WATER SYSTEM MASTER PLAN UPDATE

CROOKED RIVER RANCH WATER COMPANY

TERREBONNE, OREGON

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1.0 EXECUTIVE SUMMARY

The intent of this Master Plan Update is to analyze the Crooked River Ranch water system and demands and determine required up grades. Significant system deficiencies have been identified in the source, storage, and distribution components of the system. Upgrades are needed to bring the system into acceptable public safety and quality of service performance, and accommodate future system growth.

Existing Conditions

Crooked River Ranch currently includes approximately 1,600 connections. At full build-out of an expanded service area, there will be an anticipated 2,060 service connections. Most of the connections are single family residential dwellings. The water system includes two groundwater wells for supply, two above ground reservoirs for storage, and a combination of 2” through 12” distribution piping. Well #4 at the upper elevation of 2,760 feet produces 800 gpm. Well #2 at the lower elevation of 2,540 feet produces 800 gpm. The upper reservoir with overflow at 2,925 has a capacity of 700,000 gallons. The midway cistern between the upper level and lower level has an overflow elevation of 2,790 and 100,000 gallon capacity.

System Deficiencies

Public Safety Deficiencies:

During peak summer day uses, field observations and system modeling indicate service pressures are below 20 psi in portions of the service area. In addition to being undesirable from a service pressure standpoint, 20 psi service pressures are a health safety issue due to potential cross-contamination and lower than acceptable system pressures for firefighting needs. The Department of Human Services requires a minimum of 20psi.

Low system pressures are due to a combination of drop in reservoir water level and hydraulic losses within the distribution system at peak demands. Since the entire upper zone is fed out of the 700,000 gallon reservoir, the single 12” reservoir discharge main and closest 8” mains experience high velocities and head losses with an associated drop in system pressure during peak use periods.

Much of the existing 700,000 gallon tank is below the 20 psi level, and is considered dead storage. Based on recommended capacity calculations for both the current service area and the future expanded area, the existing system is deficit in storage.

Fire hydrants are reportedly approximately 5000 feet apart. There are small diameter standpipes throughout the resort that are inadequate for high capacity use associated with firefighting. Hydrants would typically be 500 feet apart in developed residential areas, and the current hydrant spacing is deficient.

Quality of Service Deficiencies:

Recommended minimum system service pressures for domestic systems is 35 psi. Typically, it is desirable to have at least 45 psi to eliminate customer complaints. During low use periods with full reservoir, there are isolated areas in the system below 35 psi, and significant areas below 45 psi. When the 700,000 gallon standpipe is drawn down and/or there is high demand, most of the service area can be below 35psi, with some areas below 20 psi.

Capacity for Growth Deficiencies:
There are current system deficiencies in storage and distribution that will have an increased negative impact on public safety and quality of service in an expanded service area scenario.

The existing wells are adequate to meet projected build out supply of 1,660 gpm in the existing service area but will not be capable of meeting full build out supply of 1907 gpm in the potential expanded service area. Additionally, Well 2 is old and the pumping equipment for Well 2 is old.

Storage Improvement Options
There are multiple options for increasing the storage. This report examines 4 options in detail. Option 3a would maintain the existing 2925' HGL, but provides adequate storage to keep the water level in the existing standpipe from dropping significantly. This would keep pressures above 20psi, but still lower than the desired 45psi for the higher elevation homes. Options 3b, 3c, and 3d would increase the HGL, eliminating pressure problems throughout the system.

- Option 3a (Maintain existing 2925' HGL)
    - Install new 770K gallon at-grade reservoir and booster station
    - **Initial installation cost = $1,587,300**
    - **20-year cost = $2,385,777**
- Option 3b (Increase HGL)
    - Install new 240,000K gal. reservoir and booster station at fire station
    - Install booster on existing standpipe
    - Pipe Well 4 directly to existing standpipe with dedicated supply main
    - **Initial installation cost = $1,786,900**
    - **20-year cost = $3,383,855**
- Option 3c (Increase HGL)
    - Install new elevated tank
    - Install pipe upgrade 9 (can be eliminated with 2970' HGL)
    - Increase Reservoir Discharge to 16" (can be eliminated with 2970' HGL)
    - Pipe Well 4 to existing standpipe
    - **Initial installation cost = $3,529,600 (2970' HGL)**, or $4,670,700 (2955' HGL)
    - **20-year cost = $3,568,537 (2970' HGL)**
- Option 3d (Increase HGL)
    - Install new booster at existing standpipe
    - Install future new 180,000gallon standpipe next to existing standpipe when needed for additional homes on system
    - Pipe Well 4 to existing standpipe
    - Install pipe upgrade 9 (can be eliminated with 2970' HGL)
    - Increase Reservoir Discharge to 16" (can be eliminated with 2970' HGL)
    - **Initial installation cost = $1,395,900 (2970' HGL)** or $2,537,000 (2955' HGL)
    - **20-year cost = $2,359,377 (2970' HGL)**

Recommended System Upgrades
Recommended Supply Improvements

- New 2.5 cfs Well

Recommended Storage and Pressure Improvements **Option 3d, 2970 'HGL**, above

- Install new booster at existing standpipe to increase system pressure and eliminate dead storage component
- Install future new 180,000 gallon standpipe next to existing standpipe when needed for additional homes on system

- Pipe Well 4 to existing standpipe

Recommended Distribution Improvements

- Install pipe upgrades 1, 2, & 3 for improved fire flows, looping, and connectivity
- Install pipe upgrades 11 & 12 for improved fire flows
- Install new small booster station for Canyon low pressure area
- Upgrade System Controls / Communications / Operations
- Install new Hydrants throughout system
- Additional water main upsizing on case-by-case basis

2.0 INTRODUCTION

Previous Master Plans
In 1997, Economic and Engineering Services, Inc. prepared the Crooked River Ranch Water Company 20-Year Master Plan, November 1997.

In November 2011, Crooked River Ranch Water Company authorized WHPacific to update the Water Masterplan for the Crooked River Ranch water system.

System Description
Crooked River Ranch currently includes approximately 1,600 connections. At full build-out of the existing service area, there will be approximately 1,660 service connections. With an expanded service area, there will be an anticipated 2,060 service connections. Most of the connections are single family residential dwellings. The water system includes two groundwater wells for supply, two above ground reservoirs for storage, and a combination of 2" through 12" distribution piping. Well #4 at the upper elevation of 2,760 feet produces 800 gpm. Well #2 at the lower elevation of 2,540 feet produces 800 gpm. The upper reservoir with overflow at 2,925 has a capacity of 700,000 gallons. The midway cistern between the upper level and lower level has an overflow elevation of 2,790 and 100,000 gallon capacity.

At peak hour on peak day demands, the 70' tall 700,000 gallon reservoir drops down to 45 feet. This drop of 25' represents a drop of 11 psi to customers, plus the significant hydraulic losses that occur during peak flows. Additional supply from the lower well is transferred from the midway reservoir by booster pumps up to the upper reservoir to supplement supply. At peak day demands, low pressure within the upper system is frequently reported. Pressures fall to 20 to 45 psi, with 30 to 35 psi typical. Pressures in distribution systems would typically be kept above 45 psi. This drop in pressure is due to a combination of drop in reservoir water level and hydraulic losses within the distribution system at peak demands. Since the entire upper zone is fed out of the 700,000gallon reservoir, the single 12" reservoir discharge main and closest 8" mains experience high velocities and head losses with an associated drop in system pressure during peak use periods.

We understand that the well head pressure typically maintains 78 to 85 psi. Fire hydrants are reportedly approximately 5000 feet apart. There are several small diameter standpipes that are inadequate for high capacity use associated with fire fighting. Hydrants would typically be 500' apart in developed residential areas. The Ranch is approximately 96 percent built out within the water supply area. The south half of the Ranch is not currently on the water supply system. Upon CRRWC request, we have included review of storage needs for addition of 400 homes to the south of the existing water supply area.

Due to much of the existing 700,000 gallon tank being below the 20psi level, it is considered dead storage. Based on recommended capacity calculations, the existing system has a deficit in storage. There are several options for increasing the storage as well as increasing the system pressure. The Ranch has been tentatively planning an increase in storage prior to this Masterplan Update.

The lower Well #2 was constructed in the 1970's, and there is no record of well construction. Consideration has been given to putting this well into a reduced backup service capacity due to unknown condition aging well construction and pumping equipment. This would require an additional well which would logically be located in the upper zone. Additionally, for full buildout of 2060 services, the existing wells do not provide adequate supply. A new well will eliminate this shortage.

3.0 SUMMARY AND RECOMMENDATIONS

Table 1: Source Summary

Well Number	OWRD Well Log	Drilled Depth	Casing	Year Completed	Pump	Backup Generator	Pumping Capacity
2	JEFF 888 JEFF 50662	462’	14” Steel	01/24/1990 drilled 06/29/2000 reamed, straightened, liner installed	150HP Vertical Turbine	No	800gpm
4	JEFF 880	951’	14” Steel	05/26/1994	200HP Vertical Turbine	No	800gpm
3	Unbuilt	NA	NA	NA	NA	NA	NA

Two wells pump into the system. Well 2 pumps into the lower level. Well 4 pumps into the upper level. Well 4 is the primary supply, and Well 2 is used during high use periods. The proposed well in the upper zone would likely be similar to Well 4 in construction, with1,100 gpm target capacity.

Storage Summary

The existing Crooked River Ranch consists of two reservoirs. A 70’ tall standpipe (700,000 gallons) serves the upper level and a 10’ tall cistern (100,000 gallons) serves the lower level. The upper level has areas of low pressure during peak use times when the standpipe experiences significant drawdown, combined with hydraulic losses associated with high use and high velocities.

Distribution System Summary

Water from the upper level supplies the lower level by means of a modulating valve. During peak hour uses, water from the lower level can be pumped from the cistern to the upper level distribution system using the cistern booster pump station. The water mains are primarily 4”, 6”, and 8” PVC water mains installed in the 1970’s, 80’s, 90’s and early 2000’s. Generally, the water mains are known to be in good working condition. There are some improvements that CRRWC plans to complete as budget is available, such as replacing existing 6” mains with 8” mains and looping dead end lines. Additionally, CRRWC plans to install additional fire hydrants throughout the system, as the current coverage is deficient. Existing water services are “poly” piping, which is difficult to work with. CRRWC plans to switch services to PVC or copper as time and budget allow.

Improvements

To alleviate deficient storage, low service pressure areas and low available fire flows, as well as to accommodate future development, significant infrastructure improvements need to be made. Source improvements and options for storage improvements are listed below:

<u>Source Improvements</u>

- New 2.5cfs Well

Storage Improvements

There is an existing deficit in storage since much of the 700,000 gallon reservoir is too low in elevation to provide 20psi to the higher elevation homes. There are multiple options for increasing the storage. Option 3a would maintain the existing 2925' HGL, but provides adequate storage to keep the water level in the existing standpipe from dropping significantly. This would keep pressures above 20psi, but still lower than the desired 45psi for the higher elevation homes. Options 3b, 3c, and 3d would increase the HGL, eliminating pressure problems throughout the system.

- Option 3a (Maintain existing 2925' HGL)
  - Install new 770K gallon at-grade reservoir and booster station
- Option 3b (Increase HGL)
  - Install new 240,000K gal. reservoir and booster station at fire station
  - Install booster on existing standpipe
  - Pipe Well 4 directly to existing standpipe with dedicated supply main
- Option 3c (Increase HGL)
  - Install new elevated tank
  - generator for well
  - Install pipe upgrade 9 (can be eliminated with 2970' HGL)
  - Increase Reservoir Discharge to 16" (can be eliminated with 2970' HGL)
  - Pipe Well 4 to existing standpipe
- Option 3d (Increase HGL)
  - Install new booster at existing standpipe
  - Install future new 180,000gallon standpipe next to existing standpipe when needed for additional homes on system
  - Pipe Well 4 to existing standpipe
  - Install pipe upgrade 9 (can be eliminated with 2970' HGL)
  - Increase Reservoir Discharge to 16" (can be eliminated with 2970' HGL)

Distribution Improvements

- Install pipe upgrades 1, 2, & 3 for improved fire flows, looping, and connectivity
- Install pipe upgrades 11 & 12 for improved fire flows
- Install new small booster station for Canyon low pressure area
- Upgrade System Controls / Communications / Operations
- Install new Hydrants throughout system
- Additional water main upsizing on case-by-case basis

4.0 DEMANDS

Table 2: Customer Base

	Service Connections	Projected Service Connnections at Buildout (existing service area)	Projected Service Connnections at Buildout (expanded service area)
1997 WMP Update	1,100	1,660	
Current Plan	1,600	1,660	2,060

The water system service area is considered to be approximately 96% built out.

Demand Data and Calculations

Well production and metered customer use data for the existing system was available for the years 2006-2011. The highest annual metered customer use occurred in 2011. In December 2011, during a meter calibration test, it was discovered that the Well #2 meter was highly inaccurate, and has since been replaced. It is not known how long the meter was malfunctioning. Because the meter was malfunctioning, the Well #2 meter results are erroneous and well production data should not be used for use calculations. Based on the years 2007 and 2008, when the meter readings appear to be accurate, total production numbers exceeded metered use by 12-14%, which is within expected differences for a system of this age. The general rule of thumb for planning for transmission system losses is 10%. We therefore used 2011 metered customer use data and increased those values by 13% to account for transmission system losses. Average Day Demand (ADD) and Maximum Month Demand (MMD) were calculated using these values and the month to month uses were weighted by both number of users and number of days. To obtain a value for Maximum Day Demand (MDD), production records for Well #4 were examined for summer months to obtain a MDD to MMD peaking factor to apply to the metered customer use data. Peak Hour Demand was calculated based on observations of reservoir levels during peak use hours by CRRWC staff. Finally, the observed 2011 values were compared to the previous 1997 Water Masterplan data as well as other similar communities to determine design values to use for planning purposes. To plan for future infrastructure it is recommended to utilize design values that are somewhat higher than those observed due to uncertainties in the data and to account for the likelihood that the observed use will not be the highest use per service that may occur in the future.

EXISTING (Based on 2011 use records due to high use)

2011 Observed Annual Average Day Demand (ADD):

Year 2011 (January-November) metered customer use data – Average Day (weighted by number of users/month and number of days/month):

$ADD_{observed}$ = 325.2gpd/meter, need to account for distribution system losses of 13%,

$ADD_{production}$ = 325.2 X 1.13 = **367gpd/meter**

2011 Observed Maximum Month Demand (MMD):

August, 2011 metered customer use data – Maximum Month

$MMD_{observed}$ = 567.7gpd/meter, need to account for distribution system losses of 13%,

$MMD_{production}$ = 567.7 X 1.13 = **641gpd/meter**

2011 Observed Maximum Day Demand (MDD):

Well #4 production records:

August 2011 average daily production = 82,059 ft^3 (observed maximum month, Well #4)

June 24, 2011 production = 120,800 ft^3 (observed maximum day use, Well #4)

MDD/MMD peaking factor = 1.472

$MDD_{production}$ = 1.472 X 641gpd/meter = **943gpd/meter**

Observed Peak Hour Demand (PHD):

Upper Pressure Zone:

Standpipe (10,000gal/ft) sees 8' of drawdown over 5 hour period while Well #4 and Cistern Booster are pumping into system, on maximum day.

80,000gal / (5hr X 60min/hr) = 267gpm out of standpipe

Well #4 Pump Rate = 820gpm

Cistern Booster Pump Rate = 424gpm (approximate, model 25HP pump operating at η=72%)
PHD_{upper} = 267gpm + 820gpm + 424gpm = 1511gpm
<u>Lower Pressure Zone:</u>
Cistern (10,000gal/ft) takes 5 hours to recover from 4' to 8' with Well #2 pumping in to lower zone and Cistern Booster pumping out to upper zone.
40,000gal / (5hr X 60min/hr) = 133gpm filling into cistern
Well #2 Pump Rate = 821gpm with Cistern at 4' and Booster pumping
PHD_{lower} = 821gpm – 133gpm – 424gpm = 264gpm
<u>Total PHD:</u>
PHD_{total} = 1511gpm + 264gpm = 1775gpm

Table 3: Observed vs. Design Flow Summary

		CRRWC 2011 Observed Values	**CRRWC 1997 Observed / Design Values**	**CRRWC Existing Service Area Buildout Design Values**	**CRRWC Expanded Service Area Buildout Design Values**
	Number of Services	**1579 services**		**1660 Services**	**2060 Services**
Average Day Demand (ADD)	**Observed ADD**	0.5803MGD		**0.6225MGD**	**0.7725MGD**
		403gpm		**432gpm**	**536gpm**
	ADD/service	367gpd/service	368gpd/service	**375gpd/service**	
Maximum Month Demand (MMD)	**MMD**	0.982MGD		1.411MGD	1.751MGD
		682gpm		980gpm	1216gpm
	MMD/service	641gpd/service	846gpd/service	**850gpd/service**	
	MMD/ADD P.F.	1.75	2.30	2.27	
Maximum Day Demand (MDD)	**MDD**	1.489 MGD		**1.660MGD**	**2.06MGD**
		1034gpm		**1153gpm**	**1431gpm**
	MDD/Service	943gpd/service	846gpd/service	**1000gpd/service**	
	MDD/ADD P.F.	2.57	2.3	2.67	
Peak Hour Demand (PHD)	**PHD**	1775gpm	NA	**2306gpm**	**2861gpm**
	PHD/Service(day)	1619gpd/service	NA	2000gpd/service	
	PHD/Service(minute)	1.124gpm/service	NA	1.389gpm/service	
	PHD/ADD P.F.	4.41	NA	5.33	

5.0 SOURCE FACILITIES

Table 4: Crooked River Ranch Existing Water Rights Summary

Well Number	**Water Right** (bold indicates current)	**Water Rights Capacity**	**Notes**
2	Application G 12579 Permit G 11376 Transfer T-7828 **Transfer T-9663**	2.5cfs (1,122gpm)	Use: Quasi-Municipal Transfer T-7828 added Well 4 as an additional point of appropriation. The quantity of water diverted at the new well, together with the quantity diverted at the old wells, shall not exceed the quantity of water lawfully available from the original points of appropriation.
4	Application G 12579 Permit G 11376 Transfer T-7828 **Transfer T-9663**	2.5cfs (1,122gpm)	

Crater Loop Road Well 3 (Unbuilt)	Application G 12579 Permit G 11376 Transfer T-7828 **Transfer T-9663**	2.5cfs (1,122gpm)	Transfer T-9663 changed the location of Well 3. Note: Crater Loop Road Well 3 has not yet been constructed.
	Total=	**5.0cfs (2,244gpm, 3.23MGD)***	
*Note: 2.5cfs allowed from each well, but maximum of 5.0cfs total rate.			

Table 5: Crooked River Ranch Pumping Capacity

Well Number	Existing Pumping Capacity	Future Pumping Capacity	Location
2	800gpm	Standby	T13S, R12E, NW of NW Sec 24 680 feet south & 780 feet east from NW corner, section 24
4	800gpm	Same	T13S, R12E, NE of SE Sec 16 990 feet south & 680 feet west from the E ¼ corner of section 16
Crater Loop Road Well 3	(unbuilt)	1,122gpm	T13S, R12E, NW of SE Sec 16 2550 feet north & 2100 feet west from SE Corner of section 16 (*per T-9663; however, location may be changed by water right permit amendment*)
Total Pumping Capacity	**1,600gpm (existing)**	**1,922gpm (future, w/ Well 2 out of service and new Well 3 in use)**	

Adequacy of Existing Sources to Meet Foreseeable Build-Out Demands

Well 2 is old – the exact date of installation is unknown, but the pumping equipment design plans are from 1976. The Well 2 was straightened in 2000 to fix alignment problems. The pumping equipment for Well 2 is old. A water rights transfer has been approved for drilling new Well 3 near Crater Loop Road. Considering aging infrastructure of Well 2 and the need for more supply to serve buildout demands, it is recommended that a new well be constructed.

A problem with both existing wells is that neither is adjacent to a reservoir, so if treatment is required in the future, it will be nearly impossible to get adequate contact time. Typically contact time is obtained by injecting chlorine at the well with the chlorinated water conveying directly to a reservoir where contact time occurs.

<u>Buildout in Existing Service Area:</u>

Projected Average Day Demand for full buildout (1660 services) is 0.6225MGD, or 432gpm. Projected Maximum Day Demand for full buildout is 1.660MGD, or 1153gpm. Both existing wells provide 800gpm each into the system for a combined capacity of 1600gpm.

Washington State Department of Health (DOH)* Water System Design Manual provides the following recommendations for source design:

1. Two or more supply sources available with a capability to replenish depleted fire suppression storage within 72-hours while concurrently supplying Maximum Day Demand (MDD).
   [180,000gallons*/(72hr X 60min/hr)] + 1153gpm = 1195gpm; 1195gpm<1600gpm, OK
   *Note: 180,000gallon fire storage assumed based on 1500gpm for 2 hours
2. Combined source capacity is enough to provide MDD in 18 hours or less.
   1,660,000gallons/(18hr X 60min/hr) = 1537gpm; 1537gpm<1600gpm, OK
3. With largest source out of service, remaining sources can provide Average Day Demand (ADD).
   800gpm>432gpm, OK

*(The Washington State DOH manual was used because it provides a conservative basis for design, and the State of Oregon does not have a similar manual to reference)

<u>Buildout in Expanded Service Area:</u>
Projected Average Day Demand for full buildout (2060 services) is 0.7725MGD, or 552gpm. Projected Maximum Day Demand for full buildout is 2.060MGD, or 1431gpm. Both existing wells provide 800gpm each into the system for a combined capacity of 1600gpm.

Washington State DOH Water System Design Manual provides the following recommendations for source design:

1. Two or more supply sources available with a capability to replenish depleted fire suppression storage within 72-hours while concurrently supplying Maximum Day Demand (MDD).
   [180,000gallons*/(72hr X 60min/hr)] + 1431gpm = 1473gpm; 1473gpm<1600gpm, OK
   *Note: 180,000gallon fire storage assumed based on 1500gpm for 2 hours
2. Combined source capacity is enough to provide MDD in 18 hours or less.
   2,060,000gallons/(18hr X 60min/hr) = 1907gpm; 1907gpm>1600gpm, NEED TO INCREASE SOURCE CAPACITY
3. With largest source out of service, remaining sources can provide Average Day Demand (ADD). 800gpm>552gpm, OK

With anticipated expansion of the water service area to the south, it is recommended that additional source capacity be added to the system to meet the design recommendation of meeting MDD in 18 hours or less. Currently the system is capable of supplying 1600gpm which could produce 2.06MG in less than 22 hours, which makes serving the maximum day demand technically feasible, but represents lower than recommended capacity. With the increased demands and the aging well and pumping equipment in Well 2, it is recommended that a new well be constructed. Well 2 would be kept in service and used primarily as a backup source. The water right for Crooked River Ranch allows for 2.5cfs (1,122gpm) from each well. We recommend constructing a new well with a capacity near the fully allotted amount to be able to provide full buildout production for 2060 services in the event that one of the existing wells is out of service.

800gpm(1 existing well) + 1,122gpm(proposed new well) = 1,922gpm>1907gpm, OK

<u>Preliminary Well pump sizing</u>

- <u>Option 1 - pump to at-grade reservoir at fire station (requires booster pump out of reservoir into system):</u>
  Well Site Ground Elevation = 2820’

Pumping Water Elevation = 2253’
New At-Grade Reservoir High Water Surface Elevation = 2840’
Column Loss = 20’
Misc. Headloss = 5’
Pump Rate = 1,122gpm
TDH = 2840’ – 2253’ + 20’ + 5’ = 612’
Pump Head, H_p = 62.4 x (1122/449) x 612’ / (0.8 x 550) = 217HP; use 250 horsepower

- Option 2 - pump to system at elevated Hydraulic Grade Line (requires booster pump on existing reservoir outlet to increase head by 30’):
  Well Site Ground Elevation = 2820’
  Pumping Water Elevation = 2253’
  New Increased System Hydraulic Grade Line = 2955’ (30’ increase)
  Column Loss = 20’
  Misc. Headloss = 5’
  Pump Rate = 1,122gpm
  TDH = 2955’ – 2253’ + 20’ + 5’ = 727’
  Pump Head, H_p = 62.4 x (1122/449) x 727’ / (0.8 x 550) = 258HP; use 300 horsepower

Adequacy of Water Rights
Permit G-11376 allows for the withdrawl of 5.0cfs (2,244gpm). Based on a buildout in the existing service area of 1660 services, the projected buildout Maximum Day production rate is 1537gpm (based on 18-hour day), so if no significant change or increase in commercial demand occurs, the current water rights are adequate to serve Crooked River Ranch through buildout of the existing service area. If CRRWC decides to expand the service area to the south to include 400 additional units for a total 2060 services, the design Maximum Day production rate is 1907gpm (based on an 18-hour day), and is within the current allotted water rights. As development occurs, production and use records should be examined annually to see how much water is actually being used.

The water right transfer for the additional point of appropriation allows for the new Well 3 to be constructed near the 70’ standpipe. It is more likely that the well will be constructed near the fire station, considering available property, low pressure areas in the system, and design for increased supply at the fire station to fill fire trucks. If this location is ultimately selected, a permit amendment application should be submitted to OWRD to change the location of the well and remain compliant with water rights.

6.0 STORAGE FACILITIES

For full buildout , the following design parameters are used (*see 3.0 Demands*):

Table 6: Re-statement of Design Demands

	CRRWC Existing Service Area Buildout w/Design Values 1660 Services	CRRWC Expanded Service Area Buildout w/Design Values 2060 Services
Average Day Demand	**0.6225MGD = 432gpm**	**0.7725MGD = 552gpm**
Maximum Day Demand	**1.66MGD = 1153gpm**	**2.06MGD = 1431gpm**
Peak Hour Demand	**2306gpm**	**2861gpm**

The tank volume calculations are as follows:

Total Effective Storage=Operational Storage(OS)+Equilibrium Storage(ES)+Standby Storage(SB)+Fire Storage(FS). Standby Storage and Fire Storage can be nested, and the greater of the two will be selected. Also, there is another component of total storage called Dead Storage that is below the elevation that corresponds to 20psi (minimum required pressure), which is excluded from effective storage.

Operational Storage

Minimum Operational Storage, in gallons, is 2.5 times capacity of largest pump, in gpm:
OS_{min} = 2.5 X 800gpm = 2,000gallons (2,805gallons with proposed 1,122gpm well). An additional consideration is to make OS large enough to have maximum of six pump starts per hour. Actual OS will likely be greater than 2,000 gallons depending on required water level drop for well pump and level control operation, and will be omitted from nominal tank size calculation, because it will be more than covered by typical design criteria.

Equilibrium Storage

For systems with continuous pumping capacity, the general guideline for Equilibrium Storage is 10 to 25% of the MDD. The existing system has been observed to drawdown approximately 80,000gallons (8' of depth) during peak uses. At full 2060 services buildout, this will likely rise to approximately 100,000gallons. To provide a factor of safety it makes sense to apply a factor of safety of two onto the observed, which equates to roughly 200,000gallons. This corresponds well to 10% of MDD.
ES_{min} = 0.10 X 1.660MG = **166,000gallons** (1660 Services)
ES_{min} = 0.10 X 2.060MG = **206,000gallons** (2060 Services)
Note: The recommended bottom of the equalization storage is at 30psi for all services, see pg. 12.

Emergency Storage

Emergency Storage consists of Standby Storage and Fire Storage. Standby and Fire Storage can be nested, which is recommended.

For systems with a single source, the recommended Standby Storage is two days of ADD (1.245MG for 1660 services; 1.545MG for 2060 services), which is costly to attain, and is not necessary for systems with multiple reliable water supply sources. For systems such as CRRWC with multiple water supply sources, the recommended Standby Storage is calculated assuming the largest source is out of service. If the remaining sources exceed ADD, minimum recommended Standby Storage is 200 gallons per equivalent residential unit:
SB_{min} = 200gallons X 1660 = 332,000 gallons (1661services minimum),
SB_{min} = 200gallons X 2060 = 412,000 gallons (2060 services minimum),
However, one day of average day demand is a more typical storage value that we recommend to provide at least one day of average use.
$SB_{recommended}$ = 375gallons X 1660 = 622,500 gallons (1661services minimum),
$SB_{recommended}$ = 375gallons X 2060 = 772,500 gallons (2060 services minimum),
It is worth noting that other Central Oregon utilities have higher standby storage values; for instance, Sunriver uses 150% of the ADD for planning purposes:
SB_{option} = 1.5 X 375gpd/EDU X 1660EDU = 933,750 gallons,
SB_{option} = 1.5 X 375gpd/EDU X 2060EDU = 1,158,750 gallons,

which would be 600,000gallons in excess of the minimum for 1660 services and 750,000gallons in excess of the minimum for 2060 services. The ultimate Standby Storage volume to be provided in the future will need to be determined by CRRWC.

Fire storage is typically dictated by enforcement of local fire official. Existing fire flows in the system are poor, and system improvements will be required to attain adequate fire flows in much of the system. It should be assumed that with future development in the water service are, there may be fire flows required for commercial buildings. Without knowing what size and type of construction will be required, a fire flow of 3,500gpm for 3hours is assumed. This equates to a volume of 675,000gallons.

We recommend using one average day demand of **772,500 gallons** at full buildout for Emergency Standby. This covers Standby requirements and potential reasonable future fire flow volume requirements. The nested SB and FS are required to fight fires, the recommended water level is to be at or above 20psi for all services to maintain required residual pressure (see pg. 12).

Total Recommended Storage
Total Effective Storage = ES + SB = 166,000 + 622,500 = 788,500 gallons for 1660 services
Total Effective Storage = ES + SB = 206,000 + 772,500 = **978,500** gallons for 2060 services

The highest known service in the CRRWC system is approximately elevation 2850', near the intersection of Hummingbird and Sand Ridge.
20psi @ highest lot = 2850'+ (20)(2.31) = 2896' (recommend bottom of Standby Storage=2900', 45' depth))
30psi @ highest lot = 2850'+ (30)(2.31) = 2919' (recommend bottom of Equilibrium Storage=2920', 65' depth)

Currently, the CRRWC water system includes a 700,000 gallon welded steel standpipe in the upper zone and a 100,000gallon concrete cistern in the lower zone. The lower zone served by the cistern is above 20psi at any level, and the upper zone can be served by the booster pump station out of the cistern, so the entire 100,000 gallons can be included in effective storage.

The Total Effective Storage recommended from upper zone
$ES_{recommended}$= 788,500$_{total\ effective}$ -100,000$_{cistern}$ = 688,500 gallons above 20psi (1660 services)
$ES_{recommended}$= 978,500$_{total\ effective}$ -100,000$_{cistern}$ = 878,500 gallons above 20psi (2060 services)

The upper 700,000 gallon standpipe has a base elevation of 2855' and an overflow elevation of 2925' corresponding to the 70' fill line. The standpipe has an incremental volume of 10,000gallons per vertical foot. At 20psi elevation of 2900' there is 25' to the standpipe overflow, which is 250,000 gallons. The remainder of the standpipe is below 20psi and is considered Dead Storage. Therefore, the existing storage facilities at CCRWC are deficient by the following amounts based on the above recommendations:
1660services Storage Deficiency = 688,500 – 250,000 = 438,500 gallons
2060services Storage Deficiency = 878,500 – 250,000 = 628,500 gallons

Increasing storage capacity of the system is on the long term planning agenda of CCRWC. There are many options for increasing storage, both maintaining or increasing the hydraulic grade line of the system. After preliminary reviews of various options for maintaining the existing HGL, but increasing system performance during peak hour demand and fire flows, the most cost effective method, 3a was reviewed. For an increased HGL, three options were selected for comparison, 3b, 3c, and 3d.

Options for Increasing Storage Volume:

OPTION 3a

Upgrades:

- Install new 770,000 gallon reservoir at fire station site
- Install booster station to pump from new at-grade reservoir to existing 2925' HGL system pressure
- Install backup generator and Automatic Transfer Switch to power new booster station and potentially new well in event of power outage.

Cost:

- Initial installation cost = $1,587,300
- 20-year cost = $2,385,777

Advantages:

- Obtains recommended storage volume
- Eliminates 20psi pressure areas in eastern portion of upper zone during peak hour uses
- Maintains current HGL so no decrease in Well 4 pump rate into system
- No pressure increases on existing piping that may cause leaks and/or broken mains
- Cost effective
- Maintains reliability of existing gravity standpipe

Disadvantages:

- Does not increase overall static system pressure; the high elevation lots near the Upper Ridge will still be below 35psi, and significant portions of the upper zone will be below 45psi during Peak Hour Demand
- Many fire flows (20psi residual) will be below 1000gpm

Option 3a Narrative Description:

Provide at-grade reservoir located at the fire station, with booster pump station to maintain pressure at 2925'HGL, and keep existing standpipe in service. There will be a required pump submergence volume in the proposed at-grade reservoir to prevent cavitation in the proposed booster station that will ultimately depend on characteristics (NPSH) of the selected pumps. For preliminary planning purposes, we are assuming 4' of the new tank will be Dead Storage for cavitation protection on the proposed booster station. The booster station will boost pressure to approximately the 2925'Hydraulic Grade Line and will operate on system pressure near the proposed tank and will also need to have a redundant pump off that is operated by a signal in the existing standpipe so that the new reservoir booster pump doesn't overflow the existing reservoir.
Fire station elevation = +/-2820'
Bottom of Effective Storage = *2825'*

The proposed at-grade reservoir will need to provide a minimum volume of 438,500 gallons (1660 services) or 628,500 gallons (2060 services) in addition to the 4' of Dead Storage. The proposed at-grade tank can be configured in various diameters and heights, as well as various different materials. Some good candidate construction options in this size range are bolted steel, welded steel, glass-fused-to-steel, and reinforced concrete. For volumes less than a million gallons, steel tanks are typically more cost effective than reinforced concrete. The decision for which type of steel tank is determined by the preference of the utility, as they are fairly comparable in cost. During the course of this masterplan work, CRRWC indicated a preference for welded steel to avoid maintenance issues associated with other types of steel tanks. As mentioned above, there are many different diameter-height combinations that will yield the desired volume, and the ultimate dimensions would be up to CRRWC. To limit visual impact, we recommend the at-grade reservoir should be 20' high (providing 16' effective storage). The required diameter for a 438,500 gallon (1660 services) reservoir is 68' in 16' of vertical effective storage. The required diameter for a 628,500 gallon (2060 services) reservoir is 81' in 16' of vertical effective storage. The total volume for 2060 services including dead storage is approximately 771,000 gallons with diameter of 81' by 20' high.

This option alleviates some of the extremely low (20psi range) pressures encountered throughout the project during peak hour demands, and increases fire flows on the southeast portion of the upper pressure zone. However, much of the upper pressure zone remains below the desired 45psi, and the services on Upper Ridge Road remain below 35psi, which is undesirable. Even though fire flows are increased, the hydrants in the southeast of the upper zone remain in the 500 to 700gpm range in this scenario. Since the current HGL is maintained, there would be no problems associated with increasing the pressure, such as a potential decrease in the pump rate of Well 4, or potential forming of leaks or main breaks.

OPTION 3b

Upgrades:

- Install new 240,000 gallon reservoir at fire station site
- Install booster station to pump from new at-grade reservoir to increased 2955' HGL system pressure (add 30' head)
- Install backup generator and Automatic Transfer Switch to power new fire station booster station and potentially new well in event of power outage.
- Install booster station to pump from existing 70' standpipe to increased 2955' HGL system pressure
- Install backup generator and Automatic Transfer Switch to power new standpipe booster station in event of power outage.
- Pipe Well 4 directly to existing standpipe (upstream of new booster station)

Cost:

- Initial installation cost = $1,786,900
- 20-year cost = $3,383,855

Advantages:

- Obtains full recommended storage volume
- Nearly entire project will be above 45psi during peak demands; exception is the south end of Hummingbird, which is at +/-40psi during peak hour demands and 45psi at average demands.
- Greatly improved fire flows available throughout project. Has the potential to have hydrants>900gpm with all other recommended distribution upgrades completed
- Cost effective
- Redundancy of booster stations and reservoirs increase reliability
- Maintains reliability of existing gravity standpipe by having low pressure bypass in the event both booster stations are out of service

- Piping Well 4 to standpipe prevents decrease in Well 4 pumping rate due to increased pumping pressure.

Disadvantages:

- Pressure increases on existing piping may cause increased leaks
- Higher electrical and maintenance costs due to multiple booster stations
- Operationally challenging due to multiple booster stations, reservoirs and wells

Potential Cost Savings to this option:

- Complete a detailed analysis of potential pipe replacements to assess efficacy of replacing portions of pipe run #9 with portions of pipe run #6 and/or #10
- Increasing discharge pressure of booster station to 2970' (vs. 2955'), which would represent a 45' increase in head over the existing system pressure. This could potentially reduce or eliminate the need to upsize water mains #9 and reservoir discharge. This would need to be approached with caution as it would increase risk of causing leaks or main breaks and it would increase the number of homes that would require individual PRVs.

Option 3b Narrative Description:

Provide at-grade reservoir located at the fire station, with booster pump station to increase pressure to 2955'HGL, keep existing standpipe in service with booster station to 2955'HGL. By boosting off of the existing standpipe, the entire volume would be considered effective storage volume. The total existing volume would become 700,000gallons (standpipe) + 100,000gallons (cistern) = 800,000 gallons. The required buildout volume for 1660 services is 788,000gallons and for 2060 services is 978,500gallons. Full build out deficiency for 2060 services is 178,500gallons.

The proposed at-grade reservoir would provide a volume of approximately 180,000 gallons in addition to the 4' of Dead Storage for a total of approximately 240,000 gallons. As mentioned in Option 3a, the preferred tank construction is welded steel. The dimensions for a 240,000 gallon (2060 services) reservoir is 44' diameter by 20' high.

This option for storage improvements solves the pressure problems throughout the upper pressure zone, but would be complex and expensive to operate due to the multiple pump station and multiple reservoirs considering the two booster stations, three reservoirs, and need for uniform reservoir turnover to prevent stagnation.

OPTION 3c

Upgrades:

- Install new 1,000,000 gallon reservoir at existing reservoir site, adding 30 (more cost effective to use standard size1,000,000 gallon size vs. 978,500 gallons needed)
- Remove existing 70' standpipe
- Increase reservoir discharge main to 16" (can be eliminated with 2970' HGL)
- Increase diameter of Pipe Upgrade #9 from 8" to 12" (can be eliminated with 2970' HGL)

Cost:

- Initial installation cost = $3,529,600 (2970' HGL), or $4,670,700 (2955' HGL)
- 20-year cost = $3,568,537 (2970' HGL)

Advantages:

- Obtains full recommended buildout storage volume for 2060 services

- Nearly entire service area will be above 45psi during peak demands; exception is south end of Hummingbird, which is at +/-40psi during peak hour demands and 45psi at average demands.
- Greatly improved fire flows available throughout project. Has the potential to have hydrants>900gpm with all other recommended distribution upgrades completed
- 100% gravity service at 2955' HGL. No reliance on booster pumps and standby power for emergency water.
- Simplest and least costly to operate and maintain

Disadvantages:

- Pressure increases on existing piping may cause an increase in leaks
- Well 4 pump rate expected to decrease by 50gpm from 800gpm to +/-750gpm
- High initial cost

Option 3c Narrative Description:

This option would replace the existing standpipe with an elevated storage tank at the increased HGL of 2955'. It is assumed that the tank would be located at the existing standpipe location and it is therefore recommended that the reservoir pipe be upsized to 16" and that pipe run #9 be upsized from 8" to 12" to eliminate headloss problems during peak hour demands.

The total storage volume required for the upper zone is 878,500 gallons. Elevated tanks come in standard sizes, and there is a premium charged for custom sizes. The closest standard size tank is 1,000,000 gallons. There are a variety of elevated tank styles including composite, multi-column, pedesphere, and fluted column. A commonly used style in this size range is the pedesphere due to aesthetics and security, and is the style used for cost estimating. The tank consists of an elevated steel spheroid supported by a single steel support pedestal with a flared base. Elevated tanks eliminate the dead storage component commonly associated with at-grade tanks and standpipes. This prevents stagnation problems with stored water. The standard dimensions of a 1,000,000 gallon spheroid are 74' diameter with a 40' head range.

The single elevated tank is the simplest and least costly option to operate and maintain. With the right system piping upgrades, this will eliminate pressure and fire flow problems throughout the upper zone. The main disadvantage is the high installation cost. Other disadvantages shared by all the elevated HGL options are that the increased system pressure may cause leaks or broken water mains in old piping and that Well 4 will decrease its operating point by approximately 50gpm.

Alternative Location:

There has been some discussion of alternate placement of the tank at the south end of Hummingbird Lane. In that case, pipe run #9 and existing reservoir pipe would not need to be upsized. However, there would have to be other sections of water main that would require upsizing that have not been explored with this document, but it is assumed that there would be a similar scale of cost with those improvements.

OPTION 3d

Upgrades:

- Install new booster station at existing reservoir site – eliminates dead storage component, and add 30' head
- Install backup generator and Automatic Transfer Switch to power new booster station in event of power outage.
- Pipe Well 4 directly to existing standpipe (upstream of new booster station)
- Increase reservoir discharge main to 16" (can be eliminated with 2970' HGL)
- Increase diameter of Pipe Upgrade #9 from 8" to 12" (can be eliminated with 2970' HGL)
- Install future new 180,000 gallon standpipe next to existing standpipe when additional additions to system require additional storage

Cost:

- Initial installation cost = $1,395,900 (2970' HGL) or $2,537,000 (2955' HGL)
- 20-year cost = $2,359,377 (2970' HGL)

Advantages:

- Obtains recommended storage volume for 1660 services
- Offers flexibility to add additional standpipe storage in the future
- Nearly entire service area will be above 45psi during peak demands; exception is south end of Hummingbird, which is at +/-40psi during peak hour demands and 45psi at average demands.
- Greatly improved fire flows available throughout project. Has the potential to have hydrants>900gpm with all other recommended distribution upgrades completed
- Maintains reliability of existing gravity standpipe by having low pressure bypass in event booster station is out of service
- Piping Well 4 to standpipe prevents decrease in pumping rate

Disadvantages:

- Pressure increases on existing piping may cause leaks and/or broken mains
- Some services may require individual PRVs
- Higher cost than some options

Potential Cost Savings to this option:

- Detailed analysis of potential pipe replacements to assess efficacy of replacing portions pipe run #9 with portions of pipe run #6 and/or #10
- Increasing discharge pressure of booster station to 2970' (vs. 2955'), which would represent a 45' increase in head over the existing system pressure. This could potentially reduce or eliminate the need to upsize water mains #9 and reservoir discharge. This would need to be approached with caution as it would increase risk of causing leaks or main breaks and it would increase the number of homes that would require individual PRVs.

Option 3d Narrative Description:

This option involves the installation of a new booster station at the discharge of the existing 70' standpipe. This booster station serves two purposes: 1) it eliminates the dead storage in the tank bringing total existing storage to 800,000 gallons and 2) it increases system pressure.

To achieve recommended full buildout storage for 2060 services, a 180,000 gallon additional standpipe could be constructed near the existing one, and would be 21'diameter by 70' high, at the time that development triggered the need.

This option would likely be the most cost effective in the long term, based on initial cost and lower O&M costs than Option 3b due to only having one pump station. Although the installation costs are higher with upsizing the reservoir discharge and pipe run #9, there may be opportunities to reduce or eliminate those high cost items. Additionally, the additional standpipe and pipe upgrades can be spread out over time. The initial cost item would need to be the pump station. Other items could be deferred. This option is a good option for the system in that it allows incremental upgrades to spread cost over time.

Alternative:

As opposed to adding an additional standpipe next to the existing standpipe in the future, CRRWC could add an elevated pedesphere tank at the south end of Hummingbird Lane. This would be more costly in terms of construction and required land acquisition than the additional standpipe. There is an indication that constructing elevated storage in the Hummingbird Lane may be preferable due to customer preferences.

Temporary Pressure Increase

Upgrades:

- Change operations during high water use summer seasons to keep reservoir level higher
- New pressure control and radio located at east end of system to bring midway booster station on to assist with low pressures in east end of upper pressure zone
- May install circulation pump in existing standpipe if needed

Cost:

- Initial installation cost = $9,500

Advantages:

- Will improve pressures during peak hour demands, will eliminate 20psi pressures during peak hour demands.

Disadvantages:

- Will still have low pressure areas (30psi) throughout upper zone during peak hours demands

Narrative:

Currently standpipe is operated with the well "pump off" at 65'due to reported inaccuracies with the existing transducer, and well 4 turns on at 55' – this is the operational storage and represents 100,000gallons. During peak hours on summer days there is a drawdown from 55' to 45'.

We recommend that the standpipe be operated with high water at 69' and have the well pump on within 4' (40,000gallons). This will result in a potential maximum drawdown level of 55'. Setting the well pump "off" at 69' and pump "on" near 65' will likely result in peak drawdown in the existing standpipe to 55' (assuming the same 10' of drawdown with on and midway on) which will increase the minimum experienced system pressure by approximately 5psi.

Additional consideration should be made to installing a new pressure control in the eastern low pressure area of the upper pressure zone that would turn on the existing midway booster station during low pressures. The midway booster station is currently controlled by reservoir level in the standpipe. Midway booster improves system pressure. We understand there may have been a similar system in the past.

These operational and control changes need to be evaluated against the schedule for storage improvements. Additionally, CRRWC staff should perform a detailed operations review to determine the feasibility and benefits of these operations improvements.

7.0 DISTRIBUTION SYSTEM AND HYDRAULIC MODELING

6.1 Modeling

The model was set up based on GIS data obtained from CRRWC that included horizontal and vertical locations of water services, valves, standpipes, hydrants, tanks, etc. The total design flows were applied evenly to the nodes throughout the model. In areas where heavier use is known to exist, additional nodes were added to the model to apply heavier use in those areas. Since the project is 96% built out, modeling of distribution piping expansion was not required.

System pressures should stay above 35psi to avoid customer complaints and 45psi is preferable. During fire flows, the minimum system pressure allowed by code is 20psi, although 30psi is preferable. System pressures below 20-30psi present increase risk of cross-connection contamination and pathogen intrusion. At various demand flows and reservoir levels on the existing system layout, pressures below recommended and allowable values are encountered in the model and in the field demonstrating the need for system upgrades.

We performed model runs for the following scenarios:

Existing System

1. Average Day Demand w/Existing High Standpipe Level (65') *(shows low use scenario under current high water level)*
    - Demonstrates the best expected results under current system and operations at low flows
    - Upper Ridge Rd. low pressure area at less than 45 psi at low use
    - Hummingbird Lane low pressure area at less than 30 psi at low use
    - Canyon low pressure area less than 35psi at low use – this requires small booster station to improve service pressure to this isolated area served off of a PRV zone. It is not practical to tie this area across lots to the higher pressure main.

2. Average Day Demand w/High Standpipe (70'), Wells and Booster OFF *(shows low headloss scenario and how improving current operating height would operate under low flow)*
    - Demonstrates slight reduction in areas of low pressure with increased high water level

3. Average Day Demand w/Low Standpipe (55.1'), Wells and Booster OFF *(shows low headloss scenario operating when reservoir is just above the Well 4 "on" level)*
    - Upper Ridge Rd. low pressure area less than 35psi at low use
    - Hummingbird Lane low pressure area increased area
    - Shows significant portions of upper pressure zone under 45psi, with significant portions below 40psi

4. Peak Hour Demand w/High Standpipe (70'), Wells and Booster OFF *(shows high headloss scenario and how improving current operating height would operate under high flow; used to identify high velocity/headloss mains)*
    - Large portions of upper pressure zone below 30psi
    - Hummingbird Lane low pressure area less than 20psi
    - Highest velocities/headloss identified in existing 12" reservoir discharge and 8" pipe run #9

5. Peak Hour Demand w/Low Standpipe (45'), Wells and Booster ON *(shows scenario when reservoir is at absolute lowest level and Wells and Booster are pumping into system; provides comparison with high reservoir level)*
    - Demonstrates how Well 4 and midway booster improve system pressure
    - Significant portions of upper pressure zone below 45, 40, 35, and 30psi
    - Hummingbird Lane low pressure area less than 20psi

6. Peak Hour Demand w/Medium Standpipe (55.1'), Wells and Booster OFF *(shows high headloss scenario operating when reservoir is just above the Well 4 "on" level)*
    - Demonstrates worst case scenario is at Peak Hour Demand when reservoir is drawn down to just above the point where Well 4 and midway booster turn on.
    - Upper Ridge Road below 20psi
    - Hummingbird Lane below 20psi
    - Significant portions of upper pressure zone below 20psi
    - Demonstrates need for elevated operating levels and system pressure control for booster station in short term
    - Demonstrates non-compliance (<20psi service pressure) and need for system improvements

Improved System

7. Peak Hour Demand w/Full Standpipe (70') – New At-grade Reservoir & Fire Station Booster and Pipe Upgrades #1, 2, 3 *(shows how adding reservoir at Fire Station affects system pressure. Maintains existing HGL of 2925')*
    - Adding a reservoir and booster at fire station alleviate high head losses in reservoir discharge and pipe #9, as well as assist with maintaining higher tank level
    - Upper Ridge Rd. below 35psi
    - Hummingbird Lane below 30psi
    - Significant portions of upper pressure zone below 45psi

8. (a through f) Peak Hour Demand w/Increased HGL (2955') at existing reservoir site – Options 3c or 3d *(shows how increasing HGL to 2955' affects system pressure during peak hour demand)*
    - Model run 8a shows that increasing HGL by 30' to 2955' eliminates nearly all areas with less than 35psi during Peak Hour Demand; exception is Humming bird
    - Model run 8b-8f show that 2955' HGL coupled with upsizing reservoir discharge and pipe #9 necessary to providing service pressures >45psi for nearly entire project
    - Hummingbird Lane 40psi

9. Peak Hour Demand w/Increased HGL (2970’) at existing reservoir site – no piping upgrades *(shows how increasing HGL to 2970’ affects system pressure during peak hour demand)*
   - Demonstrates how elevating HGL to 2970’ provides similar results to upsizing reservoir discharge and pipe run #9 with 2955’ HGL. This would likely require additional PRVs in the system.

6.2 Fire Flows

Fire flows show the theoretical amount of water that can be withdrawn by a pumper truck at a 20psi residual pressure. These are not the values experienced by simply opening the hydrant. Fire flows were modeled on top of Maximum Day Demand. Fire flows were modeled using the existing system as well as with various pipe and storage upgrades to determine most beneficial system upgrades. See appendix for exhibit of fire flow model runs.

Table 7: Fire Flow Results – Fire at 20psi + Maximum Day Demand

			Existing System	Option 3a (New Reservoir at Fire Station), Pipe Upgrades 1, 2, 3, 11, 12	Options 3c or 3d, Pipe Upgrades 1, 2, 3, 11, 12, 9, & Res. Disch.	Options 3c or 3d, Pipe Upgrades 1, 2,3, 11, 12, 8, 13, 14, 9, & Res. Disch.
CRRWC No.	WHP Model Node	Location	Existing 2925’ HGL	Existing 2925’ HGL	Increased 2955’ HGL	Increased 2955’ HGL
UPPER ZONE						
1	224	Big Sky Place / Peninsula	391	710	909	909
2	198	Geneva View / Peninsula	779	1108	1364	1364
3	228	Meadow / Peninsula	1231	1419	1752	1752
4	296	Chipmunk / Peninsula	938	1667	1685	1686
5	310	Chickadee / Shad	1051	2367	1616	1616
6	392	Hummingbird / Shad	1072	2167	1762	1762
7	308	Canary / Sand Ridge	867	1205	1320	1320
8	278	Cinder Cone Loop / Shad	829	1583	1648	1648
9	314	Chickadee / Quail	455	1943	1234	1244
10	564	7073 Mustang	572	1068	928	1339
11	282	Fire Station (Front)	674	2112	1153	1193
13	376	Haddock / Mustang	311	699	707	1008
14	416	Salmon / Ground Hog	239	500	631	867
15	370	Mustang / Ground Hog	261	612	669	954
16	378	Chinook / Mustang	292	604	657	918
LOWER ZONE						
17	430	Buffalo Place by Cattle	998	Lower zone flows not affected by upper zone system upgrades		
19	530	13830 Commercial Loop	1037			
21	532	13918 Commercial Loop	1039			
24	432	Business Circle / Commercial Loop across from Well 2	1022			

25	526	14367 Business Circle	955	
31	534	14231 Chinook	1178	
33	488	5105 Clubhouse Road	1317	
34	444	Between Clubhouse and Sandbager	1390	
35	544	Back side of Swimming Pool between Pool and Golf Maint. Shop	1739	

Currently there are six hydrants that model at less than 500gpm and six more that are between 500gpm and 1,000gpm. A minimum modeled fire flow of 1,000gpm at 20 psi. The following pipe upgrades are suggested to improve deficient fire flows. These upgrades are primarily for improved fire flows, and are not required for increased system service pressures, which are largely dependent on reducing headloss near the reservoir and increasing the hydraulic grade line. To get all fire hydrants to operate at a minimum fire flow of 900gpm, a combination of increasing the HGL and the pipe upgrades below are required. The determination needs to be made by CRRWC what values of fire flows at which hydrants are required/preferred. We recommend staged completion of these upgrades, to continue to improve fire flows.

Table 8: Recommended Water Main Upgrades for Fire Flow

Pipe Upgrade	Description	Reason
Segments 1, 2, & 3	Install new 8”pipes in segments #1 and #2. Replace existing 6” segment #3 with new 8”	Increases fire flows to hydrants 13-16. Segments #1 and #1 are also recommended to eliminate dead ends and increase system looping/connectivity
Segments 11 & 12	Replace existing 6” segment #11 with new 8”. Install new 12” pipe in segment #12.	Segment #11 increases fire flows to hydrants 1 & 2. Segment #12 increases fire flows to hydrants 9 &10.
Segment 13	Replace existing 8” with 12”. NOTE: May not be recommended if future water main looping is anticipated through Buckskin Ln. and Quail Rd. May not be recommended if fire department is location of new reservoir and booster station	Increases fire flows to hydrants 10 and 13-16.
Segment 8	Replace existing 8” with 12”. NOTE: May not be recommended if fire department is location of new reservoir and booster station	Increases fire flows to hydrants 10 and 13-16.
Segment 14	Replace existing 6” with 8”	Increases fire flows to hydrants 10 and 13-16.

8.0 RECOMMENDED IMPROVEMENTS

A number of recommendations to the system including control, source, storage and distribution improvements are recommended, see Tables 9 and 10a-d below.

Table 9: OVERALL INFRASTRUCTURE IMPROVEMENT RECOMMENDATIONS (APPLICABLE TO ALL STORAGE INCREASE OPTIONS)

	Description	Preliminary Unit Cost	Preliminary Subtotal	Priority	Notes
1	Install control improvements for standpipe and Booster station	$9,500	$9,500	Medium-High	Modify operations during summer months to keep reservoir higher. Explore possibility of switching booster to have pressure control component. Will have dependency on schedule of storage upgrades.
2a	Install pipe upgrades 1, 2, & 3	$1,124,300	$2,435,700	Medium-High for fire flows	Increases fire flows in SE Corner, NW Corner, and south-central. Eliminates dead end mains, increases connectivity.
	Install pipe upgrades 11 & 12	$1,311,400			
2b	Install pipe upgrade 8	$329,400	$1,545,200	Medium-High for fire flows	Improves fire flows
	Install pipe upgrade 13	$211,200			
	Install pipe upgrade 14	$1,004,600			
3	Increase storage See options below	See options below	See options below	High	Existing deficit in storage due to excess dead storage in standpipe. Required for expansion of service area.
4	Complete new well, install pumping equipment (complete)	$1,379,100	$1,379,100	Medium-High	Required for expansion of service area. Also recommended due to aging Well 2 infrastructure.
5	Install new small booster station for Canyon	$45,000	$45,000	Medium-High	Eliminates low pressure area on high elevation dead end loop served of reduced pressure zone.
6	Upgrade System Controls / Communications	$30,000	$30,000	High	Convert existing SCADA system to more user friendly interface. Needs further exploration by systems control professional
Sum of recommendations, excluding storage, Present Day Dollars=			**$5,444,500**		
7	Install new Hydrants throughout system	To be determined	To be determined	High	Currently hydrants 5,000' apart. Desire to obtain 1,000' spacing.
8	Upsize remaining 4" and 6" mains to 8".	To be determined	To be determined	Medium-Low	Needs to be determined on case-by-case basis
9	Circulation Pump in existing standpipe	To be determined	To be determined	Medium-Low	May be required if standpipe operating levels changed.
10	Install backup generator and Automatic Transfer Switch for new well	To be determined	To be determined	Low	Would increase system reliability. Needs to be weighed against historical power supply reliability. With increased storage capacity, this becomes less important.

Table 10a: INCREASE STORAGE, MAINTAIN 2925' HGL (NEW RESERVOIR AND BOOSTER STATION AT FIRE STATION)

	Description	Preliminary Unit Cost	Preliminary Subtotal	Priority	Notes
3a	Install new 770K gallon at-grade reservoir and booster station	$1,587,300	**$1,587,300**	High	Eliminates storage deficit and 20psi zones in east during Peak Hour demands. Multiple low pressure areas remain in project.

Table 10b: INCREASE STORAGE, INCREASE TO 2955' HGL (NEW RESERVOIR AND BOOSTER STATION AT FIRE STATION, NEW BOOSTER STATION OFF EXIST. STANDPIPE)

	Description	Preliminary Unit Cost	Preliminary Subtotal	Priority	Notes
3b	Install new 240,000K gal. reservoir and booster station. Install booster on exist standpipe	$1,680,100	**$1,786,900**	High	Eliminates existing deficit in recommended storage volume. Eliminates all Peak Hour pressure problems in service area. Presents control problems.
	Pipe Well 4 to exist standpipe	$106,800			

Table 10c: INCREASE STORAGE, INCREASE TO 2955' HGL (NEW ELEVATED STANDPIPE AT EXIST STANDPIPE LOCATION, SCRAP EXISTING STANDPIPE)

	Description	Preliminary Unit Cost	Preliminary Subtotal	Priority	Notes
3c	Install new **elevated tank** and generator for well	$3,529,600	$4,670,700 (**$3,529,600** with 2970'HGL which eliminates pipe upsizing for pipe #9 and reservoir discharge)	High	Eliminates existing deficit in recommended storage volume. Eliminates all Peak Hour pressure problems in service area. Simplest, most problem free system to operate.
	Install pipe upgrade 9	$993,500 (may be eliminated with 2970'HGL)			
	Increase Reservoir Discharge to 16"	$147,600 (may be eliminated with 2970'HGL)			

Table 10d: RECOMMENDED OPTION. ELIMINATE DEAD STORAGE, INCREASE TO 2955' HGL (NEW BOOSTER OFF EXIST. STANDPIPE), ADD PARALLEL STANDPIPE IN FUTURE

	Description	Preliminary Unit Cost	Preliminary Subtotal	Priority	Notes
3d	Install new booster at standpipe and generator for well	$719,000	$2,537,000 (**$1,395,900** with 2970'HGL which eliminates pipe upsizing for pipe #9 and reservoir discharge)	High	Eliminates all Peak Hour pressure problems in service area.
	Install parallel 180,000 gallon standpipe next to existing	$570,100 (can be deferred until needed)			
	Pipe Well 4 to exist standpipe	$106,800			
	Install pipe upgrade 9	$993,500 (may be eliminated with 2970'HGL)			
	Increase Reservoir Discharge to 16"	$147,600 (may be eliminated with 2970'HGL)			

9.0 REFERENCES

The following documents were referenced during the preparation of this report:

1. CRRWC, 2006-2011 Water Records, Well Withdrawls and Metered Customer Uses
2. CRRWC, Pumping and Storage Equipment Record Drawings
3. CRRWC, Hydrant Testing, 2011
4. Economic and Engineering Services, Crooked River Ranch Water Company 20-Year Master Plan, November 1997
5. Washington State Department of Health, Water System Design Manual, December 2009

10.0 APPENDIX

APPENDIX A - SYSTEM MAP & MODELING RESULTS
APPENDIX B - WATER CONSUMPTION/WELL PRODUCTION RECORDS
APPENDIX C - ITEMIZED COST ESTIMATES
APPENDIX D - ALTERNATE STORAGE UPGRADE SCHEMATIC EXHIBITS
APPENDIX E - OREGON DEPARTMENT OF HUMAN SERVICES DATA
APPENDIX F - OREGON WATER RESOURCES DEPARTMENT DATA
APPENDIX G – MODEL CALIBRATION DATA