Tech Brief

A NATIONAL DRINKING WATER CLEARINGHOUSE FACT SHEET

Reservoirs, Towers, and Tanks

Drinking Water Storage Facilities

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Summary

After water leaves the treatment plant but before it reaches the customer, it must be adequately and safely stored. This Tech Brief *explores the various aspects of water storage.*

A water distribution system transports water from the treatment facility to the user. The distribution system should supply water, without impairing its quality, in adequate quantities and at sufficient pressures to meet system requirements.

The facilities that make up the distribution system include finished water storage; pumping, transmission and distribution piping supply mains; and valves.

Storage facilities—such as reservoirs, towers, and tanks—provide storage for treated water before it is distributed. The water distribution system should have storage so that it is capable for basic domestic purposes, commercial and industrial uses, and to accommodate the flows necessary for emergencies such as fire fighting.

Storage Reservoir Functions

Service reservoirs provide the following functions:

- provide a reserve of treated water that will minimize interruptions of supply due to failures of mains, pumps, or other plant equipment;
- help maintain uniform pressure;
- provide a reserve of water for fire fighting and other emergencies;
- act as a relief valve on a system of mains supplied by pumping;
- permit a reduction in the size of distribution mains below that which would be required in the absence of a reservoir; and
- allow pumping at the average rather than peak flow rate.

Classification of Storage Requirements

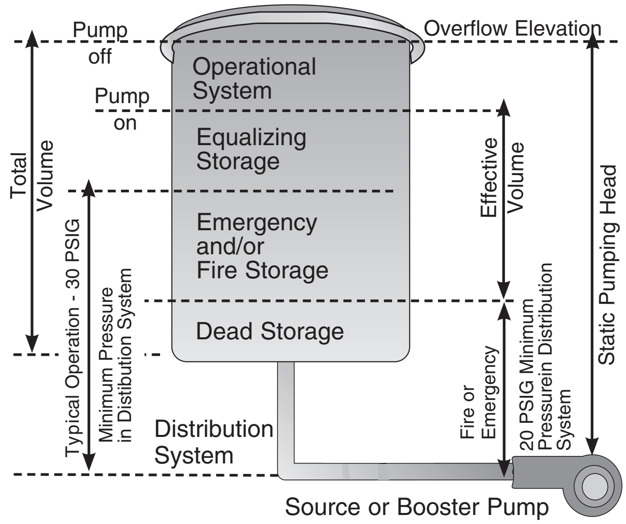
Storage volume requirements are classified by function: operating, equalizing, fire and/or emergency, and dead-storage volumes. Engineers must consider these individual volume components in combination to determine the total volume of storage capacity that is required for any system. The total storage required is typically the sum of all these functions.

Rather than requiring both fire and emergency storage, some local fire and state agencies allow systems to use the larger of either fire or emergency storage volumes. These local agency requirements need to be determined on a case-by-case basis before designing a storage reservoir. ***Figure 1 on page 2*** illustrates the different components of the total storage volume.

Operating Storage—This is the difference in volume between the "pump on" and "pump off" levels when the tank is normally being used and the sources of supply pumps to the storage tank are off.

Equalizing Storage—This storage component

Figure 1 Storage Volume Classification



is used when the source pump capacity is less than the peak system demands. The storage is needed so that water production facilities can operate at a relatively constant rate. Daily peak rates determine the volume, compared to the average daily demand and source capacity.

Fire Storage—The volume of water stored within the water system for fighting fires is known as "fire storage." The storage volume required varies with the size of city and with the size, type, and classification of construction within the service area. Storage volume requirements for fire fighting should be determined based upon state and local fire districts and municipalities. Fire authorities often refer to the latest edition of the *Guide for Determination of Required Fire Flow*, published by the Insurance Services Office to determine local fire flow requirements.

The typical minimum municipal fire flow requirement is 500 to 1,000 gallons per minute (gpm) for two hours for single family residential areas. Commercial and industrial areas fire flows can be as high as 8,000 gpm or more for many hours. Typical fire storage requirements are shown in ***Table 1***. Engineers should base the actual capacity needs upon local fire flow requirements.

Emergency Storage—This storage is used to provide water to the system during other unusual or emergency conditions. Emergency storage volume depends upon the likelihood of supply interruption and the time required to make repairs or arrange for an alternative water supply.

Dead Storage—Storage in tanks or reservoirs that cannot be drawn out or used beneficially because of piping elevations or low pressures is known as dead storage. Dead storage is typically most significant in tall standpipe-type tanks where water in the bottom of the tank cannot be used because of low system pressure.

Storage Volume Dedicated to Contact Time—Finished water stored in clearwells at water treatment plants is sometimes used to meet the disinfection contact time. In these cases, the amount of fixed volume used to meet the disinfection requirement should also be considered in the total volume and operational limits of the reservoir.

Daily Storage Volume Use Varies

Water use is greater during daylight hours—typically peaking in the mid-morning and early-evening hours. Stored water is withdrawn during these peak demand hours of the day and is replenished during minimum-demand times in the late-night and early-morning hours.

Figure 2 illustrates the hourly variation in daily water use (diurnal variation) that might occur in a typical residential community on the day of maximum water use for the year.

The shape of the diurnal curve of water demand will vary significantly between different cities because of differences in climates and local economies. Local design data should be obtained for each water system to determine storage needs. However, with an adequate source of supply capacity, equalizing storage of approximately 22 percent of the maximum daily demand is typical for small residential areas.

Storage Tank Shape and Volume

Water towers can be made of concrete or steel and can take various forms. The most suitable

Table 1 Typical Range of Storage Requirements for Fire Protection

Type of Development	Storage Volume, gallons	Storage Volume, ML
Low-density residential, 2 hr at 500 gpm	60,000	0.23
Built-up residential, 2 hr at 1,000 gpm	120,000	0.45
Light commercial, 4 hr at 2,000 gpm	480,000	1.8
Commercial, 4 hr at 4,000 gpm	960,000	3.6

Source: HDR Engineering, Inc.

form for concrete towers is a cylinder with a curved shaped bottom or with a flat bottom. Steel tanks may have a spherical or dome shaped bottom. The shape chosen is usually a compromise between function, construction and maintenance costs, and aesthetics.

The lowest water level in the tank is determined according to the pressure requirements in the pipeline. The pressure in the pipelines may vary depending on the type of community and pressure needs of different areas in a city. Typically, minimum acceptable water system pressures are 35 to 40 pounds per square inch (psi) and maximum pressures are 100 to 120 psi.

To keep pumping costs low, water depth in the tank is generally kept small. Due to structural considerations, the depth is kept equal to the diameter.

Locating Storage Reservoirs

A service reservoir stores the water and supplies it at the required pressure to the farthest point in the area. In view of the cost of pipelines and uniform pressure distribution, the reservoir should be located near the center of the service area.

In flat areas, it is relatively easy to build the water tower at the center. In hilly areas, however, it may be more advantageous to select the highest point for the construction of an elevated tank, which may lie at one end of the area instead of the center.

Apart from the center, the tank or tower can be situated between the area and the source of supply (pumping or gravity flow). When the service reservoir lies between the area and the source, all the water must pass through the elevated tank before flowing through the area. ***(See figure 3A.)***

The pressure in the water supply system depends upon the water level in the service reservoir. A water supply system needs to guarantee a minimum pressure even at the most remote point in
the area. Therefore, it is essential that the hydraulic gradient line always be above the required pressure.

When water is supplied from an impounded high-level reservoir, the service reservoir may function as a pressure-reducing device. ***(See figure 3B.)*** This reduces the possibility of damage to the pipes due to high hydrostatic pressure.

Figure 2 Hourly Water Use Variation

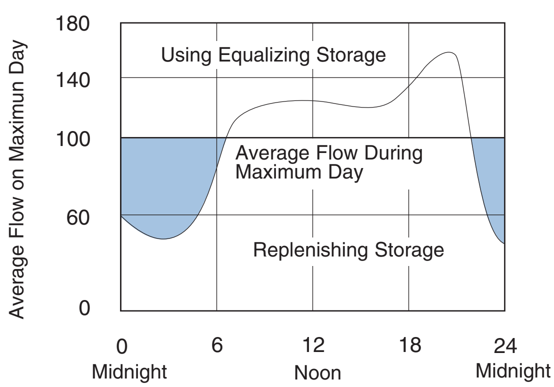
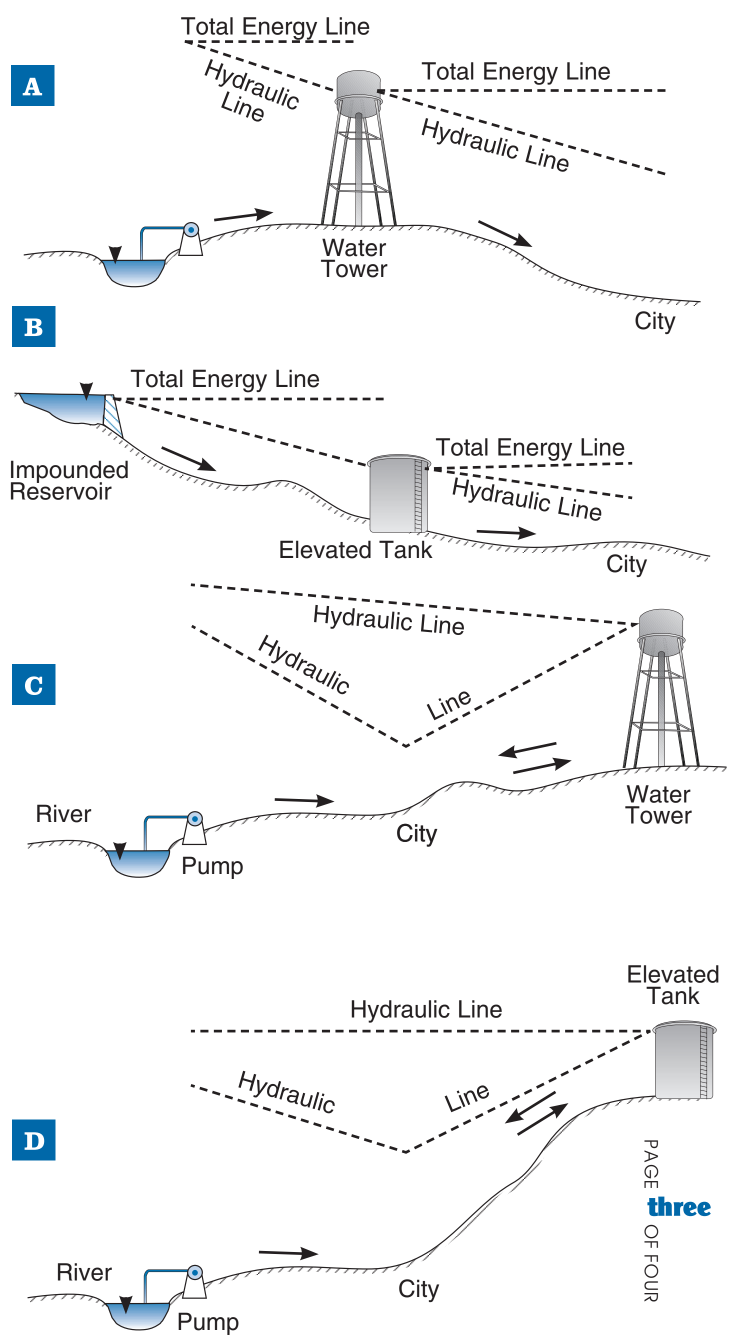


Figure 3 Service Reservoir



When the area lies between the source and the service reservoir, then most of the requirements are met by direct pumping and the excess water flows to the service reservoir. *(See figures 3C and 3D.)* In this system there may be larger fluctuations in the supply pressure.

Construction Materials

Most states permit steel and concrete construction materials. All piping, joints, and fittings should conform to American Water Works Association (AWWA) specifications. Welded steel water tanks should confirm to American National Standards Institute (ANSI)/AWWA Standard D100. Factory-coated bolted steel tanks should confirm to ANSI/AWWA D103. Wire and strand wound, circular, pre-stressed concrete tanks should confirm to ANSI/AWWA Standard D110.

The storage tanks should be painted or have cathodic protection. The AWWA standards for painting exclude the use of paints that might add toxic materials to the stored water. The paint, both external and internal, should comply with the standards prescribed by AWWA D101 and D102.

Other Considerations

All water reservoirs should be covered to protect the stored water against contamination. Overflow pipes should be brought down near the ground surface and discharged to minimize erosion. The storage structure should be designed so that there is water circulates. There should be a convenient access to the interior for cleaning, maintenance, and sampling. Rigid storage reservoirs should be vented.

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