAFFIC ENGINEER

*Haley B. Johnson*  
CITY ENGINEER

1/26/2023

DATE

01/31/2023

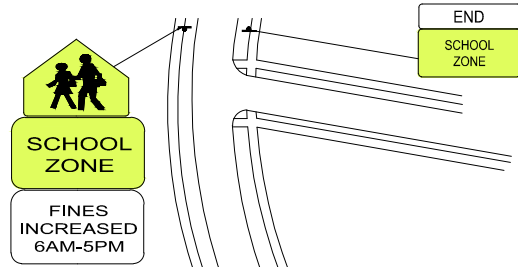
DATE

SAW-CUT AND  
LOOP DETECTOR  
INSTALLATION DETAILS

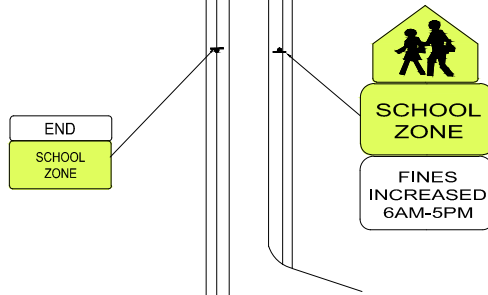
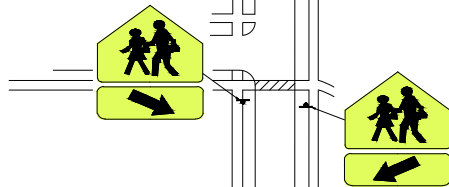
3 of 3

TE-9.3

# STANDARD



NOTE:  
 1. PLACEMENT OF SIGNS VARIES.  
 2. SHADED SIGN  INDICATES FLUORESCENT YELLOW-GREEN BACKGROUND.



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City of Aurora, Colorado

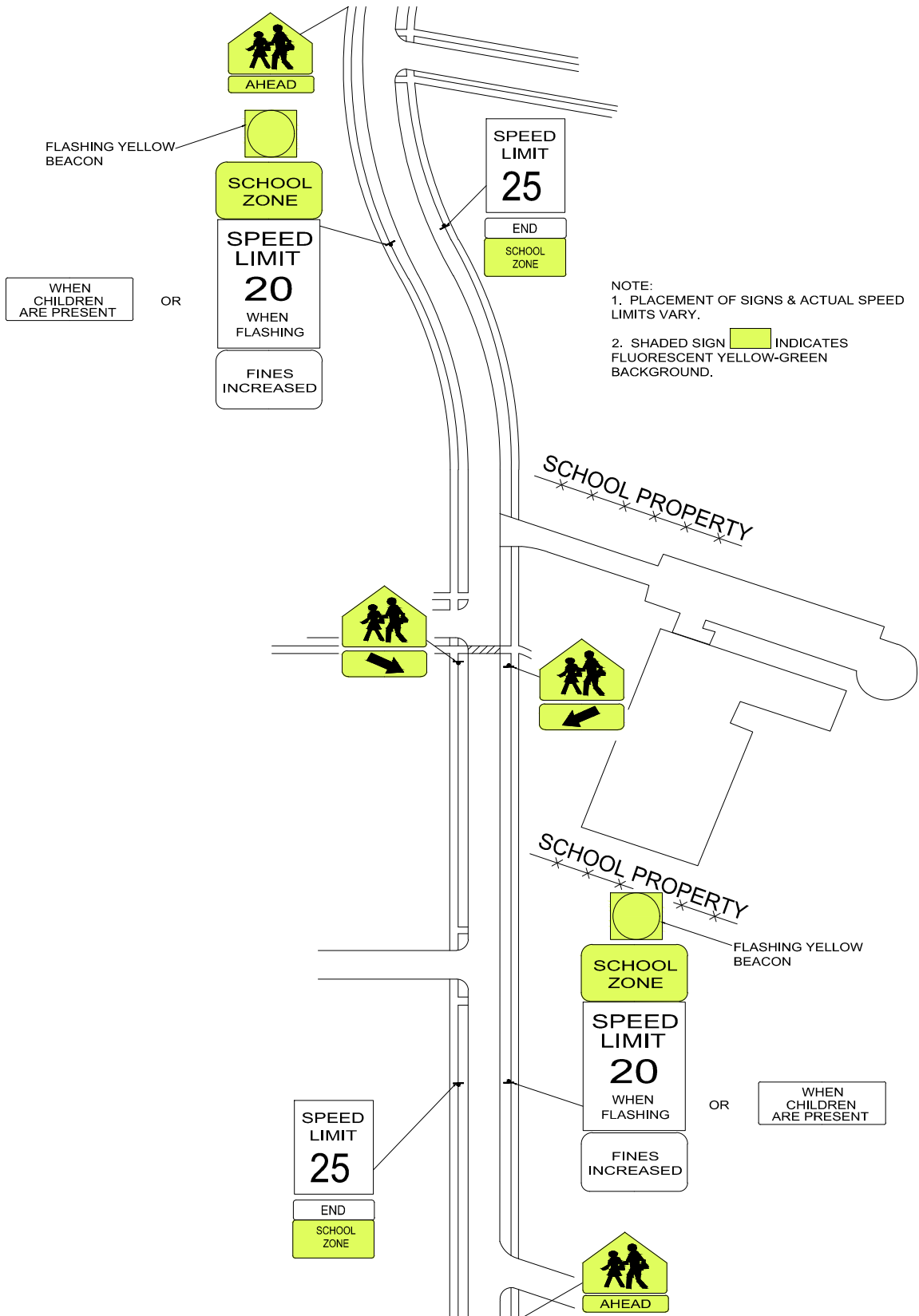
*Carla Uyanga*  
 TRAFFIC ENGINEER  
*Haley Blankenship*  
 CITY ENGINEER

1/26/2023  
 DATE  
 01/31/2023  
 DATE

SIGNAGE FOR  
 SCHOOL CROSSWALKS

1 of 2  
 TE-10.1

# STANDARD



c:\2022-roadway-specs\dwg\traf-dtts\te10-1&10-2.dwg 20 January 2023

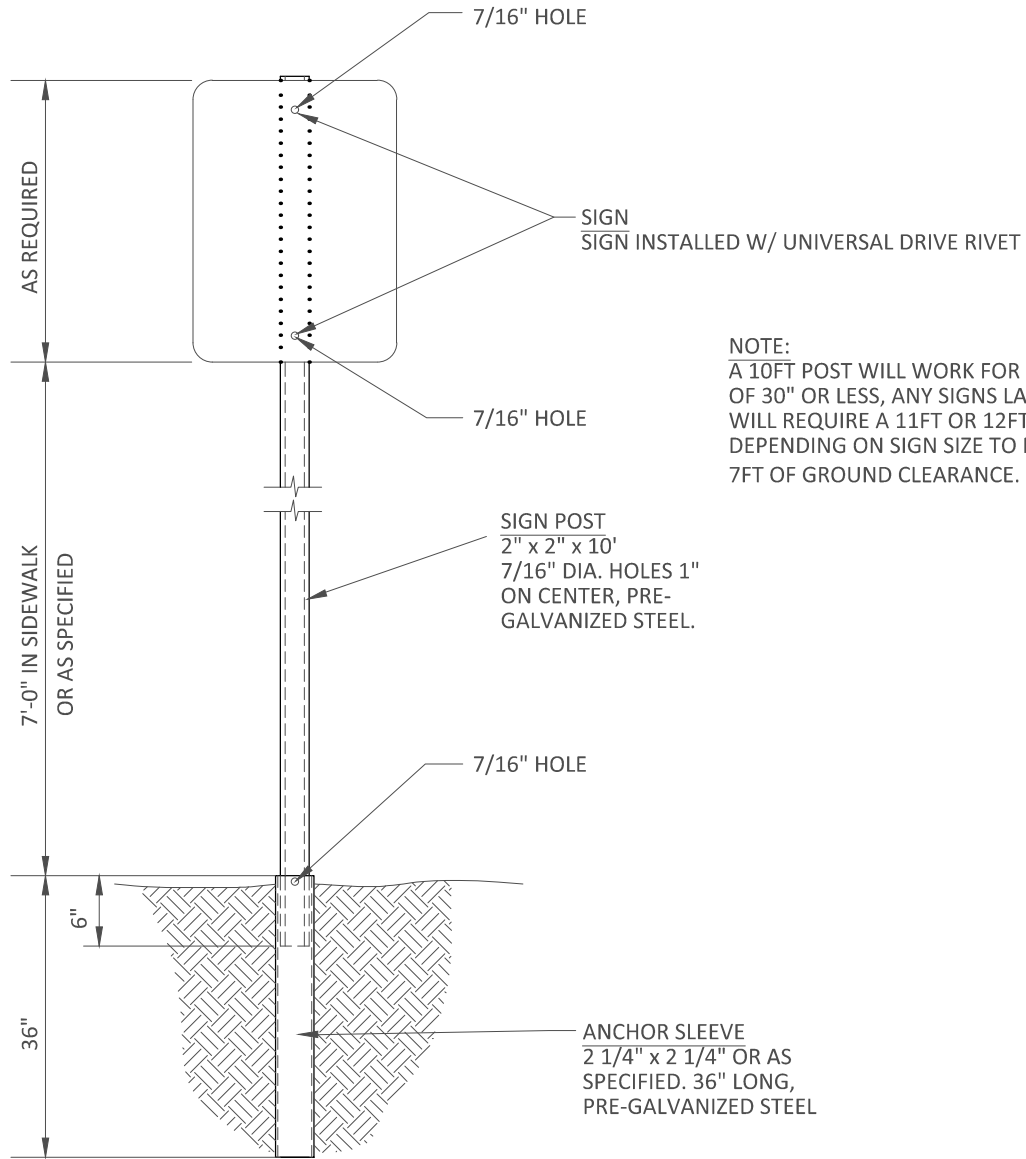
City of Aurora, Colorado  
*Carla C. [Signature]* 1/26/2023  
 TRAFFIC ENGINEER DATE  
*Alan B. [Signature]* 01/31/2023  
 CITY ENGINEER DATE

**SIGNING FOR REDUCED  
 SPEED LIMITS IN  
 SCHOOL ZONES**

2 of 2  
**TE-10.2**

# STANDARD

## SIGN SUPPORT DETAIL



NOTE:  
A 10FT POST WILL WORK FOR SIGNS  
OF 30" OR LESS, ANY SIGNS LARGER  
WILL REQUIRE A 11FT OR 12FT POST  
DEPENDING ON SIGN SIZE TO MAINTAIN  
7FT OF GROUND CLEARANCE.

### SIGN POST INSTALLATION

SHALL FOLLOW THE MANUFACTURER'S INSTRUCTIONS AND THESE SPECIFICATIONS:

NOTE: ALL TUBINGS ARE #12 U.S. GAUGE WALL THICKNESS.

1. DRIVE ANCHOR SLEEVE INTO THE GROUND, LEAVING FOUR HOLES EXPOSED FOR BOLT CONNECTION. FOR HAND INSTALLATION, DRIVE CAP OF PROPER SIZE SHALL BE USED TO PREVENT DAMAGE TO TUBING. SIDEWALK OR MEDIAN SHALL BE POURED AROUND PVC SLEEVE OR EXISTING SIDEWALK OR MEDIAN SHALL BE CORE DRILLED MINIMUM 4" CORE/PVC SLEEVE.
2. INSERT SIGN POST INTO ANCHOR SLEEVE APPROXIMATELY 6" AND BOLT IN PLACE.
3. INSTALLED SIGN AND POST SHALL BE PLUMB AND FREE OF VERTICAL AND LATERAL MOVEMENT.

City of Aurora, Colorado

*Carla Crayon*  
TRAFFIC ENGINEER  
*Heather Blomster*  
CITY ENGINEER

1/26/2023

DATE

01/31/2023

DATE

STEEL SIGN TUBING  
INSTALLATION

TE-11.0

# STANDARD

## CITY STANDARD STRIPING MATERIALS

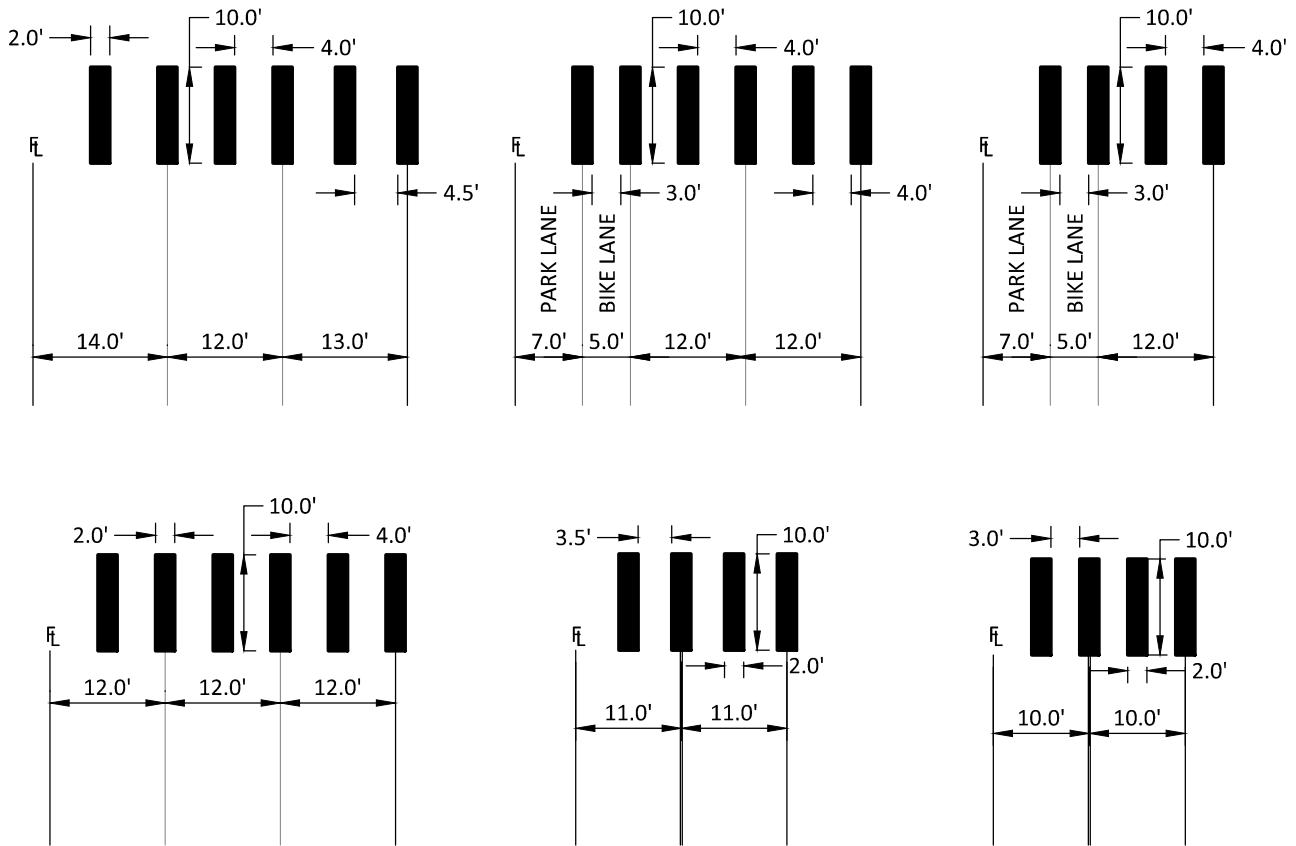
### ON ASPHALT PAVEMENT TYPE

TEMPORARY LANE LINES, SYMBOLS AND LEGENDS, AND CROSSWALKS = LESS THAN ONE YEAR = PAINT  
 PERMANENT LANE LINES = THERMOPLASTIC OR EPOXY  
 PERMANENT CROSSWALKS, SYMBOLS, AND LEGENDS = THERMOPLASTIC

### ON CONCRETE PAVEMENT TYPE

LANE LINES SOLID = EPOXY  
 SKIP DASH = INLAID PREFORMED COLD PLASTIC 380I-5  
 SYMBOLS, LEGENDS, AND CROSSWALKS = INLAID PREFORMED COLD PLASTIC L380IES OR PREFORMED THERMOPLASTIC

### EXAMPLES OF POSSIBLE LANE CONFIGURATIONS



c:\2022-roadway specs\dwgs\traf-ddis\te12-2.dwg 20 January 2023

City of Aurora, Colorado

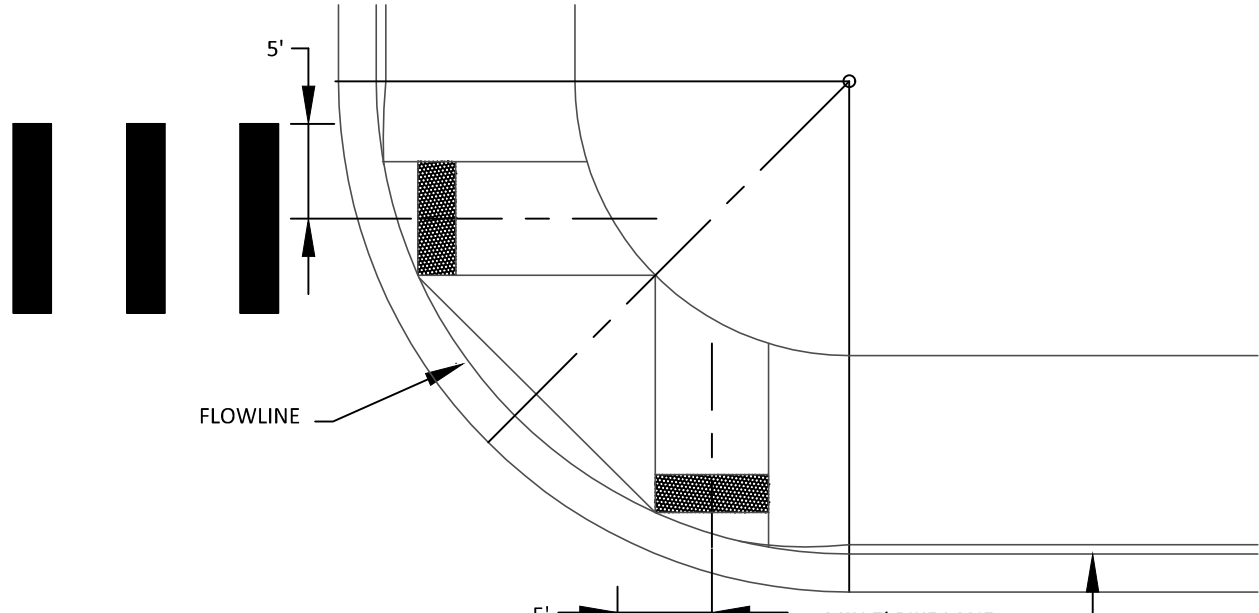
*Concepcion*  
 TRAFFIC ENGINEER  
*Alan Blahnik*  
 CITY ENGINEER

1/26/2023 DATE  
 01/31/2023 DATE

STRIPING MATERIALS  
 &  
 CROSSWALK SAMPLES

1 of 3  
 TE-12.1

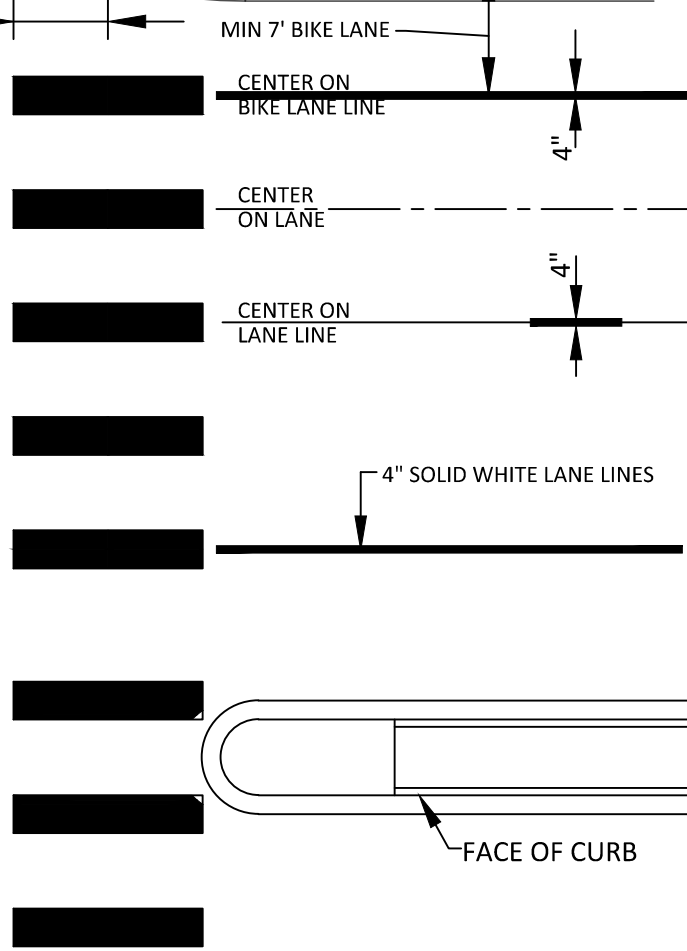
# STANDARD



**NOTES:**

- 1) "ZEBRA" STRIPES REPLACE PARALLEL WALK LINE IN SAME DIMENSION; i.e., 10'-0" OUT TO OUT.
- 2) "ZEBRA" STRIPES ARE 10'-0" x 2'-0"
- 3) "ZEBRA" STRIPES SHALL BE CENTERED ON THE CURB RAMP(S)

**ONE "ZEBRA" STRIPE IS CENTERED IN EACH TRAVEL LANE WITH ADDITIONAL "ZEBRA" STRIPE STRADDLING EACH PROJECTED LANE LINE TO LEAVE WHEEL PATHS BETWEEN STRIPES.**

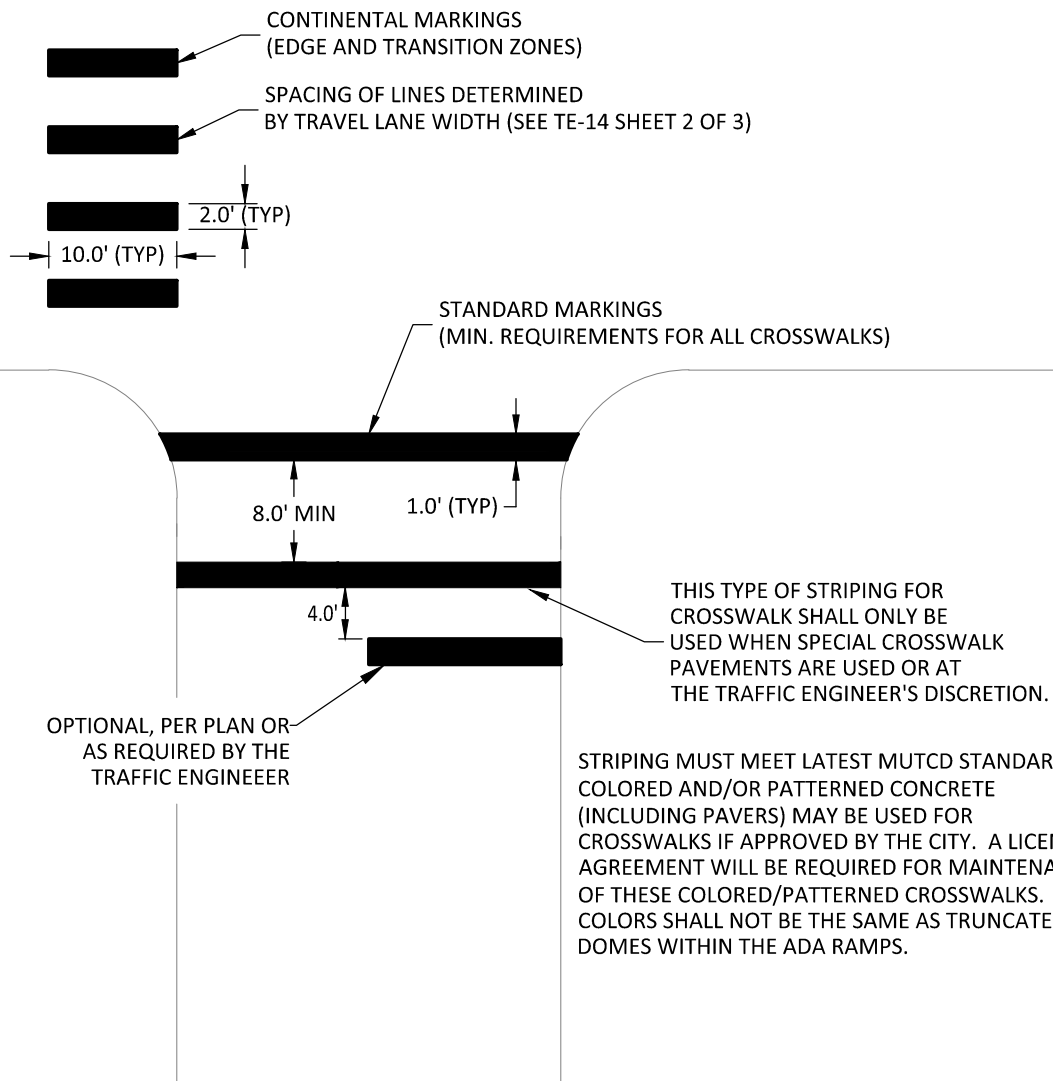


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<p>City of Aurora, Colorado</p> <p><i>Carla Compton</i> 1/26/2023 TRAFFIC ENGINEER DATE</p> <p><i>Alexander</i> 01/31/2023 CITY ENGINEER DATE</p>	<p style="text-align: center;"><b>CROSSWALK STRIPING</b></p>	<p style="text-align: center;">2 of 3 <b>TE-12.2</b></p>
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# STANDARD



q:\2022-roadway-specs\dwgs\traf-dtts\te12-3.dwg, 20 January 2023

City of Aurora, Colorado

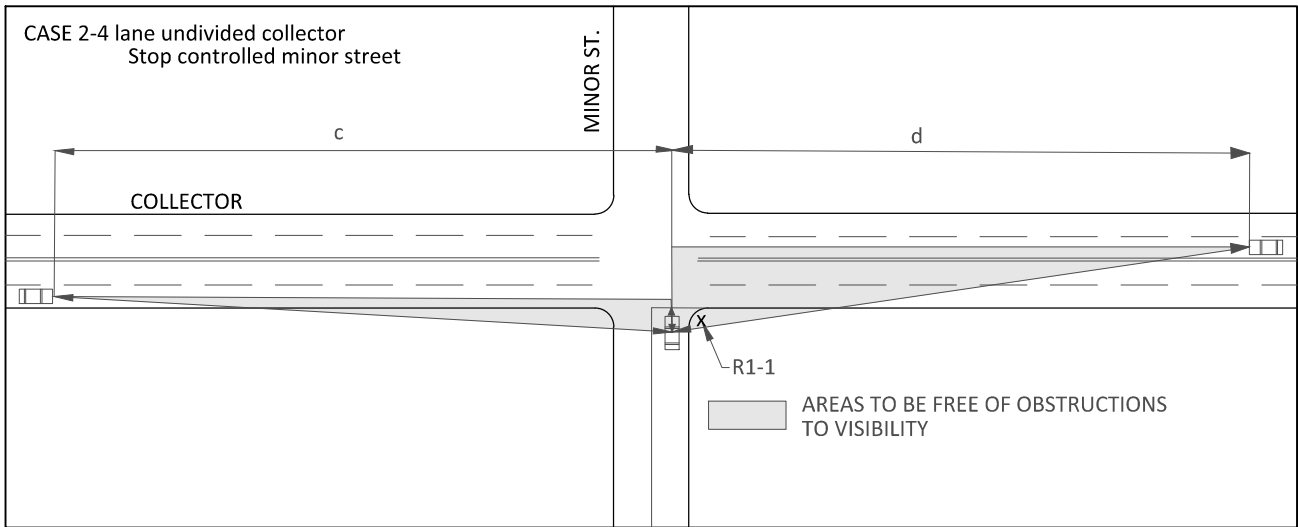
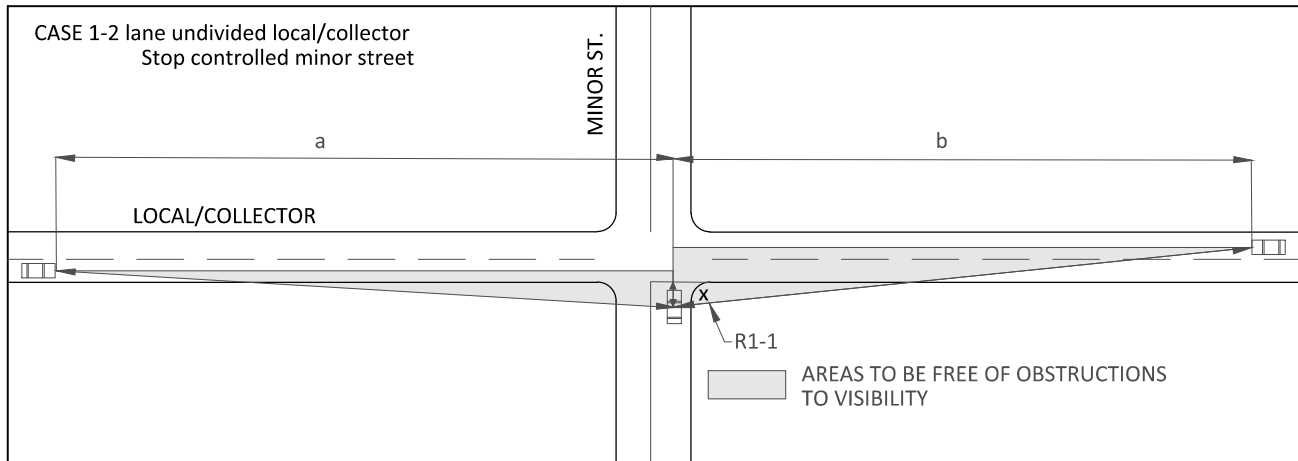
*Carla Lopez*  
 TRAFFIC ENGINEER  
*Alex B. Hansen*  
 CITY ENGINEER

1/26/2023 DATE  
 01/31/2023 DATE

CROSSWALK DETAILS  
 OTHER MARKINGS

3 of 3  
 TE-12.3

# STANDARD



DESIGN SPEED	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph
a (ft)	240	290	335	385	430	480
b (ft)	280	335	390	445	500	555
c (ft)	260	310	360	415	465	515
d (ft)	295	355	415	475	530	590

CORNER SIGHT DISTANCE MEASURED FROM A POINT ON THE CENTERLINE OF THE APPROACH LANE OF THE MINOR ROAD AT THE STOPBAR, STOP SIGN, OR BACK OF CROSSWALK AND MEASURED FROM A HEIGHT OF EYE OF 3.5 FEET ON THE MINOR ROAD TO A HEIGHT OF OBJECT OF 3.5 FEET ON THE MAJOR ROAD. METHOD OF CALCULATION FOR DISTANCE FIGURES BASED ON 2011 AASHTO GUIDELINES.

INTERSECTION SIGHT DISTANCE. INTERSECTIONS SHOULD BE PLANNED AND LOCATED TO PROVIDE AS MUCH SIGHT DISTANCE AS POSSIBLE. IN ACHIEVING A SAFE ROADWAY DESIGN THERE SHOULD BE SUFFICIENT SIGHT DISTANCE FOR THE DRIVER ON THE MINOR ROADWAY TO CROSS OR TURN ONTO THE MAJOR ROADWAY WITHOUT REQUIRING APPROACHING TRAFFIC TO REDUCE SPEED BY MORE THAN 30% OF ITS INITIAL SPEED. MINIMUMS FOR DIFFERENT SPEEDS ARE SHOWN FOR PASSENGER TYPE VEHICLES AT INTERSECTIONS WITH STOP CONTROLS. OTHER TYPES OF VEHICLES, OTHER LANE CONFIGURATIONS, AND OTHER FORMS OF TRAFFIC CONTROL HAVE DIFFERENT INTERSECTION SIGHT DISTANCE REQUIREMENTS.

CONSIDERATION SHOULD ALSO BE GIVEN TO MAINTAINING ADEQUATE SIGHT DISTANCE FOR VEHICLES TURNING LEFT FROM THE MAJOR ROADWAY ONTO THE MINOR ROADWAY. PLANTINGS IN THE MEDIAN SHOULD BE ARRANGED SUCH THAT THEY DO NOT RESTRICT VISIBILITY.

c:\2022-roadway-specs\dwgs\traf-dist\te13-1.dwg 20 January 2023

City of Aurora, Colorado

*Carla Lopez*  
TRAFFIC ENGINEER  
*John B. Hansen*  
CITY ENGINEER

1/26/2023

DATE

01/31/2023

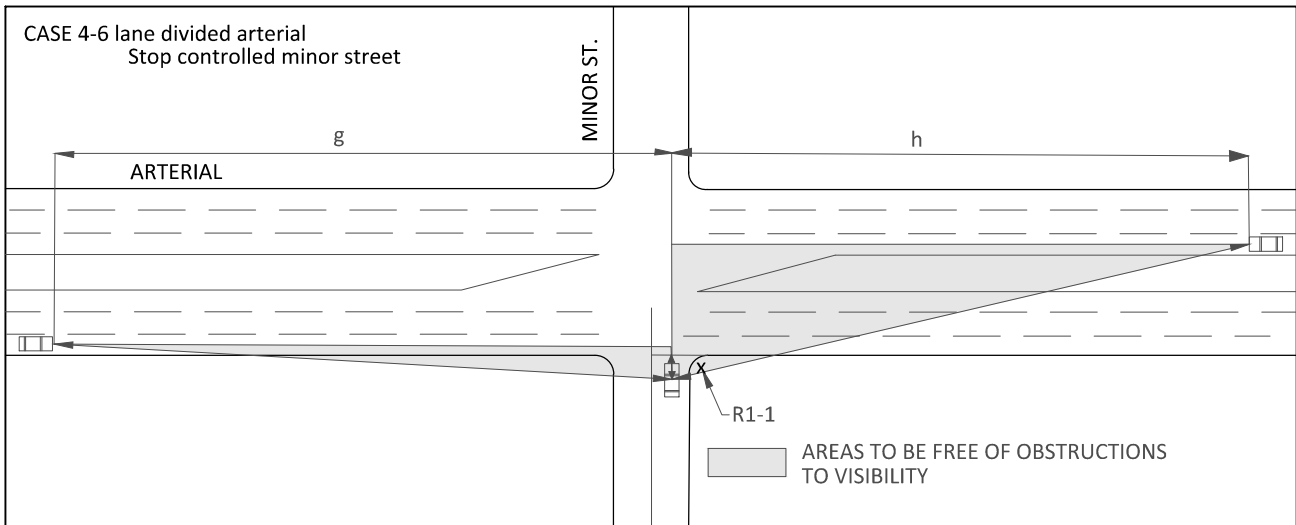
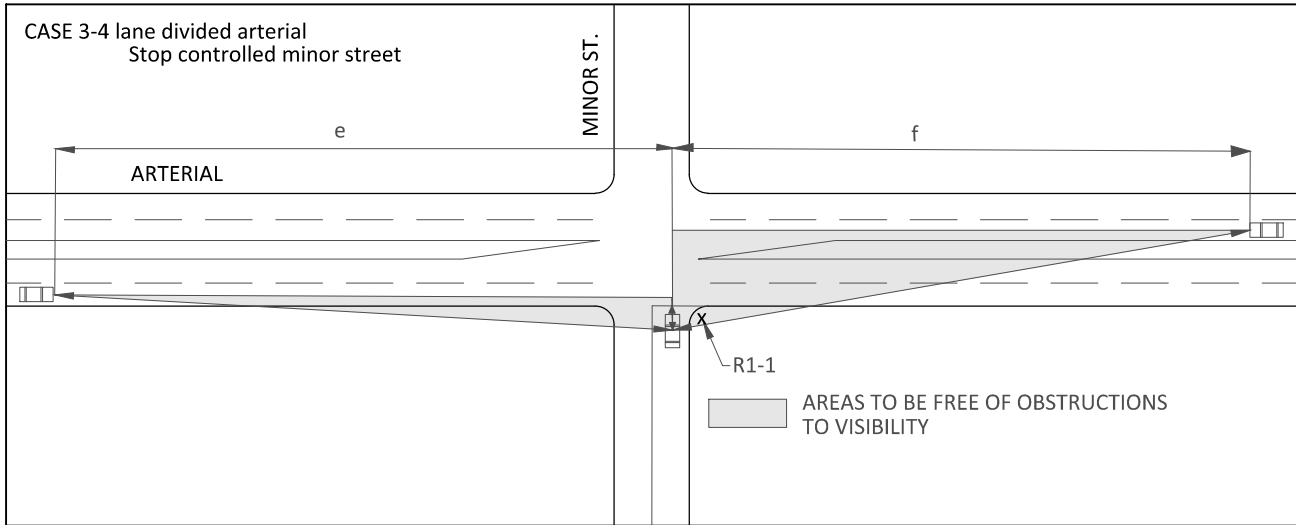
DATE

SIGHT DISTANCE  
REQUIREMENTS

1 of 3

TE-13.1

# STANDARD



DESIGN SPEED	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph
e (ft)	260	310	360	415	465	515
f (ft)	315	375	440	500	565	625
g (ft)	315	375	440	500	565	625
h (ft)	350	420	490	560	630	700

CORNER SIGHT DISTANCE MEASURED FROM A POINT ON THE CENTERLINE OF THE APPROACH LANE OF THE MINOR ROAD AT STOPBAR, STOP SIGN, OR BACK OF CROSSWALK AND MEASURED FROM A HEIGHT OF EYE OF 3.5 FEET ON THE MINOR ROAD TO A HEIGHT OF OBJECT OF 3.5 FEET ON THE MAJOR ROAD. METHOD OF CALCULATION FOR DISTANCE FIGURES BASED ON 2011 AASHTO GUIDELINES.

INTERSECTION SIGHT DISTANCE. INTERSECTIONS SHOULD BE PLANNED AND LOCATED TO PROVIDE AS MUCH SIGHT DISTANCE AS POSSIBLE. IN ACHIEVING A SAFE ROADWAY DESIGN THERE SHOULD BE SUFFICIENT SIGHT DISTANCE FOR THE DRIVER ON THE MINOR ROADWAY TO CROSS OR TURN ONTO THE MAJOR ROADWAY WITHOUT REQUIRING APPROACHING TRAFFIC TO REDUCE SPEED BY MORE THAN 30% OF ITS INITIAL SPEED. MINIMUMS FOR DIFFERENT SPEEDS ARE SHOWN FOR PASSENGER TYPE VEHICLES AT INTERSECTIONS WITH STOP CONTROLS. OTHER TYPES OF VEHICLES, OTHER LANE CONFIGURATIONS, AND OTHER FORMS OF TRAFFIC CONTROL HAVE DIFFERENT INTERSECTION SIGHT DISTANCE REQUIREMENTS.

CONSIDERATION SHOULD ALSO BE GIVEN TO MAINTAINING ADEQUATE SIGHT DISTANCE FOR VEHICLES TURNING LEFT FROM THE MAJOR ROADWAY ONTO THE MINOR ROADWAY. PLANTINGS IN THE MEDIAN SHOULD BE ARRANGED SUCH THAT THEY DO NOT RESTRICT VISIBILITY.

q:\2022-roadway-specs\dwg\traf-dtis\figs\fig3-4.dwg, 2023-01-26, 10:00 AM, 2023-01-26, 10:00 AM, 2023-01-26, 10:00 AM

City of Aurora, Colorado

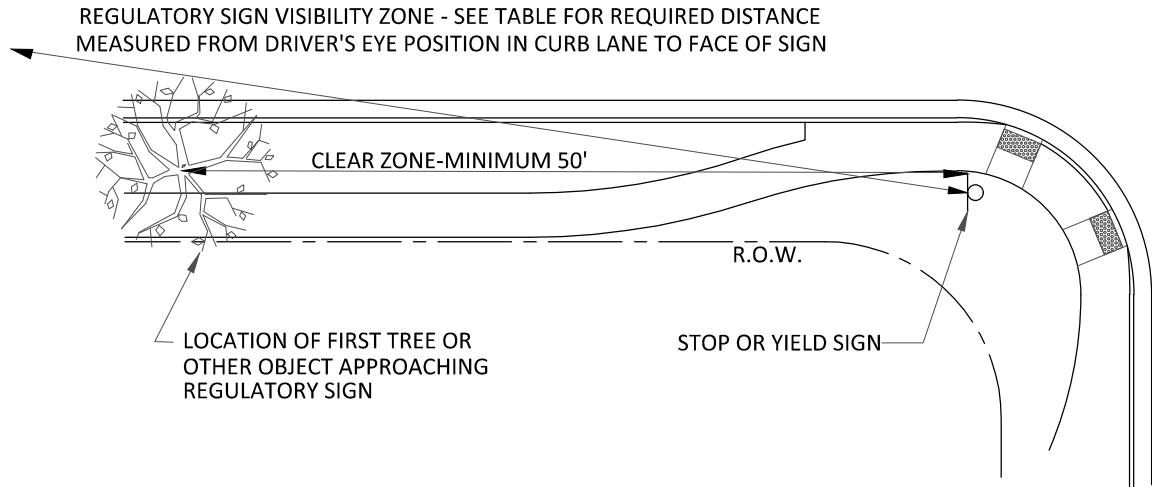
*Carla Compton* 1/26/2023  
TRAFFIC ENGINEER DATE

*Alexander* 01/31/2023  
CITY ENGINEER DATE

**SIGHT DISTANCE  
REQUIREMENTS**

2 of 3  
**TE-13.2**

# STANDARD



DESIGN SPEED	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph
REQUIRED DISTANCE	115 ft	155 ft	200 ft	250 ft	305 ft	360 ft	425 ft

## NOTES

1. A REGULATORY SIGN VISIBILITY ZONE IS REQUIRED ON ALL LOCAL, COLLECTOR, AND/OR ARTERIAL STREETS APPROACHING A STOP OR YIELD REGULATORY SIGN.
2. IN ADDITION TO THE REQUIREMENTS OF TE-13.1 and 13.2, AND THE REQUIREMENTS OF THE REGULATORY SIGN VISIBILITY ZONE AS SHOWN ABOVE, A CLEAR ZONE OF A MINIMUM OF 50' IS REQUIRED AS SHOWN ABOVE.
3. TREES OR OTHER OBJECTS NORMALLY PLACED IN THE REGULATORY SIGN VISIBILITY ZONE OR CLEAR ZONE SHALL BE INSTALLED AT A NEW LOCATION TO BE DETERMINED BY THE PLANNING DEPARTMENT, LANDSCAPE ARCHITECT, 303-739-7000.

City of Aurora, Colorado

*Concepcion*  
TRAFFIC ENGINEER

*Alan B. Khaner*  
CITY ENGINEER

1/26/2023

DATE

01/31/2023

DATE

REGULATORY SIGN  
VISIBILITY ZONE

3 of 3

TE-13.3