PERFORMANCE CRITERIA

6.1 BACKGROUND

The City of Peoria's (City's) water distribution system infrastructure recommended in this master plan is intended to provide acceptable levels of performance and reliability, while being sensitive to cost. As new infrastructure is being planned and analyzed with the use of a new hydraulic model, agreed upon "standards of measurement" are necessary to evaluate the adequacy of the infrastructure. The "standards of measurement" are the performance criteria that are utilized by Peoria and upon which this master plan is based.

Performance criteria address the following areas:

1. Water Supply Redundancy: Addresses the ability for water supplies from the City's water resources portfolio to be delivered into the distribution system under a variety of conditions.
2. Water System Reliability: Addresses conditions such that components of the distribution system collectively can deliver water even when some facilities are not in service.
3. System Operational Requirements: Addresses conditions such that water can be delivered reliably under fire flow, high demand, or other extreme or unusual operating conditions.

Water supply redundancy refers to the degree to which water can still be supplied to the City in the event that one or more of the water supply sources is unavailable. Decisions concerning the extent of redundancy are often policy decisions influenced by the price a utility is willing to pay for the redundancy compared with the risk of having to implement water use restrictions or provide a lower level of service to the customer. Under some conditions, it may be more economical for the City to implement water conservation measures than to build infrastructure that will be used only on infrequent occasions when a particular water source may be unavailable. Although no firm guidelines exist, most communities in central Arizona seek to provide redundant or backup water supplies for canal outages under average day demand conditions.

The City's water system reliability is dependent on the reliability of all the components within the system as well as the reliability of support systems and services outside of the City's control (Salt River Project [SRP], Central Arizona Project [CAP], and power supply). The level of reliability provided is usually based on historic operational experience and judgment, which results in confidence that the system can deliver water under a variety of normal and emergency conditions. Consequently, professional judgment must be used when specifying system components and the number and location of components needed to meet reliability criteria.

The level of reliability provided by the system is a function of the reliability of the major system components:

- Raw Water Sources.
- Treatment.
- Major Transmission Mains.
- Power Sources.
- Booster Stations.
- Storage Tanks.
- Pressure Reducing Valves (PRVs).

Reliability of the City's water system is provided by a combination of the following factors:

- Sufficient surface water sources and treatment capability together with groundwater production to meet maximum-day demand.
- Reserve system storage to meet emergency conditions, in addition to fire and normal operational needs.
- Transmission capability to deliver water to the distribution system.
- Looped transmission and distribution system network.
- Sufficient booster pumping capabilities with a pump station or the largest pump in a station out of service.

System operational requirements refer to the level of service provided by a utility to the customer. Levels of service include many parameters, such as maximum and minimum pressures, maximum flow velocities, storage, redundancy, and provisions for emergency conditions. Adequate pressure is usually defined in terms of a minimum pressure under certain demand conditions, such as peak hour or fire flow. Adequate fire protection refers to providing adequate storage volume and flow to meet firefighting demands. The water system is considered to be adequate when system demand conditions are satisfied while meeting system performance criteria, such as system pressure, velocity, and head loss.

6.2 WATER PRODUCTION FACILITIES

Production facilities for the water system should have sufficient capacity to meet the demands of the maximum day of the year. Existing production facilities consist of wells and the Surface Water Treatment Plants (SWTPs), i.e., the Greenway WTP and the City of Glendale's Pyramid Peak WTP. Since the SRP surface water source is from a canal system subject to downtime and disruption, it is necessary to construct sufficient production capacity from wells and CAP WTPs to meet the demand during the SRP canal dry-up period, or average day demand under emergency canal outages.

State regulations regarding emergency operation plans require that emergency conditions, such as loss of source of water supply, be addressed by the municipality.

Backup water supplies should be available for the following events:

- The SRP-owned Arizona Canal is typically out of service in late December and January.
- The SWTPs are shut down for scheduled maintenance, repairs, mechanical failure, or contaminants during average day demand conditions.
- The CAP canal is out of service due to a canal breach or other failure mode, or scheduled maintenance.
- SRP water deliveries are curtailed in the event of a severe drought.

The City's development code, Section 25-14, requires that all new developments, whose primary water source is treated surface water, provide to the City a redundant or backup water supply source, typically a water supply well.

6.3 FIRE FLOW

The City of Peoria's Fire Department has adopted and amended the 2003 International Fire Code. Minimum required fire flow rates and flow durations are specified in the International Building Code (IBC) for building area according to construction type.

For one- and two-family dwellings, the Fire Code is specific for the minimum required fire flow as follows:

- < 3,600 square foot fire area = 1,000 gpm for 2 hours duration.
- ≥ 3,600 square foot fire area = 1,500 gpm or higher for 2 hours duration (refer to International Fire Code Appendix B, Table B105.1).

Depending on the type of use, construction, and fire area, the required fire flow and duration ranges from 1,500 gpm for 2 hours to 8,000 gpm for 4 hours.

It is assumed that a major fire will not occur during the peak hour demand condition since the chance of this happening is minimal. But rather, it is more likely that a fire could occur under maximum day demand conditions.

To assess the adequacy of the modeled water system with respect to the maximum day plus fire demand condition, the land use based fire flow and duration guidelines shown in Table 6.1 are recommended.

Table 6.1 Recommended Fire Flow Criteria/Guidelines City of Peoria, Water System Master Plan		
	Flow (gpm)	**Duration (hours)**
Single Family Residential	1,000-1,500	2
Multi-family Residential	1,500-2,500	2
Commercial:		
Low Risk (retail)	3,000-4,000	3
High Risk (mall, school, etc.)	6,000-8,000	4
Industrial:		
Low Risk (manufacturing)	4,000-6,000	4
High Risk (warehousing)	8,000-10,000	4
Special purpose facilities	Criteria established on case-by-case basis – consult Fire Marshall	–

6.4 PUMP STATIONS

Usually pumping stations are the most critical components in a distribution system with respect to meeting reliability/redundancy criteria, because these facilities are subject to disruption by the following conditions:

- Power outage.
- Mechanical failure.
- Line breaks.

Table 6.2 summarizes these conditions and the criteria to be employed for reliability in this master plan.

Table 6.2 Booster Station Reliability Criteria City of Peoria, Water System Master Plan		
Condition	**Result**	**Mitigating Criteria**
Power Outage	Creates loss of pumping capacity at one or more pumping facilities.	Provide emergency backup power supply generation or dual power feed to critical facilities.
Mechanical Failure	Creates loss of pumping capacity due to one or more pumps at a facility being out of service.	Provide sufficient pumping capacity at each booster pumping station to meet maximum day demands with any one pump or the largest pump out of service (referred to as "firm capacity" of the station). This allows for pumps to be out of service due to mechanical failure or unscheduled maintenance.

Table 6.2 Booster Station Reliability Criteria City of Peoria, Water System Master Plan		
Condition	**Result**	**Mitigating Criteria**
Line Break	Occurs at or near the booster station, creating a loss of all or a portion of the pumping capacity at the facility.	A line break at or near a booster station disrupting supply is usually mitigated through multiple pumping facilities, storage, and PRV facilities.

For line breaks affecting critical pumping facilities, reliability/redundancy criteria are established so that average day demand conditions can be met on a zone-by-zone basis.

A pump station pumping to a closed system, with no other water sources or elevated storage, should be sized for the larger of peak hour demand or maximum day plus fire flow demand. Diurnal demands (peak hour) and fire demands will be met from ground set storage, and the booster stations will need to be able to pump this flow from the reservoirs. Pump stations should be designed based on the firm capacity that can be consistently provided with the largest pump out of service. In addition, pump stations that deliver water into higher zones must be sized to meet the demands of both zones, the parent and subordinate zones.

The following summarizes pump station criteria:

- When pumping to a closed system, the capacity equals the larger of peak hour demand or maximum day plus fire flow demand.
- The allowance for reliability and uncertainties in demand projections equals 10 percent of the station's firm capacity.
- Pump stations should be sized to meet demands with the largest pump out of service (firm capacity).
- When multiple booster stations supply a zone, average annual water demands should be supplied with the largest booster station out of service.

The firm capacity of booster stations that pump from reservoirs is often set so that half of the reservoir can be emptied or refilled in a six-hour period.

6.5 TRANSMISSION/DISTRIBUTION MAINS

Water system piping serves three basic purposes:

- To transfer water from the source of production to storage.
- To distribute water from the source or storage to the consumer.
- To provide a conduit to supply firefighting water.

Transmission and distribution mains are sized for the greater of the following two demand conditions:

- Maximum day demand plus fire flow, or
- Peak hour demand.

Peak hour demands are usually the controlling demand condition for pressure zones of the size found in Peoria. The following pressure criteria are recommended to assess the adequacy of the water transmission/distribution system under the two demand conditions:

- Peak Hour Demand: Pressures must be greater than 50 pounds per square inch (psi) and less than or equal to 100 psi. Criteria are established to account for distribution system and backflow prevention facility head loss in order to achieve a minimum service pressure of 40 psi (2001 Water Infrastructure Master Plan, also International Building Code).
- Maximum Day Demand plus Fire-Flow Condition: A minimum of 20 psi at the point of maximum fire draft (2001 Water Infrastructure Master Plan, also International Building Code).

The recommended water velocity criteria under maximum day demand conditions are as follows:

- Velocity ≤ 5 feet per second (fps) for pipes < 36 inches diameter
  (Head loss, HL = 2 to 7 feet/1,000 feet).
- Velocity ≤ 6 fps for pipes ≥ 36 inches diameter
  (Head loss, HL = 1 to 2.5 feet/1,000 feet).

Velocity criteria under peak hour demand conditions is as follows:

- Velocity ≤ 7 fps (HL < 10 feet/1,000 feet).

Velocity criteria under fire demand conditions is as follows:

- Velocity ≤ 10 fps.

6.6 STORAGE FACILITIES

Since production facilities are usually designed to operate at a steady rate over an extended period of time, storage reservoirs are planned to accommodate fluctuating demands. The factors included in designing reservoir capacity are diurnal demand fluctuations, fire demand, and emergency reserve storage. In some situations, it may be prudent to have an additional storage volume to provide operational storage. Storage facilities should be designed and operated to meet these conditions, while achieving storage turnover to minimize water quality degradation.

The City's 2001 Water System Master Plan recommended a storage criteria of providing the volume of one maximum day demand in system storage. This criteria will usually result in a system storage volume that is greater than needed, and may contribute to deteriorating water quality due to an inability to "turn over" storage volumes. Since Peoria's water system contains a number of production wells, system storage requirements can be offset with excess groundwater production. The following sections describe the recommended approach for determining the required system storage volume.

6.6.1 Storage for Diurnal Demand Fluctuations

Storage capacity to meet diurnal demand fluctuation is determined as the volume of water required to meet the peak hour demands exceeding the maximum day demand rate (the difference between maximum day and peak hour). For storage volume planning, a conservative value of 20 percent of maximum day demand is typically used.

$$\text{Diurnal fluctuation} = 20 \text{ percent of maximum day demand}$$

6.6.2 Storage for Fire Demand

Fire flow duration for determining zone storage requirements is determined by the local fire department, but generally ranges from 4 to 10 hours for multiple fire occurrences within a pressure zone. Given these guidelines, required storage capacities can be calculated for different fire conditions. The variables in establishing fire storage volume include determining the type of fire and the number of multiple occurrences.

For planning purposes, population can be used to calculate the required fire storage for specific pressure zones. Fire demand rates and storage volumes are determined using criteria established by the American Insurance Association according to the following equation:

$$G = 1{,}020\ \sqrt{P}\left(1 - 0.01\sqrt{P}\right)$$

Where

G = fire demand rate, gal/min

P = population in thousands

Table 6.3 summarizes these calculations.

Table 6.3 Required Fire Flow and Fire Reserve Storage City of Peoria, Water System Master Plan				
Pressure Zone Population	Fire Flow		Duration (hr)	Fire Reserve[1] Storage (MG)
	gal/min	mgd		
1,000	1,000	1.4	4	0.3
2,000	1,500	2.2	6	0.6
4,000	2,000	2.9	8	1.0
10,000	3,000	4.3	10	1.8
17,000	4,000	5.8	10	2.4
28,000	5,000	7.2	10	3.0
40,000	6,000	8.6	10	3.6
56,000	7,000	10.0	10	4.2
80,000	8,000	11.5	10	4.8
96,000	9,000	13.0	10	5.4
125,000	10,000	14.4	10	6.0

Note: (1) American Insurance Association

Using these guidelines, fire storage can be determined for each pressure zone, and an assessment made regarding multiple fire capability within a pressure zone or service area.

6.6.3 Storage for Emergency Reserve

Emergency or reserve storage capacity is an additional volume of water that is held in the reservoir to meet various emergency conditions, such as a facility outage. The amount of emergency storage that a utility should plan for is largely based on professional judgment, and is influenced by a number of factors such as power outage history, line break frequency, and overall supply redundancy. A customary rule of thumb for emergency storage is 10 percent of maximum day demand. Emergency reserve storage is also available to provide reliability/redundancy to adjacent zones through booster stations or PRVs.

6.7 DEVELOPMENT FACTORS AFFECTING DESIGN/PERFORMANCE CRITERIA

The previously discussed performance criteria apply to mature pressure zones that have achieved growth generally greater than 50 percent of build out population, and whose infrastructure is well developed with looped pipelines and a significant percentage of storage and booster pumping facilities in place.

In growth oriented communities where new pressure zones are being developed and satellite developments are being proposed, the initial population is low and new infrastructure does not usually achieve the criteria recommended for mature zones in the

early stages of development. This type of development can be referred to as "Satellite" development where the boundary condition is such that the satellite development must initially implement its own stand-alone supply and infrastructure. These conditions usually occur for the following types of growth/development:

1. Growth in a new pressure zone that is not yet connected to the City's system.
2. Growth in an existing or new pressure zone that is connected to the City's system by a single feed or "umbilical cord" type infrastructure.

Under these growth and development conditions, water usage patterns can vary significantly from patterns observed in mature pressure zones, and can greatly affect peaking factors and required storage and booster pumping. The performance criteria previously presented for mature pressure zones were based on peaking factors as follows:

- Maximum Day/Average Day = 1.6
- Peak Hour/Maximum Day = 2.0
- Peak Hour/Average Day = 3.2

For new growth areas or "Satellite" developments, it is not uncommon to experience peaking factors that exceed these values. A typical Peak Hour/Maximum Day factor for these conditions would be 2.5, or Peak Hour/Average Day factor of 4.0 or higher. The reasons for the higher peaking factor include:

3. Significantly greater proportionate share of construction water use compared to normal per capita usage during the early stages of new development. High construction water usage typically occurs at the same time of peak daily per capita water demand.
4. The character that a satellite development displays is much like a "bedroom" community, where the resident's water use patterns are all similar, and not buffered by other types of community and commercial water use.

Fire flow demands also affect the requirements for booster pumping and storage capacity. Typically for new, small developments, the maximum day plus fire flow demand condition will control the sizing of booster pumping and storage. Where as for larger, mature zone development, the peak hour demand condition will usually control the sizing of booster pumping and storage.

Therefore based on these conditions, the performance criteria may be modified at the discretion of the City to account for satellite growth impacts. The recommended minimum adjustments to the performance criteria for initial storage and pumping capacities are summarized in Table 6.4.

Table 6.4 Summary of Recommended Water System Performance Criteria City of Peoria, Water System Master Plan	
Description	**Criteria**
DEMAND AND PRODUCTION CRITERIA	
Average Day Demand	
Single Family Residential (gpcd)(1)	161
Multi-Family Residential (gpcd)(1)	194
Parks (gpad)	3,035
Loop 303 Commercial (gpad)	1,929
Projected Population Density	
Single Family (persons/dwelling)	2.9
Multi-Family (persons/dwelling)	1.7
Peaking Factors	
Maximum Day/Average Day	1.6
Peak Hour/Maximum Day	2.0
Peak Hour/Average Day	3.2
Production(2)	Maximum Day Demand plus 10%
STORAGE CRITERIA (Sum of All 3 Components)	
Equalizing	20% of Maximum Day Demand
Fire	Volume According to Table 6.3
Emergency	10% of Maximum Day Demand
TRANSMISSION/DISTRIBUTION	
Velocity/Head Loss (HL) Criteria	
Maximum Day (MD)	
Pipe <36"	<5 feet per second (fps)
Pipe ≥36"	<6 fps
Peak Hour (PH)	≤7 fps (HL <10 feet/1,000 feet)
Fire Flow Condition	<10 fps, ≥20 psi
System Pressure Criteria (SPC)	50 psi ≤ SPC ≤ 100 psi
Size Criteria (Minimum Diameter, inches)	
Section Lines/Major Arterial	16
North-South Mid-Section Lines	12
East-West Mid-Section Lines	8
All Other Lines	8

Table 6.4 Summary of Recommended Water System Performance Criteria City of Peoria, Water System Master Plan

Description	Criteria
BOOSTER PUMP STATION CRITERIA	
Without Elevated Storage	Capacity equal to larger of peak hour or MD plus fire; plus 10%
With Adequate Elevated Storage	Capacity equal to maximum day demand; plus 10%
Firm Capacity	Capacity with a single pump or the largest pump out of service

FIRE DEMAND CRITERIA

Fire demand requires a determination of both the rate of flow and the total amount of water that must be applied from storage.

Fire flow demand to be superimposed on the maximum day demand (Insurance Services Office [ISO] requirements):

- Residential = 2 hours at 1,500 gpm
- Low risk commercial/industrial = 4 hours at 3,500 gpm

ADJUSTMENTS TO CRITERIA FOR "SATELLITE" DEVELOPMENT(3)
(For Booster Pump and Storage Requirements)

Peaking Factors

Maximum Day/Average	1.6
Peak Hour/Maximum Day	2.5
Peak Hour/Average Day(4)	4.0

Storage Criteria

The early phases of development should take into consideration the demands of construction water and fire flow requirements placed on the water system. In addition to the equalizing and emergency criteria, it is recommended that sufficient storage be provided in the initial phases of development to meet a low risk commercial fire, or 4 hours at 3,500 gpm.

Booster Pumping Criteria

Booster pumping capacity should be based on the greater of peak hour/average day demand or a low risk commercial fire flow rate.

Notes:

(1) Single and Multi-Family demand includes commercial demand and 10% lost/unaccounted for water factor.

(2) Production well supply shall be 33% greater than the required production well capacity to allow for scheduled/unscheduled outages of well production facilities.

(3) Adjustments to criteria that can be applied to early phases of "satellite" development, or development that has limited connection to the City's infrastructure. These criteria are to be used at the City's discretion.

(4) Based on analysis of Zone 4W actual diurnal peaking water use.