Chapter 4
Water System Evaluation Criteria

2019 City of Billings Water Master Plan
(Draft)

City of Billings, MT

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Introduction

This chapter describes the criteria by which the water system was evaluated, including pressure, velocity, headloss, pumping, storage, and fire flow requirements. These evaluation criteria in combination with other system performance criteria are key measurements of the water system overall Level of Service (LoS) performance and its ability to meet its strategic goals and objectives. A discussion of the evaluation criteria included in this master planning effort follows.

Distribution System Criteria

Distribution system criteria are designed to address the water system pressure and pipeline requirements. These criteria are established to ensure that the existing and proposed distribution system will provide adequate, but not excessive, water pressure and the conveyance system can accommodate peak demands without excessive wear or energy usage. It should be noted that the criteria recommended below are criteria derived to protect the distribution system under repeated normal operation. These criteria are not established to limit, for example, pipeline velocities during intermittent activity such as system flushing programs or emergency events.

Water system design criteria recommended for this Water System Master Plan are generally taken from the Montana Department of Environmental Quality (DEQ) Standards for Water Works, August 9, 2014 Edition, which are based on the 10 State Standards for Water Works and augmented with our experience on similar water utility system master planning projects.

The water service pressure requirements recommended for this analysis are as follows:

- Maximum desired pressure: 120 psi
- Maximum allowable pressure: 150 psi
- Minimum allowable pressure at peak flow: 40 psi
- Minimum allowable pressure with maximum day demands plus fire flow: 20 psi

In order to help provide standardization throughout the City, provide adequate fire flows and avoid excessive velocity and head loss within the distribution system, the following pipeline design criteria are also recommended:

- Minimum pipe size for new construction w/ fire hydrant: 8 inch
- Maximum allowable velocity at peak flow: 7 feet per second
- Maximum allowable velocity at peak flow plus fire flow: 15 feet per second
- Maximum desirable head loss at peak flow: 5 feet per 1000 feet
- Maximum allowable head loss at peak flow: 10 feet per 1000 feet

Pump Station Criteria

Pump stations will be sized to handle maximum day demand flows to meet the required pressure at all junction nodes. Reservoir storage provides for flow differences between

maximum day demand and peak hour plus fire flow. Pump stations should be able to meet the required pumping rates with the largest capacity pump at that facility on standby (inactive). This operating condition is referred to as firm capacity, and will be used as the criteria to determine each facility's ability to meet various flow conditions.

Pressure Reducing Station Criteria

Pressure Reducing Stations or Pressure Reducing Valves (PRVs), as they are typically referred to, will be sized to meet maximum day demand flows in cases where the downstream pressure zone has a reservoir for flow support during maximum day plus fire flow and peak hour demand conditions. If there are no reservoirs in the downstream pressure zone, the PRV will be sized to handle peak hour plus fire flow demand. The PRV design shall include low flow and high flow pressure reducing valves operating in parallel to allow the PRV to operate over a wide range of flows from minimum night-time demand to the required maximum demand.

Water Storage Criteria

As described in Chapter 2, Water System Overview, the City of Billing water system has about 40 MGD of total water storage. Water storage requirements are typically categorized as follows;

- Operational storage. The purpose of operation storage (or equalization storage) is to provide supply to meet peak hour water demands. Over any 24-hour period, water demands will vary and operational storage helps the system meet these normal daily diurnal fluctuations in demand. During periods of high demand, the water level in a storage facility will typically drop as water flows into the system to meet the demand. During period of low demand, such as nighttime hours, reservoirs are filled in preparation for the diurnal high demand flow conditions of the next day. The amount of operational storage for a specific pressure zone will be 15 percent of the maximum day demand for that zone.
- Emergency storage. The purpose of emergency storage is to meet short-term emergency supply needs. An emergency is an unforeseen or unplanned event that may cause a water shortage in the system. The amount of emergency storage for a specific pressure zone will be 50 percent of the maximum day demand for that zone.
- Fire storage is the volume of water required to meet firefighting needs, and varies depending upon the type of development or land use that is served in each pressure zone. For example, single family residential development typically requires 1,500 gpm for 2 hours or 180,000 gallons of fire storage.

The following recommendation is from the DEQ Water Works Standards:

- Storage facilities must be sufficient, as determined from engineering studies, to supplement source capacity to satisfy all system demands occurring on the maximum day, plus fire flow demands where fire protection is provided.

It is recommended that the DEQ standard for reservoir sizing be used in this Water System Master Plan. From Section 7.01 of the DEQ standard:

- a. The minimum allowable storage must be equal to the average day demand plus fire flow demand, as defined below, where fire protection is provided.
- b. Any volume less than that required under a. above must be accompanied by a Storage Sizing Engineering Analysis, as defined in the glossary. Large non-residential demands must be accompanied by an Emergency Storage Sizing Engineering Analysis and may require additional storage to meet system demands.
- c. Where fire protection is provided, fire flow demand must satisfy the governing fire protection agency recommendation, or without such a recommendation, the fire code adopted by the State of Montana.
- d. Each pressure zone of systems with multiple pressure zones must be analyzed separately and provided with sufficient storage to satisfy the above requirements.
- e. Excessive storage capacity should be avoided to prevent water quality deterioration and potential freezing problems.

Fire Flow Criteria

To determine fire flow criteria, several references were reviewed including the International Fire Code (UFC 2012), Insurance Services Office, and the Wildland and Urban Interface Code (IWUIC 2015). Fire flow criteria are based on land use, which corresponds to zoning as shown in Table 4-1.

These fire flow criteria are recommendations, and not necessarily specific fire flows required by the fire marshal or fire protection agency. For example, in many residential areas 1,000 gpm may be sufficient. The highest fire flow required in the system is 3,500 gpm, however, it is not possible for a single hydrant to supply 3,500 gpm, even if the distribution system can supply that rate of flow *to* the hydrant. In this case, multiple nearby hydrants could assist in meeting the fire flow requirement and developments should be designed accordingly.

Table 4-1: Fire Flow Criteria Based on Land Use.

Fire Flow (GPM)	Land Uses	Justification
1500	Agricultural, Residential Single Family (incl. R150, R200, R50, R60, R60R, R70, R70R, R75, R80, R96, RLMF and RMH)	Consistent with IFC (2012), ISO and IWUIC (Wildand-Urban Interface Recommendations); 1-2 single family structures
1800	Planned Unit Development, Residential Multi Family, and Residential Multi Family Restricted	Adopted IFC
2500	Public, CBD, CC, East Billings (w/ exc of Ind'l Sanctuary), Entryway General Commercial and Entryway Mixed Use, Med Corridor, Neighborhood Commercial, and Residential Multi-Family (RMF, RMFR) and Residential Professional, East Billings Industrial Sanctuary, Highway Commercial, and So. 27th PZD	Higher Residential Density; Commercial Permitted Uses consistent with slightly higher needed demand than residential; Consistent with IFC (2012) typical ranges for non-residential structures
3500	Industrial (CI, HI, LI), Entryway Light Industrial, and airport	Hazards and Occupancy, as well as Permitted Uses consistent with higher needed demand.

References: International Fire Code (IFC), Insurance Services Office (ISO), Wildland and Urban Interface Recommendations (IWUIC)

Table 4-2. Fire Flow Requirements by Pressure Zone

Zone	Max Zone Fire Flow Demand (gpm)	Duration (hours)	Fire Flow Storage Volume (gallons)	Determining Land Use / Comments
Zone 1	3,500	3	630,000	Industrial
Zone 2	3,500	3	630,000	Industrial
Zone 2 East	3,500	3	630,000	Industrial
Zone 3	3,500	3	630,000	Industrial
Zone 3 East	2,500	2	300,000	Commercial
Zone 3 South	2,500	2	300,000	Commercial
Zone 4	2,500	2	300,000	Commercial
Zone 4 East	2,500	2	300,000	Commercial
Zone 4 North	1,500	2	180,000	Residential
Zone 4 South	2,500	2	300,000	Commercial
Zone 5	3,500	3	630,000	Industrial
Zone 5 West	1,500	2	180,000	Residential
Zone 6	1,500	2	180,000	Commercial