SECTION 02722
DRAINAGE STRUCTURES AND PIPING

PART I – GENERAL

1.1 RELATED SECTIONS
Section 02730 Sanitary Sewer System
Section 02513 Asphaltic Concrete Paving
Section 02520 Portland Cement Concrete Paving
Section 02221 Trenching, Backfilling and Compacting
Section 02400 General Utility Requirements

1.2 RELATED STANDARD DETAILS
Refer to City of Boulder Standard Details

1.3 CODES & STANDARDS
A. The most recent City of Boulder Design & Construction Standards are incorporated by reference into the University’s Standards. When there is a conflict between standards, the more stringent requirement shall apply. The University’s Civil Engineer must approve in writing any deviation from these standards prior to construction.

B. 2006 International Plumbing Code

C. 2006 International Building Code

1.4 DESIGN STANDARDS
A. Depth: The cover for all storm sewer mains shall be at least 18 inches deep, measured from the top of pipe to the final surface grade, and shall be capable of withstanding AASHTO HS-20 highway traffic loadings.

B. Slope
1. Minimum and Maximum: Minimum allowable slope shall provide flow velocities of at least 2.0 feet per second and maximum allowable slope shall provide flow velocities no greater than 10.0 feet per second during peak flow conditions.
2. Constant Slope: All storm sewer mains shall be laid at a constant slope between manholes.

C. Alignment
1. Straight Alignment: All storm sewer mains shall be laid in a straight alignment between manholes.
2. Curvilinear Mains Prohibited: Curvilinear storm sewer mains shall not be allowed.

D. Storm Water Quality Requirements

1. For new building or additions to existing buildings, an analysis of site runoff is required to be submitted in the Storm Water Report & Plan to the University’s Civil Engineer. All development is required to utilize storm water quality management practices to reduce the impacts on receiving waters. Additionally, the University is an operator of a Phase II regulated small Municipal Separate Storm Sewer System (MS4) and is required by the State of Colorado to hold a permit to discharge storm water.

2. The UDFCD Drainage Criteria Manual shall be applied to address permanent storm water quality management and erosion control for all proposed projects and developments.

   a. All proposed projects and developments shall cause no net increase in storm water runoff in the 2 year 24hr event. This can be accomplished by reducing Directly Connected Impervious Areas (DCIA) in accordance with best management practices. These include but are not limited to:

      i. All new inlets shall be placed surrounded by pervious areas
      ii. Structural controls such as the use of bioswales, grass buffers, landscaped parking lot islands, etc.
      iii. Roof drain disconnection
      iv. Pavement disconnection
      v. Tree canopy over impervious area
      vi. Pervious pavement
      vii. Detention

   b. Consult with UCB Civil Engineer prior to design of DCIA improvement techniques.

   c. All projects to the extent practicable shall have storm facilities meet LEED ssCredits 6.1 and 6.2.

   d. All proposed projects and developments shall provide Water Quality Capture Volume and a Water Quality Outlet in accordance with the UDFCD Drainage Criteria Manual unless other storm water quality facilities are approved by the Director. Projects and developments that disturb less than 1 acre of land and do not increase the impervious area or runoff shall provide storm water quality facilities to the extent practicable.

   e. Where detention pond facilities for the major and minor storm event are designed as combined facilities, the total volume for the minor storm shall be the required minor storm volume plus the required Water Quality Capture Volume. The total volume for the major storm shall be the full 100-year detention volume plus one-half the Water Quality Capture Volume.

   f. All projects and developments shall utilize “Industrial and
Commercial Best Management Practices” as defined in the UDFCD Drainage Criteria Manual.

E. Hydraulic Design

1. Refer to City of Boulder Design and Construction Standards for requirements on hydraulic design.

2. Roof Drain Connections: Connect roof drains to storm drain. Roof drains shall not be connected to foundation drains.

3. It is the University’s intention not to utilize pumping systems to convey stormwater whenever possible. If a sump pump must be used, pumps shall be installed on guide rails as shown in University of Colorado Standard Details such that access does not require confined space procedures.

4. The design engineer shall evaluate potential for localized flooding during major storm events to ensure no flooding will enter into a campus building.

F. Cleanouts

1. Cleanouts may be used on pipe less than 4” in diameter. One cleanout is required prior to each alignment change, unless a manhole is present.

G. Manholes

1. Where differences of 24 inches or less in invert elevations are called for, sloped flow channels shall be formed so the water does not undergo a vertical drop.

2. Location: Manholes shall be provided at each storm sewer main connection with another storm sewer main, at all changes in grade, slope, alignment and pipe size, and at distances not greater than the following:
   a. 400 feet, for mains 36 inches in diameter or less, and
   b. 500 feet, for mains greater than 36 inches in diameter.

H. Size

<table>
<thead>
<tr>
<th>Pipe Size Inner Diameter</th>
<th>Required inside diameter of manhole</th>
<th>Cone Required</th>
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</thead>
<tbody>
<tr>
<td>24 inches and smaller</td>
<td>4’-0”</td>
<td>4’x2’ eccentric cone</td>
</tr>
<tr>
<td>27 to 36 inches</td>
<td>5’-0”</td>
<td>5’x2’ eccentric cone</td>
</tr>
<tr>
<td>42 to 48 inches</td>
<td>6’-0”</td>
<td>6’x5’ reducer and a 5’x2’ eccentric cone</td>
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<tr>
<td>54 inches and larger</td>
<td>Special Detail</td>
<td>Special Detail</td>
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I. Covers

1. Cast iron, ASTM A48 Class 35B, heavy duty type, cover machined to fit securely without rocking. Castings shall have a hot-dipped asphalt coating.

2. Furnish with lettering cast into top reading “STORM SEWER – Drains to Creek” or an approved equivalent wording.

3. Manholes located within the 100-year floodplain, or in a location where runoff may accumulate and pond, shall be installed with a bolting-type cover, to prevent loss of the cover. The manhole ring shall be bolted to the manhole cone to prevent possible damage due to surcharge.

J. Concrete Catch Basins:

1. Inlets shall be constructed of reinforced concrete and shall conform to the dimensions and specifications as shown on the drawings. Inlet steps shall be built into and thoroughly anchored to the walls at the time of inlet construction. These steps shall conform to the requirements for manhole steps of these specifications.

2. Pre-cast Concrete Units: ASTM C478 and C789, wall “B”, wall thickness of 1/12 of internal diameter. Cast steps into units.

3. Frames and Gratings: Gray cast iron, ASTM A48, Class 30 B, fabricated for a minimum HS20 loading. Use Clean Water Act labeling on manholes and grates. All type C & D storm inlets shall be pedestrian safe and ADA compliant. No slots shall be greater than 1/2" in one direction and no holes shall be greater than 1/2" across.

K. Pipe Type:

1. Provide pipes of one of the following materials, of weight/class indicated. Provide pipe fittings and accessories of same material and weight/class as pipes, with joining method as indicated. All materials shall be new and unused. All pipe sizes and all references to pipe diameter on the drawings or in the specifications are intended to be nominal diameter, and shall be interpreted as such.

L. Fittings:

1. Furnish ells, tees, wyes, couplings and other fittings of the same type and class of material as the conduit, or of material having equal or superior physical and chemical properties as acceptable to the University of Colorado at Boulder Civil Engineer.

M. Reinforced Concrete Pipe:

1. ASTM C76, Class III, (unless otherwise shown on the drawings), with
modified tongue and groove, compression gasket joints complying with ASTM C443.

2. Reinforced concrete box sections shall comply with ASTM C789.

3. Locations: Reinforced concrete pipe may be used in all locations provided the pipe meets loading criteria.

4. Acceptance shall be on the basis of plant load-bearing tests, material tests, and inspection of manufactured pipe for visible defects and imperfections as defined in ASTM C76. Conduct three edge bearing test for load to produce a 0.01 inch crack. Conduct tests on 2% of the number of each size of pipe furnished for the project.

5. Concrete shall have a minimum compressive strength of 4000 psi.

N. PVC Sewer Pipe:

1. ASTM D3033, Type PSP, SDR 35; or ASTM D3034, Type PSM, SDR 35 with PVC, ASTM D3033 or D3034, solvent cement joints complying with ASTM D2855 using solvent cement complying with ASTM D2564; or elastomeric joints complying with ASTM D3212 using elastomeric seals complying with ASTM F477.

2. Locations: PVC sewer pipe may be used in all locations provided the pipe meets loading criteria.

O. Ductile Iron Pipe:

1. AWWA C151, thickness Class 52 with cement mortar lining, AWWA C104.

2. Pipe joints, push on type utilizing rubber ring gasket, AWWA C111 (polyvinyl wrap).

3. Fittings: Ductile iron, AWWA C110, pressure rating 250 psi with mechanical or push on joint, AWWA C111 for flanged joint AWWA C110. All fittings cement mortar lined, AWWA C104.

4. Pipe and Fitting wrap: 8 mil polyethylene film tube complying with AWWA C105.

5. Locations: Ductile iron pipe shall only be used as approved by the University of Colorado at Boulder’s Civil Engineer.

P. High Density Poly-Ethylene (HDPE) Pipe:

1. The corrugated polyethylene pipe shall be installed per manufacturer’s recommendations and ASTM D-2321, latest edition, “Standard Practice
for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications”.

2. The corrugated polyethylene pipe shall conform to AASHTO M-294, latest edition, standard specification for corrugated polyethylene pipe.

3. The corrugated polyethylene pipe shall have an essentially smooth interior wall.

4. Locations: Corrugated polyethylene pipe may be used in all locations provided the pipe meets loading criteria. The University Engineer shall approve all locations of this pipe on campus.

1.5 CONSTRUCTION STANDARDS:

A. Soil Materials:

1. Trenching, Excavation, Pipe Bedding and Cover:
   a. Conform to the requirements of Section 02221
   b. Where trench does not have sufficient strength to support pipe and bedding provide compacted trench stabilizing material or flow fill, 6” minimum depth.

B. Pipe installation

1. Notify the Owner’s Representative not less than 24 hours before laying any pipe or backfilling.

2. Install pipe in accordance with manufacturer’s specifications and leading industry standards, e.g. American Concrete Pipe Association “Concrete Pipe Field Manual” for RCP.

3. Inspect pipe before installation to detect any apparent defects. Mark defective materials with white paint and promptly remove from the site. Visual testing will be made at the job site, and pipe will be rejected on account of any deficiencies covered by ASTM Specification Designation C76 or C789 or on account of the following:
   a. Porous spots, inside or outside, having a greater area than 10 square inches and a depth of more than ¼ inch.
   b. For elliptical or quadrant reinforcement, the vertical axis in which the pipe is to be laid.
   c. Patched or repair of porous spots or other defects that are not approved by the Engineer.
   d. Exposure of reinforcement that indicates the reinforcement has been replaced.
   e. The contractor shall have approval in writing by the University’s Civil Engineer for the use of patched or repaired materials prior to installation.
4. Lay pipe beginning at the low point of system, true to the grades and alignment indicated with unbroken continuity of invert.

5. Place bell ends of plastic pipe or the bell ends of concrete pipe facing upstream.

6. After joint assembly, bring the bedding material up to pipe spring line. Place the bedding material in even lifts on each side of the pipe. Do not drop crushed rock or gravel onto the pipe. Tamp the bedding material into final position at pipe spring line and continue to one foot above the top of the pipe with the same relative compaction.

7. Work covered by this section will not be accepted until specified tests and backfilling connected with the work have been completed satisfactorily. Any section of storm sewer line that is found to be defective in tests, materials alignment, grade, or joints shall be corrected to the satisfaction of the Owner’s Representative without additional cost to the Owner.

8. Underground Type Plastic Line Marker, Manufacturer’s standard permanent, bright colored, continuous printed plastic tape with metallic core, intended for direct burial service; not less than 6” wide x 4 mils thick. Provide green tape with black printing reading “CAUTION SEWER LINE BURIED BELOW”. Place tape at two (2) depths, 2’ above pipe and 1’ below grade.

9. Place elliptical concrete pipe with elliptical reinforcing so that the reference lines indicating the top of the pipe are not more than 5 minutes of angle from the vertical plane through the longitudinal axis of the pipe.

C. Manhole Construction

1. Manholes shall be constructed of pre-cast concrete riser sections, in accordance with the detail drawing in the construction plans.

2. The top section required for change of diameter shall be eccentric cone or flat slab.

3. To bring the manhole cover to the correct elevation, the adjustment section of each manhole shall be constructed of pre-cast concrete grade adjustment rings. These rings shall be not less than six (6) inches wide. A minimum of 6” of adjustment down is required. Total adjustment height shall not exceed 18 inches for newly constructed manholes.

4. Base Pre-cast or cast-in-place concrete:
   a. Concrete, for either pre-cast or cast-in-place will have a 28-day compressive strength of not less than 4,000 psi. Pre-cast bases shall have attained a compressive strength of 4,000 psi prior to transport to the project site.
b. Sections: ASTM C 478 pre-cast concrete with minimum wall thickness 1/12 of internal diameter. Top sections shall be eccentric cones except where shown otherwise in the drawings.

5. Steps: Steps shall be copolymer polypropylene coated steel steps Model PS2PF, as manufactured by M.A. Industries or approved equal.

6. Joints: Pre-cast manhole and inlet joints shall be made watertight with RUB’RNEK, Kent Seal No. 2, or LOMOD GEL material, or approved equal. Diameter of gasket shall be as recommended by the manufacturer.

7. Concrete construction shall conform to the requirements for reinforced concrete. Concrete bases shall be poured on undisturbed ground. Pipe sections shall be flush on the inside of the structural wall (except as noted below) and project outside sufficiently for proper connection to the next pipe section. All pipelines into a manhole or an inlet shall not have a joint located less than 12 inches from the exterior wall. Where incoming pipes enter a storm drain manhole or inlet at an elevation three (3) feet or greater above the base, the incoming pipe shall project two (2) inches inside the inlet or manhole. All annular spaces around the pipe opening must be grouted.

8. The floor of the manhole outside of the channel shall be smooth and shall slope towards the channel not less than one (1) inch per foot nor more than two (2) inches per foot.

9. Trim away excess material, repair and fill lifting holes. Turn eccentric cone and steps away from roadway ditch. Install steps in straight line.

D. Pre-cast Manhole Base

1. The ground surface below pre-cast concrete bases shall be excavated six (6) inches below the elevation of the bottom of the base and backfilled with gravel or other approved material. The gravel shall be carefully leveled and smoothed as to give uniform support to the precast base over its entire area. The precast base shall be set at the proper location to center the manhole.

E. Cast in Place Manhole Base

1. Excavate for the manhole and install a crushed rock base, 12 inches thick, per Section 02221. Crushed rock base material shall extend 1 foot beyond the outside edge of the concrete manhole base. Compact to 95% relative density.

2. Form and pour concrete bases as one monolithic pour. Form the portion above the invert elevation of the sewer pipe to provide a smooth channel section.
3. Channels shall vary uniformly in size and shape from inlet to outlet.

4. Carry split pipe through manholes. Extend concrete manhole base at least 8” below pipe barrel. See University of Colorado at Boulder Standard Details.

5. Where pipe cannot be laid continuously through manholes, shape invert when manhole is being poured. Conform invert shape exactly to lower half of pipe.

6. Construct side branches with as large a radius of curvature as possible to connect to main invert. Provide smooth, clean inverts with no obstructions, allowing insertion of an expandable plug in pipe.

7. Form concrete ring monolithically with manhole base, minimum of 3” above top of pipe. Terminate future extension of pipe with bell of pipe as close as practical to manhole base. Install watertight plug in bell.

8. Do not set pre-cast manhole sections on manhole base for minimum of 2 days after base placement. Thoroughly clean top of formed concrete base ring in manhole.

F. Connection to Existing Manhole:

1. Make connections to existing manholes, where no pipe is stubbed out, in similar manner as new manhole. Core an opening in the existing manhole to insert the new pipe and attain watertight seal. Chip existing concrete bench inside manhole to provide enough thickness for mortar bed to make new smooth continuous invert. Place expandable waterstop around portion of sewer pipe into existing manhole. Use expandable grout to completely fill hole in manhole to create watertight repair.

2. If the modifications to the existing manhole deviate significantly from the approved submittal, the Owner’s Representative may require replacement of the existing manhole.

G. Concrete Catch Basin Construction

1. Refer to the University of Colorado at Boulder Standard Details.

2. Construct catch basins to the required sizes and shapes as shown in the drawings.

3. Concrete Catch Basins may be pre-cast or cast-in-place, at Contractor’s option. Use concrete which will attain a 28 day compressive strength of not less than 4,000 psi.

4. For pre-cast units, set in place to accurate elevations on firm, solid bed, plumb and level.
5. Set cast iron frames and gratings to be even with adjacent work and so that frames or gratings do not rock.

6. Construct cast-in-place units in conformance with this section and Division 3 Concrete.

7. Where the drawings indicate a sediment and/or oil and grease removal manhole, the manhole shall be Stormceptor or equal.

H. Grout:

1. Grout shall be non-shrink type with aluminum filings; grout with iron filings is not acceptable. Grout shall be “Five Star Grout,” Embeco Grout” or approved equal.

I. Joints:

1. Circular Pipe: Use push-on, rubber-gasketed, watertight type R4 O-ring as required for watertight pipe. Bells, spigots, and rubber gaskets shall conform to ASTM C361 and shall be compatible with ASTM 76 pipe barrel.

2. Noncircular pipe and box sections: Use a butyl rubber base flexible nonshrink gasket type watertight sealant. Sealant shall be Rub’RNek or equal. Joints shall be tongue and groove.

3. Completion of Tongue and Groove Mortared Joints for RCP: Seal tongue and groove joints with mortar. Lay groove end of pipe upgrade. Fill outer joint space with mortar.

J. Patching of Existing Pipe:

1. Types of pipe and methods as approved by the University of Colorado at Boulder Civil Engineer.

K. Tap Connections:

1. Make connections to existing conduits and underground structures, so that the finished work will conform as nearly as practicable to the requirements specified for new work.

2. For branch connections from the side into an existing 24” or larger conduit or to underground structures, cut an opening into the unit sufficiently large to allow 3” of concrete to be packed around the entering connection. Cut the ends of the connection passing through conduit or structure wall to conform to the shape of and be flush with the inside wall, encase the entering connection in 6” of concrete for a minimum length of 12” to provide additional support or collar from the connection to undisturbed ground.
3. Take care while making tap connections to prevent concrete or debris from entering the existing conduit or structure. Remove any debris, concrete, or other extraneous material which may accumulate.

L. Sliplining, boring and cure-in-place-pipe:
   1. Sliplining, boring and cure-in-place-pipe shall be allowed for pipe rehabilitation on a project by project basis at the discretion of the UCB Civil Engineer.

M. Closing Abandoned Utilities:
   1. Close open ends of abandoned underground utilities which are indicated to remain in place. Provide sufficiently strong closures to withstand any hydrostatic or earth pressure which may result after ends of abandoned utilities have been closed. Wood plugs are not acceptable.

N. Testing
   1. Television: All pipes shall be televised. Any defects found during televising shall be repaired.
   2. Air Tests: Comply with the City of Boulder’s Design and Construction Standards, Chapter 9, Utilities Standards for all PVC pipe used as storm sewer pipe. All PVC sections of storm sewer shall be tested, including but not limited to pipe between manholes and pipe from buildings or catch basins to manholes or mains. Any sections of pipe deemed untestable by standard means shall be brought to the attention of the UCB Civil Engineer.
   3. Notify the University 48 hours in advance of any testing.
   4. Prior to project completion, the contractor is responsible for the following pipe cleaning:
      a. Clear the interior of pipe of dirt and other superfluous material as the work progresses. Maintain a swab or drag in the line and pull past each joint as it is completed.
      b. Prior to project completion, the contractor shall water jet lines between manholes, from the upstream manhole of the new work to the next downstream manhole of the new work, in order to remove collected debris.
      c. Debris removed from pipe shall be disposed of in accordance with City and State regulations.
   5. Cleanup and Restoration
      a. Restore pavements, curbs and gutters, utilities, fences, lawns, vegetation and other improvements to condition equal to or better than before work began and to satisfaction of Owner’s Representative.
b. Complete topsoil and reseeding of site, if required.
c. All exposed earthwork impacted by the project shall achieve “final stabilization” as defined by EPA in the Clean Water Act.
d. Remove and legally dispose of all excess waste materials off the Owners property.

END OF SECTION