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General Information

A. Concept

The important design requirements of water main systems are to supply each user with sufficient volume of water for a particular designated use plus required fire flows at adequate pressure, and to maintain the quality of the potable water delivered by the treatment plant. It is important that maintenance considerations are constantly addressed in the design of water main systems. The performance of a water main system for health and fire-flow purposes depends on the Jurisdiction's ability to maintain the system at an affordable cost.

Certain planning considerations related to a new system development or system expansion requires the designer to consider factors such as future growth, cost, and system layout. For system layout, all major demand areas should be serviced by an arterial-loop system. High demand areas are served by distribution mains tied to an arterial-loop system to form a grid without dead-end mains. Areas where adequate water supply must be maintained at all times for health and fire control purposes should be tied to two arterial mains where possible. Minor distribution lines or mains that make up the secondary grid system are a major portion of the grid since they supply the fire hydrants and domestic and commercial consumers.

B. Conditions

1. **General:** Numerous agencies, besides local Jurisdictions, may stipulate conformance to water main requirements. These agencies consist of water boards, benefited water districts, rural water associations, and the Iowa Department of Natural Resources (Iowa DNR). For the purpose of uniformity, the Project Engineer should contact the Jurisdictional Engineer if there are questions on where to submit reports, plans, and specifications for conformance to specific requirements and approvals. The Project Engineer should also contact the Jurisdictional Engineer to identify local requirements. It is necessary all water main projects meet the requirements of Iowa DNR and the evidence of approval be provided to the Jurisdiction in charge. In case of conflict between the above design standards, the most restrictive requirement applies.

2. **Plans:** The plans for water mains and appurtenances should show all appropriate physical features adjacent to the proposed water mains along with horizontal and vertical controls and hydrant coverages. Other utilities, such as sanitary and storm sewers, manholes, etc., should be shown on the plans with horizontal and vertical separation distances. Design details for other utilities that do not affect the water main may not be shown on water main plans. Traffic control criteria should also be included with the plans and should follow the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD).

3. **Iowa DNR Project Submittals:** This section complies with the current edition of the Recommended Standards for Water Works (the Iowa Water Supply Design Standards by reference) as adopted by the Iowa DNR. The Project Engineer is responsible for obtaining any revisions, memorandums, and interpretations to the Iowa DNR rules and regulations.

a. General: All reports, final plans, specifications, and design criteria should be submitted at least 60 days prior to the date on which action by the reviewing authority is desired. Environmental assessments and permits for construction, to take water, for waste discharges, for stream crossings, etc., may be required from other federal, state, or local agencies. Preliminary plans and the engineer's report should be submitted for review prior to the preparation of final plans. No approval for construction can be issued until final, complete, detailed plans and specifications and the appropriate permit forms have been submitted to the reviewing authority and found satisfactory. Documents submitted for formal approval include, but are not limited to:

1) Engineer's report, where pertinent
2) Summary of the design criteria, including an up-to-date hydraulic analysis
3) Operation requirements, where applicable
4) General layout
5) Detailed plans
6) Specifications
7) Cost estimates
8) Water purchase contracts between water supplies, where applicable
9) Other information as required by reviewing authority

Where the design/build construction concept is to be utilized, special consideration must be given to: designation of a project coordinator; close coordination of design concepts and submission of plans and necessary supporting information to the reviewing authority; allowance for project changes that may be required by the reviewing authority; and reasonable time for project review by the reviewing authority.

b. Plans: Plans for water distribution system improvements should, where pertinent, provide the following:

1) General Layout, Including:

a) Suitable title
b) Name of municipality or other entity or person responsible for the water supply
c) Area or institution to be served
d) Scale
e) North point
f) Datum used
g) Boundaries of the municipality or area to be served
h) Date, name, and address of the designing engineer
i) Conformance with engineering registration requirements of the state
j) Legible prints suitable for reproduction
k) Location and size of existing water mains
l) Location and nature of existing water works structures and appurtenances affecting the proposed improvements, noted on one sheet

2) Detailed Plans, Including:

a) Stream crossings, providing profiles with elevations of the stream bed and the normal and extreme high and low water levels
b) Profiles having a horizontal scale of no more than 100 feet to the inch and a vertical scale of no more than 10 feet to the inch, with both scales clearly indicated
c) Location of all existing and potential sources of pollution that may affect the water source or underground treated water storage facilities
d) Size, length, and materials of proposed water mains
e) Location of existing or proposed streets; water sources, ponds, lakes, and drains; storm, sanitary, combined, and house sewers; septic tanks, disposal fields, and cesspools

f) All appurtenances, specific structures, equipment, water treatment plant waste disposal units, and points of discharge having any relationship to the plans for water mains and/or water works structures
g) Locations of all sampling taps
h) Adequate description of any features not otherwise covered by the specifications

c. Specifications: Complete, detailed, technical specifications should be supplied for the proposed project, including:

1) A program for keeping existing water works facilities in operation during construction of additional facilities to minimize interruption of service
2) Procedures for flushing, disinfection, and testing, as needed, prior to placing the project in service
3) Materials or other facilities including any necessary backflow or back-siphon protection

See the Iowa DNR rules and regulations for more detail on submittal of reports, plans, and specifications.

d. Local Project Submittals: Some Jurisdictions or water boards have been delegated by Iowa DNR to issue permits for minor water main extensions. Permits for all other projects must be submitted to the Iowa DNR, and evidence of approval is to be provided to the Jurisdiction in charge. Include the Treatment Agreement form if appropriate.

Size Determination

A. General

Domestic usage requirements for a service area can be determined either from past records or from general usage information shown in Table 4B-1.01. This data should then be adjusted for commercial, industrial, and projected growth factors to ensure the system's design capacity should meet future demand.

A factor in sizing main facilities is the need for fire protection. Fire flow requirements are set by the Insurance Services Office (ISO). This group determines the minimum flow the system must be able to maintain for a specified period of time in order to achieve a certain fire protection rating. Fire insurance rates are then based, in part, on this classification.

B. Network Analysis

Pipe carrying capacity depends on pipe size, pressure, flow velocity, and head loss resulting from friction. Friction factors include roughness of pipe, flow velocity, and pipe diameter. The required pipe size can be calculated when the other requirements and characteristics are known.

When the distribution system or system expansion is extensive, it may be necessary to analyze the system and balance the flow among all areas in relation to demand. This analysis requires a plot of pressures and flows at points throughout the system.

C. Velocity Requirements

Velocity of flow is also a factor in determining the capacity of pipes and, therefore, the required pipe size. Velocities should normally be 5 fps or less, due to high friction losses that occur at greater velocities. This may be difficult to obtain under normal operating conditions, and velocities can significantly exceed this guideline under fire-flow conditions.

D. Minimum Criteria

1. **Minimum Design Period Requirements:** Water mains should have a minimum size based on a hydraulic analysis utilizing 20 year design for a specified water demand. Consideration should be given to projected land uses and demand based on full development of the service area. The specified water demand depends on the area to be serviced and the type of water main (feeder, arterial, or distribution).

2. **Minimum Size Requirements:**

   a. **Water Service Stub:** The water service stub must meet the Jurisdiction's standards and provide adequate design flows.

   b. **Distribution Mains:** All water mains should be sized large enough to provide existing and future residential, commercial, and industrial water demands and fire protection flows to the area to be served. The minimum water main size is 8 inches in diameter, unless otherwise approved by the Jurisdictional Engineer. The Jurisdiction reserves the right to increase the size of the mains to meet future water demands.

   c. **Arterial or Feeder Mains:** Arterial or feeder mains, typically 12 inches and larger, should conform to an existing grid pattern or as directed by the Jurisdiction to meet long range plans of the Jurisdiction.

3. **Pressure Requirements:** The recommended minimum operating pressure of the distribution system should be no less than 35 psi. The residual pressure required under fire flow conditions should not drop below 20 psi at any hydrant or any point in the system. When operating pressure exceeds 100 psi, individual or system pressure reducing devices may be required.

E. Flow Considerations

1. **Design Flows:** The water main system must be able to meet the following flow requirements:

   a. Peak day demands plus fire flow demands.

   b. Instantaneous peak demands for water mains from source, treatment, and/or storage facilities.

2. **Peak Day Demands:**

   a. **General:** The peak day demand is the average rate of consumption on the maximum day. The maximum day is the 24 hour period during which the highest consumption total is recorded in the latest 3 year period. High consumption that will not occur again due to changes in the system, or that was caused by unusual operations, should not be considered.

   When no actual figure for maximum daily consumption is available, it should be estimated on the basis of consumption in other cities of similar character. Such estimates should be at least 2.0 times greater than the average daily water demand for cities having more than 500 people and 2.5 times greater than the average daily water demand for cities having 500 people or less.

   b. **Average Day Demand (minimum):**

   Area x Area Density x Rate = Average Daily Demand **Equation 4B-1.01**

   Number of Units x Unit Density x Rate = Average Daily Demand **Equation 4B-1.02**

Table 4B-1.01: Density

Land Use	Area Density	Unit Density	Rate
Low Density (Single Family) Residential	10 people/AC	3.0 people/unit	100 gpcd
Medium Density (Multi-Family) Residential	15 people/AC	3.0 people/unit 6.0 people/duplex	100 gpcd
High Density (Multi-Family) Residential	30 people/AC	2.5 people/unit	100 gpcd
Office and Institutional	Special Design Density[1]		
Commercial	Special Design Density[1]		
Industrial	Special Design Density[1]		

[1] Special design densities should be subject to approval by the Jurisdictional Engineer based on methodology provided by the Project Engineer.

Note: If the Project Engineer uses values different than the above table, approval by the Jurisdictional Engineer and Iowa DNR is required.

3. **Instantaneous Peak Demands:** Where existing data is not available to accurately predict the instantaneous peak demand for the design year, the following criteria may be used as a minimum for estimating the instantaneous peak demand:

   a. 220 people or less = Average day demand (gpm) x 9.0.

   b. More than 220 people = Average day demand (gpm) x $7/P^{0.167}$
   P = design year population in thousands.

   If major water users exist in the system, the peak may be greater than those listed above.

4. **Fire Flows:** The following general information is taken from the *Fire Suppression Rating Schedule* (Edition 05-2008) of the Insurance Services Office (ISO). The latest ISO requirements must be checked to verify fire flow criteria. Insurance requirements for fire protection may vary with each Jurisdiction and must be confirmed by the Project Engineer.

   a. For one- and two- family dwellings not exceeding two stories in height, the following needed fire flows should be used.

Distance Between Buildings	Needed Fire Flow
Over 100’	500 gpm
31’ to 100’	750 gpm
11’ to 30’	1,000 gpm
10’ or less	1,500 gpm

   For wood shingle roof coverings on the building or on exposed buildings add 500 gpm to the needed fire flows.

   b. Multi-family, commercial, and industrial areas are considered high risk areas. The fire flows available in these areas require special consideration. The distribution and arterial mains in the high risk areas are to accommodate required fire flows in those areas.

Facility Design

A. General

Water mains and appurtenances, including hydrants and valves, should be provided along all streets including connections to and extensions from existing water systems.

The location and spacing of water mains and their appurtenances is not only important for service and fire protection, but also maintenance requirements. Figures 4C-1.02 through 4C-1.03 show guidelines for the location of these facilities.

B. Water Mains

1. Water main pipe will typically be either polyvinyl chloride (PVC) pipe or ductile iron pipe (DIP); and meet AWWA Standards.

   Designers should use the Iowa DNR's website to determine if there are any leaking underground storage tanks (LUST) sites within 500 feet of the proposed water main: https://facilityexplorer.iowadnr.gov/facilityexplorer.

   Where distribution systems and service connections are installed in areas of known groundwater contaminated by volatile organic compounds (LUST), pipe and joint materials (non-PVC pipe) that do not allow permeation of the volatile organic compounds must be used.

   The Iowa DNR requires underground storage tank (UST) owners to meet specific design requirements for USTs installed within 1,000 feet of a community water system. The Project Engineer should determine if there is an UST within 1,000 feet of the project area. If so, the Designer should determine the need to design the water mains to prevent future permeation of any volatile organic compounds into the water system. There are various elements to consider, some of which include soil types, groundwater table depth, size of the UST, age of the UST, etc.

   Consult with manufacturers concerning permeation of the pipe walls, jointing materials, valve seats, etc.

2. Water mains should be extended to the plat or property boundaries, to the next street, or as directed by the Jurisdiction.

3. New main installation should be located in the parking area (between the curb and the property line) of the right-of-way and minimum of 4 feet behind the curb. Where possible, water mains should be located along the south and east sides of the street.

4. Dead-ends should be minimized by looping mains whenever possible. Dead-ends should terminate with an approved flushing device (blowoff, hydrant, flushing hydrant). They may terminate with an approved fire hydrant when adequate pressure is available at required flows. For maintenance considerations and when adequate fire flows are not available, flushing hydrants may be allowed by the Jurisdiction with the hydrant outlet sized and arranged to prevent the attachment of fire hoses. Unless required by a Jurisdiction, permanent inline shut-off valves

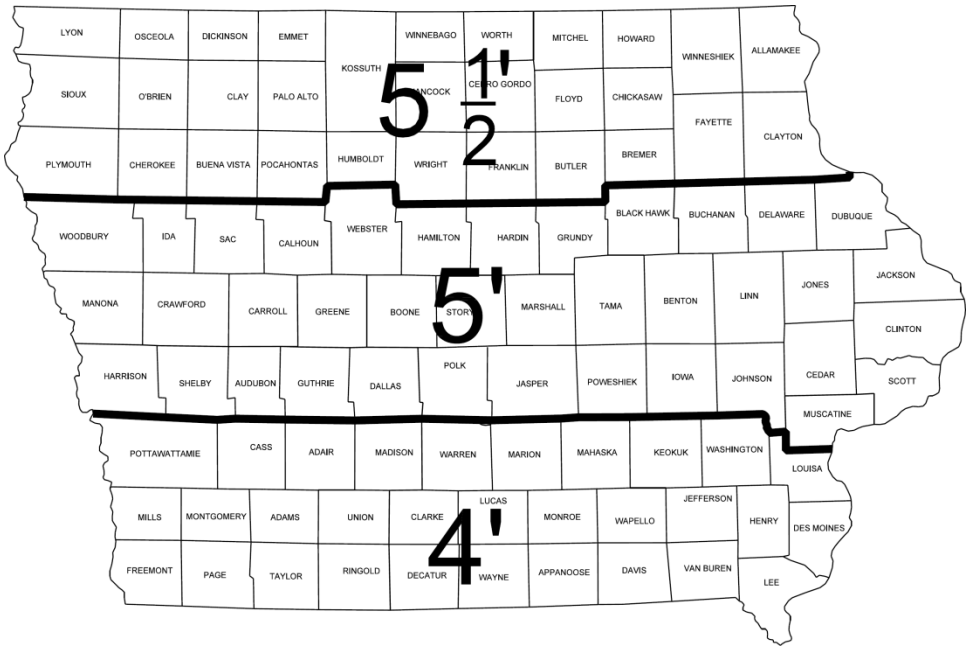
should not be placed at the end of dead-end mains. A valve may be placed one or two pipe lengths back from the end of the project. No services should be placed past the valve. These

pipes will provide sufficient support for the valve and allow a future extension to be made without impacting current water customers.

5. Water mains and extensions should be designed with a minimum cover as indicated on Figure 4C-1.01, unless more or less cover has been approved by the Jurisdictional Engineer. Greater depths of cover, surface loading conditions, or unusual trench conditions may require a stronger class of pipe according to the AWWA Standard regarding the type of pipe being installed. Where a dip must be placed in a main in order to pass under another utility, the length of the deeper main should be kept to a minimum, and bends should be considered to affect the desired offset.

6. Water mains should be adequately protected from corrosive soil environments. Comply with AWWA C105. Complete soil testing or check with the Jurisdictional Engineer to determine if corrosive soils are present within the project area. If so, include polyethylene encasement for ductile iron pipe, valves, and fittings or use of other nonmetallic pipe materials. If nonmetallic materials are used, be sure to provide polyethylene encasement for fittings and valves. In severe instances, cathodic protection may be required.

Figure 4C-1.01: Minimum Depth of Cover for Water Main Installation



C. Blowoffs

A blowoff or approved flushing device is required on all dead-end mains where a hydrant is not installed. The minimum riser assembly size should be no less than 2 diameter sizes smaller than the diameter of the water main. The flushing device should be sized to provide flows that will give a velocity of at least 2.5 feet per second in the main being flushed. When the water main is extended, the blowoff should be removed. A new valve should be placed between the existing and extended main.

D. Valves

1. As a minimum, valves should be located at intersections, such that only one unvalved pipe exists at the intersection. Valves should be equally spaced, if possible, with spacing no more than 800 feet in residential areas and no more than 400 feet in high density residential, commercial, and industrial areas. (See Figures 4C-1.02 through 4C-1.03 for valve locations at intersections).

2. Valves should not be located in the sidewalk line or in driveways.

3. All valves should be installed with valve boxes. Use slide type valve boxes in paved areas and screw type in all other areas. A screw type valve box that is located in an area to be paved should be changed to a slide type valve box as a part of the paving program.

4. No valves (except blowoff valves) should be placed at the end of a dead-end main unless required by a Jurisdiction. A valve should be installed between the existing main and new main when the main is extended. Intermediate valve locations between the end of a dead-end main and last valved street intersection may be required by the Jurisdiction to provide required valve spacing.

5. A tapping sleeve and valve should be used when making a perpendicular connection to an existing main.

6. If the project area has high water pressure, usually exceeding 100 psi, it may be appropriate to install system pressure relief valves as opposed to individual building controls. The potential for using a system pressure reducing valve is limited by the interconnected nature of a distribution system. Check with the Jurisdiction to determine the potential need for use of pressure reducing valves.

E. Fire Hydrants

1. Hydrants should comply with AWWA C502. The connecting pipe between the supply main and the hydrants should be a minimum of 6 inches in diameter and be independently valved. Fire hydrants should not be installed on water mains that do not provide a minimum pressure.

2. Hydrant drains should not be connected to or located within 10 feet of sanitary sewers.

3. Locations of fire hydrants are governed by the rules and regulations of the Iowa DNR and the local Jurisdiction and by the following principles. Satisfy each principle in the order they are listed. See Figures 4C-1.02 through 4C-1.03 for typical hydrant locations.

    a. Locate fire hydrants within 25 feet of each street intersection, measured from an end of a street paving return.

        Locate fire hydrants outside street paving returns. Avoid conflicts with storm sewers, intakes, and sidewalks. Whenever possible, locate fire hydrants at the high point of the intersection.

    b. Locate fire hydrants between street intersections to provide spacings of no more than 450 feet in single family residential districts and no more than 300 feet in all other districts. Coverage radii for structures as noted below should be checked when determining hydrant placement.

        Vary spacings slightly to place fire hydrants on extensions of property lines. When hydrants are required between intersections, they should be located at the high point of the main for air release or at a significant low point for flushing on the downhill side of an in-line valve.

When street curvature or grid patterns places a proposed protected structure at an unusual distance from the fire hydrant, the coverage radius should not exceed 300 feet in single family residential districts and 150 feet in all other districts. The Jurisdiction's fire marshall may have additional private fire protection requirements.

c. On cul-de-sac streets, hydrants should be located at the intersection of the cul-de-sac street and cross-street and the end of the cul-de-sac.

   1) For cul-de-sacs between 300 feet and 500 feet in length, an additional hydrant should be located at the mid-block.

   2) For cul-de-sacs greater than 500 feet in length, hydrants should be placed at near equal spacings, but not exceeding the spacings described above.

d. Hydrants must be located to provide the required fire flows. ISO evaluates fire hydrant locations within 1,000 feet of the test location, measured along the streets as fire hose can be laid, to evaluate the availability of water for fire protection. Hydrant capacity is credited as shown in the following table:

Hydrant Location	Credited Capacity
Within 300’ of location	1,000 gpm
Within 301’ to 600’ of location	670 gpm
Within 601’ to 1,000’ of location	250 gpm

e. Locate fire hydrants to maintain a 3 foot clear space around the circumference of the fire hydrant to create unobstructed access for the fire department.

F. Water Service Stubs

Water service stubs for each building or platted lot should be provided, including corporation stop, service line, and curb stop (shut-off) with box. Check with the Jurisdiction to determine appropriate placement location. In no case should the shut-off be in the sidewalk. Avoid locations where driveway approaches are likely to be constructed in the future.

G. Separation of Water Mains from Sewer Mains

The following comply with the Iowa Department of Natural Resources separation requirements.

1. **Horizontal Separation of Gravity Sanitary and Combined Sewers from Water Mains:** Separate gravity sanitary and combined sewer mains from water mains by a horizontal distance of at least 10 feet unless:
   a. The top of a sewer main is at least 18 inches below the bottom of the water main, and
   b. The sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth at a minimum horizontal separation of 3 feet from the water main.

   Maintain the maximum feasible separation distance in all cases. When it is impossible to obtain the required horizontal clearance of 3 feet and a vertical clearance of 18 inches between sewers and water mains, provide a linear separation of at least 2 feet and one of the following:
   a. Construct sanitary and combined sewers of water main materials meeting the requirements of SUDAS Specifications Section 5010, 2.01.
   b. Enclose the water main in a watertight casing pipe with an evenly spaced annular gap and watertight end seals.

2. **Horizontal Separation of Water Mains from Sanitary and Combined Sewer Manholes:** Ensure water pipes do not pass through or come in contact with any part of a sanitary or combined sewer manhole. Maintain a minimum horizontal separation of 3 feet.

3. **Separation of Sanitary Sewer Force Mains from Water Mains:** Separate sanitary sewer force mains and water mains by a horizontal distance of at least 10 feet unless:
   a. The force main is constructed of water main materials meeting a minimum pressure rating of 150 psi and the requirements of SUDAS Specifications Section 5010, 2.01, and
   b. The sewer force main is laid at least 4 linear feet from the water main.

4. **Separation of Sanitary and Combined Sewers and Water Main Crossovers:** Vertically separate sanitary and combined sewers crossing under any water main by at least 18 inches when measured from the top of the sewer to the bottom of the water main. If physical conditions prohibit the separation, do not place the sewer closer than 6 inches below a water main or 18 inches above a water main. Maintain the maximum feasible separation distance in all cases. Ensure the sewer and water pipes are adequately supported and have watertight joints. Use a low permeability soil for backfill material within 10 feet of the point of crossing.

   Where the sanitary sewer crosses over or less than 18 inches below a water main, utilize one of the following within 10 feet measured edge-to-edge horizontally, centered on the crossing:
   a. Construct sewer pipe of water main material.
   b. Enclose the water main in a watertight casing pipe with an evenly spaced annular gap and watertight end seals.

5. **Horizontal Separation of Storm Sewers from Water Mains:** Separate storm sewers and water mains by at least 10 feet measured edge to edge unless it is impossible to do so. When impossible to maintain a 10 feet horizontal separation, maintain a minimum separation of 3 feet and utilize one of the following within 10 feet measured edge-to-edge:
   a. Construct the water main of ductile iron pipe with gaskets impermeable to hydrocarbons.
   b. Enclose the water main in a watertight casing pipe with evenly spaced annular gap and watertight end seals.
   c. Construct storm sewer pipe of water main materials.
   d. Construct storm sewers of reinforced concrete pipe with gaskets manufactured according to ASTM C 443.

6. **Vertical Separation of Storm Sewers and Water Main Crossovers:** Vertically separate storm sewers from water mains by 18 inches measured between the outside edges of the water main and the storm sewer. Maintain the maximum feasible separation distance in all cases. Ensure the sewer and water pipes are adequately supported. Use a low permeability soil for backfill material within 10 feet of the point of crossing.

   When impossible to maintain an 18 inch vertical separation when the water main crosses over the storm sewer, maintain a minimum vertical separation of 6 inches and utilize one of the following within 10 feet measured edge-to-edge centered on the crossing:
   a. Construct the water main of ductile iron pipe with gaskets impermeable to hydrocarbons.
   b. Enclose the water main in a watertight casing pipe with evenly spaced annular gap and watertight end seals.
   c. Construct storm sewer pipe of water main materials.
   d. Construct storm sewers of reinforced concrete pipe with gaskets manufactured according to ASTM C 443.

H. Surface Water Crossings

Comply with the Recommended Standards for Water Works, 2007 Edition. Surface water crossings, whether over or under water, present special problems. The reviewing authority should be consulted before final plans are prepared.

1. **Above-water Crossings:** Ensure the pipe is adequately supported and anchored; protected from vandalism, damage, and freezing; and accessible for repair or replacement.

2. **Underwater Crossings:** Provide a minimum cover of 5 feet over the pipe unless otherwise specified in the contract documents. When crossing water courses that are greater than 15 feet in width, provide the following.

    a. pipe with flexible, restrained, or welded watertight joints,

    b. valves at both ends of water crossings so the section can be isolated for testing or repair; ensure the valves are easily accessible and not subject to flooding, and

    c. permanent taps or other provisions to allow insertion of a small meter to determine leakage and obtain water samples on each side of the valve closest to the supply source.

I. Air Relief Facilities

1. **Air Relief Valves:** At high points in water mains where air can accumulate, provisions should be made to remove the air by means of air relief valves. Automatic air relief valves should not be used in situations where flooding of the manhole or chamber may occur.

2. **Air Relief Valve Piping:**

    a. Use of manual air relief valves is recommended wherever possible.

    b. The open end of an air relief pipe from a manually operated valve should be extended to the top of the pit and provided with a screened, downward-facing elbow if drainage is provided for the manhole.

    c. The open end of an air relief pipe from automatic valves should be extended to at least 1 foot above grade and provided with a screened, downward-facing elbow.

    d. Discharge piping from air relief valves should not connect directly to any storm drain, storm sewer, or sanitary sewer.

J. Valve, Meter, and Blowoff Chambers

Wherever possible, chambers, pits, or manholes containing valves, blowoffs, meters, or other such appurtenances to a distribution system should not be located in areas subject to flooding or in areas of high groundwater. Such chambers or pits should drain to the ground surface or to absorption pits underground. The chambers, pits, and manholes should not connect directly to any storm drain or sanitary sewer. Blowoffs should not connect directly to any storm drain or sanitary sewer.

K. Thrust Blocks, Anchor Blocks, and Restrained Joints

Concrete thrust blocks, anchor blocks, and restrained joints are used to counteract joint movement at points where piping changes directions or at dead-ends.

1. **Thrust Blocks:** Concrete thrust blocks are typically used on pipes 12 inches in diameter or smaller on horizontal and upward bending fittings. Thrust blocks may be used on pipes independently or in combination with restrained joints. The minimum bearing surface table shown on SUDAS Specifications Figure 5010.101 assumes a bearing area of thrust blocks based on 1,000 psf soil pressure and 150 psi water pressure. Where water pressures are higher and/or soil conditions are poor, the designer should design the correct block size using the equation below. No bolts should come into contact with the concrete thrust blocks. If necessary, polyethylene wrap should be wrapped around the pipe, including the bolt circle, before the concrete is placed. Concrete should have a minimum compressive strength of 4,000 psi at 28 days.

   Required Area, $ft^2 = S_f$ (2) (water pressure, psi)(cross-sectional area of pipe outside diameter, in^2)
   (sin(angle of bend / 2))/(allowable soil pressure, psf)

   Note - AWWA Recommends a 1.5 factor of safety (S_f), which is not part of the table on SUDAS Specifications Figure 5010.101 or the formula above.

2. **Anchor Blocks:** Anchor blocks are typically used on pipes 12 inches in diameter or smaller on vertical downward bend fittings. Mains larger than 12 inches should use restrained joints as the primary means of thrust restraint on vertical downward bend fittings. Anchor blocks may be used on pipes independently or in combination with restrained joints. Table 4C-1.01 size of the anchor block based on a 150 psi water pressure. Where water pressures are higher, the designer should design the correct block size using the equation below Table 4C-1.01. Where an anchor block is the sole means of restraint on a vertical downward bend, the plans should detail the size and shape of the anchor block. The engineer should also verify the face of the anchor block can resist the horizontal thrust component (T_x) created by the fitting. No bolts should come into contact with the concrete thrust blocks. If necessary, polyethylene wrap should be wrapped around the pipe, including the bolt circle, before the concrete is placed. Concrete should have a minimum compressive strength of 4,000 psi at 28 days.

Table 4C-1.01: Anchor Block Sizing

Pipe Diameter	Degree Bend (Θ)	Weight (Pounds)	Volume (Cu. Yards) (V_g)	Strap Bar Size[1]	Embedment[1]
4	11.25	530	0.1	#5	18
	22.5	1,040	0.3		
	45	1,920	0.5		
6	11.25	1,100	0.3	#5	18
	22.5	2,150	0.6		
	45	3,970	1.0		
8	11.25	1,890	0.5	#5	18
	22.5	3,700	1.0		
	45	6,830	1.7		
10	11.25	2,840	0.7	#5	18
	22.5	5,560	1.4		
	45	10,270	2.6		
12	11.25	4,010	1.0	#5	18
	22.5	7,860	2.0		
	45	14,520	3.6	#7	24
14	11.25	5,390	1.4	#5	18
	22.5	10,560	2.7	#6	24
	45	19,510	4.9	#8	30
16	11.25	6,960	1.8	#5	18
	22.5	13,650	3.4	#7	24
	45	25,230	6.3	#9	30

[1] – Values were taken from the Oregon DOT Standard Detail RD250 Table C

Values in the table have a safety factor $S_f = 1$

$V_g = S_f PA \sin\Theta / W_m$ $T_x = PA (1-\cos\Theta)$

3. Restrained Joints:

a. For Pipe Diameters 8 inch through 12 inch: Provide a minimum of 40 feet of restrained pipe in all directions along the pipe from the fitting for pipe diameters 8 inch through 12 inch, depths of bury of at least 5 feet, and a maximum test pressure of 150 psi.

b. For Pipe Diameters Greater than 12 inch: Restrained joints are typically used on pipes larger than 12 inches in diameter. They may be used on other pipe sizes independently or in combination with concrete thrust blocks. See pipe manufacturer's recommendations for determining restrained lengths of pipe required.

L. Crossings

1. **Railroad Crossings:** The regulations of the railroad company involved will govern when a water main is installed under or over any railroad tracks.

2. **Roadway Crossings:** The jurisdiction responsible for the roadway should have regulations for crossing a roadway. For primary and interstate highways, the Iowa DOT is the responsible jurisdiction. For non-primary, federal-aid roadways use the most recent version of the "Policy for Accommodating Utilities on the County and City Non-Primary Federal-Aid System." For all other roadways, contact the responsible jurisdiction.

M. Flushing, Disinfection, and Pressure Tests

Before going into service, all new mains should be adequately flushed, pressure tested, and disinfected according to the rules and regulations of the local Jurisdiction and Iowa DNR. The procedures, once approved by the Jurisdiction, should be conducted under the supervision of the Jurisdiction or designated representative.

1. **Disinfection:** Disinfect the water main according to AWWA C651. Verify requirements and acceptable methods with the Engineer. Three methods of disinfecting new water mains are available. They include the tablet method, the continuous feed method, and the slug method. The tablet method is the most convenient, but the least effective. SUDAS Specifications Section 5030 indicates that the tablet method is not to be used unless approved by the Engineer. The continuous feed method is acceptable for general application. The goal for disinfection is to obtain a concentration in the new main of 25 mg/L free chlorine. The chlorine is to be retained in the pipe for a minimum of 24 hours, but no more than 48 hours.

2. **Flushing:** Once the main has passed the chlorination tests, it is to be flushed according to the requirements of AWWA C651 until the water in the new main is at the same chlorine level as the other sections of the distribution system. The velocity in the main should be at least 2.5 feet per second for adequate flushing. If there is any potential threat the highly chlorinated water will damage the environment, a neutralizing chemical should be added to the water to render it acceptable.

3. **Hydrostatic Pressure Testing:** Pressure test according to AWWA C600. All air must be expelled from the new main. The test pressure should be 1.5 times the working pressure of the system or 150 psi, whichever is greater. The test should continue for a minimum of 2 hours. If the pressure falls by 5 psi or more, additional makeup water must be added to return the pipe to the test pressure. The amount of makeup water used must meet the requirements of SUDAS Specifications Section 5030.

Figure 4C-1.02: Standard Water Main Location at Cul-de-sac

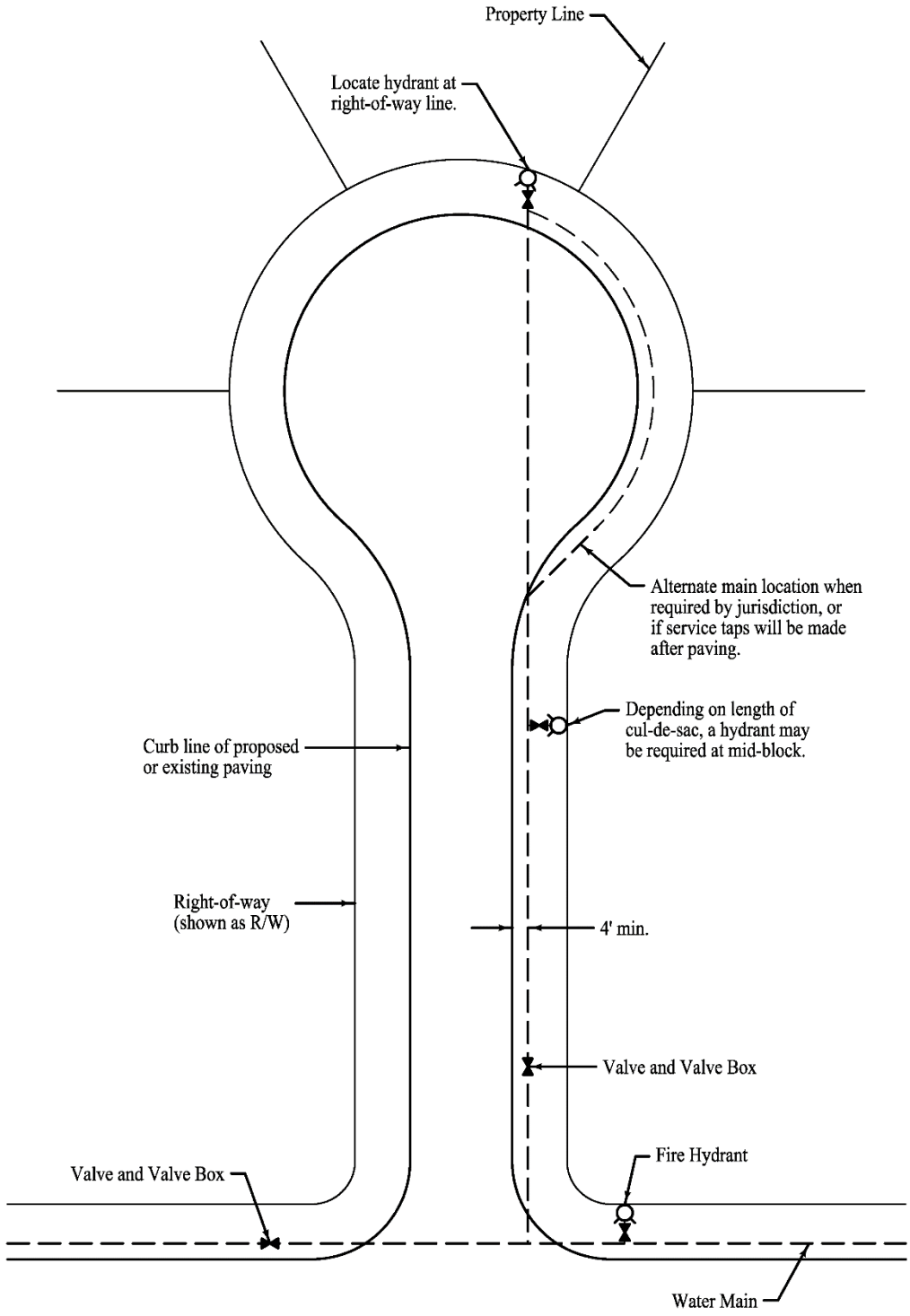
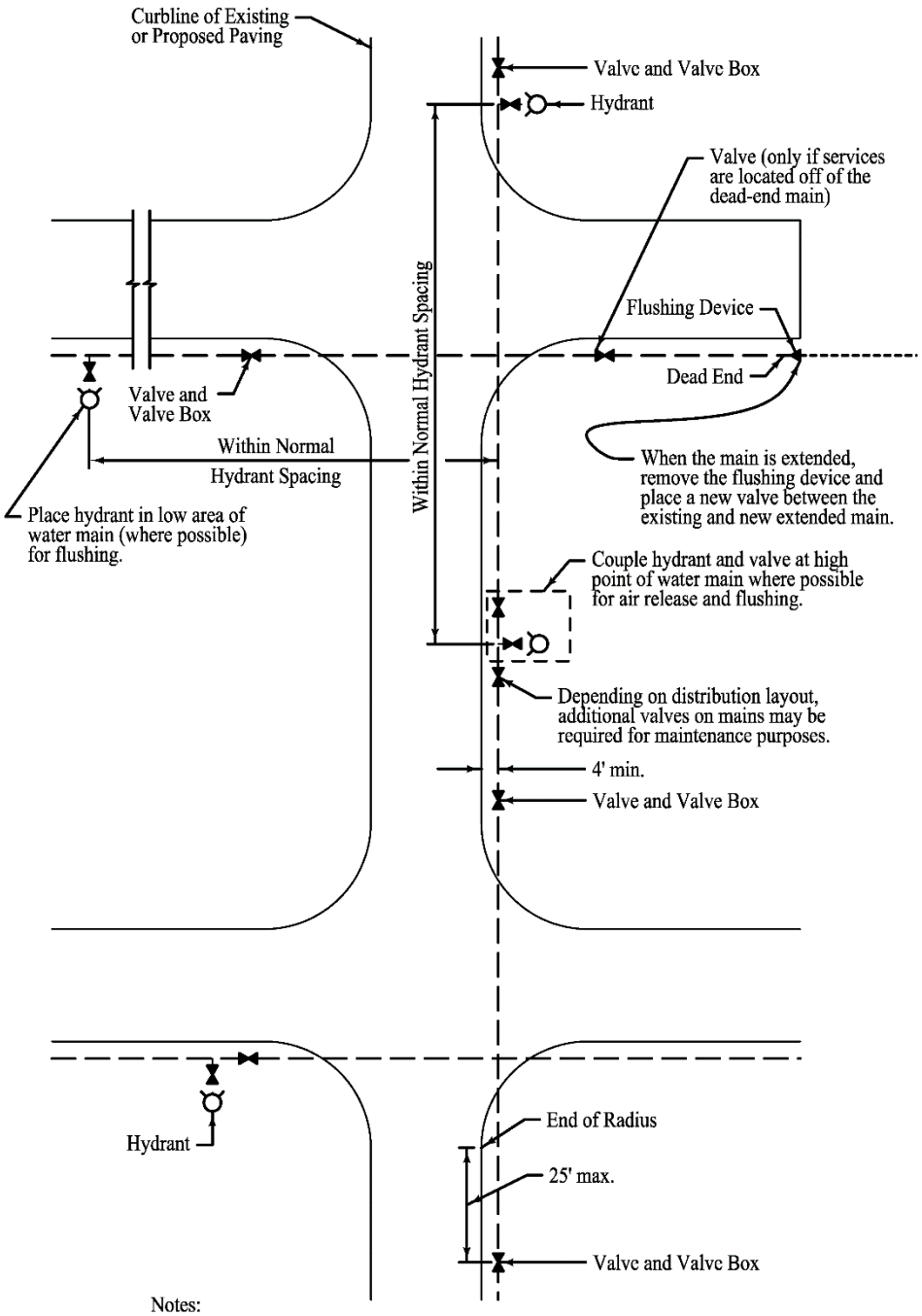


Figure 4C-1.03: Standard Water Main Location



Notes:

1. Install three valves and one fire hydrant at each intersection, except at T-intersections, which will have two valves.
2. Where possible, locate fire hydrant near high point.
3. Locate fire hydrants within 25 feet of intersection return radius, but outside of radius to avoid conflicts with storm sewers and intakes.
4. Where possible, locate fire hydrants on the downhill side of an in-line valve for air release and flusing purposes.

References

American Society of Civil Engineer Books and Manuals

American Water Works Association Standards

Great Lakes-Upper Mississippi River Board. *10 State Standards*. 2004.

Insurance Service Office (ISO). *Fire Suppression Rating Schedule*.

Iowa Administrative Rules

Iowa Department of Natural Resources Design Standards