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SECTION 100 - TITLE, SCOPE, AND GENERAL CONDITIONS

100.00 General

101.00 Title

These regulations shall be known as the Engineering Code of Standards and Specifications, 2022 Edition, and may be cited as such. They shall be referenced herein as the Standards and Specifications.

102.00 Purpose

The purpose of these Standards and Specifications is to provide acceptable standards of design, construction, quality of materials, use, location, and maintenance of public infrastructure and common facilities including, but not limited to, water supply systems, sanitary sewer systems, storm drainage systems, streets or roadways, landscaping, irrigation, open space, parks, parking lots and appurtenances.

103.00 Severability

If any section of these Standards and Specifications is found to be unconstitutional or illegal by any court, the said section shall have no bearing on the effectiveness of the rest of these Standards and Specifications, which shall remain valid.

110.00 Scope of Work

The provisions of these Standards and Specifications shall apply to the construction, enlargement, alteration, moving, removal, conversion, demolition, repair, and excavation of public and private improvements or common facilities specifically regulated herein except where an approved plan specifically states otherwise. The provisions of these Standards and Specifications apply to all construction related to public improvements or common facilities.

Alterations, additions, or repairs to existing improvements shall comply with all requirements of these Standards and Specifications unless specifically exempted by the Project Engineer.

111.00 Federal, State, County, and City of Arvada Laws

The Contractor shall be responsible to be fully informed of, and shall comply with all applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies

having jurisdiction affecting the work. The Contractor shall protect and indemnify the City and its agents against any claim or liability arising from or based on the violations of such ordinances, regulations, or laws, arising from or related to any act or omission of the Contractor, his agents or employees. The Contractor shall obtain all necessary permits as required by these Standards and Specifications and City Code prior to commencement of the work.

112.00 Changes to the Standards and Specifications

All codified policy changes to these Standards and Specifications shall be made by City Council through ordinance and incorporated herein. Changes made for clarification or easier interpretation may be made by the City Engineer provided no codified policy(s) is affected by the change(s).

113.00 Specifications by Reference

All specifications, i.e., ASTM, ACI, etc. made a portion of these Standards and Specifications by reference shall be as contained in the Arvada Municipal Code or when absent the latest published edition.

Throughout these Standards and Specifications, any section referenced shall be deemed to include all subsections of that section. Any portion of these Standards and Specifications that may be applicable to any other section, whether referenced or not, shall apply.

114.00 Supervision and Discipline by Contractor

The Contractor will supervise and direct all work. He/She will be solely responsible for the means, methods, techniques, sequences and procedures of construction. The Contractor will employ and maintain on the work site a qualified supervisor or superintendent who shall have been designated in the City's Permit System by the Contractor as the Contractor's representative at the site. The supervisor shall have full authority to act on behalf of the Contractor and all communications given to the supervisor shall be as binding as if given to the Contractor. The supervisor shall be present on the site at all times as required to perform adequate supervision and coordination of the work.

Contractor shall employ resources for completing work to full completion in the manner and time required by the Contract. All workers shall have the necessary skill and experience to perform the work assigned to them. When workers are primarily conversant in a language other than English, each crew shall have at least one person that is fluent in both English and the primary language of the workers.

The Contractor shall at all times enforce strict discipline and good order among employees and shall avoid employing on the project anyone unskilled in the work assigned.

Any person employed by the Contractor or subcontractor who does not perform the work in a proper and skillful manner shall, at the written request of the Project Engineer, be removed by the Contractor or subcontractor and shall not be employed on the project without the approval of the Project Engineer.

All equipment used on the project shall be of size and mechanical condition to meet requirements of the work and to produce a satisfactory quality of work. Equipment used shall not cause injury to the roadway, adjacent property, or other roadways.

115.00 Drawings, Specifications, Conflicts, and Discrepancies

The intent of the drawings and specifications is that the Contractor shall furnish all labor, materials, tools, equipment, incidentals and transportation necessary for the proper execution of the work in accordance with the Contract Documents to complete the project in an acceptable manner, ready for use, occupancy or operation by the Owner on City projects.

In case of conflict between the drawings and specifications, the approved project specific documents shall govern. Figured dimensions on drawings shall govern over scaled dimensions, Detailed Drawings shall govern over General Drawings, and Special Conditions shall govern over Standard Specifications or Standard Special Specifications unless otherwise directed by the contract documents.

Any discrepancies between the drawings and specifications and site conditions; or any inconsistencies, errors, omissions or ambiguities in the drawings or specifications; or any errors or omissions in the layout as given by survey points and instructions shall be immediately reported. For City Capital projects, these should be reported to the Project Engineer, in writing, who shall promptly verify and correct such inconsistencies or ambiguities in writing. Work performed by the Contractor after such discovery, until authorized or corrected by the Project Engineer, shall be done at the Contractor's risk. For Development projects, these should be reported to the Design Engineer, in writing, who shall submit an RFI to the City Permit Coordinator for review and approval.

116.00 Alternative Construction

The provisions of these Standards and Specifications are not intended to prevent the use of any material or method of construction not specifically prescribed by these procedures. Alternate equivalent or superior materials or methods shall be submitted for approval to the Project

Engineer. Sufficient evidence and proof of equivalency or superiority shall be submitted to substantiate the alternate.

The applicant for a variance shall submit to the City via a written request using the Variance Request Form and follow the sequence of approvals within that form. Written requests shall be submitted by the design engineer. The document(s) approving the variance and granting a modification shall be placed in the project files.

117.00 Additional Project Requirements

It is recognized that the requirements contained in these Standards and Specifications are not necessarily sufficient for all plans, specifications and contract administration purposes. Accordingly, the Project Engineer is authorized to develop and/or approve additional requirements and procedures necessary.

120.00 Control of Work

121.00 Authorization

121.01 City Authority

The City Engineer has the authority to stop the work whenever such stoppage may be deemed necessary. The Municipal Inspector has authority to resolve issues regarding the quality and acceptability of materials furnished, performance of the work, interpretation of the plans and specifications, and acceptable fulfillment of the requirements of these Standards and Specifications.

121.02 Authority and Duties of the Arvada Inspector or Representative

The Arvada Inspector is authorized to observe and inspect all work and all material furnished. Observations and inspections may include all procedures and the preparation, fabrication, testing, and installation of materials to be used. The Arvada Inspector or Representative is not authorized to revoke, alter, or waive any requirements of these Standards and Specifications. The Arvada Inspector is authorized to call the attention of the Contractor to any failure of the work or materials to conform to these Standards and Specifications. The Arvada Inspector or Representative is also authorized to issue a "Correction Notice" when inspection of the project reveals violation(s) of these Standards and Specifications or deviation from project Quality Control Plan and objectives. The Arvada Inspector or Representative shall have the authority to reject substandard and non-conforming materials and faulty methods until any questions at issue can be resolved by the Project Engineer.

The Arvada Inspector or Representative shall not act as foreman or perform other duties for the Contractor. Any guidance, opinion, direction, or instruction that the Arvada Inspector or Representative may give the Contractor shall not be construed as binding upon the City Engineer or the City in any way, or release the Contractor from fulfilling all of the requirements of these Standards and Specifications.

The presence or absence of the Arvada Inspector or Representative shall not relieve the responsibility or the obligation of the Contractor.

Arvada shall—at all times—have reasonable and safe access to the work whenever it is in preparation or progress, and the Contractor shall provide proper facilities for such access and inspection.

121.03 Interpretation

These Standards and Specifications are composed of written engineering standards, materials specifications and Detail Drawings. The interpretation of any section, or of any difference between sections, when appropriate, shall be made by the City Engineer, and documented in the Project File. The City Engineer may consult the Engineer of Record in this evaluation. This interpretation by the City Engineer shall be binding and controlling in its applications.

121.04 Liability

The City Engineer is charged with the enforcement of these Standards and Specifications, acting in good faith and without malice in performing his/her duties, shall not be personally liable for any damage that may accrue to persons or property as a result of any act or by reason of any act or omission in the discharge of his/her duties.

122.00 Enforcement

122.01 Stop Work Order

If work is being done contrary to the provisions of these Standards and Specifications, the City Engineer or Project Engineer may issue a written order to stop the work. The written stop work order shall be served on any persons engaged in doing or causing the work to be done and documented on the permit. The stop work order shall specify the alleged violation(s). Upon receipt of the stop work order, all work shall cease immediately until authorized to proceed by the City Engineer.

122.02 Suspension of Work

In case of Suspension of Work for any reason, the Contractor shall take precautions, as necessary, to prevent damage to the public and the project, to provide for adequate drainage and to install necessary barricades, signs, or other facilities, at his/her expense, as directed by the Project Engineer or Inspector, and as required by these Standards and Specifications. Necessary precautions shall be taken before the Contractor leaves the job site.

122.03 Removal of Unauthorized and Unacceptable Work

All work which does not conform to these Standards and Specifications and the approved plans shall be considered unacceptable work, whether the result of poor workmanship, use of defective materials, damage through carelessness or any other cause found to exist prior to Final Acceptance and Release from Warranty of the work. Unacceptable work shall be immediately removed and replaced or corrected at the expense of the contractor, in a manner acceptable to Arvada. This expense includes the total and complete restoration of all disturbed surfaces to a condition acceptable to Arvada.

Any work done without required permits (Section 180) or contrary to the instructions of the Project Engineer or Inspector shall be considered unauthorized and may be ordered removed.

123.00 Violations and Penalties

It shall be unlawful for any person, firm, or corporation to construct, enlarge, alter, repair, move, improve, remove, excavate, convert, demolish or operate on public improvements or common facilities, or permit the same to be done in violation of these Standards and Specifications. Penalties shall apply as set forth in the [Arvada Municipal Code](#).

124.00 No Waiver of Legal Rights

Arvada shall not be precluded or stopped by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work, from showing the true amount and character of the work performed and materials furnished by the Contractor, or from showing that any such measurement, estimate or certificate is untrue or incorrectly made, or that the work or materials do not conform, in fact, to these Standards and Specifications.

125.00 Contractor's License

Any person(s) performing work on public infrastructure or within the right-of-way is required to obtain a Municipal General Contractor License as set forth in the [Arvada Municipal Code](#).

126.00 Performance Guarantee

Any person performing work that requires a permit per Section 180.00 Permits and Inspections, shall provide a performance guarantee set forth in [Arvada Municipal Code](#).

127.00 Use of Arvada Rights-of-Way (ROW)

All work performed in Arvada Rights-of-Way shall conform to these Standards and Specifications and the Arvada Municipal Code.

128.00 Requirements of Other Jurisdictions

Where proposed street construction affects other agencies such as the CDOT, adjacent cities and counties or ditch companies, said construction shall be subject to the review of said agencies. Generally, where more than one requirement is imposed, the more restrictive requirement shall govern. Exceptions will be authorized in writing by the Project Engineer.

129.00 Work Conditions

129.01 Working Hours

All work to be completed on the project shall be performed during regular working hours, 7:00 a.m. until 7:00 p.m. Monday through Friday. Work hours on arterials and collector streets are from 8:30 a.m. to 3:30 p.m. There shall be no construction between 9:00 p.m. and 7:00 a.m. unless it is an emergency or is authorized by the City Manager.

Sunday, holiday, after hours work and/or road closure requests shall follow the city's established process published on the city website. The Contractor shall submit a written request to the Project Engineer to perform overtime work outside of allowable working hours or to conduct a closure of any public right-of-way. Requests for work outside regular working hours shall be received a minimum of five (5) working days prior to the proposed date of the work.

Arvada observed holidays generally include: New Year's Day, Martin Luther King, Jr. Day, Presidents' Day, Memorial Day, Juneteenth, Independence Day, Labor Day, Thanksgiving Day, Day After Thanksgiving, Christmas Day.

129.02 Ensuring Public Safety

When, in the opinion of Arvada, the Contractor has not taken sufficient precautions for the safety of the public, the protection of the work to be constructed, or structures on adjacent property, which may be damaged by processes of construction due to such neglect, and/or an emergency may arise and immediate action is considered necessary in order to protect public safety, Arvada, with or without notice to the Contractor or the Developer, may provide suitable protection by

causing such work to be done and material to be furnished and placed as Arvada may consider necessary and adequate.

The cost and expense of such work and material so furnished shall be borne by the Contractor or Developer and shall be paid upon presentation of invoices.

The performance of such emergency work under the direction of Arvada shall in no way relieve the Contractor of responsibility for damages which may occur during or after such precaution has been taken.

129.03 Final Cleanup

Upon completion of the work, the Contractor shall remove from the project area all surplus and discarded materials, rubbish, and temporary structures, and leave the project area in a neat and presentable condition. The Contractor shall restore all work that has been damaged by his/her operations, to general conformity with the specifications for the item or items involved.

Final cleanup shall include inspection of the interior of all maintenance holes, stormwater inlets and facilities within the construction limits, for construction materials, dirt, stones, or other debris deposited therein by the activities of the Contractor, and removal of sediment and/or debris. Erosion control measures shall be removed and properly disposed of after final stabilization is achieved.

130.00 Control of Materials

131.00 Samples and Tests

Any work in which untested and uninspected materials are used shall be performed at the Contractor's risk and may be considered as unacceptable and unauthorized work. Whenever there is insufficient evidence of compliance with the provisions of these Standards and Specifications or evidence that any material or construction does not conform to the requirements, the Project Engineer will require the Contractor to perform tests to demonstrate compliance. Test methods shall be as specified by the Standards and Specifications. If there are no specified test methods for the proposed alternate, the Project Engineer will determine test procedures. All tests shall be made by an approved agency. Arvada shall retain reports of such tests.

To determine if materials comply with contract requirements and these Standards and Specifications, samples may be collected and/or tests performed at the source or job destination, at the discretion of the Project Engineer. Collection of samples and completion of tests shall be

in accordance with relevant ASTM standard protocols except where methods and procedures for sampling and testing materials are otherwise set forth in these Standards and Specifications.

The Contractor shall furnish—at his/her expense—all samples, tests and reports required by the Project Engineer and shall provide such facilities for collecting and forwarding them. When requested by the Project Engineer, a written statement providing the origin, composition and process of manufacture of a material shall be provided by the Contractor. On CIP projects the City shall provide technical personnel for QA testing of the work and materials, to ascertain that the completed work complies in all respects with the requirements of the Contract Documents, the approved construction plans and reports.

132.00 Storage of Materials

Materials shall be stored to assure the preservation of quality and suitability of the work. Stored materials shall be subject to inspection at any time prior to use in the work, and shall meet all requirements of these Standards and Specifications at the time they are used. Materials shall be stored in a manner that facilitates inspection. With the Project Engineer's written approval, portions of the rights-of-way not required for public travel may be used to store materials and equipment. Any additional storage space required shall be provided by the Contractor at his/her expense.

133.00 Defective Materials

Materials not in conformance with contract requirements or these Standards and Specifications shall be considered defective and shall be rejected. Rejected materials shall be removed from the work site within seventy-two (72) hours.

134.00 Quality Assurance and Quality Control

Quality Assurance is the process followed by Arvada inspectors to assure compliance of each project to the City Standards and Specifications. Quality Control is the process that shall be implemented by the Contractor and the independent project inspectors provided by a Certified Materials Testing Agency (Independent Testing Agency) or other entity as approved by the City.

The Contractor and the Independent Testing Agency shall prepare project specific documentation that will comprise the Quality Control Plan (QCP) as part of the overall project Quality Assurance Program prior to the preconstruction conference. The QCP shall include at a minimum:

1. A summary of the Contractor's methods and procedures to ensure quality control for all major aspects of the work. The summary should discuss roles and responsibilities

- of key project personnel, qualifications of personnel, equipment to be used, project oversight, and any other project specific strategies to ensure high quality construction.
2. The Certified Materials Testing Agency shall submit a testing plan which includes the work to be observed, required inspections, and required tests, including test type and frequency, on all major aspects of the work.
 3. Qualifications of the materials tester - minimum qualifications and required certifications are listed in Section 321.00 - Qualifications for Testing Agency of these Standards and Specifications.
 4. Worksheet or other form on which data will be recorded - the worksheet shall include, at a minimum, the location of test taken, result of test, date taken, testing standard used, testing equipment, test result, and retake information for failing tests. For pipe backfill operations, test locations must also be shown on the approved utility profile plan.
 5. The name of the professional engineer responsible for review and approval of the test reports.

The frequency of testing as required in Section 322.00 - Minimum Testing Requirements of these Standards and Specifications shall be the minimum Quality Assurance requirements.

134.01 Non-Compliance with the Quality Assurance Program

Provided that ninety percent (90%) or greater of all initial tests have passed, the Quality Assurance Program is considered satisfactory and no action will be required.

If less than ninety percent (90%) but greater than seventy-five percent (75%) of all initial tests have passed, the Arvada Construction Inspection Supervisor will conduct a field meeting to be attended by:

1. Arvada Construction Inspector
2. Developer's Project Manager and field representative
3. Developer's Testing Agency's Project Supervisor (P.E.) and Technician
4. Contractor's Quality Control Manager, the Superintendent and the Foreman of the crew doing the work

The purpose of the meeting will be to discuss and determine the cause of the low rate of passing tests and to determine a course of corrective action. Testing frequency shall be increased by twenty-five percent (25%) until ninety percent (90%) or more of the tests meet the specifications and requirements at the cost of the Contractor.

If less than seventy-five percent (75%) of all initial tests have passed, production will be suspended and the Arvada Construction Inspection Supervisor will conduct a field meeting to be attended by:

1. Arvada Construction Inspector
2. Arvada Project Engineer or Project Manager
3. Developer's or General Contractor's Project Manager and field representative
4. Developer's or General Contractor's Testing Agency's Project Supervisor (P.E.) and Technician
5. Contractor's Quality Control Manager, the Superintendent and the Foreman of the crew doing the work

The purpose of the meeting will be to discuss and determine the cause of the low rate of passing tests and/or samples and to determine a course of corrective action. The Contractor's foreman and crew performing the nonconforming work may be removed from the project. Production will remain suspended until the source of the problem is identified and corrected. Upon resumption of production, the work testing and/or sampling frequency shall be increased by fifty percent (50%) until ninety percent (90%) or more of the tests/samples meet the specifications and requirements for at least three (3) working days.

140.00 Protection of Public, Private and Utility Interests

City owned utilities shall be protected in conformance with Sections 400, 500, and 600 of these Standards and Specifications. Required separations for installation shall be in conformance with Sections 400, 500, and 600 of these Standards and Specifications.. Private utilities shall be protected as required by the Owner. Damage to private utilities shall be repaired as required by the Owner.

140.01 Arvada Utility Easements

Easements must extend a minimum of ten (10) feet on either side of a public utility. The minimum easement for one utility is twenty (20) feet. The minimum easement for two (2) utilities is thirty (30) feet. The minimum easement for three utilities is forty (40) feet. Easements shall be wider when utilities are placed at greater than normal depth. All newly acquired water, sanitary sewer, and storm sewer easements shall be an exclusive utility easement to the City of Arvada with the exception of other utility crossings at a perpendicular. Where an exclusive easement cannot be obtained, including but not limited to perpendicular crossings, the City Engineer may approve a non-exclusive easement.

Easements shall not contain any of the following:

1. Permanent structure of any kind

2. Foundation of any structure
3. Permanent signs of any kind
4. Trees
5. Landscaping beyond turf, mulch, and small annuals and perennials. Small shrubs may be allowed with the permission of the Project Engineer.

141.00 Operation of Arvada Utility System Controls

Only Arvada qualified personnel shall operate control devices on all Arvada utility systems.

142.00 Use of Arvada Water

The Contractor may obtain permission to use Arvada water during construction as follows:

1. Meter users shall obtain an agreement from Utility Billing which covers: pick up and drop off scheduling, Meter information, meter uses, and backflow prevention methods. Meter deposit fee will be charged at that time.
2. Upon pick up, meter users shall provide a hydrant meter agreement stamped by Utility Billing, and a passing backflow test that will not expire within the six (6) month rental period. Backflow assembly will be inspected for damages, and proper installation will be explained at this time.
3. Upon termination of the six (6) month rental agreement, the hydrant meter will be returned to the Water Utility Division and will be inspected for damages. Damages will be reported to Utility Billing and repairs will be deducted from the security deposit.

143.00 Underground Facilities

143.01 Locates Required for Existing Utility Systems

Prior to disturbance of soils, concrete or asphalt materials, all utility line locations shall be marked on the ground with location equipment by a certified utility locator agency. All utility locates shall be plainly marked by coded paint symbols on pavement or by marked stakes in the ground at the Contractor's expense.

143.02 Subsurface Utility Engineering (SUE)

Consistent with C.R.S. §§ 9-1.5.101 et seq. , stamped plans that meet or exceed the ASCE 38-02 standard are required for all subsurface utility engineering required projects where the project:

- Has an anticipated excavation footprint that exceeds two feet in depth and is a contiguous one thousand square feet; or
- Involves utility boring; or

- The project requires the design services of a licensed professional engineer.

143.03 Exploratory Potholing Required for Existing Utility Systems

No directional drilling will be allowed in areas containing public utilities without exploratory potholing.

Prior to any directional drilling for the installation of any and/or all utilities, all existing underground utility line locations, within the path of the bore, shall be exposed by exploratory potholing, Quality Level A. Minimum information required on design plans shall meet [ASCE 38-02](#), Quality Level B designation for all utilities in the project area, and all utility crossings are required to meet ASCE 38-02, Quality Level A designation. Stamped plans shall meet or exceed the ASCE 38-02 standard for depicting and designating the underground facility location.

During installation, the exposed utility shall remain opened to the Arvada Inspector to confirm separation/clearance of the new installation as determined by the Project Engineer. Per these Standards and Specifications, all utilities, other than fiber optic and irrigation lines, shall have a minimum separation of eighteen inch (18") vertical separation and ten foot (10') horizontal separation.

After confirmation of the required separation of the new bore and the existing utility, the exploratory pothole shall be repaired per Section 837.03- Exploratory Pothole/Core Repair and/or 935.02 - Exploratory Pothole/Core Repair of these Standards and Specifications.

144.00 Permissions and Permits Required by Other Agencies

Prior to City of Arvada Permit issuance, Developers or Contractors proposing to place facilities in the vicinity of existing public, private or utility infrastructure shall obtain a written agreement from the responsible managing agency. This shall include, but not be limited to irrigation ditches, railroads, the CDOT, the CDPHE, the ACOE, County air, communication utilities, gas and electric utilities, and neighboring governmental entities.

Any work performed on a State Highway must be approved and permitted by CDOT. Traffic control requirements are to be reviewed and approved by CDOT. Any detours from a State Highway onto a City of Arvada street must have approval from the Traffic Engineer prior to the detour being implemented.

For more information, refer to Section 300 - Soils And Earthwork of these Standards and Specifications and NPDES for permit requirements.

145.00 Public Convenience and Safety

Fire hydrants shall be visible and accessible to the Fire District from the street at all times. No obstructions shall be placed within ten (10) feet of a fire hydrant.

Unless otherwise specified, the Contractor shall give written notice to property owners adjacent to proposed work and to the proper authorities in charge of streets, waterlines, gas lines, electric service, cable television and other conduits, railroads, poles, maintenance holes, catch basins and all other property that may be affected by the Contractor's operations, at least seventy-two (72) hours before breaking ground. The Contractor shall not hinder or interfere with any person in the protection of such property, or the operation of utilities at any time. The Contractor shall obtain all necessary information (including field locations, which may include exploratory potholing) with regard to existing utilities, and shall protect said utilities from damage, and shall avoid unnecessary exposure of utilities that could cause injury to the public. The Contractor shall obtain all necessary information in regard to the planned installation of new utilities, cables, conduits and transformers. The Contractor shall make proper provisions and give proper notification so that new utilities and equipment can be installed without unnecessary inconvenience to the public.

146.00 Interruption of Services

Before starting site work, the Contractor shall plan and coordinate the disconnection or interruption of all services; such as water, sewer, cable TV, telephone, gas, electric power and traffic. Disconnection and/or interruptions shall be made in accordance with the regulations of the utility that controls the supply of the service. Whenever the flow of traffic is affected, a Traffic Control Plan shall be provided in accordance with Section 149.00 - Traffic Control, Barricades and Warning Signs of these Standards and Specifications.

Arvada Utilities Department shall provide a representative to be on site to observe and approve the Contractor's disconnection or interruption of water and sewer services. Forty-eight (48) hours prior to the interruption of service, the Contractor shall notify all users whose service shall be interrupted in order for them to make provisions for necessary water storage. The notification shall, at a minimum, include the following information:

1. Service type
2. Area affected (Location, street, block)
3. Date
4. Time of shut-down
5. Duration of shut-down
6. Contractor contact information (24-hour availability)

7. Recommendations such as storing drinking water for consumption, cooking, or toilet flushing during the outage.

No line in service shall be shut down for more than a four (4) hour period at one time. Prior approval by the City Engineer is required for all shut-downs. If required by the City Engineer, temporary service shall be provided in accordance with Section 400 - Water Supply Facilities of these Standards and Specifications.

147.00 Dustproofing

The Contractor shall take all necessary steps to control dust arising from operations connected with the work. This includes, but is not limited to, dustproofing the construction area by sprinkling with water, a dust palliative, by constructing windrows, or as otherwise directed by the Project Engineer. In the event that other occurrences require countermeasures, the Project Engineer shall approve said action.

148.00 Protection and Restoration Requirements

Every reasonable precaution shall be taken to prevent the damage or destruction of public or private property such as poles, trees, shrubbery, crops, fences, and all overhead structures, wires, and cables.

Wherever necessary, or directed by the Project Engineer, the Contractor shall erect and maintain a fence or railing around any excavation or work site and place a sufficient number of amber lights about the work and keep them burning from twilight until sunrise. Watchmen shall be employed for additional security wherever needed or required by the Project Engineer.

The Contractor shall not prevent the flow of water in gutters of the street, and shall use proper means to permit the flow of surface water along gutters while work is progressing.

148.01 Protection of Storm Sewer Systems, Streams, Lakes and Reservoirs

The Contractor shall take all necessary precautions to prevent pollution of streams, lakes, and reservoirs with fuel, oil, bitumen, calcium chloride, or other harmful materials. Control measures must be implemented to capture pollutants and captured pollutants must be removed and properly disposed of.

They shall conduct and schedule their operations to avoid or minimize siltation of streams, ditches, lakes and reservoirs.

148.02 Protection of Public and Private Installations

The Contractor shall take proper precautions at all times for the protection of and replacement or restoration of streets, driveway culverts, street intersection culverts or aprons, storm drains or inlets, fences, irrigation ditches, crossings and diversion boxes, mail boxes, shrubbery, business signs, street signs, flowers, ornamental trees, driveway approaches, and all other public and private installations that may be encountered during construction. The Contractor shall have the responsibility of providing each property with access to and from the property during the time of construction. Existing driveways shall be cut, filled, and graded as required and as directed by the Project Engineer to provide permanent access. It shall be at the Contractor's expense to repair or replace damaged public or private infrastructure that was damaged during construction.

Temporary Street Signs and Business Signs shall be provided by the Contractor in the event that such permanent signs need to be removed for construction purposes. Permanent Street and Business signs shall be re-installed in the same condition in which they were before removal.

148.03 Existing Structures and Utilities to Remain

All existing poles, wires, fences, property line markers and other structures which shall be preserved in place without being temporarily or permanently relocated shall be carefully supported and protected from damage by the Contractor.

Underground utilities may exist within or immediately adjacent to areas of proposed construction. Per C.R.S. §§ 9-1.5.101 et seq. all projects that have an anticipated excavation footprint that exceeds two (2) feet in depth and is a contiguous one thousand (1,000) square feet or includes any utility boring are required to provide existing utility locations meeting the ASCE 38-02 standards. This requirement is for all utilities proposed in public Right-of-Way, easements, or publicly owned land. All utilities investigations in the project area are required to meet ASCE 38-02, Quality Level B designation, and with the design of utility crossings are required to meet ASCE Quality Level A designation. Stamped plans by a Colorado licensed professional engineer are required to meet or exceed ASCE 38-02 standards for defining underground facility locations.

All utility services shall be supported by suitable means so that services do not fail during construction or if settling of soils occurs. Where any shallow pipe exists or is constructed which may have been distressed by the Contractor's construction operations, the Project Engineer may require the Contractor to submit video of the pipe for inspection. Developer and Contractor shall be responsible for the repair of underground pipes, wires, or conduits damaged by them or their subcontractors.

148.04 Relocation, Removal and Replacement of Existing Structures and Utilities

If the Contractor encounters structures and/or utilities in conflict with the proposed Work, the structures and/or utilities shall be relocated, or removed and replaced in-kind as approved by the Project Engineer.

Abandonment or removal of Arvada utilities shall be performed in accordance with Section 332.00 - Pipe and Appurtenances of these Standards and Specifications.

148.05 Tree Protection Zone

Developer or Contractor shall provide tree protection in the form of six (6) foot high chain link fence for all construction activities located in or adjacent to any Arvada park or right-of-way landscaping. Fencing shall be erected at the canopy drip line prior to any work on the site, and shall remain in place until construction is complete. Protection requirements shall extend to neighboring trees overhanging the site. No storage of material, topsoil, vehicles or equipment shall be permitted within the tree protection zone. The Developer or Contractor shall be responsible for damage to protected trees during the course of construction. If the Project Engineer, in conjunction with the City Arborist, deems that suitable tree surgery methods are not adequate to repair the damaged tree, the damaged tree shall be removed and replaced at the Contractor's expense. See the [Arvada Land Development Code Division 4-6-2. - Tree Preservation and Replacement](#) for these requirements.

148.06 Protection of Landscaped and Irrigated Areas

The Developer or Contractor will be responsible for protecting all landscaping and irrigation in developed areas at all times. Any damage to the landscaping or irrigation will be restored to the original condition at the Developer's or Contractor's expense. Arvada owned landscape and irrigation areas will be inspected by the City's appointed representative before any approvals are made.

148.07 Correcting Damage

Developer and Contractor shall be responsible for damage or destruction of property resulting from neglect, misconduct, or omission in his/her manner or method of execution or non-execution of work, or caused by defective work or the use of unsatisfactory materials.

The Contractor shall notify the property owner of the type and extent of the damage and agree to a time schedule to repair the damage. The repair shall restore such property to a condition similar or equal to that which existed before such damage or injury was done, by repairing, rebuilding, or replacing it as may be directed, or they shall otherwise make good such damage or destruction in an acceptable manner, as determined by the Project Engineer. If damage is not repaired within the time frame agreed to by the property owner and the Contractor, Arvada will have repairs made as set forth in the [Arvada Municipal Code § 78-301](#).

Developer and Contractor shall be liable for all damage caused by storms and fire, and shall under no circumstances, start fires without first securing the necessary permits and approval of the authority having jurisdiction even though they may be ordered or required to do such burning. In burning brush, stumps, or rubbish, care shall be taken not to damage any standing trees, shrubs or other property.

149.00 Traffic Control, Barricades and Warning Signs

All construction, maintenance, park or utility work being completed within the Public Rights-of-Way shall have a Traffic Control Plan (TCP) approved by the Traffic Engineer. The TCP is a plan for guiding and handling traffic safely through the construction work zone. The TCP shall provide safe methods for movement of pedestrians, bicyclists, and motorists that travel through the work zone, and a safe area for all workers engaged in construction activity. The job specific TCP will be prepared by the Contractor for review by the City Traffic Engineer in accordance with the TCP Checklist. No work shall commence without an approved TCP. Any changes to the TCP must be approved by the Traffic Engineer prior to implementation. All control devices shall be installed and maintained in accordance with these Standards and Specifications, the “Manual on Uniform Traffic Control Devices” (MUTCD), latest editions, and CDOT Standard Plans for Traffic Controls for Highway Construction, latest editions.

Where the Contractor's work requires a full closure of any public street, road, highway, alley, trail or sidewalk, the Contractor shall follow the outlined road closure request process published on the city website. Requests shall be submitted to the project engineer or traffic engineer at least five (5) days in advance of the requested work date.

Requirements contained in the above referenced manuals and Standards and Specifications shall be strictly enforced during the progress of the work. Where the control and maintenance of traffic has not been performed as specified in the Special Conditions and/or the Contractor does not conform to the Standards and Specifications established by the City of Arvada, the Project Engineer may issue a Stop Work Order.

The Contractor shall be responsible for obtaining applicable permits as outlined in Section 144.00 Permissions and Permits Required by Other Agencies and Section 180.00 - Permits and Inspections of these Standards and Specifications. The Contractor shall:

1. Provide timely notification to, and coordination with, all affected agencies including, but not limited to the following:
 - a. Utility Companies
 - b. RTD
 - c. CDOT
2. Inform occupants of abutting properties of access limitations made necessary by the work.
3. Schedule and expedite the work to cause the least inconvenience to the public.
4. Furnish, install and maintain required traffic control devices and facilities, as required throughout the life of the contract, including periods when the work is not underway.
5. Provide flagging persons and Uniformed Traffic Control (UTC) when required. Automated Flagger Assistance Devices (AFADs) are not accepted.
6. Ensure that survey crews and other employees working in or adjacent to a traveled roadway wear personal protection equipment as required.
7. Provide adequate safeguards for workers and the general public.
8. Patrol the construction site as required to ensure that all devices are in place and operating at all times.
9. Remove traffic control devices when they are no longer needed.

Once the TCP is approved by the Traffic Engineer, the Contractor is solely responsible for the installation, maintenance, and inspection of the construction zone. The Contractor will keep a signed copy of the TCP at the work area during work hours. The work area shall be understood to include all open trenches, other excavations, material piles, equipment, obstructions, detours and other temporary roadways, and other similar hazards within or related to the project. The TCP will be available for inspection by City or State personnel. All traffic control signs that are not applicable to the given circumstance shall be removed, covered, or turned around so they do not face traffic and pose a hazard. The Contractor shall correct any deficiencies noted by the City immediately. The Contractor must remove all traffic control within forty-eight (48) hours after job completion. If the Contractor does not comply, is not available, or cannot be found, the City may make such corrections as set forth in the [Arvada Municipal Code § 78-303](#).

Projects that affect traffic on arterial and/or collector streets may require the use of a Uniformed Traffic Control (UTC) officer on the job site to direct traffic as directed per the Traffic Engineer. When the normal operation of a traffic signal must be interrupted, UTC shall be used to direct

traffic. Any expense incurred during this operation shall be borne by the Contractor. Work shall be scheduled and expedited in a manner to cause the least inconvenience to the public.

Intersection, alley, and driveway access shall be maintained at all times. If closure of an intersection is necessary it shall be done at the approval of the Traffic Engineer and shall be closed for a minimum amount of time. The Contractor shall coordinate driveway closures with property owners with final approval by the Traffic Engineer.

Unless otherwise approved by the Project Engineer, construction operations are limited to one-half of the roadway at any time. Maintenance activities in arterial and collector streets shall be planned and scheduled to minimize interference with traffic.

All temporary traffic lanes shall be a minimum of ten (10) feet in width unless otherwise authorized. In addition, lane clearance shall be a minimum of five (5) feet from an open excavation and two (2) feet from a curb or other vertical obstruction. Barricades shall be used to separate the traffic lanes from an open excavation if the five (5) feet minimum lane clearance can not be maintained. Barricades shall be painted, kept clean, weighted, and the face material shall be retro-reflective. All signs (warning, regulatory, etc.) shall be kept clean and shall be replaced when the face is damaged. These sign faces shall be retro-reflective. All signs shall be removed or turned away from the roadway immediately after they are no longer applicable, especially when left at the job site overnight.

Traffic cones are for daytime use only. Barricading devices with lights shall be used for all work that is left overnight. When lights are used, steady burn lights shall be used for delineation and channelization. Flashing lights shall be used to denote a specific hazard.

Under certain conditions the use of temporary pavement markings shall be required in addition to the devices used for delineation. This shall be shown on the TCP and the Traffic Engineer will determine the extent of the striping. When temporary markings are used, the existing markings shall be completely removed from the roadway. Painting the existing markings black will not be accepted. Temporary markings shall be installed by the Contractor. The temporary markings shall be removed when the construction is completed and the permanent markings shall be reinstalled by the Contractor.

A suitable surface shall be provided for temporary traffic lanes in work areas. When traffic is diverted from existing pavement, a temporary surface shall be provided, as approved by the Traffic Engineer, Fire Department, and any other applicable agencies.

Construction equipment not actively engaged in construction, employee vehicles, and official vehicles of the agency shall not be parked in the vicinity of the work in such a manner as to further restrict traffic flow. Vehicles and equipment in continuous or frequent use may be operated or parked in the same traffic lane as the work obstruction. Construction spoils or materials may be similarly stored in this area or on the nearby roadway or sidewalk area, provided that four (4) feet of sidewalk is kept clear for pedestrian use. To prevent the spoil bank from occupying too great a space at its base, toe boards may be used to keep it two (2) feet from the edge of the excavation on one side and two (2) feet from the edge of the traffic lane on the other. Spillage and mud trackage from trucks and equipment shall be cleaned up immediately.

Open trenches will not be allowed after work hours, without prior approval of the Project Engineer or Municipal Inspector. Whenever necessary, trenches and excavations shall be bridged to permit an unobstructed flow of traffic.

1. Bridging shall be secured against displacement by using adjustable cleats, angles, bolts, or other devices.
2. Bridging shall be installed to operate with minimum noise.
3. The trench shall be adequately shored, to support the bridging and traffic.
4. Steel plates used for bridging shall extend a minimum of one foot beyond the edges of the trench. Temporary paving materials shall be used to feather the edges of the plates to minimize wheel impact.
5. Steel plates used for bridging shall be designed by a Colorado Registered Professional Engineer.

When the work area encroaches upon a sidewalk, bike lane, walkway or crosswalk area, special consideration shall be given to pedestrian and bicyclist safety. Effort shall be made to separate pedestrians and bicyclists from the work area. Pedestrians shall not be diverted onto the roadway. An accessible pedestrian route shall be maintained through the work area at all times unless a detour route has been approved on the Traffic Control Plan.

All work shall be barricaded at all times. Between sunset and sunrise, the work area shall be properly lighted, as determined by the Project Engineer. The Contractor shall be responsible for all damages to work due to failure of barricades, signs, lights, flagging persons and watchmen.

Anytime a flagger is required to direct the flow of traffic, that flagger must be visible to traffic. Orange or Optic Yellow clothing (vest, shirt or jacket) must be worn by the flagger. For nighttime operations, this clothing must be reflectorized. The flagger shall follow the flagging procedures stated in the MUTCD. All flaggers shall be required to provide proof of having completed a flagger certification program accepted by CDOT or as approved by the Traffic Engineer. Flagger certification must be active at the time of flagging operations.

150.00 Storage and Use of Explosives

Detonation of explosives by Developers or Contractors shall only be authorized with approved State permit and must be approved by the local Fire District and the City Manager.

151.00 Surveys and Survey Monuments

151.01 Surveys

Surveys shall conform to Colorado Bylaws and Rules of Procedures and rules of Professional Conduct of the State Board of Registration for Professional Engineers and Professional Surveyors, latest edition.

151.02 Survey Monuments

Permanent survey monuments, including the replacement of monuments, range points and lot pins shall be set in accordance with the requirements of Articles 51 and 53 of Title 38, Colorado Revised Statutes, and as required by the Bylaws and Rules of Procedure of the Colorado State Board of Licensure for Architects, Landscape Architects, Professional Engineers and Professional Land Surveyors. Range points shall be protected by the installation of a survey range box per detail drawings.

151.03 Protection of Survey Monuments

The Developer and Contractor shall use every reasonable precaution to prevent the damage or destruction of survey monuments adjacent to or on the site. The Contractor shall protect and carefully preserve all aliquot corners, property, NGS, and Arvada survey control monumentation. Any monument that may be disturbed shall be referenced to a minimum of two points outside the limits of construction and replaced by a Colorado Registered Professional Land Surveyor. All monuments disturbed or removed by the Contractor, through negligence or carelessness on his/her part or on the part of his/her employees or subcontractors, shall be restored per Section 151.02 - Survey Monuments of these Standards and Specifications.

160.00 Engineering Reports

Engineering reports shall be required for all development and City projects and submitted with each application for a permit, unless waived by the Project Engineer. Engineering reports shall be prepared in conformance with the appropriate checklists that can be found on the City's website. The checklists are intended to assist in the preparation of the projects. They are minimum typical

items required to demonstrate conformance with these standards. Additional items may be necessary, which will be identified during the review process.

161.00 Preliminary Engineering Reports

The following preliminary engineering reports shall accompany all Annexation, Rezoning, Master Development Plan, and preliminary plat applications as noted below, unless waived by the Project Engineer:

1. Utility Report
2. Drainage Report
3. Traffic Analysis Report
4. Geotechnical Study
5. Phase I Environmental Assessment Report

162.00 Final Engineering Reports

At a minimum, the following final reports shall accompany all site plan, Final Development Plan, minor plat, and final plat applications, or construction documents as noted below, unless waived by the Project Engineer:

1. Utility Report
2. Drainage Report
3. Traffic Analysis Report
4. Geotechnical Studies
5. Construction Traffic Routing Plan

170.00 Plans and Specifications

Arvada requires that plans, computations and specifications be prepared and designed by a Colorado licensed Professional Engineer and landscape plans by a Colorado licensed Landscape Architect.

171.00 Construction Plans Approval

Construction Plans shall conform to the Civil Construction Drawings Checklist. All construction plans shall be reviewed for general conformance with the Standards and Specifications prior to approval by the City Engineer. Engineering design shall remain the responsibility of the

professional Design Engineer. Approved plans shall be void if a ROW permit is not issued within one year following plan approval.

172.00 GIS Data Conformance

An unlocked AutoCAD digital copy of the approved construction plans and as-built plans are required. Confirm version acceptability with Arvada's Engineering Division, including the following requirements:

1. "X-referenced" files shall have the "reference type" as "Attachment" and the "path type" as "relative path" and be tied to Arvada's GPS network system.
2. **Basis of Bearing.** The Basis of Bearing statement shall fully describe which two City of Arvada GPS Control Points were selected to establish the State Plane grid bearings used for construction drawings. Specify the State Plane grid bearing, and Modified State Plane distances between these two GPS Control Points and state the method used to derive the bearing (i.e., assumed, astronomic, geodetic, grid, reference to recorded or deposited survey, etc.).
3. **Benchmark Requirements.** All vertical control shall be based on the exclusive City of Arvada datum (approximately 2.2 feet lower than NAVD88) as provided on the City of Arvada website. Arvada survey standards are to be used for the design, construction, construction drawing and Record drawings. The project benchmark being used for construction shall fully describe the monument (i.e. monument material, diameter, length (if set), cap size and material, cap markings/stampings, etc.). The cover sheet shall include the above mentioned requirements and all information needed to establish project control.
4. **Arvada Survey Standards**
 - a. Orthometric heights are based on NAVD88 (Geoid18 being the current Geoid)
 - b. State Plane coordinates are based on the Colorado Central Zone (502)
NAD83(2011)(EPOCH 2010.0000)
 - c. Units are US Survey Feet (SFT)
 - d. Land Surveys need to be at ground. Surveys should be based upon the State Plane Coordinates as stated in (ii) and should show the "Combined Scale Factor" to convert from Grid to Ground or Ground to Grid.
 - e. Any modification from the Arvada's survey standards would need City Engineer's approval. Submit a written request with justification as to why the modification is being requested.

173.00 Access to the Approved Plans

The Contractor shall keep a set of the signed approved plans on the job site for the duration of the project.

174.00 Record Documents

Record Documents shall be prepared and submitted at the completion of the project in compliance with Section 200 – Acceptance Procedures of these Standards and Specifications. If the Design Engineer responsible for the original approved engineering construction drawings has changed prior to preparing Record Documents, the replacement Design Engineer shall agree in writing to accept the responsibility for final approval and acceptance of the public improvements.

180.00 Permits and Inspections

It shall be unlawful for any person, organization, firm or corporation to construct, enlarge, alter, repair, move, improve, remove, excavate, convert or demolish any public improvements or common facilities regulated by these Standards and Specifications without first obtaining a [Right- of- Way Permit](#), [Floodplain Development Permit](#), and/or a [Site Disturbance Permit](#) for such work in accordance with the [Arvada Municipal Code](#).

181.00 Application for Permit

All City construction related permits may be found online at Arvada's website ([Arvadaco.gov](#)) and shall be completed in accordance with the [Arvada Municipal Code](#).

A permit application shall expire if no permit is issued within one-hundred eighty (180) days following the date of the application. Plans and other data submitted with the expired permit application may be returned to the Applicant or destroyed by the Project Engineer. The permit issuance period may be extended by the City Engineer for a period up to one-hundred eighty (180) days. An extension shall be based upon a written request from the Applicant showing that circumstances beyond the control of the Applicant have prevented action from being taken. A permit extension of one-hundred eighty (180) days from the expiration date noted on the permit may be granted without an additional fee. No application shall be extended more than once. To renew action on an application that has expired, the Applicant shall resubmit plans and pay a new fee.

182.00 Permit Issuance

The application, plans, specifications and other data filed by an Applicant for a permit shall be reviewed by the Project Engineer or designated representative. The plans may be reviewed by other Arvada departments. If the Project Engineer finds that the work described in an application for a permit, including plans and other data, conforms to the requirements of these Standards and Specifications, other pertinent laws and ordinances, and that all required fees have been paid, a permit may be issued.

The City Engineer may waive the submission of plans, calculations, etc., if he/she finds that the nature of the work is such that a review of plans is not necessary to obtain compliance with these Standards and Specifications. Otherwise, all permitted plans shall have a signed City Engineer Statement. The approved plans and specifications shall not be changed, modified, or altered without authorization from the City Engineer, and all work shall be performed in conformance with the approved plans. One set of approved plans, specifications, and computations shall be retained by Arvada, and one set shall be maintained at the work site at all times during the progress of the work.

A pre-construction conference may be required prior to the issuance of any permits for construction. Invitees shall include the Project Engineer, Arvada inspectors or representatives, the developer/owner, design engineer, general contractor, subcontractors and others as appropriate. The Project Engineer will be notified five working days before construction is to begin.

The issuance of a permit shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of these Standards and Specifications or of any regulations of this jurisdiction. No permit presuming to give authority to violate or cancel the provisions of these Standards and Specifications is valid.

The issuance of a permit based on plans, specifications or other data shall not prevent the Project Engineer from requiring the correction of errors in the plans, specifications and other data, or from stopping construction operations, which are in violation of these Standards and Specifications or any other regulations of this jurisdiction.

183.00 Permit Expiration

All work covered by the permit shall be completed by the date stated on the application. Per the [Arvada Municipal Code](#), permits shall be void if work has not commenced six (6) months after issuance, unless the director has granted an extension. Cash escrows or letters of credit deposited as a performance warranty/guarantee for individual permits will be returned after voiding the permit, with administrative and any other city costs deducted.

Any Applicant holding a valid permit may apply, in writing, for an extension of the completion date noted on the permit. The request shall be based on good cause that is acceptable to the City of Arvada. The City Engineer may extend the completion date for up to six (6) months without an additional fee, provided that circumstances beyond the control of the Applicant have prevented completion of the work. If substantial changes have been made to the project, or more than six (6) months have lapsed after the permit expiration date, the Applicant shall apply for a new permit. Permit fees will be assessed for the new permit application.

184.00 Permit Suspension or Revocation

Any permit issued under the provisions of these Standards and Specifications may be revoked or suspended per [Arvada Municipal Code](#) for: (1) Violation of any material condition of the permit or of any material provision of these Standards and Specifications; (2) Violation of any material provision of any other ordinance of the city or state law relating to the work; or (3) Existence of any condition or performance of any act that the city determines constitutes or causes a condition endangering life or damage to property.

185.00 Permit Fees

The permit fee shall be calculated from unit fee rates published on the annual Fee Schedule. Fees shall be calculated on a cumulative basis. The permit fee shall be paid in full before the permit is issued.

The fee for the installation of certain public utilities, i.e. underground electrical lines, gas lines, telephone cables, TV cables, etc., or construction of Arvada's Capital Improvement Projects, may be reduced or waived by the City Engineer.

186.00 Floodplain Permit Requirements

Floodplain work shall comply with FEMA, CWCB, MHFD and Arvada's floodplain regulations. Any proposed construction or other development work in the floodplain is required to have a Floodplain Development Permit per the [Arvada Municipal Code](#). Staging and disturbance in the floodplain is to be avoided when possible and minimized in all cases. Work requiring grading in the floodplain may require detailed floodplain analysis. In all cases the Floodplain Development Permit shall include the following:

1. Floodplain Permit Application form shall be completed with all project, floodplain information, and supporting documents required by local floodplain regulations and requested by the Floodplain Administrator.
2. Letter describing the work and expected floodplain impacts, signed and stamped by a Professional Engineer licensed in Colorado.
3. FEMA Flood Insurance Rate Map (FIRM) with site annotated.
4. Project plans with floodplain delineations and creek centerline clearly shown. Where floodplain delineation modifications are proposed, both the effective/regulatory, existing and proposed delineations shall be shown.
5. Aerials of the site showing the floodplain, parcel (Arvada's web page) and overall drainage basin (MHFD interactive map).
6. Appropriate fees will be determined by the City's Floodplain Administrator and are posted on the City of Arvada website.

Any development, obstruction or activity that will result in an encroachment in or modification to the Floodway shall be analyzed using floodplain modeling and technical analysis consistent with floodplain modeling guidelines established by the Floodplain Administrator. Floodway work shall only be permitted if certification is submitted and signed by a registered Professional Engineer accurately documenting that no increase in base flood elevations will result from the proposed development, obstruction or activity. After review of the analysis, a Conditional Letter of Map Revision (CLOMR) or Conditional Letter of Map Revision based on Fill (CLOMR-F) may be required as determined by the Floodplain Administrator.

No work or storage of materials is allowed in the floodplain without an approved Floodplain Development Permit.

Floodplain Development Permits shall not be closed out until all of the permit conditions have been met and final compliance documents have been received. Applicable compliance documents may include, but are not limited to:

- FEMA Elevation Certificate
- Post-Construction Floodproofing Certificate
- Fully approved and effective Letter of Map Revision (LOMR), Letter of Map Revision based on Fill (LOMR-F), or Letter of Map Amendment (LOMA)

These documents shall be submitted to the Floodplain Administrator and accepted before issuance of a Certificate of Occupancy or Temporary Certificate of Occupancy.

187.00 Inspections

All construction work for which a Right-Of-Way Permit or Site Disturbance Permit is required shall be subject to inspection by the Project Engineer or Arvada Inspector.

It shall be the responsibility of the person performing the work authorized by a permit, to notify the Inspector that such work is ready for inspection by scheduling an inspection online via the City's adopted permitting software. If a Site Disturbance Permit is issued, an initial inspection of erosion and sedimentation control measures must be scheduled, conducted, and approved by the City before the commencement of work.

It shall be the responsibility of the person requesting an inspection required by these Standards and Specifications to provide access to and means for proper inspection of all work. All work shall be inspected by the Project Engineer or Arvada Inspector. The Inspector has the authority to halt construction when, in his/her opinion, these Standards and Specifications and/or standard construction practices and/or terms of the permit are not being followed, or the work is otherwise defective. Whenever any portion of these Standards and Specifications are violated, the Contractor will be provided written notice listing deficiencies to be corrected and whether further construction must be stopped until all deficiencies are corrected.

The Project Engineer may make or require additional inspections of any work as deemed necessary to ascertain compliance with the provisions of these Standards and Specifications and other provisions of the Arvada Municipal Code. The Contractor shall be present, shall have approved plans and permits available on site, and shall ensure that the work is accessible and ready for inspection. The Contractor shall not request an inspection if the work is incomplete, not ready for inspection, or when previously identified corrections have not been made.

The procedure for final inspection and acceptance is specified in Section 200 – Acceptance Procedures of these Standards and Specifications.

190.00 Terms, Definitions, and Acronyms

191.00 Terms

Whenever, in these Standards and Specifications, the words "as ordered", "as directed", "as required", "as permitted", "as allowed", or words or phrases of like import are used, it shall be understood that the order, direction, requirement, permission, or allowance of Arvada is intended. Similarly, the words "approved", "reasonable", "suitable", "acceptable", "properly", "satisfactory", or words of like effect and import, unless otherwise specified herein, shall mean approved, reasonable, suitable, acceptable, proper, or satisfactory in the judgment of Arvada. Whenever, in these Standards and Specifications, the words "City Engineer" or "Director of Public Works" are used, it shall be understood that the Arvada employee named therein shall be whomever is designated by the City Manager or whomever may be the authorized designee of the City Engineer or the Director of Public Works.

192.00 Definitions

Whenever the following terms are used in these Standards and Specifications, they shall be defined as follows:

1. **Approved By Arvada** - Shall mean approved by the City Engineer or designee.
2. **Approved Products List** - that list maintained by City staff and available on arvada.org that provides make and model of items to be installed or used in construction.
3. **Applicant** - A citizen, developer, contractor, consultant engineer or representative thereof, who applies for a permit or variance.
4. **Architect** - the Licensed Professional Architect-of-Record whose seal is affixed to the design plans.
5. **Arvada, City of Arvada, the City** - The City of Arvada, a Colorado home rule municipal corporation.
6. **Bonds** - Performance, labor or material payment bonds, irrevocable letters of credit and other instruments of security furnished by the developer or Contractor and his/her surety in accordance with the Subdivision Agreements or other Agreements with Arvada.
7. **Calendar Day** - A mean solar day of twenty-four (24) hours, beginning at a mean midnight within a specified time zone and on a specific day of the year.
8. **Change Order** - A written order to the Contractor authorizing an addition, deletion or revision in the Work within the general scope of the Contract Documents, or authorizing an adjustment in the Contract Price or Contract Time.
9. **City Code** - The latest, officially adopted Arvada Municipal Code.
10. **City Engineer** - The City Engineer or an appointed designee.
11. **Claim** - A demand by either party to the Contract for something due or believed to be due from the other, attributed to the performance of the Work required by the Contract Documents which is open to challenge.
12. **Common Facilities** - Facilities serving or held in common title by the owners or occupants of two or more dwelling units or commercial or industrial enterprises and covered by these Standards and Specifications.
13. **Contractor** - An individual, partnership, corporation, company, or other legal entity who has executed the contract and in so doing is responsible to the Owner for the performance of the Work in accordance with the Contract Documents.
14. **Contract Documents** - The Contract in its entirety, which includes Advertisement for Bids, Information for Bidders, Special Conditions, Addenda, Bid Bond, Bid Proposal, Bid Schedule, Project Drawings, Notice of Award, Construction Contract, Performance and Payment Bond, Notice to Proceed, General Conditions, Change

Order, Method of Measurement and Payment, and the City of Arvada "Engineering Code of Standards and Specifications for the Design and Construction of Public Improvements."

15. **Cross connection** - An actual or potential connection between any part of a potable water system and an environment that would allow substances to enter the potable water system. Those substances could include gases, liquids, or solids, such as chemicals, water products, steam, water from other sources (potable or nonpotable), and any matter that may change the color or taste of water or add odor to water.
16. **Days** - Calendar days unless otherwise specified.
17. **Developer** - The person or persons legally responsible to Arvada for construction of improvements. For Capital Improvement Projects, Arvada is the Developer.
18. **Design Engineer** - the Licensed Professional Engineer-of-Record whose seal is affixed to the design plans.
19. **Director of Community and Economic Development**- Arvada's Community and Economic Development Director or his/her authorized designee.
20. **Director of Public Works** - Arvada's Director of Public Works or his/her authorized designee.
21. **Drawings** - The part of the Contract Documents which shows the characteristics and scope of the Work to be performed and which have been prepared or approved by the Engineer.
22. **Equipment** - All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and tools and apparatus necessary for the proper construction and acceptable completion of the work.
23. **Fire District** - Arvada Fire, Adams County Fire, or Coal Creek Fire.
24. **Inspector** - The authorized representative of the Project Engineer assigned to make detailed inspections of construction work with respect to compliance with these Standards and Specifications and the plans as approved by Arvada.
25. **Measurement and Payment** - A part of the Contract Documents briefly outlining the items of work, specified in the Bid Proposal, and the method to be used to determine the quantity to be paid for after installation and acceptance.
26. **Modifications** - A change in the requirements of the City of Arvada "Engineering Code of Standards and Specifications for the Design and Construction of Public Improvements" as specified in the Special Conditions or by Addendum to the Bid Documents; or a change to the Contract accomplished through Change Order, a Written Notice or a Field Order from the Engineer or Owner.
27. **Owner** - The City of Arvada, Colorado, a municipal corporation acting through its Mayor and City Council, for whom the Work is to be performed.

28. **Permit Coordinator** - a designated City administrative coordinator who assists with the coordination, facilitation, documentation, and controlling issuance of permits through the City's permitting system.
29. **Plans** - Profiles, cross sections, and drawings, and supplemental drawings, approved by Arvada, which show the locations, character, dimensions or details of the work.
30. **Project** - The total construction of the Work, designed by the Engineer, of which the Work performed under the Contract Documents may be the whole or a part.
31. **Project Engineer** - A City representative designated by the City Engineer to serve as the Project Manager.
32. **Public Improvements** - Those rights-of-way, easements, access rights, and physical improvements which, upon formal acceptance by the city, shall become the responsibility of the city for ownership and/or maintenance and repair, unless otherwise provided, and shall include, but not be limited, to the following: curb and gutter, asphalt pavement, concrete pavement, streets of all types, survey monuments, pavement striping, sidewalks, pedestrian/bike paths, traffic signals, street lights, highways, freeways, rights-of-way, easements, access rights, construction plans, medians, bridges, acceleration and deceleration lanes, culverts, storm drainage facilities including necessary structures, channels, water lines, sanitary sewer lines, and all other improvements, which upon acceptance by the city, are intended to be for the use of and enjoyment of the public. Private storm infrastructure is expressly excluded from this definition.
33. **PVC (Polyvinyl Chloride)** - A strong, tough plastic based on resins made by the polymerization of vinyl chloride or copolymerization of vinyl chloride with minor amounts (not over 50%) of other unsaturated compounds, which are fashioned into sheets, tubing, pipe, conduit, containers, insulation, etc.
34. **Representative (Authorized)** - assigned City or consultant personnel that have been given the authority by the City Project Engineer to administer the **Contract Documents** and enforce these Standards and Specifications.
35. **Rights-of-Way** - Any public street, way, place, alley, sidewalk, easement, park, square, plaza, and city-owned right-of-way dedicated to public use.
36. **Request for Information (RFI)** - submitted to the City by the Design Engineer when a change occurs on a project after construction plans have been approved.
37. **Shop Drawings** - All drawings, diagrams, illustrations, brochures, schedules and other data which are prepared by the Contractor, a Subcontractor, manufacturer, supplier or distributor, which illustrate how specific portions of the Work shall be fabricated or installed.
38. **Special Conditions** - Special directions, provisions or requirements specific to the project and not otherwise detailed or set forth in the specifications.

39. **Standards and Specifications** - The body of directions, provisions, and requirements contained herein, describing the method or manner of construction and the qualities and quantities of the materials and work to be furnished.
40. **Subcontractor** - An individual, partnership or corporation having a direct contract with the Contractor or with any other Subcontractor for the performance of a part of the Work at the site covered by these Standards and Specifications.
41. **Substantial Completion** - That date, as determined by the City Engineer, when the construction project or a specified part thereof is sufficiently completed, in accordance with these Standards and Specifications, so that the project or a specified part can be utilized for the purposes for which it is intended.
42. **Subsurface Utility Engineering** - through Colorado legislation, a requirement or method whereby the location of underground utilities are investigated, researched, explored, and designated at differing levels, A-D, depending on the level of documentation and investigation that has been administered, to depict the horizontal and/or vertical location of utilities through the level and type of investigation applied.
43. **Supplier** - An individual, firm or corporation having a direct contract with a developer or Contractor or with any subcontractor for the manufacture or furnishing of any part of the supplies and/or materials to be used at or incorporated in, work at the site.
44. **City Traffic Engineer** - City Traffic Engineer or appointed designee
45. **Work** - The furnishing of all labor, material, equipment and incidentals necessary to produce the construction required by the Contract Documents, and all materials and equipment incorporated or to be incorporated in the project.
46. **Working Day** - Any day, exclusive of Saturdays, Sundays, and Holidays, on which weather and other conditions not under the control of the Contractor will permit construction operations to proceed, for a major part of the daylight hours, with the normal working force.
47. **Written Notice** - Any notice to any party of the Contract relative to any part of the Contract in writing and considered delivered and the service thereof completed, when posted by certified or registered mail to the said party at his last given address, or delivered in person to said party or his authorized representative on the Work.

193.00 Acronyms

AASHTO - American Association of State Highway and Transportation Officials.

ACI - American Concrete Institute

ACOE - Army Corps of Engineers

AISC - American Institute of Steel Construction

ANSI - American National Standards Institute

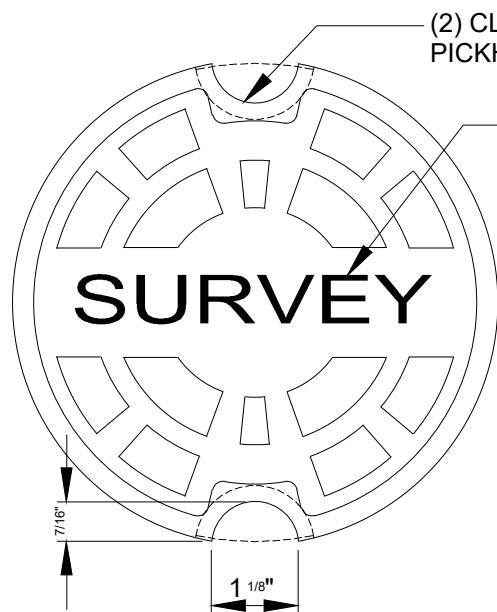
APWA - American Public Works Association

ASA - American Standards Association
ASCE - American Society of Civil Engineers
ASTM - American Society for Testing and Materials
AWG - American Wire Gauge
AWWA - American Water Works Association
BPR - Bureau of Public Roads
CDOT - Colorado Department of Transportation
CDPHE - Colorado Department of Public Health and Environment
CWCB - Colorado Water Conservation Board
CLOMR - Conditional Letter of Map Revision
CLOMR-F - Conditional Letter of Map Revision based on Fill
FCC - Federal Communications Commission
FEMA - Federal Emergency Management Agency
gpcd - Gallons per capita per day
gpm - Gallons per minute
GPS - Global positioning system
GRC - Galvanized rigid conduit.
IBC - International Building Code
IMSA - International Municipal Signal Association
IPC – International Plumbing Code
IPCEA - Insulated Power Cable Engineers Association
ITE - Institute of Transportation Engineers
KBG - Kentucky Blue Grass
LED - Light Emitting Diode
LOMR - Letter of Map Revision
LOMR-F - Letter of Map Revision based on Fill
LOMA - Letter of Map Amendment
MGPEC - Metropolitan Government Pavement Engineers Council
MHFD - Mile High Flood District (also known as Urban Drainage Flood Control District)
MUTCD - Manual of Uniform Traffic Control Devices
NEC - National Electrical Code as approved by the American Standards Assoc.
NEMA - National Electrical Manufacturers Association
NFPA - National Fire Protection Association
NPDES - National Pollutant Discharge Elimination System
MGD - Million gallons per day.
PROWAG - Public Right-of Way Accessibility Guidelines developed by the US Access Board
psi - Pounds per square inch
SUE - Subsurface Utility Engineering
UL - Underwriters Laboratories, Inc.

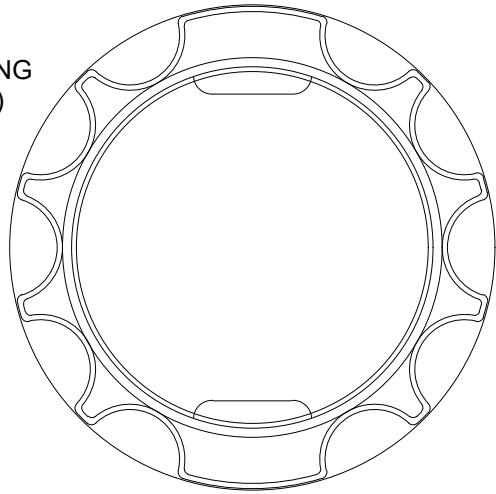
USACE - United States Army Corps of Engineers

USDA - United States Department of Agriculture

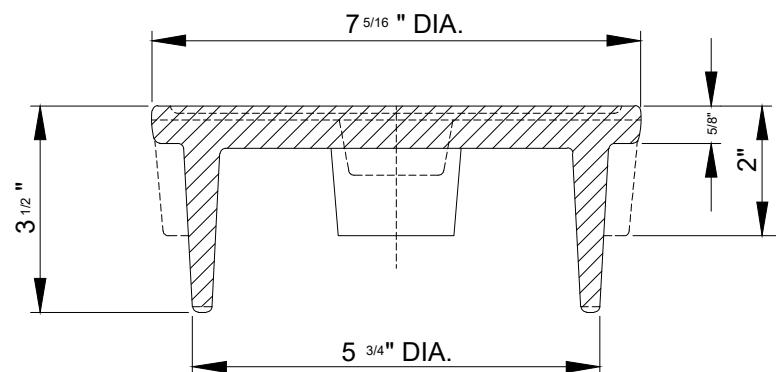
UTC - Uniform Traffic Control



PLAN VIEW



BOTTOM VIEW



SECTION VIEW

NOTE:
LID SHALL BE CAST IRON
OR DUCTILE IRON ONLY.

NO	DATE	REVISION



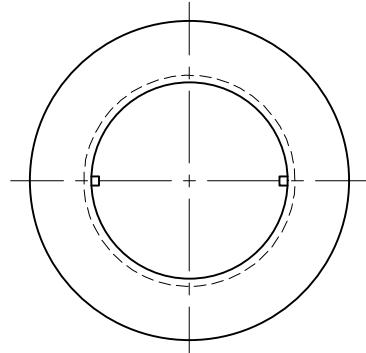
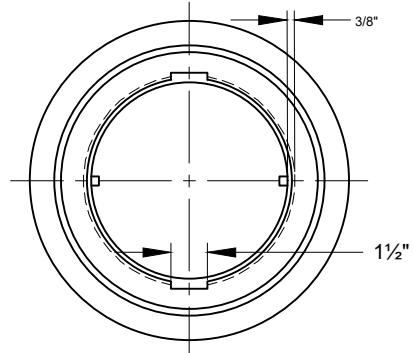
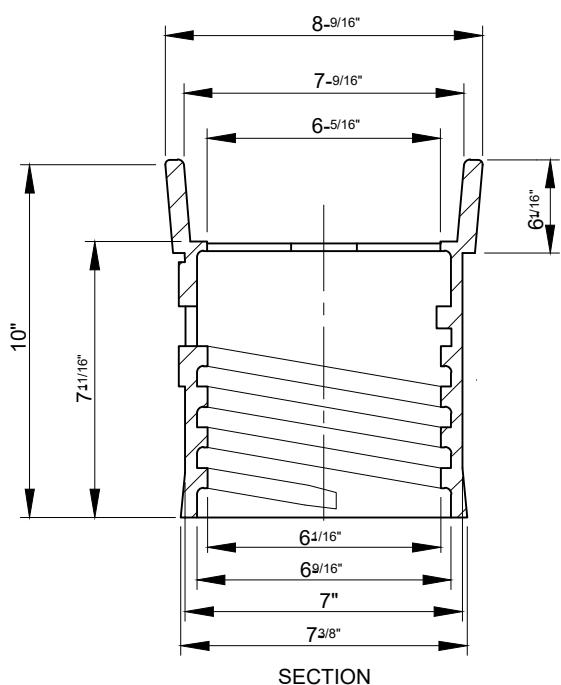
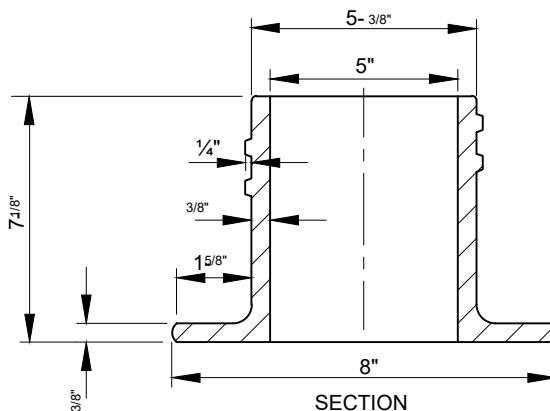
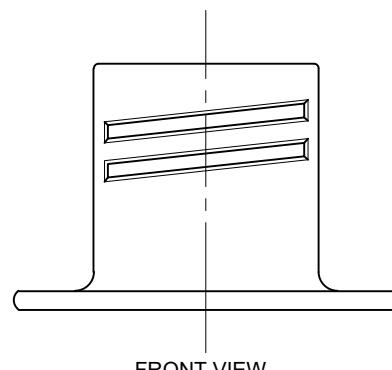
CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

**SURVEY RANGE BOX
LID DETAIL**

2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTE:

RANGE BOX SHALL
BE CAST IRON OR
DUCTILE IRON ONLY

BOTTOM END VIEWTOP END VIEWSECTIONSECTIONFRONT VIEWADJUSTABLE SURVEY RANGE BOX

NO	DATE	REVISION



CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

ADJUSTABLE SURVEY RANGE BOX

2022 ENGINEERING STANDARDS & SPECIFICATIONS

SECTION 200 – ACCEPTANCE PROCEDURES

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SECTION 200 – ACCEPTANCE PROCEDURES

201.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

210.00 Scope

The City of Arvada shall issue two types of acceptances for public improvements: (1) Initial Warranty Acceptance, which begins the warranty period and (2) Final Acceptance, which ends the warranty period.

Private improvements, such as those owned and maintained by a Homeowners Association, Metro District, or property management group, shall be constructed in compliance with approved plans and to comply with all applicable City of Arvada Standards and Specifications. Private improvements may be inspected by but shall not be accepted by the City of Arvada.

220.00 Initial Warranty Acceptance

Initial Warranty Acceptance is issued by the City Engineer and will establish a Warranty Commencement Date in writing to begin the two (2) warranty period.

221.00 Initial Warranty Acceptance Process & Inspections

Upon completion of the construction of public improvements associated with utilities, roadways, landscaping and/or irrigation, etc., the Municipal Inspector will notify the Permit Coordinator that the project is ready for initial warranty inspections. The Permit Coordinator will notify all applicable City Divisions/Departments to inspect the project for initial warranty.

Please note that a complete (all pages), draft set of the drawings (Contractor's redline as-built set) shall be submitted to the City of Arvada pursuant to the requirements outlined in this Section. In addition, the following documents are required:

1. Any applicable test reports need to have been submitted and approved; the reports will require a stamped, signed and dated cover sheet by the civil engineer stating that they have reviewed all test reports and confirm that they meet the City of Arvada Engineering Code of Standards and Specifications.

- a. Site Compaction testing reports on all trenches and/or public improvements
 - b. Sub-Grade testing reports on all trenches and/or sub-grade for public improvements
 - c. Asphalt density testing reports for all public improvements
 - d. Concrete (compressive strength) testing reports for all public improvements
2. The detention pond certification letter and spreadsheet, along with any other related documentation have been submitted and approved. If there is an underground detention pond, please submit an installation conformance letter & spreadsheet of drain times. The letter shall be stamped, signed and dated by the civil engineer.
 3. A Final Sworn Affidavit of Certified Construction Cost (for Development Projects).
 4. Any other items or Special Provisions required by a Development Agreement or as directed by the Project Engineer.

Additional documents may be required at the discretion of the Project Engineer or for CIP projects based on the contract documents. For example, non-destructive deflection testing that complies with Section 936.00 - Pavement Acceptance Testing of these Standards and Specifications may be required prior to inspection for Initial Warranty for roadways.

The Developer/Contractor will be notified in writing of all outstanding punch list items needed to be completed. For most projects, punch lists can be provided within twenty-one (21) days. The contractor will have thirty (30) days to complete the punch list items. Upon completion of the punch list items, the Developer/Contractor will notify the Permit Coordinator and Municipal Inspector in order to arrange reinspection of the project.

Within ten (10) calendar days of receipt of this punch list, the Developer/Contractor shall begin making corrections. All deficiencies shall be corrected by the Developer/Contractor within thirty (30) calendar days of receipt of the punch list. If all punch list items are not corrected within thirty (30) calendar days, Arvada has the right to draw funds from the performance guarantee on file to self-perform corrections.

A request for an extension is required to be made in writing to the Permit Coordinator to process and to be approved by the City Engineer or their designee before the thirty (30) day period has expired. Such requests for extension shall include why the extension is being requested and an estimated timeframe for completion. Arvada will review such requests and respond within seven (7) days. After the Developer has corrected the deficiencies, the Inspector will perform a

follow-up Initial Warranty Inspection. When the public improvements have been approved and accepted by all applicable City Divisions/Departments, the City of Arvada will issue an Initial Warranty Commencement letter to the Developer/Contractor within fourteen (14) days.

Private stormwater conveyance and water quality may also be inspected. Prior to the Initial Warranty inspection from the City of Arvada, all temporary structures (excluding erosion control measures), debris, mud and waste materials shall be removed unless required by the Site Disturbance Permit.

All variances from the approved construction plans shall be supported by documentation including written approval of the Project Engineer. All related testing certifications and other supporting documentation shall be submitted to the Permit Coordinator to process for review and approval by the Project Engineer. All required certifications shall contain the signature and seal of a Colorado Registered Professional Engineer.

The above time schedule may be extended only under special circumstances and with the written approval of the City Engineer.

222.00 Record Drawings

The Record Drawings shall represent the “as-built” condition of all site improvements, and shall be based upon the addenda, change orders and other data furnished. Record Drawings shall be a complete set of plans including all originally approved Construction Plan sheets. Every sheet of the Record Drawings shall be attested to and sealed by either a Colorado Registered Professional Engineer, Colorado Registered Landscape Architect (for landscape drawings only), and/or Registered Professional Land Surveyor, and every sheet shall be stamped “Record Drawing”.

The following information shall be included in the Record Drawings:

1. All approved plan revisions that have occurred since the City Engineer approved the plans.
2. For Roadways:
 - a. Elevation check at a maximum of one-hundred fifty (150) foot intervals in each flow line along the street, at each elevation breakpoint, at the PCR of each radius, at the center and ends of each crossspan and at each grade break.
 - b. Elevation at the flow line on each side of storm inlets.
 - c. Elevations at all design points shown on the cul-de-sac plans.
 - d. All locations of pavement markings.
 - e. Location of all patched areas.
 - f. Street lighting line diagram.

- g. Inspection reports, structural calculations and a list of finishes (colors, etc.) for all structures (culverts, underpasses, bridges, etc.)
- 3. Traffic Signal Rebuild or Intersection Rebuild
 - a. Signal Warrant Analysis
 - b. Vehicle Path Analysis
 - c. Curb Ramp Detail Drawings
 - d. Signal Connectivity
 - 1. Lateral Connection to Fiber Backbone
 - 2. Fiber Splice Diagram
 - e. Intersection Grading
 - f. Sub
- 4. For Sanitary Sewer and Storm Sewer:
 - a. Any changes from the approved plans in materials or pipe sizes.
 - b. Elevation of all in and out inverts at maintenance holes, inlets, and outlets. Distance between maintenance holes, and between maintenance holes and inlets or outlets.
 - c. Location of all sanitary sewer service connections.
 - d. Rim elevations on all maintenance holes and drainage inlet structures, and number of rings added during paving operations.
 - e. Elevation checks every one-hundred (100) feet in the flow line of all drainage channels.
- 5. Detention Ponds and Water Quality Improvements:
 - a. Professional Engineer certification of the final detention pond volume and the final release rate per drainage criteria.
 - b. Professional Engineer certification that all water quality features (Permanent Control Measures) were installed per the approved design documents. For underground detention and water quality control measures, the certification shall include photos detailing the installation per approved plans.
 - c. Operations and Maintenance Manual for the Detention Pond and Water Quality Improvements
 - d. Any changes from the approved plans.
- 6. For Water Mains:
 - a. Any changes from the approved plans in materials or pipe sizes.
 - b. Horizontal verification of water valves, tees, crosses, and fire hydrants if changed from the approved plans.
 - c. Location(s) and type of restraint installed.
 - d. Location of all water service connections.
- 7. For Public Landscaping and Irrigation Improvements:

- a. List of all plant material installed, including size and quantities (as certified by a Colorado Registered Landscape Architect).
- b. Horizontal verification of all structures. Show pertinent physical features such as sidewalks, bike paths, fences, ponds, buildings, parking lots and athletic fields.
- c. Horizontal verification of all irrigation pipes, irrigation heads, valve boxes, wiring, electrical boxes, controllers, meters and backflow protection devices. Noted information shall include all pipe sizes, zone numbers, valve locations, head types, valve types and model numbers and controller types and model numbers.

An unlocked AutoCAD digital copy of the updated As-Built construction plans provided in Project Control, with referenced points matching exactly with the approved Record Drawings, is also required for Initial Warranty Acceptance. Said Project Control shall be tied to the Colorado State Plane coordinate system, the vertical control, and state the combined scale factor as detailed in Section 172.00 - GIS Data Conformance of these Standards and Specifications. It shall also include instructions to convert from one system to the other. Arvada will not provide horizontal control.

223.00 Memorandum of Initial Warranty Acceptance

The City of Arvada shall issue an Initial Warranty Commencement letter upon acceptance of the public improvements into the warranty period. The two (2) year warranty period shall begin on the date of issue of the Memorandum of Construction Acceptance.

Upon issuance of the Initial Warranty Commencement letter, maintenance of the new public improvements and facilities shall become the responsibility of the City, as outlined in Section 224.00 of these Standards and Specifications below. If a repair and/or replacement is time-sensitive for continuation of service or to protect public health, the City shall have the right to perform the work and bill the Developer/Contractor. Determining if the repair and/or replacement is time-sensitive or needed for public health shall be at the sole discretion of the City. Maintenance of privately owned stormwater drainage systems, detention ponds, and water quality improvements shall remain the responsibility of the property owner or party as designated on the approved plat or Site Plan.

During the two (2) year warranty period, the City may issue the Developer/Contractor written notice requesting warranty repairs and/or replacements. The Developer/Contractor shall begin and complete repairs and/or replacements within the time period specified on the written notice. If the required repairs and/or replacements are not adequately completed within the time

specified in the written notice, the City of Arvada may make the repairs and/or replacements and draw upon the Developer's warranty performance guarantee for Development Projects or Contractors Performance Bond for City Projects.

224.00 Duration of Warranty Period for Public Improvements and Facilities

The warranty period for public improvements and facilities shall be two years with additional requirements shown in Section 233.00 - Final Acceptance/Release from Warranty by the Project Engineer of these Standards and Specifications. Note that an additional manufacturer's warranty may be required for specific equipment per equipment specifications.

225.00 Development Project Warranty Performance Guarantee

Upon issuance of the Memorandum of Initial Warranty Acceptance, the City may release a portion of the performance guarantee, provided that the balance of the performance guarantee is sufficient to fund incomplete improvements and possible warranty replacements and repairs. A minimum of twenty (20) percent of the certified public improvements costs shall be held by the City throughout the warranty period, unless otherwise stated in the Development Agreement or as required by the Project Engineer.

226.00 Contractors Performance and Payment Bond

The Performance and Payment Bond shall remain in full force and effect through the two (2) year guarantee and warranty period on City projects.

227.00 Initial Warranty Maintenance Responsibilities

227.01 Utility Maintenance

City of Arvada's Utility maintenance during the warranty period is generally limited to flushing & fire hydrant maintenance. Utility preservation operations (including, but not limited to, leak repair and replacement of faulty fittings) during the warranty period are considered repair operations and are the responsibility of the Developer or Contractor. Before the issuance of Final Acceptance / Release from Warranty, those preservation operations will be checked and if needed, done at that time.

227.02 Roadway Maintenance

City of Arvada's Public Works Streets/Roadway maintenance during the warranty period is generally limited to street sweeping and snow plowing. Pavement preservation operations including crack sealing, patching, or asphalt surface sealing during the warranty period are

considered repair operations and are the responsibility of the Developer and/or Contractor. Tree lawns are the responsibility of the property owner. Before the issuance of Final Acceptance/ Release from Warranty, those preservation operations will be checked and if needed, done at that time before final surface treatment (slurry seal, cape seal or overlay) is completed.

227.03 Parks Maintenance

City of Arvada's Parks Irrigation and Landscaping maintenance during the warranty period is generally limited to mowing, watering, trash removal, and snow plowing of park sidewalks and structures. Irrigation and landscaping preservation operations including irrigation system blow out at winter shut down, spring turn on, and the replacement of dead plant material & trees are considered repair operations and are the responsibility of the Developer and or Contractor. Before the issuance of Final Acceptance/ Release from Warranty, those preservation operations will be checked and if needed, done at that time.

227.04 Landscape and Irrigation Maintenance

City of Arvada's Parks Irrigation and Landscaping maintenance during the warranty period is generally limited to mowing, watering, trash removal, and snow plowing of park sidewalks and structures. Irrigation and landscaping preservation operations including irrigation system blow out at winter shut down, spring turn on, and the replacement of dead plant material & trees are considered repair operations and are the responsibility of the Developer and or Contractor. Before the issuance of Final Acceptance / Release from Warranty, those preservation operations will be checked and if needed, done at that time.

227.05 Stormwater Water Quality Maintenance

The City does not conduct maintenance on water quality structures during the warranty period. Landscaping preservation operations including installation of temporary irrigation and the replacement of dead plant material and trees are considered repair operations and are the responsibility of the Developer and or Contractor. Before the issuance of Final Acceptance / Release from Warranty, those preservation operations will be checked and if needed, done at that time.

230.00 Final Acceptance

The warranty period does not expire until all warranty repairs and replacements have been made and approved by Arvada.

231.00 Final Acceptance/Release from Warranty Inspection

Three (3) months before the end of the warranty period, the Permit Coordinator will send a final acceptance inspection request to all applicable City Divisions/Departments to inspect the project for final acceptance by the City of Arvada. At least sixty (60) days prior to the expiration of the warranty period, the Developer/Contractor will be notified in writing of punch list items needed to be completed and will have thirty (30) days to complete the punch list items. Follow-up inspections may reveal additional items to be corrected within the warranty period. Upon completion of the punch list items, the Developer/Contractor will notify the Permit Coordinator and Municipal Inspector in order to arrange reinspection of the project.

Within ten (10) calendar days of receipt of this punch list, the Developer/Contractor shall begin making corrections. All deficiencies shall be corrected by the Developer/Contractor within thirty (30) calendar days of receipt of the punch list. If all punch list items are not corrected within thirty (30) calendar days, Arvada has the right to draw funds from the performance guarantee on file to self-perform corrections.

A request for an extension is required to be made in writing to the Permit Coordinator to process and to be approved by the City Engineer before the thirty (30) day period has expired. Such requests for extension shall include why the extension is being requested and an estimated timeframe for completion. Arvada will review such requests and respond within seven (7) days.

After the Developer has corrected the deficiencies, the Inspector will perform a follow-up Final Acceptance Inspection. For most projects, inspections can be completed within fourteen (14) days. When the public improvements have been approved and accepted by all applicable City Divisions/Departments, the City of Arvada will issue a Final Acceptance letter to the Developer/Contractor within fourteen (14) days.

The above mentioned time schedules may be extended only under special circumstances and with the written approval of the City Engineer.

Please note that further restrictions and final acceptances process are in place for roadways as noted under Section 232 below.

232.00 Final Acceptance/Release from Warranty Work for New Roadways

At the end of the two-year (2) warranty period, newly constructed roadways shall have a minimum Remaining Service Life (RSL) of twenty (20) minus the warranty period in years (typically an RSL 18). Final Acceptance/Release from Warranty work for roadways includes pavement testing of areas of visual distress, repairs and/or replacements to concrete and asphalt, and the final asphalt surface treatment if required by the Project Engineer. The final asphalt surface treatment will depend on the condition/RSL of the roadway at the end of the warranty period. The necessary surface treatment, as determined by the Project Engineer, may range from nothing to edge milling and a two (2) inch asphalt overlay, depending on the Remaining Service Life (RSL) of the roadway.

After all concrete and asphalt repairs have been made and re-inspected, the asphalt surface treatment shall be installed, and the Developer shall request a follow-up Final Acceptance/Release from Warranty inspection. The Developer shall begin and complete the Final Acceptance/Release from Warranty work within ninety (90) days. The time period may be extended during cold weather months or under special circumstances and with the written approval of the Project Engineer. If the Developer does not begin and complete all Final Acceptance/Release from Warranty work within this time period, Arvada may make the repairs and/or replacements and draw upon the Developer's warranty performance guarantee to cover all associated costs.

232.01 Final Acceptance/Release from Warranty of Roadways in Developments with Less Than 80% Certificates of Occupancy

At the end of the two-year (2) warranty period, if less than eighty percent (80%) of the number of homes or commercial buildings along a roadway within the Development have been issued a Certificate of Occupancy, the Developer shall pay Arvada the cost to mill and overlay the roadway. The Project Engineer will prepare a cost estimate that the Developer shall pay Arvada prior to release from warranty or Arvada shall draw upon the performance guarantee. The Developer shall still be responsible for repair of all areas with visual pavement distress on the roadway as directed by the Project Engineer and any additional punch list items. At that time, the developer shall be released from Warranty obligations, and it shall become the responsibility of Arvada to complete the milling and final overlay at the appropriate future time.

233.00 Final Acceptance/Release from Warranty

After the public improvements have passed the Final Acceptance/Release from Warranty inspection or the City of Arvada has drawn upon the escrow and completed the public improvements, the Permit Coordinator shall prepare a Memorandum of Final Acceptance/Release from Warranty to be signed by the City Engineer. For most projects this can be completed within fourteen (14) days. Final Acceptance shall be issued, the warranty period shall expire, and the Permit Coordinator will release the balance of the Warranty Performance Guarantee.

SECTION 300 – SOILS AND EARTHWORK

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SECTION 300 – SOILS AND EARTHWORK

301.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

310.00 Scope

Site work shall consist of demolition, removal, and abandonment; clearing and grubbing; overlot grading; removal of topsoil; site preparation; installation and maintenance of erosion and sedimentation control measures; embankment subgrade preparation; embankment fill; excavation, trenching, bedding and backfill of pipelines and service lines; excess excavation; structure backfill; roadway excavation, backfill and compaction; borrow; dredging; and restoration and cleanup. All site work and earthwork shall comply with the requirements of these Standards and Specifications and any special criteria established by Arvada. Site work shall be completed as shown on the approved engineering plans. All workmanship and materials shall be in accordance with the requirements of these Standards and Specifications and shall conform to the lines, grades, quantities, and the typical cross-sections shown on the approved plans, or as directed by the Project Engineer.

320.00 Inspections, Observations and Testing

Materials testing shall be performed by a qualified Geotechnical engineer working under the direction of a Colorado Registered Professional Engineer and shall be paid for by the developer on private projects. Testing will be performed and/or paid for by the City on City projects unless otherwise noted in the Special Conditions for the project. All testing and retesting to meet requirements and specifications shall be at the Contractor's expense.

The Contractor shall provide access for all Arvada employees or delegates throughout the earthwork process for observation and testing purposes. The developer shall provide for full-time observation of all embankment fill, over-excavation and re-compaction, and backfill placement by the certified materials testing agency. The Contractor shall not proceed with work until the certified materials Testing Agency is on site for observation and testing, unless approved by the Project Engineer.

321.00 Qualifications for Testing Agencies

Testing Agencies working in the City of Arvada shall certify annually to the Arvada Engineering Department that they comply, as appropriate, with the requirements of:

1. American Society for Testing and Materials (ASTM), Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation, Designation C1077-06
2. American Society for Testing and Materials (ASTM), Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction, Designation D3740-01
3. American Society for Testing and Materials (ASTM), Standard Practice for Certification of Personnel Engaged in the Testing of Soil and Rock, Designation D5255-01
4. American Society for Testing and Materials (ASTM), Standard Specification for Agencies Engaged in Construction Inspection, Testing, and Special Inspection, Designation E329 - 11b

The Testing Agencies' submittal shall include, at a minimum, the inspection certificate of the Testing Agency, within the last two (2) years, by a third party such as the American Association for Laboratory Accreditation, the National Voluntary Laboratory Accreditation Program or the Cement and Concrete Reference Laboratory, as appropriate; and a copy of the Testing Agencies Quality Assurance Program.

The person responsible for and is in direct supervision of all the Quality Control testing shall be a Registered Professional Engineer in the State of Colorado and practicing in the field.

Technician conducting inspections, taking samples and performing tests must possess one or more of the following qualifications:

1. Technicians conducting soil and material testing inspection, compaction testing, or collecting samples for laboratory testing must have a WAQTC or CDOT/LabCAT Certificate and Level II or higher NICET certificate in each area.
2. Technicians conducting pavement inspections, taking asphalt samples, conducting asphalt content tests, conducting gradation tests or asphalt compaction tests and determining asphalt volumetric and strength characteristics must have the following certifications from LabCAT or equivalent.
3. Certification A - Laydown
4. Certification B - Plant Materials Control
5. Certification C - Volumetrics & Stability

6. Certification E - Aggregates
7. Certification I - Asphalt Inspector
8. Technicians taking concrete samples and conducting field tests must have a Field certification from ACI or equivalent.
9. Technicians conducting test of Portland Cement Concrete for compressive strength shall be an ACI Level I or equivalent certified technician
10. Technicians conducting tests of Portland Cement Concrete for flexural strength and determine mixture design characteristics shall be an ACI Level I or equivalent.

322.00 Minimum Testing Requirements

All materials and operations shall be tested in accordance with these Specifications and as directed by the Project Engineer. Agencies testing soil and rock shall meet the requirements of ASTM D 3740. 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 all projects. If any materials furnished or the work performed by the Contractor fails to meet the Specifications, such deficiencies shall be reported to the Engineering Inspector immediately. Preliminary written field reports and/or test results shall be given to the Engineering Inspector immediately after they are performed. Final reports shall be forwarded to the Engineering Inspector no later than one week following the testing.

Results of all tests, including failing tests, shall be reported. When the work fails to pass tests or meet Specifications, additional tests shall be taken as directed by the Project Engineer. All testing and retesting services shall be at the expense of the Contractor or Developer except for City projects where the cost of testing will be covered by the City unless otherwise noted in the Special Conditions for a City project. Testing agency personnel are not authorized to stop work or to alter, relax or release any requirements of these Specifications, or to approve, accept or reject any portion of the work.

Reports shall bear the signature of a Professional Engineer registered in the State of Colorado and competent in the required testing practice. All test reports must show the location of the test and include all information specified in the AASHTO or ASTM test procedure used. All test reports shall be attached to a written declaration letter signed by a Professional Engineer on behalf of the private engineering or geotechnical firm stating that the test results and frequency were in general compliance with the plans and specifications.

The use of a testing agency's services does not relieve the Contractor of the responsibility to furnish the required materials and to perform the required construction in full compliance with

the Specifications. Passing test results do not constitute acceptance of the work or materials represented by the test. The Contractor is solely responsible for quality control of the work.

All subgrade test results including trench compaction, subgrade preparation and stabilization etc. on private developer projects and on City projects must be submitted to the City for approval prior to placement of any asphalt or surface concrete.

Minimum Materials Testing Frequencies

Materials	AASHTO	ASTM	Minimum Frequency of Tests
Fill/Backfill			
Gradation	T27 & T11	C136	One Test per Soil Type
Atterberg Limits	T89 & T90	D4318	One Test per Soil Type
Liquid Limit, Plastic Limit & Plasticity Index of Soils (Atterberg Limits)	T89 / T90	D4318	One per Source
Moisture-Density Curve	T99 / T180	D698 / D1557	One Test per Soil Type
Moisture-Density Relations of Soils (Proctor)	T99 / T180	CP23	One Test per Soil Type
In Place Density - Nuclear	T238 / T239	D2922 / D3017	Embankment (Non-Roadway) – One Test per every 1,000 Cubic Yards for Open Space and Park Areas, otherwise, One Test per every 200 Cubic Yards (Minimum of 1 Test per Lift and 3 Tests per day)
In Place Density - Nuclear	T238 / T239	D2922 / D3017	Roadway/Subgrade (Including Sidewalk and Curb & Gutter) - One Test per every 200 Lane Feet per 8" Layer, Minimum of 3 Test per Day
In Place Density - Nuclear	T238 / T239	D2922 / D3017	Utility Trenches - One Test per 250 Lineal Feet per 6" Vertical Lift - Test Points Staggered so as not to Align on Top of the Test Below. Minimum of 3 Tests per Day. Minimum 1 Test per 6" Vertical Lift per Service Line.

In Place Density - Nuclear	T238 / T239	D2922 / D3017	Vertical Structures - maintenance holes, Inlets, Fire Hydrants & Valve Boxes - 1 Test per 6" Vertical Lift - Test Points Staggered so as not to Align on Top of the Test Below - Test Taken 1' from Structure
Proof Rolling			All Subgrade and Base Courses
Aggregate Base Course			
Gradation	T27 & T11	C136	One Test per Every 500 Tons or Fraction Thereof
Atterberg Limits	T89 & T90	D4318	One Test per Every 500 Tons or Fraction Thereof
Moisture-Density Curve	T180	D1557	One Test per Class
In Place Density	T238 & T239	N/A	One Test per Every 200 Lane Feet per 6" Lift
Thickness	N/A	N/A	One Test per Every 200 Lane Feet per 6" Lift
Proof Rolling	N/A	N/A	Final Lift - Within 24 Hours of Paving

330.00 Demolition, Removal and Abandonment

The Contractor will be held responsible to ensure the protection of all existing public improvements such as fire hydrants, street lights, traffic lights, parking meters, traffic signs, catch basins, maintenance holes, valves, survey monuments, overhead utility lines and poles, and any existing underground sprinkler or utility lines which may be damaged during the execution of the City contract or developer project. It will be the Contractor's responsibility to replace all public improvements so damaged at their own expense. Existing manhole rings and covers, valve boxes and sprinkler heads found defective shall be replaced, as directed by the City Inspector.

The Contractor shall take proper precautions for the protection of and replacement or restoration of driveway culverts, street intersection culverts or aprons, storm drains or inlets, fences, irrigation ditches crossings and diversion boxes, mail boxes, shrubbery, flowers, ornamental trees, driveway approaches and all other public or private installations that may be encountered

during the performance of work. They shall provide each property with access at all times during construction. Existing driveways shall be cut, filled and graded as required or as directed by the City Inspector to provide permanent access. Existing driveways shall be resurfaced with the then existing type of surfacing whenever surfaces are destroyed.

Before starting demolition of any structure, the Contractor shall obtain a demolition permit and appropriate Right-of-Way permits for the disconnection of all utility service connections; such as water, sewer, cable TV, telephone, gas and electrical power connected thereto. Disconnects shall be made in accordance with the regulations of the utility that controls the supply of service involved.

Underground services are to be cut, capped and marked at the main to facilitate future location of the line. Caps of underground storm and sanitary sewer shall consist of a plug being placed in the line and the opening then sealed with concrete. Markings at the end of the line shall consist of a 4 x 4 wooden stake or metal fence post driven into the ground and then tagged to note the type of facility.

The City Inspector will coordinate with Arvada staff to ensure a representative will be on site to observe and approve the Contractor's disconnect of the water and sewer services at the main line. It shall also be the responsibility of the Contractor to backfill all holes to finished grade and install concrete or asphalt surfacing when the holes excavated are in streets or paved areas. The Contractor shall correct any unsatisfactory disconnects.

Prior to the start of demolition or construction, any public survey monument or range box that may be disturbed during construction shall be referenced to a minimum of two (2) points outside the limits of construction by a Colorado Professional Land Surveyor. Any public survey monument or range box disturbed as a result of construction shall be replaced by a Colorado Professional Land Surveyor in accordance with the current Colorado Revised Statutes.

The Contractor shall remove—wholly or in part—and satisfactorily dispose of all foundations, signs, structures, fences, old pavements, abandoned pipelines, traffic control device materials and any other obstructions which are not designated on the approved plans or allowed to remain. Utilities and other items for which other provisions have been made for removal shall follow demolition; removal and abandonment procedures shown on the approved plans or as otherwise approved by Arvada. Removal of sign panels shall include all work necessary to remove the panel and attachment hardware from the existing installation. Concrete sign post bases shall be removed. Pedestals and bases shall be removed to one (1) foot minimum below the surrounding ground or subgrade, and backfilled with suitable material.

Dust suppression is required for all demolition that may create nuisance conditions. Control measures should be implemented to limit discharge into any inlet, ditch, swale, or waterway.

Where portions of structures shall be removed, the remaining parts shall be prepared to accommodate new construction. The work shall be performed in such a manner that materials left in place shall be protected from damage. All damage to portions of structures to remain shall be repaired at the Contractor's expense. Reinforcing steel that projects from a structure to remain shall be cleaned and aligned to provide an adequate bond with new construction. Dowels shall be securely grouted with an approved grout. Depressions which result from removal of structures, footings, and other obstructions, shall be filled and compacted with clean structural fill materials or an approved controlled low-strength material (CLSM) or "flowable fill" or "flash fill") mixture so as to eliminate hazards such as cave-in or accumulation and ponding of water.

Materials used for traffic detour structures supplied by the Contractor shall be the property of the Contractor. After the detour is abandoned, the Contractor shall completely remove the traffic detour structure materials and disposal of materials shall comply with Section 371.00 - Restoration and Cleanup of these Standards and Specifications.

After all demolition, removal and abandonment work is complete, the Contractor shall grade the entire contract area by properly filling, compacting, and leveling the site to existing adjacent grades or to lines and grades shown on the approved plans.

Should demolition disturb 10,000 sf or more, a Site Disturbance Permit and State Stormwater Associated with Construction Activities Permits are required prior to work commencing. Adequate control measures must be in place to reduce offsite impacts prior to the commencement of work.

331.00 Bridges, Culverts and Other Drainage Structures

Bridges, culverts, and other drainage structures in use by traffic shall not be removed until a Traffic Control Plan has been approved by the Traffic Engineer. Refer to Section 149 - Traffic Control, Barricades and Warning Signs of these Standards and Specifications.

Unless otherwise directed, the foundations or substructures of existing structures shall be removed down to one (1) foot below natural ground surface or bottom of drainageway. Where such portions of existing structures lie wholly or in part within the limits of a new structure, they shall be removed as necessary to accommodate construction of the proposed structure. Steel, concrete, and wood bridges shall be dismantled. Steel members to be salvaged shall be match-marked by the City or the Contractor with waterproof paint.

Any work within waterways must have an applicable Army Corps of Engineers Permit (see Section 180.00) and a Floodplain Permit (see Section 187.00) of these Standards and Specifications.

332.00 Pipe and Appurtenances

All pipe and appurtenances to be taken out of service shall be completely removed or abandoned in place as specified below.

1. Water Service – In accordance with Section 425.03.
2. Fire Service (mainline tee or swivel tee) – The valve on the tee shall be removed and the tee shall be capped or plugged as needed. Pipe greater than eight (8) inch diameter shall be either removed or abandoned in place by filling with CLSM. Pipe less than eight (8) inch diameter may be left in place but shall be capped or plugged at each end.
3. Main Lines - In accordance with Section 532.07 for sanitary sewer main and in accordance with Section 420.03.01 for water main.
4. Sanitary Sewer Service – In accordance with Section 532.07

Existing pipe cannot be removed and reused.

Excavation required to remove pipe or appurtenances shall be backfilled and compacted in accordance with Section 364.00 - Trenching, Backfilling and Compacting of these Standards and Specifications.

When removing appurtenances such as maintenance holes, catch basins, inlets etc., any live lines connected to these appurtenances shall be properly bypassed and shall remain in operation until abandonment is complete.

When appurtenances are to be abandoned in place, the remaining structure shall be lowered to a minimum of three (3) feet below finished grade, and shall be filled with concrete with a minimum compressive strength of three-thousand (3000) psi (at 28 days) to the top of the remaining structure and then backfilled and compacted to the required grades.

333.00 Pavement and Concrete Flatwork

All concrete or asphalt to remain shall have a straight, true break line and a vertical face. Concrete or asphalt may be cut with a cutting wheel or saw. The Inspector may require that saw-cutting be performed. All concrete removal shall be to the nearest joint. Any damage to adjacent concrete or asphalt to remain in place shall be repaired at the Contractor's expense. The minimum depth of saw cuts for repair in concrete shall be equal to one-third ($\frac{1}{3}$) the slab depth.

If areas cut for future placement of concrete or asphalt adjacent to existing asphalt or concrete are left exposed for longer than thirty (30) days or are subjected to inclement weather, the areas shall be evaluated by a Geotechnical Engineer and a recommendation shall be provided to Arvada. An additional cut of at least six (6) inches behind and/or below the existing structure—or until competent subgrade is encountered—may be required by the Project Engineer.

The Contractor shall be responsible for the cost of removal and replacement of all overbreak as determined by the Project Engineer. Concrete washout must be controlled and contained within the site and properly disposed of at the end of the project.

334.00 Cesspools, Privies, Buried Fuel and Septic Tanks

Potentially contaminated sites or project areas must conform to Section 74-160 of the Arvada Municipal Code.

Tanks that may exist on project sites shall be completely removed and contaminated soils remediated in accordance with all local and state standards. The void created shall be filled by the Contractor to finished grade.

Underground motor fuel storage tanks shall be excavated and removed under the direction and in the presence of a representative from the Arvada Fire Protection District. The Contractor shall notify the fire district twenty-four (24) hours in advance of the time he proposes to start excavation in the vicinity of the tanks.

335.00 Wells

On-site wells and well casings shall be sealed to prevent contamination of groundwater aquifers in accordance with Section 5; Abandonment Regulations, State Board of Examiners, Rules and Regulations and Water Well and Pump Installation Contractors Law, State of Colorado Division of Water Resources. All abandonment activities shall be approved by the utility that services the location, and the State Engineer. There may be instances where the well will not be plugged, but merely capped with a steel, lockable cover plate.

336.00 Buildings

A DEMO permit is required prior to any building demolition. The demolition of buildings shall include the removal from the site of all roofs, walls, chimneys, basement walls, supporting walls,

footings, footing post, caissons, basement floors; including all pipes, conduits and similar appurtenances lying therein or beneath for a depth of two (2) feet below grade.

337.00 Walls

Retaining walls and their footing shall be removed in their entirety from the site.

338.00 Disposal

No material or debris shall be disposed of or buried within the project limits without the written permission of the Project Engineer. The Contractor shall make all necessary arrangements for obtaining suitable disposal locations. If disposal shall be at other than established dumpsites, the Project Engineer may require the Contractor to furnish written permission from the property owner on whose property the materials and debris are proposed to be placed. Burning shall not be allowed without prior written approval of the Project Engineer, the Jefferson County Health and Human Services Department and the fire district.

339.00 Salvage

All salvageable material shown on the approved plans and any additional salvageable material marked by the City shall be removed without unnecessary damage in sections or pieces which may be readily transported and shall be stored by the Contractor in locations approved by the Project Engineer. The Contractor shall be required to replace any materials lost from improper storage methods or damaged by negligence. These materials include, but shall not be limited to, manhole frames and covers; inlet grates; valves and fire hydrants; landscape plant materials; fence materials; handrails; culverts; guardrail; walkway; roadway and traffic appurtenances (traffic signals and attached hardware, including mast arms and span wire) and irrigation systems and appurtenances.

340.00 Site Preparation

The Contractor shall complete all work necessary to properly prepare the site as shown on the approved plans and as specified herein. The site shall be prepared in such a manner that facilitates subsequent soils or earthwork operations. Site preparation includes clearing and grubbing, which includes but is not limited to, grading, tree and shrub removal, native grass stripping and removing and disposing of all debris within the limits of the project and other such areas as may be indicated on the plans or required by the work, grading and over-excavation. Site preparation procedures shall be performed to comply with the approved Geotechnical Report and/or plans or as designated by the City. All areas to receive fill should be inspected and tested before placement of fill. Adjacent vegetation and other items to remain shall be adequately

preserved from injury. Erosion and sedimentation control measures shall be installed and maintained as necessary to prevent off site migration of sediment.

341.00 Clearing and Grubbing

All sites to receive fill shall be cleared of organic materials, including root structures, at the Contractor's expense. Vegetation shall be pulled or grubbed in such a manner as to assure complete and permanent removal. Branches of trees extending over the roadbed shall be trimmed to give a clear height of thirteen feet and six inches (13'- 6") above the roadbed surface. All surface objects and trees, stumps, roots and other protruding obstructions not designated to remain shall be cleared and/or grubbed as required by the Project Engineer. Non-biodegradable, solid objects located at least two (2) feet below the final subgrade surface may remain at the discretion of the Project Engineer.

Arvada may establish clearing lines and designate items and materials to remain. The Contractor shall preserve all materials and items to remain. Trees scheduled to remain shall be carefully protected from damage during performance of the work. Any damage due to the Contractor's operations shall be repaired by suitable tree surgery methods. Damaged trees shall be replaced, as approved by the City at the Contractor's expense. Paint used for cut or scarred surfaces of trees or shrubs to remain shall be an approved asphalt base paint formulated especially for tree surgery.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted in accordance with these Standards and Specifications.

The Contractor shall scalp areas where excavation or embankment shall be made. Scalping shall include the removal of organic material such as brush, roots, sod, grass, residue of agricultural crops, sawdust, and vegetable matter from the surface of the ground.

Clearing shall be performed with due consideration and protection of the general public and public and private property. Any damage to streets, parking lots, utilities, plants, trees, buildings or structures on public or private property, or to benchmarks and construction staking due to the negligence of the Contractor, shall be repaired and restored to its original condition at the Contractor's expense. Areas proposed to be preserved shall be clearly staked or fenced off by the Contractor. It shall be the Contractor's responsibility to ensure that these areas are not damaged during the construction process. Any damaged areas shall be repaired or replaced at the Contractor's expense.

342.00 Staking and Grade Control

Control and construction stakes shall be set by field parties under the supervision of a Colorado Registered Professional Engineer or a Colorado Registered Land Surveyor who shall be paid by the Contractor. These field parties shall be available to check field control and to provide assistance to the Contractor. A set of approved plans shall be kept on the job site at all times by the Contractor.

It shall be the responsibility of the Contractor to maintain the alignment and grade shown on the approved plans. The alignment and grade elevation of forms shall be checked, and any necessary corrections shall be made before placing the concrete. When any form has been disturbed or any subgrade thereunder has become unstable, the subgrade shall be reconditioned or replaced in accordance with these Standards and Specifications.

350.00 Erosion Control

351.00 General

Erosion and sedimentation are natural processes, the intensity of which is increased by land disturbing activities. Erosion and sedimentation can reduce or destroy the aesthetic and practical values of neighboring properties, streams and lakes. The purpose of these erosion control criteria is to prevent pollution of state waters without placing undue burdens on the landowner, builder or community.

The primary goal of erosion control is to reduce and/or prevent movement of eroded soil sediments offsite to promote the safety, health, and general welfare of the public. Selection of the proper erosion control measures must consider the magnitude and type of erosion specific to the site, as well as the resources available for implementation. To address proper erosion control measures, a site Erosion and Sedimentation Control Plan shall be designed and implemented for every site that requires a Site Development Permit to be in regulatory compliance.

The Contractor shall comply with all federal and state environmental laws. Contractor shall make every effort to relocate wildlife prior to grading. All wetlands shall be protected by silt fencing, construction fencing, and other required control measures during grading operations and until disturbed areas are fully re-vegetated. Waterway buffers shall remain to the maximum extent practicable. Stormwater runoff waters should be directed around the construction activity to the maximum extent practicable.

352.00 Requirements

No person shall clear or grade land without implementing soil erosion and sediment controls in accordance with the requirements of these Standards and Specifications, and Arvada Municipal Code. Any grading, stripping, excavating, filling or otherwise disturbing of land within the city limits shall comply with these Standards and Specifications and Arvada Municipal Code Chapter 50.

Erosion control measures shall be designed, installed, and maintained in conformance with the MHFD Manual (Volume 3).

353.00 Submittal

A Site Disturbance Permit is required for all projects that result in land disturbance equal to or greater than 10,000 sq. ft.. The following documents shall be submitted for review and approval with the permit application:

1. Grading Plan
2. Erosion and Sedimentation Control Plans - see Section 180.00 for plan details
3. Erosion and Sedimentation Control Details
4. Truck Hauling Route
5. Traffic Control Plans
6. FEMA-Approved CLOMR or CLOMR-F (if applicable)
7. For all sites that result in land disturbance equal to or greater than one (1) acre, or part of a common plan of development or sale:
 - a. Stormwater Management Plan (SWMP)
 - b. CDPS General Permit for Stormwater Discharges Associated with Construction Activity

354.00 Erosion Control Measures

Detailed erosion control measures shall be provided to protect the following:

1. Inlets, gutters, and culverts
2. Drainageways
3. Streams or other water bodies immediately adjacent to land disturbed by construction activity
4. Cut and fill areas
5. Properties and improved streets adjacent to construction activity
6. Areas achieving final stabilization through vegetative cover
7. Other areas as required by the Project Engineer

Temporary sediment and erosion control measures including, but not limited to sediment traps, vehicle tracking controls, and silt fence shall be properly placed in accordance with the Site Disturbance Permit prior to any earthmoving on the site. Sediment and erosion control measures shall be kept in good repair and fully functional until final stabilization is achieved and approved. Temporary stabilization must be implemented for earth disturbing activities on any portion of the site where ground disturbing construction activity has permanently ceased, or temporarily ceased for more than fourteen (14) calendar days.

Permanent stabilization (sod, seed, mulching, etc.) shall be in place as soon as final grading is achieved and construction activity has ceased in accordance with the requirements in Sections 1020.00 and 1030.00 of these Standards and Specifications and Arvada Municipal Code Chapter 50.

355.00 Erosion Control Details

Refer to the MHFD Manual (Volume 3, Chapter 7) for erosion control details and installation.

356.00 Grading and Over Excavation

Grading shall be defined as earthwork between zero (0.00) feet and one (1.00) foot below existing site grade. Over-Excavation shall be defined as earthwork below one (1) foot to a depth to be determined by the Geotechnical engineering design.

356.01 Grading Methods and Requirements

Grading of filled and unfilled areas shall be to the lines and grades indicated on the approved plans. Grading shall be performed in conjunction with all necessary clearing, grubbing, stripping, filling, and compacting operations. Areas adjacent to structures and other areas inaccessible to heavy grading equipment shall be graded by approved manual methods.

The Contractor shall comply with all dustproofing requirements of Section 147 - Dustproofing of these Standards and Specifications for the duration of the project.

Final grading shall be performed to provide proper drainage for the overall site and away from site improvements that may be sensitive to moisture infiltration. In no case shall drainage from the project site be altered or controlled in a manner that may result in damage, or the potential for damage, to adjacent property or to any portion of the work from erosion or flooding.

356.02 Over Excavation / Cut and Fill Requirements

All areas with slopes greater than 4:1 shall be benched or modified by an approved method prior to receiving fill. Benching shall be performed in accordance with Section 361.01 - Preparation of Embankment Subgrade of these Standards and Specifications.

All fill shall be placed in a controlled state—tested for moisture and density- in accordance with these Standards and Specifications unless otherwise approved by the Project Engineer. Fill materials shall not be placed, stockpiled or stored in an area that is not designated on the plans or approved by the Project Engineer.

356.03 Vegetation Establishment

All areas disturbed during grading operations shall have the final graded area hydro seeded or re-vegetated with native grasses in accordance with the requirements of Section 1020.00 and 1030.00 of these Standards and Specifications.

360.00 Earthwork

Earthwork shall consist of grading, excavation, embankment, disposal, shaping and compaction of all material encountered within the limits of the project, including but not limited to excavation of ditches and channels, surface boulders, muck, rock, concrete foundations, slabs, stripping, etc. Excavation shall be performed to the line and grade and typical cross-sections shown on the approved plans or as required by the Project Engineer.

Excavation, dewatering, sheeting, and bracing shall be performed so as to eliminate any possibility of undermining or disturbing the foundation of any existing structures, utilities, pavement, and concrete flatwork.

Free-running water shall be drained from all earthwork materials prior to construction of structures, utilities, or concrete flatwork construction. Drained water shall be free from pollutants, including sediment, to the maximum extent possible. Under no circumstances shall groundwater be discharged into the storm sewer system, irrigation ditch or waterway without a Groundwater Dewatering Permit issued by the Colorado Department of Public Health and Environment.

The Project Engineer may require the Contractor to submit a proposed earth-moving diagram and map of proposed haul routes for approval.

360.01 Definitions

1. Unclassified Excavation - Any and all earthen materials encountered, including rocks and boulders, during construction. Rock formations that can be removed by ripping with a D-9 tractor in good repair with a single hydraulic ripper are considered as unclassified excavations.
2. Embankment Construction - Earthwork including preparation of the subgrade upon which embankment material shall be placed; dikes within or outside right-of-way; placement and compaction of approved material within areas where unsuitable materials have been removed; and placement and compaction of embankment materials in holes, pits and other depressions to lines and grades shown on the approved plans. Only suitable materials approved by the project Geotechnical engineer shall be used in construction of embankments and backfills
3. Suitable Material/Backfill - earthen material that consists of non-organic sands, gravels, clays, silts, and mixtures thereof. Rock with a maximum size of six (6) inches is allowable for embankment. Rock with a maximum size of three (3) inches is allowable for trench backfill. Claystone fragments exceeding three (3) inches in particle size are not to be incorporated in embankment material unless specifically approved by the project Geotechnical engineer and the Project Engineer. Bedrock that breaks down to specific soil types and sizes during excavation, hauling and placement may be considered as suitable material if they are excavated and moisture conditioned and aged for a period of time to achieve a uniform, homogeneous material.
4. Unsuitable Material - Any earthen material that contains vegetable or organic silt, topsoil, any soils with organic contents exceeding two percent (2%) by weight, wet and oversaturated soils, frozen materials, trees, stumps, certain man-made deposits, or industrial waste, sludge or landfill, lignite, or other undesirable materials.
5. Structure Excavation - Excavation of any and all materials over an area extending three (3) feet out from the outermost bottom edge of a proposed structure, up to existing grade or top of proposed grade (whichever comes first) at a 1:1 slope.
6. Structure Backfill - Earthen material that is installed around and over any structure shown on the approved plans. Imported structure backfill (Class I) shall meet the general gradation of "Class 1 Structure Backfill Material" as specified in Section 703.08 of the CDOT Standard Specifications for Road and Bridge Construction, Controlled Low-Strength Material (CLSM) "flowable fill", --OR-- "flash fill" shall confirm with MGPEC Section 19.
7. Rock Excavation - Rock excavation shall consist of igneous, metamorphic, and sedimentary rock which cannot be excavated without blasting or with the use of rippers and all boulders or other detached stones each having a volume of one cubic

yards or more, as determined by physical or visual measurements. Unless specified in the Contract, rock excavation is material that meets one of the following field test criteria to be conducted by the Contractor:

- a. Ripping Test: Material that cannot be broken down by one pass with a single tooth ripper mounted on a crawler type tractor in low gear with a minimum net flywheel power rating of two-hundred thirty-five (235) horsepower; or material that cannot be broken down with a 48,000 pound tracked excavator using a bucket with rock teeth.
- b. Seismic Test: Material that has a seismic velocity of 6,000 feet per second or greater. The Contractor shall submit the qualifications of the individual performing or interpreting the seismic testing to the Engineer a minimum of fourteen (14) days prior to testing. The ripping test will be used to resolve differences if seismic velocities fall below 6,000 feet per second.
- c. Handling Test: Any boulder or detached stone having a volume of one (1) cubic yard or more that cannot be readily broken down with the excavation equipment described above in one (1).
8. Controlled Low-Strength Material (CLSM) or Flowable Backfill - A self-leveling low strength concrete material composed of cement, fly ash, aggregates, water, chemical admixtures and/or cellular foam for air-entrainment as described in MGPEC Section 19.
9. Borrow - Backfill or embankment material which shall be acquired from designated borrow areas to make up the deficient areas which cannot be completed from excavation within work limits. All sources of borrowed material shall be approved prior to use by the project Geotechnical engineer and the Project Engineer.
10. Proof-Rolling - The application of test loads over a subgrade surface by means of a heavy pneumatic-tired vehicle to locate weak areas in subgrade. Refer to Section 370.03 - Proof-Roll Observation and Testing of these Standards and Specifications.
11. Bedding Material - Material that is installed under and around pipelines, rip-rap, low flow channels, and any other locations required by the Project Engineer. The thickness and gradation of bedding materials shall comply with Section 367.00 - Bedding for Pipelines and Service Lines of these Standards and Specifications.
12. Stabilization Material - Material which shall be placed in over-excavation areas, areas with unsuitable in situ material, or areas with a high water table in order to stabilize the existing material. Thickness of stabilization material shall be determined and installed in the field, on a case by case basis. Gradation of stabilization material shall be determined on a case by case basis and shall be approved by the project Geotechnical engineer.

360.02 Grading Tolerances

All earthwork shall be performed in such a manner that final grades after excavation, compaction of backfill, placement of rip-rap, installation of landscaping, construction of channel lining, etc. shall conform to the cross-sections shown on the approved plans. The final earthwork shall comply with the design elevations, with the following allowable tolerances:

1. 0.3 feet within the main drainage channel bottom limits.
2. 0.25 feet in cross section and 0.25 feet in sixteen (16) feet measured longitudinally on cut or fill slopes.
3. 0.5 feet in all portions of the site not included in items A. or B. above.
4. In addition to the above tolerances, positive surface drainage shall be provided on the entire site so that no depressions or ponds are formed, regardless of depth.

It shall be the Contractor's responsibility to ensure that all portions of the site drain as shown on the approved plans.

360.03 Borrow

It shall be the Contractor's responsibility to stockpile suitable materials for use in the project. Only after the Contractor estimates that sufficient suitable backfill material is stockpiled to complete all earthwork operations of the project, shall excavated material be removed from the project site.

If the Contractor fails to preserve onsite, sufficient suitable material, and removes or disposes of suitable material, suitable material shall be recovered at the Contractor's expense.

If there is an insufficient quantity of suitable material available onsite, the Contractor shall provide additional suitable material, as defined in Section 360.01 - Definitions of these Standards and Specifications.

361.00 Embankment Construction

Embankment construction shall include placement, processing, and compaction of all embankment material, and all related work required to ensure proper bond of materials with previously placed embankment material. All embankment construction should be conducted in accordance with specifications and procedures provided and under the direct supervision of the project Geotechnical engineer.

361.01 Preparation of Embankment Subgrade

No excavation shall be performed in any area until the proposed work has been staked by the Contractor, cross-sections of existing ground are determined and plotted, and all survey elevations and cross-sections shown on the approved plans are reviewed and approved by the Project Engineer. Excavation shall be performed to the lines and grades shown on the approved plans. Prior to placement of subgrade, utilities shall be installed, utility service lines shall be stubbed to the edge of the ROW, and all trenches shall be backfilled and properly compacted.

Fill shall be placed on competent subgrade as determined by the project Geotechnical engineer. The Contractor shall excavate soft, yielding, over-saturated, or otherwise unsuitable soils prior to the placement of fill.

The grade shall be maintained so that the surface is well drained at all times. When necessary, temporary drain systems shall be installed to intercept or divert surface water that may affect the work.

Where an embankment shall be constructed, unsuitable material shall be removed from the surface. The cleared surface shall be plowed or scarified to a minimum depth of six (6) inches. The embankment area shall adhere to the density and moisture content requirements shown in the following table unless otherwise approved by the project Geotechnical Engineer and the Project Engineer.

Embankment Subgrade

Soil Classification AASHTO M145	Relative Compaction By <u>Standard Proctor</u> AASHTO T99 with CP 23 (ASTM D698) (percent compaction)	Relative Compaction By <u>Modified</u> Proctor AASHTO T180 with CP 23 (ASTM D1557) (percent compaction)	Moisture Content Range (with respect to Optimum Moisture Content)
A-1 through A-5	-	95	-2 to +2 (based on AASHTO T180)
A-6 and A-7	95	-	0 to +2 (based on AASHTO T99)

Where embankments shall be placed on slopes steeper than 4:1 (horizontal to vertical), benches shall be excavated into the slope by a method approved by the project Geotechnical Engineer and the Project Engineer. Such slopes include existing and previously constructed embankments. The benches shall be cut ten (10) feet horizontally into the existing slope to create a stepped bench condition, and the vertical step shall not exceed four (4) feet unless otherwise approved by the project Geotechnical Engineer and the Project Engineer. All surfaces to receive embankment material shall be inspected and approved by the project Geotechnical Engineer immediately prior to embankment material placement.

361.02 Embankment Material Placement

No embankment material shall be placed until approved in writing by the Geotechnical Engineer.

Earthmoving equipment, watering equipment, processing equipment, and compaction equipment are the responsibility of the Contractor. Equipment shall be suitable for performing excavation and embankment work in accordance with these Standards and Specifications and the Contract schedule.

After subgrade is properly prepared, the embankment filling operation shall begin in the deepest section of the area to be filled. Embankment material shall be placed and compacted in parallel layers until the finished rough grade is reached. Temporary gaps through the embankment shall not be allowed without approval of the Project Engineer. All temporary and permanent slopes shall not be steeper than 4:1 (horizontal:vertical).

The thickness of each layer shall not exceed (before compacting) eight (8) inches or less in loose thickness when heavy, self-propelled compaction equipment is used and six (6) inches or less in loose thickness when and-guided equipment (i.e. jumping jack, plate compactor) is used.

Embankment material shall be a homogenous mixture of Suitable Material as defined in Section 360.01 - Definitions of these Standards and Specifications. The full depth of each layer shall be processed to ensure a satisfactory bonding surface for the next layer of embankment material. If more than 24 hours have lapsed between the time of compaction testing and placement of the next layer of roadway embankment, the area shall be retested.

In order to achieve uniform moisture content throughout the materials in the layer, wetting or drying of the material and manipulation shall be performed. Placement of material shall not proceed until excessively wet material has been dried and overly dry material has been wetted with methods approved by the project Geotechnical Engineer. Each layer of embankment shall

be properly processed by disking or by other approved methods so that the water is distributed uniformly throughout the layer prior to rolling and after compaction. In no case shall additional embankment material be placed until the underlying layer has been properly processed in accordance with these Standards and Specifications. Materials placed that do not comply with moisture and/or density specifications are subject to removal and replacement and/or reprocessing at the Contractor's expense.

The surfaces of previously placed embankment material that have not had material placed on them for a period of time and judged to be unsuitable by the Project Engineer or Geotechnical Engineer shall be re-processed to comply with the moisture and density requirements, prior to placement of additional material.

Proof rolling shall be performed after specified compaction has been obtained for the final lift of roadway embankment/subgrade. Areas found to be weak, areas with vertical deflection of more than $\frac{1}{2}$ inch, areas exhibiting "pumping conditions", and those areas which fail a proof roll as indicated by the Inspector shall be ripped, scarified, wetted or dried if necessary, and re-compacted to the requirements for density and moisture.

Rock and Bedrock Material In Common Embankment: Excavated material that contains solid rock consisting of cobbles, boulders or rock fragments ("rock material") less than one cubic yard in volume; a maximum thickness of one and one-half ($1\frac{1}{2}$) feet; and a maximum dimension of six (6) feet that cannot be processed by crushing, breaking or pulverizing, may be placed in embankments below ten (10) feet from the rough subgrade elevation with approval from the project Geotechnical Engineer and the Project Engineer. In no case shall claystone fragments larger than three (3) inches in any dimension be incorporated into the embankment layers. Rock material does not include the claystone bedrock formations common throughout Arvada. If placed, rock material shall be incorporated in layers no thicker than the thickness of the largest pieces. The rock material shall be carefully dispersed throughout the layers and throughout the embankment to avoid nesting. Rock fragments shall be spaced far enough apart to allow the Contractor's equipment to operate between the rock pieces. All voids shall be filled with fines material to obtain the required uniform density around the rock fragments.

Embankment areas that contain rock material shall be compacted with adequate equipment and sufficient passes to ensure that the embankments meet all specified moisture and density requirements for common embankment before the next lift is placed.

362.00 Excavation

All excavated areas shall be graded in a manner that allows adequate drainage and does not disturb material outside the limits of slopes. Excavated areas shall be within the tolerances noted in Section 360.02 - Grading Tolerances of these Standards and Specifications. When practical, all suitable material removed from the excavation shall be used in the formation of embankments, for backfilling, and for other purposes. Materials that are considered unsuitable material (including rock) or surplus by the Project Engineer will be disposed of at the Contractor's expense, in accordance with Section 338.00 - Disposal.

All groundwater pumped or drained from the work shall be disposed of according to provisions of the CDPHE low risk discharge guidance policy and CDPHE Construction Dewatering Discharge permit in a manner satisfactory to the Project Engineer, without undue interference with other work or damage to pavements, other surfaces, or property.

362.01 Excavated Material

Excavated material shall be placed so as to minimize the inconvenience to occupants traveling on streets and driveways or adjoining properties. As much as possible, excavated materials should be placed uphill of the excavation. Excavated material shall not be deposited on private property unless written consent of the property owner(s) has been filed with the Project Engineer. Erosion control measures shall be placed to protect the storm sewer system and adjacent waterways.

Suitable excavated material shall be used as backfill, fill for embankments, or other parts of the work in accordance with the appropriate sections of these Standards and Specifications.

Disposal of surplus material shall be in accordance with Section 338.00 - Disposal of these Standards and Specifications.

362.02 Excess Excavation

If in the opinion of the project Geotechnical Engineer or the Project Engineer, the material at or below the depth to which excavation for structures would normally be carried is unsuitable for the required installation, it shall be removed to such widths and depths as directed by the project Geotechnical Engineer or the Project Engineer and shall be replaced to provide a stable, non-yielding surface that is approved by the project Geotechnical Engineer and the Project Engineer.

It is the sole responsibility of the Contractor to become familiar with the existing conditions and potential excess excavation at each project site. Geotechnical reports or other data provided by Arvada may be used to assist in determining general site and soil characteristics.

If, through failure or neglect of the Contractor to conduct the excavation work in a proper manner, the surface of the subgrade is in an unsuitable condition for proceeding with construction, the unstable material shall be removed and replaced with recycled concrete, structure backfill, or other approved material at the Contractor's expense. The condition of the subgrade shall be approved by the project Geotechnical Engineer and the Project Engineer before any additional materials are placed.

363.00 Over Excavation and Re-compaction for Buildings

All over-excavation and re-compaction operations for buildings shall be done in accordance with the construction and testing procedures provided in the Final Geotechnical Report. Excavation shall extend at least twenty (20) feet outside the proposed building on all sides or as indicated in the Final Geotechnical Report to protect structure and concrete flatwork.

364.00 Trenching, Backfilling, and Compacting

This work shall consist of furnishing all labor, materials, tools and equipment for trenching, bedding, backfill, and compaction for all underground utilities located under roadways, within right-of-ways, and City owned property, as specified herein and shown on the approved plans. The excavation shall be made to lines and grades shown on the approved plans, and as established by the Project Engineer. Except where shown otherwise on the approved plans and except where the Project Engineer gives written permission to do otherwise, all trench excavation shall be made by open-cut to the depth required to construct the pipelines as shown on the approved plans. All excavation shall be 'unclassified', as defined in Section 360.01 - Definitions. All trenching shall be performed in accordance with all Occupational Safety and Health Administration (OSHA) requirements. These regulations are described in Subpart P, Part 1926 of the Code of Federal Regulations.

Excavated material can be reused as backfill provided all organic material is removed unless more stringent requirements are provided in the geotechnical report, if provided. For trenches beneath pavements and flatwork, backfill from a minimum of 1 foot below grade to grade shall consist of material meeting the requirements for AASHTO class A-1 or A-2 material. All excavated material which meets the requirements for backfill materials shall be stockpiled in a manner which shall not contaminate the excavated material, and shall be located a sufficient

distance from the trench to avoid overloading, to avoid obstructing sidewalks, driveways, or streets, and to provide the least possible interference with traffic.

364.01 Special Conditions

1. Subsurface Investigation - Prior to the connection of any planned utility line to an existing line, the Contractor shall expose the existing utility at the points of connection in order to verify the elevations and materials of construction. The Project Engineer will be notified a minimum of two (2) working days before such an investigation is performed. The Contractor shall also expose utilities as they cross each other to allow for verification of elevation and materials of construction.
2. Underground Wire, Cable, Fiber Optic, or Similar Lines - Where underground wire, cable, fiber optic or similar lines are encountered, they shall be relocated as directed by the utility owner and in accordance with their specifications. The Contractor shall coordinate this work with all other phases of construction to avoid further conflicts.
3. Gas and Electric Lines - Where underground gas and electric lines are encountered, they shall be relocated as directed by the gas and electric service provider and in accordance with their specifications. The Contractor shall coordinate this work with all other phases of construction to avoid further conflicts.

364.02 Removal of Water

The Contractor shall provide and maintain adequate equipment to properly remove and dispose of all surface or groundwater that enters the trench. Water shall be disposed of without damage to adjacent property and without being a nuisance to public health and convenience. The trench shall be dry at all times during pipe installation. The use of any sanitary sewer to dispose of trench water shall not be allowed. A Colorado Discharge Permit System (CDPS) Construction Dewatering Permit shall be required prior to construction dewatering activities should groundwater be discharged to the City storm or to waters of the State. Dewatering shall be accomplished by well points, sumping or any other method approved by the Project Engineer.

365.00 Trench Excavation for Roadways

When excavating in concrete or asphalt areas, the limits of the trench shall be string lined and the surface cut in a vertical plane. If the vertical edges of a trench in a roadway ravel during construction, they shall be trued to a vertical plane to a point twelve (12) inches outside the limits of excavation prior to milling and placing the resurfacing material, in accordance with the Detail Drawings of these Standards and Specifications

Surface materials such as concrete and asphalt shall be disposed of independently of the underlying soil. Unsuitable materials shall be disposed of by the Contractor in accordance with Section 338.00 - Disposal of these Standards and Specifications.

366.00 Trench Excavation for Pipelines and Service Lines

The width of the trench shall comply with the requirements set forth in these Standards and Specifications and shall be sufficient to allow pipe to be installed and backfill placed and compacted as shown in the Detail Drawings found in these Standards and Specifications. For RCP pipe that is bedded to springline, the space between the pipe and trench wall must be wider than the compaction equipment used in the pipe zone. Minimum trench widths for RCP installations shall be the pipe outside diameter plus sixteen (16) inches as shown in the Detail Drawings found in these Standards and Specifications.

366.01 Preparation of Foundation for Pipe Laying

When the excavation is in firm earth, care shall be taken to avoid excavation below the established grade plus the required specified overdepth to accommodate the pipe bedding material.

In case soft or otherwise unsuitable foundation material is encountered in the bottom of the trench, the project Geotechnical Engineer, Project Inspector, and/or the Project Engineer may require removal and replacement with stabilization material to provide a suitable foundation for the pipe. If the trench bottom is wet, the project Geotechnical Engineer shall determine whether it is stable. The bottom of sumps utilized for dewatering shall be two (2) inches minimum below the bottom of the trench excavation to prevent the upward flow of water into the excavation, which may result in unstable bottom conditions.

367.00 Bedding for Pipelines and Service Lines

All pipe shall be installed with sufficient bedding material to provide a minimum of six (6) inches of separation between the subsoil and the barrel of the pipe. The bedding material shall be tamped under the haunches for the full length of the pipe barrel to ensure support for the entire length of pipe. The pipe barrel shall be uniformly supported along the entire length of the pipe.

Bedding material for all PVC, HDPE, CPP, PP and DIP (“flexible pipe”) shall be material that complies with the gradation of “Fine Aggregate” as specified in Section 703.01 of the CDOT Standard Specifications for Road and Bridge Construction, well-graded sand or squeegee sand which complies with the following:

Well Graded Sand

Sieve size	Total Percent Passing by Weight
3/8 INCH	100
No. 4	70 - 100
No. 8	36 - 93
No. 16	20 - 80
No. 30	8 - 65
No. 50	2 - 30
No. 100	1 - 10
No. 200	0 - 3

Squeegee Sand

Sieve size	Total Percent Passing by Weight
3/8 inch	100
No. 200	0-5

Bedding material for all RCP shall consist of materials that meet the gradation of "No. 67 Coarse Aggregate" as specified in Section 703.00 of the CDOT Standard Specifications for Road and Bridge Construction unless otherwise recommended by the Geotechnical Engineer and approved by the City Engineer.

Bedding material shall be placed to a depth of twelve (12) inches above the barrel section of all flexible pipes. RCP shall be bedded to springline at a minimum. Bedding material shall be worked under pipe to provide uniform haunch support. Pipe shall be installed in accordance with these Standards and Specifications

Bedding for underdrain pipe or gravel for underdrain without pipe shall be well-graded washed rock ranging in size from one-half ($\frac{1}{2}$) inch minimum to one (1) inch maximum.

Bedding material for metallic pipe and fittings shall be high-resistance ($>10,000$ W-cm)

368.00 Backfill for Pipelines and Service Lines

Suitable backfill shall be as defined in Section 360.01 - Definitions of these Standards and Specifications.

The following special trench backfill requirements shall apply for utilities located in existing or planned road right-of-ways.

1. Isolated Street Cuts – Service line cuts and other isolated utility repairs or modifications in a paved street area shall be backfilled with Controlled Low Strength Material (CLSM) “flowable fill” or “flash fill” per MGPEC Section 19.
2. Constrained Areas - Areas in which proper backfill compaction cannot be achieved such as utility crossing, under curb and gutter, or any area identified by the Certified Materials Tester or Construction Inspector, shall be backfilled with Controlled Low Strength Material (CLSM) “flowable fill.”

Materials used above the subgrade level shall comply with the requirements for sub-base and base course materials as defined in Section 900 –Asphalt Mix Design and Construction of these Standards and Specifications.

Bracing installed to prevent cave-ins shall be withdrawn in a manner that shall maintain the desired support during the backfill operations. Driven sheet pilings shall be cut off at or above the top of pipe, and the portion below the cut-off line shall be left in the ground.

368.01 Backfill Compaction

Trench backfill shall be placed in lifts of eight (8) inches or less in loose thickness when heavy, self-propelled compaction equipment is used six (6) inches or less in loose thickness when hand-guided equipment (i.e. jumping jack, plate compactor) is used, processed and moisture-conditioned, and each lift thoroughly consolidated by tamping, vibrating, or a combination thereof, until the moisture content and the relative compaction complies with the values shown in the Moisture and Density Requirements for Embankment Materials table in Section 361.00 - Embankment Construction for the various soil classifications and relative compaction.

For new landscape areas, compaction shall be between ninety (90) percent or greater of the maximum Standard Proctor dry density in the top two (2) feet of soils below finished grade.

Where sidewalk or concrete trail will be constructed, soils shall be scarified for a minimum depth of twelve (12) inches, moisture treated and recompacted two (2) feet wider than the footprint of the sidewalk or trail until the moisture content and the relative compaction complies with the values shown in the Moisture and Density Requirements for Embankment Materials table in Section 361.00 - Embankment Construction of these Standards and Specifications.

369.00 Backfill of Structures in the Right-of-Way

Areas adjacent to structures located within the right-of-way such as bridge abutments, box culverts, vaults, maintenance holes, and storm inlets, and other areas inaccessible to mobile compaction equipment shall be compacted with suitable power-driven hand tampers or other approved devices. 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 six (6) inches before compacting to the required density. The Contractor shall uniformly process, maintain proper moisture in, and properly compact each lift throughout the backfilling process.

Backfill material shall not be deposited against the back of concrete abutments, concrete retaining walls, or the outside of cast-in-place concrete structures until the concrete has developed a strength of not less than eighty (80) percent of the required design strength. Backfill placed within two (2) feet of any structure shall be placed evenly on all sides to avoid unequal lateral pressures.

Compaction equipment or methods that produce horizontal or vertical earth pressures which may cause excessive displacement or loss of compaction in the backfill zone, or may damage structures, shall not be used.

Unless otherwise shown on the approved plans or directed by the Project Engineer, all sheeting and bracing used for structure excavation shall be removed by the Contractor prior to backfilling.

In the event that suitable backfill material is not available on the site, the Contractor shall import suitable backfill as defined in Section 360.01 - Definitions of these Standards and Specifications.

Where pipe is connected to a structure to be backfilled, bedding and backfilling procedures shall comply with Section 367.00 - Bedding for Pipelines and Service Lines and Section 368.00 - Backfill for Pipelines and Service Lines of these Standards and Specifications.

In constrained areas where proper compaction of backfill cannot be achieved around structures, CLSM “flowable fill” shall be used as defined in Section 360.01- Definitions of these Standards and Specifications.

370.00 Roadway Excavation, Backfill and Compaction

Prior to placement of street subgrade, base, paving and concrete materials, utilities shall be installed, utility service lines shall be stubbed to the edge of the ROW, and all trenches shall be backfilled and properly compacted.

Roadway embankments shall be constructed in accordance with Section 360.00 - Earthwork of these Standards and Specifications.

370.01 Base Course (For Composite Sections)

370.01.01 Materials

Base course subgrade shall consist of a foundation course composed of crushed gravel, approved recycled concrete, recycled asphalt or crushed stone and filler, constructed on the prepared subgrade. Materials and construction shall be in accordance with the requirements of Section 304 of the CDOT Standard Specifications for Road and Bridge Construction. Base course material gradation shall meet the requirements of Class 5 (1½" maximum) or Class 6 (1" maximum), in accordance with Table 703.03 of CDOT Standard Specifications for Road and Bridge Construction.

370.01.02 Construction

All work shall be observed and tested by the project Geotechnical Engineer or representative. The base course material shall be placed on the previously prepared subgrade at the locations and in the proper quantities to conform to the cross-sections shown on the approved plans and as directed by the Project Engineer. Geotextile fabric shall be installed if required on the approved plans or final pavement design report. Placing and spreading shall be done by means of a spreader machine, moving vehicle, motor grader, or by other approved equipment methods. The material shall be placed without segregation. Any segregated areas shall be removed and replaced with uniformly graded material at the Contractor's expense.

The thickness of each base course layer shall not exceed six (6) inches before compaction. If uniform density cannot be obtained by six (6) inch lifts, the maximum lift thickness shall not exceed four (4) inches. Each lift must be compacted with vibratory equipment.

Base course material shall not be placed on a dry or dusty soil foundation which could cause rapid dissipation of moisture from the base course material and hinder or preclude proper compaction.

Excessively dry soil foundations shall have water applied to them and shall be reprocessed and recompacted. If at any time, the subgrade construction is subjected to rain, snow or other significant events, the project Project Engineer or Geotechnical Engineer shall evaluate the affected areas prior to continuing with subgrade preparation and shall make a recommendation to the Contractor and to Arvada.

Rolling shall be continuous until the base course material has been compacted thoroughly in accordance with Section 304 of the CDOT Standard Specifications for Road and Bridge Construction. Water shall be uniformly applied during compaction to obtain the specified moisture content and to aid in consolidation. The surface of each layer shall be uniformly maintained during compaction operations.

The prepared base course surface shall be smooth and free of ruts and irregularities, and shall be true to line and grade shown on the approved plans and as directed by the Project Engineer. The base course shall be maintained in this condition by watering, drying, rolling, and/or blading until the asphalt or concrete flatwork is placed. The surface tolerance of the base course shall be in accordance with Section 304.06 of the CDOT Standard Specifications for Road and Bridge Construction.

370.02 Lime-Treated Subgrade

When required, lime treated subgrade shall comply with Section 307 of the CDOT Standard Specifications for Road and Bridge Construction. Lime-treated subgrade shall extend to the back of the sidewalk as shown in the Detail Drawings of these Standards and Specifications. Lime treatment of subgrade is disallowed during the winter months when ambient temperatures are below 40 degrees Fahrenheit. Alternative methods of soil stabilization may be allowed with approval of the Project Engineer. Soil mix design procedures shall comply with the CDOT Standard Specifications for Road and Bridge Construction.

370.03 Proof-Roll Observation and Testing

Within the twenty-four (24) hour time period prior to paving and after a moisture related weather event, subgrade compaction testing and proof-roll observation and testing (proof-rolling) with a loaded tandem wheeled vehicle or other equipment approved by the Inspector or Geotechnical Engineer.

After passing compaction tests, the Contractor and/or Owner's representative shall proof-roll the areas. No proof-roll inspections shall be performed until all underground utility testing is complete. Subgrade areas failing compaction testing or proof-rolling shall be delineated and reprocessed and/or removed and replaced in a manner approved by the project Geotechnical Engineer and the Project Engineer. Such procedures may include over-excavation, scarification, moisture-conditioning, recompaction, and/or replacement with suitable materials that comply with the moisture and density requirements. In addition to complying with moisture and density requirements, all subgrade materials shall exhibit stability during proof-rolling. Additional compaction testing and proof-rolling may be required at the discretion of the Project Engineer. All proof-rolling operations shall be at the Contractor's expense. Changes in weather such as freezing or precipitation will require reapproval of the subgrade prior to asphalt placement.

371.00 Restoration and Clean Up

At all times during construction, the Contractor shall maintain the site, including partially finished structures, material stockpiles, erosion and sedimentation control measures, and other like areas, in a reasonable state of order and cleanliness.

The grade and condition of all unsurfaced areas shall be restored to a condition equal to or better than the grade and condition immediately prior to construction unless otherwise shown in the approved plans and approved by Arvada. The Contractor shall restore or replace all seeded areas, sod, trees, landscaping materials, landscape irrigation systems, fences, and any other items, to a condition equal to or better than before the work began and to the satisfaction of the Project Engineer. All grassed areas shall be reseeded or resodded in accordance with Section 1000 – Vegetation, Parks and Recreation Construction of these Standards and Specifications and the Contractor shall be responsible for maintaining these areas until substantial growth, defined as 70% density of vegetation as compared to pre-existing conditions, occurs and Construction Acceptance Into Warranty. Refer to Section 200 – Acceptance Procedures of these Standards and Specifications.

All pavement and concrete flatwork shall be restored or replaced to a condition equal to or better than before the work began and to the satisfaction of the Project Engineer.

In the event of failure of the Developer or Contractor to complete work, correct deficiencies, or clean up a project site in a reasonable time period, the City has the right to draw upon the performance guarantee and complete the work as needed.

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SECTION 400 – WATER SUPPLY FACILITIES

401.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

401.01 Cross Connections

Cross connections shall not be allowed. For enforcement provisions, refer to City Municipal Code Chapter 102.V regarding cross connection and backflow connection controls for the treated water system.

401.02 Easements

Water pipeline shall be placed in the right-of-way and under pavement unless otherwise approved by the Project Engineer. Where the proposed water pipeline alignment is not in right-of-way, an easement shall be provided per Section 140.01 - Arvada Utility Easements of these Standards and Specifications. Landscaping more substantial than turf, perennial grasses, and flowers, as well as fencing and structures are prohibited in waterline and meter easements. In no case shall a water main be installed such that there is not a minimum of twenty feet from the centerline of the waterline to any building foundation.

410.00 Design Criteria

410.01 General

All water distribution system changes shall comply with the requirements of these Standards and Specifications for water main and service line construction and may include special criteria

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established by the City of Arvada for the overall hydraulics of the water utility system. Special criteria may be identified as part of the review process.

411.00 Design Flow Requirements

All lines shall be sized large enough to provide for domestic, commercial, irrigation, maintenance flows, and fire protection flows to the area to be served.

411.01 Potable Water Distribution System

The design of the potable water distribution system shall be based on the following:

Unit Water Demands for Future Land Use

Land Type	People per Unit	Avg. Demand	Max. Day/Avg. Day	Peak. Hr./Avg. Day
Residential - Single Family	3.3	175 GPCD*	2.5	4.0
Residential - Duplex and Townhome	2.5	175 GPCD	2.5	4.0
Residential - Multi-family	2.0	175 GPCD	2.5	4.0
Commercial**	N/A	1000 GPD/Acre	2.5	4.0
Industrial**	N/A	1500 GPD/Acre	2.5	4.0
Park**	N/A	3060 GPD/Acre	3.90	7.4

*Gallons Per Capita/Day

** These are minimum and may be increased at the discretion of the City Engineer dependent on the development.

Minimum residential population density, household density and land usage shall be as noted on the approved PUD and/or Plat, or as determined by the Arvada Planner. Fire flows may be calculated from more than one hydrant, providing the hydrants used are two-hundred fifty (250) feet in a straight, unobstructed line, to all possible fire locations in the area served and not at the end of cul-de-sacs. Fire flows required by fire district shall be:

1. Available fire flow shall be twenty (20) psi residual minimum.
2. Minimum fire flow as detailed in the International Fire Code (IFC) and adopted in Chapter 42 of the Arvada Municipal Code or as shown below, whichever is greater:
 - a. Detached dwelling (min 15' detached) 1,500 gpm
 - b. Detached dwelling unit (<15' and Multi-family) 2,000 gpm
 - c. All other buildings 2,000 gpm

- d. In all cases, minimum fire flow will be as required by the fire protection district or as needed for operational purposes (such as flushing and cleaning), whichever is greater.
3. The Developer or Contractor is responsible for obtaining fire flow tests. Scheduling of tests shall be coordinated through City Municipal Inspection with the Arvada Utility Divisions and the appropriate fire district. The design engineer is responsible for obtaining pressure test data, including supplying pressure measuring equipment. When approved by the Project Engineer, the City hydraulic model can be used to provide flow and pressure information.

Developers are responsible to design new construction, located in previously established areas, such that the total demand fire flow does not exceed the available fire flow. This may require the developer to oversize existing or install additional mains to serve the proposed project.

411.02 Service Lines

Service lines shall be adequate to supply the requirements of the property being served. The minimum size allowed for a water service line is three-quarter ($\frac{3}{4}$) inch.

The water requirements of the property being served shall be defined as "total peak demand flow." Peak domestic water requirements shall be as calculated in the latest edition of the Uniform Plumbing Code.

The irrigation demand flow and continuous load demands (when applicable) shall be added to the total peak demand flow. The service lines and meter shall be designed on the basis of the total peak demand flow. Commercial (all non-single family) properties shall meter domestic and irrigation demand flows unless otherwise approved by the Project Engineer. Commercial properties with limited irrigation demand (less than 0.25 acre or xeriscape) may use a single meter for domestic and irrigation with the approval of the Project Engineer.

Irrigation lines tapped off domestic service lines shall be tapped inside the building.

Peak demand flows for commercial, industrial or professional properties are to be designed by the design engineer and justified in the Utility Report. Justification must use a national standard such as IPC or AWWA. In the event a Utility Report is not required, justification for tap size must be presented in a memo. The requirement for tap justification may be waived by the Project Engineer.

412.00 Fire Hydrant Spacing

Fire hydrants shall be installed within dedicated streets or easements. Normal practice is to install fire hydrants on the northeast corner of the street intersections. If fire hydrants are to be installed at locations other than intersections, they shall be located on one side of the street right-of-way on lines which are established by extending property lot side lines into the street and in easements. The number and location of fire hydrants is determined by the Project Engineer and the governing fire protection district.

The maximum spacing between fire hydrants shall be as determined by the governing fire protection district but not more than six-hundred (600) feet. Hydrants and valves shall be designed such that no more than one hydrant is out of service at one time. Additionally, hydrants and valves shall be designed such that only the fire protection service or the hydrant is out of service at one time.

Hydrants shall be spaced not greater than 1,000 feet along collector and arterial roadways without domestic water service lines. All fire hydrant locations and spacing shall be reviewed and approved by the Project Engineer and the governing fire protection district.

The fire hydrant lateral lines shall be set at ninety (90) degrees to mains. The fire hydrant lateral line shall be no more than fifty (50) feet in length from the main. No horizontal bends or offsets shall be used in fire hydrant lateral lines. Under no circumstances shall any tap be made on a fire hydrant lateral line.

413.00 Fire Service Lines

All fire lines shall be installed per Colorado 8 CCR 1507-11.

413.01 Multi-family and Commercial Properties

The property owner shall maintain all fire service lines extending from the first valve on the Arvada water main. Valves on newly constructed fire lines shall be located on, and/or restrained to the tee at the main line. The entire fire line shall have restrained joints from the tee and valve to the end of the fire line. Bends are not allowed in fire lines with the exception of the ninety (90) degree vertical bend into the building. Fire lines are to be used exclusively for fire protection.

The fire service line tap shall serve only the fire protection service. A separate tap(s) are required for domestic and irrigation service. A domestic service tee may not be placed on an existing

fireline. A property requiring both a fire line and a domestic service line cannot be served from a single tap.

The fire service line shall extend perpendicular from the main to the property line and shall have a gate valve located within two (2) feet from and on the street side of the property line. When required by the fire district, a Post-Indicator Valve (P.I.V.) shall be installed on the fire service per the most recent edition of NFPA 24. Fire service lines require a backflow preventer that is listed on the Approved Products List. The backflow preventer may only be installed in an orientation that is certified.

413.02 Single-family dwellings and townhouse units

Where a fire sprinkler system shall be installed in a single family dwelling or a townhome, a single tap shall be provided.

For single family and townhome residential, any fire sprinkler systems shall be of the combination domestic/fire service line with a passive purge. Any system that requires backflow protection in the method of a backflow prevention device shall not be allowed. A pump and tank system shall be allowed if there is no automatic fill and an appropriate air gap providing sufficient backflow protection is provided. The system shall meet all requirements within these standards for construction of the service line.

Design of the system shall be as approved by the fire protection district. The system shall be designed to have a three-quarter ($\frac{3}{4}$) inch meter and a maximum flow of thirty-two (32) gpm. When a residential fire system is installed, the meter must be listed on the Approved Products List. Systems requiring greater flow and a greater meter size shall only use a meter as listed on the Approved Products List. Where a residential fire sprinkler system is installed, a tag must be installed on the meter indicating the presence of the sprinkler system.

414.00 Valve Spacing

Valves shall be placed with a maximum spacing of six-hundred (600) feet in all distribution mains and lateral lines. Spacing of valves in transmission mains may be greater than six-hundred (600) feet with the approval of the Project Engineer. Valves shall also be placed at each fire hydrant.

All waterline tees shall have a minimum of three (3) valves, and all waterline crosses shall have a minimum of four (4) valves or as required by the Project Engineer. For a succession of short blocks perpendicular to the direction of the distribution main and without residential or commercial services between them, one or more intersection(s) may have the valve in that

direction omitted, but the six-hundred (600) foot maximum spacing requirement shall be maintained. Where City blocks exceed six-hundred (600) feet in length an intermediate line valve shall be installed such that no more than twenty (20) residential units or more than one (1) commercial or industrial user will be out of service during maintenance.

Valves shall also be placed at each end of a waterline running through an easement on private property, on each side of a casing pipe, on each side of a major creek or channel crossing, and on each side (at property lines extended) of a distribution line that provides service to a hospital, school or large industrial user.

Valves shall be placed such that no more than one (1) fire hydrant is placed out of service when isolating a section of pipe. Additionally, valves shall be placed such that a fire service line and a hydrant are not both placed out of service when the section of line is isolated.

A temporary blow-off valve, in accordance with standard drawing 400-11 is required at the end of any water main which terminates and is anticipated to be extended in the future. When a future main extension is anticipated, the main shall be valved so that only one valve will have to be closed when the main is extended. The valve shall be restrained so when the one valve is closed and the line to be extended is exposed, the valve will not blow off. No service taps shall be made between this valve and the temporary blow-off valve.

415.00 Air Release and Vacuum Relief Valves

Combination air and vacuum relief valves shall be installed at each high point in all distribution mains and at high points of lateral lines, as required by the Project Engineer.

Air and vacuum relief valves shall be installed in precast maintenance holes or vaults fitted with air vents open to the atmosphere and in accordance with the Detail Drawings of these Standards and Specifications. The use of a fire hydrant to relieve air will not be allowed except with the explicit, written permission of the Project Engineer.

416.00 Blow-off Valves and Drains

416.01 Blow-off Valves

Provisions shall be included in the design to allow for the flushing of distribution mains and lateral lines at any low point in the system and any approved dead-ends. Fire hydrants are

preferred for permanent blow-offs. Fire hydrants installed as blow-offs need specific approval by the fire department to be applied to the required count and location for the fire code.

For temporary dead end water lines, a temporary blow-off valve may be permitted. The blow-off assembly shall be installed perpendicular to and on the downhill side of the waterline and shall drain to the nearest street gutter line or drainage channel. The blow-off assembly standpipe shall have a threaded end to accept a fire hose coupling. The top of the standpipe shall be between four (4) and six (6) inches below grade, in accordance with the Detail Drawings of these Standards and Specifications.

Metallic blow-offs and any metallic drain lines shall be electrically isolated from the main if the main is metallic.

416.02 Drains

Transmission line drains may be required as directed by the Project Engineer as shown in the Detail Drawings found in these Standards and Specifications.

417.00 Pipe Location and Alignment

Distribution and/or lateral mains and service lines conveying water from transmission lines to fire protection systems and customers shall be laid out and designed according to the following minimum standards. Pipe and fittings shall be those specified in Section 421 - Installation of these Standards and Specifications. When installed, the top of distribution and lateral lines shall be buried a minimum of four (4.0) feet under compacted backfill, below finished grade. These Specifications shall apply to all new construction within the City.

Distribution mains, sized sixteen (16) inches and larger in diameter, shall be grid spaced at one mile intervals. No service line taps nor any taps less than eight inches in diameter shall be made to distribution mains sized sixteen (16) inches and larger. Exceptions to this will be for air and vacuum release valves only. All connections to distribution mains shall be valved at the connection. If the connection is sixteen (16) inches or larger in diameter, there shall be a minimum of three (3) valves for tee connections and four (4) valves at cross connections. All extensions of the existing pipe network shall utilize a minimum of two (2) sources (two different pipes) unless approved in writing by the Project Engineer.

Secondary distribution mains, sized twelve (12) inches to fourteen (14) inches in diameter, shall be intermediately spaced at one (1) half mile intervals and connected at each end to the larger distribution main.

All water lines shall be looped. No dead-end lines, except lines extending into cul-de-sacs serving not less than six (6) single-family and not more than twelve (12) single-family residential units and not more than five-hundred (500) feet in length, will be permitted. Where a dead-end line is allowed, only one (1) fire hydrant shall be on the dead-end portion.

Lateral lines, sized eight (8) inches to ten (10) inches in diameter, shall be looped to the distribution mains and used to deliver to fire hydrants and the individual customer service and fire protection lines.

Six (6) inch lines, with the exception of fire hydrant laterals, are only allowed with written permission from the Project Engineer. Lines under six (6) inches shall not be allowed..

Mains and laterals shall be interconnected or looped. However, when a main or lateral is allowed to temporarily terminate, such as between filings of a subdivision, a fire hydrant or blow-off shall be installed at the point of termination.

417.01 Hydraulic Design

All pipes shall be sized large enough to provide for domestic, commercial, irrigation, and fire protection flows to the area to be served. All pipes shall be designed to provide a maximum velocity of ten (10) feet per second under all conditions, including fire flow. Distribution mains and lateral lines shall be designed using the Hazen-Williams friction coefficients and maximum head losses noted below:

Friction Coefficients and Maximum Head Losses

Pipe Size	Hazen-Williams Friction Coeff.	Max. Head Loss (all conditions)
8" - 12"	C-130	2' per 1,000'
14" - 16"	C-130	2' per 1,000'
20"	C-130	1.5' per 1,000'
Over 20"	As directed by the Project Engineer	

Pressure requirements shall be as follows:

1. Minimum pressure under peak hour demand = one-hundred (100) feet, forty-three (43) psi

2. Maximum pressure under average day demand = two-hundred fifty (250) feet, one-hundred eight (108) psi
3. Minimum residual pressure under fire flow = twenty (20) psi as measured on the second floor elevation of the unit at the highest elevation.
4. Maximum pressure fluctuation at any point in the system = thirty (30) psi as measured between all conditions.

Acceptable minimum and maximum pressures may be adjusted by the Project Engineer as needed to provide adequate service.

417.01.01 Hydraulic Design of Service Lines

Service lines with appurtenances to convey water from a distribution or lateral main in a street or easement to a structure shall conform to the following minimum standards.

The corporation stop, the meter, and that portion of the service pipe between the meter and the corporation stop on the main, shall all be of the same size. This portion of the service line must be installed in public right-of-way or an easement and will be maintained by the City.

The size of a service line from the City water main to any unit being served shall be selected such that the following design criteria are not exceeded during total peak demand flow:

1. Peak demand flow is within the meter manufacturer's operating range.
2. Service line pipe flow velocity does not exceed fifteen (15) fps.
3. The pressure drop from the City water main to any unit being served shall not be greater than thirty (30) psi and the minimum residual pressure at the foundation at any unit shall not be less than thirty (30) psi.
4. Where a residential fire sprinkler system is being installed, sufficient pressure is provided to all required hydraulic design areas.

The private portion of the service main downstream of the meter and outside the meter pit or meter vault may be upsized by one (1) pipe size.

417.02 Location (Typical)

Water mains shall typically be located north or east of the centerline of the street, unless otherwise approved by the Project Engineer.

At street intersections, valves shall be located at the extension of property lines. Fire hydrant gate valves shall be placed near the main. All fire hydrants shall have a restrained connection directly to the tee off the main.

In all instances, water mains shall extend to the boundary line of the property or subdivision served, to the center of boundary streets or to the outside of paved areas, as noted on the approved plans. A water main serving one lot shall extend the entire length across the frontage of that lot.

417.02.01 Service Line and Meter Location

For residential service, the service line between the main and the meter shall be one (1) continuous length of copper pipe with no joints. For one and one-half (1½)inch and two (2) inch services a curb stop and box shall be provided at the property line and the service line shall not contain joints. For services three (3) inch and greater, the service line shall be installed as if a water main, including a valve on the service line at the tee.

Service lines shall be installed at least ten (10) feet laterally, on the uphill side from any foreign non-potable conduit and a minimum of five (5) feet from the side property line of the lot being served unless otherwise approved by the Project Engineer.

When serving lots at the end of a cul-de-sac, the length of service line between the main and the meter at property line shall not exceed fifty (50) feet. Meters and/or curb stops with boxes shall not be installed in driveways or sidewalks without the approval of the Project Engineer and will require the curb stop/meter pit and lid must be of ductile iron as approved by the Project Engineer.

Meters must be placed outside in landscaped areas. Any other location must be approved by the Project Engineer.

417.02.02 Service Lines and Meters for Townhomes

In a townhome complex, each townhome unit on a separate platted lot shall have its own separate meter. The service line from each meter shall be directly tapped to a supply line. In addition, the service line shall only cross the common area and the unit lot of the townhome being served with the exception of HOA owned property, with the approval of the Project Engineer.

The service line to the meter shall be one continuous section of copper pipe installed perpendicular to the main or lateral supply line. Meter shall be installed at property line or at a point in the common area that is easily accessible and void of vehicular traffic at all times and located within an easement. Meter shall be installed in a landscaped area unless approved by the Project Engineer. The location of lateral supply lines and meters, to be installed in common areas; easements must be approved by the Project Engineer.

417.03 Horizontal and Vertical Alignment

Methods of deflection of PVC and ductile iron pipe joints shall be one half of the maximum manufacturer's recommendations. Pipe shall not be bent. Fittings are required for deflections to cross under utilities, but the contractor may request a variance from the Project Engineer to vertically deflect pipe joints a maximum of one degree (1°).

Changes in direction of water lines may require fittings.

For waterline lowerings that are greater in length than seventy-five (75) feet or as directed by the Project Engineer, a valve shall be installed at each end of the lowering. A hydrant shall be installed between one (1) of the valves and the adjacent forty-five degree (45°) bend to facilitate flushing of the lowered section.

Refer to detail drawings.

417.04 Pipe Depths

All water main pipe shall be installed with a minimum of four (4) feet of cover from finished grade of street to the top of the pipe barrel. Proposed installations greater than six (6) feet from finished grade require Project Engineer approval.

417.05 Relation to other Utilities and Structures

All Arvada water, sanitary sewer, and storm mainline pipes shall have a minimum separation from any structure or other utility of eighteen (18) inches vertical separation and ten (10) feet horizontal separation. Horizontal separation is measured in the horizontal plane and from outside edge of pipe to outside edge of pipe.

Arvada irrigation lines shall be a minimum of eighteen (18) inches vertical separation and three (3) feet horizontal separation from all other utilities.

If compliance with these requirements is not feasible, the Owner/Developer/Engineer shall design and construct the Utilities by means of secondary containment. Secondary containment considered by City Utilities, in order of preference for sanitary sewer, are:

1. Construct sanitary sewer from AWWA C900 or C909 pipe
2. Casing pipe
3. Encased in flow fill

In the case of storm sewer, casing or encased in flow fill shall be used.

If these required separations cannot be met, they will be addressed on a case by case basis.

ALL utility lines shall be located a minimum of ten (10) feet horizontally from existing or proposed utility lines (clear separation). Where ANY utility lines cross existing or proposed utility lines, the line's shall have a minimum of eighteen (18) inches clear separation. In the case of sewer crossing water, the sewer shall be eighteen (18) inches below the water line. If this clearance is not feasible, the crossing shall be designed and constructed so as to protect the waterline.

Minimum clearance must be maintained. If maintaining minimum clearance results in violations of other portions of these standards, additional precautions shall be taken. Sanitary sewer pipe shall be constructed of fusible PVC, AWWA C900, or AWWA C909 a minimum of ten (10) feet either side of the crossing. Storm sewer pipe shall be constructed with concrete encased joints a minimum of ten (10) feet either side of the crossing. Alternatives to fusible piping may be used with the written approval of the Project Engineer. In all cases, suitable backfill or other structural protection shall be provided to preclude settling and/or failure of the higher pipe. The Project Engineer will approve the crossing design.

417.05.01 Waterline Crossing Sanitary or Storm Line

When a waterline crosses over another wet utility that could result in cross-contamination, a minimum of three (3) feet clearance shall be maintained from outside edge of pipe to outside edge of pipe. Where approved by the Project Engineer, clearance of less than three (3) feet may occur but in no instance shall the clearance be less than eighteen (18) inches. When clearance is less than three (3) feet, the waterline will be protected as follows:

1. Water pipe shall be centered at the crossing, maximizing the distance from the joints to the crossing.
2. Other utility pipes shall be centered at the crossing, maximizing the distance from the joints to the crossing.

3. Other utility pipe shall be constructed of fusible pipe or watertight and pressure rated pipe to a minimum of ten (10) feet either side of the crossing.
4. Alternate protection may be provided with the approval of the Project Engineer.

In instances where a waterline crosses under another wet utility, protection of the waterline will be provided as detailed above.

418.00 Water Transmission Lines (Larger than 24" Diameter) Additional Design Requirements

418.01 General

Transmission lines larger than twenty-four (24) inches shall not be designed nor installed by a developer. When a development requires a transmission line larger than twenty-four (24) inches, an agreement with the City will be required wherein the developer pays for the design and installation as a City CIP project. When approved by the City Engineer, the developer may design and construct a transmission line.

Transmission lines larger than twenty-four (24) inch diameter may be Steel (S), or Ductile Iron (DI). Steel and ductile iron pipe shall be cement mortar lined. Steel pipe shall be coated at the factory with an exterior tape coating system in accordance with AWWA C214 or a cement mortar coating system in accordance with AWWA C205. Ductile iron pipe shall be coated with an asphaltic shop coating per AWWA C151 and encased with polyethylene in accordance with AWWA C105, regardless of soil conditions.

Except as herein modified, the pipe shall conform to the applicable AWWA specification. Metallic type pipe shall be designed, manufactured, tested, inspected and cathodically protected in accordance with this section of these standard specifications. Minimum wall thickness of steel pipe shall be approved by the Project Engineer.

418.02 Pre-Manufacture of Pipe Requirements

Within twenty (20) calendar days following the "Notice of Award", the Contractor shall obtain from the supplier and submit to the Engineer for review:

- **Design Calculations.** Design calculations (steel pipe only) shall comprise concise, yet complete, stress analysis of each critical section of pipe wall, girth joints, harness system, specials, outlets and appurtenances, sufficient to ascertain conformance of the pipe and fittings with these specifications. All steel pipes shall be designed in accordance with AWWA Manual M11.
- **Shop Drawings.** Shop drawings shall accurately indicate the precise geometry; type, gauge, diameter, strength, manufacturing tolerance and thickness of the elements to be incorporated in manufacture of the pipe, joints, fittings and appurtenances.

418.03 Pipe Laying Schedule and Marking Diagram

Laying schedule shall indicate by consecutive number the order and direction of installation of each pipe section, special fitting, valves, access maintenance holes, nozzles, outlets, and other appurtenances. In addition, the laying schedule shall include:

1. The station and elevation to which the bell end of each pipe shall be laid and all changes in gradient or horizontal alignment.
2. All elements of curves and bends, both in horizontal and vertical alignment.
3. The limits of each reach of any welded joints, closures or concrete encasements.

Any additional strutting or studding required during installation to prevent damage to the coating and/or lining caused by deflections beyond the allowable limits shall be the responsibility of the Contractor. The Contractor shall be responsible to be sure that all strutting remains in place until after the pipe section, special or fitting has been properly backfilled.

The manufacturer shall provide a polyethylene or other suitable bulkhead on the ends of the pipe section and on all special openings to prevent drying out of the linings. The Contractor shall be responsible to assure that the polyethylene or bulkheads remain intact on the pipe ends until the section or fitting is being installed in the trench.

418.04 Standard Joints

Standard joints for transmission line pipe shall be either an expanded bell and rolled spigot or the Carnegie bell and spigot end ring (steel pipe only), each with rubber gasket. Mechanically coupled, flanged, mechanical, restrained or welded joints may be required where called for on the drawings.

The joint construction shall be suitable for at least two-hundred fifty (250) psi water service and regardless of type shall be designed to be self-centering. The bells and spigots shall have a smooth close sliding fit at the self-centering surface, and the joint shall be capable of either symmetrical or asymmetrical joint closure and shall remain water-tight under all conditions of water service.

The joint assemblies shall be so formed and accurately manufactured that when the pipes are drawn together in the trench; they shall form a continuous watertight conduit with smooth and uniform interior surface and shall provide for a slight movement of any pipe in the pipeline due to contraction, settlement or lateral displacement.

The maximum tolerances permitted in the construction of the joint shall be that stated in the pipe manufacturer's design as approved. Any fabrication performed prior to approval of details shall be at the Contractor's risk. Approval by the Project engineer shall not be held to relieve the Contractor of any part of the Contractor's responsibility to meet all of the requirements of these specifications or of the responsibility for the correctness of the joint details.

All joints on metallic pipe shall have electrical continuity.

All metallic joints shall have corrosion protection similar to that provided for the pipe.

418.05 Harnessed Joint

Harness joint designs for steel pipe shall be submitted to the Project Engineer for approval. On steel transmission lines twenty seven (27) inches diameter and larger, the joint harness designs shall include considerations of stresses induced not only in the attachments, but also in joint rings and steel cylinder by thrust at bulkheads, bends, reducers, and valves resulting from the internal working pressure including the transient pressures. Design stresses shall not exceed fifty (50) percent of the specified minimum yield strength of the grade of steel utilized when longitudinal thrust is uniformly distributed around the circumference of the joint.

The manufacturer shall supply a mechanical method of joint restraint suitable to the Project engineer that will allow for expansion, contraction and deflection after assembly.

Proof-of-design tests need not be conducted specifically for a project. Certified reports covering tests of harnessed joints constructed in the identical fashion as that proposed may be found acceptable.

418.06 Flanges and Nozzles

Flanges in the line and for outlets of the size and at locations shown on the drawings shall meet the requirements of AWWA C207, Class "D", minimum one-hundred fifty (150) psi working.

418.07 Submittal Reviews and Revisions for CIP Projects

The Project Engineer will inspect and return comments electronically of design calculations, working drawings and other submittals to the Contractor properly executed and marked either "Reviewed", "Revise and Resubmit", "Furnish as Noted" or "Rejected" within twenty (20) calendar days after receipt thereof.

The Contractor shall review and back check indicated revisions deemed necessary by the Project Engineer to correct defects. The Contractor shall revise submittals that have been marked "Revise and Resubmit" or marked "Rejected", and shall resubmit said revisions to the Project Engineer within fifteen (15) calendar days after the Contractor's receipt thereof. Further revisions, if and when required, will be handled in accordance with the above procedure.

Only upon the Contractor's receipt of submittals marked or designated "Reviewed" or "Furnish as Noted" shall the manufacturer of pipe commence: Provided that said drawings designated "Furnish as Noted" are corrected and resubmitted to the Project Engineer immediately. Upon receipt of duly executed "Reviewed" design calculations, laying diagrams and shop drawings, the Contractor shall immediately forward up to eight (8) prints of each such approved submittals for use during construction at the City Engineers request.

Neither the inspection nor lack of inspection of any drawings, design calculation, material list, laying schedule, sample or piece of data (furnished to the Project Engineer for his review) shall waive any of the requirements of these Specifications, Drawings and Contract Documents or relieve the Contractor of any obligations thereunder; and defective workmanship, work, materials and finished product may be rejected notwithstanding conformance with Drawings and other submittals reviewed by the Project Engineer.

419.00 Backflow Requirements

419.01 General

An approved backflow prevention assembly shall be installed at the service connection to any premises where there are existing cross connections or where potential cross connections exist or where it is expected that the consumer may make piping or equipment changes which would result in the installation of cross connections. Installation of the assemblies shall be inspected and approved by the City.

419.02 Degree of Hazard

The type of backflow prevention assembly required must be consistent with the "degree of hazard" existing in the facility. The term "degree of hazard" shall be derived from the evaluation of conditions within a system which can be classified as either a "pollutional" (non-health) or a "contamination" (health) hazard. The "degree of hazard" shall be determined by the City based on the following:

1. A Health Hazard is an actual or potential threat of contamination of a physical or toxic nature to the public potable water system or the consumer's potable water system that would be a danger to health.
2. A Health Hazard requires the installation of an approved reduced pressure principle backflow assembly or an air gap.
3. An Aesthetically Objectionable Hazard is an actual or potential threat to the physical properties of the public or the consumer's potable water system or a pollution or contamination which would have a protracted effect on the quality of the potable water in the system. An aesthetically objectionable hazard requires as a minimum the installation of an approved double check valve assembly.

419.03 Approved Models

Only those models that are listed on the Approved Products List and that have met completely the laboratory and field performance specifications of the Foundation for Cross Connection Control and Hydraulic Research, of the University of Southern California, will be permitted by the City. In addition, the design for installation of backflow prevention are applicable, address

the following:

1. Water service size and location; meter size and location; backflow prevention assembly size, type, and location.
2. Backflow prevention assemblies shall be installed in the horizontal plane and inside a Building. Where a fire protection system is designed for vertical installation, only backflow prevention assemblies certified for installation in a vertical position shall be allowed
3. Vertical clearance between floor and the lowest point of the device shall be no less than twelve (12) inches or no more than thirty (30) inches.
4. Horizontal clearance between any wall and the device shall be no less than twenty-four (24) inches on the test cock side and no less than twelve (12) inches on the opposite side.
5. An underground drain line shall be provided to dispose of waste fluids developed during regular use and testing of the device. An air gap, no less than twice the diameter of the drain line, shall be provided between the relief valve outlet and the drain line.
6. Continuous service systems shall be provided with parallel backflow prevention assemblies. One device shall be operable while the other is being tested.
7. No installation of a backflow prevention device will be allowed above electrical or other equipment, where water could cause a hazard.
8. Backflow prevention devices are required on all irrigation sprinkler systems. A pressure vacuum breaker shall only be used where the device is never subjected to back pressure and installed a minimum of twelve (12) inches above the highest piping or outlet downstream of the device in a manner to preclude back pressure. An atmospheric vacuum breaker shall be used only where the device is: never subjected to continuous flow, installed on the discharge side of the last control valve and above the point of usage, and installed with the air inlet in a level position and a minimum of six (6) inches above the highest piping on the outlet it is protecting.
9. Backflow prevention assemblies, connecting lines, and drains shall be protected from freezing and thawing cycles.

420.00 Potable and Raw Water Main Construction

420.01 Materials

All pipe used for distribution mains and lateral lines, having a diameter of twelve (12) inches or less, shall be PVCO (C-909) or PVC (C-900) pipe unless otherwise approved in writing by the Project Engineer. City preference is for C909 pipe. Fire service lines to buildings and fire hydrant laterals shall be PVC DR-14, C-900 or 305 psi, C909. Distribution mains in excess of

twelve (12) inches in diameter shall be subject to approval and as directed by the City Engineer. The design engineer shall specify the pipe class as required for specific project conditions.

All pipe and main materials must be new. Existing fire lines and service lines may be reused only with written permission from the Project Engineer. When a fire line or service line is reused, the previous use must have been with potable water only. All distribution pipe material must be uniform throughout a single site unless approved in writing by the Project Engineer.

420.02 General

All references to the American Water Works Association Standards cited in these Standards and Specifications shall mean the latest edition of the AWWA Standards.

Pressure classes or ratings specified for materials in this section are minimums. The pressure class or rating for all materials used in a water supply system design shall be adequate for the water system pressure requirements.

Pipe, fittings and appurtenances to be installed in the City water system shall be equal or exceed the minimum standards as set forth by the: American Society of Testing Materials (ASTM); American Water Works Association (AWWA); American National Standards Institute (ANSI), etc. Referenced standards shall be the latest edition or revision thereof.

Manufacturers of pipe, valves and other in-line appurtenances shall furnish a certified statement that the inspection and all the specified tests have been made and the results obtained comply with the requirements of the applicable standards as herein specified. A copy of the certification shall be sent to the Project Engineer prior to installation.

420.03 Pipe

All pipes for water main construction shall be as described in this section. Each pipe shall be marked with the class designation and size. A two (2) inch wide warning tape shall be installed above all pipe for the purpose of warning of location of buried pipeline, in accordance with the Detail Drawings of these Standards and Specifications. A No. 12 AWG solid copper wire shall be attached to all pipes for the purpose of future location, in accordance with the Detail Drawings of these Standards and Specifications. Installation of all pipes shall be in accordance with the manufacturer's recommendations and these Standards and Specifications.

PVC Pipe: All PVC pressure pipes for potable water lines in sizes up through twelve (12) inch diameter shall comply with AWWA C900, pressure class two-hundred (200) psi and wall thickness dimension ratio twenty-one (DR-21) minimum.

PVC pressure pipe for potable water lines in fourteen (14) inch through thirty-six (36) inch diameter shall comply with AWWA C900, pressure rating as determined by the design conditions and approved by City Engineer.

PVCO Pipe: Molecularly Oriented Polyvinyl Chloride (PVCO) pressure pipe for potable water lines in sizes up through twelve (12) inch diameter shall comply with AWWA C909, pressure class two-hundred and thirty-five (235) psi minimum.

Ductile Iron Pipe: All ductile iron pipe shall comply with AWWA C151. Class designation shall be as shown on the approved plans or as designated by the Project Engineer for each individual project. Joints shall be mechanical or push-on and shall comply with AWWA C111. Ductile iron pipe shall have a standard cement mortar lining that complies with AWWA C104 and a bituminous outside coating approximately one (1) mil thick per AWWA C115 or C151 and encased with polyethylene in accordance with AWWA C105. Ductile iron pipe in vaults shall comply with AWWA C115.

All metallic fittings shall be coated pr AWWA C116 and be encased in polyethylene wrap per AWWA C105, regardless of soil conditions.

420.03.01 Abandonment of Water Main and Water Valves

Water main shall be abandoned only with the written approval of the Project Engineer. Water mains in the public right of way or within a City owned easement shall be removed. When approved by the Project Engineer, water mains may be abandoned in place. Pipe eight (8) inches in diameter or less shall be abandoned by capping each end with concrete. Pipe eight (8) inches in diameter or greater shall be abandoned in place by filling with CLSM and capping each end with concrete.

Where the abandonment is one leg of an active tee, the tee shall be removed and replaced with a new pipe section or fitting as required.

Water valves to be abandoned shall be removed in their entirety with a blind flange installed at the tee. Water valves that would connect to abandoned water main or no water main shall not be left in place.

420.04 Water Transmission Lines (Larger than 24" Diameter) Add'l. Requirements

The Project Engineer or his designated representative shall be permitted to make inspections necessary during the manufacture of the pipe and appurtenances to determine compliance with the specifications.

420.04.01 Certification

The manufacturer, via the Contractor, shall furnish the Project Engineer an electronic copy of the following certifications as to compliance with the specifications:

- Mill analysis and test of steel
- Hydrostatic test reports
- Compliance of materials and application of linings and coating
- Usage of Type V or modified Type II cement as required in mortar coatings on pipe, specials and fittings

420.04.02 Marking Pipe and Specials

The manufacturer shall legibly mark and number in sequence all steel pipe sections and specials in accordance with the laying schedule and pipe installation survey laying stations. All pipe specials shall be marked at each end with the top field centerline stations.

420.04.03 Lining and Coating Protection

It shall be the responsibility of the manufacturer to provide adequate strutting to prevent damage to the coating and lining caused by deflections beyond the specified allowable limits or the type of pipe supplied during handling, loading, transporting, unloading and storing.

420.04.04 Flanges and Nozzles

Flanges may be either ring type flanges or hub type flanges, but all flanges supplied must be of the same type and class. Blind flanges shall be designed in accordance with ASME Unified Pressure Vessel Code, Section VIII. The design pressure for blind flanges shall be minimum one-hundred fifty (150) psi.

Bolt holes in all flanges shall straddle field vertical centerline. Bolt holes for insulating flanges shall be three-sixteenths (3/16) inch larger than the bolt diameter.

Gaskets for standard flanged outlets shall be one-eighth ($\frac{1}{8}$) inch ring type compressed cloth inserted rubber Garlock 3000 or approved equal. Insulating flange gaskets shall be full face (Type E), G-10 glass reinforced epoxy gaskets with EPDM seal and G-10 sleeves and insulating washers per the Approved Products List.

Nozzles shall have one-quarter ($\frac{1}{4}$) inch minimum wall thickness.

The machined faces of all flanges shall be shop coated with rust preventative compound, Dearborn Chemical "No-Ox-Ld", Houghton "Rust-Veto 344" or Rust-Oleum "R-9" or approved equal. Edges and back faces of attached flanges shall be shop coated with Koppers "Bitumastic Mill Undercoat" or approved equal. All surfaces of blind flanges, except the machine's surfaces, shall be shop coated with Koppers "Bitumastic Mill Undercoat" or approved equal.

420.04.05 Mechanical Couplings

Where mechanical couplings are required, the ends of the pipe shall be prepared for flexible steel couplings, Dresser, Baker or approved equal. Plain ends for use with couplings shall be smooth and round for a distance of twelve (12) inches from the ends of the pipe, with pipe diameter not more than one-sixty-fourth (1/64) inch smaller than the nominal O.D. of the pipe. The middle ring of the coupling shall be truly round. After welding, all middle rings shall be tested by cold-expanding a minimum of one (1%) percent beyond the yield point to proof-test the weld to the strength of the parent metal. The weld of the middle ring shall be subjected to air test for porosity.

The followers shall be single-piece contoured mill section welded and cold-expanded as required for the middle rings. They shall be of sufficient strength, in the opinion of the Project engineer, to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling. The shape of the follower shall be of such design as to provide positive confinement of the gasket.

Gaskets shall be rubber-compounded material that will not deteriorate from age or exposure to air under normal storage or use conditions. The rubber in the gasket shall meet the following specifications:

1. Color - Jet Black
2. Tensile Strength - 1000 psi Minimum Surface - Non-blooming
3. Elongation - 175% Minimum Durometer Hardness - 74 + 5
4. The gaskets shall be immune to attack by impurities normally found in water. All gaskets shall meet the requirements of ASTM designation D2000 AA 709Z meeting Suffix B13 except as noted above.

In addition, where insulating couplings are required, both ends of the coupling shall have a wedge-shaped gasket which assembles over a rubber sleeve of an insulating compound in order to obtain insulation of all coupling metal parts from the pipe.

Where restraint is required on an insulating coupling, G-10 isolation washers and bolt sleeves must be installed on each restraint rod.

Each coupling shall pass a resistance test of 10,000 ohms after being assembled on the pipe for seventy-two (72) hours.

420.04.06 Closures and Correction Pieces

Closures and correction pieces for steel pipe shall be provided as required so that closures may be made due to different headings in the pipe laying operation and that correction may be made to get the pipe laying on station. Closures and correction pieces shall be provided as required by the Contractor and shall be approved by the Project Engineer.

Closures shall be so constructed as to have not less than a minimum of eighteen (18) inches and maximum of two (2) times the pipe I.D. adjustment, which may be made in the field.

The correction piece shall be a nominal length of pipe with a length of bare pipe on the spigot end for a field trim. Linings shall be held back six (6) inches from the required length on the spigot end.

420.04.07 Specials and Fittings

Unless otherwise specified herein or on the plans, all specials and fittings for steel transmission lines shall conform to the dimensions of the applicable AWWA or ASTM Standards. Specials and fittings shall be designed and constructed to be of equal or greater strength than the transmission line and shall have the same type of lining and coating as the abutting pipe. Specials and fittings shall be made of segmentally welded sections from

hydrostatically tested Pipe cylinders, with ends to mate the type of joint or coupling specified. The deflection angle between adjacent segmented bands shall not be greater than twenty-two and one-half (22 ½) degrees.

Specials and fittings for steel pipe that cannot be mechanically lined and coated shall be lined and coated by hand, using the same materials as are used for the pipe and in accordance with the applicable AWWA Standards. Coatings and linings applied in this manner shall provide protection equal to that specified for the pipe. Fittings may be fabricated from pipe that has been mechanically lined and/or coated. Areas of lining and coating that have been damaged by such fabrication shall be repaired by hand applications in accordance with applicable AWWA Standards. Areas of cement-mortar linings repaired in this manner need not be reinforced with wire mesh.

Reinforcement for wyes, tees, and nozzles shall be designed in accordance with AWWA M-11 Steel Pipe: A Guide for Design and Installation . Reinforcement shall be designed for the working pressures indicated.

Access maintenance holes with covers shall be twenty (20) inches in diameter (O.D.) as detailed on the drawings. All threaded outlets shall be forged steel suitable for 3000 pound service.

Moderate deflections and long radius curves may be made by means of beveled joint rings, by deflecting a straight pipe, by using short lengths of pipe, or by a combination of any of these methods.

Unless specifically approved by the Project Engineer, all curves for steel pipe must begin with a pipe joint or fabricated angle at the P.C. and end with a pipe joint or fabricated angle at the P.T. within station locations shown on the Drawings. All deflection angles shall fall on the curve. The laying schedule P.I.'s must meet the P.I.'s as shown on the Drawings in the horizontal direction. The laying schedule for vertical P.I.'s must meet the P.I.'s as shown on the drawings where interference is critical.

420.05 Polyethylene Wrap for Ductile Iron Pipe and Fittings

The polyethylene encasement material shall be in accordance with the Detail Drawings and the Approved Products List found in these Standards and Specifications. Polyethylene wrap is required for all ductile iron pipe and fittings.

420.06 Fittings

Ductile iron fittings shall comply with AWWA C110 and/or C153. Class designation shall be compatible with the pipe class designated for the project. Joints shall be mechanically restrained. Integral restrained joints that comply with AWWA C111 may be used with approval of the Project Engineer. Rubber gasket joints shall comply with AWWA C111. A standard thickness cement mortar lining shall be applied to comply with AWWA C104. All fittings shall be coated per AWWA C110 or C116 and be encased in polyethylene wrap per AWWA C105, regardless of soil condition.

Mechanical joint restraint shall be wedge action, self-actuating, such as "Megalugs" or approved equal. Restraints shall be protected in accordance with Section 420.19- Corrosion Protection Systems of these Standards and Specifications. No all-thread shall be used.

Steel Pipe Transmission Line Fittings: All specials and fittings shall conform to the dimensions of AWWA C208. Fittings shall be of the same material and thickness as the pipe . The minimum radius of elbows shall be two and one half (2.5) times the pipe diameter, and the maximum miter angle on each section of the elbow shall not exceed 11 ¼ degrees. If elbow radius is less than two and one-half (2.5) x pipe diameter, stresses shall be checked per AWWA M11 and wall thickness or yield strength increased if necessary. Fittings shall be equal in pressure design strength and shall have the same lining and coatings as the abutting pipe. Fittings shall be made of segmentally welded sections from hydrostatically tested pipe with ends compatible with the type of joint or coupling specified for the pipe.

Service Line Fittings: Service line fittings shall be of the manufacturer and types herein below specified only. Other manufacturers and model numbers must be approved by the Utilities Department prior to installation.

Fittings for PVC and Ductile Iron Distribution and Transmission Lines: Distribution and transmission line fittings for PVC and ductile iron pipe shall be ductile iron and in accordance with AWWA C153 and AWWA C110. Fittings shall have a three-hundred fifty (350) psi pressure rating. Fittings shall be coated both internally and externally with fusion bonded epoxy in accordance with AWWA C116. The fittings shall be furnished with mechanical joint ends in accordance with AWWA C111 and, in addition, the tee-head bolts and hexagon nuts shall conform to ASTM F3125, Grade A325 Type 3 and be fabricated from "Cor-Blue", a high strength, low alloy steel. 4" through 12" diameter fittings may also be ductile iron One-Bolt type with integral restrained joints as manufactured by One-Bolt, Inc. All metallic fittings shall be encased in polyethylene wrap per AWWA C105, regardless of soil conditions.

420.07 Gate Valves

All gate valves shall open left (counter-clockwise). Gate valves in sizes four (4) inches to twelve (12) inches shall be of the ductile iron body, non-rising stem (NRS), open left, resilient-seated type, with an AWWA standard two (2) inch square operating nut, manufactured in accordance with AWWA C509 or AWWA C515. Class designation shall be compatible with the pipe class designated for the project. Gate Valves shall be as listed on the Approved Products List.

All bolting shall be stainless steel AISI grade 304. If nuts are used on the bolts the nuts shall be 304 stainless steel and the bolt threads shall be coated with a snit-galling compound.

Valves shall comply with the requirements of ANSI/NSF 61.

Resilient gate:

The valve gate shall be ductile iron, fully encapsulated with EDPM rubber, and shall be capable of a drip-tight shutoff with flow in either direction. The EDPM shall be permanently vulcanized to the gate.

Stems:

Valve stems shall be made of stainless steel or bronze with a minimum yield strength of 40,000 psi. Stems shall be provided with separate or integral bronze thrust collars. Bronze valve stems shall contain no more than five percent (5%) zinc, no more than two percent (2%) aluminum, and no more than one percent (1%) lead. Stainless steel stems shall contain a minimum of sixteen percent (16%) chrome.

Seals and Gaskets:

Valve stem seals shall be an o-ring type, with not less than one (1) o-ring below the thrust collars and two (2) o-rings above the thrust collars. If an o-ring groove is cut into the stem, the diameter of the groove shall not be less than the root diameter of the stem threads. O-rings and gaskets shall be made of an NBR rubber to help prevent the effects of permeation. Bonnet gaskets shall be an o-ring type that completely encircles each individual bonnet bolt so that the bolts are isolated from internal or external water sources.

Protective Coatings:

The exposed ferrous surface shall be coated with a fusion bonded epoxy in accordance with AWWA C550.

420.08 Butterfly Valves

All butterfly valves shall open left (counter-clockwise). All valves having a nominal diameter of fourteen (14) inches or greater shall be geared butterfly valves designed for direct burial and shall comply with AWWA C504, Class 150B. Class designation shall be compatible with the pipe class designated for the project.

Valves shall be of the tight-closing, rubber seat type with rubber seats which are bonded to the valve body. No metal-to-metal sealing surfaces shall be permitted. Valves shall provide zero leakage at the pressure rating of the pipe in either direction. Valve discs shall rotate ninety (90) degrees from the full open position to the tight shut position. Coatings shall be equal to or exceed AWWA C550. Valve bearings shall be sleeve-type, corrosion-resistant and self-lubricating with the load not to exceed 2,500 psi.

Valve operators shall be the traveling nut type designed to withstand three-hundred (300) foot-pounds of input torque at full open or closed positions without damage to the valve or operator. Valve operators shall be fully gasketed, grease packed, designed to withstand submersion in water to ten (10) psi and operate with a two (2) inch square nut.

Manual valve operators shall be installed on the north or east side of the valve and sized and designed to develop output torques for Class 150 B operating service and shall be sufficient to seat, unseat and rigidly hold the disc in any intermediate position for the above conditions. The operator shall be capable of withstanding an overload input torque of three-hundred (300) ft/lbs at full open or closed position without damage to the valve or valve operator.

420.09 Pressure Reducing Valves

Pressure reducing valves shall operate at a pressure of one-hundred fifty (150) psi gauge and be capable of reducing a high existing pressure to a pre-adjusted lower downstream pressure for varying rates of flow without causing water hammer on the system.

All pressure reducing valves shall be 150 Class suitable for a working pressure of two-hundred fifty (250) psi. Distribution main and lateral line pressure reducing valves shall be installed in a vault and contain parallel valves for high and low flow ranges. Piping shall be ductile iron through the vault walls and extend three (3) feet past the vault walls in accordance with the Detail Drawings found in these Standards and Specifications. Oil filled differential gauges shall be installed with brass or stainless steel ball valves.

Pressure reducing valves shall be installed at location(s) noted on the approved plans. The valve shall be capable of maintaining a constant downstream pressure regardless of varying inlet pressure and shall be hydraulically operated and diaphragm-actuated with a globe or angle pattern. It shall contain a resilient, synthetic rubber disc having a rectangular cross-section contained on three and one-half (3-½) sides by a disc retainer, forming a tight seal against a single removable seat insert. The diaphragm assembly, containing a valve stem, shall be fully guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. This diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure. The diaphragm shall consist of nylon fabric with synthetic rubber and shall not be used as a seating surface. Packing glands and/or stuffing boxes are not permitted, and there shall be no pistons operating the valve or pilot controls. All necessary repairs shall be possible without removing the valve from the line. The valve shall be furnished with an indicator rod to show valve position.

The pilot control shall be a direct-acting, adjustable, spring-loaded, normally open, diaphragm valve designed to permit flow when controlled pressure is less than the spring setting. The control system shall include a fixed orifice.

The maximum fluid velocity through the valve shall not exceed fifteen (15) fps at maximum demand flow. The valve shall be designed to provide an access opening into the valve body for removing internal parts without removing the main valve body from the line. Valves shall be supplied and installed with stainless steel bolts, position indicator assembly, open and close speed controls, sustainer and preset pilot valves in accordance with City of Arvada specified pressures.

Pressure reducing valves approved for installation are as listed on the Approved Products List. Pressure reducing valves must be electrically isolated if there is electric actuation or dissimilar metals.

420.10 Fire Hydrants

Fire hydrants shall comply with AWWA C502 for dry-barrel fire hydrants, and shall be listed by Underwriters Laboratories or Factory Mutual Research Corporation. Casting or other permanent marks shall be used to confirm that fire hydrants comply with these standards.

Fire hydrants shall also comply with the following supplementary specifications:

1. Fire hydrants shall be as listed on the Approved Products List
2. Hydrants shall be rated at two-hundred fifty (250) psi operating pressure and tested at five-hundred (500) psi per Section 5.1 of AWWA C502. Production testing of each

hydrant shall be performed at five-hundred (500) psi to assure proper assembly and operation and detection of any imperfections. All iron parts as designated in Section 3.1.2 of AWWA C502 shall be ductile iron.

3. Hydrants shall be designed for five (5) feet pipe bury and shall not be buried below the first flange. The first flange shall be two (2) to four (4) inches above grade. A maximum of one (1) twenty-four (24) inch riser shall be used, and if a riser is required, a break-away coupling shall be installed at the first flange. Installation of a hydrant riser requires a separate, specific inspection. If a bury depth greater than seven (7) feet is required and approved by the City, a vertical shoe hydrant may be installed with written approval by City Engineer.
4. Nozzles shall be two, two and one-half (2-½) inch hose connections one-hundred eighty (180) degrees apart and one, four and one-half (4-½) inch pumper connection. All nozzles shall be at the same elevation. Nozzle threads shall be National Standard Fire Hose coupling screw threads as described in Appendix A of AWWA C502, unless otherwise specified. Nozzle caps shall be provided with chains and gaskets. Nozzle caps shall have the same nut configuration as the hydrant-operating nut. Nozzle shall be reverse threaded into the upper barrel and mechanically locked in place. Nozzles shall be twenty (20) to twenty-six (26) inches above finished grade.
5. Hydrant main valves shall be five and one-quarter (5¼) inch minimum and shall be of the full compression design, opening against and closing with the pressure. The main valve seat ring shall thread into a bronze sub-seat, and all gaskets sealing the seat ring shall be on a bronze-to-bronze seating surface. The seat ring threads shall not serve as a pressure seal. The entire valve and rod assembly shall be removable by use of a small lightweight seat removal wrench.
6. The drain valves shall allow complete drainage of all residual water in the hydrant. The circumferential drain passage inside the hydrant shall be bronze on all surfaces.
7. Hydrants shall be the breakaway types with a frangible groundline and rod coupling designed to break upon traffic impact to prevent further damage to the hydrant and connecting pipe. The frangible coupling shall allow the upper section to be rotated to any desired position. Couplings which employ lug devices or a breakaway barrel are not acceptable. Frangible bolts are not allowed.
8. Hydrant operating nuts shall be ductile iron and shall be Hexagonal in shape, one and one-half (1½) inch point to flat. The operating nut shall also function as a weather shield. Hydrants shall open right (clockwise).
9. The operating mechanism shall utilize two (2) o-ring seals between the revolving nut and bronze-sheathed upper section of the valve rod. The top of the rod shall also be fitted with a travel stop nut to limit downward travel on the rod. All-weather grease shall be used to provide permanent lubrication. A thermoplastic or Teflon thrust ring shall be used to reduce friction while opening the hydrant.

10. The hydrant inlet shall have mechanical joint restraint which shall be accomplished by use of wedge action, self-actuating fittings.
11. The buried portion of the hydrant shall be coated per AWWA C151, C115, and/or C116 and be encased in polyethylene wrap per AWWA C105, regardless of soil conditions. All ferrous metal parts shall be coated to comply with AWWA C550. The bonnet and nozzle cap shall be given one (1) shop coat of yellow color heavy duty alkyd enamel paint that complies with Federal Color No. 13538 Specifications. A final coat of industrial enamel VOC complying, Industrial & Marine coating paint shall be applied in the field. This paint shall be Sherwin Williams-and shall be paint code B54YZ37 – YELLOW.

420.11 Valve Boxes

All buried valves shall be provided with a valve box. Valve boxes shall be gray cast iron, ASTM A48 Class 35B, two (2) piece adjustable screw boxes with a round base and a five and one-fourth (5 $\frac{1}{4}$) inch screw-type shaft suitable for depth of cover as required. Box lids shall be marked "WATER". Valve boxes shall be listed on the Approved Products List.

All valves set at greater than normal depth shall have an extension stem provided and installed with the valve box so that the valve may be operated with a standard seven (7) foot valve key. A valve operating nut at six (6) feet or greater below final grade shall have an extension stem provided to bring the operating nut to a depth of four (4) feet below final grade. Coatings shall comply with AWWA C116 and polyethylene wrap per AWWA C105, regardless of soil conditions. Valves set greater than eight (8) feet below final grade may require a maintenance hole over the valve operator as determined by the Project Engineer.

420.12 Air Release and Vacuum Relief Valves

All combination air release and vacuum relief valves shall comply with AWWA C512. The large orifice of combination air valves shall allow air to escape during pipeline filling and to enter during drainage of the pipeline.

The valve shall consist of a body, cover, baffle, float and seat. The float shall be stainless steel designed to withstand a maximum pressure of 1,000 psi. All materials shall comply with ASTM A126 and ASTM A240.

Air release and vacuum relief valves shall be installed in a vault in accordance with the Detail Drawings found in these Standards and Specifications. Galvanized piping or fittings shall not be allowed.

Air Release-Vacuum Valves: Combination air release vacuum valves operating to one-hundred fifty (150) psi shall be of the single body, double orifice type allowing large volumes of air to escape out of the large air vacuum orifice when filling the pipeline and to close watertight when the liquid enters the valve. During closure of the large orifice, the small air release orifice shall open to allow small pockets of air to escape automatically and independently of the large orifice. The large air vacuum orifice shall also allow large volumes of air to enter through the orifice during pipeline drainage to break the vacuum. Valves shall be manufactured in accordance with AWWA C512. Drain plugs shall be removed before installation and broiler drains installed by the Contractor before the valve is put into service.

The valve body and cover shall be high strength plastic or cast iron conforming to ASTM A126, Class B. The body inlet must be baffled to protect the lower and upper floats from direct contact of the rushing air and water to prevent premature valve shut off. All floats shall be stainless steel conforming to ASTM A240, be hermetically sealed and designed to withstand a minimum of 1000 psi. The upper float shall be center guided for position shut off.

The valve seat shall be Buna-N Rubber. The seat must be fastened to the valve cover, without distortion, for drop tight shut off.

The level frame shall be Delrin conforming to ASTM D638 and the lug shall be bronze conforming to ASTM B124-55.

Guard Valve: The guard valve to be used with two (2) inch and smaller air valves shall be a full body stainless steel ball valve with female iron pipe threads and stainless steel handle, or approved equal. Connections between the air and guard valve shall be made using brass nipples conforming to AWWA C800, "Threads for Underground Service Line Fittings". Large guard valves may be flanged type. A service saddle shall be used to install taps for all combination air release vacuum valves installed on water mains. Service saddles shall conform to the manufacturer and type shown in the Approved Materials List For air release-vacuum valves installed on transmission mains larger than sixteen (16) inch diameter, saddle shall be all stainless or double strap all bronze service saddle in accordance with the Approved Materials List.

420.13 Blow-off and Drain Assemblies

The temporary blow-off shall be through a two (2) inch ball valve with a two (2) inch gate valve operating nut, box, piping and cover. Unless otherwise approved in writing by the Project Engineer, all piping shall be threaded copper and valves shall be brass. Galvanized piping and

fittings are not allowed. Refer to the Detail Drawings found in these Standards and Specifications.

Permanent six (6) inch drains shall be approved by the Project Engineer and shall be constructed in accordance with the Detail Drawings found in these Standards and Specifications.

420.14 Vaults

Vaults may be precast or cast-in-place and shall be constructed in accordance with these Standards and Specifications. Precast vaults shall be designed so that all joints and corners are waterproof. Precast and cast-in-place vaults shall be made waterproof after construction by use of sealants, epoxies, or other approved methods.

The vault roof shall be designed to support the overhead fill, any surcharge and an H-20 traffic loading. Where the cover over the roof is less than two and one-half (2½) feet or more than five (5) feet, a cast-in-place vault is required unless approved otherwise by the Project Engineer.

Cast-in-place meter vaults shall be in accordance with the Detail Drawings found in these Standards and Specifications and shall be constructed of CDOT Class B concrete with steel reinforcement in accordance with the CDOT M&S standards.

Electrical isolation between vault rebar and any metallic piping shall be maintained.

420.15 Maintenance Holes

Refer to Section 514.02- Maintenance Holes and Section 522.07 - Cast and Ductile Iron Fittings of these Standards and Specifications. Lids shall be furnished with the word “ARVADA WATER” cast on top.

420.16 Maintenance Hole Base Slabs and Base Beams

Refer to Section 522.05 - Maintenance Hole Bases and Base Beams.

420.17 Sump Pits for Vaults and Maintenance Holes

Sumps with a gravity drain line or sump pump are required for vaults or maintenance holes in areas where there is groundwater present and in all telemetry equipment and pressure regulating valve maintenance holes and vault installations. Refer to the Detail Drawings found in these Standards and Specifications.

420.18 Vent Pipes

Vent pipes shall be used in all vaults and maintenance holes to allow gasses to escape. Installations that contain electrical equipment shall have a blower attached to the vent system. Vent pipes shall be field located, as approved by the Project Engineer, at the nearest intersection of the street property line and the side lot line. Refer to the Detail Drawings found in these Standards and Specifications.

Above ground vent pipe shall be six and five-eighths (6-5/8) inch O.D. galvanized steel pipe, Grade 40 that complies with ASTM A53. The vent screen shall be three-fourths ($\frac{3}{4}$) inch No. 9-11 flattened, expanded galvanized metal screen. Below ground vent pipe shall be six (6) inch, schedule 40 PVC with glued joints. A PVC glued joint by standard pipe thread female adapter shall be used to connect the steel pipe to the PVC pipe at ground level.

420.19 Corrosion Protection Systems

When soil resistivity is less than 10,000 ohm-centimeters (OHM-CM), metallic pipe and fittings shall be protected against corrosion.

Methods to provide corrosion protection of integral metallic parts of the water transmission system are as follows:

1. Corrosion Resistant T-head Bolts and Nuts shall be 45,000 psi minimum steel with a fluoropolymer coating. See Approved Products List for allowed items, and shall be either:
 2. Ductile Iron Pipe and Fittings shall be furnished from the manufacturer with cement mortar lining and bituminous coating. Pipe and fittings shall be double wrapped with polyethylene wrap and taped at each end.
 - a. Polyethylene Wrap shall be eight (8) mil minimum, close-laminated wrap and shall be manufactured in accordance with AWWA C105 and as listed in the Approved Products List with the following additional requirements or exceptions.
 - i. Materials Polyethylene encasement shall be linear low-density polyethylene film with a minimum DFT of eight (8) mils.
 - ii. Color Polyethylene encasement shall be clear (natural color).
 - iii. Installation Flat tube material shall be used for pipe and fitting encasement; flat sheet material shall be used for valve encasement.
 - iv. Quality Control the manufacturer shall furnish a written statement that the inspection and all specified tests have been completed and

that results comply with the requirements of these Standards. A copy of the certification shall be provided to the City, if requested.

v. Polyethylene Wrapping and Taping shall be inspected by an Arvada Inspector/Representative prior to backfilling.

3. Steel Pipe and Fittings shall be furnished from the manufacturer with cement mortar lining and tape or bonded coating system.
 - a. Buried steel piping with a tape or bonded coating system shall be tested prior to backfill with a high voltage or pulsed DC ‘holiday’ detector as per ASTM G-62 and manufacturer’s instructions.
 - i. All discovered coating discontinuities or ‘holidays’ shall be repaired and re-tested.
 - b. Coating tests shall be witnessed by an Arvada Inspector/Representative prior to backfilling.
4. Butterfly and Gate Valves shall be furnished from manufacturer with a coating equal to or exceeding AWWA C550 or AWWA C116. Bolts and nuts shall either be epoxy or fluoropolymer coated. Valves shall be wrapped with a non-firming, wax based anti-corrosion wrap system. The wax wrap system shall be TRENTON anti-corrosion materials or approved equal.
5. Mechanical Joint Tees, Bends, Caps, Plugs and all other fittings shall be furnished from the manufacturer with cement mortar lining and coating system to match adjacent piping. T-head bolts and nuts shall be corrosion resistant. Any bare fittings or components shall be wrapped with a non-firming, wax based anti-corrosion wrap system. The wax wrap system shall be as listed on the Approved Products List.
6. Mechanical Joint Restraint (Wedge action, self-actuating, such as Megalugs) for ductile iron pipe shall be furnished from the manufacturer with a bituminous or epoxy coating. Mechanical joint restraint for PVC pipe shall be furnished from the manufacturer with red primer coat. T-head bolts and nuts shall be corrosion resistant. Mechanical joint restraint shall be wrapped with a non-firming, wax based anti-corrosion wrap system. The wax wrap system shall be as listed on the Approved Products List.
7. Damage to Epoxy and/or Other Material Coatings shall be repaired and inspected prior to installation.
8. Record Drawings shall provide coordinate locations of all metallic items, including but not limited to pipe, valves and fittings to “GPS backpack” accuracy. Refer to Section 200 – Acceptance Procedures of these Standards and Specifications for more information.
9. Cathodic Protection for Steel Casings all steel casings shall be protected from corrosion by a galvanic anode cathodic protection system. The galvanic anode cathodic protection system shall comprise two test stations placed at each end of each

steel sleeve that shall connect galvanic anodes to the sleeve as shown in Detailed Drawing number 400-64 to 400-67.

10. Metallic water transmission lines, eighteen (18) inches and larger, shall be cathodically protected by means of a National Association of Corrosion Engineers (NACE) designed sacrificial anode system or an impressed current cathodic protection and monitoring system. Materials to be incorporated into the system shall be as hereinafter listed unless otherwise approved as equals prior to bidding by the Project Engineer.

The cathodic protection system shall be designed by a Colorado Licensed Professional Engineer, accredited by the National Association of Corrosion Engineers (NACE) as a Cathodic Protection Specialist (CP4). Installation shall be performed under the direction of a licensed Professional Engineer who is accredited by the National Association of Corrosion Engineers as a Cathodic Protection Specialist (CP4). Each cathodic protection system shall be tested under the direction of a Colorado Licensed Professional Engineer who is accredited by the National Association of Corrosion Engineers as a Cathodic Protection Specialist (CP4). A final, continuity report on the installation and testing/monitoring procedures shall be prepared by a Colorado Licensed Professional Engineer who is accredited by the National Association of Corrosion Engineers as a Cathodic Protection Specialist (CP4) and submitted to Arvada. Testing and final report by a CP4 may be waived by the Project Engineer.

Metallic water pipe shall be electrically insulated at its connection to the transmission main. New runs of metallic pipe shall be designed for electrical continuity throughout the run, but shall be electrically insulated at connections with pipelines of dissimilar metal, dissimilar metals, casings, electrical grounding, or other locations specified. Bonding of joints shall be required. Ductile iron and steel pipelines shall be cathodically protected using a passive (preferred) or impressed current anode system as determined in the design.

Cathodic protection test stations shall be provided and shall be shown on the approved construction drawings. Test stations shall be located outside of travel lanes and readily accessible.

Cathodic protection and monitoring components shall be as listed on the Approved Products List.

420.19.01 Isolation Devices

For metallic pipes, isolation devices shall be installed as determined in the design. Isolation devices shall be listed on the Approved Products List and shall be installed in accordance with the Detail Drawings found in these Standards and Specifications.

420.19.02 Tape

The polyethylene seams and overlaps shall be wrapped and held in place by means of two (2) inch wide plastic-backed adhesive tape. The tape shall be as listed on the Approved Products List. The tape shall have adhesive that shall bond securely to both metal surfaces and polyethylene film.

420.20 Tracer Wire, Warning Tape, and Marker Posts

A No. 12 AWG solid copper wire shall be attached to all pipes, including at least one carrier pipe inside a casing pipe, for the purpose of future location. If tracer wire is not attached to a carrier pipe, it may be cad-welded to both ends of a casing pipe and terminated in test stations within ten (10) horizontal feet from the ends of the casing pipe. Split connectors as listed in the Approved Products List shall be used.

For domestic water lines, tracer wire shall be run along each fire hydrant assembly and brought to the surface to be looped through a test station and back to a ground rod, all located behind the fire hydrant. No tracer wire shall be allowed in valve boxes. Test stations shall be listed on the Approved Products List. For non-potable water lines, the tracer wire shall run along the outside of the in-line valve box, and through a hole drilled into the side of the triangle valve box with the wire then extended up to the surface. In all air-vac maintenance holes, tracer wire shall run up the stairs to the surface. Tracer wire shall be continuous through all vaults and maintenance holes.

The City of Arvada will verify continuity of all new and existing tracer wire that is located within the project site. Uninterrupted continuity is a requirement for Construction Acceptance. A qualified tester may be used with written approval by the Project Engineer.

All pipelines shall have a two (2) inch wide warning tape installed two (2) feet above the top of pipe for the purpose of warning of location of buried pipeline. The marker tape shall be blue in color with black lettering in a continuously repeating pattern with the words "CAUTION WATER LINE BELOW".

All pipeline valves, fittings, and maintenance holes that are not located in a hard paved surface, asphalt or concrete, shall have a concrete collar and a triview marker post. Marker posts shall be Rhino Industries Marking & Protection Systems or approved equal. Marker posts for domestic water shall be blue and shall include on all three sides, a decal with City of Arvada's logo and the universal "Call Before You Dig" symbol. Post and decal shall be as listed on the Approved Products List. Marker posts for non-potable water shall be purple and shall include on all three

sides, a Rhino decal SD-6309K-R with the City's logo and the universal "Call Before You Dig" symbol.

Reference Detail Drawing 400-6 for additional details.

420.21 Bedding Materials

Bedding materials shall comply with Section 367.00 - Bedding for Pipelines and Service Lines of these Standards and Specifications.

420.22 Concrete

All concrete shall comply with Section 800 – Concrete Mix Design and Construction of these Standards and Specifications for Portland cement concrete construction.

420.23 Plastic Liner Pipe (Sliplining)

Water main slip lining materials shall comply with Section 522.10.01 In-Place Rehabilitation of Existing Pipelines of these Standards and Specifications.

420.24 Steel Casings

Welded steel casing pipe shall be ASTM A53 Grade B steel and shall have an inside diameter at least four (4) inches greater than the outside diameter of the bell or joint or mechanical restraint of the carrier pipe. Casing pipe installed with a non-metallic carrier pipe shall be coal tar epoxy coated. Casing pipe that is installed with a metallic carrier pipe shall not be coated. All metallic casings shall have cathodic protection anodes and a monitoring station cad welded to each end.

Minimum Wall Thickness of the Casing Pipe

Wall Thickness	Casing O.D.
3/8"	30" and smaller
1/2"	32" or larger

All potable water carrier pipe through casings shall comply with AWWA C900 or C909.

420.24.01 Casing Spacers and Insulators

As listed on the Approved Products List and installed at a maximum center to center spacing of ten (10) feet along the carrier pipe invert with an additional spacer placed within six (6) inches of each end of the casing pipe. Spacers shall be eight (8) inch width for carrier pipe six (6) inch to fourteen (14) inch diameter, twelve (12) inch width for carrier pipe sixteen (16) inch diameter or larger. The casing spacer system manufacturer must have a current ISO 9001:2000 Registered Quality Assurance Program. The casing spacer system must maintain electrical isolation of the carrier pipe and the casing pipe.

420.24.02 End Seals for Casing Pipe

A one-eighth ($\frac{1}{8}$) inch thick synthetic rubber wrap around end seals with stainless steel bands shall be installed on the casing pipe after carrier pipe insertion. End seals shall be listed on the Approved Products List. End seals shall be watertight. Link seals may be used.

420.25 Gasket Pipe Lubricant

Gasket pipe lubricant shall be listed on the Approved Products List.

420.26 Pipe Insulation

Pipe insulation shall be as listed in the Approved Products List.

420.27 Tapping Saddles (Non-Service Type)

Tapping for a new distribution and/or transmission main is not allowed. If a situation arises where tapping is the only solution, justification shall be supplied to the Project Engineer for review. The Project Engineer may approve the tap on a case-by-case basis.

Tapping Saddles for Wet Taps of Distribution and/or Transmission Mainlines shall be manufactured by ROMAC or approved equal. Type of tapping saddle shall be determined by type and size of pipe being tapped and what size the tap is to be.

Tapping Valves: Tapping valves shall conform to all the requirements set forth herein above for resilient seat gate valves and the following:

The inlet end of the valve shall be Class 125 flange and the outlet end shall be a mechanical joint. Body of the valve and seat opening shall be sized large enough to accommodate the following sizes of shell cutters:

Shell Cutter Sizes

Tapping Valve Nominal Diameter	Shell Cutter Diameter
4"	3-7/8" +/- 1/32"
6"	5-13/16" +/- 1/32"
8"	7-7/28" +/- 1/32"
10"	9-7/8" +/- 1/32"
12"	11-7/8" +/- 1/32"

All tapping sleeves for use on PVC, ductile iron or existing asbestos cement (except for size on size taps on existing asbestos cement) water mains shall be designed for an operating pressure of one-hundred fifty (150) psi and shall be fabricated using Type 304 (18-8) Stainless Steel. Sleeve shall be furnished with gridded virgin SBR compounded gasket for water service that provides full three-hundred sixty (360) degree pipe coverage ("full gasket"). Gasket shall be shop glued to the body section of the sleeve and the gasket shall provide adequate seal for the design pressure. Sleeve flange shall be Type 304 (18-8) Stainless Steel having the flange face machined and recessed to receive standard tapping valve in accordance with MSS Standard SP-60 for sizes four (4) inch through twelve (12) inch. Flange shall conform to AWWA C207 Class D drilling. Bolts shall be Type 304 (18-8) Stainless Steel per ASTM A193 and A194. Fasteners shall be coated to prevent galling. Saddle models shall be listed on the Approved Products List. Size on size wet taps are allowed up to twelve (12) inch diameter. Size on size wet taps on asbestos cement water mains shall be as listed on the Approved Products List. Tapping sleeves for wet taps on steel water mains shall be weld on tapping outlets as listed in the Approved Products List. Weld on outlets shall be fusion bonded epoxy coated. A tapping saddle and valve, installed on an existing main, shall not be considered a substitute for a property line valve. The use of two (2) tapping saddles, when side by side or back to back, as a substitute for a cross will not be allowed. Edge of the tapping saddle must be a minimum of twenty-four (24) inches away from all joints as measured along the water main.

421.00 Installation

421.01 General

All work shall comply with AWWA C600, AWWA C605, and to the pipe manufacturer's installation instructions, except as modified by these specifications.

421.01.01 Special Boring Conditions for Potable Water Pipe

Boring of casing pipe and threading of carrier pipe shall be completed in accordance with Section 500 - Sanitary Sewer Facilities of these Standards and Specifications. Carrier pipe for water mains shall be installed in the casing pipe using approved centering, restraining casing spacers and insulators only. Steel banded skids and chocks are not allowed. Sand filler is also not allowed for water main carrier pipes.

Electrical isolation testing must be completed prior to and after backfill by a cathodic protection technician (CP2) accredited by the National Association of Corrosion Engineers. Testing by a CP2 technician may be waived by the Project Engineer.

421.02 Alignment and Grade

The waterline shall be installed to the required lines and grades with fittings, valves, and hydrants at the required locations. Record Drawings of waterline alignment, verified by a Professional Licensed Surveyor or a Professional Engineer, shall be furnished to the Project Engineer to comply with Section 200 – Acceptance Procedure of these Standards and Specifications. Refer to Section 516.00 - Relation to Other Utilities and Structures of these Standards and Specifications for additional requirements.

The grade and alignment of the pipe, structures and appurtenances shall be controlled by means of laser beams or offset grade stakes, set in the field by professional survey parties. The Contractor shall be responsible to accurately transfer said grade and alignment to the trench and construct thereto.

Laying Diagram: Each section of pipe shall be laid in the order and position shown on the laying diagram. In laying pipe, it shall be laid to the set line and grade, within a reasonable tolerance, approximately one (1) inch plus or minus. On grades of zero (0) slope, the intent is to lay pipe to grade. Fittings, valves and hydrants shall be installed at the specified stations and elevation. Three (3) copies of the approved laying diagram signed by the Contractor shall be submitted prior to installation.

421.03 Protection of Existing Underground Utilities

The Contractor shall be held responsible for the protection of public improvements as stated in Section 140.00 - Protection of Public, Private and Utility Interests of these Standards and Specifications. It shall be the Contractor's responsibility to replace all damaged public improvements at his/her own expense.

421.04 Interruption of Services

Interruption of services shall comply with Section 146.00 - Interruption of Services.

The Contractor must, in writing, advise affected users forty-eight (48) hours prior to performing work on a service, distribution or transmission line which will interrupt a customer's supply of water. Contractor prepared notices shall be hand delivered to each customer or occupant. If the occupant cannot be contacted, the written notice shall be left attached to the door knob or screen.

In addition, the Contractor must contact Arvada's Engineering Inspection Department through the City's permit system and as directed by the assigned inspector to schedule the closing of valves necessary to isolate the line or lines on which work is to be performed. Only City personnel are to operate existing system valves or new valves if they are connected to the City system.

A normal outage shall be a maximum of four (4) hours and between the hours of 8:30 a.m. and 3:00 p.m. If the outage will be greater than four (4) hours, the work shall be done in a manner to minimize the inconvenience to users, such as working at night in a continuous operation until service is restored. A connection which will require an outage longer than four (4) hours shall be subject to review by the City as to the appropriate time for the connection. If in the process of installing a connection there exists a customer, industry or building in the area that cannot be out of water such as a hospital, school, etc., the Contractor shall take appropriate means to provide and convey potable water to them at all times during the performance of the work.

Whenever a fire line serving a fire protection system is out of service, the respective fire protection district shall be notified a minimum of forty-eight (48) hours before the shut down.

421.05 Pipe Installation

Proper equipment, tools and facilities shall be provided and used by the Contractor for safe and efficient performance of the work. All pipe, fittings, valves, and hydrants shall be carefully lowered into the trench in such a manner as to prevent damage to pipe materials and to protect coatings and linings. Under no circumstances shall pipe or fittings be dropped or dumped into the trench. Any pipe or fittings that are dropped or dumped shall be removed from the work site and shall not be used.

When buried, all ductile iron pipe fittings and appurtenances shall be protected with thick polyethylene wrap. Miscellaneous steel or other ferrous pipe for blow-offs, etc., shall be

similarly protected. Refer to Section 364.00 - Trenching, Backfilling and Compacting of these Standards and Specifications for trenching, backfilling, and compaction requirements. Refer to Section 200 – Acceptance Procedures of these Standards and Specifications for survey requirements for Record Drawings of water lines.

The Arvada Inspector/Representative shall be notified at least one working day (twenty-four [24] hours) in advance of when pipe is to be installed in any trench. No pipe shall be covered until an Arvada Inspector/Representative has inspected the installation.

Installation of pipe and appurtenances shall be performed in accordance with the acceptable practices set forth by the American Society for Testing Materials (ASTM), the American Water Works Association AWWA C600, "Installation of Ductile-Iron Water Mains and their Appurtenances"; AWWA Manuals M9 "Concrete Pressure Pipe", M11 "Steel Pipe: A Guide for Design and Installation", AWWA C605, "Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water", approved plans and as modified herein.

At all times during construction of the pipeline, the Contractor shall use every precaution to prevent damage to protective coating on the pipe. No metal tools or heavy objects shall be permitted to come into contact unnecessarily with the finished coating. The Contractor will be permitted to walk upon the coating only when necessary, in which case they shall wear shoes with rubber or composition soles and heels. Any damage to the pipe or protective coating from any cause during the storage or installation of the pipeline shall be repaired prior to laying of the pipe, as directed by the Project Engineer, by and at the expense of the Contractor.

Progress of Work - The maximum amount of open trench allowed shall be that amount which, in the opinion of the Project Engineer, is reasonable and prudent for conditions existing at any particular location. That amount may be as little as sixty (60) feet at some locations. It is not the intention of this specification to impede the Contractor's progress; however, the Project Engineer will be the judge of the amount of open trench allowed.

In streets, the complete backfilling operation to the finished grade and cleanup operation shall proceed on a continuous basis and shall follow within one-hundred fifty (150) feet of the installation of the pipe. However, at the end of each working day, pipe backfill shall cover the installed pipe sufficiently to protect the coating and/or lining of the installed pipe. Any deviation from the above requirements shall be made only with the written approval of the Project Engineer.

Fire line installation shall be in accordance with this specification section and the requirements of the respective fire protection district. Fire lines shall be flushed as required by the respective fire protection district.

421.05.01 Storage of Materials

The Contractor shall store and adequately protect all material prior to installation. Any damage to the materials resulting from improper storage or handling by the Contractor shall be repaired or replaced by and at the expense of the Contractor.

Stored pipe shall at all times be supported on sawdust bags, timbers, sand bags or other suitable support. Bags shall be of sufficient size to prevent contact of the pipe coating with the ground or any obstruction. Rolling pipe sections on its coating surface will not be permitted.

When pipe laying is not in progress, the ends of the pipeline, all special openings and all pipe waiting to be laid shall be kept closed with suitable bulkheads to prevent unauthorized access by persons, animals, water or any other undesirable substances.

The bulkheads shall be designed to prevent drying out of the interior lining of the pipe. The Contractor shall introduce water into the pipe to keep the mortar lining moist where moisture has been lost due to damaged bulkheads.

It shall be the responsibility of the Contractor to prevent damage to coatings which might be caused by handling and/or embrittlement caused by storage of the completed pipe at low temperature.

PVC Pipe stored outside and to be exposed to sunlight for more than thirty (30) days shall be covered with a solid canvas to block the light. Clear plastic is not allowed as a cover. Air circulation shall be maintained under the covering.

421.05.02 Handling Pipe

Pipes, fittings, etc., shall be carefully handled and protected against damage to lining and coating, impact shocks, and free fall. All pipe handling equipment shall be approved by the Project Engineer. Pipe shall not be placed directly on rough ground but shall be supported in an approved manner which will protect the pipe against injury whenever stored at the trench site or elsewhere. No pipe shall be installed where its coating or lining shows cracks that may be harmful. Damaged coating or lining shall be repaired to the satisfaction of the Project Engineer, or a new undamaged pipe section shall be installed, at no expense to the City.

Pipe shall be handled, hauled, and placed using wide slings and padded cradles of canvas, leather, or other suitable material so designed and constructed to prevent damage to the pipe lining or coating. The use of bare metal cables, chains, hooks, or other equipment which might injure the pipe coating will not be permitted.

1. Pre-installation Coating Inspection: The Contractor shall permit and aid in the inspection of all coating on the underside of the pipe, at the time of the installation, and shall repair any damage before lowering the pipe into the trench. While being laid, the pipe shall not be rolled, skidded or otherwise moved when in contact with the ground at any point.
2. At the trench site, just prior to installing, the Contractor shall inspect the pipe coating for flaws, cracks, spalling, etc. Tape coated pipe shall be inspected for holidays with a Contractor furnished coil spring or brush type electrode, having a primary wattage no higher than twenty (20) watts and a minimum pulse, at crest voltage, of twenty (20) per second. Where holiday flaws are detected, they shall be repaired to the satisfaction of the Project Engineer before the pipe section is placed in the trench.
3. Pipe Struts: Struts in steel and pretensioned concrete cylinder pipe shall be left in place until backfilling operations have been completed. After the backfill has been placed, the struts shall be removed and will remain the property of the Contractor.

421.05.03 Pipe Laying

The Contractor, with the assistance of the Project Engineer and City Engineering Inspector, shall inspect each pipe and fitting to ensure that there are no damaged portions of the pipe. Metallic pipe joints will inherently have small amounts of burrs, gouges, weld splatter or other small defects which the Contractor will be required to remove or smooth out. On other than transmission lines the pipe shall be cut, whenever necessary, to conform to location of fittings, line or grade. All cuts shall be straight and true, in a workmanlike manner so as to leave a smooth end without damaging the pipe. All burrs shall be removed from the ends of cut pipe, and the end lightly rasped or filed.

The City Engineer may require that the new pipe be isolated from the existing system by a gap in piping until the new pipe has passed all disinfection, pressure, and bacteriological testing.

Cutting or beveling existing asbestos cement pipe will not be allowed. MOA-PVC pipe shall be used in place of MOA Asbestos-Cement Pipe.

Before placing pipe in the dry trench, each pipe section valve and fittings shall be thoroughly cleaned of all foreign material, kept clean at all times thereafter, and carefully examined for cracks and other defects before installation. Bell ends and spigot ends are to be examined with particular care. The openings of all pipe and fittings in the trench shall be closed to the satisfaction of the Engineering Inspector during any interruption to night or over the weekend.

Cement mortar coated pipe shall be inspected for cracking or spalling while supported in belted or canvas slings, prior to lowering in the trench. Where coating imperfections are found, and providing there is no visible damage to the pipe lining, straight pipe sections shall be rotated so the damaged coating is atop the pipe after being lowered and set in the trench.

The coating shall then be cement mortar repaired and allowed to cure for a period of twenty-four (24) hours before backfilling. Concrete coatings on beveled sections, bends and other special sections which cannot be rotated, as herein above described, shall be repaired to the satisfaction of the Project Engineer prior to setting in the trench.

1. Foundations: No pipe, fitting or appurtenance shall be installed upon a foundation into which frost has penetrated or at any time when the Project Engineer shall deem there is danger of the formation of ice or penetration of frost at the bottom of the excavation. No pipe shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.
2. Order of Laying Pipe:
 - a. Bell End Ahead and Uphill: Pipe shall be laid with bell ends facing in the direction of laying unless otherwise approved by the Project Engineer. In general, pipe shall be laid starting at the lower end of the line and proceeding uphill. In no case shall the pipe be laid in a downhill direction where the slope is greater than ten (10) percent, unless permitted by the Project Engineer in writing.
 - b. Downhill: When approved, pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. All bends shall be properly installed and anchored in place before continuing laying downhill
 - c. Curves: When laying pipe on curves, the intent is to lay each section to the alignment. The pipe shall be kept in alignment by placing all deflection joints or bends on the curve. Short lengths of pipe shall be used as necessary to accomplish curvature without exceeding individual

deflection specified by the manufacturer. Bends shall be used whenever individual deflections exceed those specified in these specifications.

3. Laying Procedure:

- a. Holes for Jointing and Sling Removal: Holes for jointing pipe sections and sling removal shall be excavated prior to setting the pipe in the trench. Bell holes shall have a minimum clearance of one (1) foot on each side of the pipe end and not less than eight (8) inches deep to allow room for taping or grouting the joint. For field welded joints the minimum bottom clearance shall be three (3) feet each side of the joint and one (1) foot deep.
- b. Lubricating Joint: Following final cleaning of the bell and spigot a non-toxic, water-soluble joint lubricant shall be applied to the gasket, and the spigot end of the pipe. Caution shall be exercised to ensure the correct type of gasket is used and the manufacturer's recommendations are followed when joining pipe sections.
- c. Rotating and Jointing: When the pipe is being laid, it shall be turned and placed where possible, so that any slight damaged coating will be on top. All damaged lined or coated areas shall be repaired using materials and methods as approved by the Project Engineer.
- d. Pipe shall be laid directly on bedding material. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe. The spigot end shall be aligned with the bell end and carefully centered so that the pipe is still supported by the slings such that the gasket will not drag as it is entered into the bell. The pipe shall be pulled together by an approved method such as or band and hydraulic jacking head as recommended by the pipe manufacturer. In all cases, the joint shall be assembled with the axis of the pipe lengths in a straight line; and deflection, if required, shall be taken by swinging the pipe end after the joint has been completely assembled. Pipe furnished without a depth mark shall be marked before assembly to assure insertion to the full depth of the joint. The spigot end of field cut pipe lengths shall be filed, or ground to resemble the spigot end of such pipe as manufactured. Care shall be taken to assure that the gasket is not twisted or pulled when the pipe is jointed.
- e. Where necessary to raise or lower the pipe due to unforeseen obstructions or other causes, the Project Engineer may change the alignment and/or grades. Such change shall be made by the deflection of joints, by the use of bevel adapters, or by the use of additional fittings. However, in all cases the joint shall be in conformance with Section 400 -

Water Supply Facilities of these Standards and Specifications. No joints shall be out of home any amount which, in the opinion of the Project Engineer, will be detrimental to the strength and water tightness of the finished joint. In all cases the joint opening, before grouting or finishing with the protective mortar inside the pipe, will be the controlling factor.

4. Detector Wire:

- a. The Contractor shall furnish and install detector wire on PVC water pipe as it is installed into the system. Wire shall be white, AWG size #12, type UF or USE cable, UL listed, with single copper conductor.
- b. During installation wire shall be taped to the top of the pipe exterior in a straight line. Splices due to breaks in wire continuity shall be made by stripping insulation from each wire end with wire stripper pliers. Wires shall be joined with a Dry Conn Direct Bury Lug solderless connector or approved equal installed in accordance with the manufacturer's instructions.
- c. The wire shall form a continuous electrical circuit between any two contact points on the new pipeline including branch lines and fire hydrant laterals. Wire shall be stubbed out to the point where new pipe connects to existing mains unless otherwise directed by the City representative. Where the wire terminates at a point where there is not an installed wire, a twenty (20) inch long by a one-half ($\frac{1}{2}$) inch diameter copper grounding rod shall be driven into the native soil and the tracer wire end stripped and connected to a ground rod clamp at the end of the grounding rod. Wire shall be extended to each fire hydrant installed and looped through a test station and grounded. Wire shall not be cut at the test station and shall not be connected to the test station leads. Test station shall only serve as an access point for the wire.

5. Bell and Spigot Steel Joint Seating:

- a. Pipe with Carnegie Joint End Rings: As the spigot is thrust home, its advance shall be checked by two (2) steel inserts held in the seat of the bell one-hundred eighty (180) degrees apart. These inserts shall be removed and a feeler gauge entered into the recess to detect any irregularity in the position of the rubber gasket. If the gasket cannot be felt all around, the joint shall be disassembled. If the gasket is undamaged as determined by the Project Engineer, it may be reused, but only after the bell ring and gasket have been reshaped, as previously specified. After reassembling the joint, the position of the gasket shall again be checked. The tied joints shall be jointed as above, and then the necessary wedging or clamping shall be done as recommended by the pipe manufacturer.

- 6. Pipe with Expanded Bell and Rolled Spigot Ends:**
 - a. After the joint has been pulled completely together as indicated by the stab marks, the gasket shall be checked using a feeler gauge. This check shall be made around the complete circumference of each joint to be sure that the gasket has not rolled out. If a gasket has rolled out, the joint shall be pulled apart, the gasket inspected, and, if damaged, shall be discarded and a new gasket installed. It should be noted that it is extremely important to obtain full engagement of the stab joint and to check each joint as it is laid.
 7. Each steel pipe length shall be backfilled at least partially before the next length is installed to prevent pullout or movement of the expansions and contraction.

421.05.04 Specials and Fittings

Mechanical and Flexible Coupled Joint: When installing mechanical and flexible steel couplings, care shall be taken that the connecting pipe ends, couplings and gaskets are clean and free of all dirt and foreign matter with special attention being given to the contact surfaces of the pipe, gaskets and couplings. These couplings shall be assembled and installed in conformity with the recommendation and instructions of the coupling manufacturer. All mechanical couplings shall be fusion bonded epoxy coated with stainless steel bolts.

Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Coupling bolts shall be tightened so as to secure a uniform annular space between the middle ring, follower rings and the body of the pipe with all bolts tightened approximately the same amount. Diametrically opposite bolts shall be tightened progressively and evenly. Final tightening shall be done with torque wrenches set for the torque recommended by the coupling manufacturer. All clamping torque shall be applied to the nut only.

Field Welded Joint: When laying pipe requiring a field welded joint, pipe deflection shall be limited to that which will produce a lap of one (1) and one and one-half (1½) inches.

1. **Butt Strap Joint:** Butt straps, where required, will be a minimum of six (6) inches wide, the same thickness as the pipe wall, and will be welded to one end of each pipe section so the joint can be lapped on the outside of the pipe.
 - a. On joints where butt straps are used for realignment, adjustment, or deflection, the pipe ends will be cut straight, and fillet welds shall be made on the outside of the pipe.
2. **Lap Joints:** On lap joints, exterior fillet welds shall be made as shown on the drawings. The remaining seal weld, where required, shall be three-sixteenths (3/16) inch at a

minimum. An inside weld shall not be required. The clearance, beforefield welding, between the outside circumference of the spigot end and the inside circumference of the bell end shall be not less than 0.09" nor more than 0.41".

3. Bell and Spigot Joints: Where welding of a bell and spigot joint is required, the all-around gap between the bell and spigot as delivered from the manufacturer shall not be less than one thirty-secondth (1/32) (0.03125) nor more than three thirty-secondths (3/32) (0.09375) of an inch.

Flanged Joint: Before the joint is assembled, the flange faces shall be thoroughly cleaned of all foreign material with a power wire brush. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges. All bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable approved and calibrated torque wrench to a torque value as recommended by the manufacturer. All clamping torque shall be applied to the nuts only.

Harnessed Joints: Joint harnessing by use of rods and clamps shall be installed at interference crossings; on fire hydrants, bends, offsets, domestic and fire sprinkler connections.

Rod material required to harness six (6) inch to eighteen (18) inch pipe joints is specified in Section 420.04.04 - Flanges and Nozzles of these Standards and Specifications. After the rods are bolted in place, they shall be double wrapped with eight (8) mil thick polyethylene or other approved cold applied tape. In addition to rodding restraints, bends, fire hydrants and tees shall be kickblocked against undisturbed soil with concrete.

Harnesses, where required, on twenty (20) inch and larger transmission lines, shall be of a type as specified in AWWA Manual M11.

Retainer Joints: Mechanical joint retainer glands may be used in lieu of rods and clamps for joint harnessing at interference crossings, fire hydrants, tees, bends, offsets, domestic and fire sprinkler connections. After the retainers are bolted in place they shall be wrapped with eight (8) mil thick polyethylene or other approved cold applied tape. In addition to the retainer gland all bends, fire hydrants and tees shall be kickblocked against undisturbed soil with concrete.

Insulated Joints: Extra care shall be exercised when installing insulating joints. After the insulating joint has been installed, an electrical resistance test shall be performed by an independent corrosion engineering company selected by the City. Should the resistance be found less than 10,000 ohms, the insulating joint shall be removed and any necessary repairs

made. The joint shall then be reinstalled and retested. This process shall continue until the joint is successfully tested. Retesting shall be at Contractor's expense.

Bonding Joints: The Contractor shall provide and make two (2) each electrical bonds or more between the metallic cylinders of adjoining pipe sections and across all non-insulating joints. In line valves shall be made electrically continuous where called for on the drawings.

Electrical bonds shall be installed, one each side of the Pipe crown centerline, at approximately twenty (20) degrees apart, when measured from the pipe centerline. Bonding cables shall be long enough and provide sufficient slack to a displacement of two (2) inches.

Expanded bell and spigot steel joints shall be bonded using #4 AWG or larger insulated copper wire, Cadweld CA-15 brazing cartridges and thermite weld caps. Carnegie end ring joints shall be bonded by welding each end of a six by three-eighths (6" x $\frac{3}{8}$) inches steel jumper rod, rolled to the mean diameter of the annular space between the rings, to the bell and spigot.

Bonding across insulated flanged joints or insulated couplings will not be allowed.

421.05.05 Joint Coating and Lining

The inside and outside of all joint recesses shall be thoroughly wiped clean to the satisfaction of the Engineering Inspector. In this cleaning operation all water, loose scale, dirt and other foreign material shall be removed from the surface of the pipe joints to be coated and lined in the field.

1. **Interior Joint Lining of Welded Steel Pipe Joints:** Material used for mortar lining shall conform to AWWA C205. At welded joints the Contractor shall furnish and tack weld two (2) inches by four (4) inches of 13/13 gauge self-furred welded wire fabric to the inside of the joint recess prior to application of mortar. The mortar shall be applied with a uniform pressure producing a smooth surface and a uniform thickness of lining to match the shop applied mortar lining. At no point shall there be an indentation or projection of the mortar which exceeds one-sixteenth (1/16) of an inch. Every precaution shall be taken to prevent damage to the lining. After the mortar lining has set sufficiently, clear seal compound "Protex" or equal, shall be applied to the joint lining to the satisfaction of the Project Engineer. With the approval of the Project Engineer, Probond or equal may be used in place of the welded wire fabric.
2. **Exterior Tape Coated Pipe Joints:** The exterior of all joints shall be thoroughly cleaned of all foreign material to the satisfaction of the Engineering Inspector and primed with Polyken #927 primer and wrapped with two (2) wraps of #930 Polyken tape.

Each tape layer shall be thirty five (35) mils thick and applied so that joints lap. The primer and tape shall be manufactured by the same manufacturer as the shop applied tape coating.

3. Exterior Cement Mortar Coated Pipe Joints: After cleaning, the outside joint recess shall be filled with grout composed of one (1) part cement and two (2) parts sand. The grout shall be poured under a polyethylene lined grout band placed around the joint recess and thoroughly rodded with a stiff wire. The joint recess at the top shall then be closed with a stiffer grout of the same mix as above. Except for piped joints, prefabricated joint protectors may be used as an alternative to mortaring the outside of the joint. If such protectors are used they shall be made from a high density polyester, polyurethane foam containing at least the equivalent of nine (9) bags per cubic yard of un-hydrated Portland Cement. The protectors shall be of suitable cross section to fully protect the joint rings and shall be supplied in the form of continuous rings. No backfilling around the outside of the joints shall be done until the grout has set, and the joint has been inspected and approved.
4. Interior Cement Mortar Lined Pipe Joints on Steel Pipe: After cleaning, the inside pipe joint recess shall be dry packed filled with a grout composed of one (1) part cement and one (1) part sand. This grout shall be troweled flush with the interior surface, and all excess shall be removed. At no point shall there be an indentation of the projection of the mortar exceeding one-sixteenth (1/16) of an inch.

421.05.06 Coating of Flexible Joints, Valves and Fittings for Steel Pipe

After assembly and cleaning; the exposed metal surface shall then be primed by brush or spraying and then wrapped with two (2) layers of Type II elastomeric tape, all in accordance with AWWA C209 "Tape Coatings for Steel Water Pipe and Fittings".

NOTE: When lined pipe, coated in conformance with AWWA C214 is installed, the appurtenances shall be primed and tape coated using Polyken Primer and Tape.

The two (2) layers of tape, each thirty five (35) mil thick, shall overlap the adjoining pipe sections a minimum of three (3) inches. A final six (6) inch wide tape wrap shall be placed over the above two tape wraps to seal all seams, folds or overlaps.

1. Coating Non-Metallic Pipeline Appurtenances: Metallic fittings, valves and inline appurtenances installed in nonmetallic water lines, (existing asbestos cement and

polyvinyl chloride) may be wrapped in two (2) layers of polyethylene in lieu of the Type II tape as specified above.

The polyethylene shall have a minimum thickness of eight (8) mils and shall be in accordance with AWWA C105. A two (2) inch wide, ten (10) mil thick polyethylene sensitive tape shall be used to close seams and hold folds over overlaps. Damage to polyethylene wrapped fittings and appurtenances in the trench prior to and during backfill shall be repaired to the satisfaction of the City. All polyethylene wrapping shall be repaired and in a state of readiness prior to tapping a line.

421.05.07 Field Welding Procedures

Field welding shall be performed in accordance with AWWA C206 "Field Welding of Steel Water Pipe".

All welding shall be done by skilled welders who have had adequate experience in the method and materials to be used. All welding operators shall be qualified under the provisions of AWS D1.1/D1.1M:2020. Welders shall be qualified by a local approved testing agency not more than six (6) months prior to commencing work on the pipeline. Machines and electrodes similar to those used in the work shall be used in qualification tests. The test will include welding an actual field section to the top of the pipe.

The Contractor shall furnish all materials and bear the expense of qualifying welders and submit to the City, proof of their certification.

1. Pipe Coating Protection During Welding: An eighteen (18) inch wide strip of heat resistant material shall be draped over the top half of the pipe on each side of the coating holdback during welding to avoid damage to the coating by hot weld splatter. No welding ground shall be made on the coated part of the pipe.
2. Stress relief where more than one (1) welding pass is required, the welding procedures set forth in AWWA C206 shall be strictly adhered to; all dirt, slag and flux shall be removed before the succeeding bead is applied.

421.05.08 Exterior Coatings for Pipe and Fittings

1. Steel Pipe Coatings: Exterior coating for steel pipe shall be a multi-layer eighty (80) mil prefabricated Polyken YG-111 Tape System conforming to AWWA C214 "Machine-Applied Polyolefin Tape Coatings for Steel Water Pipe", or a cement mortar

- coating conforming to AWWA C205 "Cement Mortar Protective Lining and Coating for Steel Water Pipe four (4) inches and Larger - Shop Applied".
2. Shop Applied Concrete Coating: Type V cement conforming to ASTM C150 "Specification for Portland Cement" shall be used in concrete placed in the walls of concrete cylinder pipe or on metallic pipe to be coated in accordance with AWWA C205 .
 3. Modified Type II Portland Cement, having a low tricalcium aluminate content, is considered as an equal alternate for Type V cement.
 - a. Dielectric Coating Over Concrete Coated Pressure Pipe: Prior to shipment, the exterior concrete surface shall be spray seal coated with a 100% solids cool for epoxy, applied at the rate of sixty-one (61) sq. ft. per gallon and control cured. Epoxy and its application shall conform to the latest requirements of the U.S. Bureau of Reclamation.
 4. Shop Applied Tape Coating: Shop applied tape coating shall be a continuous four (4) layer system applied to the exterior of the metallic cylinder and extend from the end of the bell to within four and one-fourth (4 ¼) inches of the spigot. It shall consist of:
 - a. Primer Layer - applied over a pipe surface prepared as specified in SSPC-SP 6 , "Surface Preparation Specification #6, Commercial Blast Cleaning or NACE TM-01-75, Visual standards for surfaces of New Steel Centrifugally Blast Cleaned with Steel Grit and Shot."
 - b. Corrosion Protection - wrapped twenty (20) mil tape layer.
 - c. Inner Mechanical Protection - wrapped thirty (30) mil tape layer.
 - d. Outer Mechanical Protection - wrapped thirty (30) mil tape layer.
 5. Ductile Iron Pipe coating: Ductile iron pipe shall have a bituminous seal coating in accordance with AWWA C151 as well as a cement mortar lining in accordance with AWWA C104.
 6. Field Coating Appurtenances: Field applied coatings for in line fittings, valves, welds and appurtenances shall conform to one of the following:
 - a. Polyethylene Encasement: Polyethylene shall be manufactured in accordance with AWWA C105 Polyethylene Encasement for Ductile-Iron Pipe Systems with the following additional requirements or exceptions.
 - i. Materials and Physical Properties: The raw material used to manufacture polyethylene film shall be Type 1, Class A, Grade E-1, in accordance with ASTM D1248. The film produced shall meet or exceed the following requirements:
 1. Tensile Strength 1200 psi min.
 2. Elongation 300% min.
 3. Dielectric Strength 800 V/mil thickness min.
 4. Thickness 0.008" (8 mils)

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|---------------|----------|
| 5. Melt Index | 0.4 max. |
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- b. Cold Applied Tape Encasement: Cold applied tape shall be Type II as described in AWWA C209 Tape Coatings for Steel Water Pipe and Fittings . Protecto-Wrap #1170 Primer and #200 Mastic Tape or equivalent has been approved for this application.
- i. When pipe is tape coated according to AWWA C214 , the appurtenance shall be field protected using Polyken #927 primer and Polyken #930 and/or #934 tape or equivalent.

421.06 Thrust Blocking, Restrained Joints and Fittings

Thrust blocks and mechanical joint restraints shall be used at all valves, bends, fittings with mechanical connections and dead ends in accordance with the Detail Drawings found in these Standards and Specifications. For high pressure or special circumstances, alternative restraint systems, such as fused pipe, may be considered. Alternative restraint systems shall be approved by the Project Engineer.

The length of restrained pipe (L) in the table shown in the Length of Restrained Pipe Detail Drawing is measured from the centerline of the fitting or valve and refers to the amount of pipe which shall be restrained. Mechanical joint restraint (wedge action, self-actuating, such as Megalugs) shall be used at all valves, bends, fittings with mechanical connections and dead ends. Tie rods shall not be used. The table shall also be used for the length of mechanical joint restraint. Restraints shall be protected to comply with Section 420.19 - Corrosion Protection Systems of these Standards and Specifications. Crosses shall be restrained in all applicable directions, and twelve (12) inch and smaller in-line valves and tees shall have mechanical joint restraint on each side of the fitting or valve.

Thrust blocking shall be in accordance with the Detail Drawings found in these Standards and Specifications. Care shall be taken to not block outlets, cover bolts, nuts, clamps or other fittings, and to ensure they are accessible. A bond breaker shall be placed between the pipe and the thrust block to aid in future removal. The thrust block shall bear against undisturbed earth.

Forming for thrust blocks and anchors may be bulk-heading around the shape of the thrust block or anchor with wood, burlap, or reinforced paper sacks filled with sand or earth. Wood forms shall be removed before backfilling. Newly placed thrust blocks shall be allowed to set undisturbed for a minimum of twenty-four (24) hours prior to any backfilling, tamping or compaction, unless otherwise approved by the Project Engineer.

Restrained Joints for steel transmission lines shall conform to the requirements set forth in AWWA M11, Steel Pipe - A Guide for Design and Installation

Joints shall be one of the following types as indicated on the construction plans:

1. Lap welded slip joint – The standard bell shall provide for a two and one-half (2½) inch lap. The minimum lap shall be one (1) inch. The design maximum joint deflection or offset shall be a one (1) inch joint pull.
2. Double welded butt strap joint - Butt straps, where required will be a minimum of six (6) inches wide, the same thickness as the pipe wall, and will be welded to one end of each pipe section so the joint can be lapped on the outside of the pipe.
3. On joints where butt straps are used for realignment, adjustment, or deflection, the pipe ends will be cut straight, and fillet welds shall be made on the outside of the pipe.
4. Flanged and bolted – Flanges shall be in accordance with AWWA C207 Class D for operating pressures to one-hundred fifty (150) psi and transient pressures to two-hundred twenty-five (225) psi. Flange face shall be coated with soluble rust-preventative compound. Bolts for flanges shall be type 316 stainless steel conforming to ASTM A193, Grade B8M, Class 1 and ASTM 194, Grade 8M nuts.
5. Mechanical coupling – Mechanical couplings and insulated mechanical couplings shall be listed in the Approved Products List. Mechanical couplings on steel water mains shall be harnessed for the maximum pressure in accordance with AWWA M11. Couplings shall be fusion bonded epoxy or nylon coated. Bolts shall also be coated or be stainless steel that is coated to prevent galling. Couplings shall be restrained at all locations shown on construction drawings and within the length to be restrained on all bends and fittings.
6. Carnegie end rings restrained by means of: circumferential clamps, snap ring, welded to both the bell and spigot ring.
7. Lateral and Distribution Lines six to twelve (6 - 12) inches: Harness rods shall be manufactured using Mild Steel (MS) conforming to ASTM A36, Standard Specification for Carbon Structural Steel . Hex nuts shall be fabricated in accordance with ASTM Designation A307, Grade A or B, hexagon heavy series.
8. Distribution and Transmission Lines fourteen to eighteen (14 - 18) inches: Harness rods shall be manufactured using High Strength (HS) Steel conforming to ASTM Designation A193, Grade B7. Nuts shall conform to ASTM A194, Grade 2H.

Mechanical joint retainer glands may be used in lieu of harness rods on PVC and Ductile grade 60-45-12 ductile iron conforming to ASTM A536. Bolt circle, holes and bolts shall be dimensioned to be compatible with standard mechanical joint bells as per specification AWWA C111 and AWWA C153. These glands shall have serrations or individually actuated gripping surfaces to maximize restraint capability to hold working and test pressures.

The retaining glands shall have a pressure rating equal to that of the pipe on which it is used and provide a minimum safety factor of 2:1. Breakaway tops shall be incorporated in the design of the actuating bolts to visually ensure proper torque. Restraint shall be UL Listed and FM approved in applicable sizes and shall be listed on the Approved Products List. Retainer gland bolts shall be torqued to manufacturer's recommended torque specification.

In lieu of harness rods, restraint devices for bell and spigot joints of PVC or Ductile Iron pipe shall consist of split restraint rings, one installed on the spigot, connected to one installed on the pipe barrel behind the bell. The restraint devices shall incorporate a series of machined serrations on the inside diameter to provide positive restraint, exact fit, 360 contact and support of the pipe wall. A split bell ring in lieu of a serrated ring may also be used behind the pipe bell. Restraint devices shall be of ductile iron, ASTM A536, Grade 65-45-12 with fusion bonded epoxy coating and connecting bolts shall be of high strength, low alloy material (Cor-Blue) in accordance with AWWA C111. Restraint devices shall be as listed in the Approved Products List. Joint restraint bolts shall be torqued to manufacturer's recommended torque specification.

421.07 Setting Valves and Fire Hydrants

Hydrant runs shall not contain bends unless approved by the Project Engineer. Hydrant tee shall not be installed in a lowering. Valve boxes shall not be installed in curb and gutter, sidewalk or crossspans.

Each hydrant shall have a six (6) inch gate valve on the hydrant run and shall be connected to the main by a six (6) inch Class 305 psi AWWA C900 PVC or Pressure Class 305 psi AWWA C909 PVCO pipe lateral. The valve shall be anchored to the swivel tee.

Hydrants shall be set with the bury line at the established finished grade. Hose nozzles shall be set parallel to the curb with the pumper nozzle facing the curb. Hydrants shall be located at least eighteen (18) inches from the center of the hydrant to the back of curb or sidewalk. If a riser is required, a break-away coupling shall be installed two (2) to four (4) inches above grade. All fire hydrant extensions shall be a single piece with a maximum length of two (2) feet. Buried sections greater than seven (7) feet shall make use of a vertical shoe supplied from the manufacturer and shall require approval from the Project Engineer.

Hydrants shall include a drainage pit with nine (9) square feet of surface area and two (2) feet of depth below the barrel of the inlet. Pits shall be backfilled with one and one-half (1½) inch, washed, crushed rock to a level six (6) inches above the barrel drain hole. A concrete thrust

block shall be placed at the bowl of each hydrant in accordance with the Detail Drawings found in these Standards and Specifications to prevent obstruction of the barrel drain hole.

Piping for fire hydrant laterals shall be rodded and/or mechanically retained and clamped between the mechanical joint end of the valve at the main and the fire hydrant.

The hydrant shall be set plumb at the end of the lateral, face the main and be adjusted to finish grade. The use of horizontal bends, vertical bends and offsets to install the lateral or tapping into the lateral line is strictly prohibited unless approved by the Project Engineer.

Valves shall be provided with valve boxes centered and plumb over the operating nut of the valve. The boxes shall be supported to prevent any shock or stress from being transmitted to the valve. All valves shall be installed using a valve box adaptor to ensure proper centering of the valve box during backfill and to maintain valve box location. Valve boxes shall be maintained in this position during backfill. Valve box covers shall be set below the subgrade level to prevent damage during street construction and later adjusted to grade at the time of paving. If the top of the valve-operating nut is greater than six (6) feet below finished grade, a valve nut extension shall be installed to bring the operating nut up to four (4) feet below finished grade.

Valves shall be handled in such a manner so as to prevent any injury or damage to any part of the valve. Joints shall be thoroughly cleaned and prepared prior to installation. If so ordered by the Project Engineer, valves shall be operated prior to installation to insure proper operation ability.

A line or outlet valve that is to be buried in soil shall be thoroughly cleaned and then wrapped as specified under exterior coating of flexible joint, valves, etc. above.

All valves shall be installed such that the valve stems are plumb and in the location shown on the drawings with disk seat bolts facing the nearest access maintenance hole.

A valve box shall be provided with three (3) inch and larger tapping valves and on the curb stops of one and one-half (1½) inch and two (2) inch service lines. The valve box shall not transmit shock or stress to the valve and shall be centered and plumb over the valve wrench nut, with the box cover screw adjusted within one-quarter (¼) inch below finish grade. It is the responsibility of the Contractor to ensure that valve boxes are centered over the valve operating nut, plumb and raised to the proper elevation prior to the final lift of asphalt being placed.

Operating nuts for butterfly valves shall be placed to the north and east of the water main.

Valve box and stem extensions shall be furnished and installed on all valves that the operator nut is greater than five and one-half (5-1/2) feet below finish grade. The top elevation of the operating nut on the valve or valve stem extension shall be no greater than four (4) feet, nor less than two and one-half (2-1/2) feet below finish grade. This also applies to curb stop valves on service lines.

421.08 Plastic Liner Pipe (Sliplining)

Installation of plastic liner pipe shall comply with Section 522.10.01 - In-Place Rehabilitation of Existing Pipelines of these Standards and Specifications.

421.09 Steel Casing and Carrier Pipe Installation

Installation of steel casing and carrier pipe shall comply with Section 523.07 - Steel Casing and Carrier Pipe Installation.

421.10 Cathodic Protection Test Stations

Underground pipeline test stations shall be installed at locations shown on the approved plans and in accordance with the Detail Drawings found in these Standards and Specifications. Locations shall be placed outside of roadways and in accessible locations for operators.

421.11 Plugging of Dead Ends

Temporary dead ends shall be installed with standard plugs or caps. Temporary dead ends shall be provided with blow-offs or fire hydrants, as required by the Project Engineer. Permanent dead ends shall be provided with fire hydrants and valves. All temporary dead ends in undeveloped lots and open lands shall be marked with a marker post.

421.12 Filling and Venting the Line

Only the Arvada Utilities Department shall operate valves.

The line shall be slowly filled with water and all air expelled from the pipe. Care shall be taken that all available hydrants (including hydrant gate valves), air relief valves, and other vents are open during the filling of the line. Where hydrants or other vents are not available in the line, the Contractor shall use a temporary two (2) inch blow-off for venting purposes. The rate of filling the line shall not exceed the venting capacity.

Weather restrictions shall be considered when filling lines with portions are exposed (such as fire service and domestic service stubs into utility rooms). Filling shall only occur between March 31st and November 1st, unless the utility room has permanent heat.

421.13 Disinfection, Testing, and Flushing of Water Lines

Disinfection, testing, and flushing shall be performed in accordance with the requirements of the Colorado Department of Public Health and Environment and shall comply with AWWA C651. All potable water lines shall go through disinfection, hydrostatic testing, bacteriological testing, and flushing prior to being placed into service. Water Operations Division personnel shall be the sole operators of all valves through which water for testing, disinfecting, and flushing is obtained and shall be given forty-eight (48) hours notice to arrange for valve operations. Both the Contractor and the Engineering Inspector shall be present when the valves are being operated.

The Utilities Division will not shut down water mains for tie-ins after 11:00 a.m. in order for water to be turned back on by 3:00 p.m. Contractor must be within 60 minutes of cutting into the water main based on the judgment of the City's Municipal Inspector and/or Water Utility Division personnel before existing mains will be isolated.

There shall be no shutdowns or tie-ins on Fridays. Existing tie-in locations shall be visualized by test holing prior to the scheduled tie-in date. Flushing operations shall take place on Fridays only if they have begun prior to 8:00 a.m. High chlorine tests shall take place on Fridays only if they have begun prior to 9:00 a.m. Pressure testing on Friday's requiring Water Operations Staff support shall begin before 9:00 a.m. Pressure testing not requiring Water Operations Staff support shall be at the discretion of the City's inspector.

1. Disinfection of Water Lines: Disinfection of potable water lines shall be performed in accordance with AWWA C651 "Disinfecting Water Mains" and to the satisfaction of the Jefferson County and Colorado Health Departments. The chlorine solution shall be retained in the water line for at least twenty-four (24) hours. A free chlorine residual at all hydrants and blow-offs shall be at least twenty-five (25) parts per million (ppm) at the end of the twenty-four (24) hour period. If the test is unsatisfactory, disinfection shall be repeated until a twenty-five (25) ppm free chlorine residual is obtained.

When cutting into or repairing an existing water line, disinfection and flushing shall comply with AWWA C651. Following the twenty-four (24) hour soak and absorption time the residual chlorine content of the water shall be no less than twenty-five (25) parts per million (milligrams per liter), when tested at any one or all fire hydrants, blow-offs, corporation stops, stub ends, etc., on the line.

Suggested methods of chlorination and their limitations are:

- a. Tablet Method: Five (5) gram calcium hypochlorite tablets, each containing three point seven five (3.75) grams available chlorine, shall only be used when the line cannot be flushed prior to chlorination. The tablet method shall not be used when trench water or foreign materials have entered the water line during installation or the ambient temperature is below forty-one (41) degrees Fahrenheit. The tablets shall be secured to the crown of each pipe section, as it is installed in the trench, with "red" PERMATEX or other approved adhesive. Under normal conditions to obtain the twenty-five (25) MG/L residual chlorine concentration, after twenty-four (24) hour solution time, will require the use of the number of tablets called for under pipe diameter and opposite pipe joint length as listed below.

Under Pipe Diameter and Opposite Pipe Joint Length

Pipe Diameter Inches	Tablets Required for 20 Ft.	CL Residual in 20 ft. Pipe mg/ L
3	1	116.97
4	2	131.59
6	3	87.73
8	6	98.69
12	12	87.73
14	17	91.31
16	22	90.47
18	28	90.98
24	49	89.56
27	62	89.53
30	77	90.07
36	111	90.17
42	151	90.12
48	197	90.01
54	249	89.89

60	308	90.07
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b. Continuous Feed Method: This method shall be used when it is necessary to flush the line prior to chlorination or for rechlorination. Water from an existing distribution source shall be made to flow at a constant rate through the line to be disinfected. Chlorine is then pumped into the line from the water supply source at a rate which will result in a chlorine concentration of no less than fifty (50) parts per million (MG/L), when tested at any or all accessible discharge locations. The amount of chlorine to be inserted per one-hundred (100) feet of pipe, to produce twenty-five (25) parts per million (MG/L) residual concentration after a twenty-four (24) hour solution time, will normally be as shown below.

Chlorine to be Inserted per 100 feet of Pipe

Pipe Diameter in.	100% CL lbs./100ft.	1% of CL Solution gal/100 ft.
6	0.061	0.73
8	0.108	1.30
10	0.170	2.04
12	0.240	2.88
14	0.333	3.98
16	0.435	5.20

c. Slug Method: The slug method shall be used for eighteen (18) inches and larger transmission mains or where use of the tablet or continuous feed method are impractical.

i. Chlorine in gaseous or super chlorinated liquid form shall be introduced at the water supply source, after the line has been filled. The chlorine slug shall be caused to traverse the entire length of the line, at a velocity, length and concentration, such that the entire interior surface of the pipe is exposed to the equivalent of three-hundred (300) MG/L of chlorine for at least three (3) hours.

d. Cut and Repair Method: When a water line breaks or is cut into and it is impossible or impractical to re-chlorinate using the continuous feed or slug methods, the following procedure shall be used.

- i. All fittings, valves, couplings and make up pipe sections shall be swabbed with a five (5) percent sodium hypochlorite solution (Clorox) or a three-hundred fifty (350) parts per million (MG/L) available chlorine solution made from calcium hypochlorite, just prior to being installed. One five (5) g. tablet as specified under the tablet method, dissolved in ten (10) liters of water is equal to three-hundred twenty-five (325) parts per million (MG/L).

Following chlorination, the water line shall be flushed through all hydrants and blow-offs until the water runs clear with no chlorine residual in excess of that carried in the existing system. As a minimum, the total volume of the water line being tested shall be flushed. The Contractor shall be responsible for metering and paying Arvada for water used for flushing.

The Contractor shall take all necessary precautions to prevent the flow of strong chlorine solution into existing water facilities and shall be responsible for damages done by heavily chlorinated water. Sodium thiosulfate shall be used when flushing water on the ground and to waterways that do not contain fish. Vita-D-Chlor Neutral, or approved equal, shall be used when flushing to waterways with fish. Contractors' proposed method of dechlorination must be approved by the Project Engineer and be performed within the limits set forth in the NPDES permit, as issued to the City by the Colorado Department of Health. Flushing to the sanitary sewer shall only be allowed with permission from the Project Engineer.

During flushing the line shall be visually inspected for turbidity. If the inspection is unsatisfactory, the line shall be flushed again. If the turbidity test fails a second time, the line shall be re-chlorinated and then re-flushed.

A City representative shall be present and operate all valves during flushing and dechlorination of lines.

2. Pressure Testing Lines: Once the line has been successfully chlorinated and flushed, the line must be pressure tested. Hydrostatic testing shall only be performed after the line has been cleaned of debris, concrete anchor blocks have cured, and all backfill is in place.

- a. The hydrostatic test pressure shall be one-hundred fifty (150) psig at the lowest point in the line or section under test. Fire lines shall be tested at two-hundred (200) psig. Test pressure shall be maintained continuously for a minimum period of two (2) hours. Pressure shall be applied in a manner satisfactory to the Project Engineer with all testing apparatus furnished by the Contractor. Where directed by Project Engineer, a higher test pressure may be required.

- b. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain the specified leakage test pressure after the air in the pipeline has been expelled and/or displaced with water. No pipe installation will be accepted if the leakage in U.S. gallons per hour is greater than that set forth herein below in accordance with AWWA C600, C604, C605 and M11:Allowable leakage for steel pipe is for o-ring rubber gasket joints only. The allowance shall be zero (0) on all-welded or mechanically coupled steel pipe and for all fire lines.

Allowable Leakage - Elastomer Joint Pipe

Pipe Diameter (Inches)	Nominal Allowable Leakage US Gallons per Hour per 1,000 feet per 24 hours	
	DIP and PVC	Steel
4	0.33	
6	0.50	
8	0.66	
12	0.99	0.94
14	1.16	1.10
16	1.32	1.26
18	1.49	1.42
20	1.66	1.58
24	1.99	1.89
30	2.48	2.37

36	2.98	2.84
42	3.48	3.31
48	3.97	3.79
54	4.47	4.26

The City reserves the right to substitute its own calibrated meter and/or pump for the Contractor's meter or pump for testing.

After the line has successfully passed pressure testing the line shall be flushed and must sit for sixteen (16) hours before bacteriological testing.

3. **Bacteriological Analysis of New Water Mains:** Prior to placing any new water main in service a bacteriological analysis of the water in the new main shall be performed by the City. A minimum of sixteen (16) hours after the new main is flushed following the pressure test a bacteriological sample will be obtained by the City. Results of the bacteriological analysis shall be available twenty-four (24) hours after the sample was obtained. If the bacteriological analysis turns up positive a second test shall be taken. If the second test turns up positive the main shall be re-chlorinated and the process started over until a negative bacteriological analysis is obtained. Only after a negative bacteriological analysis is obtained can a new water main be placed in service and water is transferred to the new main.

Bacteriological analysis of cuts and breaks is required unless waived by the Project Engineer. Lines that have had cuts or breaks that result in customers out of service may be put back in service while waiting for the analysis results.

4. **Placing Line in Service:** A line will only be accepted for tapping and/or placing in service after all of the following conditions have been met:
- a. The main has been installed to the satisfaction of the Engineering Inspector and all pertinent notes and measurements have been made.
 - b. The main has been successfully filled, chlorinated, de-chlorinated and pressure tested to the requirements of the City of Arvada.
 - c. A bacteriological sample has been collected and results indicate that no E. Coli or total coliform bacteria are present.

Connection to the City system shall be in a neat and workmanlike manner. An Engineering Inspector shall be present at all times during the construction of the connection. Under no circumstances shall a non-disinfected main, which cannot be isolated, be connected to an existing disinfected main. Disinfection of the line shall meet the requirements of the Jefferson County and Colorado Health Departments.

The City is not responsible for water tightness of its valves and existing facilities. If existing valves leak, the City will assist in reducing the influx of water, but the Contractor must use methods at his own disposal to work with the resulting leakage.

421.14 Leakage

Pressure and leakage tests shall be conducted to comply with AWWA C600 and Section 421.13. The maximum length of line to be tested shall be 1,000 feet. Leakage in excess of tolerances shall be located and made watertight by the Contractor.

Potable or raw water systems with pressures greater than one hundred fifty (150) pounds per square inch (psi) shall be tested to a pressure of two-hundred (200) pounds per square inch (psi) at the low point of the section being tested for the duration of two (2) hours.

421.15 Concrete Vaults

Refer to Section 800 - Concrete Mix Design and Construction and Section 400 - Water Supply Facilities of these Standards and Specifications.

Vent piping from maintenance holes and vaults shall be in accordance with Section 420.18.

421.16 Painting of Appurtenances

This section applies only to appurtenances such as vent pipe, bollards, etc. This section does not apply to water pipe nor casing pipe.

Painting: All metal exposed to atmosphere or buried in the ground, except aluminum, brass, bronze, or copper, shall be painted.

All exposed metal and that portion of the black steel vent pipes that is to be buried shall be given two (2) coats of CA-1180 mastic cold coating or equal as manufactured by Protecto Wrap Company, Denver, CO, except for metal with shop applied coating approved by the Project Engineer. All metal exposed to the atmosphere shall be painted with one (1) coat of red-lead priming paint and two (2) coats of aluminum paint, unless otherwise directed by the Project

Engineer.

All surfaces to be painted shall be cleaned of oil, grease, weld spatters, burrs, grit, dust, or other objectionable surface irregularities. Cleaning solvent used shall be mineral spirits or equivalent.

Paint shall not be applied, except under shelter, during wet, damp, or foggy weather, or when windblown dust, dirt, debris, or insects will collect on freshly applied paint. Paint shall not be applied at an air temperature below fifty (50) degrees Fahrenheit, or to surfaces of metals, such as the surface of a valve or pipe containing cold water, with a temperature below fifty (50) degrees Fahrenheit regardless of the air temperature, or when metal temperature and atmospheric conditions cause condensation on the surface of the metal. Painted surfaces which have become damaged prior to acceptance shall be repainted with the same or equivalent paint used in the original application to the satisfaction of the Project Engineer.

422.00 Inspections

Refer to Section 188.00 - Inspections of these Standards and Specifications.

Adequate inspections assure compliance to Arvada requirements and are the basis for Arvada's recommendation that said improvements be accepted for maintenance and for release of performance guarantees. It is the responsibility of the Contractor to contact the Project Inspector a minimum of one (1) full working day (twenty-four [24] hours) in advance of the required inspections. Required inspections shall include:

1. Stockpiled Materials – Verify that materials meet Standards and Specifications and approved submittals, including but not limited to: bedding material, pipe, fittings, valves, valve boxes and fire hydrants. All stockpiled materials shall be protected from the elements.
2. Excavation – Verify proper trench depths, shoring, spoil pile location, dewatering, and location and protection of existing utilities.
3. Installation – Verify proper bedding depth, alignment and grade, clean pipe and lubricants. Check that chlorine tablets are affixed to the inside of the pipe, and verify “slicing in” of bedding at haunches. Tracer wire is securely attached to the top of pipe, metallic fittings are wrapped with polyethylene, fittings have corrosion resistant bolts and nuts, and fire hydrants have proper drainage rock. Non-potable water lines shall be purple in color or have purple plastic wrap and warning tape.
4. Thrust Blocks and Restraints – Verify proper size of concrete thrust blocks and adequate bond breaker, and proper torque of bolts for mechanical restraints.

5. Corrosion Control and Cathodic Protection - Verify all corrosion control devices and components are properly installed and inspected prior to backfill. Inspection shall be by a NACE Certified Cathodic Protection Technician (CP2) and tested after backfill under the supervision of a NACE Certified Cathodic Protection Specialist (CP4). Use of CP2 and/or CP4 may be waived by the Project Engineer.
6. Backfill and Compaction – Verify proper methods of backfill and compaction, depths of lifts, moisture control, and backfill material free of large rock, organic or frozen material.
7. Loading and Testing – Verify that loading and testing methods adhere to these Standards and Specifications.
8. Tie In – After successful testing, tie in dead end to loop the system.
9. Service Taps – Verify proper tapping procedures. For direct taps, the line is under pressure. For saddle taps, torque on the saddle is checked. Verify that there are no leaks at the corporation stop and the coupon has been removed. Verify copper service line has proper gooseneck, the service line runs correctly to the yoke at the meter pit, and the water is on at the meter pit.
10. Construction Acceptance into Warranty – Refer to Section 200 – Acceptance Procedures. General items include:
 - a. All temporary structures, debris, mud and waste materials shall be removed from public property.
 - b. All relative testing certifications and documentation shall be submitted to Arvada. Include all compaction tests. Copies of originals are acceptable.
 - c. All curb stop boxes are raised to grade and checked for valve accessibility.
 - d. All water services shall be marked with a “V” by saw cutting into the face of the curb where the service extends into the property.
 - e. All water valve boxes are at construction grade, straight and cleaned out to check for access to valve nut and ability to get a valve key on the nut and operate the valve. Verify that all valves that should be open are open. Tracer wire test stations shall be accessible.
 - f. All fire hydrants shall be checked for ability to be pressurized.
 - g. Conduct fire inspections and tests on the fire lines per the requirements of the fire district and the Colorado Division of Fire Prevention and Control.
11. Final Acceptance/Release from Warranty – Refer to Section 200 – Acceptance Procedures of these Standards and Specifications. General items include:
 - a. Each water valve box shall be cleaned out to check for access to the valve nut and the ability to get a valve key on the nut and operate the valve. All valves that should be open are open. Tracer wire test stations shall be accessible.
 - b. All fire hydrants shall be checked for ability to be pressurized.

423.00 Water Service Line Construction

423.01 General

All water service line locations shall be marked on the face of the curb by saw cutting a “V” symbol where services cross under the curb. Where no curb exists, an aluminum tag, blue in color and one and three-quarter (1 ¾) inch diameter, shall be fastened to the asphalt where the service crosses two (2) feet from the edge of pavement with a two (2) inch long PK nail. Water service lines shall be in a separate trench, except as approved by the Project Engineer, and shall be a minimum of ten (10) horizontal feet from sewer service lines. Water service lines shall be a minimum of eighteen (18) vertical inches above any sanitary sewer crossing. All water service lines shall be stubbed into the lot either ten (10) feet beyond the back of the sidewalk or curb or five (5) feet beyond any utility easement, whichever is greater, and shall be marked at the end of the water service with a wood 2x4 painted blue.

423.02 Excavation

All excavation shall comply with Section 362.00 - Excavation.

423.03 Water Taps and Service Line Locations

Water Service Line taps are not allowed in the following conditions:

1. On any transmission Water Main,
2. On mains sixteen (16) inches and greater,
3. Where the main pressure is less than forty (40) psi,
4. Within a Water Main lowering,
5. Within twenty-four (24) inches of another Water tap,
6. Within twenty-four (24) inches from both the back of the bell and the spigot insertion line and from any MJ fitting,
7. On Fire Hydrant Laterals,
8. On Fire Service Lines,
9. Under traffic calming devices,
10. Within ten (10) feet on either side of a utility crossing, AND
11. So the meter pit is located in the driveway and/or service line is under the driveway.

424.00 Water Service Line Equipment and Materials

424.01 Water Service Lines

Water service lines shall be sized to adequately supply the requirements of the property being served. The minimum size line shall be three-quarters ($\frac{3}{4}$) inch. The acceptable material for a three-quarter ($\frac{3}{4}$) inch to two (2) inch service line is a seamless Type K copper tube. Three (3) inch diameter service lines shall be four (4) inch AWWA C900 or 909 pipe outside the meter vault and three (3) inch ductile iron inside the vault. Four (4) inch diameter service lines shall be AWWA C900 or C909 pipe outside the vault and ductile iron inside the vault.

Copper water service lines shall be electrically isolated from the main line at the corporation stop and in the meter vault.

424.02 Water Service Saddles

Water service saddles shall be required for all water lines for water service taps as determined by the Project Engineer. Service saddles shall be brass or bronze, shall comply with AWWA C800, and be listed on the Approved Products List.

424.03 Meters

All meters shall be purchased from Arvada and shall be installed, owned and maintained by Arvada Utilities Maintenance. All single family residential meters shall be size five-eighths ($\frac{5}{8}$) inch x three-quarters ($\frac{3}{4}$) inch, unless otherwise approved by the Project Engineer. No meter shall be installed until the Project Engineer has approved the proposed installation. Permanent water meters shall be installed prior to the issue of the Certificate of Occupancy.

424.04 Potable Water Sampling Stations

All Single and Multi-family residential housing subdivisions, townhomes, condominiums, apartments and mobile home parks shall provide a location for City employees to access the potable water system to sample for water quality monitoring. Single family residential housing subdivisions shall provide a location at the potable meter pit at a public park. Multi-family residential developments including townhomes, condominiums, apartments and mobile home parks shall provide a location at the potable meter pit at a public park, or, if one is not available, at the complex's office off of their service meter pit. Installation shall be in a publicly accessible area such as a park, lawn, or landscaped border. Sampling Station exact location shall be determined through the design process and approved by City of Arvada staff.

Details of its location and connection shall be in accordance with the Detail Drawings found in these Standards and Specifications.

The sampling station shall be thirty six inch (36) inch bury, with a three-quarter ($\frac{3}{4}$) inch FIP inlet and a three-quarter ($\frac{3}{4}$) inch hose nozzle. The station shall be enclosed in a lockable, non-removable, aluminum-cast housing. When opened, the station shall require no key for operation and the water will flow in an all brass waterway. All working parts will also be of brass and be removable from above ground without digging. Exterior piping shall be galvanized steel. A copper vent tube with shut-off valve will enable each station to be pumped free of standing water to prevent freezing and to minimize bacteria growth. Sampling Station shall be listed in the Approved Products List. All Potable Water Sampling Stations shall be installed in accordance with the Detail Drawings found in these Standards and Specifications.

The sampling station shall be installed with a valve to isolate it from the system. Requirements of the Cross-Connection and Backflow Control Program will apply.

424.05 Outside Meter Settings

All outside meters shall be installed in a horizontal position and housed in a maintenance hole or vault in accordance with the Detail Drawings found in these Standards and Specifications. The installation of the water meter shall comply with the following unless otherwise approved by the Project Engineer.

1. All meters not installed within the right-of-way shall require an easement dedication ten (10) feet wide and extending five (5) feet behind the meter.
2. The meter shall be installed in a pit, maintenance hole or vault which shall allow free and easy access and adequate room for installation, inspection and maintenance, and shall provide protection from freezing.
3. All fittings shall be brass or copper.
4. A pressure regulator (see Approved Products List) shall be installed on all water services before the meter is installed. The pressure regulator shall be installed where the water service line enters the building, downstream of the ball or gate shut off valve.
5. A ball or gate valve shall be installed where the water service line enters the building.
6. Water meters are to be installed only in landscaped areas.

424.06 Inside Meter Setting and Remote Readers

Inside meters shall only be used with written approval by the Project Engineer in unusual circumstances. All inside meter settings shall be installed in a manner which shall allow free and easy access and adequate room for installation, inspection and maintenance, and shall provide

protection from freezing. Meters installed inside buildings shall not be more than eighteen (18) inches from the wall through which the water service line enters the building, unless otherwise approved in writing by the Project Engineer.

Inside meter settings shall not be allowed in crawl spaces, closets or other places where free and easy access is not provided. Meter sizes one and one-half (1½) inch and two (2) inch installed inside buildings shall be provided with a floor drain. Refer to the Detail Drawings found in these Standards and Specifications. Installation shall conform to the following:

1. The meter setting shall be installed in the basement, a utility closet, or similar area, which shall allow free and easy access and adequate room for installation, inspection, and maintenance.
2. The meter yoke shall be a minimum of twelve (12) inches and a maximum of four (4) feet above floor level in a horizontal position and have a minimum of twelve (12) inches clearance from all surrounding obstructions.
3. A ball or gate valve shall be installed on both the upstream and downstream side of the water meter.
4. A pressure regulator, adjustable from twenty-five (25) to seventy-five (75) psi shall be installed between the meter yoke and downstream valve. The regulator shall be listed on the Approved Products List unless otherwise approved in writing by the Project Engineer.
5. All fittings shall be brass or copper.
6. A curb stop shall be installed for inside meters regardless of meter size.

424.07 Meter Bypass Line

A bypass line shall be required for all domestic use one and one-half (1 ½) inch and larger meters, unless otherwise approved by the Project Engineer, whether installed in an outside or inside setting. Bypass lines shall contain an independent control valve and shall not contain tees, plugs or other outlets, and shall be in accordance with the Detail Drawings found in these Standards and Specifications. The control valve on the bypass line shall be lockable. A bypass line may be required on services smaller than one and one-half (1½) inches if deemed necessary by the Project Engineer. All bypass lines shall be electrically isolated from the main service line.

424.08 Valves for Use with Meters

Valves for services three (3) inches and larger for use with ductile iron water service lines shall be gate valves with cast iron bodies. All gate valves larger than three (3) inches shall be supported by adjustable steel valve supports.

424.09 Meter Couplings

All meters one and one-half (1½) inch and larger shall be installed with a coupling to allow for the removal of the meter without disturbing the pipe. Couplings shall comply with the Approved Products List.

424.10 Meter Yokes (Copper Setters)

Meter Yokes (Copper Setters) shall comply with the Approved Products List with an angle ball valve and a padlock wing on the inlet side of the meter. Water service connections shall be compression fittings, with a “110”, “Cam Pack”, or “Mac Pack” type fitting and shall be vertical.

424.11 Meter Pits and Covers

Meter pits for (1) inch meters and smaller shall comply with ASTM D1505 and D746 and shall be listed in the Approved Products List. Meter pit covers shall be tight fitting with double lids for frost protection. Meter pit covers and domes shall be cast iron. Aluminum shall have a polymer coating such as an epoxy. Meter pits and covers shall be in accordance with the Approved Products List and Detail Drawings found in these Standards and Specifications. Placement of meter pits shall be a maximum of five (5) feet from the front property line. Meters not located in the right-of-way shall require an easement dedication ten (10) feet wide and extending five (5) feet behind the meter.

424.12 Corporation Stops

Corporation stops provide the connection for the water service line to the waterline. Corporation stops are also required in air and vacuum valve and large butterfly valve installations. Corporation stops are available in standard sizes three-quarter, one, one and one-half and two (¾, 1, 1½ and 2) inches. Refer to the Detail Drawings found in these Standards and Specifications and the Approved Products List. Tapered threads other than the inlet thread of corporation valves shall comply with ANSI/ASME B1.20.1. Two spiral wraps of three (3) mil PTFE (Teflon) tape shall be wrapped clockwise around the inlet threads on the closed corporation stops. Liquid sealants or other lubricants shall not be used.

424.13 Curb Stops

Curb stops are required for meters one and one-half (1 ½) inch and larger. Curb stops are set on the service line on the inlet side of the meter pit and provide a means to shut off the service line. Placement of the curb stop and stop box can vary from a maximum of five (5) feet outside the front property line to a maximum of five (5) feet inside the front property line. Curb stops shall be buried a minimum of four (4) feet and a maximum of five (5) feet – six (6) inches. Placement

of the curb stop and stop box outside the front property line is preferred. Refer to the Detail Drawings found in these Standards and Specifications and the Approved Products List. Curb stops shall not be installed under concrete or asphalt unless approved by the Project Engineer and shall have a traffic approved curb box. Use of a “stop and waste” valve is prohibited.

424.14 Curb Stop Service Boxes

Curb stop service boxes shall be cast iron, Buffalo type. The bottom part shaped like an inverted “U” straddling the service line, shall have a flanged bottom so as to support itself. Curb stop service boxes shall comply with the Approved Products List. Curb stop boxes shall be to grade and be accessible at the time of meter installation.

424.15 Brass Fitting Couplings

Compression couplings for brass fittings are preferred. Flared fittings may be used.

424.16 Backflow Preventers

Backflow preventers shall be installed on all commercial water service lines and on all residential water service lines that serve more than two units. Refer to [Arvada Municipal Code](#) Chapter 13-07-100 Backflow Prevention Devices for additional requirements.

Acceptable backflow preventers are listed on the Approved Products List.

425.00 Tapping the Main

All Taps shall be Wet Taps. Shutting down any portion of the water system shall only be allowed when uncontrolled circumstances do not permit a wet tap. Any shut down of the water System must be approved in writing by the City Engineer.

Tapping of PVC pipe shall be made with a Tapping Saddle.

Arvada’s Water Utility Department, unless otherwise approved by the City Engineer, shall complete tapping of all water lines up to and including two (2) inch diameter taps. Notification shall be given to the Water Utility Department two (2) working days (forty-eight [48] hours) in advance of the tap in order to provide ample time to schedule the work. In those instances where Arvada crews are not available to complete taps in a timely manner or when the tap is over two (2) inches in diameter, the tap may be installed by a contractor or plumber licensed by Arvada who specializes in the installation of water taps.

Arvada shall be responsible for maintaining that portion of the water service line, corp stop and meter as shown on the detail drawings and as set forth in the Arvada Municipal Code.

Service saddles and corporation stops meeting the standards shall be supplied and installed by the Contractor. Taps will be made by City crews only after release of mains by the Project Engineer following their installation, submittal of health release certifications, payment of appropriate fees and completion of the tap application papers. Service installations shall be performed by a Contractor licensed and bonded with the City of Arvada.

Any excavation and dewatering necessary for tapping shall be completed prior to the arrival of the Water Utility Division Tap Crew. The Contractor shall excavate, expose the main at least twenty-four (24) inches on all sides, and provide a safe dry trench for the City tapping operation. A safe dry trench perpendicular to the main is considered as being:

1. Three (3) feet wide by five (5) feet long and excavated to a depth of one (1) foot the Main.
2. When unstable ground conditions exist or the trench is deeper than five (5) feet, the trench must be shored, sheeted or sloped and dewatered before City crews will make the tap.
 - a. PVC pipe shall not be tapped when the ambient temperature or the temperature of the PVC is less than thirty-two (32) degrees Fahrenheit. If taps are desired when the temperature is less than thirty-two (32) degrees Fahrenheit, reasonable precautions will be taken by City crews but any pipe failures will be the responsibility of the Contractor and/or developer.
 - b. Dry tapping of a distribution or lateral main is strictly prohibited unless approved by the Utilities Department. A tapping saddle and valve, installed on an existing main, shall not be considered a substitute for a property line valve. The use of two (2) tapping saddles, when side by side or back to back, as a substitute for a cross will not be allowed.
3. 3/4" through 1" Service Tap - Connection of a three-quarter or one (3/4 or 1) inch diameter service line to four (4) inch through twelve (12) inch laterals or mains main shall be made by wet tapping the line by means of a corporation stop into an approved service saddle. Direct tapping into the line is not allowed. In all instances the corporation stop, when in place on the service saddle, shall be at an angle of forty-five (45) degrees above springline and perpendicular to the centerline of the lateral or main being tapped.
4. 1-1/2" through 2" Service Tap – One and one-half through two (1-1/2 through 2) inch diameter service line connections to four (4) inch through twelve (12) inch laterals or mains shall also be made by wet tapping the line by means of a corporation

- stop installed by the Contractor into an approved service saddle. The service saddle shall be mounted on the line such that the corporation stop installed then is perpendicular to the centerline and at the springline of the lateral or main being tapped.
5. 3" and Larger Service Tap - Three (3) inch and larger service lines shall be connected to the lateral or main by means of an approved stainless steel tapping saddle and resilient seat tapping valve installed perpendicular thereto. Valve boxes and cover shall be installed directly over the valve operating nut on all valves three (3) inches and larger.

425.01 Fire Sprinkler Lines

Piping for four (4) inch and larger buried fire sprinkler lines from existing water mains to buildings or structures with internal sprinkler systems shall be Class 200 PVC (Polyvinyl Chloride) conforming to AWWA C900 or Class 235 PVCO (Polyvinyl Chloride Oriented) conforming to AWWA C909 only and shall extend perpendicular from the water main. All joints shall be restrained from the mechanical joint end of the gate valve at the water main through the vertical ninety (90) degree bend installed under the building wall inside the building or structure. Only gate valves are allowed on fire lines regardless of fire line diameter. Piping for two (2) inch buried fire sprinkler lines from existing water mains to buildings or structures with internal sprinkler systems shall be Type K soft copper (with quick joint compression or flared brass fittings) to within five (5) feet of the building or structure where it shall transition to Type L rigid copper with silver soldered joints through the vertical ninety (90) degree elbow installed under the building wall inside the building or structure.

425.02 Water Service Lines

Connection of copper to all metallic water mains shall be electrically insulated by means of an approved insulator fitting installed on the corporation stop. After installation, the fitting shall be cleaned and wrapped with a double layer of eight (8) mil polyethylene before backfilling. An insulator fitting shall also be installed on the outlet side of the meter setter.

1. Curb Stop Valve, Valve Boxes and Meters: Single family service line installations shall terminate at a meter yoke in the meter pit or curb stop (under approved conditions only) at a point near the property line. See Standard Drawings. Service lines one and one-half (1 ½) inch and larger shall terminate at a curb stop valve and box at or near property or easement line. Curb stop valves shall be of the same size as the service pipe. A curb stop valve shall be installed on each service line leaving a manifold.

2. Service Line Crossing a Foreign Line: A water service line crossing over a foreign line (storm sewers, water transmission lines, etc.) shall be insulated through areas and at points where its bury is less than four (4) feet. Butt joints between sections and side slits in insulation shall be duct or mole taped upon placement around the service line.
3. Backfill of Service Lines in Streets: Service line trenches cut through surfaced streets or adjacent to existing curbs, gutters, and sidewalks in public ROW shall be bedded using squeegee and backfilled using Flash Fill or Flow Fill Material.
4. Granular bedding material shall be compacted to seventy (70) percent relative density for sand materials as determined by the relative density of cohesionless soils test, ASTM D4253 . The trench shall be filled with Flow Fill or Flash Fill material to within six (6) inches of the finished street grade and the trench then topped out to finish grade with four (4) inches of CDOT Grading S asphaltic concrete and a two (2) inch top lift of CDOT Grading SX asphaltic concrete. Asphaltic concrete shall be placed and compacted in accordance with these Specifications and shall be minimum six (6) inch thickness or match existing asphalt, whichever is greater.

425.03 Abandonment of Service Taps

The tapping saddle (if used) and corporation stop shall be removed and the hole covered with a main line-size by twenty-four (24) inch long stainless steel repair clamp. The repair clamp shall be on the Approved Product List.

If the main line is cast iron or ductile iron pipe, the pipe shall be rewrapped in accordance with Section 420.05. The meter, yoke, and meter lid shall be returned to the City. The meter pit shall be backfilled and compacted to finished grade.

426.00 Pumping Facilities

426.01 General

In locations where Arvada's water distribution system may not be capable of providing adequate water pressure, Arvada may require the construction of a pumping facility to provide proper service. Arvada may not approve the installation of a pumping facility where, in the opinion of the Project Engineer, such installation would be injurious to the operation, or future operation, of Arvada's water system.

The City shall design and construct any required pumping stations that shall become part of the public water system. An agreement between the developer and the City will provide for the

developer to pay for the improvement. When approved by the City Engineer, the developer may design and construct a pump station.

The pumping facility shall comply with all requirements of the Colorado Department of Health and of these Standards and Specifications. Arvada shall require that the Developer prepare Record Drawings and an electronic (AutoCAD) file of the pumping facility in accordance with Section 200 – Acceptance Procedures of these Standards and Specifications. Upon completion of the pumping facility, the Contractor shall also provide Arvada with two (2) copies of an “Operation & Maintenance Manual” for the facility.

427.00 Design Criteria

427.01 Pumps and Pump Station

Pump stations shall be designed for the maximum flow anticipated using the design criteria in this Section 400 - Water Supply Facilities with the largest pump out of service.

Pump station design shall follow the recommendations and standards of the Hydraulics Institute.

A Standby Generator, capable of operating the entire station, shall be provided. The Generator may be housed inside a separate all-weather enclosure. A generator not housed inside a building shall be hospital grade.

427.02 Controls and Supervisory Control and Data Acquisition (SCADA)

All new controls, telemetry equipment, and security equipment shall be compatible with and easily integrated into Arvada's system. Controls and SCADA systems are subject to review and approval by the Project Engineer prior to installation.

427.03 Site Improvements

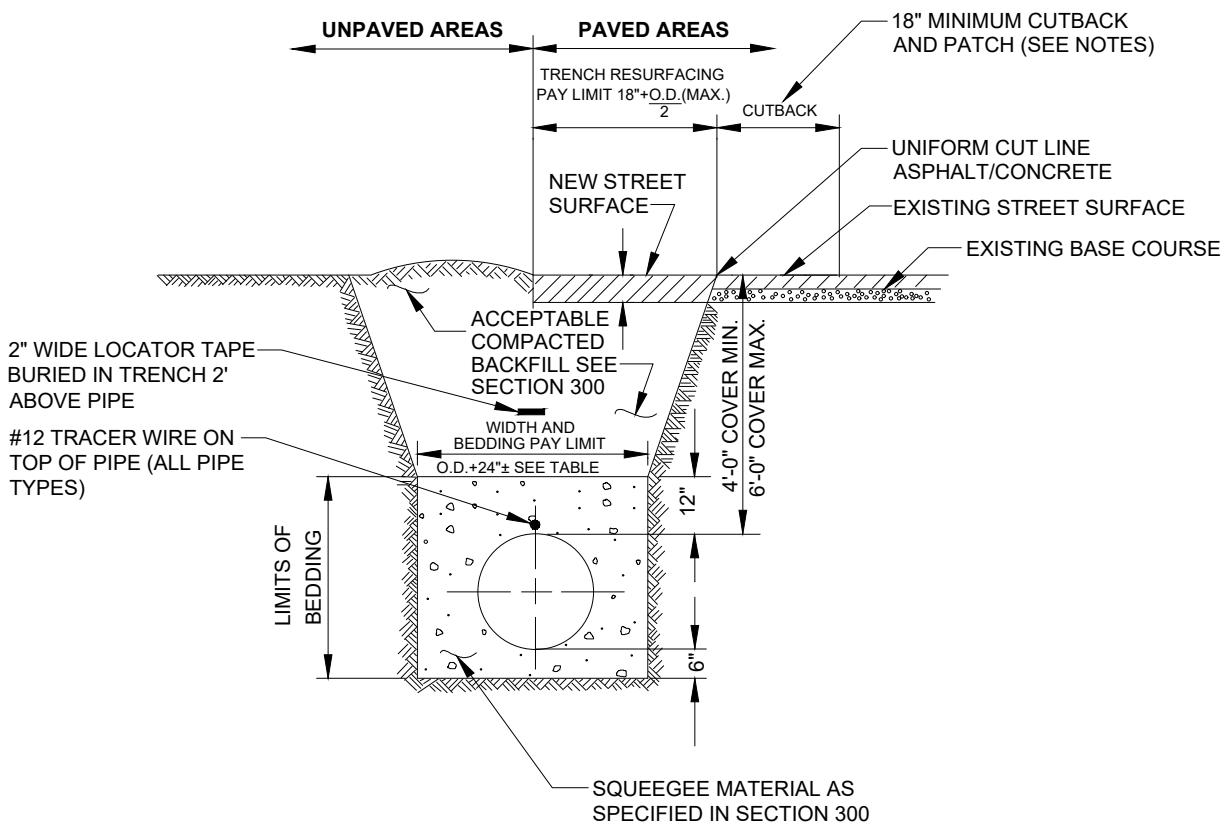
Refer to Section 550.05 - Site Security and Improvements of these Standards and Specifications.

428.00 Trenching, Backfilling and Compacting

Trenching, backfilling and compacting shall comply with Section 364.00 - Trenching, Backfilling and Compacting.

429.00 Restoration and Cleanup

Restoration and cleanup shall be completed in accordance with Section 371.00 - Restoration and Cleanup of these Standards and Specifications.



TYPICAL TRENCH SECTION

NOTES:

1. PAVING SHALL COMPLY WITH SECTION 700.
2. TRENCH WALLS TO BE SUPPORTED AS REQUIRED BY O.S.H.A.
3. MINIMUM COVER OVER PIPE TO BE BELOW OFFICIAL STREET GRADE.
4. FOR ASPHALT PATCH DEPTH REFER TO THE REQUIREMENTS IN SECTION 700 OF THE STANDARDS AND SPECIFICATIONS.
5. CUTBACK AS REQUIRED BY PROJECT ENGINEER.

PIPE DIAMETER	MINIMUM WIDTH	MAXIMUM WIDTH
4"	1'-4"	2'-4"
6"	1'-6"	2'-6"
8"	1'-8"	2'-8"
12"	2'-0"	3'-0"
16"	2'-4"	3'-4"
20"	2'-8"	3'-8"
24"	4'-0"	5'-0"

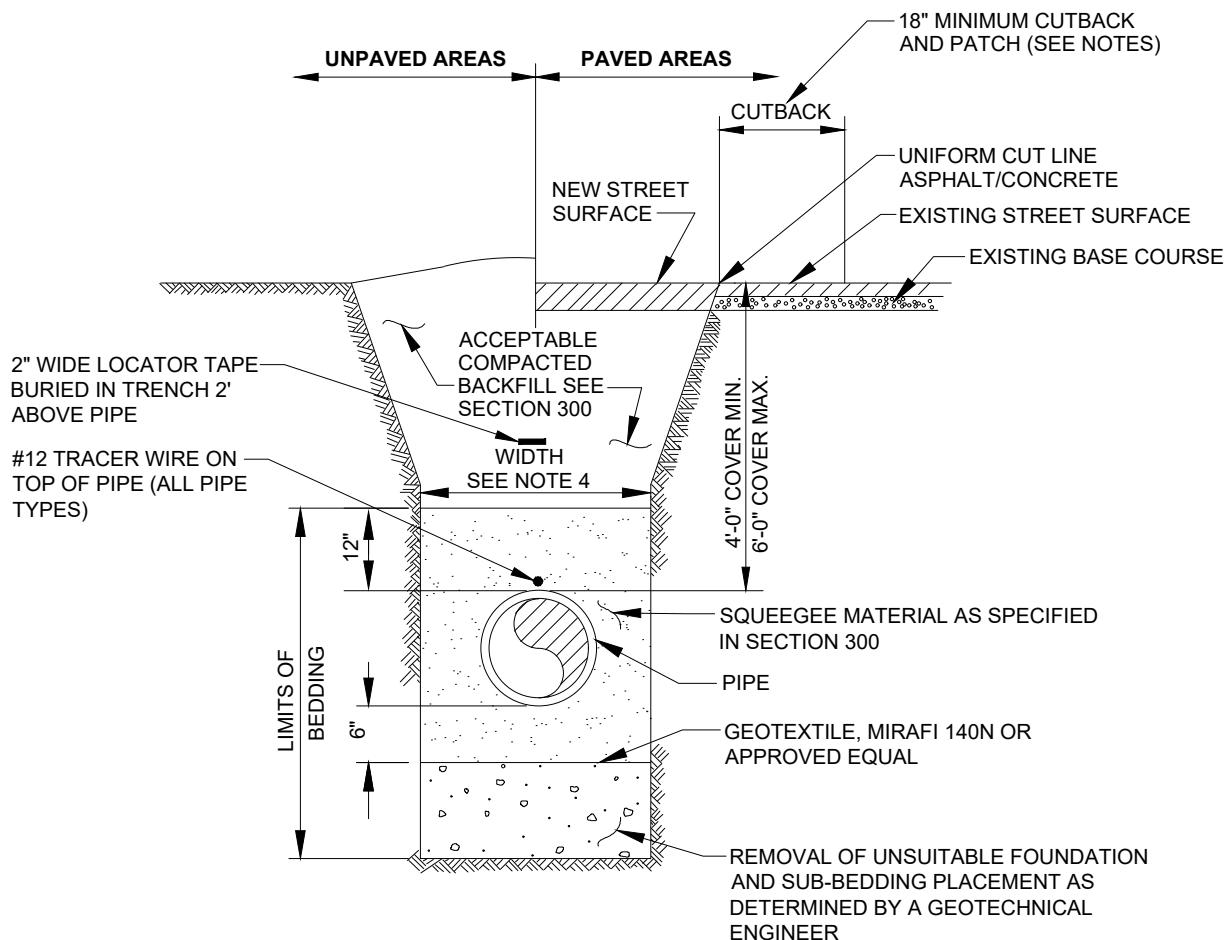
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**TYPICAL TRENCH SECTION
PIPE PROTECTION
WATER MAINS**

2022 ENGINEERING STANDARDS & SPECIFICATIONS

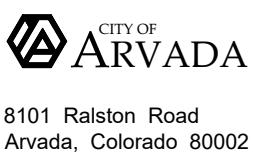


TYPICAL TRENCH SECTION

NOTES:

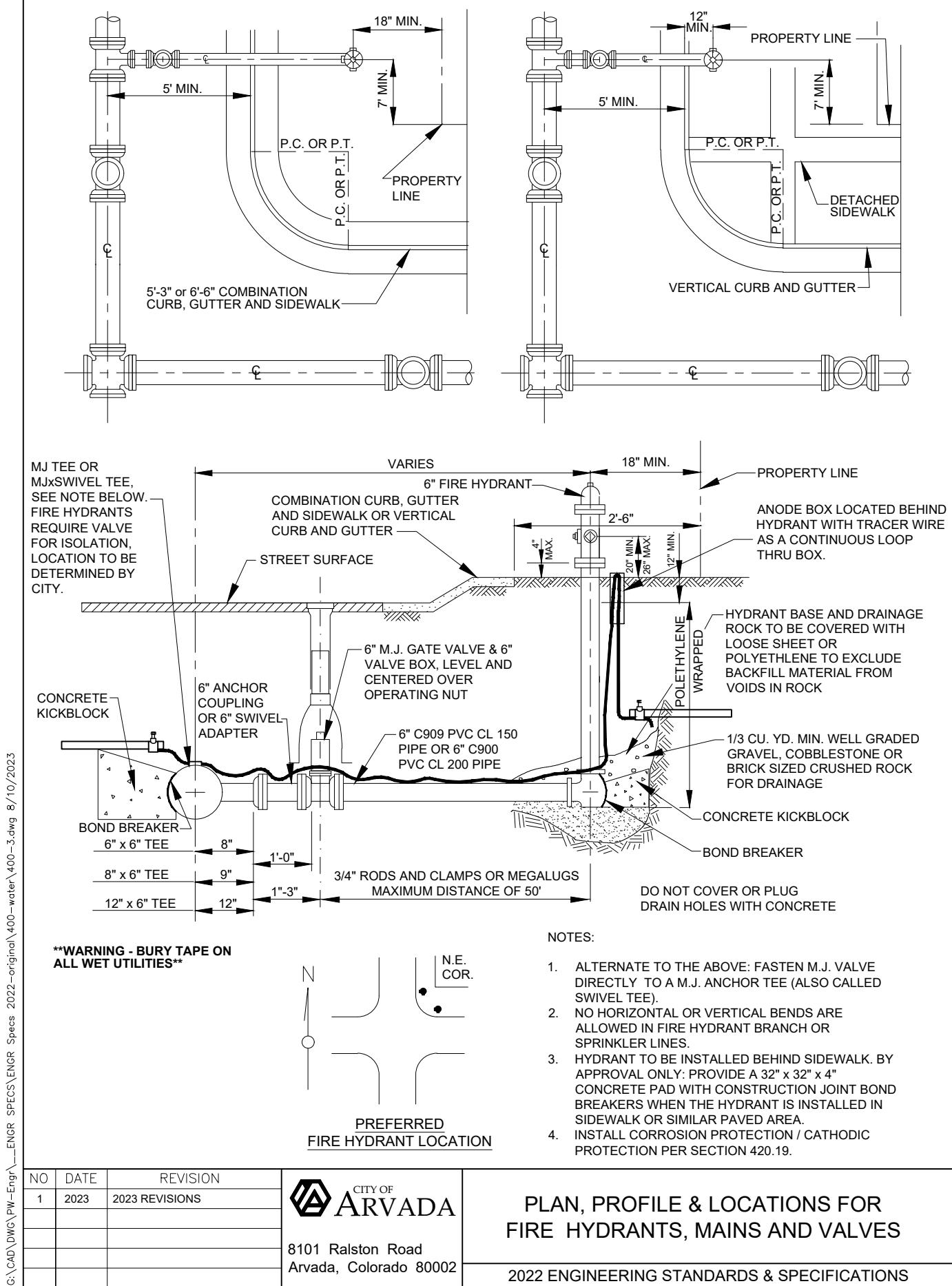
1. MINIMUM COVER TO BE 4.0' BELOW OFFICIAL STREET GRADE.
2. TRENCH WALLS TO BE SUPPORTED AS REQUIRED BY O.S.H.A.
3. PIPE SHALL BE BEDDED FROM 18" BELOW THE BOTTOM OF THE PIPE TO 12" ABOVE THE TOP OF THE PIPE.
4. TRENCH WIDTH SHALL NOT BE MORE THAN 16" NOR LESS THAN 12" WIDER THAN THE LARGEST OUTSIDE DIAMETER OF PIPE.
5. COMPACTION SHALL BE IN ACCORDANCE WITH SECTION 300.
6. PIPE BEDDING SHALL BE PLACED AGAINST UNDISTURBED SOIL IN THE TRENCH BOTTOM, HOWEVER WHERE ADVERSE SOIL IS ENCOUNTERED IN THE TRENCH BOTTOM, SOIL SHALL BE REMOVED AND TRENCH STABILIZATION MATERIAL SHALL BE PLACED IN ACCORDANCE WITH THE RECOMMENDATIONS OF A GEOTECHNICAL ENGINEER.
7. MINIMUM COVER OVER PIPE TO BE BELOW OFFICIAL STREET GRADE.
8. FOR ASPHALT PATCH DEPTH REFER TO THE REQUIREMENTS IN SECTION 700 OF THE STANDARDS AND SPECIFICATIONS.
9. CUTBACK AS REQUIRED BY PROJECT ENGINEER.

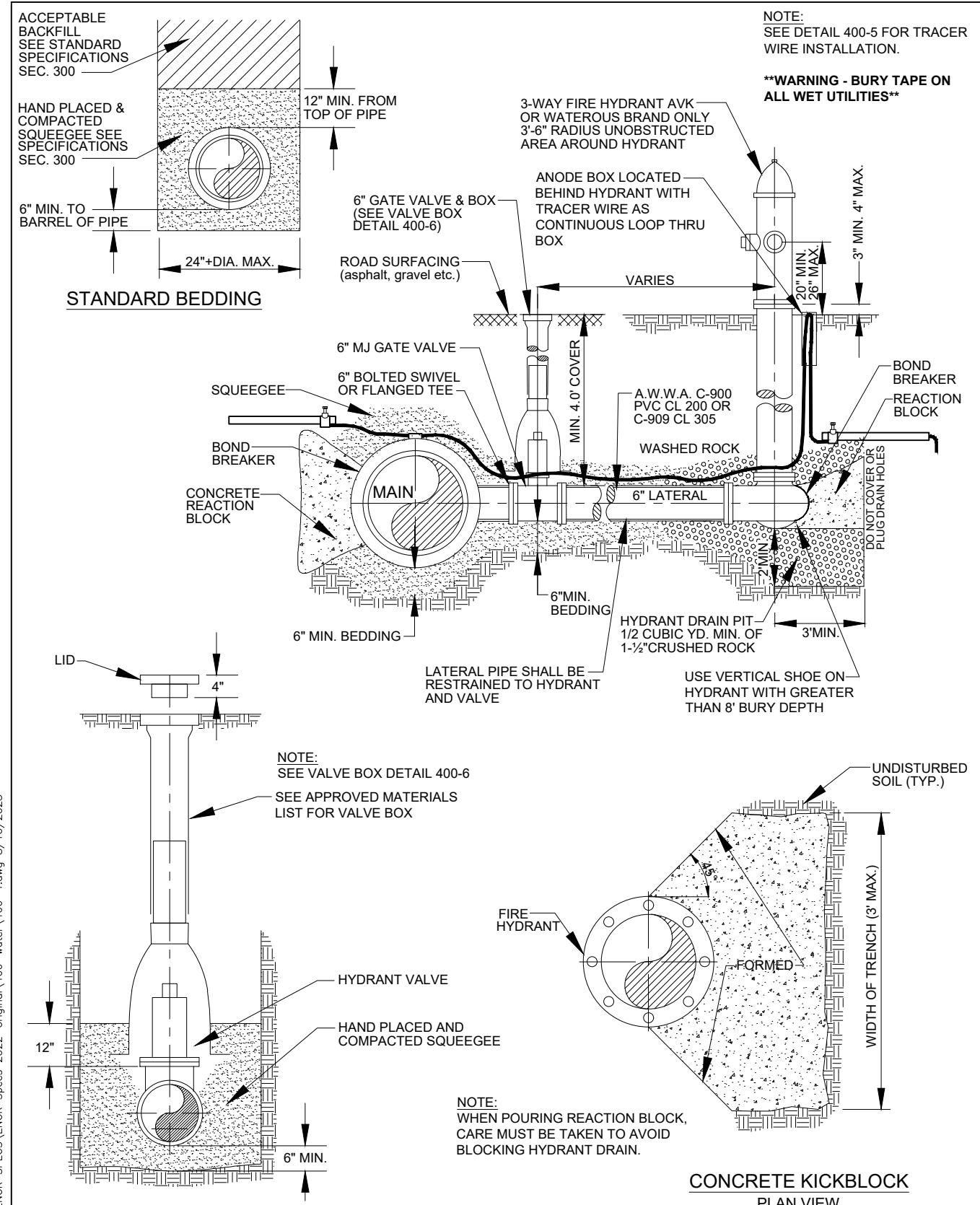
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**TYPICAL TRENCH SECTION FOR
WATER MAIN PIPELINES IN
UNSTABLE SUBGRADE**

2022 ENGINEERING STANDARDS & SPECIFICATIONS





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FIRE HYDRANT INSTALLATION

2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTE:
TRACER WIRE BOX LOCATED
SO AS TO BE ACCESSIBLE BY
WATER DIVISION PERSONNEL.

FOR GROUND, USE 20" LENGTH
 $\times \frac{3}{8}$ " DIA. COPPER GROUND
ROD. ATTACH WIRE WITH 3/8"
COPPER GROUND
ROD CLAMP

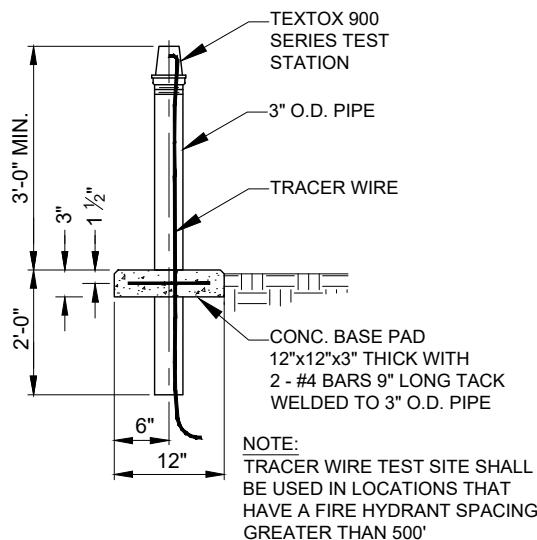
FOR FIRE HYDRANTS ANODE BOX
LOCATED BEHIND HYDRANT WITH
TRACER WIRE AS CONTINUOUS
LOOP THRU BOX AND GROUND
INTO THE BANK, A MINIMUM OF
18" DEEP

TRACER WIRE TO BE WHITE AWG
#12 UF OR USE CABLE UL LISTED
SINGLE TYPE COPPER CONDUCTOR

DRY CONN DIRECT
BURY LUG

USE $\frac{3}{8}$ " DIA. \times 20" COPPER GROUND
ROD WHEN TYING TO EXISTING
TRACER WIRE SYSTEM, OR IF THERE
IS NO TRACER WIRE TO TIE TO

FIRE HYDRANT TRACER WIRE (ALL)



TRACER WIRE TEST SITE

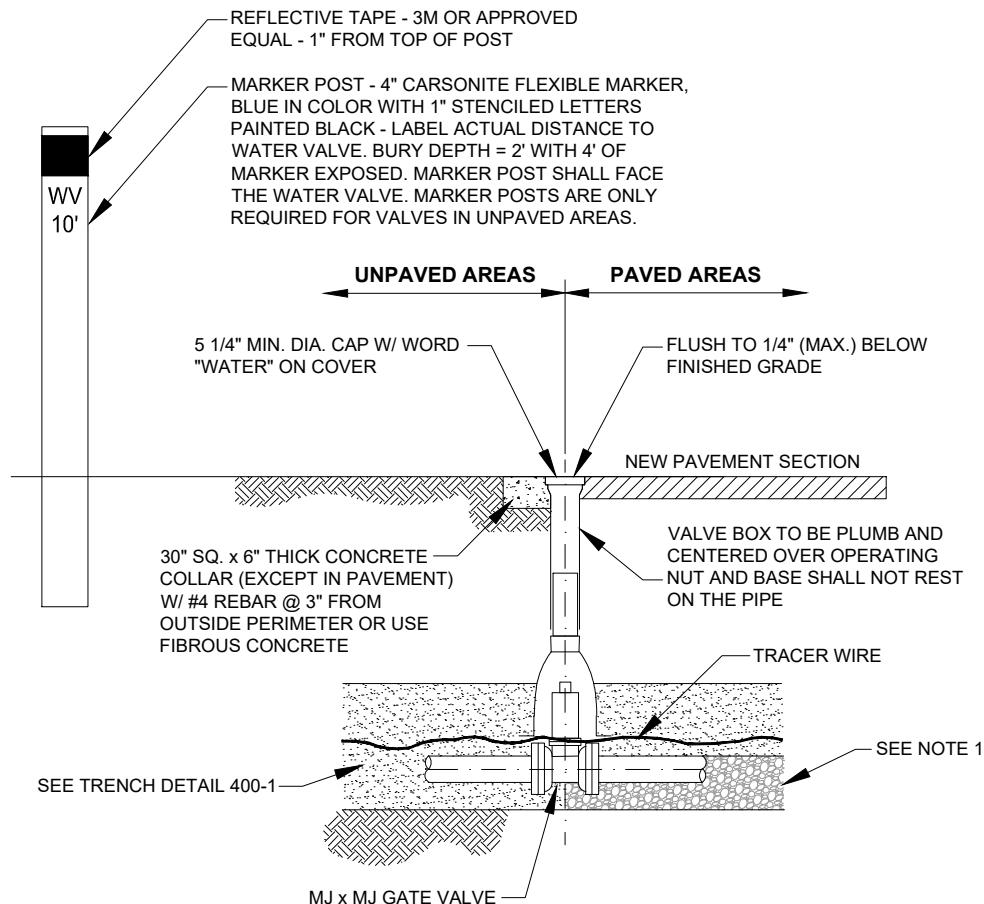
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TRACER WIRE & TEST SITE DETAILS

2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

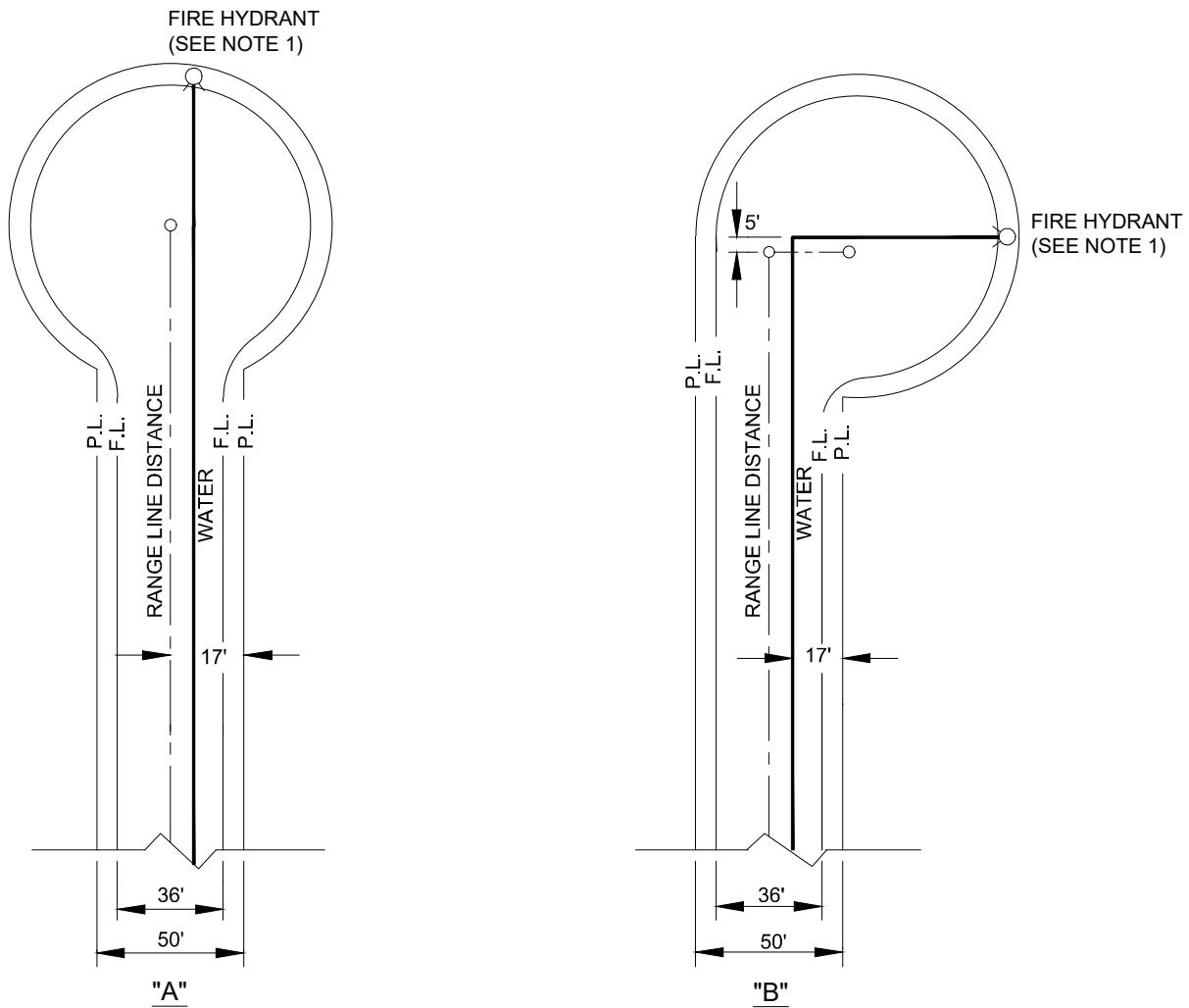
- CARE SHALL BE TAKEN WHEN INSTALLING VALVES TO ASSURE PROPER SUPPORT OF THE VALVE. THE CITY ENGINEER MAY REQUIRE 3/4" CRUSHED ROCK TO BE INSTALLED UNDER THE VALVE TO PROVIDE PROPER SUPPORT.
- VALVES SHALL NOT BE PLACED IN CONCRETE SIDEWALKS, CROSS PANS, GUTTERS OR OTHER DRAINAGEWAYS.
- OPERATING NUTS OR EXTENSIONS SHALL NOT BE SET CLOSER THAN TWO (2) FEET FROM FINAL GRADE. IF THE OPERATING NUT IS DEEPER THAN SEVEN (7) FEET FROM FINAL GRADE, PROVIDE A 1 1/4" EXTENSION SHAFT W/ CENTERING RING. OPERATOR EXTENSIONS SHALL BE CONNECTED TO THE VALVE OPERATOR NUT USING A PIN. THE EXTENSION SHAFT SHALL INCLUDE A 1/4" THICK TRASH RING LOCATED 6" BELOW THE NON-RISING PORTION OF THE VALVE BOX. THE DIAMETER OF THE TRASH RING SHALL BE 1/8" LESS THAN THE INSIDE DIAMETER OF THE VALVE BOX.
- CONCRETE COLLARS & MARKER POSTS ARE REQUIRED WHEN VALVE IS LOCATED IN AN UNPAVED AREA.
- VALVE BOXES ARE TO BE BROUGHT UP TO GRADE AT THE TIME OF PAVEMENT PLACEMENT OR OVERLAY. VALVE BOX ADJUSTING RINGS ARE NOT ALLOWED.

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VALVE BOX DETAIL



TYPICAL PLAN FOR CUL-DE-SACS

NOTES:

1. WHEN THE DISTANCE BETWEEN AN 8" MAIN AND THE CENTER OF A CUL-DE-SAC IS LESS THAN 600' BUT GREATER THAN 150' THE BRANCH LATERAL SHALL TERMINATE AT A FIRE HYDRANT. HYDRANT SHALL BE LOCATED WITHIN 5' OF END OF PIPE.
2. A TEE OR ELBOW SHALL BE INSTALLED AT THE END OF PIPE.

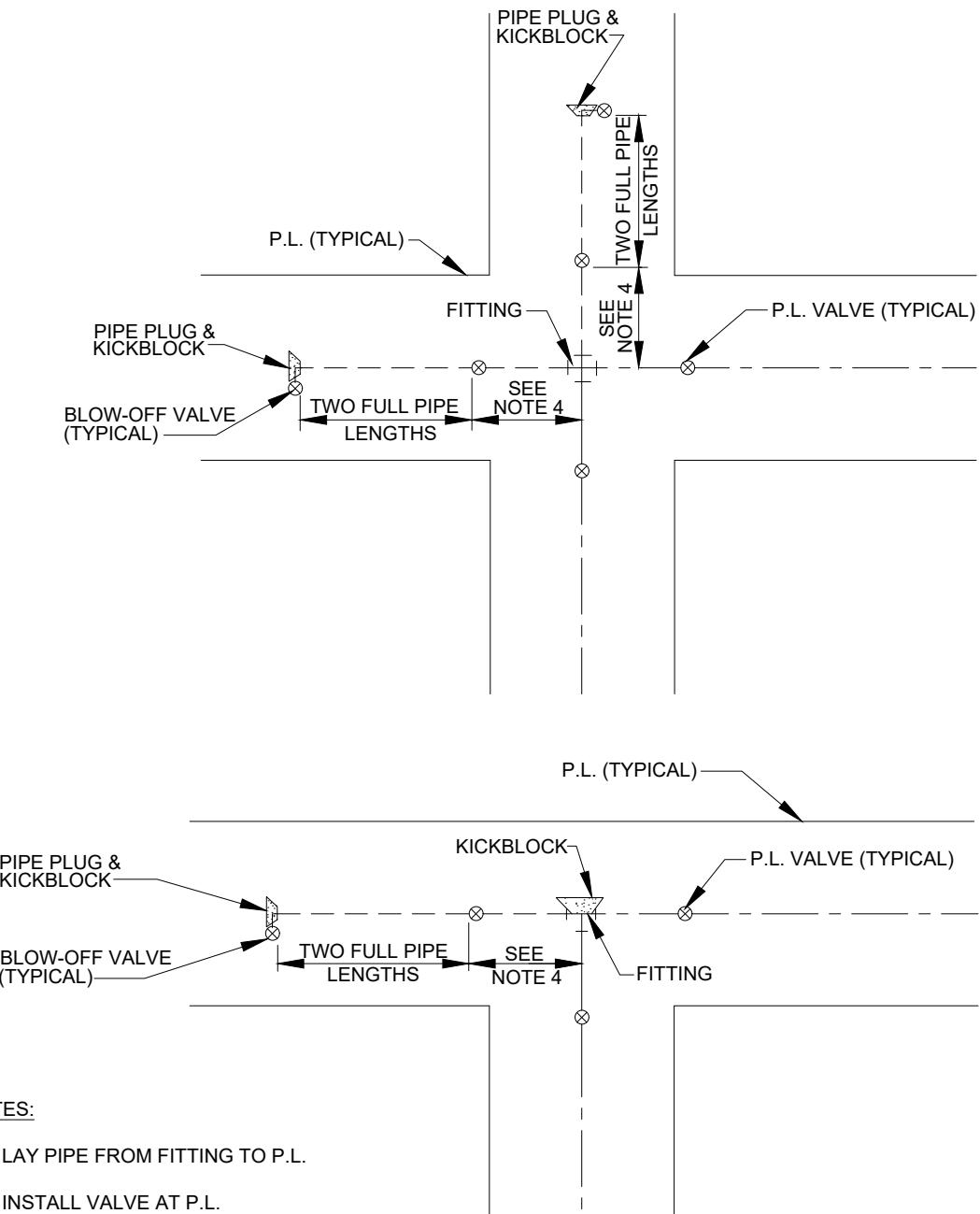
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WATER DISTRIBUTION SYSTEM TYPICAL PLAN FOR CUL-DE-SACS

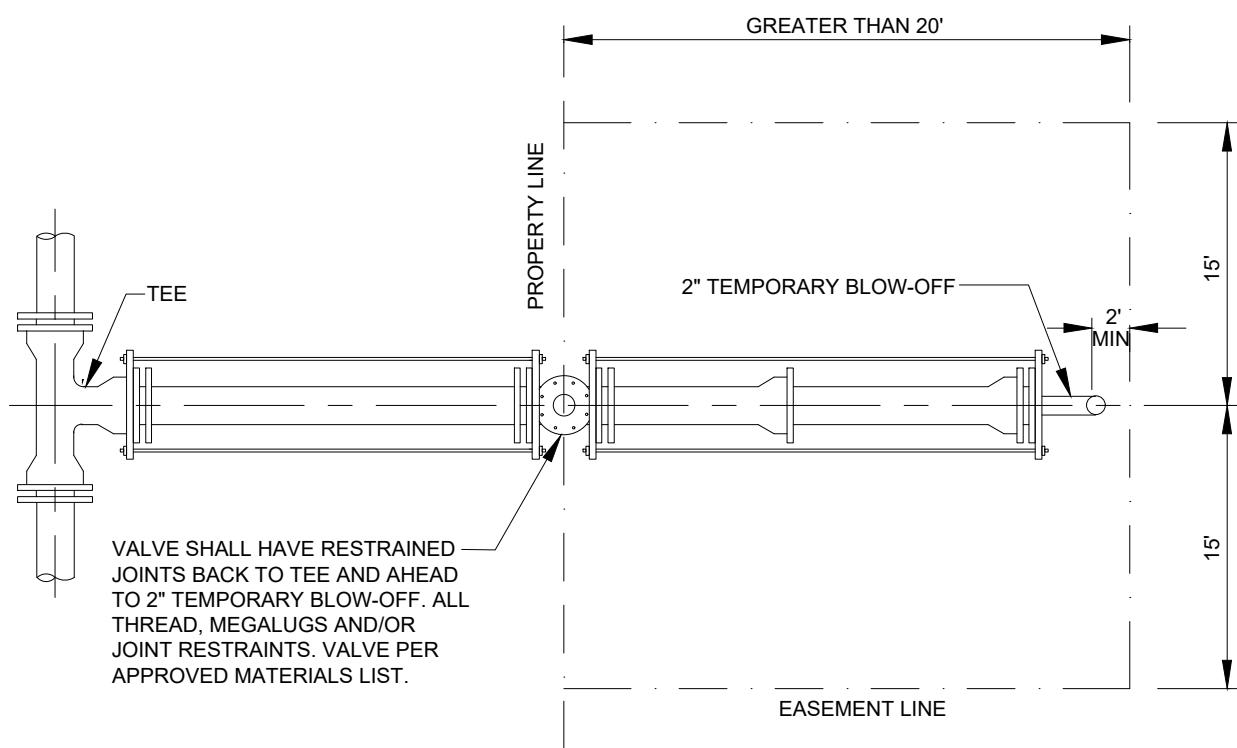
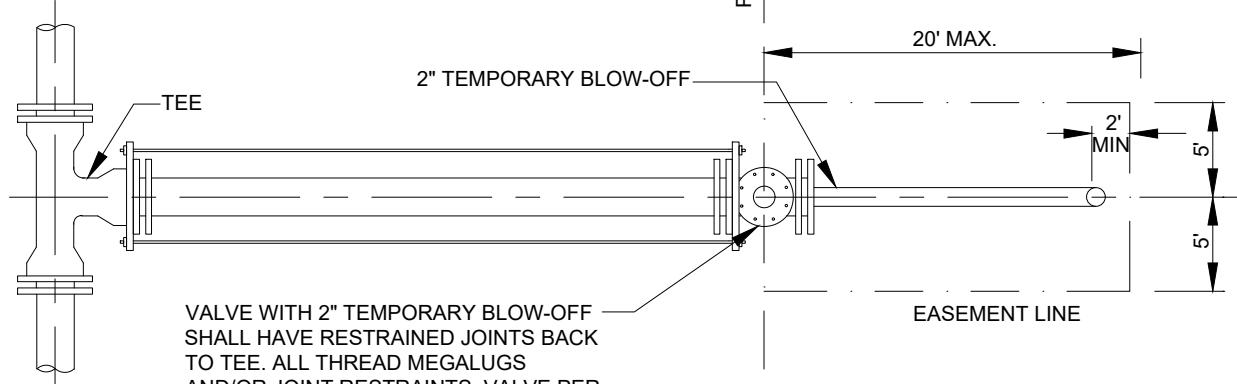
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NOTES:

1. LAY PIPE FROM FITTING TO P.L.
2. INSTALL VALVE AT P.L.
3. STUB OUT TWO FULL PIPE LENGTHS FROM VALVE, PLUG END OF PIPE INSTALL BLOWOFF AND KICKBLOCK.
4. ALTERNATIVE TO NOTE 3: PROVIDE RESTRAINED JOINTS FROM VALVE TO FITTING AND ELIMINATE THE TWO FULL LENGTHS OF PIPE OUT OF VALVE AND TEMPORARY BLOW-OFF.

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				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOT TO SCALE

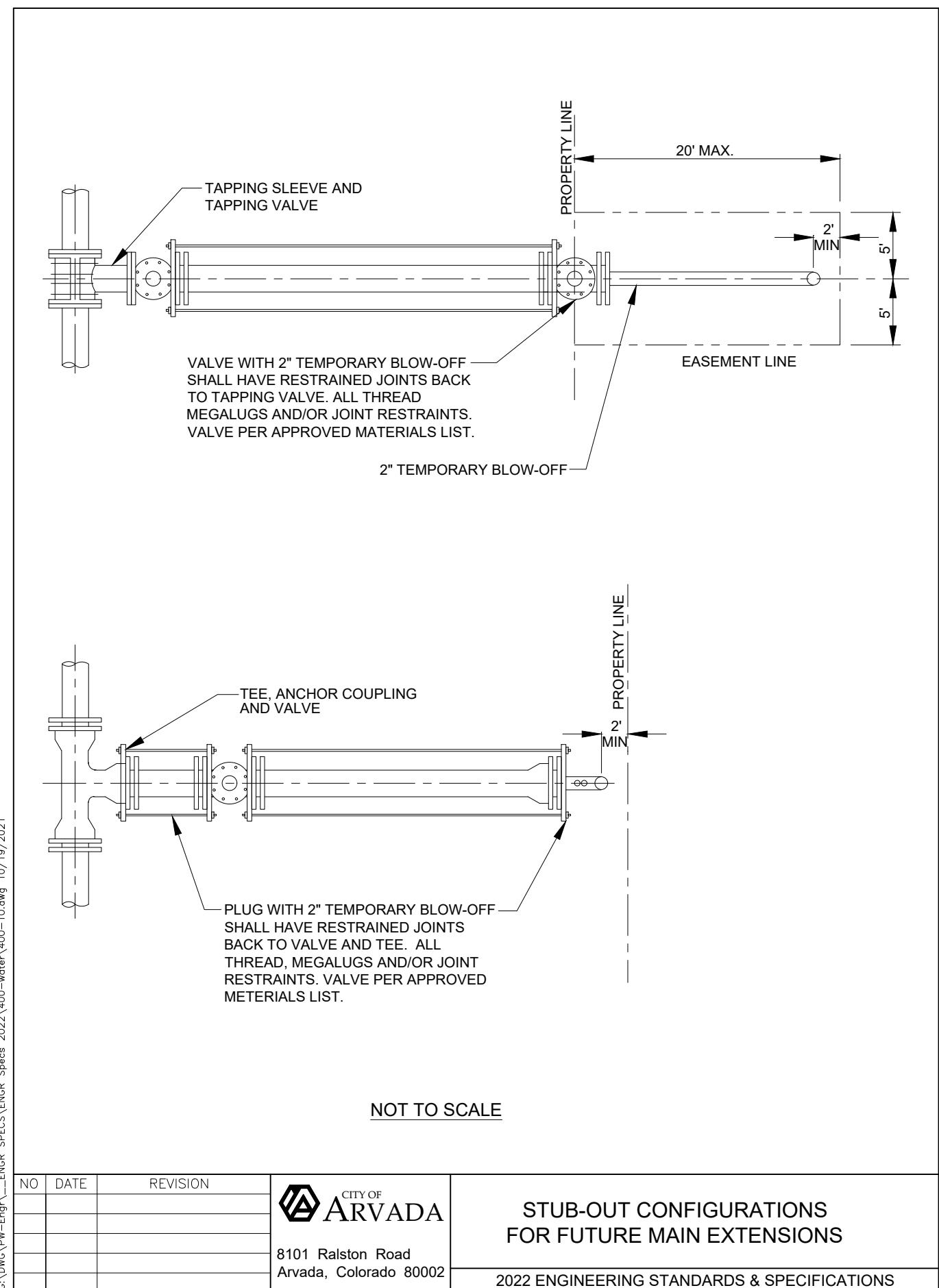
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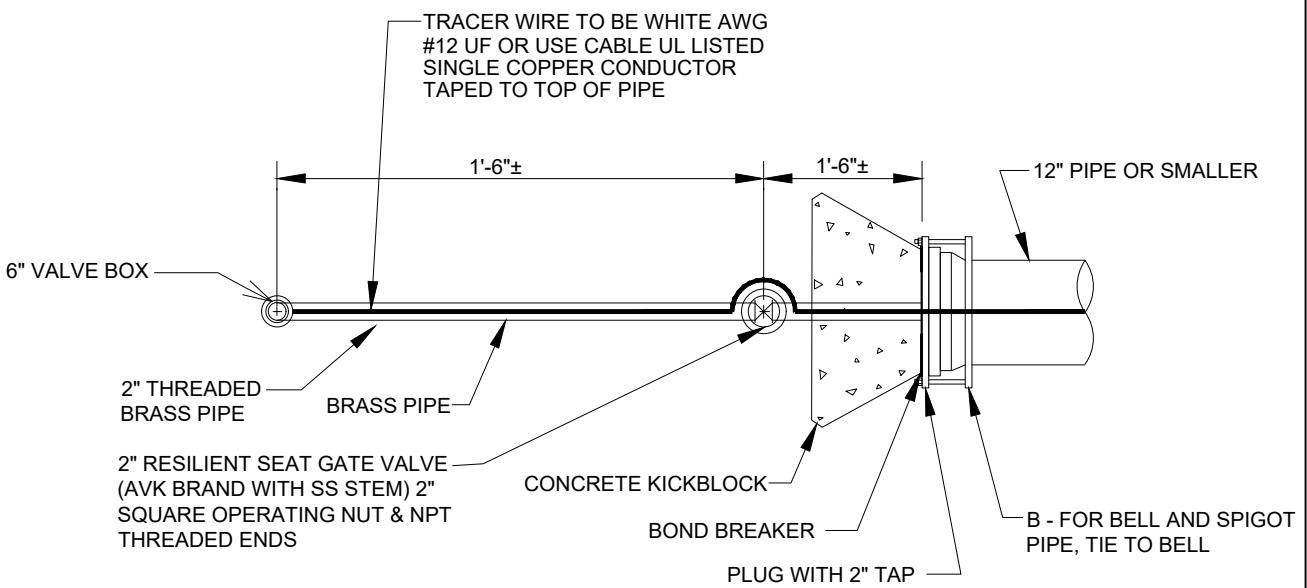


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STUB-OUT CONFIGURATIONS FOR FUTURE MAIN EXTENSIONS

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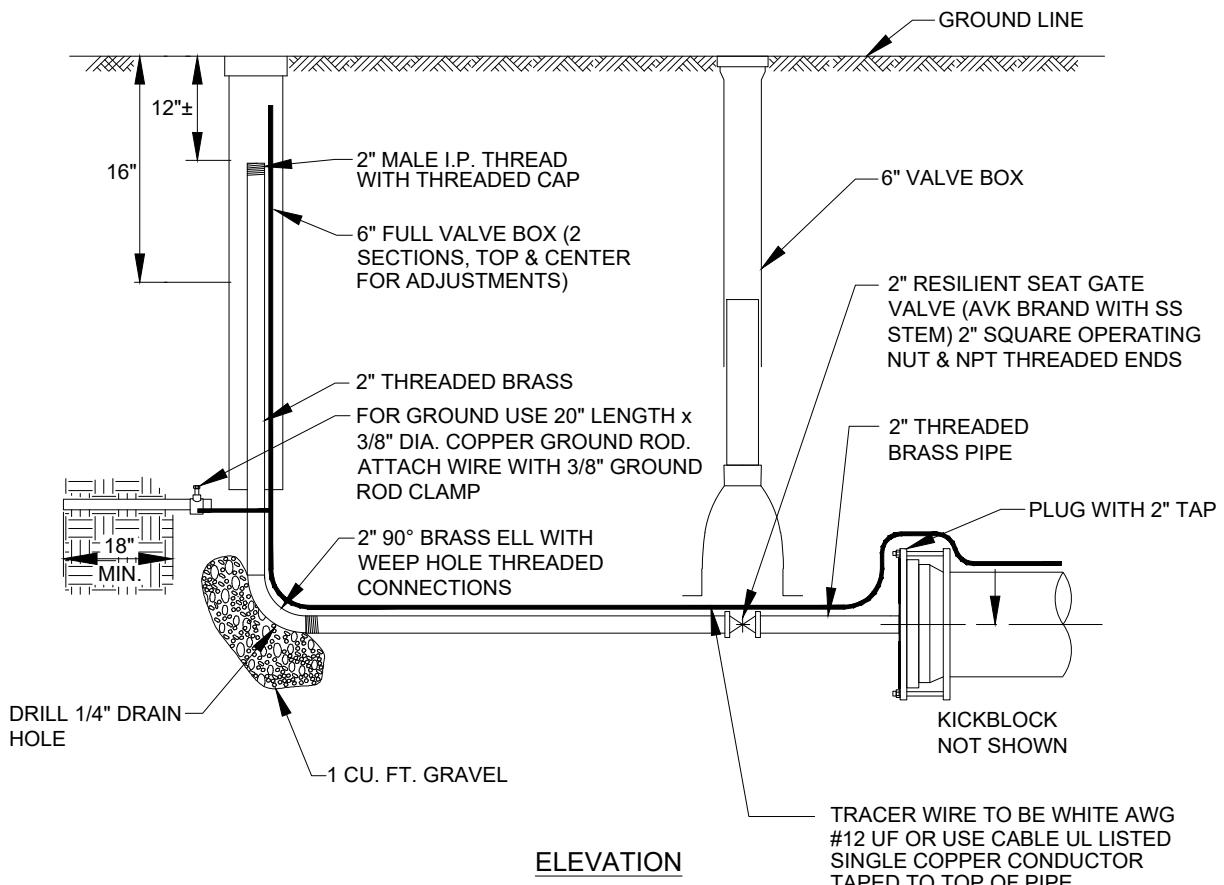




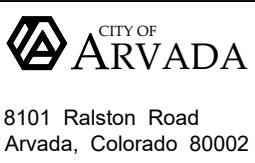
NOTE:

1. PLUG SHALL BE MECHANICALLY RESTRAINED.

PLAN

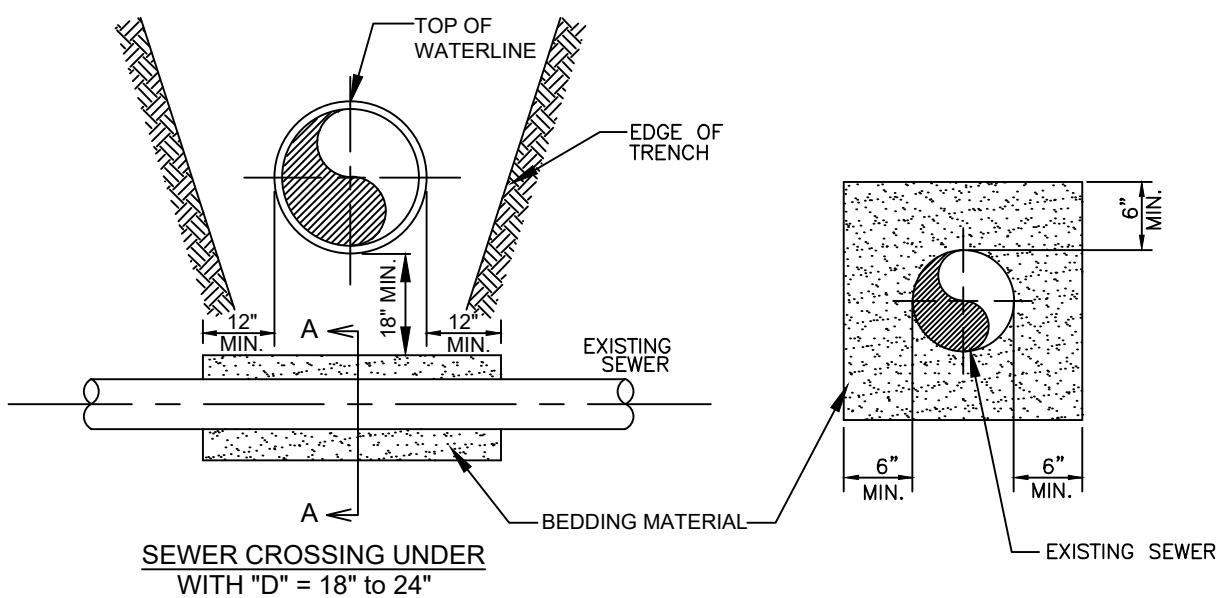
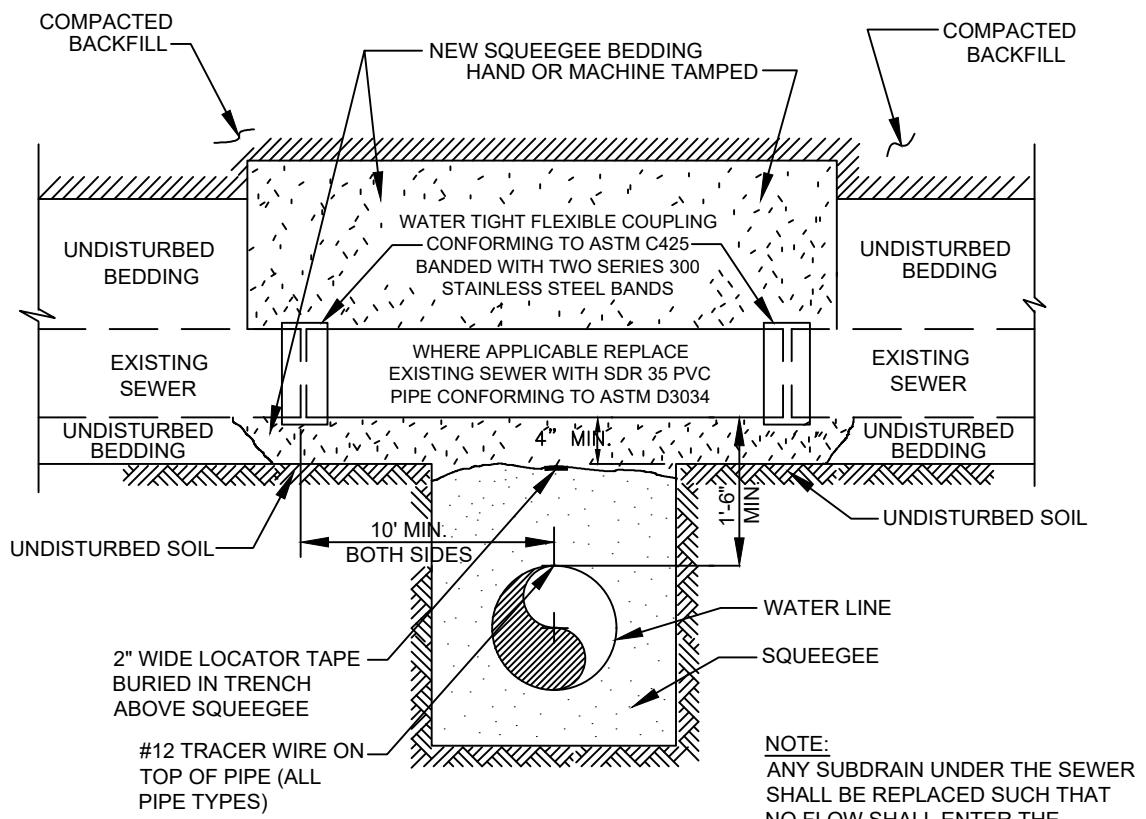


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BLOW-OFF INSTALLATION
FOR 12" AND SMALLER PIPE

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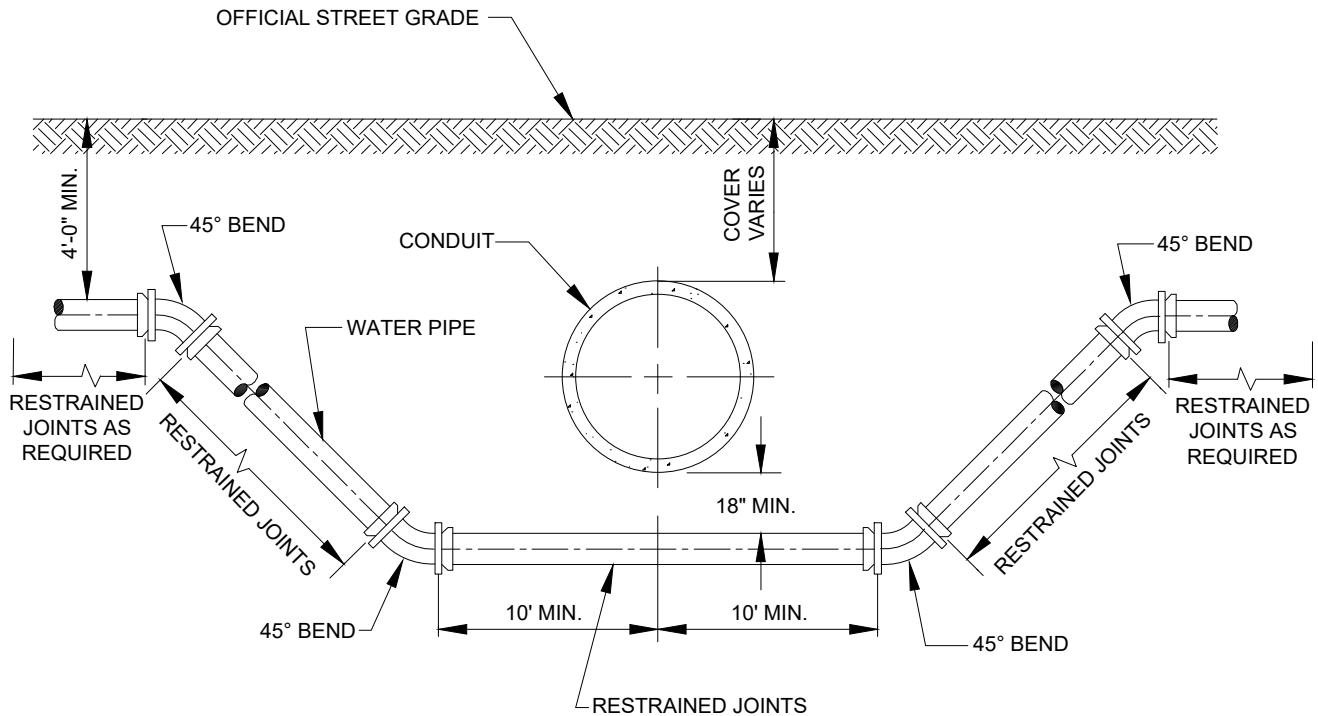


NOTE:
ALL EXISTING SEWER DAMAGED DURING
INSTALLATION MUST BE REPLACED WITH
PVC PIPE. REPLACE SEWER WITH
WATERTIGHT PIPE.

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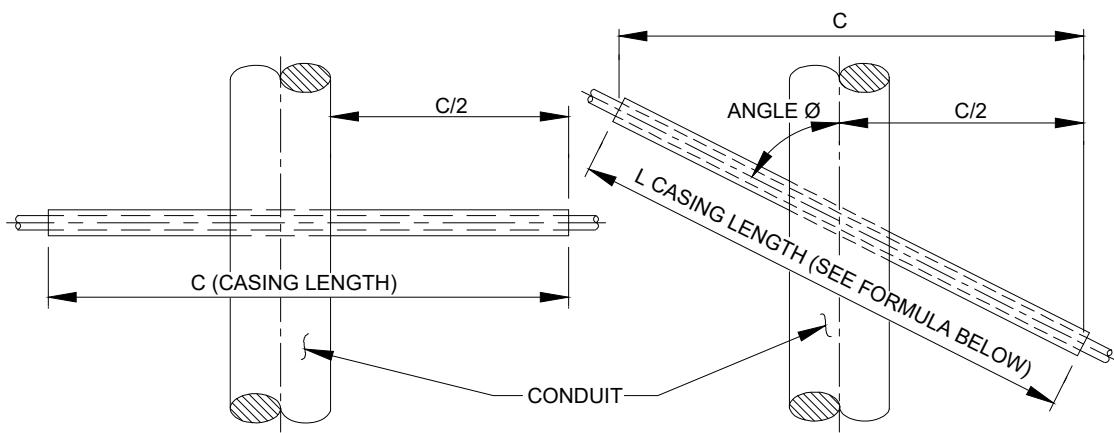
CROSSING STORM AND SANITARY SEWERS



NOTES:

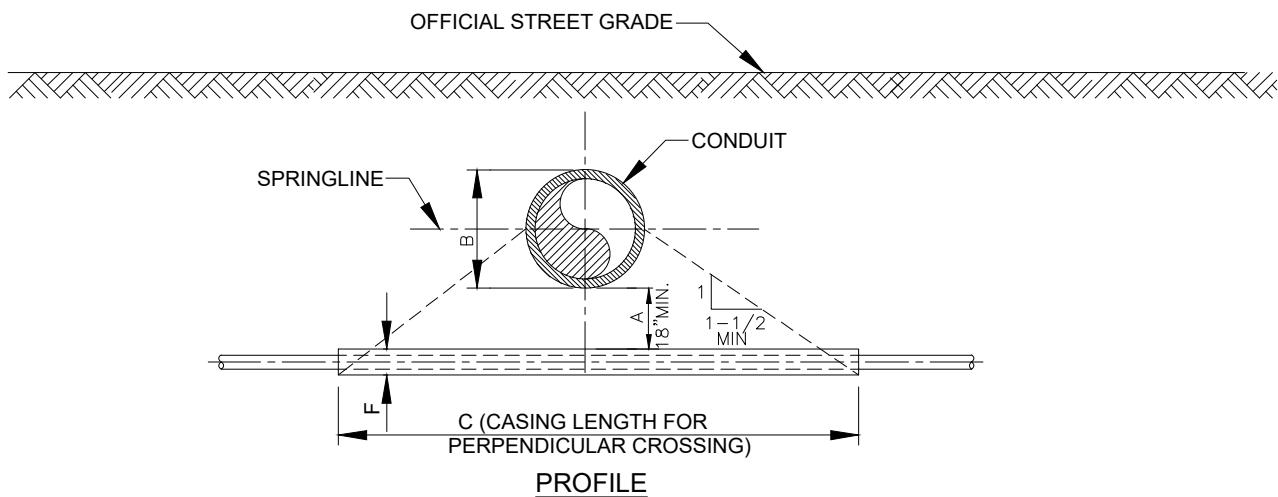
1. LENGTH OF EXTENSION OF PIPE AND RESTRAINED JOINTS SHALL BE IN ACCORDANCE WITH THESE ENGINEERING STANDARDS.
2. CATHODIC PROTECTION SHALL BE AS REQUIRED IN ACCORDANCE WITH THESE ENGINEERING STANDARDS.
3. A BORED CROSSING MAY BE REQUIRED BY THE CITY ENGINEER.
4. CONDUIT CROSSING SHALL MEET REQUIREMENT FOR CROSS-CONTAMINATION PROTECTION AS NEEDED PER SECTION NO. 400. WHERE WATER LINE IS LESS THAN THREE FEET FROM POTENTIAL ATMOSPHERIC TEMPERATURES, SUCH AS IN STORM WATER, WATER LINE SHALL BE INSULATED FROM CONDUIT.
5. PIPE SHALL BE CENTERED AT CROSSING IN BOTH DIRECTIONS.

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PLAN FOR PERPENDICULAR CROSSING

PLAN FOR ANGLE CROSSING



FORMULA FOR FINDING C:

$$C = B + (2)(1.5)$$

PERPENDICULAR CROSSING CASING LENGTH
 O.D. CONDUIT
 CONSTANT
 RATIO OF MIN. SLOPE

CASING O.D.
 VERTICAL DISTANCE BETWEEN CASING AND CONDUIT
 1/2 O.D. CONDUIT

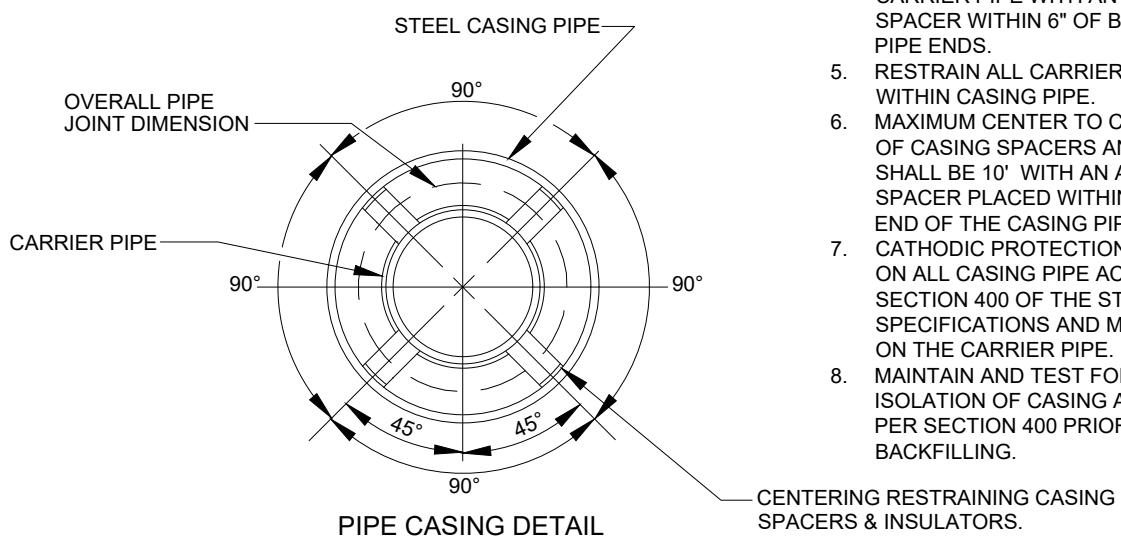
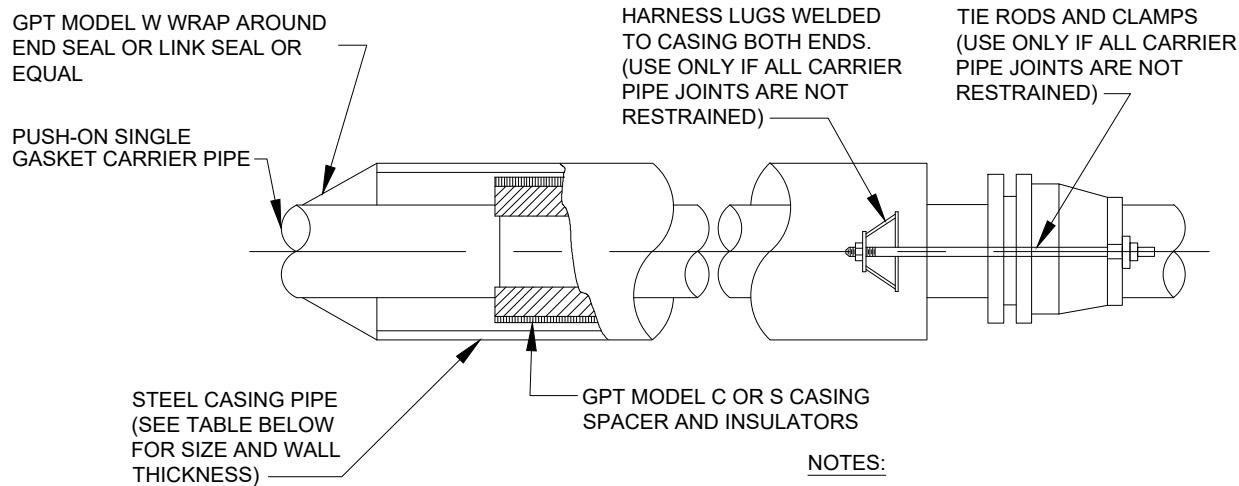
FORMULA FOR FINDING L:

$$L = \frac{C}{\sin \theta}$$

NOTES:

- FINAL APPROVAL OF BORING AND CASING METHOD AND MATERIALS SHALL BE OBTAINED FROM THE ENGINEER PRIOR TO CONSTRUCTION.
- SOIL AT ENDS OF CASING SHALL BE STABLE AT ALL TIMES.
- CATHODIC PROTECTION SHALL BE PROVIDED FOR STEEL CASING AS REQUIRED BY THE ENGINEER.
- CASING PIPE SHALL BE ONE PIECE, STRAIGHT, ROUND AND OF NEW MATERIAL.

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NOTES:

1. CENTERING RESTRAINING CASING SPACERS AND INSULATORS SHALL BE USED TO INSTALL CARRIER PIPE.
2. TRENCH LAID CASINGS SHALL BE DESIGNED AND INSTALLED TO CONDUIT STANDARDS.

CARRIER PIPE NOMINAL DIA.	CASING PIPE		MINIMUM SPACER LENGTH
	MIN. O.D.	MIN. WALL THICK	
4"	12"	0.375"	8"
6"	16"	0.375"	8"
8"	18"	0.375"	8"
12"	22"	0.375"	8"
16"	28"	0.375"	12"
20"	32"	0.500	12"
24"	36"	0.500"	12"

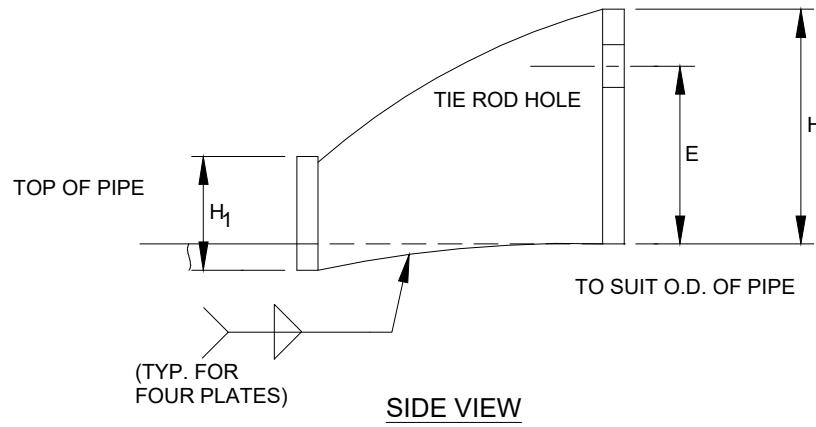
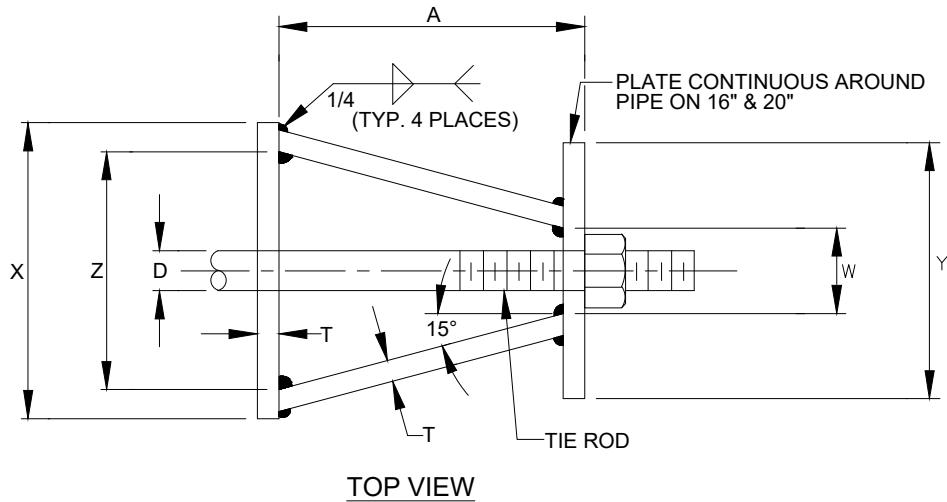
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BORE CASING DETAILS FOR WATER AND SANITARY SEWER MAINS

2022 ENGINEERING STANDARDS & SPECIFICATIONS

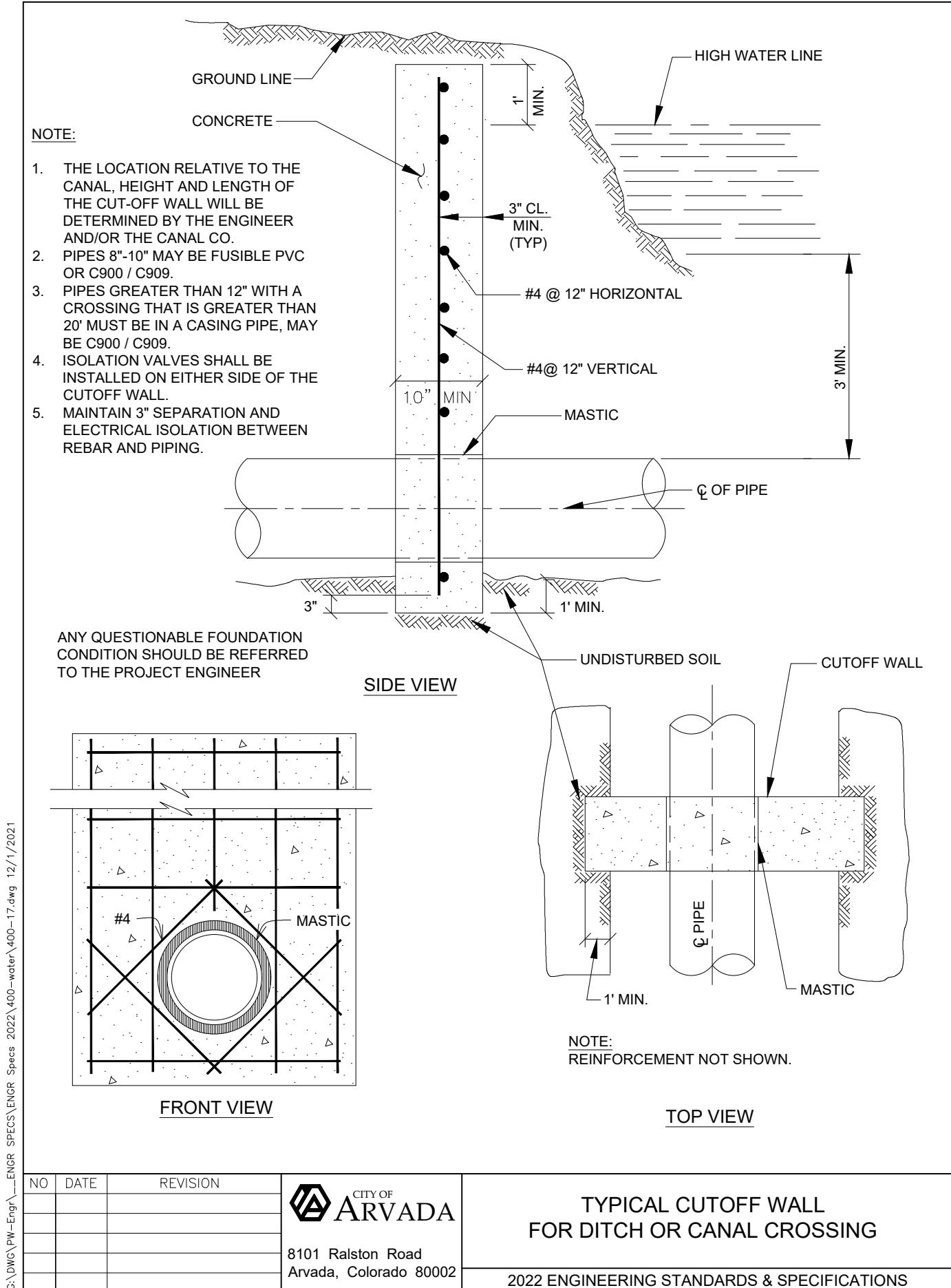


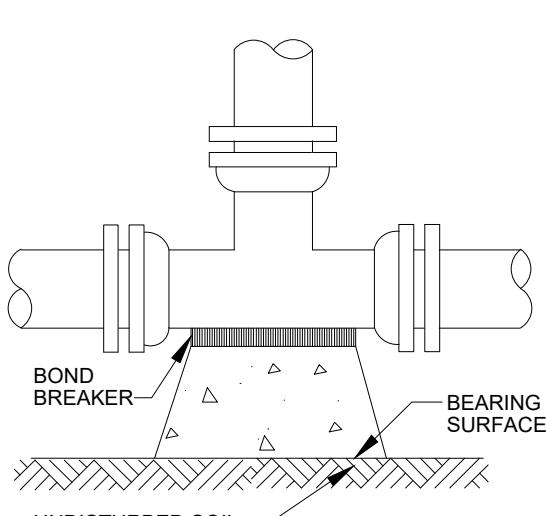
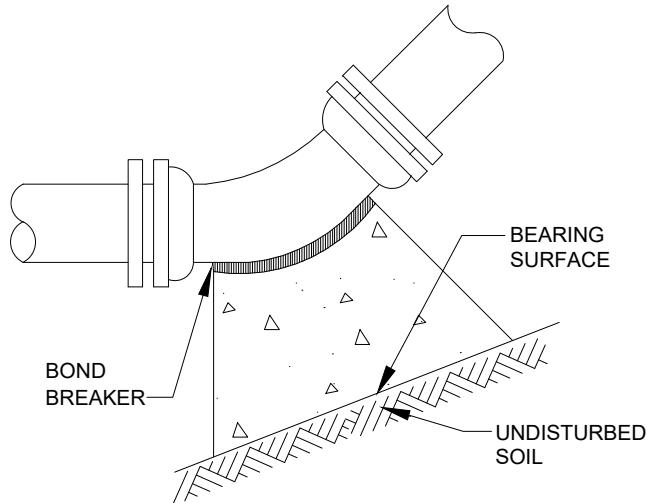
W/O FLANGED LUGS	CARRIER PIPE NOMINAL DIA.	STUD DIA. D	A	W	Z	T	H	E	H ₁	Y	X
	4" TO 12"	3/4"	5"	1-1/2"	3-3/4"	3/8"	4-1/8"	3-1/8"	2"	4-1/2"	5"
	16"	1"	5-3/4"	1-3/4"	4-1/2"	1/2"	4-1/2"	3-1/4"	2"	RING	6"
	20"	1-1/4"	7-1/2"	2"	5-3/4"	5/8"	5"	3-3/4"	2-1/2"	RING	7-1/2"

NOTES:

1. USE TWO HIGH STRENGTH STEEL TIE RODS AT END OF CASING.
2. TIE ROD HOLE DIAMETER 1/8" LARGER THAN STUD DIAMETER.
3. BOTTOM EDGE OF ALL PLATES SHAPED TO FIT O.D. OF PIPE.
4. HARNESS LUGS AS PER AWWA MANUAL M-II.

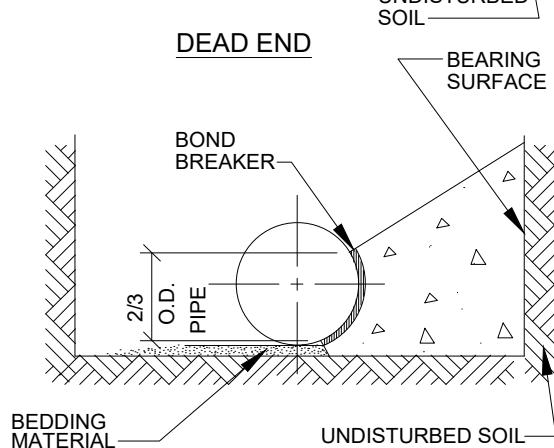
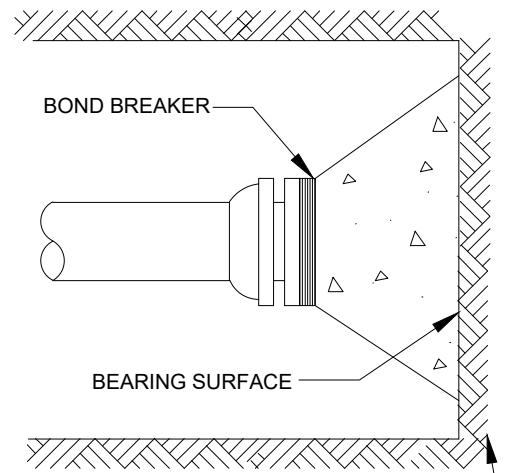
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	COMBINATION FLANGED HARNESS LUG DETAILS		
				2022 ENGINEERING STANDARDS & SPECIFICATIONS		





NOTE:

1. BEARING SURFACES SHOWN IN CHART ARE MINIMUM.
2. BASED ON 150 PSI INTERNAL PIPE PRESSURE PLUS WATER HAMMER. 3", 4", 6", 8" AND 12" WATER HAMMER = 110 P.S.I. 16", 20" AND 24" WATER HAMMER = 70 P.S.I.
3. BASED ON 3,000 psf SOIL BEARING CAPACITY.
4. ALL BENDS, TEE BRANCHES AND DEAD ENDS SHALL BE RESTRAINED AND KICK BLOCKED.



TYPICAL CROSS SECTION

MINIMUM BEARING SURFACE AREA
(IN SQUARE FEET)

SIZE OF PIPE	BENDS				TEE OR DEAD END
	11 1/4 °	22 1/2 °	45 °	90 °	
3"	1.00	1.00	1.00	1.00	1.00
4"	1.00	1.00	1.00	1.50	1.50
6"	1.00	1.25	2.25	3.00	3.00
8"	1.00	2.00	4.00	5.25	5.25
12"	2.25	4.50	8.75	11.25	11.25
16"	3.75	7.50	14.50	27.00	19.00
20"	5.00	10.00	19.50	35.50	25.00
24"	7.00	14.00	27.75	51.00	36.00

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	
		CONCRETE KICKBLOCKS BEARING SURFACES AND INSTALLATION		
		2022 ENGINEERING STANDARDS & SPECIFICATIONS		

CONCRETE KICKBLOCKS

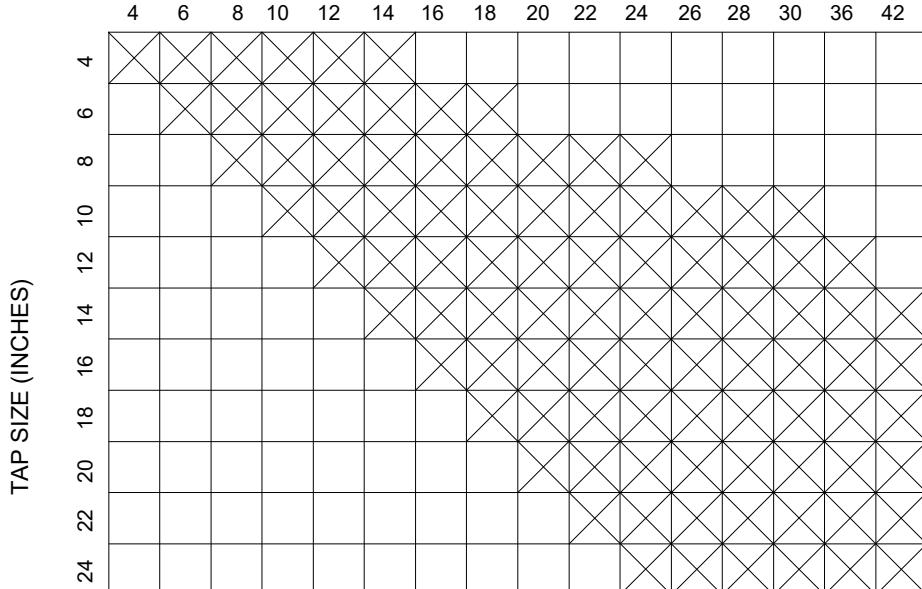
WATER MAIN AND TAP SIZE COMBINATIONS WHICH REQUIRE A
CONCRETE KICKBLOCK BEHIND THE MAIN AT THE TAPPING
SLEEVE OR SADDLE.

ALL WATER MAINS



INDICATED CONCRETE KICKBLOCK REQUIRED

MAIN SIZE (INCHES)



NOTE:

1. ANY KICKBLOCK REQUIREMENTS FOR WATER MAIN AND TAP SIZE COMBINATIONS OTHER THAN THOSE SHOWN ABOVE WILL REQUIRE SPECIAL DESIGN APPROVAL BY THE ENGINEERING DIVISION.
2. ALL CONNECTIONS SHALL BE TEE, UNLESS WET TAP IS APPROVED BY PROJECT ENGINEER.
3. SERVICES ABOVE 4" MUST BE APPROVED BY CITY OF PROJECT ENGINEER PRIOR TO CONNECTION.

NO	DATE	REVISION

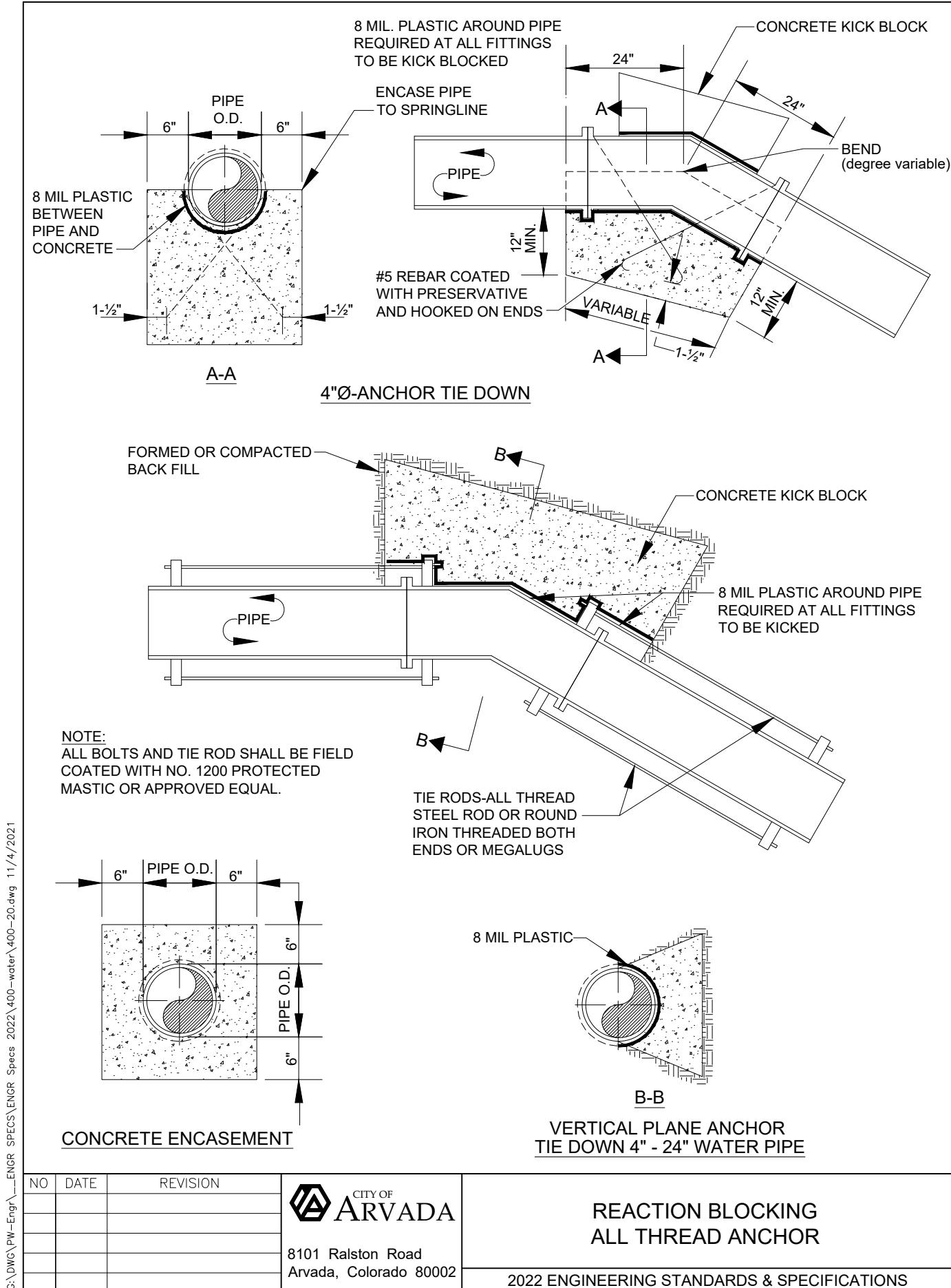


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CONCRETE KICKBLOCKS FOR WET TAPS

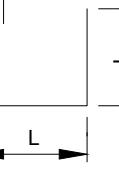
2022 ENGINEERING STANDARDS & SPECIFICATIONS



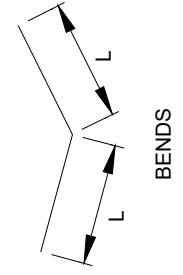
ROD DIAMETER, GRADE & LENGTH OF RESTRAINED PIPE

PIPE SIZE	4"			6"			8"			12"			16"			20"			24"		
FITTING	D	L	G	D	L	G	D	L	G	D	L	G	D	L	G	D	L	G	D	L	G
90° BEND	3/4"	30'	M.S.	3/4"	45'	M.S.	3/4"	61'	M.S.	3/4"	86'	H.S.	1"	108'	H.S.	1 1/4"	132'	H.S.	—	155'	—
TEE, PLUG	—	—	—	—	—	—	—	—	—	—	—	—	1"	108'	H.S.	1 1/4"	132'	H.S.	—	155'	—
VALVE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
45° BEND	3/4"	9'	M.S.	3/4"	13'	M.S.	3/4"	21'	M.S.	3/4"	25'	M.S.	1"	32'	M.S.	3/4"	39'	H.S.	—	45'	—
22 1/2° BEND	3/4"	1'	M.S.	3/4"	4'	M.S.	3/4"	5'	M.S.	3/4"	7'	M.S.	3/4"	8'	M.S.	3/4"	10'	M.S.	—	12'	—
11 1/4° BEND	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	M.S.	—	3'	—

NOTES:



90° BEND



BENDS

1. LENGTH OF RESTRAINED PIPE MEASURED EACH WAY FROM BENDS.
2. CLAMPS AND RODS NOT ALLOWED FOR 30" & LARGER PIPES. MEGALUGS NOT ALLOWED FOR PIPES LARGER THAN 48" DIAMETER.
3. D=DIAMETER, L=LENGTH, G=GRADE, M.S.=MILD STEEL, H.S.=HIGH STRENGTH.
4. MINIMUM 4.5' GROUND COVER REQUIRED.
5. BASED ON 150 PSI INTERNAL PRESSURE, FOR L AND PRESSURES LISTED ON SHEET 20 FOR D AND G.
6. M.S. = MILD STAINLESS STEEL ROD ASTM A36 (36,000 psi TENSILE STRENGTH).
7. H.S. = HIGH STRENGTH STAINLESS STEEL ROD ASTM A193 GRADE B7 (125,000 psi TENSILE STRENGTH)
8. NUTS SHALL BE ASTM A307 GRADE A OR B HEXAGON HEAVY SERIES. HIGH STRENGTH NUTS SHALL BE ASTM A194 GRADE 2H
9. SEE TIE ROD DETAIL DRAWING. ALSO, TIE ROD COUPLING DETAILS, CLAMP DETAILS AND SET CLAMP DETAILS.
10. LENGTH REFERS TO THE AMOUNT OF PIPE WHICH MUST BE RESTRAINED TOGETHER AND IS NOT NECESSARILY THE LENGTH OF THE RODS.
11. LENGTH OF RESTRAINED PIPE CHART IS ALSO FOR THE LENGTH OF JOINT RESTRAINT FOR MEGALUGS.
12. CROSSES MUST BE RESTRAINED IN ALL APPLICABLE DIRECTIONS.
13. 24" AND SMALLER IN LINE VALVES AND TEES SHALL HAVE A MECHANICAL JOINT RESTRAINT DEVICE ON EACH SIDE OF THE FITTING OR VALVE.
14. CONTRACTOR MUST NOTIFY THE UTILITIES DIVISION WHEN EXCAVATING NEXT TO AN EXISTING LIVE VALVE SO THAT A SECOND VALVE UPSTREAM OR DOWNSTREAM CAN BE CLOSED.
15. ALL PIPE JOINTS WITHIN CASING PIPES SHALL BE RESTRAINED.

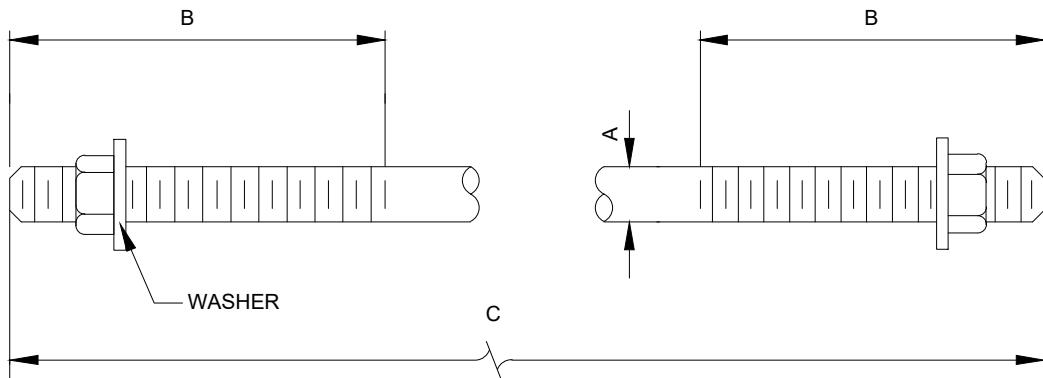
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LENGTH OF RESTRAINED PIPE

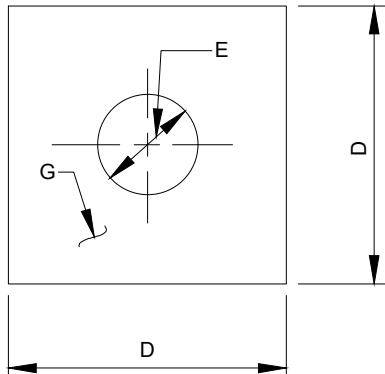
2022 ENGINEERING STANDARDS & SPECIFICATIONS



TIE ROD DETAILS

NOTE:

1. SEE TIED JOINTS, ROD DIMENSIONS SHEET.
2. SEE CLAMP DETAILS AND DIMENSIONS (SHEET 23) FOR PROPER PLACEMENT OF WASHERS.
3. MS=MILD STEEL A36 (36,000 psi TENSILE STRENGTH). HS=HIGH STRENGTH SS GRADE B7 (125,000 psi TENSILE STRENGTH).
4. INSTALL G-10 ISOLATION WASHERS AND SLEEVES IF REQUIRED PER SECTION 400.

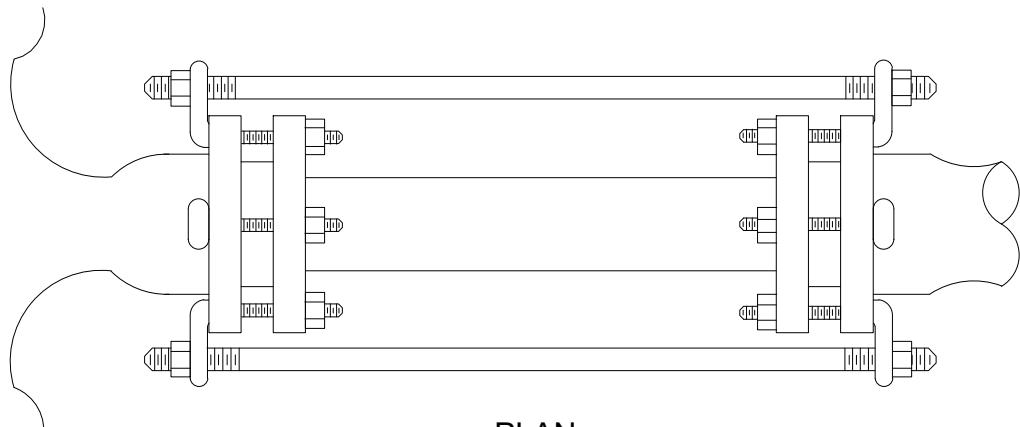


WASHER DETAIL

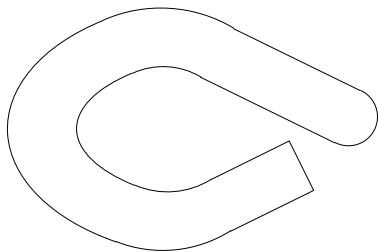
TIE RODS			
A	B	C	
ROD DIAMETER	THREAD LENGTH	ROD LENGTH	GRADE
3/4", 1"	6"	1' TO 11' & 20'	MS
3/4", 1-1/2"	ALL THREAD	1' TO 11' & 20'	HS

WASHERS		
D	E	G
WIDTH	HOLE DIAMETER	THICKNESS
5"	1/8" Larger than Rod Ø	1/2"
6"	1/8" Larger than Rod Ø	5/8"

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PLAN



DETAIL

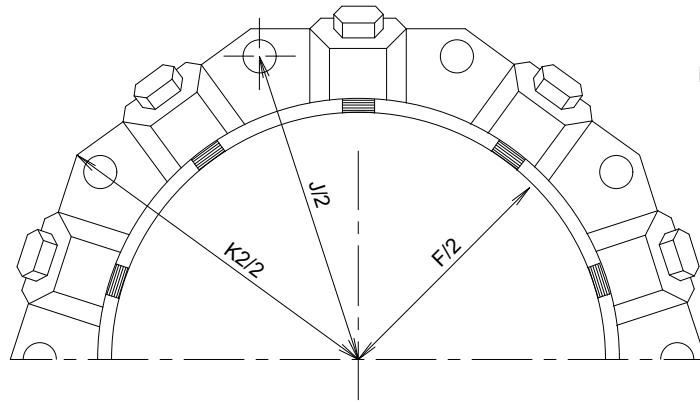
DIMENSIONS

ALLOWABLE PIPE DIAMETER INCHES	BOLT SIZE	NO. OF BOLTS REQUIRED
4	3/4"	2
6	3/4"	2
8	3/4"	2
10	3/4"	4
12	3/4"	6

NOTES:

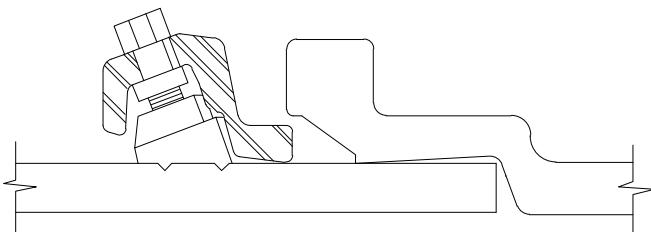
1. FOR APPROVED MANUFACTURERS, SEE THE APPROVED MATERIAL LIST.
2. THE BOLT MAY BE HEAT TREATED.
3. INSTALL G-10 ISOLATION WASHERS AND SLEEVES IF REQUIRED PER SECTION 400.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	JOINT RESTRAINT DETAIL EYE BOLTS

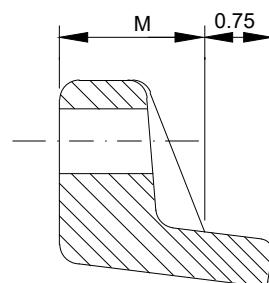


NOTE:
FOR OTHER APPROVED MECHANICAL
JOINT RESTRAINT DEVICES SEE THE
APPROVED MATERIAL LIST.

MECHANICAL JOINT RESTRAINT



WEDGE DETAIL

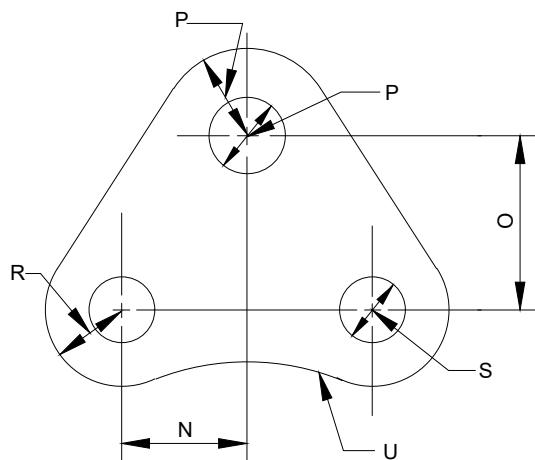
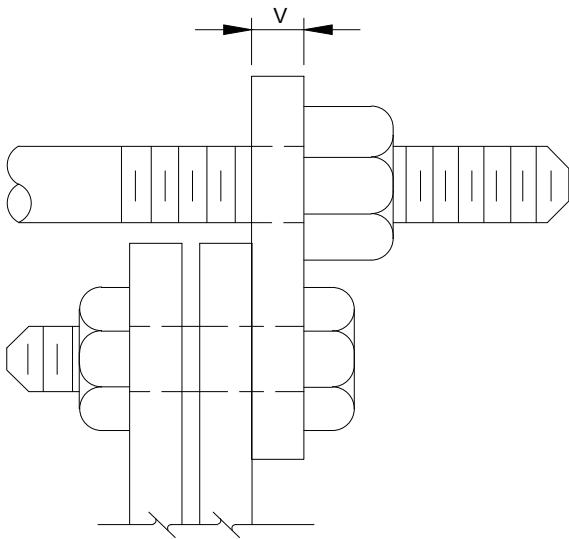


BOLT HOLE DETAIL

DIMENSIONS

	NOMINAL PIPE SIZE	NO. OF BOLTS	NO. OF WEDGES	K2 INCHES	J INCHES	F INCHES	M INCHES	
PVC	4"	4	4	9.13	7.50	4.90	0.50	PVC
	6"	6	6	11.13	9.50	7.00	0.50	
	8"	6	6	13.38	11.75	9.15	0.62	
	12"	8	8	17.88	16.25	13.30	0.75	
	14"	10	10	20.38	18.75	15.49	0.88	
	16"	12	12	22.63	21.00	17.58	0.88	
	18"	12	12	24.88	23.25	19.68	1.13	
	20"	14	14	27.13	25.50	21.79	1.25	
	24"	16	16	31.63	30.00	25.99	1.42	
	30"	20	20	39.12	36.88	32.22	1.50	
DIP	36"	24	24	46.00	43.75	38.52	1.50	DIP
	30"	20	20	39.12	36.88	32.17	2.25	
	36"	24	24	46.00	43.75	38.47	2.25	
	42"	28	28	53.48	50.62	44.67	3.88	
	48"	32	32	60.36	57.50	50.97	3.88	

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				2022 ENGINEERING STANDARDS & SPECIFICATIONS		



FLANGE LUG DETAIL

DIMENSIONS (IN INCHES)

PIPE DIA.	N	O	H.S. ROD		M.S. ROD		R	S	U	V	PIPE DIA.
			P	ROD DIA.	P	ROD DIA.					
3	2-1/8	2-9/16	7/8	3/4	7/8	3/4	3/4	5/8	2-3/8	3/4	3
4	1-7/16	2	7/8	3/4	7/8	3/4	3/4	5/8	3-1/8	3/4	4
6	1-13/16	2-1/16	7/8	3/4	7/8	3/4	7/8	3/4	4	3/4	6
8	2-1/4	2-1/4	7/8	3/4	7/8	3/4	7/8	3/4	5-1/8	3/4	8
10	1-7/8	2-1/16	7/8	3/4	7/8	3/4	1	7/8	6-1/4	3/4	10
12	2-1/4	2-5/16	7/8	3/4	-	-	1	7/8	7-5/8	1	12
16	2-1/8	2-7/16	1-1/8	1	-	-	1-1/8	1	9-5/8	1-1/8	16
20	2	2-5/8	1-3/8	1-1/4	-	-	1-1/4	1-1/8	11-3/8	1-1/4	20
24	RODS AND CLAMPS NOT ALLOWED									24	

NOTES:

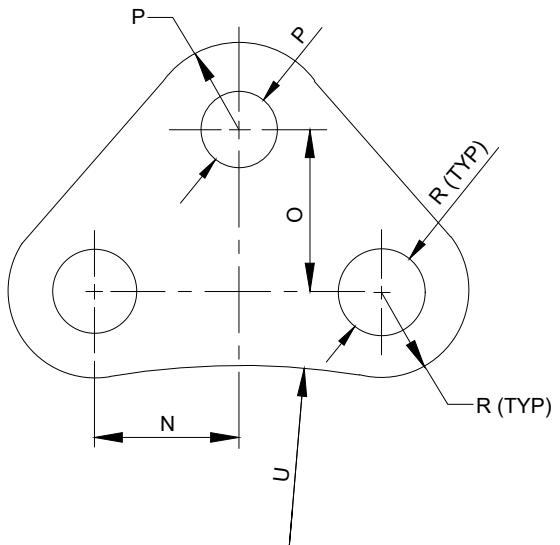
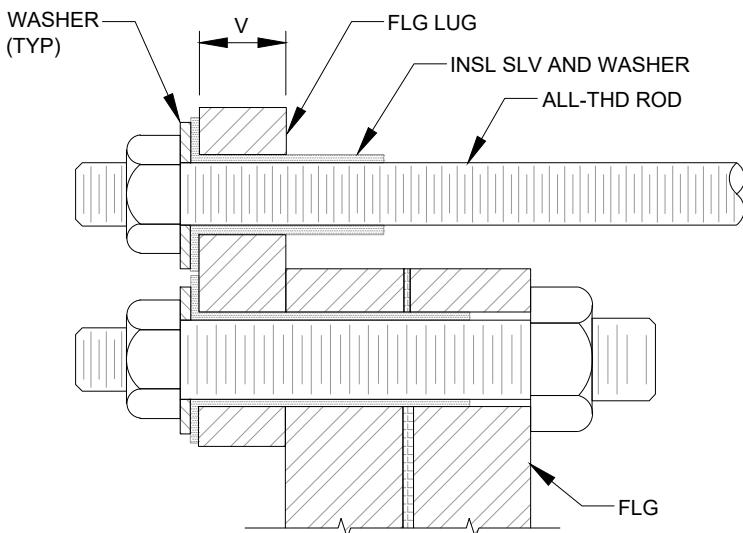
1. MS MEANS MILD STEEL ROD ASTM A36. (NUTS SHALL BE ASTM A307 GRADE A OR B HEXAGON HEAVY SERIES.)
2. HS MEANS HIGH STRENGTH STEEL ROD ASTM A193 GRADE B7. (NUTS SHALL BE ASTM A194 GRADE 2H.)

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FLANGE LUG DETAIL



INSULATED FLANGE LUG DETAIL

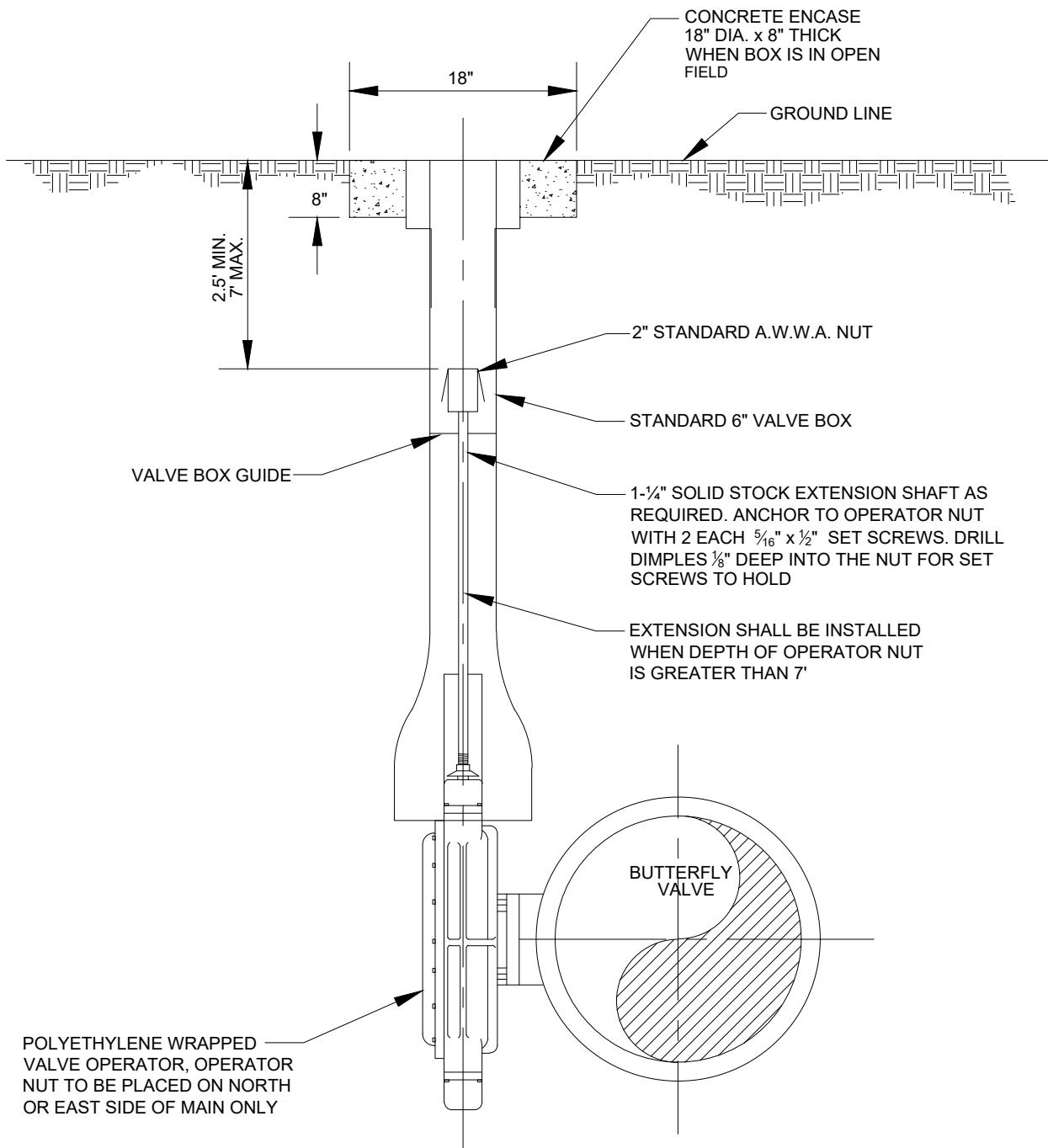
DIMENSIONS (IN INCHES)

PIPE DIA.	N	O	P	ROD DIA.	NO OF RODS	R	U	V	PIPE DIA.
3	2-1/8	2-9/16	1	3/4	2	7/8	2-1/4	3/4	3
4	1-7/16	2	1	3/4	2	7/8	3	3/4	4
6	1-13/16	2-1/16	1	3/4	2	1	3-7/8	3/4	6
8	2-1/4	2-1/4	1	3/4	2	1	5	3/4	8
10	1-7/8	2-1/16	1	3/4	2	1-1/8	6-1/8	3/4	10
12	2-3/16	2-5/16	1	3/4	2	1-1/8	7-1/2	1	12
16	2-1/16	2-7/16	1-1/4	1	2	1-1/4	9-1/2	1-1/4	16
20	1-15/16	2-5/8	1-1/2	1-1/4	2	1-3/8	11-1/4	1-3/8	20
24	RODS AND CLAMPS NOT ALLOWED								24

NOTES:

1. EQUALLY SPACE RODS AND FLANGE LUGS AROUND FLANGE.
2. RODS ARE ASTM A 193 GRADE B7 WITH ASTM A 194 GRADE 2H NUTS.
3. LUGS ARE ASTM A 36 PLATE.
4. DESIGN PRESSURE:
 - A. 3-INCH THROUGH 16-INCH - 260 POUNDS PER SQUARE INCH.
 - B. 20-INCH - 220 POUNDS PER SQUARE INCH.

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				2022 ENGINEERING STANDARDS & SPECIFICATIONS	

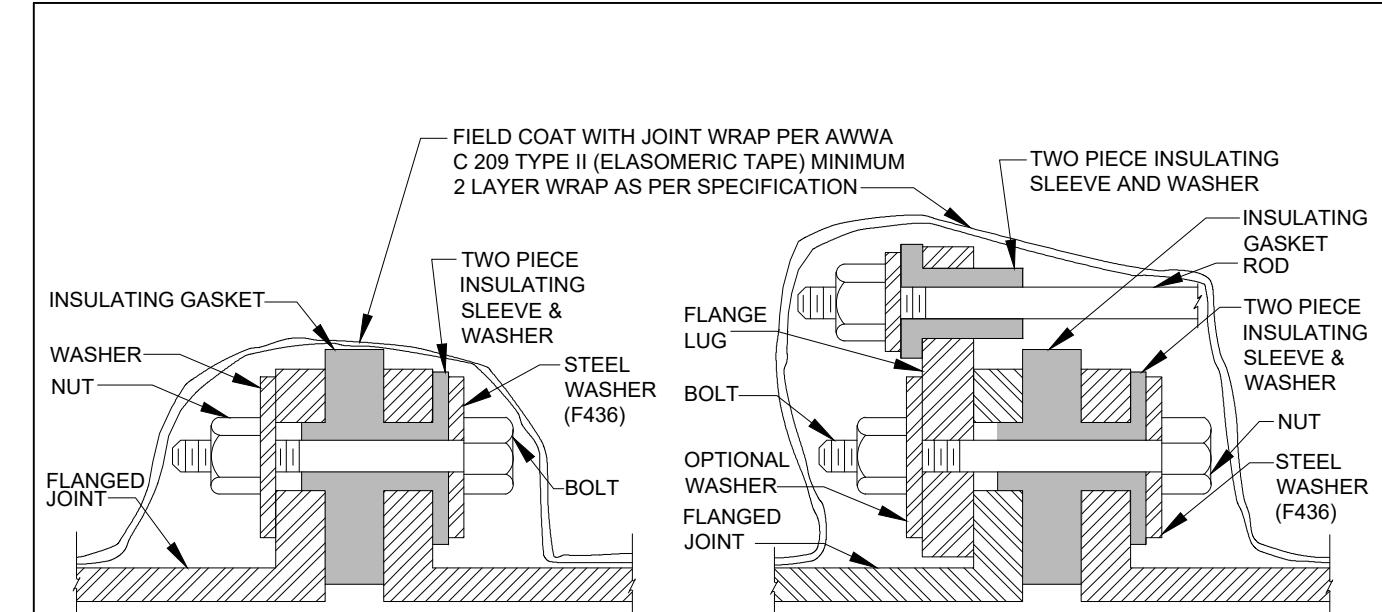


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TRANSMISSION MAIN BUTTERFLY VALVE INSTALLATION

2022 ENGINEERING STANDARDS & SPECIFICATIONS

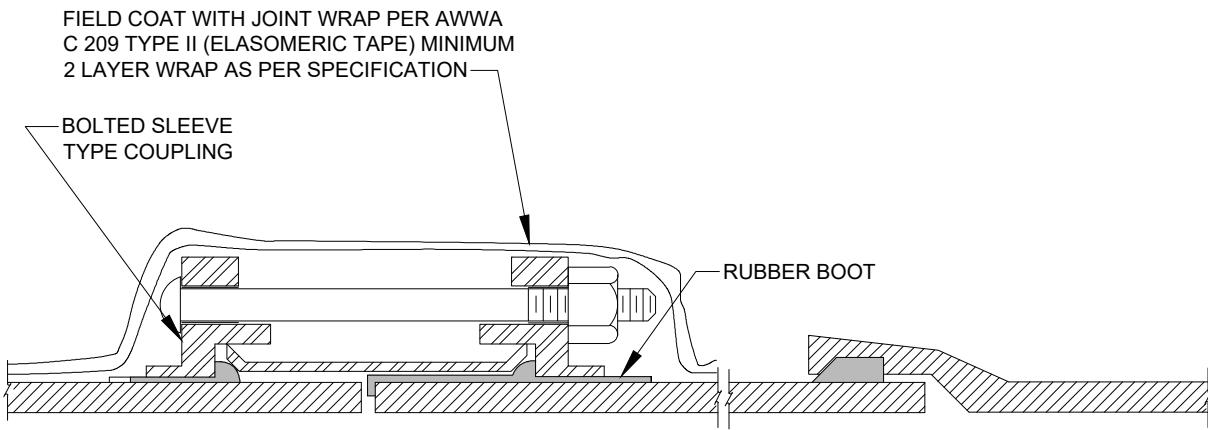


INSULATED JOINT

INSULATED ROD

NOTE:

1. FOR ABOVE GRADE OR VAULTED LOCATIONS, INSTALL INSULATING WASHERS ON BOTH SIDES OF FLANGED CONNECTION.



INSULATED BOLTED SLEEVE TYPE COUPLING

NOTE:

1. TEST ALL INSULATORS PRIOR TO BACKHILL AND INSTALLTION OF FIELD COATING AS PER SECTION 420.19.

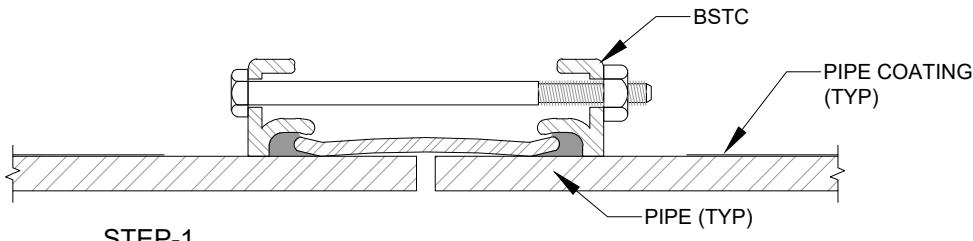
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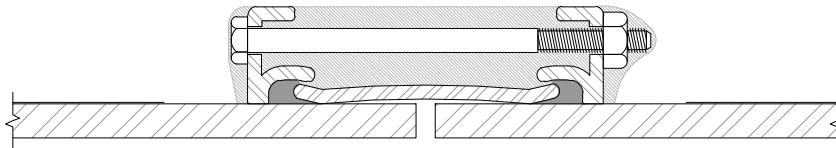
INSULATED JOINTS, RODS AND BOLTED SLEEVE TYPE COUPLINGS

2022 ENGINEERING STANDARDS & SPECIFICATIONS



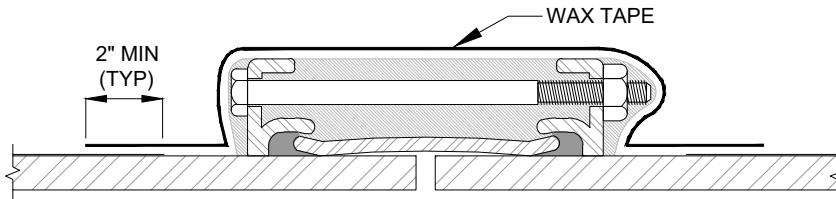
STEP-1

CLEAN TO REMOVE ALL FOREIGN MATTER AND EXCESS MOISTURE. ACHIEVE SSPC-SP2. APPLY 3 MILS OF PRIMER TO UNCOATED PIPE, COUPLING SURFACES, AND PIPE COATING WHERE WAX, TAPE AND WRAP WILL LAP.



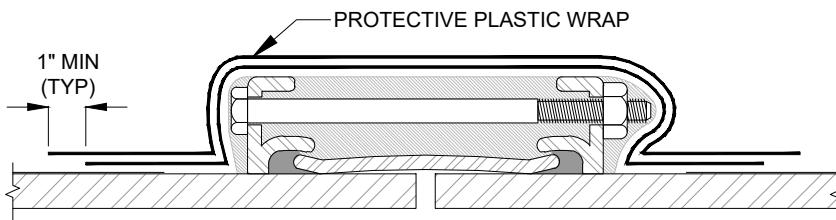
STEP-2

APPLY FILL MASTIC IN SHADED AREA TO PROVIDE A UNIFORM SURFACE TO WHICH WAX TAPE CAN BE APPLIED WITHOUT BRIDGING OR VOIDS.



STEP-3

CIRCUMFERENTIALLY INSTALL WAX TAPE AROUND PIPE AND COUPLING TO PROVIDE A MINIMUM THICKNESS OF 70 MILS. OVERLAP SHALL BE 1-INCH MINIMUM. OVERLAP ON PIPE COATING SHALL BE 2-INCH MINIMUM.



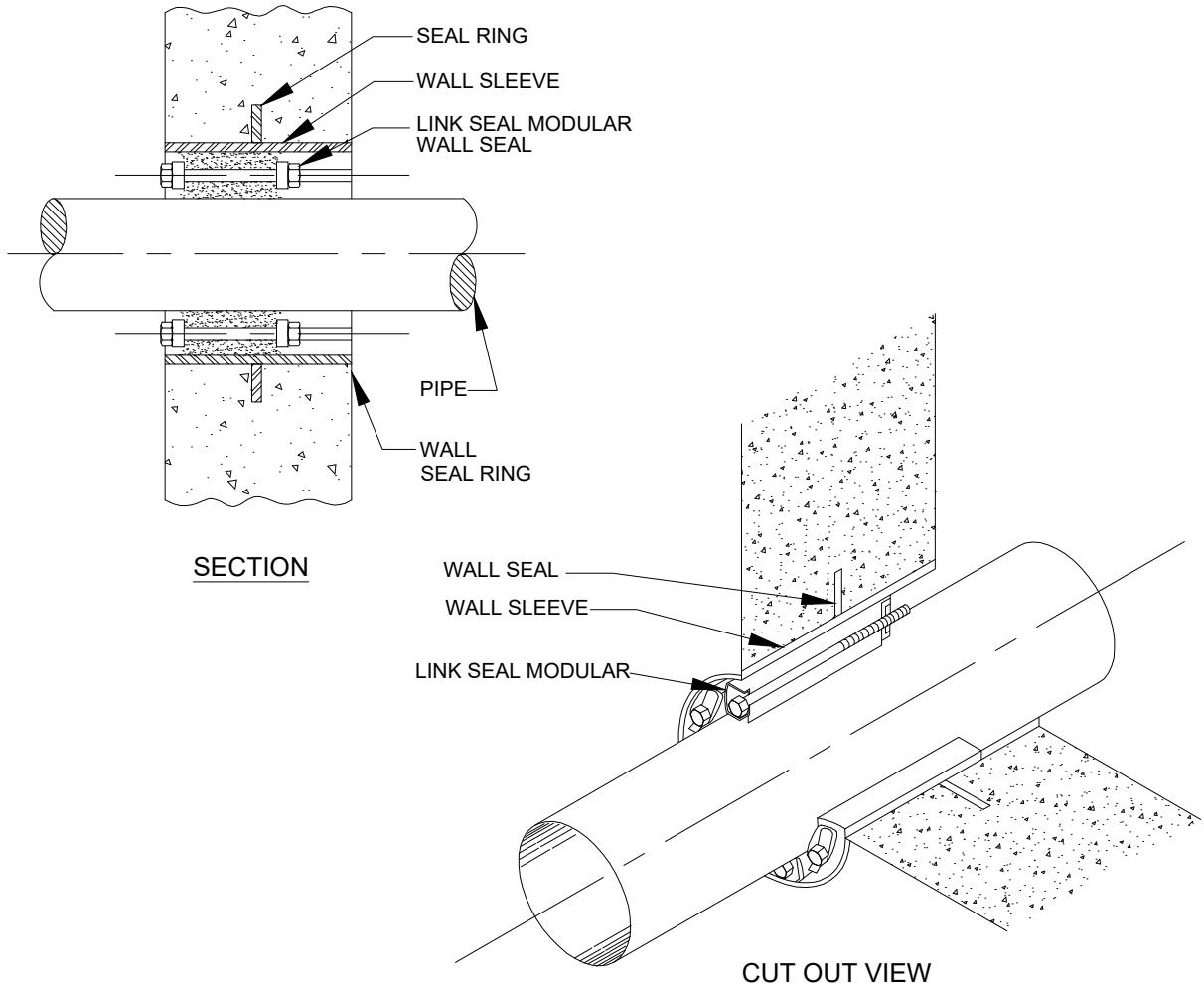
STEP-4

CIRCUMFERENTIALLY INSTALL PROTECTIVE PLASTIC WRAP 1.5 MILS MINIMUM THICKNESS OVER WAX TAPE. OVERLAPS SHALL BE 1-INCH MINIMUM.

NOTE:

NON-INSULATED BOLTED SLEEVE TYPE COUPLING CONNECTION SHOWN. DETAIL APPLIES TO ANY BURIED BOLTED SLEEVE TYPE COUPLING CONNECTION.

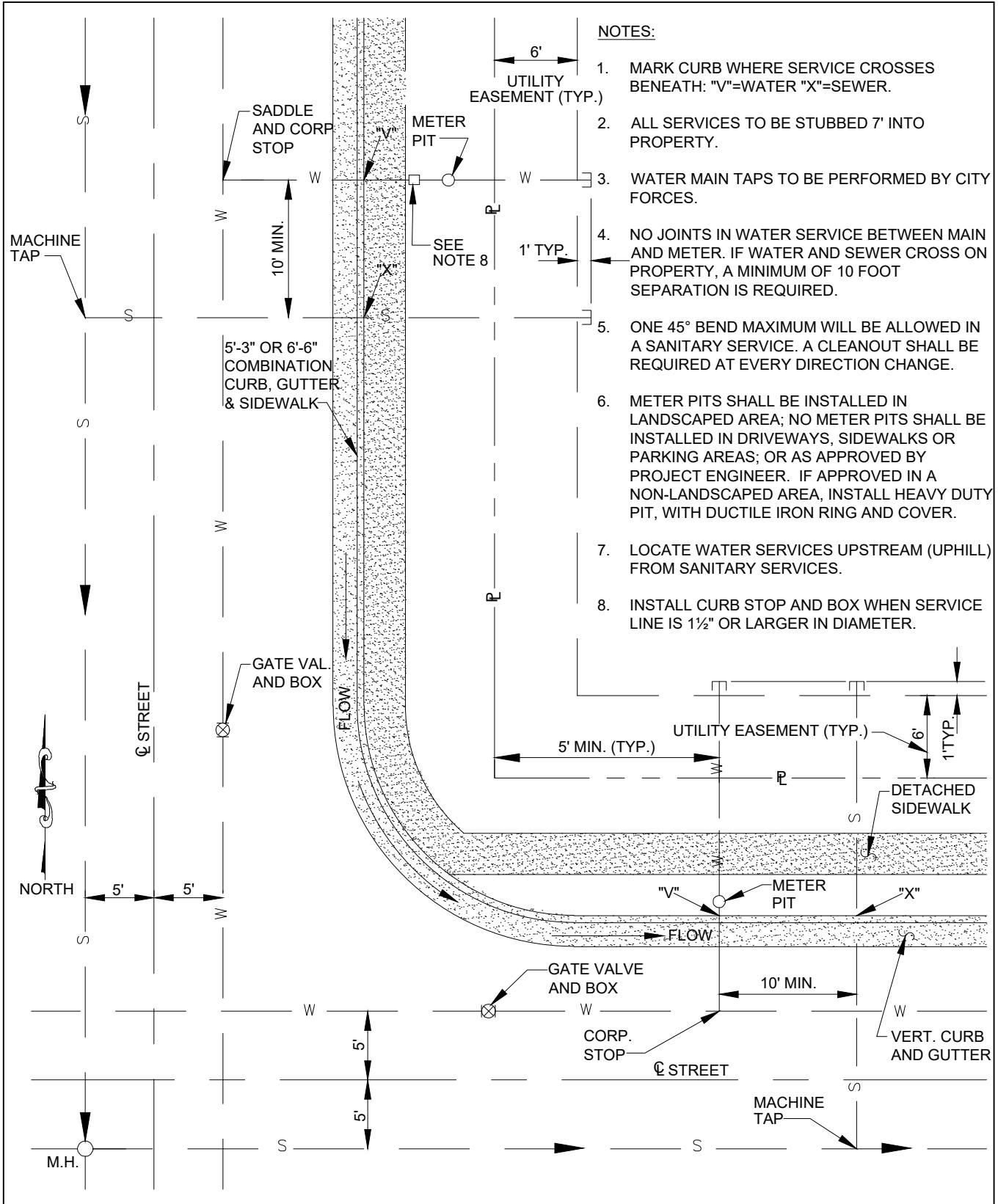
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	FIELD INSTALLATION WAX TAPE (BOLTED STEEL SLEEVE TYPE COUPLING CONNECTION)
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



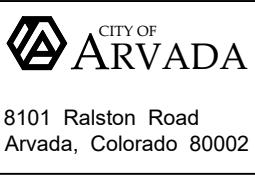
NOTES:

1. SEALS SHALL BE MODULAR MECHANICAL TYPE, CONSISTING OF INTERLOCKING SYNTHETIC RUNNER LINKS SHAPED TO CONTINUOUSLY FILL THE ANNULAR SPACE BETWEEN THE PIPE AND WALL OPENING. LINKS SHALL BE LOOSELY ASSEMBLED WITH BOLTS TO FORM A CONTINUOUSLY RUBBER BELT AROUND THE PIPE WITH A PRESSURE PLATE UNDER EACH BOLT HEAD AND NUT. AFTER THE SEAL ASSEMBLY IS POSITIONED IN THE SLEEVE, TIGHTENING OF THE BOLTS SHALL CAUSE THE RUBBER SEALING ELEMENTS TO EXPAND AND PROVIDE AN ABSOLUTE WATER-TIGHT SEAL BETWEEN THE PIPE AND WALL OPENING. THE SEAL SHALL BE CONSTRUCTED SO AS TO PROVIDE ELECTRICAL INSULATION BETWEEN THE PIPE AND THE WALL. THE PIPE TO WALL PENETRATION CLOSURES SHALL BE "LINK SEAL" AS MANUFACTURED BY THUNDERLINE CORPORATION, OR APPROVED EQUAL.
2. CONTRACTOR SHALL DETERMINE THE REQUIRED INSIDE DIAMETER OF EACH INDIVIDUAL WALL OPENING OR SLEEVE BEFORE ORDERING, FABRICATING OR INSTALLING. THE INSIDE DIAMETER OF EACH WALL OPENING SHALL BE SIZED TO FIT THE PIPE AND LINK-SEAL TO ASSURE A WATER TIGHT JOINT. IF PIPE O.D. IS NON STANDARD DUE TO COATING, INSULATION, ETC., CONSULT THE FACTORY FOR ENGINEERING ASSISTANCE AND RECOMMENDATION BEFORE PROCEEDING WITH WALL OPENING DETAIL.
3. INSTALLATION SHALL BE IN ACCORDANCE WITH MANUFACTURER RECOMMENDATIONS.

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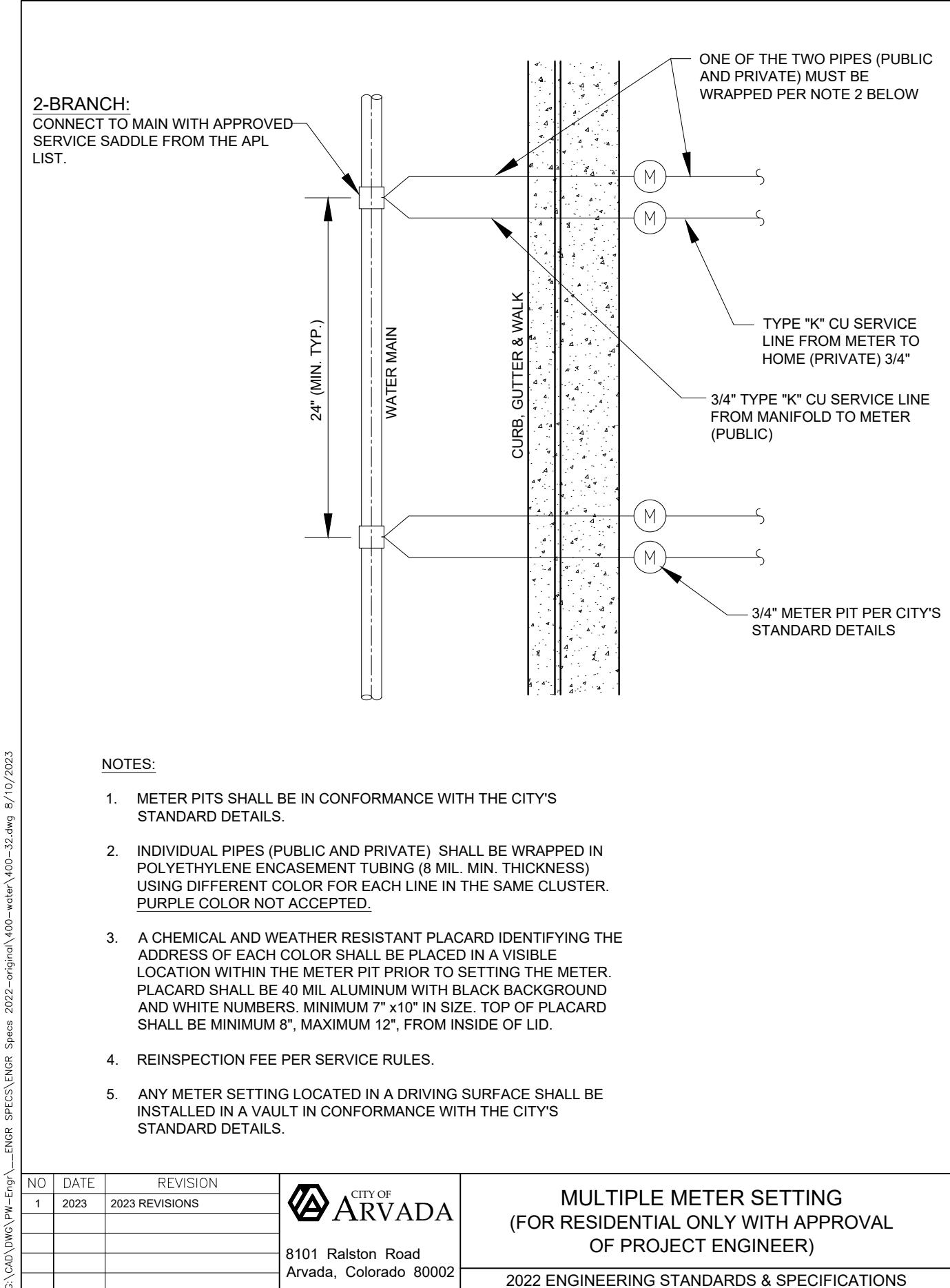


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1	2023	2023 REVISIONS



UTILITY SERVICES TYPICAL LAYOUT

2022 ENGINEERING STANDARDS & SPECIFICATIONS



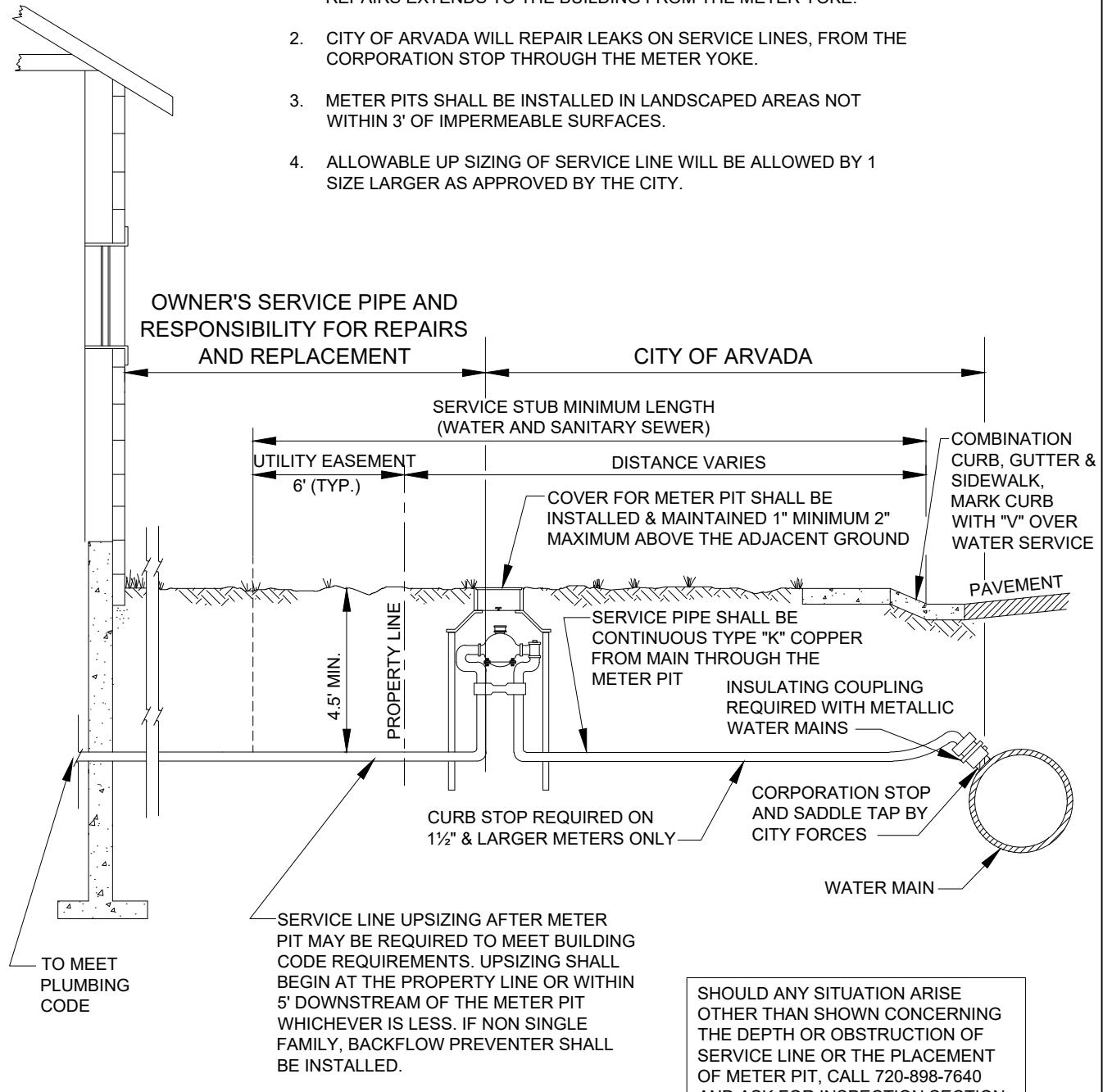
GENERAL METER NOTES

1. LOCATION OF METER PIT TO BE APPROVED BY PROJECT ENGINEER REPRESENTATIVE IN THE FIELD. LID TO BE A MINIMUM OF 18" FROM BACK OF WALK.
2. ALL SETTINGS MUST BE INSPECTED BY THE ENGINEERING DIVISION BEFORE BACKFILLING.
3. IF THE STREET OR GROUND IS NOT TO FINAL GRADE AT THE TIME OF INSTALLATION OF THE METER, THE OWNER MUST RAISE OR LOWER THE METER VAULT WHEN THE FINAL GRADE IS ESTABLISHED. ALSO THE METER YOKE MUST BE ADJUSTED TO 14" TO 18" BELOW THE TOP OF THE FROST LID.
4. GALVANIZED JOINTS AND PIPING SHALL NOT BE ALLOWED.
5. A BYPASS IS REQUIRED ON ALL METERS 1-1/2" AND LARGER UNLESS OTHERWISE SPECIFIED BY PROJECT ENGINEER. 1-½" AND LARGER IRRIGATION ONLY METERS DO NOT REQUIRE A BYPASS.
6. THE SERVICE LINE THROUGH AND ON BOTH SIDES OF THE METER PIT MUST BE OF TYPE K COPPER (3/4"-2").
7. THE SERVICE LINE SHALL BE TRACEABLE TO THE BUILDING FOUNDATION. IF THE MATERIAL OF THE SERVICE LINE IS NOT TRACEABLE, TRACER WIRE SHALL BE INSTALLED.
8. NO CONNECTIONS SHALL BE MADE IN THE METER PIT. ANY CONNECTIONS INCLUDING UPSIZING MUST BE MADE MORE THAN 5 FT. FROM THE METER PIT ON THE DOWNSTREAM SIDE.
9. VALVES SHALL BE IN CONFORMANCE WITH THESE STANDARDS:
 - A. VALVES LESS THAN 3" SHALL BE FULL PORT BALL VALVES ONLY. ALL BALL VALVES SHALL BE LOCKABLE.
 - B. ALL GATE VALVES 3" AND LARGER SHALL CONFORM WITH ARVADA'S STANDARD SPECIFICATIONS (SEE SECTION 400) AND APPROVED MATERIALS LIST.
10. ALL VALVES 3 INCH DIAMETER AND LARGER INSIDE VAULTS SHALL BE SUPPORTED BY ADJUSTABLE STEEL PIPE VALVE SUPPORTS. 1-1/2 INCH DIAMETER AND LARGER METERS SHALL BE SUPPORTED BY CONCRETE BLOCKS WITH STEEL SHIMS, IF REQUIRED BY UTILITIES DIVISION.
11. MAINTENANCE HOLE RINGS AND COVERS SHALL BE IN CONFORMANCE WITH DRAWING 400-61 OF THESE ENGINEERING STANDARDS. NO STEP SHALL BE MORE THAN 18" - 24" FROM FINISHED GRADE.
12. METER PITS AND COVERS SHALL BE IN CONFORMANCE WITH SECTION 400 OF THESE ENGINEERING STANDARDS.
13. OTHER METER SETTINGS: SETTINGS OF METERS OTHER THAN SHOWN AND DETAILED HEREIN SHALL BE CONSIDERED AS NON-STANDARD AND SHALL REQUIRE PRIOR APPROVAL OF PROPOSED PIPING LAYOUT, METER SETTING AND STRUCTURAL DESIGN OF VAULT FOR EACH SEPARATE INSTALLATION.
14. ON 1½" & LARGER VAULT SETTINGS, INSTALL RAMNECK BETWEEN SET RING AND ALL RISER RINGS (OR ON LID SECTION WHEN RISERS ARE NOT REQUIRED) TO PREVENT INFILTRATION.
15. CURB BOXES, METER PITS, METER VAULTS AND AMR DEVICES SHALL BE PROTECTED THROUGHOUT CONSTRUCTION. NO METER MAY BE REMOVED FROM ITS INSTALLED LOCATION UNTIL THE EXISTING TAP HAS BEEN CUT AT THE MAIN.
16. INSTALL ELECTRICAL ISOLATION DEVICES AT MAIN CONNECTION AND WITHIN METER AS PER SECTION 400.

NO	DATE	REVISION	 CITY OF ARVADA <small>8101 Ralston Road Arvada, Colorado 80002</small>	GENERAL METER NOTES
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				2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTES:

1. OWNER'S RESPONSIBILITY FOR LEAK REPAIR AND REPLACEMENT SHALL BE UP TO AND INCLUDING THE TUBE NUT WHICH THREADS ONTO THE METER YOKE OUTLET. OWNER'S RESPONSIBILITY FOR REPAIRS EXTENDS TO THE BUILDING FROM THE METER YOKE.
2. CITY OF ARVADA WILL REPAIR LEAKS ON SERVICE LINES, FROM THE CORPORATION STOP THROUGH THE METER YOKE.
3. METER PITS SHALL BE INSTALLED IN LANDSCAPED AREAS NOT WITHIN 3' OF IMPERMEABLE SURFACES.
4. ALLOWABLE UP SIZING OF SERVICE LINE WILL BE ALLOWED BY 1 SIZE LARGER AS APPROVED BY THE CITY.



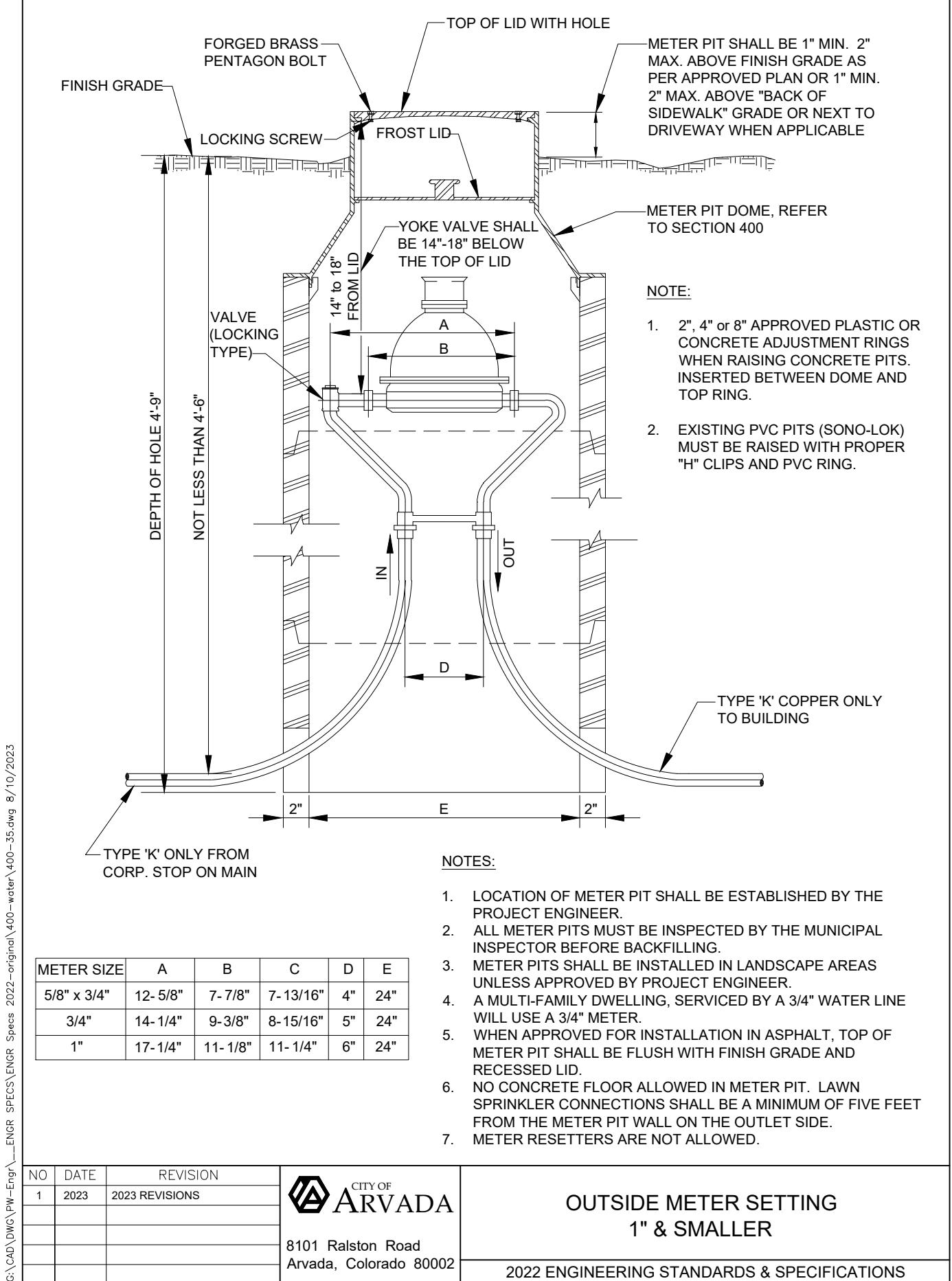
NO	DATE	REVISION
1	2023	2023 REVISIONS



8101 Ralston Road
Arvada, Colorado 80002

**WATER SERVICE, PROFILE
5/8" x 3/4", 3/4" AND 1"**

2022 ENGINEERING STANDARDS & SPECIFICATIONS



**CONCRETE MAINTENANCE HOLE
BASE BEAMS AS REQUIRED BY
PROJECT ENGINEER, (9"x12"x60")
(SEE DETAIL BELOW)**

NOTES:

1. A 60" INSIDE DIA. MAINTENANCE HOLE PIT BY MINIMUM 4' HEIGHT IS REQUIRED FOR 1½" AND 2" METERS.
2. JOINTS INSIDE METER VAULT SHALL BE EITHER THREADED, COMPRESSION OR FLARE.
3. SEE DETAIL SHEET NO. 400-33 FOR ADDITIONAL NOTES.
4. NO CONCRETE TO BE LAID IN FLOOR OF METER MAINTENANCE HOLE.
5. BOTTOM OF PIT TO HAVE 12" LAYER OF 1½" CRUSHED ROCK.
6. THE DISTANCE BETWEEN RUNGS, CLEATS, AND STEPS SHALL NOT EXCEED 12" AND SHALL BE UNIFORM THROUGHOUT THE LENGTH OF THE LADDER AND ALIGNED UNDER THE LID.
7. VAULT WALL PENETRATIONS MUST BE GROUTED WITH CONCRETE.
8. COPPERSETTER OR COPPER METER YOKE FOR 1-1/2" AND 2" WILL BE NO HIGHER THAN 15" WITH A BY-PASS AND BOOT FOR BY-PASS PROVIDED WITH SETTER. (OR ABILITY TO LOCK OFF).
9. METER GAP SHALL BE 13¼" FOR 1½" SERVICE AND 17¼" FOR 2" SERVICE.

ELEVATION

DETAILS:

- (1) CURB STOP
- (2) TYPE K COPPER TUBING
- (3) COPPERSETTER /METER YOKE WITH BYPASS, SEE SECTION 400
- (4) METER UNIT
- (5) 1"x23" PIPE
- (6) MECH. IRON PIPE TO FLARE COUPLING FROM INLET SIDE OF COPPERSETTER AND OUTLET SIDE OF CHECK VALVE OR COMPRESSION
- (7) FLAT MAINTENANCE HOLE LID WITH 24" COMPOSITE LID OPENING
- (8) CONCRETE BLOCK SUPPORTS 5"x12"x12"

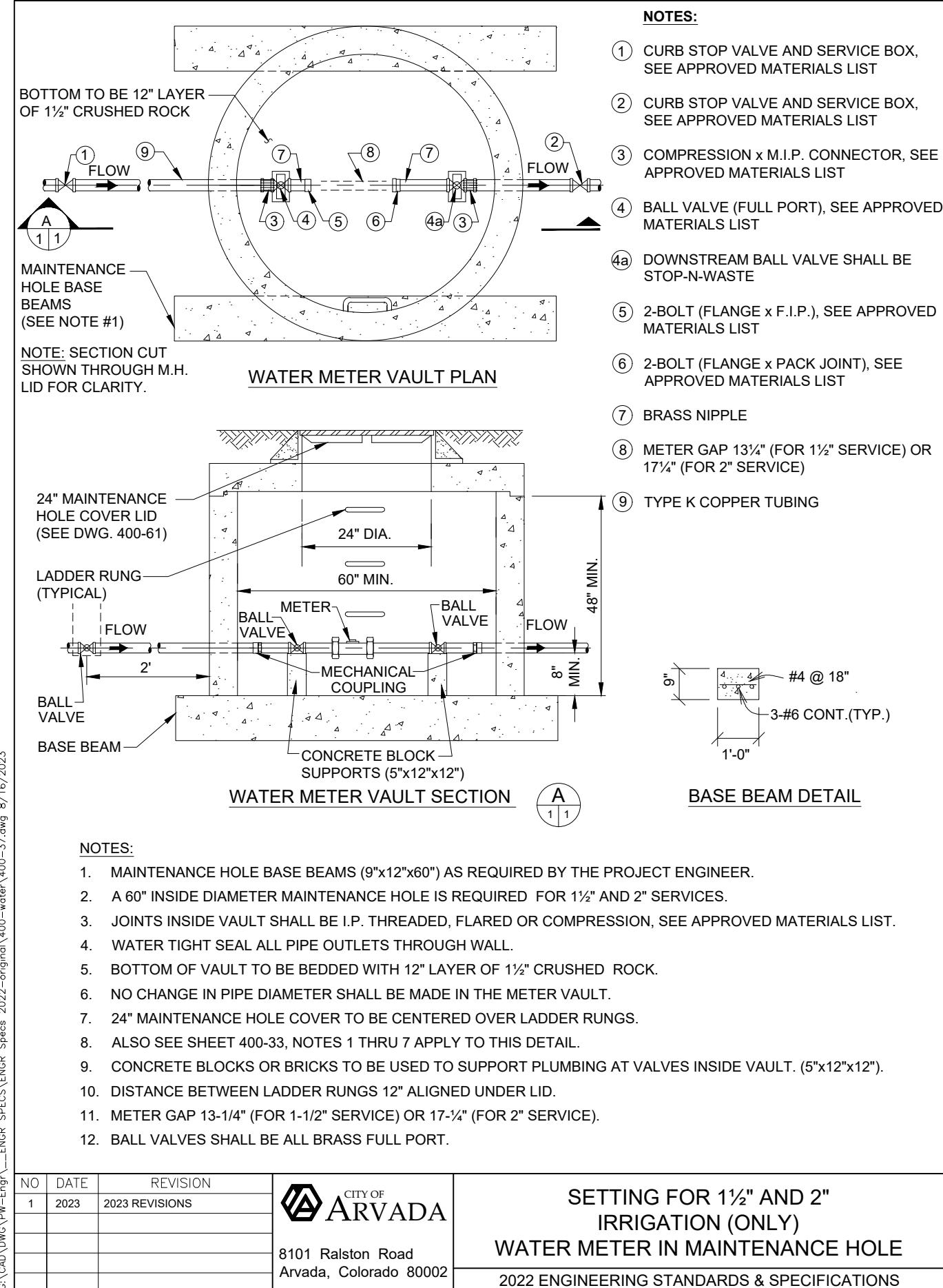
BASE BEAM DETAIL

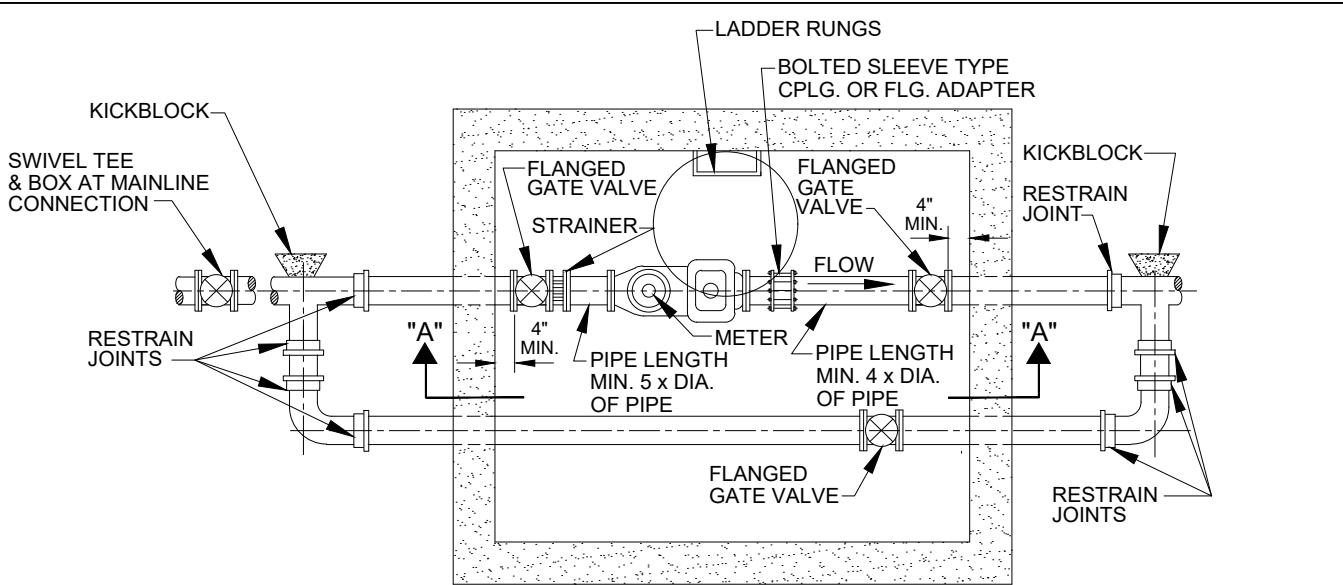
CITY OF ARVADA
8101 Ralston Road
Arvada, Colorado 80002

**SETTING FOR 1-½" AND 2"
WATER METER WITH BYPASS IN
MAINTENANCE HOLE**

2022 ENGINEERING STANDARDS & SPECIFICATIONS

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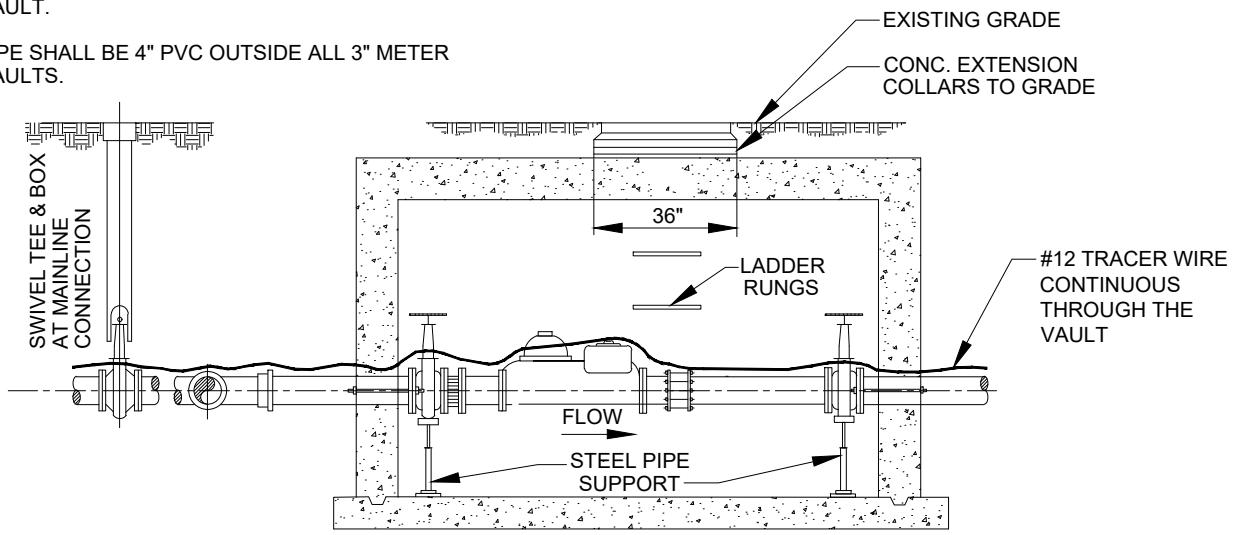
NOTES:

1. ALL INTERNAL PIPING MUST BE DUCTILE IRON WITH FLANGE FITTINGS. ALL INTERNAL BOLTS MUST BE STAINLESS STEEL WITH BRASS NUTS.
2. METER TO BE INSTALLED ON STRAIGHT THROUGH LINE (NOT BYPASS), ALSO SAME SIDE AS VAULT ENTRY/ACCESS HOLE.
3. ALL INTERNAL VALVES TO BE RESILIENT SEAT GATE VALVE LHO W/HAND WHEEL OPERATOR.
4. WATER STRAINER MUST BE OF ALL BRONZE CONSTRUCTION OR EPOXY COATED DUCTILE IRON.
5. VAULT KNOCKOUTS FOR PIPING EXIT TO BE FILLED W/LINK SEAL OR EQUIVALENT. INSTALLATIONS BELOW GROUNDWATER LEVEL SHALL REQUIRE WATERPROOF SEALANT BETWEEN ALL COLD JOINTS TO PREVENT GROUNDWATER FROM ENTERING VAULT.
6. PIPE SHALL BE 4" PVC OUTSIDE ALL 3" METER VAULTS.

PLAN OF PIPING

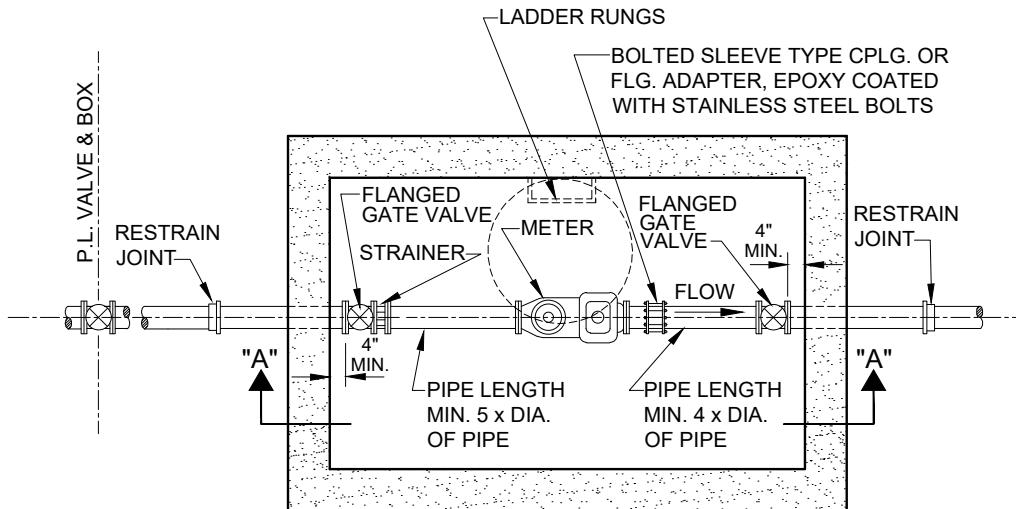
NOTE:

STEEL PIPE SUPPORTS ARE NOT SHOWN IN THIS VIEW. PIPE SUPPORTS ARE TO BE USED AT EACH GATE VALVE.



SECTION "A"

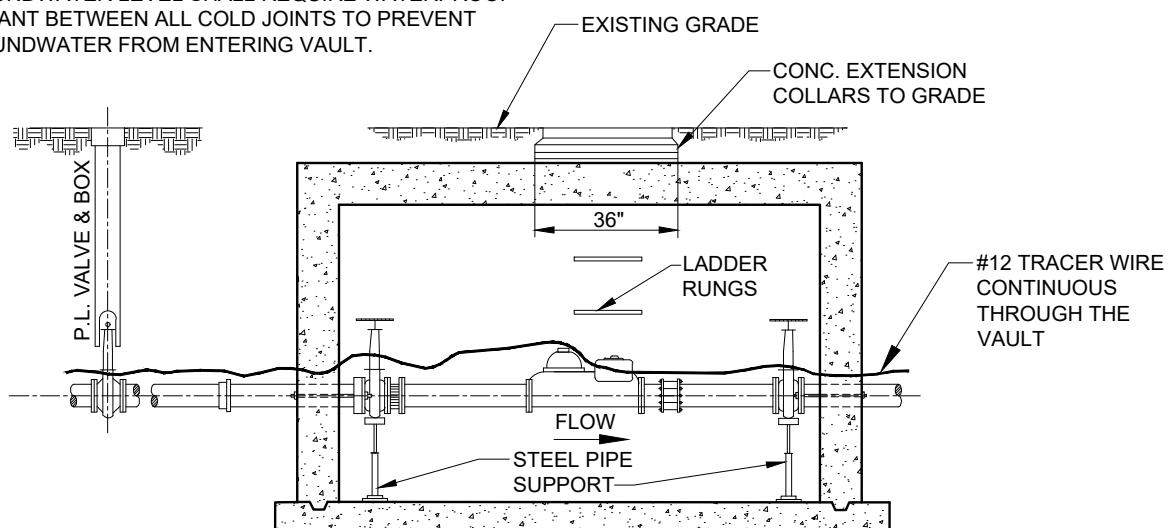
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	PIPING LAYOUT FOR 3", 4", 6" & 8" COMPOUND OR TURBINE METER SETTING WITH BYPASS
1	2023	2023 REVISIONS		
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



PLAN OF PIPING

NOTES:

1. ALL INTERNAL PIPING MUST BE DUCTILE IRON WITH FLANGE FITTINGS. ALL INTERNAL BOLTS MUST BE STAINLESS STEEL WITH BRASS NUTS.
2. A BYPASS IS NOT REQUIRED ON IRRIGATION ONLY METER SETTINGS.
3. ALL INTERNAL VALVES TO BE RESILIENT SEAT GATE VALVE LHO W/HAND WHEEL OPERATOR.
4. WATER STRAINER MUST BE OF ALL BRONZE CONSTRUCTION OR EPOXY COATED DUCTILE IRON.
5. CHECK VALVE TO BE OF ALL BRONZE OR EPOXY COATED DUCTILE IRON BODY.
6. VAULT KNOCKOUTS FOR PIPING EXIT TO BE FILLED W/LINK SEAL OR EQUIVALENT. INSTALLATIONS BELOW GROUNDWATER LEVEL SHALL REQUIRE WATERPROOF SEALANT BETWEEN ALL COLD JOINTS TO PREVENT GROUNDWATER FROM ENTERING VAULT.



SECTION "A"

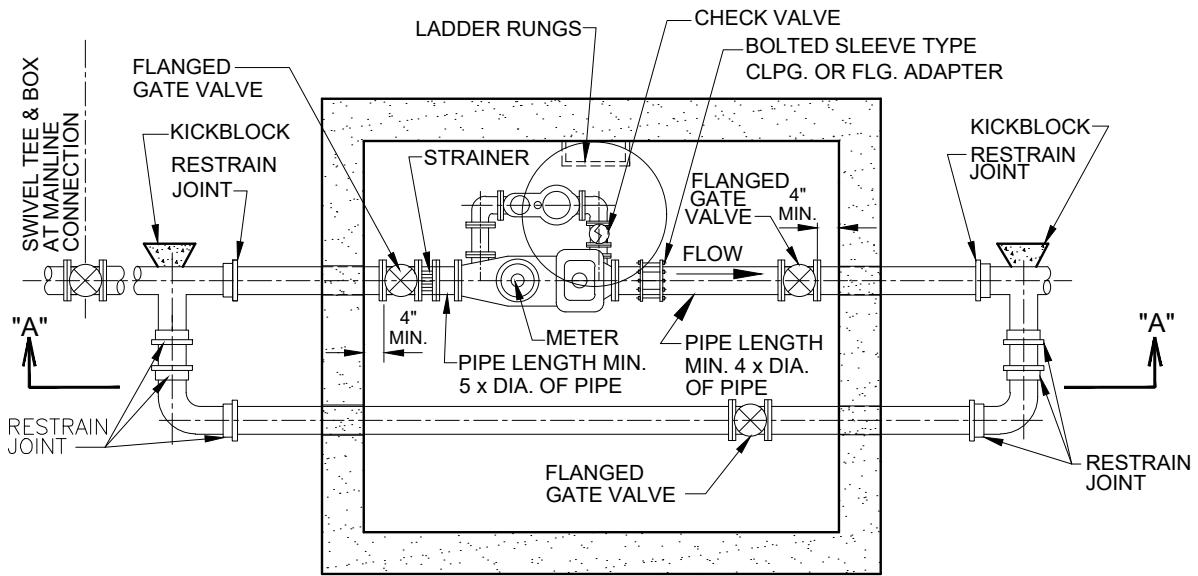
NO	DATE	REVISION



8101 Ralston Road
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**PIPING LAYOUT
FOR 3", 4", 6" & 8" TURBINE METER SETTING
"IRRIGATION ONLY"**

2022 ENGINEERING STANDARDS & SPECIFICATIONS

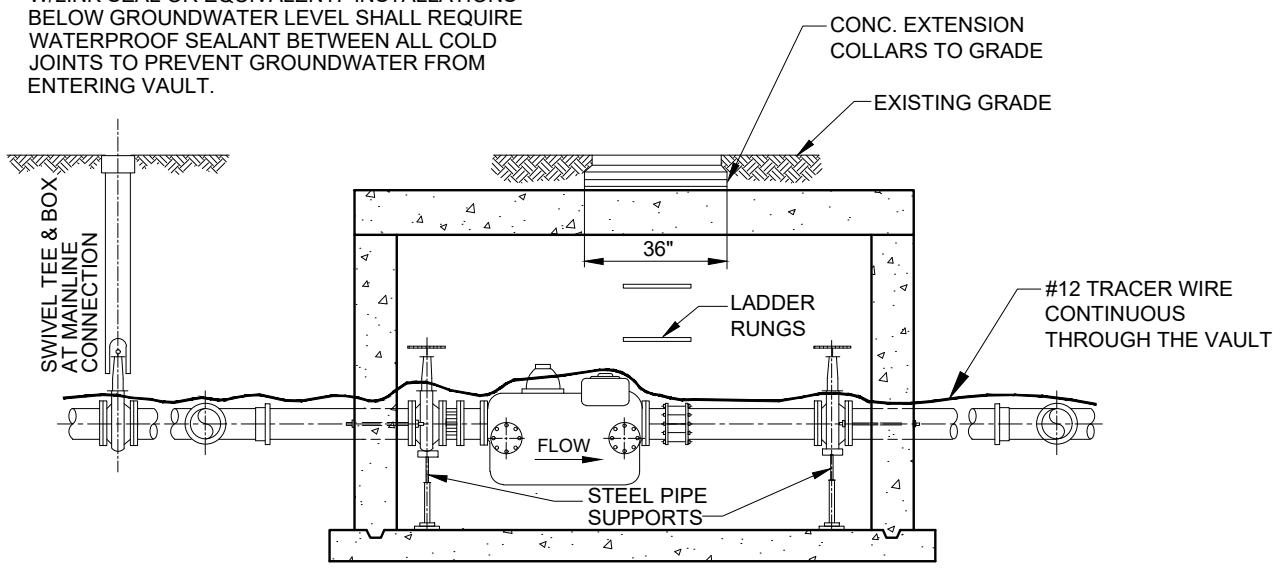


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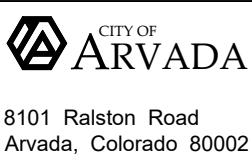
1. ALL INTERNAL PIPING MUST BE DUCTILE IRON WITH FLANGE FITTINGS. ALL INTERNAL BOLTS MUST BE STAINLESS STEEL.
2. ALL INTERNAL VALVES TO BE RESILIENT SEAT GATE VALVE LHO W/HAND WHEEL OPERATOR.
3. WATER STRAINER MUST BE OF ALL BRONZE CONSTRUCTION OR EPOXY COATED DUCTILE IRON.
4. CHECK VALVE TO BE OF ALL BRONZE OR EPOXY COATED DUCTILE IRON BODY.
5. CHECK VALVE TO BE OF ALL BRONZE OR EPOXY COATED DUCTILE IRON BODY.
6. VAULT KNOCKOUTS FOR PIPING EXIT TO BE FILLED W/LINK SEAL OR EQUIVALENT. INSTALLATIONS BELOW GROUNDWATER LEVEL SHALL REQUIRE WATERPROOF SEALANT BETWEEN ALL COLD JOINTS TO PREVENT GROUNDWATER FROM ENTERING VAULT.

NOTE:

1. BACKFLOW PREVENTION INSIDE BUILDING IS REQUIRED.
2. STEEL PIPE SUPPORTS NOT SHOWN IN THIS VIEW PIPE SUPPORTS TO BE USED AT EACH GATE VALVE.

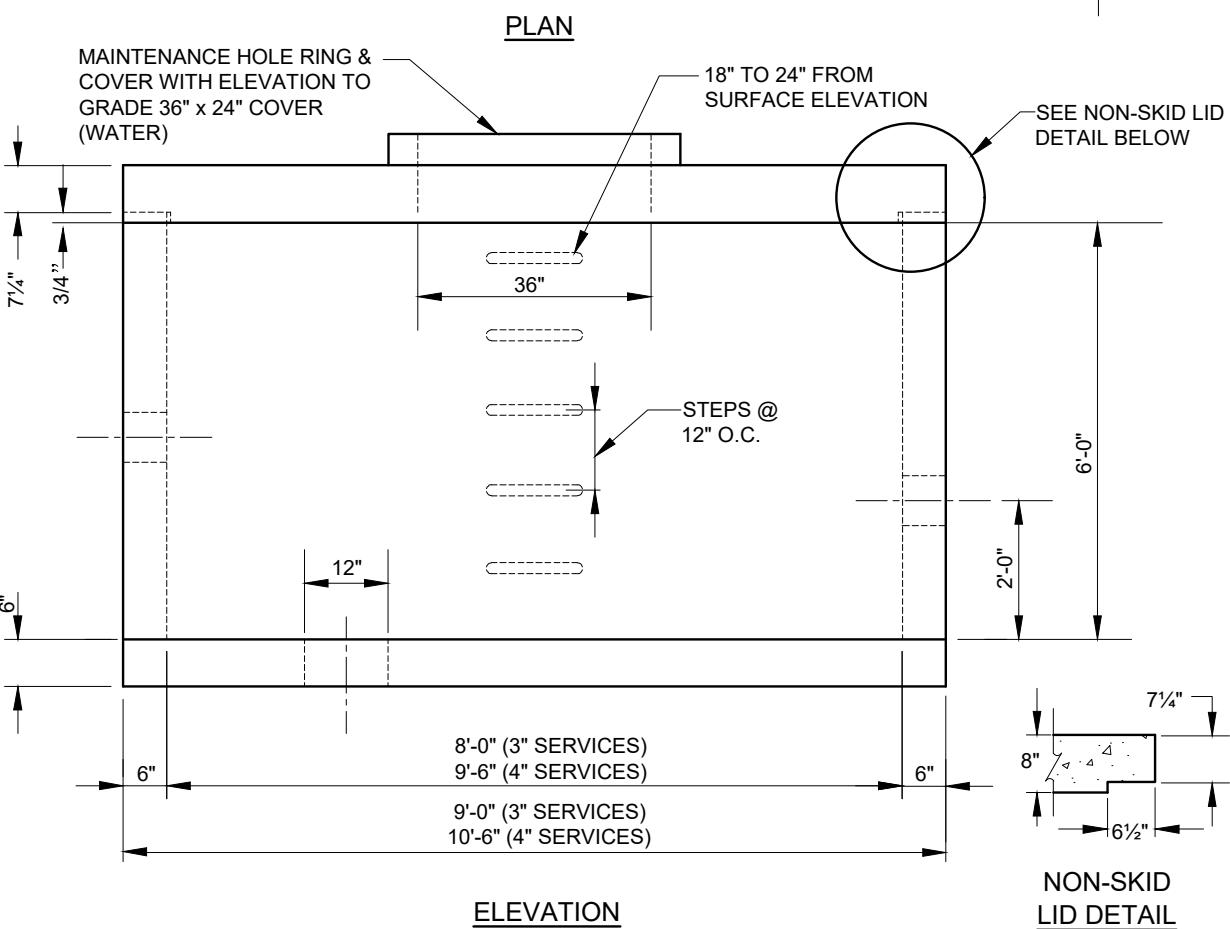
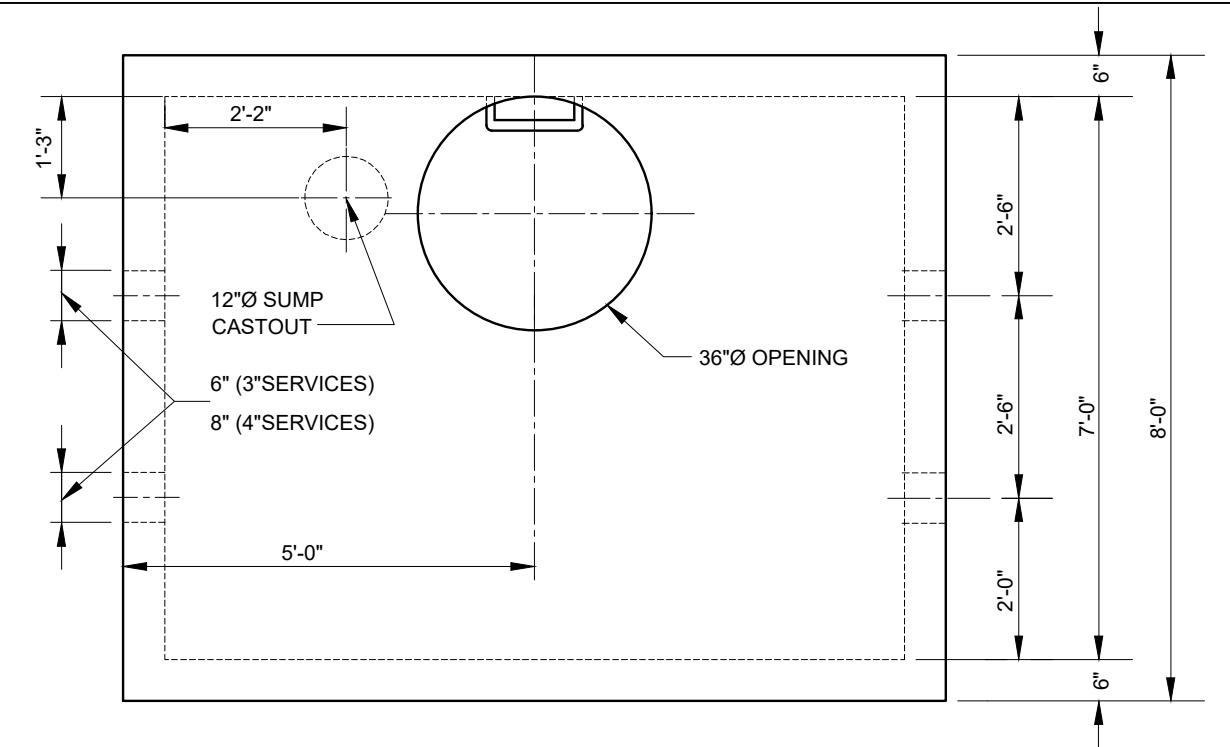


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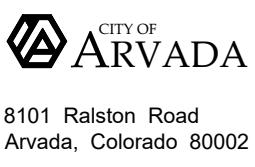


**PIPING LAYOUT FOR
F. M. C. T. METER WITH BYPASS
6" & 8" SERVICES ONLY**

2022 ENGINEERING STANDARDS & SPECIFICATIONS



NO	DATE	REVISION
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**ARVADA 3" AND 4" WATER SERVICES
METER VAULT WITH BYPASS**

2022 ENGINEERING STANDARDS & SPECIFICATIONS

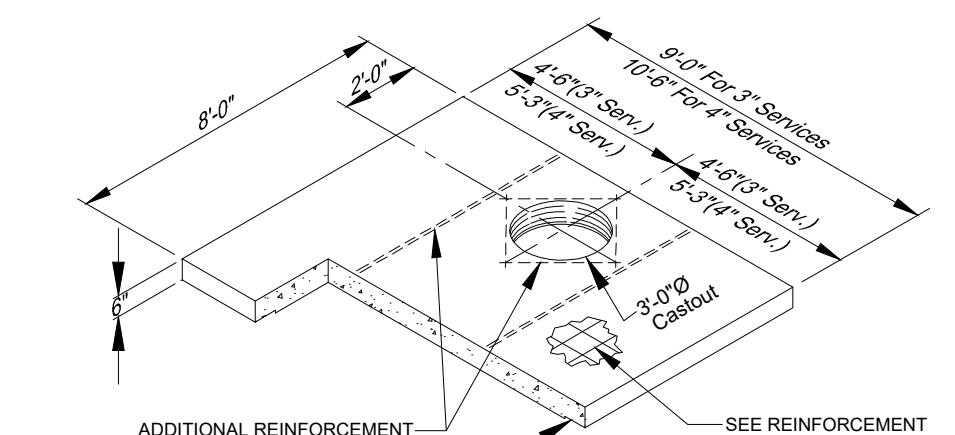
CASTOUT NOTE:

FOR 3" METER VAULTS:
PIPE I.D.=3" CASTOUT=6"

FOR 4" METER VAULTS:
PIPE I.D.=4" CASTOUT=8"

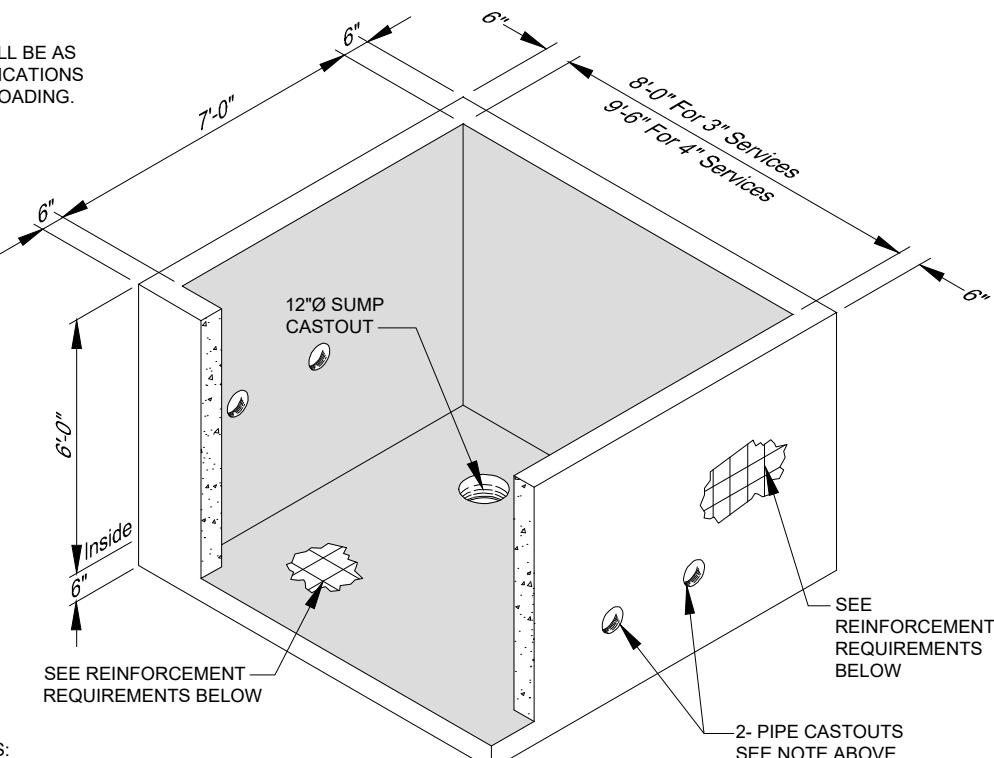
NOTE:

1. PRECAST VAVLTS MEETING THESE DIMENSION REQUIREMENTS ARE ALLOWED.
2. STEEL REINFORCEMENT SHALL BE AS PER MANUFACTUERS SPECIFICATIONS TO PROVIDE H-20 HIGHWAY LOADING.



SEE REINFORCEMENT REQUIREMENTS BELOW

3/4" NON SKID JOINT



SEE REINFORCEMENT REQUIREMENTS BELOW

2- PIPE CASTOUTS
SEE NOTE ABOVE

REINFORCEMENT REQUIREMENTS:

MINIMUM REINFORCEMENT FOR POURED IN PLACE VAULTS

COVER: #5 @ 5" O.C.E.W. #7 DIAGONALLY AROUND OPENING AND (4)
#7 ACROSS COVER ADJACENT TO OPENING (2 BARS EACH SIDE @ 3"
O.C.).

WALLS: #4 @ 12" O.C.E.W. 1" CLEAR FROM INSIDE

BASE: #5 @ 12" O.C.E.W. 1" CLEAR FROM TOP OF SLAB.

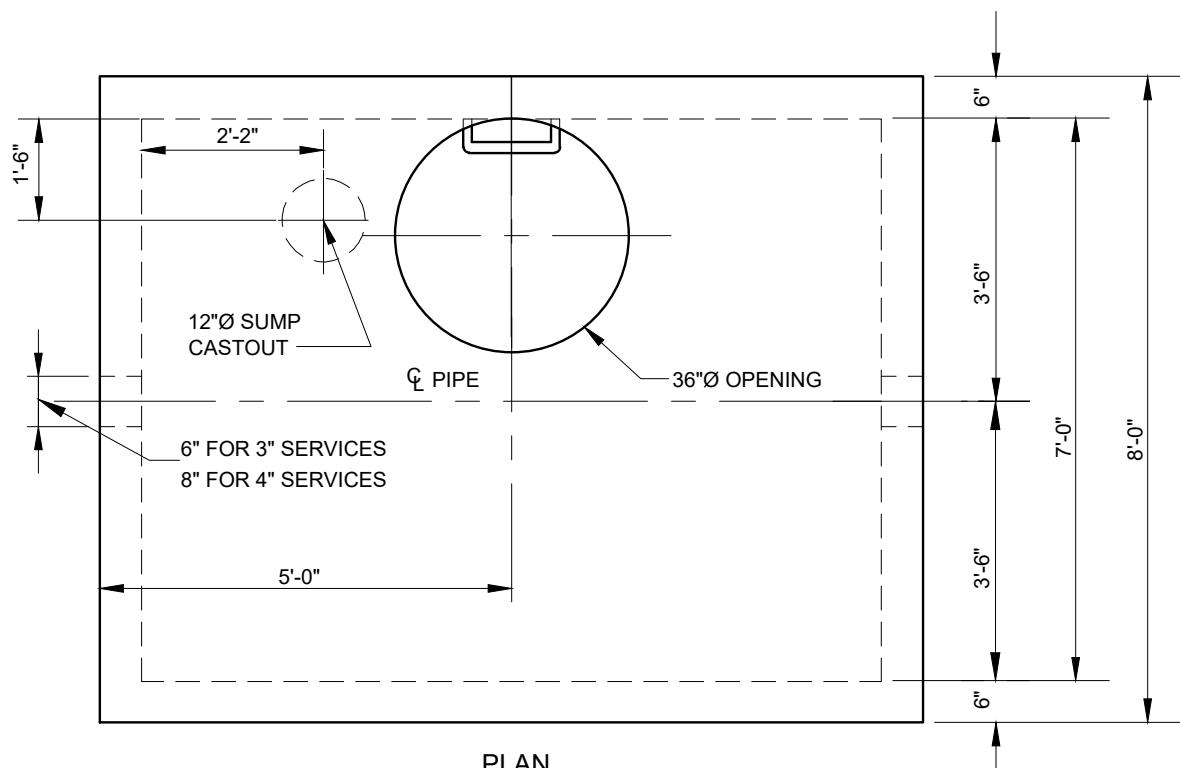
CORNER DOWELS: #5 BAR 2'-0"X 2'-0" @ 12" O.C.

WALL DOWELS: #5 BAR 3'-0"X 3"-0" @ 12" O.C.

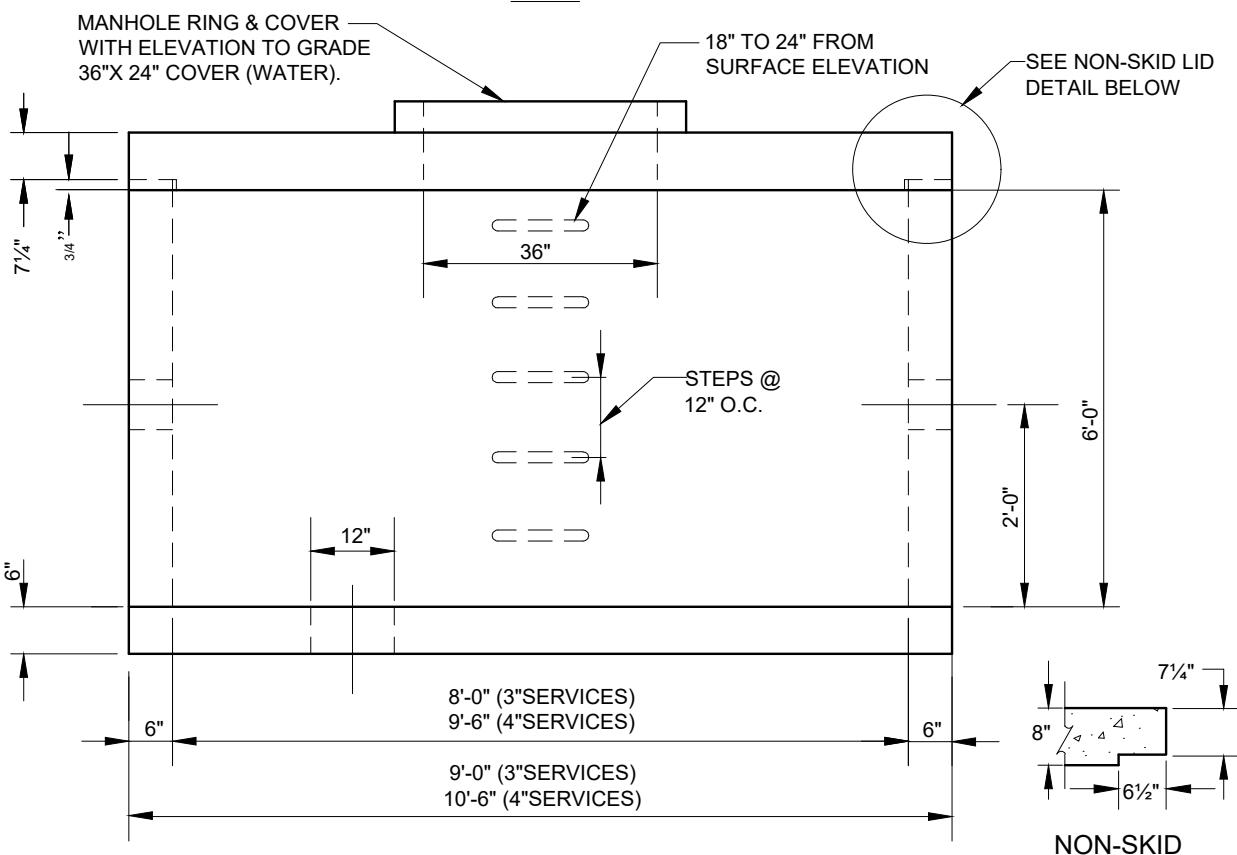
DESIGN FOR H-20 HIGHWAY LOADING.

4000 P.S.I. MINIMUM STRENGTH TYPE II CONCRETE.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	ARVADA 3" AND 4" WATER SERVICE METER VAULT WITH BYPASS ISOMETRIC VIEW
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



PLAN



ELEVATION

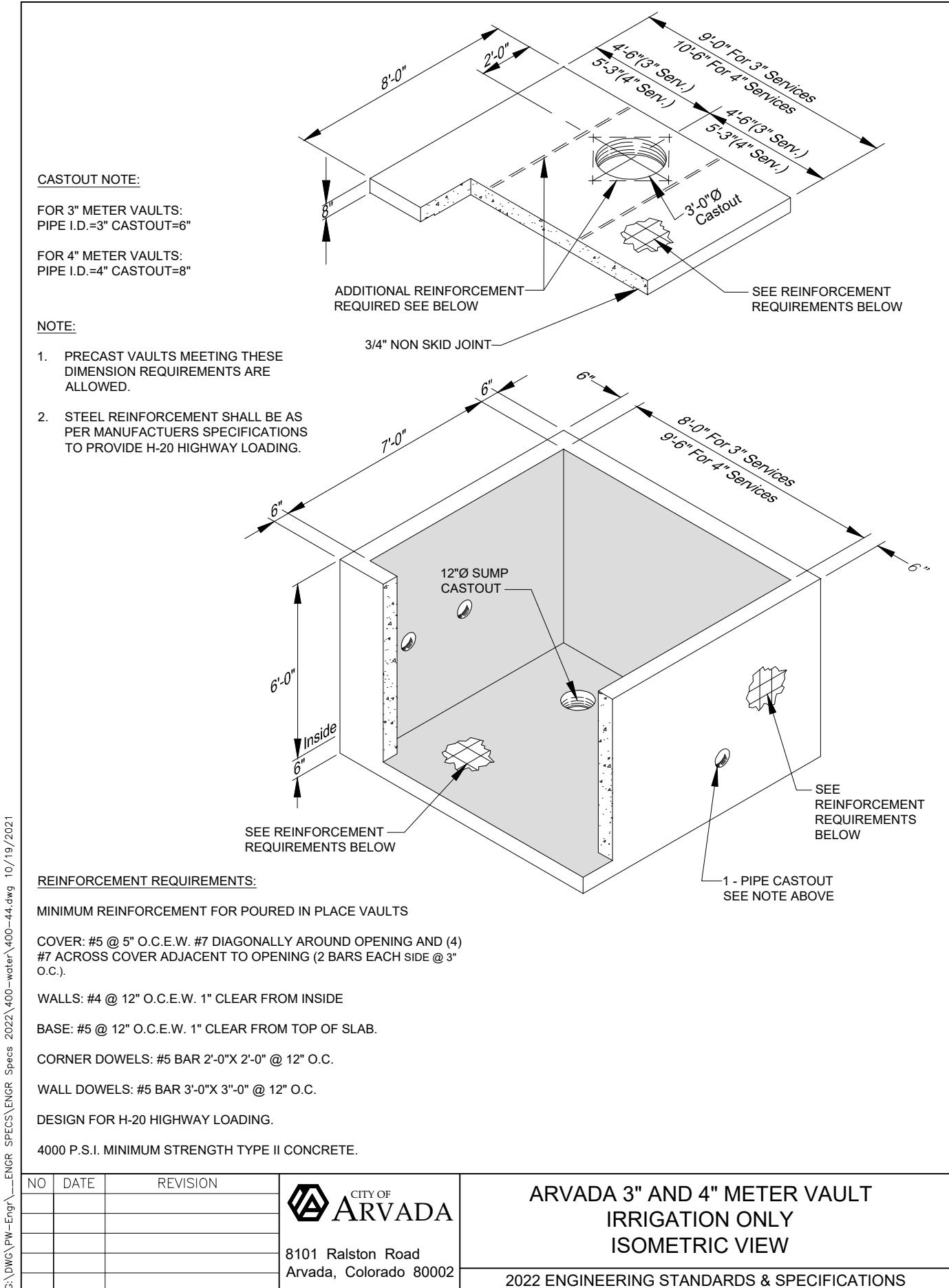


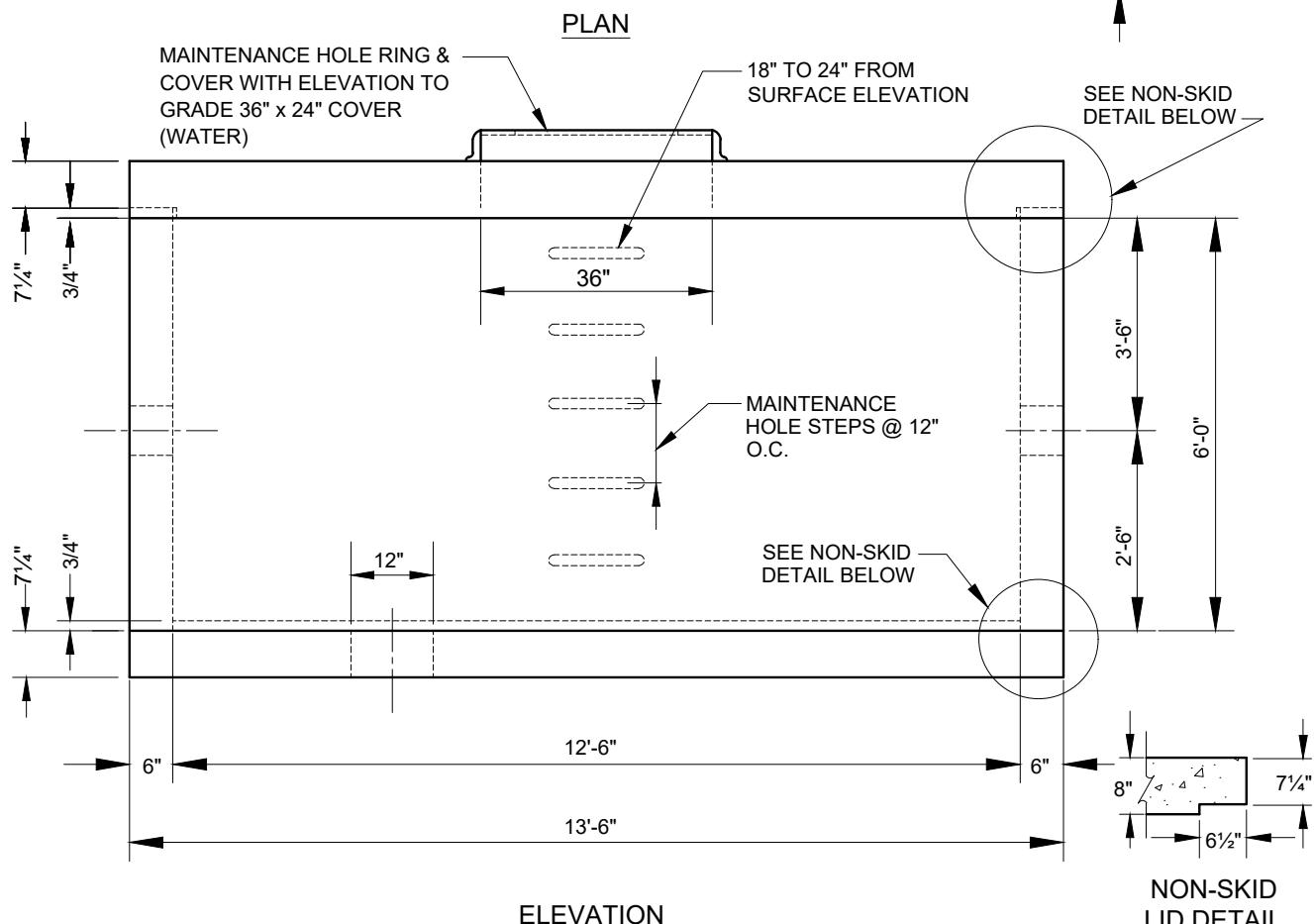
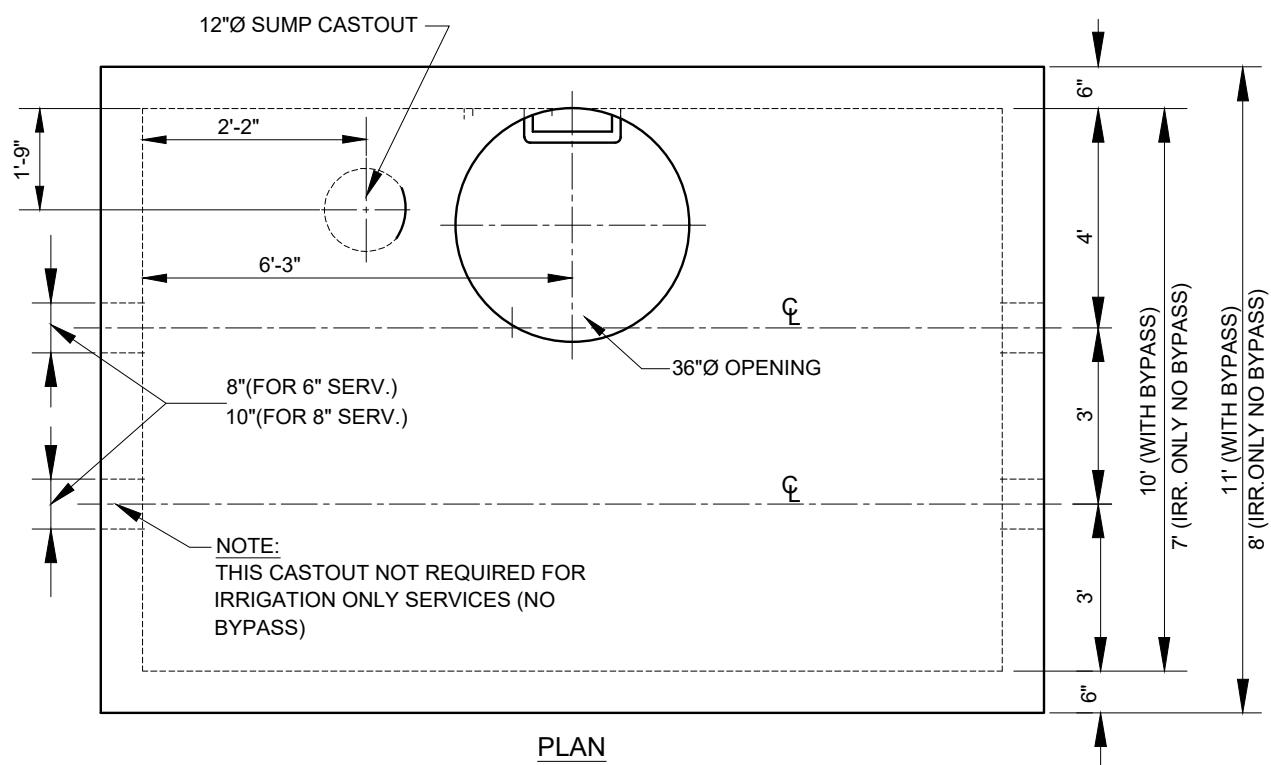
CITY OF ARVADA

8101 Ralston Road
Arvada, Colorado 80002

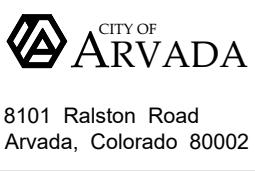
ARVADA 3" AND 4" METER VAULT IRRIGATION ONLY

2022 ENGINEERING STANDARDS & SPECIFICATIONS





NO	DATE	REVISION
1	2023	2023 REVISIONS



ARVADA 6" AND 8" WATER METER VAULT

2022 ENGINEERING STANDARDS & SPECIFICATIONS

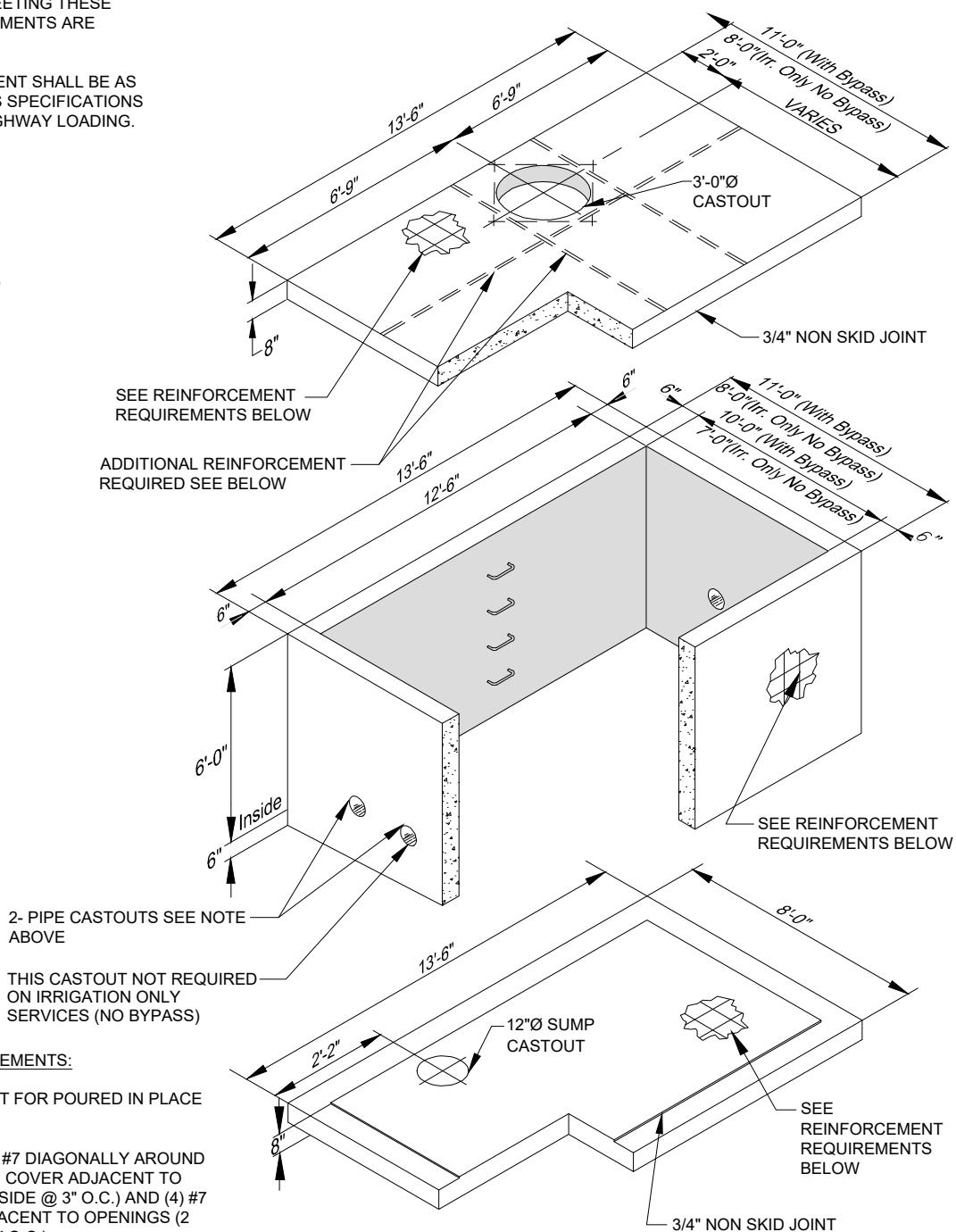
NOTE:

1. PRECAST VULTS MEETING THESE DIMENSION REQUIREMENTS ARE ALLOWED.
2. STEEL REINFORCEMENT SHALL BE AS PER MANUFACTURERS SPECIFICATIONS TO PROVIDE H-20 HIGHWAY LOADING.

CASTOUT NOTE:

FOR 6" METER VAULTS:
PIPE I.D.=6" CASTOUT=9"

FOR 8" METER VAULTS:
PIPE I.D.=8" CASTOUT=11"



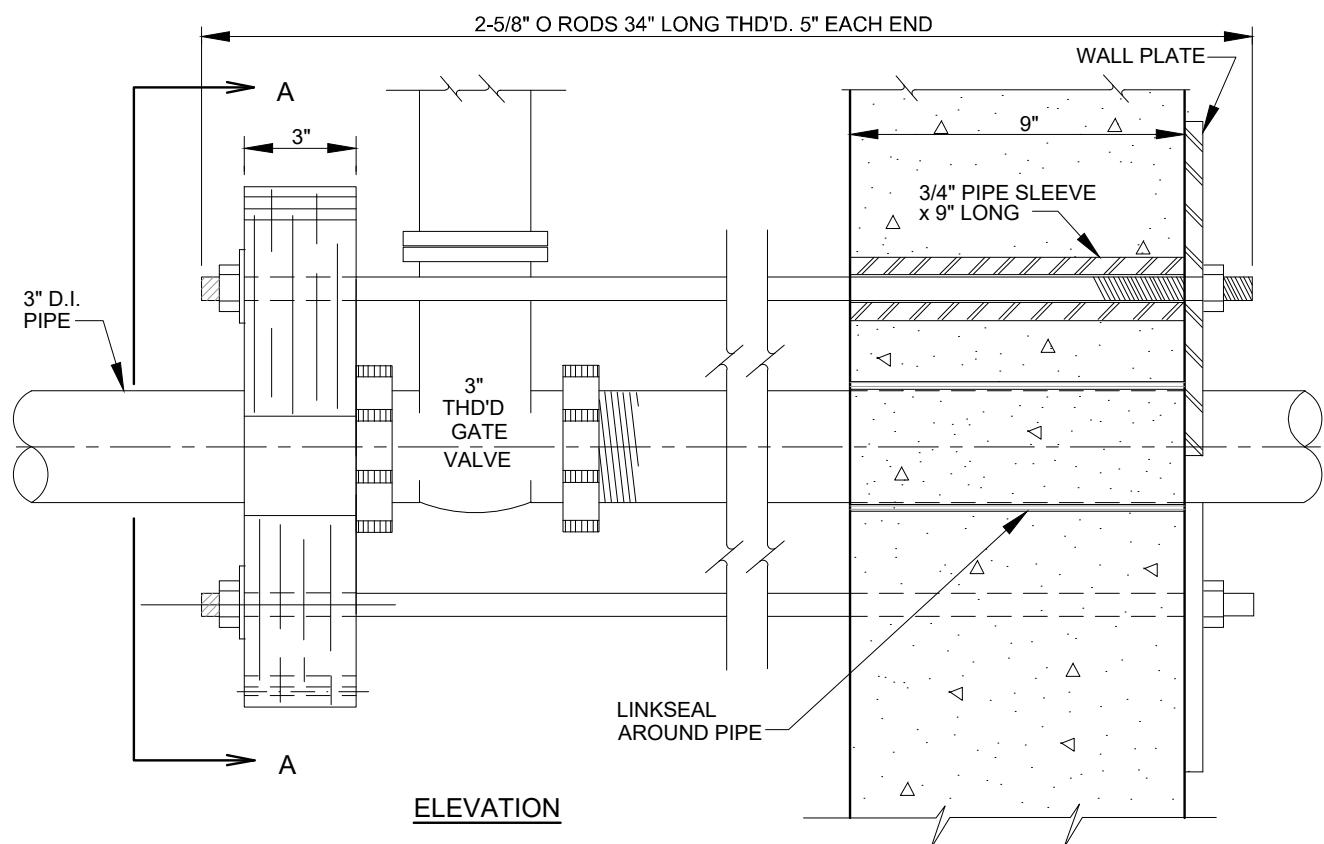
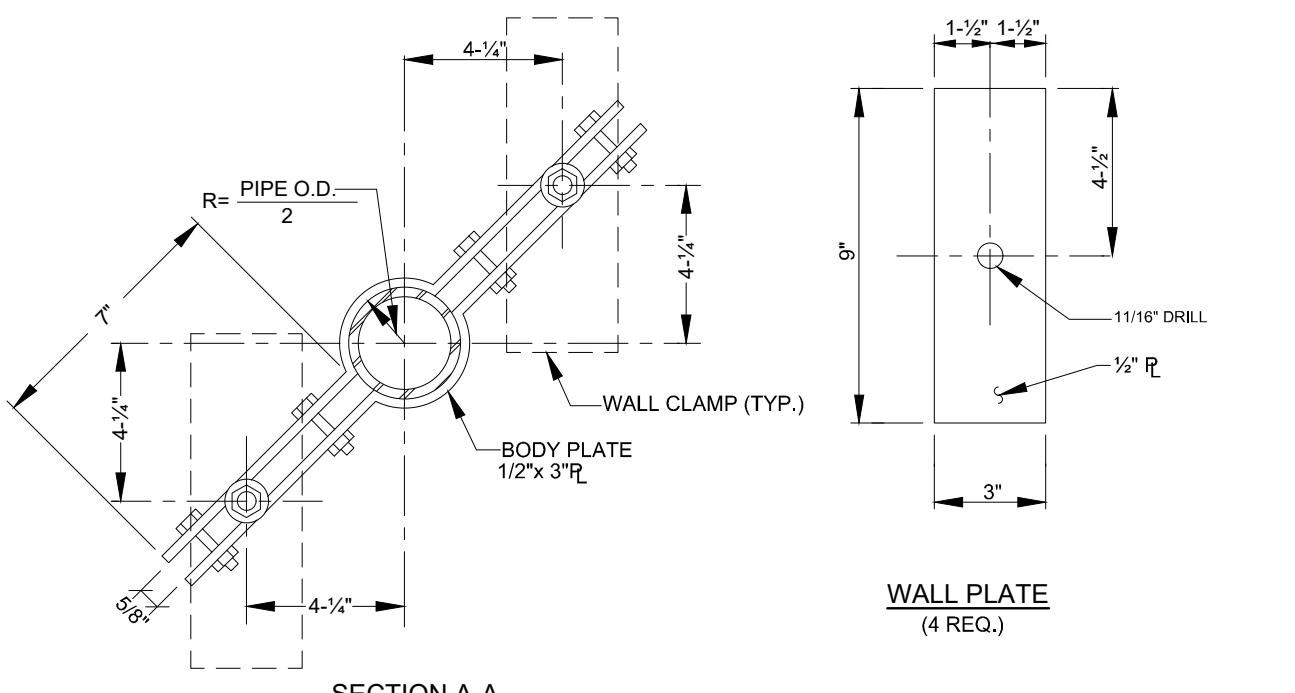
NO DATE REVISION



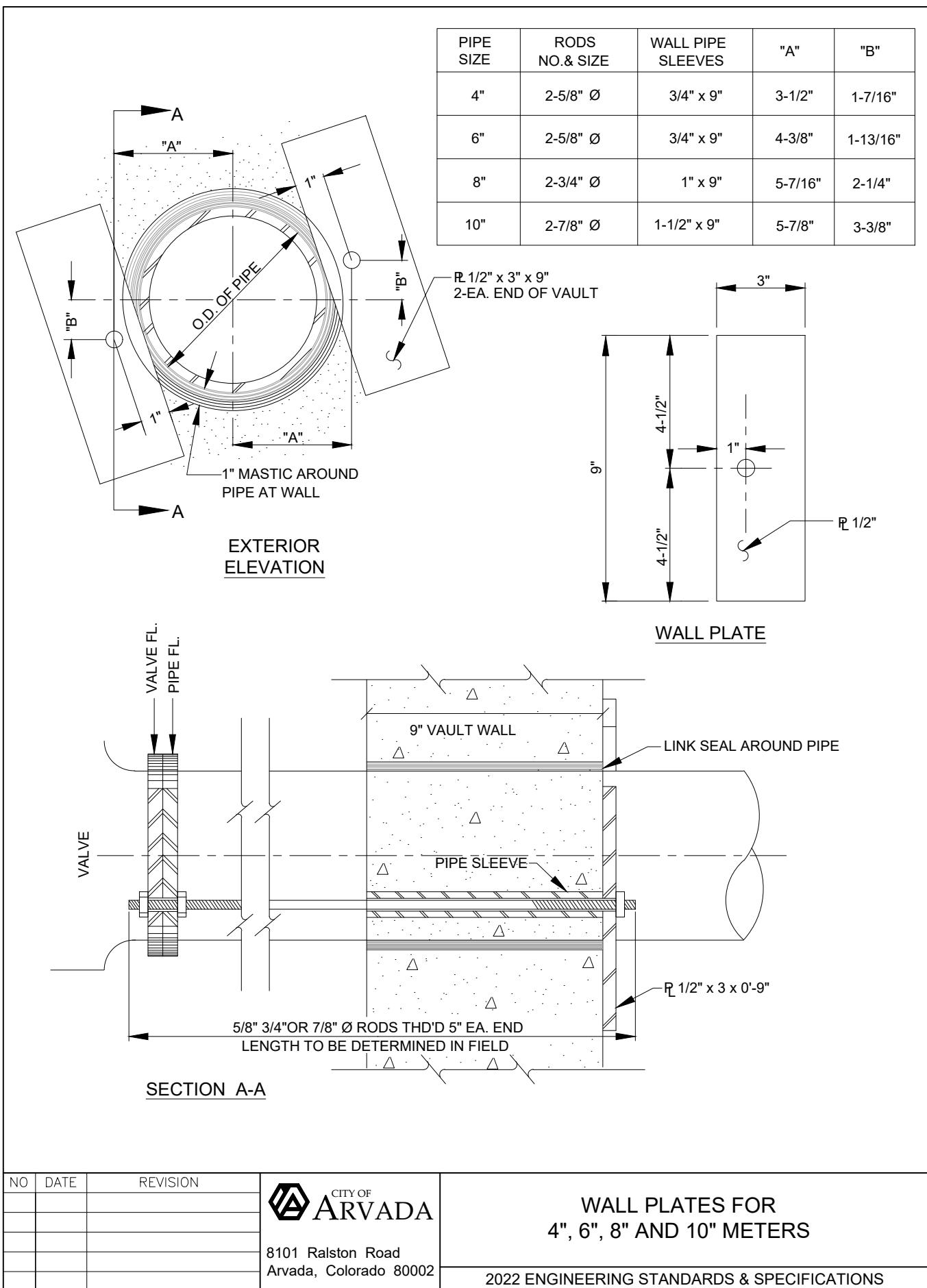
8101 Ralston Road
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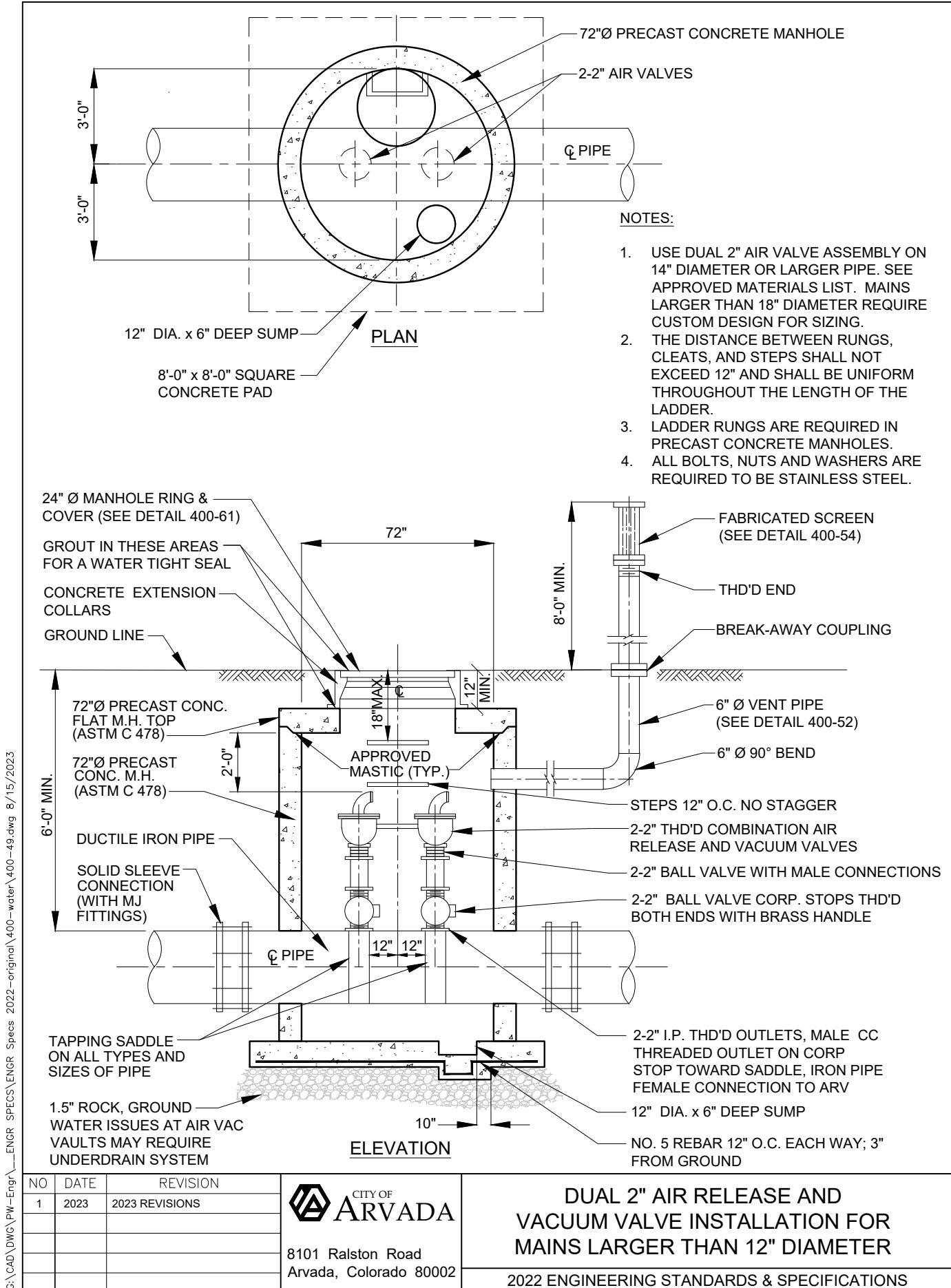
**ARVADA 6" AND 8" WATER METER VAULT
ISOMETRIC VIEW**

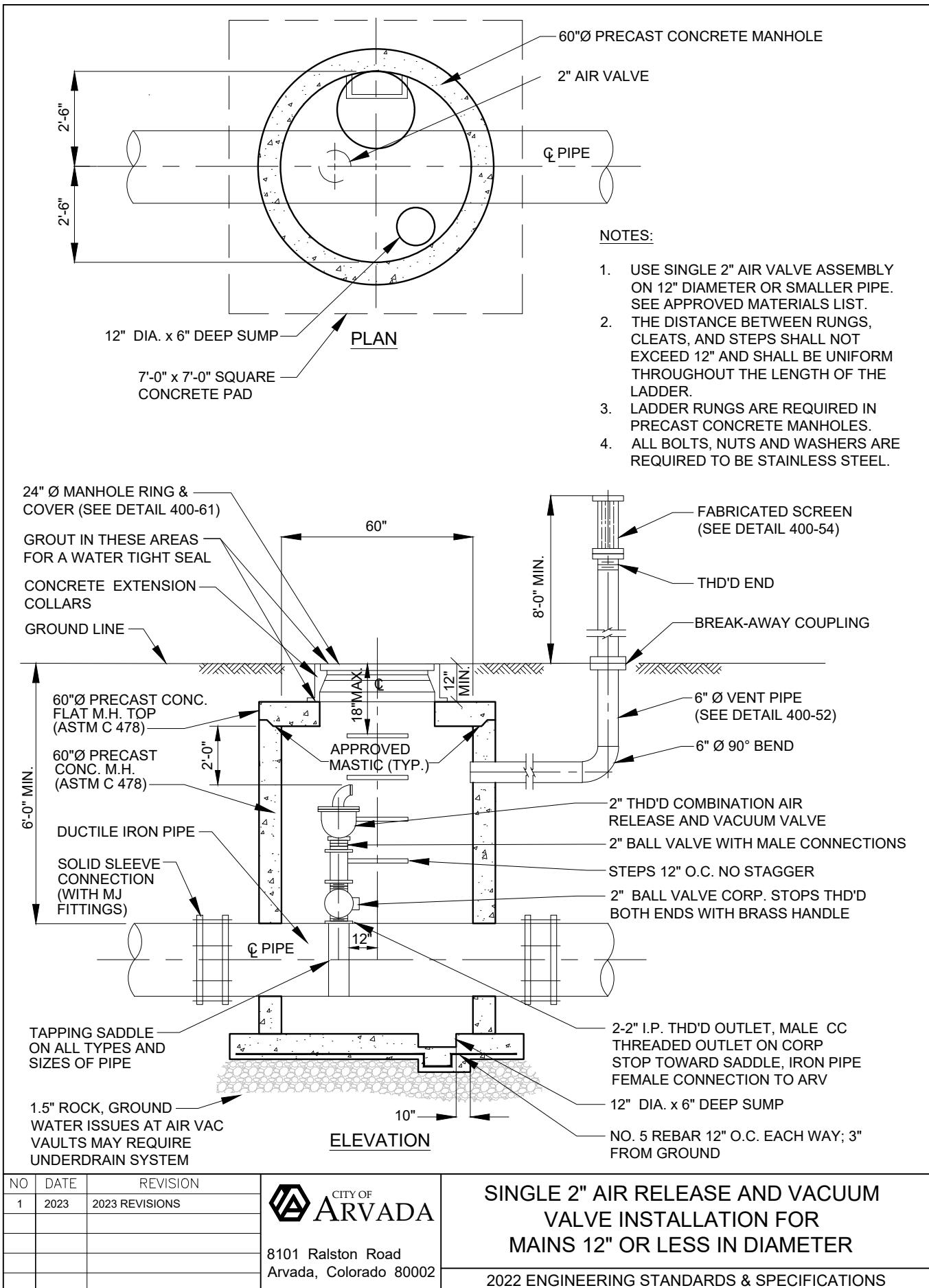
2022 ENGINEERING STANDARDS & SPECIFICATIONS

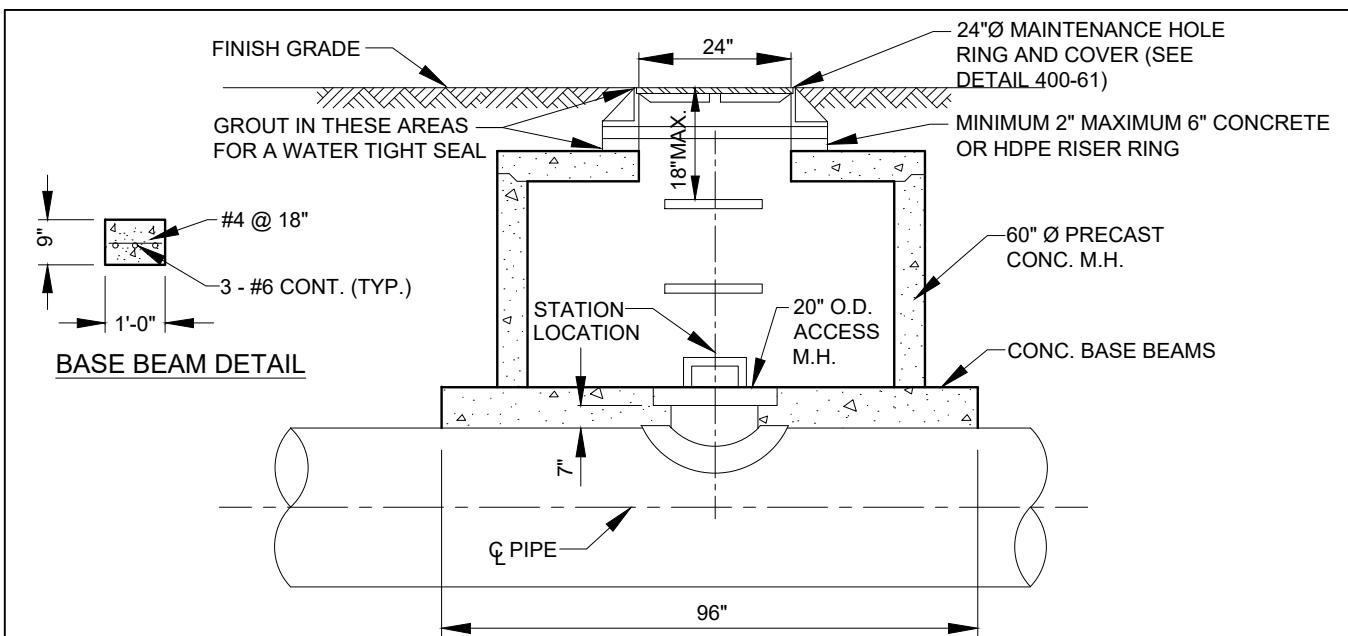


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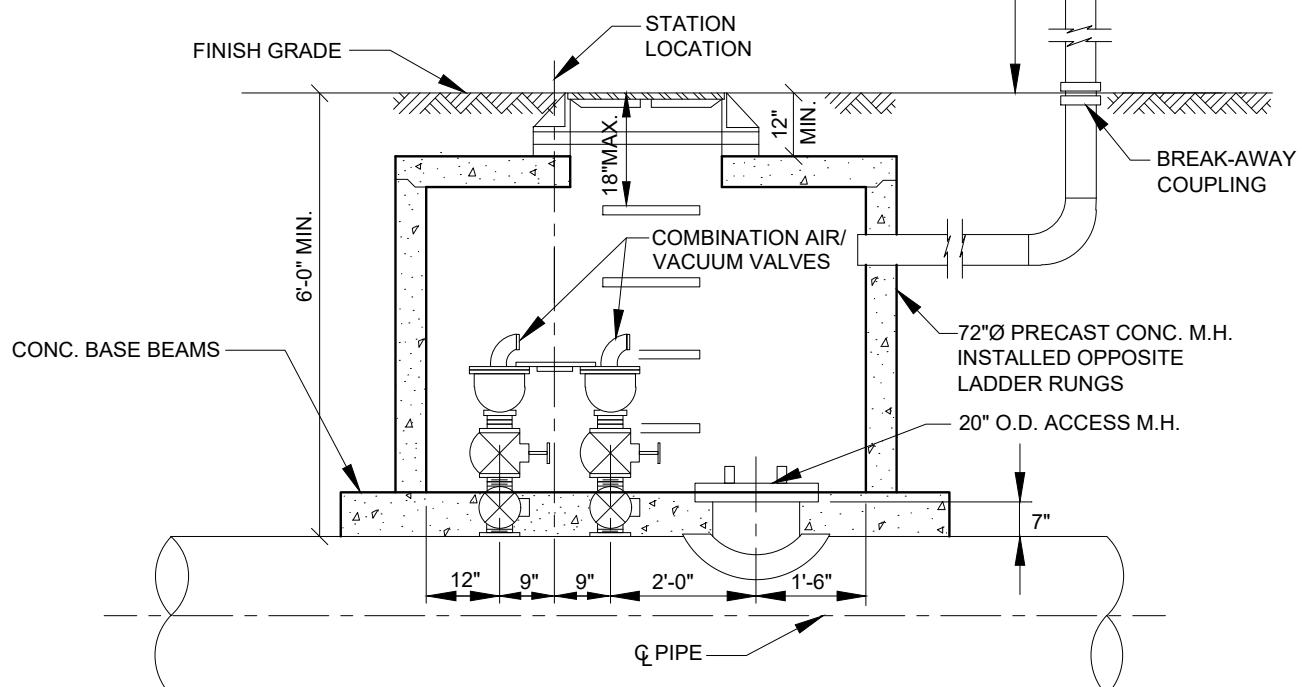
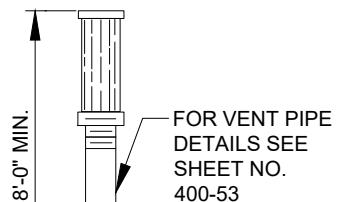
NOTES:

- SEE DETAILS THIS SHEET FOR CONCRETE MAINTENANCE HOLE BASE BEAMS AND AIR / VACUUM VALVE DETAILS.
- LADDER RUNGS ARE REQUIRED IN PRECAST MAINTENANCE HOLES. THE DISTANCE BETWEEN RUNGS, CLEATS AND STEPS SHALL NOT EXCEED 12" AND SHALL BE UNIFORM THROUGHOUT THE LENGTH OF THE LADDER.

ACCESS MAINTENANCE HOLE

NOTE:

- USE 2" AIR VALVE ASSEMBLY ON 18" OR SMALLER PIPE
- LARGER MAINS REQUIRE CUSTOM DESIGN FOR SIZING



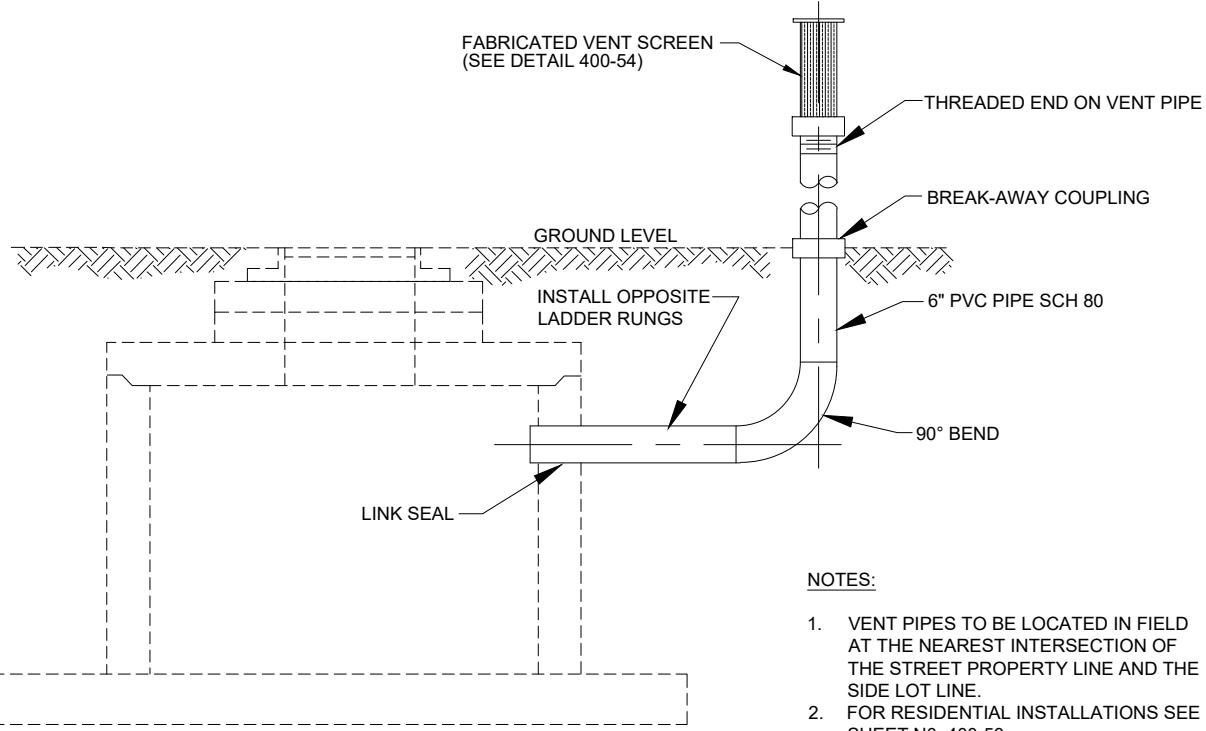
AIR VALVE ASSEMBLY WITH ACCESS MAINTENANCE HOLE

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1	2023	2023 REVISIONS

CITY OF ARVADA
8101 Ralston Road
Arvada, Colorado 80002

ACCESS MAINTENANCE HOLE &
DUAL AIR AND VACUUM VALVE ASSEMBLY
WITH ACCESS MAINTENANCE HOLE

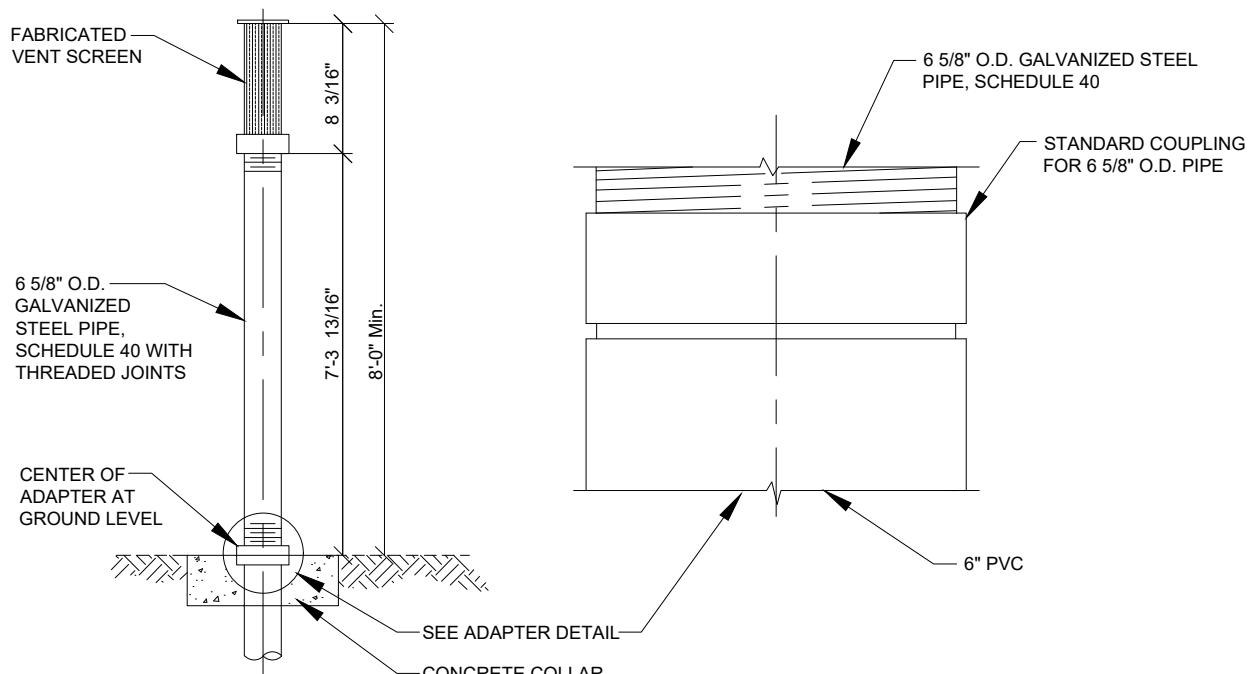
2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

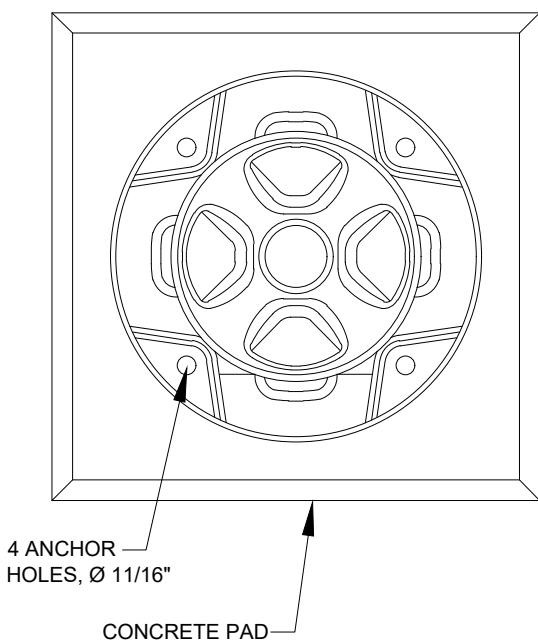
1. VENT PIPES TO BE LOCATED IN FIELD AT THE NEAREST INTERSECTION OF THE STREET PROPERTY LINE AND THE SIDE LOT LINE.
2. FOR RESIDENTIAL INSTALLATIONS SEE SHEET NO. 400-53.

VENT PIPE INSTALLATION



VENT PIPE AND BLACK IRON COUPLING DETAILS

NO	DATE	REVISION	CITY OF ARVADA  8101 Ralston Road Arvada, Colorado 80002	VENT PIPE DETAIL
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



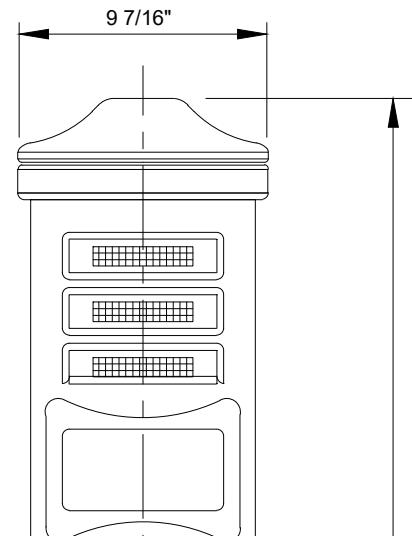
BASE DETAIL

NOTE:

COLOR SHALL FLAT BLACK TO MATCH SURROUNDINGS.

GROUND LINE

1'-6" x 1'-6" x 6"
CONCRETE PAD



14 3/16"

6" VENT PIPE PVC
SCHEDULE 40

ROUND VENT SCREEN

NO	DATE	REVISION

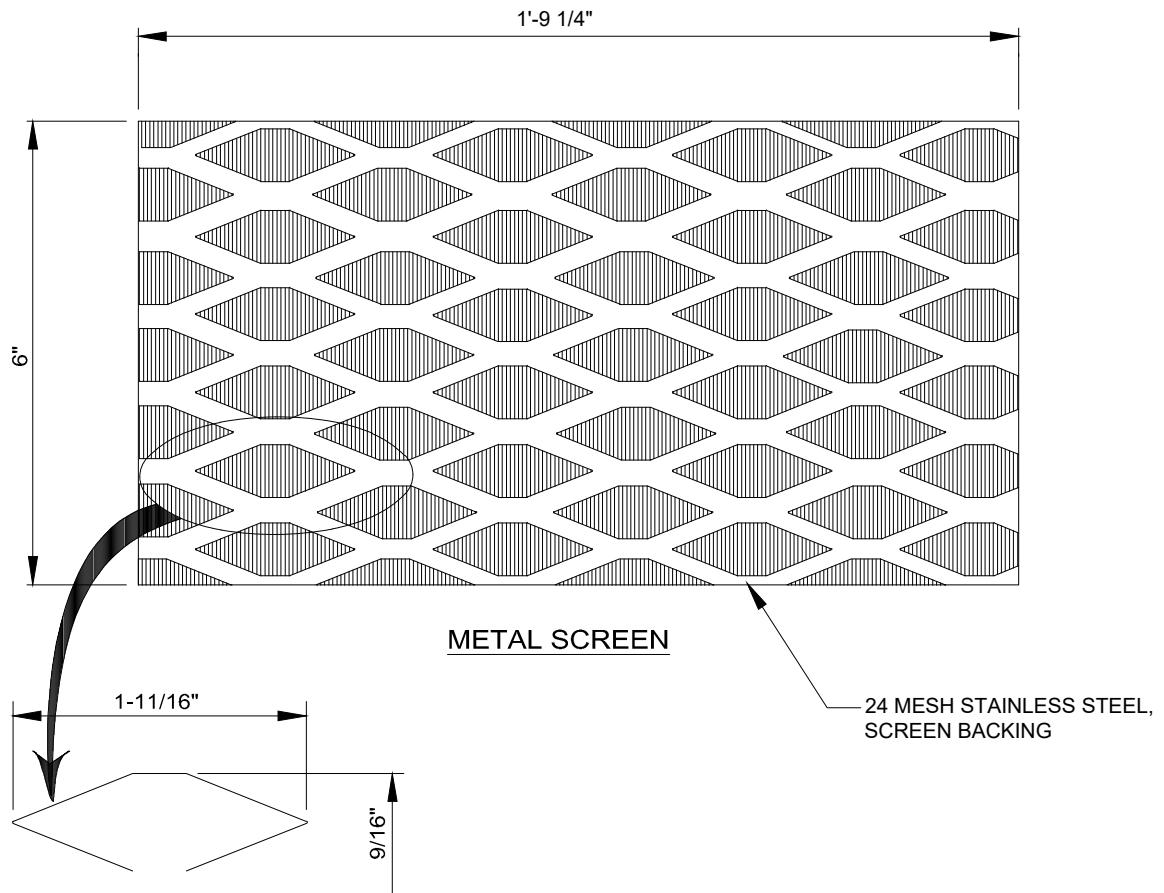
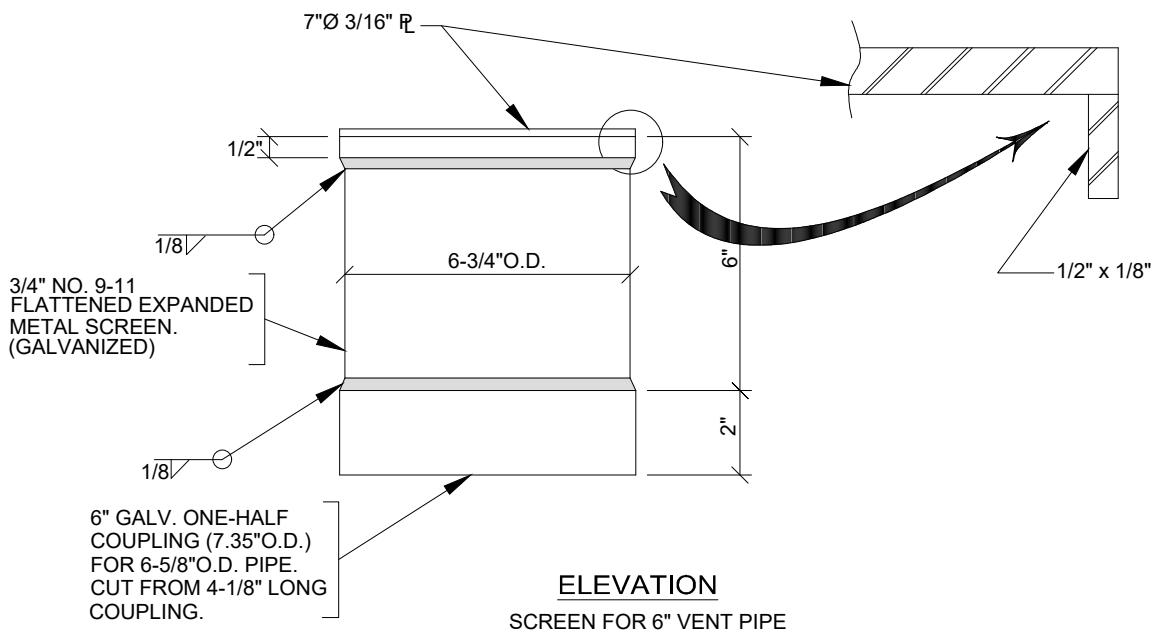


CITY OF
ARVADA

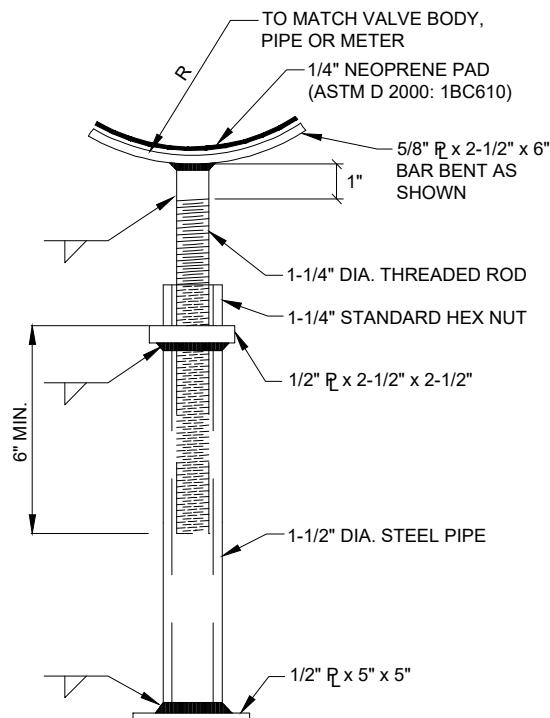
8101 Ralston Road
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RESIDENTIAL VENT ASSEMBLY

2022 ENGINEERING STANDARDS & SPECIFICATIONS

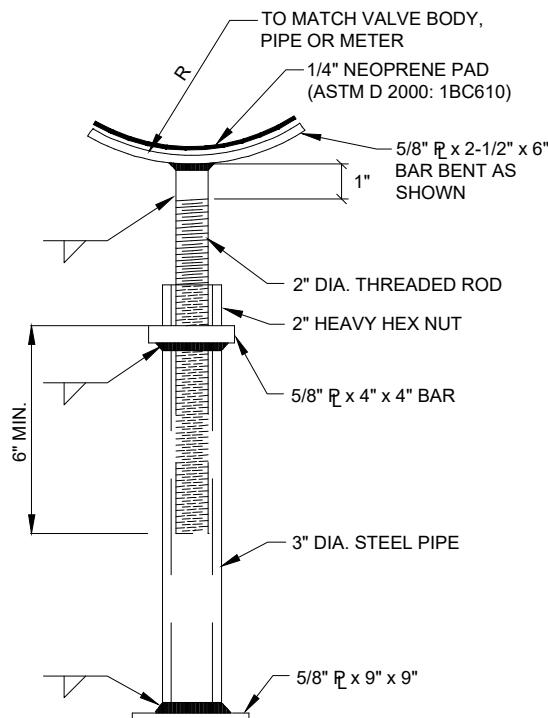


NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	6" DIAMETER VENT PIPE SCREEN
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

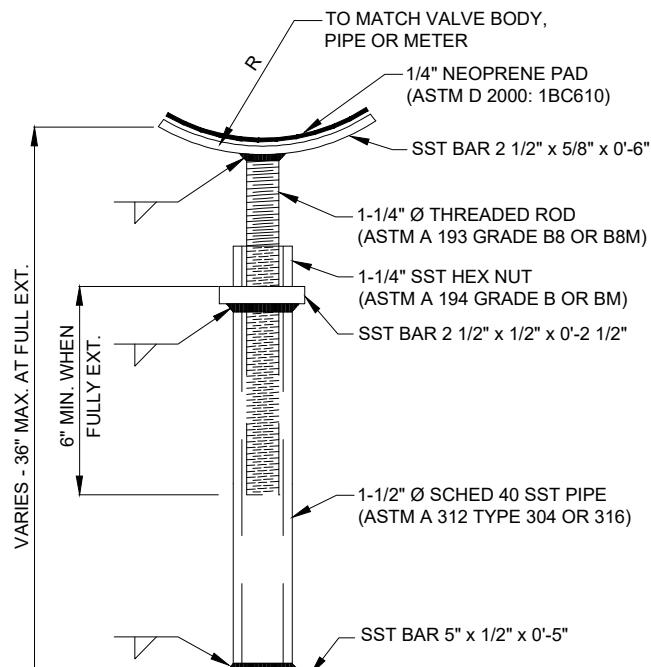


**ADJUSTABLE-SUPPORT
(STANDARD)**

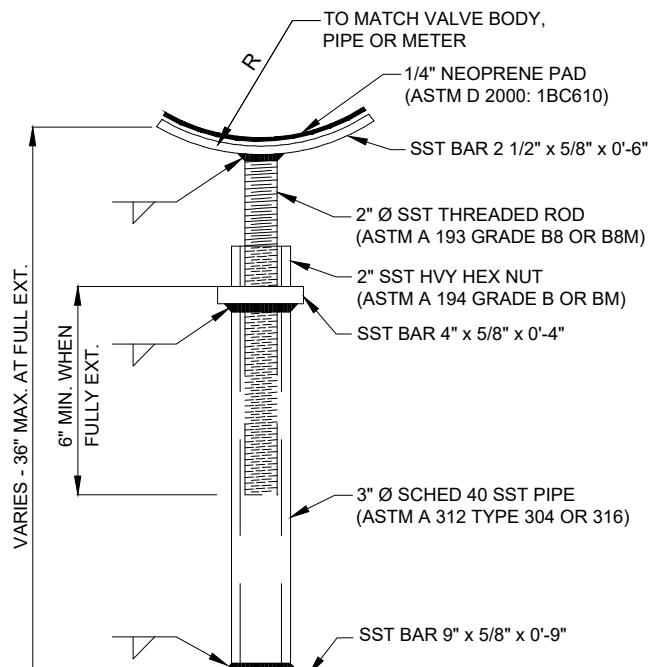
NOTE:
1. INSTALL AS DIRECTED BY
PROJECT ENGINEER.
2. INSTALL A BRICK UNDER
SUPPORT BASE.



**ADJUSTABLE-SUPPORT
(HEAVY DUTY)**



**STAINLESS STEEL
ADJUSTABLE-SUPPORT
(STANDARD)**

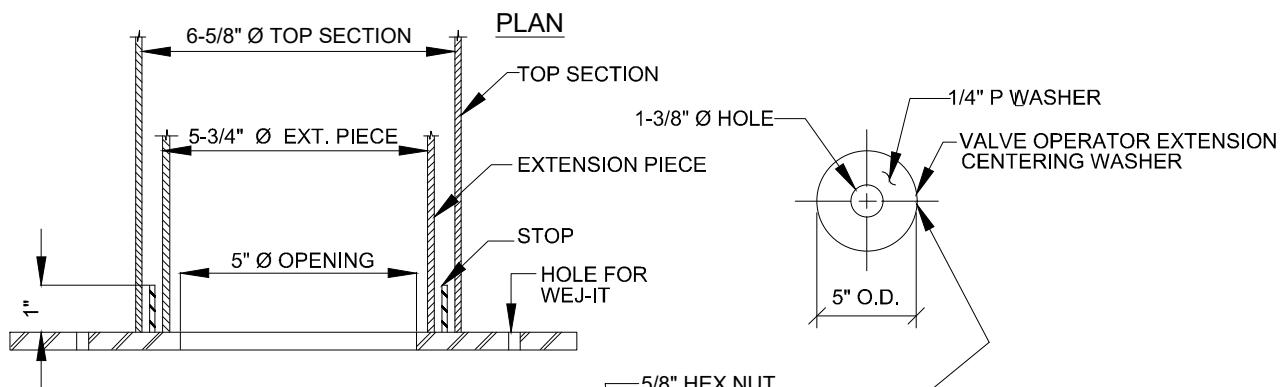
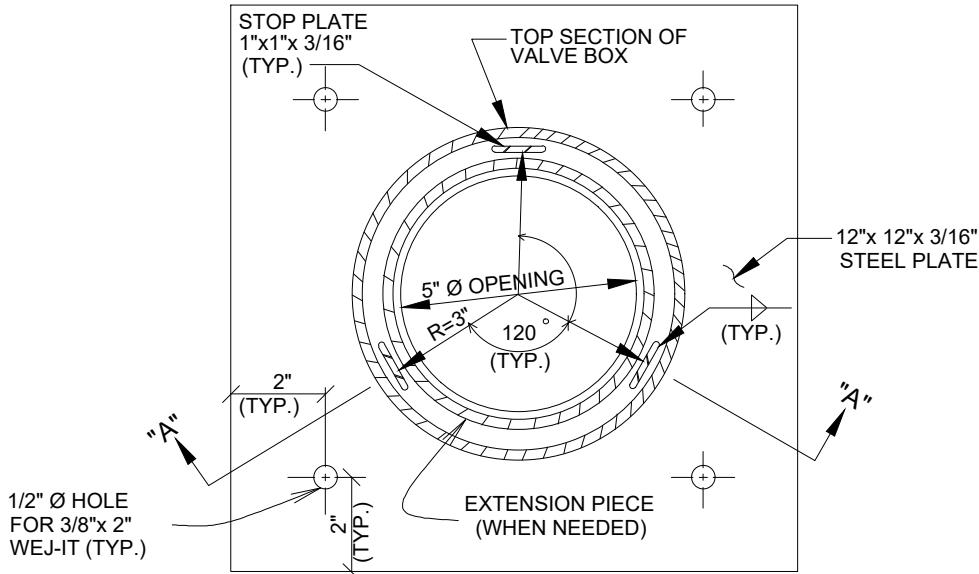


**STAINLESS STEEL
ADJUSTABLE-SUPPORT
(HEAVY DUTY)**

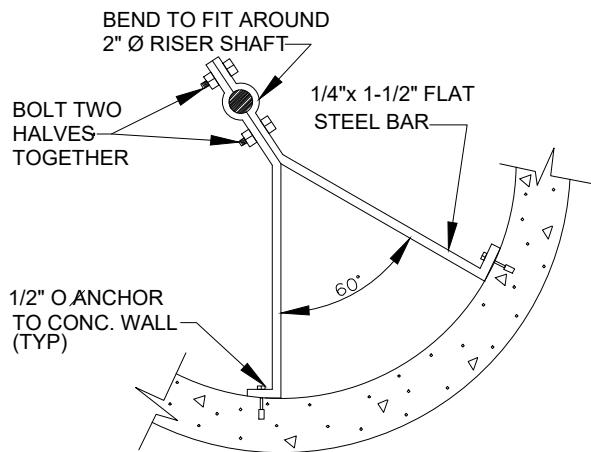
NO	DATE	REVISION

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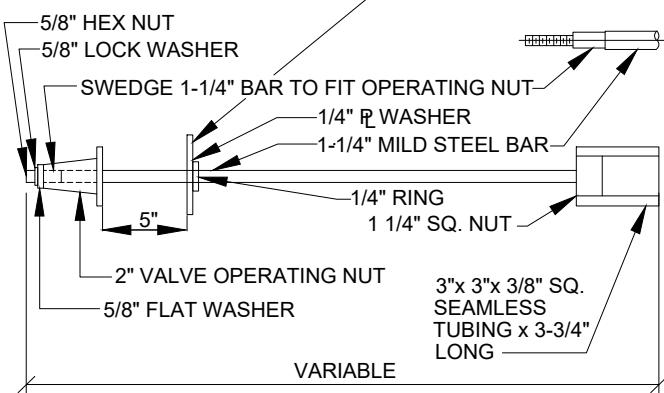
ADJUSTABLE STEEL PIPE AND VALVE SUPPORT



SECTION "A"- "A"



EXTENSION GUIDE



VALVE OPERATOR EXTENSION

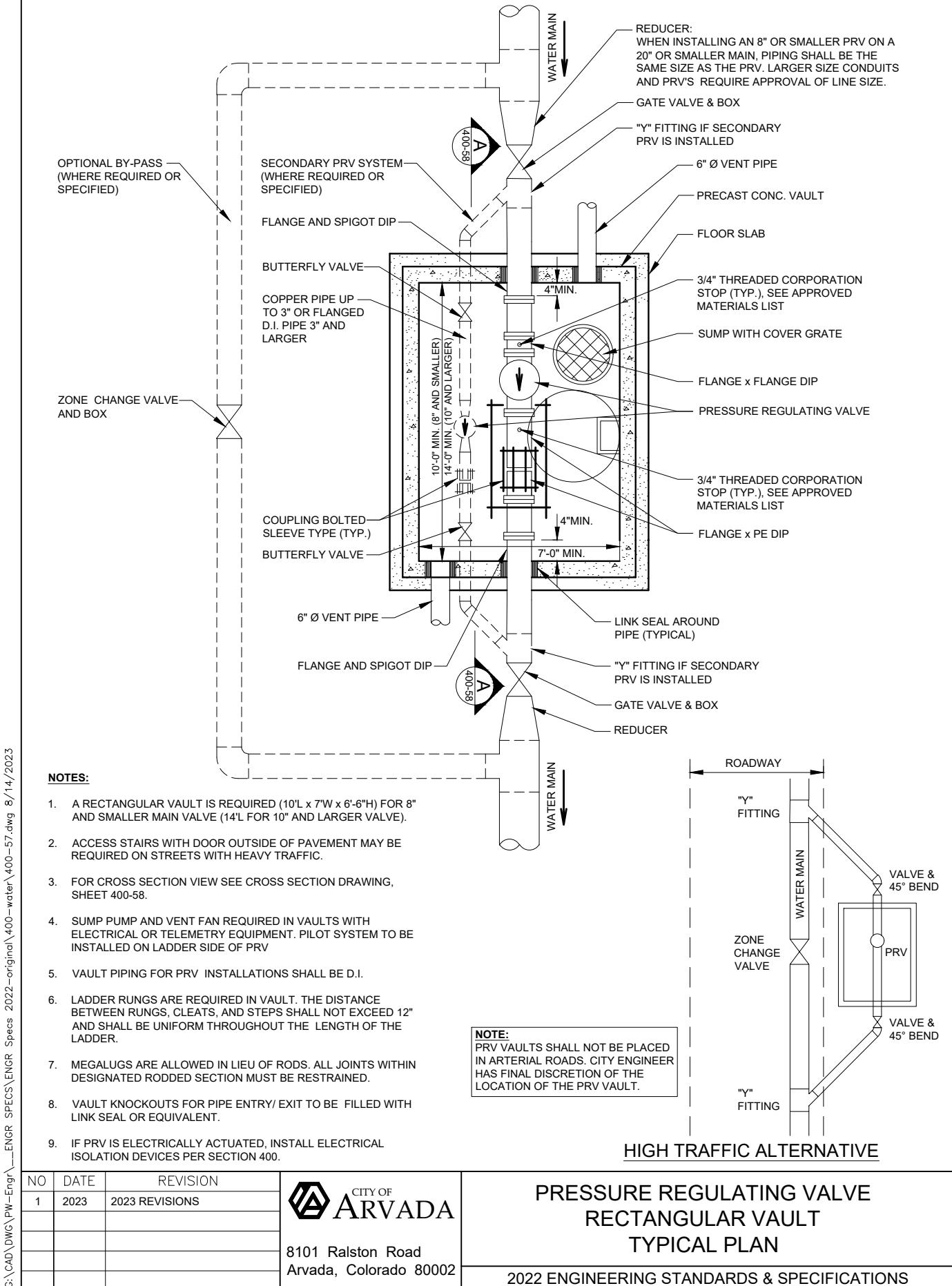
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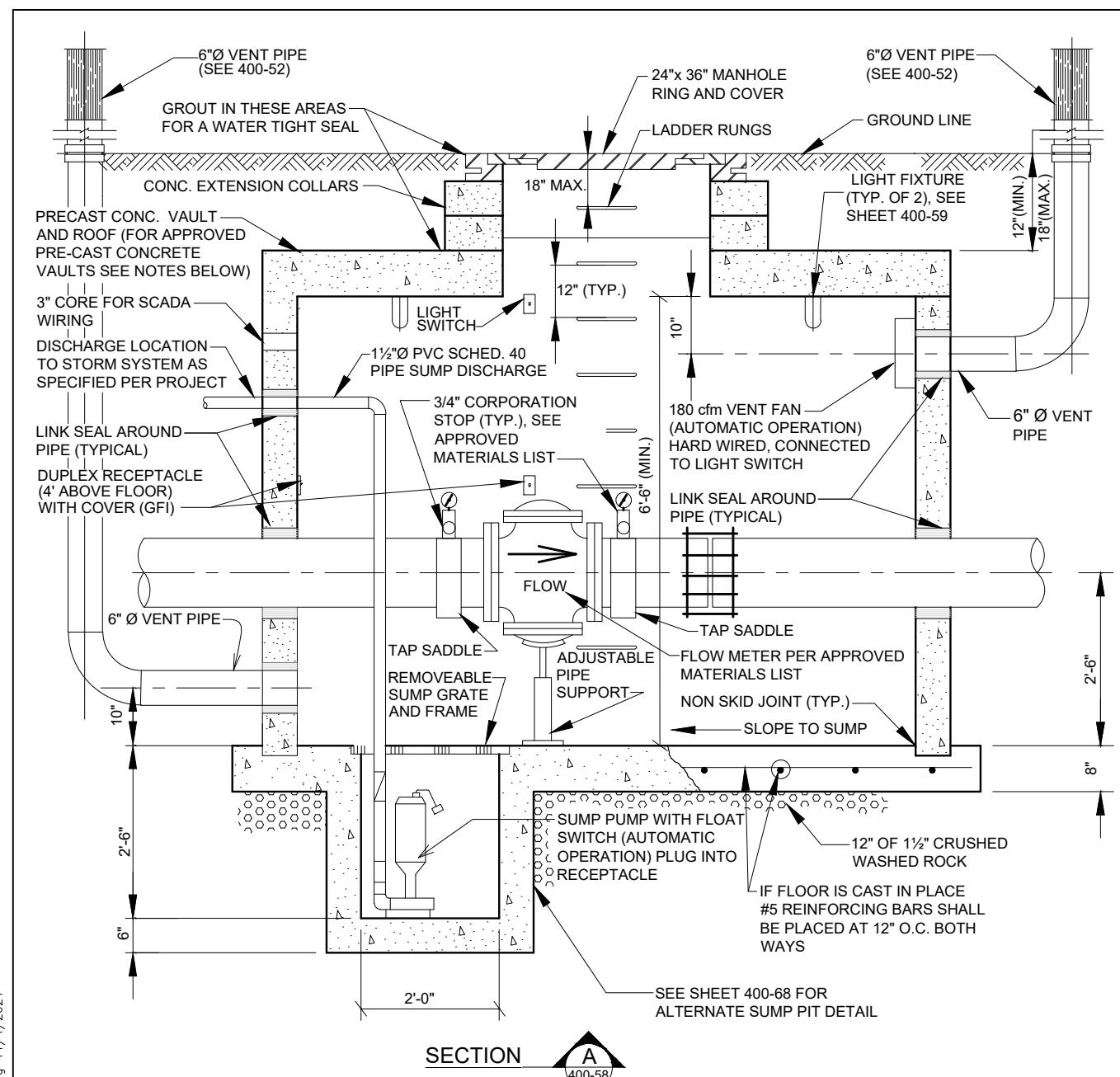


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VALVE BOX SUPPORT PLATE AND VALVE
OPERATOR EXTENSION GUIDE

2022 ENGINEERING STANDARDS & SPECIFICATIONS





NOTES:

- APPROVED PRECAST CONCRETE VAULTS: AMCOR CONC. INC. (10'L x 7'W x 6'-6"H) FOR 8" AND SMALLER MAIN VALVE (14'L FOR 10" AND LARGER MAIN VALVE).
- CITY ENGINEERS APPROVAL IS REQUIRED FOR SUMP PUMP DISCHARGE TO STORM SEWERS.
- SEE SHEET 400-57 FOR PLAN VIEW.
- BYPASS NOT SHOWN THIS VIEW.
- INTERIOR BREAKER BOX TO BE MOUNTED ON SAME WALL AS LADDER RUNGS (MIN. 4' ABOVE FLOOR) INDIVIDUAL CIRCUITS SHALL BE PROVIDED FOR LIGHTS AND OUTLETS.
- PRESSURE GAUGES TO BE MOUNTED ON 3/4" CORPORATION STOPS.
- CONDUIT RUNS SHALL BE PARALLEL TO WALLS AND FLOOR.
- ALL WALL PENETRATIONS SHALL BE SEALED WITH LINK SEAL OR EQUIVALENT.
- ALL BOLTS, NUTS AND WASHERS ARE REQUIRED TO BE STAINLESS STEEL.
- WHEN IN UNPAVED AREAS, THE TOP OF THE VAULT SHALL BE 2" TO 4" ABOVE FINISHED GRADE.

SECTION

A
400-58

NO	DATE	REVISION



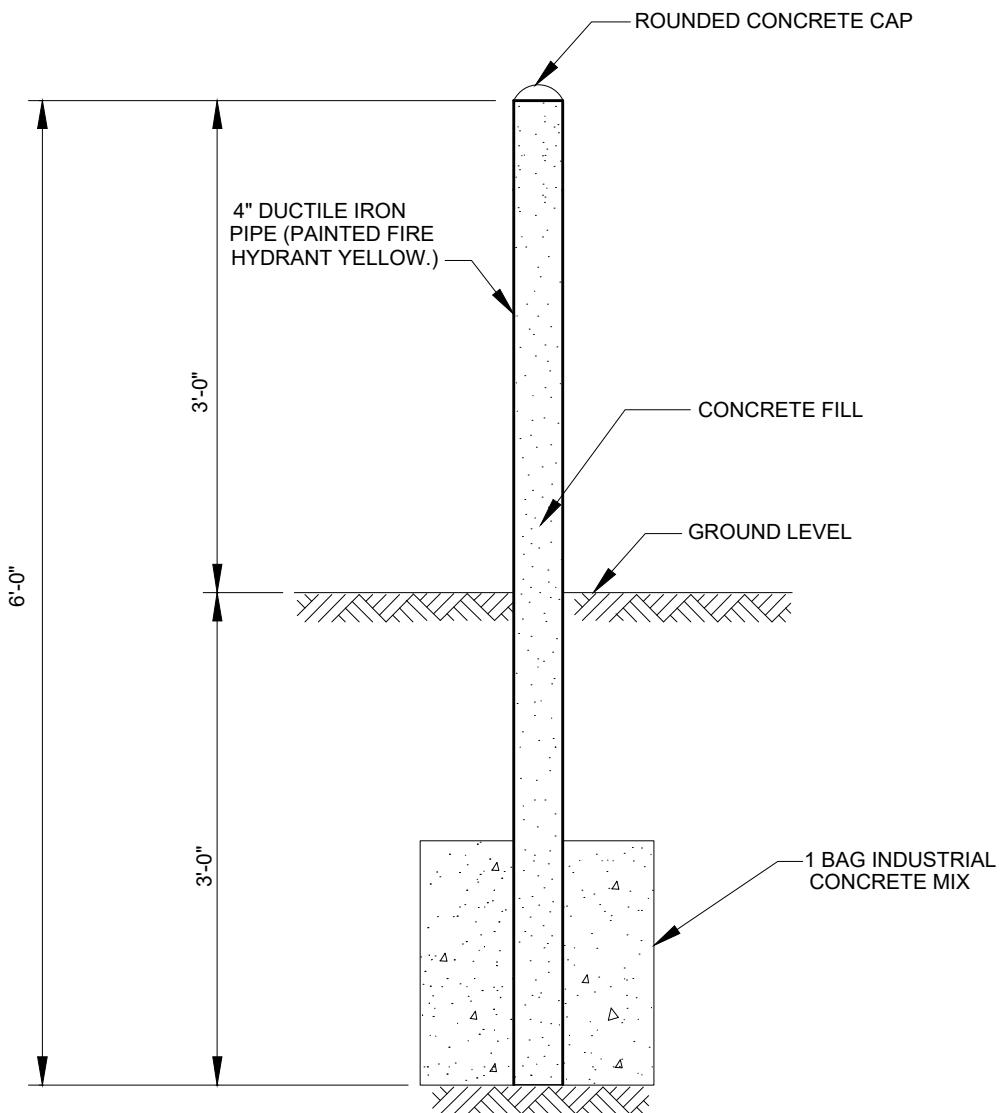
8101 Ralston Road
Arvada, Colorado 80002

**PRESSURE REGULATING VALVE
RECTANGULAR VAULT
CROSS SECTION**

PRV VAULT PIPING AND APPURTENANCES NOTES

<u>DESIGNATION</u>	<u>DESCRIPTION AND/OR SPECIFICATION</u>
VAULT	H-20 HIGHWAY LOADING
VENT PIPING	6" PVC, SCHEDULE 40, FITTINGS AND SCREEN
GATE VALVES	MJ, WHEEL OPERATOR, AWWA C-509, RESILIENT SEAT, OPEN LEFT.
PRV	PRESSURE REGULATING VALVE CL. 150, 30 TO 300 PSI UP, 20 TO 200 PSI DOWN OR SINGER BRAND MODEL 106-PR-R. PRV TO BE SUPPLIED WITH POSITION INDICATOR ASSEMBLY, OPEN AND CLOSE SPEED CONTROLS, SUSTAINER INTERIOR EPOXY COATING AND PRESET PILOT VALVES IN ACCORDANCE WITH CITY SPECIFIED PRESSURES. ALL BOLTS, NUTS AND WASHERS ARE REQUIRED TO BE STAINLESS STEEL.
SUMP GRATE AND FRAME	SEE APPROVED MATERIALS LIST.
FLUID GAUGE 0-150 PSI	SEE APPROVED MATERIALS LIST.
MAINTENANCE HOLE FRAME AND COVER	SEE APPROVED MATERIALS LIST.
SUMP PUMP	1/3 HP SUBMERSIBLE SUMP PUMP WITH AUTOMATIC OPERATION.
VENT FAN	180 CFM VENT FAN WITH AUTOMATIC OPERATION.
ELECTRICAL	WEATHER PROOF: WEATHER HEAD: BREAKER, JUNCTION AND SWITCH BOXES, SWITCHES, 2 DUPLEX GFCI RECEPTACLES WITH COVERS. 2 CFI SEALED INDUSTRIAL NON-CORROSIVE LUMINARIES WITH 2' 26 WATT LED BULBS. TUBING, CONDUIT, GROUND ROD, WIRE, EXTERIOR DISCONNECT BOX, METER BOX ETC.
MISCELLANEOUS	TIE RODS OR MEGALUGS, COAX CONDUIT, CORPORATION STOPS, SPOOL PIECES, TEES, COUPLINGS, MASTIC, SEALS, SUMP DISCHARGE PIPING, ETC. SEE DRAWINGS: 400-57 AND 400-58 FOR PLAN VIEW, CROSS SECTION AND ADDITIONAL NOTES.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	PRESSURE REGULATING VALVE SYSTEM PIPING & APPURTENANCES
1	2023	2023 REVISIONS		2022 ENGINEERING STANDARDS & SPECIFICATIONS



IDENTIFICATION MARKS ON POSTS (REFERENCE POSTS ONLY)
SHALL BE 3" DIA. CIRCLES BROKEN IN VERTICAL CENTER POINTING
TO APPURTENANCE, WITH 1" STENCILS INSIDE CIRCLES INDICATING
TYPE OF APPURTENANCE (MH, 12" GATE VALVE, ETC.) AND THE
DISTANCE IN FEET AND INCHES FROM POST.

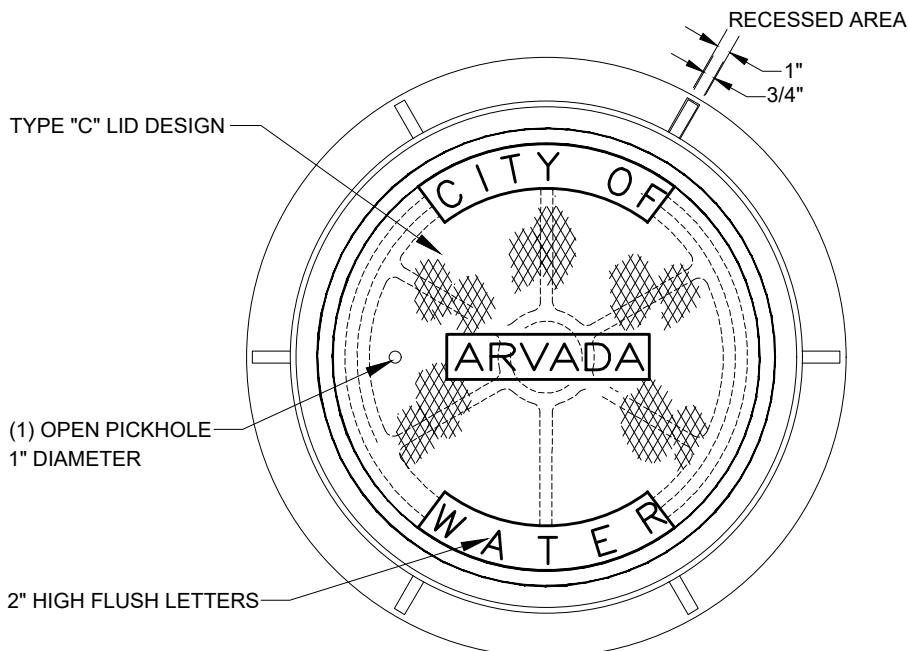
NO	DATE	REVISION



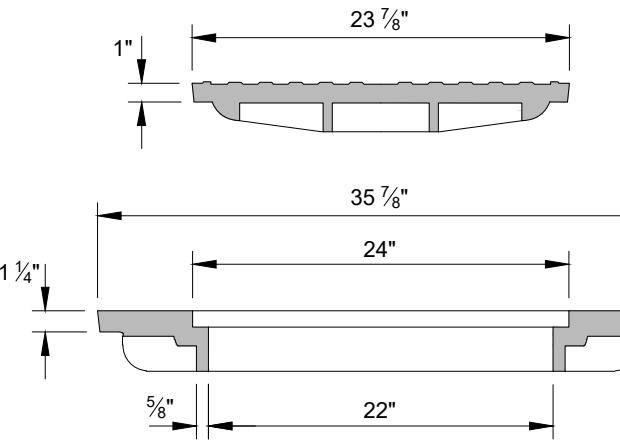
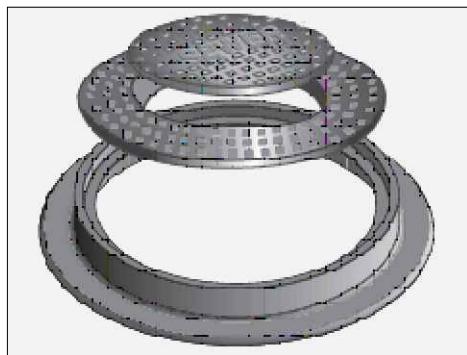
CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

REFERENCE POST OR HYDRANT BOLLARD
TYPICAL DETAIL

2022 ENGINEERING STANDARDS & SPECIFICATIONS

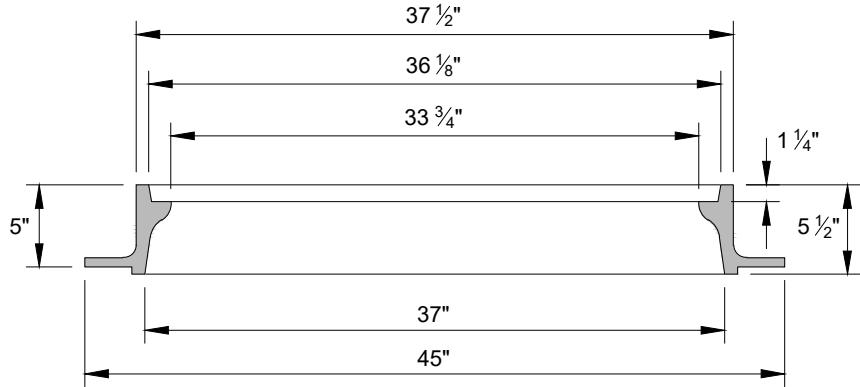


PLAN VIEW FRAME AND LID



NOTE:

SEE APPROVED MATERIALS
LIST FOR FRAMES AND LIDS.



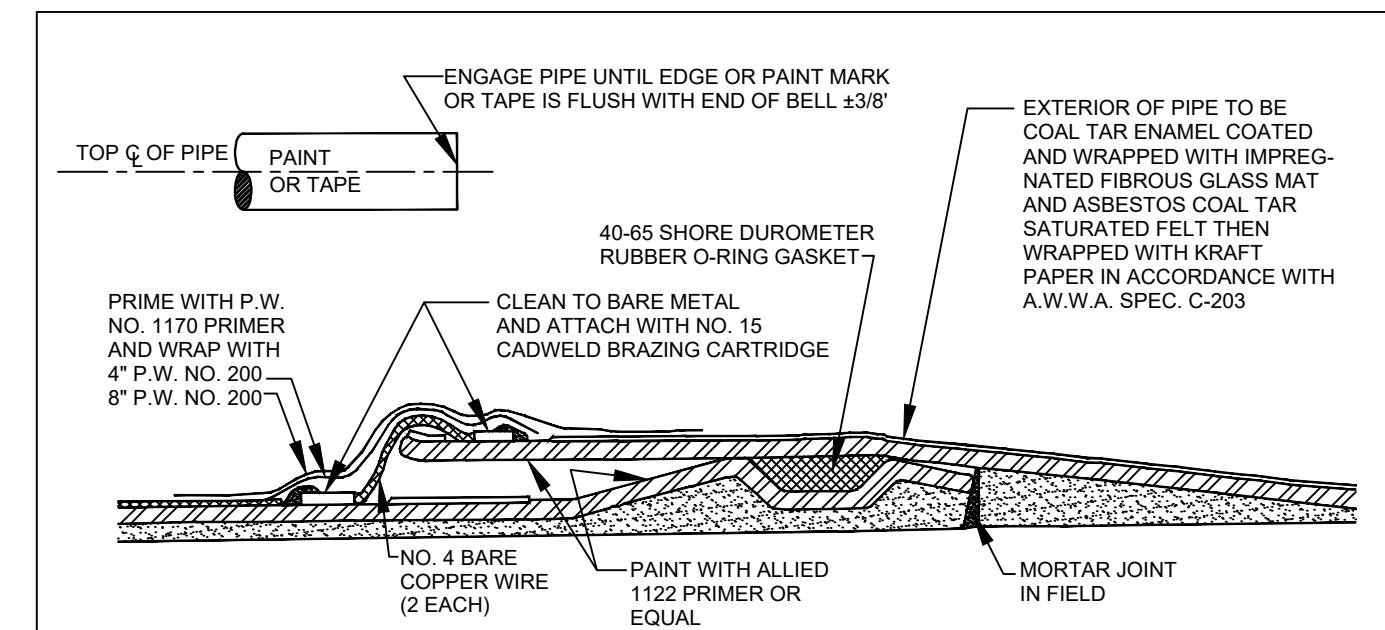
NO	DATE	REVISION
1	2023	2023 REVISIONS



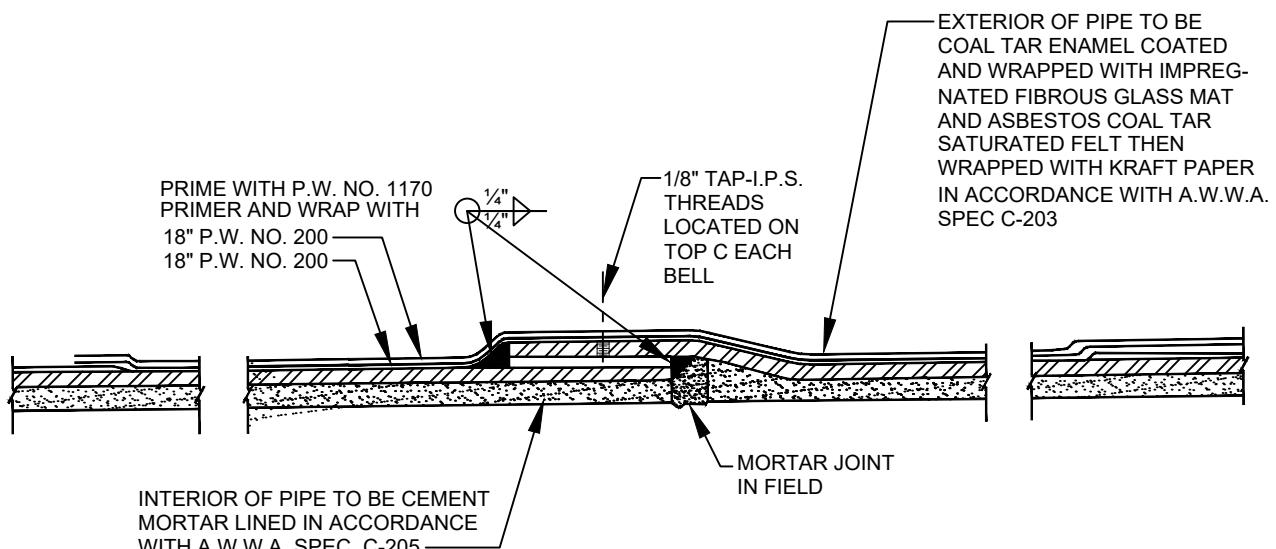
CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

WATER METER OR VALVE VAULT
FRAME AND LID DETAIL

2022 ENGINEERING STANDARDS & SPECIFICATIONS

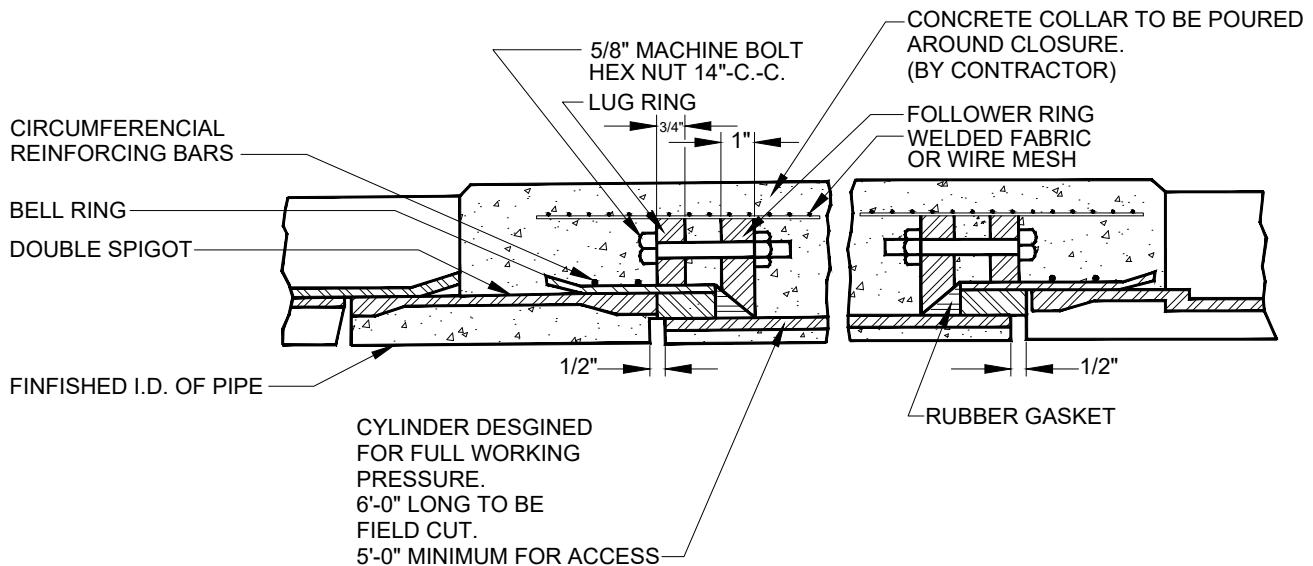


BONDING O-RING JOINT FOR STEEL PIPE



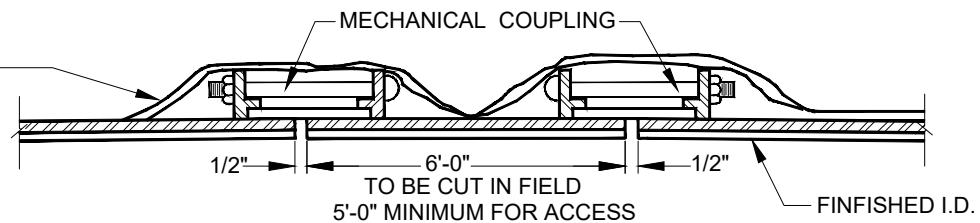
FIELD WELDED LAP JOINT FOR STEEL PIPE

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	O-RING JOINT AND WELDED JOINT DETAILS STEEL PIPE LINES
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



FOR PRESTRESSED CONCRETE CYLINDER PIPE

FIELD COAT WITH
P.W. NO. 1170 PRIMER
& NO. 200 TAPE AS
SPECIFIED OR EQUAL



FOR STEEL PIPE

NOTE:

1. INSTALL CP CONTINUITY BOND CABLES IF REQUIRED PER SECTION 400.

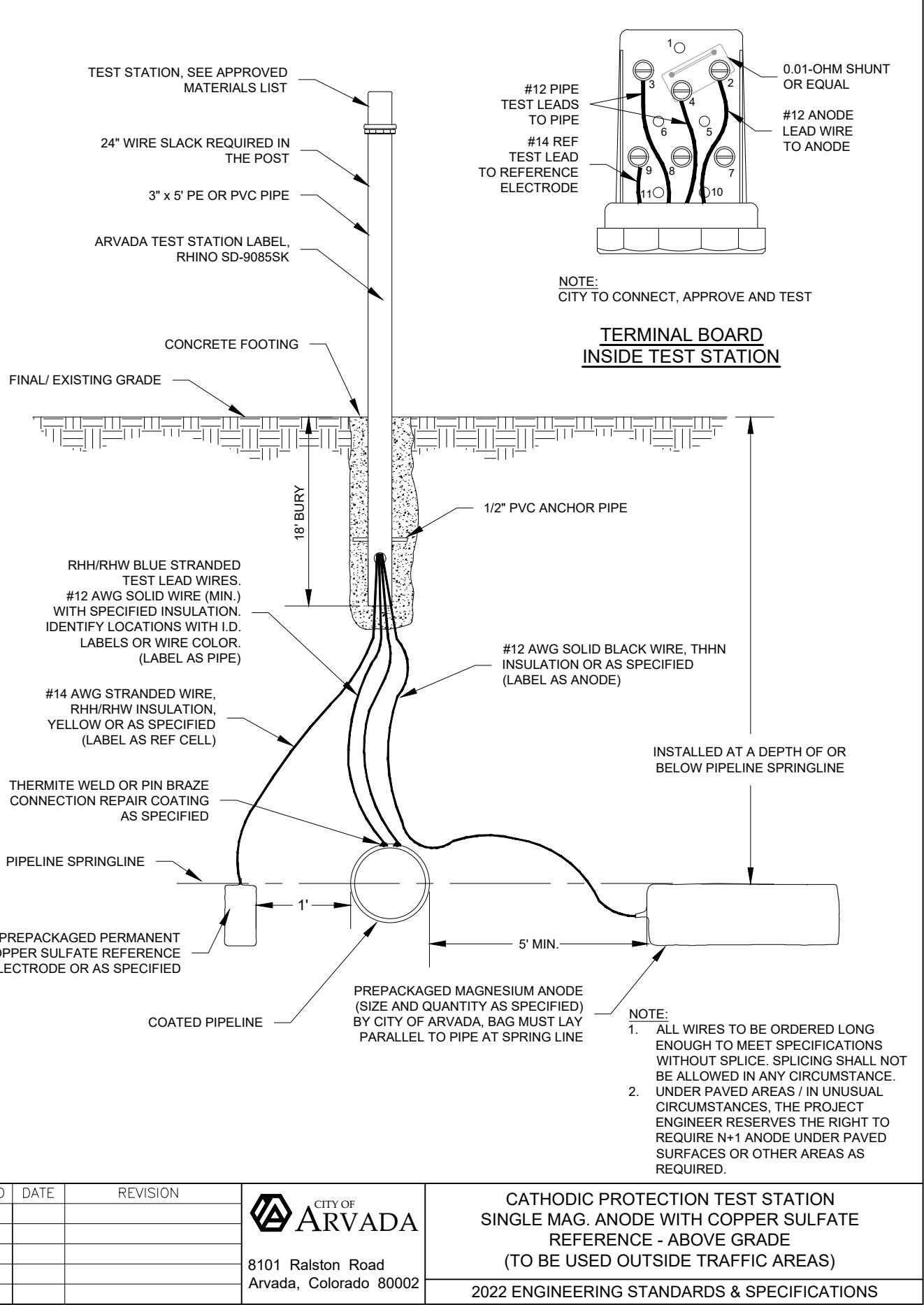
NO	DATE	REVISION

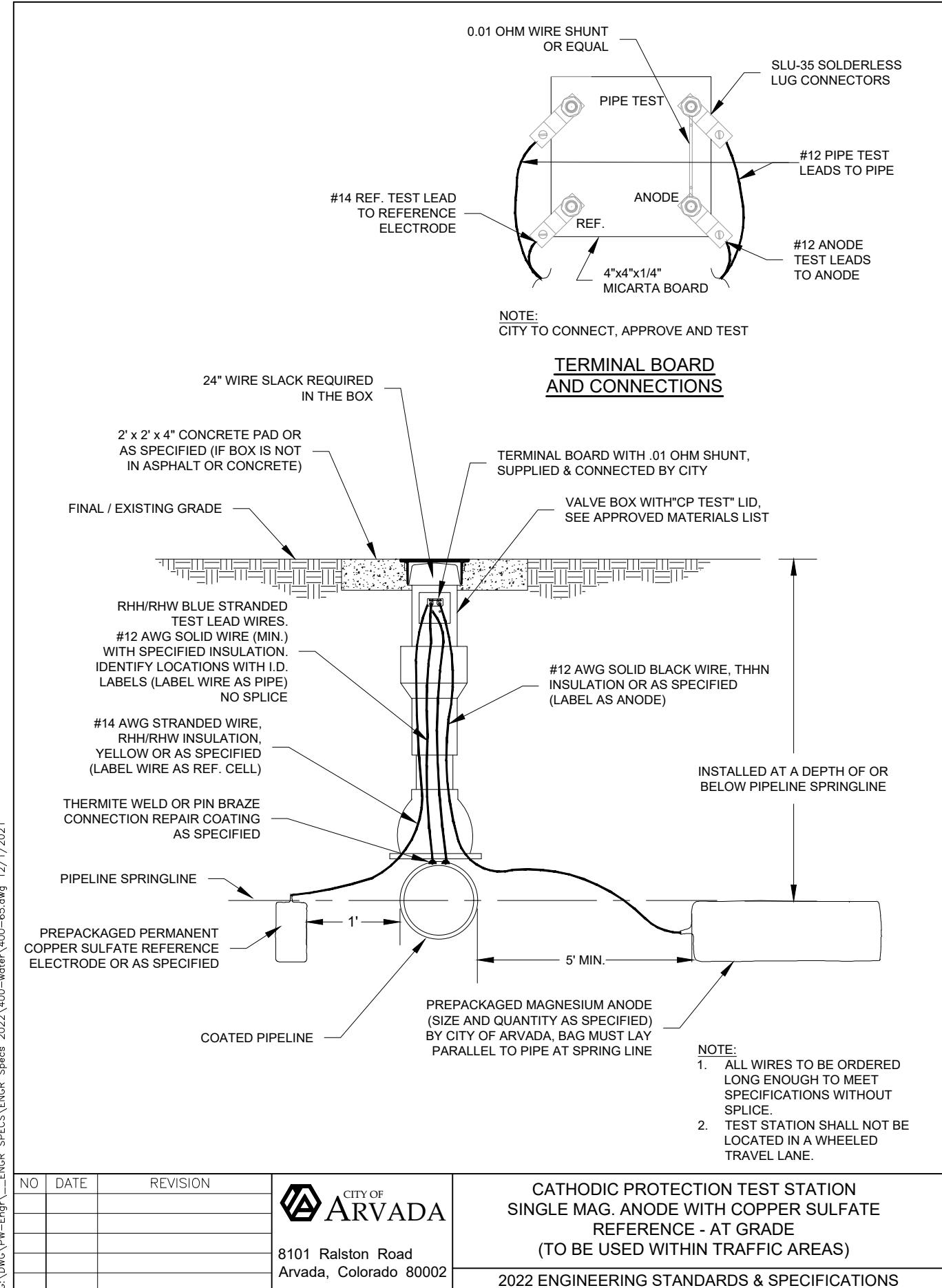


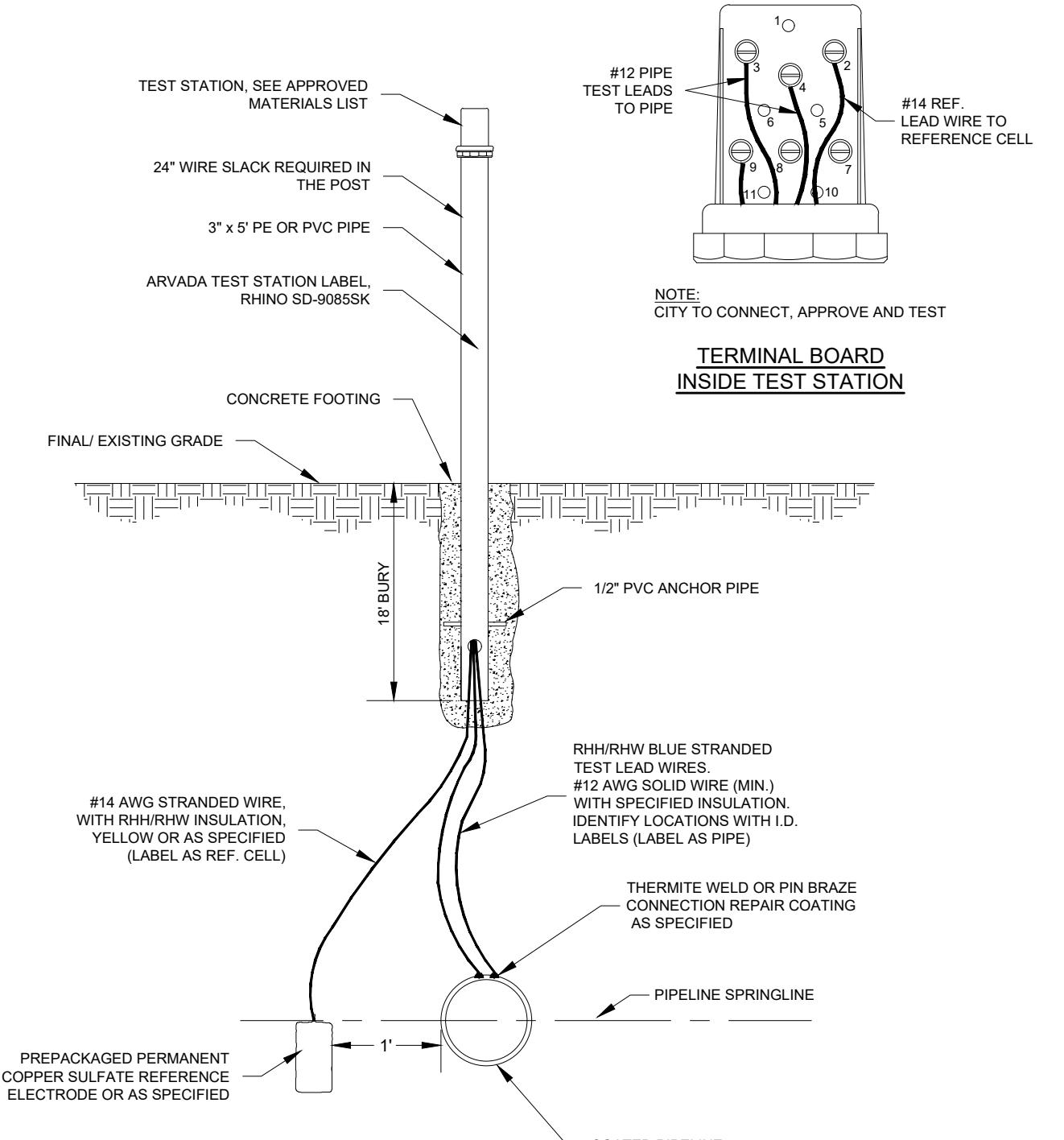
CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

**CLOSURE FOR CONCRETE
AND STEEL PIPE**

2022 ENGINEERING STANDARDS & SPECIFICATIONS

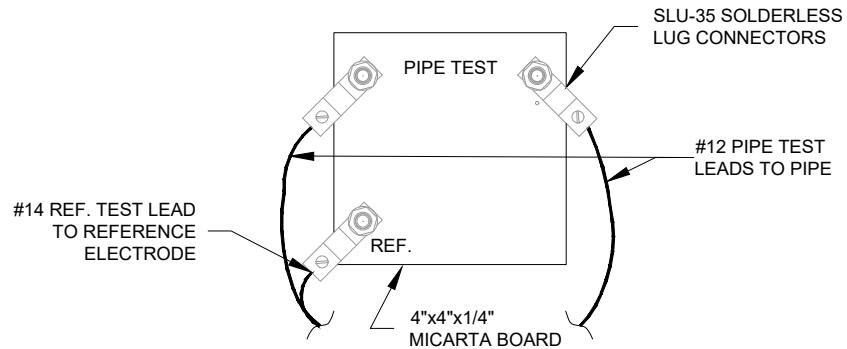




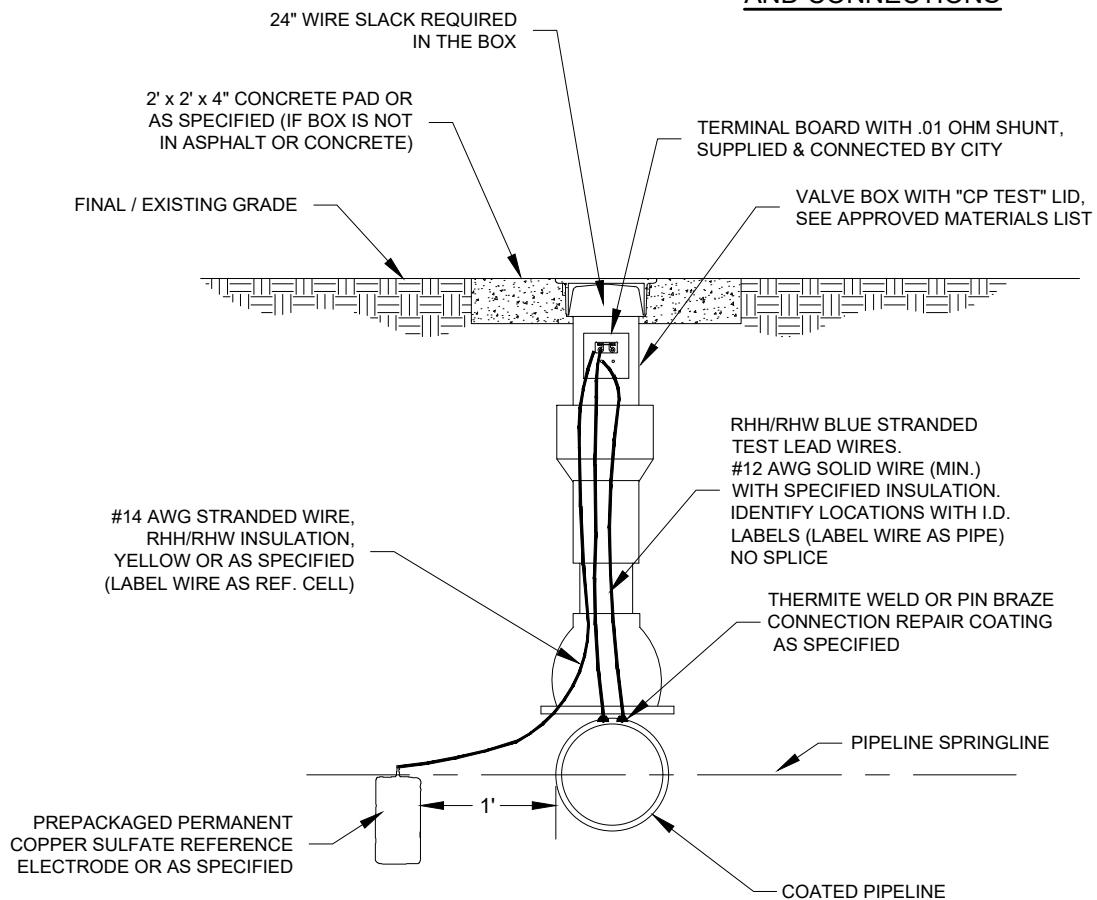


NOTE:
ALL WIRES TO BE ORDERED LONG ENOUGH TO MEET SPECIFICATIONS WITHOUT SPLICE

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CATHODIC PROTECTION TEST STATION POTENTIAL WITH COPPER SULFATE REF. ELECTRODE - ABOVE GRADE (TO BE USED OUTSIDE TRAFFIC AREAS)
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

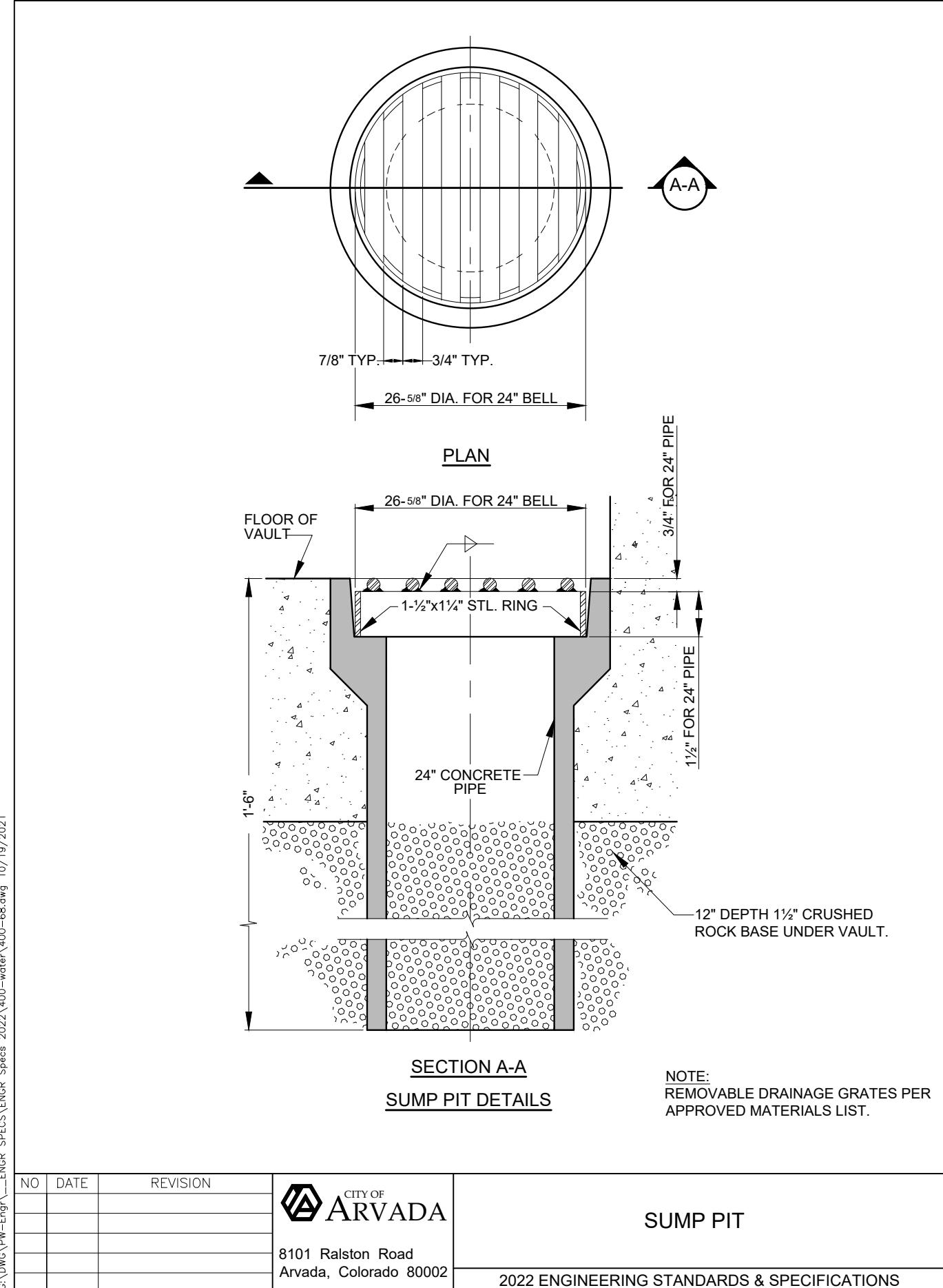


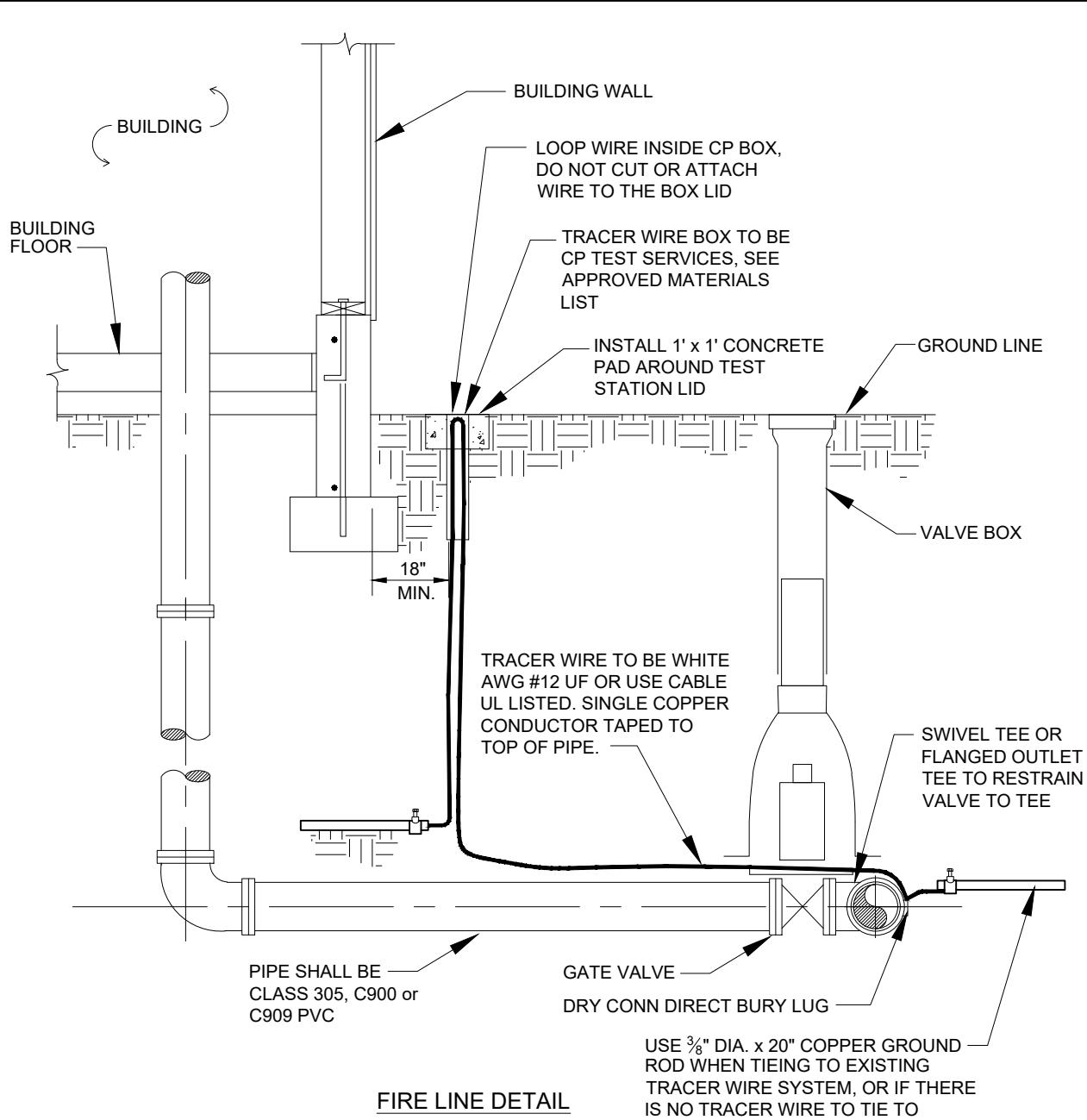
TERMINAL BOARD AND CONNECTIONS



- NOTE:
1. ALL WIRES TO BE ORDERED LONG ENOUGH TO MEET SPECIFICATIONS WITHOUT SPLICE.
 2. TEST STATION SHALL NOT BE LOCATED IN A WHEELED TRAVEL LANE.

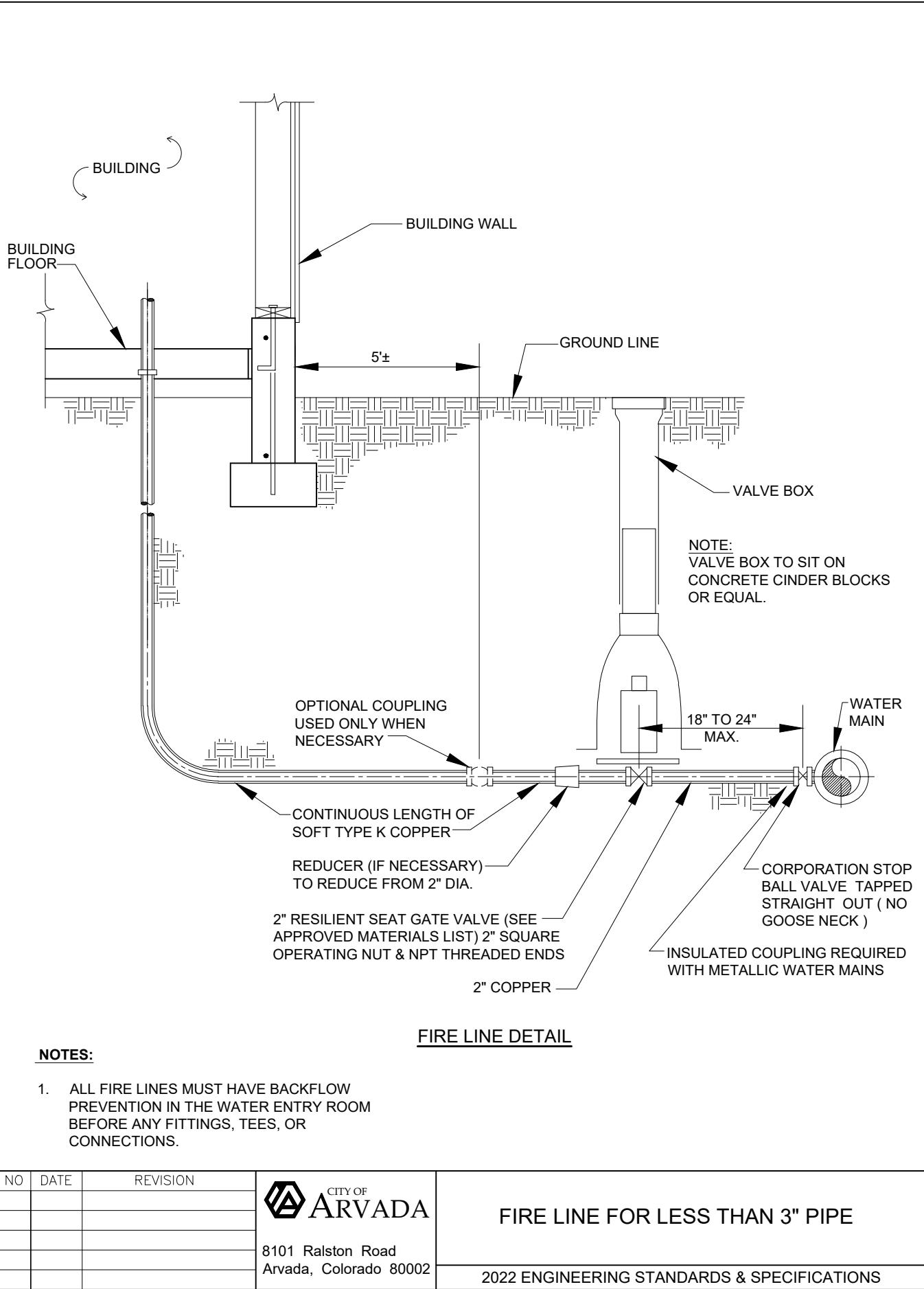
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CATHODIC PROTECTION TEST STATION POTENTIAL WITH COPPER SULFATE REF. ELECTRODE - AT GRADE (TO BE USED WITHIN TRAFFIC AREAS)
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



**NOTES:**

1. ALL FIRE LINES SHALL BE INSTALLED BY A CERTIFIED FIRE LINE CONTRACTOR IN ACCORDANCE WITH THE REQUIREMENTS OF THE FIRE DISTRICT.
2. FOR MULTI FAMILY COMMERCIAL INSTALLATIONS, DOMESTIC AND FIRE LINES SHALL BE RUN SEPARATELY TO THE MAIN.
3. PIPE SIZE TO BE APPROVED BY THE FIRE DISTRICT.
4. ALL FIRE LINES MUST HAVE BACKFLOW PREVENTION IN THE WATER ENTRY ROOM BEFORE ANY FITTING, TEES OR CONNECTIONS.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	FIRE LINE FOR 4" AND LARGER PIPE 2022 ENGINEERING STANDARDS & SPECIFICATIONS
1	2023	2023 REVISIONS		



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SECTION 500 – SANITARY SEWER FACILITIES

501.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

510.00 Design Criteria

511.00 General

All extensions of and/or additions to Arvada sewer systems shall comply with the requirements of these Standards and Specifications for sewer main and service line construction.

512.00 Design Flow

<u>Source</u>	<u>Average Daily Contribution</u>	
	Gallons Per Day	
<u>Residential</u>		
Multi-family	(100 g/c/d) (1.7 c/u)	
Townhouses	(100 g/c/d) (2 c/u)	Where: g/c/d=gal/capita/day
Apartments	(100 g/c/d) (2 c/u)	and
Duplex	(100 g/c/d) (2.5 c/u)	c/u=capita/unit
Single Family Detached	(100 g/c/d) (3.3 c/u)	
<u>Commercial⁽¹⁾</u>		
Hotel-Motel	50 (No. employees + No. Beds)	
Hospitals	200 (No. employees + No. Beds)	
Restaurants	15 (No. employees) + 4 (meals/day)	
Offices	15 (No. employees)	
Service Station	15 (No. employees + 2 X No. pumps + 10 X No Bays)	
Schools	20 (No. employees + No. students)	
Self Service Laundry	50 (No. of machines)	
Theater	5 (No. of seats)	
Warehouses	15 (No. of employees)	
General Planning	1000 gallons/acre/day	

Industrial⁽¹⁾

Factories	15 (No. employees) + industrial and cafeteria waste
General Planning	1000 gallons/acre/day
Other	Evaluate separately

Peak Hour Factor = PHF*

$$\text{PHF} = 1 + (14/(4 + P^{0.5})) \text{ or } \text{PHF} = 1 + (14/(4 + 10Q)^{0.5}) \text{ and } P \leq 4.0$$

Where: P = saturation population in 1000's or fraction thereof.

Where: Q = average day flow in cfs, to a point

Infiltration/Inflow

Diameter Type Inches	Pipe Type	I/I Gal/Day/Inch Dia./Mile
8-27	PVC (Polyvinyl Chloride)	50
24-54	RCP (Reinforced Concrete)	200

Design Flow Rate = Q = cfs = Summation of all Average Daily Contributions converted to cfs x PHF where applicable + I/I

- (1) Average daily flow rates set forth in Appendix I, Table 1-3 of the Uniform Plumbing Code shall govern in case of discrepancies.

513.00 Hydraulic Design

Maximum design flow in sewers shall be based on the calculated peak flow and the calculated I/I flow. Depth of flow shall be calculated using a Manning's n of 0.013 or greater unless otherwise directed by the Project Engineer. Maximum depths shall be:

Sewer pipe 12" and smaller d/D no greater than 0.50
Sewer pipe 15" and larger d/D no greater than 0.75

The minimum velocity at the peak design flow rate shall be two (2) feet per second. Where actual flow shall be considerably below the design flow for several years, the Project Engineer may require that the minimum velocity be attained by suitable grades at the partial peak design flow rate. Maximum allowable velocity shall not exceed ten (10) feet per second at seventy five (75) percent flow depth in the pipe.

Care shall be taken to design invert elevations at maintenance holes in such a manner that the energy gradient is consistently falling in the direction of flow. In addition, when the velocity of an upstream sewer entering a maintenance hole at peak flow is above critical velocity, the hydraulic gradient shall be computed to ensure that a surcharge shall not occur at a service connection, and that the energy gradient shall remain level across the maintenance hole.

513.01 Hydraulic Design of Connection to Existing Sewer

Where required by the Project Engineer, the existing sewer will be evaluated to ensure that the additional flow does not exceed design capacity. The length of evaluation will be determined by the Project Engineer. Areas highlighted by the City's model as near or exceeding capacity of the system will indicate when evaluation is needed. The Project Engineer may also require surveying maintenance hole inverts of the existing sewer to confirm capacity of the existing sewer.

514.00 Design Details

514.01 Sewer Mains

Sanitary sewer mains shall be eight (8) inch diameter or larger. Service connections shall be four (4) inch diameter or larger. The following minimum grades (based on Manning's formula $n = 0.013$) shall apply:

Minimum Grades

Sewer Diameter (Inch)	Minimum Grade (Percent)	Maximum Grade (Percent)
4	2.0 or 1/4 inch/foot	8.0
6	1.0 or 1/8 inch/foot	6.0
8	0.50	19.0
10	0.28	14.0
12	0.22	11.0
15	0.15	8.2
18	0.12	6.4
21 or larger	As approved by the Project Engineer	

When approved by the Project Engineer for specific areas, a Manning's $n = 0.011$ may be used and the above grades adjusted accordingly to maintain a minimum velocity of two (2) feet per second.

Sewer mains shall ordinarily have a minimum of eight (8) feet of cover to the finished ground surface. Less than eight (8) feet of cover must be approved by the Project Engineer. Sewer lines shall be designed to ensure a two (2) percent minimum slope from one (1) foot below the bottom of the lowest foundation to the sewer service connection. Where a pipe has less than four (4) feet of cover, provisions shall be made to protect the pipe from impact and loading.

Sewer mains shall be extended at least ten (10) feet uphill from the lowest lot corner of the uppermost lot to be served adjacent to the sewer main. Sewer mains shall terminate in a maintenance hole. Service connections shall not be made at maintenance holes, unless otherwise approved by the Project Engineer. All stub-outs for future extension of the sanitary sewer shall be terminated in a precast maintenance hole base.

514.02 Maintenance Holes

Maintenance holes shall be a minimum of forty-eight (48) inches diameter, and shall be provided at every change in direction, grade and connection to other sewer mains. A maintenance hole shall be installed at the end of a sewer line and provide plugged stub-outs, for future extensions. Cleanouts at the terminus of a sewer line will not be allowed. Maximum maintenance hole depth is fifteen (15) feet unless approved by the Project Engineer.

The maximum spacing shall be four hundred (400) feet for lines fifteen (15) inches diameter or smaller and five hundred (500) feet for lines eighteen (18) inches diameter or larger. Where two (2) or more pipes enter a maintenance hole, the Project Engineer will approve the maintenance hole design size. Sewer lines shall not be deflected between maintenance holes, in line or grade.

Maintenance holes shall be forty-eight (48) inches diameter for lines eight (8) inches to fifteen (15) inches in diameter, or sixty (60) inches for lines eighteen (18) inches and larger. Where the maintenance hole depth is fifteen (15) feet or deeper, the maintenance hole diameter must be sixty (60) inches minimum.

Flow through inverts in maintenance holes shall provide a minimum of: 0.2 ft. drop in a straight through maintenance hole or a maintenance hole angled at forty-five (45) degrees or less; and 0.3 ft. drop in maintenance holes angled greater than forty-five (45) degrees. The maximum allowable deflection through a maintenance hole connecting eighteen (18) inches and larger diameter lines shall be forty-five (45) degrees. When approved by the Project Engineer, an

interior drop between inverts for main lines may be greater than 0.3 feet but in no cases shall it be greater than two (2) feet.

The channel shall be sloped uniformly between the pipe inverts.

Drop Maintenance Holes. When unavoidable, a drop maintenance hole may be used with written permission from the Project Engineer. If approved, the barrel and cone sections of the drop maintenance hole and the adjacent upstream and downstream maintenance hole shall be given two (2) coats, each ten (10) mil thick, of an approved epoxy type material that is inert to hydrogen sulfide or a one-half ($\frac{1}{2}$) inch minimum thickness spray applied coating of Calcium Aluminate Cement. The design and proposed materials shall be per Detailed Drawings. The City will not approve drop maintenance holes on the basis of cost.

Maintenance holes serving areas anticipated to generate excessive hydrogen sulfide (specifically multiple restaurants, breweries, and others as required by the Project Engineer) will be required to be lined. Multiple restaurants is defined as more than two (2) for a single section between maintenance holes or as required by the Project Engineer.

Sampling maintenance holes as required by Metro Wastewater District shall be installed to the District's requirements on private property.

514.03 Service Connections

Wye or tee fittings shall be provided on the sewer main for service connections at each lot or building site shown on the plans. Fittings shall be angled upward so that the upper invert of one-eighth (1/8) bend connected to the fitting shall have an elevation equal to or higher than the inside crown of the sewer main. Six (6) inch cleanouts shall be installed at seventy-five (75) foot intervals on all sanitary sewer services. Cleanouts are also required at any changes in vertical or horizontal alignment. Refer to Section 532.03 - Service Stub-ins to Property Line of these Standards and Specifications.

For all new services six (6) inch and larger, the service shall connect to the main at a maintenance hole.

New services shall not be installed on sewer mains larger than twelve (12) inches. Where unavoidable, written permission of the Project Engineer is required. Where allowed by the Project Engineer, a maintenance hole will be installed and the service invert shall be a minimum of one (1) foot higher than the crown of the downstream sewer main.

515.00 Location Details

Sanitary sewer lines, including the outside edge of a maintenance hole, shall be located a minimum of three (3) feet from the edge of gutter pans. Sanitary sewer mains installed in local or connector streets shall typically be located five (5) feet west or south of the centerline of the streets, unless otherwise approved by the Project Engineer. Service connections shall not be permitted to cross an arterial street.

Where sanitary sewer mains are installed in easements, they shall ordinarily be located in the center of the easement, provided that maintenance holes can be located to provide reasonable access for maintenance crews. When a sanitary sewer main is located in an easement, all maintenance holes shall be accessible by an all-weather, drivable surface a minimum of ten (10) feet wide.

516.00 Relation to other Utilities and Structures

All Arvada water, sanitary sewer, and storm mainline pipes shall have a minimum separation from any structure or other utility of eighteen (18) inches vertical separation and ten (10) feet horizontal separation measured from the edge of pipe to edge of pipe. Arvada fiber optic conduit shall be a minimum of eighteen (18) inches vertical separation and two (2) feet horizontal separation from other private utilities.

If compliance with these requirements is not feasible, the Owner/Developer/Engineer shall design and construct the Utilities by means of secondary containment. Secondary containment considered by City Utilities, in order of preference for sanitary sewer, are:

1. Construct sanitary sewer from AWWA C900 or C909 pipe
2. Casing pipe
3. Encased in flow fill

In the case of storm sewer, casing or encased in flow fill shall be used.

If these required separations cannot be met, they will be addressed on a case by case basis.

All utility lines shall be located a minimum of ten (10) feet horizontally from existing or proposed utility lines (clear separation). Where any utility lines cross existing or proposed utility lines, the line's shall have a minimum of eighteen (18) inches clear separation. In the case of sewer crossing water, the sewer shall be eighteen (18) inches below the water line. If this

clearance is not feasible, the crossing shall be designed and constructed so as to protect the waterline.

In all cases, suitable backfill or other structural protection shall be provided to preclude settling and/or failure of the higher pipe. When minimum clearance is not feasible, the sanitary sewer pipe may be installed in a steel casing in accordance with these Standards and Specifications if approved by the Project Engineer. The Project Engineer will approve the crossing design.

An approved cut off wall or plug shall be installed in the trench, around, under and over a sewer line that crosses under an open ditch, channel or stream. The wall or plug shall be constructed on the downstream or downhill side, parallel to the open flow so as to prevent water from following the sewer trench.

517.00 Underdrain Pipe

Underdrains are privately owned infrastructure and are not a City-maintained utility. Underdrains are to be placed on private property, such as HOA tracts. Where an underdrain may need to cross or be located in the right-of-way for a short distance, approval of the Project Engineer is required.

Where indicated by geotechnical investigations, underdrains may be required for construction of sanitary sewer pipes. Underdrains for the purpose of protecting sanitary sewer pipes shall be located directly below the sanitary pipe with cleanouts separated from sanitary sewer maintenance holes. Underdrains for sanitary sewer shall be provided only as directed by the Project Engineer.

520.00 Sanitary Sewer Main Construction

520.01 Protection of Existing Underground Utilities

The Contractor shall be held responsible for the protection of public improvements as stated in Section 140.00 - Protection of Public, Private and Utility Interests of these Standards and Specifications. It shall be the Contractor's responsibility to replace all public improvements damaged at his or her own expense.

521.00 Site Work and Earthwork

521.01 General

Site work and earthwork shall comply with Section 300 – Soils and Earthwork of these Standards and Specifications.

521.02 Trenching, Backfilling and Compacting

Trenching, backfill and compaction shall comply with Section 364.00 - Trenching, Backfilling and Compacting of these Standards and Specifications.

521.03 Preservation of Monuments

Refer to Section 140.00 - Protection of Public, Private and Utility Interests of these Standards and Specifications.

522.00 Materials

522.01 Sewer Main Line Pipe

Unless otherwise approved by the Project Engineer, all sewer main line pipe and fittings shall be Polyvinyl Chloride (PVC) and shall comply with ASTM D3034 or F679 (SDR 35), or ASTM F794 and F949 for profile wall pipe. All pipe and fittings shall be subject to inspection by Arvada. All joints shall be factory-prepared compression type (elastomeric gasket joint), providing a watertight seal. Solvent cement joints shall not be used.

For pipe installation depths greater than twenty (20) feet, pipe material and bedding conditions shall be determined by engineer design calculations and submitted for approval by the Project Engineer.

Sewer pipe for force mains shall be pressure rated. Refer to Section 420.03 - Pipe of these Standards and Specifications. Valves for force mains shall be plug valves and shall open right.

522.01.01 Sewer Service Line Pipe

Unless otherwise approved by the Project Engineer, all sewer service line pipe and fittings shall be Polyvinyl Chloride (PVC) and shall comply with ASTM D3034 or F679 (SDR 35), or ASTM F794 and F949 for profile wall pipe. All pipe and fittings shall be subject to inspection by Arvada. All joints shall be factory-prepared compression type (elastomeric gasket joint), providing a watertight seal. Solvent cement joints shall not be used.

For pipe installation depths greater than twenty (20) feet, pipe material and bedding conditions shall be determined by engineer design calculations and submitted for approval by the Project Engineer.

522.02 Underdrain Main Line Pipe

When approved by the Project Engineer, all underdrain main line pipe and fittings shall be Polyvinyl Chloride (PVC), white in color, and shall comply with ASTM D3034, SDR 35, and shall be a minimum of six (6) inch diameter. Pipe shall be solid wall pipe unless groundwater is present, as indicated in the geotechnical investigation. If groundwater is present, the underdrain mainline pipe shall be perforated in the lower quadrant and shall be wrapped with a geotextile fabric to keep soil fines from entering the pipe. Where underdrain is to be constructed under sewer mains, a clean-out shall be provided near each maintenance hole for the underdrain as shown in the Detail Drawings. Suitable fittings shall be provided for construction of the six (6) inch clean-outs and bends at maintenance holes.

522.03 Plugs

A gasketed plug, as recommended by the pipe manufacturer, shall be provided to seal the end of a wye connection or a dead-end stub. Plug locations shall be marked below ground with a wood 2x4 and above ground with a steel T-post with green flagging.

522.04 Maintenance Holes

Maintenance hole bases may be constructed of cast-in-place concrete or precast concrete. Precast reinforced concrete risers (barrel sections) and tops shall comply with ASTM C478.

Maintenance holes shall be in accordance with the Detail Drawings found in these Standards and Specifications.

The top of the maintenance hole vault shall be a minimum of twelve (12) inches and a maximum of eighteen (18) inches below the finished street or ground surface elevation. Concrete extension risers or collars shall be used to bring the maintenance hole ring and cover up to the finished street or ground surface elevation. Maintenance holes five (5) feet deep or less shall be constructed as flat-top maintenance holes and cones shall be of the eccentric type.

Steps shall have a minimum tensile strength of 38,000 psi, minimum yield strength of 35,000 psi, and an elongation of not less than ten (10) percent in two (2) inches. Steps shall carry a load of (1,000 pounds when projected six (6) inches from the wall and 1,500 pounds when projected four (4) inches from the wall without permanent deformation. Steps shall be one-half (1/2) inch diameter steel-reinforcing rods completely encapsulated in Copolymer Polypropylene and as listed in the Approved Products List. Steps shall be spaced in accordance with the Detail

Drawings found in these Standards and Specifications. The minimum distance from the finished ground (street) surface to the first step shall be twenty-four (24) inches, and the maximum shall be thirty (30) inches.

522.05 Maintenance Hole Bases and Base Beams

The minimum slab thickness shall be eight (8) inches. The minimum reinforcement shall be #4 reinforcing steel at twelve (12) inches on center, each direction or welded wire fabric, 4x4/W4xW4. The placing, fastening, splicing and supporting of reinforcing steel and wire mesh or bar mat reinforcement shall be in accordance with the approved plans, the Detail Drawings found in these Standards and Specifications and the latest edition of "CRSI Recommended Practice for Placing Reinforcing Bars." Splicing of the welded wire fabric shall be by lapping one space and securing the wire mesh together. All wire fabric shall conform to the requirements of the "Wire Reinforcement Institute, Inc."

Maintenance hole base beams shall be precast, reinforced concrete. The beams shall be twelve (12) inches wide by nine (9) inches deep by eight (8) feet long. Beams shall be set at a minimum of twelve (12) inches from the outside edge of the pipe.

522.06 Concrete

Concrete shall comply with Section 800 – Concrete Mix Design and Construction of these Standards and Specifications. Type II Portland cement shall be used, unless otherwise recommended by the Geotechnical Engineer. Concrete encasement of sewer pipe shall comply with Section 516.00 - Relation to Other Utilities and Structures of these Standards and Specifications.

522.07 Cast and Ductile Iron Fittings

All cast iron maintenance hole rings and covers and other iron castings shall comply with ASTM A48 Class 35B. Fittings shall be in accordance with the Detail Drawings found in these Standards and Specifications. Ductile iron rings and covers shall comply with ISO 1083. All metal bearing surfaces between the ring and cover shall be machined or fabricated to ensure good seating. Maintenance hole lids shall be provided with a non-slip pattern on the surface that lies flush with the elevation of the ring. Lids shall be furnished with the words "City of Arvada Sanitary" cast on top as shown in Detail Drawings found in these Standards and Specifications. Manufacturer and model shall be as listed in the Approved Products List.

522.08 Joint Sealant

522.08.01 For Maintenance Hole Sections, Tongue and Grooved Pipe

Preformed water repellent sealant conforming to federal specification SS-S-210A superseding Interim Federal Specification SS-S-00210 headed "Sealing Compound, Preformed Plastic for Pipe Joints". Approved manufacturer as listed in the Approved Products List.

522.08.02 Watertight Joint Seals for Maintenance Hole and Pipe Sections

Type M or O rubber gasket as recommended by the pipe or maintenance hole manufacturer is required below groundwater level.

522.08.03 Chemical Joint Sealant

Acrylamide base gel grout, urethane effectiveness requirements set forth in the Environmental Protection Agency publication entitled, "Chemical Sealants for Elimination of foam grout or an approved equal. Grout shall exceed or meet the I/I". When handled and mixed in strict accordance with the manufacturer's recommendations the chemical grout sealant must: be able to react in moving water, withstand submergence in water without degradation and be impervious to water penetration over the life of the grout; be flexible after curing and be able to withstand freeze-thaw and wet-dry cycles; be biodegradable and resistant to concentrations of acids, alkalis and organics found in normal sewage.

522.08.04 Transition Between Unlike Materials

Prefabricated adaptors that are water tight, structurally sound and will provide a smooth continuous invert. See Approved Products List for acceptable manufacturers.

522.09 Bedding Materials

Bedding materials shall comply with Section 367.00 - Bedding for Pipelines and Service Lines of these Standards and Specifications.

522.10 In-Place Rehabilitation

522.10.01 In-Place Rehabilitation of Existing Pipelines

In-place rehabilitation of existing pipelines may be by cured in-place pipe, expanded in-place pipe, pipe bursting, point repair or joint sealing methods in accordance with plans approved by the City Engineer.

The City shall design and construct any required in-place rehabilitation of an existing pipeline that shall remain part of the public sewer system. An agreement between the developer and the City will provide for the developer to pay for the improvement. When approved by the Project Engineer, the developer may design and construct an in-place rehabilitation of an existing pipeline.

522.10.02 In-Place Rehabilitation of Existing Maintenance Holes

Interior maintenance hole barrel and eccentric cone surfaces as well as benches and invert of all maintenance holes to be rehabilitated shall be treated with two coats, each ten mil thick, of an approved epoxy type material that is inert to hydrogen sulfide or a one-half ($\frac{1}{2}$) inch minimum thickness spray applied coating of Calcium Aluminate Cement. Coatings shall be applied by coating manufacturer's certified applicators only. Mixing and application of the protective coatings shall be in strict conformance with the direction of the coating manufacturer.

Surface preparation of the existing interior maintenance hole surface to be restored shall be high pressure water blasted with a minimum 2,000 psi water pressure or sandblasted to remove existing coatings and all foreign matter before application of new coating.

Any new concrete interior cone and barrel surfaces shall be allowed to cure, after casting, for a minimum of ten (10) days. After curing, the surfaces to be treated shall be sweep sand blasted or high pressure water blasted to remove latents or curing agents thereon. Following surface blasting the concrete surfaces shall be inspected for deterioration, i.e. exposed aggregate, spalling, holes, corroded, exposed steel, etc.

If rehabilitated with approved epoxy type material, exposed aggregate surfaces shall be coated with approved epoxy gel, applied with a trowel or squeegee so that the aggregate is completely covered. Spalled areas and holes one or more inches deep shall be filled with a high strength cementitious grout. In each instance the gel or grout shall provide a finish surface level with the surrounding area prior to coating.

Exposed steel areas, after cleaning by blasting, shall be treated with two coats of an EPA approved Dyna Bond System 1. Each coat shall be applied at ten (10) mils wet film thickness each. A minimum of thirty (30) minutes shall separate the application of the first and second coat. A minimum of thirty-six (36) hours cure time shall be provided between the application of the final coat of Dyna Bond System 1 and the application of the protective coating hereinafter detailed.

Holidays or pinholes found in the protective coating or penetration through protective coatings at joints, fasteners, steps or other items installed after the coating system is complete in place shall

be repaired by applying additional approved protective coating. Surfaces to be repaired shall be roughened with coarse sandpaper in the vicinity of the repair if the repair is to be undertaken after five (5) days have elapsed from application of the final coat of protective coating material.

522.11 Steel Casings

Steel casing pipe shall meet all requirements of Section 420.24 - Steel Casings.

All carrier sanitary sewer pipe through casings shall comply with AWWA C900 or C909.

All sanitary sewer carrier pipe joints shall have mechanical restraint inside the casing. Cathodic protection, casing spacers, and casing end seals shall be specified per design engineer recommendations. Carrier pipe supports shall be glass reinforced polymer runners similar to the system shown in the Detail Drawings found in these Standards and Specifications

522.12 Warning Tape and Marker Posts

All pipelines shall have a six (6) inch wide, detectable, magnetic warning tape installed twelve (12) inches above the bedding, for the purpose of warning of location of buried pipeline. For sanitary sewer lines, the marker tape shall be green in color with black lettering in a continuously repeating pattern with the words "Caution Sanitary Line Below".

All pipeline maintenance holes that are located in an open field, shall have a concrete collar and a triview marker post. Marker posts shall be as listed in the Approved Products List. Marker posts for sanitary sewer shall be green and shall include on all three sides, a City of Arvada's logo and the universal "Call Before You Dig" symbol.

523.00 Installation

523.01 General

Installation of PVC sewer main shall comply with ASTM D2321.

523.01.01 Interruption of Sanitary Service

The Contractor must, in writing, advise affected users forty-eight (48) hours prior to performing work on a service or collector line which will interrupt a customer's wastewater line. Contractor prepared notices shall be hand delivered to each customer or occupant. If the occupant cannot be contacted, the written notice shall be left attached to the door knob or screen.

In addition, the Contractor must notify Arvada's Wastewater Division (720-898-7770) of the schedule for plugging and bypassing maintenance holes necessary to isolate the line on which work is to be performed.

The Contractor shall provide all labor, materials and equipment to properly handle and divert all sewage flow when required for construction.

If sewage backup occurs and enters buildings, private property, irrigation ditches, streams or storm drains during Contractor's bypassing operations, the Contractor shall be responsible for clean-up, repair, property damage and all costs and claims.

A normal outage shall be a maximum of four (4) hours and between the hours of 8:00 a.m. and 2:00 p.m. If the outage will be greater than four (4) hours, the work shall be done in a manner to minimize the inconvenience to users, such as working at night in a continuous operation until service is restored. A connection which will require an outage longer than four (4) hours shall be subject to review by the City as to the appropriate time for performing the work.

If in the process of installing a connection, there exists an industry or building in the area that cannot be out of sanitary service such as a hospital, school, etc., the Contractor shall provide wastewater disposal service to them at all times during the performance of the work.

523.02 Alignment and Grade

Field parties, under the supervision of a Registered Professional Land Surveyor or Professional Engineer licensed to practice in the State of Colorado, shall determine alignment and grade of the pipe and the location of sanitary sewer system appurtenances. The sewer line shall be installed to the required lines and grades with appurtenances at the required locations. Record Documents of sanitary sewer system alignment, verified by a Professional Licensed Surveyor or a Professional Engineer, shall be furnished to the Project Engineer to comply with Section 200 – Acceptance Procedures of these Standards and Specifications.

523.03 Underdrain Pipe

Underdrains shall be installed where shown on the approved plans and as required by Section 517.00 - Underdrain Pipe of these Standards and Specifications. The underdrain pipe shall be installed to a true line and grade and held in place with underdrain bedding material as shown on the Detail Drawings found in these Standards and Specifications.

523.04 Sewer Pipe Installation

Proper equipment, tools and facilities shall be provided and used by the Contractor for safe and efficient performance of the work. All pipe and sanitary sewer appurtenances shall be carefully lowered into the trench in such a manner as to prevent damage to pipe materials and to protect coatings and linings. Under no circumstances shall pipe or fittings be dropped or dumped into the trench. Any pipe or fittings that are dropped or dumped shall be removed from the work site and shall not be used.

The Arvada Inspector/Representative shall be notified at least one working day (twenty-four [24] hours) in advance of when pipe is to be installed in any trench. No pipe shall be covered until an Arvada Inspector/Representative has inspected the installation.

Sewer lines shall be constructed continuously upgrade from an existing sanitary sewer except when otherwise approved by the Project Engineer. Special care shall be taken to lay sewer pipe to exact line and grade with spigot ends pointing in the direction of flow.

Sewer pipe shall be secured in place by installation of bedding material tamped under and along it up to a level of twelve (12) inches over the top of the pipe to comply with Section 367.00 - Bedding for Pipelines and Service Lines of these Standards and Specifications. Backfill material shall be installed and compacted to comply with Section 368.00 - Backfill for Pipelines and Service Lines of these Standards and Specifications.

All sewers shall be kept thoroughly clean and free of gravel, dirt and debris. Whenever work ceases for any reason, the unfinished end of the pipe shall be securely closed with a temporary tight-fitting plug.

523.05 Connections to Existing Maintenance Holes

Modifications to existing maintenance holes shall not jeopardize structural integrity. Sewer pipe connections to existing maintenance holes, where there is no pipe stubbed out, shall be made in accordance with the Detail Drawings found in these Standards and Specifications. The Contractor shall core drill as small an opening in the existing maintenance hole as necessary to insert the new sewer pipe. The existing concrete flow channel shall be chipped to the cross-section of the new pipe in order to form a smooth continuous flow channel similar to what would be formed in a new concrete base. Non-shrink grout shall be used to finish the new channel and invert and to seal the new sewer line so the junction is watertight. If the existing maintenance hole is deemed structurally deficient or damaged, the maintenance hole shall be replaced if required by the Project Engineer.

523.06 Construction of Maintenance Holes and Cleanouts

Maintenance holes shall be constructed in accordance with the Detail Drawings found in these Standards and Specifications. Concrete bases shall extend at least eight (8) inches below the bottom of the pipe and at least two (2) inches over the top of the pipe. The concrete maintenance hole bench shall slope upward at least two (2) inches per foot from the top of the pipe.

Pipes connecting to cast-in-place maintenance hole bases shall have a water stop in accordance with the Detail Drawings found in these Standards and Specifications. A water stop gasket shall also be used for new connections to existing maintenance holes.

The maintenance hole flow channel shall be made of concrete and shall conform exactly to the lower half of the pipe it connects. Changes in flow direction shall be constructed with as large a radius of curvature as possible. Flow channels shall be finished with cement mortar and left smooth and clean.

Precast barrel sections shall not be placed on the base until after it has reached sufficient strength to provide support without damage. All joints of precast barrel sections shall be sealed by asphaltic mastic (Ram-Neck) or by pre-lubricated profile gaskets to ensure an air-tight / leak-proof seal between each precast section bearing seat.

All sewer clean-outs that are not contained in maintenance holes shall be provided with a valve box and a "sewer" lid.

523.07 Steel Casing and Carrier Pipe Installation

Tunneling and boring operation methods shall be approved by the Project Engineer. Excavation and casing installation shall be performed simultaneously. At no time shall the advancing edge of the casing trail the excavation by more than twelve (12) inches.

Tracer wire shall be taped to the carrier pipe before installation of carrier pipe supports and installed in the steel casing along with the carrier pipe. A test station, similar to those required at fire hydrants, shall be installed for the tracer wire in the Arvada ROW near each end of the steel casing pipe. A separate, electrically isolated, tracer wire shall be welded to each end of the casing. Uninterrupted continuity shall be tested in accordance with the requirements of Section 420.20 - Tracer Wire and Warning Tape and Marker Posts of these Standards and Specifications.

The casing pipe shall be installed by boring or jacking up grade from the outlet end. When excavation exceeds the advancing edge of the casing by more than twelve (12) inches or sloughing of the hanging wall occurs such that voids are created along or above the casing, external grouting of the casing shall be required. Grouting shall be accomplished by pumping at between five (5) and ten (10) psi equal parts of Portland Cement and mortar sand mixed with sufficient water to provide a slump of less than two (2) inches through grout holes in the casing until all voids are filled. Grout holes, one (1) inch to two (2) inches in diameter, shall be provided or drilled in the casing on four (4) foot centers along the pipe arch and at eight (8) foot centers along each spring line. As grouting advances, each of the completed grout holes shall be plugged to a watertight condition.

Following installation of the carrier pipe in the casing pipe, corrosion control and cathodic protection components shall be installed in accordance with the requirements of Section 420.19 - Corrosion Protection Systems of these Standards and Specifications.

523.07.01 Casing Pipe Joints

Sections of the steel casing shall be trimmed, beveled and aligned in the pit so when welded together the thrust of the boring machine will be uniformly transmitted through the casing in a horizontal plane. Welds shall be made to provide solid firm watertight connections without the use of butt straps.

523.07.02 Casing Pipe Sections Alignment

When the carrier pipe is installed for gravity flow, the horizontal and vertical alignments of the casing pipe, when in place, shall not vary from those called for on the plans by more than the following:

Alignment	Entrance	Midpoint	Outlet
Horizontal	0.02'	0.35'	0.70'
Vertical	0.02'	+ 0.10' - 0.05'	+ 0.20' - 0.10'

523.07.03 Carrier Pipe Installation

Carrier pipe interior and the access pits at each end shall be kept free of water at all times during the insertion of the carrier pipe. The carrier pipe shall have centering and restraining casing spacers and insulators as per Section 420.24.01 - Casing Spacers and Insulators installed every

ten (10) feet on the carrier pipe prior to insertion with an additional spacer placed within six (6) inches of each end of the casing pipe.

Once the casing spacers and insulators are properly attached to the carrier pipe barrel, the section is ready for insertion. Subsequent sections shall be properly lubricated, gasketed and joined to each other as they are set. The assembled line shall then be progressively threaded through the casing by means of applying force at the exposed end of the carrier pipe. Care shall be exercised to provide watertight joints and to protect the ends of the pipe as they are pulled or pushed, by uniformly transferring said force through the carrier pipe axially along its horizontal plane.

On gravity lines it may be necessary to vary the location and thickness of casing spacers and insulators to obtain a uniform invert grade throughout the carrier pipe. This is especially critical when the alignment and grade for the casing pipe approaches the minimum allowable limits specified.

Following installation of the carrier pipe in the casing pipe, electrical isolation testing between the carrier pipe and casing pipe must be performed in accordance with the requirements of Section 420.19 - Corrosion Protection Systems.

After acceptance of electrical isolation testing, end seals shall be installed as per Section 420.24.02 - End Seals for Casing Pipes.

523.08 Wyes for Service Connections

Wyes shall be angled upwards so that the flowline of a forty-five (45) degree bend connected to the fitting shall have an elevation equal to or higher than the inside crown of the sewer main. Watertight plugs shall be installed in each service connection stub. Record Document measurements shall be made to reference the wye to the nearest downstream maintenance hole before backfill. Record Documents shall comply with Section 200 – Acceptance Procedures of these Standards and Specifications.

523.09 Contamination and Dilution

During construction and until such time that the new lines have been tested and accepted for warranty, the point of connection to the existing system shall remain plugged. Dilution of normal sewage flows with ground water or debris from the new lines will not be allowed.

523.10 PVC Pipe Storage

Meet all requirements of Section 421.05.01 - Storage of Materials.

524.00 Testing and Inspection

Refer to Section 188.00 - Inspections of these Standards and Specifications.

Adequate inspections assure compliance to Arvada requirements and are the basis for Arvada's recommendation that said improvements be accepted for maintenance and for release of performance guarantees. It is the responsibility of the Contractor to contact the Arvada Inspector a minimum of one (1) full working day (twenty-four [24] hours) in advance of the required inspections. Required inspections shall include:

1. Stockpiled Materials – Verify that materials meet Standards and Specifications and approved submittals, including but not limited to: bedding material, pipe, fittings, valves, valve boxes, and fire hydrants.
2. Excavation – Verify proper trench depths, shoring, spoil pile location, dewatering, and location and protection of existing utilities.
3. Installation – Verify proper bedding depth, alignment and grade, clean pipe and lubricants. Verify “slicing in” of bedding at haunches.
4. Corrosion Control and Cathodic Protection - Verify all corrosion control devices and components are properly installed and inspected prior to backfill by a NACE Certified Cathodic Protection Technician (CP2) and tested after backfill under the supervision of a NACE Certified Cathodic Protection Specialist (CP4)
5. Backfill and Compaction – Verify proper methods of backfill and compaction, depths of lifts, moisture control, backfill material free of large rock and organic or frozen material, and proper compaction effort and passing tests. Verify that the sewer force main has warning tape. Verify that tracer wire has been installed on all carrier pipes contained in a casing and that it has a passing continuity test.
6. Testing – Verify that testing methods comply with these Standards and Specifications. Verify that Arvada has witnessed all low pressure air tests of pipe, vacuum testing of maintenance holes and any other testing requirements such as deflection testing. Mandrel testing for flexible pipe with depths of cover equal to twenty (20) feet or more must be witnessed by Arvada. Mandrel testing shall be performed by a certified third party.
 - a. Prior to Construction Acceptance into Warranty, the Contractor shall conduct tests for water-tightness. Tests shall be completed under the observation of the Arvada Inspector/Representative. Low pressure air testing of the sewer lines (including services) and vacuum testing of all maintenance holes shall be required by the Project Engineer. The Contractor shall provide all equipment and personnel necessary to perform the required tests. The Arvada Inspector/Representative shall record times and pressure and vacuum

- readings during the test period. A test section shall not be any longer than the length of pipe between adjacent maintenance holes.
- b. The Project Engineer may require that the first two (2) maintenance holes, including the main between them, of all sewer projects be tested before further construction to permit initial observation of the quality of construction workmanship. The Project Engineer may require additional testing during the course of construction if infiltration appears to be excessive or the quality of workmanship is questionable.
7. Construction Acceptance into Warranty – Refer to Section 200 – Acceptance Procedures of these Standards and Specifications. General items include:
 - a. All temporary structures, debris, mud and waste materials shall be removed from public property.
 - b. All relative testing certifications and documentation shall be submitted to Arvada, including all compaction tests. Copies of originals are acceptable.
 - c. All sanitary sewer service locations shall be marked by saw cutting an “X” or “S” (or an “X” or “S” to indicate an underdrain system is present) into the face of the curb where the service extends into the property.
 - d. All sanitary sewer maintenance holes are at construction grade, clean with ladders straight. Verify that underdrain cleanouts are clear and capped and that all sanitary sewer lines have been jetted.
 - e. Prior to requesting a Construction Acceptance into Warranty inspection, the Contractor shall clean sanitary sewer mains and shall have the lines inspected with TV video equipment. A copy of the videotape and written report shall be submitted to Arvada for review. Video shall also include an audio description of pipe and maintenance hole deficiencies, and camera location during the inspection. Any sections that contain debris or obstructions shall be cleaned and re-videotaped. Video shall be continuous from maintenance hole to maintenance hole, and all notations shall correspond to the approved construction plans. If, after visual inspection of the sanitary sewer lines the Project Engineer suspects that there is a problem, alignment, and/or deflection tests may be required at the Contractor’s expense.
 8. Final Acceptance/Release from Warranty – Refer to Section 231.00 Final Acceptance and Release from Warranty Inspection by the City Engineer of these Standards and Specifications.
 - a. Verify that all temporary structures, debris, mud, and waste materials are removed from public property.
 - b. Verify that all sanitary sewer maintenance holes are clean.

Prior to Construction Acceptance into Warranty, the Contractor shall jet rod the sewer lines, and a video inspection and written log shall be performed, recorded and submitted to Arvada. The Arvada Inspector/Representative shall review the recorded video and log for inadequacies in the system. If inadequacies are noted, the Contractor shall make repairs deemed necessary by the Arvada Inspector/Representative.

524.01 Air Testing Pipeline

Air testing shall comply with UNI-BELL UNI-B-6. The portion of the line being tested shall be termed “acceptable” if the time required in minutes for the pressure to decrease from 3.5 to 3.0 psig (greater than the average back pressure of any groundwater that may be over the pipe) shall not be less than the time shown for the given diameters in the following table:

Specification Time Required for a 0.5 PSIG Pressure Drop for Size and Length of Pipe

1 Pipe Diameter (in.)	2 Minimum Time (min: sec)	3 Length for Minimum Time (ft)	4 Time for Longer Length (sec)	Specified Minimum for Length (L) Shown (min:sec)							
				100ft	150ft	200ft	250ft	300ft	350ft	400ft	450ft
4	1:53	597	.190L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	.427L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	.760L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
21	9:55	114	5.235L	9:55	13:05	17:27	21:49	26:11	30:32	34:54	39:16
24	11:20	99	6.837L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
27	12:45	88	8.653L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	64:54
30	14:10	80	10.683L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	15:35	72	12.926L	21:33	32:19	43:56	53:52	64:38	75:24	86:10	96:57
36	17:00	66	15.384L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23
42	19:74	57	20.942L	34:54	52:21	69:49	87:15	104:42	122:10	139:37	157:04
48	22:67	50	27.352L	45:35	68:23	91:11	113:58	136:46	159:33	182:21	205:09

If groundwater is higher than the top of the pipe, the test pressure is to be increased. An air pressure adjustment shall be added to the normal test starting pressure when groundwater is present. The height of groundwater in feet shall be divided by all readings. (For example, if the height of water is eleven (11) and one half (1/2) feet, then the added pressure shall be five (5) psig. This increases the three point five (3.5) psig to eight point five (8.5) psig, and the two point five (2.5) psig to seven point five (7.5) psig. The allowable drop of one pound and the timing remain the same. In no case however, should the starting test pressure exceed nine (9.0) psig.

Sections of pipe that fail the air test shall have the defects repaired and the pipe retested until the testing requirements are met.

524.02 Vacuum Testing Maintenance Holes

The City reserves the right to require a vacuum test on all new maintenance holes installed, particularly in areas where the groundwater level is high or where there are questions regarding the integrity of the new barrel sections. All maintenance holes shall be vacuum tested in accordance with ASTM C1244. All lift holes and any pipes entering the maintenance hole shall be plugged prior to a vacuum being drawn and the drop over a specified time determined. The test head shall be placed at the top of the maintenance hole in accordance with the manufacturer's recommendations. A vacuum of ten (10) inches of mercury shall be drawn on the maintenance hole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off. The time shall be measured for the vacuum to drop to nine (9) inches of mercury. The maintenance hole shall pass if the time for the vacuum reading to drop from ten (10) inches of mercury to nine (9) inches of mercury meets or exceeds the values indicated below.

Vacuum Testing Maintenance Hole Requirements

Depth (feet)	<u>Diameter, inches</u>								
	30	33	36	42	48	54	60	68	72
Time, seconds									
<=8	11	12	14	17	20	23	28	29	33
10	14	15	18	21	25	29	33	38	41
12	17	18	21	25	30	35	39	43	49
14	20	21	25	30	35	41	46	51	57
16	22	24	39	34	40	46	52	58	57
18	25	27	32	38	45	52	59	65	73
20	28	30	35	42	50	63	65	72	81
22	31	33	39	46	55	64	72	79	89
24	33	38	42	51	59	64	78	87	97
26	36	38	46	55	64	75	85	94	105
28	39	42	49	59	69	81	91	101	113
30	42	45	53	63	74	87	98	108	121

524.03 Deflection Testing Pipe

When required, all flexible material sewer pipelines shall be tested for vertical deflection after placement and compaction of backfill if deemed necessary by the Arvada Inspector/Representative. Method of testing shall be by deflectometer of the rigid GO/No-GO

type device or an alternative method permitted by the Project Engineer. Maximum allowable deflection shall be five (5) percent of the pipe diameter. Any and all pipe with vertical deflection greater than the allowable shall be excavated, removed from the pipeline, replaced, backfilled and compacted and retested until the testing requirements are met.

524.04 Infiltration and Exfiltration Testing

When required, infiltration and exfiltration tests shall be conducted to comply with UNI-BELL standards. Whenever the rate of infiltration or exfiltration is found to exceed the prescribed amount, the Contractor shall stop all construction. The Contractor shall make appropriate repairs by methods acceptable to the Project Engineer and shall continue to test the conduit until it is proven satisfactory.

Arvada shall not accept any sanitary sewer line where infiltration or exfiltration tests show leakage in the sewer line and maintenance holes exceeding fifty (50) gallons per inch diameter per mile per day between adjacent maintenance holes.

525.00 Connection to Arvada's Sewer System

Flow of any kind into the existing sewer system shall not be allowed until the sewer has been satisfactorily completed and approved for use by the Project Engineer.

530.00 Sanitary Sewer Service Line Construction

531.00 Materials

531.01 Polyvinyl Chloride (PVC)

Pipe and fittings shall comply with ASTM D3034. All joints shall be factory prepared compression type (elastomeric gasket joint), providing a watertight seal. A compression stop, as recommended by the pipe joint manufacturer, shall be provided to seal the end joint of dead-end stubs.

531.02 Sewer Service Saddles

Molded, gasketed "Wye" saddles shall be installed and manufactured to ASTM D3034, SDR 35, ASTM F679 and F1336 Specifications. Saddle shall be banded to the sewer main with stainless steel straps. Saddles shall be as listed on the Approved Products List.

532.00 Installation

Installation of PVC sanitary sewer services shall comply with ASTM D2321 and to the pipe manufacturer's installation instructions.

532.01 Location and Alignment of Service

Sanitary Sewer Service Line connections to the new main line shall be made with a wye. Sanitary Sewer Service Line connections to an existing main line shall be made with a tapping saddle.

Sanitary Sewer Service Line taps are not allowed in the following conditions:

1. On any Sanitary Sewer Force Main,
2. On any Sanitary Sewer Main stub out,
3. Within thirty-six (36) inches of another Sanitary Sewer service tap on the same side of the pipe or twenty-four (24) inches on opposite sides of the pipe,
4. Within twenty-four (24) inches from both the back of the bell and the spigot insertion line,
5. Within five (5) feet of a Sanitary Sewer maintenance hole,
6. Directly into a Sanitary Sewer maintenance hole,
7. Under traffic calming device, and
8. Within ten (10) feet of either side of a utility crossing.

At no time shall the service line be closer than three (3) feet to a side property line, and no service line may be constructed through or in front of an adjoining property. Sewer service lines shall be typically located a minimum of ten (10) feet to the low side of the water service or as shown on the approved plans.

If necessary, the service may be constructed with no more than four horizontal forty-five (45) degree bends between the house plumbing and the sanitary sewer main. A two way cleanout is required within five (5) feet of a building foundation on all new sewer services and sewer service replacements. If more than two (2) bends are used, a two (2) way cleanout must be installed in the service line between the house and the sanitary sewer main. A two (2) way cleanout must also be installed at a maximum interval spacing of one-hundred (100) feet in all residential sanitary sewer service lines over one hundred (100) feet long. House plumbing shall come out of the house on the side paralleling the main to which the connection is to be made. All clean-outs shall be located on the property served and shall not be located in the right-of-way.

Cleanouts shall be installed to comply with the International Residential Code (IRC), the International Plumbing Code (IPC) and as described herein. Unless specific approval is obtained

in writing from the Project Engineer, all sanitary sewer service lines shall have a minimum depth of three (3) feet.

Maintenance holes and/or cleanouts shall be installed in commercial or industrial service lines, between the building and sewer main at all horizontal changes in flow and/or at a maximum interval spacing of one-hundred (100) ft. Installation shall be performed in the same manner as specified for main line installations.

Sanitary service lines are not allowed to cross property other than the property being served, unless prior approval has been obtained from the Project Engineer. Except as permitted below, the underground water service pipe and the building drain or building sanitary sewer shall be not less than ten (10) feet apart horizontally and shall be separated by undisturbed or compacted earth. Under extenuating circumstances, the sanitary sewer service pipe may be placed in the same trench with the building drain or building water service pipe provided prior written approval is given by the Project Engineer and the following conditions are met:

1. The bottom of the water service pipe at all points shall be at least twelve (12) inches above the top of the sewer line at its highest point.
2. The water service pipe shall be placed on a solid shelf excavated at one side of the common trench.
3. The water service line is one (1) continuous section of Type "K" copper tubing, joint free.
4. The sewer service pipe shall be watertight and pressure rated to a minimum of one-hundred 100 psi.

In cases where the water and sewer service lines shall cross one another, installation shall comply with Section 516.00 - Relation to Other Utilities and Structures of these Standards and Specifications.

532.02 Crossing Sidewalk or Curb (Existing or Proposed)

If the service line is installed prior to the placement of the sidewalk or curb, the trench shall be backfilled in accordance with Section 368.00 - Backfill for Pipelines and Service Lines of these Standards and Specifications.

532.03 Service Stub-ins to Property Line

Sanitary sewer service line locations shall be marked on the curb with an "X" and with a line under it "X" to indicate an underdrain system. All service stub-ins shall be stubbed into the lots, ten (10) feet minimum beyond the R.O.W. or utility easement. All service stub-ins shall be

plugged and marked in accordance with Section 522.03 - Plugs of these Standards and Specifications.

The property owner shall be responsible for owning and maintaining the service line from the tap to the building connection.

532.04 Tapping the Main

Where wyes have not been installed in the sewer main, sanitary sewer tapping saddles shall be used for four (4) inch services only. Sewer tapping saddles shall be double strapped saddles with rubber gasket pipe sealant.

532.05 Industrial

All buildings (warehouses, etc.) constructed as a shell, with the intention of only being used for subdivided suites for commercial purposes, shall be required to install service connections extending a minimum of six (6) feet outside of the building with a clean-out for each set of proposed bathrooms or suites. All commercial and industrial facilities shall have a clean out on the outside of the building, located a minimum of three (3) feet from the building, on the service connection.

All commercial and Industrial Service Facilities shall comply with Chapter 13.28 of the Arvada Municipal Code.

532.06 Other Requirements

Rainwater leaders, roof drains, surface drains or groundwater drains shall not be connected to the sanitary sewer system nor connected to City Owned Underdrains. Each sanitary sewer service system shall be separate from the drainage system. Grease, oil and grit traps shall be designed and installed where required by the provisions of the IRC and the IPC and as required by the Project Engineer.

532.07 Sanitary Sewer Main and Service Abandonment

Sanitary sewer mains shall be abandoned only with the written approval of the Project Engineer. Sanitary sewer mains in the public right of way or within a City owned easement shall be removed. When approved by the Project Engineer, sanitary sewer mains may be abandoned in place. Pipe eight (8) inches in diameter and less shall be abandoned by capping each end with concrete. Pipe eight (8) inches in diameter or greater shall be abandoned in place by filling with

CLSM and capping each end with concrete.. Where a pipe is abandoned at a maintenance hole, the pipe shall be plugged with concrete at the maintenance hole and removed for a minimum of two (2) feet. Any maintenance holes on abandoned sanitary sewer mains shall be removed and shall be backfilled in accordance with Section 300.

Sanitary service connections to City mains that are to be abandoned shall be removed at the main and repaired using a repair clamp. If more than one service tap is required to be abandoned along a sewer main and the spacing between these taps is less than fifty (50) feet, then the pipe between and including the sections at the taps shall be replaced. Service lines in the right of way shall be removed. The service may be abandoned in place on private property, with the approval of the property owner, with a minimum of two feet of pipe filled with concrete or CLSM.

Prior to filling with concrete or CLSM any pipe to be abandoned in place shall be flushed with clean water to remove debris. The flushing water shall be properly captured and treated and not released to the storm water system or a natural channel. Flushing water and debris shall not be discharged to downstream sanitary sewer piping.

540.00 Sewage Lift Stations

541.00 General

The City of Arvada prefers not to install lift stations. In those locations that cannot be served by gravity into the existing Arvada system, Arvada may approve the construction of a sewage lift station. The sewage lift station, as determined by the Project Engineer, may be either a temporary or a permanent facility. All lift stations shall be privately owned unless approved by the Project Engineer. Privately owned lift stations must be contained within a building and meet all requirements of CDPHE and the IPC.

If a publicly owned lift station is approved by the Project Engineer, the City shall design and construct any required pumping stations that shall become part of the public sewer system. An agreement between the developer and the City will provide for the developer to pay for the design and construction of the improvement. When approved by the Project Engineer, the developer may design and construct a pump station.

The sewage lift station shall satisfy all of the requirements of the Colorado Department of Public Health and Environment (CDPHE) and these Standards and Specifications. The City shall prepare the "Application for Site Approval" for submission to the CDPHE and prepare a set of Record Document drawings of the sewage lift station that complies with Section 200 – Acceptance Procedures of these Standards and Specifications.

Lift station design shall not incorporate submersible pumps.

A security system is required for all lift stations, and it shall be approved by Arvada prior to installation.

550.00 Design Criteria

550.01 Odor and Corrosion Control

The potential for odor generation shall be evaluated, and if recommended shall be provided at the lift station. The method of odor control shall be as determined by the Project Engineer.

The potential for corrosion shall be evaluated, and if recommended shall be provided at the lift station. The method of corrosion protection shall be as determined by the Project Engineer.

The maintenance hole receiving the discharge from a force main shall be corrosion protected. The downstream sewer system shall be evaluated for the need for odor control and corrosion protection, and, if recommended, facilities shall be included for odor control and corrosion protection.

Internal corrosion protection shall be by a product that produces “A Total Lining System for Large Wastewater Structures” and “A Total Lining System for Maintenance Holes”. The complete system shall provide a corrosion resistant liner that protects the walls of both structures and maintenance holes from the severe effects of hydrogen sulfide in a wastewater environment and eliminates water infiltration and exfiltration.

The product shall be as listed in the Approved Products List.

550.02 Wet Well Construction

The wet well shall consist of a cast-in-place reinforced concrete structure divided into two (2) compartments. The two (2) compartments shall be interconnected with a valve or gate. The dual compartments shall allow the draining of one compartment for cleaning or maintenance without affecting the operation of the station. A division box shall be provided upstream of the wet well to allow the sewage lift station flows to be directed into either or both of the wet well compartments. A removable screen, or heavy-duty grinder, as determined by the Project Engineer, shall be provided in the inflow into each wet well compartment to collect debris.

550.03 Pumps and Pump Station

Pumps shall be installed in a dry well adjacent to the wet well, and be of a type and design acceptable to Arvada. Submersible pumps shall not be allowed unless site conditions specifically warrant. The use of submersible pumps shall require the written approval of the Project Engineer.

The pump station shall be designed utilizing a minimum of three (3) pumps. Each pump shall be capable of pumping the peak design flow. Two (2) pumps shall be located in the primary wet well. The third pump shall be located in the second overflow/maintenance wet well.

All pump equipment shall be manufactured and supplied by the same company. The pump station shall be an above ground structure sized to accommodate all of the pumps, electrical equipment and controls required to operate the facility. The station shall be lighted, heated and well ventilated, and shall be designed for easy expansion if required by the Project Engineer.

The architectural finish of the station shall blend with that of the surrounding architecture as much as possible.

A standby generator, capable of operating the entire station for a minimum of four hours, shall be provided and located outside the building in an all-weather enclosure.

550.04 Controls and Supervisory Control and Data Acquisition (SCADA)

Pump operation shall feature automatic sequencing of the pump operation to balance pump wear. Pumps shall be controlled by predetermined wet well levels measured by mercury float switches.

A SCADA system shall be incorporated into the system to automatically contact Arvada in case of an emergency. The SCADA system shall be equipped with several channels so it shall be capable of differentiating between a variety of emergency conditions including high and low wet well levels, pump failures and power failure.

The SCADA system shall be compatible with Arvada's system and shall be reviewed and approved by the Project Engineer prior to installation.

The controls, SCADA equipment, miscellaneous electrical equipment and automatic power switch shall be installed in a control room located on the above ground floor of the pump station.

550.05 Site Security and Improvements

Site security shall be provided based on site assessment and shall comply with Arvada requirements.

A six (6) foot high chain link fence with barbless wire, or other approved material, shall be installed around the perimeter of the sewage lift station site. Upon completion of the lift station construction, all disturbed areas within the site shall be fertilized, seeded and mulched to comply with Section 1030.00 - Grass Specifications of these Standards and Specifications.

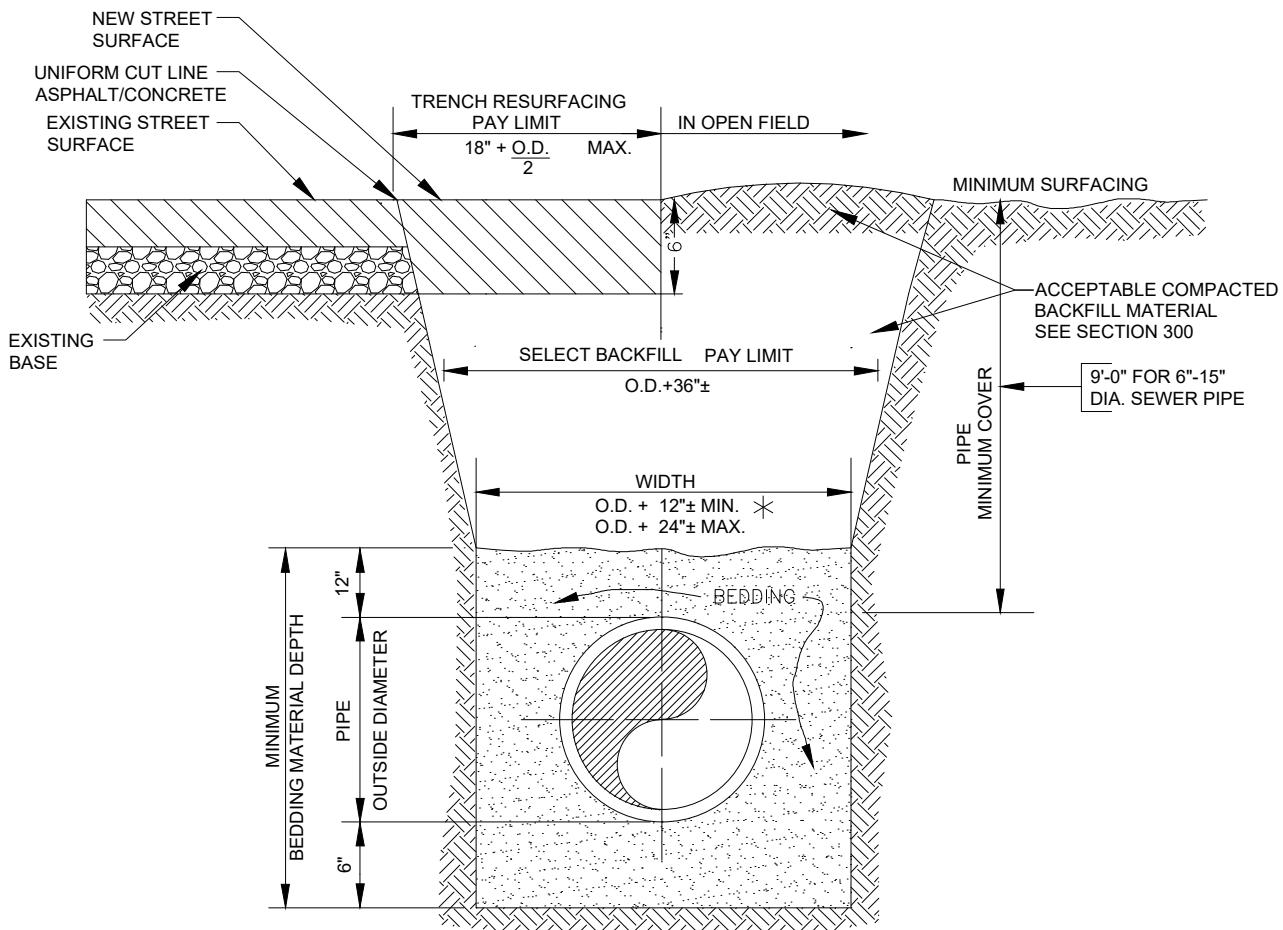
Depending on site location, landscaping improvements may be required by the Project Engineer.

550.06 Force Main / Gravity Transition Maintenance Holes - Downstream Maintenance Holes

The maintenance hole that transitions the flow from the force main to start the gravity flow shall be lined as specified in Section 550.01 - Odor and Corrosion Control. The downstream maintenance holes from the transition maintenance hole, for a total of the next five (5) maintenance holes, shall also be lined as specified in Section 550.01 - Odor and Corrosion Control.

560.00 Restoration and Cleanup

Restoration and cleanup shall be completed and shall comply with Section 371.00 - Restoration and Cleanup of these Standards and Specifications.

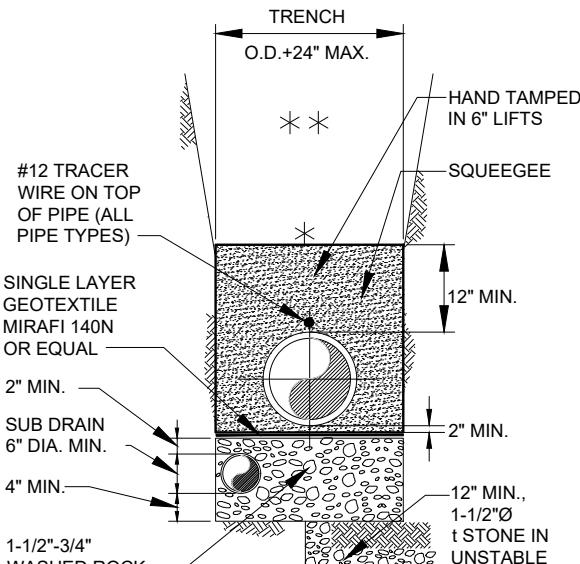


TYPICAL TRENCH SECTION

NOTES:

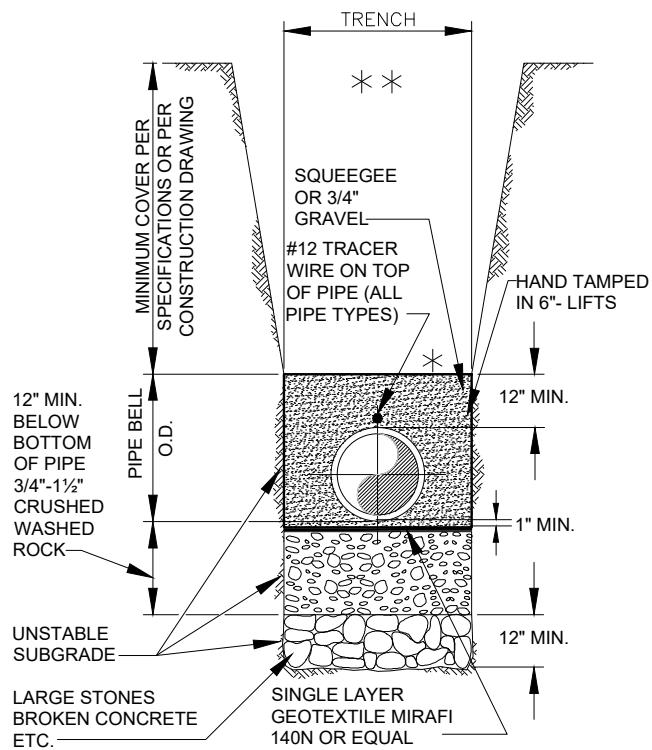
1. PAVING SHALL COMPLY WITH SECTION 700.
2. TRENCH WALLS TO BE SUPPORTED AS REQUIRED BY O.S.H.A.
3. MINIMUM COVER OVER PIPE TO BE BELOW OFFICIAL STREET GRADE.
4. FOR ASPHALT PATCH DEPTH REFER TO THE REQUIREMENTS IN SECTION 700 OF THE STANDARDS AND SPECIFICATIONS.
5. CUTBACK AS REQUIRED BY PROJECT ENGINEER.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	PIPE BEDDING AND BACKFILL LIMITS SEWER MAINS
1	2023	2023 REVISIONS		
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

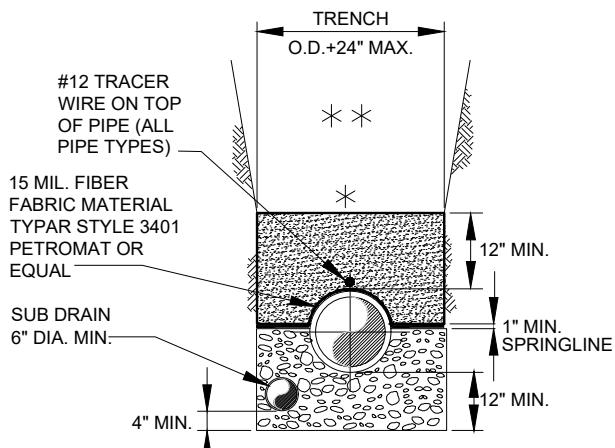


PIPED UNDERDRAIN

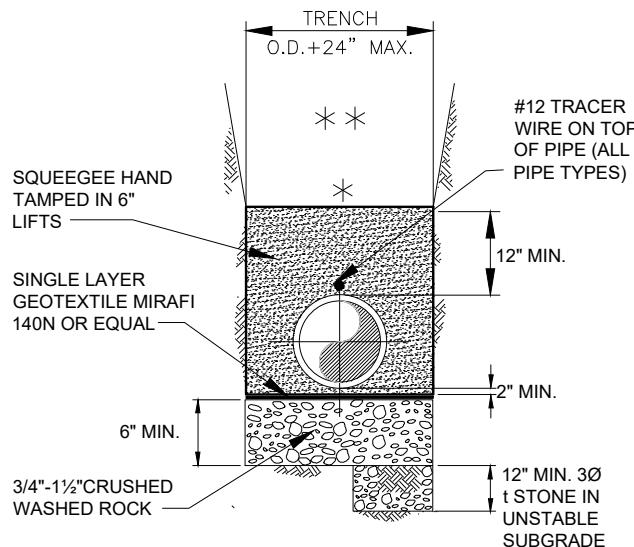
NOTE:
IF A GEOTEXTILE SOCK IS USED ON THE
UNDERDRAIN PIPE, SQUEEGEE MAY BE
USED TO BED THE UNDERDRAIN AND
MIRAFI WILL NOT BE REQUIRED.



UNSTABLE SUBGRADE



PIPED UNDERDRAIN



GRAVEL UNDERDRAIN

UNDISTURBED GROUND
LIMIT OF SLOPING OR BENCHING OF TRENCH WALLS.
MACHINE COMPACTED TRENCH BACKFILL

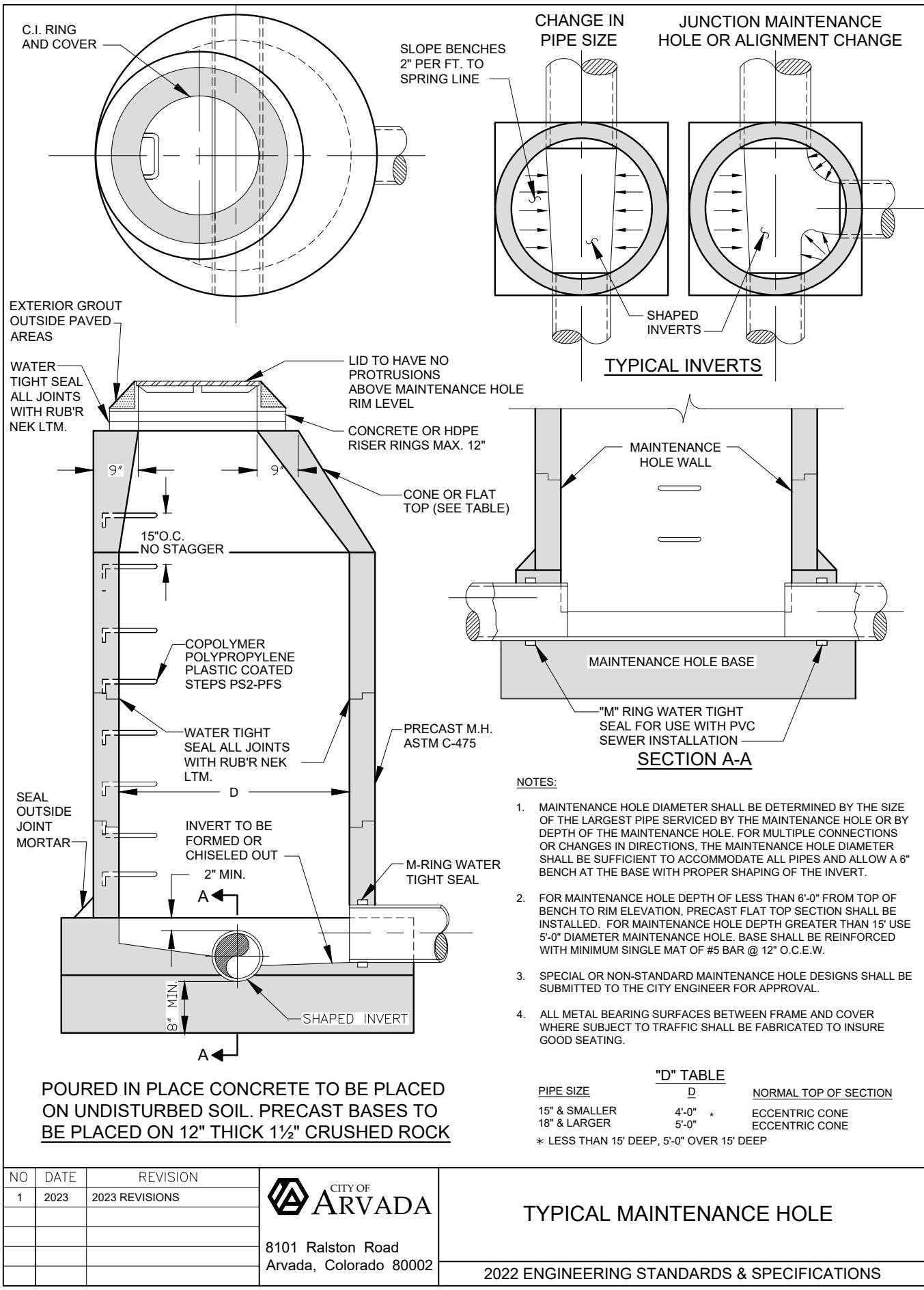
NO	DATE	REVISION
1	2023	2023 REVISIONS



CITY OF
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8101 Ralston Road
Arvada, Colorado 80002

UNSTABLE SUBGRADE AND UNDERDRAIN BEDDING

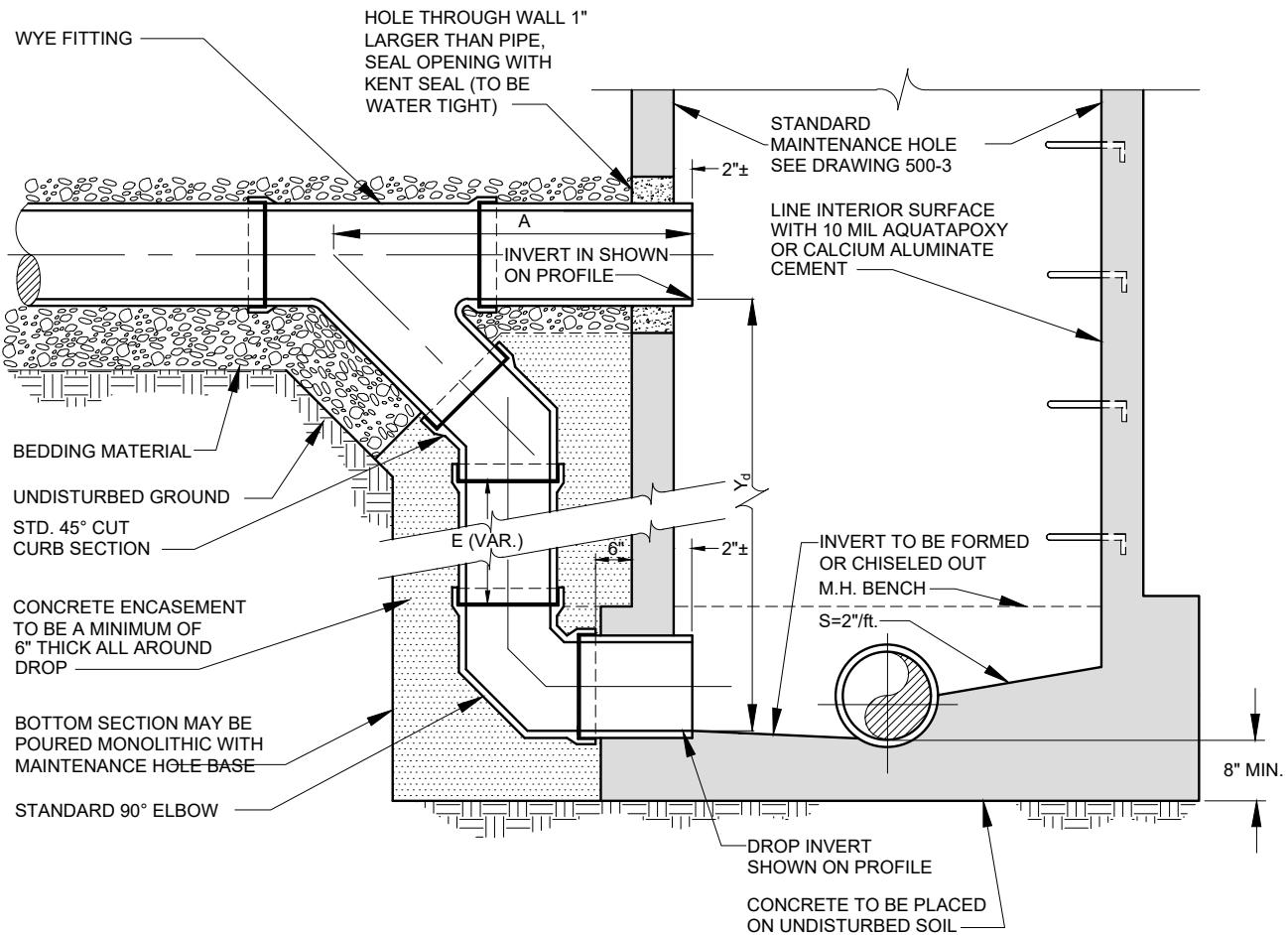
2022 ENGINEERING STANDARDS & SPECIFICATIONS



DIMENSIONS (NOMINAL)	A (INCHES)	Y_d (INCHES)
PIPE DIAMETER (INCHES)	8 10 12 15	8 10 12 15
POLYVINYL CHLORIDE (PVC)	42 47 49 65	31 37 39 55

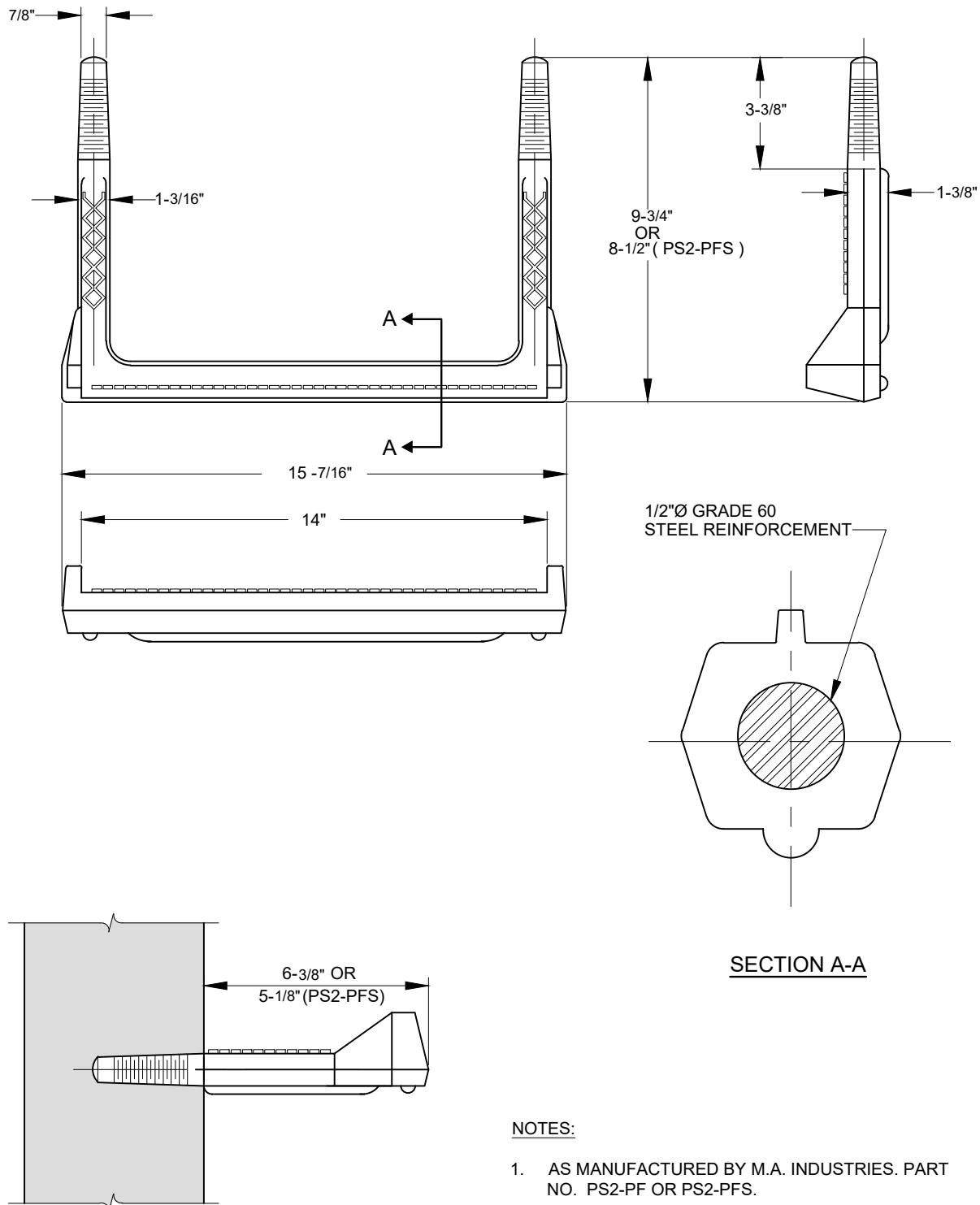
NOTES:

1. P.V.C. PIPE AND FITTINGS ONLY (ASTM D-3034 SDR 35).
2. FOR PAYMENT PURPOSES: ALL FITTINGS, PIPE, CONCRETE ENCASEMENT, EXCEPT SPECIAL WYE FITTING, SHALL BE INCLUDED IN THE COST OF THE OUTSIDE DROP. THE COST OF THE WYE FITTING SHALL BE INCLUDED IN THE UNIT PRICE BID FOR LINE PIPE.
3. DIAMETER OF DROP SHALL NOT BE LESS THAN THE LINE PIPE DIAMETER.
4. FOR 18" DIAMETER PIPE AND LARGER, OUTSIDE DROP DETAIL SHALL BE A SPECIAL DESIGN.
5. ALL REQUIRED WALL OPENINGS SHALL BE PRECAST BLOCK-OUTS OR CORE DRILLED. JACK HAMMERING OF OPENINGS IS NOT ALLOWED.
6. A MAINTENANCE HOLE OUTSIDE DROP IS NOT FEASIBLE FOR A DROP OF LESS THAN 18". THE ABOVE DIMENSIONS INDICATE ONLY THE MINIMUM DROP OBTAINABLE WITH AVAILABLE FITTINGS AND MATERIAL. GREATER DROPS THAN THIS ARE POSSIBLE BY ADDITION OF THE APPROPRIATE PIPE LENGTH AT DIMENSION E.



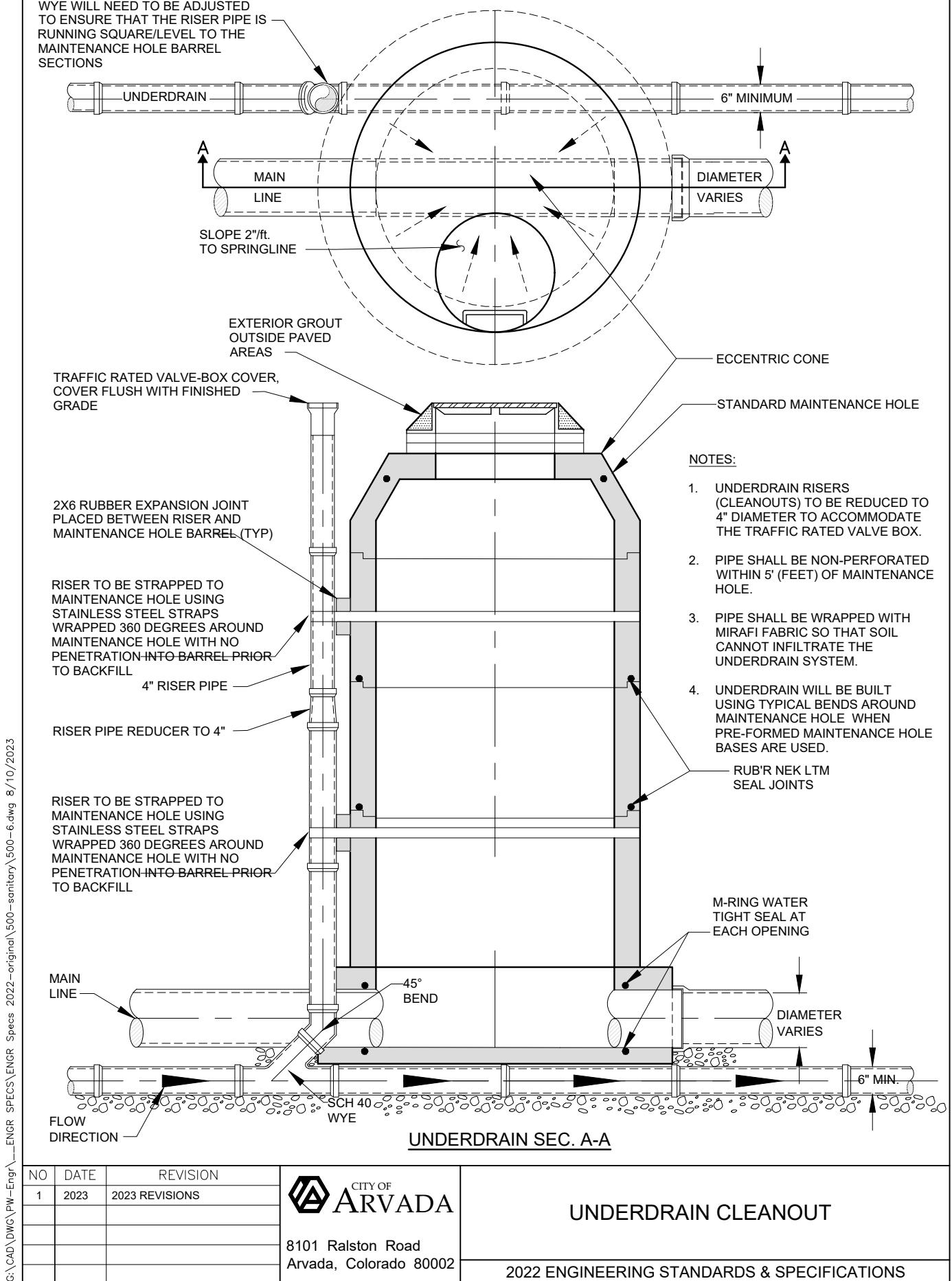
MAINTENANCE HOLE SECTION

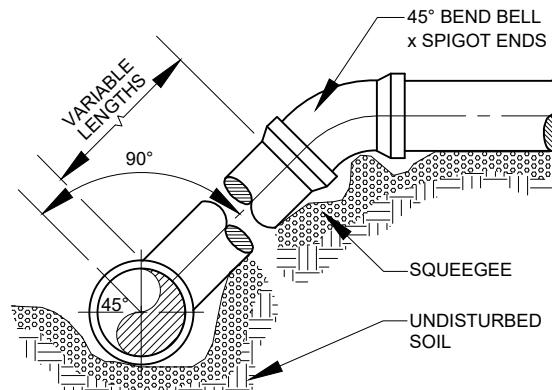
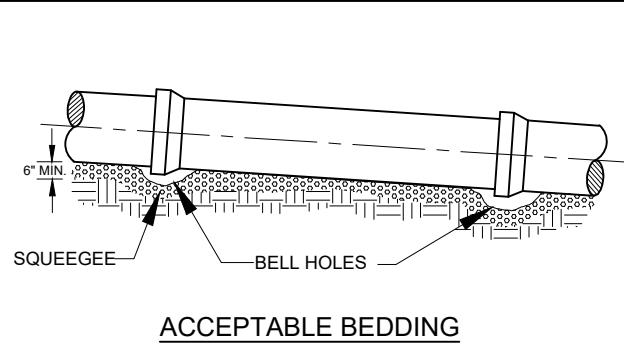
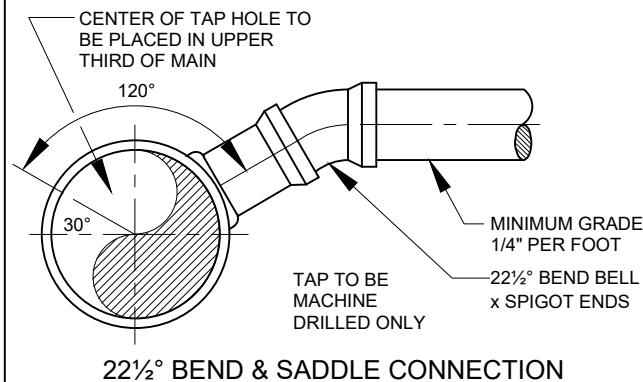
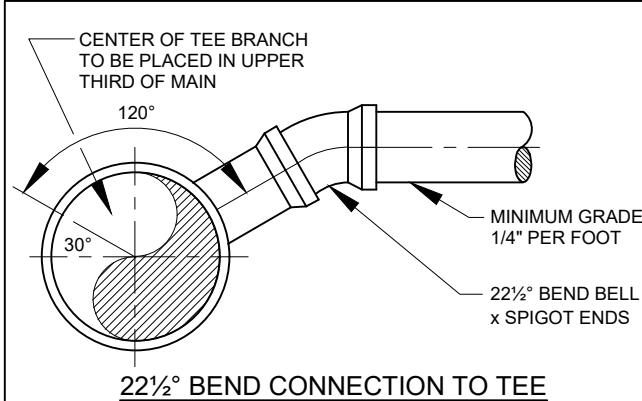
NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	MAINTENANCE HOLE EXTERIOR DROP TYPE 2022 ENGINEERING STANDARDS & SPECIFICATIONS
1	2023	2023 REVISIONS		

NOTES:

1. AS MANUFACTURED BY M.A. INDUSTRIES. PART NO. PS2-PF OR PS2-PFS.
2. CAPACITY 2,500 LBS. WITH STEP EXTENDED 6-3/8" FROM WALL.
3. MATERIAL COPOLYMER POLYPROPYLENE PLASTIC, WITH 1/2"Ø GRADE 60 STEEL REINFORCEMENT.

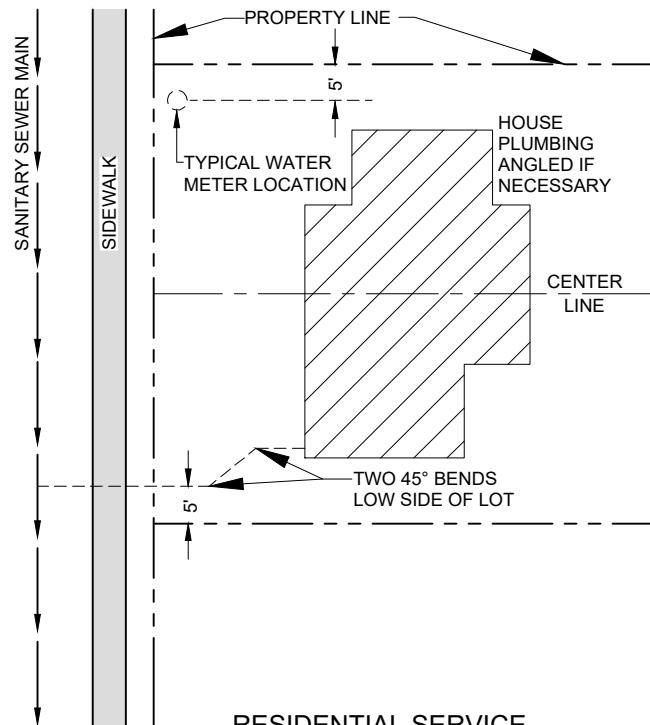
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	MAINTENANCE HOLE STEP
1	2023	2023 REVISIONS		
				2022 ENGINEERING STANDARDS & SPECIFICATIONS





NOTES:

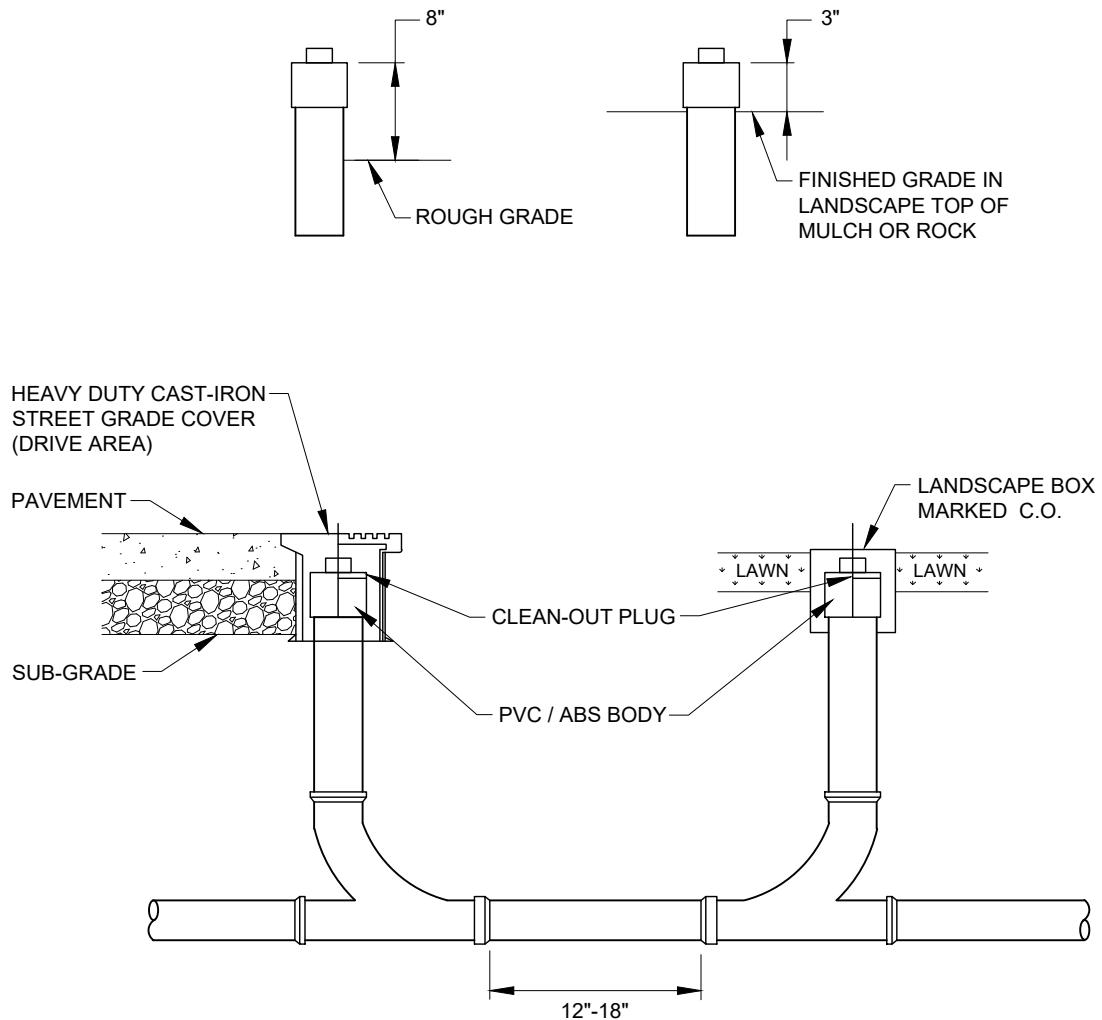
1. BELLS SHALL NOT TOUCH THE SIDES OR BOTTOM OF THE BELL HOLE.
2. THE BARREL SECTION SHALL BE SUPPORTED THROUGHOUT ITS LENGTH WITH SQUEEGEE.
3. SERVICE TAPS SHALL BE IN LINE TEE OR MACHINE TAPPED. HAND TAPS SHALL NOT BE ALLOWED.
4. SERVICE LINES SHALL BE LOCATED A MINIMUM OF TEN FEET DOWNSHILL FROM THE WATER SERVICE LINE.
5. THE CURB SHALL BE MARKED WITH "X" WHERE THE SERVICE LINE CROSSES THE CURB.
6. JOINTS SHALL BE WATER TIGHT.



NO	DATE	REVISION

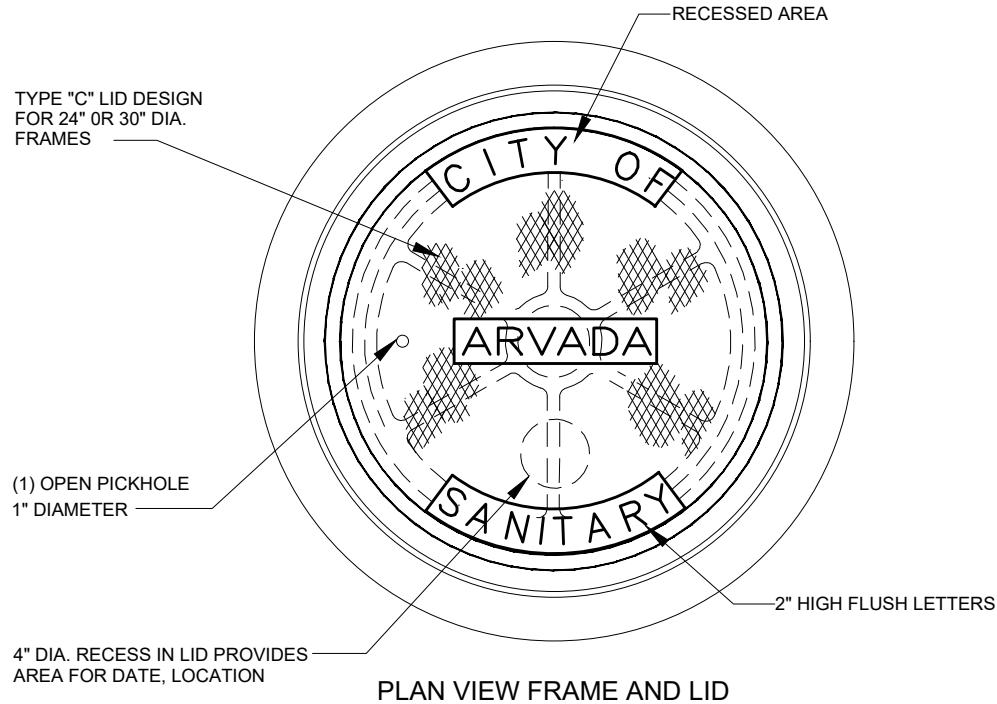
CITY OF ARVADA
8101 Ralston Road
Arvada, Colorado 80002

SANITARY SEWER SERVICE DETAIL

NOTE:

1. A TWO WAY CLEAN-OUT SHALL BE INSTALLED WITHIN 5' OF A BUILDING FOUNDATION ON ALL NEW SEWER SERVICES AND SEWER SERVICE REPLACEMENTS.
2. A TWO WAY CLEAN-OUT IS REQUIRED ON ALL SEWER SERVICES WITH MORE THAN TWO BENDS OR OVER 100 FEET IN LENGTH.
3. ALL CLEAN-OUT ADAPTERS ARE TO BE GLUED IN PLACE.

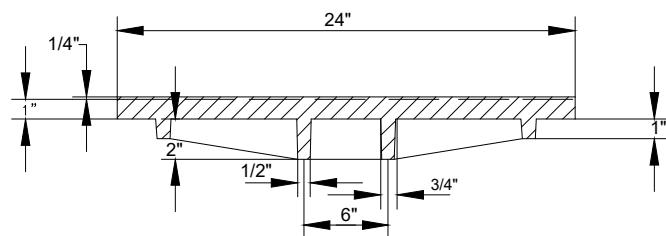
NO	DATE	REVISION	CITY OF ARVADA	SANITARY SEWER SERVICE CLEAN-OUT
1	2023	2023 REVISIONS		
			8101 Ralston Road Arvada, Colorado 80002	2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTE:

4" AND 6" SET RINGS ALL THE SAME DIMENSION EXCEPT HEIGHT.

LID SECTION

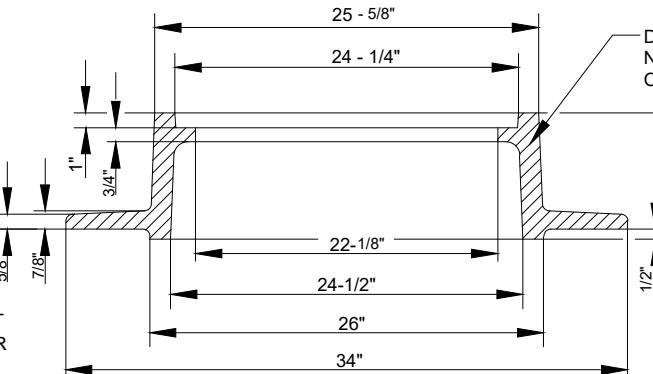


NOTE:

30" DIAMETER FRAME (NOT SHOWN) SHALL BE DEETER #1197 OR NEENAH R-1798 OR EQUAL.

8" SET RING

DEETER #1258
NEENAH R-1706
OR EQUAL



NO	DATE	REVISION
1	2023	2023 REVISIONS



CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

SANITARY MAINTENANCE HOLE
FRAME AND LID DETAIL

2022 ENGINEERING STANDARDS & SPECIFICATIONS

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SECTION 600 – STORM DRAINAGE FACILITIES

601.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

610.00 Design Criteria

Major drainageway improvements, storm outfalls and regional detention or water quality enhancement facilities shall be designed for the Mile High Flood District's (MHFD) Maintenance Eligibility Program and shall comply with any related criteria or documentation developed by the City. Per Colorado Revised Statutes 32-11-221(1), design, construction, and vegetation requirements of drainage facilities other than collection systems must be approved by MHFD.

The proposed construction shall not damage upstream or downstream properties. The planning and design of the drainage system shall not transfer the problem from one location to another.

Except where specified in these Standards and Specifications, the procedure, criteria, and standards set forth in the latest revision of the Mile High Flood District, Urban Storm Drainage Criteria Manual—hereby referred to as the MHFD Manual—shall be instituted for the analysis of any drainage system. Current engineering practices and drainage methodology, as well as common sense, shall be involved with the analysis of any drainage system.

Hydrologic runoff analysis shall be based on appropriate existing or proposed land use and topographic characteristics of those areas.

Stormwater facilities shall be designed and constructed in accordance with the MHFD Manual (Volume 3).

The Federal Emergency Management Agency (FEMA) regulatory floodplain maps and boundaries are available from FEMA's website and shall be shown on all preliminary and final drainage plans. Refer to the Arvada Municipal Code for permitted uses in the floodplain.

All detention basin facilities shall be designed in accordance with the MHFD Manual. Retention facilities shall only be allowed with written approval from the City Engineer and the Division of Water Resources or Colorado Water Conservation Board.

Construction that impairs surface or subsurface drainage shall not be approved. The City reserves the right to issue and enforce more stringent criteria should adverse conditions exist. Designs that vary from the criteria shall require written approval of a variance by the City Engineer prior to final approval of the plans.

Natural topographic features shall be the basis of location for easements and future runoff calculations. Where defined, existing drainage patterns and slopes shall be used. The drainage facilities shall be able to handle the design flows with no erosion damage to the system.

Streets shall not be used as primary floodways for major storm runoff. The amount of runoff in the streets shall not exceed the limits established in Section 615.04 - Street Flow Capacities of these Standards and Specifications.

For inlet and manhole details, refer to the latest edition of CDOT M&S Standards. Reference City of Arvada standard details for Storm Manhole Frame and Lid Detail. Other inlets and maintenance holes may be approved by the Project Engineer on a case-by-case basis.

Stormwater detention facilities or natural drainageways shall be used whenever feasible. Any alteration to natural drainage patterns shall not be approved unless a thorough investigation and analysis shows no hazard or liability. The City Engineer will have final authority over any system design.

Public drainage facilities and all detention facilities shall be in an easement or public right-of-way. All drainage improvements shall be as natural in appearance as possible to be aesthetically pleasing. Maintenance access and easements shall be provided for all drainage, flood control, and water quality facilities.

Irrigation ditches shall not be used as the outfall of any drainage basin unless approved by the irrigation ditch company. All irrigation ditch piping must be approved, signed and dated by the President or other authorized officer of the ditch company, prior to approval by the City Engineer.

611.00 Design Methods

611.01 Minor and Major Design Storms

Every urban area has two separate and distinct drainage systems whether or not they are actually planned for and designed. One is the initial system, which corresponds to the minor (or ordinary) storm recurring at regular intervals. The other is the major system, which corresponds to the major (or extraordinary storm), which has a one-percent (1%) chance of being equaled or exceeded in any given year ("100-year storm"). Since the effects and routing of storm waters for the major storm may not be the same as for the minor storm, all storm drainage plans submitted for approval shall be submitted in detail in two separate phases: one indicating the effects of the minor storm and the other showing the effects of the major storm.

1. Minor storm provisions: The objectives of minor storm planning are to minimize inconvenience, to protect against recurring minor damage, to reduce rising maintenance costs, to create an orderly drainage system and to provide a sociological benefit to the urban resident. The minor storm drainage system may include curb and gutter, storm sewer, swales, and other open drainageways and detention facilities.
2. Major storm provisions: The major storm shall be considered the 100-year storm. The objectives of the major storm planning are to eliminate substantial property damage or loss of life and shall be as directed and approved by the Project Engineer. Major drainage systems may include storm sewers, open drainageways and detention facilities. The correlation between the minor and major storm system shall be analyzed to ensure a well-coordinated drainage system.

611.02 Storm Return Periods

The minor and major storm design return periods shall not be less than those shown below:

Design Storm Return Periods

Land Use or Zoning	Design Storm Return Period	
	Minor Storm	Major Storm
Residential	5-year	100-year
Business	5-year	100-year
Public Building Areas	5-year	100-year
Parks, Greenbelts, etc.	5-year	100-year
Open Channels and Drainageways	- ¹	100-year
Detention Facilities	- ¹	100-year

¹The MHFD Manual shall be consulted for appropriate designs for stages lower than the 100-year storm.

611.03 Rainfall Intensities

Access NOAA Atlas 14 at <https://hdsc.nws.noaa.gov/hdsc/pfds/> for rainfall depth-duration-frequency values. Precipitation data locations should be identified as close to the project area as possible.

611.04 Runoff Computations, Colorado Urban Hydrograph Procedure (CUHP)

The CUHP method is generally applicable to basins greater than ninety (90) acres, and the CUHP is required for watershed areas larger than one-hundred sixty (160) acres. The procedures for the CUHP, as explained in the MHFD Manual (Volume 1), shall be followed in the preparation of drainage reports and storm drainage facility designs in Arvada. The design storms distribution to be used with the CUHP method are presented in the Rainfall Chapter of the MHFD Manual (Volume 1).

611.05 Runoff Computations, Rational Method

The Rational Method shall be utilized for sizing storm sewers and for determining runoff magnitude for smaller watersheds. The limit of application of the Rational Method is approximately ninety (90) acres. When the drainage basin exceeds ninety (90) acres, the CUHP method shall be used.

The procedures for the Rational Method, as explained in the MHFD Manual (Volume 1), shall be followed in the preparation of drainage reports and storm drainage facility designs in Arvada.

611.06 Runoff Coefficients

Rational method runoff coefficients: The runoff coefficient (C) to be used in conjunction with the Rational Method shall not be less than those listed in the Runoff Chapter of the MHFD Manual.

611.07 Roughness Coefficients

Minimum Values of Roughness Coefficient (n)

Type of Channel and Description			Minimum
Closed Conduits:			
Concrete Pipe:			
		Culverts with bends, connections & debris	0.013
		Storm sewer	0.013
		Subdrain with open joints	0.016
PVC Pipe			0.011
Concrete Surfaces (bottom & sides):			
		Smooth finish	0.015
		Unfinished	0.017
Concrete Bottom (with sides of):			
		Mortared stone	0.020
		Dry rubble or riprap	0.030
Gravel Bottom (with sides of):			
		Formed concrete	0.020
		Dry rubble or riprap	0.040
Excavated or Dredged Channels and Ditches:			
	Earthen, Straight & Uniform, no brush or debris:		
		Grassed, less than 6" high with:	
		Depth of flow < 2.0 feet	0.035
		Depth of flow > 2.0 feet	0.030
		Grassed, approx. 12" high with:	
		Depth of flow < 2.0 feet	0.060
		Depth of flow > 2.0 feet	0.035
		Grassed, approx. 24" high with:	
		Depth of flow < 2.0 feet	0.070
		Depth of flow > 2.0 feet	0.035

		Earth bottom with riprap on sides	0.040
Rock or Shale Cuts:			
		Smooth and uniform	0.035
		Jagged and irregular	0.040
		Curb and Gutter (concrete)	0.016

612.00 Detention

612.01 General

Detention is required for all new development, expansion and redevelopment that result in land disturbance of one (1) acre or more, to control 100-year peak flows. Detention may be provided in Onsite, Subregional or Regional facilities. Full Spectrum Detention is the required approach to reduce flooding and stream degradation impacts by controlling peak flows for a range of events. Guidance for Full Spectrum Detention design is provided in the Storage chapter of the MHFD Manual (Volume 2).

Extended detention basins (EDB) are not recommended for drainage areas less than two (2) impervious (not total) acres. For drainage areas less than 2 impervious acres, attenuation shall be incorporated within a green infrastructure facility such as a rain garden, permeable pavement or a sand filter as part of the Low Impact Development (LID) practice.

Parking lot detention is prohibited and shall not be considered in the design process.

612.02 Equation Method

If not specified otherwise in the Master Plan or by the Project Engineer, the simplified equation method found in the Storage chapter of Volume 2 of the MHFD Manual may be used to design detention ponds for drainage areas smaller than ten (10) total acres. However, if the calculated allowable release is greater than the historic runoff, a different method shall be used to determine the storage requirements.

If the drainage area is larger than ten (10) total acres, UD-Detention or CUHP/EPA SWMM analysis shall be used to design the detention ponds.

612.03 Facilities in Parallel or in Series

To assess the performance of multiple detention facilities arranged in parallel or in series, MHFD allows only hydrograph routing using CUHP and EPA SWMM. See the Storage chapter of the MHFD Manual (Volume 2).

613.00 Water Quality

613.01 General

Water quality is required for all new development, totaling 10,000 sq ft or more. The main purpose of designing storm drainage facilities to provide water quality is to treat and attenuate the excess storm runoff from developed areas. Water quality may be provided in Onsite, Subregional or Regional facilities.

613.02 Water Quality Design Standards

Facility design standards in this section shall comply with Division 4-1-3 of Arvada City Code and complies with the most current Colorado Department of Health and Environment (CDPHE) Municipal Separate Storm Sewer System (MS4) Phase II General Permit.

In accordance with MHFD, it is not recommended that Extended Detention Basins (EDB's) be used to meet water quality treatment requirements for tributary basins between 2 and 5 impervious (not total) acres. Either a "treatment train" approach, (contributing stormwater treated upstream of the EDB), or another form of LID practice should be chosen. For all EDB's proposed for tributary basins larger than 5 impervious acres, designs shall comply with the most recent MHFD Volume 3 criteria at the discretion of the City Engineer.

If one-hundred percent (100%) of the applicable development site cannot practicably be treated, documentation describing this justification must be provided in the Final Drainage Report.

614.00 Low Impact Development (LID)

614.01 General

LID is a comprehensive land planning and engineering design approach to managing stormwater runoff with the goal of mimicking the pre-development hydrologic regime. LID emphasizes conservation of natural features and use of engineered, on-site, small-scale hydrologic controls that infiltrate, filter, store, evaporate, and detain runoff close to its source.

LID practices are the individual techniques implemented as part of overall development or integrated into traditional development, including practices such as bioretention (rain gardens), green roofs, permeable pavements, grass swales, minimizing directly connected impervious areas (MDCIA), minimizing unnecessary impervious areas, and other infiltration-oriented practices.

LID is not limited to a set of practices targeted at promoting infiltration, but is rather an overall site planning approach that promotes natural runoff reduction strategies and water quality improvements to benefit all residents within the city.

614.02 Requirements and Design Considerations

LID should be the first priority in stormwater runoff design for all new development, expansion, and redevelopment that result in an increase of impervious area in conjunction with the *Four Step Process for Stormwater Management* outlined in the MHFD Manual (Volume 3). Additional information on the LID design process may be found on the EPA's LID Urban Runoff page. LID is a critical component of both storm water quality and runoff reduction. Additional consideration may be given to LID practices not specified within the MHFD Manual.

For development, expansion, and redevelopment that requires attenuation, LID should be used as the first step in the design process. Certain LID practices can be used to meet detention and water quality requirements under the MS4 Permit. Detention and water quality shall adhere to sections above.

For development, expansion, and redevelopment in which ground disturbance is 10,000 sq ft or greater, but less than one (1) acre, LID design will be required. Certain LID practices may overlap to aid in meeting site landscaping requirements under the Land Development Code. LID shall be used to ensure the site's proposed runoff volumes mimics historic hydrologic conditions. Proposed discharge points for a site shall be consistent with historic discharge points.

Acceptable forms of LID practices within the City are as follows:

- Permeable pavement
- Rain garden
- Bioswale
- Grass swale
- Grass buffer
- Extended Detention Basin
- Sand filter
- Hydrodynamic separators (approved on a case by case basis)

Green roofs and underground water quality shall not be allowed except by approval of the City Engineer.

615.00 Conveyance Design Standards

615.01 Open Channels

Alterations or improvements to major drainageways that qualify, or could qualify, for the MHFD Maintenance Eligibility Program (MEP) shall be approved by MHFD. Improvements such as storm sewer outfalls, regional detention/water quality facilities and culverts shall be designed and constructed in accordance with MEP standards. This includes, but may not be limited to, obtaining construction drawing approval and ensuring MHFD inspects the infrastructure during construction and when the project is complete.

Open channels for local drainageways shall be designed for the 100-year storm and shall conform to the MHFD Manual for preservation and design of natural stream corridors.

615.02 Storm Sewers and Storm Inlets

Except as subsequently modified, the design of storm sewers and inlets shall conform to the criteria set forth in the MHFD Manual. Storm sewers and inlets shall be of sufficient capacity to adequately carry the expected runoff from the minor design storm.

The storm sewer system shall be installed at all locations where the allowable street capacity is exceeded or wherever ponding of water is likely to occur.

The invert elevation of storm sewer outfalls into channels shall be at least one (1) foot above the channel invert.

The minimum allowable pipe size for public storm sewer systems shall be as follows:

Minimum Allowable Pipe Size

Type of Conduit	Min. Inside Pipe Dia.
Main Trunk Sewer	18"
Individual Laterals	15"

Pipe diameters of less than fifteen (15) inches may be allowed on private property; however, a variance request shall be submitted by the owner to the Project Engineer in writing, and approval shall be obtained from the City Engineer prior to final design.

Arch pipes may be allowed where design conditions dictate, provided that the minimum equivalent cross-sectional areas are not less than those specified above. All storm sewer conduits shall have sufficient structural strength to withstand a design load of 85,000 lb.

Maintenance hole diameters shall be a minimum of sixty (60) inches for lines fifteen (15) inches to twenty-one (21) inches diameter, and seventy-two (72) inches for lines twenty-four (24) inches to thirty (30) inches diameter. For storm pipe larger than thirty (30) inches diameter, a CDOT box base manhole or Project Engineer approved manhole design is required. Where two or more pipes enter a manhole, the Project Engineer will approve the manhole design size.

The maximum allowable distance between maintenance holes or other suitable appurtenances for cleanouts shall not exceed those listed below:

Maximum Allowable Manhole Spacing

Inside Diameter	Maximum Allowable Distance Between maintenance holes and Cleanouts
36" and smaller	400 feet
larger than 36" - smaller than 60"	500 feet
60" & Larger	750 feet

The velocity for the minor flows in conduits shall not be less than two (2) feet per second.

Storm inlets shall be utilized at all points where ponding or sump conditions exist. Inlets shall be curb opening inlets, type "R", or grated inlets with curb openings. All inlets shall be similar and equal to those in the latest revision of the CDOT M&S Standards or as approved by the Project Engineer.

Grated inlets shall be recommended for bicycle traffic as defined in the Approved Products List.

All storm sewer inlets shall be labeled in accordance with the CDOT Curb Inlet Type R or as required by Arvada Utilities.

The theoretical capacity and spacing of storm inlets shall be analyzed using the criteria and reduction factors set forth in the MHFD Manual.

The size of outlet pipes from stormwater inlets shall be based on the theoretical capacity of the inlet. All pipe outlets shall be protected in accordance with the MHFD Manual (Volume 2).

615.03 Culverts

Culvert capacities shall be at least equal to the capacities of culverts designed in accordance with the procedures outlined in Federal Highway Administration Hydraulic Design Series Number 5, "Hydraulic Design of Highway Culverts". The Project Engineer will approve the shape, location and type of construction of culverts.

Culverts shall be sized to have sufficient capacity to pass all of the runoff from the major storm if twenty percent (20%) of the pipe is plugged.

The following design criteria shall be utilized for all culvert design:

1. The culvert, including inlet and outlet structures, shall properly convey water and debris at all stages of flow.
2. Culvert inlets shall be designed to minimize entrance and friction losses. Inlets shall be provided with either flared end sections or head walls with wing walls. Projecting ends are not acceptable. Large structures shall be designed to resist hydrostatic uplift forces.
3. Culvert outlets shall be designed to avoid sedimentation, undermining of culvert, or erosion of downstream channels. Outlets shall be provided with either flared end sections or headwalls, with wingwalls and riprap. Projecting ends are not acceptable. Additional outlet control, in the form of riprap, channel shaping, etc., may be required.
4. Culvert slopes shall be selected to eliminate excessive velocities and scour. Generally, the minimum slope of culverts shall be limited to one-half ($\frac{1}{2}$) percent.
5. Headwater ponding above culvert inlets shall not be acceptable if such ponding appears likely to cause property or roadway damage, culvert clogging, saturation of fills, detrimental upstream deposits of debris, or inundation of existing or future utilities and structures.
6. Tailwater height at the outlet shall be subject to approval by the Project Engineer.
7. Culverts shall be analyzed to determine whether discharge is controlled by inlet or outlet conditions for both the minor storm discharge and the major storm discharge. Computations for selected culvert sizes shall be submitted to the Project Engineer for approval. Computer programs such as the FHWA HY8 may be used to design culverts.
8. Minimum Allowable Size: The required size of a culvert shall be based on adequate hydraulic design analysis.

- a. Circular culverts under roadways shall have a minimum diameter of thirty-six (36) inches.
 - b. Oval culvert dimensions shall be forty-two (42) inches by twenty-seven (27) inches or larger.
 - c. Box culverts shall have a minimum height of six (6) feet.
 - d. Smaller culvert sizes may be approved by the Project Engineer
9. An overflow path shall be provided in case the culvert becomes plugged.
10. Where physical conditions dictate, multiple culvert installations may be approved by the Project Engineer.
11. The structural design of culverts shall conform to the methods and criteria recommended by the manufacturer of a specific type of culvert for the specified embankment conditions.

615.04 Street Flow Capacities

Except as modified herein, the criteria set forth in the MHFD Manual shall be used to analyze and to determine the adequacy of streets as a function of the drainage system. Both the minor storm runoff and major storm runoff shall be considered, and calculations showing such runoff at critical sections shall be submitted. A storm sewer system shall be installed at all points where the maximum allowable street encroachment occurs. The following criteria shall apply in the determination of allowable street flow capacities:

1. Street, curb and gutter, sidewalks, crosspans and curb cuts shall conform to all applicable sections of these Standards and Specifications.
2. Where no curb exists, street encroachment shall not extend past the public ROW.
3. Street encroachment, flow depths, and inundated area limits for the minor and major design storms shall not exceed the limitations set forth below:

Allowable Street Encroachment and Depth of Flow for Minor Storm Runoff

Street Classification	Maximum Encroachment
Local	No curb overtopping. Flow may spread to the crown of the street.
Connector	No curb overtopping. Flow spread shall leave the equivalent of one 12 foot driving lane clear of water.
Arterials	No curb overtopping. Flow spread shall leave the equivalent of two 12 foot driving lanes clear of water – one lane in each direction. No more than two lanes in each direction shall be flooded.

**Allowable Depth of Flow and Inundated Area for
Major Storm Runoff**

Street Classification	Allowable Depth and Inundated Areas
Local & Connector	Lowest entry to residential dwellings and public, commercial, and industrial buildings shall not be less than twelve (12) inches above the 100-year water surface elevation. The depth of water over the gutter flowline shall not exceed twelve (12) inches or the limits of the right-of-way.
Arterial	Lowest entry to residential dwellings and public, commercial, and industrial buildings shall not be less than twelve (12) inches above the 100-year water surface elevation. The depth of water at the street crown shall not exceed six (6) inches to allow operation of emergency vehicles. Depth of water over gutter flow line shall not exceed twelve (12) inches or the limits of the right-of-way.

Cross-street flow occurs when runoff flowing in a gutter flows across the street to the opposite gutter or inlet. Allowable cross-street flow is summarized in the following table:

Allowable Cross-Street Flow

Street Classification	Initial Storm Flow	Major Storm Flow
Local	Six (6) inches depth in crossspan	Twelve (12) inches of depth above gutter flow line
Connector	Six (6) inches of depth in crossspan	Twelve (12) inches of depth above gutter flow line
Arterial	None	No cross-street flow. Maximum depth of upstream gutter of twelve (12) inches.

615.05 Relation to other Utilities and Structures

All Arvada water, sanitary sewer, storm, and reuse water mainline pipes shall have a minimum separation from any structure or other utility of eighteen inches (18") vertical separation and ten feet (10') horizontal separation. Arvada fiber optic conduit shall be a minimum of eighteen

inches (18") vertical separation and two feet (2') horizontal separation from other private utilities. Arvada irrigation lines shall be a minimum of eighteen inches (18") vertical separation and three feet (3') horizontal separation from all other utilities.

If compliance with these requirements is not feasible, the Owner/Developer/Engineer shall design and construct the Utilities by means of secondary containment. Secondary containment considered by City Utilities, in order of preference for sanitary sewer, are:

1. Construct sanitary sewer from AWWA C900 or C909 pipe
2. Casing pipe
3. Encased in flow fill

In the case of storm sewer, casing or encased in flow fill shall be used. If these required separations cannot be met, they will be addressed on a case-by-case basis.

615.06 Sidewalk Chase Drains

When proposed lot grading has portions of three (3) or more lots (tracts are considered a lot) draining to a shared lot line swale to a roadway, a sidewalk chase drain shall be installed to convey drainage through the sidewalk to the gutter. In areas with detached sidewalk and tree lawns, the sidewalk chase shall continue through the tree lawn and curb to the gutter. Site grading should be designed to avoid the use of sidewalk chase drains when possible. There will not be more than one chase drain per three-hundred (300) linear feet.

Refer to Detail Drawings for sidewalk chase drain construction and installation details.

620.00 Storm Drainage Construction

620.01 Protection of Existing Underground Utilities

The Contractor shall be held responsible for the protection of public improvements as stated in Section 140.00 - Protection of Public, Private and Utility Interests of these Standards and Specifications. It shall be the Contractor's responsibility to replace all public improvements damaged at his/her own expense.

621.00 Site Work and Earthwork

621.01 General

Site work and earthwork shall be performed in accordance with Section 300 – Soils and Earthwork of these Standards and Specifications.

621.02 Trenching, Backfilling and Compacting

Trenching, backfilling and compacting shall be performed in accordance with Section 364.00 - Trenching, Backfilling and Compacting of these Standards and Specifications.

621.03 Revegetation

Revegetation is critical to the proper functioning of detention basins, retention ponds, wetland basins, Low Impact Development facilities and riparian areas. Revegetation is also necessary to stabilize adjacent areas disturbed during construction. Successful revegetation is required to close-out common regulatory permits associated with working in waterways, including Arvada Site Disturbance Permit, State of Colorado stormwater discharge permits and, USACE 404 permits. Because of Colorado's semi-arid climate, prevalence of introduced weeds, and difficult soil conditions encountered on many projects, revegetation can be challenging and requires proper planning, installation, and maintenance to be successful. Arvada recommends that developers include a revegetation specialist (i.e., ecologist, landscape architect, and wetland scientist) who is experienced in restoration ecology and local native plant communities as part of the overall project team to assist with project planning, direction, construction observation, monitoring, and long-term maintenance supervision for revegetation aspects of drainage projects. Early involvement of qualified professionals can help to identify site constraints and site preparation requirements, identify sensitive areas that should be protected during construction, select appropriate plants and installation procedures, and develop plans for continued plant establishment once the construction phase is complete.

Revegetation shall be in compliance with the requirements set forth in Section 1000.

622.00 Materials

622.01 Pipe

Reinforced Concrete Pipe (RCP) shall be manufactured to comply with ASTM C76. All applicable portions of Section 706 - Concrete and Clay Pipe of the CDOT Standard Specifications for Road and Bridge Construction shall apply.

Polyvinyl Chloride Pipe (PVC) shall be manufactured to comply with ASTM F794/F949 (ribbed) or ASTM D3034, SDR-35 (smooth). All joints shall be factory prepared compression type (elastomeric gasket joint), providing a watertight seal. PVC shall not be installed in public ROW, City easements or traffic loading areas.

High Density Polyethylene Pipe (HDPEP) shall be manufactured to comply with ASTM D3350, with the minimum cell classification of 315412C. Requirements for test methods, dimensions and markings shall comply with AASHTO Designation M-294. HDPEP shall comply with ASTM D2412 for a maximum of five percent (5%) deflection. HDPEP shall not be installed in public ROW, City easements or traffic loading areas.

Polypropylene pipe (PP), Advanced Drainage System, Inc's HP Storm Polypropylene Pipe (PP or Polypro) for Storm Drainage Applications, or approved equal, shall be manufactured to comply with ASTM D2321, ASTM F477 and ASTM F2881. Requirements for test methods, dimensions and markings shall comply with AASHTO Designation M-330. Pipe diameters 12-inch and up to and including sixty (60) inch diameter will be allowed. The pipe shall be installed per the manufacturer's specifications and detailed drawings. PP or Polypro may be installed in public ROW, City easements or traffic loading areas.

Watertight joints shall be joined with a gasketed bell and spigot joint meeting the requirements of ASTM F2881. Gaskets shall be installed by the pipe manufacturer and installed with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the bell and gasket during assembly. Spigots shall have gaskets. PP or Polypro Storm pipe will be allowed in the City of Arvada's right-of-way and under pavement for all roadways.

Other storm sewer pipe materials may be approved at the discretion of the Project Engineer. Pipe class designation or gauge shall be as shown on the approved plans or as designated by the Project Engineer for each individual project. Pipe material shall be selected based on strength and soil conditions.

All pipes shall be inspected by the Arvada Inspector/Representative in order to allow for rejection of pipe that fails to conform to the requirements of these Standards and Specifications. Defects shall be marked so as not to disfigure the rejected pipe. Rejected pipe shall be removed from the job site within twenty-four (24) hours.

622.02 Pipe Joints

All pipe joints shall be watertight. RCP joints shall comply with ASTM C443. HDPEP and PP joints shall comply with ASTM D3212. PCSP and CAP joints shall comply with AASHTO Section 26.4.2.4.f. Cement mortar joints shall be constructed with a mortar mixture composed of one (1) part Portland cement to three (3) parts sand and enough water to produce a workable mix. Mortar that has started to set shall be discarded and a new batch prepared. PP joints shall comply with ASTM D3212 and ASTM F477.

622.03 Maintenance holes and Inlets

Inlets shall be constructed in accordance with the most current version CDOT M&S Standards, unless otherwise approved by the Project Engineer.

Maintenance hole construction including materials ,access ring and cover sets for all inlet types, shall comply with all applicable portions of Section 522.04 - maintenance holes of these Standards and Specifications. Manhole frame and lid shall conform with the detail 600-1.

622.04 Manhole Base Slabs & Base Beams

Refer to Section 522.05- Manhole Bases and Base Beams of these Standards and Specifications.

622.05 Concrete

Concrete shall conform to Section 800 – Concrete Mix Design and Construction of these Standards and Specifications. Type II cement shall be used except where sulfate resistant cement is required. Concrete encasement of pipe shall conform to the details shown on the approved plans.

622.06 Cast and Ductile Iron Fittings

Refer to Section 522.07 - Cast and Ductile Iron Fittings of these Standards and Specifications. All public owned storm manhole lids shall be furnished with the words “City of Arvada Storm Sewer” cast on top as shown in Detail Drawings found in these Standards and Specifications. All privately owned storm manhole lids shall not have “City of Arvada Storm Sewer” cast on top. Manufacturer and model of all lids shall be as listed in the Approved Products List.

622.07 Bedding Material

All applicable portions of Section 367.00 - Bedding for Pipelines and Service Lines of these Standards and Specifications shall apply.

622.08 Riprap, Boulders and Filter Cloth

Riprap, boulders and filter cloth shall be installed at locations shown on the approved plans, or in locations designated by the Project Engineer.

Rock used for riprap and boulders shall meet all the latest requirements in the MHFD Construction Specifications and shall be hard, durable, angular in shape, and be free from cracks,

overburden, shale and organic matter. Neither breadth nor thickness of a single stone shall be less than one-third ($\frac{1}{3}$) its length, and rounded stone shall not be approved. The rock shall sustain the abrasion test (Los Angeles machine - ASTM C535) and shall sustain a loss of not more than ten percent (10%) after twelve (12) cycles of freezing and thawing (AASHTO test 103 for ledge rock procedure A). The rock shall have a minimum specific gravity of 2.50. Classification and gradation for riprap are shown below. Specific material and installation specifications for riprap and boulders shall be adhered to and can be found in MHFD's Construction Specifications, available at www.mhfd.org.

The riprap designation and total thickness of riprap shall be as specified on the approved plans. The maximum stone size shall not be larger than the thickness of the riprap.

Soil riprap shall consist of a uniform mixture of soil and riprap without voids. The soil material shall be native or topsoil mixed with sixty-five percent (65%) riprap and thirty-five percent (35%) soil by volume.

Classification and Gradation of Riprap

Riprap Designation	% Smaller Than Given Size By Weight	Intermediate Rock Dimension (Inches)	d(50)* (Inches)
Type VL	70-100	12	6**
	50-70	9	
	35-50	6	
	2-10	2	
Type L	70-100	15	9**
	50-70	12	
	35-50	9	
	2-10	3	
Type M	70-100	21	12
	50-70	18	
	35-50	12	
	2-10	4	
Type H	70-100	30	18
	50-70	24	
	35-50	18	
	2-10	6	
Type VH	70-100	41	24
	50-70	33	
	35-50	24	
	2-10	9	

*d (50) = Mean particle size

** To minimize vandalism, mix Types VL and L riprap with topsoil and bury it with a minimum of six (6) inches of topsoil, vibration compacted and revegetated.

Filter cloth shall be manufactured especially for the stability of erosion control construction and made from polyethylene, polypropylene or polyester yarns. Filter cloth shall meet the requirements of CDOT Class B drainage geotextile as specified in Section 712 of the CDOT Standards and Specifications for Road and Bridge Construction. Filter material which is to be placed on top of the filter cloth (at specified thickness) prior to placement of the riprap shall meet the bedding requirements in the MHFD Manual (Volume 1).

When requested by the Project Engineer, the Contractor shall furnish copies of test reports from a certified testing laboratory for the following:

1. Gradation and soundness of riprap
2. Gradation of filter material
3. Strength and characteristic tests for filter cloth
4. Compaction tests of the prepared subgrade

623.00 Installation

Refer to Section 523.01 - General of these Standards and Specifications.

623.01 Alignment and Grade

Refer to Section 523.02 - Alignment and Grade of these Standards and Specifications.

623.02 Protection of Existing Underground Utilities

Refer to Section 140.00 - Protection of Public, Private and Utility Interests of these Standards and Specifications.

623.03 Wet Trench

Refer to Section 366.00 - Trench Excavation for Pipelines and Service Lines of these Standards and Specifications.

623.04 Storm Sewer Pipe Installation

Refer to Section 523.04 - Sewer Pipe Installation of these Standards and Specifications.

623.05 Connections to Existing Maintenance Holes

Refer to Section 523.05 - Connections to Existing maintenance holes of these Standards and Specifications.

623.06 Construction of Open Channels

All open channel construction shall meet the latest requirements and specifications in the MHFD Manual.

All work shall conform to details in the approved plans and supplemental specifications.
Construction shall comply with Section 523.02 - Alignment and Grade of these Standards and Specifications.

623.07 Boulders, Riprap and Filter Cloth

Excavation for boulders and riprap shall conform to Section 300 – Soils and Earthwork of these Standards and Specifications.

Filter cloth shall be placed according to the manufacturer's specifications. Holes, rips or other damage to the filter cloth shall be repaired or replaced at the Contractor's expense, in accordance with the manufacturer's recommendations.

Stabilization material, as described in Section 360.01 - Definitions of these Standards and Specifications, shall be placed on top of the filter cloth (where filter cloth is used) to the required thickness. The material shall be placed using equipment that shall not rip, tear or otherwise damage the filter cloth. Any damaged areas shall be promptly repaired at the Contractor's expense. The material shall be leveled to a finished surface that is within one (1) inch of the specified thickness.

Boulders and riprap shall be placed to conform to the details shown on the approved plans. Specific material and installation specifications for riprap and boulders shall be adhered to and can be found in MHFD's Construction Specifications, available at www.mhfd.org.

Filter cloth, stabilization material, or riprap shall not be placed on frozen ground.

623.08 Testing

623.08.01 Pipe – Water Tightness

All pipes shall be tested for water tightness in accordance with the manufacturer's requirements.

1. Reinforced concrete pipe (RCP) shall be tested in accordance with ASTM C443.
2. High density polyethylene pipe (HDPE) shall be tested in accordance with ASTM D3212.
3. Polyvinyl chloride pipe (PVC) shall be tested in accordance with ASTM D3212.
4. Spiral-ribbed aluminized steel pipe (CMP, ASP) does not require water tight joints.
5. Polypropylene pipe (PP) shall be tested in accordance with ASTM F477

623.08.02 Pipe – Deflection

All flexible pipe shall be tested for deflection in accordance with Section 524.03 - Deflection Testing Pipe of these Standards and Specifications.

623.08.03 Maintenance Holes

All maintenance holes shall be tested in accordance with Section 524.02 - Vacuum Testing maintenance holes of these Standards and Specifications.

623.08.04 Infiltration and Exfiltration

If deemed necessary by the Project Engineer, the storm sewer system shall be tested in accordance with Section 524.04 - Infiltration and Exfiltration Testing of these Standards and Specifications.

624.00 Inspections

Refer to Section 188.00 - Inspections of these Standards and Specifications.

Adequate inspections assure compliance to Arvada requirements and are the basis for Arvada's recommendation that said improvements be accepted for maintenance and for release of performance guarantees. It is the responsibility of the Contractor to contact the Municipal Inspector a minimum of one (1) full working day (twenty-four [24] hours) in advance of the required inspections. Required inspections shall include:

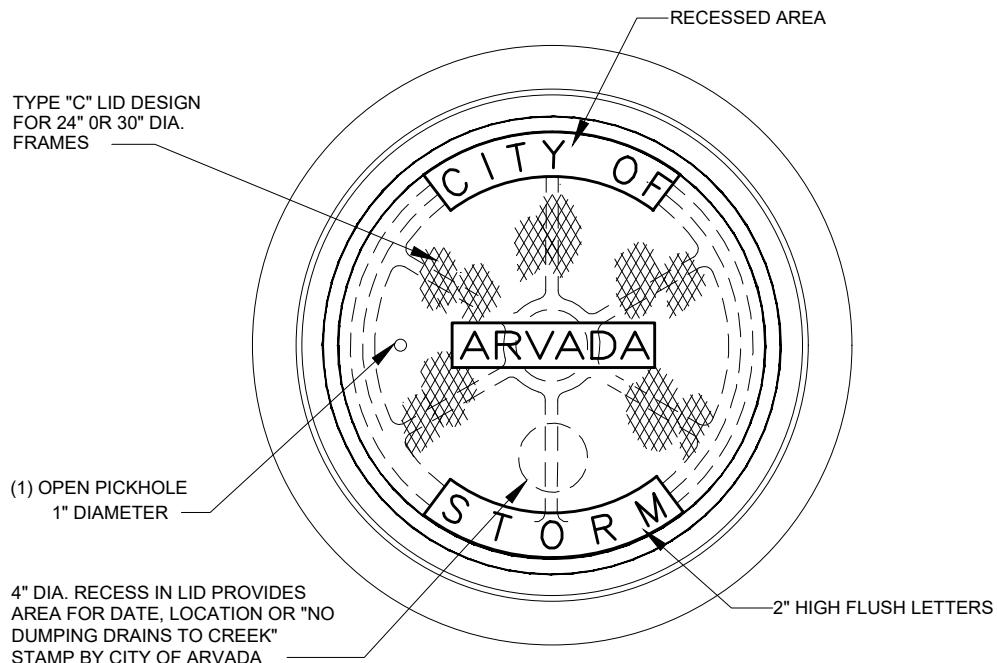
1. Stockpiled Materials – Verify that materials meet Standards and Specifications and approved submittals, including but not limited to: bedding material, pipe, fittings, valves, valve boxes, and fire hydrants. Verify that pipe meets roundness specifications and that bells and spigots are not cracked or chipped.
2. Excavation – Verify proper trench depths, shoring, spoil pile location, dewatering, and location and protection of existing utilities.
3. Installation – Verify proper bedding depth, alignment and grade, clean pipe and lubricants. Verify “slicing in” of bedding at haunches and that all lifting holes in RCP are plugged.
4. Backfill and Compaction – Verify proper methods of backfill and compaction, depths of lifts, moisture control, backfill material free of large rock and organic or frozen material, and proper compaction effort and passing tests.
5. Testing – Verify that testing methods comply with these Standards and Specifications.
6. Storm Drainage Facilities – Verify that all storm drainage facilities including, but not limited to, detention basins, retention basins, constructed wetlands, Low Impact Development (LID) and underground detention facilities are constructed in accordance with the approved construction drawings. LID and underground detention facilities

must be inspected at specific intervals to ensure all components of the facilities are installed correctly as determined by the City Engineer.

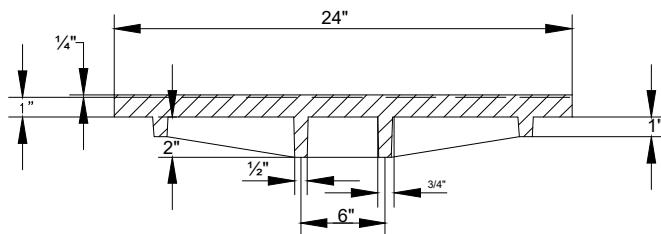
625.00 Operations and Maintenance Requirements

An important part of all Stormwater Quality Facilities is the continued maintenance of the facilities to ensure that they will function as designed. Maintenance is necessary to preclude the facility from becoming unhealthy and to retain its effectiveness. Sediment and debris must be periodically removed from channels, storm sewers, and stormwater quality facilities. Trash racks and street inlets must be regularly cleared of debris to maintain system capacity. Channel bank erosion, damage to drop structures, crushing of pipe inlets and outlets, and general deterioration of the facilities must be repaired in order to avoid reduced conveyance capacity, unsightliness, and ultimate failure.

Maintenance of stormwater quality facilities and infrastructure shall be outlined as an appendix to the Drainage Report and shall contain a detailed outline of the recommended care schedule of any stormwater quality facility for the site. In addition, an Operations and Maintenance (O&M) Manual will be required as a separate document to be given to the responsible party for maintenance.

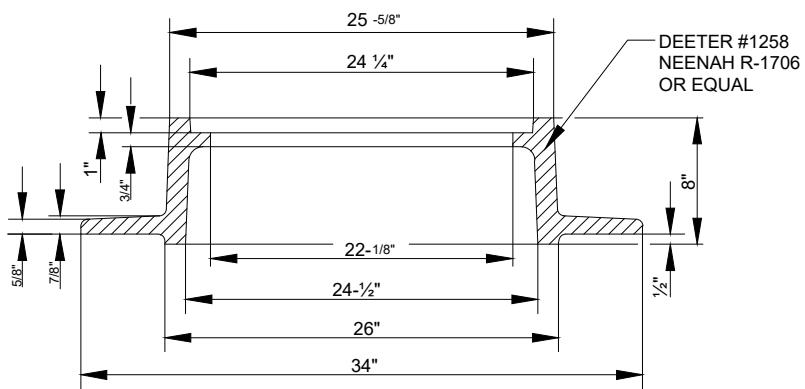


PLAN VIEW FRAME AND LID



LID SECTION

NOTE:
4" AND 6" SET RINGS
ALL THE SAME DIMENSION
EXCEPT HEIGHT.



NOTE:
30" DIAMETER FRAME
(NOT SHOWN) SHALL
BE DEETER #1197
OR NEENAH R-1798
OR EQUAL.

NO	DATE	REVISION
1	2023	2023 REVISIONS



8101 Ralston Road
Arvada, Colorado 80002

STORM MAINTENANCE HOLE
FRAME AND LID DETAIL

2022 ENGINEERING STANDARDS & SPECIFICATIONS

SECTION 700 – ROADWAY AND PARKING LOT DESIGN, TRAFFIC CONTROL DEVICES AND STREET LIGHTING

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SECTION 700 – ROADWAY AND PARKING LOT DESIGN, TRAFFIC CONTROL DEVICES AND STREET LIGHTING

701.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

710.00 Scope

New and redevelopments shall provide a Traffic Analysis Report that complies with Section 160.00 - Engineering Reports of these Standards and Specifications. All requirements of the City's Land Development Code, Zoning Ordinances and other applicable Titles of the City's Municipal Code and the City's Comprehensive Plan shall be met. Roadway design and ROW modifications shall conform to the latest edition of PROWAG: Accessibility Guidelines, AASHTO: A Policy on Geometric Design of Highways and Streets, AASHTO: Roadside Design Guide, these Standards and Specifications, and any other requirements determined by the City. If these standards are inconsistent with one another, or with other listed guidelines the more restrictive provision will control.

The design and installation of traffic control devices and street lighting shall comply with these Standards and Specifications, all applicable portions of the latest edition of the CDOT Standard Specifications for Road and Bridge Construction and the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD), and any other requirements determined by the Traffic Engineer. If these standards are inconsistent with one another, or with other listed guidelines the more restrictive provision will control.

Prior to the installation of any traffic control devices, the Traffic Control Device Plan and associated submittals shall be approved by the Traffic Engineer and all underground utilities shall be located. All traffic control devices shall be installed and maintained by the Developer or Contractor through the warranty period, unless otherwise stated in the Development Agreement.

710.01 Roadway Inspections

Refer to Section 188.00 - Inspections and Section 931.00 - Roadway Inspections of these Standards and Specifications for required inspections during roadway construction.

720.00 Roadway Design

721.00 Street Design Criteria

Roadway classification is based on the role a street fulfills within the street and highway system while accommodating twenty (20) year forecasts of the future traffic average daily trips (ADT). For further information on functional classification and ADT see the City's Comprehensive Plan and the Street Design Criteria Table below. Typical street sections shall conform to the City's Land Development Code, Comprehensive Plan, and Typical street sections as shown in the Detail Drawings found in these Standards and Specifications. Collector and arterial streets shall be constructed along the general alignment shown in the Comprehensive Plan, and whenever a traffic engineering analysis of the future traffic volumes indicates the need for a collector or arterial typical section.

Additional ROW may be required to satisfy other criteria contained in these Standards and Specifications. Areas outside the typical section shall be contour graded, compacted, and sloped, as required for proper drainage, soil stability, and maintenance accessibility. Cut and fill slopes steeper than four horizontal to vertical (4:1) shall require supporting calculations provided by the Project Geotechnical Engineer based on a soils analysis.

All raised roadway medians shall be at least four (4) feet wide from back of curb to back of curb. The Project Engineer may require or allow modifications to the typical street sections on a case-by-case basis due to factors such as surrounding land use, access, or right-of-way constraints. Street design criteria for various street classifications are listed in the table below:

Street Design Criteria

Design Element	Arterial Parkway	Major Collector	Collector	Minor Collector	Local
ADT	>15,000	< 15,000	< 8,000	< 3,000	< 1,000
ROW Width ¹	121'	86'	71'	78'	64'
Roadway Width (Flowline to Flowline) ¹	72'	53'	40'	46'	34'
Total Through Lanes	4	2	2	2	2
Travel Lanes width	12'	11'	11'	10'	---
Bike Lanes width ²	5'	5'	5'	6'	---
Raised Median	17'	8'	---	---	---
Curb & Gutter	6" Vertical with 2' Gutter			Mountable w/ 2' gutter	
Plant Strip/Amenity Zone ³	8'	8'	8'	8'	8'
Sidewalk Width ³	7'	7'	6'	6'	5'
Flow Line Curb Radius	35' min	35' min	25' min	25' min	20' min
Design Speed	45 mph	45 mph	40 mph	35 mph	30 mph
Typical Posted Speed Limit ⁴	40-45 mph	40 mph	30-40 mph	30-35 mph	25 mph
Cross Slope without Super Elevation	2%				
Super Elevation Max.	4%	4%	4%	Not Allowed	Not Allowed
Min. Horizontal Curve ⁵ (4% Superelevation)	711'R	711'R	533'R	---	---
Min. Horizontal Curve ⁵ (Normal Crown)	1039'R	1039'R	762'R	510'R	333'R
Max. Street Grade	6%	7%	7%	7%	7%
Min. Street Grade	2.0%				
Max. Grade at Intersection	2% for 300'	3% for 300'	4% for 150'	4% for 100'	4% for 100'
Tangents Between Horizontal and Vertical Curves	150' min	100' min	100' min	N/A	N/A

¹ Minimum width. Width may increase with parking, accel, decel and turn lanes.

² Width does not include buffer or separation. See typical sections for more information.

³ The Project Engineer may modify the required width and location to accommodate a range of designs.

⁴ Typically posted speed is minimum 5 mph under design speed

⁵ Centerline

721.01 Horizontal Alignment

Streets shall generally be aligned to bear a reasonable relationship to topography. Horizontal curves shall conform to the Street Design Criteria table. Minimum spacing between intersection centerlines shall be as follows:

Intersection Centerline Spacing

Street Type	Spacing
Local	150'
Collector	400'
Arterial Parkway	600'

Streets with offset intersections shall have a minimum separation of one hundred and twenty-five (125) feet from centerline to centerline of the streets or shall be aligned with existing intersections. Where a curve radius of three hundred and thirty-three (333') feet, for through local streets, cannot be achieved, a seventy-five (75) foot curve radius with a bulb on the outside of the curve may be allowed. Refer to Detail Drawings. Curve radii noted in the Street Design Criteria table are permitted only where sufficient sight distance to an intersection is provided.

Streets shall intersect or connect to other streets as closely as possible to right angles but shall not deviate more than thirty (30) degrees from a right angle. Horizontal and vertical alignment and ROW limits shall be coordinated to not obstruct sight distance at intersections, in accordance with the Detail Drawings found in these Standards and Specifications. Curb return radii shall be as shown on the Street Design Criteria table. Where two different street types connect, the larger curb return radius shall apply. In cases of skewed intersections the curb return radius shall be large enough to accommodate an appropriate design vehicle of the Project Engineer's choosing.

721.02 Vertical Alignment

Street centerline profile grades shall be as shown in the Street Design Criteria table. Where a street is curved and minimum profile grade is desired, the centerline grade shall be adjusted so that the curbline grade on the outside of the radius shall be no less than the minimum street grade specified on the Street Design Criteria table.

Centerline profile grades shall not exceed four percent (4%) for a distance of at least one hundred (100) feet to either side of an intersecting centerline. Gutter flowline grades shall be no less than

one percent (1.0%) along curb returns, in cul-de-sacs and bulb areas, and other areas where gutter flowline grades do not directly parallel centerline profile grades.

The minimum K values for crest and sag vertical curves shall be in accordance with the following table:

MINIMUM 'K' VALUE FOR CREST AND SAG VERTICAL CURVES

Design Speed (MPH)	Minimum K Value	
	Crest	Sag
15	3	10
20	7	17
25	12	26
30	19	37
35	29	49
40	44	64
45	61	79
50	84	96
55	114	115

721.03 Major Structures

Major structures, such as retaining walls, box culverts and bridges, that are appurtenant to proposed street and/or parking lot construction, shall conform to the structural design and loading requirements of the CDOT Standard Specifications for Road and Bridge Construction and the geometric and drainage requirements of these Standards and Specifications. Plans and supporting calculations for major structures shall be prepared by a Colorado Registered Professional Engineer.

721.04 Traffic Barriers and Guardrail

Traffic barriers including guardrail shall conform to the guidelines of the CDOT Standard Specifications for Road and Bridge Construction.

721.05 Design Element Coordination

Horizontal and vertical alignment continuity shall be provided between new and existing streets to achieve safe and aesthetically pleasing transitions. Construction shall be staged to eliminate grade and alignment conflicts and unnecessary damage to existing or newly constructed

facilities. Street design and proposed construction shall be coordinated with drainage and utility facilities.

722.00 Fire Apparatus Access Roads and Emergency Access

Emergency access roads shall have a minimum roadway clear width of twenty-four (24) feet. Where aerial access is required, the emergency access roads shall have a minimum roadway clear width of twenty-six (26) feet and provide the required setbacks per the adopted fire code. Where an entire residential development has approved fire sprinkler systems installed, the minimum clear roadway width shall be twenty (20) feet.

723.00 Half Streets

Where half streets are allowed, sufficient additional ROW shall be dedicated and additional width shall be constructed to allow sufficient paved width to accommodate two directions of traffic and parking fronting developing lots. If the full street section has bicycle lanes, sufficient additional ROW shall be dedicated and additional width shall be constructed to allow bicycle lanes in two directions.

724.00 Cul-de-sacs

Cul-de-sacs shall be in accordance with the Detail Drawings found in these Standards and Specifications and will only be allowed on Local Streets. Lengths of cul-de-sacs are recommended to be between one hundred forty (140) feet and five hundred (500) feet. Proposed cul-de-sac lengths that are not in this range shall be fully justified and based on the following considerations:

1. Intersection vehicular traffic capacity
2. Emergency vehicle response time
3. Pedestrian trip time to bus routes
4. Reduction of double travel distances for service and patrol vehicles
5. Utility systems, drainage, and open space access
6. Other requirements by Arvada
7. Emergency Access Locations
8. Presence of approved fire sprinkler systems in all structures

For cul-de-sacs between 501-750 feet in length, the clear roadway width shall be a minimum of twenty-six (26) feet wide. And where cul-de-sacs exceed seven hundred and fifty (750) feet in length special approval is required from the fire protection district.

Surface drainage shall be directed toward the intersecting street, or if this is not reasonably practical, a drainage structure and easement shall be provided at the end of the cul-de-sac. Specially designed temporary cul-de-sacs may be allowed when approved by the Project Engineer and fire district.

725.00 Parking Lots and Private Street Systems

Private street systems and parking lots shall conform to Arvada Land Development Code, Municipal Code, ADA/Prowag, Fire Code, and all other applicable criteria.

726.00 Intersections

Intersections shall be designed to provide for the safety of motorists, pedestrians, and bicyclists. At street intersections, property lines shall provide adequate ROW for curb ramps and utilities. Refer to the AASHTO Green Book and the Detail Drawings found in these Standards and Specifications.

727.00 Acceleration and Deceleration Lanes

Refer to the most recent Colorado State Highway Access Code for when auxiliary acceleration/deceleration may be required based on criteria for Non-Rural Arterials. Exact Classification to be determined in coordination with the Traffic Engineer.

When auxiliary acceleration/deceleration lanes are necessary, the most recent Colorado State Highway Access Code shall be used for design specifications.

Deceleration or acceleration lanes may be required for unique factors such as high speeds, traffic density, access volume, truck usage, sight distance, and other features that create operational or safety reasons as determined by the Traffic Engineer.

728.00 Pavement Design

The design methodology provided in this section is based upon the 1993 American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures, the Metropolitan Government Pavement Engineers Council (MGPEC) Pavement Design Standards (latest edition), and the Colorado Department of Transportation (CDOT) Roadway Design Manual (latest edition). The design methodology in this section is prescriptive in nature and represents the minimum requirements of a pavement design for the City.

728.01 Pavement Design – General

A geotechnical investigation and pavement design report is required for all new paved roadways and fire lanes as well as for reconstruction or modification of existing paved roadways and fire lanes. All subgrade investigations and pavement designs shall be completed by or under the supervision of and signed by a Professional Engineer registered in the State of Colorado.

As outlined in the MGPEC Standards Sections 1.4 through 1.6 these Standards are intended to provide a pavement design based on actual subgrade soil conditions prior to paving. As a result, these Standards should be used in a prescriptive manner to prepare a Pavement Design to be submitted to the City for approval. This Pavement Design would be considered a final document, and upon approval would be used for the construction of subject roadways. Preliminary designs are typically used only for division budgeting and planning purposes and are typically not submitted for approval beyond the initial development or subdivision process. Such a design should be clearly labeled as "Preliminary". A preliminary design should be performed based on the subgrade soil types most likely to be encountered at rough grade following grading and installation of underground utilities. Preliminary designs should always include the stipulation that a final Pavement Design or Design Confirmation Report shall be conducted in accordance with these Standards once the subject roadways are at rough grade.

A Design Confirmation Report should be prepared and submitted by the Design Engineer where a final Pavement Design Report cannot be prepared. The Design Confirmation Report should include sufficient soil sampling, field and laboratory testing, compaction reports for embankment materials placed, etc. to confirm the preliminary design is appropriate for the actual subgrade materials.

728.02 Field Exploration

The field investigation shall consist of borings or other suitable methods of sampling subgrade soils to a depth of at least five (5) feet below proposed subgrade elevation (ten -10- feet below proposed subgrade on arterial roadways), at spacings of not more than two-hundred fifty (250) feet unless otherwise accepted by the Project Engineer. Additional borings should be made to investigate anomalous conditions such as drainages, soft spots, areas of existing pavement distress, etc. Every fourth hole shall be at least ten (10) feet deep. Where the length of the proposed new street is less than two-hundred fifty (250) feet, two borings shall be made. Soil samples shall be sampled using a "California" type sampler (or "split-spoon" or equal) for disturbed samples. The boring logs generated during geotechnical explorations should record the blows/foot, boring number, and sample description. The sampler device used shall be noted in the boring logs. A representative bulk sample of the upper five (5) feet of the subgrade shall be taken from each boring. Boring logs shall include a description of soil types encountered, samples taken, blow counts, moisture conditions, free water and anomalous conditions.

If a preliminary report was previously prepared for the project, a Design Confirmation Report should be prepared and submitted for review. The exploration for the Design Confirmation Report should include:

1. Sampling to provide one subgrade sample for each two-hundred fifty (250) linear feet along the alignment.
2. Samples of the subgrade soils, using a "California" type sampler, with liners (either drive samples obtained by drill rig or utilizing a hand sampler) that are representative of any embankment material or moisture treated subgrade zone.
3. A description of soil types encountered, samples obtained, blow counts (if obtained), moisture conditions, free water and anomalous conditions.
4. Compaction Test Reports for any embankment materials placed.

728.03 Laboratory Testing

The purpose of the laboratory testing program is to classify subgrade material and determine support properties and movement potential. Testing for soil classification, soil swell/collapse, and subgrade support shall conform to the MGPEC Standards Section 3.1 except where noted below.

Soil Classification - All samples of the subgrade soils shall be tested to determine classification in accordance to AASHTO specifications and procedures. The minimum requirements are as follows:

Soil Classification Requirements

Soil Test, AASHTO Test Procedure	Test Frequency
Soil Classification, AASHTO M145	Each soil type in each boring
Natural Moisture, AASHTO T265	Two tests per boring
Density, AASHTO T204	Two tests per boring
Liquid Limit, AASHTO T89	One test per boring
Plastic Limit, AASHTO T90	One test per boring
Percent Passing No. 200, AASHTO T11 (fine grained soils only) or Gradation Analysis, AASHTO T27 (fine or coarse grained soils)	One test per boring
Sulfate Tests, AASHTO T290	1 test each 1,000 feet of roadway with a minimum of 2 per project

Swell Tests - 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" samples in general accordance with ASTM D4546, Method B under a surcharge load of two-hundred (200) psf. A minimum of one (1) test per two(2) borings shall be conducted on borings with soil groups other than A-1 through A-4.

Subgrade Support Testing - For the soil groups which govern the design (as determined in MGPEC Standards Section 3.1A) of the pavement system, subgrade support testing shall be performed in accordance with the following table for both Pavement Design or Design Confirmation Reports.

Type	Standard	Description
Laboratory R-Value	CP-L 3101	Resistance R-Value and Expansion Pressure of Compacted Soils or Aggregates by Means of Hveem Stabilometer

Laboratory CBR	ASTM D1883 – Samples should be run using soaked CBR as the default condition	
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728.04 Pavement Thickness Design

The design methodology is based upon the 1993 AASHTO Guide for Design of Pavement Structures equations and considers Traffic and Subgrade Resilient Modulus as the primary variables. Traffic loading requirements are presented in Section 728.04.01 of these Standards and Specifications. The Subgrade Resilient Modulus and swell/consolidation analysis shall be determined in accordance with Section 728.04.02. The design equations for flexible and rigid pavements are presented in Section 728.04.03 and 728.04.04, respectively. Alternatives will be considered with advances in pavement design methods and paving material changes. Any deviation from guidelines presented in this document must be technically justified and approved by the City.

728.04.01 Equivalent Single Axle Load (ESAL)

A primary factor in pavement design is the loading of traffic on the roadway. This is a combination of the volume of traffic and the weight of the vehicles on the street. This factor is described in terms of 18,000 pound Equivalent Single Axle Loads (ESAL)'s. The calculation of ESAL's is based on the following information:

1. ADT
2. Lane distribution
3. Truck volumes
4. Truck weights and axle configurations

Since this information is not always readily available for all streets, this manual provides minimum ESAL values for City street classifications. Calculated ESALs must be equal to or greater than the Minimum ESALs listed in table below. The intersections of Collector and Arterial streets shall increase the ESALs by a factor of 1.5. The Project Engineer may increase the minimum ESAL at any location, if, in their opinion, traffic conditions warrant.

Minimum ESAL Values

Location	Minimum Equivalent Single Axle Load (ESAL)
Arterial	2,200,000
Collector	1,500,000
Local or Private Street	73,000
Fire lane	73,000
Parking, Cars Only	36,500
Parking, All Others	73,000

Alternatively, pavement design can be completed using a roadway specific ESAL value. ESAL can be calculated using the technique described in the most recent CDOT M-E Pavement Design manual. The calculations, input data, and any assumptions must be reviewed and accepted by the City.

The pavement design procedure in this Section provides for a twenty (20) year service life of all pavements, given that normal maintenance is provided to keep roadway surface in an acceptable condition.

728.04.02 Subgrade Support Characterization

Subgrade support shall be determined as described in the MGPEC Pavement Design Standards (current edition) Section 4.2.

Swelling soils should be mitigated in accordance with MGPEC Section 4.2.B.

The depth of moisture treatment is described in MGPEC Section 4.2.B. Alternatively, the depth of moisture treatment may be determined using the “Effective Depth of Moisture Treatment” figure in the Colorado Department of Transportation Pavement Design Manual may be used in place of the Depth of Moisture Treatment table in this Section.

Subgrade soils can be stabilized in accordance with MGPEC Section 4.2.D.

728.04.03 Flexible Pavement Structural Section

Flexible Pavement Strength Coefficients – The table below contains the standard design coefficients for various pavement materials. Nonstandard design coefficients may be used only if approved in advance by the City. In addition, design values must be verified by predesign mix test data and supported by daily construction tests; or, redesign values will be required.

Strength Coefficients

Pavement Structure Component*	Strength Coefficients	(Limiting Test Criteria)
Plant Mix Seal Coat	.25	
Hot Bituminous Pavement	.44	
Existing Bituminous Pavement	.30 .24	(9-15 years) (>15 years)
Unbound Granular Base (Aggregate Base Course)	0.09 0.12	Soft Subgrade [$M_r < 5,000$ psi] Firm Subgrade [$M_r \geq 5,000$ psi]
Chemical Treated Subgrade (Including lime treated subgrade)	0.11 Higher strength coefficients may be justified per 2014 CDOT Pavement Manual, Section 3.5.	Assumes 160 psi - 7 day compressive strength
Cement Treated Aggregate Base	.23	(7 day, 640-1000 psi)
Mechanically Stabilized Base (MSB)	0.15	Assumes 6 inches to 12 inches of aggregate

*The combination of one or more of the following courses placed on a subgrade to support the traffic load and distribute it to the roadbed.

Flexible Pavement Design Equations and Inputs - Flexible pavements shall be designed using the 1993 AASHTO Design Equation presented below, or Pavement Design Software using this equation:

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2 - 1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where:

W_{18} = 18-kip equivalent single axle loads (ESALs) over design life
 Z_R = Standard normal deviate (function of the design reliability level)
 S_o = Overall standard deviation (function of overall design uncertainty)
SN = Structural Number
 ΔPSI = Serviceability loss at end of design life (P_o =initial- P_t =terminal)
 P_o = Initial serviceability; P_t = Terminal serviceability
 M_R = Subgrade resilient modulus (psi)

Values in the following table shall be inputted into the Design Equation or Pavement Design Software that uses that equation. Any variation shall be justified in the Pavement Design Report.

Flexible Pavement Design Inputs

Parameter	Input Values
Design Life	20 years
18k ESAL	See Section 729.04.02
Reliability Level (%), Refer to 1993 AASHTO for Z_r value	95% - Arterial 90% - Collector Streets 85% - Local Streets and Parking Lots
Overall Standard Deviation, S_o	0.44
Initial Serviceability, P_o	4.5
Terminal Serviceability, P_t	2.5 – Arterial and all Collector Streets 2.0 – Local Streets and Parking Lots
Subgrade Resilient Modulus	Refer to MGPEC Pavement Design Standards Section 4.2
Layer Strength Coefficients, a_i	See Strength Coefficients Table
Drainage Coefficient, m	1.0

Flexible Pavement Section Thickness Calculation - Flexible pavement section thickness shall be calculated based on the structural number determined using the 1993 AASHTO Design Equation, and the equation below:

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

Where:

SN = Structural number

a_1 = Strength coefficient of asphalt

a_2 = Strength coefficient aggregate base or chemically treated subgrade

a_3 = Strength coefficient subbase layers

D_1 = Depth of asphalt (inches)

D_2 = Depth of aggregate base or chemically treated subgrade (inches)

D_3 = Depth of subbase layers (inches)

m_2, m_3 = Drainage coefficient

728.04.04 Rigid Pavement Structural Section

Use of Rigid Pavements will only be allowed with written permission of the City Engineer. Use of rigid pavements is prohibited where underlying soils have a PI greater than ten (10). Design of rigid pavements shall conform to MGPEC Pavement Design Standards (current edition) Section 5.2

The design of rigid (Portland Cement Concrete – PCC) pavements is a function of structural quality of the subgrade soil (R-value or CBR), traffic (ESALs), and the strength of the concrete (working stress). In comparison to the strength of the concrete slab, the structural contributions of underlying layers to the capacity of the pavement are relatively insignificant. Therefore, the use of thick bases or subbases under concrete pavement to achieve greater structural capacity is considered to be uneconomical and will not be considered.

728.04.05 Minimum Pavement Sections

The following table provides the minimum acceptable pavement sections for public roadways in the City of Arvada. These pavement thicknesses may be used for preliminary planning purposes. Final pavement designs must be based on actual subgrade support test results. If the calculated pavement sections indicate sections thinner than the Minimum Pavement Sections shown in the table below, the Minimum Pavement Sections shall govern. The following table lists these minimum thicknesses for each roadway classification.

Minimum Pavement Sections

Classification	Minimum ESAL	Composite Section		Full Depth Hot Mix Asphalt (inches)	Portland Cement Concrete (inches)*
		Hot Mix Asphalt (inches)	Aggregate Base Course or Treated Subgrade (inches)		
Arterial	2,200,000	7.5	12.0	10.5	10.0
Collectors**	1,500,000	7.0	10.0	9.5	9.0
Local Street and Private Street	73,000	4.0	6.0	6.0	5.5
Fire Lane	73,000	4.0	6.0	6.0	5.5
Parking, Cars Only	36,500	4.0	6.0	5.5	5.0
Parking, All Others	73,000	4.0	6.0	6.0	5.5

*Rigid Pavement (Portland Cement Concrete) only permitted with permission of City Engineer.

**Includes Major Collectors, Collectors, and Minor Collectors

728.04.06 Alternate Pavement Designs

The City understands the need to consider emerging technologies in pavement design. In light of this, any alternate pavement design will be reviewed and considered with respect to the following criteria:

1. Initial construction cost
2. Life cycle cost
3. Construction delay and impact
4. Facility maintenance and ease of repair
5. Pavement noise, smoothness
6. Industry capacity and local contractor capability
7. Special design provisions such as edge drains behind the curbs to intercept moisture from adjoining development and prevent it from adversely affecting the road subgrade and paving section.

The City reserves the right to make the pavement type selection using these and/or other criteria on City funded projects.

Warm mix asphalt (WMA) may be allowed as an alternate asphalt mixture provided that all material requirements and specification standards are met and as approved by the Project Engineer.

728.05 Pavement Design Report Deliverables

Deliverables for Final Pavement Design Reports and Design Confirmation Reports shall be as described in the MGPEC Pavement Design Standards (current edition) 6.1 and 6.2 respectively.

729.00 Signage and Pavement Markings

730.00 Signs

730.01 Street Name Signs

Street name signs shall be furnished and installed by the Contractor or Developer and may be inspected by Arvada before and after installation. Street name signs shall have white letters on a blue background, consist of the standard Arvada logo, and shall comply with the following:

1. All signs shall be constructed with 0.080-inch aluminum blanks. They shall have three-eighths ($\frac{3}{8}$) inch holes punched in the center two (2) inches from the bottom and top edges, white diamond grade, retro-reflective sheeting, with blue Electro Cut film, retro-reflective letters or numbers.
2. The street name blank shall be nine (9) inches in height, with six (6) inch Series C upper case letters or numbers and three (3) inch FHWA Series C upper case prefix or suffix.
3. There shall be an adequate space to the left of the street name to provide for the placement of the City of Arvada logo. The logo shall be placed in the left face side of the sign and centered accordingly. Refer to details for specific spacing.
4. The length of the sign shall vary due to the length of the street name. FHWA Series B letters may be permitted to maintain the length of the street name sign.
5. Signs shall have a one-half ($\frac{1}{2}$) inch white diamond grade, retro-reflective border for non-signalized intersection signs, signs mounted to signal equipment shall have a one (1) inch diamond grade, retro-reflective border.
6. Silk-screened signs are acceptable if they are manufactured with diamond grade, retro-reflective sheeting and 3M "Scotchlite" Brand Process Colors transparent inks or equivalent. Signs fabricated with diamond grade sheeting with translucent 3M "EC" film or equivalent are also allowed.

7. At every cross intersection, two (2) street name signs shall be provided for each named street. At every tee intersection, one (1) street name sign shall be provided for each named street.
8. Signs manufactured with sheeting and letters placed back to back on the same sign blank are not permitted.

For sign installation, sign posts and support posts see Section 730.06 - Sign Installation and Section 731.00 - Sign Posts and Support Posts of these Standards and Specifications.

Prior to installing custom signs and/or posts in a development, the Developer or Contractor shall obtain a signed maintenance agreement with the Director of Public Works, and approved copies shall be sent to the Public Works Field Operations Superintendent.

730.02 Stop Signs and Yield Signs

Stop signs shall be installed at all approaches to streets designated by Arvada as through streets. Stop signs shall be mounted on the same support posts as street name signs where possible. All signs shall have white diamond grade, retro-reflective sheeting with red Electro Cut film and meet the MUTCD Conventional Road Dimension charts and the MUTCD Standard Highway Signs.

For sign installation, sign posts and support posts see Section 730.06 - Sign Installation and Section 731.00 - Sign Posts and Support Posts of these Standards and Specifications.

730.03 Other Signs

Regulatory, warning, guide, informational, and custom signs shall be installed at locations reviewed and approved by the City Traffic Engineer or designee. All signs shall have high intensity, retro-reflective sheeting and shall meet the MUTCD Conventional Road Dimension charts and the MUTCD Standard Highway Signs. School and pedestrian warning signs shall be fluorescent yellow/green with diamond grade, retro-reflective sheeting.

For sign installation, sign posts and support posts see Section 730.06 - Sign Installation and Section 731.00 - Sign Posts and Support Posts of these Standards and Specifications.

730.04 “No Parking” Signs

“No Parking” signs shall be installed at locations designated and/or approved by the Project Engineer or designee. All signs shall have high intensity, retro-reflective sheeting and shall meet the MUTCD Conventional Road Dimension charts and the MUTCD Standard Highway Signs.

Fire lane signs shall be provided in locations dictated by the adopted fire code for emergency access roads or as specified by the fire district, whichever is more restrictive.

For sign installation, sign posts and support posts see Section 730.06 - Sign Installation and Section 731.00 - Sign Posts and Support Posts of these Standards and Specifications.

730.05 Sign Dimensions

Signs shall be fabricated in accordance with the dimensions described on the MUTCD Conventional Road Dimension charts and the MUTCD Standard Highway Signs.

730.06 Sign Installation

Install per MUTCD Section 2A.20 and the CDOT Standard Specifications for Road and Bridge Construction.

All special mounting hardware shall be galvanized. All mounting nuts and bolts shall be steel and shall be five sixteenth inch (5/16") diameter x two and one half inch (2-1/2") respectively. Mounting washers shall be steel and shall be three eighths inch (3/8"). No rivets or other alternatives allowed for mounting of signs to posts.

731.00 Sign Posts and Support Posts

All sign supports and sign posts shall conform to specifications for perforated square steel tubing and to the latest ASTM A-569-72, Standard Specifications for Cold Rolled Carbon Steel, Commercial Quality. Tubing with plain finish, shall be roll-formed from twelve (12) gauge (.105 U.S.S Gauge) hot rolled steel, ASTM A1011 Grade 50 pickled and oiled. Tubing with galvanized finish shall be roll-formed from twelve (12) gauge (.105 U.S.S. Gauge) hot rolled steel, galvanized material ASTM A653 Grade 50. The average minimum yield strength after cold forming shall be 60,000 PSI. Posts shall conform to the following sign dimensions:

Sign Post Dimensions

Number of Signs	Sign Post Dimensions	Support Post Dimensions
1	1-3/4" x 1-3/4" x 8'	2" x 3'
2	1-3/4" x 1-3/4" x 10'	2" x 3'
3+	1-3/4" x 1-3/4" x 12'	2" x 3'

The finished members shall be straight and shall have a smooth, uniform finish. Consecutive sizes of tubes shall freely telescope with a minimum amount of play. All holes and cut-off ends

shall be free of burrs. Seven-sixteenth (7/16) inch diameter holes shall be punched on one (1) inch centers on the entire length of all sides of the tube. All posts shall be galvanized.

732.00 Pavement Markings

The Contractor shall submit a Striping and Pavement Marking Plan to the Traffic Engineer for approval. The Striping and Pavement Marking Plan shall meet the requirements outlined in the MUTCD. All pavement markings in Table Typical Pavement Markings shall consist of preformed thermoplastic material conforming to Sections 713.12, 713.13, and 713.14 of the CDOT Standard Specifications for Road and Bridge Construction. No low VOC Solvent Paint, Epoxy or Tape shall be installed in the City's ROW. The Contractor is solely responsible for placement and maintenance of all necessary temporary and permanent pavement markings until Construction Acceptance into Warranty is issued.

Standard Pavement Marking Drawings

Drawing	Page
On Street Bike Lane with No Parking	TR-2
Bike Lane and Arrow Symbol	TR-3
On Street Bike Lane with Parking Lane	TR-4
On Street Bike Lanes with Auxiliary Lanes	TR-5
Shared Bike lane Symbol	TR-6
On Street Shared Bike Lane Sharrows - No Parking	TR-7
On Street Shared Bike Lane with Parking Lane and Sharrows	TR-8
Crosswalks	TR-9
Railroad Grade Crossing Pavement Markings	TR-10

All temporary pavement markings shall comply with Section 627 of the CDOT Standard Specifications for Road and Bridge Construction.

732.01 General

Pavement marking materials and construction shall comply with Sections 627, 713.12, 713.13, and 713.14 of the CDOT Standard Specifications for Road and Bridge Construction, and the approved plans. Placement shall comply with the MUTCD, the CDOT M&S Standards and the manufacturer's recommendations. All pavement markings shall be 0.125 mil thick.

732.02 Typical Pavement Marking

Typical Pavement Markings

Double Yellow Line	4" with a 4" separation gap (4-4-4)
Median Yellow Line	4"
Yellow Passing Line	4" X 10' gap spaced 30' (ft)
White Turn Pockets	6"
Decel. or Accel. Lane	6"
White Skip Lines	4" X 10' gap spaced 30'
White Edge Line	4", 6" for bike lanes
White 45° Diagonal Hatch Line	8" at 15' spacing

732.03 Typical Crosswalks and Stop Bars on Minor Roadways

1. When no center road lines are present, center a crosswalk bar on the road and space every next bar four (4) feet apart towards the gutter edge.
2. Align crosswalks to pedestrian ramps.
3. Keep crosswalk bars parallel to the traveling lane lines even if the crosswalk is skewed.

Typical Crosswalks and Stop Bars on Minor Roadways

Crosswalk Bars	2' x 8'
Stop Bars	12" from center of road to edge of gutter

732.04 Crosswalks and Stop Bars on Major Roadways

1. Center crosswalk bars on designated travel lane markings of the road and place bars parallel and next to the gutter. Then, space bars a minimum of four (4) feet apart as necessary. Crosswalk bars shall not be placed in the wheel paths of travel lanes.
2. Align crosswalk bars to pedestrian ramps.
3. Keep crosswalk bars parallel to the traveling lane lines even if the crosswalk is skewed.

Crosswalks and Stop Bars on Major Roadways

Crosswalk Bars	2' x 8'
Stop Bars	24" from travel center yellow to edge of gutter

732.05 Surface Preparation

A general cleaning of the pavement surface is required prior to placing beaded preformed thermoplastic materials. The cleaning shall remove oil, dirt, dust, grease, and other foreign materials. It is recommended that new thermoplastic pavement markings be applied immediately after new asphalt has been placed, thereby reducing the necessary surface preparation and allowing the asphalt rollers to inlay preformed pavement marking material. If the roadway striping cannot be placed immediately following paving operations, then it is the sole responsibility of the Contractor to apply and maintain temporary pavement markings to sufficiently delineate travel lanes until permanent pavement markings can be placed. Pavement markings shall be placed within two (2) weeks of completion of paving operations, exceptions to be reviewed and approved by City Traffic Engineer.

732.05.01 Removal of Pavement Markings

Existing pavement markings shall be removed by water blasting (if approved) or grinding unless a new surface will be immediately applied (seal coat, chip seal, etc). In such instances, the existing pavement markings may be ground so that a flush surface is achieved for the seal coating.

732.06 Prior to Placement of Pavement Marking Materials

1. Control Points: Set control points to ensure compliance with the approved Striping Plan.
2. Conflicts: Verify that there are no conflicts between the approved Pavement Marking Plan and existing pavement markings.
3. Material: Verify the pavement marking materials to be installed.
4. Surface Preparation: Ensure the surface is cleaned and free of moisture, oil, dirt, dust, grease, and other foreign materials. Verify whether sandblasting or primer is required.
5. Temperature: Check that air temperature complies with the manufacturer's recommendations.
6. Signing Conflicts: Check for conflicts with signage.

732.07 Placement of Pavement Markings

During the placement of pavement markings, regular checks shall be performed to ensure that the surface is clean and dry. The Contractor shall regularly check pavement markings for good workmanship and straightness. When placing pavement markings, the following requirements apply:

1. Application Procedures: Application procedures shall comply with the manufacturer's recommendations and these Standards and Specifications.
2. Application Rate: Application rate of pavement marking materials shall comply with these Standards and Specifications.
3. Reflective Beads: Check that the application rate of reflective beads complies with specified requirements.
4. Protection: Traffic cones shall be used to prevent damage to new pavement markings.
5. Permanent Markings: Verify proper application of all permanent markings.
6. Conflicting Pavement Markings: Pavement markings shall not be conflicting or confusing.
7. Preformed Thermoplastic Pavement Markings: For the application of preformed pavement markings, consider the following:
 - a. Heating: Ensure that equipment provides proper heating and placement of material.
 - b. Existing Pavement: When placed on existing cold pavement, check for a clean, dry, and properly prepared surface. Verify if sandblasting is required. Ensure that primer, if required, has been properly applied. Check for appropriate splicing sequence.

740.00 Traffic Signals

741.00 Control of Work

The design criteria for all traffic signals shall be per the 2015 AASHTO "LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, First Edition", including interim revisions. An ultimately wind velocity of 130 MPH and a mean recurrence interval of seventeen-hundred (1,700) years and an effective performance tested mitigation device approved by the City allowing for a fatigue importance Category II shall be used for all designs. The fatigue loads shall be calculated on the requirements of Section 11 of the 2015 AASHTO "LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, First Edition", including interim revisions and the following conditions:

1. Natural wind gusts based on the yearly wind velocity of 11.2 MPH.

2. Truck-induced gust loads, as required by the owner of the structures.

An alternative traffic signal design without a mitigation device may be used if it meets the above mentioned criteria in addition to a Category III galloping-induced cyclic loads and a fatigue importance of Category III.

741.01 Regulations and Code

Traffic signal materials and installation shall comply with these Standards and Specifications. Items not referenced in these Standards and Specifications shall conform to the latest edition of the Colorado Department of Transportation “Standards and Specifications for Road and Bridge Construction” and the Manual on Uniform Traffic Control Devices. All electrical equipment shall comply with these Standards and Specifications. In addition to the requirements of the approved plans, standard special provisions and project special provisions, all material and work shall comply with the National Electrical Code (NEC), the National Electrical Manufacturers Association (NEMA), the Rules for Overhead Electrical Line Construction of the Public Utilities Commission, the Standards of the American Society for Testing Materials (ASTM), the American Standards Association (ASA) and all local ordinances and regulations that may apply.

741.02 Inspection

All material delivered to the site shall be subject to inspection—prior to or during installation—as deemed necessary by the City Inspector/Representative. The City Inspector/Representative may request samples of certain materials from the factory or warehouse for testing purposes prior to delivery on the site. Material which has been rejected by Arvada shall not be delivered to the work site, and any material rejected at the work site shall be immediately removed from the site. Failure by the City to note faulty material or workmanship during progress of the work shall not relieve the Contractor of the responsibility of removing and/or replacing faulty materials at the Contractor’s expense during the warranty period.

Any work within the public ROW shall require two (2) working days [forty-eight (48) hours] prior notice to Arvada by the Contractor or Developer.

Any new traffic signal, or modification of the existing traffic shall comply with the approved construction plans.

741.03 Traffic Control

Refer to Section 149.00 - Traffic Control, Barricades and Warning Signs of these Standards and Specifications.

741.04 Equipment List and Drawings

The Contractor shall submit a list of all materials and equipment proposed to be used in the work to the Traffic Engineer a minimum of five (5) working days prior to installation for approval. The submittal shall include all equipment and material as identified on the plans or in the specifications by the manufacturer's name which is necessary or customary in the trade to identify such equipment and material. The list shall include the name of manufacturer, size, material composition and catalog number of unit. Supplemental data, including detailed scaled drawings and wiring diagrams of any non-standard or special equipment, and any proposed deviation from the approved plans shall be submitted to the Traffic Engineer for approval.

The Contractor shall furnish all materials, equipment and labor needed to install and maintain temporary traffic signals during progress of the work. All intersections presently signalized shall be kept in operation until the new signal equipment is properly installed and ready for operation. If in the opinion of the Traffic Engineer, this is not possible because the installation of new equipment is in the same location as existing equipment, the Contractor shall not proceed with any work, which may cause the present equipment to become inoperative until all necessary replacement equipment is onsite.

Existing traffic signals shall remain operational until changing over and connecting new equipment. Signals shall be operational at the close of each day's work, over weekends, and during times when the Contractor is not working. When removal of a signal from operation is proposed, Arvada shall be notified in writing two (2) working days (forty-eight [48]) hours in advance.

741.05 Coordination with Other Agencies and Contractors

Refer to Section 144.00 - Permissions and Permits Required by Other Agencies of these Standards and Specifications.

741.06 Traffic Signal Start-Up Procedures

The Contractor shall deliver all new traffic signal cabinets and controllers to the City for inspections, testing and programming a minimum of fifteen (15) working days prior to installation. The Contractor is responsible to schedule delivery and pick-up of all equipment with

the Traffic Engineer. The City shall install all signal timings prior to the first turn on. The Contractor shall have a representative present at the first turn on.

742.00 Traffic Control Materials

742.01 Signal Heads

- A. All signal units shall be modular section type and shall be adjustable with respect to positioning and lens replacement. Heads shall be polycarbonate or approved equivalent, black in color and shall meet the requirements of the latest version of the ITE standards "Vehicle Traffic Control Signal Heads: Light Emitting Diode (LED) Circular Signal Supplement" and "Vehicle Traffic Control Signal Heads: Light Emitting Diode Arrow Traffic Signal Supplement". Unless otherwise indicated on the plans, all signal and pedestrian displays shall be City Traffic Engineer or designee approved LED type and shall conform to the appropriate sections below.
- B. Visors shall be detachable tunnel type, open at the bottom; be black in color on the outside and flat black on the inside.
- C. Lenses shall be in accordance with ITE Specifications.
- D. Sockets shall be fixed focus.
- E. Doors on the signal heads, for the installation of lamps or other maintenance, shall not require use of any tool whatsoever to be opened. Doors and lenses shall be equipped with neoprene weatherproof gaskets to insure against infiltration of moisture, road film, and dust. Each three color signal unit shall have the socket leads from all signal sections connected to a terminal board stamped with identifiable terminals. There shall be a terminal for color indication plus a common terminal where one lead from each socket shall terminate. The terminal board shall be mounted in the middle section and be properly insulated. All openings, top and bottom, shall be for one-half inch (1/2") pipe or pipe mounting brackets. Gaskets shall be supplied for top and bottom openings.
- F. Traffic signal heads shall be attached using standard ASTRO-BRAC assembly or approved equivalent. Side of pole signal heads shall be installed with banding blocks and ninety (90) degree elbows with nipple length determined by the size of the head so as not to interfere with closing doors.
- G. All pedestrian indications shall be countdown indication and LED. All heads shall be polycarbonate and black in color.

742.02 Back Plates

- A. Where shown on the plans, back plates shall be furnished and installed on signal faces. No background light shall show between the back plates and the signal face or between sections. All back plates are to be of aluminum construction, black in color, and shall be the louvered type. Back plates shall provide a five inch (5") border for all twelve inch (12") signal heads.
- B. Traffic signal heads requiring back plates shall be drilled for three-sixteenths inch diameter by one-half inch (3/16" x 1/2") pan head bolt with nut and lock washer. If the manufacturer fails to supply as described, it shall be the contractor's responsibility to do so. When installing back plates on the traffic signal head, the contractor shall furnish three-sixteenths inch (3/16") fender washers between bolt head and back plate.
- C. The manufacturer shall fabricate all back plates with a three-sixteenths inch (3/16") washer on both sides of each rivet which is used to hold each section of the back plate together.
- D. Back plates shall have two (2) inch yellow retro reflective border tape that outlines the outside edge of each back plate.

742.03 Traffic Signal Lamps

- A. LED indications shall be furnished for all signal indications unless defined otherwise in the standard drawings and shall include all circular (ball) and all arrow indications. Traffic LED indications shall meet the requirements of the latest version of the ITE Standards.
- B. Verification of LED adherence to ITE standards shall be through a 3rd party "Nationally Recognized Testing Laboratory (NRTL)" to demonstrate compliance to Section 6.3 (Production Tests & Inspections) of the latest ITE VTCSH Full Ball specification dated June 27th, 2005 (for LED ball modules), and ITE VTCSH Arrow specifications dated July 1st, 2007 (for LED arrow modules), and ITE PTCSI Pedestrian specification dated March 19th, 2004 (for LED pedestrian combo or countdown modules). Third Party lab must have NRTL status. Proof of certification must be documented. Proof of certification must be presented when requested by the City Traffic Engineer or designee.
- C. When incandescent bulbs are defined in the plans, traffic signal bulbs shall be as listed on the Approved Products List. They shall be one-hundred sixteen (116) watt, one-hundred thirty (130) volt for all twelve (12) inch indications. Bulbs shall be sixty-nine (69) watt, one-hundred thirty (130) volt, for all eight (8) inch indications.

D. All incandescent lamps shall have an 8,000 hour minimum rating.

E. If the manufacturer recommends a lower rating, the City of Arvada shall be advised of this recommendation and will have the option to decide which rating will be used.

F. Lenses shall be clear.

742.04 Electrical Cable

Electrical signal cables shall be fourteen (14) AWG multi conductor, stranded, copper wire manufactured to meet International Municipal Signal Association (IMSA) 19-1 specifications or approved equivalent. Each conductor in the cable shall be individually insulated and rated at six-hundred (600) volts. There shall be a minimum of four (4) and a maximum of nine (9) strands per conductor. There shall be a separate twenty-one (21) conductor cable installed from the controller cabinet to the bottom hand hole of each signal pole. From that point, a separate five (5) or seven (7) conductor cable for each overhead signal shall be spliced to the twenty-one (21) conductor cable. Outboard signal heads shall use seven (7) conductor cable to accommodate for present or future left turns.

742.05 Service Cable

Two (2) No. TRW 8, seven (7) strands, tinned, soft drawn copper wire, one sixteenth inch (1/16") neoprene insulation, black and white in color.

742.06 Detectors

A. Radar Detection: Stop bar detection shall be installed for all mainline approaches that have a protected left turn phase and all side street approaches, unless otherwise noted on the plans. Stop bar radar detection to be used shall be as listed on the Approved Products List. These units shall typically be mounted on the back of the opposing traffic's mast arm. Please contact Summit Traffic Solutions, the local vendor representative, for specific mounting locations at each intersection and for turn-on assistance and programming.

Advance detection shall be installed on any approach where the posted speed limit is forty (40) mph or above. Advance radar detection to be used shall be as listed on the Approved Products List. These units shall typically be mounted on the front of the approaching traffic's mast arm. Please contact Summit Traffic Solutions, the local vendor representative, for specific mounting locations at each intersection and for turn-on assistance and programming.

B. Inductive Loop Detection: This specification defines the minimum design operational and performance requirements for multiple channel, digital self-tuning inductive loop detectors. Detector units shall be card rack mounted plug in type and operate from an external twenty-four (24) VDC power supply. Detector units shall be in full compliance with the environmental and size requirements of NEMA standard TS1 Section 15 and meet the design, operation, electrical and functional performance requirements of both TS1 and TS2 specifications.

1. The front panel shall include an erasable, write-on channel identification area and clearly indicated switch operating position. I.D. area one (1) centimeter square per channel minimum.
2. All component parts and test points shall be clearly identified by permanent markings of circuit referenced on the P.C. Board. Integrated circuit devices having sixteen (16) or more leads shall be socket mounted to facilitate repair and maintenance of units.
Detectors supplied to this specification shall be warranted by the supplier to be free of defects in materials and workmanship for a period of five (5) years from date of shipment from manufacturer.
3. Each detector unit shall include two (2) or four (4) complete detector channels. Each channel shall sequentially energize its loop inputs to eliminate crosstalk (mutual coupling) between large, very closely spaced adjacent loops connected to the same unit. The sequential time sharing and digital processing of loop inductance data shall be accomplished on a single LSI microcircuit per unit for maximum reliability. The method of measuring shall be crystal reference digital period counting and multi-channel scanning. Only one channel input per unit shall be active at any point in time.
 - a. Sequential scanning shall fully prevent crosstalk between channels of a detector connected to closely spaced or overlapped loops for directional detection.
 - b. Sequential scanning shall allow two (2) detection channels to operate with full performance using a common home run cable.
 - c. Sequential scanning shall allow two (2) or more detection channels to be connected to a single detection amplifier with full operating performance, including separate mode and sensitivity selection capability on each channel.
4. Each channel of the sensor unit shall automatically self-tune to any loop and lead-in inductance from twenty (20) to twenty-five hundred (2500) microhenries within two (2)

seconds with full sensitivity after application or interruption of supply voltage. Units shall also track changes in loop/lead-in electrical characteristics, as might reasonably be expected to occur in undamaged loops, properly installed in sound pavements, without producing false indications or changes in sensitivity.

5. Each detector unit shall be provided with a loop test switch position to verify loop system integrity and reduce maintenance costs. The "open loop test" position shall indicate a previous fault via the front panel indicator. The memory shall remain intact and can be queried repeatedly. Existing detections shall not be reset and the memory shall only be reset by power interruption as by removing and reinserting the plug in detector units.

6. Each channel shall include a sixteen (16) position push type wheel switch to allow selection of eight (8) pulse sensitivities, seven (7) presence levels and a "Reset" and an "Off" position. Each detector unit shall include eight (8) sensitivity selections in 2:1 steps that can be correlated to the relationship of the number of turns of wire in a loop versus the sensitivity required to detect a specified vehicle. The selections shall be designed to allow detection of licensable vehicles in loops of two (2) or more turns electrically in series, parallel or series/parallel configuration in non-reinforced or reinforced pavements with lead-in/home run combinations from fifty (50) feet to 1,000 feet. The number of turns in a loop, electrical configuration of multiple loops and pavement type shall dictate the sensitivity required for proper predictable detection.

7. If specified, channel presence time shall be modified if delay or extension time is selected. The timing switch shall select delay or extension or "Off", if no timing is desired. Internal DIP switches shall provide for selection of "Delay" time of 0 to 31 seconds in 1.0 second increments and "Extension" time of 0 to 7.75 seconds in 0.25 second increments.

8. Presence indicators shall be wide angle, high brightness type LED suitable for sunlight visibility. When timing is selected and a channel is active that channel's indicator shall flash at four (4) Hz during Delay and at sixteen (16) Hz during Extension to indicate timing is in progress. Further, the timing shall be aborted when the vehicle is no longer present and/or the channel control input shall become inactive. The Delay timer shall be reset when a vehicle leaves the loop prior to time out and shall abort when the control input becomes inactive. The Extension timer shall operate and reset when a vehicle leaves the loop and be aborted when the control input becomes inactive. Each timer (Delay and Extension) shall be provided with buffer circuitry to enable or disable the timer, based on an external input (green gate) signal. The circuit shall be designed

for AC or DC input control on AC powered units and for DC control on DC powered units.

9. Each detector unit shall utilize a ΔL = (Delta L) thresholding technique to provide a more constant, predictable vehicle detection sensitivity with series added inductance, i.e., many loops connected in series and/or long lead-in/home runs will generally require the same sensitivity setting as would be required for a single loop with short lead in, to simplify setup.

10. Each channel shall automatically recover from intermittent opens or multiple shorts to ground. Each channel shall tolerate and continue to operate with no change with a single point short to ground on the loop or lead in system. Each channel shall provide a continuous, non-resettable (fail safe) output and indication in response to an open loop/open lead in system. The open loop indication and output shall not be resettable as long as the open exists, except that they shall be defeated when the channel "Off" position is selected.

11. Extended features shall include: Two (2) serial ports (front panel RS232 and Edge connector Xmit/Recve), TS1 and TS2 compatible from manual or software switch, microloop occupancy detection, traffic counting capable to include long-loop presence count from fifteen (15) minute to infinite intervals all accessible from either serial interface, Dual Detect and Fault LED indicators per channel, External inputs to control Timing functions and enable Remote Reset, Extended diagnostics, programming and Live status available via serial interface utilizing windows compatible software.

12. Loop Wire - Refer to Approved Products List. Loop wire shall consist of single conductor No. 14 stranded THHN with an outer protective sleeve.

13. Loop Lead-In Cable - Detector loop lead-in cable shall be a four (4) conductor 0.25 inch diameter, shielded and jacketed cable suitable for installation in a pavement saw slot, conduit or direct burial. Conductors shall be AWG No. 18 stranded copper with polypropylene insulation. The conductors shall be twisted at least six (6) turns per foot. Color rotation shall be black, red, white, green. The interior of the cable shall be filled with an amorphous material which prevents water penetration. Aluminized polyester shielding shall be applied around the conductors to prevent electromagnetic interference. The Cable jacket shall consist of black high density polyethylene. The jacket shall not be degraded by prolonged exposure to typical pavement runoff components. The cable shall be suitable for operation at temperatures of 60°C to +80°C. (Canoga 30003 43#18 AWG shielded loop detector lead in cable or approved equivalent.).

C. Emergency Vehicle Preemption: Emergency vehicle detectors for emergency vehicle preemption to be used shall be as listed on the Approved Products Lists. Placement of the Detectors shall be determined by the City Traffic Engineer or designee. Optical phase selector modules for emergency vehicle preemption to be used shall be as listed on the Approved Products Lists. The lead-in cable for the Emergency Vehicle Optical Detectors to be used shall be as listed on the Approved Products Lists.

742.07 Pedestrian Push-Button Station

A. General:

1. Pedestrian push button stations to be used shall be as listed on the Approved Products Lists. Pedestrian push buttons shall be ADA compliant accessible detectors and integral with the push button/push button sign station.
2. The button housing shall be black in color and shall include a 9" W x 12" H sign, MUTCD Reference # R10-3, or approved equivalent, and shall be installed as shown on the Standard Details.
3. Pedestrian push buttons shall be of tamper proof design.
4. The assembly shall be weatherproof.
5. The housing shall be shaped to fit the curvature of the pole to which it is attached to provide a rigid installation. Saddles shall be provided to make a neat fit when required.
6. Push-buttons shall be located in accordance with ADA specifications and the MUTCD.
7. Push button locators shall only be used where specified in the plans and project specials and may be considered by the City Traffic Engineer or designee on a per project basis. When push button locators are requested, this function shall be integrated as part of the pedestrian push button, the pedestrian push button shall be of the manufacturer and model number specified and shall conform to the MUTCD.
8. Audible tactile pedestrian indications shall only be used where specified in the plans and project specials and may be considered by the City Traffic Engineer or designee on a per project basis. When audible tactile pedestrian indications are requested, they shall be

per the Approved Products List and shall conform to the MUTCD. The system shall consist of a Central Control Unit and Pedestrian Push Button Stations, as described below, and hand held infrared devices, PC with USB A-B cable, or Ethernet connections to CCU2EN for programming the system settings. The System shall be manufactured by an ISO 9001:2008 registered company.

- B. Pedestrian Push-Button Cable: Two (2) conductor No. 14, seven (7) strands, tinned, soft drawn copper wire, one sixteenth inch (1/16") neoprene insulation. Conductors to be twisted. Color coded one (1) white and one (1) black.

742.08 Traffic Signal Poles, Pedestals and Mast Arms

Traffic signal poles, pedestals, and mast arms shall be of the general configuration shown on the standard drawings.

A. New Structures:

1. All new signal poles and mast arms shall be hot dipped galvanized according to ASTM standard A123.
2. All exterior surfaces shall be coated with a rust inhibitive Epoxy Polyamide Primer to a minimum dry film thickness of 5.0 mils on the bottom eight (8) feet and 3.0 mils on the remainder of the pole and mast arms. The top coat shall consist of one coat of a product listed on the Approved Products Lists to a minimum dry film thickness of 3.0 mils. The finish shall be Arvada Bronze in color, Valmont Specification F540DE.
3. Any surface areas damaged during handling or installation shall be repaired immediately with a spot coat of epoxy primer and a polyurethane finish as specified above. The paint manufacturer's application instructions shall be followed.

B. Existing Structures:

1. All designated previously installed signal poles and mast arms shall be field painted. All exterior surfaces shall be cleaned and examined for damaged paint, and any such damage shall be given a spot coat of primer and the entire exterior surface repainted. Previously painted surfaces whether finish or prime coats, shall be scuff sanded to yield 500 PSI of adhesion with particular attention paid to the lower eight feet (8') of the pole. Inspection of the poles prior to application of the finish coat is required.

2. A finish coat of a product listed on the Approved Products Lists shall be applied over the primer or previously painted surfaces. Two (2) coatings shall be applied leaving approximately six (6) mils of dry film. The color shall be a dark bronze formula which is available from the City Traffic Engineer or designee.
3. The painting shall be done in a neat and workmanlike manner and shall be applied either by hand brushing or spraying. The City Traffic Engineer or designee reserves the right to require the use of brushes for the application of paint if the work done by the paint spraying machine prove unsatisfactory or objectionable.
4. All designated traffic and pedestrian signal heads shall be painted flat black unless otherwise specified. Previously painted controller cabinets shall be painted white.

742.09 Controller Cabinet

A. General:

1. All controllers and auxiliary equipment shall be housed in a factory wired, weatherproof, metal cabinet following NEMA specification TS2 Type P. The cabinet shall have minimum interior dimensions, exclusive of stiffeners, shelf brackets, etc., of height forty-six (46) inches, width twenty-nine (29) inches, and depth fifteen (15) inches.
2. The cabinet shall be constructed of 0.125 minimum thickness bare aluminum. Cabinets shall be braced internally or by folded seams in order to provide sufficient rigidity to withstand normal handling and transport to the field location without deforming.
3. The main door shall have a self-locking, keyed, tumbler lock with two (2) keys. Hinges shall be mounted on the cabinet in such a way that interchangeability of doors is possible between cabinets of like size and manufacturer. Hinge pins shall be stainless steel. Doors shall have neoprene gaskets of sufficient thickness to provide a rain tight and dust tight seal.
4. A police or auxiliary door shall be provided. It shall be constructed so that no sharp edges protrude from the main door and shall provide access to panel with labeled switches for automatic to flashing operation and signal power on/off.
5. The cabinet shall be equipped with a thermostatically controlled ball bearing fan with a capability of at least one-hundred (100) cubic feet per minute. The fan shall be

mounted in a weatherproof housing attached to the top of the cabinet. The thermostat shall be adjustable to turn on between ninety (90°) Fahrenheit and one-hundred fifty (150°) Fahrenheit and be so mounted as to be easily accessible for adjustment from the front of the cabinet. Cabinet shall have internally mounted fluorescent tube light and one gooseneck incandescent light.

6. The cabinet shall have two shelves each capable of supporting seventy-five (75) pounds. Shelves shall be supported on brackets which provide for height adjustments. Each cabinet shall contain a ten (10) mil thick plastic envelope with side opening. It shall be a minimum size of 10" x 12" and be attached to the door by screws.

7. Assembly Wiring All cabinet wiring shall be neatly arranged and laced or enclosed in plastic tubing. No harness or wire shall be attached to any shelf rack or other point where it may be damaged by movement of shelves or doors.

8. Terminal Facilities Terminal facilities (load bays) shall be firmly attached in a position not less than six (6) inches from the bottom of the cabinet so as to provide easy access and maximum convenience to the user.

9. Side mounted auxiliary panels shall be firmly installed with the forward edge not more than four (4) inches from the door sill and not less than six (6) inches from the bottom of the cabinet in all cabinets.

10. The load bay and its associated equipment, harness, switches, etc., shall be grouped on removable panels. Each panel or group of receptacles and connecting cables shall be arranged to permit so that work can be performed on panel backs or cables.

11. A load switch bay and flash transfer capability is required for each phase. Load switches shall be provided for only the phases shown on the plans.

12. The load bay shall be protected by a main circuit breaker. A gas tube surge arrester with MOV and a suitable radio interference filter shall be supplied. The arrester shall be a three (3) electrode type with the following ratings:

- a. Impulse Breakdown: less than 1,000 volts in less than 0.1 microseconds at 10 KV per microsecond.
- b. Standby Current: less than one (1) milliampere
- c. Striking Voltage: greater than two-hundred twelve (212) VDC

- d. Energy Capability: capable of withstanding pulses of peak current each of which will rise in eight (8) microseconds and fall in twenty (20) microseconds to one half the peak voltage at three (3) minute intervals.
 - e. Peak Current Ratings shall be 20,000 amps. The MOV shall have ratings equal to or better than a General Electric type VI50LA20A. The RFI filter shall have a current rating equal to or greater than the main circuit breaker capacity.
13. Field terminals shall be screw type, capable of accommodating at least three (3) #12AWG wires. All terminals in the load bay shall be permanently identified by engraving, silk screening or contrasting plastic labels. Terminal blocks shall be the barrier type and no live parts shall extend above the barrier.
14. A convenience outlet with a ground fault interrupter fused at fifteen (15) amps shall be provided. It shall be located in a position which is convenient and safe for service personnel.
15. All AC power busses, switch or relay lugs and/or similar activity connection points which extend more than one and one-half inches (1-1/2") from the panel are to be protected by insulation for safety. The locations of these items shall provide reasonable protection for service personnel.
16. Signal power relays shall be mercury wetted, equal to or greater than circuit breaker capacity. Flash transfer relays shall be as manufactured by Midtex Model 136 62 T 3A1, 120 VAC, DPDT, 30 amp with Jones Plug base and dust cover or approved equivalent.
17. Flasher. The cabinet shall be equipped for flashing operation of signal lights with a two (2) circuit solid state flasher in accordance with the latest NEMA specifications (15 amps per circuit). Flashing operation shall be set for flashing yellow on all main street approaches and red on all other approaches. Pedestrian and turn signals shall be extinguished during flashing operation. The flashing mechanism shall remain in operation during shutdown or removal of controller.
18. Load Switches. The cabinet shall be equipped with solid state load switching assemblies in accordance with the latest NEMA specification. Each load switch to be equipped with a three (3) input LED indicator. Load switches shall contain three (3) separate cube type solid state relays, which use a solid state switch which is capable of operations at 240 VAC and 25 amps when properly heat synced but derated to ten (10) amps when used in load pack assembly.

19. Conflict Monitor/Malfunction Management Unit (MMU). The cabinet shall have provision for conflict prevention in accordance with the latest NEMA TS2 specification. Conflict prevention shall be provided by a conflicting display monitor unit that monitors all green, yellow and walk displays and detects absence of reds to cause flashing operation and stop timing if conflicting indications are detected. Removal of the monitor from the cabinet shall cause flashing operation.
20. Emergency Vehicle Preemption. The cabinet shall be equipped and wired with an Opticom Card rack mount for GTT Model. All equipment shall be capable of accommodating a minimum of two modules with capability of four channel operation.
21. Ground Wire - Single conductor, AWG No. 8, soft-drawn bare copper wire.

742.10 Controllers

A. General:

1. Compatibility: The local controller and cabinet shall be 100% compatible with the City of Arvada's existing computerized signal system which utilizes Econolite equipment. The local controller to be used shall be as listed on the Approved Products List.
2. An actuated controller shall be completely solid state, electronic device capable of selecting and timing traffic movements. It shall provide timing and load switch control for each major vehicular phase, including concurrent associated pedestrian movements. The controller shall conform to the latest NEMA and ATC specifications and shall provide for complete and full operation of eight (8) phases from within either a TS1 or TS2 Type P cabinet.
3. The controller shall have all electronic components easily accessible and arranged in functional groupings on the printed circuit boards. Printed circuit boards shall be designed to facilitate identification of components for maintenance purposes. Printed circuit design shall be of NEMA specification quality and designed so that components can be removed and replaced without permanent damage to the board or track.
4. Front-panel inputs shall be via touch screen or by clearly labeled elastomeric keypad. These shall use a ten (10) digit numerical keypad, Main and Sub keys, toggle keys, special function and enter keys, six function keys, status and help keys and a large, four (4) direction cursory control key.

5. The display shall be a seven inch (7"), color, TFT (Thin Film Transistor) LCD (Liquid Crystal Display) with high brightness. It shall be readable in direct sunlight. The display shall perform over the NEMA temperature range and shall have a resolution of 800 X 480 with an eighteen (18) bit color depth. The luminous intensity shall be a minimum of eight-hundred (800) nits. The display shall include an industrial, resistive touch screen that can be operated with gloved hands. The touch screen and display shall not be affected by condensation or water drops.
6. All circuitry components shall be available on the open market and the original manufacturer's part number shall be shown on the part's list.
7. Overlap programming shall be provided through the keyboard. Protected-Permissive Left Turn, Flashing Yellow Arrow shall be an overlap programming choice.
8. An entry mode to any single phase parameter of a keyboard controller shall not affect any other parameter or the same parameter on another phase, unless programmed by specific keyboard instructions, such as, "copy" sequences or other prescribed methods of rapid program entry.
9. Every controller supplied shall be the manufacturer's latest, first line production model tested and delivered by a domestic manufacturer who is regularly engaged in the construction of such equipment.
10. Each controller shall be supplied with a complete set of operational and service manuals, wiring schematics and parts layout up to a maximum of ten (10) sets per order. Any controller for which these documents are not available is not a production model within the meaning of these specifications.
11. Each controller shall have a SD card slot.
12. Preemption. All actuated controllers shall be equipped to accommodate four (4) E.V.P. inputs and one (1) railroad preemption input. Controller software shall be capable of being updated, database copied, or logs from a USB memory stick or a SD card.
13. A Logic Processor shall be capable of testing inputs, outputs and timers. If true, it shall set inputs, outputs or other functions. The logic processor shall be programmed by the end user to accomplish unusual operations.

14. The controller shall offer Peer to Peer operation using the logic processor to test for conditions at neighboring intersections over Ethernet.
15. The controller shall offer sequence choices following preemption to service the longest queue, pedestrian movements interrupted, phases interrupted or free for one (1) cycle with special timing before returning to coordination.

B. Coordination Unit:

1. The coordination unit shall be an internal function within each local controller and shall meet, as a minimum, the following functional requirements.
2. The coordinator shall provide one-hundred twenty (120) patterns each consisting of a cycle length, splits in seconds or percentages and an offset in seconds or percentage.
3. Standard NEMA functions shall be used to control the intersection timing.
4. The coordinator shall be capable of changing the controller's phase sequence upon command.
5. The coordinator shall be capable of setting the intersection free by loss of system sync, cycle/offset false commands, free command and telemetry failure.
6. The coordination unit shall be capable of setting the intersection into a flashing operation in accordance with the *Manual on Uniform Traffic Control Devices for Streets and Highways*, latest edition.
7. The controller shall be capable to operate using an internal Ethernet or serial port.
8. Time base coordination mode shall be provided as a backup with all standard coordination features available. At least two (2) 7-day programs shall be available with fifty (50) additional holiday programs in the event of a master controller or communications failure. Time base standby mode shall be programmable for an entire year with automatic daylight savings and leap year changes.

742.11 Uninterrupted Power Supply (UPS)

A. General:

1. A UPS shall be incorporated in all new traffic signals and where otherwise specified in the plans and/or project specials. The UPS to be used shall be as listed on the Approved Products List.
2. The UPS shall be installed per manufacturer's specifications.
3. Programming software and manuals shall be supplied with each UPS and shall become the property of the City at the completion of the project.
4. A UPS shall include all labor, equipment, and materials necessary to install the UPS complete-in-place.

B. Operational Specifications:

1. Power Input/Output:

- a. Use 120VAC, 60Hz, single phase source input.
- b. Provide for input surge suppression.
- c. Output a single phase pure AC sine-wave regulated at 120VAC ($\pm 3\%$), 60 Hz.
- d. Be capable of operating in the voltage range of 85VAC to 135VAC without using the batteries.
- e. Be of double-conversion/true on-line design.

Double-Conversion/True On-Line: As a double-conversion/true on-line design, the UPS shall be in an “always on” condition such that it continuously monitors the input and provides continuous frequency and voltage regulation of the output. Upon loss of power, the UPS shall transfer to battery mode in 0ms. No transfer time shall be experienced when transitioning to/from full UPS operation.

- f. Be installed in series with the utility power such that the UPS powers the entire traffic signal cabinet and all associated equipment.

2. Temperature:

- a. -34.6 Degrees F to 165.2 Degrees F (-37 Degrees C to +74 Degrees C).
- b. Humidity – 10% to 90% non-condensing.

3. Run Time:

- a. Provide for full signal operation at an average of seven-hundred (700) Watts for a minimum of two (2) hours, with additional minimum flash time of two (2) hours.
- b. Provide for user definable full run time settings to define full run time prior to the UPS transitioning to flash operation.
- c. Provide for user definable battery level flash settings by which the user can change battery level flash settings.
- d. Remain in, or automatically transition to flash operation, when utility power fails and the UPS battery levels are below, or fall below, the user defined battery level settings.
- e. Restore the signal to full operation any time utility power is restored or power is supplied via the generator receptacle.
- f. Include a low battery cutout to prevent critical discharge of, and damage to, the UPS batteries.
- g. Provide a battery recharge of 95% within eight (8) hours.

4. Indications, Alarms, Faults:

- a. Provide a means by which the user can accurately check the battery charge level, and UPS load level.
- b. Provide indications which display the current condition of the UPS including the presence or absence of a critical UPS fault, and the presence or absence of utility power.
- c. Provide an automatic bypass switch by which the UPS unit is bypassed and runs off utility power if a critical internal UPS fault occurs.
- d. Provide a single dry contact relay output and alarm trigger with user definable trigger options to notify the owner of critical events and/or failures to include:
 - UPS critical fault
 - Loss of utility power input
 - Low battery condition

5. Switches, Ports, Receptacles, Controls:

- a. Provide Ethernet SNMP port for remote configuration and monitoring of the UPS via the traffic/transportation network.
- b. Provide a bypass switch by which the user can manually bypass the UPS and power the signal via utility power. This feature is to be used in the case of UPS failure and/or the need for UPS maintenance or repair services.

- c. Include a generator receptacle accessible via the exterior of the traffic and UPS cabinets.
 - d. Provide automatic sensing of generator power. The UPS shall be configured such that the UPS provides regulated 120VAC, 60Hz, single phase output power to run the signal in full operation and recharge the UPS batteries while under generator power. The UPS shall be configured to run the signal in full operation regardless of the UPS' battery charge level. The UPS unit shall automatically sense when generator power is applied, and when generator power fails. The UPS shall be configured such that it automatically reverts to generator power when generator power is applied. When generator power fails (generator power falls outside of acceptable signal tolerances), the UPS shall automatically revert to either utility power or UPS battery power respectively based upon the availability at the time.
 - e. Provide all required software and cabling for both networked remote and local UPS monitoring and management.
6. Hardware, Software, Cabling: All UPS units shall include all components, hardware, cabling, installation manuals, and software required for complete installation, operation, programming, monitoring, and maintenance of the UPS system.
7. Warranty: All proposed UPS equipment shall be warranted for a period of two (2) years by the manufacturer.

742.12 Aluminum Pedestal Mounts

Aluminum pedestal mounts (Type III) shall be either of two (2) types, as called for in the plans and specifications. Center mount with two (2) side ports, plain or offset mount serrated with one (1) side port.

742.13 Mast Arm Brackets

Mast arm brackets to be used shall be as listed on the Approved Products List and shall be installed ninety (90) degrees to the roadway.

742.14 Instructions and Wiring Diagrams

All equipment shall be provided with three (3) sets of complete installation instructions, including a complete chart of field connections as well as a manual for the controller, containing service instructions, wiring diagrams, trouble-shooting procedures, etc. Each and every

component used shall be clearly referenced in the service manual and its value, ratings and manufacturer part number shall be given.

742.15 Guarantee

The contractor shall include in his proposal all warranties and/or guarantees with respect to materials, parts, workmanship and performance of the product to be supplied. The minimum guarantee period for the product shall be two (2) year from the date of final acceptance of the contract. The contractor shall attach to the bid a statement that all material to be supplied is either in exact accordance with the specifications or shall list in detail any and all deviations therefrom. The supplying of equipment that is not in accordance with the specification and on which the contractor has indicated no exception shall be cause for rejection of the equipment and correction of the non-specification items entirely at the contractor's expense.

743.00 System Communications

743.01 Ethernet Managed Switch

A. An Ethernet Managed Switch shall be provided with all traffic signals. The Ethernet switch to be used shall be as listed on the Approved Products List.

B. An Ethernet Managed Switch shall include all equipment, and materials necessary to install the item complete-in-place, including, but not limited to, switch operating system, SFPs, hardened power supplies, power cords, CAT5e Ethernet cables, console serial cables, and single-mode fiber patch cords.

C. Unless otherwise specified, the contractor shall be responsible for proper programming, setup, and testing of the Ethernet Managed Switch. The City shall provide IP addresses to the contractor. At the City's discretion, the City may opt to have their maintenance contractor or other third party complete Ethernet Managed Switch, setup and/or testing. When the City's maintenance contractor or other third party is enlisted for programming, setup, and/or testing of the Ethernet Managed Switch, associated costs for the maintenance contractor or third party labor shall be the responsibility of the City.

743.02 Radio/Wireless Communications

When radios are specified in the project plans and/or specifications, and unless otherwise specified, radios to be used shall be as listed on the Approved Products List and shall include the radio, power supply, antenna, antenna surge/lightning suppressor, equipment mounts, and all associated cabling, connectors and strain relief hardware as required to support Ethernet

communications to the local traffic signal controller. All materials shall be as approved by the radio manufacturer.

A site survey with the local vendor representative shall be required during the design process and prior to installation to assure radio communication is functioning appropriately.

Unless otherwise specified, Yagi antennas shall be used. The antenna gain for each Yagi antenna shall be determined as a result of the wireless site survey.

When specified in the project plans and/or specifications, a wireless site survey shall be required and shall include both a site analysis and spectrum analysis to verify line-of-sight and define existing wireless link interference prior to installation. A wireless site survey report shall be issued to the City Traffic Engineer or designee following a wireless site survey and shall define installation requirements, including use of an antenna riser(s), and anticipated link signal loss.

Where use of antenna pole risers are specified or requested, antenna riser lengths shall be limited such that the riser extends no more than ten (10) feet beyond the top of the traffic signal pole or structure. Where additional height is required, written authorization shall first be required from the City's Traffic Engineer or designee.

While installation includes radio programming, the City may opt to have the radio turned over to them for programming prior to installation, returning the radio to the Contractor after programming for completion of field installation. Where the Contractor is to complete radio programming, the City Traffic Engineer or designee shall provide programming parameters as required.

When being directed by the City Traffic Engineer or designee, and prior to antenna installation, the City Traffic Engineer or designee shall define the structure on which to mount the antenna, the antenna orientation, and the direction in which to point the antenna.

743.03 Traffic Signal Interconnect Cable - Fiber Optic

A. General Fiber Specifications:

1. Unless otherwise noted, all traffic signal interconnect communications shall be accomplished through a fiber optic cable system.
2. Fiber optic cable shall be of the count and configuration specified in the Plans or supplemental documentation as provided by the City.

3. Fiber optic cable shall comply with the latest version of all industry standards designated herein, including all addendums and revisions. Applicable standards development organizations are expected to include, but are not limited to, Telcordia Technologies (formerly Bellcore), Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA), International Telecommunications Union (ITU), International Electrotechnical Commission (IEC), American Society for Testing and Materials (ASTM), Insulated Cable Engineers Association (ICEA), National Fire Protection Association (NFPA).
4. Fiber optic cable used for projects in the City of Arvada shall be new and unused, unless otherwise specified in the Plans or directed by the City Traffic Engineer or designee.
5. Fiber optic cable construction shall conform to the requirements of ICEA S-87-640 Optical Fiber Outside Plant Communications Cable and Telcordia GR-20 Generic Requirements for Optical Fiber and Optical Fiber Cable. The cable shall employ a non-armored, all-dielectric, loose tube design for outside plant installation with a single outer jacket and dry water blocking materials in the cable interstices and buffer tubes.
6. Fiber optic cable installation into a building shall conform to the requirements of Article 770 of NFPA 70 National Electrical Code (NEC).
7. All fibers in the fiber optic cable must be usable single mode optical fibers conforming to the requirements of ITU-T G.652D for zero water peak and low polarization mode dispersion. It shall also conform to the requirements of Telcordia GR-20.
8. All optical fibers shall be free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
9. Unless otherwise specified in the Plans or directed by the City Traffic Engineer or designee, no less than twenty-five (25) feet of fiber cable slack shall be neatly coiled within each pull box (non-splice location) included as part of the fiber optic cable run. Fifty (50) feet of fiber slack shall be coiled in all pull boxes designated as a splice location.

B. Fiber Specification Parameters:

1. Color Code: The individual colors for optical fibers and cable buffer tubes shall comply with the TIA-598 Optical Fiber Cable Color Coding standard.
 2. Central Strength Member: The central strength member functions as an anti-buckling element, and shall be a glass/epoxy composite dielectric rod. A polyethylene overcoat shall be applied to the central member to provide the proper spacing between buffer tubes during stranding.
3. Cable Buffer Tubes:
- a. Optical fibers are enclosed within buffer tubes that have a diameter several times larger than the diameter of the fibers. The optical fibers are loose within the buffer tubes allowing the fibers to move freely. The loose buffer tubes shall have a minimum 2.3 mm diameter depending on the number of fibers contained within each buffer tube.
 - b. Buffer tubes shall be constructed out of industry standard polybutylene terephthalate or similar thermoplastic polymer.
 - c. Each buffer tube shall contain twelve (12) fibers.
 - d. Filler rods may be included in the cable core to lend symmetry to the cable cross-section where needed.
 - e. The buffer tubes (and filler rods, if necessary) shall be stranded in a Reverse Oscillation Lay (ROL) technique around the central strength member to allow for easy mid-span access. The core of buffer tubes shall be wrapped with two counter helically applied threads to bind together the cable core.
 - f. Binders shall be applied with sufficient tension to secure the buffer tubes to the central strength member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.
 - g. Tensile strength shall be provided by high tensile strength aramid yarns, fiberglass yarns, or both.
 - h. Water blocking of the cable core interstices and inside the buffer tubes shall be accomplished via dry water blocking elements.
 - i. Each buffer tube shall be color coded with distinct and recognizable colors in accordance with EIA-359 Colors for Color Identification and Coding and TIA-598. Buffer tube coloring shall be stable during temperature cycling and shall not be subjected to fading or smearing onto each other or into the dry water blocking material in each buffer tube. Colorings shall not cause fibers to stick together.

4. Cable Outer Jacket Characteristics:

- a. All-Dielectric cables shall be sheathed with medium or heavy density polyethylene. The minimal nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and dry water blocking material. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
- b. The cable sheath shall be free of holes, splits, and blisters.
- c. For ease of outer jacket removal, a minimum of one clearly identifiable polyester ripcord shall be provided directly under the cable sheath.

5. Cable Outer Jacket Markings:

- a. For standard outer jackets, printed characters shall be indent printed with white characters for black jackets, and black characters for non-black jackets.
- b. The characters shall be of proper height and space to produce good legibility. A minimum character height of two (2) mm shall be required.
- c. The cable length shall be sequentially marked in “feet” at a minimum spacing of 1 meter intervals. The length intervals shall not be reset to zero on any length of the cable. The actual cable length must be within \pm 3% of the marked length.
- d. Each length of the cable shall be marked with manufacturer’s name, manufacturer’s part number, month and year cable was manufactured, fiber counts, fiber type, telephone handset symbol (as required by Section 350G of the National Electrical Safety Code) and manufacturer’s serial number.

6. Cable Packaging:

- a. The manufacturer shall supply the product using their standard reel sizes, methods, apparatus, and lagging. The Contractor shall order standard reel sizes specific to the project in an effort to minimize the introduction of passive attenuation due to unnecessary reel-to-reel cable splices. The minimum barrel diameter of the reel shall not be less than thirty (30) times the cable diameter.
- b. Reels are assumed to be in good working condition, firm, and able to support the product through shipping and final installation. Reels shall be clean, dry, and free of excessive dirt. All reels shall be checked for high nails, stave fit, and proper stenciling.
- c. Each wood reel shall be permanently marked with the manufacturer’s name, “OPTICAL CABLE”, an arrow with the words “CABLE END” to indicate the position of the outer cable end, an arrow with the words “ROLL THIS WAY” to

indicate the direction that the reel shall be rolled to prevent loosening, and reel number.

- d. Outer layers of the reel shall be covered with a protective wrap to limit the solar heating of the cable.
- e. Each end of the cable shall have end seals in order to prevent moisture ingress into the cable during shipping, storage, or installation.
- f. The top end of the cable shall be securely fastened to the inside of the reel flange to prevent the cable from becoming loose in transit or during handling. The bottom end, "Test Tail", shall be approximately three meters in length and easily accessible. The end shall be protected within a cable slot and be securely fastened to the outside of the reel flange with wire ties or walkout straps.
- g. Each cable shall have certified test data securely fastened to the reel in a waterproof wrapping. The certified test data shall include the following information:

- Cable Number
- Date
- Customer Name
- Ordered Length
- Customer Order Number
- Ship Length
- Customer Cable Code
- Customer Reel Number
- Customer Attenuation Specifications
- Final Attenuation Inspection Test Report for Each

Fiber:

- Number of Fibers
- Type of Fibers
- Cable Construction
- Authorized Signature

- h. Each cable shall have a reel tag securely fastened to the reel in a waterproof wrapping. The reel tag (Cut Length Data Sheet) shall include the following information:

- Cable Number
- Date
- Customer Name
- Ordered Length

- Customer Order Number
- Ship Length
- Customer Cable Code
- Customer Reel Number
- Customer Attenuation Specifications
- Number of Fibers
- Beginning and Ending Sequential Length Markings
- Gross Weight
- Net Weight
- Inspected By Signature

743.04 Fiber Optic Splicing and Terminations

A. Description:

This work consists of furnishing and installing hardware used to splice and terminate single mode fiber optic cable. All fiber optic industry standards referenced herein shall be the current, adopted version that is active, including all amendments, changes and revisions noted by its respective standards development organization.

B. Materials:

1. Fiber optic splice closures shall utilize a dome closure design with an end plate system that allows independent access to each cable port without disruption to the surrounding cables. For backbone-to-lateral splices and backbone-to-backbone splices, the fiber optic splice closure shall not exceed nine (9) inches in diameter by eighteen (18) inches in length. The closure shall be able to accommodate a maximum of one-hundred forty-four (144) single fusion splices and support the corresponding management of buffer tubes and trays required. The closure shall accommodate both loose tube butt and mid-span access splicing. A minimum of four (4) cable ports shall be provided on the end plate system and the closure shall be rated for below grade installation within a splice vault or manhole. The closure shall have the capability to be assembled and disassembled without the need for any special tools. The closure shall be tested and approved in accordance with Telcordia GR-771 Generic Requirements for Fiber Optic Splice Closures by an independent outside laboratory. Closures shall be re-enterable, re-usable, hermetically sealed and utilize flexible grommet cable seals at each cable port appropriate for the fiber optic cables being fusion spliced. At a minimum, each closure shall include an end plate with buffer tube organizer, one (1) dome, one (1) dome gasket, one (1) dome collar, silicone lubricant, hose clamps

(appropriate for number of cable ports), flexible grommet cable seals appropriate for the number of cables, strength member brackets (as needed), port seals (for sealing unused cable ports), mounting bracket kit (for installation within splice vaults and maintenance holes), cable support hooks (for orderly coiling of fiber optic cable in splice vaults and maintenance holes) and other required accessories not specifically mentioned herein.

2. Fusion splicing of backbone-to-backbone and backbone-to-lateral fiber optic cables shall be stored and protected within the fiber optic splice enclosure. The Contractor shall utilize a fusion splicer that automatically positions, aligns and fuses together two (2) stripped, cleaned and cleaved optical fibers with an electric arc. The Contractor shall provide strain relief and protection of each stripped fiber splice by utilizing heat-shrink sleeves and housing the splices in splice trays within the closure. The maximum individual splice loss of single-mode fiber shall not exceed 0.10 dB.

3. Fiber optic termination assemblies shall include termination patch panel, connector bulkheads, single mode lateral fiber optic cable (lateral fiber optic cable) and associated hardware. Termination panel shall be configured with the required number of connector ports as shown in the Plans. If no connector port information is provided in the Plans, a minimum of six (6) ports shall be required for a six (6) fiber lateral cable and a minimum of twelve (12) ports shall be required for a twelve (12) fiber lateral cable, unless otherwise specified by the City Traffic Engineer or designee. The fiber optic termination assemble connector bulkheads shall be single mode, Straight Tip (ST), Ultra Physical Contact (UPC) type. The lateral fiber cable shall be factory terminated on one (1) end with ST connectors, the other end shall be pigtailed. The lateral fiber optic cable shall be of an appropriate length as noted on the Plans for splicing to the backbone fiber optic cable at the splice vault or manhole adjacent to the traffic signal controller cabinet. If no length is provided on the Plans, the minimum cable length shall be one-hundred (100) feet. The lateral fiber optic cable shall be designed and tested in accordance with Telcordia GR-3152 Generic Requirements for Hardened Multi-Fiber Optical Connectors.

4. Each fiber optic termination assembly utilized for projects in the City shall be outdoor-rated for operation in temperatures ranging from -40°F to +158°F. Its lateral fiber optic cable shall be rated for outside plant installation and use all-dielectric cable construction.

5. The factory terminated ST connectors on the lateral fiber optic cable shall have an UPC finish for single-mode fiber with an insertion loss not exceeding 0.5 dB and a reflectance of \leq -50 dB as specified by TIA-568-C.3 Optical Fiber Cabling Components.

Each connector shall utilize a ceramic ferrule and the durability of the connector shall change ≤ 0.2 dB by 500 re-matings in accordance with TIA-455-21 Mating Durability of Fiber Optic Interconnecting Devices.

C. Construction Requirements:

The Contractor shall provide the City with one (1) copy of the manufacturer's installation instructions for each type of fiber optic splice closure and fiber optic termination assembly. All installations shall be in accordance with the manufacturer's recommendations, except as otherwise directed by the City Traffic Engineer or designee. All additional costs including damage to fiber optic cables, splice closures, fiber optic termination assemblies and optical end equipment caused by the Contractor's neglect of recommended procedures shall be the Contractor's sole responsibility.

If not provided by the City, the Contractor shall submit a Method Statement to the City Traffic Engineer or designee indicating cable routing, splice points and cable end splicing locations. Installation of splice closures and terminating hardware shall not be permitted until the schematic diagram has been approved by the City Traffic Engineer or designee.

The fiber optic termination assembly's lateral fiber optic cable shall be back fed, pigtailed end, in a continuous run from the traffic signal controller cabinet to the backbone fiber optic cable splice location. The length of the lateral fiber optic cable shall be sized adequately when ordering the product to accommodate both the run distance and coiling requirements in splice vaults and maintenance holes as designated on the Plans or described in the City's fiber optic specifications. Strain relief for the lateral fiber optic cable shall be provided at a minimum of two (2) locations within the traffic signal controller cabinet.

The Contractor shall splice fiber cables at locations shown on the Plans and as approved by the City Traffic Engineer or designee in the Contractor's Method Statement. All splices shall be enclosed within a splice closure as approved by the City. Following successful splicing, the splice closure shall be placed inside the splice vault or manhole. The Contractor shall use tools and hardware recommended by the splice closure manufacturer.

Only proposed active (lit) fibers shall be spliced in the closure and terminated in the traffic signal controller cabinet, unless otherwise specified by the Plans. All unused (dark) fibers of both the backbone and lateral fiber optic cables shall remain uncut and be neatly coiled in the splice tray within the closure. All unused buffer tubes shall remain uncut and neatly coiled along with the buffer tubes used for splicing in appropriate locations in the splice closure.

Backbone and lateral fiber optic cable buffer tubes and fiber strands shall be labeled on the splice tray prior to sealing of the closure.

Unless otherwise specified on the Plans, the Contractor shall coil a minimum of one-hundred (100) feet of backbone and lateral fiber optic cables in splice vaults and maintenance holes.

The Contractor shall ensure that all cable coils are attached to the cable management hardware in all splice vaults and maintenance holes as stipulated by the City Traffic Engineer or designee.

The Contractor shall utilize a fiber optic termination assembly at each traffic signal controller cabinet, unless otherwise shown on the Plans or directed by the City Traffic Engineer or designee.

Unless otherwise specified by the Plans or directed by the City Traffic Engineer or designee, all fiber jumpers connected to the fiber optic termination patch panel in traffic signal controller cabinets shall utilize single-mode fiber that conforms to the requirements stated in the City's fiber optic specifications and have a, UPC finished, ST connector on the fiber optic termination patch panel end and an appropriate connector type for connection to the optical end equipment. The reflectance value of the connectors on both ends of each jumper shall conform to the connector requirements previously stated.

743.05 Testing, Identification and Administration of Fiber Optic Infrastructure

A. General:

1. Work Included

- a. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the fiber optic work called for in the Contract.

2. Scope

- a. This section includes the minimum requirements for acceptance testing, identification and administration of backbone and lateral fiber optic cabling.
- b. This section includes the minimum requirements for the following:
 - i. Fiber optic test instruments
 - ii. Fiber optic testing
 - iii. Identification
 - Tags and associated labeling
 - Labels and associated labeling

iv. Administration

- Test results documentation
- As built drawings

c. Testing shall be carried out in accordance with this document. This includes testing the attenuation of the installed fiber optic cable plant with an Optical Loss Test Set (OLTS) and the installed condition of the cabling system (and its components) with an Optical Time Domain Reflectometer (OTDR).

d. OLTS testing shall be performed on each terminated strand of fiber in the cable (patch panel to patch panel).

e. OTDR testing shall be performed on each strand of fiber in the cable (terminated with a connector or bare end).

f. All tests shall be documented including the following:

- i. OLTS dual-wavelength attenuation measurements for single mode fiber optic links.
- ii. OTDR traces and event tables for single mode fiber optic links.

3. Quality Assurance

a. All testing procedures and field-test instruments shall comply with applicable requirements of the following recognized standards:

- i. TIA-455-78 – (FOTP 78) Optical Fibers – Part 1-40: Measurement Methods and Test Procedures – Attenuation
 - TIA-455-133 – (FOTP 133) Optical Fibers – Part 1-22: Measurement Methods and Test Procedures – Length Measurement
 - TIA-455-160 – (FOTP 160) Optical Fibers – Part 1-50: Measurement Methods and Test Procedures – Damp Heat (Steady State)
 - TIA-526-7 – (OFSTP 7) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
 - TIA-568-C.3 – Optical Fiber Cabling Components Standard
 - TIA-606 – Administration Standard for the Commercial Telecommunications Infrastructure (including the requirements specified by the City, unless the City specifies their own labeling requirements)

b. Only trained technicians who have successfully attended an appropriate fiber optic training program, which includes testing with an OLTS and an OTDR, and have obtained a certificate as proof thereof shall be allowed to perform fusion splicing, fiber connectorization and fiber optic cable testing. These certificates

must have been issued by any of the following organizations or a City-approved equivalent organization:

- i. Fiber optic cable manufacturer
- ii. Fiber optic patch panel and/or connector manufacturer
- iii. Test equipment manufacturer
- iv. Approved training organizations:
 - Association of Cabling Professionals (ACP)
 - Building Industry Consulting Service International (BICSI)
 - Electronics Technicians Association (ETA)
 - Fiber Optic Association (FOA)
 - International Municipal Signal Association (IMSA)

The Contractor shall provide a copy of each proposed technician's valid certificate or ID card to the City Traffic Engineer or designee for review and approval, including a list of task(s) associated with each technician.

- c. The City Traffic Engineer or designee shall be invited to witness and/or review field testing.
 - i. The City Traffic Engineer or designee shall be notified of the start date of the testing phase five (5) business days before testing commences.

4. Submittals

- a. Manufacturers catalog cut sheets and specifications for fiber optic field test instruments including OLTS (power meter and source) and OTDR.
- b. A list of all cable segments and corresponding fiber optic strands to be tested (unless already called out in Plans).
- c. Test reports.

5. Acceptance of Test Results

- a. Unless otherwise specified in writing by the City Traffic Engineer or designee, each cabling link shall be in compliance with the following test limits:
 - i. Optical Loss Testing
 - Single Mode Fiber - The link attenuation shall be calculated by the following formulas:
 - Link Attenuation (dB) = Cable Attenuation (dB) + Connector Attenuation (dB) + Splice Attenuation (dB)
 - Cable Attenuation (dB) = Attenuation Coefficient (dB/km) x Cable Length (km)
 - Attenuation Coefficient = 0.35 dB @ 1310 nm and 0.25 dB @ 1550 nm

- Connector Attenuation (dB) = # of Connector Pairs x Connector Loss (dB)
- Maximum Allowable Connector Loss = 0.50 dB
- Splice Attenuation (dB) = # of Splices x Splice Loss (dB)
- Maximum Allowable Splice Loss = 0.30 dB

ii. OTDR Testing

- Reflective events (connections) shall not exceed 0.50 dB.
- Non-reflective events (splices) shall not exceed 0.30 dB.

b. All installed cabling links shall be field tested and pass the test requirements and analysis described in 50.3.5 section C. Any link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link meets performance requirements. Test results for all links shall be provided in the test results documentation in accordance with Part 3.

c. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with the Contract and to the satisfaction of the City Traffic Engineer or designee.

6. Measurement and Payment Procedures

a. Measurement of fiber optic cable warning tags and labels shall be as specified in 50.3.5 section C. Compensation for the fiber optic cable warning tags and labels shall be considered as included in the price paid for total LINEAR FEET of new fiber optic cable and no additional compensation shall be allowed thereof. The compensation for fiber optic cable warning tags and labels shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals required to perform the work.

b. Measurement of record copy drawings and as-built drawings shall be as specified in 50.3.5 Section D. Compensation for the record copy drawings and as-built drawings shall be considered as included in the price paid for total linear feet of new fiber optic cable and no additional compensation shall be allowed thereof. The compensation for record copy drawings and as-built drawings shall include full compensation for furnishing all labor, materials, equipment and incidentals required to perform the work.

c. Measurement of OLTS testing shall be as specified in Section 1.02D. Compensation for OLTS testing shall be based on the total number of new fiber STRANDS tested and no additional compensation shall be allowed thereof. The

compensation for OLTS testing shall include full compensation for furnishing all labor, materials, tools, equipment, calibration and incidentals required to perform the testing, including completion of the End-to-End Attenuation Testing table(s) provided in the Plans in accordance with 50.3.5 Section C2i of these Specifications.

d. Measurement of OTDR testing shall be as specified in Section 1.02E.

Compensation for OTDR testing shall be based on the total number of new fiber STRANDS tested and no additional compensation shall be allowed thereof. The compensation for OTDR testing shall include full compensation for furnishing all labor, materials, tools, equipment, calibration and incidentals required to perform the testing, including test results documentation in accordance with Sections 50.3.5 Sections C2J and D.

B. Products

1. Fiber Optic Cable Testers

a. The field test instrument shall be within the certified calibration period of one calendar year.

b. OLTS

i. Single mode fiber optic light source

- Provide dual laser light sources with central wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).
- Output power of -10 dBm minimum

ii. Power meter

- Provide 1310 nm and 1550 nm wavelength test capability.
- Power measurement uncertainty of ± 0.25 dB.
- Store reference power measurement
 - Save at least 100 results in internal memory
 - PC interface (serial or USB)

iii. Length measurement (optional)

Length measurements shall be made with an OLTS only if it is capable of measuring the optical length of the fiber using time-of-flight techniques.

c. OTDR

i. OTDR shall have internal non-volatile memory and removable memory device with at least 8 MB capacity for results storage.

ii. OTDR shall have serial and USB ports to transfer data to a PC.

iii. OTDR shall provide wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).

- iv. OTDR shall provide event dead zones of 11.5 ft. (3.5 m) maximum at 1310 nm and 1550 nm.
- v. OTDR shall provide attenuation dead zones of 32.8 ft. (10 m) maximum at 1310 nm and 39.4 ft. (12 m) maximum at 1550 nm.
- vi. OTDR shall support a distance range of not less than 32,810 ft. (10,000 m).
- vii. OTDR shall have a dynamic range of at least 10 dB at 1310 nm and 1550 nm.

d. Integrated OLTS and OTDR

- i. Test equipment that combines into one instrument an OLTS and an OTDR may be used.

2. Identification

a. Fiber Optic Cable Warning Tag

Figure 1.



Fiber Optic Cable Warning Tag

- i. Tag shall have the following minimum dimensions: 1.75" (width) x 3.875" (length).
- ii. Each tag shall have three (3) 0.167" holes on each side as shown in Figure 1.
- iii. Tag shall have an orange background with black foreground and text as shown in Figure 1 indicating: CAUTION - FIBER OPTIC CABLE
- iv. Below the text FIBER OPTIC CABLE in Figure 1, the Contractor shall write-in SMFO for single mode fiber optic cable and XX for the fiber count of the cable, e.g., "SMFO 48" for 48-strand single mode fiber optic cable. A permanent industrial marker shall be utilized for writing on the tag such as the Sharpie Mean Streak® Permanent Marking Stick or Sharpie Industrial Fine Pen.
- v. Tag shall be made from 0.02" thick vinyl.
- vi. Two (2) 8" black cable ties shall be included with each tag.

- vii. Tag must have a minimum five (5) year written warranty for outdoor durability.
- viii. One tag shall be placed on each fiber optic cable (e.g., backbone or lateral) entering a pull box, splice vault, manhole, traffic signal controller cabinet or building as required in Part 3 of this document. Where a splice closure is located in a splice vault or manhole, tags shall be placed on each side of the splice closure for the backbone and lateral cable(s).

b. Fiber Optic Cable Label

Figure 2. Fiber Optic Cable Label



- i. Label must have the following minimum dimensions:
 - A = 1.00"
 - B = 2.50 "
 - C = 0.75"
- ii. Label shall meet the adhesion, defacement, exposure and legibility requirements of UL 969 Marking and Labeling Systems.
- iii. Labels shall be temperature stable from -94°F to +158°F.
- iv. Labels shall either be preprinted using a mechanical means of printing (e.g., laser printer) or field printable using a handheld or portable label printer (e.g., smear-proof ribbons or thermal printing).
- v. Labels shall have a vinyl substrate with a white printing area and a clear "Tail" that self laminates the printed area when wrapped around the cable.
- vi. One label shall be placed on each fiber optic cable (e.g., backbone or lateral) entering a pull box, splice vault, manhole, traffic signal controller cabinet or building. Where a splice closure is located in a splice vault or manhole, labels shall be placed on each side of the splice closure for the backbone cable(s).

vii. The text on each label shall be as defined in Section 50.3.5.C.3.

3. Administration

- a. Administration of the documentation shall include test results of each fiber link.
- b. The test result information for each link shall be recorded in the memory of the field test instrument upon completion of the test.
- c. The test result records saved within the field test instrument shall be transferred into a Microsoft Windows™ -based spreadsheet or database utility that allows for the review, archiving and maintenance of these test records.

C. Execution:

1. General

- a. All tests performed on single mode fiber optic cabling that use a laser in a test set shall be carried out with safety precautions in mind by the Contractor.
- b. All cables, termination panels and associated components shall be fully assembled and labeled prior to the initiation of field testing. Any testing performed on incomplete systems shall be redone on completion of the work.

2. Fiber Optic Cable Testing

- a. Contractor shall verify that the test jumpers (OLTS) and test fiber box (OTDR) are of the same fiber core size and connector type as the cable system.
- b. Contractor shall verify that optical sources are stabilized and have center wavelengths within ± 20 nm as stipulated in Section 50.2.5.B.
- c. Contractor shall ensure that the power meter and light source are calibrated at each of the nominal test wavelengths and traceable to the National Institute of Standards and Technology (NIST) Special Publication 250-54 calibration standard. The OTDR must also be calibrated and traceable to the NIST calibration standard. Calibration certificates shall be provided to the City Traffic Engineer or designee for review and approval to ensure that the power meter, light source and OTDR have each been calibrated within the past calendar year. Any test equipment whose calibration certificate is over two (2) years old, must be recalibrated and a copy of the new calibration certificate provided to the Traffic Engineer or designee for review and approval prior to use on this Contract.
- d. Contractor shall verify that all field test instruments have the latest software and firmware installed.
- e. Contractor shall verify that the power meter and the light source are set to the same wavelength.
- f. Contractor shall ensure that all system connectors, adapters and jumpers are properly cleaned prior to and during measurement.

- g. Link test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) shall be generated.
- h. Testing of the cabling shall be performed using high quality test jumpers of the same fiber type and core diameter as the cabling under test. The test jumpers for OLTS testing shall be between 3.3 ft. (1 m) and 16.4 ft. (5 m) in length. The test fiber for the OTDR testing shall be approximately 984 ft. (300 m) for the launch cable so that the first connector on the link is visible in the trace.
 - i. OLTS Testing
 - ii. Single mode links shall be tested at 1310 nm and 1550 nm in accordance with TIA-526-7 for patch panel to patch panel testing.
 - iii. The Contractor shall follow the test procedures established by the referenced standard to accurately conduct performance testing.
 - iv. Prior to the initiation of OLTS testing, a reference reading shall be made and recorded between the light source and power meter using the test jumper. The reference reading shall be re-measured after every two-hundred (200) measurements or every eight (8) hours, whichever occurs first. The reference readings shall be provided to the City Traffic Engineer or designee.
 - v. End-to-end link attenuation does not include any active or passive devices other than cable, connectors and splices.

j. OTDR Testing

- i. Single mode links shall be tested at the appropriate operating wavelength for anomalies and to ensure uniformity of cable attenuation, determine connector insertion loss and measure splice loss. Refer to Section 50.2.5.B for operating wavelengths.
- ii. Each fiber link shall be tested at the dual-wavelength and bi-directionally to meet transmission equipment certification.
- iii. A test fiber box shall be installed between the OTDR and the first patch panel, unless otherwise recommended by the OTDR manufacturer.
- iv. Cable Acceptance: The Contractor shall evaluate the integrity, overall length and fiber attenuation in dB/km for each fiber strand in the cables before and after installation. The City will use this information to check the cable against its specification, uncover point defects due to handling during transport or installation and effectively measure terminated and unterminated fibers.
 - Before Installation Cable Inspection – Prior to cutting a reel into sections and installing the various cable segments, the Contractor shall utilize an OTDR to evaluate the fiber optic cable's initial

quality and integrity. The Contractor shall access one cable end from the reel to verify the length and attenuation of each fiber in the cable for comparison to the cable manufacturer's factory test results. All detected point faults and/or discontinuities caused by shipping and handling shall be brought to the attention of the City Traffic Engineer or designee. All test results shall be provided to the City or its designated representative and approved in writing before cable installation can begin.

- v. Trace Documentation: All OTDR traces shall be stored electronically.
- vi. Connector and Splice Loss: The Contractor shall measure and document all field-installed connectors and fusion splices so that a determination can be made about their acceptability or if they need to be redone.

3. Identification

a. Labeling

- i. Fiber Optic Cable Warning Tag: The fiber optic cable type and fiber count shall be handwritten by the Contractor as specified in Section 50.3.5 B.
- ii. Fiber Optic Cable Label: The labeling strategy for this type of label shall conform to the requirements below, as specified in Section 50.3.5B and as shown in Figure 2.
 - Highway where the fiber optic cable is located.
 - Backbone (BB) or lateral (LT) fiber optic cable.
 - Destination of fiber optic cable from building, traffic signal controller cabinet, pull box, splice vault or manhole.
 - Allowable abbreviations consist of the following:
 - Building (BLDG)
 - City Hall (CH)
 - East (E)
 - Eastbound (EB)
 - Manhole (MH)
 - North (N)
 - Northbound (NB)
 - Pull box (PB)
 - Quadrant of intersection or interchange (QD)
 - South (S)

- Southbound (SB)
- Splice vault (SV)
- Traffic Signal controller cabinet (TS)
- West (W)
- Westbound (WB)

D. Administration:

1. Test Results Documentation:

- a. Provide one (1) digital copy either by email or CD-ROM version of test results documentation to the City Traffic Engineer or designee for review and approval
- b. Test results shall be organized and bound in a logical order. It shall start at one (1) end of a corridor and logically progress to the end of the corridor rather than skipping around. OLTS and OTDR test results shall be separated within the same document.
- c. Results of every attenuation test shall be included.
- d. The Contractor shall expand the vertical and horizontal scales used on the OTDR display to maximize the amount of detail shown on the OTDR traces, even if these parameters can be adjusted later using the display software. The software and applicable licenses required to read the OTDR traces shall be provided to the City at no extra charge.
- e. OTDR traces must identify the end points of the fiber under test and the fiber designation. If this information is not provided by the trace itself, the Contractor shall provide a cross-reference table between the stored trace file name and the fiber designation.
- f. For each field-installed connector and fusion splice performed by the Contractor, an OTDR measurement shall be made bi-directionally unless approved by the City Traffic Engineer or designee at the 1310 and 1550 nm wavelength and averaged to ensure it meets the required specifications.
- g. Test results saved within the field test instrument shall be uploaded to the PC unaltered. The file format, Comma Separated Value (CSV), shall not be accepted because it does not provide adequate protection of these records.
- h. The test results documentation shall be provided to the City Traffic Engineer or designee within ten (10) working days of completion of tests. The Contractor shall retain a copy to aid preparation of as-built documentation.
- i. The detailed test results documentation data is to be provided for each tested optical fiber and shall contain the following information;

- i. The identification of the highway corridor where the fiber was installed (as specified by the City Traffic Engineer or designee).
- ii. The name of the test or test limit and its relationship to the segment of the highway corridor.
- iii. The name of the Contractor and its personnel performing the test
- iv. The date and time that the tests were conducted.
- v. The manufacturer, model number and serial number of the field test instrument.
- vi. The name and version of the test software and firmware.
- vii. The fiber identification number.
- viii. The length for each optical fiber as calculated by the OLTS or OTDR.
- ix. The index of refraction used for length calculation when using a length capable OLTS.
- x. Test results of OLTS attenuation for each link at the appropriate wavelengths and the margin (difference between measured and calculated).
- xi. Test results of OTDR link traces and event tables at the appropriate wavelengths.
- xii. The overall Pass/Fail evaluation of the link under test for OLTS and OTDR measurements.

2. Record Copy and As-built Drawings

- a. The intent of the as-built drawings is to provide accurate and detailed information, in a useful format, to any party, private or public, that has a need to locate, excavate, modify or expand installed infrastructure. Questions regarding as-built drawings shall be directed to the City Traffic Engineer or designee. Discretion shall be employed in the drafting of as-builts in terms of the functional quality of the drawings. If too much information is included on one (1) sheet as to make its use impractical to comprehend, a second or third drawing shall be required.
- b. It is recommended that the Contractor maintain a tabloid sized set of approved plans on site and, during construction, accurately mark these plans with record information. As an example, the color green could be used to indicate all additions and the color red to indicate all deletions. Clear and concise notes and sketches shall accompany changes marked on the plans to document the basis for the modifications.

c. The following requirements shall be applied to each as-built plan developed for the City. As-built drawings shall be prepared by revisions to the original, approved plans. At no time shall the original plan data be accepted as the as-built data. The following general requirements shall be required for all as-built drawings:

- i. All drawings shall bear the name, address and telephone number of the firm preparing the drawing and the date the as-built data is added to the original via the revision block.
- ii. All drawings shall bear the name of the Contractor(s) along with a statement (with an original signature on each sheet) stating that the as-built drawings reflect the true conditions in the field and that all construction standard specifications and product qualities have been met or exceeded.
- iii. "as-built drawing" shall be clearly labeled on each sheet.
- iv. Street names shall be on all streets. All easements and right-of-way shall be shown and clearly labeled.
- v. If the fiber optic infrastructure is to be private (not to be dedicated to the City), then it shall be clearly stated on each sheet.
- vi. The locations and description of any existing utility lines(overhead or underground, as applicable) known to exist within the construction area.
- vii. The locations and dimensions of any changes to poles, cabinets and buildings, as applicable.
- viii. Changes in details of the design or additional information such as approved placement details, conduit sizes, material changes, etc.
- ix. Where plans or specifications allow options, only the option actually used in the construction shall be shown on the as-built drawings.

d. Record copy drawings shall be provided by the Contractor to the City Traffic Engineer or designee at the end of the project in electronic format. The drawings shall be in AutoCAD or PDF format and include notations reflecting the as-built conditions of any additions to or variation from the drawings provided such as, but not limited to, cable routing, fiber assignments and terminations. AutoCAD or PDF drawings shall include OLTS results in a tabular format for historical baseline information.

e. The as-built drawings shall include, but are not limited to, network layout diagrams, splice diagrams and port-to-port jumper terminations. The as-builts shall include all field changes made up to construction completion including:

- i. Field directed changes to splicing

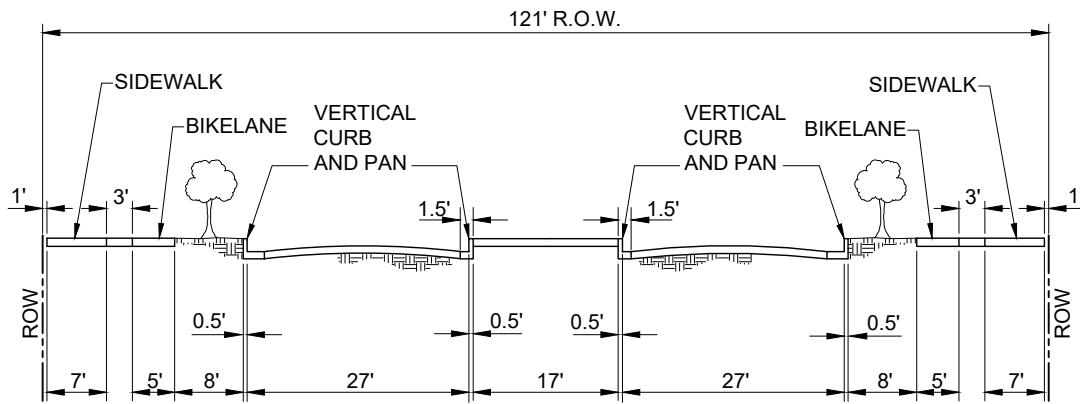
- ii. Field directed changes to terminations
- iii. Backbone cable type or routing changes
- iv. Lateral cable type or routing changes
- v. Pull box or splice vault type or location changes
- vi. Splice closure and associated component changes
- vii. Termination patch panel changes
- viii. Jumper and/or connector type changes
- ix. End equipment changes
- x. Associated detail drawings to help explain changes

750.00 Street Lighting

Streetlights shall be provided at all arterial street/road intersections and as required on all newly developed and dedicated public streets in the City to deliver adequate and uniform lighting coverage. In general street light poles shall not be placed within sidewalks or curb ramps.

The land developer shall submit street light plan and design during the plan review process. The developer must provide a copy of the proposed site plan with proposed streetlight layout design and appropriate photometric analysis as required during the development application process.

Construction of the new streetlights shall be coordinated between the developer, appropriate electrical utility and the electrical contractor.

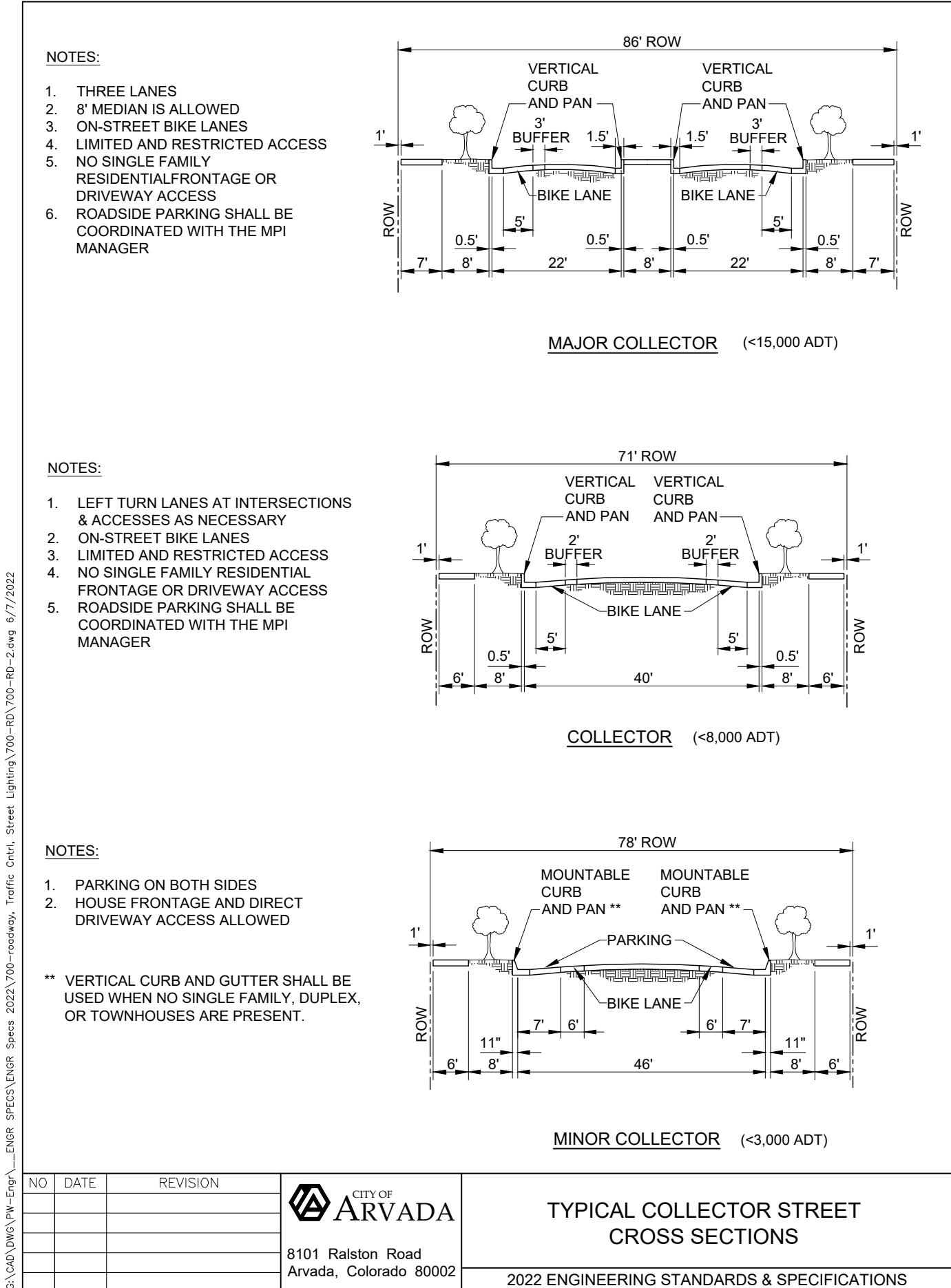


NOTES:

1. ACCESS CONTROL (RAISED MEDIAN)
2. ROADSIDE PARKING SHALL BE COORDINATED WITH THE MPI MANAGER.

ARTERIAL PARKWAY (>15,000 ADT)

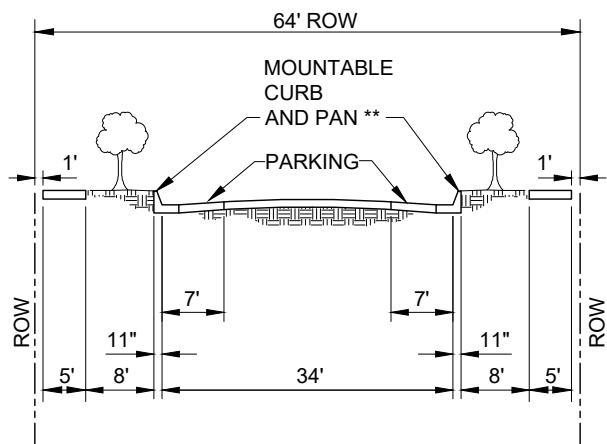
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TYPICAL ARTERIAL STREET CROSS SECTIONS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

1. PARKING ON BOTH SIDES

** VERTICAL CURB AND GUTTER SHALL BE USED WHEN NO SINGLE FAMILY, DUPLEX, OR TOWNHOUSES ARE PRESENT.



LOCAL STREET (<1000 ADT)

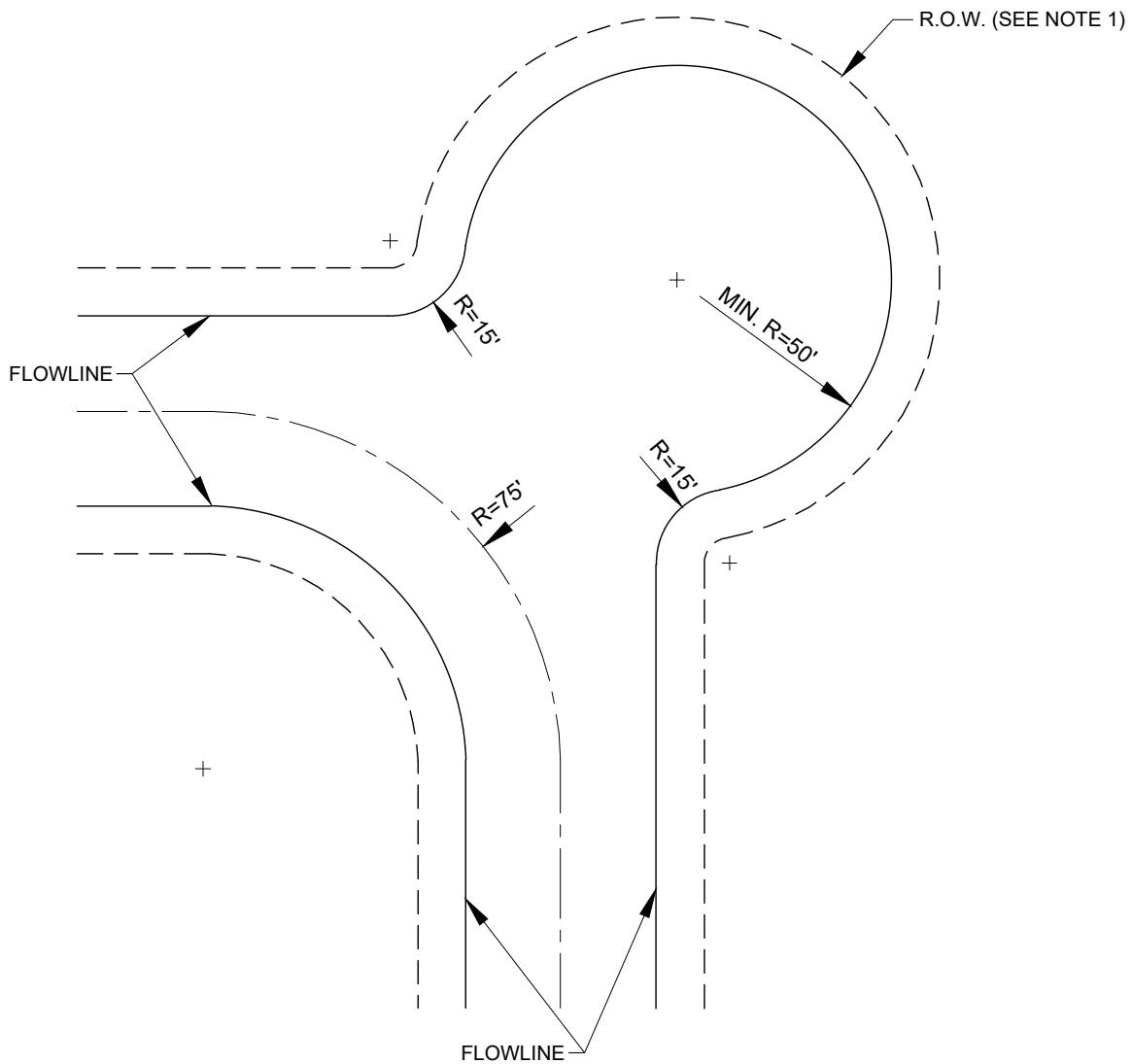
NO	DATE	REVISION



CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

**TYPICAL LOCAL STREET
CROSS SECTIONS**

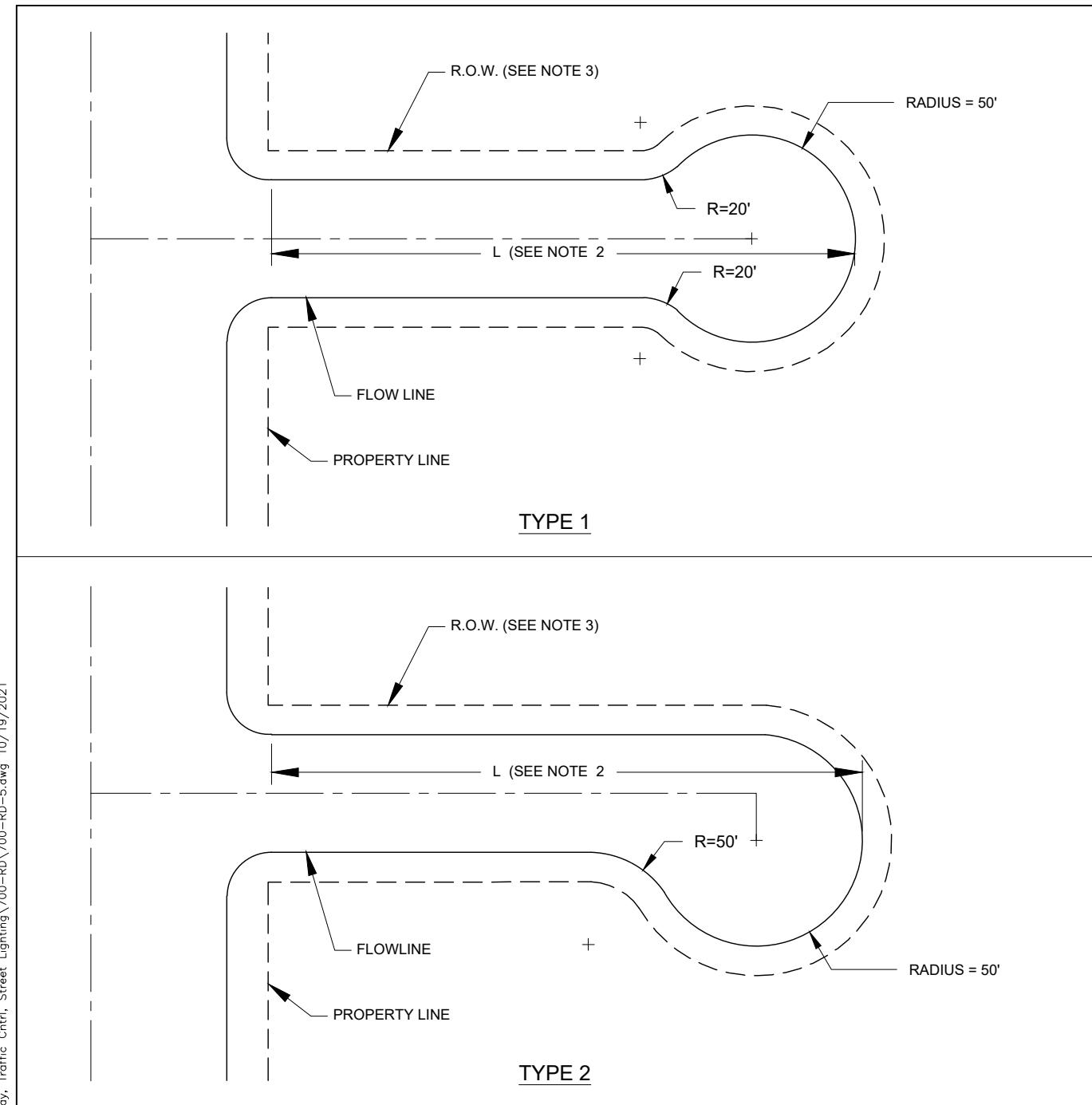
2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

1. THIS CONFIGURATION OR A SIMILAR CONFIGURATION IS RECOMMENDED FOR USE WHERE MINIMUM CENTERLINE RADII CANNOT BE USED. THE INTENT IS THAT THE BULB AND OPPOSITE CURB RADIUS BE SUCH THAT AN APPROACHING DRIVER WILL PERCEIVE THE CONFIGURATION AS A DEAD END STREET THUS CAUSING A VOLUNTARY REDUCTION IN SPEED SUFFICIENT TO SAFELY NEGOTIATE THE 75' CENTER LINE RADIUS. THIS 75' CENTER LINE RADIUS CONFIGURATION IS THE ONLY RADIUS PERMITTED OTHER THAN THOSE SPECIFIED IN SECTION 721.01.

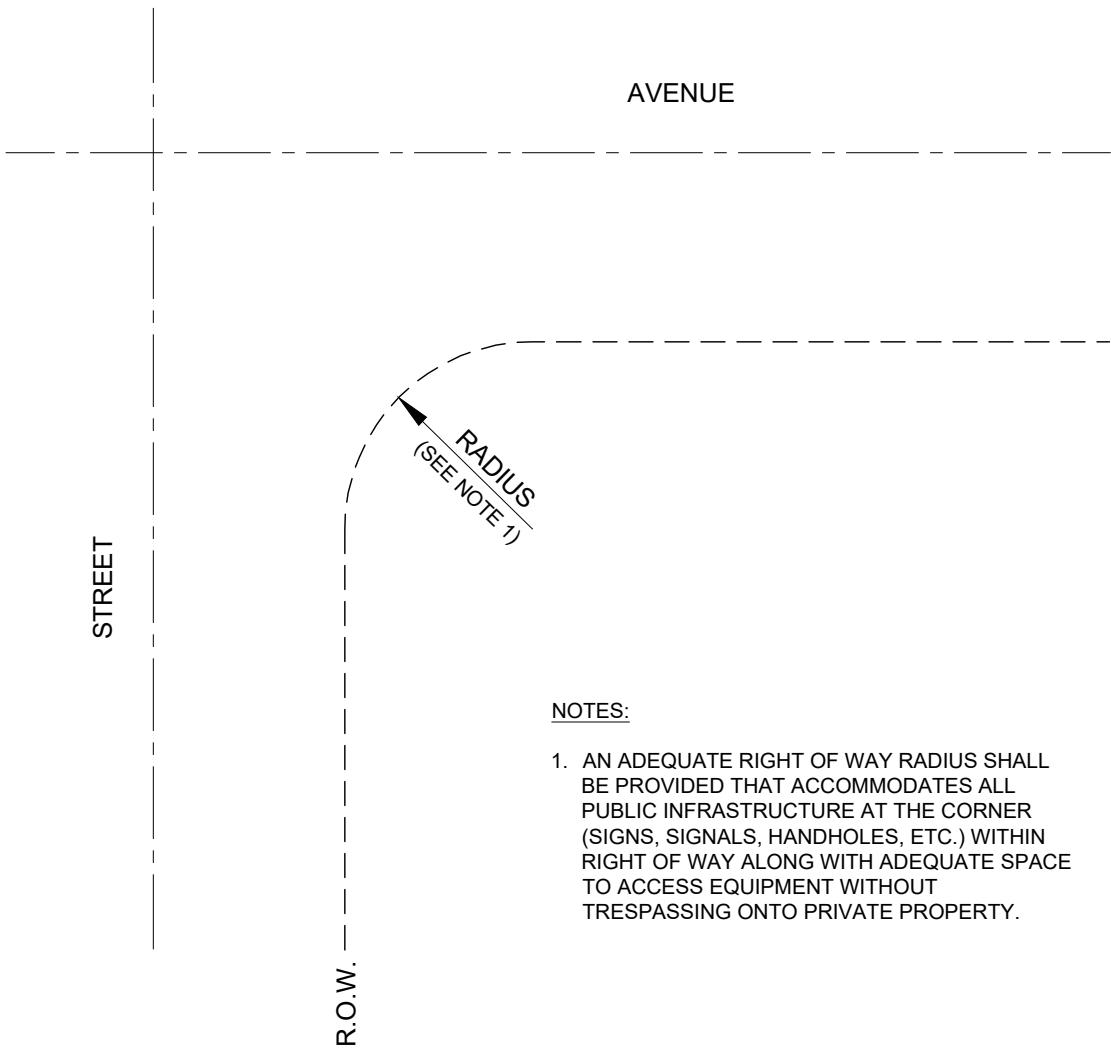
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	90 DEG TURN - LOCAL ACCESS STREETS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

1. WIDTH OF TYPE 1 & 2 CUL-DE-SACS TO CONFORM TO APPLICABLE TYPICAL STREET CROSS SECTIONS.
2. SEE SECTION 725.00 CUL-DE-SACS FOR LENGTH (L) REQUIREMENTS.
3. R.O.W. LINES ARE TO BE PARALLEL TO AND OFFSET FROM THE FLOWLINE A DISTANCE IN ACCORDANCE WITH 700-2 AND 700-3.

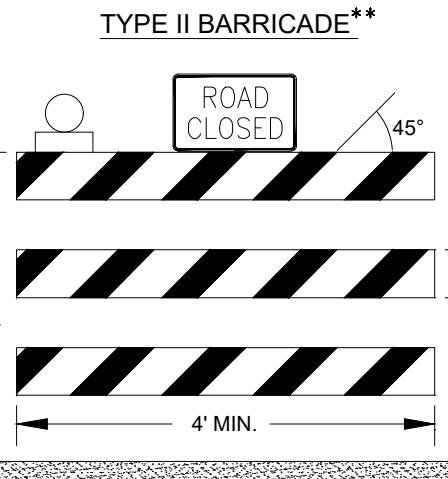
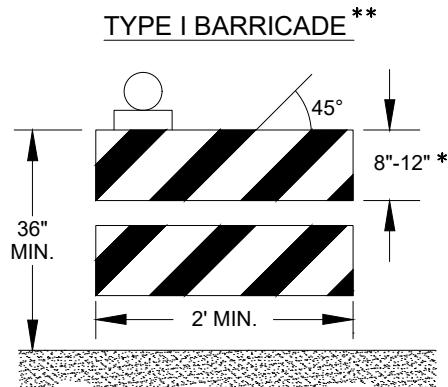
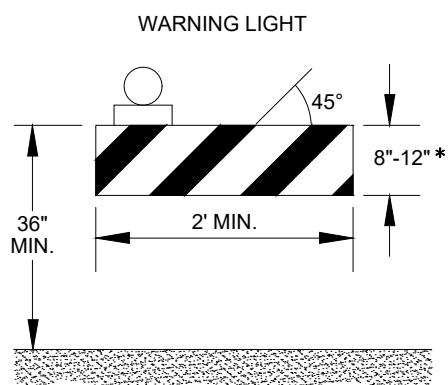
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CUL-DE-SACS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

1. AN ADEQUATE RIGHT OF WAY RADIUS SHALL BE PROVIDED THAT ACCOMMODATES ALL PUBLIC INFRASTRUCTURE AT THE CORNER (SIGNS, SIGNALS, HANHOLES, ETC.) WITHIN RIGHT OF WAY ALONG WITH ADEQUATE SPACE TO ACCESS EQUIPMENT WITHOUT TRESPASSING ONTO PRIVATE PROPERTY.

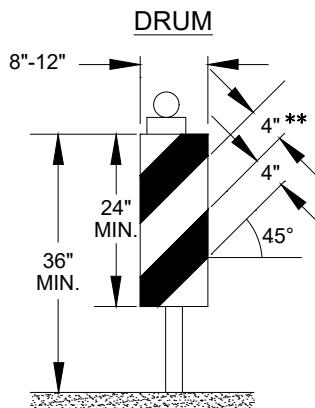
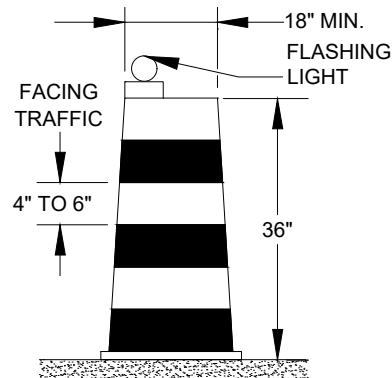
NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	INTERSECTION R.O.W. 2022 ENGINEERING STANDARDS & SPECIFICATIONS



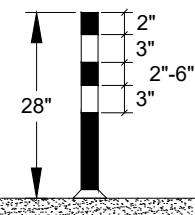
TYPE III BARRICADE **

* NOMINAL LUMBER DIMENSIONS ARE SATISFACTORY FOR BARRICADE RAIL WIDTH DIMENSIONS

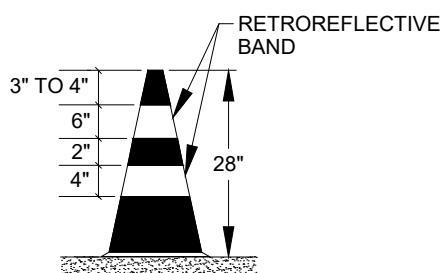
** RAIL STRIPE WIDTHS SHALL BE 6 INCHES EXCEPT WHERE RAIL LENGTHS ARE LESS THAN 36 INCHES, THEN 4 INCH WIDE STRIPES MAY BE USED. THE SIDES OF BARRICADES FACING TRAFFIC SHALL HAVE RETROREFLECTIVE RAIL FACES.



VERTICAL PANEL



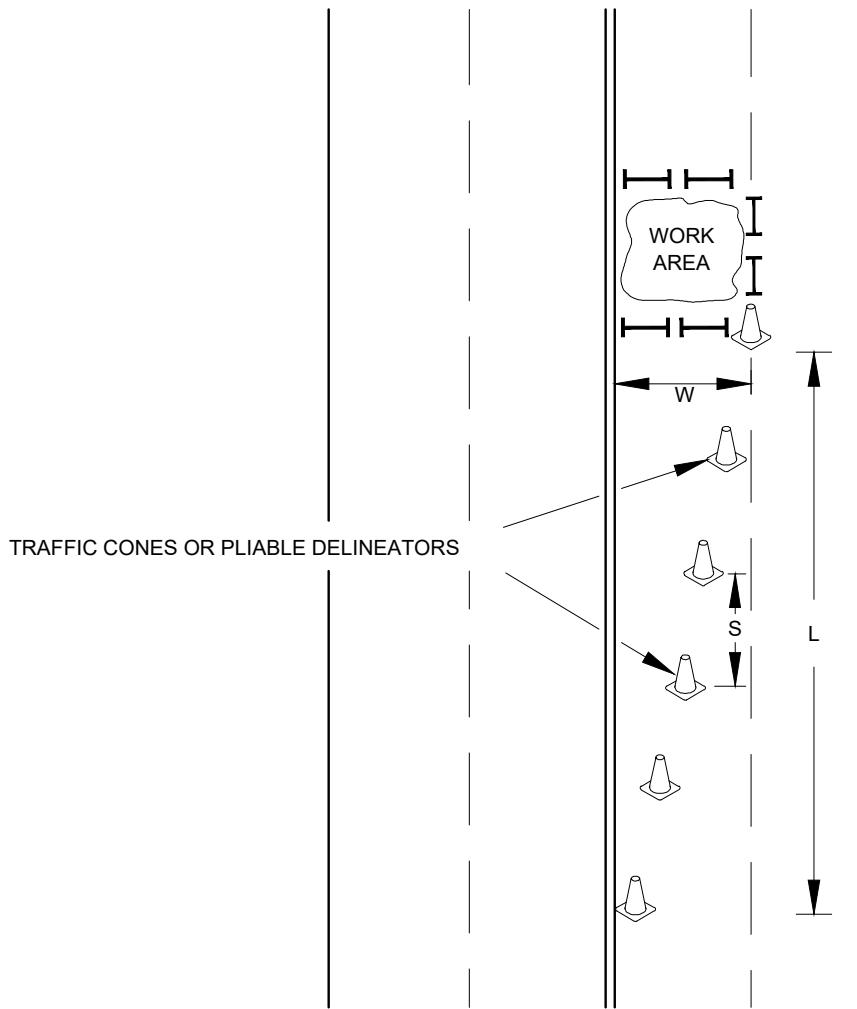
TUBULAR MARKERS



CONES

NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

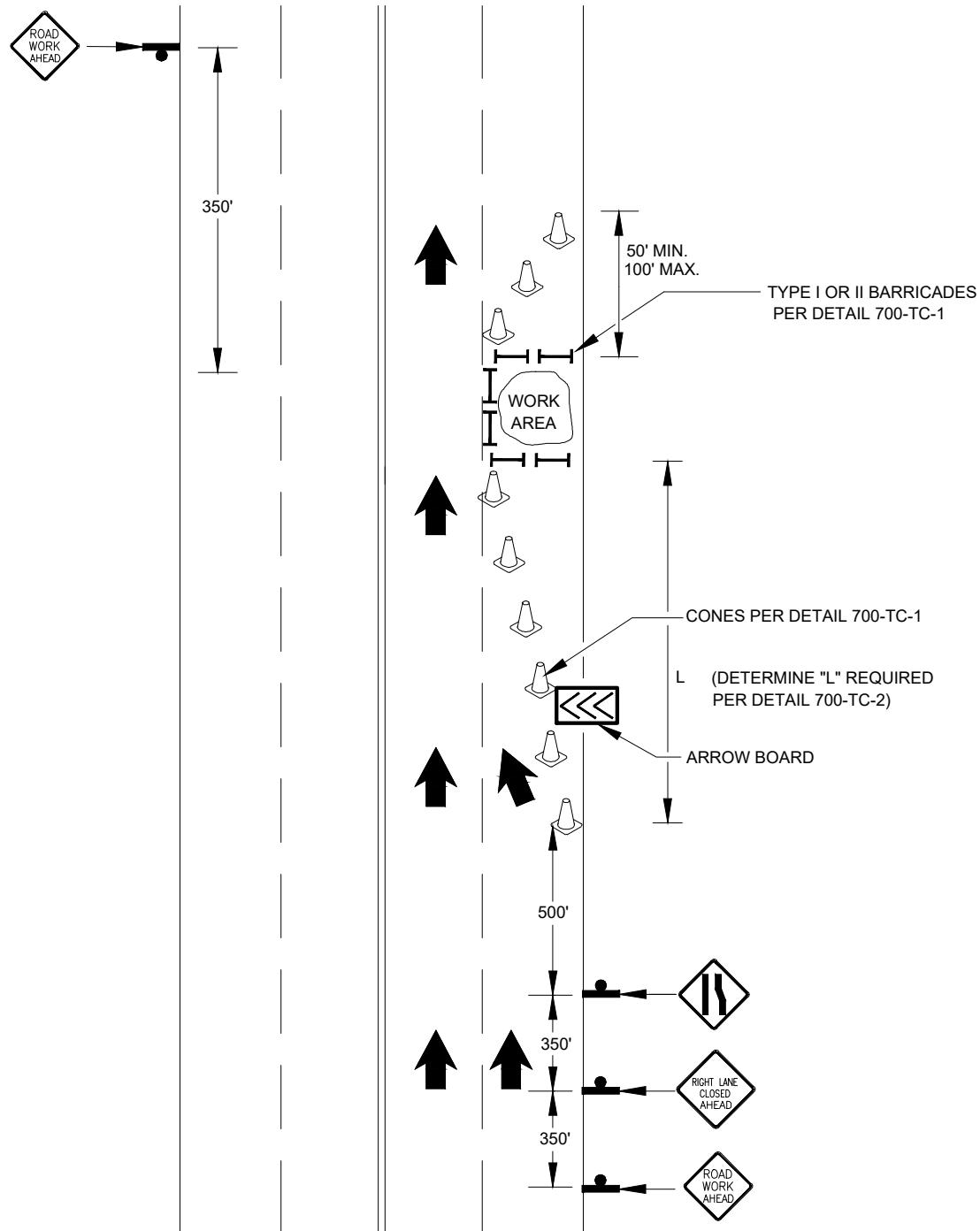
NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	BARRICADES & CHANNELIZING DEVICES
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



SPEED LIMIT	MINIMUM TAPER LENGTH (L) LANE WIDTH (W)			MAXIMUM SPACING (S)
	10'	11'	12'	
25 MPH	105'	115'	125'	25'
30 MPH	150'	165'	180'	30'
35 MPH	205'	225'	245'	35'
40 MPH	270'	295'	320'	40'
45 MPH	450'	495'	540'	45'

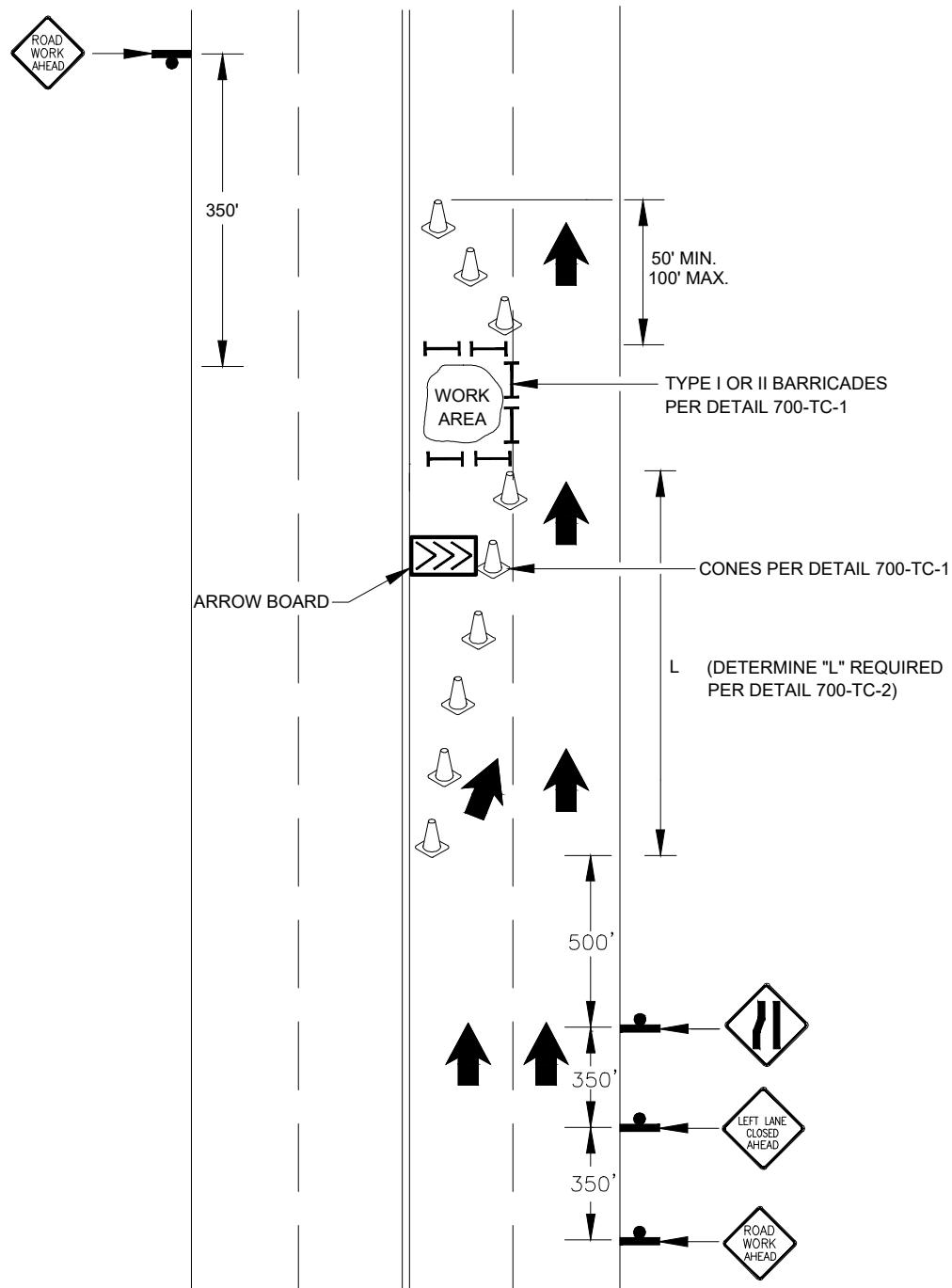
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	SPACING & TAPER LENGTH
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



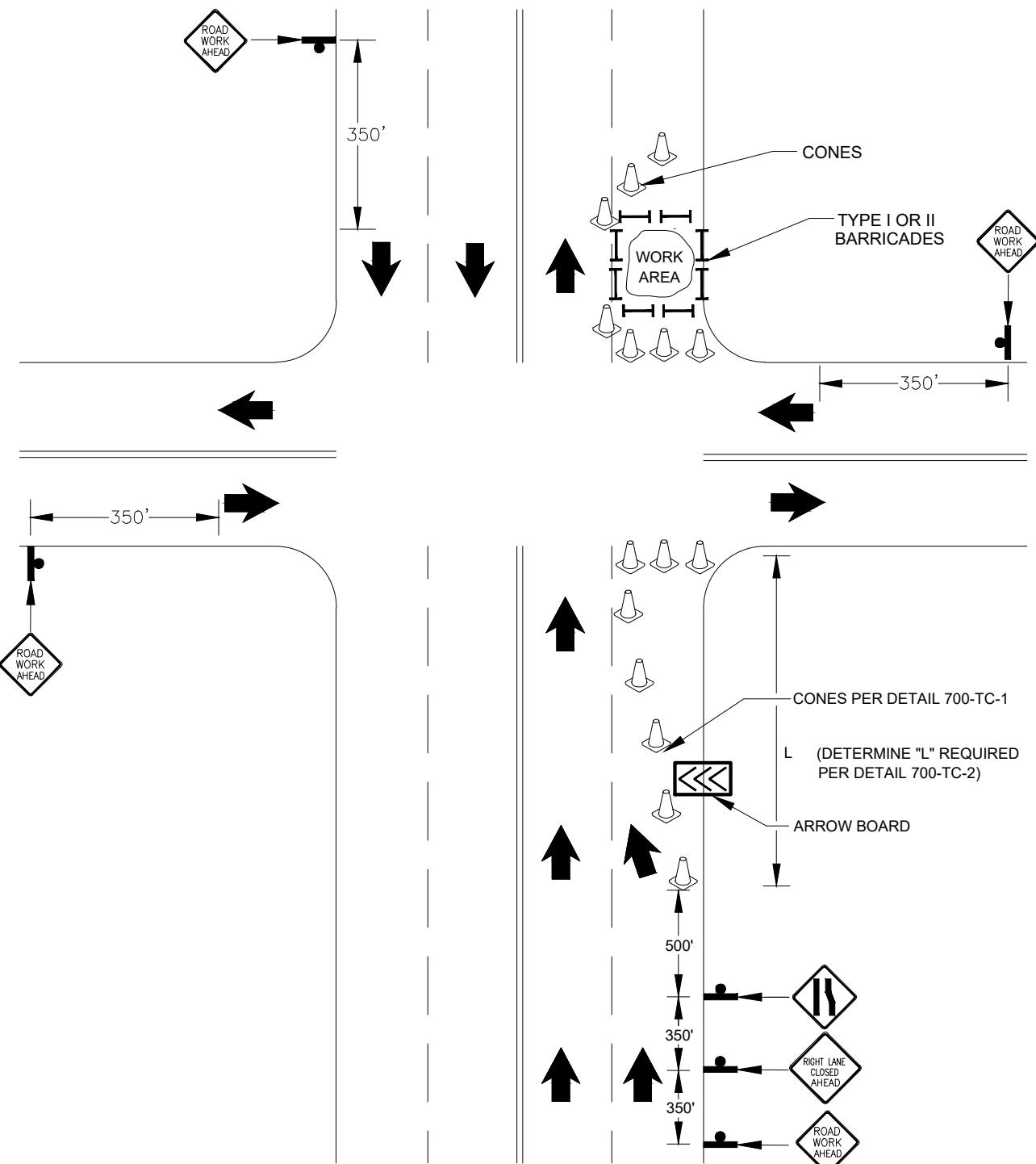
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CLOSURE OF RIGHT LANE HIGH VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



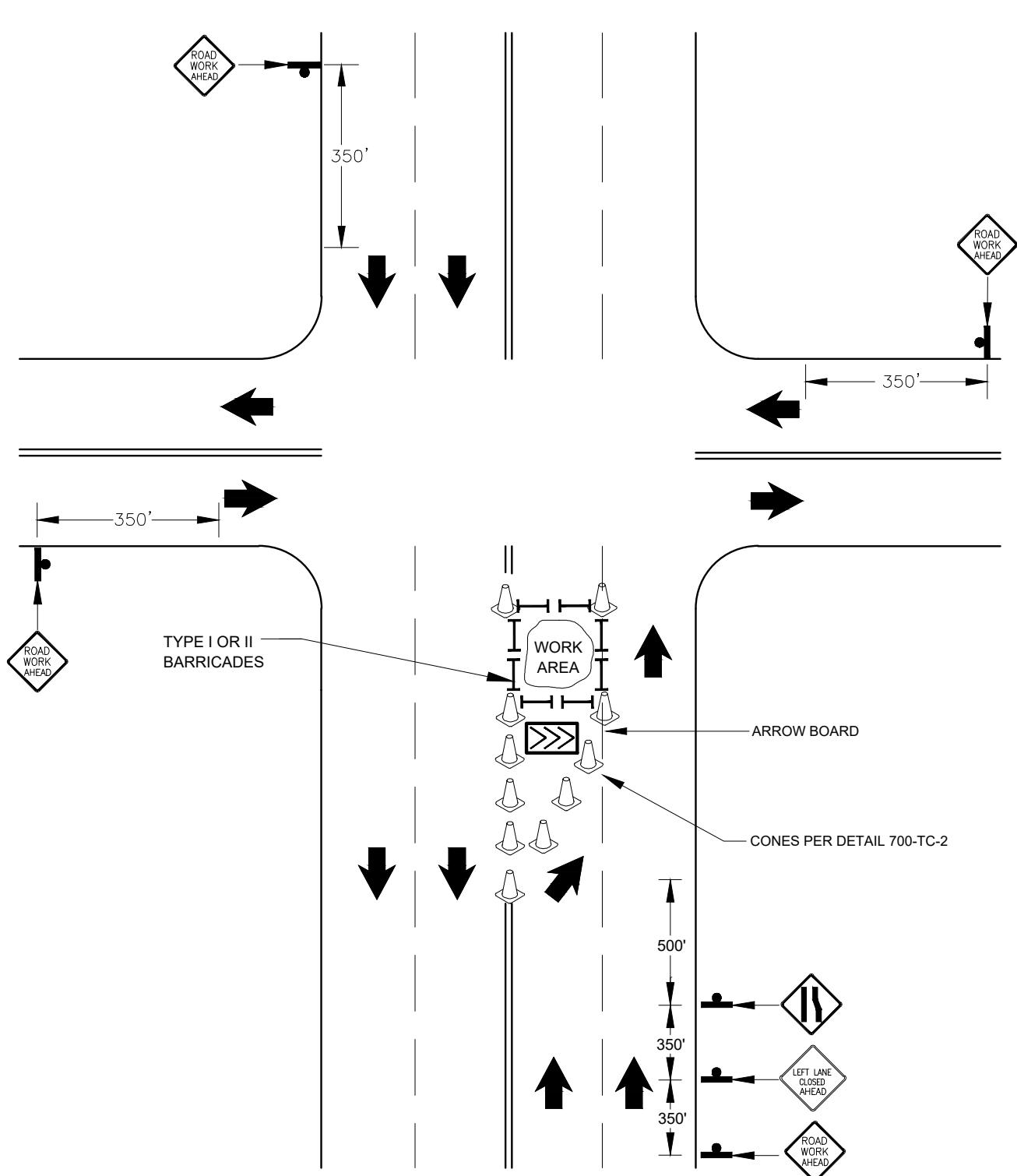
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CLOSURE OF LEFT LANE HIGH VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



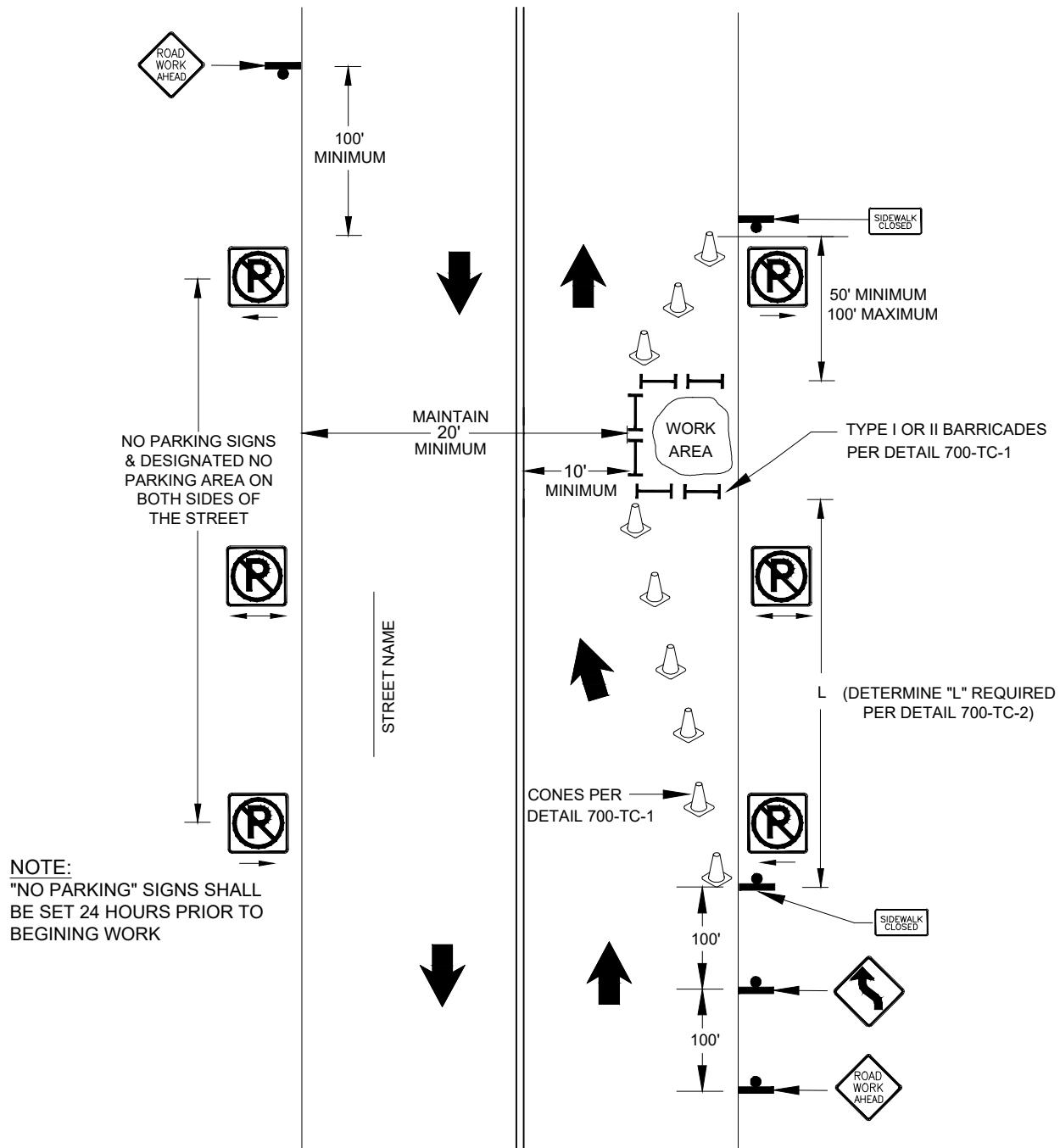
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	RIGHT LANE CLOSURE ON FAR SIDE OF INTERSECTION HIGH VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



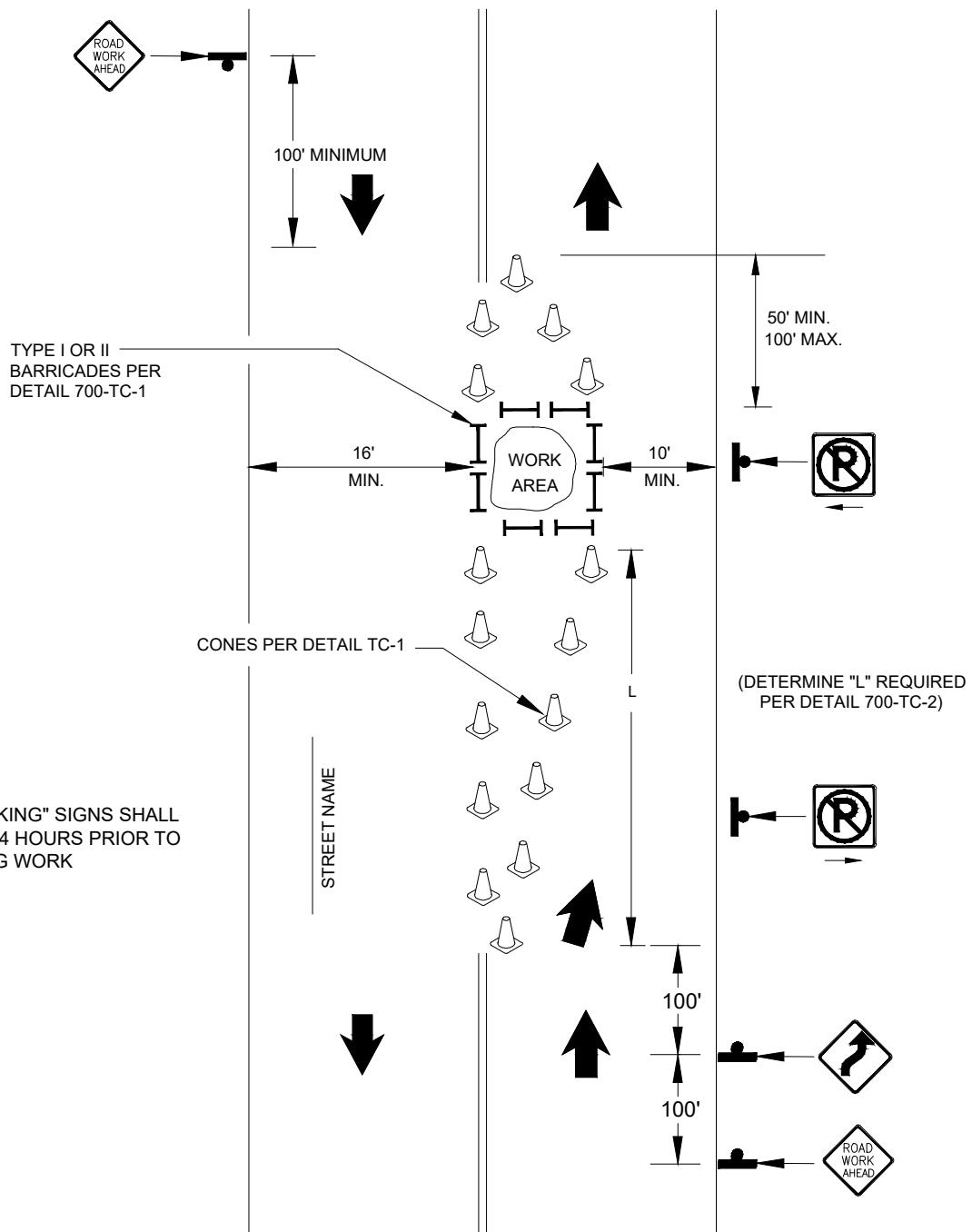
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	LANE CLOSURE ON NEAR SIDE OF INTERSECTION HIGH VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

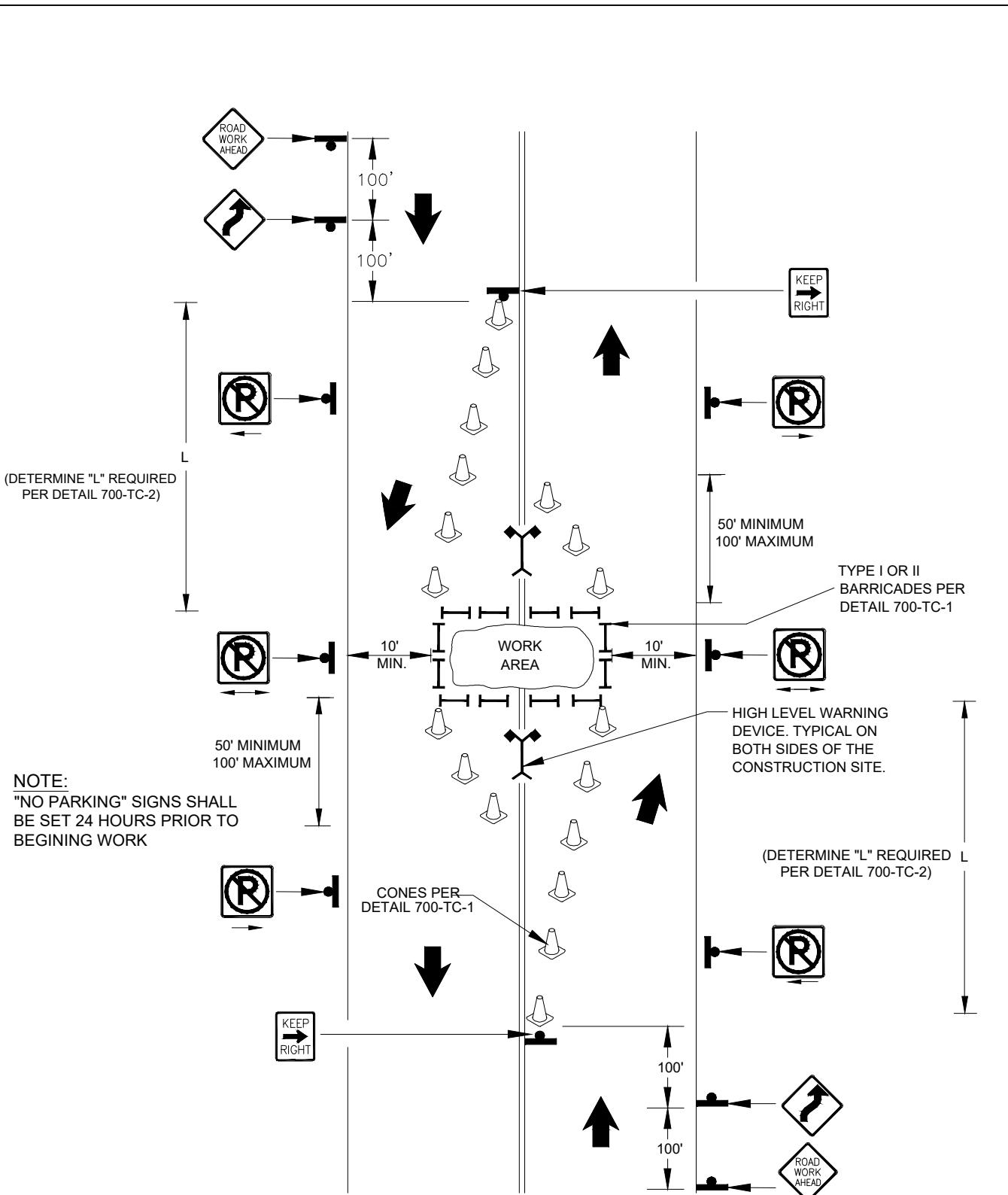


NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CLOSURE RIGHT SIDE OF ROADWAY LOW VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

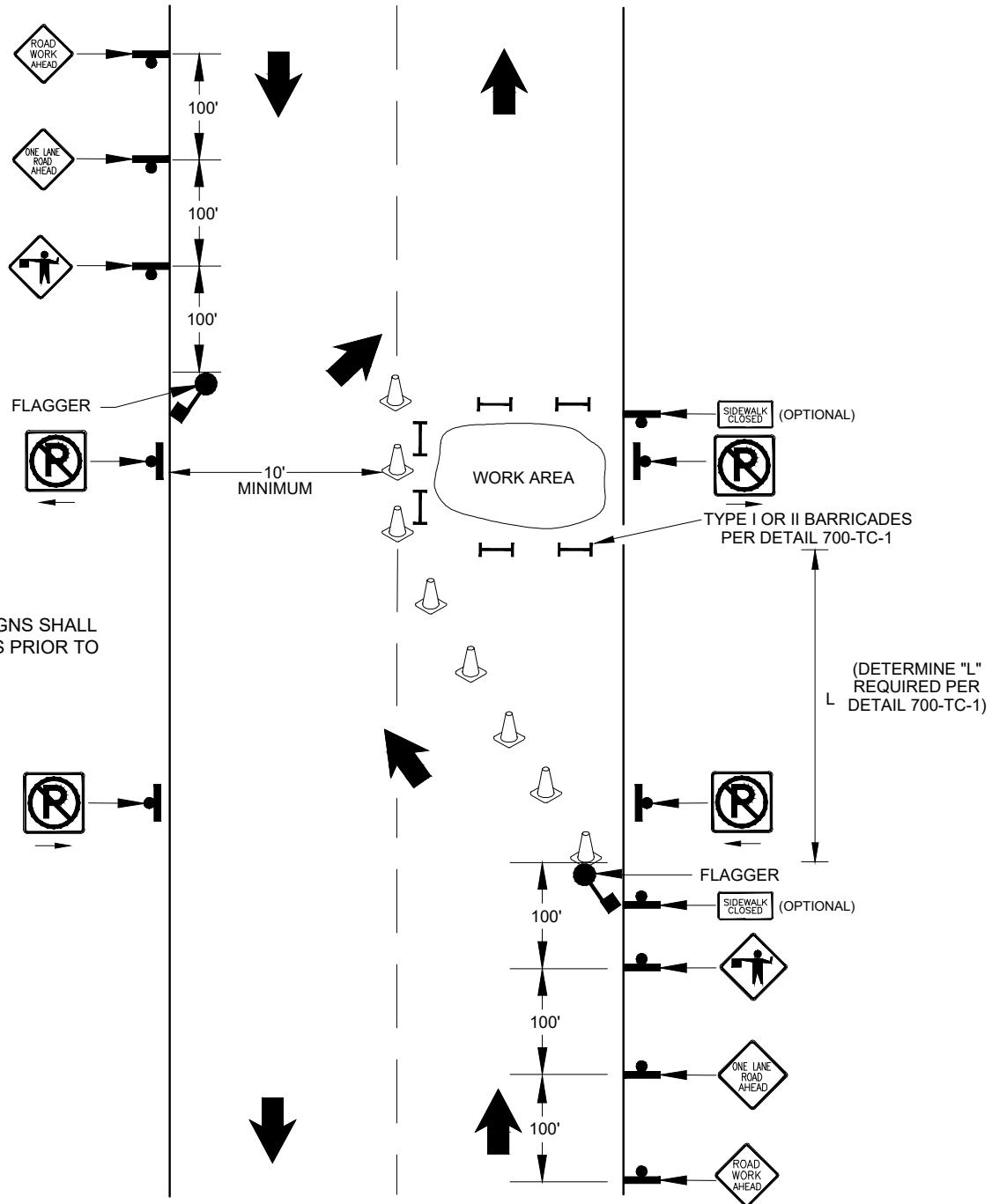


NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CLOSURE LEFT SIDE OF ROADWAY LOW VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



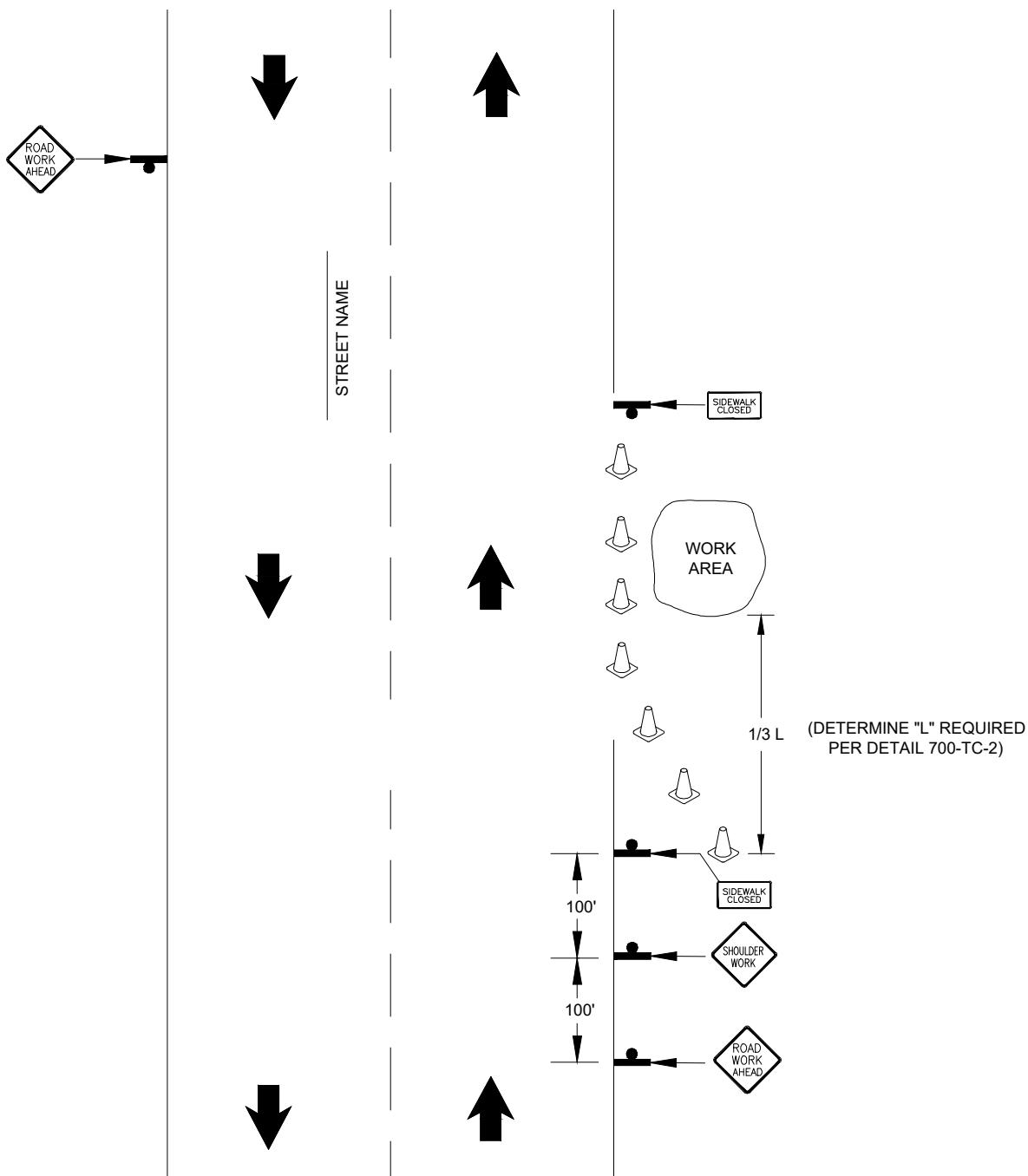
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CLOSURE CENTER OF ROADWAY LOW VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



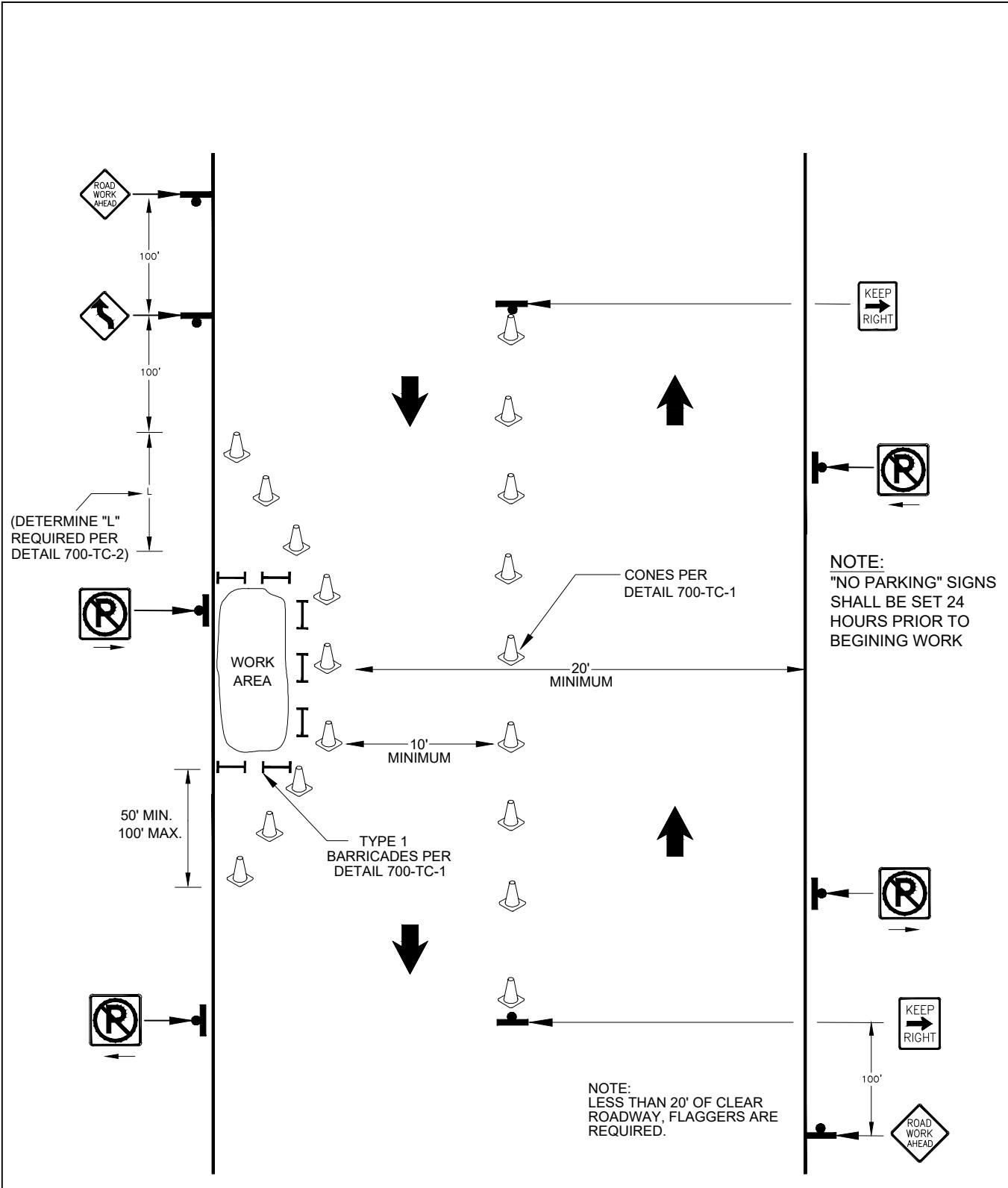
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	LANE CLOSURE WITH FLAGGER LOW VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



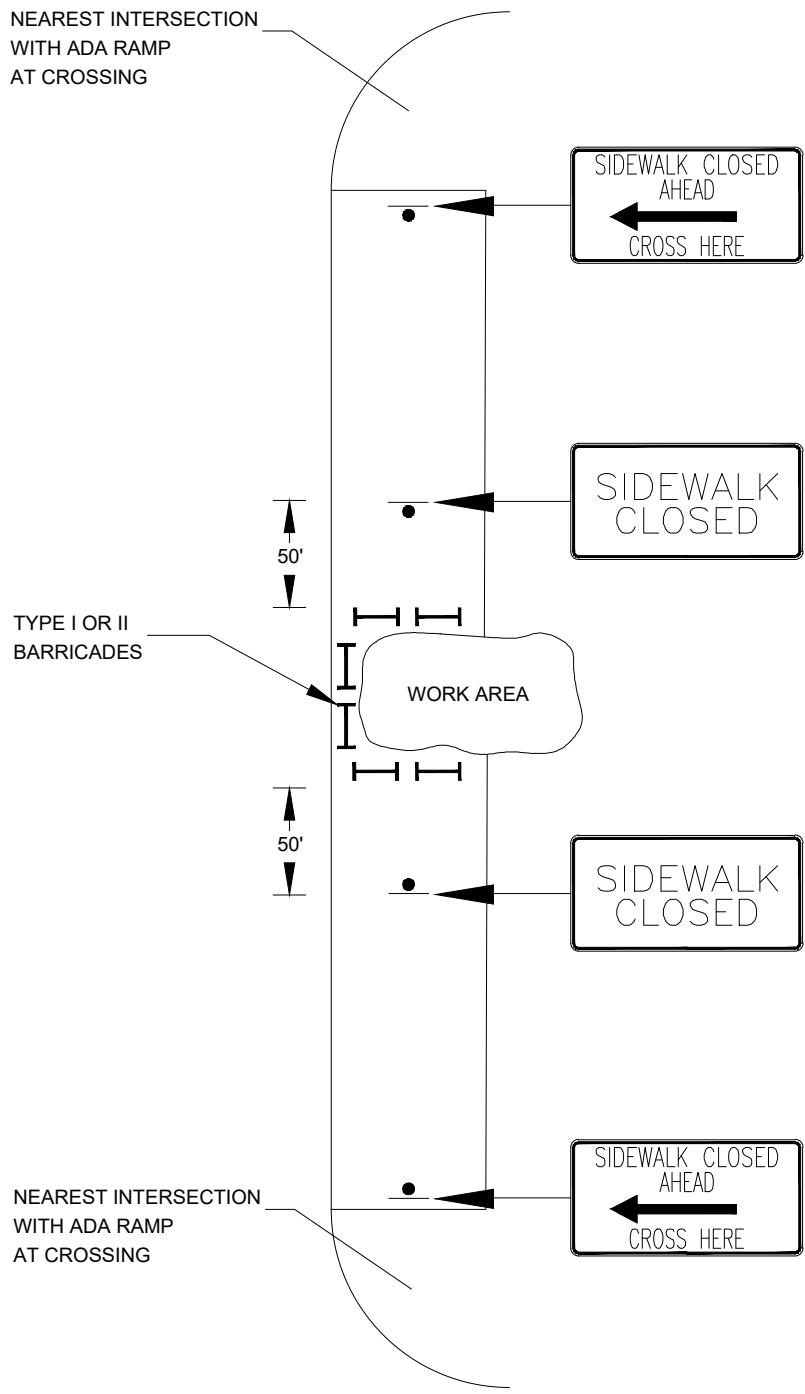
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	SHOULDER WORK LOW VOLUME STREET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



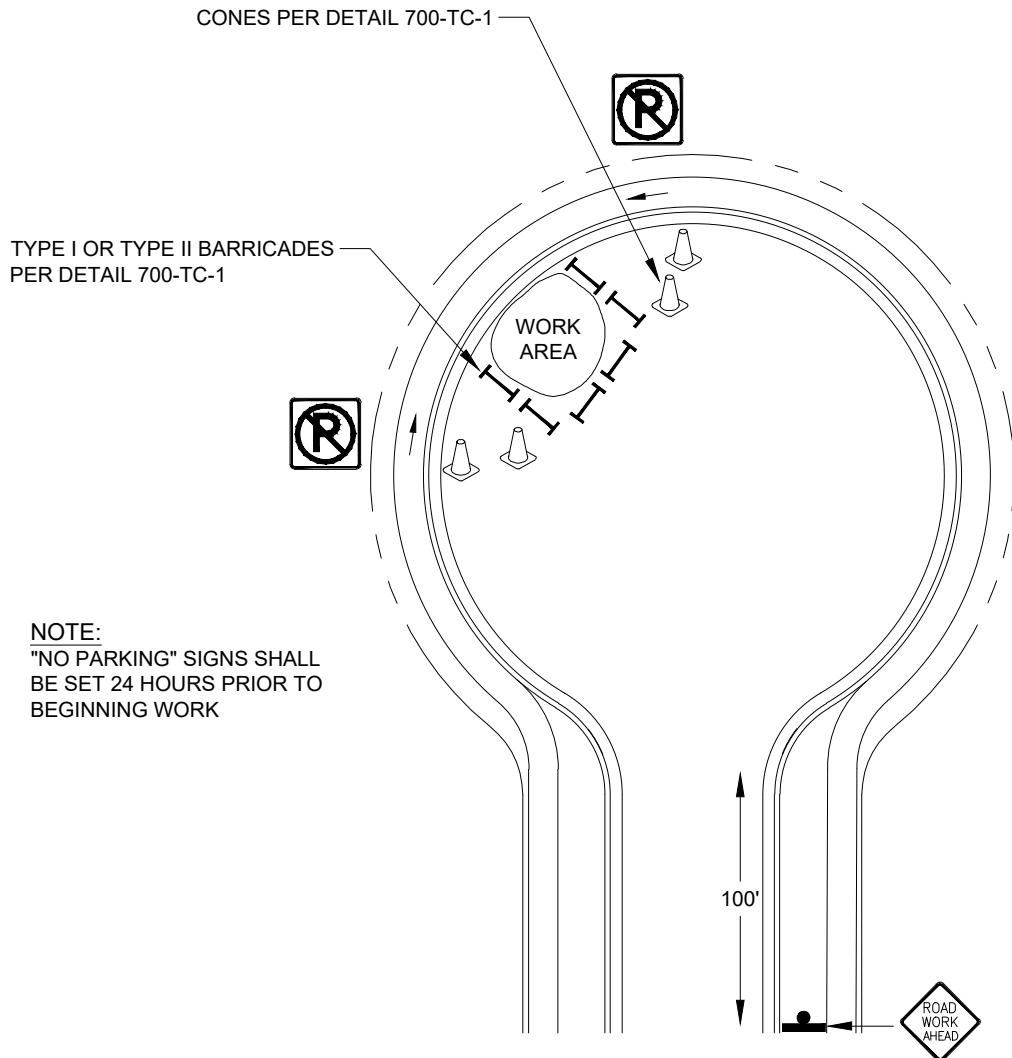
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRAFFIC CONTROL LOW VOLUME STREET WITH NO CENTERLINE
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRAFFIC CONTROL TYPICAL SIDEWALK
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

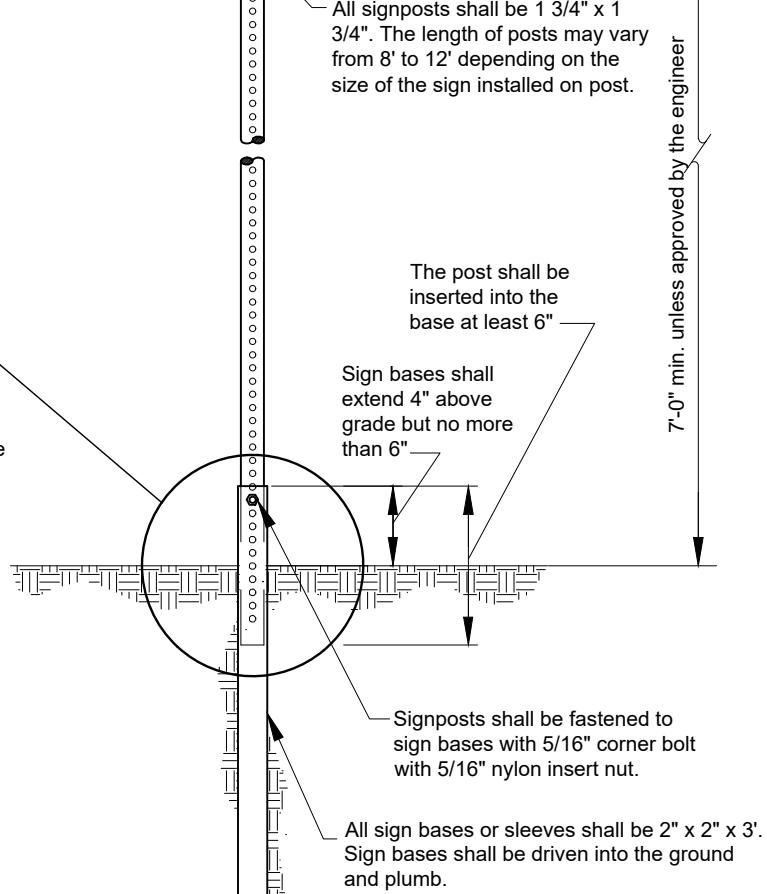
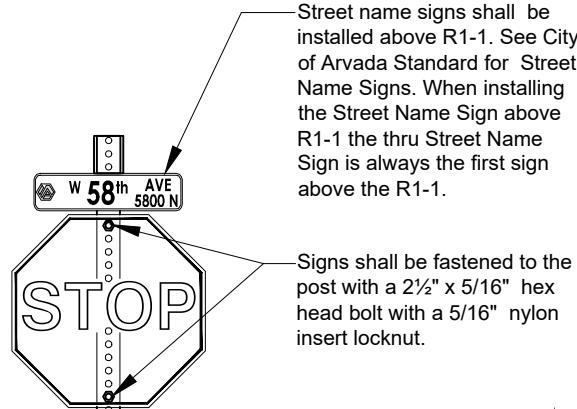
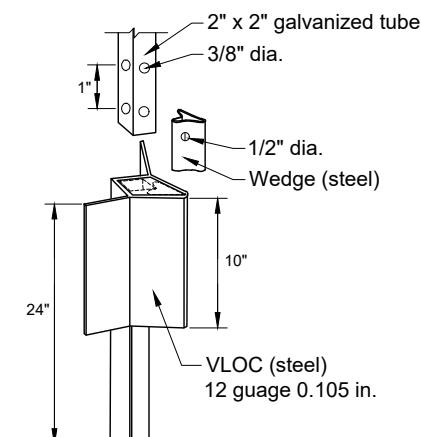
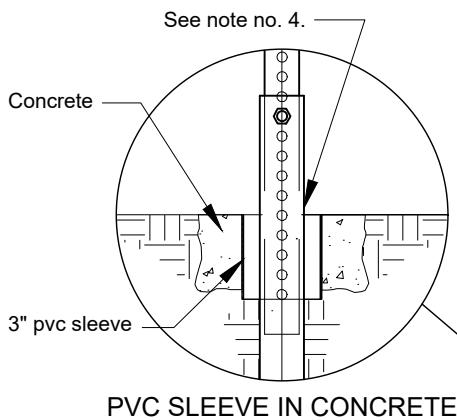


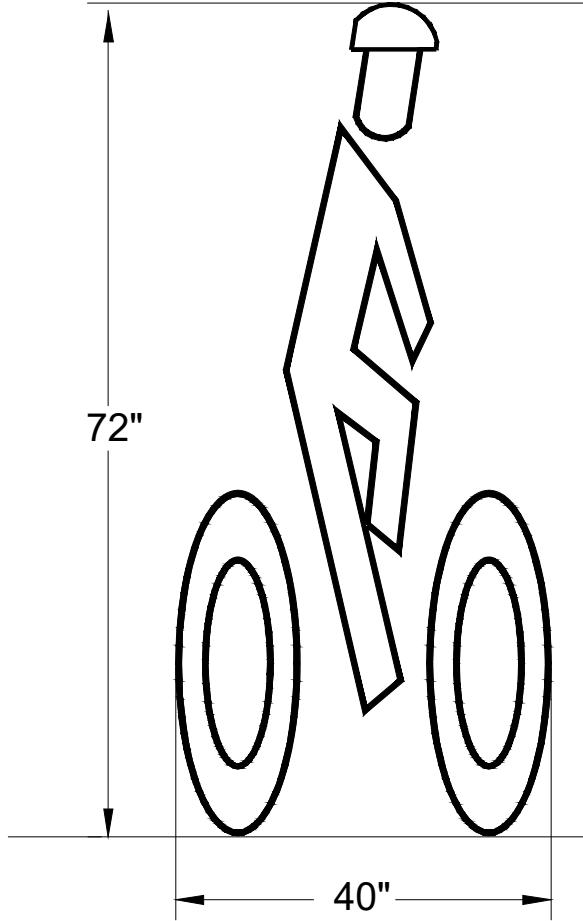
NOTE: ALL TEMPORARY TRAFFIC CONTROL SHALL BE IN CONFORMANCE
WITH THE LATEST EDITION OF THE MUTCD AND ARVADA STANDARDS

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CUL-DE-SAC
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

GENERAL NOTES:

1. All tubing shall be 12 gauge and galvanized coated from factory to enhance corrosion protection.
2. All tubing shall have corner welds that are coated to protect weld line from corrosion.
3. All tubing shall have 7/16" holes spaced on 1" centers on all 4 sides, and shall be free of any fragments both inside and outside of tubing that would hinder the tubing from telescoping.
4. In locations where a sign is to be installed in concrete, a 3" PVC sleeve shall be installed prior to concrete placement. The sleeve shall be equal in length to the concrete depth and flush with the concrete finished surface.
5. 30" x 30" R1-1 background material shall be White Diamond Grade material. Face shall be Red Electro Cut (EC Film) NO ink.
6. Street Name Sign background material shall be White Diamond Grade material. Face shall be Blue Electro Cut (EC Film) NO ink.

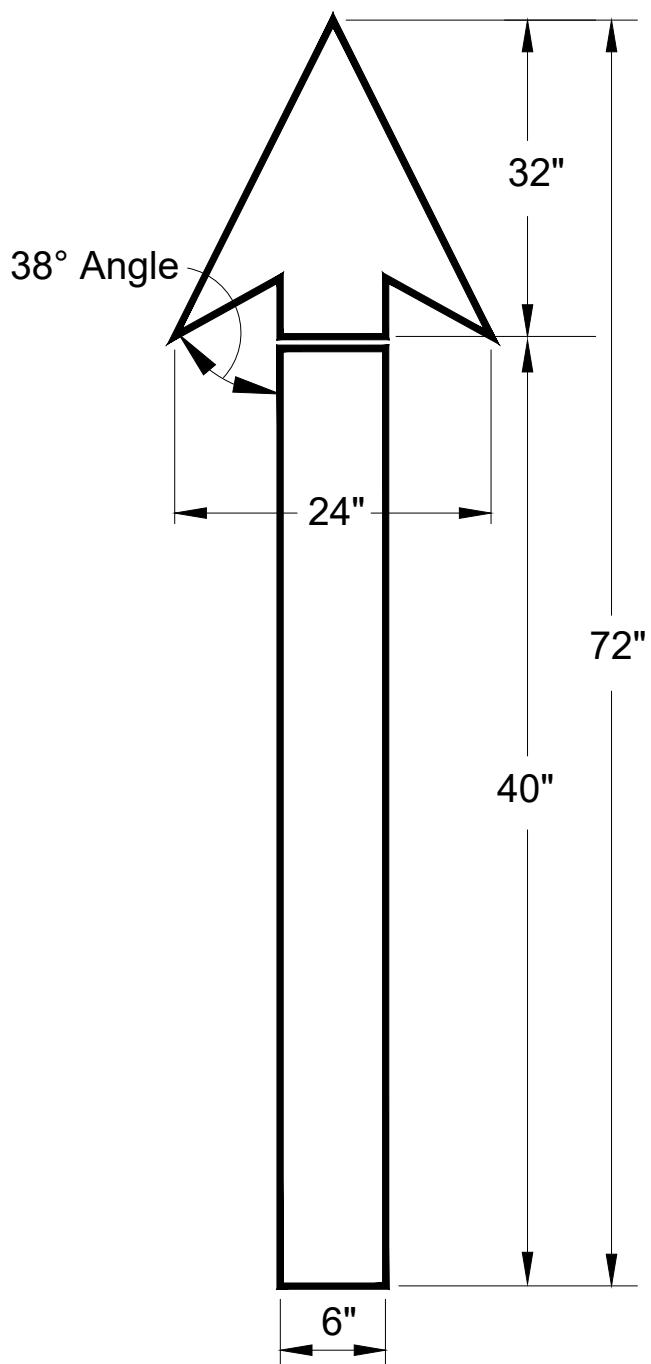




BIKE LANE SYMBOL

NOTES:

- (1) ALL BIKE ARROWS AND BIKE SYMBOLS SHALL BE HOT APPLIED PREFORMED THERMOPLASTIC PAVEMENT MARKINGS, MINIMUM OF 90 MILS OR ALTERNATIVE AS APPROVED BY THE TRAFFIC ENGINEERING DIVISION
- (2) RIGHT FACING SYMBOL
- (3) GRIND ASPHALT DOWN 1/8" TO ENSURE PROPER INSTALLATION DEPTH, REMOVE ALL DEBRIS FROM THE APPLICATION AREA
- (4) PREPARE SURFACE WITH 2 PART SEALANT
- (5) BURN DOWN PAVEMENT MARKINGS, WHILE INSTALLING MARKINGS APPLY GLASS BEADS TO THE BURNED DOWN SURFACES



2 PIECE ARROW SYMBOL

NO	DATE	REVISION
1	2023	2023 REVISIONS



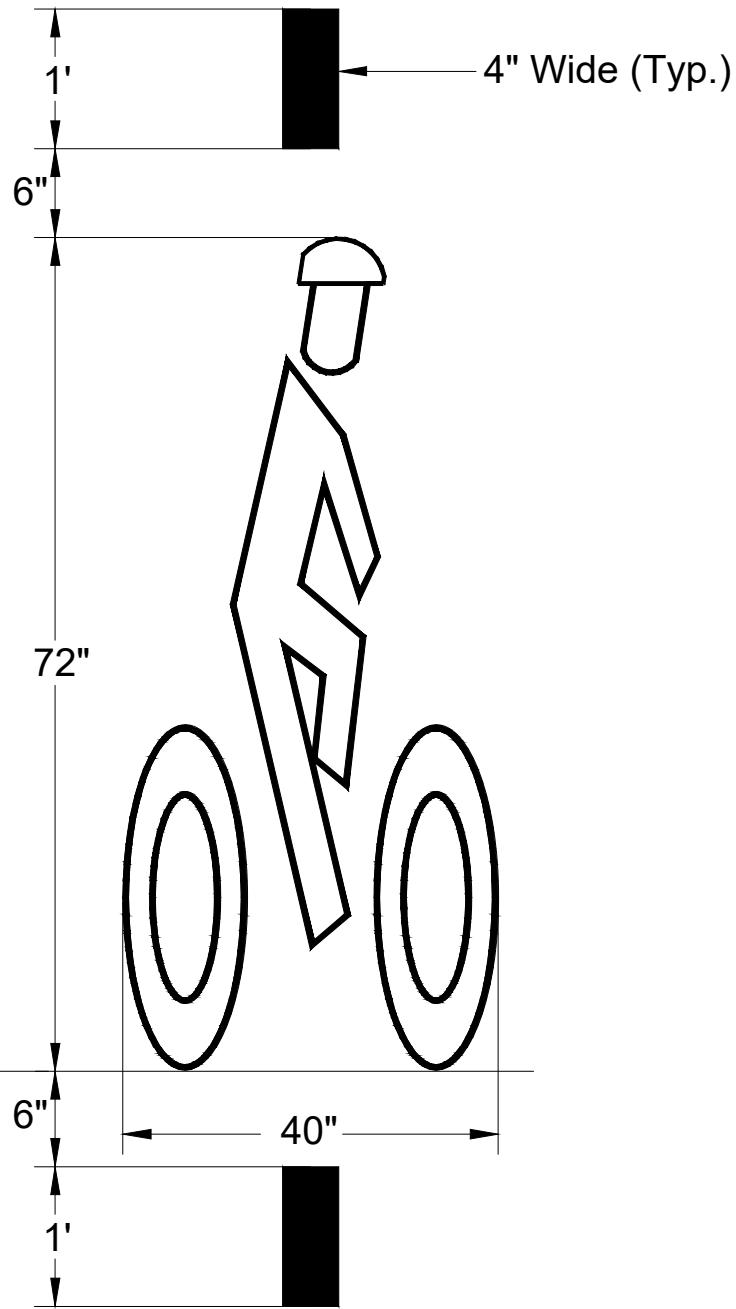
8101 Ralston Road
Arvada, Colorado 80002

BIKE LANE AND
ARROW SYMBOL

2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTES:

- (1) ALL BIKE LANE DETECTOR SYMBOLS SHALL BE HOT APPLIED PREFORMED THERMOPLASTIC PAVEMENT MARKINGS, MINIMUM OF 90 MILS OR ALTERNATIVE AS APPROVED BY THE TRAFFIC ENGINEERING DIVISION
- (2) RIGHT FACING SYMBOL
- (3) GRIND ASPHALT DOWN 1/8" TO ENSURE PROPER INSTALLATION DEPTH, REMOVE ALL DEBRIS FROM THE APPLICATION AREA
- (4) PREPARE SURFACE WITH 2 PART SEALANT
- (5) BURN DOWN PAVEMENT MARKINGS, WHILE INSTALLING MARKINGS APPLY GLASS BEADS TO THE BURNED DOWN SURFACES

**BIKE LANE DETECTOR SYMBOL**

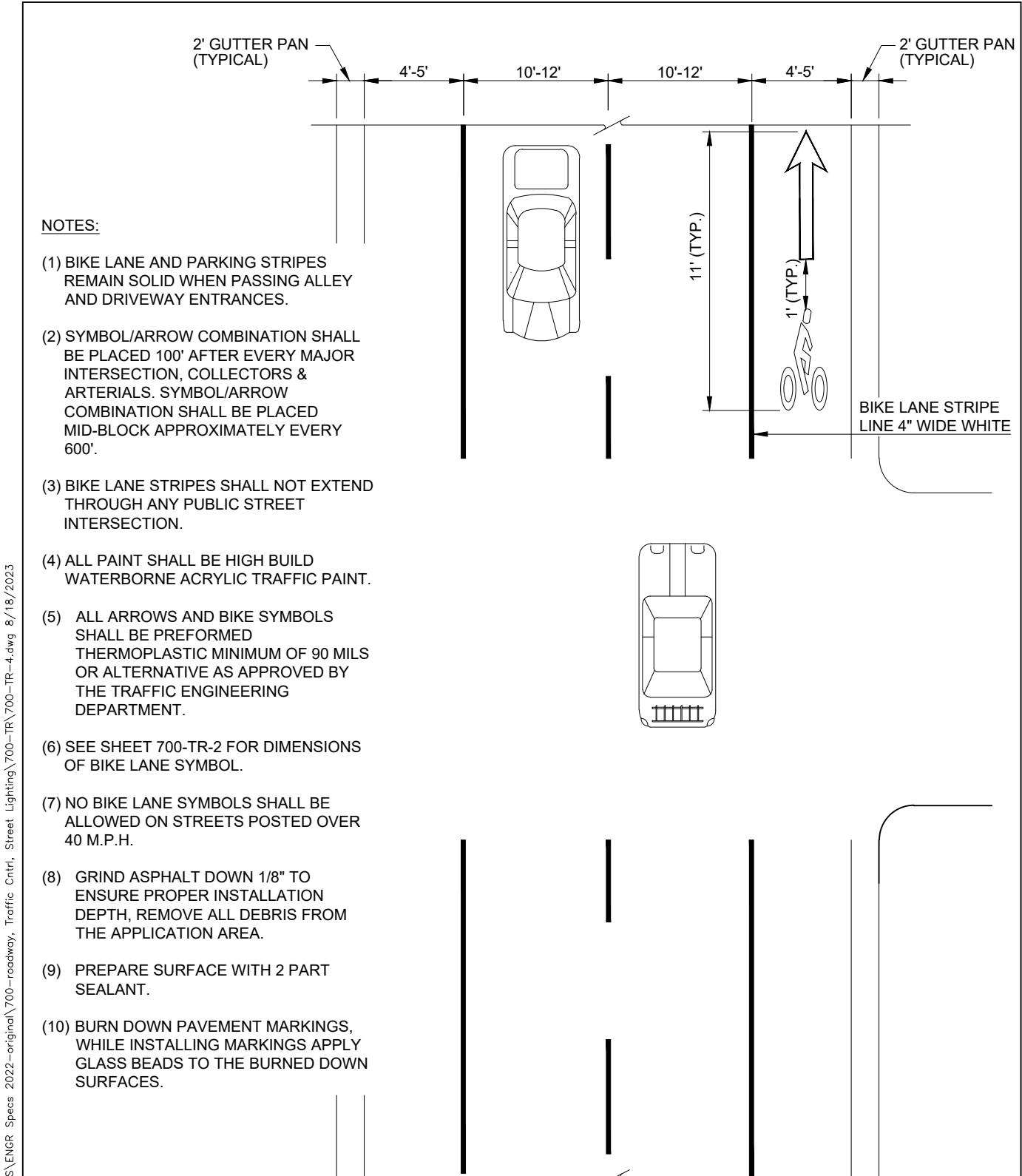
NO	DATE	REVISION
1	2023	2023 REVISIONS



CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

**BIKE LANE DETECTOR
PAVEMENT MARKING**

2022 ENGINEERING STANDARDS & SPECIFICATIONS



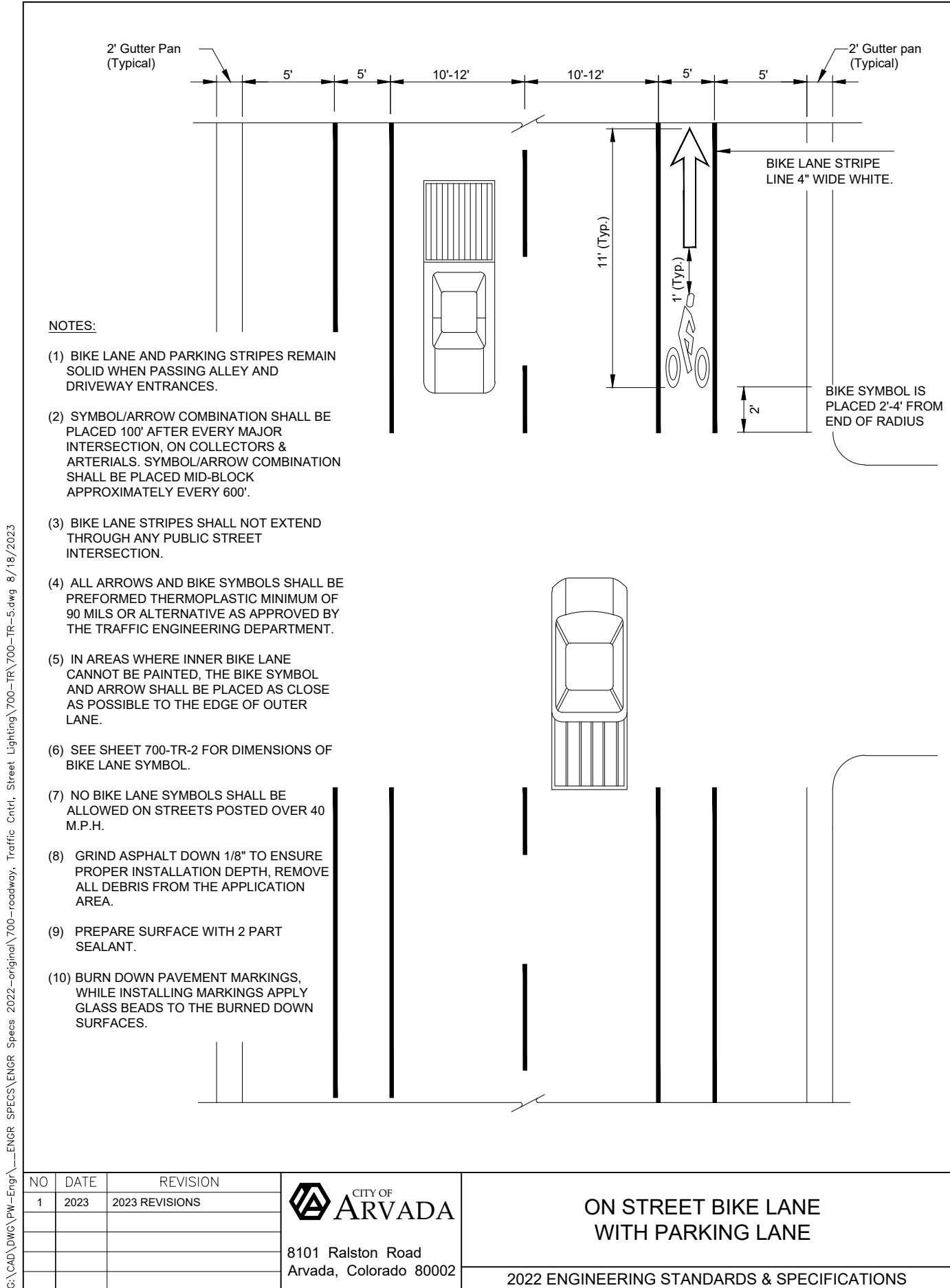
NO	DATE	REVISION
1	2023	2023 REVISIONS

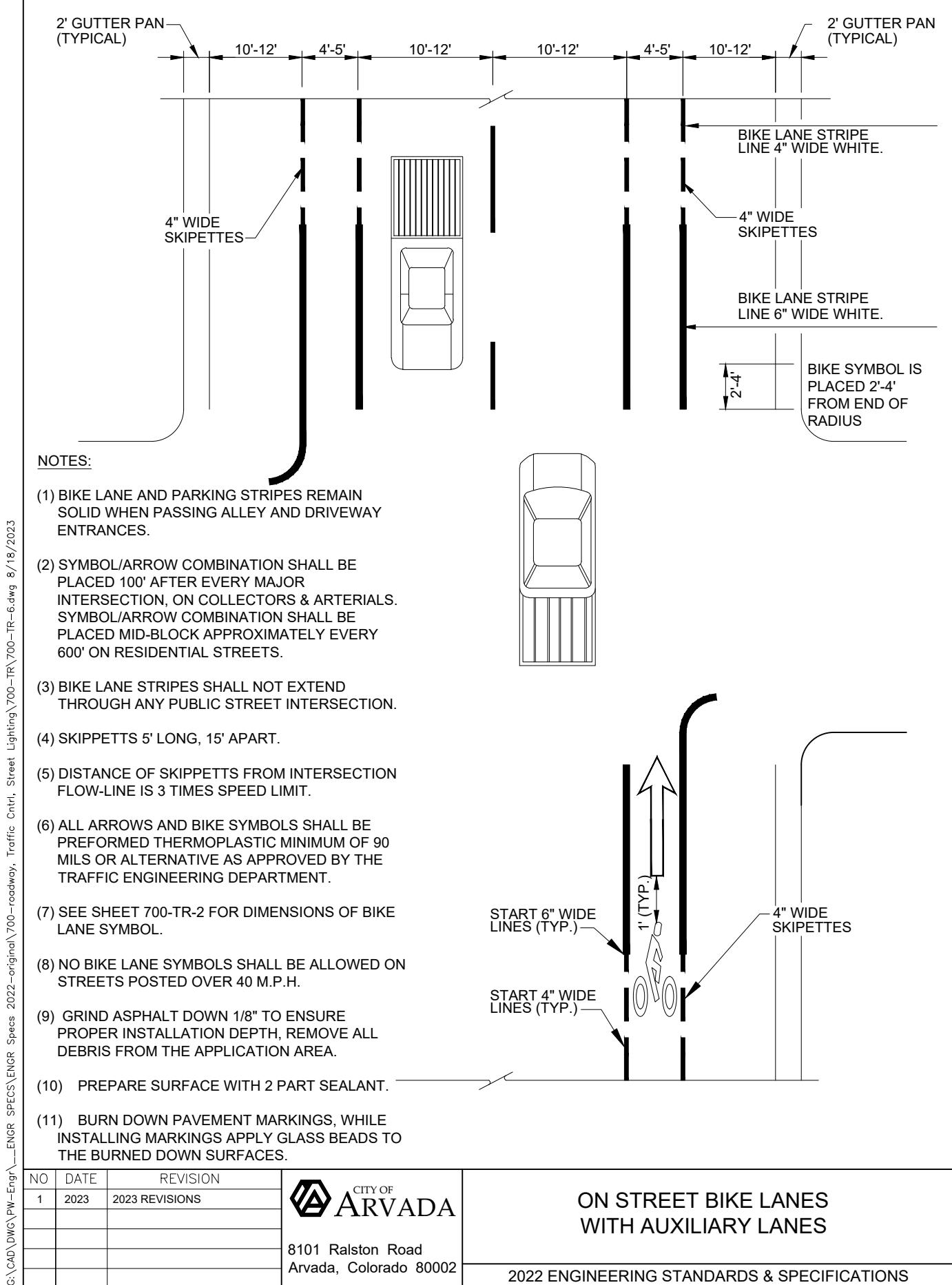


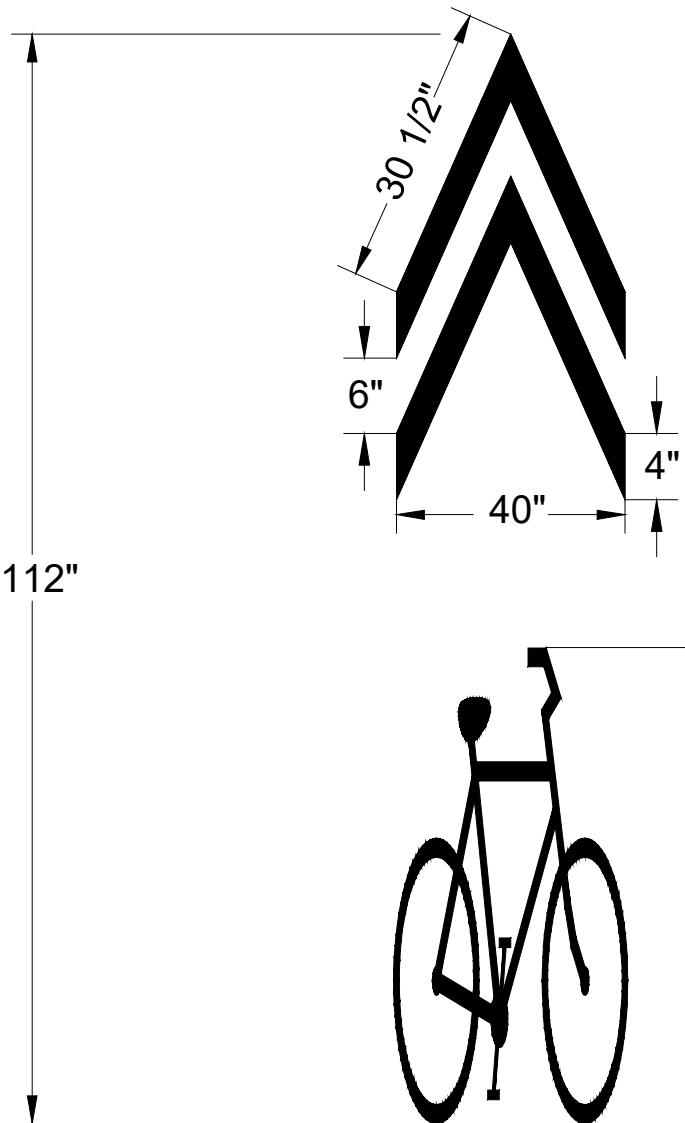
8101 Ralston Road
Arvada, Colorado 80002

ON STREET BIKE LANE WITH NO PARKING

2022 ENGINEERING STANDARDS & SPECIFICATIONS





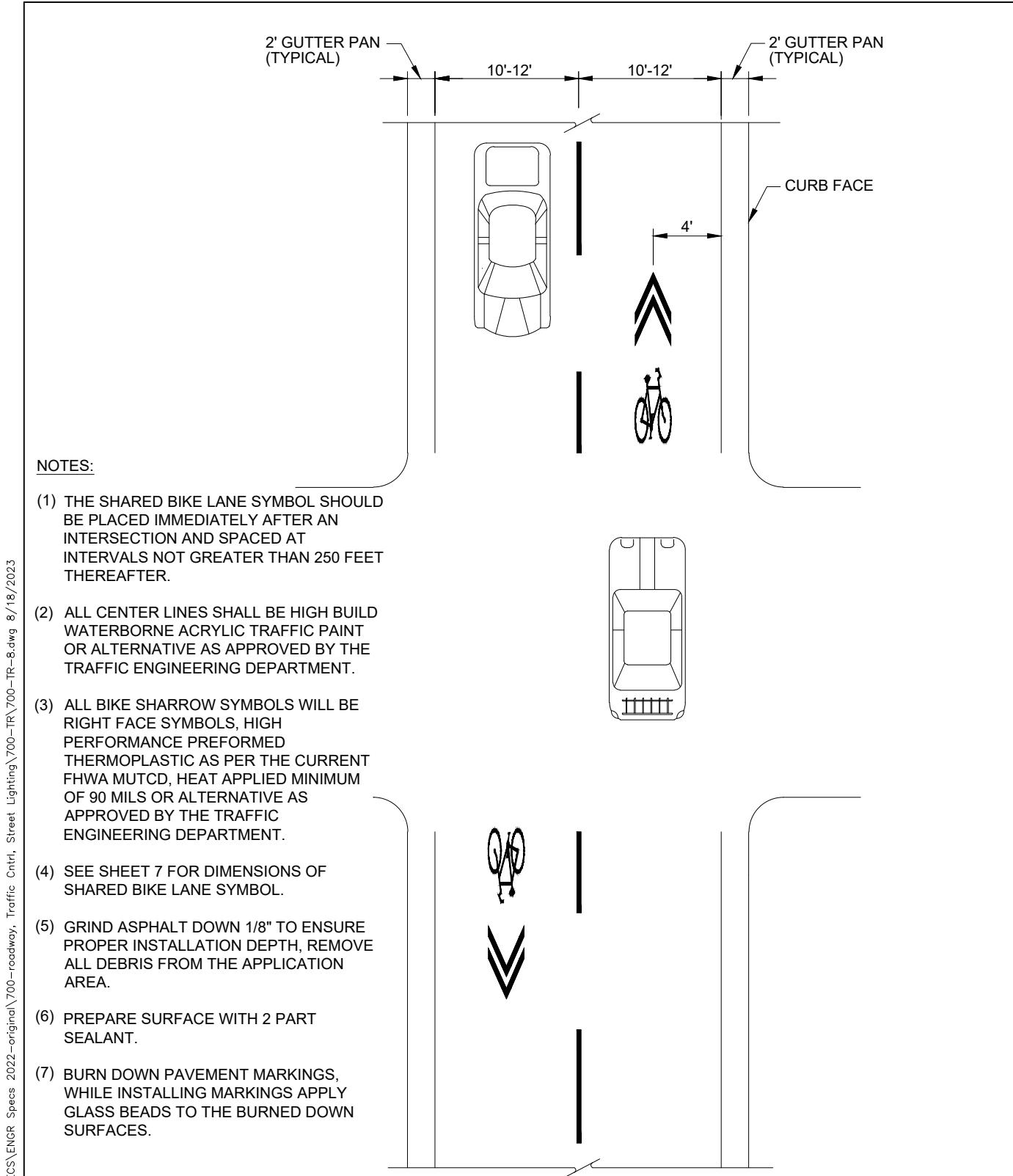


NOTES:

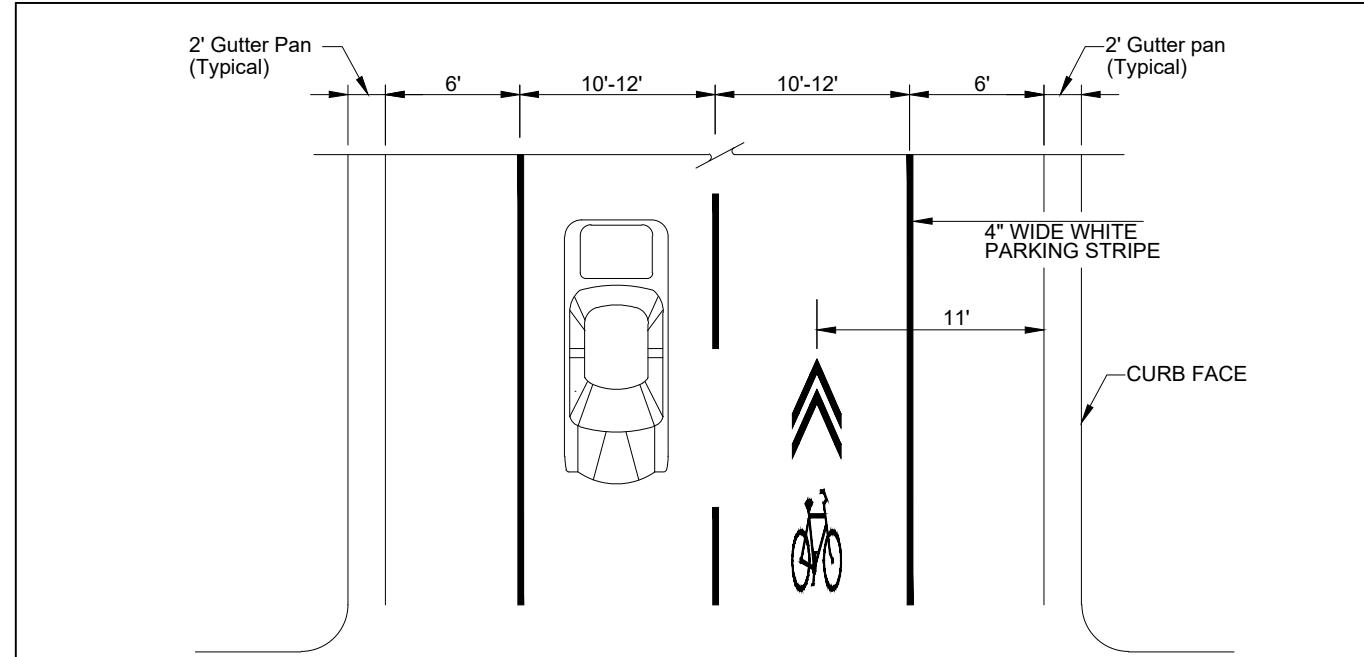
- (1) SHARED BIKE LANE SYMBOL SHOULD BE PLACED IMMEDIATELY AFTER AN INTERSECTION, COLLECTORS & ARTERIALS AND SPACED AT INTERVALS NOT GREATER THAN 250 FEET THEREAFTER.
- (2) ALL BIKE SHARROW SYMBOLS WILL BE RIGHT FACE SYMBOLS, HIGH PERFORMANCE PREFORMED THERMOPLASTIC AS PER THE CURRENT FHWA MUTCD, HEAT APPLIED MINIMUM OF 90 MILS OR ALTERNATIVE AS APPROVED BY THE TRAFFIC ENGINEERING DEPARTMENT.
- (3) GRIND ASPHALT DOWN 1/8" TO ENSURE PROPER INSTALLATION DEPTH, REMOVE ALL DEBRIS FROM THE APPLICATION AREA.
- (4) PREPARE SURFACE WITH 2 PART SEALANT.
- (5) BURN DOWN PAVEMENT MARKINGS, WHILE INSTALLING MARKINGS APPLY GLASS BEADS TO THE BURNED DOWN SURFACES.

112" x 40" BIKE SHARROW

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	SHARED BIKE LANE SYMBOL	2022 ENGINEERING STANDARDS & SPECIFICATIONS
1	2023	2023 REVISIONS			

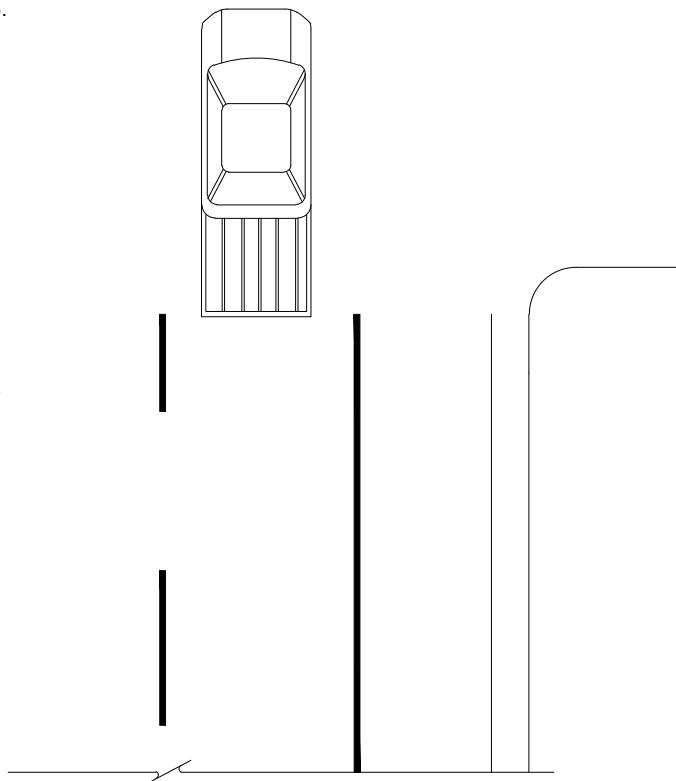


NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	ON STREET SHARED BIKE LANE WITH SHARROW - NO PARKING
1	2023	2023 REVISIONS		2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

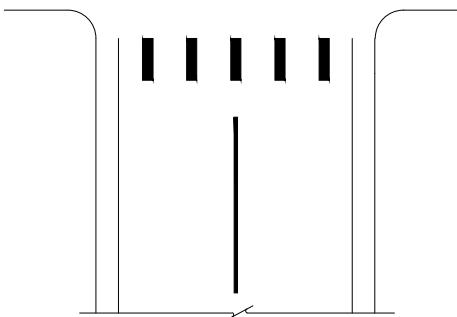
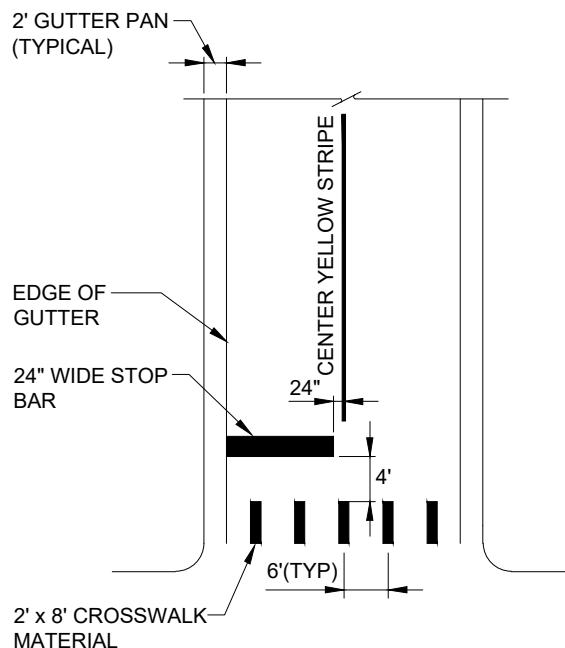
- (1) PARKING STRIPES REMAIN SOLID WHEN PASSING ALLEY AND DRIVEWAY ENTRANCES.
- (2) SHARED BIKE LANE SYMBOL SHOULD BE PLACED IMMEDIATELY AFTER AN INTERSECTION, COLLECTORS & ARTERIALS AND SPACED AT INTERVALS NOT GREATER THAN 250 FEET THEREAFTER.
- (3) ALL CENTER LINES, PARK LANE LINES SHALL BE HIGH BUILD WATERBORNE ACRYLIC TRAFFIC PAINT OR ALTERNATIVE AS APPROVED BY THE TRAFFIC ENGINEERING DEPARTMENT.
- (4) ALL BIKE SHARROW SYMBOLS WILL BE RIGHT FACE SYMBOLS, HIGH PERFORMANCE PREFORMED THERMOPLASTIC AS PER THE CURRENT FHWA MUTCD, HEAT APPLIED MINIMUM OF 90 MILS OR ALTERNATIVE AS APPROVED BY THE TRAFFIC ENGINEERING DEPARTMENT.
- (5) SEE SHEET 700-TR-7 FOR DIMENSIONS OF SHARED BIKE LANE SYMBOL.
- (6) GRIND ASPHALT DOWN 1/8" TO ENSURE PROPER INSTALLATION DEPTH, REMOVE ALL DEBRIS FROM THE APPLICATION AREA.
- (7) PREPARE SURFACE WITH 2 PART SEALANT.
- (8) BURN DOWN PAVEMENT MARKINGS, WHILE INSTALLING MARKINGS APPLY GLASS BEADS TO THE BURNED DOWN SURFACES.



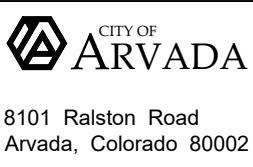
NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	ON STREET SHARED BIKE LANE WITH PARKING LANE AND SHARROW
1	2023	2023 REVISIONS		2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTES:

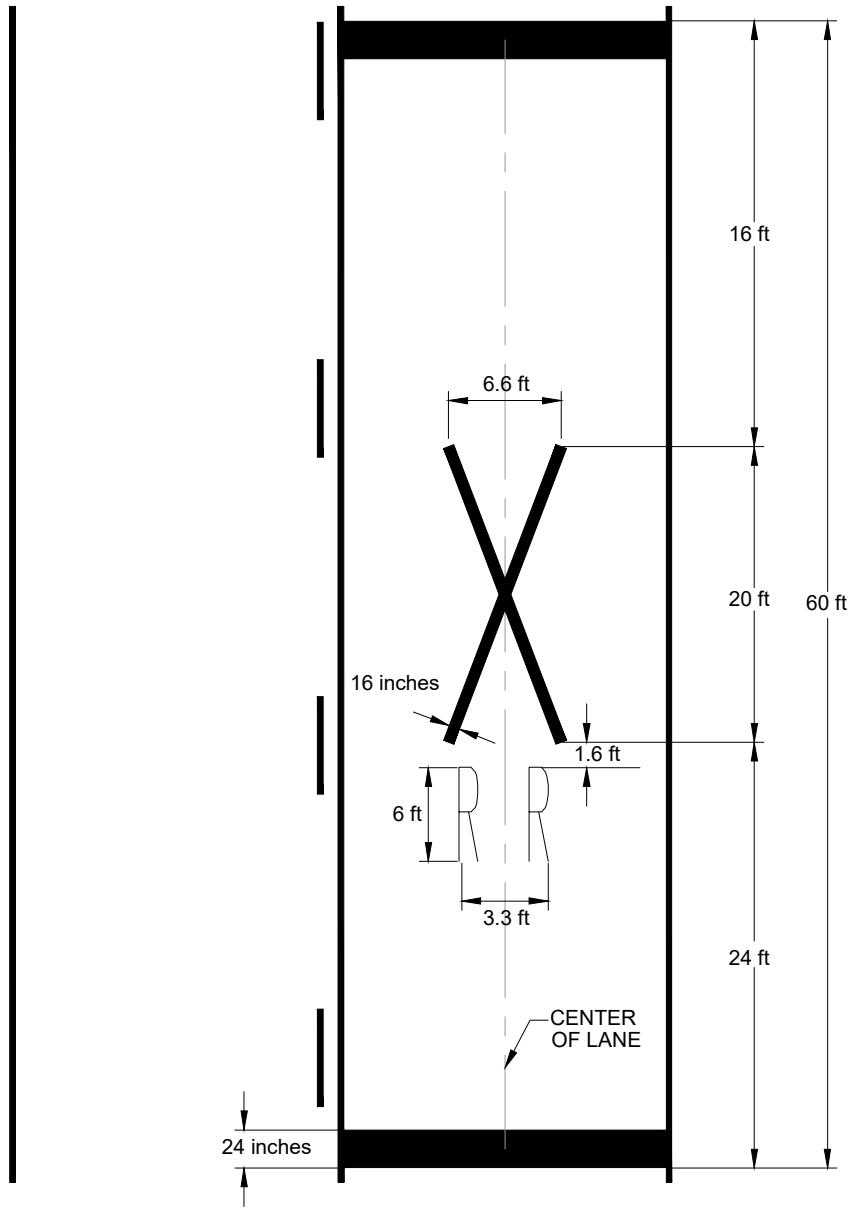
- (1) ALL CROSSWALKS SHALL BE PREFORMED THERMOPLASTIC MINIMUM OF 125 MILS OR ALTERNATIVE AS APPROVED BY THE TRAFFIC ENGINEERING DEPARTMENT, CROSSWALK DIMENSIONS ARE 8' LONG BY 2' WIDE.
- (2) ALL STOP BARS SHALL BE PREFORMED THERMOPLASTIC MINIMUM OF 125 MILS OR ALTERNATIVE AS APPROVED BY THE TRAFFIC ENGINEERING DEPARTMENT, 24" WIDE AND 24" FROM CENTER OF ROAD TO EDGE OF GUTTER.
- (3) ENSURE PROPER CROSSWALK SIZE FROM EITHER ENNIS-FLINT, CROWN TECHNOLOGY, GEVEKO MARKINGS OR APPROVED SUBSTITUTE BY TRAFFIC ENGINEERING.
- (4) GRIND ASPHALT DOWN 1/8" TO ENSURE PROPER INSTALLATION DEPTH, REMOVE ALL DEBRIS FROM THE APPLICATION AREA.
- (5) PREPARE SURFACE WITH 2 PART SEALANT.
- (6) BURN DOWN PAVEMENT MARKINGS, WHILE INSTALLING MARKINGS APPLY GLASS BEADS TO THE BURNED DOWN SURFACES.



NO	DATE	REVISION
1	2023	2023 REVISIONS

**CROSSWALKS AND STOP BARS**

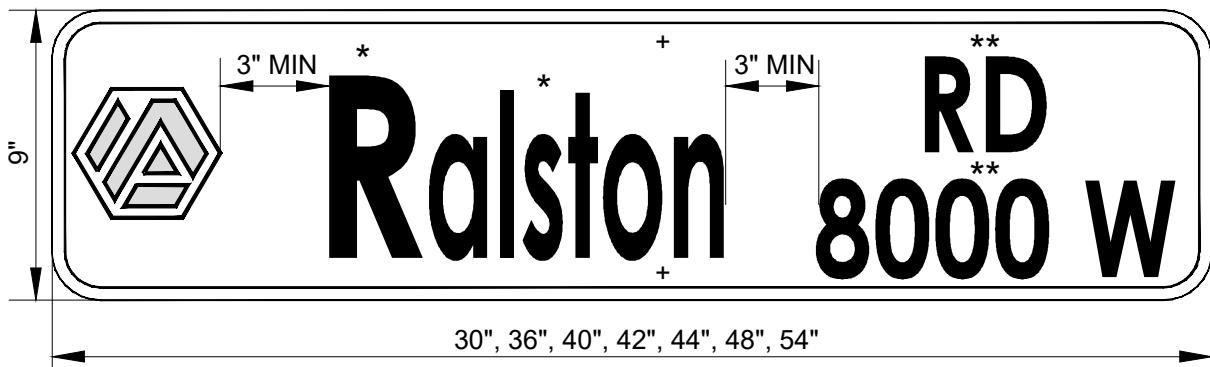
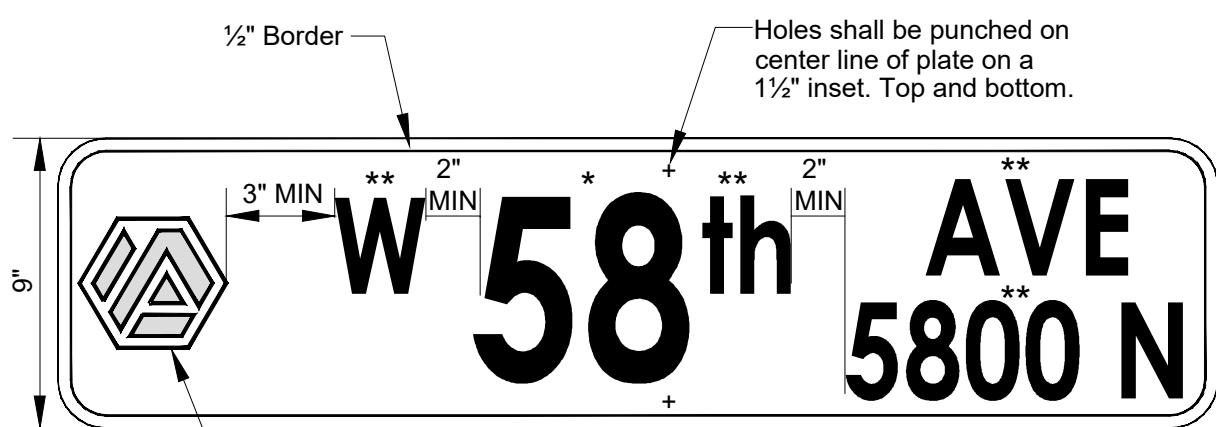
2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTES:

- (1) ALL RAILROAD GRADE CROSSING PAVEMENT MARKINGS
PER THE LATEST FHWA MUTCD STANDARDS.

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	RAILROAD GRADE CROSSING PAVEMENT MARKINGS	2022 ENGINEERING STANDARDS & SPECIFICATIONS



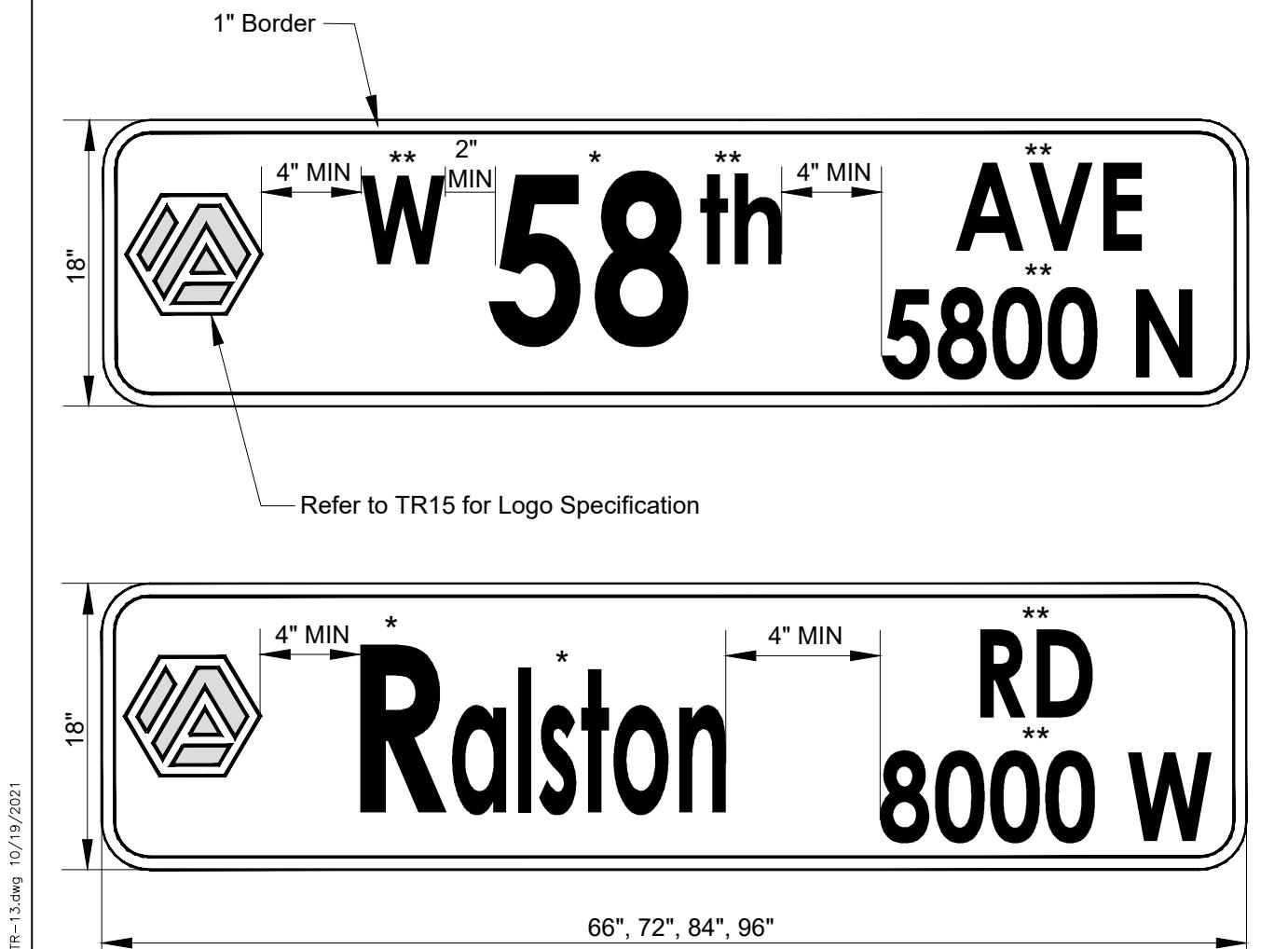
Notes:

1. This standard shall be used at all non-signalized intersections.
2. Sign blanks shall be 0.080 gauge aluminum.
3. Sheeting material shall be (White) VIP Diamond Grade (3M) overlayed with (3M) Blue E.C. film. (Text, logo & border are white).
4. Sign face shall be placed on one side of blank only.
5. Holes shall be 3/8 inch diameter free of burrs and sharp edges.
6. Corner radii shall be 1 1/2 inch.
7. Signs for private streets shall conform to this specification except the City Of Arvada logo shall not be used.
8. All text shall be series "Highway Gothic "C" Font".
9. The following abbreviations shall be used for signs: AVE, CIR, DR, RD, LANE PKWY, PL, CT, WAY, FRNTG RD.
10. All street name signs over 40" shall be bolted at each end with 5/16" x 3/4" bolt and nut (1" inch from edge of sign of sign inward and 4 1/2" from top edge).
11. All street name signs shall be double blades.

* = All font size shall 6" height.

** = All font size shall be 3" height.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	STREET NAME SIGN (POST MOUNTED)
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



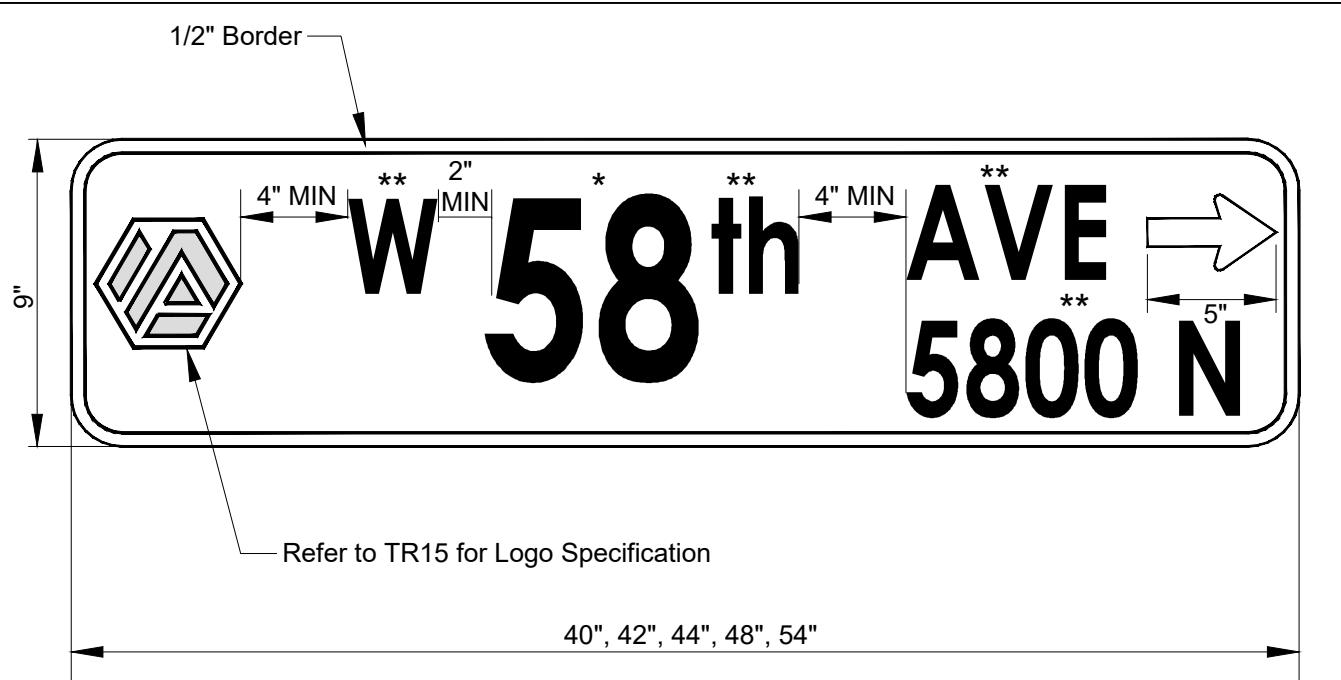
Notes:

1. This standard shall be used at all signalized intersections.
2. Sign blanks shall be 0.080 gauge aluminum.
3. Sheeting material shall be (White) VIP Diamond Grade (3M) overlayed with (3M) Blue E.C. film. (Text, logo & border are white).
4. Sign face shall be placed on one side of blank only.
5. Corner radii shall be 3 inch.
6. All text shall be series "Highway Gothic "C" Font".
7. The following abbreviations shall be used for signs: AVE, CIR, DR, RD, LANE PKWY, PL, CT, WAY, FRNTG RD.

* = All font size shall 10" height.

** = All font size shall be 5" height.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	STREET NAME SIGN (SIGNAL MOUNTED)
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



Notes:

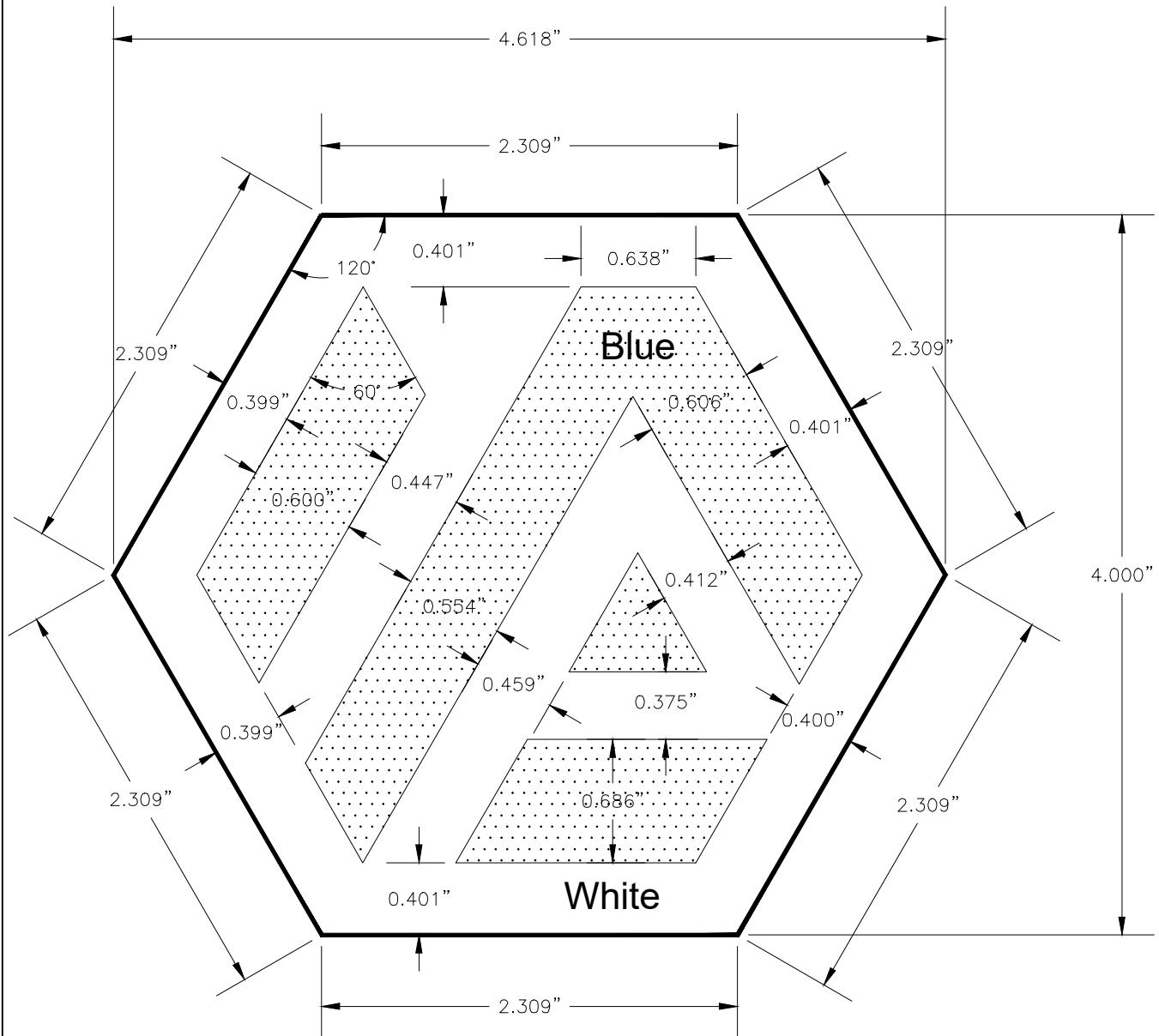
1. This standard shall be used at all non-signalized intersections where the name changes or the name is in one direction.
2. Sign blanks shall be 0.080 gauge aluminum.
3. Sheeting material shall be (White) VIP Diamond Grade (3M) overlayed with (3M) Blue E.C. film. (Text, logo & border are white).
4. Holes shall be 3/8 inch diameter free of burrs and sharp edges.
5. Sign face shall be placed on one side of blank only.
6. Corner radii shall be 1½ inch.
7. All text shall be series "Highway Gothic "C" Font".
8. The following abbreviations shall be used for signs: AVE, CIR, DR, RD, LANE PKWY, PL, CT, WAY, FRNTG RD.
9. All street name signs over 40" shall be bolted at each end with 5/16" x 3/4" bolt and nut (1" inch from edge of sign of sign inward and 4 1/2" from top edge).
10. All street name signs shall be double blades.

* = All font size shall 6" height minimum.

** = All font size shall be 3" height minimum.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	STREET NAME SIGN WITH DIRECTION ARROW (POST MOUNTED)	2022 ENGINEERING STANDARDS & SPECIFICATIONS

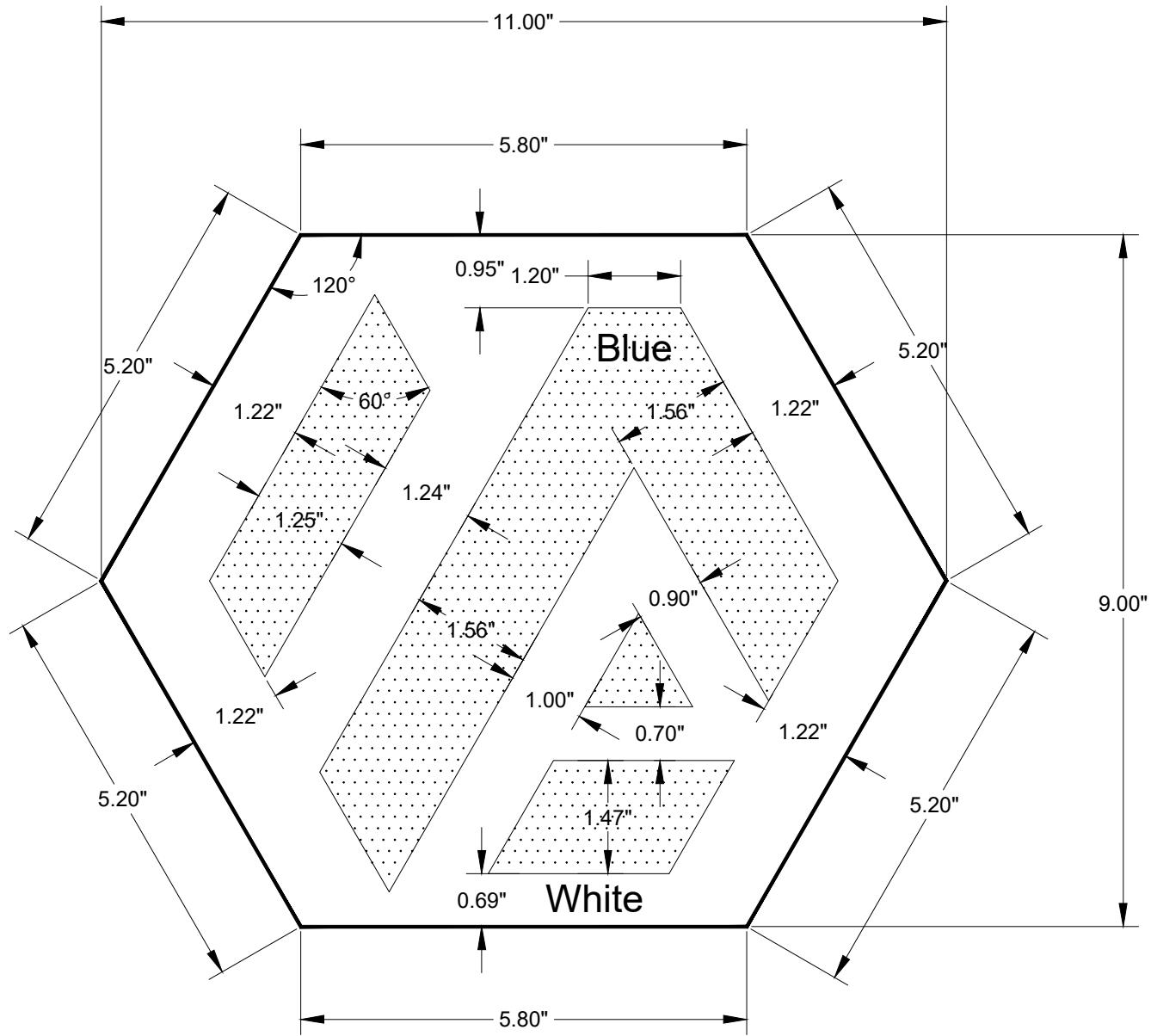
City Logo for 9" High Street Name Sign



See TR-12 "STREET NAME SIGN (POST MOUNTED)" for sheeting material and color.

NO DATE REVISION  CITY OF ARVADA
8101 Ralston Road
Arvada, Colorado 80002 SIGN LOGO FOR
NON-SIGNALIZED INTERSECTIONS
(POST MOUNTED)
2022 ENGINEERING STANDARDS & SPECIFICATIONS

**City Logo for 18" High
Overhead Street Name Sign**



See 700-TR-13 "STREET NAME SIGN (SIGNAL MOUNTED)" for sheeting material and color.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	SIGN LOGO FOR SIGNALIZED INTERSECTIONS (SIGNAL MOUNTED)
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

GENERAL NOTES

1. TRAFFIC SIGNAL MATERIALS AND INSTALLATION SHALL COMPLY WITH THE CITY OF ARVADA ENGINEERING STANDARDS AND SPECIFICATIONS, 2022 EDITION. ITEMS NOT REFERENCED IN THESE DOCUMENTS SHALL CONFORM TO THE LATEST EDITIONS OF THE STATE OF COLORADO "STANDARDS AND SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION", THE STATE OF COLORADO "STANDARD PLANS", THE "MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES", THE "NATIONAL ELECTRIC CODE", AND ALL LOCAL ORDINANCES AND REGULATIONS THAT APPLY, EXCEPT AS NOTED ON THE PLANS, STANDARDS SPECIAL PROVISIONS, OR PROJECT SPECIAL PROVISIONS.
2. CONDUIT, POLE, PULL BOX AND CONTROLLER CABINET LOCATIONS ARE APPROXIMATE. EXACT LOCATIONS SHALL BE DETERMINED BY THE CONTRACTOR AND SHALL BE VERIFIED BY THE CITY OF ARVADA IN THE FIELD. TRAFFIC SIGNAL POLES AND MAST ARMS SHALL NOT BE ORDERED UNTIL THE EXACT LOCATION OF THE POLE BASES IS FIELD VERIFIED. THE CONTRACTOR SHALL CONTACT THE CITY (720-898-7740) A MINIMUM OF 48 HOURS AND A MAXIMUM OF 96 HOURS PRIOR TO STARTING TRAFFIC SIGNAL CONSTRUCTION.
3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR LOCATING ALL EXISTING OVERHEAD AND UNDERGROUND UTILITIES AND THE PROTECTING OF THESE UTILITIES. LOCATIONS SHOWN ON THE PLANS ARE APPROXIMATE AND NOT ALL UTILITIES ARE NECESSARILY SHOWN. THE CONTRACTOR SHALL CONTACT ALL THE APPROPRIATE ENTITIES TO LOCATE UNDERGROUND FACILITIES AT LEAST 48 HOURS PRIOR TO COMMENCEMENT OF CONSTRUCTION. THE EXACT LOCATION OF EACH UTILITY SHALL BE FIELD VERIFIED BEFORE COMMENCING WORK. THE CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MAY OCCUR AS A RESULT OF THE CONTRACTOR'S FAILURE TO LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.
4. THE CONTRACTOR SHALL FURNISH AND INSTALL A METERED ELECTRICAL SERVICE PEDESTAL AT THE LOCATIONS SHOWN ON THE PLANS OR AS DIRECTED BY THE CITY. POWER SOURCE AT EACH INTERSECTION SHALL BE DETERMINED BY THE CITY AFTER MEETING WITH XCEL ENERGY. THE POWER SOURCE SHALL BE IDENTIFIED ON THE CONSTRUCTION PLANS. POWER INSTALLATION, INCLUDING THE SERVICE PEDESTAL METER, SHALL MEET XCEL ENERGY REQUIREMENTS. PULL SEPARATE WIRE FOR STREET LIGHTS AND TAG "FOR XCEL ENERGY STREET LIGHT" AT BOTTOM OF MAST ARM POLE. CONTRACTOR SHALL EXTEND ELECTRICAL POWER FROM THE POWER SOURCE TO THE NEW CONTROLLER CABINET.
5. PAYMENT SHALL BE MADE ONLY FOR ITEMS IN THE PAY ITEM LIST. ALL OTHER ITEMS TO PROVIDE A FULLY FUNCTIONAL TRAFFIC SIGNAL INSTALLATION SHALL BE CONSIDERED INCIDENTAL TO THE WORK.
6. THE CONTRACTOR IS RESPONSIBLE FOR OBTAINING ALL PERMITS FROM THE APPROPRIATE AGENCIES. THE CONTRACTOR SHALL SUBMIT A TRAFFIC CONTROL PLAN FOR CONSTRUCTION TO THE CITY WITH THE PERMIT APPLICATION 48 HOURS IN ADVANCE OF CONSTRUCTION. A RIGHT OF WAY WORK PERMIT WILL NOT BE ISSUED WITHOUT AN APPROVED TRAFFIC CONTROL PLAN.
7. WORKING HOURS SHALL BE IN COMPLIANCE WITH THE CITY OF ARVADA ENGINEERING STANDARDS AND SPECIFICATIONS, 2022 EDITION.
8. THE CONTRACTOR SHALL PROVIDE THE CITY WITH EQUIPMENT SPECIFICATIONS/DESCRIPTIONS AND OBTAIN APPROVALS BEFORE ORDERING THE EQUIPMENT.
9. UPON COMPLETION OF THE WORK, THE CONTRACTOR SHALL SUBMIT RECORD DRAWINGS, CORRECTED PLANS AND ANY ADDITIONAL DATA REQUIRED BY THE CITY SHOWING IN DETAIL ALL CONSTRUCTION CHANGES.
10. THE SIGNAL POLES SHALL BE FABRICATED BY VALMONT INDUSTRIES TO ARVADA STANDARDS UNLESS OTHERWISE APPROVED. THE POLES SHALL BE FACTORY PAINTED ARVADA BRONZE. SIGNAL POLE FOUNDATIONS SHALL BE INSTALLED ACCORDING TO THE CITY OF ARVADA STANDARDS AND SPECIFICATIONS, 2022 EDITION.
11. THE CONTROLLER SHALL BE AN ECOLITE COBALT ADVANCED TRANSPORTATION CONTROLLER THAT CAN COMMUNICATE WITH THE CITY'S ECOLITE CENTRACS SYSTEM. THE CONTROLLER CABINET SHALL BE A TS2 TYPE 1 P CABINET AND SHALL BE NATURAL ALUMINUM. THE CONTROLLER CABINET SHALL BE INSTALLED SUCH THAT WITH THE FRONT DOOR OPEN, A TECHNICIAN VIEWS BOTH THE CONTROLLER AND THE INTERSECTION. THE CONTROLLER CABINET SHALL BE MOUNTED ON A FIBERGLASS REINFORCED POLYMER CONCRETE BASE. EMERGENCY SIGNAL CONTROLLER CABINET SHALL BE A POLE-MOUNTED TS2 G CABINET. TRAFFIC SIGNAL CONTROLLERS SHALL BE DELIVERED TO THE CITY FOR INSPECTION AND PROGRAMMING AT LEAST 15 DAYS PRIOR TO INSTALLATION.
12. ALL SIGNAL HEADS SHALL BE BLACK POLYCARBONATE. ALL OVERHEAD SIGNAL INDICATIONS SHALL HAVE BACKPLATES. BACKPLATES SHALL BE LOUVERED WITH 2-INCH YELLOW RETROREFLECTIVE BORDER TAPE THAT OUTLINES THE OUTSIDE EDGE OF EACH BACKPLATE. PLACEMENT OF SIGNAL AND PEDESTRIAN HEADS SHALL BE APPROVED BY CITY TRAFFIC PERSONNEL.
13. MAST ARM SIGNAL HEADS SHALL BE MOUNTED APPROXIMATELY LEVEL WITH ONE ANOTHER, WITH A 17 TO 19 FOOT CLEARANCE ABOVE GRADE AT THE HIGHEST PAVEMENT ELEVATION. MAST ARM MOUNTED SIGNAL HEADS SHALL HAVE A MINIMUM 8-FOOT SEPARATION.
14. ALL VEHICLE AND PEDESTRIAN INDICATIONS SHALL BE APPROVED LED, NON-GLARE TYPE. ALL VEHICLE INDICATIONS SHALL BE 12". ALL PEDESTRIAN INDICATIONS SHALL BE 16".
15. PEDESTRIAN SIGNALS SHALL BE COUNTDOWN TYPE AS PER CITY SPECIFICATIONS. PEDESTRIAN PUSH BUTTONS SHALL BE POLARA INS2 NAVIGATOR PUSH BUTTON STATION. PEDESTRIAN PUSH BUTTONS SHALL BE ADA COMPLIANT ACCESSIBLE DETECTORS AND INTEGRAL WITH A PUSH BUTTON/PUSH BUTTON SIGN STATION.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	GENERAL TRAFFIC SIGNAL EQUIPMENT INSTALLATION NOTES
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

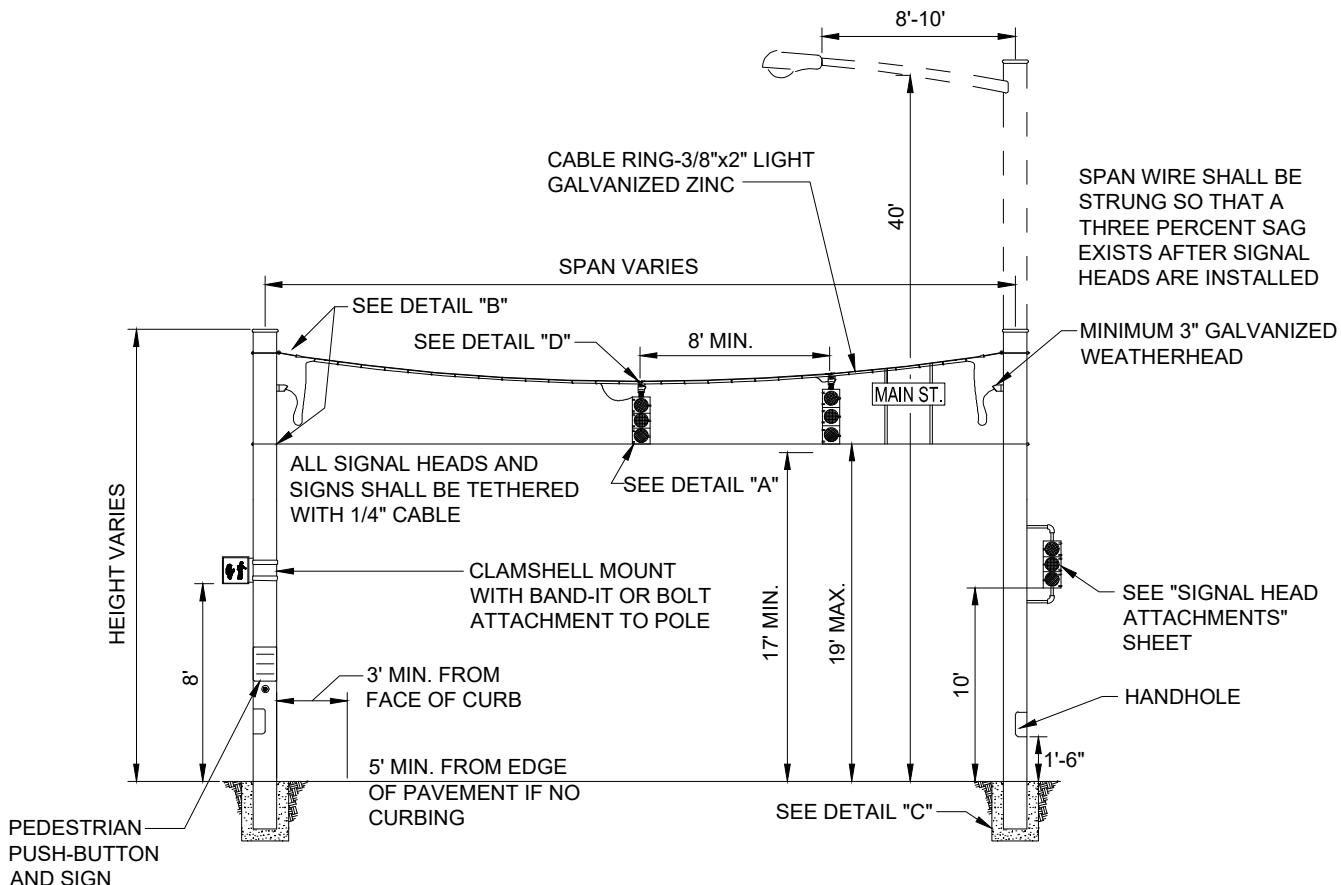
GENERAL NOTES (continued)

16. ALL SIGNAL HEADS SHALL BE WIRED SEPARATELY FROM SIGNAL HEAD TO HANDHOLE ABOVE GRADE AT THE BASE OF THE SIGNAL POLE WITH NO OVERHEAD SPLICES. A SEPARATE 19-CONDUCTOR CABLE SHALL RUN FROM THE CONTROLLER CABINET TO THE HANDHOLE AT EACH POLE WITH NO SPLICES.
17. TRAFFIC SIGNAL INDICATIONS MOUNTED ON MAST ARMS SHALL BE FURNISHED WITH ASTRO-TYPE MOUNTING BRACKETS.
18. UNINTERRUPTED POWER SUPPLY (UPS) SHALL BE PROVIDED TO RUN EACH TRAFFIC SIGNAL FOR A MINIMUM OF 2 HOURS IN ALL PHASES AND FLASH UP TO AN ADDITIONAL 3 HOURS.
19. ALL CONDUIT SHALL BE DIRECTIONALLY BORED UNDER EXISTING STREETS UNLESS ANOTHER METHOD IS APPROVED BY THE CITY OF ARVADA. ALL CONDUIT SHALL BE SCHEDULE 80 PVC. ALL CONDUIT SHALL INCLUDE A #12 LOCATE WIRE AND A MULE TAPE PULL LINE. ALL PULL BOXES SHALL BE FIBERGLASS REINFORCED POLYMER CONCRETE, INSTALLED FLUSH WITH THE GROUND.
20. LUMINAIRES SHALL BE LED WITH LIGHT OUTPUT EQUIVALENT TO A 250 WATT HPS AT A 30 FT. MOUNTING HEIGHT UNLESS OTHERWISE APPROVED. LUMINAIRE ORIENTATION SHALL BE INSTALLED AS INDICATED ON THE PLANS. WIRING FOR LUMINAIRES SHALL BE PROVIDED FROM THE POWER SOURCE TO THE END OF THE LUMINAIRE ARM. A BREAKAWAY INCLINE FUSE SHALL BE PROVIDED AT THE HAND HOLE ACCESS AT THE BASE OF THE POLE.
21. THE CONTRACTOR SHALL USE AN APPROPRIATE PREFABRICATED, MOBILE, AND APPROVED MEANS FOR CAPTURING AND REMOVAL OF ANY AND ALL CONCRETE WASHOUT.
22. THE CONTRACTOR SHALL REPLACE ANY DAMAGED LANDSCAPING, INCLUDING TOPSOIL, GRASS, IRRIGATION SYSTEM COMPONENTS, TREES, SHRUBS, GROUND COVERS AND MULCH, TO THE ORIGINAL CONDITION. SOD SHALL MATCH EXISTING.
23. THE CONTRACTOR SHALL ENSURE THAT NO MATERIALS, EQUIPMENT, OR VEHICLES ARE STAGED OR PARKED NEAR WETLAND OR DRAINAGE AREAS. THE CONTRACTOR SHALL REMOVE IN A TIMELY MANNER ALL SEDIMENT, MUD DEBRIS OR OTHER POTENTIAL POLLUTANTS WHICH MAY BE DISCHARGED TO, OR ACCUMULATE IN, THE FLOW LINES AND PUBLIC RIGHT-OF-WAYS AS A RESULT OF CONSTRUCTION ACTIVITIES ASSOCIATED WITH THIS PROJECT.
24. THE SIGNAL SHALL NOT BE TURNED ON OR STARTED IN FLASH UNTIL THE CITY HAS INSPECTED AND APPROVED THE INSTALLATION, AS WELL AS THE APPROPRIATE PAVEMENT MARKINGS ARE IN PLACE, UNLESS APPROVED BY THE CITY.
25. STOP LINE DETECTION SHALL BE BY PRESENCE RADAR DETECTORS (WAVETRONIX SMART SENSOR MATRIX), UNLESS SHOWN OTHERWISE ON PLANS. ADVANCE DETECTION SHALL BE BY ADVANCE RADAR DETECTORS (WAVETRONIX SMART SENSOR ADVANCE).
26. ALL SIGNAL EQUIPMENT NOT SPECIFICALLY IDENTIFIED TO BE SALVAGED OR RELOCATED SHALL BE REMOVED AND DISPOSED OF BY THE CONTRACTOR.
27. ALL SALVAGED SIGNAL EQUIPMENT TO BE REMOVED SHALL BE PROVIDED TO THE CITY OF ARVADA INDIANA SHOPS AT 6701 INDIANA ST., ARVADA, CO. CONTACT THE TRAFFIC ENGINEERING DIVISION (720-898-7740) TO ARRANGE DELIVERY.
28. OPTICOM PREEMPTION SYSTEM SHALL BE INSTALLED FOR PREEMPTING THE DIRECTIONS AS INDICATED ON THE PLANS. THE PREEMPTION SYSTEM SHALL BE COMPATIBLE WITH THE CITY'S EXISTING SYSTEM. OPTICOM WIRE SHALL BE USED FOR THE INSTALLATION.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	GENERAL TRAFFIC SIGNAL EQUIPMENT INSTALLATION NOTES
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

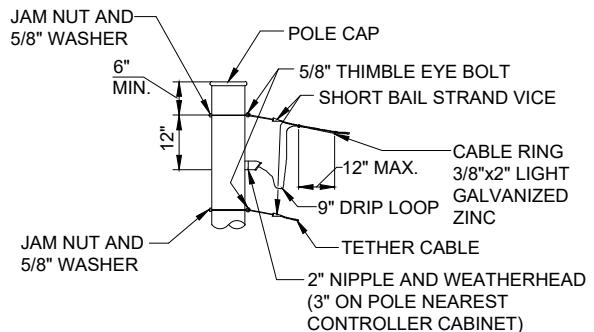
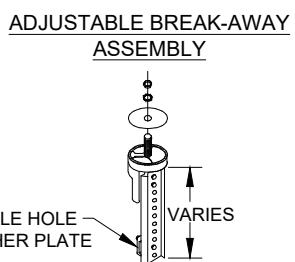
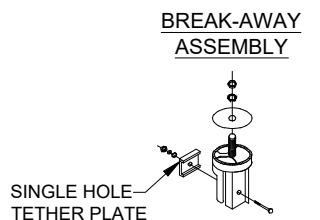
NOTES

1. SPAN WIRE POLES SHALL HAVE 1 COAT OF ZINC RICH MATERIAL FROM THE BASE TO A POINT 10' ABOVE THE BASE. AND FINISHED WITH 1 COAT OF RUST INHIBITIVE PRIMER AND 1 COAT OF ARVADA BRONZE, VALMONT SPECIFICATION F377DE FINISH PAINT. PAINT COLOR SPECIFICATION TO BE SUPPLIED BY CITY UPON REQUEST. POLE SURFACE SHALL BE WIPE CLEAN AND FREE OF DEBRIS PRIOR TO FINISH APPLICATION. FINISH APPLICATION SHALL BE COMPLETED PRIOR TO INSTALLATION OF SIGNAL/PEDESTRIAN HEADS AND PEDESTRIAN PUSH BUTTONS. FOLLOWING INSTALLATION OF THESE ITEMS, CONTRACTOR SHALL TOUCH UP NICKS AND ABRASIONS AS NEEDED.
2. DESIGN CRITERIA SHALL MEET THE 2015 AASHTO LRFD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS, FOR A WIND VELOCITY OF 130 MPH.
3. SPAN WIRE POLES SHALL BE FABRICATED OF STEEL WITH A MIN. DIAMETER OF 12", A MIN. YIELD STRENGTH OF 35 KSI. AND A MIN. WEIGHT PER LINEAR FOOT OF 49.5 LB. FOR 12" DIA. POLES. POLES SHALL BE INSTALLED SO THAT THEY WILL BE PLUMB WHEN DEFLECTED BY THE INSTALLED LOAD. SPAN WIRE CABLE SHALL BE A MINIMUM OF 3/8 INCH DIAMETER RATED AT A MINIMUM OF 13,000 POUNDS.
4. SPAN WIRE SIGNAL HEADS SHALL HAVE ONE POWER FEED WIRE PER HEAD. CONNECTIONS SHALL BE MADE ONLY ON THE SIGNAL HEAD TERMINALS, WITH NO EXTERNAL SPLICES.

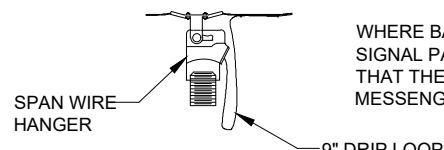
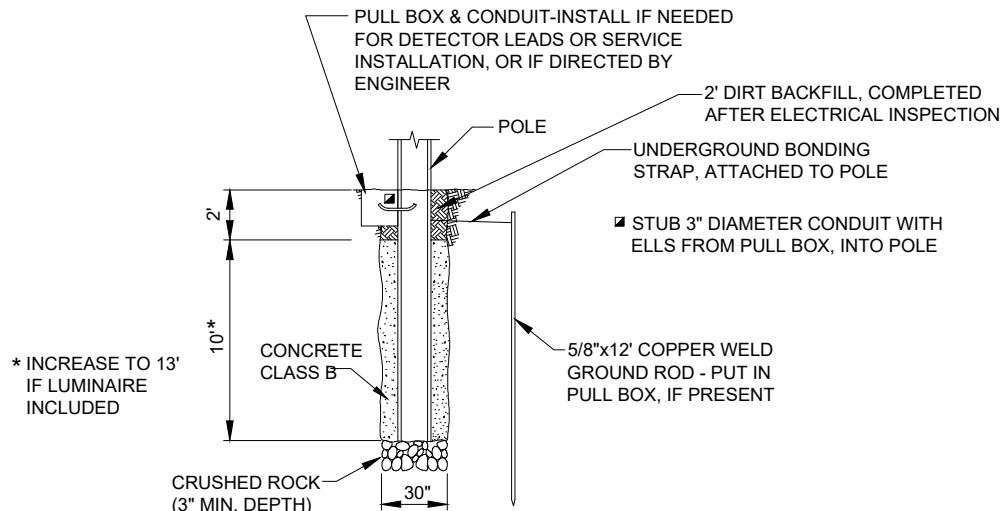


SPAN WIRE POLE DETAIL
(FOR SPECIAL USE, WITH PRIOR APPROVAL OF CITY ONLY)

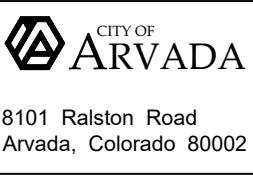
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	SPAN WIRE POLE INSTALLATION TEMPORARY INSTALLATION ONLY
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



DETAIL "A"
TETHERING OPTIONS



NO	DATE	REVISION

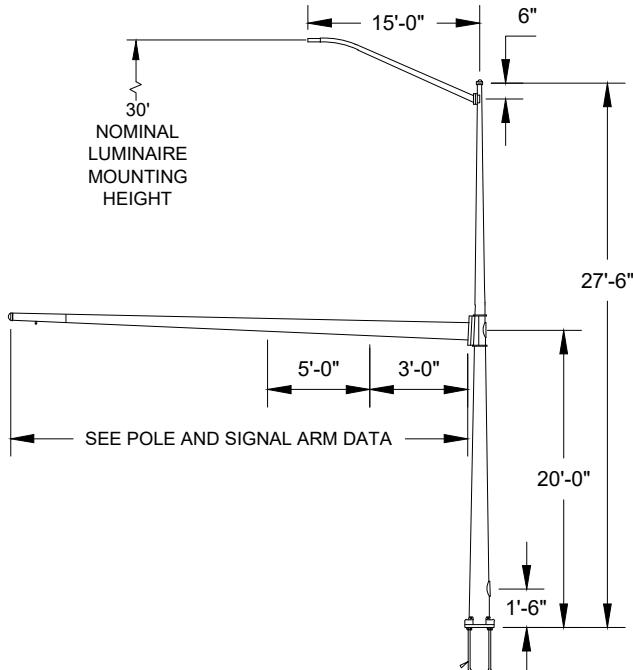


SPAN WIRE POLE INSTALLATION
TEMPORARY INSTALLATION ONLY

2022 ENGINEERING STANDARDS & SPECIFICATIONS

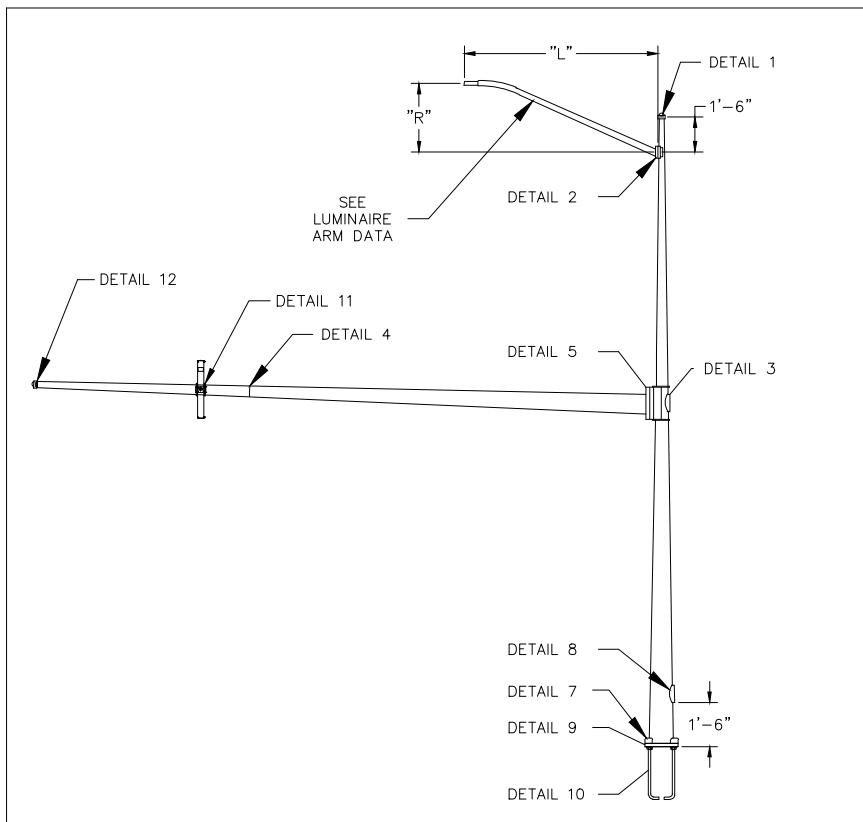
NOTES

1. THE INTENT OF THE MAST ARM AND POLE PERFORMANCE CRITERIA SHEET IS TO PROVIDE A PERFORMANCE STANDARD FOR TRAFFIC SIGNAL INSTALLATIONS WITHIN THE CITY OF ARVADA. MANUFACTURING STANDARDS AND SUBMITTALS MUST MEET THE LISTED CRITERIA AND CERTIFICATION REQUIREMENTS BELOW.
2. THE CONTRACTOR IS REQUIRED TO PROVIDE DRAWINGS FOR ALL TRAFFIC SIGNAL POLES, MAST ARMS AND CONNECTIONS THAT HAVE BEEN CERTIFIED (STAMPED BY A COLORADO PROFESSIONAL ENGINEER) TO BE IN COMPLIANCE WITH THE DESIGN CRITERIA CONTAINED HEREIN AND THE CITY OF ARVADA SPECIFICATIONS.
3. ALL TRAFFIC SIGNAL POLES AND MAST ARMS SHALL BE STRAIGHT-TAPERED, TUBULAR STEEL. THE POLE AND MAST ARMS SHALL BE DOUBLE GALVANIZED COLORED/FINISHED USING A HYDROSTATIC POWDER COAT PAINT PROCESS (OR AN APPROVED EQUAL) DURING FABRICATION.
4. ALL TRAFFIC SIGNAL POLES AND MAST ARMS SHALL BE DELIVERED TO THE PROJECT SITE (OR DESIGNATED DELIVERY YARD) WRAPPED OR PROTECTED IN A WAY NOT TO SCRATCH OR MAR THE EQUIPMENT DURING TRANSPORT.
5. TWO HANHOLES ARE REQUIRED ON TRAFFIC SIGNAL LIGHT POLES WITH MAST ARMS; ONE AT THE BASE OF THE POLE AND ONE AT THE MAST ARM CONNECTION. PEDESTAL POLES SHALL HAVE ONE HANHOLE. IN BOTH INSTALLATIONS, THE HANHOLE OPENING AT THE BASE OF THE POLE(S) SHALL BE 5"x8" (MINIMUM). THE HANHOLE OPENING AT THE MAST ARM CONNECTION SHALL BE 4"x6" (MINIMUM). HANHOLE COVERS SHALL BE FASTENED BY MACHINE SCREWS (STAINLESS STEEL) MOUNTED AT THE TOP AND BOTTOM OF EACH COVER. MACHINE THREADED "L" BRACKETS SHALL BE WELDED INSIDE THE POLE HANHOLE TO ACCEPT SCREWS.
6. THE MAST ARM TAPER RATE SHALL BE -0.14 INCH PER FOOT. THE MAST ARM SHALL HAVE A RAKE OF APPROXIMATELY 2 FEET ABOVE HORIZONTAL WHEN FULLY LOADED.
7. ALL SPLICES IN STEEL MAST ARMS, STEEL MAST ARM POLES AND SPAN WIRE POLES SHALL BE CRIMP CONNECTORS.



TYPICAL SIGNAL POLE AND MAST ARM ILLUSTRATION

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRAFFIC SIGNAL POLES AND MAST ARMS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



MATERIAL DATA			FINISH DATA
COMPONENT	ASTM DESIGNATION	MIN. YIELD (KSI)	FINISH NOTES:
TAPERED TUBES	A595 GR.A OR A572	55	SYSTEM: CUSTOMER SPECIFIED BASE COAT: HOT-DIP GALVANIZED TO ASTM A123
PLATES	A36	36	PRIME COAT: HIGH BUILD EPOXY POWDER FINISH COAT: TGIC POWDER
ANCHOR BOLTS	F1554 GR.55	55	COLOR: ARVADA BRONZE SPEC: F-540BO
GALVANIZING HARDWARE	F2329		
SIGNAL ARM CONN. BOLTS	A325		
LUM. ARM CONN. BOLTS	SAE GR.5		

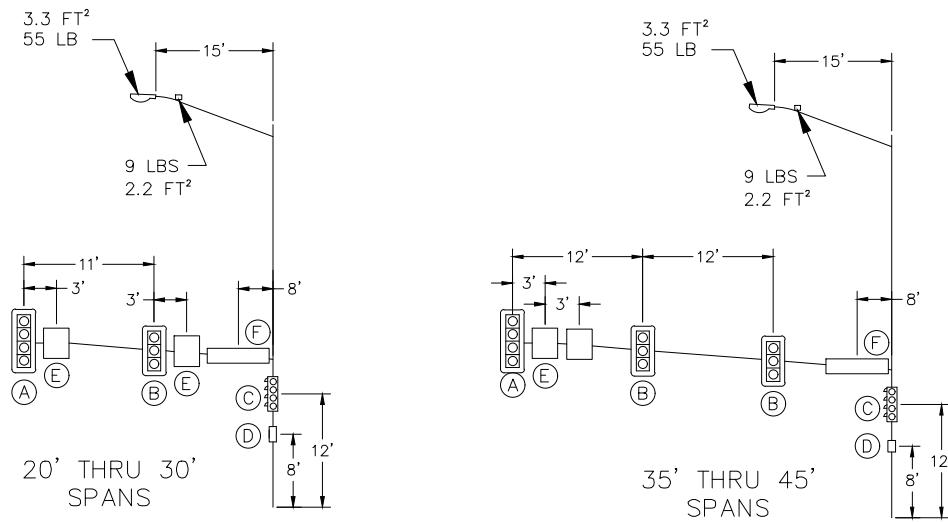
DESIGN CRITERIA:

THE SIGNAL MAST ARM TRAFFIC STRUCTURES SHOWN ON THIS DRAWING HAVE BEEN DESIGNED IN ACCORDANCE WITH THE LOADING AND NOMINAL STRENGTH REQUIREMENTS OF THE 2015 AASHTO "LRFD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES, AND TRAFFIC SIGNALS, FIRST EDITION" SLTS-1 INCLUDING LATEST INTERIMS. THE WIND LOADS WERE CALCULATED FROM AN ULTIMATE WIND VELOCITY OF 130MPH WITH A MEAN RECURRENCE INTERVAL OF 1700 YEARS AND AN EFFECTIVE PERFORMANCE TESTED MITIGATION DEVICE APPROVED BY CITY OF ARVADA ALLOWING FOR A FATIGUE CATEGORY OF II. THE FATIGUE LOADS WERE CALCULATED ON THE REQUIREMENTS OF SECTION 11 OF THE CODE, AND THE FOLLOWING

DESIGN CONDITIONS:

- STRUCTURES ARE DESIGNED TO RESIST NATURAL WIND GUSTS BASED ON THE YEARLY MEAN WIND VELOCITY OF 11.2 MPH.
- STRUCTURES ARE NOT DESIGNED TO RESIST GALLOPING-INDUCED CYCLIC LOADS DUE TO THE USE OF EFFECTIVE MITIGATION DEVICE.
- STRUCTURES ARE DESIGNED FOR TRUCK-INDUCED GUST LOADS, AS REQUIRED BY THE OWNER OF THE STRUCTURES.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRAFFIC SIGNAL POLES AND MAST ARMS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



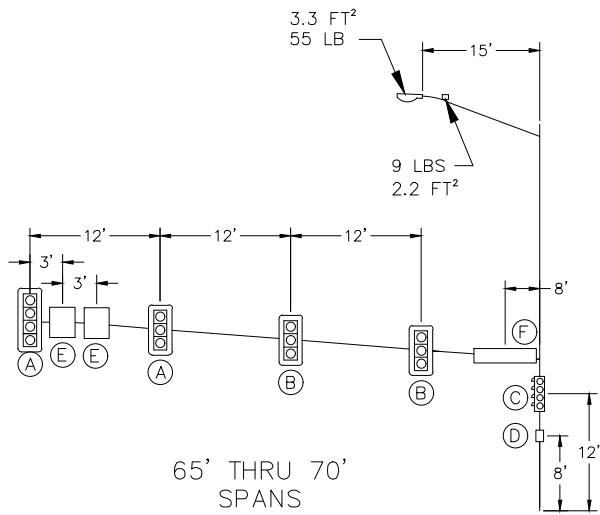
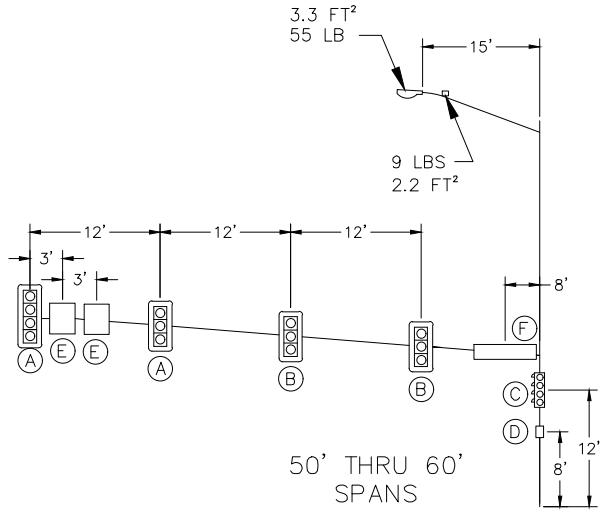
LOAD NOTES:

1. LOADS SHOWN ARE FOR DESIGN PURPOSES ONLY AND NOT FOR CONSTRUCTION. IF THESE LOADS ARE EXCEEDED PLEASE CONTACT THE ENGINEER FOR A SPECIAL DESIGN.

DEVICE	DESCRIPTION	PROJ. AREA (FT ²)	WEIGHT (LBS)
Ⓐ	12"-4 SEC. SIGNAL WITH BACKPLATE	11.60	65
Ⓑ	12"-3 SEC. SIGNAL WITH BACKPLATE	8.67	38
Ⓒ	DUAL-12"-4 SEC. SIGNAL NO BACKPLATE(VERTICAL)	5.44	60
Ⓓ	DUAL-16"-PEDESTRIAN SIGNAL	8.00	80
Ⓔ	30" X 36" REGULATORY SIGN	7.50	25
Ⓕ	18" X 96" STREET NAME SIGN	10.47	38
Ⓖ	TR1 MITIGATOR DEVICE	1.20	38

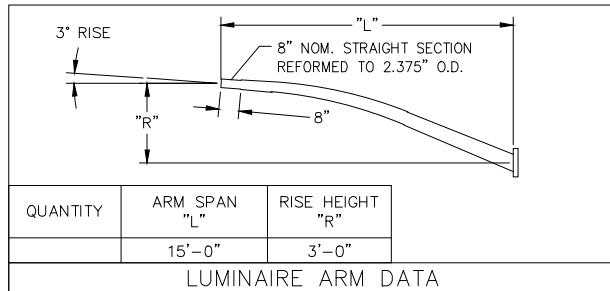
MAXIMUM LOADING INFORMATION

NO	DATE	REVISION	CITY OF ARVADA	8101 Ralston Road Arvada, Colorado 80002	TRAFFIC SIGNAL POLES AND MAST ARMS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS	

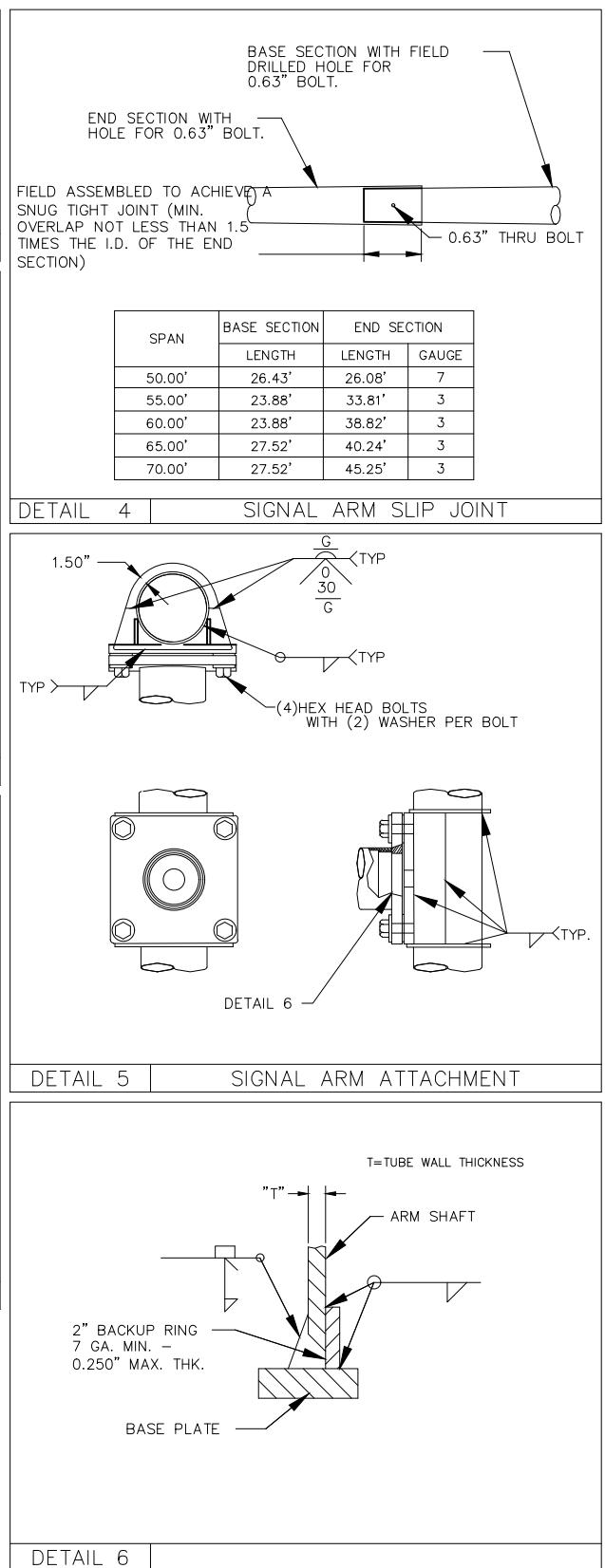
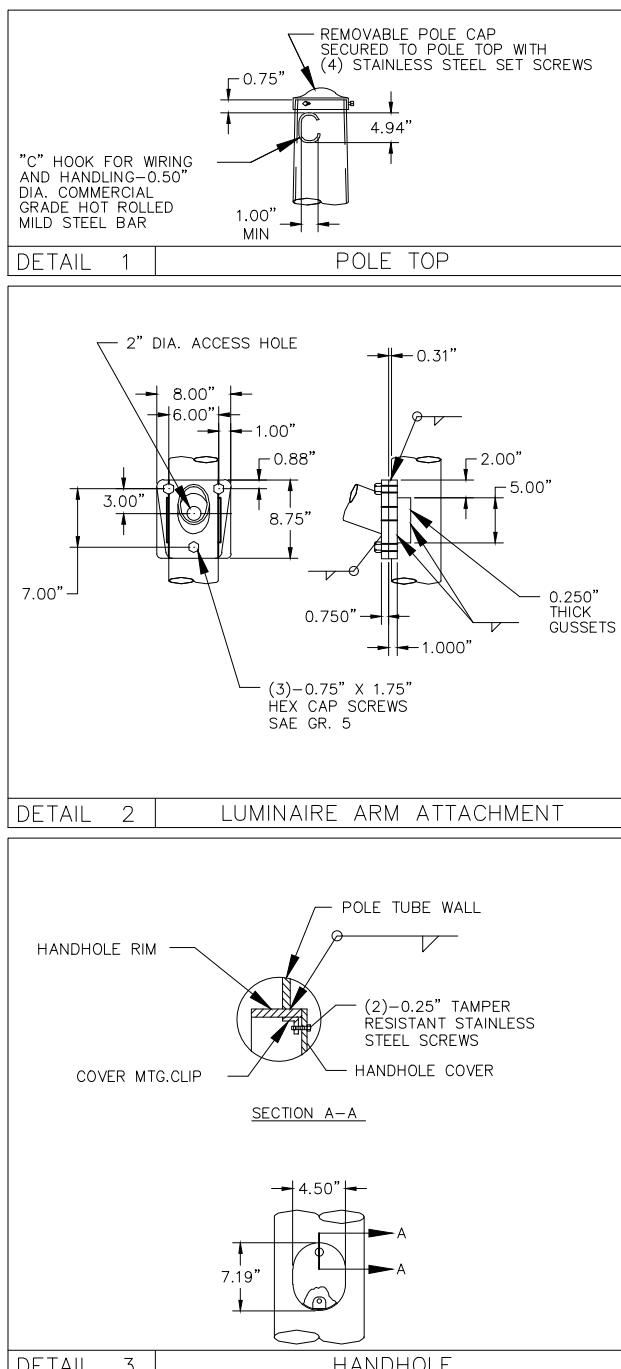


NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRAFFIC SIGNAL POLES AND MAST ARMS 2022 ENGINEERING STANDARDS & SPECIFICATIONS

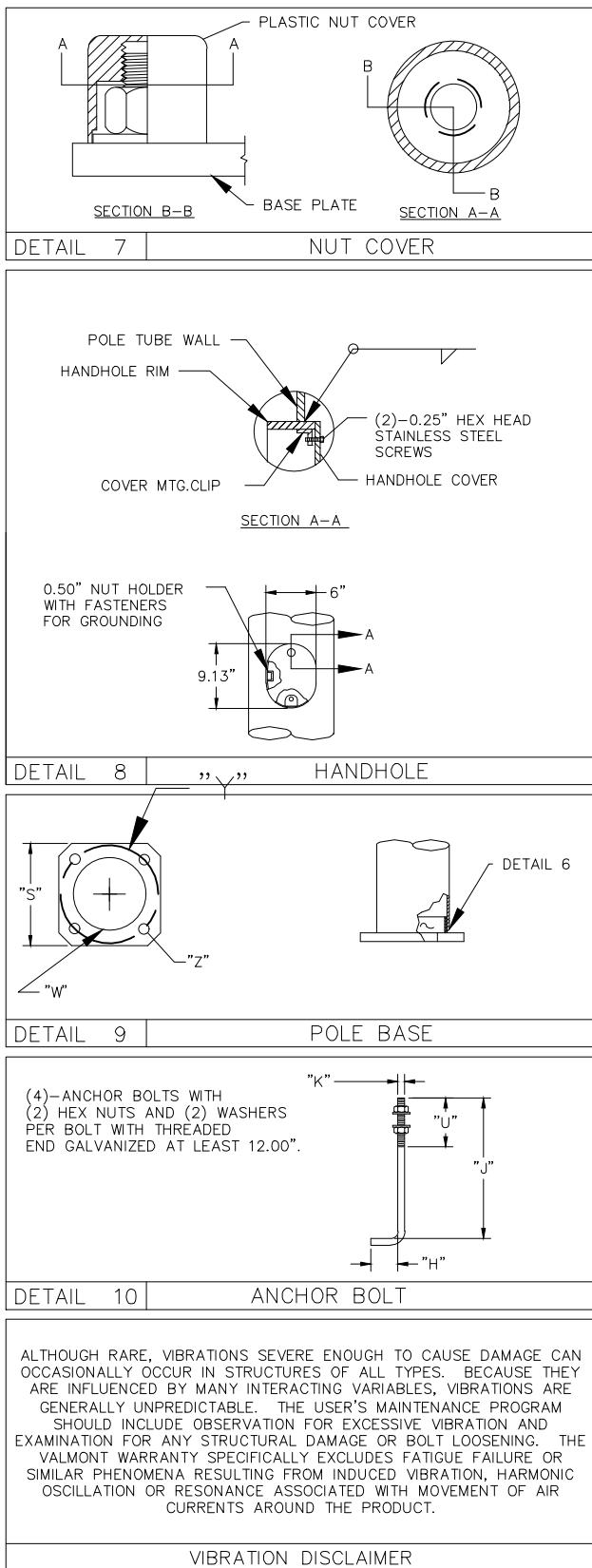
ITEM	DESIGN NUMBER	SINGLE ARM SPAN (FT)	POLE BASE				ANCHOR BOLT			
			SQUARE "S" (IN)	BOLT CIRCLE "Y" (IN)	CENTER HOLE "W" (IN)	HOLE "Z" (IN)	DIA. "K" (IN)	LENGTH "J" (IN)	HOOK "H" (IN)	THREAD LENGTH "U" (IN)
ARVADA	1	20	20.00	19.00	9.75	1.75	1.50	54.00	6.00	8.00
ARVADA	1	25	20.00	19.00	9.75	1.75	1.50	54.00	6.00	8.00
ARVADA	1	30	20.00	19.00	9.75	1.75	1.50	54.00	6.00	8.00
ARVADA	2	35	21.00	20.00	11.00	2.00	1.75	84.00	6.00	8.00
ARVADA	2	40	21.00	20.00	11.00	2.00	1.75	84.00	6.00	8.00
ARVADA	2	45	21.00	20.00	11.00	2.00	1.75	84.00	6.00	8.00
ARVADA	3	50	23.00	22.00	13.00	2.25	2.00	84.00	6.00	10.00
ARVADA	3	55	23.00	22.00	13.00	2.25	2.00	84.00	6.00	10.00
ARVADA	3	60	23.00	22.00	13.00	2.25	2.00	84.00	6.00	10.00
ARVADA	4	65	24.50	23.50	10.00	2.63	2.25	89.00	7.00	12.00
ARVADA	4	70	24.50	23.50	10.00	2.63	2.25	89.00	7.00	12.00



NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRAFFIC SIGNAL POLES AND MAST ARMS	
				2022 ENGINEERING STANDARDS & SPECIFICATIONS	

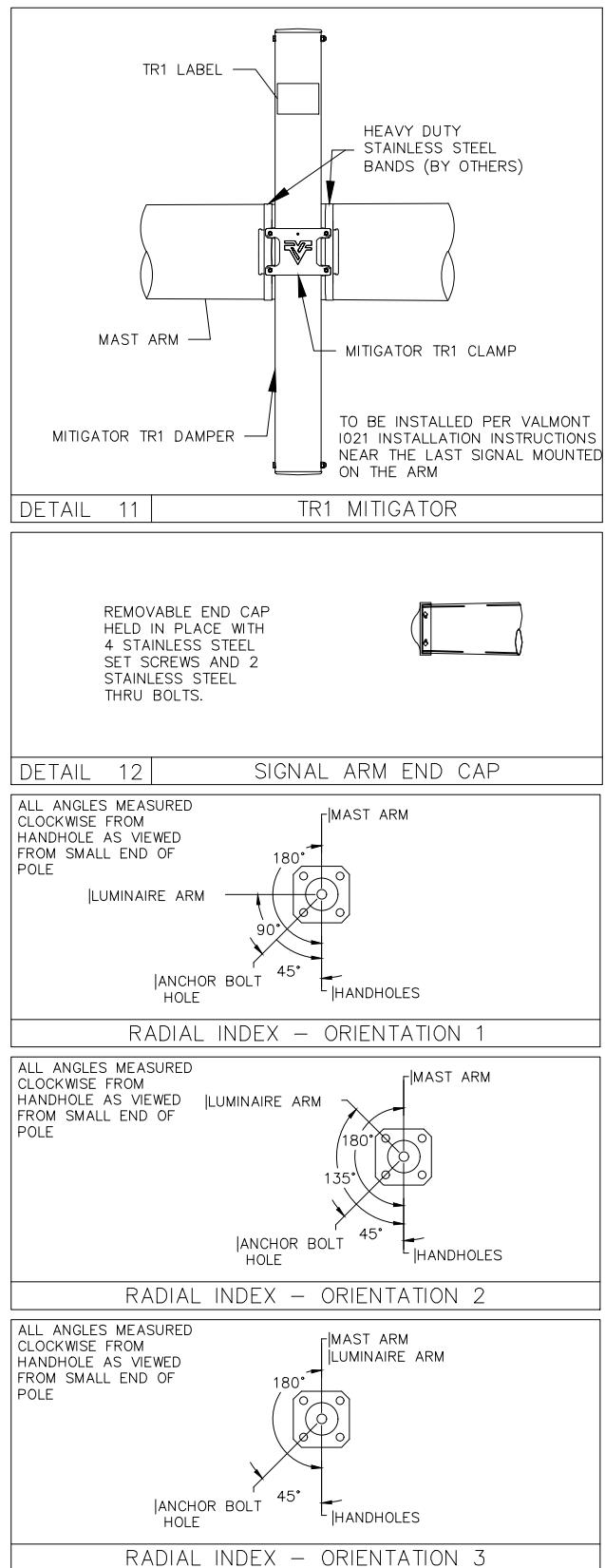


NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRAFFIC SIGNAL POLES AND MAST ARMS 2022 ENGINEERING STANDARDS & SPECIFICATIONS



ALTHOUGH RARE, VIBRATIONS SEVERE ENOUGH TO CAUSE DAMAGE CAN OCCASIONALLY OCCUR IN STRUCTURES OF ALL TYPES. BECAUSE THEY ARE INFLUENCED BY MANY INTERACTING VARIABLES, VIBRATIONS ARE GENERALLY UNPREDICTABLE. THE USER'S MAINTENANCE PROGRAM SHOULD INCLUDE OBSERVATION FOR EXCESSIVE VIBRATION AND EXAMINATION FOR ANY STRUCTURAL DAMAGE OR BOLT LOOSENING. THE VALMONT WARRANTY SPECIFICALLY EXCLUDES FATIGUE FAILURE OR SIMILAR PHENOMENA RESULTING FROM INDUCED VIBRATION, HARMONIC OSCILLATION OR RESONANCE ASSOCIATED WITH MOVEMENT OF AIR CURRENTS AROUND THE PRODUCT.

VIBRATION DISCLAIMER

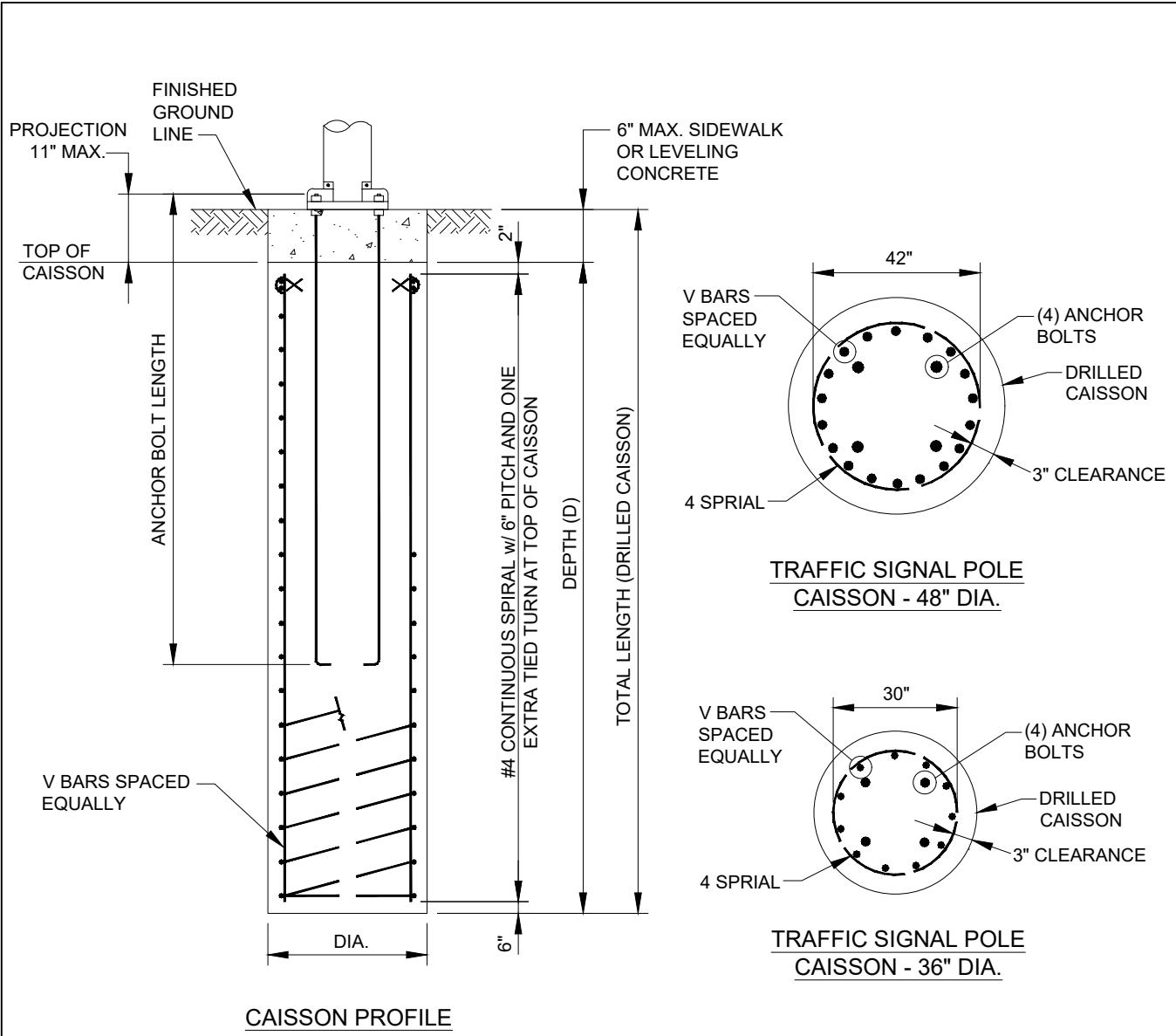


NO	DATE	REVISION

CITY OF ARVADA
8101 Ralston Road
Arvada, Colorado 80002

TRAFFIC SIGNAL POLES AND MAST ARMS

2022 ENGINEERING STANDARDS & SPECIFICATIONS



CAISSON PROFILE

FOUNDATION SCHEDULE						
DESIGN NUMBER	MAST ARM LENGTH (FT.)	CAISSON DATA				
		DIA. (IN.)	DEPTH (D) (FT.)		V BARS	
			COHESIVE SOIL	COHESIONLESS SOIL	SIZE	TOTAL
1	20 TO 30	36	15.0	12.0	#9	11
2	35 TO 45	48	16.0	12.0	#9	18
3	50 TO 60	48	22.0	15.0	#9	18
4	65 TO 70	48	26.0	15.0	#9	18

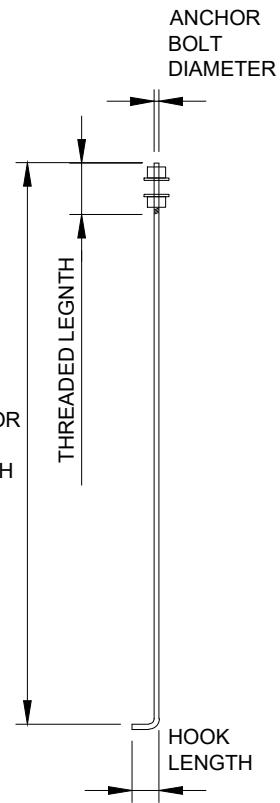
NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	MAST ARM SIGNAL POLE FOUNDATION	
				2022 ENGINEERING STANDARDS & SPECIFICATIONS	

NOTES:**ANCHOR BOLTS**

1. FOUR (4) ANCHOR BOLTS SHALL BE PROVIDED FOR EACH CAISSON WITH TWO (2) HEX NUTS AND TWO (2) WASHERS PER BOLT WITH THREADED END GALVANIZED TO AT LEAST 12" FROM END.
2. LENGTH, THREAD LENGTH, HOOK LENGTH, AND DIAMETER OF EACH ANCHOR BOLT SHALL BE AS NOTED IN THE TRAFFIC SIGNAL POLE AND MAST ARM DETAILS.
3. ANCHOR BOLTS SHALL BE MEDIUM STRENGTH, MILD STEEL OR ALLOY STEEL WITH MINIMUM DESIGN YIELD STRENGTH OF ASTM F1554 GRADE 55, OR 55 KSI. ALLOY ANCHOR BOLTS SHALL CONFORM TO THE REQUIREMENTS OF ASTM A193 GRADE B7. MEDIUM STRENGTH, MILD STEEL ANCHOR BOLTS SHALL CONFORM TO THE REQUIREMENTS OF A MODIFIED ASTM A36 (WITH 55 KSI YIELD STRENGTH), OR ASTM A572 GRADE 55.
4. WELDED SPLICING OF A ROD MATERIAL FOR ANCHOR BOLTS WILL NOT BE PERMITTED.
5. THREADS FOR ANCHOR BOLTS SHALL BE ROLLED OR CUT THREADS OF UNIFIED COARSE THREAD SERIES IN ACCORDANCE WITH ANSI B1.1. FOR ROLLED THREADS, THE DIAMETER OF THE UNTHEADED PORTION SHALL NOT BE LESS THAN THE MINIMUM PITCH DIAMETER NOR MORE THAN THE MAXIMUM MAJOR DIAMETER OF THE THREADS.
6. ALL THREADS FOR BOLTS AND NUTS SHALL HAVE CLASS 2 FIT TOLERANCES IN ACCORDANCE WITH ANSI B1.1.

NUTS AND WASHERS

7. NUTS FOR ALLOY STEEL ANCHOR BOLTS SHALL CONFORM TO ASTM A194 GRADE 2H OR ASTM A563, HEAVY HEX, GRADE DH CLASS 12. NUTS FOR MEDIUM STRENGTH, MILD STEEL ANCHOR BOLTS SHALL CONFORM TO ASTM A194 GRADE 2H OR ASTM A563, GRADE D OR BETTER. ALL THREADS FOR NUTS SHALL HAVE A CLASS 2B TOLERANCE IN ACCORDANCE WITH ANSI B1.1. WHEN NUTS ARE TO BE GALVANIZED, THE UNTAPPED BLANKS SHALL BE GALVANIZED PRIOR TO CUTTING THE THREADS.
8. EXPOSED NUTS SHALL BE GALVANIZED OR COATED WITH A ZINC-RICH COATING IF THE ANCHOR BOLTS ARE NOT GALVANIZED.
9. WASHERS INSTALLED WITH ANCHOR BOLTS OF ANY TYPE SHALL CONFORM TO THE REQUIREMENTS OF ASTM F436 AND SHALL HAVE THE SAME FINISH OR COATING AS THE BOLT AND NUT.

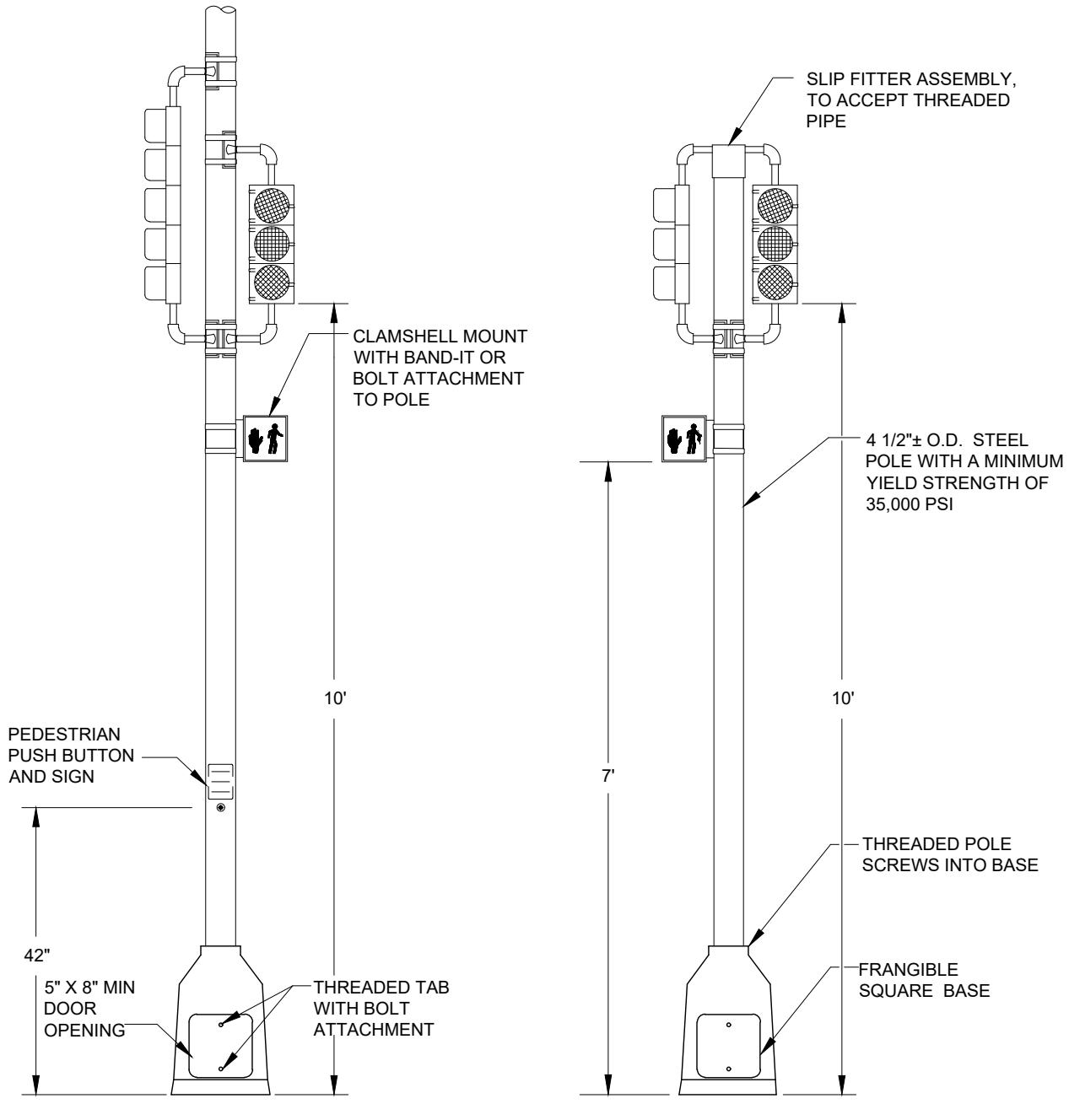
**ANCHOR BOLT DETAIL**

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	MAST ARM SIGNAL POLE FOUNDATION ANCHOR BOLT DETAIL
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

CONSTRUCTION NOTES

1. DESIGN OF FOUNDATIONS IS BASED ON TRAFFIC SIGNAL POLE CONFIGURATIONS PROVIDED BY VALMONT INDUSTRIES, INC. REFER TO CITY OF ARVADA TRAFFIC STANDARD DRAWINGS FOR ANY ADDITIONAL TRAFFIC POLE INFORMATION.
2. DESIGN CRITERIA: 2015 AASHTO LRFD STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS, FIRST EDITION.
3. A DESIGN WIND VELOCITY OF 130 MPH HAS BEEN USED FOR THE DESIGNS HEREIN.
4. ALL FOUNDATIONS ON THIS SHEET ARE FOR SINGLE MAST ARM POLES, EXCEPT AS NOTED.
5. THE DESIGNS HEREIN ASSUME THAT SIGNALS ARE INSTALLED WITHIN THE ROADWAY PRISM WITH THE FOLLOWING SOIL PARAMETERS:
 SOIL DENSITY $y = 110 \text{ LB./CU.FT.}$
 SOIL COHESION = 750 LB./SQ.FT. FOR MEDIUM STIFF COHESIVE SOIL
 SOIL Ø ANGLE = 30° FOR MEDIUM DENSE COHESIONLESS SOIL
 SF = 1.25 FOR TORSIONAL RESISTANCE AND 3.0 FOR FLEXURAL RESISTANCE
6. CONTACT THE ENGINEER IF ANY OF THE FOLLOWING SOIL CONDITIONS ARE ENCOUNTERED DURING DRILLING:
 - A. SIGNALS WILL NOT BE INSTALLED WITHIN THE ROADWAY PRISM
 - B. THE SOIL HAS A HIGH ORGANIC CONTENT OR CONSISTS OF SATURATED SILT AND CLAY
 - C. THE SITE WON'T SUPPORT THE WEIGHT OF THE DRILLING RIG
 - D. THE FOUNDATION SOILS ARE NOT HOMOGENOUS
 - E. FIRM BEDROCK IS ENCOUNTERED
 - F. CAVING SOILS
 - G. GROUNDWATER
 - H. EXPANSIVE SOILS
 - I. TRASH
 - J. BOTTOM OF CAISSON WILL EXTEND BELOW BOTTOM OF ANY ADJACENT BUILDING OR RETAINING WALL FOUNDATION
 - K. SLOPES GREATER THAN 10%
7. CAISSENS SHALL BE PLACED AGAINST UNDISTURBED EARTH.
8. CAISSENS SHALL BE CONSTRUCTED WITH NON-AIR ENTRAINED COOT CLASS BZ CONCRETE IN ACCORDANCE WITH SECTION 503 OF THE STANDARD SPECIFICATIONS. REINFORCING STEEL SHALL BE GRADE 60.
9. CAISSON CONCRETE SHALL REACH THE SEVEN DAY PREDICTED STRENGTH PRIOR TO INSTALLING THE SIGNAL STRUCTURE.
10. FOUNDATION TO BE PROVIDED WITH 4 CONDUIT STUB OUTS (2 - 3" & 2 - 2"). DIRECTION TO BE DETERMINED BY CITY OF ARVADA ENGINEER AND IS TO BE CONSIDERED AS PART OF THE FOUNDATION BID ITEM.
11. BASE PLATE, NUTS AND NUT COVERS TO BE FURNISHED BY POLE MANUFACTURER. ANCHOR BOLTS ARE TO BE FURNISHED BY THE CONTRACTOR AND ARE INCLUDED IN THE COST OF THE FOUNDATION.
12. FOUNDATION SHALL BE PAID BY THE FEET OF DEPTH DRILLED. USE OF THE SHORTER FOUNDATION FOR COHESIONLESS SOIL SHALL BE ALLOWED ONLY BY APPROVAL OF THE CITY OF ARVADA TRAFFIC ENGINEER.
13. PLUMBING OF POLES SHALL BE ACCOMPLISHED BY ADJUSTING NUTS AFTER LOADING OF MAST ARM.
14. EACH END OF CAISSON TIES TO BE TERMINATED WITH A 135" HOOK AROUND A LONGITUDINAL BAR.
15. DESIGN IS BASED ON A HORIZONTAL GROUND SURFACE CONDITION IN THE VICINITY OF THE CAISSON. CAISSENS SHOULD NOT BE INSTALLED AT SITES WITH A SLOPE EXCEEDING 10 PERCENT.
16. LEVELING CONCRETE SHALL BE 4,500 PSI CLASS B AIR ENTRAINED CONCRETE.
17. YIELD STRESS OF REINFORCING STEEL SHALL BE MINIMUM 60,000 PSI.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	MAST ARM SIGNAL POLE FOUNDATION CONSTRUCTION NOTES
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



TYPICAL SIGNAL HEAD MOUNTING DETAIL

ALTERNATE: ALUMINUM POLES MAY BE USED AS "REPLACEMENTS" BUT ONLY WHEN SPECIFIED, SUCH AS "KNOCKDOWN" SITUATIONS

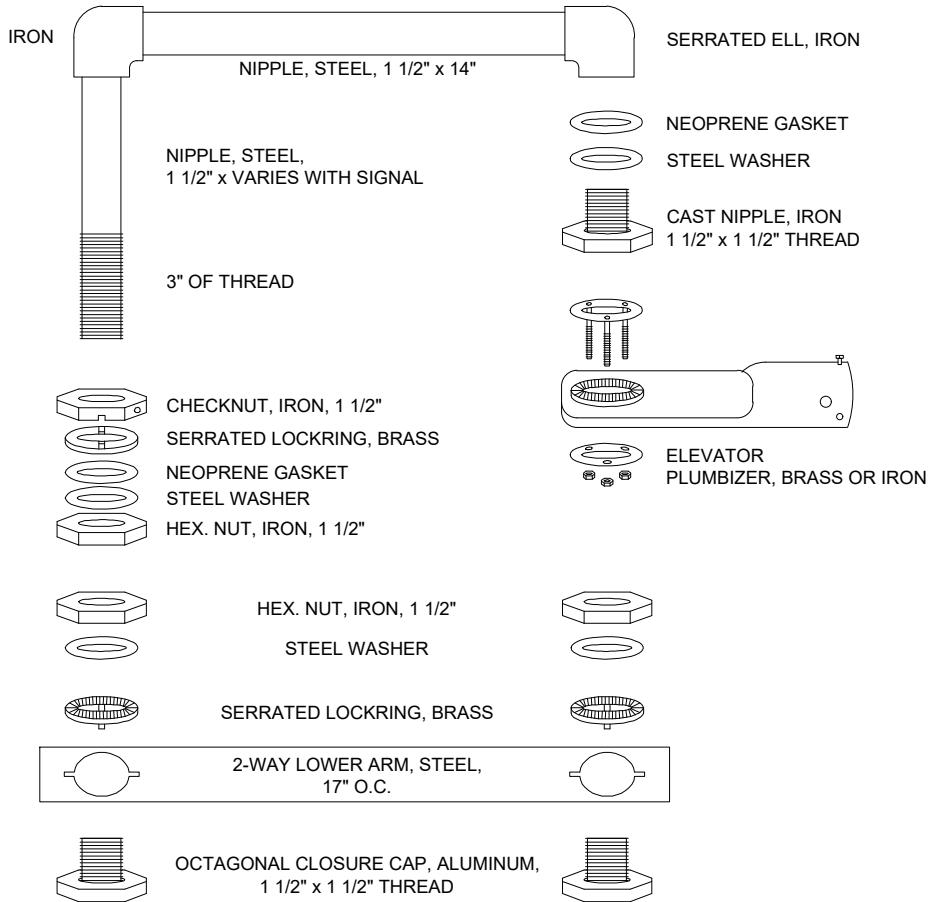
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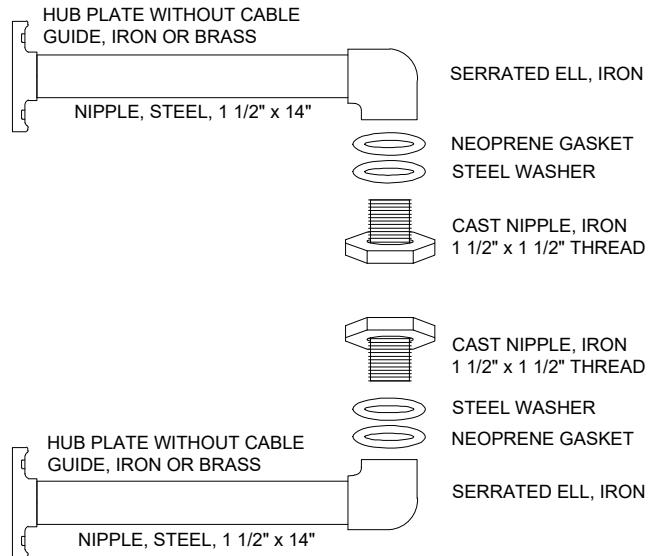
8101 Ralston Road
Arvada, Colorado 80002

TYPICAL SIGNAL HEAD MOUNTING

2022 ENGINEERING STANDARDS & SPECIFICATIONS

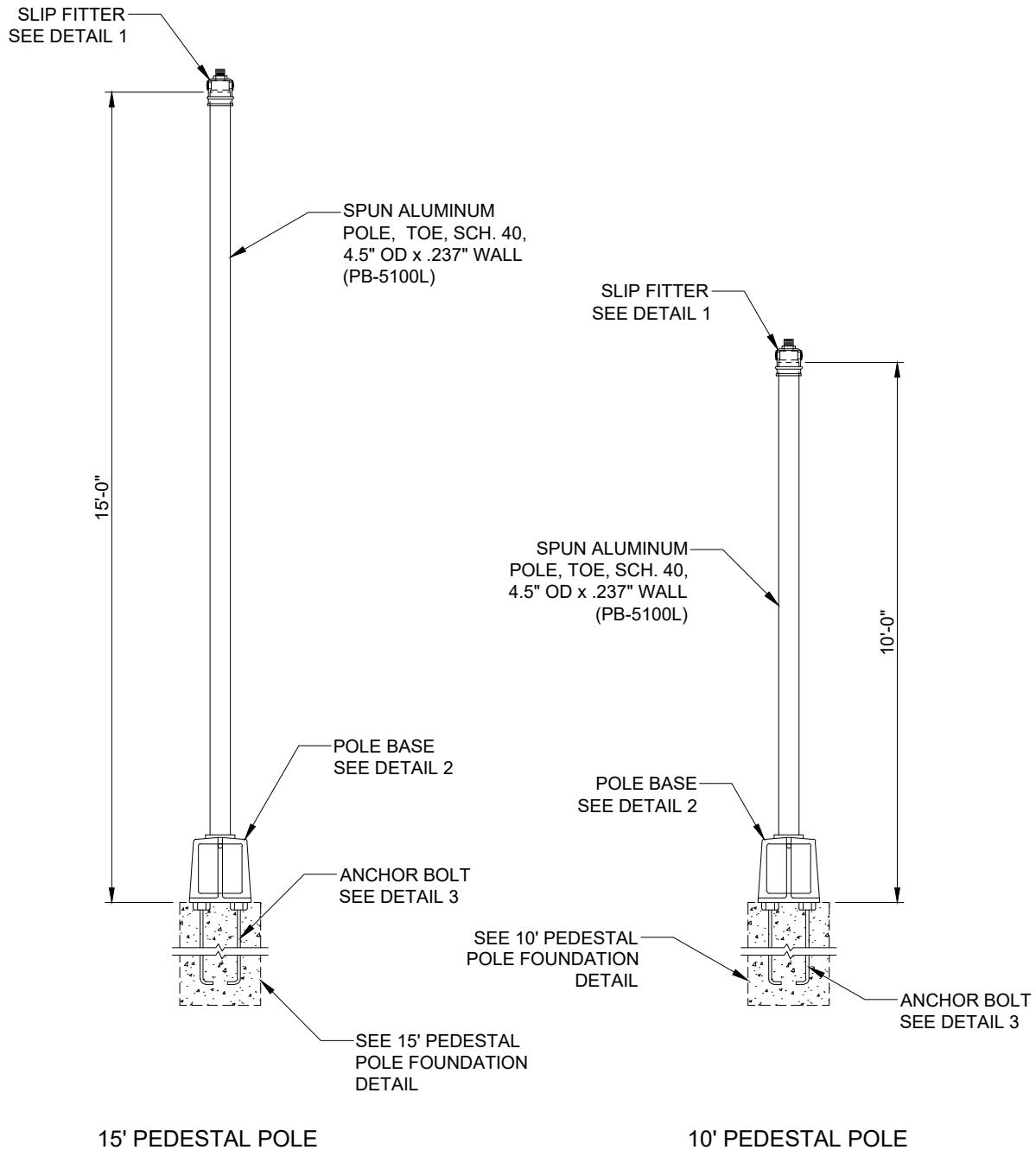


5 SECTION SIGNAL HARDWARE

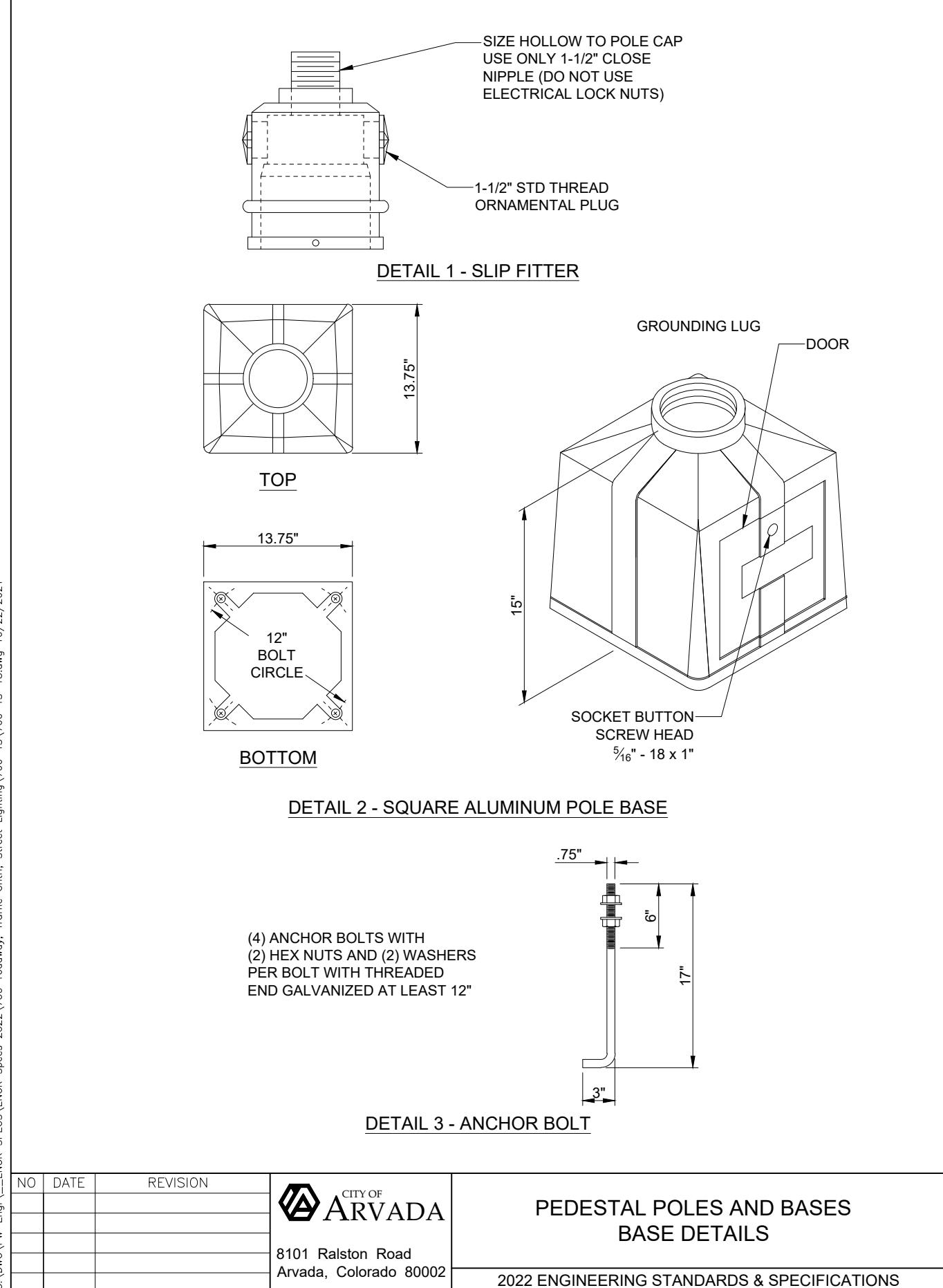


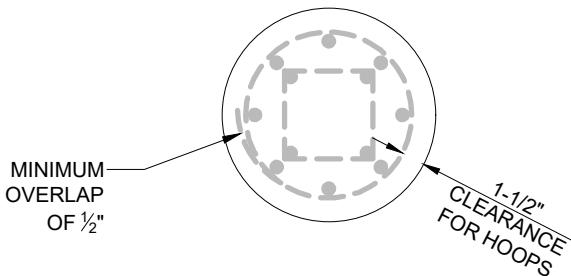
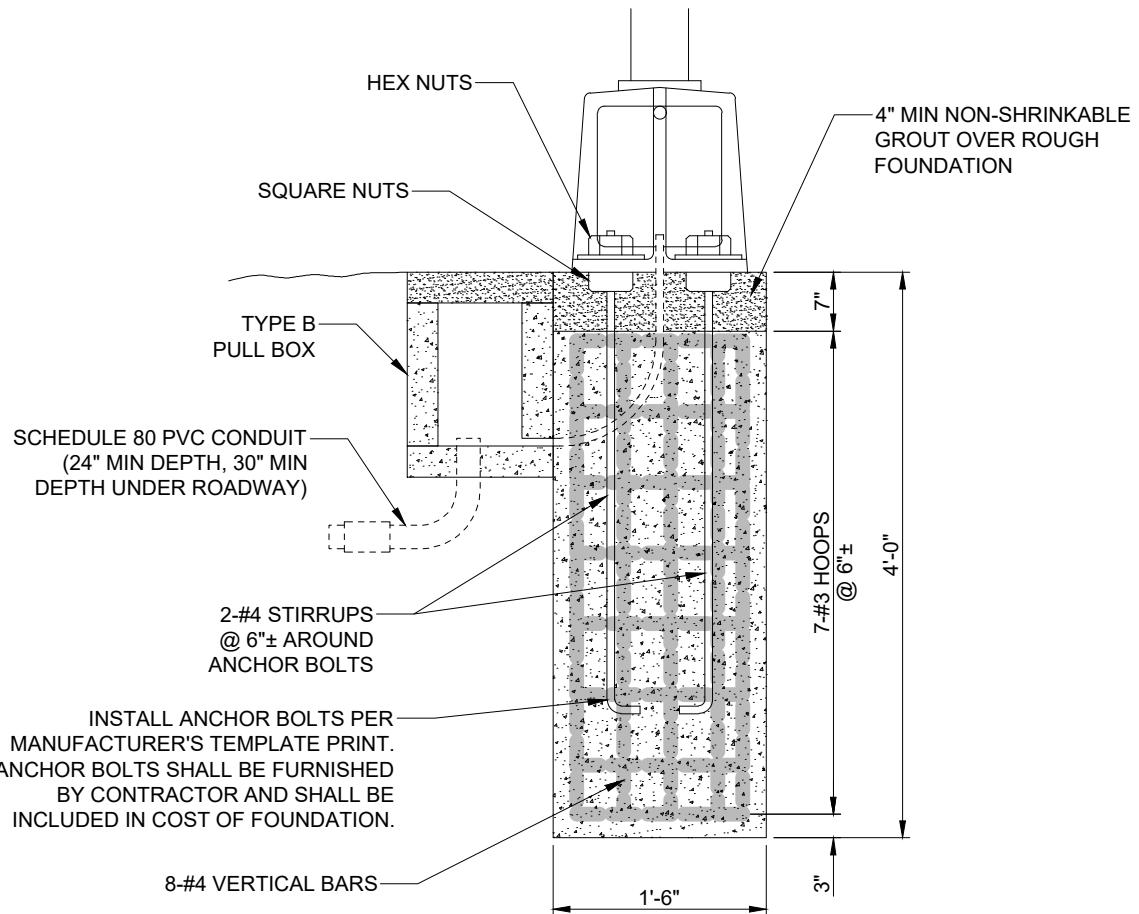
SIDE OF POLE SIGNAL HARDWARE

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	SIGNAL HEAD ATTACHMENTS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	PEDESTAL POLES AND BASES 10" AND 12" POLES
				2022 ENGINEERING STANDARDS & SPECIFICATIONS





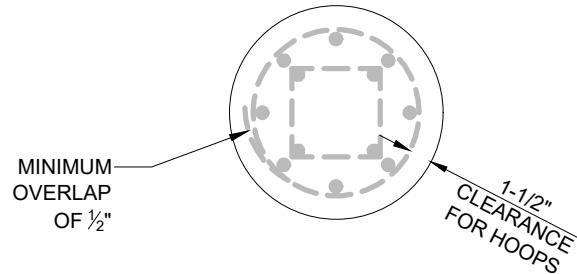
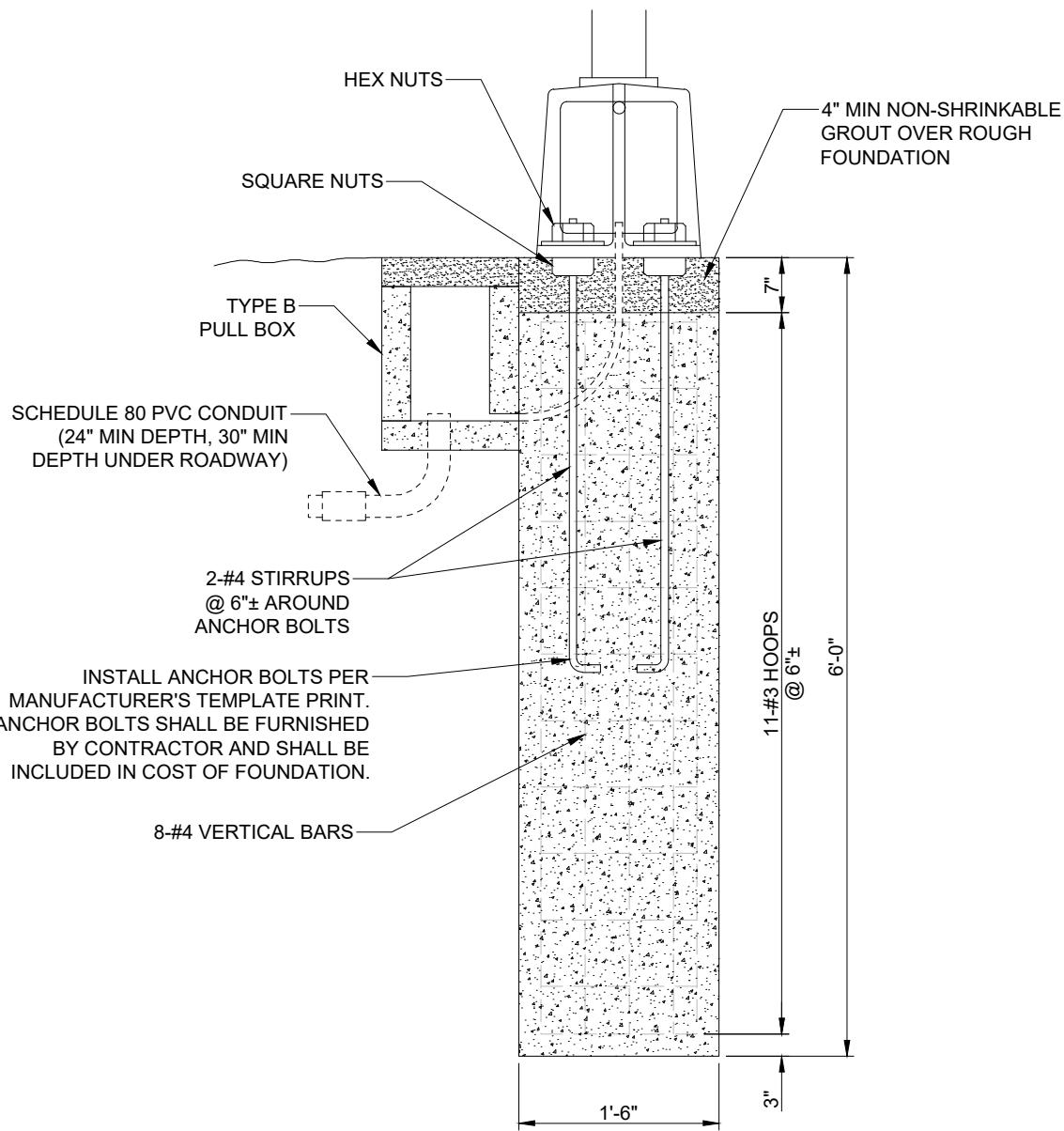
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8101 Ralston Road
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PEDESTAL POLES AND BASES 10" FOUNDATION

2022 ENGINEERING STANDARDS & SPECIFICATIONS



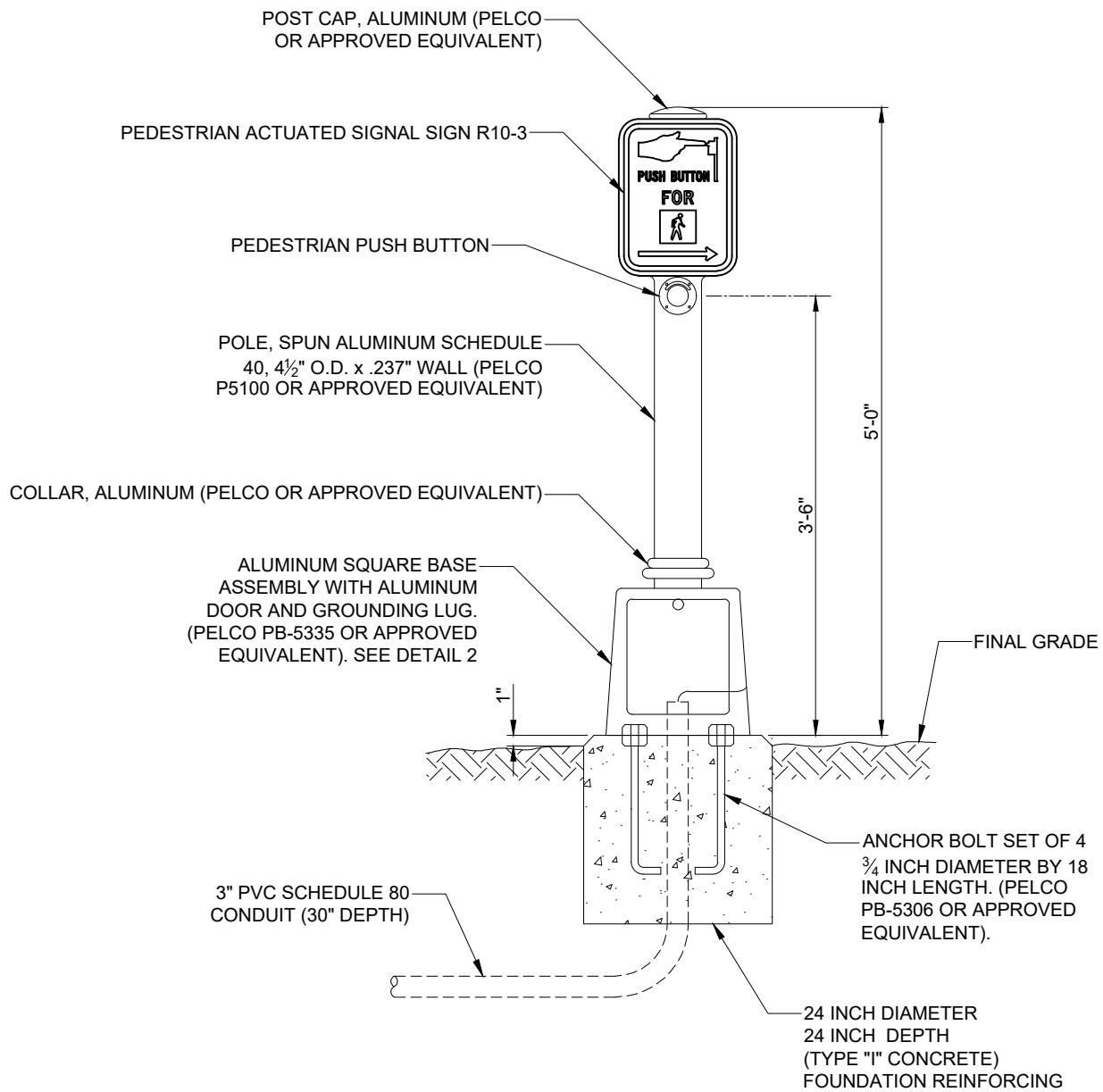
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PEDESTAL POLES AND BASES 15" FOUNDATION

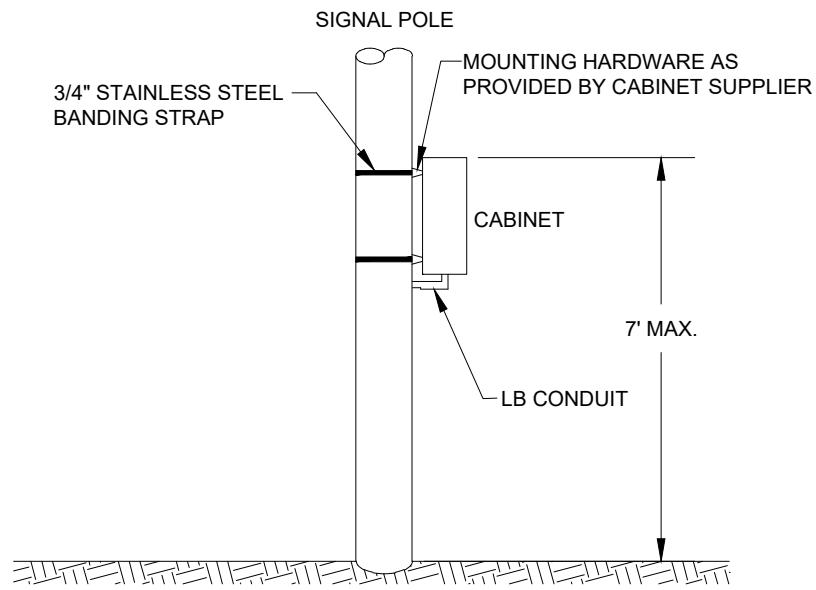
2022 ENGINEERING STANDARDS & SPECIFICATIONS



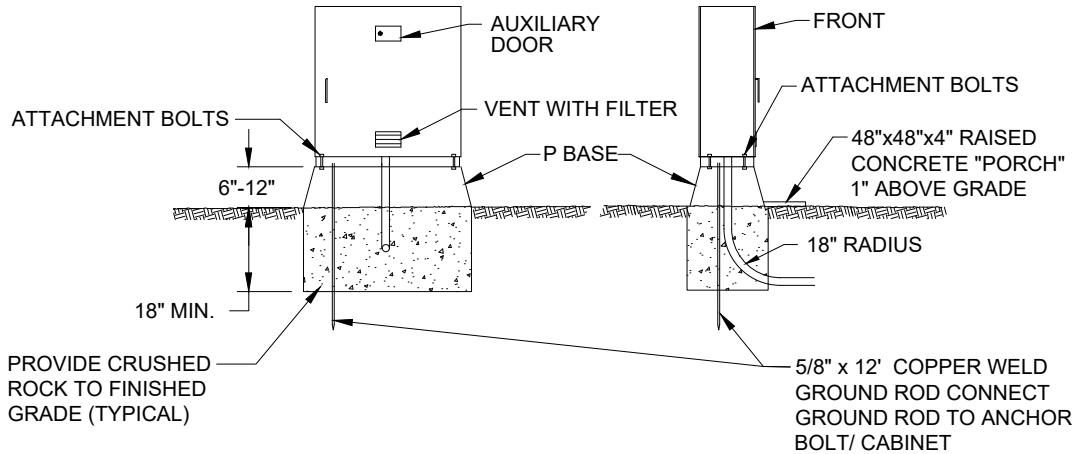
CONSTRUCTION NOTES:

1. ALL SEPARATELY GROUNDED ELEMENTS AT AN INTERSECTION SHALL BE BONDED TOGETHER TO FORM AN INTERSECTION GROUNDING NETWORK.
2. GROUND WIRE SHALL BE #6 STRANDED.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	PEDESTAL POLES AND BASES PEDESTRIAN PUSH BUTTON POLE FOUNDATION
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



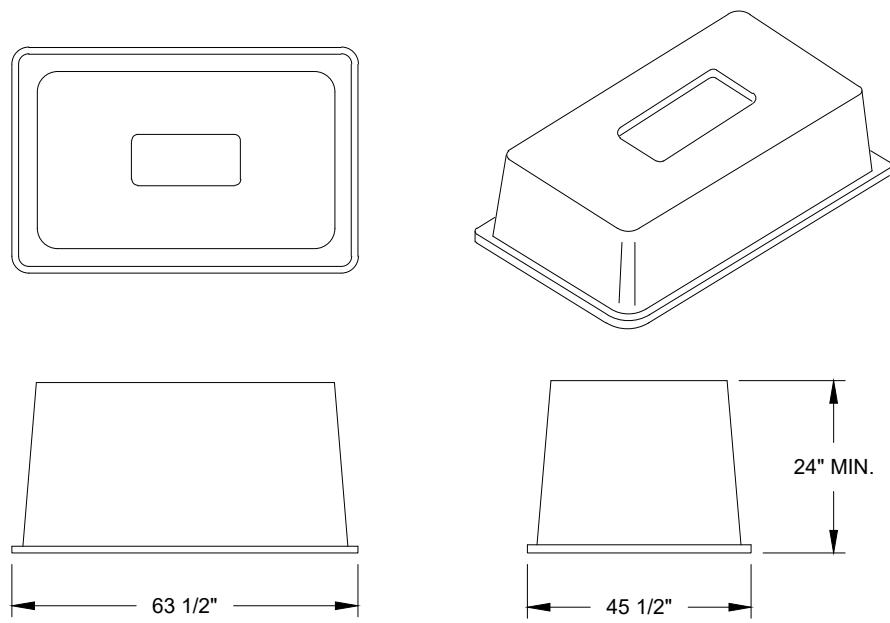
TYPICAL SIDE-OF-POLE MOUNTED
CONTROLLER CABINET



TYPICAL BASE MOUNTED CONTROLLER CABINET AND
FIBERGLASS REINFORCED POLYMER CONCRETE FOUNDATION

NOTE: CONTROLLER CABINETS SHALL BE INSTALLED
SUCH THAT WITH THE FRONT DOOR OPEN A TECHNICIAN
VIEWS BOTH THE CONTROLLER AND INTERSECTION.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CONTROLLER BASE AND CABINET
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NEMA CABINET BASE (TYPE "P")

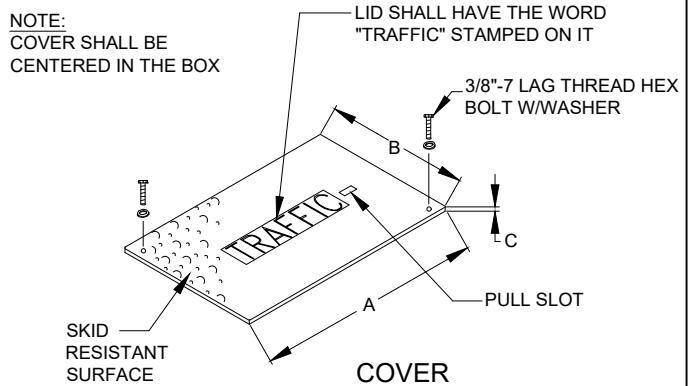
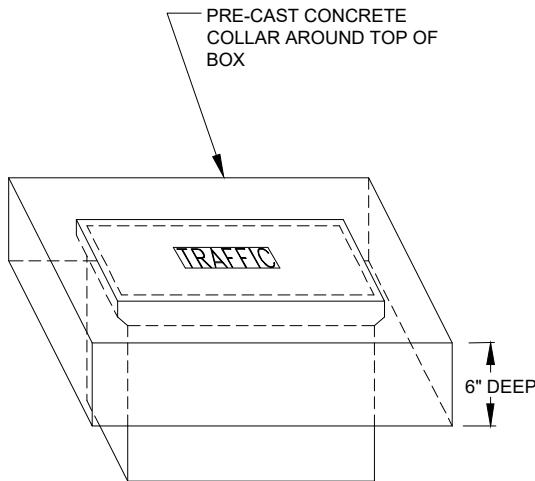
NO	DATE	REVISION



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CONTROLLER BASE AND CABINET

2022 ENGINEERING STANDARDS & SPECIFICATIONS

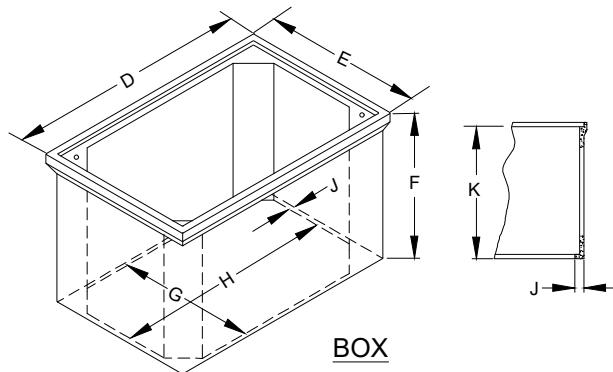


CONCRETE COLLAR

ONLY INSTALLED WHEN SPECIFIED IN THE CONSTRUCTION PLANS OR AS DIRECTED BY THE CITY

NOTE:

1. ANY PULL BOX LOCATED WITHIN THE SIDEWALK SHALL BE INSTALLED WITH A PEDESTRIAN RATED LID.



TYPICAL PULL BOX

FIBERGLASS REINFORCED POLYMER CONCRETE DESIGNED FOR SERVICE LOAD (MINIMUM) OF 20,000 LBS. OVER A 10" SQUARE

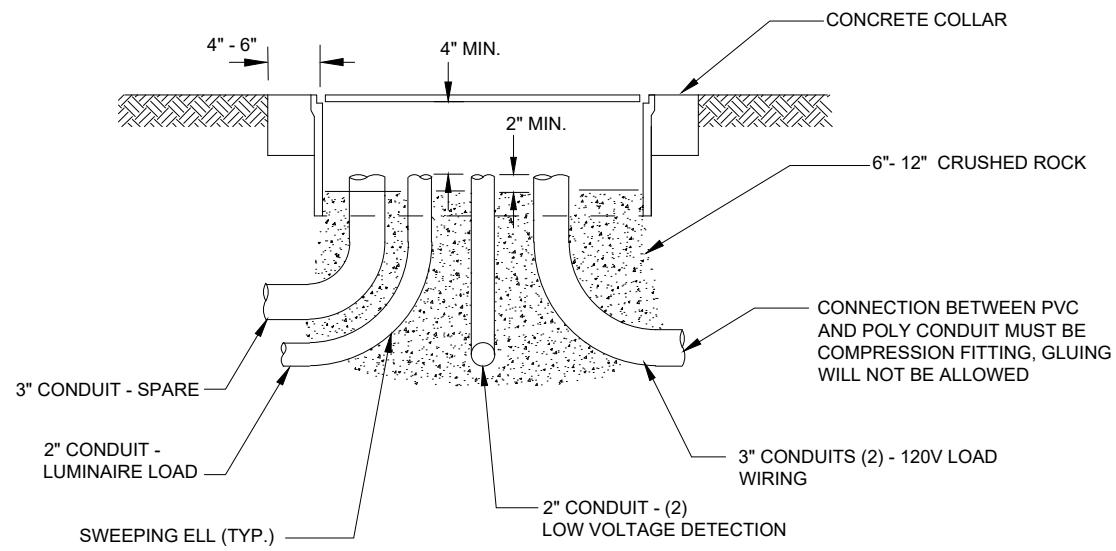
TABLE OF DIMENSIONS (MINIMUMS)

TYPE	DESCRIPTION	DIMENSIONS (IN.)									
		A	B	C	D	E	F	G	H	J	K
S	Electrical Service & Detectors 12x12x12	12 7/8	12 7/8	3/8	14 3/4	14 3/4	12	12	12	1/2	11 1/4
M	Pedestal Pole 13x24x12	23 1/4	13 3/4	2	25	15 1/2	12	11 3/4	21 1/4	1/2	10
LG	Signal Pole/Cabinet Home Run 24x36x18	35 5/8	24	3	37 5/8	26	18	22 1/4	33 7/8	1/2	15
LG	Fiber - Intermediate 24x36x18	35 5/8	24	3	37 5/8	26	18	22 1/4	33 7/8	1/2	15
XL	Fiber - TS Cabinet 30x48x18	47 5/8	30 1/8	3	49 5/8	32 1/8	18	28 1/8	45 5/8	1/2	15

* LABEL "TRAFFIC" FOR DETECTOR BOXES AND LABEL "ELECTRICAL" FOR ELECTRIC BOXES

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	PRECAST PULL BOX DETAILS					

2022 ENGINEERING STANDARDS & SPECIFICATIONS



TYPICAL PULL BOX INSTALLATION

THE CONCRETE SCHEDULE
(NUMBER & SIZES OF CONDUITS)
SHALL BE PER THE APPROVED PLANS

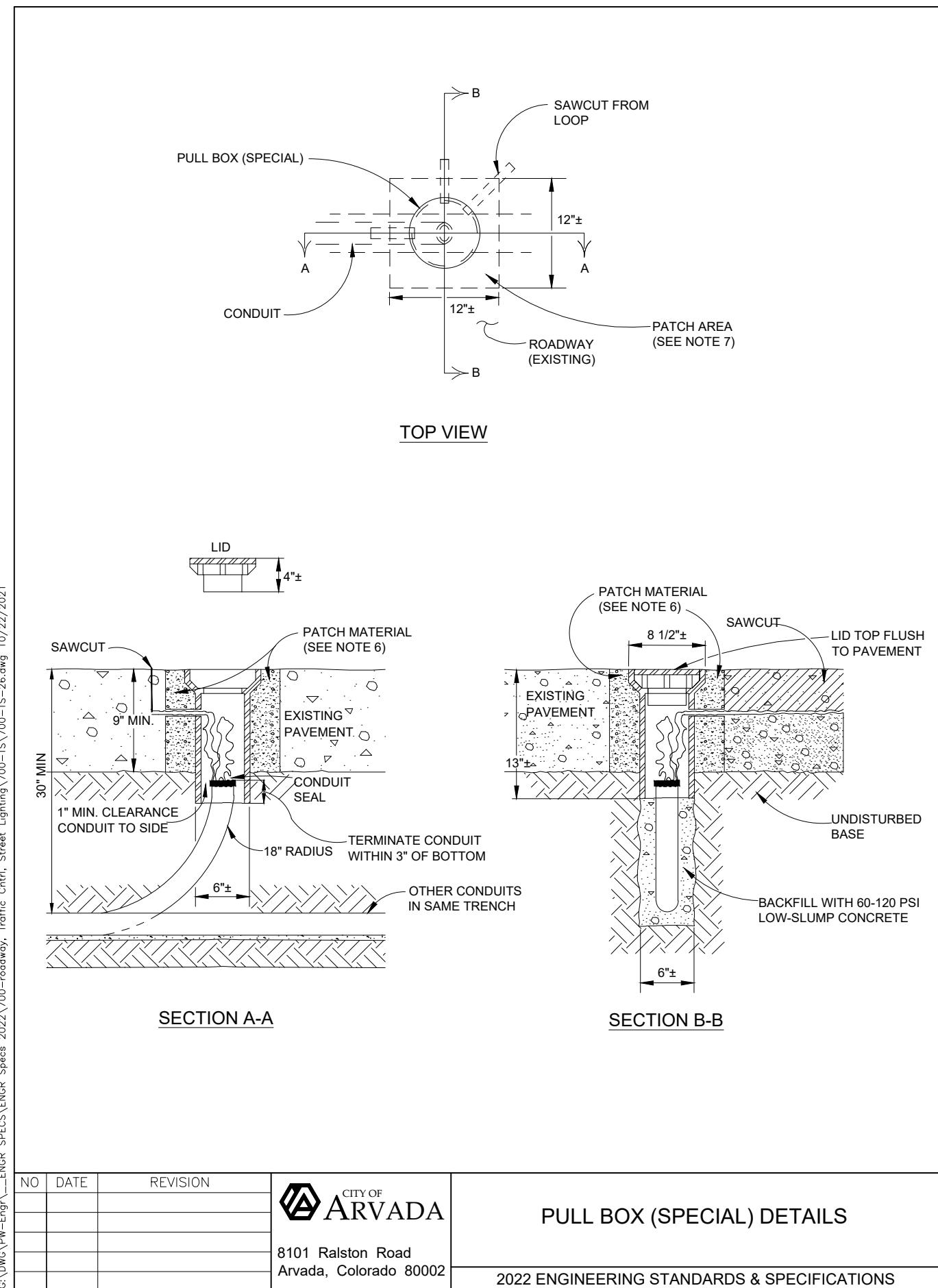
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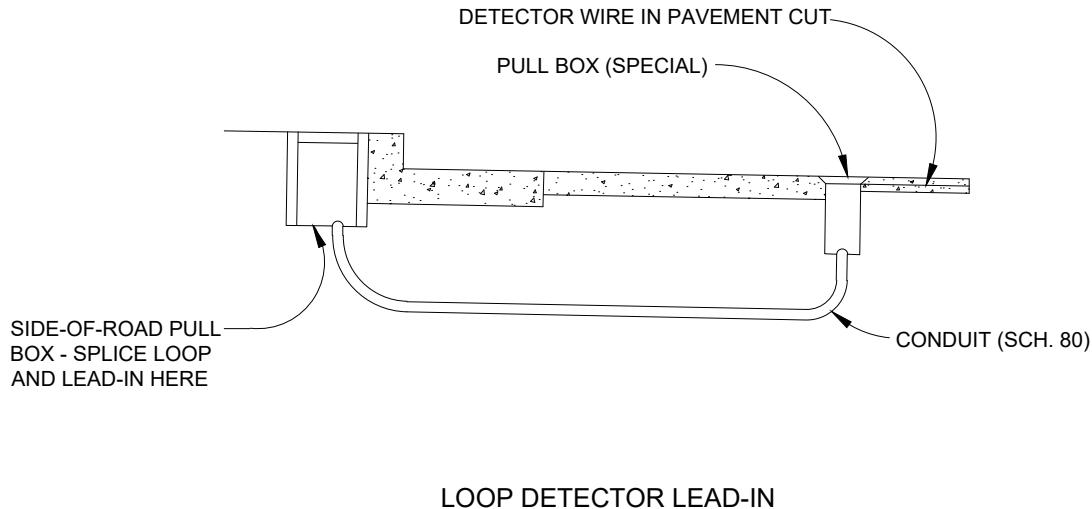
PRECAST PULL BOX DETAILS

2022 ENGINEERING STANDARDS & SPECIFICATIONS

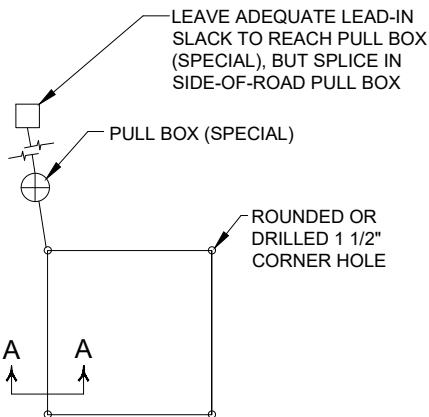


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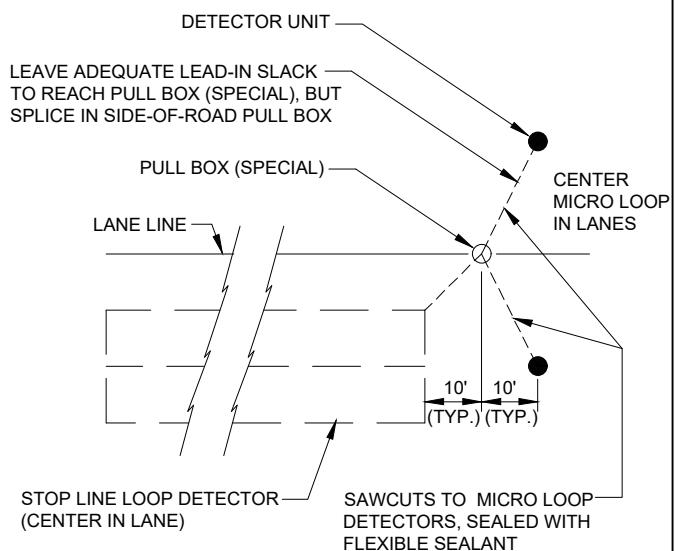
1. PULL BOX (SPECIAL) SHALL BE A WATER VALVE STEM TYPE PULL BOX MADE OF CAST IRON OR CAST ALUMINUM. THE PULL BOX SHALL HAVE CAPABILITY OF ACCEPTING RISER RINGS FOR FUTURE OVERLAYS. THE LID SHALL HAVE THE WORD "TRAFFIC" PRINTED ON IT.
2. PULL BOX (SPECIAL) SHALL HAVE 3/4" TO 1" DIAMETER HOLES DRILLED FROM THE TOP TO ACCEPT LOOP WIRE. THE DRILLED HOLES SHALL HAVE RUBBER GROMMETS INSTALLED. THE NUMBER OF HOLES SHALL BE AS PER PLANS OR AS DIRECTED BY THE CITY.
3. 2' MINIMUM SLACK OF LOOP WIRES IS TO BE PROVIDED IN THE SIDE-OF-ROAD PULL BOX, SO THAT ALL TESTING CAN BE OUTSIDE OF THE PULL BOX. DETECTOR LEADS SHALL BE SPLICED IN SIDE-OF-ROAD PULL BOX, NOT IN PULL BOX (SPECIAL).
4. PULL BOX (SPECIAL) SHALL NOT BE LOCATED IN VEHICLE LANES, BUT SHALL BE TYPICALLY LOCATED ON A LANE LINE. FOR EDGE-OF-ROAD LOCATIONS, MAINTAIN A MINIMUM OF 12" FROM CONCRETE GUTTER PAN.
5. ALL WORK LISTED ABOVE FOR INSTALLATION OF PULL BOX (SPECIAL) SHALL BE PAID FOR SEPARATELY, AND SHALL NOT BE INCLUDED IN THE PRICE OF THE CONDUIT.
6. PAVEMENT HOLE FOR PULL BOX SHALL BE EITHER CORE DRILLED TO FULL DEPTH, OR SAW CUT TO FULL DEPTH IN A 12"x12" SQUARE. FOR CORE DRILLING, PULL BOX (SPECIAL) SHALL BE GROUTED IN PLACE. FOR SAW CUT HOLES, THE HOLE SHALL BE FLOW FILLED OR FLASH FILLED AND SHALL MATCH THE EXISTING PAVEMENT MATERIAL DEPTH. MINIMUM ASPHALT DEPTH SHALL BE 9".

LOOP DETECTOR LEAD-IN

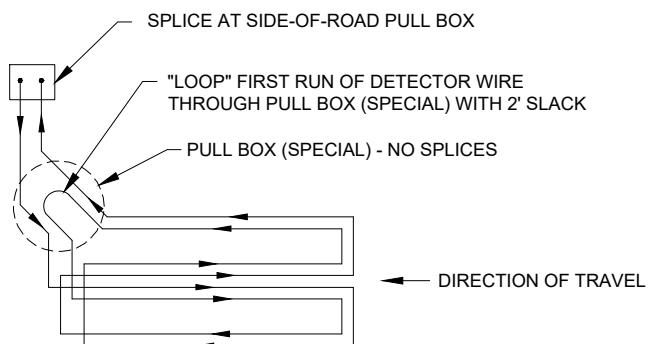
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	PULL BOX (SPECIAL) DETAILS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



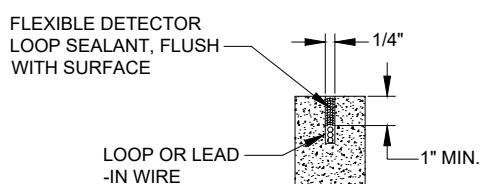
TYPICAL 6'x6' LOOP (3'-TURNS)



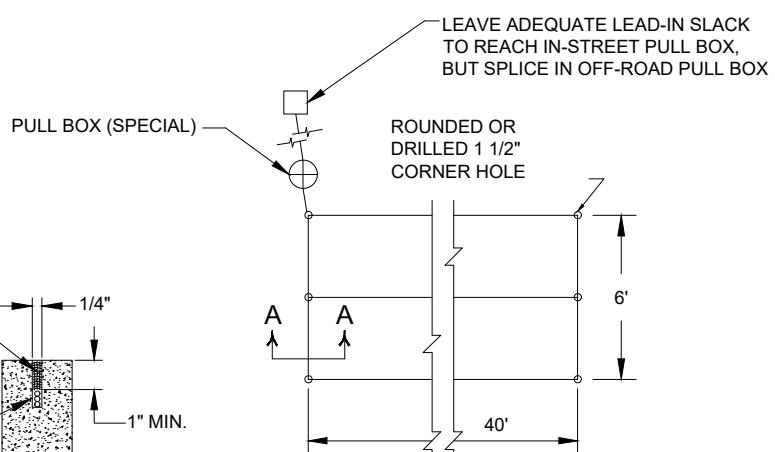
MICRO LOOP DETECTOR



QUADRAPOLE WIRING



SECTION A-A



TYPICAL 6'x40'
QUADRAPOLE LOOP

LOOP SAW CUT AND INSTALLATION

NO	DATE	REVISION



8101 Ralston Road
Arvada, Colorado 80002

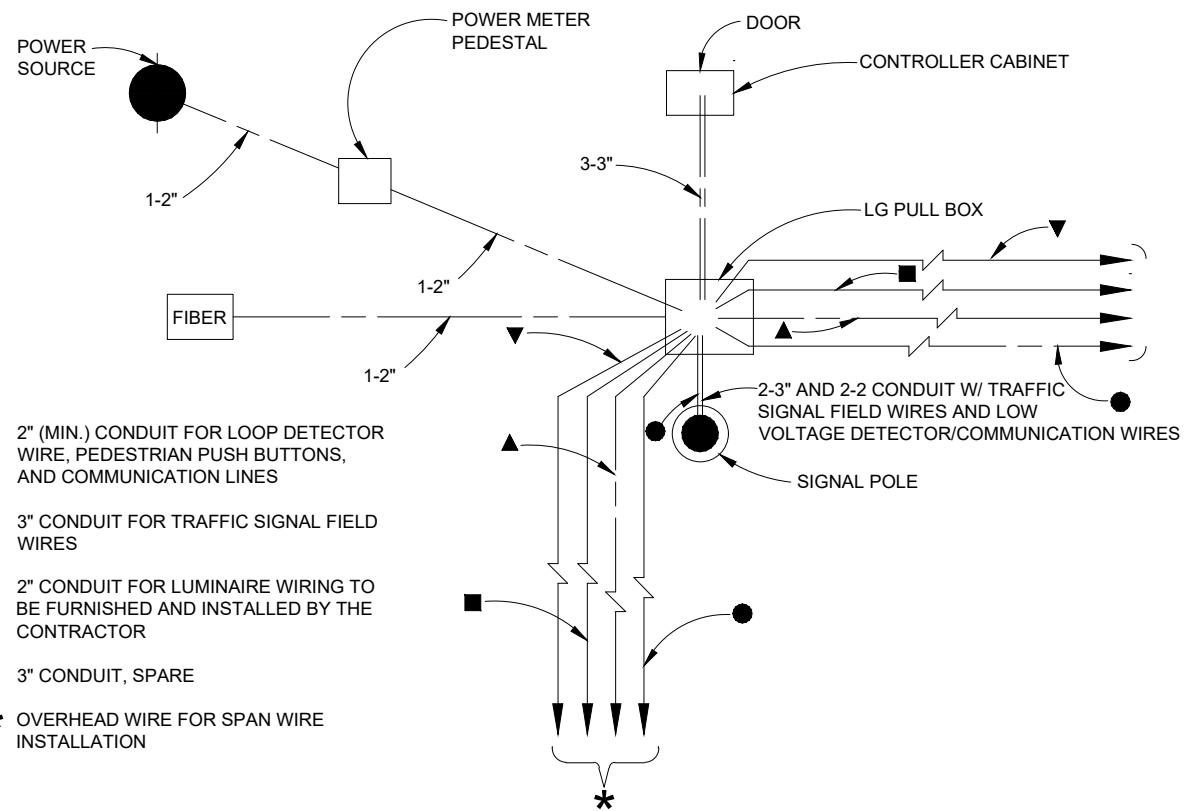
DETECTOR INSTALLATIONS

2022 ENGINEERING STANDARDS & SPECIFICATIONS

LOOP DETECTOR NOTES

1. ALL DETECTOR LOOPS SHALL BE #14 AWG THHN WIRE ENCASED IN PVC OR POLYETHYLENE TUBING.
2. IMMEDIATELY BEFORE LAYING THE LOOP CABLE, THOROUGHLY CLEAN AND DRY SAW CUT WITH HIGH PRESSURE OIL-FREE COMPRESSED AIR.
3. USE A BLUNT, NON-METALLIC INSTRUMENT TO PUSH WIRE INTO SLOT. DO NOT COIL LEAD WIRE.
4. LOOP WIRE SHALL BE CONTINUOUS (NO SPLICES) FROM THE SIDE-OF-STREET PULL BOX. SPLICES IN PULL BOX SHALL USE A WATERPROOF SPLICE KIT TO ASSURE THAT WATER DOES NOT INFILTRATE WIRE.
5. CONTINUITY TEST FOR EACH LOOP SHALL BE CONDUCTED:
 - 1) BEFORE ANY LOOP SEALANT IS INSTALLED AND
 - 2) AFTER LOOP SEALANT IS INSTALLED AND LEAD-IN CABLE IS SPLICED AND CONNECTED TO THE CONTROLLER. "RESISTANCE-TO-GROUND" AND "INDUCTANCE" SHALL BE MEASURED AND RECORDED FOR EACH TEST.
6. DETECTOR WIRE ACROSS BRIDGE JOINTS SHALL BE ENCASED IN A 12" SECTION OF 3/4" PVC PIPE THAT SPANS THE JOINT AREA.
7. WHERE AN ASPHALT OVERLAY IS PART OF THE WORK, ALL DETECTORS, LEAD-IN WIRE, AND CONDUIT SHALL BE IN PLACE BEFORE THE FINAL LIFT OF ASPHALT PAVEMENT IS APPLIED.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	DETECTOR INSTALLATIONS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



UNDERGROUND POWER SOURCE SCHEMATIC
FOR SIGNALS WITH LUMINAIRES

NO	DATE	REVISION



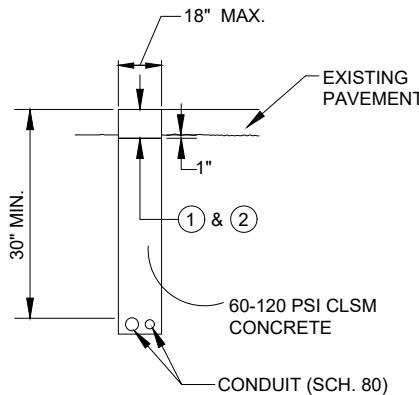
8101 Ralston Road
Arvada, Colorado 80002

UNDERGROUND POWER SCHEMATIC AND
CONDUIT DETAILS

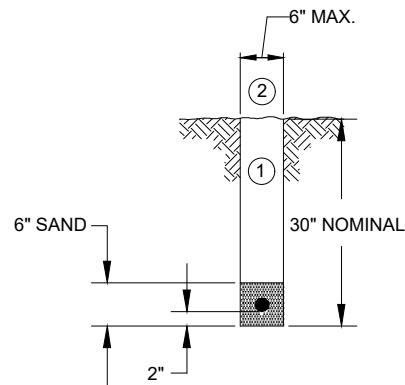
2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTES

1. CONTRACTOR TO PROVIDE ALL WIRING UP TO POWER SOURCE. UTILITY COMPANY RESPONSIBLE FOR FINAL HOOK-UP AT POWER SOURCE.
2. INDIVIDUAL CIRCUIT WIRING SHALL BE TAGGED PER STANDARD SPECIFICATIONS.
3. WHERE REQUIRED BY UTILITY COMPANY, CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING PERMIT AND INSPECTION FROM THE CITY OF ARVADA.
4. CONTRACTOR SHALL STRICTLY ADHERE TO CITY OF ARVADA ELECTRICAL INSPECTION REQUIREMENTS. CONTACT CITY OF ARVADA TRAFFIC ENGINEERING AT 720-898-7400 FOR FURTHER INFORMATION.
5. TRAFFIC SIGNAL CONDUIT SHALL NOT CARRY WIRING OF OTHER UTILITIES.
6. EXCEPT FOR LOOP DETECTOR LEADS, ALL SPLICES SHALL BE IN HANDHOLES AT POLE BASES AND NOT IN PULL BOXES.
7. WIRE NUT SPLICES SHALL BE USED FOR ALL CONNECTIONS. SOLDERING AND CRIMPING WILL NOT BE ALLOWED.
8. CONTRACTOR SHALL PROVIDE 2 WIRING DIAGRAMS OF THE SIGNAL INSTALLATION TO THE CITY.
9. UNLESS ALLOWED BY THE ENGINEER, WIRE SHALL NOT OCCUPY MORE THAN 40% OF THE INSIDE AREA OF CONDUIT
10. CONDUITS IN PAVED RIGHTS-OF-WAY SHALL BE BORED UNLESS OTHERWISE APPROVED BY THE CITY ENGINEER. IF ALLOWED, THE CONDUIT TRENCH DETAIL BELOW SHALL BE USED..

NOTES

- (1) HOT BITUMINOUS PAVEMENT (PATCHING) OR PORTLAND CEMENT CONCRETE PATCH, FULL DEPTH PLUS 1" (4" MIN). MATCH EXISTING PAVEMENT TYPE AND DEPTH
- (2) FOR ASPHALT PATCH, 48 HOUR NOTICE TO THE CITY OF ARVADA ENGINEERING DIVISION REQUIRED PRIOR TO INSPECTION

CONDUIT TRENCH DETAILNOTES

- (1) BACKFILL AND TAMP WITH NATIVE MATERIAL TO MATCH COMPACTION OF SURROUNDING GROUND
- (2) RESEED OR RESOD SURFACE AT DIRECTION OF THE ENGINEER

UNDER GRASS/GROUND
TRENCHING DETAIL

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	UNDERGROUND POWER SCHEMATIC AND CONDUIT DETAILS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

LEGEND
(MODIFY TO SPECIFIC CONDITION)

	PEDESTRIAN PUSH BUTTON STATION
	PEDESTRIAN SIGNAL HEAD
	LUMINAIRE
	TRAFFIC SIGNAL HEAD
	TRAFFIC SIGNAL HEAD W/ BACKPLATE
	TRAFFIC SIGNAL CONTROLLER & CABINET
	TRAFFIC SIGNAL POLE AND FOOTING
	TEMPORARY TRAFFIC SIGNAL SPAN WIRE POLE
	TRAFFIC SIGNAL POLE WITH MAST ARM
	TRAFFIC SIGNAL PEDESTAL POLE
	PEDESTRIAN PUSH BUTTON POST ASSEMBLY
	TRAFFIC CONDUIT - PVC SCHEDULE 80
	FIRE PREEMPTION UNIT
	TRAFFIC SIGN MOUNTED ON POLE/MAST ARM
	PULL BOX
	PULL BOX (SPECIAL)
	SERVICE METER HOUSING
	RADIO COMMUNICATION ANTENNA
	PTZ CAMERA
	MICROWAVE VEHICLE RADAR DETECTOR
	DETECTION ZONE WITH PHASE NUMBER
	POWER SOURCE

NOTE:

1. ALL TRAFFIC SIGNAL PLANS SHALL INCLUDE A TABULATION OF TRAFFIC SIGNAL ITEMS AND QUANTITIES. PAY ITEMS SHALL BE IN CONFORMANCE WITH THE LATEST CDOT PAY ITEMS UNLESS DIRECTED OTHERWISE BY THE CITY OF ARVADA.



R10-3
9" x 12"

**TYPICAL PEDESTRIAN
PUSH-BUTTON SIGN**
(ONE EACH PEDESTRIAN
SIGNAL HEAD LOCATION)

NO	DATE	REVISION



8101 Ralston Road
Arvada, Colorado 80002

TYPICAL TRAFFIC SIGNAL PLAN

2022 ENGINEERING STANDARDS & SPECIFICATIONS

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SECTION 800 – CONCRETE MIX DESIGN AND CONSTRUCTION

801.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

810.00 Scope

All Portland cement concrete work within any street, parking lot or ROW or in any part of the water system, sanitary sewer system, or storm drainage system of Arvada.

811.00 Inspections

Refer to Section 188.00 - Inspections and Section 931.00 - Roadway Inspections of these Standards and Specifications.

Adequate inspections assure compliance to Arvada requirements and are the basis for Arvada's recommendation that improvements be accepted for maintenance and/or for release of performance guarantees. It is the responsibility of the Contractor to contact the Project Inspector a minimum of one (1) full working day (twenty-four [24] hours) in advance of the required inspections. Concrete shall not be placed until all forms and reinforcement have been observed by the Project Inspector. Required inspections shall include:

1. Subgrade – Verify that material on which concrete shall be placed is to the line, grade, and cross-section shown on the approved plans, is not frozen or excessively dry at the surface, and meets all compaction requirements.
2. Forms/Reinforcing Steel – Verify that forms are set to proper grade and alignment, adequately braced, and set for proper thickness of concrete. Rebar is properly placed and spaced, at least fifty (50) percent of intersections are tied, and proper distances from surface grade and forms are maintained. Verify that electrical isolation of the forms/reinforcing steel is obtained from all other metallic piping, conduits, and structures per Section 420.19.
3. Concrete Delivery and Testing – Confirm that mix design submittals are approved by Arvada, and testing/sampling frequency, slump, air, and minimum/maximum air and concrete temperatures comply with approved mix designs and applicable ASTM's.
4. Cure and Flush – Verify that finished concrete complies with approved grades and alignment and is properly cured and protected from freezing. Contractor shall verify

that concrete pavement surfaces comply with the smoothness requirements of Section 412.17 - Surface Smoothness Test of the CDOT Standard Specifications for Road and Bridge Construction.

5. General Items Include:

- a. All temporary structures, debris, mud and waste materials shall be removed from public property.
- b. Grout and seal all cracks in concrete using "Deery Super Gray 800-13" or approved equal. Fill all gouged areas of concrete with an approved epoxy. Remove and replace all areas of broken concrete. Subgrade failures shall be corrected before pouring back.
6. Construction Acceptance Into Warranty – Refer to Section 221.00 - Initial Warranty Acceptance Process & Inspections of these Standards and Specifications.
7. Final Acceptance/Release from Warranty – Refer to Section 232.00 - Final Acceptance and Release from Warranty work for Roadways by the City Engineer of these Standards and Specifications.

820.00 Concrete Mix Design

Concrete shall be composed of Portland cement, aggregate and water, and shall be reinforced with steel bars or steel wire fabric where required. 1.5 lbs/cy of virgin polypropylene fibrillated fibers shall be plant batched into the mix for all concrete used in flatwork.

All Portland cement concrete mixes utilized within any street, parking lot or ROW shall be from the CDOT Pre-Approved Concrete Mix Designs list. If utilizing an alternative mix design, concrete mix design information shall be prepared in accordance with ACI 301 Section 4.2 and submitted to the Project Engineer for approval. At least two (2) sets of certified twenty-eight (28) day strength test results shall also be submitted. No concrete shall be placed until the concrete mix design has been approved.

A separate mix design submittal shall be required for concrete to be pumped. Mix designs shall be prepared in accordance with ACI 211 and 304, as applicable.

821.00 Materials

821.01 Cement

All cement used in concrete work shall comply with CDOT Specifications Section 701 - Hydraulic Cement. When requested by the Project Engineer, the Contractor shall furnish the Project Engineer with a certificate from the manufacturer or an acceptable testing laboratory stating that the cement meets the requirements of these Standards and Specifications.

821.02 Fly Ash

All fly ash used in concrete work shall comply with CDOT Specifications Section 701 - Hydraulic Cement. The Project Engineer may require a certificate from an approved testing laboratory stating that the fly ash meets the requirements of these Standards and Specifications. Class C fly ash shall not be permitted where sulfate resistant cement is required.

821.03 Water

Potable, non-alkaline water in accordance with CDOT Specifications subsection 712.01 - Water and devoid of salts and other injurious elements for concrete mixing shall be used.

821.04 Admixtures

All admixtures used in concrete work shall comply with CDOT Specifications Sub-section 711.03 - Chemical Admixtures and with Project Engineer approval.

821.05 Aggregate

Fine and coarse aggregates are regarded as separate ingredients and each shall be well graded and in accordance with CDOT Specifications sub-sections 703.01 and 703.02.

822.00 Mix Properties

Mix properties of Portland cement concrete for flatwork shall comply with Class B requirements of CDOT Specifications Section 601 - Structural Concrete. Additional concrete mix designs may be approved for decorative, non-structural concrete at the discretion of the Project Engineer.

822.01 Colored Concrete

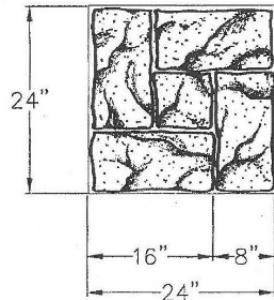
Where required on the approved plans, or as approved by the Project Engineer, colored concrete shall comply with the following:

1. All typical properties of flatwork as specified in Section 821.00 - Materials and Section 822.00 - Mix Properties of these Standards and Specifications.
2. 1.5 lbs/cy of 100% virgin polypropylene fibrillated fibers shall be plant batched into the mix for all concrete.
3. Color shall be per plan.
4. The Contractor shall pour a mock-up for approval by the Project Engineer prior to initiating work.

822.02 Textured Concrete

Where required on the approved plans, or as approved by the Project Engineer, colored and textured concrete shall comply with the following:

1. All typical properties of flatwork as specified in Section 821.00 - Materials and Section 822.00 - Mix Properties of these Standards and Specifications.
2. 1.5 lbs/cy of 100% virgin polypropylene fibrillated fibers shall be plant batched into the mix for all concrete.
3. Color shall be from the Arvada approved products list, or approved equal and mixed per manufacturer's recommendation. Color shall match adjacent existing median materials.
4. Stamp patterns shall be from the Arvada approved products list, or approved equal.
5. Color hardener shall be specially formulated for installation of patterned concrete, grade "Heavy Duty".
6. Color curing compounds shall comply with ASTM C309 and with all applicable air pollution regulations.
7. Normal set or retarded set water reducing admixture shall comply with ASTM C494.
8. No calcium chloride shall be added to the concrete mix.
9. Antiquing release shall be two (2) parts Stone Gray and one (1) part Deep Charcoal.
10. Acrylic Sealer shall be used from the Arvada Approved Products List.
11. The Contractor shall pour a mock-up for approval by the Project Engineer prior to initiating work.



822.03 Controlled Low Strength Materials (CLSM)"Flowable Fill"

CLSM may be used as structure backfill, as backfill for pipelines and service lines, or as backfill for "dry utility" (electric, gas, telephone, fiber and/or cable) service repair work trenches. CLSM ("flowable fill") mix designs shall be from the City and County of Denver Approved CLSM list and submitted to the Project Engineer for approval prior to placement.

CLSM shall be placed in confined areas and under pipe haunches with methods approved by the Project Engineer. When backfilling pipelines and service lines, CLSM shall be properly layered to prevent pipe from floating.

CLSM shall conform to MGPEC Section 19.

822.04 Controlled Low Strength Materials (CLSM) "Flash Fill"

CLSM ("Flash Fill") mix designs shall be from the City and County of Denver Approved CLSM list and submitted to the Project Engineer for approval prior to placement. CLSM used as backfill for isolated pipeline and/or service line repair/replacement, or to fill abandoned pipelines and appurtenances shall conform to MGPEC Section 19.

CLSM shall be placed in confined areas and under pipe haunches with methods approved by Project Engineer. When backfilling pipelines and service lines, CLSM shall be properly layered to prevent pipe from floating.

823.00 Ready-Mixed Concrete

The use of ready-mixed concrete shall in no way relieve the Applicant of the responsibility for proportion, mix, delivery, or placement of concrete. All ready-mixed concrete shall comply with ASTM C94.

Concrete shall be continuously mixed or agitated from the time the water is added until the time of use, and discharge from the truck should begin within ninety (90) minutes or three-hundred (300) revolutions after it comes in contact with the mixing water or with the aggregates. In accordance with ASTM C94, water may be added to ready-mix concrete one (1) time in order to get slump within range, as long as the specified water-cement ratio is not exceeded. After installation of concrete has begun, no water may be added.

The contractor shall collect delivery or batch tickets from the driver for all concrete used on the project and shall deliver them to the City Inspector. Hand written batch tickets will not be accepted. Batch tickets shall provide the following information in accordance with ASTM C94:

1. Name of ready-mix batch plant
2. Serial number of ticket
3. Date
4. Truck number
5. Name of purchaser
6. Specific designation of job (name and location)
7. Mix # or specific class or designation of the concrete

8. Amount of concrete in cubic yards
9. Time loaded or of first mixing of cement and aggregates
10. Water added by receiver of concrete and his/her initials
11. Weights of fine and coarse aggregates
12. Type, brand and amount of cement
13. Type, brand and amount of admixtures
14. Weight (in gallons) of water, including surface water on aggregates
15. Allowed water (in gallons) to be added.
16. Gallons of water added by truck operator.

The Contractor shall add the following information to the batch ticket at the placement site:

17. Discharge time
18. Water-cement ratio (bridge deck concrete only)
19. Air content
20. Slump
21. Revolutions
22. Location of batch in placement

824.00 Steel Reinforcing and Forms

824.01 Epoxy Coated Steel Reinforcing

The placement, fastening, splicing and supporting of epoxy coated reinforcing steel (in accordance with AASHTO M284) and wire mesh or bar mat reinforcement shall comply with the plans and the latest edition of CRSI Recommended Practice for Placing Reinforcing Bars and ACI 117. Before being positioned, all reinforcing steel shall be thoroughly cleaned of mill and rust scale and of coatings that may destroy or reduce the bond. Where there is delay in depositing concrete, reinforcement shall be re-inspected and cleaned if necessary.

Reinforcement shall be carefully formed to the dimensions indicated on the approved plans by the cold bending method. Cold bends shall be made so that the inside diameter of the bend measured on the inside of the bar shall be as follows:

Cold Bending Diameters

Bar Size	Grade 60
#3 through #8	6 bar dia.
#9, #10, and #11	8 bar dia.
#14 and #18	10 bar dia.

The inside diameter of bend for stirrups and ties shall not be less than four (4) bar diameters for sizes #5 and smaller, and five (5) bar diameters for #6 and #8. Reinforcement shall not be bent or straightened in a manner that may injure the material. Bars with kinks or bends shall not be used except where shown on the plans. Heating of reinforcement shall not be permitted.

Reinforcing steel shall be accurately placed and secured against displacement by using annealed iron wire of not less than No. 18 gauge, or by suitable clips at intersections. A minimum of fifty (50) percent of intersections shall be secured. Where necessary, reinforcing steel shall be supported by metal chairs or spacers, precast mortar blocks, or metal hangers. Splicing of bars, except where shown on the plans, shall not be allowed without approval of the Project Engineer.

Welded wire fabric for concrete reinforcement shall be of the gauge, spacing, dimensions, and form specified on the plans or Detailed Drawings and shall comply with "Specifications for Welded Steel Wire Fabric for Concrete Reinforcement" (ASTM A185) or "Specifications for Welded Deformed Steel Wire Fabric for Concrete Reinforcement" (ASTM A497).

Contractor shall submit shop drawings of the reinforcement to the Project Engineer for approval. Unless otherwise shown on the plans, the minimum clear cover for reinforcing steel shall be the following, as specified in Section 3.3 of ACI 301 (current edition):

Concrete exposure	Member	Reinforcement	Specified Cover, inches
Cast against and permanently in contact with ground	All	All	3
Exposed to weather or in contact with ground	All	No. 6 through No. 18 bars	2
		No. 5 bar, W31 or D31 wire, and smaller	1-1/2
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars	1-1/2
		No. 11 bar and smaller	3/4
	Beams, columns, pedestals, and tension ties	Primary reinforcement, stirrups, ties, spirals, and hoops	1-1/2

824.02 Forms and Form Setting

Forms shall have sufficient strength to withstand—without deformation—the pressure resulting from placement and vibration of the concrete. Forms shall be constructed so that the finished concrete shall conform to the shapes, lines, grades and dimensions indicated on the approved plans. Any form which is not clean and which has not had the surface prepared with commercial form oil to effectively prevent bonding, staining, and softening of concrete surfaces shall not be used.

Forms may generally be wood or metal and shall have a depth equal to or greater than the slab thickness. Plywood forms, plastic coated plywood forms, or steel forms shall be used for all surfaces requiring forming which are exposed to view, whether inside or outside any structure. Surfaces against backfilled earth, interior surfaces of covered channels, or other places permanently obscured from view, may be formed with forms having sub-standard surfaces.

Forms that have become worn, bent, or broken shall not be used. Each section of form shall be straight, not warped, and free of defects likely to cause irregular surfaces. The Contractor shall set a minimum length of three hundred (300) feet of forms to grade prior to placing concrete. In cases where the length of one run is less than three hundred (300) feet, the Contractor shall set forms to grade for the entire run.

The face of curbs shall be formed, unless otherwise permitted by the City Inspector. Forms shall be secured to resist the pressure of the poured concrete without springing or settlement. The connection between sections shall be performed by a method in which the joint shall be free from movement in any direction.

Forms shall not deviate more than one-quarter ($\frac{1}{4}$) inch from the design line and grade.

When concrete pavement is constructed on a curve, flexible forms shall be used having a radius of two hundred (200) feet or less, unless otherwise directed by the City Inspector. Face forms shall be pre-formed to the proper radius. Care shall be exercised to ensure the required cross section is maintained around the entire radius.

The Contractor shall provide an approved metal straight edge, ten (10) feet in length, to check the alignment of the forms prior to placing the concrete, and to check the concrete surface during the finishing operation.

Forms shall not be disturbed until the concrete has hardened sufficiently to permit removal without damaging the concrete, or until forms are not required to protect the concrete from mechanical damage. Crowbars or other heavy tools shall not be used against green concrete when removing forms. Forms shall be thoroughly cleaned before re-oiling and reuse.

Walks shall not be opened to pedestrian traffic for a minimum twenty-four (24) hours after placement. Curb cuts, curb and gutter and cross plans shall not be opened to vehicular traffic for a minimum of seven (7) days after placement or until concrete has attained 80% of its specified twenty-eight (28) day field strength.

825.00 Concrete Testing

The requirements of this section shall apply to testing services for all concrete curb and gutter, sidewalk, pavement, slope paving, retaining walls, structures, and for all miscellaneous concrete testing.

A representative of the concrete testing agency shall inspect, sample, and test material and production of concrete as required by the Project Engineer. Minimum testing frequency shall be as specified below.

Concrete	AASHTO	ASTM	Minimum Test Frequency
Sampling	R60	C172	One Test First Load of the Day, then every 50 Cubic Yards
Compressive Strength**	T22	C39	One Set First Load of the Day, then every 50 Cubic Yards
Temperature	N/A	C1064	One Test First Load of the Day, then every 50 Cubic Yards
Slump	T119	C143	One test First Load of the Day, then every 50 Cubic Yards
Air Content	T196 / T121 / T152	C173 / C138 / C231	One test First Load of the Day, then every 50 Cubic Yards

*Concrete samples must be taken in accordance with AASHTO R60 or ASTM C172

**One set of cylinders shall consist of 5 cylinders (2 @ 7 day break, 2 @ 28 day break, 1 @ 56 day break)

Any test failures shall trigger testing for the next three (3) loads. The concrete testing agency shall report all test and inspection results to the Project Engineer and Contractor immediately after they are performed. All test reports shall include the exact location of the work at which the batch represented by a test was deposited. The report of the strength test shall include

detailed information on storage and curing of specimen prior to testing, the project number, and the location of the concrete (curb, manhole, inlet, sidewalk, paving, etc.).

The concrete testing agency or its representative is not authorized to revoke, alter, relax, expand or release any requirements of these Standards and Specifications, nor to approve or accept any portion of the work. When it appears that any material furnished or work performed by the Contractor fails to fulfill specification requirements, the testing agency shall report such deficiencies to the Project Engineer and the Contractor.

830.00 Concrete Construction

831.00 Placing Concrete

Before placing concrete, debris shall be removed from the space to be occupied by the concrete. The forms and all concrete surfaces shall be thoroughly wetted. The concrete shall be placed on soils prepared in accordance with Section 361.00 - Embankment Construction of these Standards and Specifications. Soils should be slightly moistened but not muddy prior to concrete placement. Concrete shall be placed and compacted so that it is free from honeycomb and free from pockets of segregated aggregate. Sections of segregation or honeycomb revealed by removal of the forms shall be removed and replaced or otherwise repaired as approved by the City Inspector.

Concrete shall not be placed until all forms and reinforcing steel have been inspected and approved by the Arvada Inspector/Representative. Verify that electrical isolation of the forms/reinforcing steel is obtained from all other metallic piping, conduits, and structures per Section 420.19.01 - Isolation Devices. Concrete shall be handled from the mixer to the place of final deposit as rapidly as possible by methods that prevent separation or loss of ingredients. The concrete shall be deposited in the forms as close as practicable in its final position to avoid re-handling. It shall be deposited in continuous layers, the thickness of which generally shall not exceed twelve (12) inches. Concrete shall be placed in a manner to avoid segregation and shall not be dropped freely more than five (5) feet. If segregation occurs, the Arvada Inspector/Representative may require the concrete to be removed and replaced at the Contractor's expense. Cement, which for any reason has become partially set or which contains lumps shall be rejected.

Concrete shall be placed in one (1) continuous operation, except where keyed construction joints are shown on the plans or as approved by the City Inspector. Delays in excess of thirty (30) minutes may require removal and replacement of concrete by the City Inspector. At the end of the work day, or in case of an unavoidable interruption of more than thirty (30) minutes, a transverse construction joint shall be placed at the point of stopping work, provided that the

section on which work has been suspended shall not be less than five (5) feet long. Sections less than five (5) feet in length shall be removed. Concrete shall not be placed when the weather is stormy, dusty, or inclement to a degree that precludes good workmanship.

831.01 Vibrating

All concrete shall be compacted by internal vibration using mechanical vibrating equipment. Concrete in floor slabs, sidewalks, or curb and gutter which is not placed against form linings shall be either tamped or vibrated. Care shall be taken to vibrate only long 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 309R, Chapter 5. 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 to require removal and replacement of concrete at the Contractor's expense. The Contractor shall be responsible for any defects in the quality and appearance of the concrete.

831.02 Workability

The consistency of concrete shall be kept uniform and shall be checked by means of certified slump tests. At all times concrete shall have a consistency such that it can be worked into corners and angles of the forms and around joints, dowels and tie-bars by the construction methods which are being used without excessive spading, segregation or undue accumulation of water or laitance on the surface. If concrete fails to conform to the proportions of the approved mix design for any reason, such concrete shall not be incorporated in the work but shall be discarded from the project site as waste material at the Contractor's expense. Water may not be added at the job site without permission of the City Engineer.

831.03 Installation of Colored Patterned Concrete

Special concrete mix with integral color shall be placed and screeded to the proper grade, and floated to a uniform surface in the normal manner for slabs on grade. While the concrete is still plastic, the imprinting tools shall be applied to make the desired patterned surface. The pattern shall be matched at imprint edges and joints.

Color curing compound, thinned in the proportion of one (1) part curing compound to one (1) part mineral spirits (paint thinner), shall be applied uniformly with a roller or sprayer. The coverage shall be approximately six hundred (600) to six hundred fifty (650) square feet per gallon of unthinned curing compound. At times when the air temperature is at or near freezing,

the slab shall be cured using suitable curing blankets. The slab shall later be sealed with the color curing compound when the air temperature is above freezing.

Use of blankets and/or heaters may be necessary to maintain the concrete at or above fifty (50) degrees Fahrenheit for three (3) days after placement. The cured surface shall be cleaned to remove any residual materials.

831.04 Weather Limitations

831.04.01 Extreme Weather Concreting

During extreme weather conditions, placement of concrete shall be allowed only when the temperature of the concrete placed in the forms is between fifty (50) degrees Fahrenheit and ninety (90) degrees Fahrenheit. Cold weather placement of concrete shall comply with the minimum concrete placement temperature table below.

No concrete shall be placed, regardless of the present temperature, when the weather forecast predicts freezing weather before final set of the concrete unless special means of heating and protection are used. Protection against freezing is the Contractor's responsibility regardless of the weather forecast or climatic conditions at the time of placement. Minimum concrete temperatures, as listed below, shall be maintained for a minimum of seventy-two (72) hours after the concrete has been placed or until at least 60% of the twenty-eight (28) day field strength has been obtained, whichever is greater.

Minimum Concrete Placement Temperature

Air Temperature	Section Thickness, Minimum Dimension (inches)	
	< 12 in.	12-36 in.
Above 30°F	60°F	55°F
0°F-30°F	65°F	60°F
Below 0°F	70°F	65°F
Minimum Concrete Curing Temperature		
	55°F	50°F

Small structures and slabs shall be protected by completely covering fresh concrete with suitable curing blankets to prevent freezing. Large structures and vertical walls shall be protected against freezing by enclosing the structure with heating devices capable of providing uniform and even

heat throughout the structure. Heaters shall be vented so that combustion gases are exhausted outside the enclosure in order to avoid carbonation of the fresh concrete. If in the opinion of the Inspector, the protection provided is inadequate, concreting shall cease until conditions or procedures are satisfactory to the Inspector.

Cold weather is defined as a period when, for more than three (3) consecutive days, the following conditions exist:

1. The average air temperature is less than forty (40) degrees Fahrenheit.
2. The air temperature is not greater than fifty (50) degrees Fahrenheit for more than one half of any twenty-four (24) hour period.

Concrete placed in cold weather shall be protected from extreme temperatures as follows:

1. A temperature of at least fifty (50) degrees Fahrenheit for the first seventy-two (72) hours shall be maintained.
2. After the first seventy-two (72) hours and until the concrete is seven (7) days old, it shall be protected from freezing temperatures.
3. Concrete adjacent to heating devices shall be insulated from direct heat of the unit that may dry it out prior to being properly cured.
4. Temperatures shall be measured by maximum and minimum thermometers furnished by the Contractor and installed adjacent to the concrete.

Concrete slabs shall not be placed, regardless of temperature conditions, if the supporting ground is frozen or contains frost. Use of salt or other additives to prevent concrete from freezing is not allowed. If the City Inspector determines that the cold or inclement weather protection is inadequate, concrete placement shall stop until adequate weather conditions exist or until protection procedures are acceptable to the City Inspector. Concrete which has been frozen shall be removed and replaced as required by the City Inspector.

831.04.02 Hot Weather Concreting

Except by written authorization, concrete shall not be placed if the temperature of the plastic concrete cannot be maintained at ninety (90) degrees Fahrenheit or lower. Placement of concrete in hot weather shall comply with ACI 305R.

832.00 Concrete Pavement and Flatwork

The installation of Portland cement concrete pavement, including materials, equipment, foundation and construction methods shall comply with Section 412 of the CDOT Standard Specifications for Road and Bridge Construction and these Standards and Specifications.

Concrete pavements shall be installed as shown on the approved plans or as approved by the Project Engineer. The Contractor shall furnish steel pins to use in setting grades for concrete pavement.

The subgrade shall conform to the specified cross section. Immediately prior to placing concrete, the subgrade shall be tested for adequate compaction and moisture to a minimum depth of six (6) inches or as specified in the approved Geotechnical Report. Concrete shall not be placed on any portion of the subgrade that has not been inspected by an Arvada Inspector/Representative. There shall be no puddles or pockets of mud when the concrete is placed, and the subgrade shall be cleared of any loose material.

Curb, curb ramps, gutter, sidewalk, cross pan, and driveway construction shall conform to all applicable provisions, Detailed Drawings of these Standards and Specifications, and U.S. Access Board PROWAG Guidelines .

832.01 Portland Cement Treated Base

In those instances where deemed necessary by the project Geotechnical engineer and approved by the Project Engineer, Portland cement treated base may be required.

832.02 Curb and Gutter

The section to be constructed shall be as identified on the approved plans and as shown on the Detail Drawings of these Standards and Specifications.

832.03 Sidewalks

Detached sidewalks along local residential streets shall be a minimum of four (4) inches thick and all other sidewalks shall be a minimum of six (6) inches thick, and shall be constructed as shown on the approved plans. Areas of sidewalk or concrete trails crossed by driveways or in parks, open spaces or greenbelts shall be constructed with a minimum of six (6) inch thick concrete.

832.04 Crosspans and Curb Return Fillets

Typical crosspan sections are shown in the Detail Drawings found in these Standards and Specifications. Where unusual conditions exist, additional reinforcing steel and special joints may be required by the Project Engineer.

832.05 Curb Cuts and Driveways

Curb cuts in six (6) inch vertical curbs shall be constructed at all driveway locations and at additional locations, as shown on the approved plans and in the Detail Drawings found in these Standards and Specifications

832.06 Curb Ramps

Curb ramps shall be installed at locations designated by the Project Engineer and as shown on the approved plans. Directional curb ramps, rather than diagonal or corner curb ramps, shall be installed unless site conditions or constraints prohibit their placement; or their placement creates an unsafe or undesirable condition for pedestrians or wheelchair travel along the sidewalk. The curb ramps shall be constructed with slopes, landings, and detectable warnings (truncated domes) as shown in the latest revision of the Colorado Department of Transportation M&S Standards. Truncated domes shall be from the CDOT approved products list and the contractor shall follow specific installation details per the manufacturer. Replaceable cast-in-place (wet set) truncated dome panels shall be easily removed and replaced, made of fiber reinforced fiberglass/composite material, and color shall contrast the surface applied to. Panels shall have a beveled edge for wheelchair egress. No truncated dome pavers shall be used within City ROW. Panel size shall have a depth of two (2) feet.

832.07 Medians and Islands

Medians and islands shall be constructed as identified on the approved plans and as shown on the Detail Drawings of these Standards and Specifications.

832.08 Joints

Joint materials shall comply with the following specifications:

Joint Material Specifications

	AASHTO
Preformed expansion joint filler (Bituminous Type)	M33
Preformed sponge rubber and cork expansion joint fillers	M153
Preformed expansion joint fillers (fiber board)	M213

Non-bituminous type materials shall be placed in widths shown on the approved plans or three-eighths ($\frac{3}{8}$) inch wide when not specified. Bituminous type materials shall be used for concrete paving and structural construction where joint sealers are not required.

All joints shall be constructed straight and plumb and shall extend through the entire section from edge to edge and to the depths specified.

832.08.01 Expansion Joints

Expansion joint material shall be provided at the following locations and shall be in place prior to placement of concrete:

1. Between back of sidewalk and driveways, alleys, or service walk
2. Between new concrete and existing buildings
3. At other unyielding structures or elements (hydrants, power pole, etc)
4. As shown on the approved plans
5. As directed by the City Inspector

Reinforcing steel bars (#3 or #4, 18" long minimum) shall be used to tie together new and existing concrete pavements and flatwork. Refer to the Detail Drawings found in these Standards and Specifications for expansion joints.

Expansion joint filler, which is one-half ($\frac{1}{2}$) inch thick, preformed, non-extruding bituminous-treated fiber board conforming to AASHTO Specification M-213, shall be used to form transverse expansion joints. Concrete tie-ins shall have reinforcing steel bars (#4 minimum) extending a minimum of twelve (12) inches into the concrete in each direction.

832.08.02 Contraction Joints

Transverse joints shall be placed at maximum intervals of ten (10) feet to control random cracking. Joints shall be formed, sawed, or tooled to a minimum depth of one-third ($\frac{1}{3}$) of the total thickness of the pavement or flatwork. If divider plates are used, the maximum depth of plates shall not be greater than one-half ($\frac{1}{2}$) depth at the finished surface and shall be no less than fifteen-sixteenths (5/16) inch thick. Refer to the Detail Drawings found in these Standards and Specifications for contraction joint details.

The curb and gutter or sidewalk shall be divided into blocks not less than five (5) feet or more than ten (10) feet long using metal templates not less than one-sixteenth (1/16) inch or more than one-quarter ($\frac{1}{4}$) inch thick. Templates shall be a minimum of four (4) inches deep. Templates shall be designed to attach securely to the forms in such a manner as to prevent movement while the concrete is being placed and consolidated. Templates shall be removed prior to the concrete taking its initial set.

If a curbing machine or other method not requiring the use of templates is approved, dummy joints formed by a jointing tool or other approved means shall be used. Dummy joints shall extend into the concrete for at least one-third ($\frac{1}{3}$) of the depth (no less than two (2) inches) and shall be approximately one-eighth ($\frac{1}{8}$) inch wide.

832.08.03 Tooled Joints

Tooled joints shall be spaced as follows:

1. Not more than ten (10) feet or less than five (5) feet apart in curb and gutter, sidewalk, and combination curb-walk
2. Joints in both directions, equally spaced at not greater than ten (10) foot intervals, as applicable in driveways and plazas
3. As directed by the City Engineer

832.09 Ponding

Ponding of water in concrete pavement and flatwork shall not exceed one-eighth ($\frac{1}{8}$) inch in depth. Where ponding exceeds one-eighth ($\frac{1}{8}$) inch in depth, pavement or flatwork shall be removed and replaced at the Contractor's expense.

833.00 Concrete Structures

833.01 Forms

Refer to Section 824.02 - Forms and Form Setting of these Standards and Specifications for requirements for appurtenant concrete structures

833.02 Concrete Placement

Refer to Section 831.00 - Placing Concrete of these Standards and Specifications for requirements for appurtenant concrete structures.

833.03 Expansion Joints

Expansion joint filler, which is one-half ($\frac{1}{2}$) inch thick, preformed, non-extruding bituminous-treated fiber board conforming to AASHTO Specification M-213, shall be used to form transverse expansion joints. Concrete tie-ins shall have reinforcing steel bars (#4 minimum) extending a minimum of twelve (12) inches into the concrete in each direction.

834.00 Cleanup

The exposed surfaces of concrete shall be thoroughly cleaned upon completion of the work. Within forty-eight (48) hours after forms are removed, the area behind the sidewalk or curb shall be cleaned, backfilled and graded to provide a smooth even surface.

835.00 Backfill of Concrete Work

When forms are removed and the concrete has gained sufficient strength, 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 backfill shall be level with the top of the concrete for at least two (2) feet and then sloped as shown on the approved plans or as directed by the Project Engineer.

836.00 Protection Against Vandalism

It shall be the responsibility of the Contractor to protect all concrete work against damage or vandalism. When required, a guard shall be stationed over fresh work until the concrete is sufficiently set to prevent damage at the Contractor's expense. Concrete damaged in any way by vandals shall be removed and replaced at the Contractor's expense.

Anti-graffiti materials shall be installed as shown on the approved plans or as required by the City Inspector. Prior to installation, technical information regarding proposed anti-graffiti materials shall be submitted to the Project Engineer for approval.

837.00 Repairs

After stripping concrete forms, any concrete found to be inconsistent with the approved plans, is out of alignment, not level, or showing a defective surface shall be removed and replaced at the Contractor's expense as directed by the City Inspector. The Project Engineer may give written permission to patch the defective area. Ridges and bulges may be removed by grinding if approved by the City Inspector. Honeycombed and other defective concrete that does not affect the integrity of the structure may be chipped out and the vacated areas filled if approved by the City Inspector.

The repaired area shall be patched with a non-shrink, non-metallic grout with a minimum compressive strength of 5,000 psi in twenty-eight (28) days. All repair areas treated with an epoxy-bonding agent shall have the approval of the Project Engineer before the repair filling is placed.

837.01 Flatwork Repairs and Replacement

All edges of the existing flatwork to remain shall be saw cut. Flatwork repairs and replacement shall be as directed by the City Inspector and at the Contractor's expense.

837.02 Concrete Structure Repairs

Bolt-holes, tie-rod holes, and minor imperfections as approved by the City Inspector, shall be filled with dry-patching mortar composed of approximately one (1) part Portland cement to two (2) parts of regular concrete sand (volume measurement) and only enough water so that after the ingredients are mixed thoroughly, the mortar sticks together when 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.

837.03 Exploratory Pothole/Core Repair

When exploratory utility potholing is performed, the Contractor shall repair the pothole in the following manner.

Concrete:

- Exploratory potholing voids are to be backfilled and the core patched with a temporary patching material immediately after initial potholing is complete.
- All material disturbed and/or removed during the exploratory operation shall be replaced with an approved flow-fill mix.
- Squeegee shall not be allowed as backfill material except for use as pipe bedding with a twelve inch (12") maximum depth over the pipe.
- Within seventy-two (72) hours of initial drilling, or within a reasonable and practical amount of time after completion of the projected work, potholes will be permanently patched.
- Any exploratory pothole and/or patch that are deemed dangerous shall be repaired immediately
- Any exploratory potholing in concrete such as, but not limited to; sidewalk, curb & gutter, cross-pans, curb-ramps, concrete median structures or driveways, shall require the complete stone of concrete replaced.
- Colored or patterned concrete shall be replaced with the same color and pattern of the existing concrete.

838.00 Finishing, Curing and Protection

Concrete finishing, curing, and protection shall comply with ACI 301 except where described differently below.

838.01 Finishing

Where applicable, finishing shall be performed with a metal screed designed to give proper shape to the section as detailed. Particular care shall be used to finish the gutter flowline to a true uniform grade. Face forms shall be left in place until the concrete has hardened sufficiently so that they can be removed without injury to the curb.

The Contractor shall use at all times, a ten (10) foot straight edge for finishing curb and gutter sections. Irregularities shall be corrected by adding or removing concrete. All disturbed places shall be floated with a wooden or metal float that is not less than three (3) feet long and not less than six (6) inches wide, and screeded. No water or cement shall be added to the surface of the concrete to aid in finishing. Edges of the concrete and joints shall be carefully finished with an edger having a one-eighth inch ($\frac{1}{8}$) inch radius prior to the concrete reaching initial set. Concrete shall be finally finished with a wood float and lightly broomed to a slightly roughened surface. On grades less than one (1) percent, the Contractor shall check for depressions before final finish so that no ponding exists.

Exposed faces of curbs and sidewalks shall be finished to the line and grade shown on the plans. Surface shall be floated to a smooth but not slippery finish. Sidewalk and curb shall be broomed or combed and edged, unless otherwise indicated by the City Inspector. After completion of brooming and before concrete has initial set, all edges in contact with the forms shall be tooled with an edger having a three-eighths ($\frac{3}{8}$) inch radius.

No dusting or topping of the surface or sprinkling with water to facilitate finishing shall be permitted.

Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. 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. The surface shall be left sound, smooth, even, and uniform in color. Mortar used in pointing shall not be more than thirty (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.

838.02 Curing and Protection

Fresh concrete shall be adequately protected from weather damage and mechanical injury during the curing periods. Should damage occur, the concrete shall be removed and replaced at no cost to the City. The selected curing process shall be started as soon as it can be performed without injury to the concrete surface.

Curing compounds shall be white pigmented liquid membrane forming on non-colored concrete and conform to AASHTO M 148. Curing compounds shall be clear on colored concrete or as recommended by the manufacturer. All curing compounds shall be installed per manufacturer's recommendations.

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.

For Concrete placed between April 1 through September 14:

For normal Portland Concrete Pavement, 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).

For Concrete placed between September 15 and March 31:

A combination cure-sealer shall be used for Portland Concrete Pavement and other related flatwork, sidewalks, and vertical surfaces placed during these dates, or when the Project Engineer predicts an event where they expect to receive snow, freezing conditions and/or the need for use of de-icing materials within twenty-eight (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, sid, 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.

Burlap cloth made from Jute or Kenaff shall conform to AASHTO M 182. Sheet materials for curing concrete shall conform to AASHTO M 171.

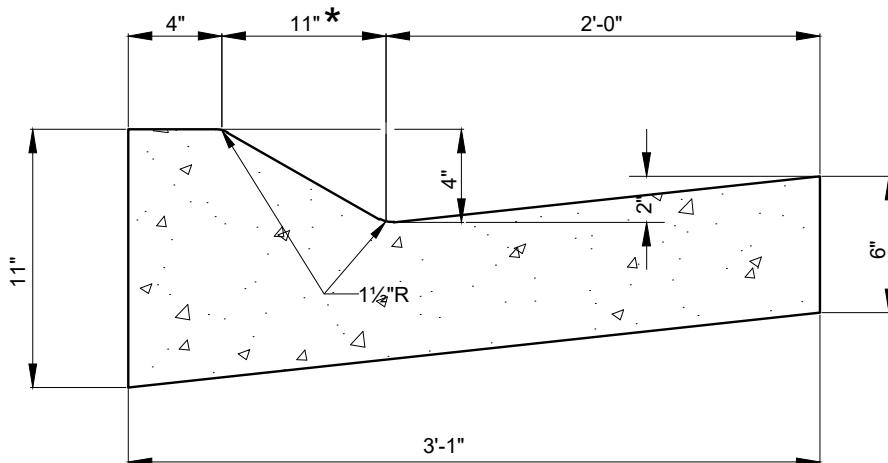
839.00 Defective Concrete

If concrete is found defective from testing, placing, curing or for other causes, and if the Contractor is so directed, he must remove and replace the concrete at no cost to the City.

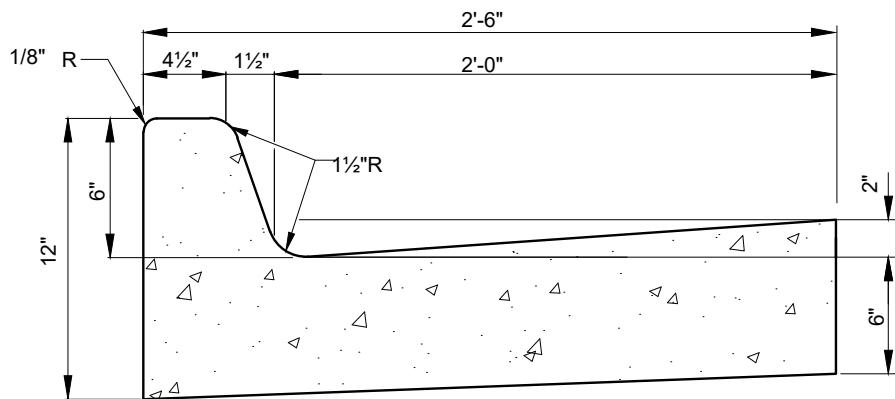
Strength requirements shall be in accordance with ACI 214, Section 4.2. Strength level will be determined acceptable if the averages of all sets of three (3) consecutive strength test results equal or exceed the specified strength (f'_c). No individual test result may fall below the specified strength (f'_c) by more than five-hundred (500) psi.

If either of these requirements are not satisfied, steps shall be taken to increase the average of subsequent strength results. Evaluation of strength test results, and investigation of low strength-test results shall be in accordance with ACI 301 and ACI 318. When twenty-eight (28) day strength test results are below the minimum specified strength, fifty-six (56) day cylinders can be evaluated to verify minimum specified strength. Core specimens must be obtained following ASTM C42.

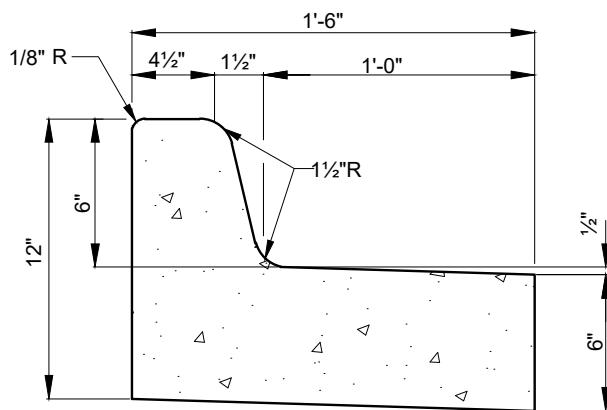
Sidewalks, and vertical surfaces must meet ASTM C-1315 Type II800.26



MOUNTABLE CURB & GUTTER, MG



6" VERTICAL CURB & 2' GUTTER, CG



6" VERTICAL CURB & 1' SPILL PAN, CP

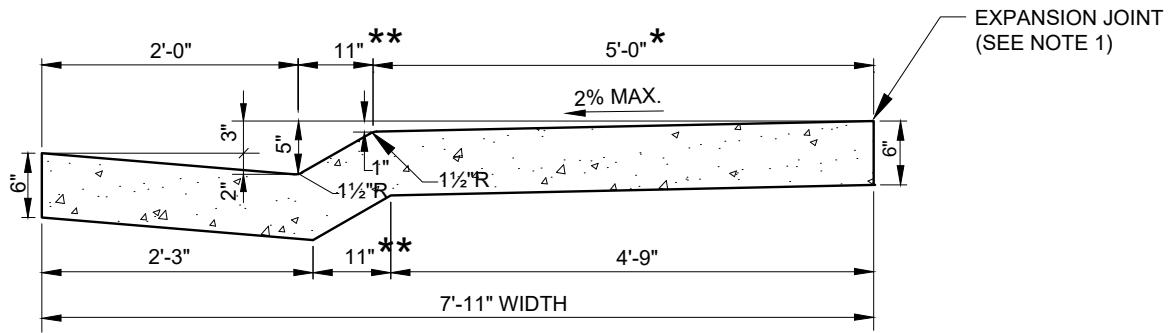
NOTE:

1. ALL CONCRETE TO BE 4500 PSI PER SECTION 822.00 OF CITY STANDARDS.
 2. SUBGRADE TO BE COMPAKTED PER SECTION 331.01.
 3. TRANSITION BETWEEN CURB & GUTTER TYPES SHALL BE DONE OVER A 10 FOOT MINIMUM LENGTH.
 4. GUTTER CROSS SLOPES SHALL BE 1/2" PER FOOT WHEN DRAINING AWAY (SPILL) FROM THE CURB AND 1" PER FOOT WHEN DRAINING TOWARDS (CATCH) THE CURB.
- * MAY BE REDUCED TO 7" IN RETROFIT CONDITIONS , AS APPROVED BY THE PROJECT ENGINEER.

NO	DATE	REVISION	CITY OF ARVADA
			8101 Ralston Road Arvada, Colorado 80002

MOUNTABLE AND VERTICAL
CURB AND GUTTER SECTIONS

2022 ENGINEERING STANDARDS & SPECIFICATIONS



7'-11" MOUNTABLE CURB & SIDEWALK

NOTE:

1. SIDEWALK WIDTH SHALL NOT BE REDUCED FOR INSTALLATION OF EXPANSION JOINT.
- * MAY BE REDUCED TO 4' IN RETROFIT CONDITIONS , AS APPROVED BY THE PROJECT ENGINEER.
- ** MAY BE REDUCED TO 7" IN RETROFIT CONDITIONS , AS APPROVED BY THE PROJECT ENGINEER.

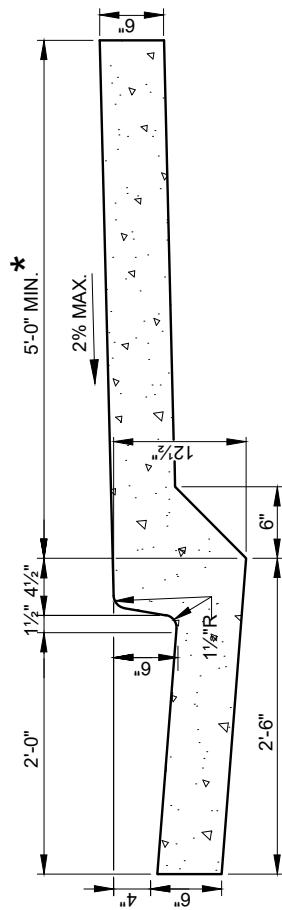
NO	DATE	REVISION



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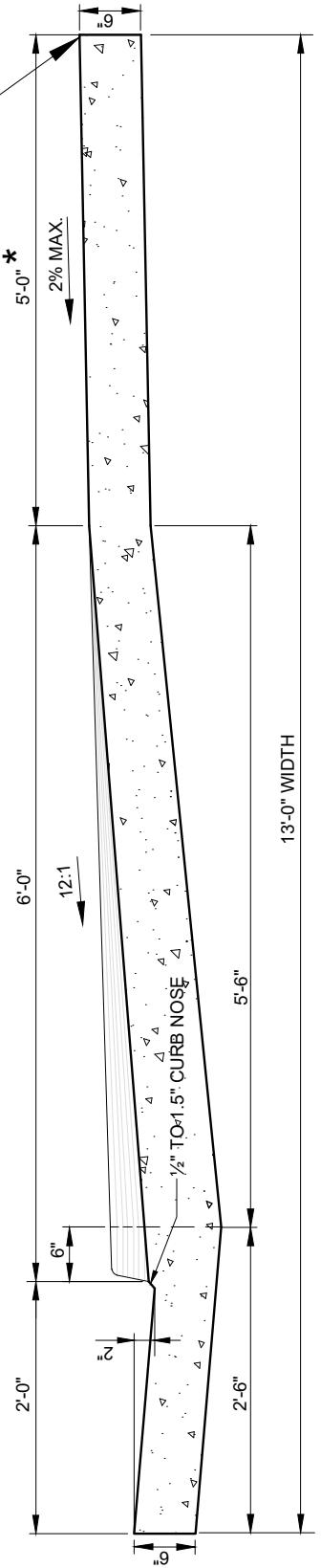
MOUNTABLE CURB, GUTTER
AND SIDEWALK SECTION
AND CURB CUT SECTION RETROFIT

2022 ENGINEERING STANDARDS & SPECIFICATIONS



VERTICAL CURB WITH SIDEWALK

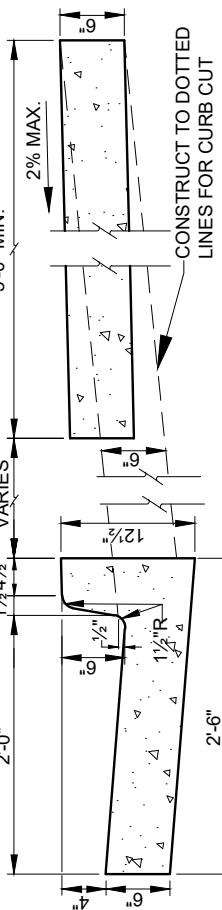
EXPANSION JOINT
(SEE NOTE 1)



CURB CUT IN VERTICAL CURB WITH SIDEWALK

NOTE:

1. SIDEWALK WIDTH SHALL NOT BE REDUCED FOR INSTALLATION OF EXPANSION JOINT.
- * MAY BE REDUCED TO 4' IN RETROFIT CONDITIONS , AS APPROVED BY THE PROJECT ENGINEER



VERTICAL CURB WITH DETACHED WALK

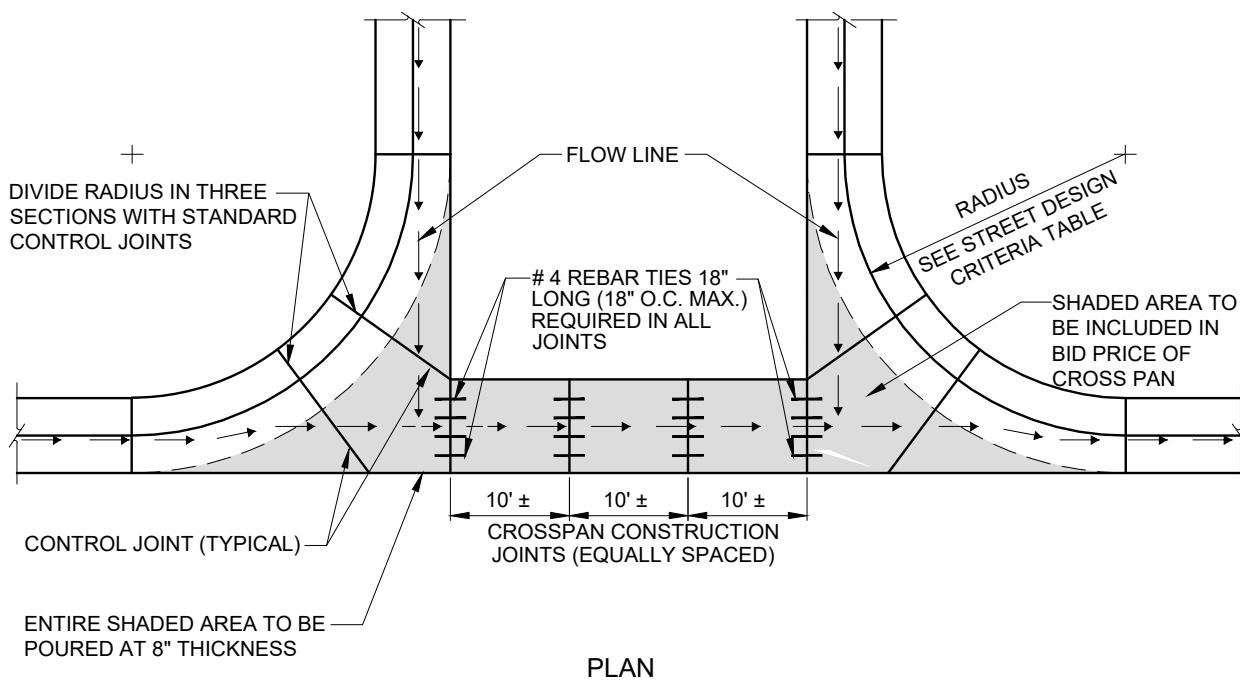
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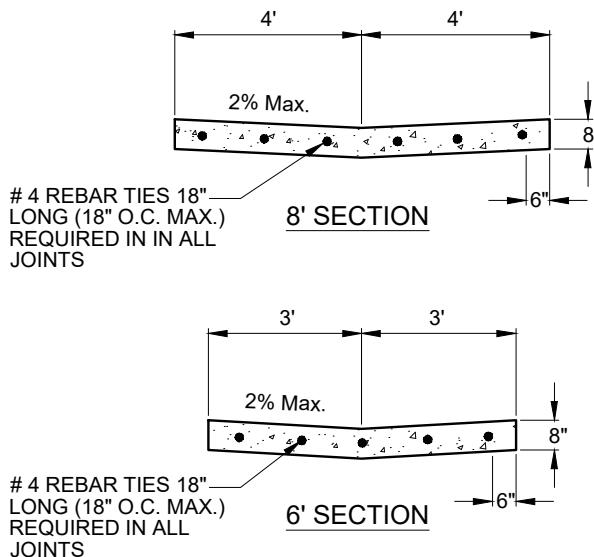
CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

**VERTICAL CURB, GUTTER
AND SIDEWALK SECTIONS
AND CURB CUT SECTIONS**

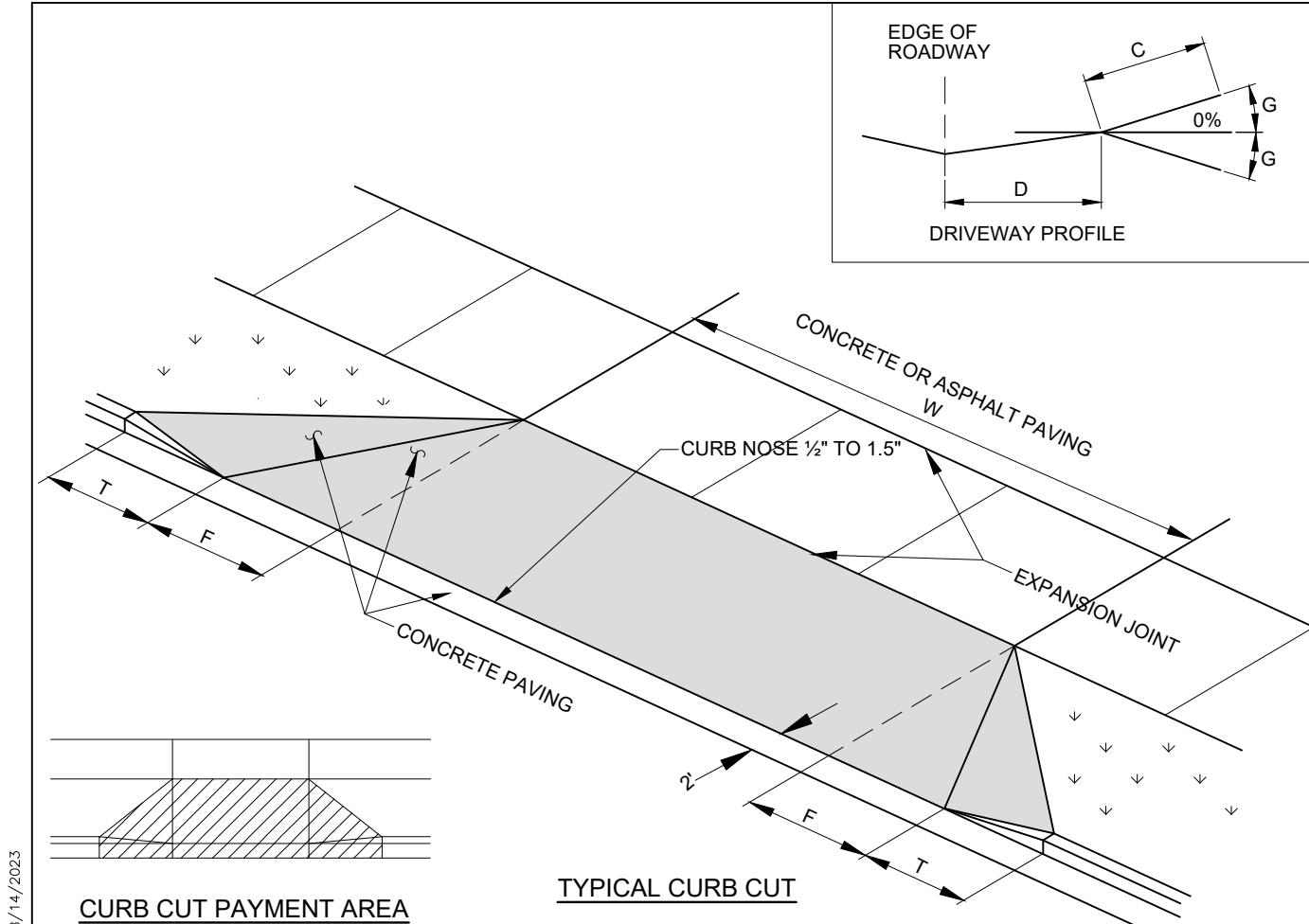
2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTE:

1. REBAR SHALL BE CENTERED FROM TOP AND BOTTOM.
2. 1.5 LBS/CY FIBERMESH REQUIRED IN ALL CONCRETE FOR CROSSPANS.
3. SUBGRADE 6" MIN. OF AGGREGATE BASE COVER TO BE COMPACTED TO section 331.01.
4. REMOVE CROSSPAN FROM EXISTING CONTROL JOINT FOR ALL PIPELINE AND UTILITY CROSSINGS UNDER CROSSPANS.
5. ALL REBAR SHALL BE EPOXY COATED, SECURED IN PLACE WITH 2 PART EPOXY PER MANUFACTURERS INSTALLATION INSTRUCTIONS.



NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CROSSSPAN
1	2023	2023 REVISIONS		
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

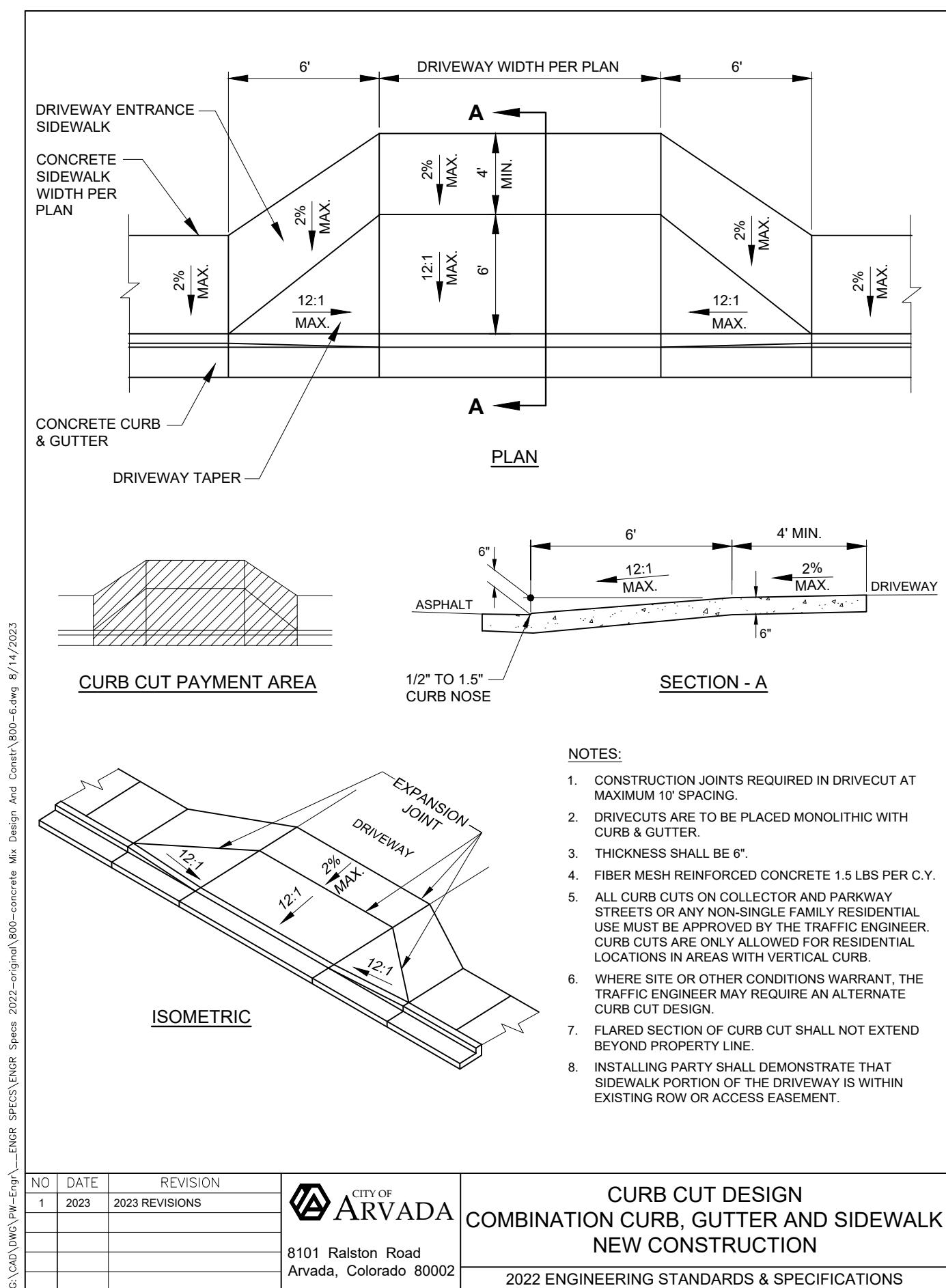


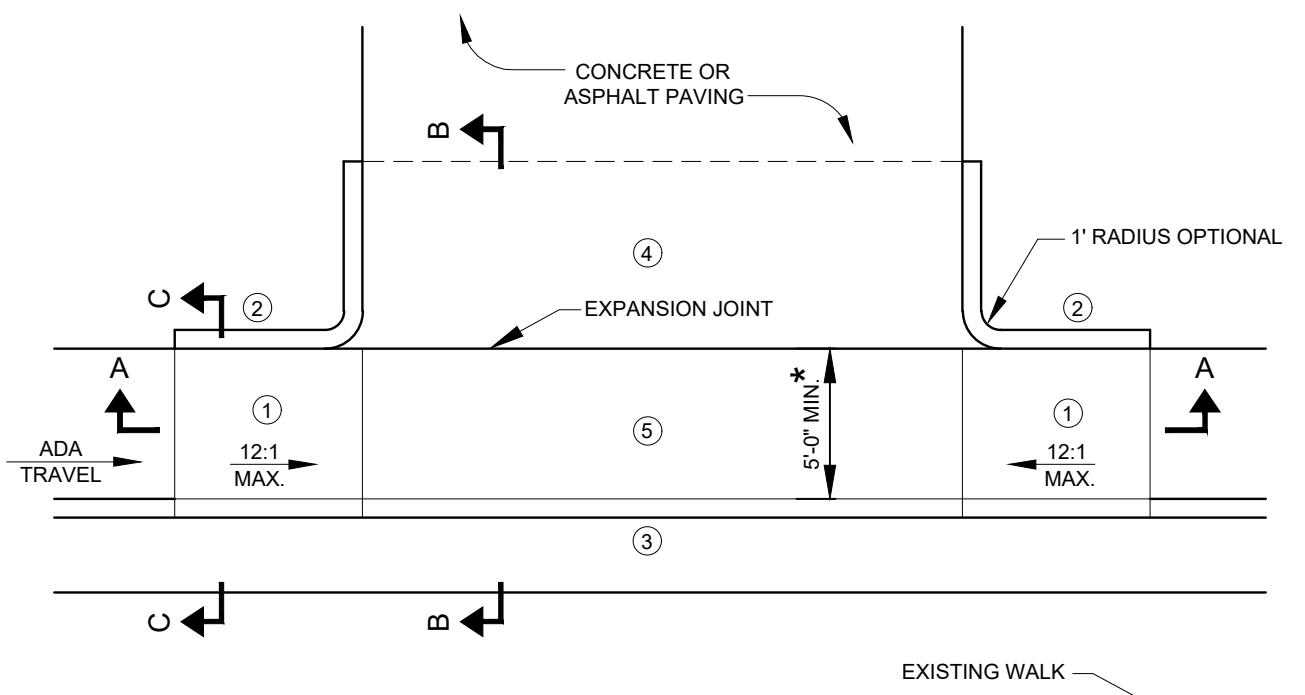
STREET TYPE	WIDTH OF THROAT W		D	FLARE F	TRANSITION T	MAXIMUM DRIVEWAY GRADE CHANGE G		
	SINGLE FAMILY	OTHER USES				DESIRABLE	ABSOLUTE	CONTROL DISTANCE C
MINOR OR LOCAL	8'-30'	20'-30'	4'-6"	0'	5'	$\pm 6\%$	VEHICLE CLEARANCE	10'
COLLECTOR	12'-30'	20'-30'	7'	0'	6'	$\pm 3\%$	$\pm 6\%$	10'
PARKWAY	12'-30'	20'-30'	10'	4'	6'	0%	$\pm 3\%$	40'

NOTES:

- CONSTRUCTION JOINTS ARE REQUIRED AT EACH SIDE OF WARPED SECTION AND EVERY 10' ALONG THE DRIVE SECTION, AND SHALL ALIGN WITH SIDEWALK CONSTRUCTION JOINTS. SEE DETAIL 800-9 FOR CONSTRUCTION JOINT DETAILS.
- THICKNESS SHALL BE 6".
- FIBER MESH REINFORCED CONCRETE 1.5 LBS PER C.Y.
- ALL CURB CUTS ON COLLECTOR AND PARKWAY STREETS OR ANY NON-SINGLE FAMILY RESIDENTIAL USE MUST BE APPROVED BY THE TRAFFIC ENGINEER.
- WHERE SITE OR OTHER CONDITIONS WARRANT, THE TRAFFIC ENGINEER MAY REQUIRE AN ALTERNATE CURB CUT DESIGN.
- FLARED SECTION OF CURB CUT SHALL NOT EXTEND BEYOND PROPERTY LINE.

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CURB CUT DESIGN DETACHED SIDEWALK	
1	2023	2023 REVISIONS		2022 ENGINEERING STANDARDS & SPECIFICATIONS	

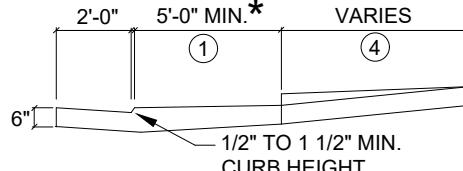




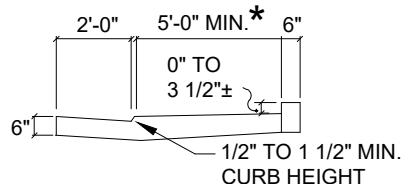
- ① ELEVATION TRANSITION RAMP, 4' MIN. WIDTH BETWEEN CURBS, 2% MAX. X-SLOPE, 1:12 MAX. SLOPE, NO COLOR CONTRAST.
- ② HEADER CURB FOR ELEVATION BREAK INSIDE OR OUTSIDE DRIVE
- ③ 1/2" TO 1 1/2" CURB HEIGHTS
- ④ ELEVATION ADJUSTMENT AREA, LENGTH TO BE DETERMINED BY DRAG CONSIDERATION, OWNERS DISCRETION, OR 10% MAX. IN DIRECTION OF VEHICULAR TRAVEL
- ⑤ 2% MAX. X-SLOPE IN DIRECTION OF ADA TRAVEL

NOTE:

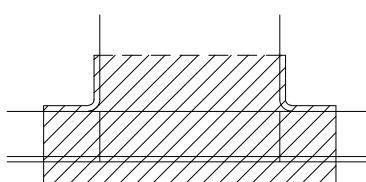
1. 6" MINIMUM CONCRETE THICKNESS.
 2. FIBER MESH REINFORCED CONCRETE 1.5 LBS PER C.Y.
 3. CURB CUTS ARE ONLY ALLOWED FOR RESIDENTIAL LOCATIONS IN AREAS WITH VERTICAL CURB.
- * MAY BE REDUCED TO 4' IN RETROFIT CONDITIONS, AS APPROVED BY THE PROJECT ENGINEER



SECTION B-B
DRIVEWAY



SECTION C-C
TRANSITION RAMP



CURB CUT PAYMENT AREA

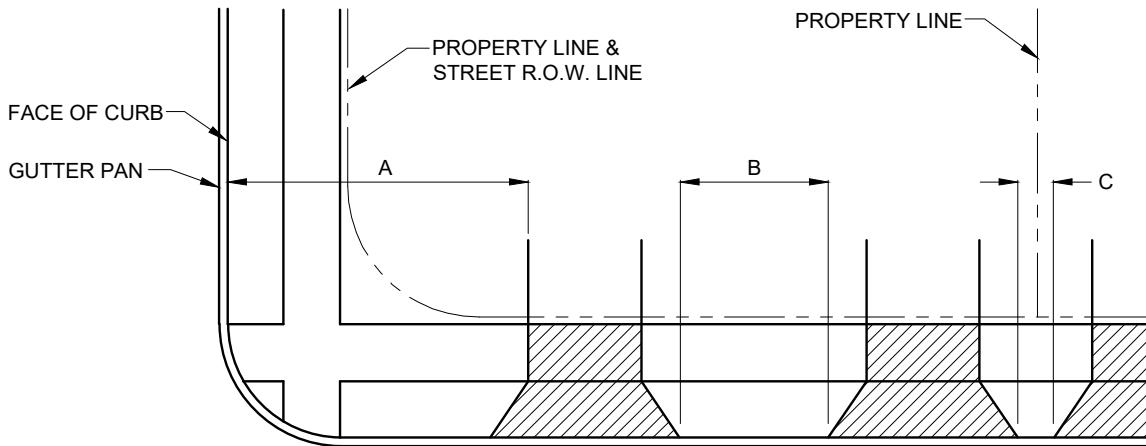
NO	DATE	REVISION
1	2023	2023 REVISIONS



8101 Ralston Road
Arvada, Colorado 80002

OPTIONAL CURB CUT FOR DRIVEWAY

2022 ENGINEERING STANDARDS & SPECIFICATIONS

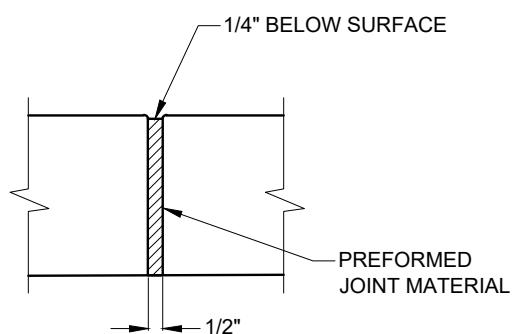
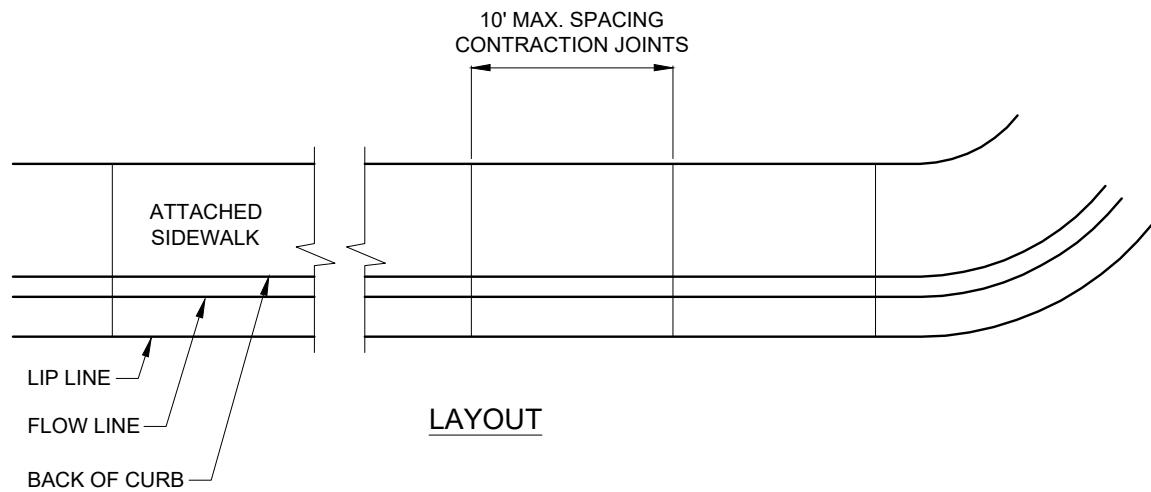


ENTRANCE TYPE	DIMENSIONS		
	A	B	C
RESIDENTIAL	35' MINIMUM	20' MINIMUM	5' MINIMUM (SEE NOTE 2)
COMMERCIAL/ INDUSTRIAL	50' MINIMUM	30' MINIMUM	5' MINIMUM (SEE NOTE 2)

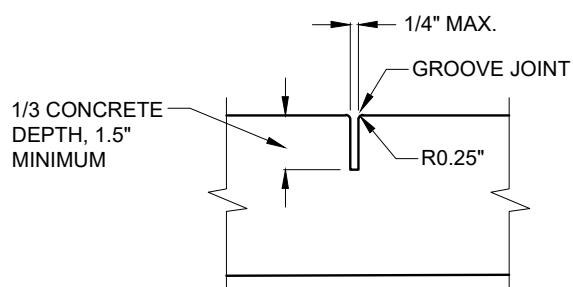
NOTE:

1. LAYOUT APPLIES TO LOTS FRONTING RESIDENTIAL LOCAL ACCESS STREETS ONLY. NECESSARY DRIVE CUTS ON OTHER STREET TYPES SHALL BE BASED ON INDIVIDUAL ANALYSIS OF TRAFFIC CONDITIONS AS APPROVED BY THE CITY TRAFFIC ENGINEER.
2. DRIVEWAYS MAY BE COMBINED AT LOT LINES BY MUTUAL AGREEMENT OF ADJACENT LOT OWNERS.
3. COMMERCIAL / INDUSTRIAL DIMENSIONS SHALL BE BASED ON INDIVIDUAL ANALYSIS OF TRAFFIC CONDITIONS AS APPROVED BY THE CITY TRAFFIC ENGINEER.

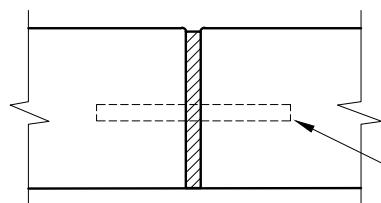
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	DRIVE CUT LOCATION & SPACING
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



EXPANSION JOINT



CONTRACTION JOINT



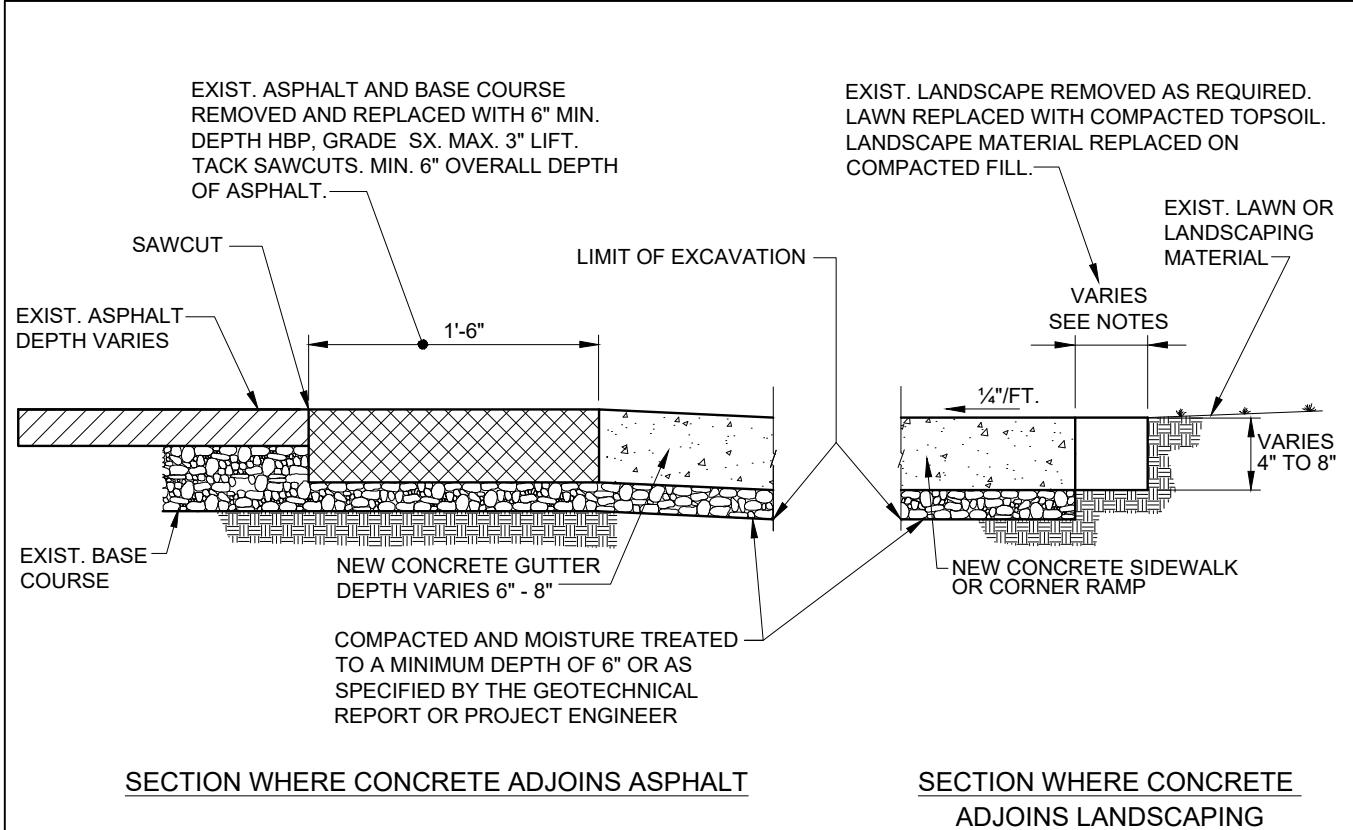
DOWELED JOINT

DRILL & INSERT REBAR
CENTERED ON JOINT INTO
EXISTING CONCRETE
6" CONCRETE = # 3 x 18"
> 6" CONCRETE = # 4 x 18"

NOTE:

1. EXPANSION JOINT MATERIAL SHALL BE NON-EXTRUDING AND RESILIENT TYPE TO MEET AASHTO SPEC. M-213.
2. WHEN DETACHED SIDEWALKS ARE INSTALLED JOINT SPACING SHALL MATCH SIDEWALK WIDTH (5'MIN.).

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	JOINT DETAILS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



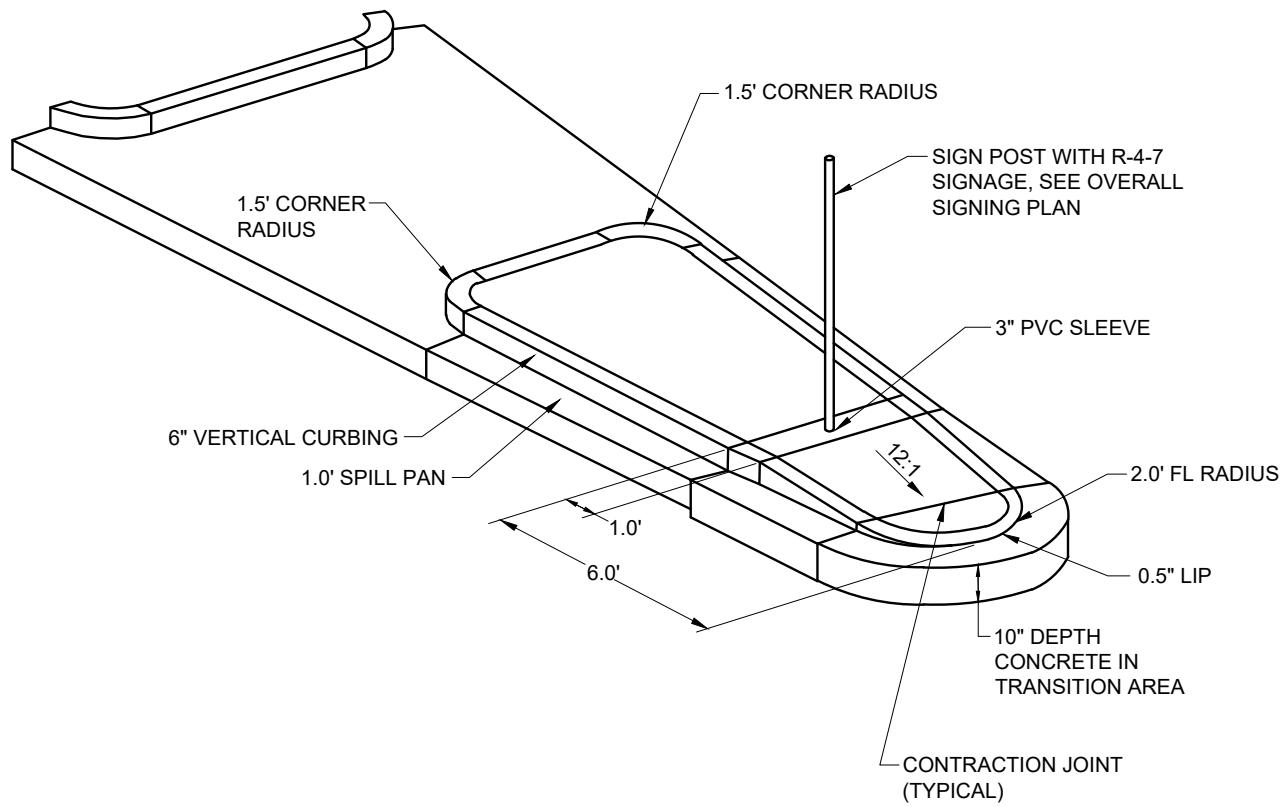
NOTES:

- PAY ITEM(S) FOR CONCRETE REPLACEMENT SHALL INCLUDE REMOVAL OF EXISTING CONCRETE AND ALL WORK SHOWN AS NOTED ON STANDARD DETAIL.
- REPLACEMENT SHALL MEET STREET GRADE, STREET CROSS SLOPE AND DRIVEWAY GRADE. REPLACEMENT SECTION AND ADJOINING 10' SECTIONS SHALL DRAIN. CONTRACTOR SHALL CHECK FORMS FOR STREET MATCH AND DRAINAGE PRIOR TO CONCRETE PLACEMENT. CITY SHALL BE NOTIFIED OF DISCREPANCIES PRIOR TO CONCRETE PLACEMENT.
- MINIMUM 5 FT. LENGTH FROM EXISTING CONTROL JOINT SHALL BE REMOVED FOR ALL PIPELINE AND UTILITY CROSSINGS UNDER CONCRETE.
- PATCHING ADJACENT TO NEW CONCRETE SHALL NOT TAKE PLACE UNTIL THE CONCRETE ATTAINS A MINIMUM OF 3000 PSI.

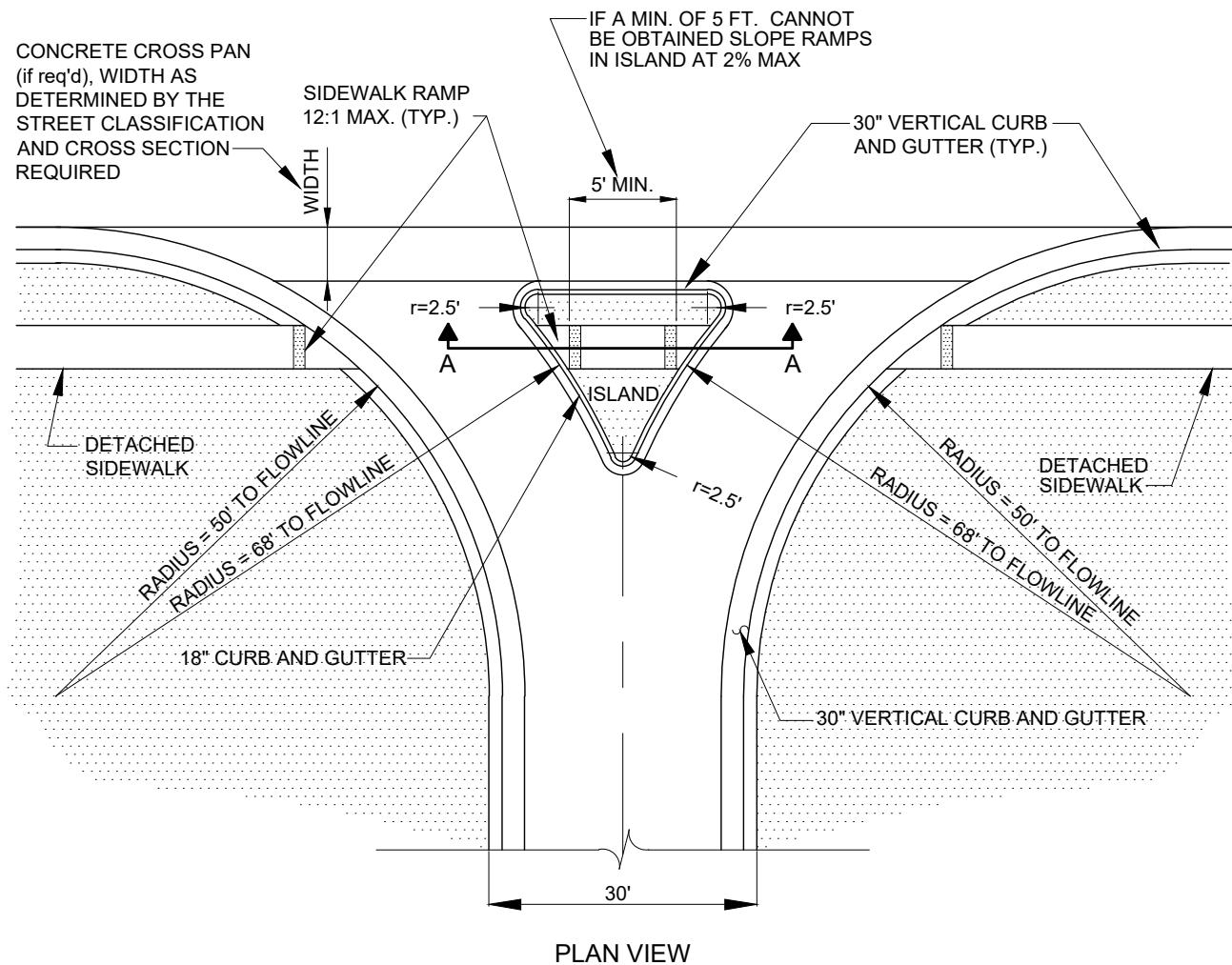
LANDSCAPE NOTES:

- LAWN STRIPS REMOVED FOR FORMS SHALL BE REPLACED WITH SOD WHEN THE STRIP IS WIDER THAN 6".
- SPRINKLER SYSTEMS AND LANDSCAPING SHALL BE SHIFTED OR REMOVED AND REPLACED AS NECESSARY FOR FORMS AND CONCRETE REPLACEMENT.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	CONCRETE REPLACEMENT DETAILS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	SPLITTER ISLAND BULLNOSE
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



PLAN VIEW

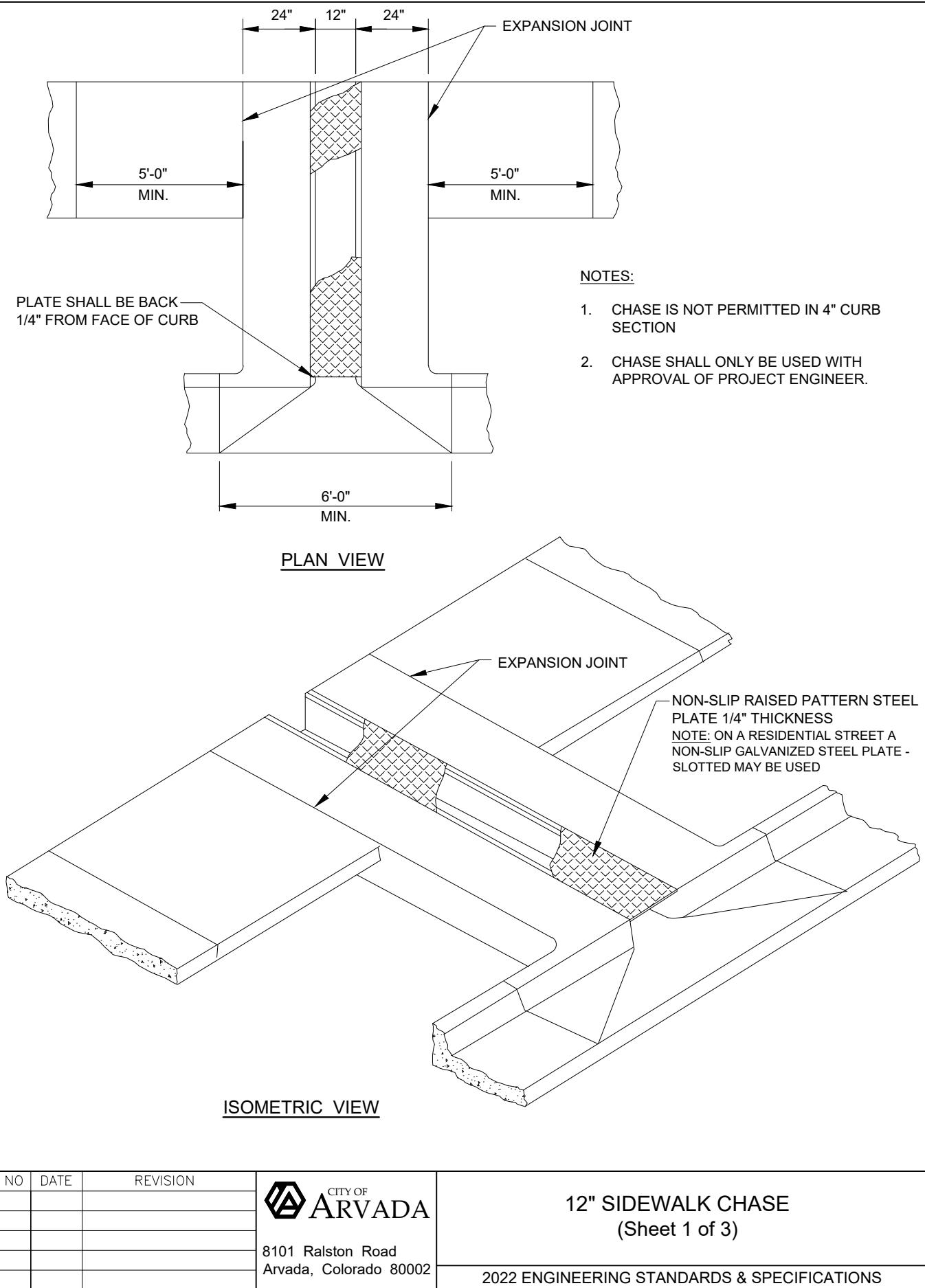


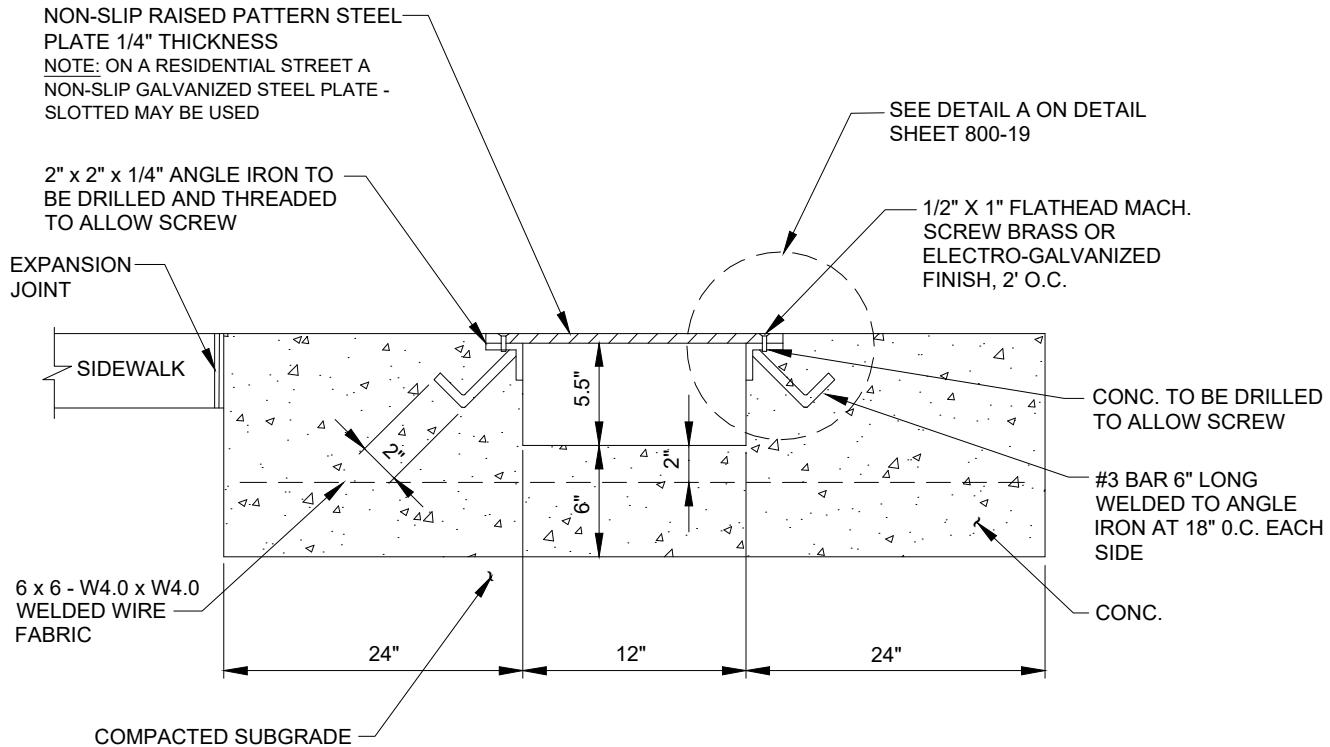
SECTION A-A

NOTES:

1. WHERE ISLAND IS ADJACENT TO THROUGH TRAFFIC LANES, THE ISLAND SHALL BE OFFSET 2' FROM THE FLOWLINE EXTENDED.
2. ISLAND SURFACING SHALL BE COLORED AND STAMPED CONCRETE, BAUMANITE, EXPOSED AGGREGATE, OR LANDSCAPING OF A TYPE COMPATIBLE WITH ADJACENT LANDSCAPING. ASPHALT SHALL NOT BE USED AS THE ISLAND SURFACING.
3. ALL RAMPS SHALL BE CONSTRUCTED AS PER SPECIFICATIONS OF THE CITY OF ARVADA.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	RIGHT TURN IN / OUT TRAFFIC ISLAND (Major Entrance)
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



SIDEWALK CHASE DETAIL

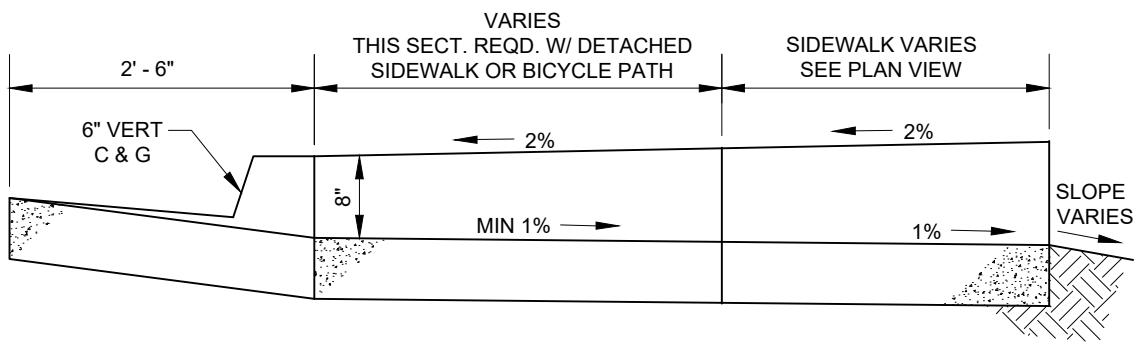
NO	DATE	REVISION



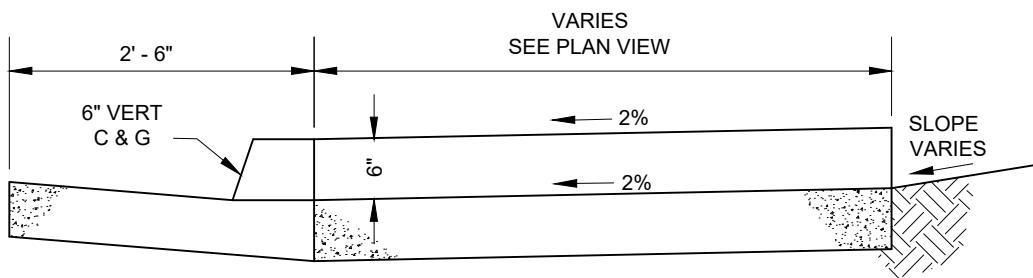
8101 Ralston Road
Arvada, Colorado 80002

12" SIDEWALK CHASE (Sheet 2 of 3)

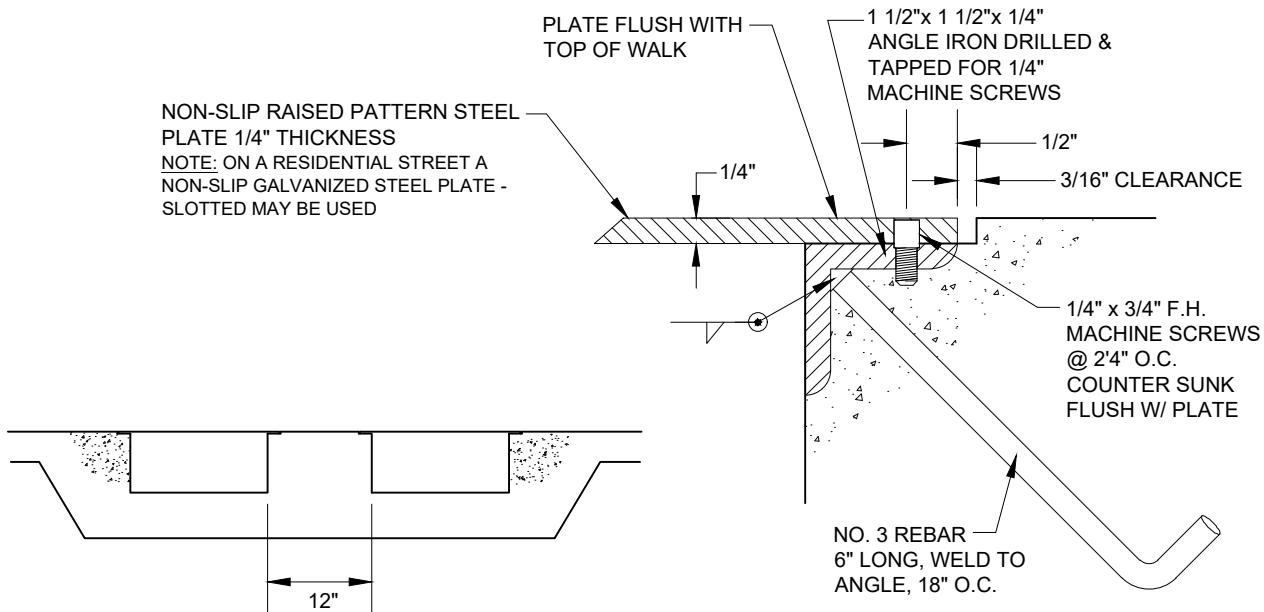
2022 ENGINEERING STANDARDS & SPECIFICATIONS



FLOW FROM GUTTER



FLOW TO GUTTER



MULTIPLE CHASE
WHEN OPENINGS LARGER THAN
12" ARE REQUIRED

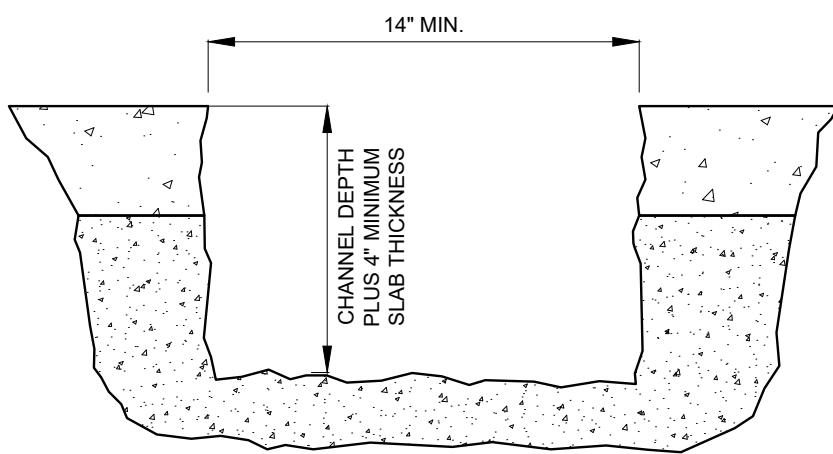
DETAIL A

NO	DATE	REVISION

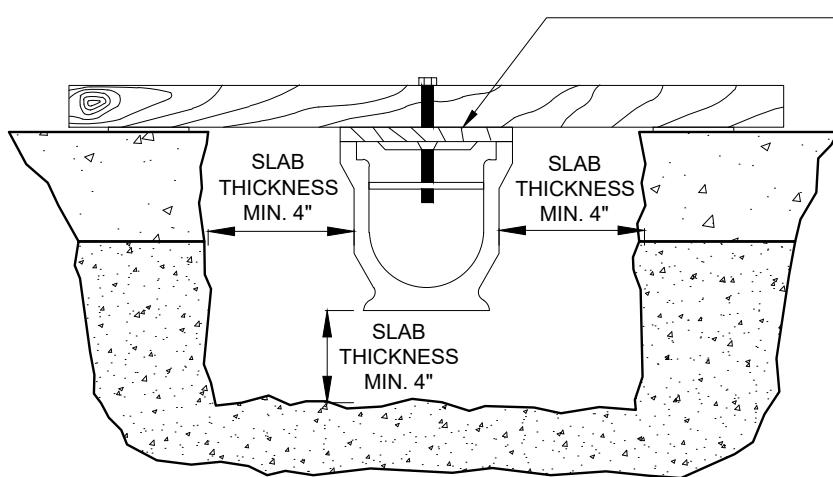


CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

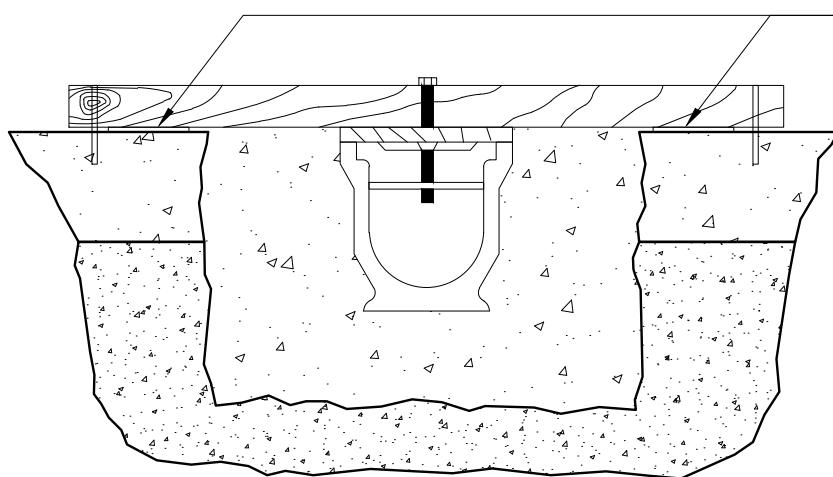
12" SIDEWALK CHASE
(Sheet 3 of 3)



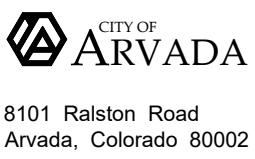
NOTE:
USE OF 1/2" SHIMS AT THE
CHANNEL, AS ILLUSTRATED,
WILL HELP TO PREVENT
WATER PONDING ADJACENT
TO THE DRAIN CHANNELS.



NOTE:
USE OF 1/4" SHIMS AT THE
FLOOR, AS ILLUSTRATED,
FACILITATES CONCRETE
FINISHING.

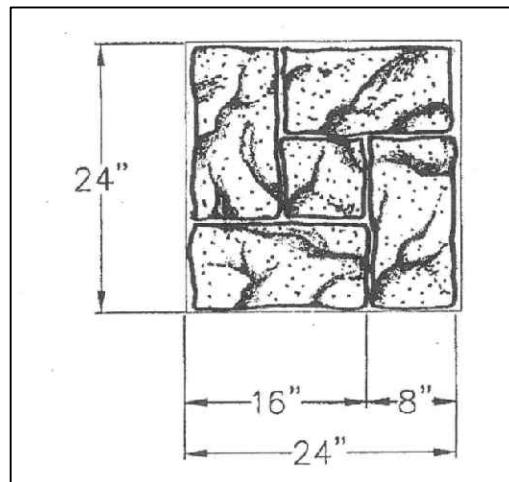


NO	DATE	REVISION



SIDEWALK CHASE - RETROFIT INSTALLATION IN RESIDENTIAL AREAS

2022 ENGINEERING STANDARDS & SPECIFICATIONS



NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	MEDIAN COLORED CONCRETE
1	2023	2023 REVISIONS		2022 ENGINEERING STANDARDS & SPECIFICATIONS

SECTION 900 –ASPHALT MIX DESIGN AND CONSTRUCTION

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920.00 Asphalt Pavement Design	900-2
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930.00 Asphalt Pavement Construction	900-4
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937.00 Grinding	900-13
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SECTION 900 –ASPHALT MIX DESIGN AND CONSTRUCTION

901.00 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

910.00 Scope

The intent of this section is to specify materials and methods to be used for the construction, overlaying, sealcoating and other surface treatments along with pavement rejuvenating of streets, parking lots, and other miscellaneous work requiring the use of asphalt pavement. This section shall cover work associated with aggregate base course, bituminous base and pavements of the plant mix type, bituminous prime coat, bituminous tack coat, rejuvenating applications and asphalt overlays. All workmanship and materials shall comply with these Standards and Specifications and shall conform to the lines, grades, depths, quantities and the typical pavement cross section(s) shown on the approved plans or as directed by the Project Engineer.

920.00 Asphalt Pavement Design

921.00 Asphalt Mix Design Properties

All asphalt pavement material (APM) shall be plant-mixed asphalt unless otherwise approved in writing by the Project Engineer. Materials and construction shall comply the Metropolitan Government Pavement Engineers Council (MGPEC) Pavement Design Standards (latest edition) with the following modifications:

1. Grading ST(3/8) is not allowed.
2. The gradation of the mineral aggregate shall be grading SG (1 inch nominal), S (3/4 inch nominal) or SX (1/2 inch nominal). A combination of SG and S, or S and SX (in varying lifts) may be used for new street construction. In no case shall grading SG be used for a permanent final lift of asphalt; however, the Project Engineer may require the use of grading SG in a pavement section. Grading SX (1/2 Inch Nominal) shall be used for the permanent final lift or overlay of all asphalt, unless approved by the Project Engineer.
3. All asphalt pavement mix designs shall be based off of City and County of Denver Standard Drawing 12.7 -Typical Asphalt Mix Details by Traffic Use or Lift Position.

Asphalt mixes shall be from the City and County of Denver Approved Hot Mix Asphalt Designs List and shall be submitted to the Project Engineer for approval fourteen (14) days prior to placement.

922.00 Asphalt Sampling and Testing

Materials testing shall be performed by a qualified geotechnical engineer working under the direction of a Colorado Registered Professional Engineer and shall be paid for by the developer on private projects. Testing will be performed and/or paid for by the City on City projects unless otherwise noted in the Special Conditions for the project.

At any time during construction and/or the warranty period, the Project Engineer may require a Colorado Registered Professional Engineer to certify the quality of materials or construction procedures, at the Contractor's expense. All commercial testing and laboratory work necessary to establish the job mix formula and to ensure conformance of materials and workmanship shall be by recognized methods and as specified in these Standards and Specifications. An electronic copy of all test reports shall be submitted to the Project Engineer.

HOT MIX ASPHALT (HMA)	AASHTO	ASTM	Minimum Test Frequency
Sampling	T168	D979 / D3665	One Test Per Every 1,000 Tons Or Fraction Thereof (Not Less Than One Test Per Day)
In Place Density	T310-01	D1188 / D2950	Nuclear One Test Every 200 Lineal Lane Feet Per Lift Of In Place Hot Bituminous Paving Mixtures. Minimum 4 Tests Per Intersection.
Longitudinal Joint Density	T166-93	D1188	One Test Per 1,000 Lineal Feet (Or Fraction Thereof) Per Lift
Maximum Specific Gravity of HMA	T209	D2041	One Test Per Every 1,000 Tons Or Fraction Thereof (Not Less Than One Test Per Day)
Asphalt Content	T164 / T269 / Tp53	D2172 / D3202 / Ps90	One Test Per Every 1,000 Tons Or Fraction Thereof (Not Less Than One Test Per Day)
Air Voids and VMA	T269	D3203	One Test Per Every 1,000 Tons Or Fraction Thereof (Not Less Than One Test Per Day)

Thickness (Coring)	T166	D2726 / D3549	One Test Per Every 500 Lineal Lane Feet Per Layer Of In Place Hot Bituminous Paving Mixtures
Aggregate Gradation	T27	C136	One Test Per Every 1,000 Tons Or Fraction Thereof (Not Less Than One Test Per Day)-

930.00 Asphalt Pavement Construction

931.00 Roadway Inspections

Refer to Section 188.00 - Inspections of these Standards and Specifications.

Adequate roadway inspections assure compliance to Arvada requirements and are the basis for Arvada's recommendation that roadway improvements be accepted for maintenance and/or release of the performance guarantee. It is the responsibility of the Contractor to schedule inspections online in advance of the required inspections. Required roadway inspections shall include:

- A. Utilities and Culverts – All utility pipes, conduits and culverts have been installed in accordance with the approved plans and these Standards and Specifications.
- B. Curb and Gutter, Sidewalks and Crossspans – Verify that all concrete improvements have been installed in accordance with the approved plans and these Standards and Specifications.
- C. Structures – Verify that all structures have been installed in accordance with the approved plans and these Standards and Specifications.
- D. Subgrade/Base Course – Verify that the surface proposed to be built upon meets all requirements including, but not limited to, depth of treatment, type of treatment, moisture content, compaction and an approved proof-roll.
- E. Paving and Testing – Verify that mix design and submittals are approved. Verify that minimum air and asphalt temperatures adhere to these Standards and Specifications. Asphalt shall have a "weather-proof" tarp. The beds of trucks hauling asphalt shall be clean, and the asphalt shall be free of debris. Verify that thickness of asphalt pavement, rolling equipment and patterns, and grade of utility castings comply with the approved plans and these Standards and Specifications. If during paving operations specified surface tolerances are not maintained paving operations shall be suspended until satisfactory corrections, repairs, or equipment replacements are made.

- F. Construction Acceptance into Warranty – Refer to Section 200 - Acceptance Procedures of these Standards and Specifications. General items include:
1. Pavement Deflection Testing in accordance with Section 936.00 - Pavement Acceptance Testing of these Standards and Specifications.
 2. Remove and replace areas of failing asphalt. Subgrade failures shall be corrected before patching areas, in accordance with these Standards and Specifications, may be required by the Project Engineer.
 3. Major areas of ponding on a new pavement should be milled and repaved or the area fixed with infrared patching.
- G. Final Acceptance/Release from Warranty – Refer to Section - 231.00 Final Acceptance and Release from Warranty Inspection of these Standards and Specifications. General items include:
1. Pavement deflection testing and/or core sampling of all areas of failing asphalt.
 2. Crack seal all cracks including edge cracks.
 3. Remove and replace areas of failing asphalt. Subgrade failures shall be corrected before placing asphalt.
 4. The final asphalt overlay or seal coat shall be determined by the Project Engineer based on the visual and structural quality of the roadway at the end of the warranty period. All areas requiring any final surface treatment including, but not limited to; slurry seal, chip seal, cape seal and/or micro-chip seal, a final top lift or an overlay of asphalt shall be cleaned and prepared, including, but not limited to:
 - a. All lips of gutters, inlets, and crossspans shall have concrete exposed to a depth equal to the thickness of the final top lift or overlay of asphalt.
 - b. All joints shall be straight (vertical) and shall have a minimum elevation difference equal to the specified lift thickness. This is to ensure that an asphalt mat of consistent thickness is installed from edge of gutter to edge of gutter.
 - c. All weeds shall be cut, and debris, mud, and waste materials removed.
 - d. Before paving, tack coat shall be applied to the area(s) that are to receive a final top lift or overlay of asphalt, including exposed concrete faces and utility castings.

932.00 Hauling and Delivery

Each truck shall use covers to protect the mix during transport. A load of mix that is delivered with improper gradation, thermal segregation or temperature below the specified minimum delivered temperature shall be rejected. Delivered mix temperature shall be measured behind the paver screed.

Asphalt pavement materials shall be discharged from production facilities at temperatures presented in Table 20.4B-1 in MGPEC Item 20 (latest edition). The minimum delivered mix temperature, measured behind the paver screed, shall be 235°F for PG 58-28 and PG 64-22 binders and 280°F for PG 76-28. Initial compaction shall begin immediately after placement and be continuous until the desired relative compaction is achieved. Once the surface temperature of the layer being compacted drops to or below 185°F, further compaction effort shall not be applied unless approved by tester or City Inspector. If the mixture contains modified asphalt cement (PG 76-28) and the surface temperature falls below 230°F, further compaction effort shall not be applied unless approved by tester or City Inspector.

933.00 Weather Limitations

Hot mix asphalt shall be placed only on properly constructed subgrade and interim lifts that are free from water, snow, ice, and frozen subgrade. The asphalt shall be placed only when weather conditions permit the pavement to be properly placed and finished as determined by the City Inspector. The Hot mix asphalt shall be placed only when both the air and surface temperatures equal or exceed the temperatures specified in Table below:

Compacted Layer Thickness (Inches)	Minimum Air and Surface Temp. (Degrees F and rising)	
	Top Layer	Layers Below Top Lift
2 to < 3	50	40
3 or more	45	35

Air temperature shall be taken in the shade. Surface is defined as the existing base on which the new pavement is to be placed.

The Project Engineer may waive minimum temperature requirements for placing prime coats and layers of asphalt below the top layer of the pavement section.

934.00 Construction of Pavement

The minimum allowable compacted lift thickness shall be two (2) inches. The generally accepted standard for compacted lift thickness is three times (3X) the nominal maximum particle size (NMPS). In no case shall the compacted asphalt layer thickness be greater than four times (4X) the nominal maximum particle size (NMPS).

Gradation	Minimum lift thickness	Maximum thickness
SG	3"	4"
S	2 1/2"	3"
SX	2"	3"

Maintenance holes, valve boxes and survey range boxes shall be adjusted to within one-quarter inch ($\frac{1}{4}$ ") below finish grade before the final surface course of asphalt is placed. The Contractor shall remove all foreign matter found or introduced into them in the performance of this work, and it shall be his responsibility to ensure proper compaction around them after they have been adjusted. maintenance holes, valve boxes and range boxes should be set to final grade just prior to the final lift of asphalt being placed on newly constructed or newly re-constructed streets.

maintenance holes, valve boxes and range boxes that are not raised prior to placement of the final surface course of HBP (either due to oversight or at Contractor's option) shall be raised and/or adjusted in accordance with the following:

If maintenance holes are not set to grade prior to the final lift of HBP being placed, the Contractor shall vertically and uniformly cut the existing asphalt mat full depth three (3) feet square around the center of the manhole with sides parallel and perpendicular to street centerline. maintenance holes shall be raised to proper grade using concrete riser rings. If more than twelve inches (12") of concrete riser rings are required to raise the manhole lid to final grade, then a new manhole barrel section must be installed to allow the lid to be set to grade with less than twelve (12") of concrete riser rings. If range boxes and valve boxes are not set to grade prior to the final lift of asphalt being placed, the asphalt mat shall be core drilled full depth twelve (12") diameter centered on the valve box or range box. Auger drilling shall not be allowed. Range boxes shall then be set on compacted subgrade at the proper elevation to match final grade. Adjustable range boxes shall be screw adjusted to within one-quarter inch ($\frac{1}{4}$ ") below existing grade. Valve boxes shall also be screw adjusted to within one-quarter inch ($\frac{1}{4}$ ") below final grade. Drop in type valve box risers shall not be allowed on newly constructed or newly re-constructed streets. New hot mix asphalt (Grading SX, $\frac{1}{2}$ " mix) shall be placed and properly compacted in the excavated area. The entire area in the vicinity of the raised manhole, valve box or range box

shall then be infrared repaired to blend the patch with the existing asphalt and to eliminate any vertical joints in the final lift of asphalt.

On streets that are being sealed, the Contractor shall cover the maintenance holes, valve boxes and survey range boxes with roofing paper or other suitable material prior to sealing.

The covering shall be left in place for a minimum of forty-eight (48) hours after which it shall be removed and disposed of. All covers shall be clean when work is complete.

On streets that are being overlaid with asphaltic concrete the Contractor shall adjust the valve and range boxes by screwing the adjustable rings upward to finish grade, prior to final rolling.

In the case of manhole rings, the Contractor shall vertically and uniformly cut the existing asphalt mat eight (8) inches from the ring and remove the mat and base to a depth of six (6) inches below finish grade. Rings shall then be removed and the existing riser rings adjusted and pointed to provide the required subgrade for resetting the set rings, free of pressure points. Once the ring is reset to finish grade the collar eight (8) inch x six (6) inch void between the mat and the ring) shall be filled with asphaltic concrete and compacted in accordance with these Standards and Specifications.

934.01 Base Course Composite

All work shall be observed and tested by the project Geotechnical engineer or representative and certified by a Colorado Registered Professional Engineer. The standard procedures for base course composite construction include the following:

- A. The subgrade shall be prepared and conditioned to comply with the approved pavement design using all specifications. After passing compaction tests, the subgrade shall be proof-rolled in accordance with Section 370.03 - Proof-Roll Observation and Testing of these Standards and Specifications.
- B. All failing areas shall be delineated by both the City Inspector and/or the project Geotechnical engineer and shall be reworked and retested until passing.
- C. Base course (Aggregate Base/Recycled Concrete) shall be placed, prepared, and conditioned to meet approved pavement design using these Standards and Specifications.
- D. After passing all compaction tests, the base course shall be proof-rolled.
- E. All failing areas shall be delineated by both the City Inspector and/or project Geotechnical engineer and shall be reworked and retested until passing.

- F. In the event the subgrade, base course or any step of this process is subject to rain, snow or other factors after the proof-roll has been performed, the City Inspector and/or Geotechnical engineer shall evaluate the areas proposed to be paved and shall make a recommendation to the Project Engineer. Paving shall not commence unless approved by the Project Engineer.

934.02 Lime Stabilized Composite

Lime stabilization shall comply with Section 370.02 - Lime-Treated Subgrade of these Standards and Specifications.

934.03 Full Depth Asphalt

Subgrade preparation for full depth asphalt sections approved by the City Inspector will comply with Section 361.00 - Embankment Construction of these Standards and Specifications.

934.04 Asphalt Placement and Compaction

Asphalt placement and compaction shall comply with MGPEC Item 20 (latest edition).

The mixtures shall be laid upon an approved surface, spread and struck off to obtain the required grade and elevation after compaction. Along the lip lines of gutters and crosspans sufficient bituminous material shall be deposited so that, after compacting, the wearing surface will remain not less than one-eighth inch ($\frac{1}{8}$ ") nor more than one-quarter inch ($\frac{1}{4}$ ") above the concrete. The median curb wearing surface will be from one-quarter inch ($\frac{1}{4}$ ") to one-half inch ($\frac{1}{2}$) below concrete.

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 the required compacted thickness plus twenty-five (25) percent. Carefully move or minimally work the HMA mix with the use of rakes, lutes, or shovels to avoid segregation. Mixtures made with modified asphalt cement require more rapid completion of handwork areas than for unmodified mixtures. Hauling and placement sequences shall be coordinated so that the paver is in constant motion. Excessive starting and stopping shall not be allowed. A construction joint shall be placed at any time the paver stops, and the screed drops enough to cause a surface dip in violation of Section 11.13.1, Surface Tolerances; or the mat temperature falls below the breakdown temperature allowed in Section 11.12, Compaction. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable. Echelon paving will be permitted.

Asphalt density tests shall be taken by a Certified Materials Testing Agency per Section 311.02 Minimum Testing Requirements of these Standards and Specifications. Densities shall be between ninety-two (92) percent and ninety-six (96) percent of the Rice unit weight (theoretical maximum density) as determined by an independent asphalt testing laboratory. Other methods of determining unit weight are subject to approval by the Project Engineer.

The joints in any pavement layer shall not fall in a wheel track or path. The joints in the top layer of new pavement not built on top of an existing pavement shall be located on lane lines, or as shown on the plans. The longitudinal joints shall be compacted to a target density of ninety-two (92) percent of the theoretical maximum specific gravity. The tolerance shall be \pm four (4) percent. The theoretical maximum specific gravity used to determine the joint density will be the average of the daily theoretical maximum specific gravities of the material that was placed on either side of the joint. Density (percent relative compaction) will be determined in accordance with CP 44. Longitudinal joint density tests shall be taken by a Certified Materials Testing Agency as specified in Section 322.00 - Minimum Testing Requirements of these Standards and Specifications.

Rocks generated from raking at joint tie-ins or vertical projections shall not be broadcast on the new mat, but shall be placed back in the paver hopper or asphalt truck. Racking will not be allowed except to correct major problems of grade and elevation.

934.05 Tack Coat

Materials and construction shall comply with MGPEC Item 20 (latest edition).

934.06 Seal Coat

Seal coat materials and construction shall comply with Section 409 of the CDOT Standard Specifications for Road and Bridge Construction. The type of bituminous material, cover aggregate, and rates of application shall be as shown on the approved plans.

934.07 Rejuvenating Agent

Rejuvenating agent materials and construction shall comply with Section 407 of the CDOT Standard Specifications for Road and Bridge Construction.

934.08 Joint and Crack Sealant

Sealant materials and construction shall comply with Section 408 of the CDOT Standard Specifications for Road and Bridge Construction.

935.00 Trench Cuts and Exploratory Pothole/Core Repair

935.01 Trench Cuts

Utility trench patches shall be in accordance with the Detail Drawings found in these Standards and Specifications. Backfill of utility trenches shall comply with Section 364.00 - Trenching, Backfilling and Compacting of these Standards and Specifications.

The Contractor shall place a temporary, cold mix, asphalt patch in all street cuts immediately after completing backfill and compaction if a permanent hot mix asphalt patch cannot be installed. Portions shall not be left on any trench patch at the end of the working day if the depth of the patch is lower than the existing street surface.

When pavement cuts are required, the following conditions shall be met so as to avoid interference with traffic:

1. Pavement cuts in streets shall be open only between 8:30 am and 3:30 pm
2. Two-way traffic shall be maintained at all times around the construction area. A Traffic Control Plan (TCP) shall be prepared in accordance with 141.13 Traffic Control, Barricades and Warning Signs and submitted to the Traffic Engineer for approval prior to the start of construction.

Trench cut asphalt repairs in streets less than five (5) years old shall be subject to approval by the Director of Public Works and special asphalt repair requirements in accordance with the Detail Drawings found in these Standards and Specifications. The applicant shall be responsible for maintenance of the permanent patch for a period of two years.

935.02 Exploratory Pothole/Core Repair

When exploratory utility potholing is performed, the Contractor shall repair the pothole in the following manner.

Asphalt:

- Exploratory potholing voids are to be backfilled and the core patched with a temporary patching material immediately after initial potholing is complete.
- All material disturbed and/or removed during the exploratory operation shall be replaced with an approved flow-fill mix.

- Squeegee shall not be allowed as backfill material except for use as pipe bedding with a twelve inch (12") maximum depth over the pipe.
- Within seven (7) days of initial drilling, or within a reasonable and practical amount of time after completion of the projected work, potholes will be permanently patched.
- Portions shall not be left on any trench patch at the end of the working day if the depth of the patch is lower than the existing street surface.
- Any exploratory pothole and/or patch that are deemed dangerous shall be repaired immediately.
- All permanent repairs shall be made to look symmetrical and/or uniform. No jagged, uneven patches will be allowed.
- All edges and patch areas shall be dried, cleaned and tacked. All newly placed asphalt shall be maximum one-half inch (1/2") mix (SX) and shall be compacted properly in two (2) inch lifts.
- See Detail Drawings found in these Standards and Specifications for more information.

Potholing in streets less than five (5) years old shall be subject to approval by the Director of Public Works and special asphalt repair requirements. The applicant shall be responsible for maintenance of the permanent patch for a period of two years.

936.00 Pavement Acceptance Testing

At the discretion of the Project Engineer, the Developer may be required to furnish the City with an electronic copy of a Pavement Evaluation Report utilizing non-destructive deflection testing to assess and predict the performance of the pavement prior to Acceptance into Warranty. The pavement evaluation shall be performed in accordance with accepted engineering practices. The report shall generally incorporate the following testing and pavement evaluation techniques:

- A. Pavement surface evaluation
- B. Soil borings in areas of high deflection
- C. Pavement deflection analysis (Falling Weight Deflectometer, Dynaflex or other method approved by the Project Engineer)

The Pavement Evaluation Report shall evaluate the existing condition of the base and binder course by performance of deflection tests at a minimum of one-hundred fifty (150) foot spacing per traffic lane over the deepest utility trench, at every manhole and storm inlet, and at all areas of visual distress. The report shall determine the Remaining Service Life (RSL) of the roadway. Pavement deflection testing and the final top lift or overlay of asphalt shall only be performed between April 1st and October 1st, unless permission is granted by the Project Engineer.

If the pavement section is not projected to meet a twenty (20) year or greater pavement life from the time of installation based on the pavement deflection test results, the report shall detail the deficiencies and associated causes and shall recommend remedial measures to develop a twenty (20) year design life. The Project Engineer will evaluate the report and inform the responsible party of the required pavement operations.

Pavement Deflection Testing is not required for Arvada Capital Improvement Projects (CIP's) or street reconstruction, unless otherwise specified in the contract documents.

937.00 Grinding

Grinding shall consist of "milling", "grinding", or "cold planing" the existing pavement surface to establish a new surface profile and cross section in preparation for a bituminous overlay. After grinding, the surface shall have a grooved or ridged finish that is uniform and resistant to raveling or traffic displacement. This textured surface shall have grooves of one-quarter ($\frac{1}{4}$) inch \pm one-eighth ($\frac{1}{8}$) inch.

Grinding shall consist of milling the existing pavement to a minimum depth of two (2) inches and as required by the Pavement Deflection Testing Report or specified in the contract documents, unless otherwise directed by the Project Engineer. Grinding around utility castings shall be to a minimum depth of one and one-half (1 $\frac{1}{2}$) inches and as required by the Pavement Deflection Testing Report or specified in the contract documents. The maximum deviation between the top of the milled pavement and top of the manhole or water valve box shall be no more than three-quarters ($\frac{3}{4}$) of an inch in areas open to traffic. This condition may be achieved by placing a temporary wedge of hot mix asphalt (HMA) around the structure. This temporary taper shall be removed prior to placement of new HMA pavement.

Contractor shall protect existing concrete adjacent to milling areas so not to chip or gouge the existing concrete.

Repair of valve boxes and/or maintenance holes damaged during all milling operations will be the sole responsibility of the Contractor. Repair to include saw cutting +/- 3'X3'X6", excavating, replacing all damaged parts to final resurfacing grade and repaving.

Material recovered during the milling operation shall be disposed of by the Contractor at his expense, unless otherwise directed.

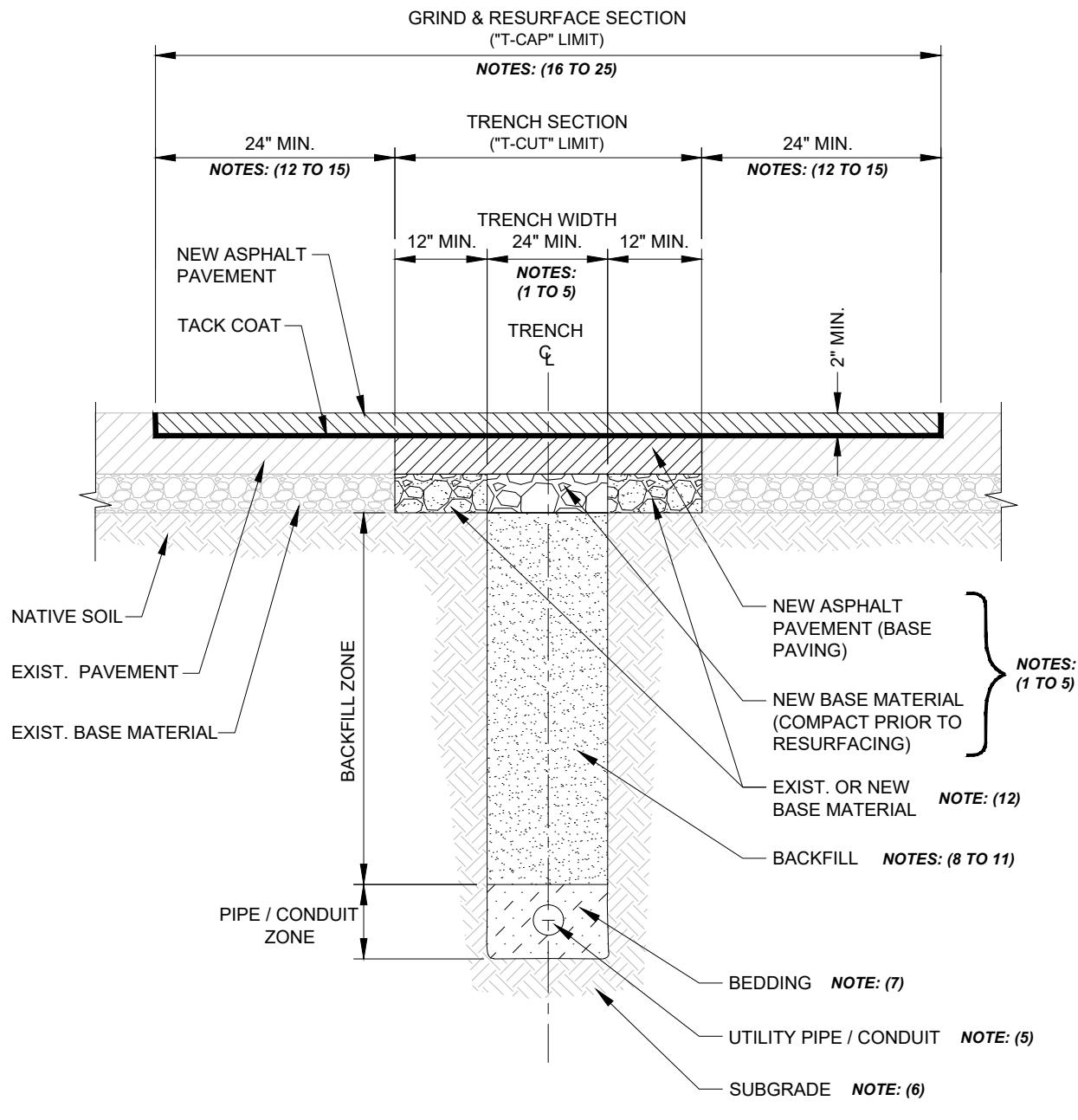
Unless otherwise approved, overlay of a milled street shall be within fifteen (15) days after the street is milled.

The Contractor shall remove the cuttings immediately behind the grind machine by belt loader, end loader, power sweeper and/or by hand. The grinding machine shall be equipped with a pressurized watering system for dust control. Flushing into Arvada's storm drainage system as a means of cleanup shall not be allowed.

938.00 Acceptance of Public Roadways

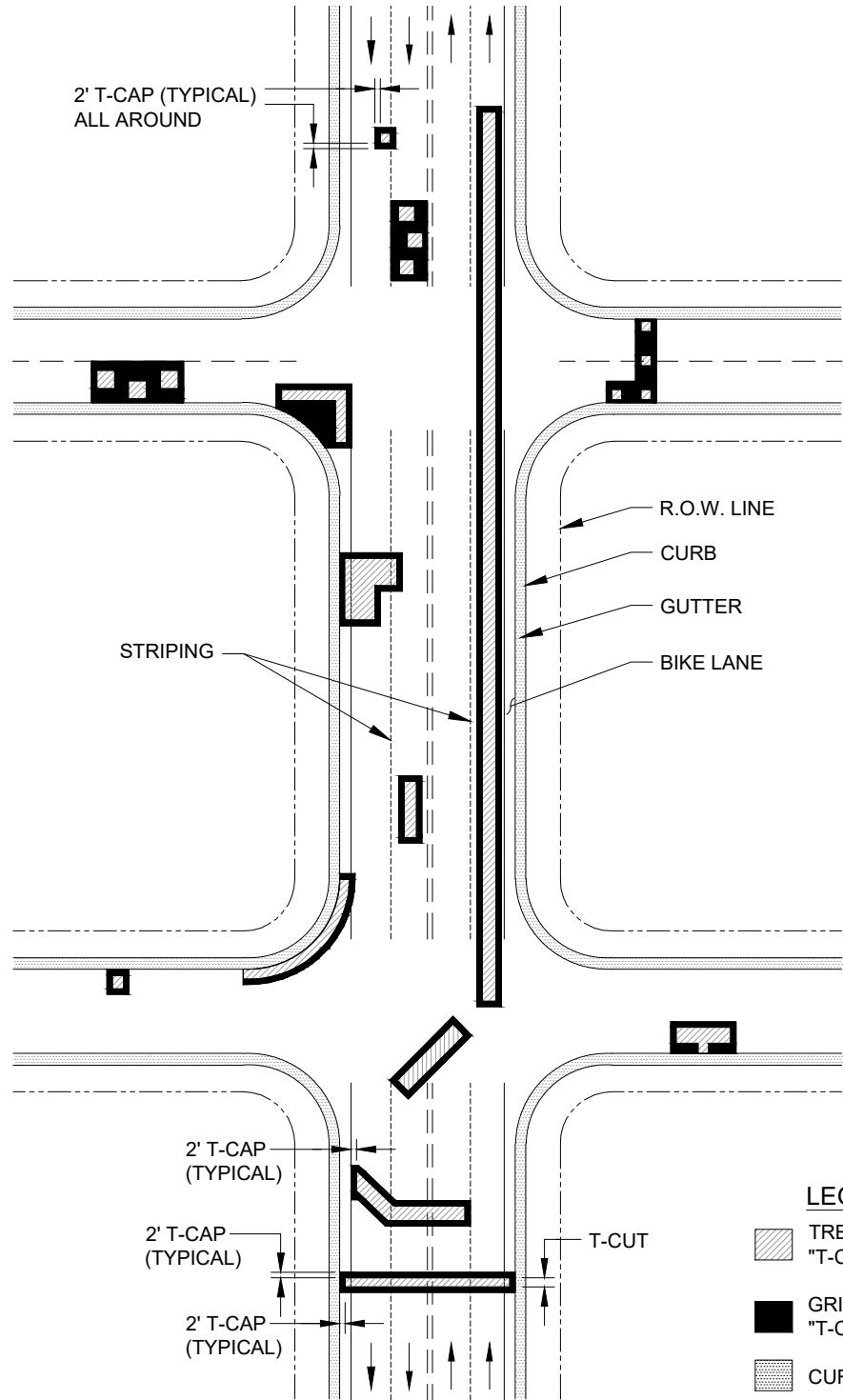
Workmanship shall meet all Arvada Standards and Specifications. This includes thickness, crowns, drainage, areas around maintenance holes and service covers, trench settlement and edges against curb and gutter and drain pans. Acceptance of roadways shall comply with Section 200 – Acceptance Procedures of these Standards and Specifications. Pavement shall not exhibit any distress such as alligator cracking, block cracking, edge cracking, potholes, trench settlement, raveling, heaving, sinking, separation from curb and gutter, patching or ponding at the completion of the warranty period. Ponding of water in asphalt pavement shall not exceed one-eighth ($\frac{1}{8}$) inch in depth. Where ponding exceeds one-eighth ($\frac{1}{8}$) inch in depth, pavement shall be removed and replaced, milled and repaved, or the area fixed with infrared patching at the discretion of the Project Engineer. Material that is obviously defective shall be isolated and rejected by the Project Engineer without regard to sampling sequence or locations within a lot.

When disagreements concerning determination of specification compliance occur only valid tests from both the City and Contractor will be considered. The City shall determine validity. Generally, valid tests are those in which sampling and test 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.



SEE STANDARD DETAIL 900-2
**FOR EXAMPLES OF GRIND AND
RESURFACE T-CAP LIMITS**

**SEE STANDARD DETAILS 900-3 & 900-4
FOR T-TRENCH AND ASPHALT
RESTORATION NOTES**



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CITY OF ARVADA
8101 Ralston Road
Arvada, Colorado 80002

EXAMPLES OF GRIND AND RESURFACE T-CAP LIMITS

2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTES:

ALL WORK SHALL COMPLY WITH THE LATEST ARVADA ENGINEERING STANDARDS AND SPECIFICATIONS.

LIMITS OF REMOVALS, TRENCH WIDTH:

1. ALL PAVEMENT REMOVED SHALL HAVE STRAIGHT EDGES. CUT DEPTH SHALL BE FULL DEPTH THROUGH THE EXISTING PAVEMENT ALL CUTS SHALL BE NEAT, STRAIGHT, VERTICAL CUTS WITH NOT BROKEN EDGES.
2. ALL LONGITUDE PAVEMENT CUTS SHALL BE UNINTERRUPTED APPROXIMATELY PARALLEL TO THE TRENCH (MAX. 1:6 LONGITUDINAL VARIANCE).
3. IF A SAW UT IN PAVEMENT FALLS WITHIN 2 FEET OF AN EXISTING CURB, GUTTER, OR EDGE OF PAVEMENT, THE ADDITIONAL PAVEMENT SHALL BE REMOVED AND RECONSTRUCTED.
4. WHEN SAW CUTTING PAVEMENT, THE MAXIMUM OVERRUN ALLOWED FOR ANY SAW CUT BEYOND THE BOUNDARY REMOVAL LIMITS OF EXISTING PAVEMENT SHALL BE 2 INCHES.
5. TRENCH WIDTH SHALL BE MINIMUM 24 INCHES. UNDERCUTTING TRENCH WALLS IS NOT PERMITTED.

BEDDING:

6. BEDING MATERIAL SHALL BE PLACED ON FIRM AND UNYIELDING SUBGRADE. SOFT, SPONGY, UNSTABLE, UNSUITABLE MATERIAL SHALL BE REMOVED AND REPLACED WITH ACCEPTABLE MATERIAL.
7. BEDDING SHALL CONFORM TO THE LATEST ARVADA ENGINEERING STANDARDS AND SPECIFICATION.

BACKFILL:

8. EXCAVATIONS SHALL BE BACKFILLED WITH AN APPROVED MATERIAL COMPLYING WITH THE LATEST ARVADA ENGINEERING STANDARDS AND SPECIFICATION. NATIVE SOIL MAY ONLY BE USED WITH PROJECT ENGINEER APPROVAL. SOIL TESTING SHALL BE REQUIRED TO BE PROVIDED TO THE CITY INSPECTOR. BACKFILL MATERIALS SHALL BE COMPACTED TO 95% RELATIVE DENSITY AND SHALL BE WELL GRADED AND HANDLED IN A MATTER TO PREVENT SEGREGATION BY PARTICLE SIZE.
9. BACKFILL MATERIAL SHALL B PROPERLY CONSOLIDATED.
10. BACKFILL MATERIAL SHALL BE MADE SMOOTH AND LEVEL BEFORE PLACING BASE AND BASEMENT.
11. JETTING IS NOT AN APPROVED DENSIFICATION METHOD.

TRENCH SECTION:

12. AFTER THE EXCAVATION HAS BEEN BACKFILLED, THE EXITING PAVEMENT SHALL BE REMOVED TO A LINE AT LEAST 12 INCHES BACK OF THE FIRM BANKS OF THE TRENCH ("T-CUT"). EXISTING CMB OR CAB BASE MATERIAL IN THIS AREA SHALL BE COMPACTED AND NEW BASE MATERIALS SHALL BE PROVIDED TO MATCH THE SURROUNDING BASE THICKNESS AS NECESSARY.
13. NEW BASE MATERIAL SHALL MATCH THE EXISTING BASE THICKNESS AND SHALL BE COMPACTED TO 95% RELATIVE DENSITY.
14. NEW ASPHALT SECTION SHALL MATCH EXISTING PAVEMENT THICKNESS, OR 6 INCHES, WHICH EVER IS GREATER.
15. ASPHALT PAVING WILL OCCUR NO SOONER THAN 24 HOURS AFTER FLOWFILL BACKFILL OF TRENCH. ASPHALT CONCRETE PAVING WILL OCCUR NO SOONER THAN 1 HOUR FOR FLASHFILL.

(Notes continued on Standard Detail Sheet 900-4)

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	T-TRENCH AND ASPHALT RESTORATION NOTES (Sheet 1 of 2)	2022 ENGINEERING STANDARDS & SPECIFICATIONS

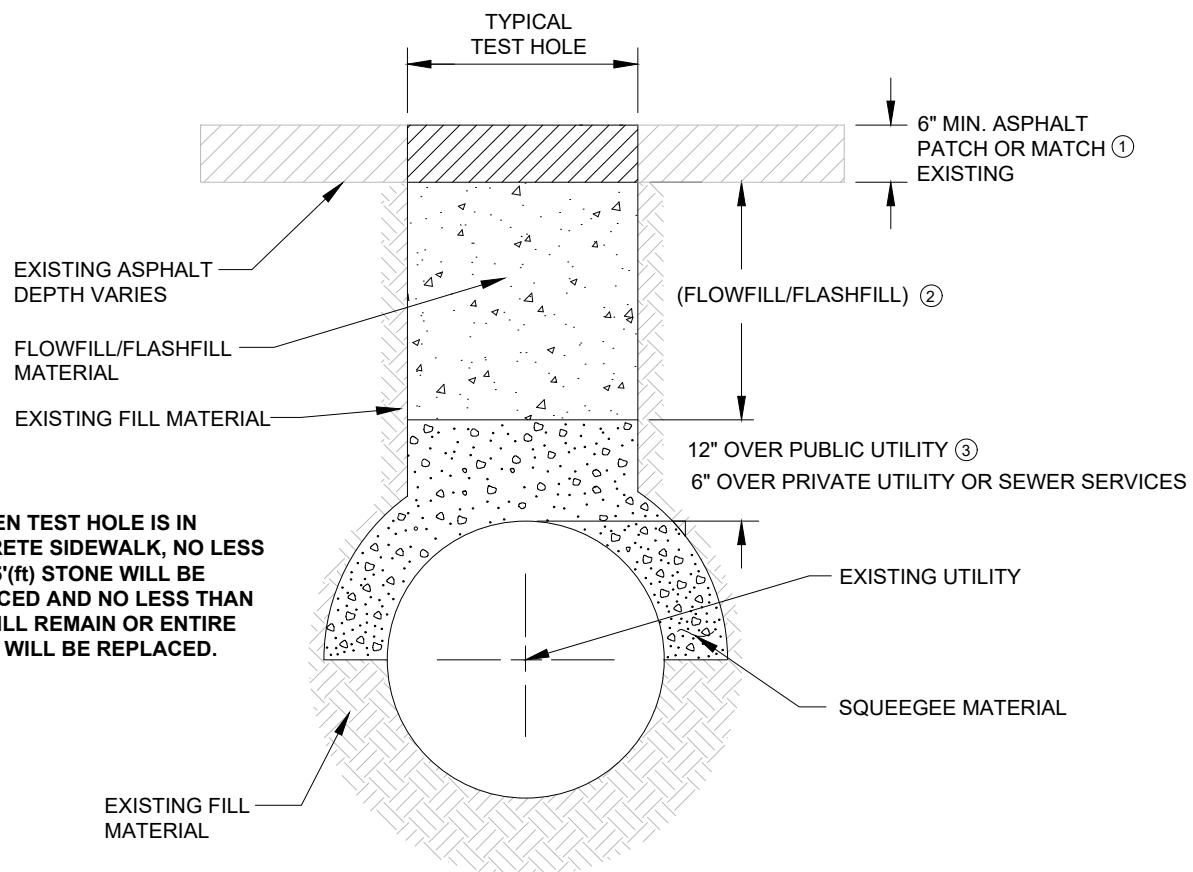
NOTES (continued):

GRIND AND RESURFACE SECTION:

WITHIN 7 CALENDAR DAYS AFTER BACHILLING, ASPHALT SHALL BE COLD MILLED AND RESURFACED AS FOLLOWS:

16. EXISTING ASPHALT CONCRETE SHALL BE GROUND DOWN TWO INCHES (2").
17. "T-CAP" LIMITS SHALL BE FROM ARVADA STANDARD DETAIL 900-2 "EXAMPLES OF GRIND AND RESURFACE T-CAP LIMITS".
18. "T-CAP" LIMITS SHALL EXTEND AT LEAST 2 FEET BEYOND THE TRENCH SECTION ("T-CUT" LIMITS). MINIMUM "T-CAP" DIMENSIONS SHALL BE 5 FEET x 5 FEET.
19. "T-CUT" AND CORRESPONDING "T-CAP" (AS APPLICABLE) IS REQUIRED FOR ALL EXCAVATION WITH A SURFACE AREA OF 3 SQ. FT. OR GREATER.
20. WHERE LIMITS OF "T-CAPS", "T-CAPS", TEST HOLES OR CORED HOLES ARE WITHIN 4 FT. OF EACH OTHER, THE PAVEMENT SURFACE RESTORATION SHALL BE COMBINED, BLENDDED AND SQUARED USING "T-CAPS" TO ENCOMPASS ALL AREAS IN BETWEEN AS SHOWN IN FIGURE 1.
21. IMPACTED BAKE LANES - "T-CAP" LIMITS SHALL FULLY ENCOMPASS ANY BIKE LANE IMPACTED BY THE TRENCH, AND SHALL HAVE A LENGTH THAT EXTENDS AT LEAST 2 FEET BEYOND THE ASPHALT REMOVAL LIMITS IN THE DIRECTION OF BIKE TRAFFIC.
22. WHEN THE "T-CAP" LIMIT IS WITHIN 2 FEET OR LESS FROM A CURB OR GUTTER, THE "T-CAP" LIMIT SHALL EXTEND TO THE CURB OR GUTTER.
23. PAVEMENT SHALL BE LEVEL WITH ADJACENT ROADWAY ELEVATIONS AND SHALL PROVIDE A SMOOTH SURFACE PER THE LATEST ARVADA ENGINEERING STANDARDS AND SPECIFICATION AND ARE SUBJECT TO ACCEPTANCE BY THE CITY MUNICIPAL INSPECTOR.
24. "T-CAP" AND PERMANENT BASE PAVING MAY BE PERFORMED ON THE SAME DAY WHEN FEASIBLE.
25. WHEN "T-CAP" LIMIT FALLS WITHIN A VEHICULAR WHEEL PATH THE LIMITS MAY BE ADJUSTED AT THE DISCRETION OF THE CITY INSPECTOR.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	T-TRENCH AND ASPHALT RESTORATION NOTES (Sheet 2 of 2)	2022 ENGINEERING STANDARDS & SPECIFICATIONS



TYPICAL TEST HOLE RESTORATION

NOTES:

- ① THE VOID THAT IS CREATED SHALL BE FILLED WITH TWO (2) OR THREE (3) LIFTS OF "SX" BITUMINOUS ASPHALTIC SURFACING MATERIAL TOTALING SIX (6) INCHES IN DEPTH OR MATCH EXISTING ASPHALT DEPTH, WHICHEVER IS GREATER. LIFTS SHALL BE COMPACTED AND TACKED PER CITY OF ARVADA STANDARDS AND SPECIFICATIONS. A POGO STICK MUST BE USED ON LOWER LIFTS OF ASPHALT UNTIL PROPER COMPACTION IS ACHIEVED, TOP LIFT SHALL BE FLAT COMPACTION FOR A SMOOTH FINISH. HOT MIX SHALL BE USED UNLESS OTHERWISE APPROVED BY THE CITY INSPECTOR.
- ② FLOWABLE FILL WILL BE USED FOR THE FULL DEPTH OF ALL TEST HOLES WITHIN EXISTING STREETS, PER CITY OF ARVADA STANDARDS AND SPECIFICATIONS. ASPHALT SHALL NOT BE PLACED UNTIL THE FLOWABLE BACKFILL HAS LOST SUFFICIENT MOISTURE AND FILLED COMPLETELY AT ONE TIME.
- ③ SQUEEGEE BEDDING SHALL BE CONSOLIDATED BY TAMPING, VIBRATING OR A COMBINATION THEREOF, TO 70% RELATIVE DENSITY AS DETERMINED BY ASTM D209. FOR RESTORATION ON 27"(in) OR LARGER RCP PIPE, FLOWABLE FILL SHALL BE USED IN PLACE OF SQUEEGEE.
4. RESTORATION WORK SHALL BE COMPLETED WITHIN SEVEN (7) CALENDAR DAYS AFTER FLOWFILL/FLASHFILL IS COMPLETE, WEATHER PERMITTING.
5. FOR EXISTING ASPHALT ROADWAY THAT IS 5 YEARS OR NEWER RESTORATION SHALL FOLLOW STANDARD DRAWING 900-1 THROUGH 900-4.

NO	DATE	REVISION



CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

TYPICAL TEST HOLE RESTORATION

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SECTION 1000 – PARKS AND RECREATION CONSTRUCTION

1000.00 Scope

1001.00 Privately-Owned Landscaping

Landscaping that is privately owned or maintained shall be designed and constructed in accordance with the Arvada Land Development Code.

1010.00 Site Design And Preparation

Site preparation shall be completed in accordance with Section 300 – Soils And Earthwork Of these Standards and Specifications.

Adequate drainage shall be taken into account for all site design and preparation. Grades shall not exceed 4:1(horizontal:vertical) in shrub beds, mulched areas, or turf areas. Grades shall not be designed to drain onto residential lots.

1011.00 Furnishings and Structures

Every project is unique in nature and the furnishing manufacturer/style may vary. Submittals for site furnishings such as benches, picnic tables, trash cans, dog waste stations, etc. are required for all new park and open space projects and shall be submitted to the Project Manager for approval prior to installation. All site furnishings shall be surface mounted and meet current local and state ADA requirements.

Park shelters and pavilions shall include a minimum of one (1) accessible picnic table and a minimum of two (2) trash receptacles.

The following furnishing and structure locations, requirements and exceptions shall be coordinated with the Project Engineer:

- A. Park Rules signs shall be installed for all parks.
- B. Dog bag dispenser stations shall be installed in all parks.
- C. All fences shall be installed with an eighteen inches (18") wide concrete mow band (no metal edging). Fencing material shall be approved by an Arvada representative.

- D. Seating areas shall be installed near playgrounds and other strategic locations to take advantage of shade and views.
- E. Site furnishings or sign posts installed in manicured turf shall be installed with twelve-inch (12") concrete maintenance buffers.
- F. All passive park locations shall include a minimum of one (1) trash receptacle.

1012.00 Dog Parks

- A. Dog park surfacing shall be turf or pea gravel material as approved by the Project Engineer.
- B. Dog park pea gravel color shall be approved by Arvada.
- C. Dog park fencing shall be forty-eight inches (48") minimum height.
- D. Dog park shall have two (2) separate areas for large dogs and small dogs with separate entrances to access each area.
- E. A potable water source for dog drinking water must be available.
- F. Benches and/or shade structures are recommended where feasible.

1013.00 Lighting

The work covered in this section involves the purchase and installation of park and trail lighting. These standards provide the tools needed to understand the design goals of Arvada Parks and Urban Design for lighting pedestrian trails. The following have been identified as most important regarding lighting design:

- Create a design that enhances the pedestrian experience.
- Provide safety and security for the people using the trails and parks.
- Create a design that reflects Arvada's history.
- Use of efficient lighting technologies.
- Ease of maintenance and vandal resistance.
- Exercise fiscal responsibility.

1013.01 Design Considerations

Luminaire Mounting Height: The luminaire mounting height can range from ten feet (10') to fifteen feet (15') above finished grade with the lower range more subject to vandalism and the higher range marginal for pedestrian-scale lighting. Luminaire mounting height of twelve feet (12') is generally acceptable for pedestrian lighting, but can be higher based on budgetary constraints.

Minimum Initial Footcandles for Trail Lighting: The minimum initial footcandles (Fc) level shall be one (1.0) Fc.

Spacing Between Poles: The normal spacing is between five point zero (5.0) to five point five (5.5) times the luminaire mounting height for an efficient pedestrian trail lighting luminaire's optics, so the pole spacing can range from fifty feet (50') to approximately eighty feet (80') on center.

Corrected Color Temperature of the Light Source: The corrected color temperature of the LED light source shall be three-thousand 3000K, as it appears less glaring.

Color Rendering Index of the Light Source: The color rendering index (CRI) of the LED light source shall be seventy (70) CRI.

The Design Engineer or Landscape Architect Engineer shall calculate the lighting levels using a computer-aided program that produces a point-by-point photometric calculation to ensure the proper lighting level is achieved.

A light loss factor of zero point nine (0.9) shall be utilized for all LED lighting calculations.

Types of Conditions: The following trail conditions must be considered during the lighting design process:

- Pedestrian trails
- Trail intersections
- Trails next to buildings
- Crosswalks
- Bridges
- Wayfinding and interpretive illumination

Power: The power source for the trail lighting system shall be two-hundred forty (240) volts single phase. Where possible, the power supply for new trail lighting shall be an extension of the existing trail lighting circuit. The Design Engineer shall conduct a load study to determine the available spare capacity of the existing lighting circuit to determine the available spare capacity. Where the existing circuits are not adequate to supply the new lighting, a new electrical service shall be installed. The meter pedestal consists of a Tescoflex 26-000 (metered), Milbank CP3A, or approved equal.

1013.02 Materials

Luminaries and Poles: The consultant shall submit luminaries and poles to Parks and Urban Design for approval.

Bases: All lighting poles shall be mounted to reinforced concrete pole bases as approved by Parks and Urban Design. Top of pole bases shall be set flush with grade and include concrete mow strips around the perimeter of the bases. Poles shall be located to maintain twenty-four inches (24") of clearance from the pole to the edge of the trail as required to conform with bike trail safety standards. Exact location shall be coordinated with the existing utilities and trail easements.

Conduit and wire: Wiring for all lighting circuits shall be copper conductors concealed in conduit. Minimum wire size shall be #8 to limit voltage drop to an acceptable level and allow for future additions. All underground conduits shall be Schedule 40 PVC conduit, and all above grade exposed conduit shall be rigid steel. Conduit inside of a building is allowed to be EMT conduit where it is not subject to physical damage. The minimum size for underground conduit feeding trail lighting poles shall be one and one-half inch (1-½") Schedule 40 PVC. Underground conduit shall be buried thirty inches (30") below grade.

Direct buried cable is not allowed.

Trenches for underground conduit shall be coordinated with existing utilities and landscape. Adjust location of the trench as required to avoid conflict. Locate conduit trenches outside the existing tree drip line. Where it is not possible to locate outside the drip line, the conduit shall be bored under the tree roots. Conduit bore shall be a minimum of three feet (3') deep.

The Design Engineer shall conduct voltage drop calculations for all lighting circuits. Limit the voltage drop in all circuits to three percent (3%) of the nominal voltage rating.

Controls: The trail lighting shall be turned on at dusk and off at dawn with a single photoelectric control located at the power source. Photoelectric control devices mounted on each pole or luminaire are not allowed. A bypass switch shall be installed at each photoelectric control device to allow the photocell to be bypassed for manually turning on the lighting for testing. Lighting controls shall also include a time clock to allow the trail lighting to be turned off late at night or early morning to conserve energy.

All lighting control panels shall have a laminated control diagram attached to the inside of the panel. Control diagram shall identify circuit numbers and a list of the pole identification numbers that are powered by each circuit. Construction Documents shall include, but not limited to, the following:

- a. Proposed Lighting: All luminaires shall be graphically located on the plans including all light standards, fixtures, pull boxes, transformers and other construction components.

- b. Point of Connection: The electrical utility service point shall be shown on the plans. If the point of connection is not within the project site, the service point shall be identified in a vicinity map detail. Any fees associated with the connection to the utility shall be enumerated by an appropriate bid item.
- c. Light Fixture Legend: Shall include symbols for luminaires, poles, fixture types, conduit size, panels and utility service points.
- d. Lighting Fixtures Schedule: Shall identify the fixture type as shown on the plans, the manufacturer and model number, lamp type and wattage, voltage required and any notes that pertain specifically to each fixture type.
- e. Panel Schedule: Shall designate circuits with the number of devices being served, voltage, number of phases, short circuit rating, load continues amperage, etc.
- f. Lighting Details: Shall be provided within construction documents to further define special construction details pertaining to the lighting equipment and construction and so that contractors can provide consistent competitive bids.
- g. Lighting Specifications shall be provided on the plans or provided in the specifications. Specifications must include at a minimum, everything included in the Light Fixture Schedule, plus fixture cut-sheets for each luminaire, standard and lamp used.

1014.00 Street Landscaping

1014.01 Medians and Parking Islands

All elevated center islands and medians shall have an eighteen (18) inch minimum width colored and patterned concrete border. Islands and traffic medians with turf shall have mower access ramps for maintenance for each individual turf area. Parking lot areas shall have stop blocks or buffer zones for vehicle overhang. Stop blocks shall be a minimum of 70" long x 5.75" wide x 3.5" high.

1014.02 Amenity Zone

An *amenity zone* is the area between the back of curb and edge of detached sidewalk. Amenity zones shall follow these requirements:

- A. No plants shall be placed within two feet (2') of the curb.
- B. Trees require eight feet (8') minimum width.

C. Shrubs and plants require four feet (4') minimum width.

1020.00 Soil Preparation

1021.00 General

Soil preparation amendments shall be provided on all areas to be seeded, sodded, or otherwise planted. The Contractor shall provide all labor, equipment and materials necessary to complete the topsoil preparation as required by the approved plans and these Standards and Specifications.

If the area to be developed is undisturbed or infested with bindweed, Canadian thistle, or any other noxious or objectionable weeds, the vegetation shall be controlled by two (2) chemical applications of glyphosate at a rate recommended on the product label.

Prior to seeding or sodding and in accordance with the requirements of the applicable section of the City Standard Specifications, the area to be landscaped shall be cleared, grubbed, and graded to within one-half inch of finish grade.

All irregularities in the ground surface, except the saucers for trees and shrubs in rough grass seeding areas, shall be removed. Special measures shall be taken to eliminate all low spots and pockets that would trap water and to clear the area of one to one and one-half inch and larger rocks or other debris. No ponding water will be allowed and shall be corrected.

All property pins shall be set and clearly marked before construction begins and shall be preserved until Final Acceptance.

1022.00 Materials

1022.01 Soil Amendments and Fertilizer

The contractor shall submit bag tags and/or truck load tickets for all products. The contractor shall apply one or more of the following as directed by the Project Engineer:

- (A.) Organic slow-release fertilizer (6-1-1, NPK): Biosol, or city approved equal.
- (B) Natural soil conditioner: Earthgreen Menefee Humate All Natural Organic Soil Conditioner, or City approved equal.
- (C) Mycorrhizal inoculum: AM-120 Standard, or City approved equal.
- (D) Triple superphosphate (P₂O₅ with an N-P-K of 0-46-0)
- (E) If a soil analysis indicates sufficient amounts of the above elements the City may, at its discretion, waive the requirement to fertilize.

(F) Compost shall be a well decomposed, stable, weed free organic matter source. It shall be derived from: agricultural, food, or industrial residuals; biosolids (treated sewage sludge); yard trimmings; source-separated or mixed solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (< 1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived. The product shall be certified through the U.S. Composting Council's (USCC) Seal of Testing Assurance (STA) Program.

Product Parameters

Parameters	Reported as (units of measure)	General Range
pH	pH units	6.0-7.5
Soluble Salt Concentration (electrical conductivity)	dS/m (mmhos/cm)	Maximum 5
Moisture Content	%, wet weight basis	30-60
Organic Matter Content	%, dry weight basis	30-65
Particle Size	% passing a selected mesh size, dry weight basis	98% pass through $\frac{3}{4}$ " screen or smaller
Stability Carbon Dioxide Evolution Rate	Mg CO ₂ -C per g OM per day	<2
Maturity Indicator	Carbon to Nitrogen Ratio (C/N)	<12
Maturity Indicator	Ammonia N/Nitrate N Ratio	<4
Maturity (Cucumber Bioassay) Seed Emergence and Seeding Vigor (each)	% relative to positive control	Minimum 80% (each)
Maturity (Red Clover lopyralid Sensitive Plants - Bioassay) Seed Emergence and Seed Vigor (each)	% relative to positive control	Minimum 80% (each)
Physical Contaminants (inerts)	% dry weight basis	

Chemical Contaminants	mg/kg (ppm)	Meet or exceed US EPA Class A standard, 40 CFR 503.13, Tables 1 & 3 levels
Biological Contaminants (Select PAthogens: Fecal Coliform Bacteria, or Salmonella)	MPN per gram per dry weight MPN per 4 grams per dry weight	Meet or exceed US EPA Class A Standard, 40 CFR 503.32(a) levels

Notes:

- 1 Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, The US Composting Council)
- 2 US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3 levels = Arsenic 41ppm, Cadmium 39ppm, Copper 1,500ppm, Lead 300ppm, Mercury 17ppm, Molybdenum 75ppm, Nickel 420ppm, Selenium 100ppm, Zinc 2,800ppm.
- 3 US EPA Class A standard, 40 CFR § 503.32(a) levels = Salmonella <3 MPN/4grams of total solids or Fecal Coliform <1000 MPN/gram of total solids.
- 4 CITY landscape architects and project engineers may modify the allowable compost specification ranges based on soil analysis, specific field conditions and plant requirements.

*Before delivery of the compost, the supplier must provide a copy of the lab analysis, performed by a STA Program certified lab, verifying that the compost meets the product parameters listed above. The lab analysis should not be more than 90 days old. *Truck delivery tickets must match the approved compost.

Organic materials shall be applied at a rate of five (5) cubic yards per one-thousand (1,000) square feet in all manicured turf areas and shrub beds. Native areas will require three (3) cubic yards per one-thousand (1,000) square feet. Organic material shall be a certified Class I or II compost product, depending upon specific project applications. Lab analysis of the organic material shall be submitted for approval prior to delivery. Organic materials shall contain less than 10 mmhos/cm of soluble salts and shall have a pH in the range of 6.0-8.2 and a 30-35% moisture content. Due to the difference in moisture content of organic materials, certification of material volume may be required. Mountain peat will not be accepted.

Starter fertilizer shall be a complete starter fertilizer having the chemical analysis of Nitrogen-18, Phosphorous-46, Potash-0. Fertilizer shall be delivered to the site in new, unopened bags bearing the manufacturer's name and the chemical analysis. Fertilizer shall conform to all Colorado Department of Agriculture fertilizer laws.

Starter fertilizer shall be applied at five (5) pounds per one-thousand (1,000) square feet after fine grading is complete and before sod or seed is planted.

1022.02 Topsoil

Areas to be revegetated shall be prepared with topsoil and soil preparation amendments. The CITY has the prerogative of deleting all or a portion of the soil preparation requirements when topsoil is imported, depending on topsoil quality and quantity. Topsoil amendments shall meet the requirements of section 1021.00 - General and 1022.01- Soil Amendments and Fertilizer of these Standards and Specifications.

The Contractor shall salvage within the project limits, or acquire when needed, loose friable loam (“topsoil”) reasonably free of admixtures of subsoil, refuse, stumps, roots, rocks, brush, weeds, heavy clay, toxic substances or other material which would be detrimental to the proper development of vegetative growth.

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, spread and keyed to the underlying material at locations and to the thickness shown on the approved plans.

Topsoil shall not be incorporated into any embankment fill or backfill material without prior approval of the project Geotechnical engineer and the Project Engineer.

Areas to receive topsoil shall be scarified to a six (6) inch depth to improve the bond of topsoil to subsoil. Place topsoil to a minimum depth of six (6) inches after settlement. Spread evenly and grade to elevations and slopes shown on the approved plans. Hand rake areas inaccessible to machine grading.

If sufficient on-site material is not available, the contractor shall furnish and install imported topsoil in the manner described above. Topsoil shall be mixed thoroughly with the salvaged topsoil prior to placement.

Utilize manufactured topsoil as the top layer, placing over scarified subgrade to a depth of six (6) inches.

Protect completed areas where topsoil has been spread from traffic to prevent compaction. Any areas that, as determined by the city engineer, become compacted due to the contractor’s construction traffic shall be reconstructed.

All imported topsoil shall be a loam or sandy loam conforming to ASTM D 5268. At least ten (10) days prior to topsoil delivery, notify the city of the source(s) from which topsoil is to be furnished. Topsoil shall be furnished by the contractor and shall be a natural, friable soil representative of productive soils and shall meet the following conditions. Topsoil shall be free from weeds, sod, and material larger than 1-inch, toxic substances, litter or other deleterious material. The topsoil shall have an acidity in the range of pH 6.5 to pH 8.5, and shall be screened and meet the following mechanical analysis:

Screen Size	% PASSING	% RETAINED
1 Inch Screen	100	0
½ Inch Screen	97-100	0-3
#100 Mesh Sieve	60-40	40-60

Soil Texture:

Sand: 30% - 50%

Silt: 30% - 50%

Clay: 5% - 30%

Soluble Salts: Electric conductivity (EC) shall be less than two (2.0) mmhos/cm for turfgrass areas, dryland areas, and planting beds.

1023.00 Process

No sod or seeding shall occur until the Inspector has inspected and approved the soil preparation. The following process shall apply to native areas as well.

Upon establishment of approved grades, the soil surface shall be loosened by rototilling to a minimum of eight (8) inches (for a 20% to 30% inclusion rate), and all materials over two (2) inches in diameter shall be removed and the soil surface shall be reasonably free of large clods, roots, and stones greater than two (2) inches, and other material which will interfere with seeding and subsequent site maintenance. Higher inclusion rates are necessary for upgrading marginal soils, as determined by the city engineer. All amendments, fertilizers, and compost shall be mixed thoroughly into the soil surface to a depth of eight (8) inches by means of a rototiller, soil mixer or similar equipment. Do not leave mycorrhizal inoculum exposed to sunlight for more than four hours. The surface shall then be finish-graded, compacted to the approved elevations and the soil surface shall be raked smooth prior to seeding.

Seeding shall take place within forty-eight (48) hours of soil preparation, unless otherwise approved by the Project Engineer.

Organic materials shall be applied when the surface is within two-tenths (0.2) of a foot of final grade. No organic material containing manure shall be stockpiled on the site for more than eight (8) hours before it is incorporated into the soil.

After tilling, the areas to be sodded/seeded shall be raked, graded, and rolled to final grade with gently sloping surfaces to adequately drain surface water run-off. The finished surface shall be even and uniform, with no soil clumps or debris larger than one (1) inch in diameter. The prepared soil surface shall be on an even plane with all sidewalks, curbs, or borders for seeded areas and shall be three-fourths ($\frac{3}{4}$) of an inch below for sodded areas. On sloping ground, the final disc harrowing operation shall follow on the general contour. In no case shall slopes or sodded or seeded areas exceed four horizontal to one vertical (4:1).

1030.00 Grass Specifications

1032.01 Bluegrass/Turfgrass Sod

Prior to installation, the sod blend shall be submitted for approval by Arvada Project Engineer. The variety of sod may vary based upon projected land use. An approved variety of drought-tolerant sod shall be used in passive park and right-of-way areas to ensure low water use. Athletic grass blends shall be used in high use park areas and on athletic fields.

Sod shall be strongly rooted and free of noxious weeds, undesirable plants, roots, stones, and other foreign materials that are detrimental or may hinder proper development of the sod. The sod shall be procured from areas where the soil is reasonably fertile and contains a high percentage of loamy topsoil. The sod shall be cut from living, thickly matted turf. The sod shall be mowed to a height not to exceed two and one half (2- $\frac{1}{2}$) inches and thoroughly watered before the sod is cut. All sod shall be cut to provide a minimum thickness of three-fourths of an inch ($\frac{3}{4}$ ") of soil adhering to the roots. The Contractor shall furnish written proof of sod variety to Arvada. Sod shall be tested by the Colorado State University laboratory or a certified laboratory at the Contractor's expense if requested by Arvada.

1032.02 Bluegrass/Turfgrass Seed

Seed shall be furnished in sealed, unopened, standard containers and labeled in accordance with the USDA Rules and Regulations and the Federal Seed Act. Seed certification tags shall be delivered to Arvada to verify compliance with these Standards and Specifications. Seed shall be fresh, clean, pure live seed equal in quality to the standards for "Certified Seed" and shall pass

the USDA test for germination of eighty-five (85) percent and for purity of ninety (90) percent. 90% Complete Mix Blue Seed shall consist of the following:

1. 25% Compact Kentucky Blue Grass (KBG)
2. 25% Aggressive KBG
3. 20% Midnight KBG
4. 20% American KBG
5. 10% Perennial Rye

Seed shall be free of *Poa annua* and all noxious or objectionable weed and shall have a maximum weed crop of one-tenth (0.1) percent. Arvada Parks may require tests of seed verification at the Contractor's expense. Seed specifications and application rate may vary based on projected land use.

The seed mixture and rate of seed application shall be submitted for approval by the Project Engineer before seeding shall begin. Seed specifications may vary based on projected land use.

1032.03 Native Seed

All areas shall be prepared according to these Standards and Specifications specified in Section 1020.00 before seeding will occur. Seed blends shall be pre-approved by Arvada prior to seeding. Seed shall be furnished in sealed, unopened, standard containers and labeled in accordance with the USDA Rules and Regulations and the Federal Seed Act. Seed certification tags shall be delivered to Arvada to verify compliance with these Standards and Specifications. Seed shall be fresh, clean, pure live seed equal in quality to the standards for "Certified Seed". Arvada may require seed verification tests at the Contractor's expense. Seed specifications and application rate may vary based on projected land use. Native Grass blend shall consist of the following:

1. 20% Perennial Ryegrass, Elgon (Tetraploid)
2. 20% Desert Wheat Grass (Nordan)
3. 10% Blue Grama (Alma)
4. 10% Side Oats Grama (Butte)
5. 10% Big Bluestem (Bison)
6. 10% Coated Creeping Meadow Foxtail (Garrison)
7. 10% Indian Grass (Tomahawk)
8. 10 % Streambank Wheatgrass (Sodar)

If this blend can not be made a suitable substitute, such as a Dryland Pasture Mix, must be presented for approval to the Project Engineer before application.

Cover crops may be required in certain applications as designated in section 1034.02 - Bluegrass/Turfgrass Seeding of these Standards and Specifications. If a cover crop is required it shall be a steril form of sorghum, oats, barley, or an equivalent product as approved by the Project Engineer.

1032.04 Seed Top Dressing

Mulching material shall be applied immediately after seeding.

For hydroseeding, slurry mix shall not be combined with hydroseeding. Apply hydro-mulch (wood fibers in a water slurry) at a minimum rate of two-thousand (2,000) lbs/acre with a three (3) percent guar gum tackifier. Hydromulch shall be applied to both native and bluegrass seed installations immediately after seed application.

For drill-seeded areas: Grain straw shall be used at an application rate of four-thousand (4,000) lbs/acre of air-dried material. Straw shall be certified weed-free and shall be used on native seeding only. Straw shall be applied over the seeded surface at the minimum rate of two thousand (2,000) pounds per acre and with partial embedment into the soil by a crimper or similar implement. Straw shall be applied immediately after seed application.

For steep slopes hand or mechanical broadcasted:

- (A) Mulch netting shall be firmly held in place with pins spaced not more than ten linear feet apart. In sandy or extremely loose soil, the pins shall be located not more than 5 linear feet apart.
- (B) Jute netting or similar approved materials shall be installed according to the manufacturer's recommendations.
- (C) Excelsior mat shall be installed according to the manufacturer's recommendations.

1033.00 Process - Sod

The sod bed shall be lightly watered immediately prior to installing the sod. All sod strips shall be placed tightly against each other so there are no apparent open joints. Joints between ends of strips shall be staggered at least one (1) foot between adjacent rows. At the end of walks and drives, the sod shall have the same final grade as the abutting surfaces. At curbs, the sod shall have the same final grade as the top of the curb. Sod placed on slopes equal to four horizontal to one vertical (4:1) shall be staked with wire pins not less than six (6) inches long and spaced not more than thirty (30) inches apart. The pins shall be driven into the ground at an angle against the flow of the water until the top of the stake is just below the top of the soil and root mat. Sod

shall be installed at the bottom of the slope and shall progress upward with strips laid transverse to the slopes. Immediately after the sod has been laid, it should be tamped or rolled with approved equipment to eliminate all air pockets and to provide a smooth, even surface. Immediately after rolling or tamping the sod, sufficient water shall be applied to completely saturate the sod. The sod shall be watered as often as required to prevent drying out. In settled areas, the sod shall be removed, settled areas shall be regraded and the sod shall be reinstalled.

1033.01 Care, Handling, and Transportation

Care shall be exercised at all times to retain native soil on the sod roots during transportation, handling and planting. Dumping sod from vehicles shall not be permitted. The sod shall be transported to the site within twenty-four (24) hours from the time it is cut, unless it can be stored to the satisfaction of Arvada. During delivery and while in stacks, all sod shall be kept moist and protected from exposure to the wind, sun and freezing. All sod delivered to the site shall be installed within twenty-four (24) hours of delivery. All damaged or dry sod shall be rejected.

Sod may be transported on or across the site on pallets by forklift. Damage to the sod bed by vehicles shall be kept to a minimum, and any damaged areas shall be re-graded prior to sodding. Damage caused to paving, curbs, fence, plants or other objects during sodding, shall be repaired or replaced as directed by Arvada at the Contractor's expense.

1034.00 Process - Seed

1034.01 General

Seed shall be drilled into the prepared seedbed. The seeder shall be equipped with a satisfactory feeding mechanism, an agitator, double disc furrow openers, depth bands and packer wheels.

On sloping land, the seed shall be applied following the general contour. Top-dressing shall be applied immediately after seed application following section 1032.04 - Seed Top Dressing of these Standards and Specifications. In areas where seed drilling is not feasible, a broadcast method may be substituted. If a broadcast method is used, the seeding rate shall be doubled and the area shall be dragged after seeding and top-dressing applied.

Seeding shall not be performed during windy weather or when the ground is frozen or otherwise untilable. Seeding portions of the designated areas may be permitted before construction is complete in order to take advantage of the growing season, with prior approval of the project manager.

1034.02 Bluegrass/Turfgrass Seeding

Seed shall be sown to a depth of one-quarter ($\frac{1}{4}$) inch into the prepared seedbed. Seed drilling shall be performed in two (2) separate applications, crossing the area at right angles to one another to guarantee proper coverage.

All seeding shall occur between March 1st and October 1st unless approved in writing by the City Parks representative.

1034.03 Native Seeding

Seeding shall be hydroseeded unless otherwise approved by the Project Engineer. Areas larger than 1 acre with slopes of 4:1 or flatter may be drill seeded and areas with slopes greater than 4:1 may be hand broadcast, if approved by the Project Engineer. The contractor shall submit seed bag tags for all seeding methods.

Hydroseeding shall occur as a separate process prior to hydromulching. Do not mix seed and mulch together in one slurry application process.

If approved, seed may be drill seeded. Mechanical power-drawn drills shall have depth bands set to maintain a planting depth between $1\frac{1}{4}$ inch and $1\frac{1}{2}$ inch and shall be set to space the rows not more than 2 inches apart. In addition, the drill shall be equipped with multiple seed boxes from which large smooth, small smooth, and appendaged (i.e. fluffy or trashy) seed can be metered evenly. Seed that is extremely small shall be sowed from a separate hopper adjusted to the proper rate of application. Seed shall not be drilled or sown during windy weather or when the ground is frozen or otherwise untilable. If inspections indicate that strips wider than the specified space between the rows planted have been left or other areas skipped, the city may require immediate re-sowing of seed in such areas at the developer's expense. During all seeding operations, proper functioning of the seed drill will be demonstrated to the satisfaction of the city upon request.

If approved, seed may be hand or mechanical broadcasted. Hand method of broadcasting seed will be permitted only on small areas not accessible to machine methods. All seed sown by broadcast-type seeders shall be "raked in" or otherwise covered with soil to a depth of at least 1 and $\frac{1}{4}$ - inch.

The minimum standard for any dryland grass is eight (8) seedlings of the seeded species per square foot. If requested by the city, this count/inspection shall be taken four (4) weeks after germination by a qualified botanist. Any area not meeting the specifications on germination will be touch up seeded in one of the following methods:

- (A) Hand Broadcast and Incorporation
- (B) Mechanical Broadcast and Incorporation
- (C) Interseeding with Seed Drilling Equipment

Seed shall be sown to a depth of one and one-half inches ($1\frac{1}{2}$ "') into a prepared seedbed as specified in Section 1020.00 - Soil Preparations and 1034.00 - Process - Seed of these Standards and Specifications. Initial seeding shall occur between March 1st and April 15th unless approved by the Project Engineer. Initial seeding shall be determined to be successful if there is an average germination rate of seventy-five to eighty-five (75-85) percent per square yard in the entire seeded area. If initial seeding fails to meet this germination success rate, a second seeding will occur within the next seeding window, either between March 1st to April 15th or between September 1st and October 15th. Germination must meet the minimum germination rate before final acceptance.

Cover crops shall be applied to native seeding areas in the following situations:

1. South facing slopes
2. Slopes with a grade greater than 4:1

1035.00 Maintenance

1035.01 Sod Grass Areas

The proper care and maintenance of the sodded areas shall be the responsibility of the Contractor until Initial Warranty Acceptance. Maintenance operations shall begin as soon as each portion of the area is sodded. The maintenance shall consist of repair and replacement of eroded areas, watering, mowing (once sod is established), weeding, fertilizing, and re-sodding as necessary to provide an even, consistent stand of grass. All sod replacement required by Arvada shall be done at the Contractor's expense. Any areas determined by Arvada to be thin, weak or dead shall be replaced.

1035.02 Seed Grass Areas - Bluegrass/Turf grass and Native

The Contractor shall guarantee the health of the stand of grass until the entire project has been accepted by the City Parks representatives. Any new grass deemed by Arvada Parks to be thin, weak, or dead shall be reseeded according to these Standards and Specifications and germinated prior to the beginning of the warranty period.

The Contractor shall erect suitable signs at strategic points notifying the public to keep off the seeded areas until the lawn is well established. Any traffic damage that may occur prior to Final

Acceptance/Release from warranty of the work shall be repaired and reseeded at the Contractor's expense.

1035.03 Mowing

During the maintenance period, after a suitable stand of Bluegrass or turfgrass has been established, the Contractor shall mow all lawn areas a minimum of two times to a height of two inches in the field.. Frequency of mowing shall be determined by the growth rate of the grass, and at no time should the clippings exceed more than one-third ($\frac{1}{3}$) of the total leaf blade. Only turf-type mowers shall be used for this operation.

Native grass mowing may be necessary as designated by the Arvada Park representatives. If mowing of native grasses is required it shall be to a height no shorter than 5 inches. At no point should native grasses have more than 50% of their leaf surface removed during any one (1) mowing. It is recommended that clippings are not collected during mowing operations for native areas in an effort to spread the seed throughout the area.

1035.04 Additional Fertilizing

At the time of the first mowing, the Contractor shall apply a commercial fertilizer to Bluegrass areas or turfgrass areas with the chemical analysis Nitrogen-20, Phosphorous-5, Potash-5 plus 2% Fe, at an application rate of 5 pounds per 1,000 square feet. When applied, the fertilizer shall be dry and free-flowing, and care should be taken to prevent burning. Fertilizer containing iron shall be cleaned off from any structures or concrete areas. Any areas disturbed or damaged by the Contractor during fertilizing operations shall be repaired in accordance with these Standards and Specifications at the Contractor's expense.

1035.05 Watering

The Contractor shall be responsible for watering newly seeded and sodded area(s) a minimum of two (2) times per day (early-morning and early evening) and for keeping areas moist until the lawn is established. The Developer shall be responsible for the cost of water usage until Initial Warranty Acceptance of the Project. This shall also apply to native areas that have been constructed with irrigation zones.

1040.00 Planting Specifications

1041.00 General

The scope of work involves furnishing all plants, equipment, materials, labor and supervision necessary for the installation of plant materials as indicated on the approved plans and in these Standards and Specifications. Acceptable trees, shrubs, ornamental grasses and perennials for landscaping in Arvada are included in the City of Arvada Recommended Plant List. Other plant materials may be submitted for review and approval by the Project Engineer.

1042.00 Materials

The following section shall discuss the specifications for the materials used during the installation of plant materials for the City of Arvada.

1042.01 Ornamentals, Perennials, Shrubs, and Trees

The Contractor shall furnish and install all plants shown on the approved plans.

All plant materials shall:

- A. Be alive, healthy and established in the container in which they are sold
- B. Have a normal, well developed branch structure typical of the chosen species and a well developed root system
- C. Show sufficient annual growth
- D. Have plump buds, well fitted for the species
- E. Have an attached tag indicated the species
- F. Meet ANSI standard Z60.1

All plant materials shall be free from:

- A. Defects or mechanical damage
- B. Disfiguring knots
- C. Bark abrasions and discolorations
- D. Plant diseases, insect eggs, wood bores, and all forms of insect infestation
- E. Wilted or dried out leaves

1042.02 Additional Requirements for Trees

- A. All trees supplied are to come ball/burlap and/or containerized. Preference shall be given to trees grown and/ or established in air pruned containers.
- B. All trees shall have the typical form or shape characteristic of the species with healthy, sound growth. Excessive shoot growth suggesting heavy fertilizer use shall be rejected.

- C. All trees shall have a single trunk with a dominant leader unless indicated as a “clump form”
- D. Root systems shall be fibrous and healthy in nature.

Tree rejection criteria:

- A. Any tree with a shape or form that does not meet the characteristics of the species.
- B. Obvious defects in the root system such as girdling roots, circling roots, root bound/ container bound root systems, undersized root systems, broken or loose root balls/ systems, etc.
- C. Any tree lacking a strong central lead and single trunk unless indicated as “clump form”
- D. Any tree with a topping cut made during the current growing season.
- E. Any tree with large pruning wounds (one (1) inch or greater) that do not show signs of compartmentalization.
- F. Any tree with damage from sun scald, frost damage, transportation/ poor handling, etc.
- G. Any tree damaged during the process of transportation or planting
- H. Trees with lateral limbs that have undesirable aspect ratios indicating codominance of the limbs.
- I. The City of Arvada reserves the right to reject any tree for reasons not specifically indicated above. A reasonable explanation will be provided to the contractor in this instance.

All plant materials shall conform to the measurements noted in the plant specifications and on the approved plans. Rejected plant material shall be indicated with red marking tape upon inspection. Trees shall be inspected before they are planted. Trees that are planted previous to being inspected and are found to meet rejection criteria shall be replaced at the contractors expense.

1042.03 Transportation of Plant Materials

All plant material shall be properly prepared and shipped in accordance with recognized industry standards. Plant material shall be kept moist, fresh, and protected from injury, and excessive drying or other adverse conditions due to changes in climate or caused by transportation. Such protection shall encompass the entire period the plant material is in transit.

1042.04 Storage of Plant Material

The contractor shall be responsible for any and all temporary storage of plant material prior to and during tree planting operations. Plant material shall be planted on the day of delivery if possible. Any plant material not planted upon arrival shall be stored in an area in which the plant

material is protected from weather and mechanical damage. Any material stored for more than twelve (12) hours shall be healed in with mulch and the root system kept moist until installation. Failure to properly store plant material will result in the rejection of the plant material.

1042.05 Backfill

Backfill for tree planting operations shall consist of soil excavated from planting pits. Excavated material shall be free from wood, rocks, trash, packaging material, or large stones/rocks when added back into the planting pit. Care shall be taken to break up any large clumps of soil before backfilling.

1042.06 Soil Amendments

The only approved soil amendments shall be a pre-approved mycorrhiza product. The product shall be approved by a designated representative of the City of Arvada, such as the City Forester, before application. All newly planted trees shall receive this soil amendment. No fertilizer(s) shall be applied at any time.

1042.07 Staking

All trees shall be staked and guyed using the following materials:

- A. Stakes: Two Six-foot (6') tall steel tee posts,
- B. Wires: A double strand of #20 gauge galvanized wire
- C. Nylon straps: One and one-half (1-½) inch wide nylon strap with eyelets at each end.
- D. PVC Pipes: Install clean cut white PVC pipes to each guy wire for visibility.

1042.08 Water

Water for plant material shall be clean and fresh. The Contractor shall be responsible for transporting water to all tree planting sites.

1042.09 Mulch and Edging

All trees and planting beds shall be mulched with natural, reground/recycled wood chips between two (2) inches and four (4) inches in length. Where approved by Arvada, cobble or rock mulch may be substituted for fibrous mulch. However, a ring of natural mulch will still be placed under the drip line of any newly planted trees. Edging, if included, will be shown on the drawings.

1042.10 Weed Barrier Fabric

Weed Barrier fabric shall not be installed for any and all planting bed areas, including areas with wood mulch, cobble, or rock. Any weed barrier fabric that is installed will be removed at the contractors expense.

1042.11 Planting Plan Design

The planting plan shall include a broad range of plant materials to prevent a monoculture. Landscaping projects are encouraged to follow the Urban Forestry Diversity Formula.

1. Within each of the large tree and shrub categories, not more than 30 percent of the deciduous or conifer trees installed on a subject property shall be of a single genus, and not more than 20 percent of the deciduous or conifer trees installed on a subject property shall be of a single species.
2. A minimum of ten percent of the trees shall be evergreen.
3. The Director may require biodiversity of street trees that are planted in public rights-of-way in order to serve the purpose of this section.

The following are required sizes:

- A. Deciduous Shade Trees: Caliper shall be between one and one half inch (minimum 1-½") to two and three-quarter inch (maximum 2 ¾")
- B. Deciduous Ornamental Trees: Caliper shall be between one and one half inch (minimum 1-½") to two and three-quarter inch (maximum 2 ¾")
- C. Coniferous Evergreen Trees: Height shall be between six feet (minimum 6') and eight feet (maximum 8') tall
- D. Shrubs: Number five (#5) container
- E. Ornamentals and Perennials: number one (#1) container
- F. Groundcover Plants: number one (#1) container

Plant size changes may be necessary based on availability. Substitutions shall be approved by Arvada Parks Project Manager.

1043.00 Planting

The following section shall discuss the processes for the installation of plant materials for the City of Arvada.

1043.01 Location Staking

The Contractor shall stake the proposed locations of all trees and shrubs on-site for approval by Arvada prior to planting. The Contractor shall arrange to have the locations of all utility lines (including but not limited to water, sewer, storm, gas, electrical, phone, and irrigation) marked prior to the inspection. The contractor shall be responsible for informing the City of Arvada when the utility mark outs are completed. Arvada reserves the right to move, shift or adjust any or all of the stakes to better achieve the planting design intentions as shown on the approved drawings.

1043.02 Planting Seasons

Planting may occur whenever the soil conditions are favorable or as authorized by the Project Engineer. Tree planting shall occur, when possible, during April-July or in the Autumn after leaf drop as authorized by the Project Engineer.

1043.03 Pruning of Tree Material

Pruning shall be performed before installation of the plant material *if* required. Pruning should be limited to removing any small broken or dead limbs that did not result in the rejection of the plant material. All pruning shall be performed with clean, sharp, sterile tools designed for arboricultural use. A good set of hand pruners should suffice. All pruning will conform to currently approved arboricultural practices.

1043.04 Planting Procedures for Trees

1. Site Excavation: All tree planting holes shall be dug by hand. Alternate forms of excavation may be used *if* approved by the Project Manager. The diameter of the planting hole shall be at least two (2) times the diameter of the root system. Depth of the planting hole shall be equal to the vertical dimension of the true root ball. Excessive soil built up on top of the root ball above the root flare should not be included in determining this depth. The depth of the hole shall be set so that the root flare sits two inches (2") above grade for ball and burlap root systems and at finished grade for containerized trees. Soil at the bottom of the hole shall be left undisturbed and firm as to prevent settling of the rootball.
2. Equipment: If equipment is used to excavate the planting site, such as an auger, time shall be taken to scour the edges of the planting hole to remove glazed sides. Time shall be taken to ensure the planting hole remains as close to circular as possible.

3. Root System: All containers shall be ***completely*** removed from the root ball before backfilling the hole. No wire, burlap, twine, or plastic shall remain on the root ball or in the planting hole. All efforts shall be made to prevent the root ball from breaking during the process of removing the container. Any root balls that fall apart while removing the root system container shall not be planted. All traditional ball and burlap trees shall have any excessive soil above the root flare removed. Any trees grown in solid containers or air pruned containers shall be examined for circling root systems. If there is a circling root system, appropriate measures shall be taken to mitigate this such as slicing the roots or shaving the root system. Any tree found to be planted with the container still attached shall be replaced at the contractors expense.
4. Placing the tree in the hole: The tree shall be placed carefully into the hole to prevent damage to the root system/ root ball. The tree shall not be lifted into the planting hole by the trunk or limbs. The tree shall be planted as close to the center of the hole as possible. The trunk shall be made to be plumb. Any trees planted crooked or leaning shall be removed and replaced at the contractors expense.
5. Soil Amendment: The mycorrhiza product detailed in section 1042.06 - Soil Amendments of these Standards and Specifications shall be added during the backfill process or the watering process depending upon the label requirements of the product.
6. Backfill: The soil removed from the planting hole during excavation shall be used as the backfill material in accordance with section 1042.05 - Backfill of these Standards and Specifications.. Do not compact the soil during backfill. No backfill material shall be placed on top of the root ball. A berm shall be constructed around the outer edge of the planting hole using backfill material. The berm shall be constructed using the remaining backfill material and shall be no less than three inches (3") in height and no more than six inches (6").
7. Watering: All trees shall be watered at the time of planting. Trees shall be watered with a minimum of twenty-five gallons of water (25 gallons). Care shall be taken to make sure large air pockets are removed from the back fill at this time. A shovel may be used to gently work the backfill into the planting hole while watering to ensure that the backfill is properly worked back into the planting hole and all large air pockets are eliminated. Replace any soil that settles after watering.
8. Mulching: Mulch shall be placed to a depth of no less than two inches (2") and no more than three inches (3"). The mulch shall be placed so that it fully covers the entirety of the

planting hole, backfill, and berm. The mulch shall come out past the berm by at least one inch (1") but no more than three inches (3"). Mulch shall not be piled up or "volcanoed" around the base of the tree.

9. **Staking:** Immediately after installation, all deciduous and coniferous trees shall be staked. Staking shall be done with two (2) six-foot (6') tall steel tee posts. Two (2) stakes shall be used for all trees, deciduous and conifer. Stakes shall be placed in undisturbed ground outside the edge of the tree mulch ring. The tree shall be guyed using a one and one-half inch (1-½") wide nylon strap with eyelets on each end. A double strand of #20 gauge galvanized wire shall be used to connect the nylon strap to the steel t-post. A clean cut white PVC pipe shall be installed on the wire between the nylon strap and the t-post. The contractor shall be responsible for the removal of all tree stakes approximately one (1) year after installation date.
10. **Tree installation on a hill:** Planting procedure will follow the previous guidelines. However, the uphill side of the slope will be used to determine the planting depth of the tree. Soil will be built up forming a large berm on the downhill side of the planting hole in order to raise the ground level to be even around the root ball/tree

1043.05 Clean-Up

1. The contractor shall keep all areas of work clean, neat, and orderly at all times. All rocks, concrete, gravel, containers, wires, ropes, equipment, excess soil, etc. and other tree planting debris must be thoroughly removed from each planting site.
2. All materials shall be cleaned up and removed from the work area daily. Under no circumstances shall accumulation of soil and/or other debris be allowed in such a manner as to result in a hazard to the public.

1044.00 Maintenance

Following the installation of plant material, the Contractor shall be responsible for all maintenance until the project receives Initial Warranty Acceptance. Maintenance shall include hand-watering, weeding, spraying, cultivating, trimming, mulching, tree-wrapping, tightening and repairing guy wires, removal and replacement of all dead materials, and resetting plants to proper grade and an upright position as required. By the time of final inspection for final acceptance, plant grower tags shall be removed. The landscaping shall be finally accepted for warranty and guaranteed by the Contractor, after the following conditions have been met.

1044.01 Tree Wrapping

After installation, all deciduous trees shall be wrapped by the contractor from November 1st until April 1st of the following year. No wrapping shall be permitted until the trees have been inspected by the Project Manager. The trunks of all trees shall be wrapped spirally from bottom to top, overlapping the seams and entirely covering the trunk from the ground up to the first branch. The tree wrap shall be neat, snug and secured with black vinyl electrical tape at the top, middle, and bottom sections of the wrap. If the wrap has a label on it, it shall be installed so that the label faces the trunk and is not visible once installation is completed. Only approved four-inch (4") wide tree wrap shall be used. The tree wrap must be brown and designated for use as a tree/trunk wrap. No tree wrap with an asphalt layer shall be installed. All tree wrap shall be removed and disposed of by the contractor beginning April 1st.

1044.02 Watering

The contractor shall water all trees manually at least twice a month, but no more than once a week, with 25 gallons of water.

1045.00 Guarantee and Warranty of Plants

Arvada shall inspect plant materials for conformance to the approved plans and these Standards and Specifications. Unsatisfactory plant material shall be rejected. Inspections may be performed onsite for projects with less than twenty (20) plants and at the supplying nursery for projects with twenty (20) or more plants, unless plant material is coming from out of state in which case it will be inspected upon arrival. Following is the sequence of required inspections:

- A. Prior to installation
- B. After installation
- C. Six (6) months after Construction Acceptance into Warranty
- D. Before Final Acceptance/Release from Warranty

The Contractor will replace all plants which die during the two year warranty. Exceptions will be made for plants which die during this period due to vandalism or neglect. Replacement materials will be identical in size and species to the original plants specified. Replacement materials will conform to the standards in section 1042.00 - Materials of these Standards and Specifications. The Parks Project Manager reserves the right to reject any replacement materials not meeting City of Arvada Standards as laid out in standard 1042.00.

Contractor agrees to replace dead plants within two weeks after notification or as directed by the Parks Project Manager. All warranty replacement of plant materials shall be performed according to standard 1044.00. The Parks Project Manager will maintain an accurate copy of the planting plan indicating which specimens were removed and/or replaced.

1050.00 Landscape Irrigation Systems

1051.00 General

If a developer/owner is responsible for installation of an irrigation system that will be privately owned, controlled and maintained, the following specifications apply to their installation through the vacuum breaker. Downstream of the vacuum breaker, the developer/owner and their contractor are not controlled by these specifications, unless the developer/owner chooses, by reference, to incorporate all or portions of these specifications in their project.

The Contractor will locate equipment in positions indicated on approved irrigation plans as much as possible. The Project Engineer shall review and approve deviations prior to installation. Work of this Section generally includes provisions for the installation of an underground irrigation system including the following:

- A. Static pressure verification and coordination of irrigation system installation with landscape material installation.
- B. Trenching, refilling and compacting trenches.
- C. Complete irrigation system including but not limited to piping, valves, fittings, heads, central control system, controllers and wiring, and final adjustments to insure complete coverage.
- D. Water connections.
- E. Replacement of unsatisfactory materials.
- F. Clean-up, inspections, and approval.
- G. Tests.

1052.00 Materials

1052.01 Automatic Irrigation Control System

An electric controller (or “clock”) will be supplied, installed and operated by the Contractor during construction and until any contract-related turf/landscape is established and approved by the city. Upon completion and city acceptance of the project, the Contractor will remove the installed electric controller and install the city’s Motorola controller, unless otherwise specified.

The Motorola controller will be purchased by the City; a cost for which each developer will reimburse the city as a condition of approval for the irrigation system.

Installation:

- A. For city owned or controlled projects, the Contractor shall:
 1. Install the controller in accordance with manufacturer's instructions as detailed and where shown on the construction plans.
 2. Connect remote control valves to the controller in the same numerical sequence that is shown on Drawings.
 3. Coordinate with the Inspector for the review and approval of the final location for the controller prior to installation.
 4. Ensure that each controller installation shall include a dedicated separate ground wire and grounding rod, per the manufacturer's recommendations.
 5. Install all above-ground conduits with rigid galvanized pipe and appropriate fittings. Likewise, the Contractor will install all below-ground conduits with schedule 40 PVC.
 6. Furnish a temporary electric controller during the contract period.
 7. Upon completion of each project, the Contractor will remove the electric clock and install the city's Motorola controller. The Motorola controller will be purchased by the City (a cost which developers will reimburse the City as a condition of approval for the irrigation system, or as otherwise approved in a Development Agreement between the City and the developer).

1052.02 Control Wiring

The Contractor will position wire alongside the pressure supply mainline or sub-mainline, where possible. If wire is not located with the mainline, the Contractor will position it alongside non-pressure piping. These requirements will be verified by the Project Engineer.

Low Voltage:

- A. Electrical Control Wire - AWG UFUL approved No. 14 direct burial copper wire.
- B. Electrical Common Wire - AWG UFUL approved No. 12 direct burial copper wire.
- C. Wire Colors:

1. Control Wires - Red
 2. Common Wires - White
 3. Master Valve/Flow Meter Wires - 2 Blue, 2 Purple, 2 Orange (6 wires total to each unit)
 4. Spare Control Wires – Black
 5. Spare Common Wires – Yellow
 6. Tracer Wire – Green AWG UFUL No. 14 direct burial copper wire
- D. If multiple controllers are utilized, and wire paths of different controllers cross each other, both common and control wires from each controller shall be different colors approved by the Project Engineer.
- E. Control and Tracer Wire connections and splices shall be made with 3M DBY or approved similar dry splice method in an approved splice box, such as a Carson #910-10
- F. Installation
1. The Contractor will:
 - a) Bury control wiring between controller and electric valves in pressure supply line trenches, strung as close as possible to the pressure supply lines. The Contractor will position this wire consistently below and to one side of the pipe, or in separate parallel trenches.
 - b) Bundle all 24-volt wires at 10-foot intervals and lay with a pressure supply line pipe or other pipe to one side of the trench.
 - c) Provide an expansion loop at every pressure pipe angle fitting, every electric control valve location (within the valve box), and every 500 feet. The Contractor will form an expansion loop by wrapping wire at least 8 times around a $\frac{3}{4}$ -inch pipe and withdrawing pipe.
 - d) Master valve wires shall be run sub grade, in continuous conduit from irrigation controller pad to backflow/master valve assembly pad.

High Voltage: Type required by local codes and ordinances, of proper size to accommodate needs of equipment serviced.

- A. Installation
1. The Contractor shall:
 - a) Provide 120-volt power connection to the automatic controller.
 - b) All electric work shall conform to local codes, ordinances, and authorities having jurisdiction. All high voltage electrical work shall be performed by an electrician licensed in Arvada.

- c) All electric lines underground will be installed in UL approved schedule 40 P.V.C. pipe with warning tape placed above the pipe.
- d) Make all splices and E.C.V. connections using 3M DBY or similar approved, dry splice method.
- e) Install all control wire splices not occurring at the control valve in a separate wire stub box.
- f) Install one control wire for each control valve.
- g) Run four spare #14 AWG UF control wires and two # 12 AWG UF common wire from controller pedestal to the end of each and every leg of the pressure supply mainline. The Contractor will label spare wires at the controller and at the wire stub box. Specification spare wires are in addition to spare wire stubs noted on Construction Documents.

1052.03 Lateral Tracer Wire

Lateral Tracer Wire – One # 14 UF copper tracer wire in the same trench with all lateral lines running continuously from valve to end of lateral line. Coil an additional 12" at all bends and an additional 24" in valve box.

1052.04 Master Valves

Master valve(s) will be purchased by the City out of the project budget and supplied to the contractor when they are ready to install the backflow preventer(s).

Flow Units: The Contractor will install, per the Manufacturer's recommended specifications:

- A. All Master Valves / Flow Units will be installed above ground – per details.
- B. All Master Valves / Flow Units will be ARAD Valves, normally closed.
- C. All Master Valves shall be installed vertically, above grade, immediately downstream of shutoff #2 on Backflow Preventer.

1052.05 Electric Control Valves

Show size and type on Drawings having manual flow adjustment and manual bleed nut (Rainbird EFB-CP Series or approved equal for clean water systems and Rainbird 300 BPES or approved equal.) For all control valves, the contractor will include a true-union ball valve if the control valve is 1 inch or less. For control valves larger than 1 inch, a standard threaded ball valve shall be installed. All ball valves shall be the same size as the control valve, installed on the inlet side of the valve (see details or install per manufacturer's recommendations).

The Contractor shall install the valve cross-handle 3 inches below finished grade where shown on the construction plans and as detailed. When grouped together, allow at least 12 inches between valve box sides. When installed adjacent to curbing and walks, allow 24 inches between valve box and walk/curb. Install each remote control valve in a separate valve box. Install each valve box lid flush with grade. All electric Control Valves under 1 inch will have a True-Union Ball Valve installed on the inlet side of the valve.

1052.06 Sprinkler Heads

- A. As indicated on the construction plans. The Contractor shall use fabricated riser units in accordance with the construction plans, or as otherwise specified, with riser nipples of the same size as the riser opening in the sprinkler body (Rainbird or approved equal). For all pop-up spray heads, the contractor shall use Rain Bird M.P.R. plastic nozzle no van nozzles allowed, and no marlex fittings allowed.
- B. Installation
 1. The contractor shall:
 - a) Install sprinkler heads in positions as shown on the approved plans.
 - b) Set each head in the specified position relative to finished grade to comply with the Manufacturer's recommendation, or as otherwise detailed.
 - c) Space heads not to exceed the maximum indicated on the Irrigation Plans.
 - d) Install heads on double swing-joint risers of schedule 40 PVC pipe. Angled nipple relative to non-pressure line shall be no more than 45 degrees or less than 10 degrees.
 - e) Adjust part circle heads for full coverage of the landscaped area, avoiding paved surfaces.
 - f) Adjust heads, as needed, to the correct height after sod is installed.

- g) Ensure plant placement shall not interfere with intended sprinkler head coverage, piping, or other equipment.
- C. If a distribution problem is identified by the Inspector, the City may request nozzle changes or other adjustments.

1052.07 Pipe

General Piping: No Galvanized pipe will be allowed on any irrigation system, unless specifically approved in the project specifications.

- A. Pressure Supply Lines - Class 200 PVC BE (1" - 2 1/2"), Class 200 PVC RT (3" through 10").
- B. Non-pressure Lines - Class 200 PVC BE.
- C. PVC Sleeving – Class 200 PVC.
- D. Snake pipe in trench as much as possible to allow for expansion and contraction. Do not install a pipe when the air temperature is below 40 degrees F. Place manual drain valves at low points and dead ends of pressure supply piping to ensure complete drainage of the system as required. When pipe installation is not in progress, or at the end of each day, the Contractor will close the pipe ends with a tight plug or cap. The Contractor will install PVC Pipe in accordance with the manufacturer's recommended specifications.

Plastic Pipe and Fittings:

- A. Identification Markings:
 1. Identify all pipe with following indelible markings:
 - a) Manufacturer's name.
 - b) Nominal pipe size.
 - c) Schedule of class.
 - d) Pressure rating.
 - e) NSF (National Sanitation Foundation) seal of approval.
 - f) Date of extrusion.
- B. Solvent Weld PVC Pipe - Manufactured from virgin polyvinyl chloride (PVC) compound in accordance with ASTM D2241 and ASTM D1784; cell classification

12454-B, Type 1, Grade 1.

1. Fittings - Standard Wright, Schedule 40, injection molded PVC; complying with ASTM D1784 and D2466, cell classification 12454-B.
 - a) Threads - Injection molded type (where required).
 - b) Tees and ells - Side gated.
 2. Threaded Nipples - ASTM D2464, Schedule 80 with molded threads.
 3. Joint Cement and Primer - Type as recommended by manufacturer of pipe and fittings. Only Weldon P-70 Primer and Weldon 711 Gray Glue or Weldon 725 Wet & Dry Glue will be allowed.
 4. Installation
 - a) The Contractor shall lay pipe and make all plastic to plastic joints in accordance with manufacturer's recommendations.
- C. Gasketed End Pipe - Manufactured from virgin Polyvinyl Chloride compound in accordance with ASTM D2241 and ASTM D1784; cell classification 1254-B, Type 1, Grade 1.
1. Fittings and Services Tees (3" and 4") - Ductile iron, grade 70-55- 05 in accordance with ASTM A-536. Fittings shall have deep bell push-on joints with gaskets meeting ASTM F-477. Unless otherwise indicated in the project specifications, all fittings will have pipe restraints and thrust blocks. 6" and larger pipe will have a mechanical joint fitting.
 - a) Gaskets - Factory installed in pipe and fittings, having a metal or plastic support within the gasket or a plastic retainer ring for the gasket.
 - b) Lubricant - As recommended by the manufacturer of pipe fittings.
 - c) All gasketed fittings will have Leemco Joint Restraints or approved equal. Leemco Joint Restraints will be attached per manufacturer's installation guide.
 2. Installation:
 - a) The Contractor will lay pipe and make pipe-to-fittings or pipe-to- pipe

joints following OR70 recommendations (Johns-Manville Guide for Installation of Ring-Tite Pipe) or follow the pipe manufacturer's recommendations.

- b) The Contractor shall construct thrust blocks behind all gasketed fittings, tees, bends, reducers, line valves, and caps in accordance with pipe manufacturer's recommendations. The Contractor shall size thrust blocks as specified for each project.

1052.08 Quick Coupler Valves

Brass two-piece body designed for working pressure of 150 PSI; operable with quick coupler. Equip quick coupler with locking rubber cover. Key size and type as shown on plans and specifications for each project. (Rainbird 44 R.L.C. / 1-inch rubber locking cover or approved equal.)

The Contractor will install quick couplers on double swing-joint assemblies of Schedule 80 PVC pipe, plumb and flush to grade. Angled nipple relative to pressure supply line shall be no more than 45 degrees and no less than 10 degrees. Install quick coupling valves.

1052.09 Drain Valves

The Contractor will install a Ford $\frac{3}{4}$ -inch slotted, manual drain valves at locations shown on plans. Provide a six cubic foot drainage sump under each drain valve.

1052.10 Gate Valves and Isolation Valves

Gate Valves and Isolation Valves for 3/4 inch through 2 Inch Pipe – a “Ford B-44 Curbstop Ball Valve.”

Gate Valves and Isolation Valves for 2 $\frac{1}{2}$ Inch Pipe - Brass construction; solid wedge, IPS threads, and non-rising stem with **square operating nut**.

Gate Valves and Isolation Valves for 3 Inch and Larger Pipe - Iron body, brass or bronze mounted AWWA gate valves with a clear waterway equal to full nominal diameter of valve, mechanical joint-type only. Valves shall be able to withstand a continuous working pressure of 200 psi and be equipped with a **square operating nut** and resilient wedge seat.

1052.11 Valve Boxes

Installation

- A. The Contractor will:
1. Install one valve box for each type of valve installed. (Valve box extensions are not acceptable.) Install a gravel sump at each valve location after compaction of all trenches. Place gravel inside the valve box after the valve box is backfilled and compacted.
 2. Brand the controller letter and station number on the lid of each valve box. Letter and number size shall be no smaller than 1 inch and no greater in size than 1 1/2 inches. Depth of branding shall be no more than 1/8 inch into valve box lid.

Required with installation of the following:

- A. Gate Valves, Isolation Valves, Quick Coupling Valves, Drain Valves and Wire Stub Box Carson/Brooks #910-10 box, or equal, with ID branded on lid.
- B. 3/4 inch through 2 inch Control Valves (which includes a true union ball valve in the same box - Carson Brooks #1220-12 Jumbo box with valve # branded on lid that corresponds to the valve number identified for the same zone on the controller chart..
- C. 3 inch and larger control valves will have the true union ball valve in a separate Carson 1220-12 Jumbo Valve Box. Each control valve will be in a separate Carson 1220-12 Jumbo Valve Box with valve # branded on lid that corresponds to the valve number identified for the same zone on the controller chart.

1053.00 Process

1053.01 Staking

- A. The Contractor will mark, with water-based marking paint, the intended routing of the main pressure supply line and flag heads for all zones. The Contractor will contact the Inspector 48 hours before this work will be completed and request an inspection of the staking based on the design plans with the Contractor's recommended site adjustments. The Inspector shall review staking and recommend changes that the contractor may choose to make or not. Whether the contractor chooses to make the changes or not, the Contractor is ultimately responsible for resolving coverage problems due to the placement of irrigation heads.

- B. If a Project has significant topography, freeform planting beds, or other amenities, which could require changes to the layout of irrigation equipment from the approved design plans, the Contractor will submit an RFI for City approval.

1053.02 Sleeving

- A. The Contractor will install sleeving under curbs, gutters, paving and pavers, trails and concrete sidewalks, prior to installation of these structures and surfaces, wherever piping and wiring are intended on the irrigation plans. The contractor will compact backfill around sleeves to 95% Modified Proctor Density within 2% of optimum moisture content in accordance with ASTM D1557. Compaction shall be verified by the project manager or the Parks Maintenance staff.

1053.03 Trenching

- A. Trench excavation shall follow, as much as possible, the intended layout shown on irrigation plans. The contractor will dig trenches straight and vertical, that support pipes continuously on the trench bottom. The contractor will ensure that the trench bottom is an open, level surface cleared of all rock and other inorganic and organic debris.

1. Clearances:

- a) Piping 3" I.D. and Larger – The contractor will ensure that trenches are sufficient width (14 inches minimum) to properly assemble and position pipe in trench prior to installation of the pipe and fittings. The Contractor will also ensure that the clearance for piping 3 inches or larger is a minimum of 5 inches horizontally on both sides of the pipe.
- b) Piping Smaller than 3 Inches – The contractor will ensure that trenches are a minimum of 7 inches wide for all pipes smaller than 3" I.D. prior to installation of the pipe and fittings.
- c) Line Clearance – The contractor will provide not less than 6 inches of horizontal clearance between each irrigation line and not less than 5 feet of horizontal clearance between irrigation lines and underground utilities, located within the project. No vertical stacking of irrigation pipe is allowed on any new irrigation installation project and no vertical stacking of irrigation pipe is permitted around existing irrigation pipe unless written approval is given by the Project Engineer.

- d) These requirements will be verified by the Project Engineer.
- 2. Pipe and Wire Depth: The contractor will ensure the proper depth for each of the following pipe classifications intended for the project:
 - a) Pressure Supply Mainline - 24 inches from top of pipe to finished grade.
 - b) Pressure Supply Sub-mainline - 24 inches from top of pipe to finished grade.
 - c) PVC Sleeving – Sleeves will be set at the depth required for each irrigation pipe. Pipes with different depth requirements will be placed in separate sleeves at the required depths below finished grade.
 - d) Non-pressure Piping (for gear-driven and rotor heads) - 18 inches from top of pipe to finished grade.
 - e) Non-pressure Piping (pop-up spray heads) - 12 inches from top of pipe to finished grade.
- 3. Boring will be permitted only where pipes must pass under obstruction(s) which cannot be removed, such as tree root zones, pavements, etc. In backfilling bore, final density of backfill shall match that of surrounding soil. It is acceptable to use sleeves of suitable diameter installed first by jacking or boring, and pipe laid through sleeves. Observe the same precautions as though pipes were installed in an open trench. No tunneling will be allowed.

1053.04 Piping Under Paving

- A. Provide for a minimum cover of 18 inches between the top of the pipe and the bottom of the aggregate base for all pressure and non-pressure piping installed under asphaltic concrete or concrete paving or other pavements.
- B. Provide squeegee sand (a layer 6" below pipe and 6" above pipe) bedding under all pipe located under areas intended for new asphalt or concrete paving
- C. Compact backfill material in 6" lifts at 95% Proctor Density determined in accordance with ASTM D155-7 using manual or mechanical tamping devices.
- D. (If paving has not occurred) Set in place, cap, and pressure test all piping to the satisfaction of the Inspector prior to trench backfilling and paving operations.

- E. Pipe under existing walks or concrete pavement by jacking, boring, or hydraulic driving.

1053.05 Backfilling

The Contractor will not begin backfilling operations until all required system tests have been completed, except within ten (10) feet of trails or sidewalks open to the public.

1053.06 Static Pressure Verification

The Contractor shall field verify the static pressure available at the project site, prior to commencing work or ordering irrigation materials, and submit findings, in writing, to the Project Engineer. If the Contractor fails to verify static water pressure prior to commencing work or ordering irrigation materials, the Contractor shall be required to make the irrigation system operational and replace any landscape materials damaged by irrigation system problems.

1053.07 Winterization

Contractor winterization shall be within three (3) work days after notification by the Project Engineer. The Contractor will remove all water from the system using compressed air or a similar method approved by the Project Engineer. Likewise, the Contractor will recharge, operate, and adjust the irrigation system, repairing any malfunctions encountered, during April of the following season on a date within seven (7) calendar days of notification by Project Engineer.

1053.08 Field Quality Control

The Contractor will satisfy the following requirements:

- A. Flushing - After piping, risers, and valves are in place and connected, but prior to installation of sprinkler heads and quick coupler assemblies, the Contractor will thoroughly flush the piping system under full head of water pressure from dead end fittings. Maintain flushing for 5 minutes through the end of all pressure lines and non-pressure lines. Once all contamination from the inside of the pipes is cleared, the Contractor will cap risers.
- B. Testing – The Contractor will conduct tests in the presence of the Inspector. The Contractor will provide a minimum of 48 hours notice in advance of the testing. The Contractor will supply force pumps and all other test equipment. With a minimum of two pressure gauges (of 160 P.S.I.) or as determined by the City.

After backfilling and installation of all valves, the Contractor will fill the pressure supply line with water, and pressurize it to 120 PSI, then hold that pressure without any loss of pressure and without any additional pressurization, for a test period no less than 2 hours. Leakage, Pressure Loss shall not be evident during the test period. If leaks or pressure loss are detected, the Contractor will repair them. As needed, the Contractor will retest the system until test pressure can be maintained for duration of test and until all leaks are repaired. Before final acceptance, the Contractor will ensure that the pressure supply line shall remain under pressure for a period of 48 hours with static pressure. The Contractor is required to eliminate any water losses. The system will not be accepted until this requirement is satisfied.

1053.09 Adjusting

Upon completion of installation, the Contractor will "fine-tune" the entire irrigation system by regulating valves, adjusting irrigation head patterns and break-up arms, and setting pressure reducing valves at pressures necessary to provide optimum and efficient coverage. The Contractor will flush and adjust all sprinkler heads for optimum performance and prevent overspray onto walks, roadways, and buildings as much as possible. The Contractor will ensure that irrigation heads of the same type shall be operating at the same pressure +/- 7%.

- A. If it is determined that irrigation adjustments will provide proper coverage and improved water distribution as determined by the Inspector, the Contractor shall make these adjustments prior to Final Acceptance, as directed by the Inspector. Such adjustments may include changes in nozzle sizes, degrees of arc, and control valve throttling.
- B. The Contractor will set all sprinkler heads perpendicular to finished grade unless otherwise directed for optimum performance.
- C. If elements of the system do not conform to the requirements in the specifications due to unauthorized changes or poor installation practices, the Contractor shall immediately make corrections.

1060.00 Recreation Facilities

1061.00 General

Selection of recreation equipment shall be approved by Arvada prior to purchase by the Contractor. In selecting equipment, the brand, style, color, size and other criteria shall be considered and jointly selected by the Contractor and Arvada. All installations of equipment shall be done by the Contractor.

1062.00 Ballfields

1062.01 Skinned Infield

Adequate drainage shall be taken into account in all ball field designs. Infield slopes shall be between half (1/2%) percent and one and one half (1-1/2%) percent. Infield shall be designed so that drainage falls away from the infield surface. Outfield slopes shall be between one and one-half (1/2%) percent and one (1%) percent. Outfields shall be designed so that drainage falls away from the infield surface.

Install Razum Red® Infield Mix with Stabilizer for baseball or softball field surfacing, Color “Reddish Brown”.

A. Razum Red® infield mix with Stabilizer shall be produced by use of mechanical pugmill blender and metering controls for accurate proportioning of soil binder @ 8 lbs. per ton. Soil binder shall be a natural, non-toxic, non-staining, odorless, environmentally safe powder. The powder binder shall be “Stabilizer®” as manufactured and patented by Stabilizer Solutions, Inc. Product to have 64% pre-consumer recycled content. Soil binder shall have 30 years experience at same formulation.

Razum Red infield Mix with Stabilizer Gradation:

PART 3 - Sieve Size (mm)	Sample Mix % Retained	Infield Mix Guidelines
#5/4.0	0.0	0
#10/2.00	2.3	<=3%
#18/1.00	20.8	>50% of total sand combined
#35/.50	20.9	
#60/0.25	13.8	
#140/0.10	9.1	
#270/0.05	4.6	<=5%

Stabilizer®	8#’s/ton	
USDA Texture	Sandy/loam	
Sand	69.2	65-75%
Silt	16.9	
Clay	13.9	>=13%
SCR	1.2	<=1.2

1062.01.01 Execution

1062.01.02 Preparation

- A. The infield area shall be excavated eight (8) inches below grade and eight (8) inches of suitable infield mixture consisting of an approved blended mix of sand, silt, and clay and shall be installed; laser leveled, and compacted to a firm, smooth surface. All mixtures shall require submittal and be approved by the Project Engineer.
- B. Proper base preparation is essential in the performance of the Razum Red® Infield Mix with Stabilizer. Base material should be leveled or laser graded to same grade as Razum Red® Infield Mix with Stabilizer. Base material has to be level to ensure Razum Red® Infield Mix with Stabilizer is at a uniform depth of four (4) to six (6) inches across entire field.
- C. Pre-soak base material with water prior to installing Razum Red® Infield Mix with Stabilizer and allow base to dry. Once dry, compact base to 95% compaction. Sand is not an acceptable base.

1062.01.03 Blending

- A. Razum Redr® Infield Mix with Stabilizer is a solely owned process. Blending procedures are performed only by a licensed Stabilizer® “Razum Red” Infield Mix blender and can only be sold through licensed Stabilizer® “Razum Red” Infield Mix Dealers.

1062.01.04 Placement/Compaction

- A. Place Razum Red® Infield Mix with Stabilizer at a 4” to 6” compacted depth. Allow for an approximate 1 inch cushion for compaction

1. Estimated Coverage:
 - a. 1" Depth = 180 sqft. Per ton
 - b. 2" Depth = 90 sqft. Per ton
 - c. 3" Depth = 60 sqft. Per ton
 - d. 4" Depth = 45 sqft. Per ton
 - e. 6" Depth = 30 sqft. Per ton
- B. Grade Razum Red® Infield Mix with Stabilizer with box blade, laser grader or equal to <=1% slope.
- C. Water heavily for full-depth moisture penetration of profile. Water activates Stabilizer®, saturate to total depth. Apply 25 to 45-gallons of water per 1-ton. Application test moisture using a probing device reaching full depth.
- D. Compact Razum Red® Infield Mix with Stabilizer once moisture begins to dry and surface is able to accept roller without any deformation or pumping.
 1. Compaction can be achieved by a 1-ton double-drum roller
 2. Compact material making 1 to 2 passes.
 3. Use plate compactor, water roller, or hand tamp on edges and hard to reach areas.
- E. Check for low areas and add additional Razum Red® Infield Mix with Stabilizer to level.

1062.01.05 Inspection

- A. Finished surface shall be uniform, solid under foot, with desired amount of loose surface material. Compacted Razum Red® Infield Mix with Stabilizer shall be firm to full depth with no soft areas.

1062.01.06 Yearly Maintenance

- A. Add new Razum Red® Infield Mix with Stabilizer as needed.
- B. Rip and till the field once a year to bring fresh material to the surface. Avoid tilling base material or any outside soil in with Razum Red® Infield Mix with Stabilizer.
 1. If infield is dry, water the infield throughout the profile the night before.
 2. Mark base pegs and sprinkler heads if in the infield.
 3. Sweep all calcined clay off of infield
 4. Rip open infield with tractor rippers to make the tiller's job easier.
 5. Add additional Stabilizer®, with a drop spreader at this time. Stabilizer® should be

spread 1 lb per 45 square feet on the infield.

6. Till to a 2-2.5 inch depth and always beware of getting into your base material when you are tilling.
7. After tilling, the infield should be leveled, preferably by a laser grader to achieve a $\leq 1\%$ slope.
8. New infield mix should also be added at this time, leveled, watered, and rolled.

C. Level and compact field as needed with box blade or laser grader to $\leq 1\%$ slope.

1062.01.07 Repairs

- A. Excavate damaged area to the depth of the Razum Red® Infield Mix with Stabilizer and square-off sidewalls.
- B. Mix Razum Redr® Infield Mix with Stabilizer with water and apply to the excavated area to finish grade.
- C. Compact with an 8" to 10" hand tamp or 1000 lb. Roller.

1062.02 Softball Infield

Infields shall be cut on a seventy (70') foot arc from the back center of the pitching plate. Home plate shall be twenty-five (25') feet from the backstop, and the foul line shall be twenty-five (25') feet from wing fences. The pitching plate shall be located fifty (50') feet from the back point of home plate. Up to three (3) sets of approved base receptacles shall be provided to accommodate play of different age groups. Infields shall include at least (4-7) irrigation heads designated to water the infield surface. The irrigation head layout design shall be shown on the approved plans.

1062.03 Baseball Infield

Infields shall be cut on a ninety-five (95') foot arc from the back center of the pitching plate. Home plate shall be thirty-five (35') feet from the backstop with foul lines thirty-five (35') feet from wing fences. The pitching plate shall be located sixty (60') feet six (6") inches from the back point of home plate. Up to three (3) sets of base receptacles shall be provided to accommodate play of different age groups. Infields shall include at least (5-7) irrigation heads designated to water the infield surface. The irrigation head layout design shall be shown on the approved plans. Dugouts shall have two (2) entrances on each end to the playing surface.

1062.04 Field Composition

The infield area shall be excavated eight (8") inches below grade and eight (8") inches of suitable infield mixture consisting of an approved blended mix of sand, silt, and clay and shall be installed; laser leveled, and compacted to a firm, smooth surface. All mixtures shall require submittal and be approved by the Project Engineer.

1062.05 Field Drainage

All areas outside of ball field fencing such as concrete bleacher pads, walks and landscaping shall be graded to drain away from the field surface. Construct concrete drainage pan on perimeter of outfield fences, and wings.

1062.06 Fencing

A. Fabric:

1. All chain-link fabric shall be #6 gauge, knuckled selvage top. Outfield wing fencing and home run fence can be #9 gauge. Dugout sides and backs can be #9 gauge.
2. Fabric must have knuckled selvage bottom; two and one-half (2-1/2) inch mesh.
3. Fabric must be continuous length (no splices permitted),

B. Posts and Rails:

1. Backstop support posts shall be four-inch (4") O.D. minimum, 7.29 lbs. per foot of pipe.
2. Terminal and gate posts shall be 2-7/8" O.D. minimum, 4.64 lbs. per foot of pipe.
3. Line posts shall be 2-%" O.D. minimum, 3.117 lbs. per foot of pipe.
4. Top rail and horizontal bracing shall be 1-5/8" O.D. minimum, 1.836 lbs. per foot of pipe.

C. Fittings and Hardware:

1. Top rail caps, rail end caps, brace bands, tension bands shall be pressed steel or cast steel; all commercial quality.
2. Nuts and bolts shall be commercial fencing quality.
3. All top rail caps shall be rounded top with no points or extrusions.

D. Wire and Ties:

1. Post and rail tie wires shall be #12-1/2 gauge steel.

- a. Tie wires on line posts: 12" on center (maximum).
 - b. Tie wires on rails: 24" on center (maximum).
2. Tension wire shall be #7 gauge steel wire.
 - a. Tension wire shall be woven through fabric in all applications, or attached to fabric using galvanized steel hog rings, minimum #9 gauge steel and woven through fabric at the second diamond, 4" from bottom.
 - b. Fencing over 4'-0" height: Additional tension wire, continuous length, woven through fabric at 2'-0" above bottom of fabric.
 - c. Backstops: Continuous length, woven through fabric at bottom, 18" and 36" above bottom.

3. Tension bar shall be 3/16" x 4" steel.

E. Dimensions:

1. Backstop dimensions shall be thirty (30') feet tall and eighty (80') to one hundred (100') feet in total length based on age group. Baseball backstops shall include a hood. The hood on baseball backstops may be nine (9) gauge fabric.
2. Wing fences and dugout faces shall be ten (10') feet tall from the backstop to a distance of one-hundred (100') feet.
3. Wing fences from the ten-foot (10') tall section to the home run fence (if applicable) shall be four feet (4') high; poly-cap fence top protector shall be installed in four feet (4') wing fence.
4. Dugout fence sides and backs shall be six (6') feet tall.
5. Home run fences shall be eight (8') feet tall; poly-cap fence top protector shall be installed in the outfield fence.
6. All posts, terminal, line, and backstop posts shall be spaced ten (10') feet apart or less, with even spacing, except for dugouts.
7. Backstop boards shall be installed on both sides of the chain-link fence with carriage bolts. Rounded-side of carriage bolt towards the field of play and cut flush with the bleacher-side board. On the backstop portion, they shall consist of two (2) 2 x 12's. The elevated wing fence shall consist of one (1) 2 x 12. The board material shall be approved

by the Project Engineer. Boards should be synthetic or pressure treated and stained before installation.

1062.07 Dugout Covers

All dugouts shall be covered with a metal roofed structure to be approved by the Project Engineer prior to installation. Dugout dimensions shall be thirty feet (30') by ten feet (10') with a latchable gate with hinges welded to post.

1062.08 Scoreboards

Power source sleeved with grey conduit, from score board location on outfield light pole and located behind home plate area.

1062.09 Soccer Field / Football Field / Multi-Use Field Specifications

Adequate drainage shall be taken into account in the field design. Field slopes shall be between one-half ($\frac{1}{2}$) percent and one and one half ($1\frac{1}{2}$) percent as determined by the Parks Project Manager..

1062.10 Subsurface Drainage

When drainage is required in landscaped areas it shall include the following material; four inch or larger perforated PVC pipe, three-fourths inch ($\frac{3}{4}$ ") crushed granite rock, tracer wire and approved landscape fabric. Trench line shall be no less than fourteen-inch (14") depth and two feet wide. Contractor shall install in succession; excavate trench line, line entire trench with fabric, install four-inch (4") or larger perforated PVC pipe with clean out drains, install #14 gauge wire (brown in color) to run the entire length, install three-fourths inch ($\frac{3}{4}$ ") washed granite rock on the top and sides of perforated PVC pipe and wrap with fabric to eliminate soils from contaminating rock. Rock sock shall finish three (3) inches below the finished grade. Contractor shall install two (2) to three (3) inches of organic soils placed on top of fabric and then reinstall manicured turf, native seed or landscaping.

1063.00 Playground Equipment

1063.01 Proposal Submittals

The manufacturer's representative shall provide the following items and information to Arvada with each playground proposal:

- A. Complete three-dimensional drawings of equipment.

- B. Individual components specifications and schematic drawings of the play system.
- C. A minimum of three (3) references for similar work recently completed. Each reference shall include a brief summary of work completed, location, and the owner's representative name and phone number.
- D. A schedule of work that includes the time it shall take to order and receive the playground equipment and the time it shall take to install once the play equipment is delivered.
- E. The name and qualifications of the installer of playground equipment.
- F. All guidelines, standards, laws and regulations that pertain to CPSC, ASTM and ADA shall be followed at the time of installation of equipment and surfacing.
- G. Warranties for playground equipment installed for Arvada shall meet or exceed the guidelines mentioned in section F, above. A letter from the manufacturer stating that the playground equipment shall meet or exceed the latest Consumer Product Safety Commission Guidelines and ASTM F1487. Letters from the manufacturers shall reference the model number or drawing numbers of each unit.

1063.02 Safety and ADA Requirements

All playground equipment shall meet or exceed the latest CPSC Handbook for Public Playground Safety Guidelines. All play equipment and the protective ground space area around the equipment shall meet or exceed ASTM F1487 Standard Consumer Safety Performance Specifications for Playground Equipment for public use.

All playground equipment shall comply with the current ADA guidelines using ASTM F1487. This can be accomplished either by a safety surface or a ramp system as determined by Arvada. The safety surface shall be an ADA approved surface for accessing the transfer point. The color of the surface shall be approved by Arvada.

1063.03 Protective Ground Space Area

The play system layout for each site shall include a safety surface area surrounded by a protective barrier. The safety surfacing shall be engineered wood fiber (EWF) or Poured in Place (PIP) and shall be specified by Arvada. EWF products shall meet the specifications in ASTM F2075: Standard Specifications for Engineered Wood Fiber and be tested to comply with ASTM F1292. EWF sieve and testing analysis should be available to Arvada staff upon request. Initially install all EWF to a minimum depth of fifteen inches (15") for 2-12 year old and 5-12 year old playgrounds, twelve inches (12") for 2-5 year old playgrounds, or the largest critical fall height in relation to the playground, whichever is greater. Finished grade on safety surfacing is not to exceed 2% slope. The sub base shall be compacted prior to EWF installation. A subsurface

drainage system shall be installed under each protective surface area. The drainage system design shall be approved by Arvada prior to installation.

A concrete border shall surround all new playground installations. The thickness and depth shall be shown on the approved plans.

1063.04 Materials

Playground equipment components shall comply with the following material requirements:

- A. Wooden structures shall not be allowed.
- B. All decking and steps shall be coated.
- C. Metal slides shall not be allowed unless specifically requested by Arvada.
- D. Support posts shall be five-inch (5") OD steel with corrosion protection, a powder-coated finish and metal caps.
- E. Playground decks shall be metal with PVC coating.
- F. Deck to deck riser enclosures shall be metal.
- G. Swing support framework shall be five-inch (5") OD steel with corrosion protection, a powder-coated finish and metal caps.

1063.05 Installation, Inspection, and Warranty

An installer or playground vendor representative shall supervise the unloading of all materials shipped to the individual job sites. Footings, subgrades, and drainage shall all be inspected by Arvada staff prior to supplying a finish grade. Playground equipment installers shall provide Arvada staff with a copy of the equipment manufacturer installation guidelines and equipment specifications prior to installing playground equipment. A company representative, along with Arvada staff shall conduct a post-installation inspection to certify the proper installation of playground equipment. Arvada staff reserves the right to inspect materials prior to installation with or without the Installer's representative present. Safety fencing shall be installed and maintained by the Installer until the installation is complete, the playground has been inspected, deficiencies have been corrected, and the project has been issued Initial Warranty Acceptance.

1070.00 Trails and Paths

1071.00 Maintenance Paths and Primary Walkways

All maintenance paths within the parks, open land areas, or greenbelts, which shall be utilized by the public and Arvada maintenance staff, shall be a minimum of ten (10) feet wide, and shall be constructed with a minimum of six-inch (6") thick concrete. The concrete shall comply with Section 800 – Concrete Mix Design And Construction of these Standards and Specifications. In

Specific Areas, Primary walkways shall be required to be wider than eight (8) feet, and a three-foot (3') wide crusher fines (“soft”) shoulder may be required.

1072.00 Soft Trails

Where applicable, soft trails shall be three (3) to eight (8) feet wide and constructed with a running slope less than 12.5:1 (horizontal:vertical). Short sections of trail may be constructed up to a maximum slope of 7:1, if approved by Arvada.

1072.01 Soft Trail Materials

Soft trail aggregate shall be three-eighths ($\frac{3}{8}$) inch minus decomposed granite or crushed material. It shall be gray unless otherwise approved. On slopes greater than 12:1 (horizontal:vertical) or locations identified as potential wash out areas a binder material shall be used. Binder material shall be StaLok® brand stabilizer. Binder material shall be used according to manufacturers specifications.

Timbers for cross members shall be eight (8) inch by eight (8) inch pressure-treated wood, recycled rubber or plastic. Each timber shall be anchored in place with three (3) twenty-four inch (24") #4 steel reinforcing bars (rebar).

1072.02 Trails With Slope Less Than 12:1 (Horizontal:Vertical)

Soft trails with a slope of less than 12:1 (horizontal:vertical) shall be constructed with a minimum of four (4) six (6) inches of compacted soft trail aggregate. Aggregate material shall be compacted in place to at least ninety-five (95) percent of the maximum standard proctor dry density as defined in ASTM D698.

1072.03 Trails With Slope Equal To Or Greater Than 12:1 (Horizontal:Vertical) and Washout Areas

Soft trails with a slope equal to or greater than 12:1 (horizontal:vertical) shall be constructed with four (4) to six (6) inches of soft trail aggregate stabilized with a binder material. Aggregate and binder materials shall be compacted in place to ninety-five (95) minimum of the maximum standard modified Proctor dry density as defined in ASTM D698. Binder mixing and installation shall strictly comply with the binder manufacturer’s recommendations.

Soft trails with a slope equal to or greater than 8:1 (horizontal:vertical) or identified as a washout potential area shall receive mitigation efforts. Wash out mitigation will use cross timbers as the preferred method but other mitigation systems such as, but not limited to: pipes, water bars, and

culverts, may be used if approved by the Project Engineer. Mitigation efforts shall be installed on the uphill part of the trail from the areas that have been identified as a potential wash out area so as to prevent water from running down the trail to the potential wash out area causing damage.

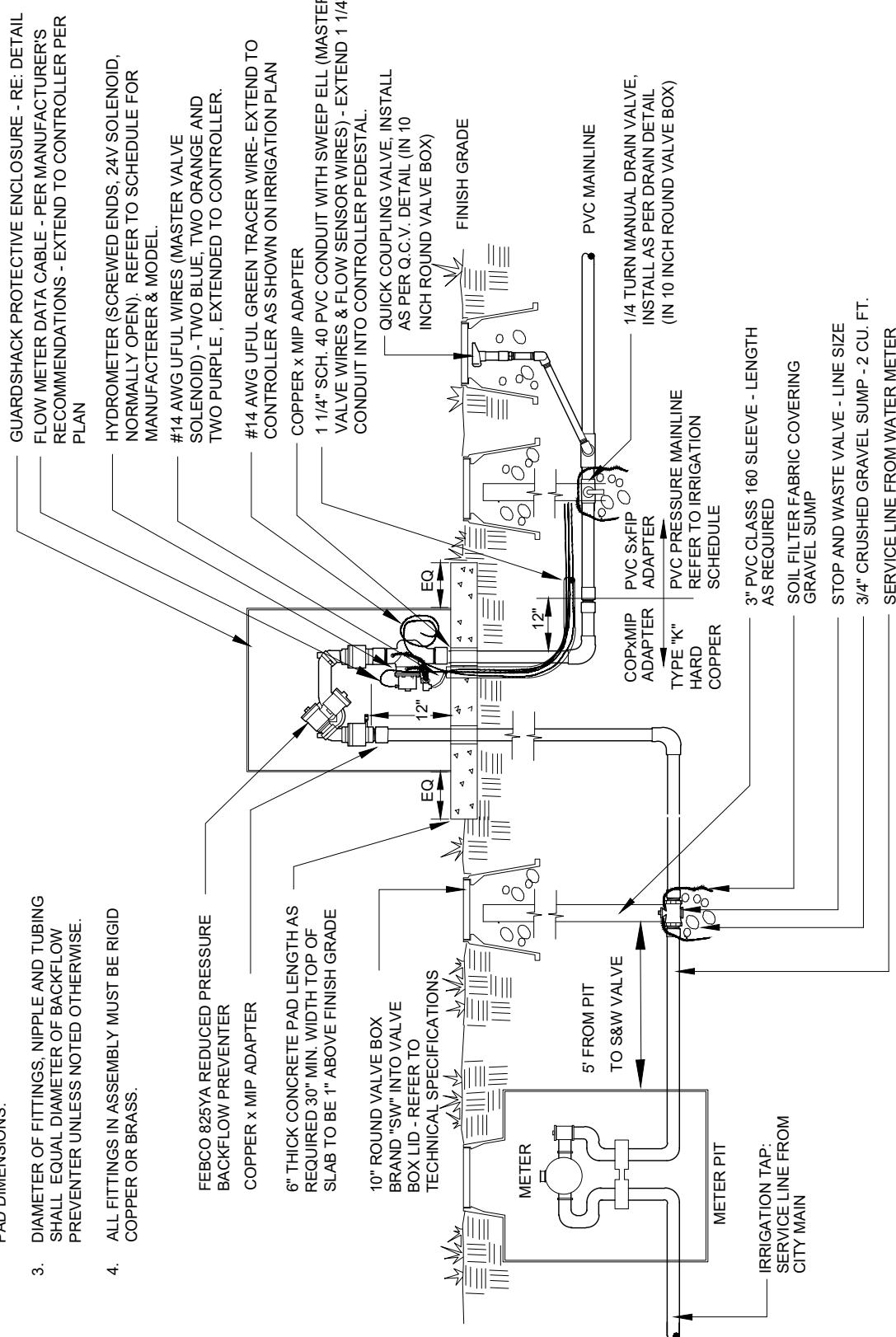
- A. Cross Timbers: Timbers shall be installed at twenty (20) foot intervals along the trail alignment. Timbers shall be installed at fifteen (15) degrees from perpendicular to the trail centerline. The top of the timbers shall be at the same level as the trail surface, and the bottom of the timbers shall be keyed into the binder-stabilized subgrade. Each timber shall be anchored in place with rebar as specified in 1072.01. No part of the rebar shall protrude above the top of the timber.

1072.04 Cross Slope

Soft trails shall be constructed with a uniform two (2) percent cross slope to encourage water to run-off to the side of the trail. If a slope can not be constructed into the trail then a crown in the center of the trail with a slope not to exceed 20:1.

NOTE:

1. CONCRETE PAD PENETRATIONS TO BE 1" LARGER THAN TUBING DIAMETER.
2. REFER TO ENCLOSURE DETAIL FOR CONCRETE PAD DIMENSIONS.
3. DIAMETER OF FITTINGS, NIPPLE AND TUBING SHALL EQUAL DIAMETER OF BACKFLOW PREVENTER UNLESS NOTED OTHERWISE.
4. ALL FITTINGS IN ASSEMBLY MUST BE RIGID COPPER OR BRASS.



NO	DATE	REVISION

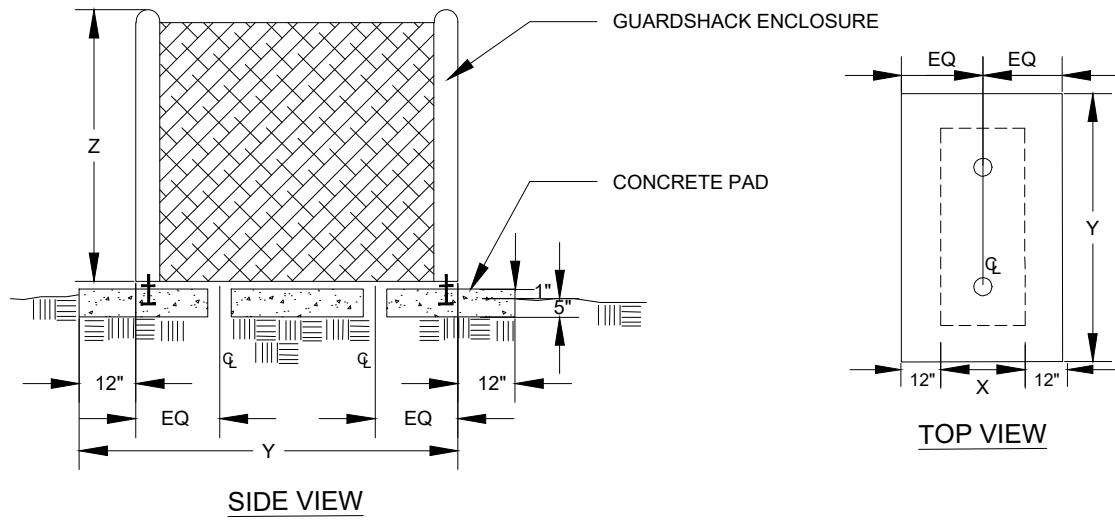


CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

POTABLE POINT OF CONNECTION 3/4" - 2"

2022 ENGINEERING STANDARDS & SPECIFICATIONS

BFP MODEL/SIZE	ENCLOSURE MODEL	X	Y	Z
FEBCO 825YA 3/4" & 1"	GS-5	10"	24"	18"
FEBCO 825YA 1½" & 2"	GS-1	10"	34"	24"



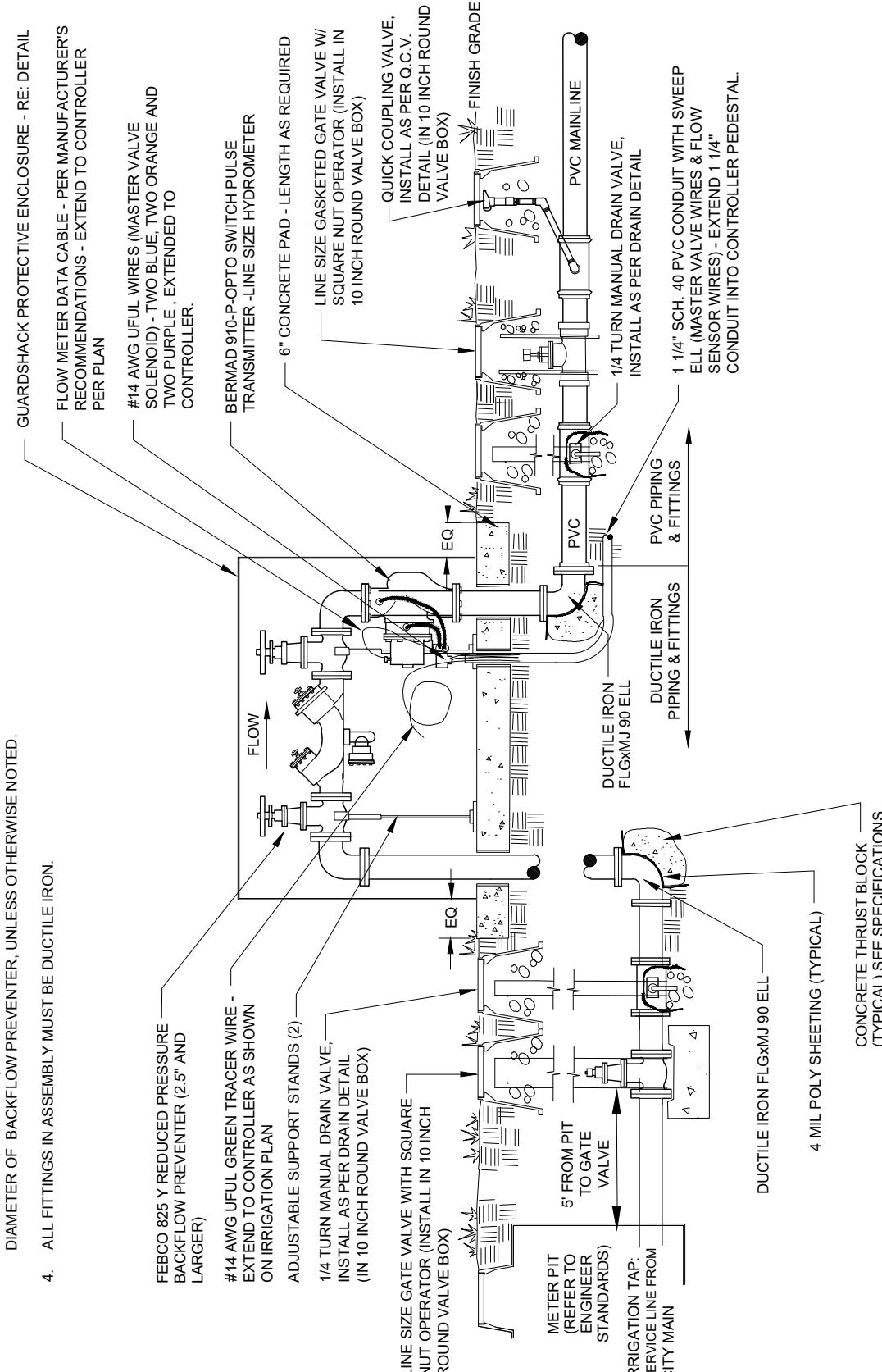
NOTES:

1. PAD PENETRATIONS FOR BACKFLOW PREVENTER RISERS TO BE 1" LARGER THAN RISER DIAMETER.
2. TOP SURFACE OF CONCRETE PAD SHALL BE 1" ABOVE FINISH GRADE.
3. INSTALL ENCLOSURE ANCHORS AS PER MANUFACTURER'S RECOMMENDATIONS.
4. PROVIDE OWNER WITH KEYED PADLOCK FOR ENCLOSURE.
5. PROVIDE ENCLOSURE IN FEDERAL GREEN COLOR. UNLESS OTHERWISE NOTED (SEE SCHEDULE).

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	BACKFLOW ENCLOSURE 3/4" - 2"
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTE:

1. CONCRETE PAD PENETRATIONS TO BE 1" LARGER THAN TUBING DIAMETER.
2. REFER TO ENCLOSURE DETAIL FOR CONCRETE PAD DIMENSIONS.
3. DIAMETER OF FITTINGS, NIPPLE AND PIPING SHALL EQUAL DIAMETER OF BACKFLOW PREVENTER, UNLESS OTHERWISE NOTED.
4. ALL FITTINGS IN ASSEMBLY MUST BE DUCTILE IRON.



NO	DATE	REVISION

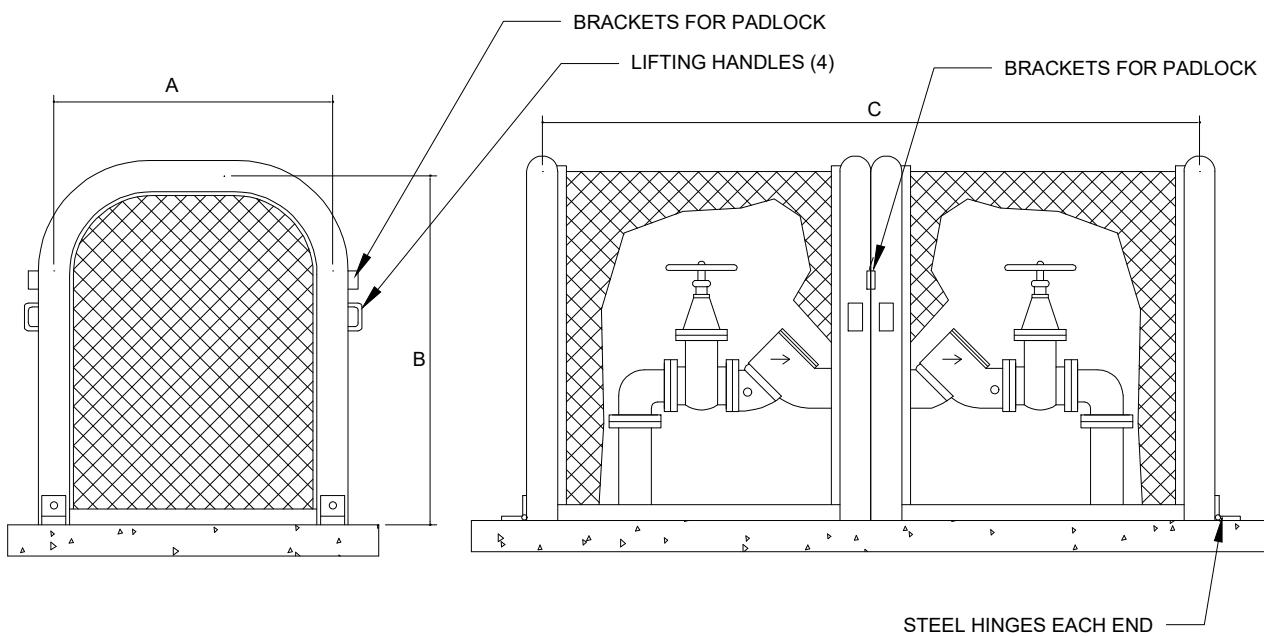


CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

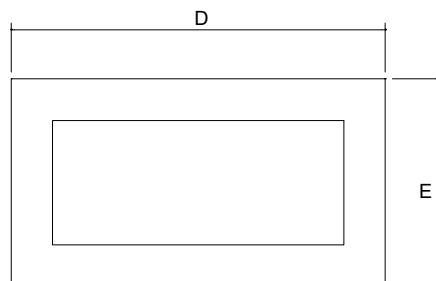
POTABLE POINT OF CONNECTION 2 1/2" & LARGER

2022 ENGINEERING STANDARDS & SPECIFICATIONS

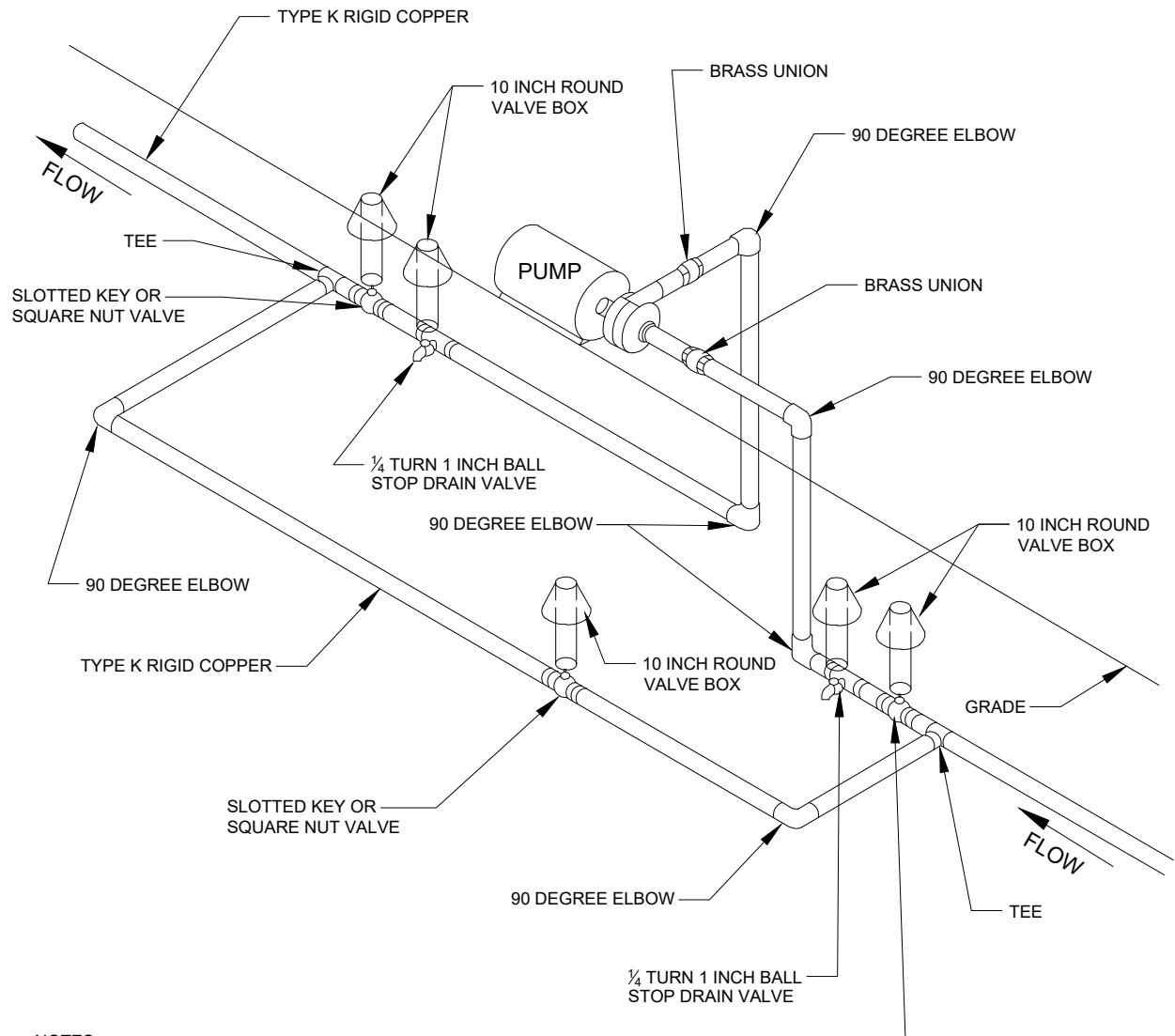
ENCLOSURE & PAD DIMENSIONS					INSIDE DIMENSIONS	FEBCO 825YD/805YD		FEBCO 860		
ENCLOSURE MODEL	A	B	C	D	E	W x H x L	SIZES	LENGTHS	SIZES	LENGTHS
GS-5	26"	40"	68"	92"	50"	24"x40"x66"	2½" 3"	54½" 60¼"	2½" 3"	51" 60¼"
GS-6	26"	40"	82"	106"	50"	24"x40"x80"	4"	72½"	4"	68¼"
GS-7	32"	48"	98"	122"	56"	30"x48"x96"	6"	86¾"	6"	63"
GS-8	40"	60"	101.5"	126"	64"	38"x60"99.5"	8"	100¾"	8"	96½"

**NOTES:**

1. INSTALL ENCLOSURE ANCHORS AS PER MANUFACTURER'S RECOMMENDATIONS.
2. PROVIDE OWNER WITH KEYED PADLOCK FOR ENCLOSURE.
3. PROVIDE ENCLOSURE IN FEDERAL GREEN COLOR.
4. PAD PENETRATIONS FOR BACKFLOW PREVENTER RISERS TO BE 1" LARGER THAN RISER DIAMETER.
5. TOP SURFACE OF CONCRETE PAD SHALL BE 1" ABOVE FINISH GRADE.
6. SEE SCHEDULE FOR MATERIAL FABRICATION AND POWDER COATING SPECIFICATIONS.
7. MINIMUM 4" THICK CONCRETE PAD.
8. UNLESS SPECIFIED, ALL SIZES FIT NRS AND OS&Y ASSEMBLIES. (SOME OS&Y TOLERANCES ARE NARROW)

**PAD DIMENSIONS**

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	BACKFLOW ENCLOSURE 2 1/2" & LARGER	
				2022 ENGINEERING STANDARDS & SPECIFICATIONS	

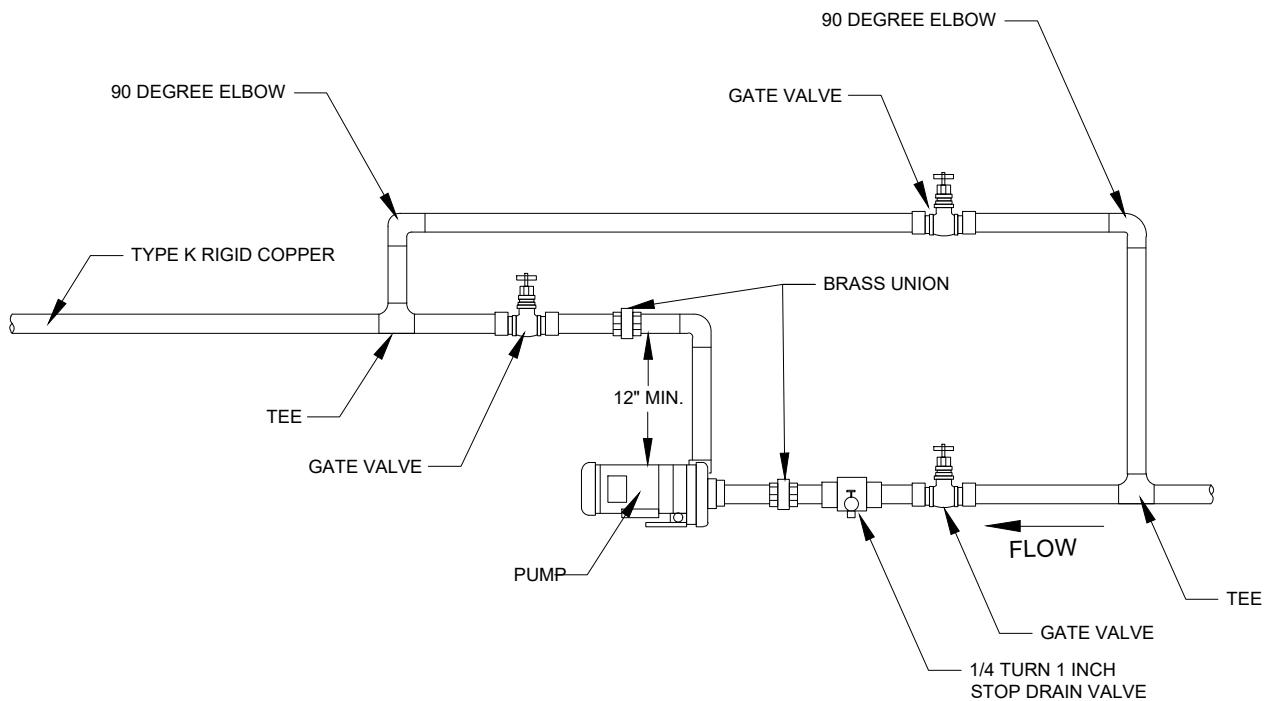


NOTES:

1. ALL FITTINGS SHALL BE BRASS OR TYPE K COPPER.
2. UNDERGROUND PUMP BYPASS FOR 2" AND SMALLER PIPE, LARGER BYPASSES SHALL BE DESIGNED AND APPROVED ON PLANS.

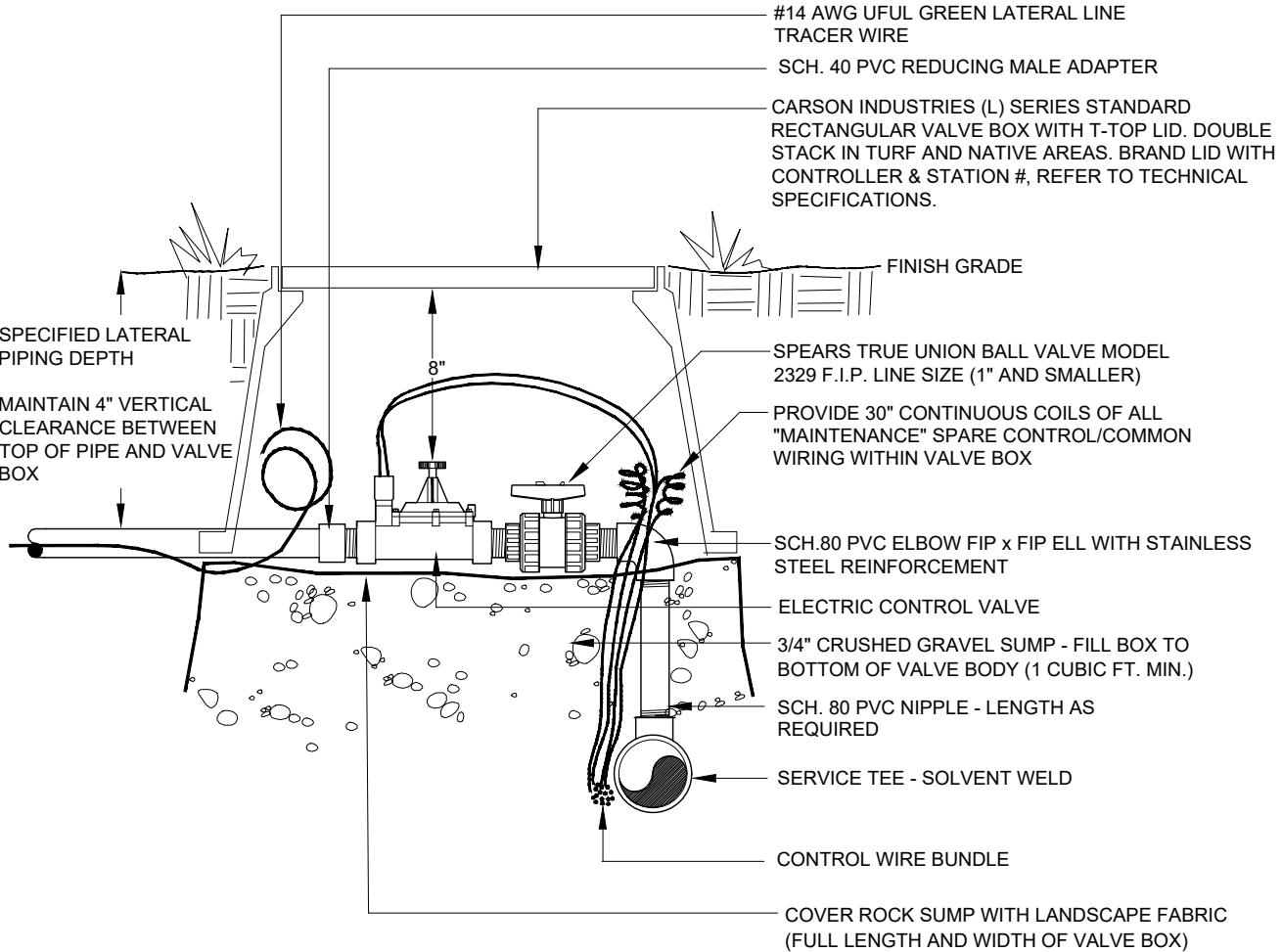
SLOTTED KEY OR
SQUARE NUT VALVE

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	UNDERGROUND PUMP WITH BYPASS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTES:

1. ALL FITTINGS SHALL BE BRASS OR TYPE K COPPER.
2. PUMP BYPASS FOR 2 1/2" AND SMALLER PIPE,
LARGER BYPASSES SHALL BE DESIGNED AND
APPROVED ON PLANS.

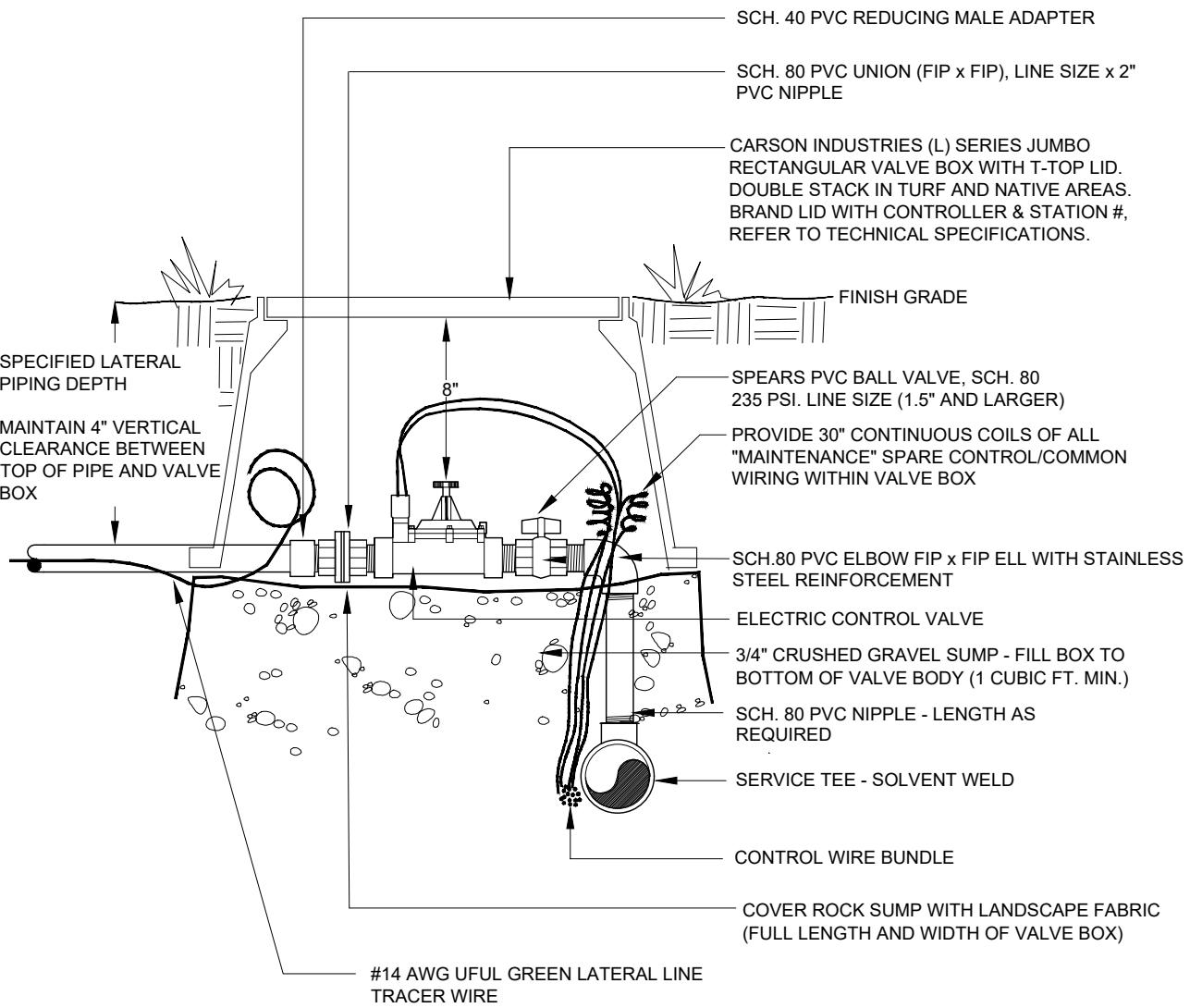
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TYPICAL PUMP WITH BYPASS IN PUMP HOUSE
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTE:

1. DIAMETERS OF BALL VALVES, PVC FITTINGS AND NIPPLES SHALL EQUAL ELECTRIC CONTROL VALVE DIAMETER.
2. VALVE BOXES SHALL BE INSTALLED PARALLEL OR PERPENDICULAR TO ADJACENT SIDEWALKS AND HARD SURFACES WHERE APPLICABLE.
3. PROVIDE 48" MINIMUM SEPARATION BETWEEN ALL VALVE BOXES.
4. TURF AREAS WILL REQUIRE MINIMUM OF 2 VALVE BOXES TO BE STACKED ON TOP OF EACH OTHER.
5. DO NOT MODIFY SIDE WALLS OF VALVE BOX. ANY MODIFIED VALVE BOX WILL BE REJECTED.

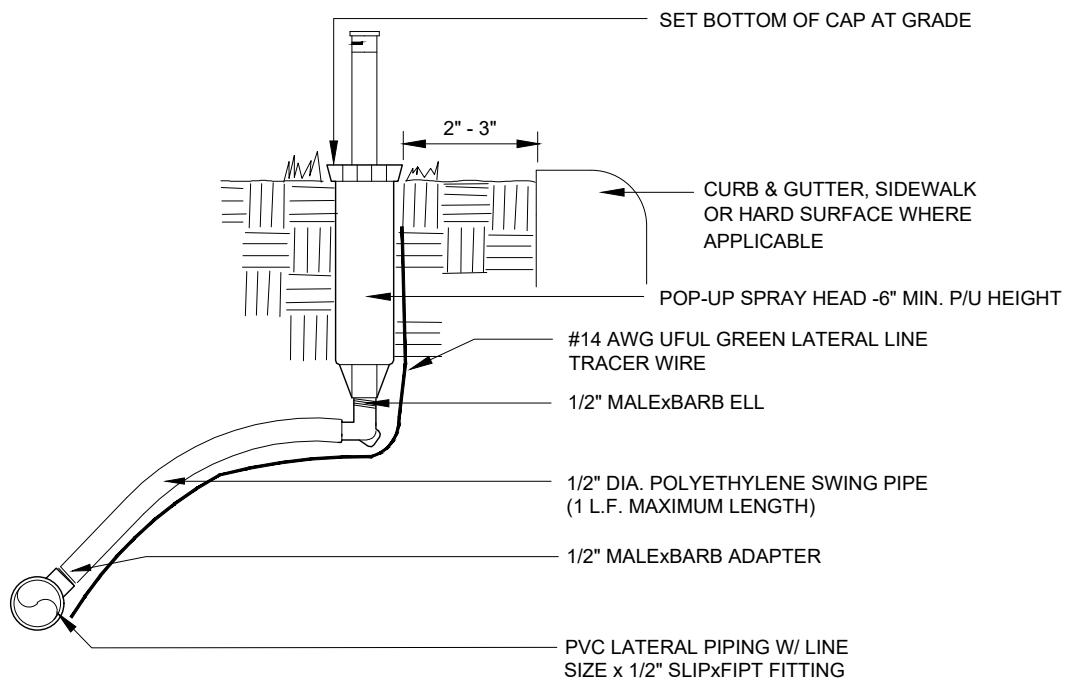
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	ELECTRIC CONTROL VALVE 3/4" & 1"
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTE:

1. DIAMETERS OF BALL VALVES, PVC FITTINGS AND NIPPLES SHALL EQUAL ELECTRIC CONTROL VALVE DIAMETER.
2. VALVE BOXES SHALL BE INSTALLED PARALLEL OR PERPENDICULAR TO ADJACENT SIDEWALKS AND HARD SURFACES WHERE APPLICABLE.
3. PROVIDE 48" MINIMUM SEPARATION BETWEEN ALL VALVE BOXES.
4. TURF AREAS WILL REQUIRE MINIMUM OF 2 VALVE BOXES TO BE STACKED ON TOP OF EACH OTHER.
5. DO NOT MODIFY SIDE WALLS OF VALVE BOX. ANY MODIFIED VALVE BOX WILL BE REJECTED.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	ELECTRIC CONTROL VALVE 1 1/2" & LARGER
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTE:

1. SET HEAD PERPENDICULAR TO FINISH GRADE.

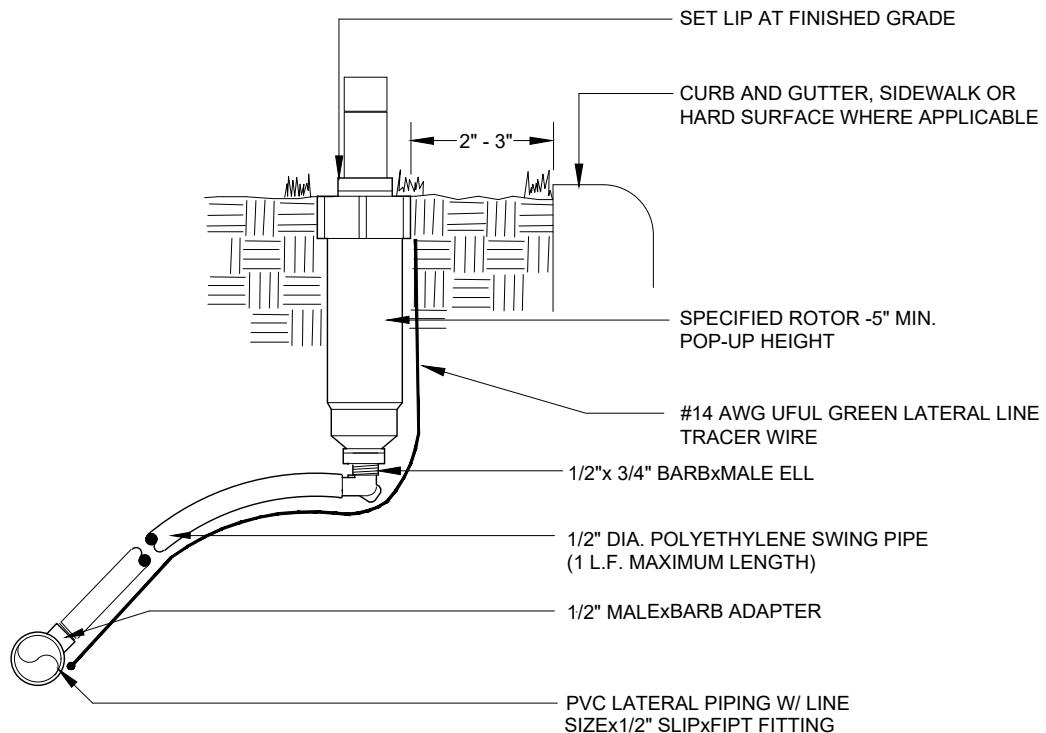
NO	DATE	REVISION



8101 Ralston Road
Arvada, Colorado 80002

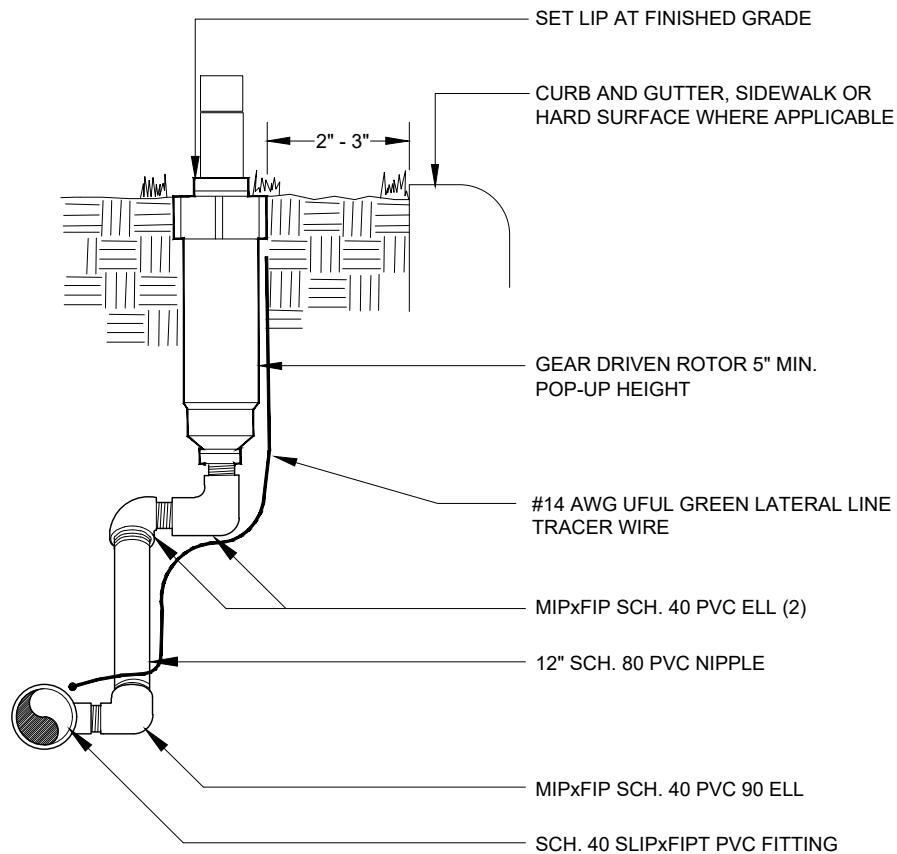
POP-UP SPRAY WITH SWING PIPE

2022 ENGINEERING STANDARDS & SPECIFICATIONS

NOTE:

1. SET HEAD PERPENDICULAR TO FINISH GRADE.
2. DIAMETERS OF FITTINGS AND NIPPLES SHALL EQUAL ROTOR INLET DIAMETER.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	3/4" ROTORS WITH SWING PIPE
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

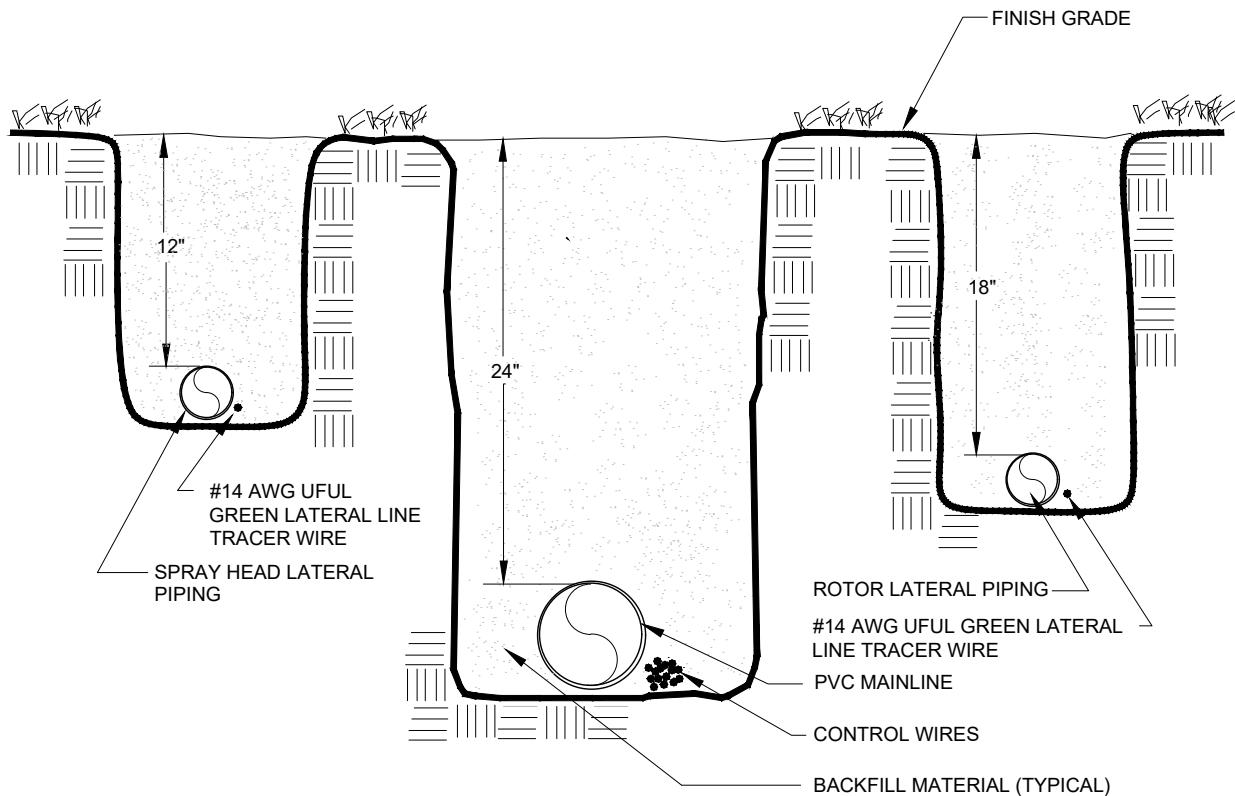


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NOTE:

1. SET HEAD PERPENDICULAR TO FINISH GRADE.
2. DIAMETERS OF FITTINGS AND NIPPLES SHALL EQUAL ROTOR INLET DIAMETER.
3. APPLY TEFLON TAPE TO ALL PVC MALE THREADED FITTINGS.

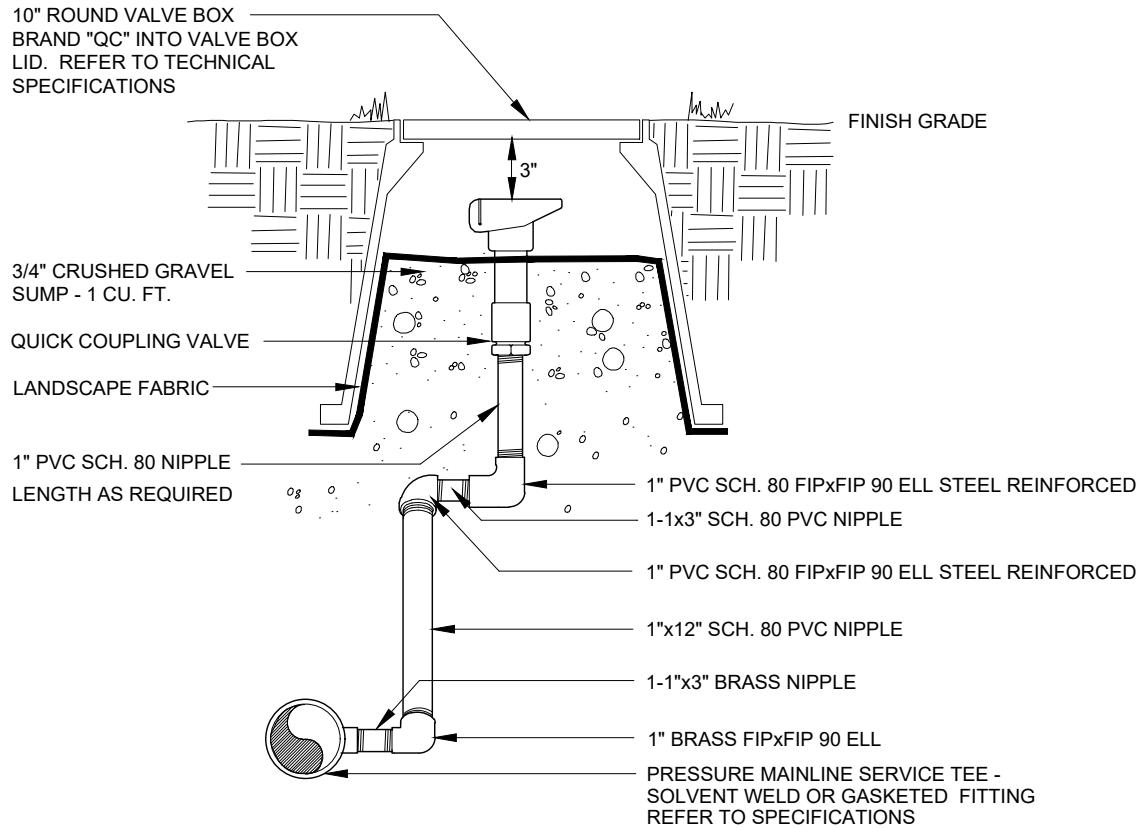
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	1 " & LARGER ROTORS
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTE:

1. REFER TO TECHNICAL SPECIFICATIONS FOR MINIMUM TRENCH WIDTHS.

NO	DATE	REVISION	CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	TRENCH DEPTH
				2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTE:

1. APPLY TEFLON TAPE TO ALL THREADED NIPPLES.

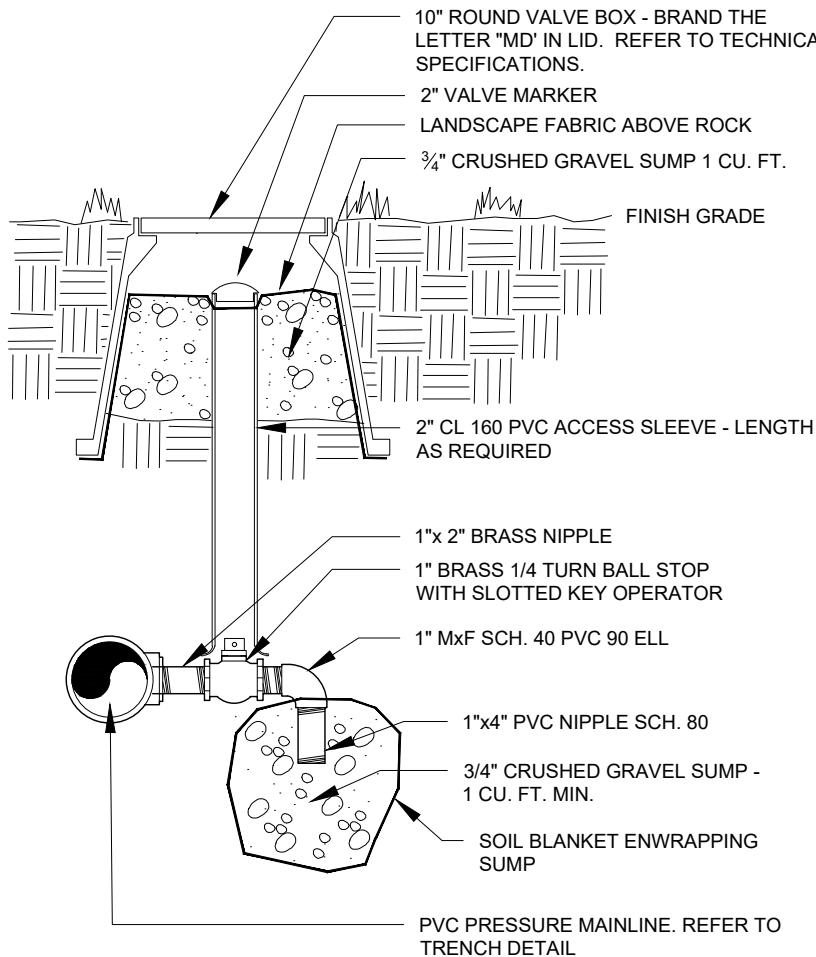
NO	DATE	REVISION



8101 Ralston Road
Arvada, Colorado 80002

QUICK COUPLER VALVE

2022 ENGINEERING STANDARDS & SPECIFICATIONS



NOTE:

1. APPLY TEFLON TAPE TO ALL MALE THREADED PVC FITTINGS AND ALL NIPPLES.

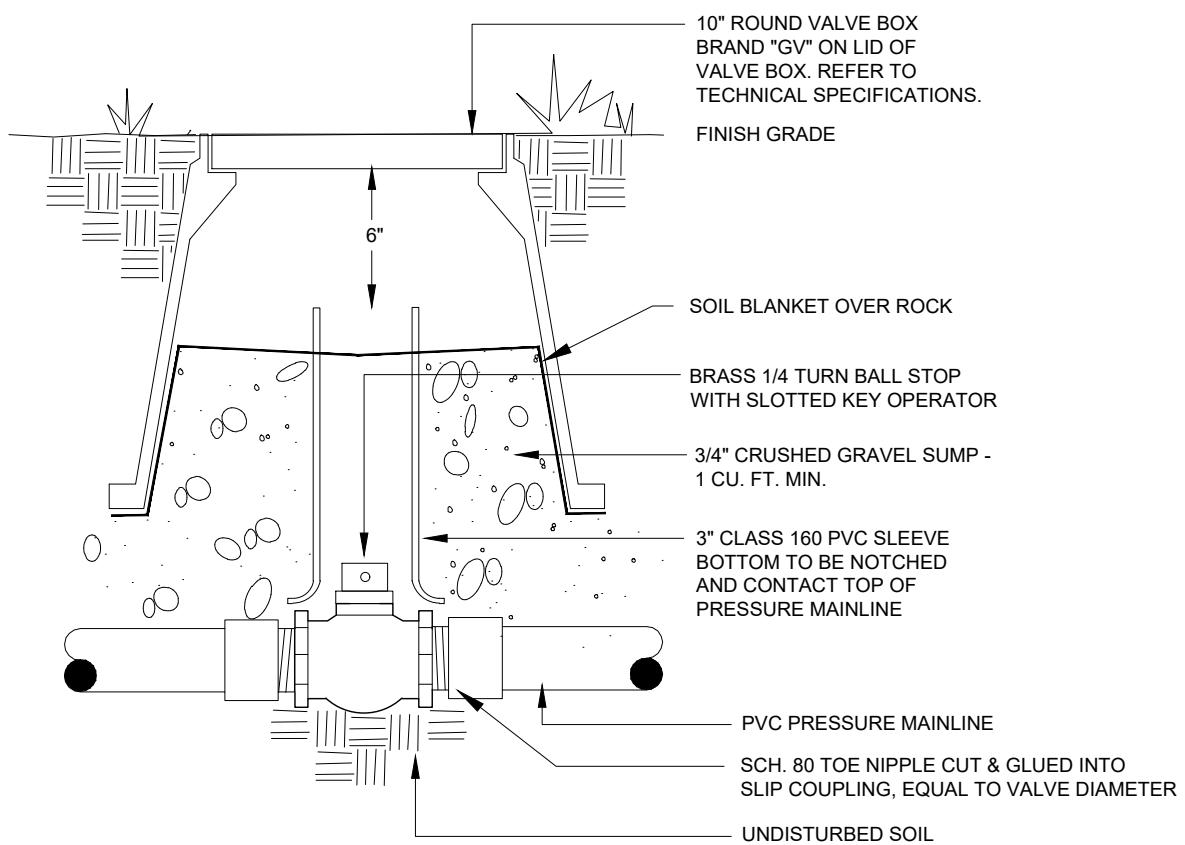
NO	DATE	REVISION



8101 Ralston Road
Arvada, Colorado 80002

MANUAL DRAIN VALVE

2022 ENGINEERING STANDARDS & SPECIFICATIONS



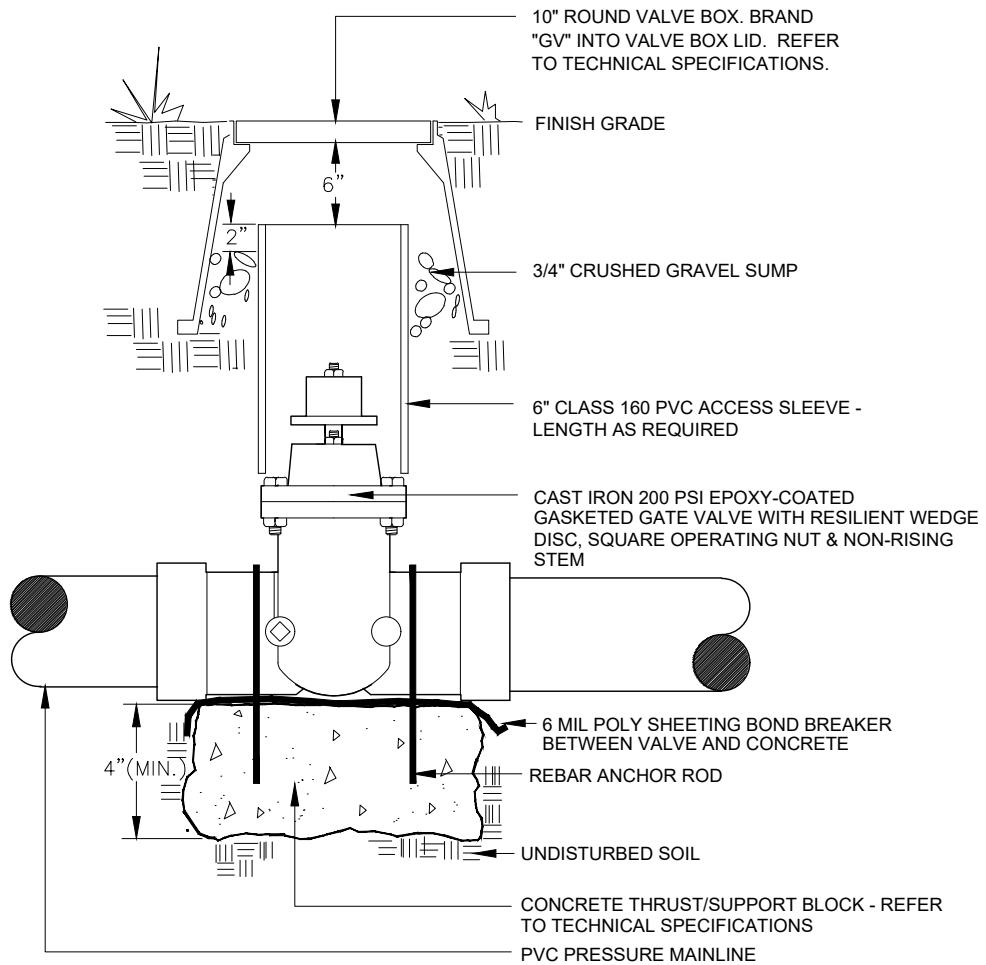
NO	DATE	REVISION



8101 Ralston Road
Arvada, Colorado 80002

ISOLATION VALVE 2" & SMALLER

2022 ENGINEERING STANDARDS & SPECIFICATIONS



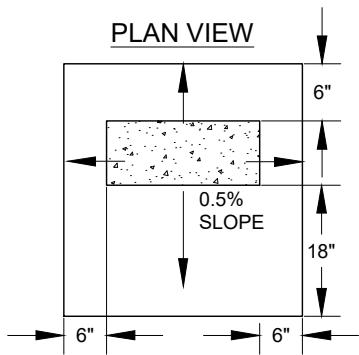
NO	DATE	REVISION



CITY OF
ARVADA
8101 Ralston Road
Arvada, Colorado 80002

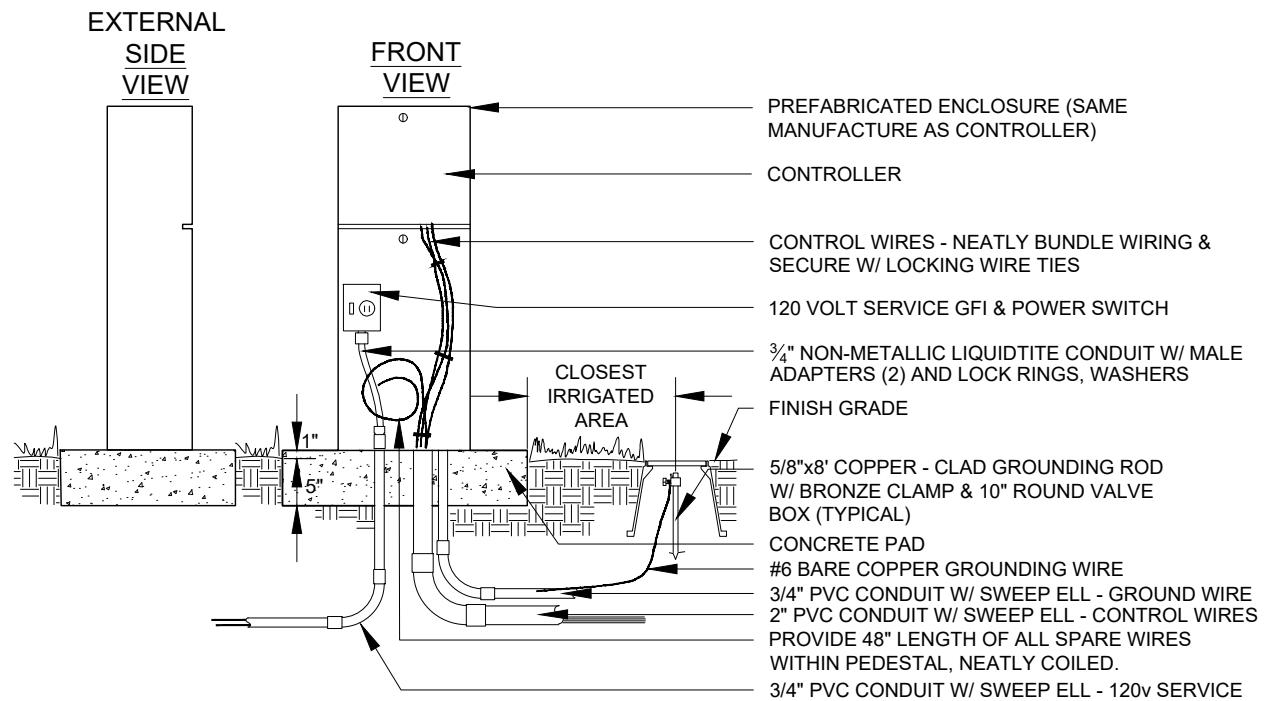
ISOLATION VALVE 2 1/2" & LARGER

2022 ENGINEERING STANDARDS & SPECIFICATIONS

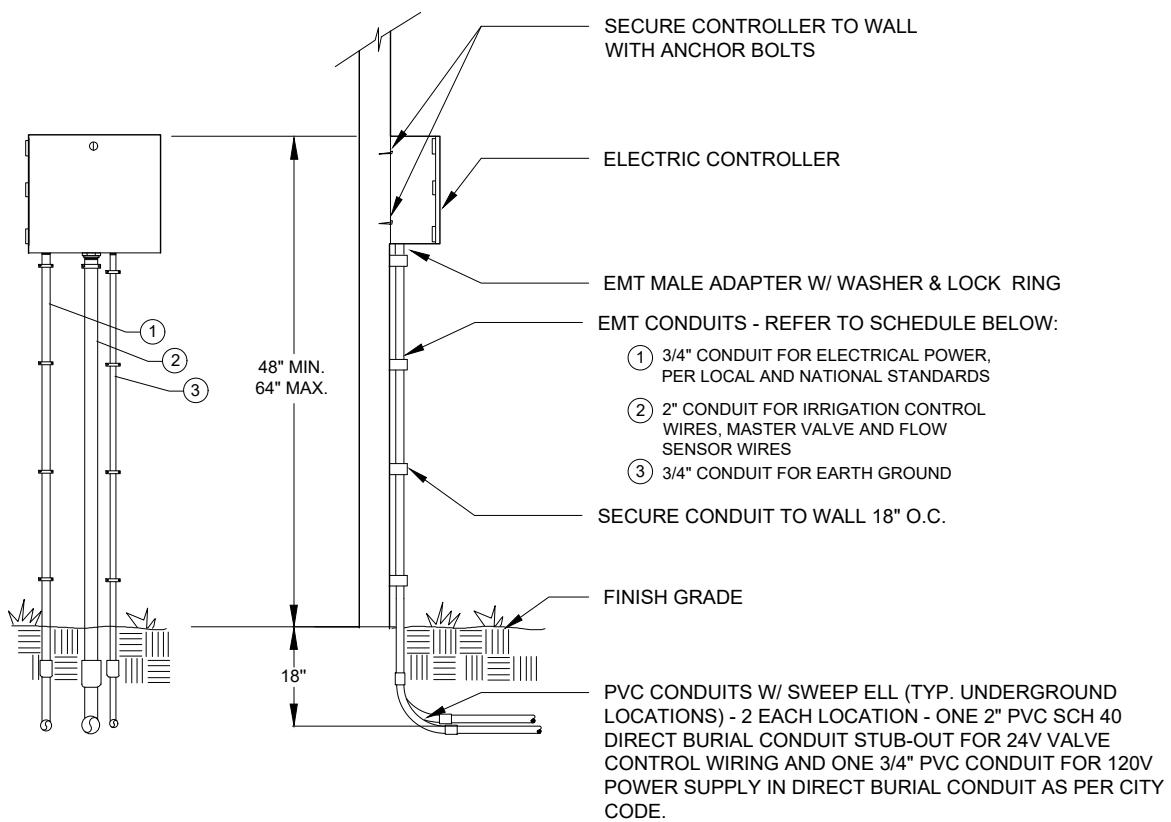


NOTES:

1. STAND ALONE PEDESTAL CONTROLLER, NO FLOW SENSOR.
2. CONTRACTOR TO GROUND AND PROVIDE SURGE PROTECTION FOR CONTROLLER IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS AND GROUND ROD(S) SHOWN.
3. CONTROLLER GROUNDING SHALL COMPLY W/ MANUFACTURER'S SPECIFICATIONS.
4. INSTALL A DISCONNECT SWITCH AND 120 VOLT GFIC RECEPTACLE WITHIN PEDESTAL.
5. ALL ELECTRICAL WORK TO CONFORM TO LOCAL CODE.
6. INSTALL RAIN SENSOR ON THE CONTROLLER, NOT SHOWN.



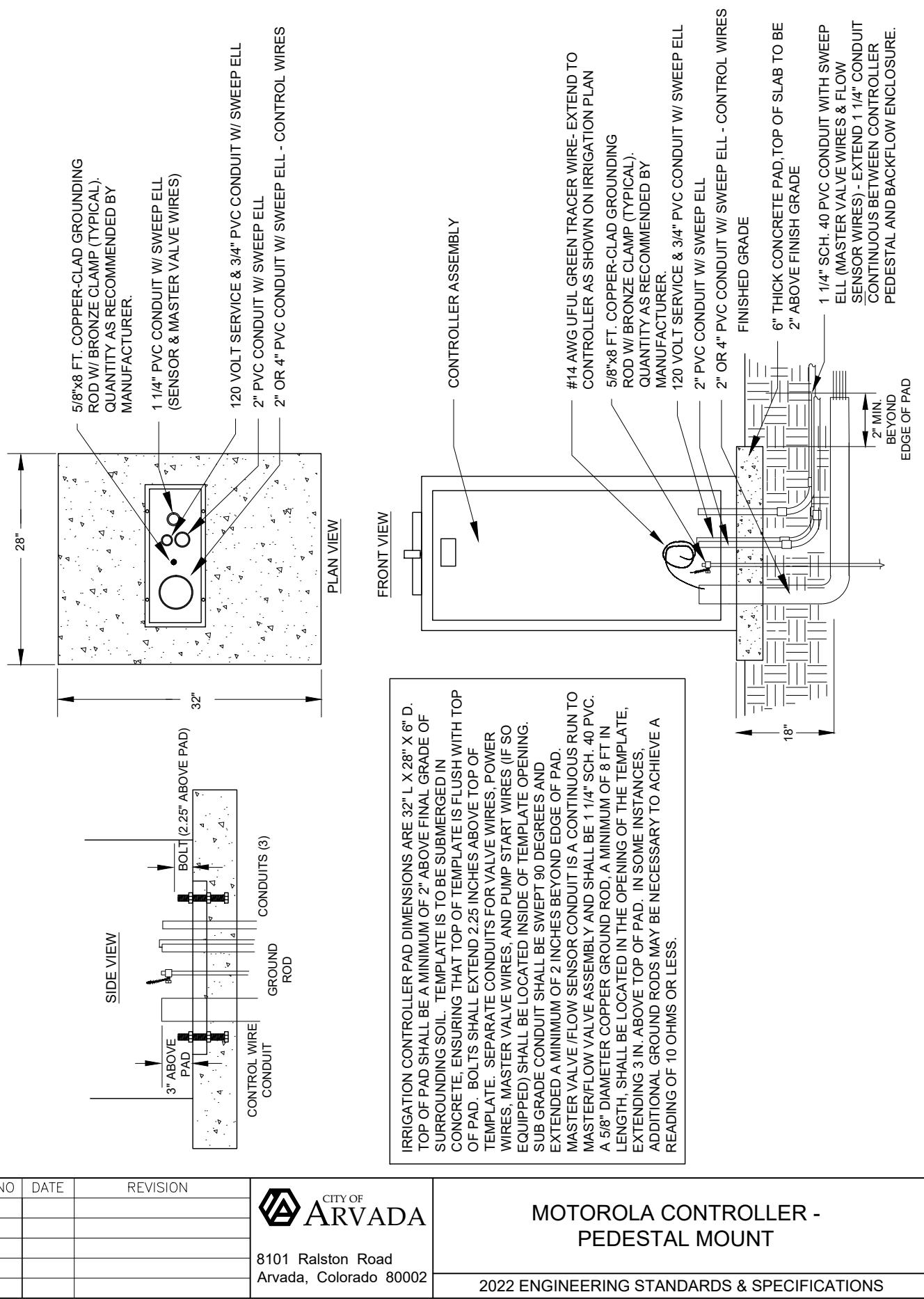
NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	STAND ALONE CONTROLLER - PEDESTAL MOUNT
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

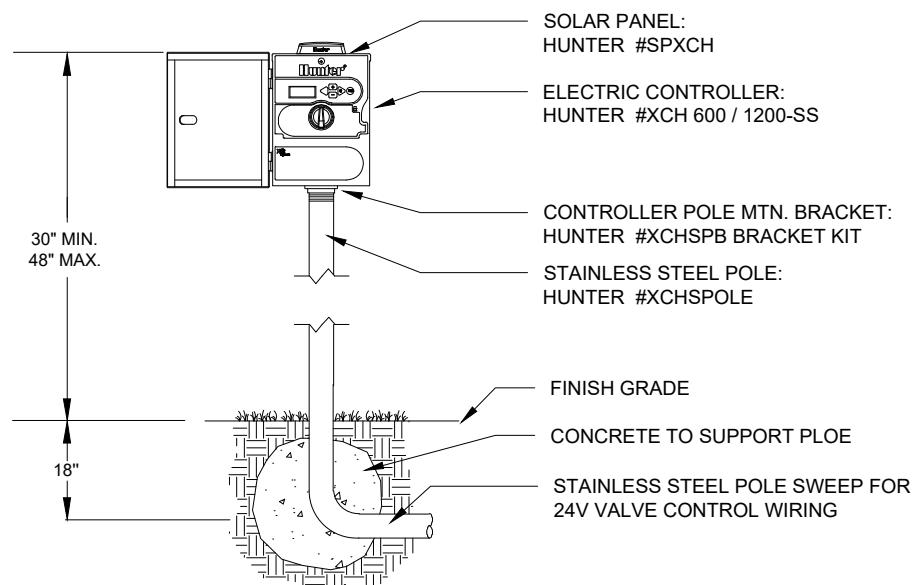


NOTE:

1. INSTALLATION TO BE COMPLETED IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATIONS.
2. STAND ALONE CONTROLLER, NO FLOW SENSOR.
3. INSTALL RAIN SENSOR ON THE CONTROLLER, NOT SHOWN.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	STAND ALONE CONTROLLER - WALL MOUNT
				2022 ENGINEERING STANDARDS & SPECIFICATIONS





NOTE:

1. INSTALLATION TO BE COMPLETED IN ACCORDANCE WITH MANUFACTURE'S SPECIFICATIONS.
2. CHANGE 24V SOLENOIDS WITH HUNTER #458200 DC LATCHING SOLENOIDS FOR ALL CONTROL VALVES.
3. INSTALL RAIN SENSOR ON THE CONTROLLER, NOT SHOWN.

NO	DATE	REVISION	 CITY OF ARVADA 8101 Ralston Road Arvada, Colorado 80002	STAINLESS STEEL SOLAR CONTROLLER - POLE MOUNT
				2022 ENGINEERING STANDARDS & SPECIFICATIONS

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SECTION 1100 - CONTROL, MEASUREMENT AND BASIS OF PAYMENT

1100.0 Contractor Responsibilities

The Contractor shall be responsible to be fully informed of, and shall comply with all sections of these Standards and Specifications, applicable laws, ordinances, rules, regulations and orders of the city, county, state, federal or public bodies having jurisdiction affecting the work.

1110.00 Scope

This section applies to all work completed under City contracts associated with Capital Improvement Projects. The intent of this section is to specify measurement and payment methods to be used for the construction that is typical among most City Capital Improvement Projects. This section shall cover details pertaining to measurement units and methods, partial payments, retainage withholding and release, and details on what is considered to be part of the Work. Additionally this section covers modifications and substitutions of costs and prices should the need arise.

1120.00 General Requirements

1121.00 Procurement and Contracting Requirements

Procurement and contracting for the construction of capital and other improvements follows procedures set forth in the Purchasing Ordinance in the Arvada Municipal Code.

1121.01 Taxes

The Contractor will pay all applicable sales, use and other similar taxes required by the laws of the State of Colorado and as set forth in the Arvada Municipal Code. Where a project is exempt from such tax, the amount of such tax shall not be included in any bid proposal submitted to the City. The Contractor shall file with the Project Engineer a certified copy of the Certification of Exemption, prior to commencing Work.

1121.02 Notice to Proceed

The Notice to Proceed shall be issued within seven (7) calendar days of the execution of the Contract by the Owner. Should there be a reason why the Notice to Proceed cannot be issued within such a period, the time may be extended by mutual agreement between the owner and the Contractor.

1121.03 Preconstruction Conference

A meeting of City project personnel, Contractor project personnel and other stakeholders will be held prior to the beginning of construction of all projects, at which topics pertinent to the successful prosecution of the work will be discussed.

1121.04 Value Engineering Change Proposals (VECP) by the Contractor

The Contractor is encouraged to develop and offer proposals for improved construction techniques, alternative materials, and other innovations. Proposals must provide a project comparable to the Owner's original design either at lower cost, improved quality, or both. Bid prices shall not be based on the anticipated approval of a Value Engineering Change Proposal (VECP). Proposals shall be submitted only by the successful bidder after contract award. Net cost savings shall be split equally between the Contractor and the Owner. Any delay to the project due to a VECP submittal and review shall be considered within the Contractor's control and will be non-excusable with the exception of those delays that are approved as part of the VECP. The Contractor shall have no claim against the Owner for additional costs or delays resulting from the rejection or untimely acceptance of a VECP.

1121.04.01 Submittal of Conceptual Proposal

If submitting a proposal that requires a significant amount of design or other resources, the Contractor may submit an abbreviated Conceptual Proposal for preliminary evaluation which should include, at a minimum, the below items:

1. General description of the difference between the existing Contract and the proposed change, and the advantages and disadvantages of each, including effects on service life, maintenance costs, ease of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction.
2. Conceptual plans and a description of proposed changes to the Contract specifications.
3. Statement specifying the following
 - a. when a response to the conceptual proposal is required to avoid delays to the existing contract prosecution.
 - b. the amount of time necessary to develop the full Proposal.
 - c. the date by which a Contract Modification Order must be executed to obtain maximum benefit from the Proposal.
 - d. the Proposal's impact on time for completing the Contract.

1121.04.02 Submittal of Full Value Engineering Change Proposal

Change Proposal should include, at a minimum, the below items:

1. General description of the difference between the existing Contract and the proposed change, and the advantages and disadvantages of each, including effects on service

life, maintenance costs, ease of maintenance, desired appearance, safety, and impacts to the traveling public or to the environment during and after construction.

2. A complete set of plans and specifications showing the proposed revisions relative to the original Contract. This portion of the submittal shall include design notes, construction details, and any additional documentation such as, but not limited to, surveys, geotechnical reports, documentation, or calculations and shop drawings required to complete the work.
3. The proposed plans and specifications shall be signed and sealed by the Contractor's Colorado licensed Professional Engineer.
4. A cost comparison, summarizing all the items that the proposed VECP replaces, reduces, eliminates, adds, or otherwise changes from the original Contract work, including all impacts to traffic control, detours and all other changes.
5. A description of any previous use or testing of the proposed changes and the conditions and results.
6. An estimate of any effects the VECP will have on other costs to the Owner.
7. A statement of life cycle costs, when appropriate. Life cycle costs will not be considered as part of cost savings but shall be calculated for additional support of the Proposal.
8. Statement specifying when a response to the proposal is required, the date by which a Contract Modification Order must be executed to obtain maximum benefit from the Proposal, and the Proposal's impact on time for completing the Contract.

1121.04.03 VECP Proposal Acceptance

If the VECP is accepted, a Contract Modification Order will authorize the changes and payment. At the completion of the project, the Contractor shall furnish the City with PE-stamped Record sets, and As-Constructed plans showing the VECP work.

1121.04.04 VECP Proposal Rejection

The Project Engineer may reject any Proposal that requires excessive time or costs for review, evaluation, or investigation. Proposals that lower the quality of the intended project or require Right of Way acquisition will be rejected. If a VECP is rejected, the work shall be completed in accordance with the Contract at contract bid prices.

The City retains the right to utilize any accepted Proposal or part thereof on other projects without obligation to the Contractor.

1121.05 Changes in Contract Price

The contract price on City projects may be changed only by a Change Order. The value of any work covered by a Change Order or of any claim for increase or decrease in the contract price shall be determined by one or more of the following methods in the order of precedence listed below:

1. Contract Unit Prices. If a change is ordered in an item of work covered by a contract unit or lump sum price, then an adjustment in the contract price will be made based upon the increase or decrease in quantity of the contract unit or lump sum price.
2. Agreed Prices. Adjustments in contract price for changes ordered that are not covered by contract unit or lump sum price, will be determined by agreement between Contractor and Owner. If unable to reach agreement, the Owner may direct the Contractor to proceed on the basis of extra work in accordance with Paragraph 3 below.
3. Extra Work. When the price for extra work cannot be agreed upon, the Owner will pay for the extra work based on the accumulation of costs as provided below.
 - a. Daily Reports by Contractor. At the close of each working day, the Contractor shall submit a daily report to the Project Engineer, together with applicable delivery tickets, listing all labor, materials, and equipment for that day, and for other services and expenditures when authorized. An attempt shall be made to reconcile the report daily, and it shall be signed by the Project Engineer and the Contractor. In the event of disagreement, pertinent notes shall be entered by each party to explain points which cannot be resolved immediately. Each party shall retain a signed copy of the report. Reports by subcontractors or others shall be submitted through the Contractor. Contractor's daily reports shall itemize the following:
 - i. Labor. The report shall show the names of workers, classifications, and hours worked.
 - ii. Material. The report shall describe and list quantities of materials used.
 - iii. Equipment. The report shall show type of equipment, size and hours of Operation, including loading and transport, if applicable.
 - iv. Other Services and Expenditures. Other services and expenditures shall be described in such detail as the Project Engineer may require.
 - b. Basis for Establishing Costs.

- i. Labor. The costs of labor will be the actual cost for wages for each craft or type of workers at the time the extra work is done, plus employer payments of payroll taxes and insurance, health and welfare, pension, vacation, and other direct costs resulting from federal, state or local laws, as well as assessments or benefits required by lawful collective bargaining agreements. The use of a labor classification which would increase the extra work cost will not be permitted unless the Contractor establishes the necessity for such additional costs. Labor costs for equipment operators and helpers shall be reported only when such costs are not included in the invoice for equipment rental.
- ii. Materials. The cost of materials, or equipment to be incorporated in the work, shall be at invoice or lowest current price at which such materials are locally available and delivered to the job site in the quantities involved, plus freight and delivery. The Owner reserves the right to approve materials and sources of supply, or to supply materials to the Contractor if necessary for the progress of the extra work. No markup shall be applied to any material provided by the Owner.
- iii. Tool and Equipment Rental. No payment will be made for the use of tools which have a replacement value of \$400 or less. Regardless of Ownership, the rates to be used in determining equipment rental costs shall not exceed rates approved or authorized by the City at the time the extra work is performed in accordance with CDOT Standard Specifications 109.04(c). The rental rates paid shall include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs and maintenance of any kind, depreciation, storage, insurance and all incidentals. Necessary loading and transportation costs for equipment used in performing the extra work shall be included. If equipment is used intermittently and, when not in use, could be returned to its rental source at less expense to the Owner than holding it at the work site, it shall be returned, unless the Contractor elects to keep it at the work site at no expense to the Owner. The reported rental time for equipment already at the job site shall be the duration of its use on the extra work, commencing at the time it is first put into actual operation on the extra work.

- iv. Other Items. The Owner may authorize other items which may be required on the extra work. Such items include labor, services, material and equipment which are different in their nature from those required for the work and which are of a type not ordinarily available from the Contractor or any of the subcontractors. Invoices covering all such items in detail shall be submitted with the request for payment.
- v. Invoices. Vendors' invoices for material, equipment rental, and other expenditures, shall be submitted with the request for payment. If the request for payment is not substantiated by invoices or other documentation, the Project Engineer may establish the cost of the item involved at the lowest price which was current at the time of the report.

c. Markup

- i. Work by Contractor. The following percentage shall be added to the Contractor's costs and shall constitute the markup for all overhead and profits:
 - Labor (1.67 x certified payroll) 15
 - Materials 15
 - Equipment Rental 10
 - Other Items and Expenditures 10
- ii. Work by Subcontractor. When all or any part of the extra work is performed by a subcontractor, the markup established herein shall be applied to the subcontractor's actual cost of such work, to which a markup of five percent on the subcontracted portion of the extra work may be added by the Contractor.

4. Other Causes. Any other cause which, in the opinion of the Project Engineer, entitles the Contractor to additional time, including but not restricted to acts of the public enemy, acts of any government in either its sovereign or any applicable contractual capacity, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes and unforeseeable severe abnormal weather.

1121.06 Changes in Contract Time

The contract time on City projects may be changed only by a Change Order. The Contractor shall notify the Project Engineer promptly and in writing of any occurrence or conditions which, in the Contractor's opinion, entitle him to an extension or reduction in contract time. Such notice shall be submitted in ample time to permit full investigation and evaluation of the Contractor's claim. Failure to provide such notice shall constitute a waiver by the Contractor of any claim. The Project Engineer shall acknowledge the Contractor's notice within seven days of its receipt. Changes in contract time for the completion of the work shall be stipulated by Change Order:

1. When changes in the work occur.
2. When work is suspended by the Owner.
3. For unforeseeable causes beyond the control and without the fault or negligence of the Contractor, his subcontractor or supplier and which were not the result of their fault or negligence.
4. When delays in the progress of the work caused by:
 - a. Any act or neglect of the Owner, his employees or agents.
 - b. Other Contractors employed by the Owner.
 - c. Any delay in furnishing of drawings, information or return of shop drawings by the Project Engineer.
 - d. Any other cause which, in the opinion of the Project Engineer, entitles the Contractor to additional time, including but not restricted to acts of the public enemy, acts of any government in either its sovereign or any applicable contractual capacity, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes and unforeseeable severe abnormal weather.

1121.07 Time for Completion and Liquidated Damages

The date of beginning and the time for completion of the work on City projects are essential conditions of the contract documents and the work embraced shall be commenced on the date specified in the Notice to Proceed.

The Contractor will proceed with the work at such rate of progress to ensure full completion within the contract time. It is expressly understood and agreed, by and between the Contractor and the Owner, that the contract time for the completion of the work described in the contract documents is a reasonable time, taking into consideration the average climatic and economic conditions and other factors prevailing in the locality of the work.

A daily charge will be made against the Contractor for each calendar day, including free time, that any work remains uncompleted after the expiration of contract time. This daily charge, determined by the original contract amount for the project from the table herein below, will be deducted from any money due the Contractor. This deduction will be considered liquidated damages, not a penalty.

The general schedule of liquidated damages set forth below is an amount, agreed to by the Contractor and the Owner, as reasonably representing additional construction engineering costs incurred by the Owner if the Contractor fails to complete performance within the contract time on City or Arvada projects. Final determination of Liquidated Damages shall be determined by the Owner's Project Engineer and will reside within the executed contract documents.

Liquidated Damages Schedule

Original Contract Amount		Daily Charge
From More Than	To and Including	
\$0	\$150,000	\$500
150,001	250,000	600
250,001	500,000	800
500,001	1,000,000	1,400
1,000,001	2,000,000	2,000
2,000,001	4,000,000	3,300
4,000,001	10,000,000	3,900

Over \$10,000,000 - daily charge will increase by \$300 increments for each \$1,000,000 over \$10,000,000.

Permitting the Contractor to continue and finish the work or any part thereof after elapse of contract time will not operate as a waiver on the part of the Owner of any of its rights under the contract.

Any deduction assessed as liquidated damages under this section shall not relieve the Contractor from liability for any damages or costs resulting from delays to other Contractors on the project or other projects caused by a failure of the assessed Contractor to complete the work according to contract times.

The Contractor shall not be charged with liquidated damages or any excess cost when a change in contract time is approved as outlined in Section 1121.07 - Time for Completion and Liquidated Damages of these Standards and Specifications.

The Owner shall have the right to deduct the amount of liquidated damages from any monies due or to become due to the Contractor, or to sue for and recover compensation for damages for non-performance of the work, from the Contractor and his surety, as stipulated in the contract documents.

1121.08 Contractor Claims for Adjustment and Disputes

This section details the process through which a Contractor and Arvada (the “Parties”) agree to resolve any issue that may result in a dispute. The intent of this process is to resolve issues early, efficiently, and as close to the project level as possible. Specific time frames may be extended by mutual consent of the Parties. In these subsections, when a time frame ends on a Saturday,

Sunday, or holiday, the time frame shall be extended to the next scheduled work day. As used in this section, “day” means calendar day.

An “Issue” is defined as the following:

- A conflict between any instructions, interpretations, or directives, issued by the Project Engineer and the Contract Documents;
- Error(s) or omission(s) in the Contract Documents;
- A difference in site condition from what was represented in the Contract Documents;
- Any instruction, interpretation, or directive issued by the Project Engineer resulting in acceleration or deceleration of the Contractor’s performance under the Contract Documents;
- Any delay, regardless of cause, encountered by the Contractor; or
- Any other matter or circumstance that the Contractor believes requires a change in the Contract Documents, time for performance or deadlines, or contract amount.

A “Dispute” is an Issue which the Contractor and the Project Engineer have not been able to resolve in a timely manner.

The Contractor shall be barred from pursuing any administrative, equitable, or legal remedy for any Issue when:

- The Contractor did not bring the Issue to the Project Engineer’s attention in writing within 14 days of the Contractor becoming aware of the Issue or within 14 days of when the Contractor should have become aware of the issue; or
- The Contractor failed to continually (weekly or as otherwise approved by both Parties) work with Arvada toward a resolution.

The process set forth in this section 1121.08 - Contractor Claims for Adjustment and Disputes of these Standards and Specifications shall be exhausted in its entirety prior to the initiation of any litigation. Failure to comply with the requirements set forth in this section 1121.08 bars Contractor from any further administrative, equitable, or legal remedies.

1. *Prerequisites to Commencing the Dispute Resolution Process.*

a. Contractor Request for Adjustment.

- i. If the Contractor encounters an Issue, the Contractor shall give the Project Engineer written notice of the Issue and request an adjustment or change to the Contract Documents (“Request”) within 14 days of discovering the Issue necessitating a Request. For the purposes of this section, an e-mail to the Project Engineer will constitute written notice.
- ii. The Request must contain the below information at the time it is submitted to the Project Engineer. Failure to provide all the information listed below

will result in an incomplete Request that will not be considered by the Project Engineer.

1. Date;
2. Clearly labeled with sequential numbering (if Contractor is making multiple Requests);
3. A complete description of the Issue, possible Contractor actions or solutions to minimize the costs of the Request, and an estimate of the adjustment in the contract time or contract amount, as applicable; and
4. All relevant documents and materials supporting the Request.

b. Contractor's Obligations.

- i. Contractor shall permit the Project Engineer to examine and copy any other records the Project Engineer may deem necessary to determine the facts or contentions involved in the Request.
- ii. Contractor shall keep full and complete records of the costs and additional time incurred for any Request.
- iii. The Contractor shall retain those records until there is a final resolution of the Request or subsequent Claim, or for three years after acceptance of the project, whichever is longer.
- iv. Following submission of a Request, the Contractor shall diligently continue performance of its obligations under the Contract Documents to the maximum extent possible.
- v. Contractor shall work with the Project Engineer to negotiate an acceptable resolution to the Request.

c. Project Engineer's Duties.

- i. The Project Engineer will maintain a record composed of all written documentation comprising the Request until there is a final resolution of the Request, subsequent Claim, or Appeal pursuant to this section 1121.08.
- ii. The Project Engineer shall respond in writing to any timely Request within 21 days of receipt of the complete and itemized Request. The Project Engineer shall consider all documentation and materials provided by Contractor in support of its Request. The Project Engineer may reject a Request if such Request is incomplete. Failure of the Project Engineer to respond within the 21 day time period shall be deemed a denial of the Request.
- d. If the Project Engineer and Contractor agree to an adjustment or change, the Project Engineer shall facilitate an amendment to the Contract Documents in

accordance with the Contract Documents and any other City Code requirements. An amendment is not effective and binding until it is executed by the Parties in writing.

- e. If a Request is denied by the Project Engineer, in whole or in part, and the Project Engineer and Contractor are otherwise unable to reach an agreement, the Issue becomes a Dispute and Contractor may initiate the Dispute Resolution Process detailed below.
2. *Dispute Resolution Process.* To initiate the dispute resolution process, the Contractor shall provide written Notice of Intent to Claim to the City Engineer upon 14 days of the Project Engineer's denial of the Request. Claims made pursuant to this Dispute Resolution Process will not be considered unless the Contractor has first complied with the prerequisites to commencing the dispute resolution process, as set forth in Section 1 above.
 - a. Contractor shall diligently continue performance of the Contract Documents during the Dispute Resolution Process to the maximum extent possible.
 - b. Written Notice of Intent to Claim. The written Notice of Intent to Claim shall be clearly titled as "Notice of Intent to Claim" and dated. The Notice shall be sent via certified mail addressed to the City Engineer. All Notice of Intent to Claim shall be numbered sequentially. Such Notice of Intent to Claim shall contain, at a minimum, the following:
 - i. Project title and number;
 - ii. Date of the event giving rise to the Dispute;
 - iii. A description of the Issue and the events giving rise to the Dispute, including the original Request and the Project Engineer's decision or denial;
 - iv. The reasons why the Contractor believes the Request is necessary;
 - v. An accounting or estimate of all additional costs associated with the Request; and
 - vi. Contractor's plan for mitigating costs or delays associated with the Request.
 - c. Submittal of Claim. The Contractor shall, within seven days after it submits a Notice of Intent to Claim, submit to the City Engineer a complete and itemized Claim that includes the claimed increase in Contract Time, and/or Contract Amount. The Claim shall be sent via certified mail addressed to the City Engineer. The Contractor may request an extension of time to submit the Claim, which extension may be granted by the City Engineer, provided that good cause is shown. The Claim must be described in sufficient detail to allow the City

Engineer to evaluate the basis of and costs associated with said Claim. A Claim for an increase in Contract Amount shall be submitted based on actual costs whenever possible, rather than an estimate or opinion, shall be supported by invoices, time cards, and other business records commonly accepted in the industry.

- i. Contractor shall furnish, upon request, all additional information and data that the City Engineer determines is needed to aid in resolving the Claim through negotiation or is required to complete an evaluation of the Claim.
 - ii. The Contractor shall submit with its Claim a notarized certificate, executed under penalties of perjury, that:
 1. The Claim is made in good faith;
 2. All supporting data are accurate and complete to the best of the Contractor's knowledge and belief;
 3. The amount requested accurately reflects that Contract adjustment for which the Contractor believes the City is liable; and
 4. The prices stated for material and equipment are the lowest reasonably available to the Contractor and include all available discounts.
 - iii. If the Contractor is an individual, the certification shall be executed by that individual; if the Contractor is not an individual, the certification shall be executed by an officer or general partner of the Contractor.
- d. City Engineer Review. The City Engineer shall review the Claim and render a written decision to the Contractor to either affirm, overrule, or modify the Project Engineer's decision, in whole or in part, in accordance with all Contract Documents and the following procedure:
- i. Within 21 days after receipt of the Contractor's Claim, or receipt of all additional information requested by the City Engineer pursuant to subparagraph 2(c)(i) above, whichever is later, the City Engineer will meet with the Contractor and the Project Engineer to discuss the merits of the Claim.
 - ii. The City Engineer will consider all written documents provided with the Notice to Claim and Claim and any oral presentations in support of that record made by the Contractor or the Project Engineer during the meeting following receipt of Contractor's Claim.
 - iii. The City Engineer will render a written decision to the Contractor within 42 days from the meeting described in subparagraph 2(d)(i) above.
 - iv. Contractor shall respond to the City Engineer's decision in writing within 14 days acknowledging receipt of the decision and indicating Contractor's denial or acceptance of the City Engineer's decision.

- v. If the City Engineer fails to render a written decision to the Contractor within the specified 42 day time period, or within any extended time period as agreed by the parties, the Contractor must either: (1) accept this as a denial of the Claim, or (2) appeal the Claim to the Director of Public Works in accordance with subsection 3 below, in the same manner as if the City Engineer had denied the Contractor's Claim.
 - vi. If the Contractor accepts the City Engineer's denial of the Claim, the Claim is resolved and no further action will be taken. If the Contractor does not respond within 14 days, it will be assumed the Contractor has accepted the denial.
 - vii. If the Contractor rejects the City Engineer's denial of the Claim or a satisfactory adjustment cannot be agreed upon within 30 days of the City Engineers written decision, the Contractor may further pursue resolution of the Dispute by providing written notice of Contractor's appeal of the City Engineer's decision ("Notice of Appeal") to the Director of Public Works within 14 days, in accordance with subsection 3 below.
 - viii. If the City Engineer overrules or modifies the Project Engineer's decision, in whole or in part, and/or the Contractor and City Engineer are able to reach a satisfactory adjustment, then the City Engineer or Project Engineer will facilitate an amendment to the Contract Documents in accordance with the Contract Documents and any other City Code requirements. An amendment is not effective and binding until it is executed by the Parties in writing.
3. *Appeal to the Director of Public Works.* Contractor shall submit its written Notice of Appeal to the Director of Public Works within 14 days of Contractor's rejection of the City Engineer's decision. The Notice of Appeal shall be clearly titled as "Notice of Appeal" and dated. The Notice of Appeal shall be sent via certified mail addressed to the Director of Public Works. Appeals will not be considered unless the Contractor has first complied with Section 1- *Prerequisites to Commencing the Dispute Resolution Process*, and with Section 2 – *Dispute Resolution Process*.
- a. Contractor may request an extension of time to submit the Notice of Appeal, which may be granted by the Director of Public Works, provided that good cause is shown. In no event will the extension of time exceed 21 days.
 - b. Written Notice of Appeal. All Notices of Appeal shall be clearly titled as "Notice of Appeal" and shall be numbered sequentially. Such Notice of Appeal shall contain, at a minimum, the following:
 - i. Project title and number;
 - ii. A copy of Contractor's Request to the Project Engineer;

- iii. A copy of the Project Engineer's Written Decision, if available;
 - iv. A copy of Contractor's written Notice of Intent to Claim and Claim;
 - v. A copy of the City Engineers written decision on Contractor's Claim, if available;
 - vi. A copy of all documents previously provided to the Project Engineer and the City Engineer in support of Contractor's Request; and
 - vii. An explanation of the basis for appealing the City Engineer's Decision, which shall describe the Claim in sufficient detail to allow the Director of Public Works to evaluate the basis of and costs associated with Contract's Claim.
- c. Contractor shall diligently continue performance of the Contract Documents to the maximum extent possible while an appeal is pending pursuant to this section.
- d. Director of Public Works Review. Within 21 days after receipt of Contractor's Notice of Appeal, the Director of Public Works will meet with the Contractor and City Engineer to discuss the merits of the Dispute.
 - i. During this meeting, Contractor will have an opportunity to present Contractor's Request and basis for appeal to the Director of Public Works. The City Engineer will have an opportunity to present on their written decision on Contractor's Claim.
 - ii. Absent compelling circumstances as determined by sole discretion of the Director of Public Works, the Director of Public Works will not consider any written documents, other than clarification and data supporting previously submitted documentation, which has not previously been made available to the City Engineer and properly made a part of the record.
 - iii. The Director of Public Works will review the appeal and will render a final written decision to the Contractor. The Director of Public Works' decision shall constitute a final agency decision. Any final agency decision rendered pursuant to this provision may be appealed as set forth in Colorado Rules of Civil Procedure Rule 106(a)(4).
- 4. *Waiver of Claims*. Failure to strictly meet any of the requirements of this section 1121.08 in a timely and complete manner shall constitute a waiver by the Contractor and shall bar Contractor from any further administrative, equitable, or legal remedy.
- 5. *Costs and Attorneys Fees*. In the event any suit or action is initiated to enforce the terms of the Contract Documents and/or the Engineering Specifications Book, should Arvada prevail, Arvada will be entitled to recover from the Contractor all of its reasonable costs and attorneys fees incurred in connection with the suit or action.

1121.09 Default of Contract

1. The Project Engineer may send a written notice of intent to find the Contractor in default to the Contractor and the Surety by certified mail for any of the reasons listed below. The notice will describe the conditions causing the impending default, advise them of the actions required for remedy and state that if the conditions have not been corrected within ten days of receipt of the notice, the Owner will find the Contractor in default.
 - a. Fails to begin the Contract work within the time specified to begin work, or
 - b. Fails to perform the Contract work with sufficient resources to assure its timely completion, or
 - c. Discontinues the Contract work, or
 - d. Fails to resume discontinued Contract work, or
 - e. Becomes insolvent, is declared bankrupt, commits an act of bankruptcy or insolvency, allows a final judgment to remain unsatisfied for a period of ten calendar days, makes an assignment for the benefit of creditors, or
 - f. Is a party to fraud.

If the Contractor fails to correct the conditions identified in the notice of intent to find the Contractor in default within ten calendar days of receipt, the City may serve the Contractor with an immediate notice of default and take prosecution of the work from the Contractor. Copies of the default notice will also be sent, by certified mail, to the Contractor and the Surety.

2. The Project Engineer may send a written notice of intent to find the Contractor in default to the Contractor and the Surety by certified mail for the reason listed below. The notice will include a stop work order which will require the Contractor to cease work on the Contract Items that are unacceptable. The notice will describe the conditions causing the impending default, advise the Contractor of the actions required for remedy and state that if the conditions have not been corrected within ten days of receipt of the notice, the City will find the Contractor in default.

The Owner may send a written notice of intent under this part (2) if the Contractor fails to perform the work to Contract requirements or neglects or refuses to correct or remove and replace rejected materials or unacceptable work. The Contractor shall not resume work on the unacceptable Contract items until the following conditions have been met:

- a. The Contractor shall submit a written proposal to the Project Engineer outlining the procedures which will be followed by the Contractor to correct the unacceptable items, and;
- b. The Project Engineer and the Contractor shall meet to discuss the written proposal, and;

- c. The Project Engineer will issue written permission for the Contractor to commence work.

If the Contractor fails to meet these three conditions within ten calendar days of receipt of the notice of intent to find the Contractor in default, or if at any time after the Contractor resumes work, the work does not meet Contract requirements or the Contractor again neglects or refuses to correct or remove and replace rejected materials or unacceptable work, the Owner may serve the Contractor with an immediate notice of default and take prosecution of the work from the Contractor. Copies of the default notice will also be sent, by certified mail, to the Contractor and the Surety.

1122.00 Measurement and Basis of Payment

All work completed under City contracts will be measured in place by the City Inspector, according to United States Standards of measures, using methods generally recognized as conforming to good engineering practices and as specified herein.

Payment to the Contractor on City projects will be made only for the actual quantities of contract items constructed and installed in accordance with the plans and specifications. Payment made at the contract unit price or lump sum amount bid shall be full compensation for furnishing all labor, materials, equipment, appurtenances, taxes, insurance, permits and incidentals necessary to complete the work as shown on the plans and as required by the specifications and acceptable manner and for all risk, loss, damage, or expense of whatever character arising out of the nature of the work or the prosecution thereof.

Work or materials for which there are pay items and which are to be paid separately will be included in the approximate quantities listed in the Bid Schedule. Each item, fixture, piece of equipment, etc., shall be complete in place, operational and accepted. Work or materials that are essential to the project but for which there are no pay items, will not be measured and paid for separately but shall be included in the project work. No additional payment, over the amount bid, will be made for related work to any item unless specifically called for in the contract. Neither will payment be made for materials wasted, rejected or placed outside of plan limit lines.

1122.01 Modifications to Unit Costs

At the direction of the Project Engineer items that are normally paid on a unit basis may be paid on a lump sum basis.

1122.02 Substitutions

Whenever a material, article or piece of equipment is identified on the drawings or specifications by reference to brand name or catalog number, it shall be understood that this is referenced for

the purpose of defining the performance or other salient requirements and that other products of equal capacities, quality and function shall be considered. The Contractor may request, in writing, the substitution of a material, article, or piece of equipment of equal substance and function for those referred to in the Contract Documents by reference to brand name or catalog number, and if, in the opinion of the Project Engineer, such material, article, or piece of equipment is of equal substance and function to that specified, the Project Engineer may approve its substitution and use by the Contractor. Any cost differential shall be deductible from the contract price and the Contract Documents shall be appropriately modified by Change Order. The Contractor warrants that if substitutes are approved, no major changes in the function or general design of the project will result. Incidental changes or extra component parts required to accommodate the substitute will be made by the Contractor without a change in the contract price or contract time.

1122.03 Payment Requests

Arvada will comply with CRS §§ 24-91-101 through 24-91-110, Construction Contracts with Public Entities, as amended.

Arvada shall pay Contractor for the Work requested by Arvada and rendered by Contractor under the Contract Documents. Contractor shall prepare monthly for Project Engineer's approval, a payment estimate of the actual work performed and materials placed in accordance with the contract documents.

Not more than eighty (80) percent of the cost of materials and equipment delivered and suitably stored at or near the project site, but not incorporated in the work may be included in a payment estimate; provided however, the Contractor furnishes invoices and supportive data establishing title in the name of the Owner, to the Project Engineer.

The amount to be retained from partial payments will be ten percent of the value of completed work, exclusive of mobilization and payment for materials on hand. When the retainment on contracts exceeding \$80,000 in value has reached five percent of the amount of the contract, no further retainment will be made. Amount of retainment will be held until such time as final payment is made with the following provision: When ninety-seven and one-half percent of the work has been completed, the Engineer may, at his discretion and with the consent of the Surety, reduce the retained amount to twice the value of the work remaining to be done.

Payment from Arvada of the approved request will be due NET thirty (30) days, unless otherwise stated and agreed to by the parties in the Contract Documents.

1122.04 Initial Warranty

Upon receipt of an approved designated semifinal estimate (punchlist), as prepared by the Project Engineer, the Contractor shall, in writing, request the Project Engineer to make an initial warranty acceptance inspection in preparation for probationary acceptance of the work by the Owner. The Project Engineer, upon receipt of written request for the initial warranty acceptance inspection, shall promptly make said inspection of the work and issue to the Contractor a written notice (punchlist) advising him of any deficiencies, corrective measures or clean up that he must complete prior to preparation of the final payment request and probationary acceptance of the work.

1122.05 Final Payment Request, Acceptance and Release

Upon completion of the Work on City projects and cleanup of the project site, the Project Engineer, within ten calendar days thereafter shall:

1. Review the final payment request prepared by the Contractor that shows the total value of the work completed in accordance with the contract documents and as modified by any Change Orders, less the value of:
 - a. Partial payments previously made by the Owner to the Contractor.
 - b. Retention of any claims, on file with the Owner, against the Contractor.
 - c. Estimated costs of completing any incomplete or unsatisfactory items of the work.
 - d. Payments advanced by the Owner, to subcontractors, material and equipment suppliers or others which are known by the Contractor to have been made but not previously accounted for.
 - e. Liquidated damages not previously paid to the Owner by the Contractor.
2. Advise the Owner and Contractor by written notice that:
 - a. The work has been inspected and accepted by the Project Engineer under the conditions of the contract documents.
 - b. The work, effective the date of the notice, is placed under probationary acceptance, at the Contractor's expense, for a period of two (2) years.
 - c. The entire balance shown on the final payment request, as prepared by the Project Engineer, is due and payable within 30 calendar days from date of approval thereof by the Contractor.

The Contractor shall, at the Owner's request, furnish satisfactory evidence that all obligations of the nature designated above have been paid, discharged or waived. If the Contractor fails to do so, the Owner may, after having notified the Contractor, withhold from the Contractor's unpaid compensation a sum of money deemed reasonably sufficient to pay any and all such lawful claims until satisfactory evidence is furnished that all liabilities have been fully discharged, in accordance with the terms of the contract documents, but in no event shall the provisions of this

sentence be construed to impose any obligations upon the Owner to either the Contractor, his surety, or any third party. Such funds shall not be withheld longer than ninety days following the date fixed for final settlement as published unless an action is commenced within that time to enforce such unpaid claim and a notice of lis pendens is filed with the City.

At the expiration of such ninety day period, the City shall pay to the contractor such moneys and funds as are not the subject of suit and lis pendens notices and shall retain thereafter, subject to the final outcome thereof, only sufficient funds to insure the payment of judgments which may result from such suit. Failure on the part of a claimant to comply with the provisions of Colorado Revised Statute Section 38-26-101, 38-26-106, and this section shall relieve the City from any liability for making payment to the contractor.

1123.00 Project Facilities

Items: Field office, laboratory, sanitary.

Measurement: (Each) - The number of project facilities will be measured by the actual number of facilities completed with furnished utilities, as called for in the Contract Documents.

Payment: Payment at the contract amount bid will be paid for project facilities furnished and maintained throughout the duration of the project, as follows: Fifty (50) percent upon first utilization, fifty (50) percent balance will be prorated and paid according to the percent of the original contract amount approved for payment, but subject to retainage. Restoration of the field facility areas will not be paid for separately, but shall be included in the cost of the item.

1124.00 Mobilization

Measurement: (Lump Sum) - No measurement for mobilization will be made.

Payment: Partial payments, subject to contract retainage, for mobilization will be made each month as the work progress as follows:

Original Contract Amount*	Mobilization Contract Amount Bid
Earned**	Payable
5%	25%
10%	50% (less prev. payment)
25%	60% (Less prev. payment)
75%	100% (less prev. payment)

*Original contract amount less contract amount bid for mobilization

**Payment for materials on hand will not be included as a percent of original contract earned

until said materials on hand have been incorporated into the work and accepted for item payment.

1125.00 Equipment Rental

Items: Backhoe, Dragline, Dozer, Front End Loader, Lo-Boy, Patrol Pump, Roller, Truck, etc.

Measurement: (Hour) - The quantity to be measured will be the number of hours or fraction thereof that the Bid Schedule specified piece of equipment is used, as directed.

Payment: The actual number of hours the specified piece of equipment is used will be paid for at the contract hourly rate bid. No measurement or payment will be made for labor, mobilization, time equipment is mechanically inoperative, attachments, piping, discharge lines, channelization, excavation, backfill, grading, etc., but shall be included in the work.

NOTE: Hourly rates shall not exceed the hourly rates recognized by the Colorado Department of Transportation plus 1.35 times the operator's hourly rate.

1130.00 Soils and Earthwork

1131.00 Clearing and Grubbing

Measurement: (Acres) (Lump Sum) - The quantity of clearing and grubbing shall be measured in acres or fraction thereof or in lump sum for a specified area acceptably cleared and/or grubbed including scalping and shrub removal, within the project limits, to a depth of three (3) feet below the existing surface. No measurement will be made when the Bid Schedule calls for clearing and grubbing a specified area on a lump sum basis. Removal of vegetation with a trunk that measures smaller than twelve (12) inches in diameter when measured four (4) feet above the existing surface shall be paid for as clearing and grubbing.

Payment: The accepted areas will be paid for at the contract unit price or lump sum amount bid. When the Bid Schedule does not contain an item for clearing and grubbing, the work will not be paid for directly, but will be considered as a subsidiary obligation of the Contractor under other contract items.

Trees, plants, structures, etc. that are not to be removed shall be fully protected from injury by the Contractor at Contractor's expense. Contractor is responsible for costs associated with restoration and replacement of trees, plants, structures, etc. that are damaged by Contractor.

1132.00 Transplanting Plants, Shrubs, Trees

Measurement: (Each) - The quantity of transplanting to be measured will be the actual number of plants of the various types transplanted and accepted in their final location and in healthy condition at the end of a ninety (90) day maintenance period.

Payment: The accepted quantities of the various plants transplanted, as specified in the Bid Schedule, will be paid for at the contract unit price bid. No separate measurement or payment will be made for digging, balling, spraying, debudding, pruning, transporting, fertilizing, watering and maintaining, but shall be included in the work.

1133.00 Demolition

Measurement: (Each) (Lump Sum) - Demolition will be measured as the number of locations where structures have been razed or removed and area properly graded and accepted.

Payment: Accepted areas on which demolition has been performed will be paid for at the contract amount bid for the specified location. No separate measurement or payment will be made for: clearing and grubbing, removal of buildings, foundation, basement slabs, cesspool, privies, buried fuel and septic tanks, wells, well casing, slabs on grade; disconnect and protection of public utilities or improvements; hauling and disposal of rubble, furnishing, hauling, placing, compacting fill and grading the area to drain; protection of facilities designated to remain, but shall be included in the work.

1134.00 Removal of Structures or Obstructions to Salvage or Waste

Items: Buildings and foundations; bridges, culverts and other drainage structures; concrete curb, gutter, sidewalk, crossspans and pavement; maintenance holes, fence, pipe, valves, meters, traffic devices, trees, etc.

Measurement: (Each) (Lump Sum) (Linear Feet) (Square Feet) (Square Yard) - Measurement will be made for removal for salvage or waste according to the unit specified in the Bid Schedule. Only count will be made of items removed on a lump sum basis. Tree stumps and roots must be removed to a minimum depth of three (3) feet below existing grade.

Payment: The accepted quantities will be paid for at the contract unit price bid for each of items removed for salvage or waste specified in the Bid Schedule. No separate measurement or payment will be made for dust suppression, site security, sawing, removing, hauling and disposal, excavation and subsequent backfill to finish grade, but shall be included in the work.

The contract unit price bid shall also include the salvage of materials removed, their custody, preservation, storage and disposal as specified in the Contract Documents.

1135.00 Excavation and/or Borrow

Items: Borrow, embankment, excavation, muck, rock, unclassified.

Measurement: (Lump Sum) (Cubic Yard) - Measurement for excavation, embankment and/or borrow will be made according to the unit specified on the Bid Schedule. No measurement will be made when the item is specified as a lump sum.

When payment is specified on a volume basis, all except excavation, stripping and borrow shall be measured in its original position by cross-sectioning the area excavated. Volume will then be computed from the cross-section measurements by the average end area method. Embankment material, when called for on a volume basis, will be measured in its final compacted position without allowances being made for stripping or subsidence due to compaction of the base of fills.

Payment: The accepted quantities of excavation, embankment, or borrow, called for on the Bid Schedule, will be paid for at the contract unit price bid. Payment made shall be full compensation for royalties on material, excavation, haul, rehandling from stockpile, wetting, compacting, shaping and disposal of surplus material.

1136.00 Stormwater Protection and Erosion Control During Construction

Measurement: (Lump Sum) - Where listed as a bid item, payment shall be for the installation and maintenance of required erosion control measures, including straw bales, waddles, rock socks, vehicle tracking pads, silt fence, etc.

NOTE: For projects that extend beyond three months, and as allowed by the Project Engineer, maintenance measures may be paid at periodic intervals for erosion control.

Payment: Accepted erosion control measures will be paid for at the contract unit bid price. No separate measurement or payment will be made for various measures required for installation such as stakes, grading, etc. but shall be included in the work.

1137.00 Trenching, Backfilling, and Compacting

1137.01 Trench Resurfacing

Items: Base course, asphalt, concrete

Payment: Accepted quantities of trench resurfacing will be paid for at the respective contract unit price bid. A separate line item and accepted quantities for cutback and patch will be paid for at the respective contract unit price bid. The quantity will be limited to the width of cutback approved by the project Engineer. No separate measurement or payment will be made for wetting and compacting trench backfill, subgrade densification and shaping, vertical trueing of existing surface along each side of the trench, placing materials outside the established prism limits, tacking existing surface edges, traffic control, etc., but shall be included in the work.

1137.02 Materials for Bedding, Backfill, etc.

Items: Bed course, filter media, select and/or structural backfill, special backfill

Measurement: (Cubic Yard) - Measurement of select materials called for in the Bid Schedule shall be computed between horizontal and vertical neat lines and planes.

A. Circular Conduits: Calculated volume between:

1. Vertical planes perpendicular to the conduit centerline between stations shown on the drawings or as directed; and between;
2. Vertical planes each side and parallel with the conduit centerline. The spacing between the planes shall not exceed three (3) feet plus the outside diameter of the conduit in feet for trenches over five (5) feet deep and shall not exceed two (2) feet plus the outside diameter of the conduit in feet for trenches less than five (5) feet deep, and between;
3. Two (2) horizontal planes, one being one (1) foot above and parallel with the outside crown of the conduit and one at base course subgrade or at finish grade, whichever is the lower in elevation.

B. Bedding Material: Calculated volume of material lying within the prism shown on the Standard Detail Drawings or construction plans. Except no measurement will be made for trench rock stabilization or conduit bedding material installed below a horizontal plane located one (1) foot above the conduit crown centerline.

C. Bridges and Irregular Shaped Structures: Calculated volume to vertical neat lines one and one-half (1 ½) feet outside and parallel to the outline of the foundation plan and between horizontal planes at elevation limits shown on the drawings or as directed.

Payment: Accepted quantities of select materials will be paid for at the contract unit price bid for the items as they appear in the Bid Schedule. No separate measurement or payment will be made for material royalties, haul, dewatering, compaction, etc., but shall be included in the work.

NOTE: Cost of trench dewatering, disposal of surplus material, trench stabilization, conduit bedding below and to the elevation specified in the Contract Documents shall be in the contract unit price bid for the conduit or pipe in place.

1140.00 Water, Sewer, and Storm Facilities

1141.00 Reset, Relocate, Reconnect Adjust

Items: Barricade, fence, gate, mailbox, manhole barrel, cover, cone, flat top, ring or steps; pipe, pole, structures; sewer service; traffic devices; water meters, services and valves.

Measurement: (Each) (Lineal Feet) (Square Yards) - The quantity to be measured shall be the actual number, length or area of the various items removed, stored, reconnected, relocated, adjusted and reset to service, when specified on the Bid Schedule.

Payment: The accepted quantities of item reset to service will be paid for at the applicable contract unit price bid. No separate measurement or payment will be made for work related materials necessary to reset the item to service; such as posts, hardware, wire, mailbox, excavation, backfill, concrete, rewiring, bedding, joint material, collars, connecting bands; but shall be included in the work.

1142.00 Flow Control, Special Fittings and Measure Devices or Systems

Items: Meters, pumps, special fittings and valves; flumes, drain and head gates; recorders, totalizers, telemetry and electrical systems. NOTE: Fire hydrants are excluded.

Measurement: (Each) - The actual number of the various devices or systems specified in the Bid Schedule installed and accepted.

Payment: The accepted number of flow control, special fittings and measuring devices or systems will be paid for at the contract unit price bid. No separate payment will be made for excavation, dewatering, bedding, in line fittings and connectors, supports, riser guides and extension, valve box with covers, backfill, grading, mounting brackets, electrical conduit, wire etc., but shall be included in the work.

1143.00 Fire Hydrants

Measurement: (Each) - Actual number of five and one quarter inch ($5\frac{1}{4}$ ") three-way fire hydrants installed to grade, including any fire hydrant extensions required.

Payment: The accepted number of fire hydrants will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation, dewatering, six (6) inch flanged gate valve with box and cover at main, hydrant extensions, bedding, six (6) inch PVC AWWA C900 CL 200 or AWWA C909 CL 150 lateral pipe, gravel underdrain, tie rods, shackle, tape wrapping, concrete anchor block, backfill, grading, etc., but shall be included in the work.

1144.00 Piping in Vaults

Measurement: (Lump Sum) - No separate measurement will be made of Piping installed in vaults or within three (3) feet of the vault exterior surface.

NOTE: In line valves, meters, telemetry and electrical systems will be measured and paid for separately as called for in the Bid Schedule.

Payment: - Accepted in vault piping will be paid for at the contract unit price bid. No separate measurement or payment will be made for the various types, sizes or length of pipe and fittings required, tie-rods, corporation stop, gauges, pipe and device supports, structural steel, steel plates, hardware, gaskets, tubing, insulating and joint bonding material, tape wrapping, gasket and outlet sealants, vents, conduit, etc., but shall be included in the work.

1145.00 Casing Pipe - Jacking or Boring

Measurement: (Lineal Feet) - The quantity of casing pipe, according to the type and size called for in the Bid Schedule, will be measured along the pipe centerline between the limits designated on the plans or as directed.

Payment: Accepted quantity of casing pipe will be paid for at the contract unit price bid. No separate measurement or payment will be made for special insurance, excavation, pit sheeting and shoring, dewatering, pressure grouting, skids, chucks, stulls, stringing and anchoring carrier pipe, furnishing and installing sand in voids between the carrier and casing pipe if required, bulkheads, cathodic protection (32 lb. anode bags), backfill, disposal of surplus material, etc., but shall be included in the work.

NOTE: The length of carrier pipe will be paid for separately from the applicable contract unit price bid for pipe, installed through the casing.

1146.00 Pipelines and Utility Trenches

Items: Drainage, sanitary sewer and water lines; sanitary and water service lines; irrigation, siphon, underdrain and vent lines.

NOTE: Fire hydrant laterals and flared end treatments are excluded.

Measurement: (Lineal Feet) - Pipe of the various types, classes and sizes called for in the Bid Schedule will be measured by the lineal foot along the in place pipe centerline, between points of connection with existing facilities or extremities specified on the plans.

NOTE: Deduction in measured quantities will be made for piping in vaults and pipe at maintenance holes and structures where the concrete inverts are cast in place and shaped. No deduction in measured length will be made for in line fittings and valves.

Payment: - Accepted quantities of pipe will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation, dewatering, trench stabilization material, bedding material, in line fittings and connectors, tape wrapping, gasket and joint materials, all thread ties, joint restraints, concrete anchor blocks, clay trench and inversion plugs, backfill, disposal of surplus materials, etc., but shall be included in the work.

1146.01 Cathodic Protection Devices and Systems

Items: Anode Field, Conductors, Controller, Deepwell Anode System, Rectifier, Submerged Anode System, Test Station.

Measurement: (Each) (Lump Sum) - Cathodic protection will be measured by the actual number of the various devices and/or systems, specified on the Bid Schedule, installed.

Payment: Accepted quantities of the cathodic protection devices and systems will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation, drilling, dewatering, caldwell thermite bonding, insulating, ridged conduit, wire, reference electrodes, ground rod, junction box, backfill, energizing, testing, training owner's personnel in operating the system, retesting, etc., but shall be included in the work.

1146.02 Connections to Existing Facilities

Items: Inlet, manhole, and pipe connections.

Measurement: (Each) - The quantity to be measured shall be the actual number of connections made between a new installation and an existing facility.

Payment: Accepted number of connections made to an existing facility will be paid for at the contract unit price bid. No separate measurement or payment will be made for connecting to water taps made by City crews, excavation, dewatering, tapping, cutting, chipping, drilling;

furnish and installing; fittings, tie-rods, anchor blocks, tape wrapping, jointing material, gasket sealants, reshaping manhole inverts, backfill, etc., but shall be included in the work.

1146.03 Chlorination and Pressure Tests

Items: Drainage, sanitary sewer and water lines.

Measurement: (Each) - The quantity of chlorination and/or pressure tests shall be the number of pipe stretches tested between two (2) adjacent maintenance holes on sanitary and storm sewer lines, or the number of stretches of water main tested between the line extremities as shown on the plans. No count will be made of lateral connections to immediate adjacent valves or service lines extending from the main.

Payment: Accepted chlorination and pressure tests will be paid for at the contract unit price bid. No separate measurement or payment will be made for chlorination and flushing of water lines, retesting when prior tests have failed, furnishing and connecting approved bulkheads, connectors, tubing, piping, compressor, pump, water, volumetric and pressure gauges, etc., to test water lines at 150 psig or sewer lines to 3.5 psig; but shall be included in the work.

1146.04 Pipeline Inspection and / or Cleaning

Items: Root removal, scouring, television inspection.

Measurement: (Lineal Foot) - The actual number of lineal feet of pipe requiring root removal, inspected and/or scoured, measured along the pipe centerline between consecutive maintenance holes, to the limits specified in the Contract Documents or as directed.

Payment: Accepted quantities of line inspected and/or scoured, as called for in the Bid Schedule, will be paid for at the contract unit price bid. No separate measurement or payment will be made for flow diversion or control; equipment set ups, film, traffic control, collecting data and reporting location of line failures; removal and offsite disposal of purged solids; repair of service lines damaged in performing the work etc., but shall be included in the work.

1146.05 Pipe Joint Rehabilitation

Items: Joint testing, joint sealing, proof testing.

Measurement: (Each) - The actual number of pipe joints tested and/or sealed of the various pipe sizes called for in the Bid Schedule.

Payment: Accepted quantities of joints tested and/or sealed will be paid for at the contract unit price bid. No separate measurement or payment will be made for flow diversion or control, equipment set ups, retests of joints sealed, traffic control, etc., but shall be included in the work.

1146.06 Pipe Joint Repair

Measurement: (Each) - The actual number of point repairs made, in which thirteen and one-half (13 ½) feet or less of new equivalent size pipe is installed.

Payment: Accepted quantities of point repairs made, of the various sizes of pipe specified in the Bid Schedule, will be paid for at the contract unit price bid. No separate measurement or payment will be made for mobilization, traffic control, excavation, trench shoring, dewatering, flow diversion or control, service line reconnects, watertight couplings or fittings, locating and protecting other utilities, bedding and backfill placement and compaction, disposal of waste and surplus materials, etc., but shall be included in the work.

1146.07 Pipe Slipliner

Items: Access pits, service reconnects, sliplining.

Measurement: (Lineal Feet) (Each) - In place slipliner, of the various thickness and sizes called for in the Contract Documents, will be measured along the pipe centerline, between points of reconnects. Measurement of the access pits and service line reconnects will be the actual number of access pits for insertion and/or service connections made to the in place liner pipe.

Payment: The accepted number of lineal feet of slipliner pipe installed and/or the number of designated access pits or service reconnects made will be paid for at the respective contract unit price bid therefore. No separate measurement or payment will be made for mobilization, traffic control, excavation, manhole rehabilitation, flow diversion and/or control, shoring, power, thermal jointing, cement stabilized sand, circle seal clamps, sealing at maintenance holes, saddles, gaskets, backfill, disposal of surplus material, restoration of property, etc., but shall be included in the work.

1146.08 Removal and Disposal of Asbestos-Cement (AC) Pipe

Measurement: (Lineal Feet) - Measurement shall be based on the proper removal and disposal of the actual number of lineal feet of AC pipe encountered on the project that is required to be removed in order to complete the work. Removal of AC pipe is considered to be a Class II Asbestos removal according to OSHA standards. Contractor shall be responsible for following the regulations and procedures carefully and proceeding accordingly. Contractor may consider having a certified asbestos removal contractor perform this part of the work as a subcontractor. Contractor shall also be responsible for following any of the Colorado Department of Public Health and Environment's (CDPHE) Asbestos Regulations or Jefferson County Health Department standards that apply to AC pipe removal. Should Contractor engage a certified asbestos removal contractor to perform this work, Contractor shall ensure the subcontractor follows all regulations and procedures established by OSH, CDPHE, or the Jefferson County Health Department pertaining to AC pipe removal.

Payment: "Removal and disposal of AC pipe will be paid for at the contract unit bid price. No separate payment will be made for complete removal and disposal of the AC pipe in accordance with applicable OSHA standards, CDPHE standards and Jefferson County Health Department standards, or for additional costs involved for removal and disposal of AC pipe, but shall be included in the work.

1146.09 Piling

Items: Sheet, steel, timber.

Measurement: (Square Feet) (Linear Feet) - Number of facial square feet of sheet piling or the lineal feet of steel and timber piling installed, to cut off elevation.

Payment: Accepted quantities of piling will be paid for at the contract unit price bid for each of the various types specified in the Bid Schedule. Payment made shall be full compensation for furnishing and driving piling including splicing, cut offs not used, drilling holes to facilitate driving, capping, pile shoes, jetting, blasting, painting exposed surfaces, etc., but shall be included in the work.

1150.00 Concrete

1151.00 Flatwork

Items: Crossspans, curbs, gutters, pavement, sidewalk, driveway pans, slabs on grade, median.

Measurement: (Square Yard) (Lineal Feet) - Concrete flatwork will be measured as the actual number of square yards or lineal feet of exposed surface concrete placed to the thickness, shape and length specified in the Contract Documents.

Payment: Accepted quantities of concrete flatwork will be paid for at the contract unit price bid for the applicable type of concrete flatwork specified in the Bid Schedule. No separate measurement or payment will be made for base course material and/or subgrade preparation including compaction, fine grading, expansion joint, reinforcing steel, dowels, tie bar, joint filler, etc., but shall be included in the work.

1152.00 Structural Concrete

Items: Bridges, box culverts, catch basins, cut off walls, diversion structures, head and wing walls, inlets, vaults.

Measurement: (Cubic Yard) (Each) - Bulk structural concrete will be measured by the cubic yard in accordance with the neat line dimensions called for in the Contract Documents. Deductions in

the bulk measurement will be made for voids, wherein the volume of concrete displaced exceeds one (1) cubic foot. No deduction will be made for the volume of reinforcing steel contained therein.

Minor structures such as catch basins, diversion structures, cut off walls, etc., may be measured as the actual number installed, when so specified in the Bid Schedule.

Payment: The accepted quantity of structural concrete and or structures cast in place will be paid at the contract unit price bid. No separate measurement or payment will be made for structural excavation, dewatering, foundation stabilization, forming, embedded frames, grates, access covers, reinforcing or structural steel, colored concrete, etc. but shall be included in the work.
NOTE: Deck concrete within plan limits for curb, gutter, sidewalk and transitions shall be included in the contract unit price bid, when basins and inlets are to be paid for on the per each basis.

1153.00 Miscellaneous Concrete

Items: Anchor blocks, pipe encasement.

Measurement: (Each) (Lineal Feet) (Cubic Yard) - The quantity of anchor block concrete will be computed as the volume of concrete placed between end bulk heads. Set perpendicular to the pipe and between two (2) vertical planes; one (1) which clears the pipe springline by the lesser of one half the pipe outside diameter or twelve (12) inches, and one (1) passing through the pipe centerline, less the concrete volume displaced by one half the pipe end area. Pipe encasement will be measured along the pipe centerline, between bulkheads and neat lines specified in the Contract Documents.

Payment: Accepted quantities of miscellaneous concrete will be paid for at the contract unit price bid, in accordance with the various items called for in the Bid Schedule. No separate measurement or payment will be made for excavation, dewatering, bulkheads, reinforcing steel, curing, frost protection, etc., but shall be included in the work.

1154.00 Precast Concrete

Items: - Box culverts, catch basins, inlets, pre-stressed members, maintenance holes, vaults, flared end sections

Measurement: (Each) - Actual number of precast structures of the various sizes and shapes specified in the Contract Documents.

Payment: Accepted quantities of precast structures will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation, dewatering, rock stabilization, shaped inverts or bases, eccentric cones, flat top covers, joint and outlet gasket or sealants, exterior drop pipe and fittings, concrete cast outs, steps, leveling rings, sump pit frame and grate; vent and sump piping; access frames and covers, backfill, etc., but shall be included in the work.

NOTE: Concrete curb, gutter, sidewalk and transitions cast in place shall be included in the contract unit price bid for catch basin and inlet.

1160.00 Structural

1161.00 Reinforcing Steel - Epoxy Coated

Measurement: (Pounds) - Reinforcing steel will be measured by computing the unit weight of steel called for on the plans. Exceptions will be made for design revisions or proven error in excess of two (2) percent of the quantities specified in the Bid Schedule.

Payment: Accepted quantities of reinforcing steel will be paid for at the contract unit price bid. No allowance will be made for supports, clips, wire or other material used to anchor the reinforcement in place or epoxy coating, but shall be included in the work.

1162.00 Structural Members

Items: Steel, timber.

Measurement: (Thousand feet board measure) (Pound) - Timber will be measured by the (TFBM); steel will be measured by computing the unit weight of material actually incorporated in the work.

Payment: Accepted quantities of structural timber or steel will be paid for at the contract unit price bid. No separate measurement or payment will be made for structural excavation, hardware, bolts, rivets, alloys, plates, galvanizing, epoxy coating, castings, welding, fabricating, bearing devices, connectors, rollers, drain pipe, waterproofing membrane, damproofing, water stops, painting, structural backfill, etc., but shall be included in the work.

1163.00 Railing

Items: Hand rail, guardrail, end anchors.

Measurement: (Lineal Feet) (Each) - Railing of the various sizes and types called for in the Bid Schedule will be measured along the centerline of the railing between ends, including transitions. Guardrail end anchors will be measured as the actual number installed and accepted.

Payment: Accepted quantities of railing and end anchors will be paid for at the contract unit price bid for the type specified. No separate measurement or payment will be made for guardrail terminal sections, concrete, reinforcing steel, anchor bolts, hardware, cable, rod, nuts, washers, posts, etc., but shall be included in the work.

1164.00 Drilled Caissons

Measurement: (Linear Foot) - Drilled caissons will be measured by the linear foot from ground line or elevation shown on the plans to the bottom of the hole as drilled.

Payment: Accepted quantities of the various diameters of caisson specified in the Bid Schedule will be paid for at the respective contract unit price bid. No separate measurement or payment will be made for dewatering, furnishing and placing reinforcing steel, Class "A" concrete, splicing, etc., but shall be included in the work.

1165.00 Miscellaneous

Items: - Access cover and frame, embedded items, flared end sections, grate and frame, tied joints, manhole steps, reshape manhole inverts, trash guards, meter pits, meters, etc.

Measurement: (Each) - The quantity of miscellaneous items will be measured by the actual number of items installed as specified in the plans or Contract Documents

Payment: Accepted quantities of miscellaneous items will be paid for at the contract unit price bid for each of the various items that appear in the Bid Schedule. No separate measurement or payment will be made for subsidiary items essential to making the items functional as intended, but shall be included in the work.

1166.00 Crib or Bin Wall

Items: Steel, concrete, timber.

Measurement: (Square feet) - Crib walls of the various types and design specified in the Bid Schedule will be measured by the number of square feet of facial area which parallels the centerline of the roadway or channel.

Payment: Accepted quantities of the various types specified in the Bid Schedule will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation;

furnishing and installing Class "B" concrete, reinforcing steel; furnishing placing and compacting backfill, etc., but shall be included in the work.

1167.00 Fence and Gates

Measurement: (Lineal Feet) (Each) - Fence will be measured along the base of the fence between the end post of each continuous run of fence but excluding gate openings. Gates will be measured by the actual number of the various sizes or types installed.

Payment: Accepted quantities of fence and gates will be paid for at the contract unit price bid for the various types and sizes called for in the Bid Schedule. No separate measurement or payment will be made for clearing and grubbing, grading along the alignment; line, end, corner and line brace posts; braces, guyes, concrete, painting and cut surface treatment of wood posts cut in the field, but shall be included in the work.

1168.00 Payment Reduction for Concrete

All work performed and all materials furnished shall conform to the line, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the contract. For those items of work where working tolerances are not specified, the Contractor shall perform the work in a manner consistent with reasonable and customary manufacturing and construction practices.

When the Owner determines that 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 unless the Engineer determines that the work can be accepted at a reduced price. Payment reduction (CIP work only), when allowed, shall be accomplished by adjusting pay quantities as indicated herein and applying the contract unit prices to the reduced quantities. If allowed, the Owner shall:

- A. Document the basis for acceptance by a notice which shall provide for an appropriate adjustment in the payment quantity for such work or materials not otherwise provided for in this section.
- B. Notify the Contractor in writing that the payment shall be adjusted in accordance with this section.
- C. In lieu of payment (quantity) adjustment, permit correction or replacement of the finished product provided the correction or replacement does not adversely affect the work or the Owner.

Materials shall be sampled and tested by a qualified testing laboratory in accordance with the sampling, testing schedules, and procedures contained in Section 825 Concrete Testing. 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 Owner'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 Owner may establish a lot consisting of the quantity represented by any number of consecutive random samples from one to seven inclusive. Testing results that are determined to have sampling or testing errors, as determined by the Owner, shall not be used.

Materials or work shall only be evaluated for price adjustment when deviations from Specification occur on any of the individual tests for the lot. The several individual test values shall be averaged and the percentage of payment (quantity) reduction for the lot shall be determined by the applicable table. This shall apply only when a payment reduction element is listed in a table below.

Payment adjustment for those elements not included in a table shall be determined by the Owner.

The Contractor shall not have the option of accepting a payment reduction in lieu of producing material meeting the specifications. Continued production of non-specification material shall not be permitted. Material that is obviously defective shall be isolated and rejected without regard to sampling sequence or location within a lot.

The pay factor for concrete that is allowed to remain in place at a reduced price shall be determined according to tables below, and shall be applied to the quantities for the Item. If deviations occur in air content and strength within the same batch, the pay factor for the batch shall be the product of the individual pay factors.

PAY FACTORS

Percent Total Air	
Deviations from Specified Air (percent)	Pay Factor
0.0 - 0.2	0.98
0.3 - 0.4	0.96
0.5 - 0.6	0.92
0.7 - 0.8	0.84

0.9 - 1.0	0.75
Over 1.0	Reject

Strength	
Below Specified Strength (psi)	Pay Factor
1 - 100	0.98
101 - 200	0.96
201 - 300	0.92
301 - 400	0.84
401 - 500	0.75
Over 500	Reject

1170.00 Asphalt

1171.00 Aggregates and Asphalt Materials

Items: Base course, cover coats, foundation drains, gravel underdrains, patching, pit run, plant mix asphalts, seal coats, special backfill, treated base.

Measurement: (Ton) (Square Yards) - Measurement of aggregates and asphalt materials shall be the actual tons, evidenced by certified weight tickets, of the various types, grades or classes of materials, or placed in the work or the number of surface square yards when specified on the Bid Schedule.

Payment: The accepted quantities of materials will be paid for at the contract unit price bid. No separate measurement or payment will be made for barricading, traffic control, sweeping, disposal of waste materials, subgrade preparation, hauling, placing, wetting, rolling, shaping, compacting, etc., but shall be included in the work.

Pay items for patching on City projects shall be complete-in-place to include sawcutting, removal of existing asphalt, excavation to subgrade of the specified patch section, placement of base and new hot bituminous pavement material, and compaction of all layers.

The pay items for overlaying on City projects shall be complete-in-place to include sweeping and tack coating of existing bituminous pavement.

1172.00 Liquid Agents for Asphalt Surface Treatment

Items: Emulsions, prime coat, rejuvenating agents, tack coat.

Measurement: (Gallon) - Liquid agents for asphalt surface treatment will be measured as the actual number of gallons sprayed in place. The pay quantity for emulsified asphalt and/or rejuvenating agent shall be the number of gallons of concentrate before dilution and mixing with water.

Payment: The accepted quantities of the various liquid agents will be paid for at the contract unit price bid. No separate measurement or payment will be made for traffic control, blotter materials, or water used as diluent, but shall be included in the work.

1173.00 Cold Milling

Measurement: (Square Yards/Vertical Inch) - Cold milling will be measured as the actual number of square yards of surface area milled to an average depth of one inch, or fraction thereof.

EXAMPLE: A milled section twenty-seven (27) feet long, uniformly tapered from two and one quarter ($2 \frac{1}{4}$) inches below the gutter lip line and which daylights with the existing asphalt surface eight (8) feet and perpendicular therefrom will be measured as: $(27 \text{ ft.} \times 8 \text{ ft.}) / 9 \text{ ft./sq. yd.} = (2-1/4 \text{ in.}/2) = 27.0 \text{ square yards.}$

Payment: The accepted quantities will be paid for at the contract unit price per square yard per inch of depth bid. No separate measurement or payment will be made for traffic control, disposal of milled materials, maintenance of milled surface, prior to resurfacing etc., but shall be included in the work.

1174.00 Slope and Ditch Paving

Items: Bituminous, concrete, dry or grouted rubble.

Measurement: (Cubic Yards) (Ton) - Bituminous slope and ditch paving will be measured by the number of tons in place and accepted. Measurement of the various other types will be by the

cubic yard based on dimensions shown on the plans, as directed or measured by the average end area method.

Payment: Accepted quantities of the various types of slope paving specified in the Bid Schedule will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation, haul, mortar or concrete used for grout, top coat, etc., but shall be included in the work.

1175.00 Hauling

Measurement: (Cubic Yard Mile) (Ton Mile) - Haul shall be the product obtained by multiplying the number of units of material removed; from its original center of volume or mass position; by the mean distance in miles or fraction thereof to its center of placement volume or mass.

Payment: The quantity of haul measured as provided above will be paid for at the contract unit price bid. Unless specifically specified in the Bid Schedule, no separate payment will be made for haul but shall be included in the various items of the work.

1176.00 Mud Jacking

Measurement: (Square Yard) - The quantity to be measured will be the number of superficial square yards or fraction thereof, of concrete mud jacked to grade between construction joints.

Payment: The accepted quantity of surface area will be paid for at the contract unit price bid. No separate measurement or payment will be made for drilling and plugging of holes, dewatering, soil cement materials, etc., but shall be included in the work.

1177.00 Painting

Items: Pavement marking with paint, thermoplastic or tape; steel, wood and concrete structures

Measurement: (Lineal Feet) (Square Feet) (Each) - The quantity to be measured shall be the actual exposed length or surface area of marking or painting installed. Painting of structures will be the actual number of the various types and sizes thereof, specified in the Bid Schedule, and no measurement of the surface area will be made.

Payment: Accepted quantities of pavement marking, and structure painting will be paid for at the contract unit price bid. No separate measurement or payment will be made for traffic control, dewatering, sand or grit blasting, protection of existing cathodic protection systems, protection of adjoining properties during blasting and/or painting, site restoration, disposal of surplus materials, etc., but shall be included in the work.

1178.00 Subgrade Treatment

Items: Heating and scarifying bituminous surface, reconditioning subgrade, treatment at the base of cuts and fills.

Measurement: (Square Yard) - Subgrade treatment will be measured by the square yard of existing surface area treated and reconditioned.

Payment: The accepted quantities of the various types of treatment, called for in the Bid Schedule, will be paid for at the contract unit price bid. No separate measurement or payment will be made for removal, windrowing or tilling in place and recompaction, wetting, rolling, blading, shaping, finishing and maintenance of the finished surface prior to acceptance, but shall be included in the work.

1179.00 Payment Reduction for Asphalt

All work performed and all materials furnished shall conform to the line, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the contract. For those items of work where working tolerances are not specified, the Contractor shall perform the work in a manner consistent with reasonable and customary manufacturing and construction practices.

When the Owner determines that 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 unless the Engineer determines that the work can be accepted at a reduced price. Payment reduction (CIP work only), when allowed, shall be accomplished by adjusting pay quantities as indicated herein and applying the contract unit prices to the reduced quantities. If allowed, the Owner shall:

- A. Document the basis for acceptance by a notice which shall provide for an appropriate adjustment in the payment quantity for such work or materials not otherwise provided for in this section.
- B. Notify the Contractor in writing that the payment shall be adjusted in accordance with this section.
- C. In lieu of payment (quantity) adjustment, permit correction or replacement of the finished product provided the correction or replacement does not adversely affect the work or the Owner.

Materials shall be sampled and tested by a qualified testing laboratory in accordance with the sampling, testing schedules, and procedures contained in Section 825 Concrete Testing. 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 Owner'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 Owner may establish a lot consisting of the quantity represented by any number of consecutive random samples from one to seven inclusive. Testing results that are determined to have sampling or testing errors, as determined by the Owner, shall not be used.

Materials or work shall only be evaluated for price adjustment when deviations from Specification occur on any of the individual tests for the lot. The several individual test values shall be averaged and the percentage of payment (quantity) reduction for the lot shall be determined by the applicable table. This shall apply only when a payment reduction element is listed in a table below.

Payment adjustment for those elements not included in a table shall be determined by the Owner.

The Contractor shall not have the option of accepting a payment reduction in lieu of producing material meeting the specifications. Continued production of non-specification material shall not be permitted. Material that is obviously defective shall be isolated and rejected without regard to sampling sequence or location within a lot.

The pay factor for pavement that is allowed to remain in place at a reduced price shall be determined according to tables below, and shall be applied to the quantities for the Item. If deviations occur in multiple Items within the same batch, the pay factor for the batch shall be the product of the individual pay factors.

For thickness deficiencies, payment reductions shall be per Lot, based upon a Lot encompassing 500 lineal lane feet or the quantity between tests, and shall be at the cost of the entire pavement system. The entire pavement system shall include only those items placed as part of this contract and those items impacted: mobilization, traffic control, subgrade preparation, pavement materials and installation, striping, and traffic signal loops need to be considered.

PAY FACTORS

Density	
Density (percent)	Pay Factor
98.01 - 100.00	Reject
97.01 - 98.00	0.95
93.00 - 97.00	1.00
92.00 - 92.99	0.95
91.00 - 91.99	0.90
90.00 - 90.99	0.80
Below 90.00	Reject

Asphalt Content	
Deviation from Mix Design (percent)	Pay Factor
Less than 0.30	1.00
0.3 - 0.55	0.90
Greater than 0.55	Reject

Thickness	
Deficiency from Plan Minimum Thickness (inch)	Pay Factor
Less than 0.25	1.00
0.26 - 0.50	0.90
0.51 - 0.75	0.80
0.76 - 1.00	0.60
Above 1.00	Reject

1180.00 Traffic

1181.00 Traffic Control

Measurement: (Lump Sum) - No separate measurement will be made for maintaining and channelizing traffic as required by the latest revision of the "Manual on Uniform Traffic Control Devices for Streets and Highways" and the Colorado Department of Transportation supplement thereto.

Payment: Payment of the contract amount bid will be paid as follows: 25 percent will be paid upon the first utilization of traffic control devices or flag persons.

75 percent balance will be prorated and paid according to the percent of the original contract amount approved for payment, but subject to retainage.

Payments made shall be full compensation for: furnishing, erecting, maintaining, moving, removing and disposing of temporary control devices; providing traffic control management, flagging and pilot car operation.

1182.00 Traffic Control Devices

Measurement: (Each) - Traffic control devices will be measured by the actual number of the various types specified on the Bid Schedule, installed.

Payment: Accepted quantities of traffic control devices will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation, concrete footings, pedestals, posts, structural frame members, sign panels, mounting brackets, backing angles, hardware, lighting fixtures, electrical equipment, lamps, switch boxes, photo-electric controls, controllers, conduit, wiring, cable, cabinets, faces, loop detectors, magnetometer detectors, sensors, amplifiers, mast arms, cable, painting, messages, pavement cutting and sawing, backfill, asphalt replacement, electrical hookup between power source and switch, etc., but shall be included in the work.

1183.00 Fiber Optic Splicing and Terminations

Measurement: (Each) Fiber optic splice closure shall be measured by each and shall include all fusion splicing, splice trays, heat-shrink sleeves, labor, materials, tools, equipment and incidentals required to fusion splice the cable.

Fiber optic termination assembly shall be measured by each and shall include all labor, materials, tools, equipment and incidentals required to splice its integrated fiber optic cable pigtail to the backbone cable. It shall also include:

- All required optical attenuators, fiber optic jumper cables, CAT5e cables and serial cables (as applicable) within each traffic signal controller cabinet where a fiber optic termination assembly is installed and at corresponding fiber optic termination panels at City Hall.

Payment:

- Payments shall be made according to the pay items below:

Fiber Optic Splice Closure	Each
Fiber Optic Termination Assembly	Each

- Testing fiber optic cable shall be measured and paid for separately in accordance with the City's "Testing, Identification and Administration of Fiber Optic Infrastructure" standard specification.

1190.00 Parks and Recreation

1191.00 Park Facilities

Items: - Benches, buildings, comfort stations, drinking fountain, flagpole, lighting, playground equipment, picnic tables, trash receptacles, shelters, signs

Measurement: (Each) - The quantity of park facilities shall be the actual number of the various units, specified in the Bid Schedule, installed and accepted.

Payment: The accepted quantities will be paid for at the contract unit price bid. No separate measurement or payment will be made for excavation, backfill, permanent or temporary utilities, barricades, masonry, specialty items, doors, frames, windows, hardware, ceramic tile, roofing, flashing, insulation, carpentry, timber, glass, glazing, painting, special coating, plumbing, drainage, fixtures, heating, ventilating, electrical work, etc., but shall be included in the work.

1192.00 Sprinkler and Irrigation Systems

Items: Irrigation pipe and fittings, power conduit and control wire, sprinkler heads, swivels and backflow prevention devices, pressure reducing and drain valves, manual and/or automatic control valves and controllers, meters, pits, quick couplers, strainers, in line valves and boxes.

Measurement: (Each) (Lineal Feet) - The quantities to be measured will be the actual number of the various units; and/or the lineal feet of electrical and sprinkler pipe, including fittings; installed and accepted.

Payment: The accepted quantities will be paid for at the contract amount or unit price bid, for the various items and types that appear in the Bid Schedule. No separate measurement or payment will be made for excavation, concrete, anchor or thrust blocks, sump aggregate, water, backfill, etc., but shall be included in the work.

1193.00 Topsoil

Measurement: (Cubic Yards) - On site stripped topsoil shall be measured in the stockpile, by the average end area method. Imported topsoil shall be measured by the average end area method in its original location or by a pre-determined and agreed to hauling unit bed volume count delivered to the site.

Payment: Accepted quantities of topsoil will be paid for at the contract unit price bid. No separate measurement or payment will be made for hauling, screening or removal of oversize rock and debris, subgrade preparation, placing, shaping, etc., but shall be included in the work.

1194.00 Lawn Sod and Seeding

Measurement: (Square Yard) (Acre) (Lump Sum) - The quantity of lawn sod and/or seeding will be measured as the number of square yards or acres of surface area, providing acceptable growth. When lawn sod and seeding is measured as Lump Sum no separate measurement shall be made. Lump Sum quantity shall be as outlined on the construction drawings or in the Special Conditions.

Payment: Accepted quantities of lawn sod or seeding will be paid for at the contract unit price bid. No separate measurement or payment will be made for grading, tilling, seeding, drilling, fertilizing, mulching, placing sod, watering, maintaining, mowing, etc., but shall be included in the work.

1195.00 Planting Trees, Shrubs

Measurement: (Each) - The quantity of planting to be measured will be the number of plants, of the types and sizes specified in the Bid Schedule, planted and accepted.

Payment: The accepted quantities of plants will be paid for at the contract unit price bid. No separate measurement or payment will be made for handling, pruning, anchor stakes, soil conditioners, fertilizer, excavation, backfill, mulching, irrigating, seasonal spraying, maintenance and/or replacement until accepted, but shall be included in the work.

1196.00 Fabric Materials

Items: Filter, geotextile, geogrid, impervious.

Measurement: (Square Yard) - Fabric will be measured as the number of surface square yards covered.

Payment: Accepted quantities of the various types of fabric specified in the Bid Schedule will be paid for at the contract unit price bid. No separate measurement or payment will be made for overlap, securing pins, vinyl bonding, bituminous tack coat, etc., but shall be included in the work.

1197.00 Soil Sterilization

Measurement: (Lump Sum) (Square Yards) - The quantity of soil sterilization shall be the actual number of area surface square yards treated as specified in the Contract Documents. No measurement will be made when the item in the Bid Schedule is specified as lump sum.

Payment: Accepted quantities of soil sterilization will be paid for at the contract unit price bid. Water will not be measured and paid for separately but shall be included in the work.