Water System Master Plan Update
for
Cedar City, Utah

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Note: The italicized text represents the new language that is apart of the master plan update and the regular font text represent the language that is apart of the previous master plan.

INTRODUCTION

This is an executive summary of the Water System Master Plan Report for Cedar City, Utah. The purpose of the study was to develop a plan to guide development of the City's water resources and construction of its distribution facilities. The implementation of this plan will help to insure a quality level of service for the City's water customers.

The main objective of the study was the preparation of a water master plan document. This was accompanied by a number of related objectives listed below:

- Provide the necessary engineering, administration, clerical and other personnel required to successfully update the master plan of the Cedar City culinary water system and secondary irrigation system, including water rights, supply, transmission, storage, and distribution.
- Evaluate the City's existing system to identify current capacities, pressures, lay-out, and deficiencies.
- Determine capacities, locations, costs, schedules, and general solutions to plan the Cedar City Water System for the next 25 years utilizing water use projections.
- Re-evaluate the feasibility and impacts of a partial or City-wide secondary irrigation system on the culinary water system.
- Evaluate factors to be considered in the plan development which include: population growth, water use projections, land use, water rights, water conservation, water quality, economics, fire flow requirements, the City's General Plan, cooperative efforts and recommended interface with the Central Iron County Water Conservancy District (CICWCD), identifying the roles of Cedar City and the CICWCD in relation to each other, the need for obtaining water from the Lake Powell Pipeline project and other sources from outside the basin, as well as state, federal, and environmental regulations that may impact the City's water system.
- Check, update, and calibrate the City's existing culinary water and secondary irrigation system EPANET model.
- Model all future improvements to the City's culinary water system to ensure that all desired parameters are met, including fire flow capabilities and model all future improvements to the City's secondary irrigation system.
- Prepare a written report that details the findings of the master plan study.

In order to accomplish the project objectives, Brown and Caldwell performed nine tasks outlined in the project scope.

WATER SUPPLY

The City's population growth continues to drive the need to develop additional water supplies. The subject demands particular concern as the City is supplied from a limited watershed that is shared with other growing communities; and, because all of the water within the basin is already fully appropriated. The City's current culinary water sources include *7* wells and 3 groups of springs. They are located as shown in Figure ES-1. The City *currently has two wells available for secondary irrigation supply, Cemetery and Northfield Wells. A site visit was made to each of the wells to assess their condition. The springs could not be visited because of snow though City staff provided some comments regarding their condition.*

Water Rights

City owned water rights associated with these sources include both surface and groundwater rights. The primary surface water rights owned by the City are in Coal Creek. These are currently used for irrigation. The City has three rights in Coal Creek totaling 2.51 cfs or 1.62 mgd. In addition, as of October 2008 the City owns shares in five irrigation companies which have water rights in Coal Creek with an approximate yield of 775.53 acre-ft. The City should be aware of the priority date when purchasing or acquiring additional water rights.

The City's groundwater rights are, for the most part, already developed in existing wells. Some of the rights that remain undeveloped are in wells that have poor quality water or have extremely low yield.

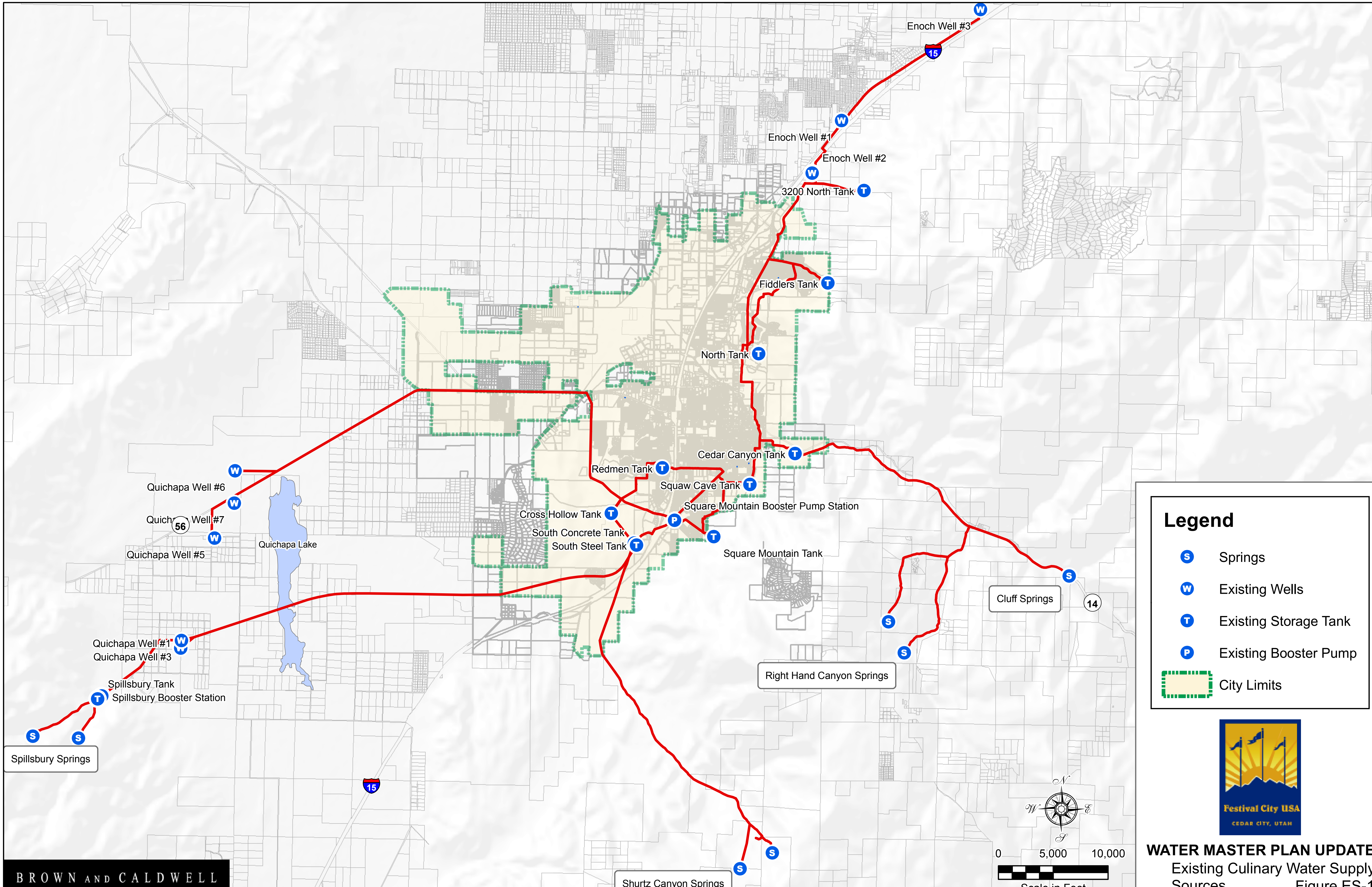
The City has water rights to several springs located generally in Cedar Canyon, Shurtz Canyon and near Quichapa (Spillsbury). There is a total of 2.59 cfs in Cedar Canyon, 2.245 cfs in Shurtz Canyon and 20 cfs in Spillsbury Spring.

Water Use Projections

Projections of water use for the potable water system were developed. The City provided population projections that projected to build-out year 2050 summarized in Table ES-1. *Average daily water use was calculated by multiplying population projections by a unit water use rate of 229 gallons per capita per day (gpd/capita). The unit use rate is an average based on 2007 population and water supply records. Maximum daily requirements are 2.28 times the average annual daily use.*

Table ES-1 Projected Water Supply Needs

		Projected Potable System Needs (mgd)	
Year	Population*	Average Daily	Maximum Daily
2007	26,480	6.06	13.85
2008	27,599	6.32	14.43
2010	29,961	6.86	15.67
2015	36,644	8.39	19.16
2020	44,566	10.20	23.30
2025	53,896	12.34	28.18
2032	69,663	15.95	36.42
2040	92,148	21.10	48.18
2050	128,078	29.33	66.97



WATER MASTER PLAN UPDATE
Existing Culinary Water Supply Sources Figure ES-1

Future Supplies

Water for Cedar City is supplied from the Cedar Subarea basin. Previous studies indicate that the basin has a sustainable water yield of approximately 33,500 AF per year. All water within the basin is currently appropriated and existing use actually exceeds safe yield. This is confirmed by the City's well records which show a significant drop (ranges from 50 to 75 feet over the past 10 years)) in aquifer levels even since the previous master plan. Studies performed for CICWCD, based on the projected demands in this report, forecast an additional aquifer water level decline of approximately 175 feet by the year 2040 if current withdrawal trends continue.

Trans-basin import options are currently being considered. These include Colorado River Water through the Lake Powell pipeline project and groundwater from Snake Valley.

Future Water Source Options

The City's future water source options for developing additional supplies for both potable and non-potable use include groundwater, aquifer storage, springs, surface water, blending, and wholesale purchase.

Groundwater

Further supplies can be pumped from the aquifer by drilling new wells or possibly refurbishing existing agriculture wells associated with acquired water rights. However, new well diversions must be offset with retirement of equivalent existing groundwater withdrawals to avoid depletion of the aquifer. Development of up to 10 new wells west of the City, each producing 1,500 gallons per minute would be required to meet 2032 demand. Location may be dictated by hydraulic constraints of the distribution system and aquifer capacity. Based on the USGS groundwater study and discussions with Central Iron County Water Conservancy District, new well sources would best be located between South Westview Drive and Quichapa Lake, south of State Route 56 and near the existing Quichapa well field area.

Aquifer Storage and Recovery

Based on aquifer characteristics, ASR should be a viable option in the Cedar City Valley. ASR involves the temporary storage of excess surface water supply such as Coal Creek in an aquifer. Following treatment, water is stored in the aquifer until peak demand requires extraction and use. Areas considered favorable for ASR are usually also those areas favorable for ground-water development (ie. Quichapa and Enoch Wellfields).

Springs

As previously mentioned, the City's water rights include the rights to several spring sources. It appears that a significant portion of these rights are still undeveloped. An important element of the City's water supply plan could be to fully develop these water rights.

Surface Water

A review of the flow records for Coal Creek indicates that it could provide a significant supply of water if stored and treated. The availability of this source is dependent upon the amount of use by the other higher priority users on Coal Creek.

Blending High and Low Quality Water

A means of increasing water supply for culinary use might be to blend low quality ground or surface water with existing high quality water sources. While this option appears feasible from source and water quality aspects, it would be difficult to accomplish operationally.

CICWCD Wholesale System Connections

Central Iron County Water Conservancy District (CICWCD) is constructing a wholesale water system to supply water to communities in Iron County. The District's transmission facilities lie to the west of the developed portions of the City. Several points of connection convenient to the City's water distribution system have been identified. The District will also serve as the wholesale agency for delivering Colorado River trans-basin diversion water from the Lake Powell Pipeline. The District has indicated that the price of water for sources developed within the basin will be competitive with the City's development of their own sources. Lake Powell water, however, will likely be significantly higher in cost due to the cost of diversion and pumping.

WATER CONSERVATION

The study included an update of the water conservation plan, previously prepared as part of the water master plan. Efforts included a review of the effectiveness of the City's water conservation program and an update of the recommended implementation plan. The update provides ongoing guidance in the same direction as previously recommended with refinements based on current regulation as well as the efforts and results of the recommendations already implemented.

New water conservation rules have been adopted by the State of Utah since completion of the previous plan. The State of Utah Code, Title 73, Chapter 10, Section 32 (73-10-32) requires each "retail water provider" to prepare, adopt and file with the Division of Water Resources, a conservation plan.

The previous plan consisted of three programs:

1. *System Water Audits and Leak Detection*
2. *Public Information*
3. *Non-Promotional Pricing*

The previous water conservation recommendations were developed by evaluating the water savings and cost-effectiveness of typical conservation Best Management Practices (BMPs).

Implementation Progress

Since the completion of the previous plan, the City has begun implementation of all three recommended conservation measures. In addition, the City has adopted a daytime water restriction ordinance, not mentioned in the previous plan. And, the City has implemented customer water surveys and large landscape conservation incentives as conservation measures that were also not part of the recommended plan but were listed as BMPs considered during plan development.

Evaluation of Conservation Program Effectiveness

There are some indications that the City has made significant progress in conserving water. These include reductions in unit water use rates and in percent UMW and UAW water. Since 1997 the unit water use rate (water production divided by population) has steadily fallen from an average rate of 261 gpcd to 229 gpcd in 2007. This represents a reduction of approximately 14 percent. The UMW water percentage (related to UAW) as well as volume have also fallen. The ratio of UMW to total water production fell from 18 percent in 1997 to 10 percent in 2007. And, at 6.2 percent, the UAW percentage is less than the goal of 10 percent.

Additional water conservation trends can be seen by comparing the change in water use to the corresponding increase in population since the previous plan. Table ES-1 summarizes the increase of indoor, outdoor, billed, un-metered water use as well as total water production and population over the past 10 years. The table reveals that increase in indoor water usage was nearly flat. Outdoor water use, on the other hand, increased substantially. Un-metered water use actually declined. However, the decline was offset by a corresponding increase in billed water use which suggests that the City's accounting of billed water use has improved (which should have translated to better water revenues). Overall, water production increased more slowly than population over the same time period, suggesting that conservation achieved to date is about 7 percent. That is halfway to the program's total water conservation goal of 14 percent.

Table ES-2 Water Conservation Trends

Water Use	Production Volume (gal)		Increase		
	1997	2007	Amount (gal)	% Total	% Annual
Indoor	781,097,972	800,569,911	19,471,939	2%	0.25%
Outdoor	540,365,894	1,198,816,989	658,451,095	122%	8.29%
Billed	1,321,463,866	1,999,386,900	677,923,034	51%	4.23%
Un-Metered	290,077,434	213,699,700	(76,377,734)	-26%	-3.01%
Production	1,611,541,300	2,213,086,600	601,545,300	37%	3.22%
Population	**1997**	**2007**	**Amount**	**% Total**	**% Annual**
	18,398	26,480	8,082	44%	3.70%

From the trends, it would also appear that much of the savings are attributable to the reduction of indoor water use as well as elimination of some water losses such as leaks or storage tank overflows. It can be concluded that the City's conservation efforts have been very successful. It *should be noted however that additional savings could be accomplished in reducing outdoor water use since it grew at much greater rate than the rate of population growth.*

Recommended Program Updates

The same measures recommended in the previous plan are again recommended for this plan update. No additional measures are recommended. While all of the recommended measures have been implemented to one degree or another, not all of the activities associated with each measure have been fully implemented. Conservation efforts should be continued with increased focus on outdoor water use to accomplish the savings goal. All other measures already implemented by the City should be continued. Specific ongoing or improved efforts are detailed in the following paragraphs.

<u>System Water Audits Leak Detection and Repair</u>

UAW is less than 10 percent and leak detection project confirmed that water losses from leaks are insignificant. Thus a leak detection and repair program would not be cost effective. However, the City should continue to perform the annual audit as well as monitor customer billing for extreme changes in individual customer usage as a maintenance measure.

<u>Public Information</u>

The City has a good beginning to a public information program but more could be accomplished. An improved campaign should be developed, focused on areas where greatest conservation can be achieved (like outdoor use). The State has a number of public information documents already prepared that could be used to augment the City's efforts. The City could increase its level of communication to customers through the newsletter by providing more frequent conservation related information. The City could also employ or designate an existing employee (ideally a public information specialist) to devote part of their time to public education around conservation. And, the City could incorporate a xeriscape demonstration garden into one of its parks or building landscapes.

<u>Non-Promotional Water Pricing</u>

Rates should be reviewed periodically both to quantify the initial impact as well as to see that the conservation effect continues over time. Some adjustment to the rates may be considered at the time they are up for an increase for financial reasons in response to the results of the monitoring. Additional rate adjustments combined with increased focus through a public information program may be effective in further reducing outdoor water usage.

Other Implementation Considerations

In addition to the program update recommendations, the following should be addressed by the City in their conservation plan and program to comply with the State of Utah requirements:

1. *Establishment of a timeline for action and an evaluation process to measure progress for all conservation measures.*
2. *One City Council meeting every 5 years to discuss and adopt the conservation plan with provisions for public comment. A copy of the meeting minutes should be attached to the plan as an appendix.*

3. *Delivery of the plan to City leaders, Iron County and the media.*
4. *The plan should include a drought/emergency element.*

EXISTING CULINARY SYSTEM

The City's existing culinary water system is comprised of a pipe network, water storage facilities, a transmission system and water supply facilities.

Pipe Network

The existing distribution network consists of pipes ranging in size from 1 to 20-inches in diameter. *The majority of pipes are constructed of a variety of materials including ductile or cast iron and galvanized steel, with a few polyvinylchloride (PVC) material.*

Because of the significant elevation change across the service area, the distribution pipe network has been divided into pressure zones to keep delivery pressures within desired limits. *The current distribution pipe network has five main pressure zones. There are also ten sub-zones within four of the five pressure zones.*

Storage

Cedar City operates and maintains 11 water storage tanks. *The tanks have combined total storage capacity of about 18 million gallons.* All of the tanks with the exception of South Concrete Tank are of steel construction. Of the *11* storage tanks all but one are used to serve the operation of the distribution system directly, providing operational and emergency storage. *However, one of the 11 storage tanks used to serve the distribution system, South Concrete Tank, is currently not active due to structural damage.*

The Spillsbury Tank is the only tank that does not serve the distribution system directly. It is used to store spring water from the Spillsbury springs located south of the Quichapa well field to the west of town. Water is pumped from the Spillsbury reservoir to South Steel and Concrete Tanks for distribution into the system.

Water levels in all tanks with the exception of South Concrete Tank are monitored by the City's SCADA system.

Supply Facilities

Water for the culinary distribution system is supplied from both springs and wells. There are seven existing wells located in two separate well fields. They have a combined design production capacity of *10,600* gallons per minute *or 15.26 million gallons per day*. Because of draw-down and age of the equipment, however, only *7,248* gpm or *10.48 million gallons per day* can reportedly be delivered. There are also three main spring sources. They have a combined average flow of *907* gpm. The production has also been reduced to protect the wells and pumps from over pumping. The production has been reduced to match the yield of the aquifer.

The Quichapa well field is located to the west of Cedar City and accounts for the majority of well water produced. Wells No. 1 and 3 are located within close proximity of each other. Wells 5, 6 and 7 are also grouped together.

The Enoch well field is located to the north of town. It is comprised of three wells, however, one of the wells is currently not being used by the City. For the most part, the wells in the Enoch well field pump to the 3200 North Tank. However, during peak demand periods, a portion of the water form the Enoch well field bypasses the tank and is pumped directly into the distribution system. In the future, Cedar City would like to be able to utilize the storage capacity in the 3200 North Tank more effectively so that the water does not have to pump directly into the distribution system. This situation will be addressed later in the report.

Three spring sources also supply culinary water. Each of the sources is actually a group of springs which are collectively conveyed to the distribution system. They include Spillsbury Springs, Shurtz Canyon Springs, and Cedar Canyon Springs.

Transmission

The City has an extensive water transmission system which conveys water from the sources to storage or distribution. Transmission facilities also include two pump stations. They are used to fill storage tanks serving the upper pressure zones. Two main transmission pipelines transport water to the distribution system from supply sources located to the west of town. A 20-inch diameter pipeline extends from Quichapa Wells 5, 6 and 7, delivering water directly into existing Pressure Zones 2 and 4 and conveying water to the Cross Hollow Tank. A 16-inch diameter pipe also extends from the Quichapa Well Field serving Quichapa Wells 1 and 3 as well as the Spillsbury Springs conveying water to South Steel Tank.

WATER MODEL DEVELOPMENT

A hydraulic computer model of Cedar City water distribution system was redeveloped for the City to bring it up to date with current facilities and to be consistent with the GIS mapping and database. City staff was interviewed to understand system operations and clarify questions concerning the available data.

Physical Facilities

The new model was rebuilt using available data obtained from City records. GIS layers for piping, valves, and hydrants were imported directly into the hydraulic modeling software, H_2OMAP Water. Main sources of available data about the water system are City staff, facilities database contained in GIS, and an existing EPANET model created from previous master plan updates.

Pipes

Pipes were created by direct import from GIS data. The existing system shows that there are approximately 5,000 pipes in the model. Pipe information includes pipe length, diameter, material, and roughness. Diameters and material type were imported directly from the GIS database. Where the diameter was not provided in the database, the City was asked to provide the missing information. The Hazen-Williams friction or "C" factor was assigned based on the pipe material for each pipe. However, calibration indicated that pipe roughness for each has increased very little over the years, and that a general roughness value of 120 is more appropriate.

Junctions

H_2OMap Water assigned junctions in the model at all changes in pipe diameter (reducers), pipe connections (tees and taps), intersections (crosses), dead ends (plugs), and hydrant locations. H_2OMap Water assigned approximately 4,700 junctions to pipes in the model. Additional junctions not contained in the GIS system added for modeling purposes were assigned the same identification format.

Pumps

Pump locations were determined from the existing EPANET model. In a typical model, pump hydraulics are represented by a curve that defines the pump's head versus flow relationship. Manufacturer pump curves for booster stations and well pumps, provided by the City were used for this purpose. Pump curves were entered into the model using the multi-point curve option. This option allows the pump relationship of head versus flow to be entered as a series of points. Operational controls were added to reflect field control settings or the intent of manual operational practices and procedures as provided by the City.

Wells and Springs

Wells and springs are represented in the model as fixed head reservoirs. Initially, the water surface elevation of each well was set to the average dynamic water level. The dynamic water level was established by taking the ground elevation from the contour map and subtracting the average dynamic depth provided by the City.

Valves

Pressure reducing valves have been given the settings provided by the City except where calibration indicated a different setting from those given.

Model Organization

Several scenarios were created for this study to simulate system performance with different system demands, facilities and operational settings. The scenarios included in the model are categorized as follows:

1. *Base*
2. *Calibration*
3. *Existing System Conditions*
4. *Short-term Conditions*
5. *Build-out Conditions*

The Base scenario is not used for evaluation purposes; it stores model facility data for all of the other scenarios. The Calibration scenarios were created to simulate the system on the day of field testing. The remaining scenarios were used to evaluate the system at the different planning periods previously discussed in this report. Existing System Condition scenarios were used to determine deficiencies in the existing system and evaluate immediate improvements intended to correct the deficiencies. Long-term or Build-out Condition scenarios were created to evaluate improvements to meet increased demand over the larger service area for build out year, respectively. For each planning period, the water system was evaluated under average of maximum day demand and fire flow demands.

Development of Water Demands

Domestic water demand was allocated in the model to accurately represent the distribution of demands in the system. Existing demands are based on the City's billed water use records. Future demands were distributed in the model using unit use rates and land use data for the future service area. Allocation of future demand is discussed in Section 7.

Existing System Demands

The City's 2007 billing records were used for distribution of the existing system demands. An average daily water demand for the maximum month was calculated for each customer from the billing record, which was then assigned to the closest junction node in the model based on the customer address.

The highest annual water use to date for the City was recorded in 2007. During 2007, annual water use averaged 6.0 mgd (4,188 gpm). The highest average monthly water use occurred in the month of July. The maximum day water production recorded for the system is 13.85 MGD in 2007. However, tank overflows are estimated at 500 gpm. Therefore, maximum day demand has been adjusted downward to 13.125 mgd (9,115 gpm). Peak hour demand, calculated from SCADA records was determined to be 16,329 gpm.

Fire Flow Demands

For both future and existing system hydrants, fire flow demands were assigned in the model based on the land use surrounding each hydrant except where specifically required otherwise by the fire department. The largest of the fire flow rates associated with the neighboring land uses was assigned to the hydrant.

Model Calibration

The model was calibrated to ensure that model results are representative of actual system operations. The calibration process includes performing field tests on the system and then making appropriate adjustments to the computer model until the results match the data gathered during testing.

Tank levels, pumping rates, and pressure fluctuations were monitored during each test. Adjustments were made to the model until pressures in the model matched the recorded field data from before and during the hydrant test. The calibration process revealed some closed isolation valves and connectivity issues that had been overlooked in the model development process. City staff verified the changes that needed to be made to the model. Roughness factors assigned to the pipes in the model are industry accepted values based on pipe material.

EXISTING CULINARY WATER SYSTEM EVALUATION

An evaluation of the existing culinary water distribution system was performed. The evaluation required the conversion and calibration of the City's existing distribution system computer model. Evaluation included analyses of the pipe network, the transmission system, storage capacity and supply facilities.

Distribution Pipe Network Evaluation

An evaluation of the distribution pipe network was performed under normal peak operating and fire flow conditions using the computer model. Peak operating conditions include the annual maximum day water use (maximum day) and the peak instantaneous water use (peak. instant). A fire flow evaluation was also performed for the entire distribution pipe network.

Modeling results of peak operating conditions revealed several areas that do not meet the evaluation criteria established at the beginning of the study. These problem areas include low pressures, high pressures, high head loss, and insufficient fire flows.

System Service Pressures

Model simulations revealed a number of pressure deficiencies in the water distribution system. Pressures below 45 psi can be expected under maximum day as well as peak instant conditions. Low pressures can be seen at Zone 3 / 5, Zone 3 / 4 and Zone 2 / 3 boundaries. City officials are aware that additional valves appear to be open because low pressures are problematic along 200 South. They can be expected under maximum day as well as peak instant conditions. Most low pressures are caused by the location of the pressure zone where its boundary is set too high for the hydraulic grade of the pressure zone.

High pressure is a more widespread problem than low pressure. It is less of a concern however, because high pressures do not limit the availability and acceptability of service to the customer. High pressures were found to exist in *Pressure Zone 2, 3, and 4, beyond 150 psi*.

System Piping Headless Rates

Some distribution system piping was found to have headloss rates greater than the suggested seven feet per 1000 feet under maximum day demand conditions. *Pipes shown as having high headloss are in the range of 4 – 12-inches in diameter. High headlosses are of concern since they appear to be the cause of low pressures under normal operating conditions, specifically in Zone 2. Thus, it may cause insufficient fire flows under fire or emergency flow conditions.*

System Fire Flow Capacity

The distribution pipe network was also analyzed for its fire flow capacity. The analysis was performed using the distribution system computer model, and was based on maintaining a 20 psi minimum pressure residual at maximum day demand, with fire flows as required by the State Rules for Drinking Water Systems.

Results of the analysis indicate significant areas with less than required fire flow available. The problem areas are a result of distribution system headloss. In addition, it was noted that some hydrants are connected to pipes less than 6-inches in diameter. This contributes to the incidence of low fire flow capacity and is in violation of State Rules for Drinking Water Systems. *The capacity of the distribution system was also found to be deficient at the location of many of the site specific fire flows including Smead, Genpack and Cerro Copper.*

Transmission System Evaluation

The computer modeling results indicated that the existing transmission system facilities have sufficient capacity for current flows. A review of transmission system operation revealed that a significant amount of water is being conveyed at unnecessarily high pressures. High capacity pumping increases pumping costs. With some transmission system improvements, much of the water could be pumped to the reservoirs serving Pressure Zone 3, boosting only the water needed to the upper pressure zones. This could potentially reduce pumping costs and increase well production capacity.

A Business Case Evaluation (BCE) was conducted on the 16" South Quichapa Transmission Pipeline. A corrosion study conducted by Corrosion Control Technologies, Inc. suggested that the pipe may be near the end of its useful life. A failure in this pipe could have serious consequences in maintaining sufficient water supply, especially during summer months. The study indicated that cathodic protection would be sufficient in protection against severe corrosion damage. Several alternatives were analyzed and compared for the probability of pipe failure based on life cycle cost and risk of failure. Results indicated that the risk costs of the "Do Nothing" alternative were slightly higher than the cost to protect the entire segment of the pipe identified to be at risk by the report.

Storage Evaluation

Calculations confirm that the Cedar City culinary water system has more than the required total storage capacity. At present, the City has *18* million gallons of storage. *Operational and fire emergency storage needs requires approximately 10.78 million gallons leaving 7.28 million gallons as remaining storage used for emergency.* Storage was also found to be sufficient when evaluated by pressure zone.

City staff has reported that several storage tanks have operational problems. These tanks include 3200 North Tank, and Cedar Canyon Tank. Both regularly overflow during the summer months when demand is high. Combined water loss is approximately 500 gpm with the majority of the overflow occurring at 3200 North Tank. However, because of headloss in the pipes that convey water from the tank into and through the distribution system in pressure zone two, not all of the water pumped from the Enoch wells can be used. The bleeding of water from pressure Zones 3 and 4 into Zone 2 is a contributing cause as well.

Overflow occurs at Cedar Canyon Tank because it is sited at a lower elevation than the other reservoirs serving Zone 3. It was actually constructed at an elevation more consistent with Pressure Zone 2. As a result, the hydraulic grades of the other tanks prevent the Cedar Canyon Tank from draining properly.

Supply Facilities Evaluation

The supply facilities evaluation focused on well output and energy costs. Results show that wells are not producing at original design capacity and are barely able to meet current water demands. One of the reasons that the City's wells are producing less than design capacity is headloss in the transmission piping. Another reason City wells are producing less than design capacity is the declining groundwater table. Production has also been reduced to protect the wells and pumps from over pumping. The production has been reduced to match the yield of the aquifer.

FUTURE CULINARY WATER SYSTEM ANALYSIS

Two planning horizons were established with the City; one for immediate improvements needed to correct existing problems and another for build-out to the future annexation declaration boundary.

Build-out Model

Future water system improvements were developed through the creation and use of a hydraulic model to simulate build-out development conditions. The existing system hydraulic model was used as the basis for development. Pressure zone boundaries were modified and additional ones established for the undeveloped areas west of town. New piping was laid out along the existing and future transportation corridors established in the City's Transportation Master Plan. Future transmission, storage, supply and pumping facilities were also added. Projected demands were allocated to the model and the proposed facilities were sized to meet the previously established design criteria.

Future Pressure Zones

To facilitate operations and management of the distribution system, considerable effort was placed into reconfiguring the pressure zones. This was done by increasing the number of zones and distributing the sources of supply relative to elevations. Thus, pressure zones were adjusted to serve a narrower range of elevations and maintain more favorable pressures.

Build-out Demands

Future demands in the model were calculated on a unit-area basis for currently undeveloped areas and added to the existing model demands. Unit-use rates were developed for each future land use type based on unit use rates for existing development. These current use rates were calculated using a representative sample of the water-billing data and the City Planning Department development definitions of each land use type.

Future Storage Requirements

A storage analysis was completed for the build-out system to identify additional storage required to meet the system criteria. City officials recommended keeping the same ratio of emergency storage to existing storage capacity, 275 gallons/capita. Based on the projected build-out population of 128,078 and emergency storage to total storage capacity ratio, the emergency storage will account for 40% of total capacity. The build-out system evaluation revealed the need for six new tanks in addition to the planned Ashdown and 800 South Tanks (already planned). The total volume of proposed storage requirement is 38.6 MG.

Future Transmission System Improvements

Transmission main from North Quichapa Well Field will be connected to Proposed Zone 8 Storage Tank, Central. The transmission main from five new wells in the newly established well field will also connect to Proposed Zone 8 Storage Tank, Central. Four wells from the proposed well field will pump water to 800 South Tank where some water will discharge into Zone 7 and some pumped to Cross Hollow Tank. Two new wells will transmit water to Proposed Zone 3 Storage Tank, South supplying Zone 3. Similarly, two proposed wells will supply Proposed Zone 3 Storage Tank, South that serves Zone 7. Finally, three wells in the proposed Quichapa well *field will supply Proposed Zone 8 Storage Tank, South serving Zone 8. Transmission main from Enoch Well Field will transmit water to 3200 North Tank and a capacity of 4,500 gpm will be pumped to Proposed Zone 7 Storage Tank, North. The future transmission system will accommodate 16 new wells in the Quichapa Well Field and three new wells in Enoch Well Field at full build-out, in addition to connections to Central Iron County Water Conservancy District (CICWCD) service lines.*

Immediate Improvements Model

The immediate improvements are a subset of the future build-out improvements. Brown and Caldwell created a model of the existing system with the proposed immediate improvements for analysis. All improvements were tested under 24-hour extended period and steady-state fire flow conditions to confirm their effectiveness.

SECONDARY IRRIGATION

The study also evaluated the feasibility of implementing a pressurized secondary irrigation system and the impact of such a system on the culinary water system and *considered the feasibility of using wastewater scalping as a source of secondary water supply.*

Existing Facilities

Cedar City currently has a secondary irrigation system which consists of a single transmission main, *two storage facilities, two supply wells, and a booster station*. The transmission main is a 12-inch diameter pipe that parallels I-15. The *existing storage reservoir identified in the previous plan at the south end of the system has been re-constructed. The reservoir will have a finished capacity of approximately 99 acre-feet* (32.3 MG) and is located at about 2090 W, Royal Hunte Drive.

Water Supply

The City uses the Cemetery and Northfield Wells as a source of water for the existing secondary irrigation system. The use of the Cemetery Well as an irrigation supply is limited by the high TDS content of the water.

In addition to the Cemetery and Northfield Wells, Cedar City currently has surface water from Coal Creek that can be used for irrigation purposes. Cedar City also owns shares in five irrigation companies that are supplied by Coal Creek. The 200 North Pump Station is currently being built to utilize a portion of the City's irrigation shares in Coal Creek.

Current Water Use

The water is supplied to *six* connections, including: the cemetery, golf course, Bicentennial Park softball and soccer fields, Canyon View High School, Canyon View Middle School, and Cedar City High School. Now that the reservoir is completed, Southern Utah University is connected to the system, but in past years has chosen not to use the water because of the water's high TDS content. *Once the reservoir is completed Southern Utah University will begin to use secondary irrigation water.*

Delivery Alternatives

The study evaluated two separate delivery alternatives. The first alternative is a Partial City System that would expand delivery of secondary water to major irrigation water users currently served by the culinary water system and to new developments. The second alternative is a complete City-wide System that would deliver secondary water to all areas within the City limits. The alternatives were developed and evaluated using hydraulic computer models.

Secondary Irrigation Design / Evaluation Criteria

Criteria used in this study *are a continuation of those established in the previous master plan and are based on previous experience,* the State of Utah Rules for Public Drinking Water Systems Part II Design and Construction Standards for Systems, and good engineering judgment. It has been assumed that operational pressure should be a minimum of 45 psi and a maximum of 120 psi. This range provides adequate service without causing pressure related failures to the pipe network and allows sprinkler systems to function properly.

Partial City System

The Partial City System (Partial System) would continue to deliver water to the current users and add several new major water users. The new major users would include all City parks and schools not currently served by the existing system. In addition to the major users, the Partial System *evaluation assumed the City would require* that all new developments construct the necessary infrastructure and use secondary irrigation water.

Table ES-3 summarizes the required improvements to the existing secondary irrigation system for the Partial System alternative.

Table ES-3 Summary of Required Improvements for Partial System

Requirement	Improvement
To service Cedar Middle School	Booster Pump- 10 hp
To service residential area	Booster Pump- 100 hp
Water source- Coal Creek	200 North Pump Station
To met north end peak demands	Storage reservoir at elevation 6,000 ft
Water source- north end of City	Re-equip Enoch South Well and convert 12-inch transmission pipeline
To regulate pressures	Install 2 PRVs

City-wide System

The City-wide System would also continue serving the current major users and new development but would add all other areas that are within the City limits. The City-wide System would require the same improvements as listed under the Partial System. The main difference between the two systems is the need for additional supply sources and storage facilities.

Table ES-4 provides a summary of the required improvements that would be necessary to expand the Partial City system to a full City-wide secondary irrigation system. All other improvements shown on the Partial City system would remain as shown under that alternative.

Table ES-4 Summary of Required Improvements for City-wide System

Requirement	Improvement
Service to Cedar Middle School and additional residents	Increase size of booster pump – 75 hp
Service to all existing individual residences	Delivery system pipe network
Service to south end residential areas	Increase size of booster pump- 200 hp
Additional water source	200 North Pump Station
Increase pipeline capacity	Replace existing 12-inch pipeline from Leigh Hill Reservoir to the proposed 100 hp booster station with 16-inch pipe and on 200 North from 1150 West to 200 North Pump Station with 18-inch pipe

Future Water Requirements

To meet the peak demands for a Partial System, as shown in the table above, the City must use at least some of its surface water rights from Coal Creek in addition to what is supplied from the Cemetery Well.

For the City-wide system, it appears that in addition to the Cemetery Well, Northfield Well and all current surface water rights, another 1.1 cfs of irrigation water supply capacity would need to be acquired. These additional rights could be obtained by change application for existing unused City-owned culinary water rights, purchase of additional surface water rights (Coal Creek rights or irrigation company shares), or purchase of private well(s) with water rights.

Water Quality

Under the Partial City System, assuming 3.5 cfs from the Cemetery Well with a TDS of 3,000 mg/l and 3.7 cfs from other sources with an average TDS of 500 mg/l, the mixed TDS would be approximately 1,715 mg/l. Under the City-wide System, assuming 3.5 cfs from the Cemetery Well with a TDS of 3,000 mg/l and 9.0 cfs from other sources with an average TDS of 500 mg/l, the mixed TDS would be approximately 1,200 mg/l.

If irrigation sources are not mixed, the City's intent is to have the Cemetery Well be dedicated to the Golf Course. The Northfield Well, the 200 North Pump Station, and the Leigh Hill Reservoir will provide water to the other customers on the secondary irrigation system. By letting the Golf Course have the Cemetery Well full time, the concerns of poor water quality will be minimized throughout the irrigation system.

Wastewater Scalping Facility

An evaluation was completed to consider the feasibility of using wastewater scalping as a source of secondary water supply. A proposed wastewater scalping facility would be located northeast of the airport. The treated reuse water would be pumped into the City and used as a source to recharge aquifer storage.

Wastewater scalping facilities that were considered ranged in size from 1 MGD to 5 MGD of treated water. The estimated capital cost for a 1 MGD wastewater scalping facility is approximately $10,000,000 and a 5 MGD wastewater scalping facility is approximately $40,000,000. The respective annualized O&M cost are estimated at $200,000 and $1,000,000.

Cost Estimates

A brief review of capital and operating costs was completed for each alternative for comparison with each other and other potential water supply options.

Capital Costs

The estimated capital cost for the Partial City System would be approximately *$4,800,000*. The additional cost to convert to a City-wide System would be approximately *$21,100,000* (a total cost of *$25,900,000*).

Prioritized Cost for Partial System

The unit cost per flow rate determines the most cost effective users to add to the system and will help prioritize when the users will be added. Because various users are downstream of one another, a number of users must be added to the Partial System in sequence.

Secondary Irrigation Operation and Maintenance Costs

Annual operation and maintenance costs are estimated to be *$73,900* and *$178,900* for the Partial City System and City-wide System, respectively.

Impacts to Culinary System

The Partial System would reduce the maximum day demands for culinary water by approximately *3.1* mgd. The City-wide System would reduce the maximum day demands for culinary water by approximately *7.5* mgd. The reduced demands would allow the City to reserve their higher quality water sources for future culinary water needs.

Secondary Irrigation Preferred Alternative

The Partial System was determined to be the preferred alternative because of its lower cost and because it did not require the acquisition of additional water resources. Figure ES-2 shows the Partial System layout of improvements.

The cost of the water under the Partial System alternative, including operation and maintenance, would be approximately $123 per acre-ft ($0.38/1000 gal.). The City-wide System water would cost approximately $256 per acre-ft ($0.78/1000 gal.).

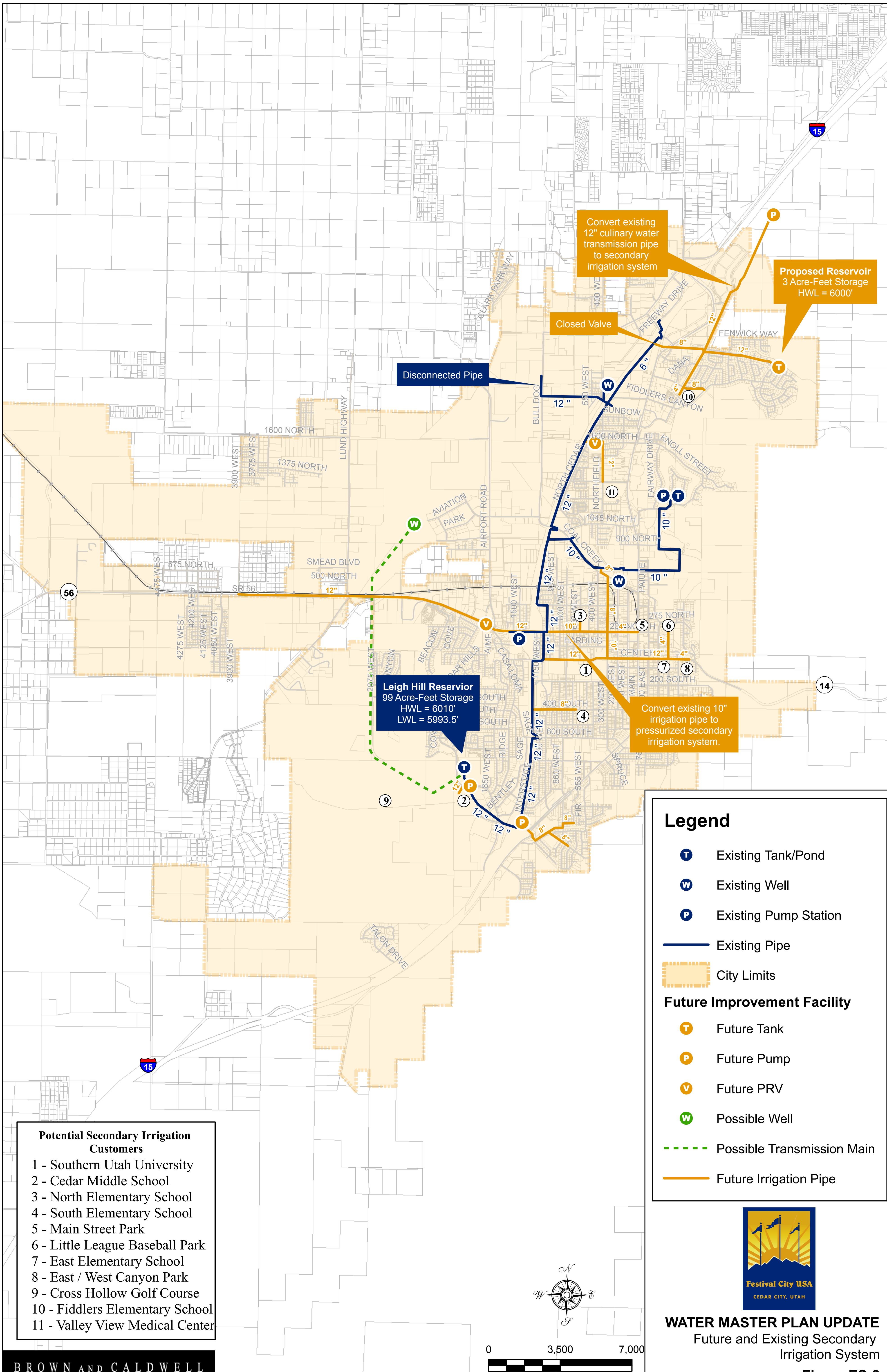
The Partial System could also be implemented using the water rights and sources already owned by the City. The City-wide System on the other hand would require the acquisition of additional water rights for either surface water from Coal Creek or for groundwater from an additional well.

RECOMMENDATIONS

A plan was created to guide the continued development and improvement of Cedar City's culinary water system. The plan is based on the combined findings of each part of the evaluation. It includes provisions for supply, distribution, transmission and storage needs. The plan also includes a suggested implementation schedule based on priority of needs and expected growth.

Supply

The following water supply improvements are recommended:



WATER MASTER PLAN UPDATE
Future and Existing Secondary Irrigation System
Figure ES-2

- *Develop an additional 22.57 mgd capacity of potable water supply for the water distribution system and an additional 2.08 mgd capacity of non-potable supply for the secondary irrigation system by the year 2032.*
- *Optimize capacity of existing diversions to take full advantage of facilities and water rights. This includes rehabilitation of spring collection and conveyance piping, well casing rehabilitation and re-plumbing of Quichapa Wells 5, 6, and 7 to discharge to the Proposed Zone 8 Storage Tank, Central and pump station.*
- *Acquire additional groundwater rights (approximately 8,000 AF by 2032) through the City's water acquisition ordinance, being careful to retire irrigation uses to offset new groundwater diversions*
- *Site and Drill approximately 10 additional wells as supply for the culinary water distribution system for 2032. One of the wells will need to be constructed in the Enoch well field and Enoch Well #2 will need to be refurbished or re-drilled. The remainder should be drilled in a new wellfield located south of Route 56 between South Westview Drive and Quichapa Lake or within the existing Quichapa well field. Each well will need to produce 1,500 gpm.*
- *Study and implement aquifer recharge to optimize the available groundwater resource.*

Figure ES-3 illustrates the plan for development of future water supplies.

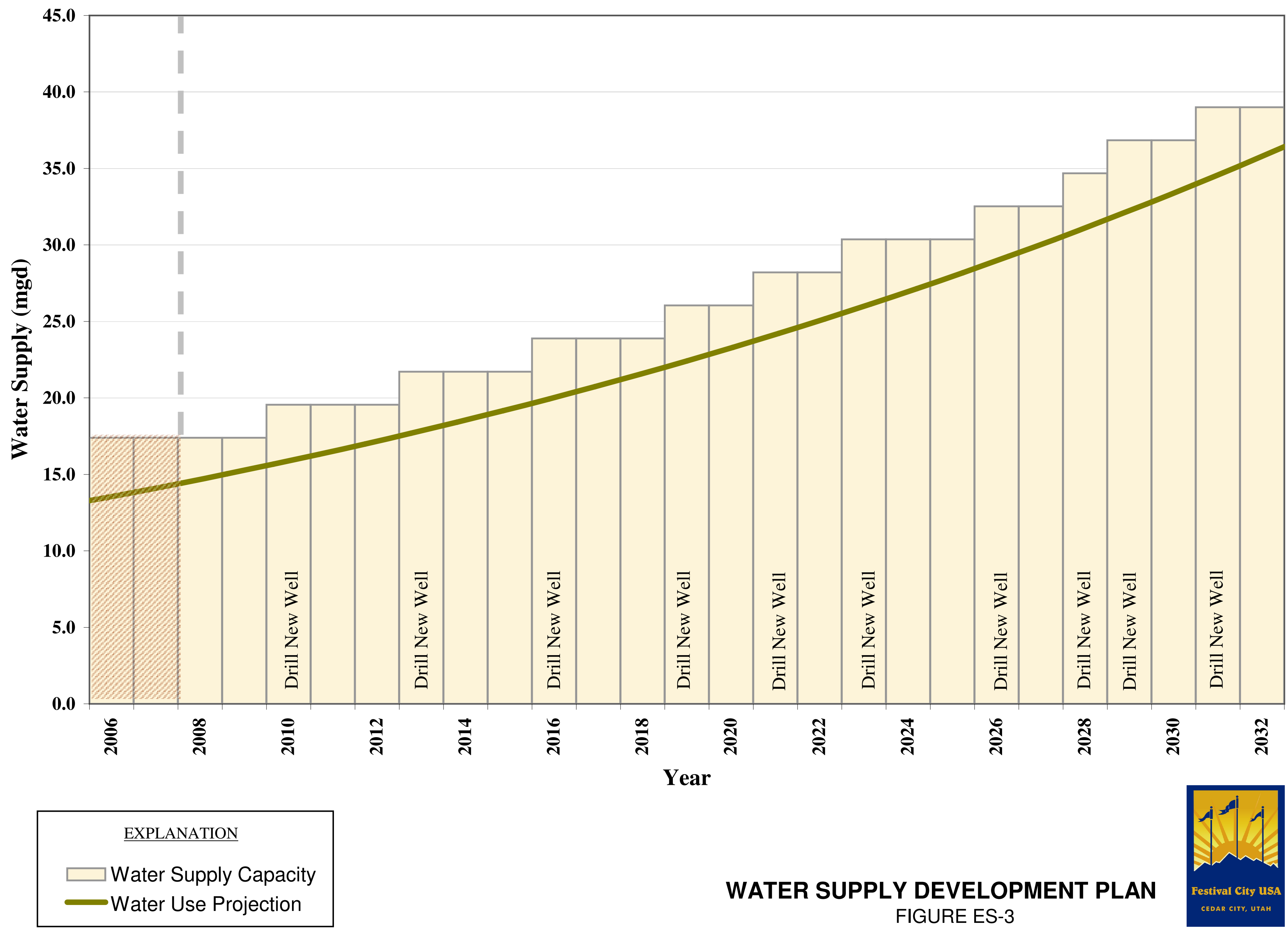
Secondary Irrigation System

Recommendations related to the distribution system facilities include provisions for transmission, storage and pumping to meet future needs. There are several determining factors that can be used to select a preferred alternative. The two main controlling factors for this study are cost and availability of water supply. The cost of the water under the Partial System alternative, including operation and maintenance, would be approximately $123 per acre-ft ($0.38/1000 gal.). The City-wide System water would cost approximately $256 per acre-ft ($0.78/1000 gal.). The Partial City System would be the preferred alternative and the system could be constructed to accommodate future expansion.

***Culinary Water* Distribution System**

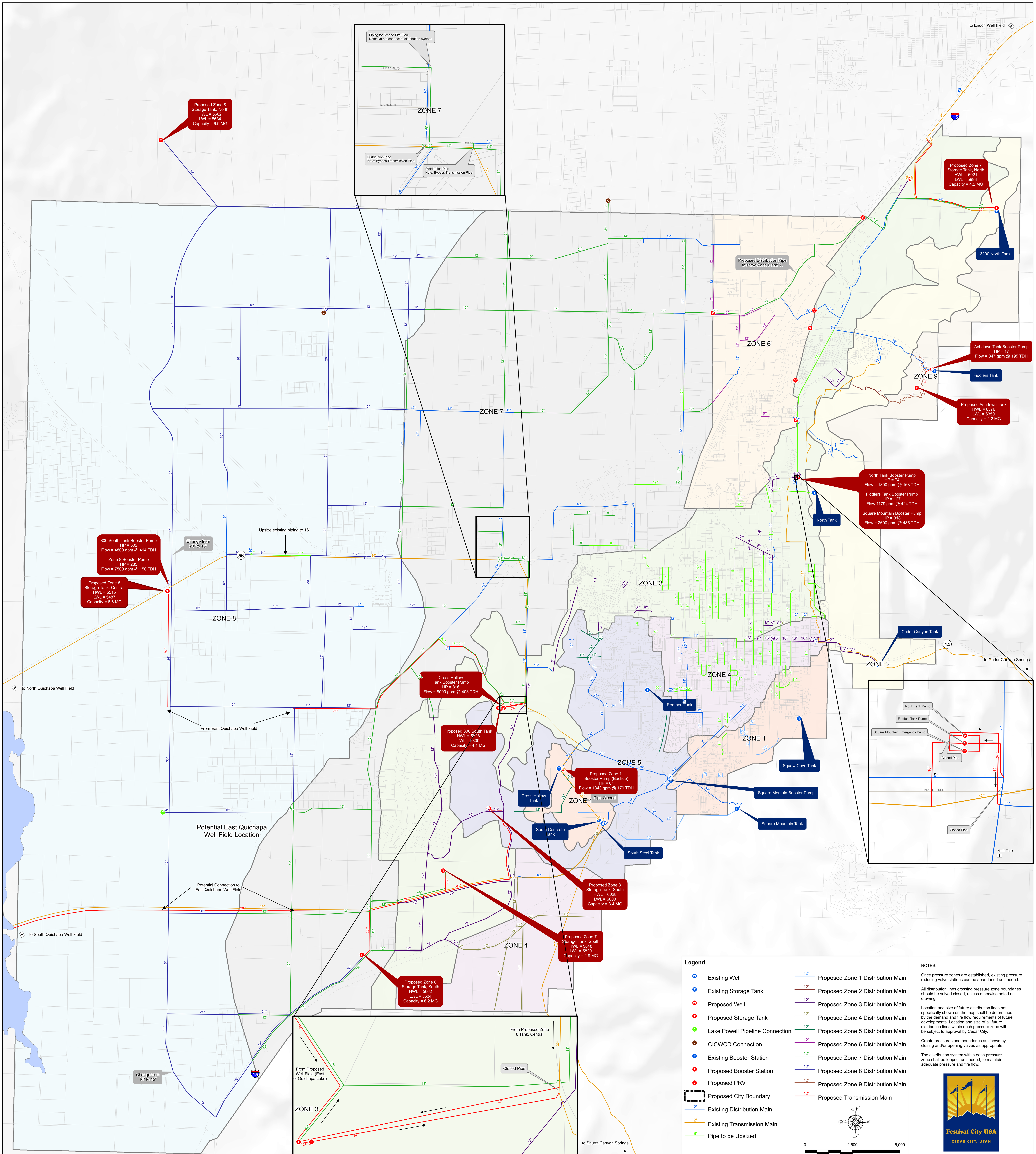
Recommendations related to the distribution system facilities include provisions for piping, storage and transmission systems to meet existing and future needs. *The improvements were grouped into projects and categorized as short-term or long-term projects. Short-term projects address existing problems in the system and long-term projects include improvements for future demands.*

A distribution system plan was developed to accommodate the increased demands anticipated for build-out development within the study area boundaries. Figure ES-4 is a map of the recommended water system improvements. A key part of the plan was the development of pressure zones to regulate pressures within recommended limits. The immediate recommended plan contains the existing 5 separate pressure zones including their sub zones where as the build-out plan contains 9 pressure zones.



WATER SUPPLY DEVELOPMENT PLAN

FIGURE ES-3



BROWN AND CALDWELL	PROJECT NO. 134355	PROJECT	CEDAR CITY WATER MASTER PLAN UPDATE	Figure
	REVISED DATE 06-19-09	TITLE	Build-out Culinary Water System Improvement	ES-4

Build-out distribution piping was laid out to follow existing or proposed road rights-of-way as shown in the City's Street Master Plan. In most cases only main distribution pipes (12-inches and larger) were included in the plan. The recommendations shown also include existing pipes which require replacement. Pipe replacement was recommended where existing facilities have insufficient capacity to meet current and/or future needs (i.e. pipes less than 6-inches diameter or with high headloss).

Transmission System

Transmission system recommendations include piping, as well as booster pump improvements. They are shown in Figure ES-4. The recommendations were developed specifically to integrate the distribution, storage and supply recommendations.

In addition to the specific projects identified in the implementation plan, it is recommended that full cathodic protection of the 16-inch Quichapa Transmission pipeline be installed in accordance with the recommendations of the Corrosion Control Technologies, Inc. Nov. 2007 Report.

Storage

Additional storage will also be required to meet future demands. Future storage needs were evaluated by zone. A total of *38.6* million gallons of additional storage will be required *by year 2032 and 77 million gallons by build-out.* They should be generally located as shown in Figure ES-4. *Additional studies should be undertaken to select specific tank sites beyond year 2032.*

Non-Capital Improvement Recommendations

Additional recommendations were developed that are not part of the capital improvements plan. They include:

- *Repair/maintain water supply meters. This should be corrected to improve accuracy of documentation and improvement of future updates.*
- *Collect and store hourly flow data for supply meters. The data is valuable in performing future operational analyses and model updates.*
- *Make remote level sensor at Cedar Canyon Tank more reliable. The level sensor at Cedar Canyon is solar powered and often fails to read.*
- *Investigate piping upstream of fire flow tests 5 and 8 to determine cause of discrepancies during calibration. This should be performed prior to design and construction of recommended improvements at these locations (See projects S-7 and S-10).*

Implementation Plan

The improvements were grouped into projects and categorized as short-term or long-term projects. Short-term projects address existing problems in the system and long-term projects include improvements for future demands. The recommendations are shown in Figure ES-4.

Short-Term Projects

Short-term projects are designed to resolve existing problems in the distribution system. They should be implemented immediately or in the near future. The short-term improvements were sized to meet both existing and future demands.

Pipe Installation and Replacement Projects

The existing system model was modified to reflect immediate improvements that will benefit the system. First, overflow problems at 3200 North and Cedar Canyon Tanks were evaluated. After the evaluation of identified options, a booster pump positioned along Knoll Street near the Golf Course is recommended to pump water from 3200 North Tank up to Fiddlers Tank, North Tank and Square Mountain Tank for emergency. Boosting water from the distribution line to Fiddlers Tank will utilize the water in 3200 North Tank, preventing overflow and maintaining adequate levels. However, boosting water from the distribution line to North Tank will re-circulate water and may not prevent overflow of water in 3200 North Tank. A benefit for this option does reduce demands from Cross Hollow and Square Mountain Tanks which supplies water to Fiddlers Tank. Another benefit for this option is to allow water transmission between 3200 North to North, Fiddlers, and Square Mountain Tanks. Finally, North Tank has low water level issues but will be maintained with a booster pump connecting to the distribution main within the zone it serves.

Cedar Canyon Tank is currently a supply source to Zone 3. Due to the hydraulic grade and additional capacity of Squaw Cave, Redman and South Steel Tanks, the tank does not get a chance to supply the Zone. Therefore, utilizing its service to Zone 2 will prevent overflow and help mitigate its water level to an acceptable level.

The existing distribution piping network shows pipe networks 6-inchs or smaller. Upsizing these pipes will reduce headloss and eliminate low pressures allowing to separate all pressure zones from one another.

Long-Term Projects

Long-term projects are recommended to enhance performance of the distribution system as the City expands and approaches build-out conditions. A key part of the Long Term Plan is the development of pressure zones to regulate pressures within recommended limits. The recommended plan contains nine separate pressure zones. The hydraulic grade of each pressure zone is regulated by the water surface of the storage tanks serving the zone, except where supplied solely by PRV.

Distribution piping was laid out to follow existing or proposed road rights-of-way as shown in the City's Street Master Plan. In the build-out plan, main distribution pipes of 12-inches and larger were included in the plan. The recommendations shown also include existing pipes which require replacement. Pipe replacement was recommended where existing facilities have insufficient capacity to meet current and/or future needs (i.e. pipes less than 6-inches diameter or with high headloss and velocity). The build-out plan suggests replacing all distribution mains less than 6-inch with 8-inch and larger pipes.

PURPOSE

The purpose of this project is to develop an updated Water Master Plan for Cedar City, Utah. This plan will support the City's development and construction of its water resources distribution facilities. Implementation of this plan will provide a quality level of service for the City's water customers.

OBJECTIVES

The purpose of this project was to update the City's water master plan, previously completed in 1998. Similar to the previous master plan, the main objectives of this study included:

- Updating and calibrating the water system hydraulic model to simulate 24-hour operation.
- Updating the City's water supply plan
- Recommendation of transmission system improvements to facilitate storage tank operation and maximize the use of available supply capacity
- Evaluation of storage, distribution, and transmission facilities capacities
- Development of a capital improvements plan
- Updating the secondary irrigation system plan
- Updating the conservation plan

PROJECT SCOPE

Brown and Caldwell performed nine tasks outlined as the project scope to complete the project objectives listed above. Each task is described in the following paragraphs.

Task 1 – Data Acquisition

Brown and Caldwell initiated a kickoff meeting with Cedar City officials. Project related data and information submitted by the City were reviewed to determine it's sufficiency for project objectives. An information request list was developed and submitted to the City on a weekly basis. Additional project information was obtained during site visits. Weekly Coordination meetings were scheduled with the City to discuss project progress, issues and results. Brown and Caldwell conducted an internal QA/QC peer review during the course of the project.

Task 2 – Projections/Coordination

Current system-wide water use was determined from water production records. Average annual, maximum day and peak hour demand conditions were determined for the 2007 period of records. Individual user water demands from billing data were calculated. Customer accounts were geocoded using meter address locations and street mapping. System diurnals and future demand forecast were calculated and allocated based on land use plans and population projections provided by the City.

Task 3 – Culinary Supply

An on-site investigation was performed on transmission and distribution facilities. The water supply plan from previous master plan was updated and extended to 2032 horizon. A one day water supply workshop was conducted with the City. The purpose of the workshop was to establish a policy for water rights and recommend a relationship with Central Iron County Water Conservancy District.

Task 4 – Culinary Transmission System

The existing water system model was rebuilt with GIS information and calibrated to existing operations. An extended period simulation with operational controls and diurnal patterns was created. The maximum day demand, calculated in Task 2, set was assigned to the model. A build-out model was developed from the existing system model to include future piping layout based on the master street plan.

A draft calibration plan was formulated and submitted to the City for review and approval. Based on the calibration plan, hydrant flows and pump tests were performed focusing on areas that did not calibrate well from the previous master plan study. The plan identified locations to perform the hydrant flow and pump tests. Brown and Caldwell coordinated the tests and the City provided the assistance in conducting the tests.

A computer model scenario for each hydrant test was developed. Model calibration results were compared to field data by measuring against calibration criteria. Results outside the established criteria were identified and adjustments to the model were made to satisfy results. Written suggestions for improvement were made for discrepancies of calibration at some test site locations.

The City extracted SCADA data of 24-hour flow, tank levels, and status for dynamic model calibration. The data was summarized and compared with model results. A model scenario was developed to simulate a 24-hour period of water usage. Results were compared to SCADA data. Operational settings and controls were adjusted in the model until satisfactory model results were obtained. Suggestions were made to improve the dynamic calibration for discrepancies at test locations.

A technical memorandum with criteria was created to be used in conjunction with the evaluation of water storage, transmission, and distribution system piping and the design of proposed improvements. This memorandum was an update to the criteria developed for the previous Master Plan.

Hydraulic capacities and reliability were evaluated for transmission system facilities. Recommendations were developed for identified problems and deficiencies in the system. A rehabilitation and replacement analysis of South Quichapa transmission was performed. A benefit/cost analysis was developed for South Quichapa rehabilitation and replacement analysis based on assumptions made by Brown and Caldwell and the City.

Task 5 – Culinary Water Storage

Existing culinary water storage was evaluated with the calibrated model. Water storage analysis consists of evaluating supply capacities, pressure zone boundaries, and optimizing storage tank levels in terms of filling and empting. Problems and deficiencies were identified and recommendations were created for improvements. The existing system hydraulic schematic from the previous master plan was updated.

Future storage capacity was analyzed for the build-out model. The analysis consisted of evaluation and recommendation of pressure zone boundary changes, potential new pressure zones, and potential future storage. The future system hydraulic schematic was updated from the previous master plan.

Task 6 – Culinary Water Distribution System

The existing distribution system was evaluated to determine its capacity to deliver water under peak day demand and fire flow conditions. Deficiencies due to pipe velocity, pipe diameter and fire flow were identified based on criteria established in Task 4. The following model scenarios were evaluated:

1. 24-hour maximum day demand and peak instantaneous demand.
2. Average of maximum day demand plus fire flow.

Future system evaluation was performed to accommodate future changes in water system service strategy, future development planning, and deficiencies in the existing system. Booster pump station operations were also evaluated in the model. Recommendations were developed to improve pump operations for existing and future conditions.

Task 7 – Secondary Irrigation

The existing secondary irrigation system model was re-evaluated. A new plan was developed and tailored to provide beneficial results in the near-term. The plan makes use of available supplies where needed most with a reasonable cost. Wastewater scalping was considered and evaluated as a secondary irrigation source.

Task 8 – Water Conservation

Conservation activities employed to date were reviewed and summarized. Conservation achievements were quantified and additional measures that would provide cost-effective reduction in water use were identified.

Task 9 – Report

Identified improvements were grouped into projects. Planning level cost estimates was prepared for each project. Previous bid tabs from construction projects were reviewed and utilized as a source of construction cost data.

A 25-year capital improvements plan (CIP) was developed for the distribution system. The CIP grouped improvements into projects and prioritized them in order of importance. A short-term plan was developed to address immediate needs with fire flow and water service issues. Projects were coordinated with mapping to illustrate required improvements\

A water master plan report (this document) was prepared and submitted to the City for adoption. As an update and in an effort to provide continuity, the report text from the previous plan was used and modified where needed to reflect the updated or new results from this study. In the Chapters that follow, the text is printed in italics where modified from the previous report.

GENERAL

The City's population growth continues to drive the need to develop additional water supplies. The subject demands particular concern as the City is supplied from a limited watershed that is shared with other growing communities; and, because all of the water within the basin is already fully appropriated. This section reviews water supplies currently in use, presents the quantity of water needed to meet the projected requirements for planning period and identifies the availability of supplies to meet those future needs.

EXISTING WATER SOURCES

The City's current culinary water *sources (diversions) and associated capacities* are listed in Table 2-1 and are shown in Figure 2-1.

Table 2-1 Culinary Water Source Summary

Source	Current Production Capacity (gpm)	Design Capacity (gpm)	Annual Production[1] (ac-ft)
Quichapa Well No. 1	*658*	*900*	*85.8*
Quichapa Well No. 3	*1,098*	*1,300*	*769.7*
Quichapa Well No. 5	*1,329*	*2,000*	*791.3*
Quichapa Well No. 6	*1,280*	*1,500*	*1827.0*
Quichapa Well No. 7	*1,134*	*1,500*	*616.7*
Enoch Well No. 1	*900*	*1,300*	*970.5*
Enoch Well No. 3	*1,924*	*1,500*	*467.0*
Spillsbury Springs	*200*	*225*	*297.0*
Shurtz Canyon Springs	*350*	*500*	*485.7*
Cedar Canyon Springs	*400*	*750*	*653.0*
Total	***9,273 (13.35 mgd)***	***11,475 (16.52 mgd)***	***6963.7***

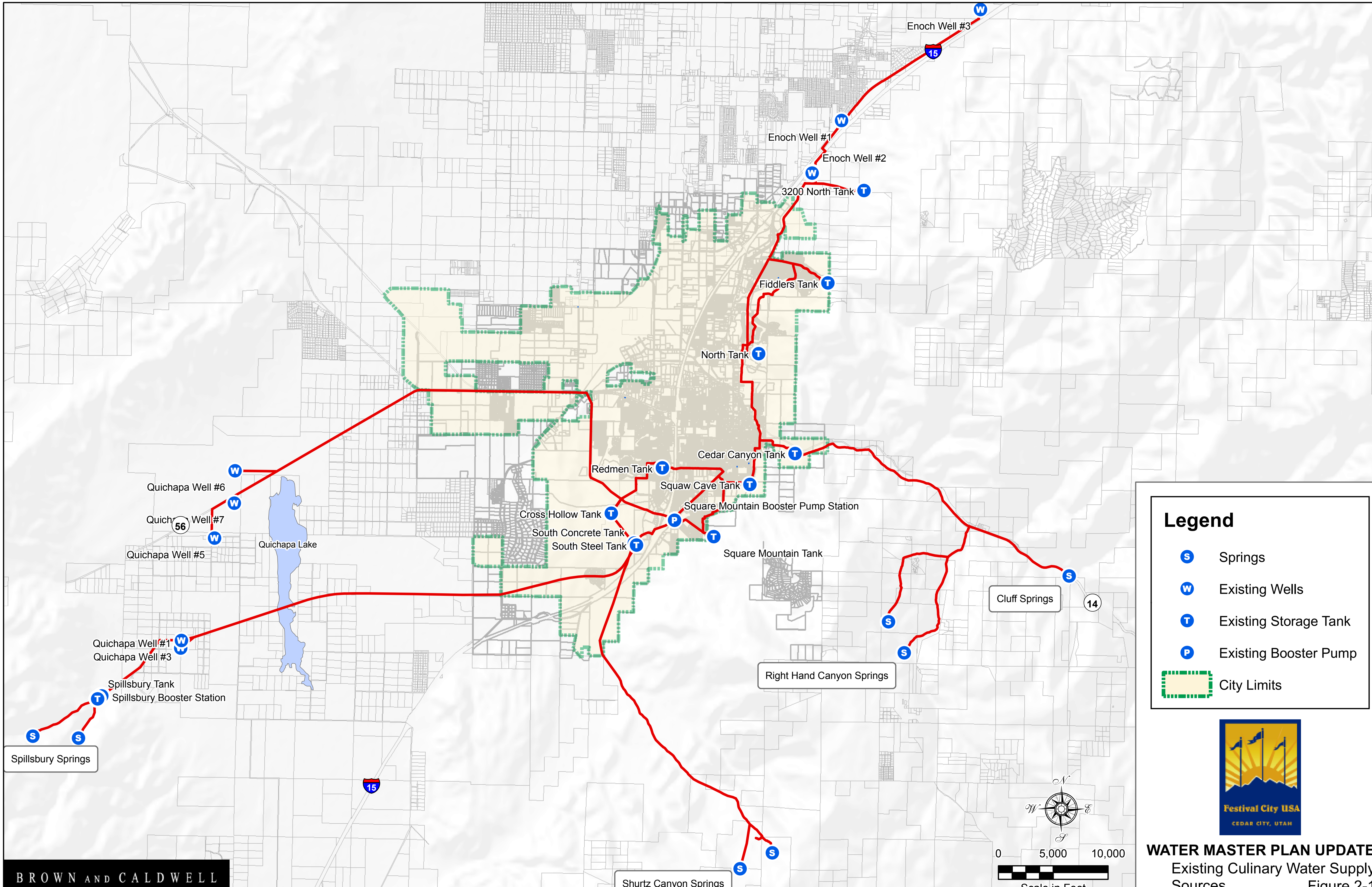
(1) Based on 2007 Annual Report.

Current production reflects reported well capacities under current operating conditions and average spring flow rate for each spring source. Design capacity is the original rated pump production and average summer (July) flow rate for the springs.

Cedar City currently has two wells available for secondary irrigation supply, Cemetery and Northfield Wells. The total water right of these wells is 5.0 cfs, or not to exceed 1,224 ac-ft annually. Current annual production is about 699 acre-ft.

A site visit was made to each of the wells to assess their condition. The springs could not be visited because of snow though City staff provided some comments regarding their condition. The assessment concluded that:

- *Wells are over pumping the aquifer. The water surface has declined significantly over time.*
- *Well pumps are changed so frequently that accurate records are difficult to maintain*
- *Not all wells have backup power*
- *High discharge pressures (300+ psi) at Quichapa wells exceeds manufacturer warranty*



BROWN AND CALDWELL

WATER MASTER PLAN UPDATE
Existing Culinary Water Supply Sources
Figure 2-1

- *Some wells need new well house*
- *Spring collector piping reportedly exposed, risk of failure and contamination.*

A more detailed summary of the findings of the supply facilities site visit is provided in Appendix B.

EXISTING WATER RIGHTS SUMMARY

City owned water rights include both surface and groundwater rights. Water rights documentation gathered during the course of the study has been compiled and included for reference in appendix A of this report.

Surface Water

The primary surface water rights owned by the City are in Coal Creek. They are currently used for irrigation. The City owns three rights in coal Creek totaling 2.51 cfs or 1.62 mgd. These water rights are listed below in Table 2-2.

Table 2-2 Coal Creek Water Rights

Source	Water Right No.	Flow	
		cfs	mgd
Coal Creek	73-423	0.38	0.25
Coal Creek	73-529	0.21	0.14
Coal Creek	73-1011	1.92	1.24
Total		**2.51**	**1.62**

In addition, the City owns shares in five irrigation companies which have water rights in Coal Creek. Table 2-3 shows the irrigation company stock owned by the City.

Table 2-3 Irrigation Water Stock

Irrigation Company	Total Company Shares	Cedar City Shares	Class	Water Yield/Shares (Acre-ft.)	Total Water (Acre-ft.)
North Fields Irrig. Co.	679.8	107.16	1	0.75	80.37
		119.75	3&4	0.75	89.81
		30.47	A	0.75	22.85
Subtotal					**193.03**
South Field	704.2	75.3205	1	0.75	56.49
West Field		93.08325	1	0.75	69.81
Subtotal					**126.30**
East Extension	744.25	7.5	1&2	0.75	5.63
		2.5	3&4	0.75	1.88
Subtotal					**7.51**
Bulldog Ditch	Approx. 520	84.027	A	0.75	63.02
Coal Creek	Approx. 9,100	514.2286	B	0.75	385.67
Total					**775.53**

(1) The City administers 34.08 shares

The average yield is 0.75 acre-feet per irrigation share. This may be less than the actual yield for the various irrigation companies; however, this provides a conservative estimate of the water that is available for use by Cedar City in the irrigation companies.

Groundwater

Cedar City's groundwater rights are, for the most part, already developed in the wells listed in Table 2-4 below. Some of the rights that remain undeveloped are in wells that have poor quality water or have extremely low yield. Ground water rights owned by the City are also listed in Table 2-4.

As noted in Table 2-4, some rights have been consolidated by change application and are used for multiple wells. For example, the five Quichapa Wells are under one change application that consolidated eight rights.

Table 2-4 Groundwater Rights

Source	Water Right No.	Diversion Limit (ac-ft)	Flow	
			cfs	gpm
Hidden Hills Cove Phase 1 Sycamore Trails PUD	*73-62*	*62.44*		
Enoch Well No. 1, 2 & 3	*73-131 73-161 73-1076 73-2373 73-2374 73-2375*	*61.0 325.6 1447.9 64.0 4.062 10.408*	*1.05 2.0*	*471 898*
Quichapa Well No. 1, 3, 4, 5, 6, 7	*73-361 73-1048 73-1919 73-2944*	*1,905.9 (1) 3,619.8 100.77*	*6.22 5.0*	*2,792 2,244*
Joe Burgess	*73-172 73-1770*	*4.2 11.6*		
Cemetery & Northfield Wells	*73-1023 73-2122*	*1,200 24.0*	*5.0*	*2244*
Morton's Flat Well	*73-151*	*181.0*	*0.25*	*112*
Underground Well (Cox Well Field)	*73-1093 73-1820 73-1831*	*2.19 4.37 4.37*	*0.016 0.006 0.006*	*7.18 2.69 2.69*
Steve Sevy Annexation	*73-154 73-155 73-156 73-189 73-190 73-1925*	*(2) (2) 64.232 159.104 99.12 2.498*		
Cedar City Industrial Park Well	*73-2477*	*32.6*	*0.045*	*20*
Cedar Park Townhomes PUD/Joe Burgess	*73-1088 73-1842*	*81.2 3.0*		
Sage Springs	*73-2203*	*2.0*		
Wallace & Marilyn Heap	*73-2334*	*2.0*		
Darla Allen	*73-2357*	*2.0*		
Ronald K. Stanley	*73-3250 73-3251*	*62.0 79.85*		
Amy Dixie	*73-3655*	*29.0*		

(1) Included in 73-361, (2) Included in 73-156

Springs

The City has water rights to several springs located generally in Cedar Canyon, Shurtz Canyon and near Quichapa (Spillsbury). Table 2-5 shows each springs water right and its approved flow. There is a total of 2.59 cfs in Cedar Canyon, 2.245 cfs in Shurtz Canyon and 20 cfs in the Quichapa area, which is called Spillsbury.

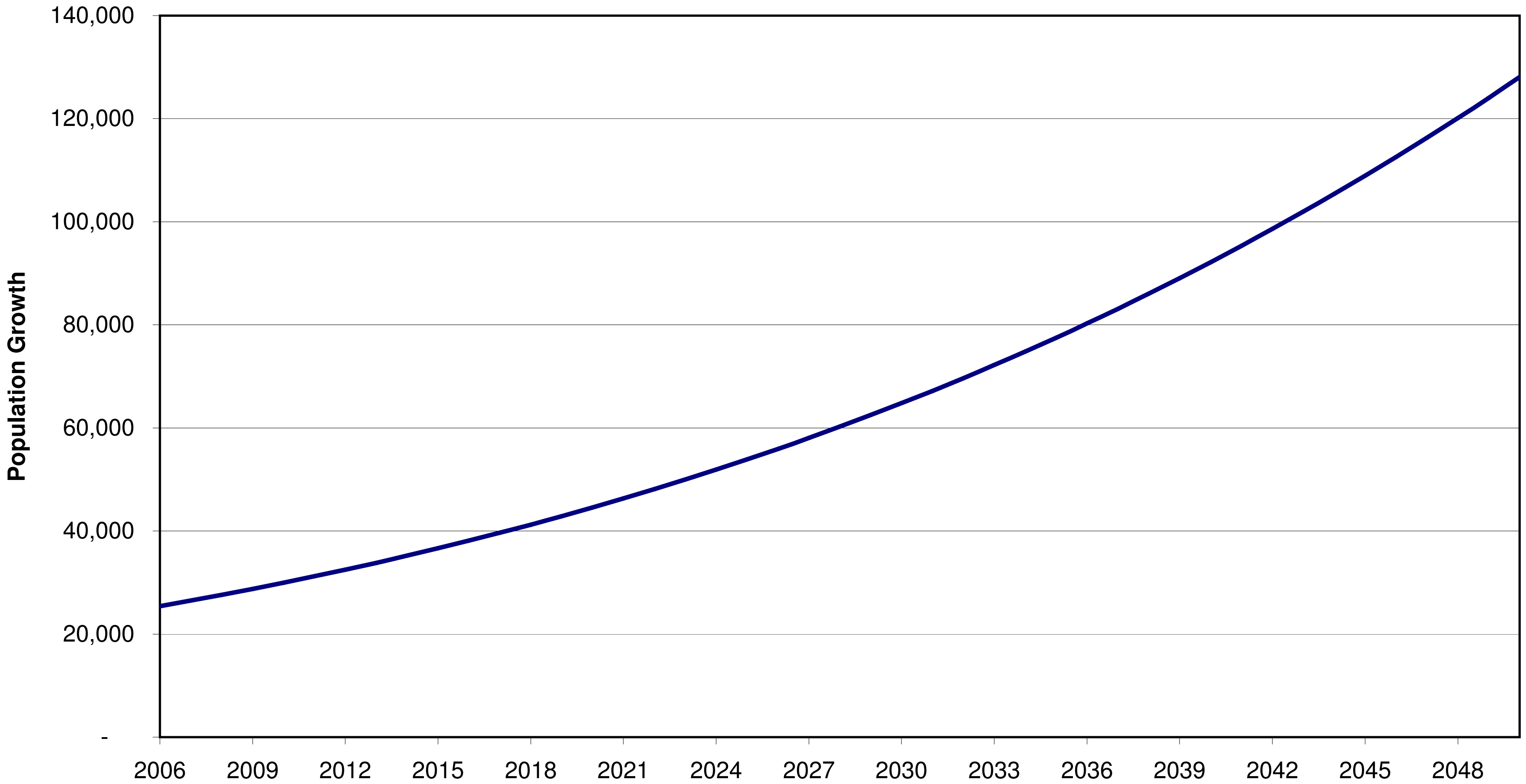
Table 2-5 Spring Water Rights

Water Right No.	Change Application	Source Name	Location of Diversion	Flow ac-ft	Flow cfs
Cedar Canyon Springs					
73-904	a1267	Cluff Spring	Sec 35, T36S R10W	609.8	1.26
73-956		Upper Barnson	Sec 5 T 37S R 10W	161.4	0.223
73-957		Lower Will Williams	Sec 5, T37S R10W	48.5	0.067
73-958		Dry Spring	Sec 32, T36S R10W	40.5	0.056
73-960		Barnson Trail	Sec 32, T36S R10W	120.9	0.167
73-961		Lower Head House	Sec 32, T36S R10 W	120.9	0.167
73-962		Raspberry	Sec 31, T36S R10W	48.5	0.067
73-963		White Rock	Sec 29, T36S R10W	161.4	0.223
73-1080		Upper Poise		(1)	(1)
73-1081		Lower Poise		(1)	(1)
73-1082		West Big		(1)	(1)
73-1083		East Big		(1)	(1)
73-1858	a1267	Chatterly	Sec 26, T36S R10W	260.6	0.36
		Total		**1572.5**	**2.59**
Shurtz Canyon Springs					
73-905				(3)	(3)
73-959		Upper Black Rock	Sec 32, T36S R11W	32.6	0.045
73-1896		Urie Spring	Sec 23, T37S R11W	59.0	0.25
73-2139	a1461	Birch Spring Upper	Sec 23, T37W R11W		
73-2139	a1461	Three Ledge No. 1	Sec 27 T37S R11W		
73-2139	a1461	Three Ledge No. 2		1182.6	1.95
73-2139	a1461	Three Ledge No. 3			
73-2139	a1461	Upper Poise No. 2			
		Total		**1274.2**	**2.245**
Spillsbury Springs					
73-866				(2)	(2)
73-990	a13127	3 Springs (Quichipa)	Sec 11, T37S R11W	1922.53	20.0
73-1001		Duncan Leeches Crk		(2)	(2)
73-1125		Watson Gulch		(2)	(2)
73-1133		Willow Spring Stream		(2)	(2)
		Total		**1922.53**	**20.0**

(1) Combined with 73-2139
(2) Combined with 73-990
(3) Covered by 73-1080, 73-1081, 73-1082, 73-1083

WATER USE PROJECTIONS

Projections of water use for the potable water system were developed. They were based primarily on projected population increase. The City provided population projections that projected to build-out year 2050. Figure 2-2 illustrates the projected growth pattern provided by the City.



PROJECTED POPULATION GROWTH

FIGURE 2-2

Projected water supply requirements for future needs are shown in Table 2-6. Average daily water use was calculated by multiplying population projections by a unit water use rate of 229 gallons per capita per day (gpd/capita). The unit use rate is an average based on 2007 population and water supply records. Maximum daily requirements are 2.28 times the average annual daily use.

Table 2-6 Projected Water Supply Needs

Year	Population	Projected Potable System Needs (mgd)	
		Average Daily	Maximum Daily
2007	26,480	6.06	13.85
2008	27,599	6.32	14.43
2010	29,961	6.86	15.67
2015	36,644	8.39	19.16
2020	44,566	10.20	23.30
2025	53,896	12.34	28.18
2032	69,663	15.95	36.42
2040	92,148	21.10	48.18
2050	128,078	29.33	66.97

By 2012, projected data indicates the City's current water supplies will be exhausted.

FUTURE WATER SUPPLY

Water for Cedar City is supplied from the Cedar Subarea basin. Previous studies indicate that the basin has a sustainable water yield of approximately 33,500 AF per year. All water within the basin is currently appropriated and existing use actually exceeds safe yield. This is confirmed by the City's well records which show a significant drop (ranges from 50 to 75 feet over the past 10 years) in aquifer levels even since the previous master plan. Studies performed for CICWCD, based on the projected demands in this report, forecast an additional aquifer water level decline of approximately 175 feet by the year 2040 if current withdrawal trends continue. A copy of the report is provided in Appendix B.

Since the basin cannot sustainably support additional withdrawals, any additional water use by the City and others within the Basin must be offset by reducing an equivalent amount of existing use, conservation, or importing water to the Basin.

Reducing equivalent use can be accomplished through purchase or other means to acquire both the right and convert existing diversions to a higher use. These include:

- *Water rights purchase or receipt through appropriate water rights turn in policy coupled with converting associated agricultural or other use to either potable or household irrigation use. Converting the use is a vital piece because there are more "paper" water rights than the available resource can support. It is estimated that at current population projections and water use rates, the entire available basin water resources will be required to serve potable uses. This is the direction currently being taken by the City to provide additional potable supplies. Studies performed by CICWCD indicate that this option can support the projected development in the Basin through approximately the year 2032. It should be noted that the City's current water right turn in policy does not require accompanying retirement of actual diversion.*

- *Treatment of wastewater effluent combined with aquifer recharge to convert current agricultural use to secondary irrigation supply or indirect potable use. This could be used to extend the available resource.*
- *Aquifer Recharge of Coal Creek flows to eliminate evaporation from Lake Quichapa. This will also extend the available resource by eliminating evaporation from the Lake and storing the water in the ground water aquifer.*

Elimination of current demand through conservation provides capacity for additional water supply development. Conservation opportunities are discussed in Section 3 of this report.

Trans-basin import options are currently being considered. These include Colorado River Water through the Lake Powell pipeline project and groundwater from Hamlin Valley, Pine Valley, and Wah-Wah Valley. Based on current regulations, imported water cannot be used to augment the groundwater resource through aquifer recharge. Therefore water imports must either be used as a secondary irrigation supply or be accompanied by surface water treatment prior to use as a potable supply.

FUTURE WATER SOURCE OPTIONS

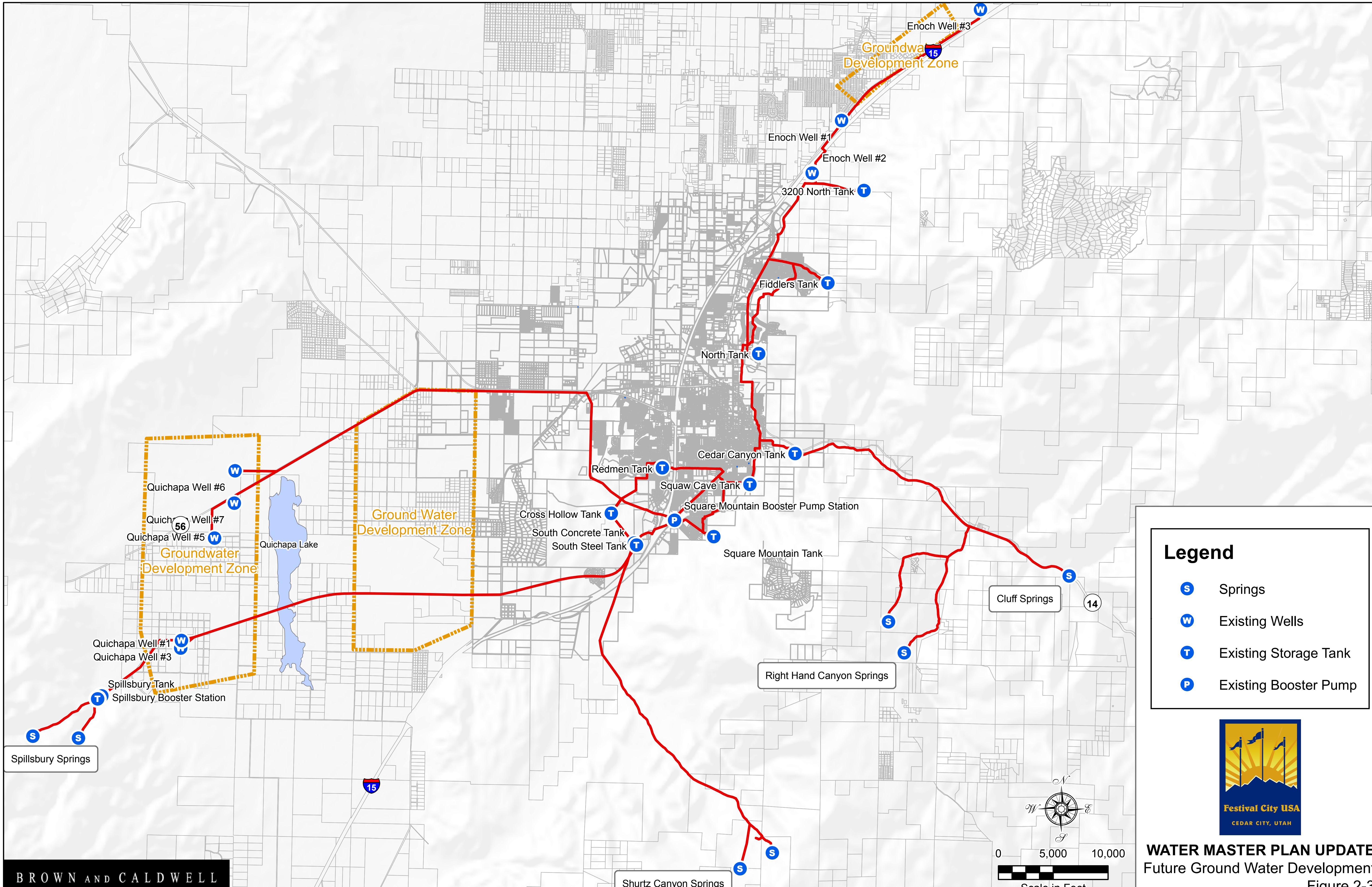
The City's future water source options for developing additional supplies for both potable and non-potable use include groundwater, aquifer storage, springs, surface water, blending, and wholesale purchase.

Groundwater

Currently, water supplies for the system are drawn from the Valley-Fill Aquifer through wells. Further supplies can be pumped from the aquifer by drilling new wells or possibly refurbishing existing agriculture wells associated with acquired water rights. However, new well diversions must be offset with retirement of equivalent existing groundwater withdrawals to avoid depletion of the aquifer. Development of up to 10 new wells west of the City, each producing 1,500 gallons per minute would be required to meet 2032 demand. Location may be dictated by hydraulic constraints of the distribution system and aquifer capacity. Based on the USGS groundwater study and discussions with Central Iron County Water Conservancy District, new well sources would best be located between South Westview Drive and Quichapa Lake, south of State Route 56 and near the existing Quichapa well field area. Figure 2-3 shows the area where water may be obtained. This area is considered to having high quality water supplies as indicated by the USGS groundwater study. New wells may also be sited in the vicinity of the existing Enoch wellfield. The number of additional wells to be drilled in Enoch area is three to meet 2032 demands.

Aquifer Storage and Recovery

Based on aquifer characteristics, aquifer storage and recovery (ASR) should be a viable option in the Cedar City Valley. ASR involves the temporary storage of excess water supply (usually through injection wells and/or infiltration basins) in an aquifer. This water is then stored in the aquifer until peak demand requires extraction and use. For example, it may be possible to recharge Coal Creek surface water during early spring (say March through May) in favorable areas (e.g., near the Enoch and Quichapa Well Fields), and this water, which would be added to storage, would then be pumped out during the remainder of the year. A strategy such as this, if possible, should help reduce water level declines that may occur as a result of over-pumping.



WATER MASTER PLAN UPDATE
Future Ground Water Development
Figure 2-3

Areas considered favorable for ASR are usually also those areas favorable for ground-water development. In the case of ASR, there has to be a thick enough unsaturated zone above the water table such that any ground-water mound that develops from injection or infiltration of water does not reach land surface. Both the Quichapa and Enoch well fields look favorable for ASR, with both areas having high transmissivities and relatively deep ground water (mostly greater than 50 feet below ground surface). As mentioned above, one source of water for recharge could be Coal Creek surface water during early through late spring runoff, depending on downstream demand for this water. *Surface spreading in aquifer recharge zones is the most cost effective method. Recharge zones have been identified by USGS. One of the most obvious locations for recharge is at the gravel pits near the City airport. Aquifer storage by direct injection would require treatment to drinking water standards before discharge to groundwater. Once treated, the water could be gravity fed (or pumped) to the Quichapa and/or Enoch well fields for injection through existing wells or new wells drilled for that purpose. It should be noted that a State permit for deliberate aquifer recharge is required.*

Springs

The City's water rights include the rights to several spring sources as listed in Table 2-5. It was not within the scope of this study to conduct an in-depth study of the feasibility of developing these sources. However, it does appear that there are significant water rights available, particularly in the Quichapa area, for additional spring water development. An important element of the City's water supply plan could be to fully develop these water rights.

Surface Water

A review of the flow records for Coal Creek indicates that the average annual flow in the creek is about 33 cfs for the period 1938 through 1996, with a low flow in dry years of about 6 cfs and a high flow in excess of 1,000 cfs. Without storage, the water supply from Coal Creek is highly variable. However, there still may be a supply sufficient to warrant the investment in either treatment or secondary irrigation uses of this water supply. This is dependent upon the amount of use by the other higher priority users on Coal Creek during the low flow period.

A review of limited water quality data prepared by the Utah Division of Water Quality indicates that Coal Creek water is of reasonable quality. For example, the Total Dissolved Solids (TDS), which is a key indicator of water quality, averages *350* mg/l with a range from a high of *750* mg/l to a low of 182 mg/l. A major concern with this water is the sediment loads carried by high flows. Careful attention must be paid to the handling of sediment for any water treatment facility used on Coal Creek.

Blending Low and High Quality Water

A means of increasing water supply for culinary use might be to blend low quality (ground or surface) water with existing high quality water. To get an estimate of the usefulness of this approach, a calculation was prepared that assumed a low quality source of 1000 mg/l TDS to be blended with a high quality source (Quichapa wells) of 150 mg/l TDS. The resultant product of this blending is shown on the following table:

Table 2-7 Water Quality Blending Comparison

Quichapa Water		Poor Quality Water		Product Water	
Flow (gpm)	TDS (ppm)	Flow (gpm)	TDS (ppm)	Flow (gpm)	TDS (ppm)
1,000	150	214	1,000	1,214	300
1,000	150	417	1,000	1,417	400
1,000	150	700	1,000	1,700	**500**
1,000	150	1,125	1,000	2,125	600

Based on this analysis, it is possible to substantially increase the culinary water supply by blending the two sources together, provided that the City's water customers are willing to tolerate a higher TDS level than they have been experiencing. The State Secondary Standard for TDS in drinking water is 500 mg/L.

CICWCD Wholesale System Connections

Central Iron County Water Conservancy District (*CICWCD) is constructing a wholesale water system to supply water to communities in Iron County. Phase I of construction is schedule for completion in 2008. The District's transmission facilities lie to the west of the developed portions of the City. Several points of connection convenient to the City's water distribution system have been identified. Hydraulic grades are planned to be higher than Cedar City's distribution system, facilitating deliveries to the City. However, information regarding available delivery capacities from the District system connection points was not available. The District will also serve as the wholesale agency for delivering Colorado River trans-basin diversion water from the Lake Powell Pipeline. The District has indicated that the price of water for sources developed within the basin will be competitive with the City's development of their own sources. Lake Powell water, however, will likely be significantly higher in cost due to the cost of diversion and pumping.*

CONCLUSIONS

Since the only resource currently available to the City is from a closed basin all water entering the basin will eventually either end up as groundwater or leave the basin by evaporation or other consumptive use. That means that groundwater diversions are the obvious choice in meeting future water needs. Surface water diversion coupled with treatment for potable use is more expensive than pumping groundwater and does not make sense if the water can be stored in and retrieved from groundwater aquifers with acceptable water quality characteristics. Surface water should be used where economically feasible as a secondary irrigation supply to offset potable demands. Further development of the City's secondary irrigation system would serve to reduce demands on the culinary system reducing the need to develop additional potable water sources. In addition to new wells, it is recommended that future sources include connection to the CICWCD wholesale system to provide reliability.

GENERAL

The purpose of Section 3 is to *review the effectiveness of the City's water conservation program and update the recommended implementation plan. The previous master plan reviewed the water conservation potential for Cedar City, described State Water Conservation Guidelines, profiled current water use, described the general benefits of saving water, and provided an implementation plan with selected conservation measures. This update provides ongoing guidance in the same direction with refinements based on current regulation as well as the efforts and results of the recommendations already implemented.*

STATE OF UTAH GUIDELINES FOR WATER UTILITIES

New water conservation rules have been adopted by the State of Utah since completion of the previous plan. The State of Utah Code, Title 73, Chapter 10, Section 32 (73-10-32) requires each "retail water provider" to prepare, adopt and file with the Division of Water Resources, a conservation plan. The Code was passed by the State Legislature in 2004 and amended to its current form in 2007. 73-10-32 outlines the requirements of the plan which include the following as taken directly from the Code:

- *a clearly stated overall water use reduction goal*
- *an implementation plan for each of the water conservation measures it chooses to use, including a timeline for action and an evaluation process to measure progress;*
- *a requirement to devote part of at least one regular meeting every five years of its governing body to a discussion and formal adoption of the water conservation plan, and allow public comment on it;*
- *a requirement that a notification procedure be implemented that includes the delivery of the water conservation plan to the media and to the governing body of each municipality and county served by the retail water provider; and*
- *a copy of the minutes of the meeting (public discussion and adoption) and the notification procedure which shall be added as an appendix to the plan.*

The Code further suggests that the water conservation plan may include information regarding:

- *the installation and use of water efficient fixtures and appliances, including toilets, shower fixtures, and faucets;*
- *residential and commercial landscapes and irrigation that require less water to maintain;*
- *more water efficient industrial and commercial processes involving the use of water;*
- *water reuse systems, both potable and not potable;*
- *distribution system leak repair;*
- *dissemination of public information regarding more efficient use of water, including public education programs, customer water use audits, and water saving demonstrations;*
- *water rate structures designed to encourage more efficient use of water;*
- *statutes, ordinances, codes, or regulations designed to encourage more efficient use of water by means such as water efficient fixtures and landscapes;*

- *incentives to implement water efficient techniques, including rebates to water users to encourage the implementation of more water efficient measures; and*
- *other measures designed to conserve water.*

From the provisions of 73-10-32 it is clear that the previous water conservation recommendations are consistent with the State's conservation plan requirements. However, there are several requirements associated with the implementation plan, adoption and notification that need to be added. The Code also requires that the plan be updated at a minimum every five years. Without conservation plan compliance (meaning adoption, notification and updating), the City is not eligible to receive State funds for water development.

PROFILE OF CURRENT WATER PRODUCTION

Table 3-1 provides a profile of updated indoor and outdoor water use as well as un-metered water (UMW), as recorded by the City's billing system. The current profile is somewhat different than situation reported in the previous master plan. While the volume of indoor use over the past 10 years increased only slightly, outdoor use doubled and total UMW actually decreased.

Table 3-1 Updated Water Use Profile

Water Use	2007 Total Use (gal)	2007 Percent Total	1997 Total Use (gal)	1997 Percent Total
Indoor Use	800,569,911	36%	781,097,972	48%
Outdoor use	1,198,816,989	54%	540,365,894	34%
Total Billed	1,999,386,900		1,321,463,866	
Un-Metered	213,699,700	10%	290,077,434	18%
Production	2,213,086,600		1,611,541,300	

Obviously, outdoor water use makes up the largest portion of the City's water use and as a result, water demands for the culinary water system increase substantially in the summer. Peak summer water use may be more than six times average winter use.

The previous profile also divided indoor and outdoor use between residential and non-residential use categories. This information was not available for this study. However, it is recommended that additional study be performed by the City to examine these trends as well to determine if one category should be targeted for conservation measures above another.

Growth

It is expected that Cedar City will continue to experience significant growth. Since completion of the previous plan, population has increased from 18,398 to 26,480 (2007), or about 3.7 percent annually. As presented in Section 2, the expected population in 2032 is 69,663, an annual increase of about 3.94 percent. This represents a 25 year growth of 163 percent over current

(2007) numbers. Therefore, water conservation programs should be designed for both existing and future customers.

Summary of Where to Place Conservation Effort

From the perspective of deferring proposed water capital improvement projects, the reduction of summer peak-day water use would be effective. Prime targets to reduce peak-day use are the exterior uses by single families and by public agencies. Improved efficiency at local government-owned sites would target concentrations of turf (parks and playing fields) and set a good example and establish credibility with the general public. *The recommended conservation measures of the previous plan focused on these priorities and they continue to be the focus of this update.*

GENERAL BENEFITS FROM SAVING WATER

Quantifiable benefits to Cedar City by reducing water demand include:

- Reduction in operation and maintenance (O&M) expenses resulting from lower pumping energy
- Deferral or downsizing of capital facilities- Lowering the rate of increase in demand can postpone facility construction and, in cases where growth is slowing, avoid the next water supply or treatment increment. The types of water utility capital facilities most likely affected include water storage reservoirs, raw-water transmission facilities, *new well development*, finished water storage, and *booster* pumping stations. Fewer or smaller facilities also reduce staffing costs.

In addition, wastewater utilities can benefit from reduced indoor water use which translates into reduced wastewater flows. While this reduces O&M costs of existing facilities, wastewater capital facilities are less affected because most are designed for peak wet weather flow, which is not significantly affected by reduced average dry weather flows.

A balanced perspective should also consider the reduction in water revenues. Conservation programs can suppress water sales, lowering revenues. If the reduction occurs slowly, say less than 1 percent per year *(as has been the case over the past 10 years since the initial plan formulation)*, then the revenue loss impacts can be mitigated by periodic rate adjustments. These adjustments would be handled similar to operating cost increases due to inflation and can be integrated into financial planning.

PREVIOUS PROGRAM

The previous plan consisted of three programs:

1. *System Water Audits and Leak Detection*
2. *Public Information*
3. *Non-Promotional Pricing*

The previous water conservation recommendations were developed by evaluating the water savings and cost-effectiveness of typical conservation Best Management Practices (BMPs). The water savings are computed by multiplying unit water savings, per measure, by a market penetration or installation rate, and then multiplying by the number of units in a particular service area, such as dwelling units targeted by a particular program. Cost-effectiveness was evaluated by first estimating costs and then computing the cost of water saved. The evaluation was done using the expected population growth.

The cost-effectiveness was evaluated in terms of the cost of water saved, in dollars per 1000 gallons. This was computed by dividing the present worth of the initial and/or annual costs by the total water saved over the next *25* years. Table *3-2* shows the results of the previous analysis. Measures that were selected for the plan are indicated by an "x" in the last column. The residential retrofit and *ultra low flush* (ULF) toilet replacement measures were not selected because they overlap with the conservation due to the natural replacement of fixtures. The other measures not selected either offered too little water savings or *came* at too high a cost.

Table *3-2* Cost-Effectiveness of Measures

Measure	Total Water Saved (mil gal)	Unit Cost of Water Saved ($/1000 gal)	Recommended For Plan
Residential Water Surveys	80	0.60	
Residential Retrofit	955	0.45	
System Water Audits, Leak Detection and Repair	3895	0.15	X
Non-Residential Landscape Ordinance	399	0.28	
Large Landscape Conservation and Incentives	253	1.47	
High-Efficiency Appliance Promotion	136	0.55	
Public Information	772	0.22	X
Com/Ind/Inst Conservation	49	1.70	
Non-Promotional Pricing	1642	0.02	X
Residential ULF Toilet Replacement	363	0.69	
Non-Res ULF Toilet Replacement	228	0.49	

Also included in the plan was the naturally occurring conservation due to plumbing fixture replacement.

Shown in Table 3-3 are the savings expected for the previously recommended plan. Note that the percentage of total water use reduction is 8 percent in water use (billings) by 2022. Expected savings in production, which include reduction of unaccounted for water was considerably more, 14 percent. The annual costs also vary with population, as more budget is required to reduce demand in a larger system. Overall the plan was to save 1.6 mgd by 2022. The unit cost of the water saved was projected to be $0.10 per 1000 gallons saved or $33 per acre-foot saved. The reason this is so low is that the naturally occurring conservation due to plumbing fixture replacement is free, the cost to adjust the rates is just the cost of the rate study, the public information is inexpensive and whereas the system water audits leak detect costs are relatively high, the water saved should also be high. In other words water conservation was determined to be an excellent investment for Cedar City. It is doubtful that additional supplies could be developed, treated, and distributed for such a low cost.

Table 3-3 Previously Recommended Plan for Savings

Measure	Water Saved-High Growth (mgd 2022)	Annual Cost ($/year)
System Water Audits	0.84	45,000
Public Information	0.13	12,500
Non-Promotional Pricing	0.39	2,000
Total Savings Due to Measures	1.36	59,500
Natural Fixtures Replacement	0.20	0
Grand Total Water Savings	1.56	59,500
Savings in Water Use, %	8.08	
Savings in Production, %	14.37	

The selected programs for the previous plan are described in more detail in the following paragraphs.

System Water Audits Leak Detection and Repair

Some system water losses, or unaccounted-for water (UAW), are authorized. The purpose of this measure is to reduce unauthorized use of water such as leaks from older and broken pipes, joints, or valves. Up to 40 percent of all UAW can be attributed to leaks. For example, if the UAW is greater than 10 percent of total production, then the leakage could be 4 percent, and the City may find a leak-detection and repair program beneficial. Lower UAW levels usually indicate that leak-detection and repair would not be cost-effective.

This goal involves reducing UAW, as a percentage of production to 10 percent. In many cases the easy savings have probably been found and the City will need to move into leak detection and repair to get the value less than 10 percent.

Every year a preliminary system water audit would be completed by the City. The audit would involve the following steps:

1. Determine metered sales
2. Determine other system verifiable uses
3. Determine total supply into system
4. Divide metered sales plus other verifiable uses by total supply into the system to determine UAW. If this quantity is less than 0.9 (more than 10 percent UAW), a full scale audit is needed.

When needed Cedar City would complete water audits of their distribution systems using a methodology consistent with that described in AWWA's "Water Audit and Leak Detection Guidebook."

Where the water audit indicates that leak detection and repair would be cost-effective, Cedar City would initiate a leak-detection and repair program. In addition, Cedar City would check customer bills for extreme changes that may indicate a leak on the customer's property. This step can be automated by programming the billing system to flag water bills with consumption greater than 25 percent of the previous year's consumption. The City would encourage these customers to look for leaks.

Cedar City will need to conduct water distribution piping leak detection surveys and repair leaks discovered during the surveys. The goal of the program should be to begin inspection of the pipes in older downtown areas, then working outward to the outer limits the service area until all the piping has been inspected. The desired time to inspect all water distribution pipes for leaks is on the order of four years. Re-inspection of the pipes will begin upon the completion of the first overall survey and subsequent repairs. Leak survey equipment will be used in the initial survey. When a leak is located a crew with a leak detector would be called in to pinpoint the leak. The leak is then found and fixed by a repair crew.

Most of the work conducted by each leak detection and repair crew involves surveying the water distribution lines systematically. However, sometimes a water use customer calls the City concerned that his/her water bill is unusually high. In this case, an investigator would assess the situation with leak detection equipment to determine if in fact a leak is present on the property. If a leak is present, then it is the customer's responsibility to have the leak repaired. The only instance that the City would repair the leak is if City personnel caused the break in the pipe during the investigation.

Public Information

This measure would expand existing public information efforts. It serves as the 'glue' to tie all the other measures together. It would not only address specific measures but also cultural/social aspects of establishing or enhancing a water conservation ethic among the Cedar City customers; most 'importantly, it would convey to the public an understanding of why water conservation is important. Programs include theatrical productions, poster contests, T-shirt design contests, speakers to employee and community groups, presentations and tours with hands-on demonstrations; radio and television time, and printed educational material such as bill inserts. Utilities will attempt to put the water use from the same period in the prior year on customer water bills. Public education would continue to be used to raise awareness of other conservation measures available to Cedar City customers.

A public information program needs goals, staff, materials and a theme to be effective. The program will also need an annual budget to carry out the program. The following steps could be used to add the new program:

- Develop a clean and persuasive statement purpose
- Choose an appropriate theme
- Identify key target groups
- Select members for a water conservation committee
- Identify communication paths, resource materials, and volunteers

- Design and implement specific campaigns
- Ensure effective coordination and follow-through

This measure targets all customers within the Cedar City service area. The coordinator would develop the program following the steps listed above. Once a purpose statement has been created, a water conservation theme would be decided upon. This could be based on the results of this study which will identify where most of the conservation benefits will come from.

A program logo reflecting the theme should then be selected. The image could be realistic, stylized, or a friendly caricature; and it should be given a suitable name. This theme can be retained or modified as needed in the future.

A public information specialist would likely devote most of their time to public education. Additional staff may be involved to help by educating the public through a speakers bureau, tours, producing bill inserts, creating displays at fairs and nurseries, giving presentations, and creating low water-use gardens. This program will likely be carried out with in-house staff. Certain parts of the development could be contracted out, such as graphics and printing. A water conservation committee could be created to receive input from consumers affected by the program, to advise the water conservation coordinator about new programs, materials, and means of communicating with target groups; assist in ideas; and help develop and implement specific education programs. The committee could consist of an elected official as chairperson, representatives of interested agencies and parties, and technical personnel.

To convey to the customers the importance of water conservation, the program may seek to explain why construction of water facilities may be necessary if water conservation is not practiced, how much these facilities would cost, and then compare these costs to what benefits can be received from conserving water. Public information would be used to promote the other selected conservation programs as well.

The various media forms including bill inserts, ads, and television and radio spots can be used to instill a conservation ethic in the community. Specific material compliments the other programs such as free audit programs so that the customers are aware of how to take advantage of existing conservation programs. For example, a spring bill insert could publicize the availability of irrigation audits to qualified customers (larger water users) or the availability of free water audit or retrofit kits for homeowners.

Low water use landscaping is often promoted through demonstration gardens and brochures, developed through a public education program. Cedar City could start a Xeriscape program that could include demonstration gardens at the water department's office.

Non-Promotional Water Pricing

Under this measure Cedar City would modify their existing water rate structures to target reducing consumption. Traditional objectives in rate structure design include that the rates be based on the costs to serve, that they provide adequate and stable revenues, that they be fair or equitable among customer classes and volume users, and that they be easy to implement and administer. Non-promotional or conservation rates provide a financial incentive to ratepayers to reduce their water use, usually by applying a surcharge on peak months' usage or by charging a higher unit rate for water as more units are used. These rates are often not based on historical costs to serve each customer group or rate block and therefore are held, by some ratepayers, to be unfair. It is, therefore, essential that new rates be developed through a public process that assures acceptance of the purpose and design of the rate structure. It is important to recognize that, for whatever new type of rate structure selected, greater leverage can be achieved from a combination of price with indoor and outdoor conservation programs than from price alone. Non-promotional water pricing makes the most sense as part of a broad demand management program.

In the evaluation of water rate alternatives two types of rates were considered: Rates with relatively low water allowances in the service charge, and inclining block rates. There are other rate forms that can be considered. Also most utilities have different rates for different classes of customers.

Non-promotional rates, especially inclining block rates, are sometimes perceived by ratepayers as being unfair. Public hearings will be required to hear the rate payers sentiments and to respond to them regarding the purpose of the rates and the design of the rate structure. Non-promotion rates should be presented to the public more as a subtle, but constant, reminder that water is a precious commodity that should not be wasted than as an unyielding deterrent to water use for traditionally acceptable applications. The public should be reminded that they can minimize the effect of rate shock by implementing the various conservation measures that Cedar City endorses, whether or not they are chosen as participants in the programs that are restricted (for budget and practical implementation reasons) to a limited number of participants per year.

IMPLEMENTATION PROGRESS

Since the completion of the previous plan, the City has begun implementation of all three recommended conservation measures. In addition, the City has adopted a daytime water restriction ordinance, not mentioned in the previous plan. And, the City has implemented customer water surveys and large landscape conservation incentives as conservation measures that were also not part of the recommended plan but were listed as BMPs considered during plan development.

The non-promotional water pricing, the customer water survey, and the large landscape conservation incentive measures were enacted under City Council Resolution No. 05-0126 in January of 2005. The resolution established an inclining block water rate schedule with the stated intent to encourage water conservation. A copy of the Resolution along with the specific of the rates and structure can be found in Appendix C of this report. The resolution mandated the offering of water audits for both culinary and pressurized irrigation water system customers as a public service "to identify and recommend specific water conservation measures." It also established a classification for large irrigation users and required a separate irrigation meter or connection to the City's pressurized irrigation system. The resolution assigns a monthly water allotment to each user based on acreage and evapotranspiration rates. A separate rate for large irrigation users (for culinary or pressurized irrigation system) was established based on the allotments to encourage irrigation efficiency and conservation.

The City's public education efforts have included the following:

- *The City's annual "Consumer Confidence Report" includes water conservation tips and educational information. This is mailed out to all Cedar City residents in June or July of each year.*
- *The City's monthly newsletter. The newsletter is sent with the customer's monthly billing. Water conservation information is often included in the newsletter.*
- *The State's "Slow the Flow" campaign. The campaign provides water conservation information via television and radio.*

Each year as part of the City's annual water report, a system-wide audit of leakage and unaccounted-for water is performed. In addition, the City performed an actual leak detection survey several years ago and the system was reportedly found to be "pretty tight". Specific results of the survey and the annual audits were not available for this report but the City indicated that their UAW percentage was currently at 6.2 percent.

Cedar City has also adopted an ordinance (City Ordinance Section 37-7-1) to restrict daytime watering using culinary water. The purpose is to improve irrigation efficiency by reducing evaporation. Outside watering from the culinary system is restricted between the hours of 8:00 AM and 6:00 PM. The City strictly enforces this regulation during the summer. Under certain circumstances, a variance can be given by the City Engineer.

EVALUATION OF CONSERVATION PROGRAM EFFECTIVENESS

The previous plan provided a number of indicators and conservation milestones that can be used to measure progress or identify a trend. They include:

- *Reduction of UAW below 10 percent*
- *14.3% savings in water production*
- *8.1% savings in water use (billings) by 2022*

There are some indications that the City has made significant progress in conserving water. These include reductions in unit water use rates and in percent UMW and UAW water. Since 1997 the unit water use rate (water production divided by population) has steadily fallen from an average rate of 261 gpcd to 229 gpcd in 2007. This represents a reduction of approximately 14 percent. The UMW water percentage (related to UAW) as well as volume have also fallen. The ratio of UMW to total water production fell from 18 percent in 1997 to 10 percent in 2007. And, at 6.2 percent, the UAW percentage is less than the goal of 10 percent.

Additional water conservation trends can be seen by comparing the change in water use to the corresponding increase in population since the previous plan. Table 3-4 summarizes the increase of indoor, outdoor, billed, un-metered water use as well as total water production and population over the past 10 years. The table reveals that increase in indoor water usage was nearly flat. Outdoor water use, on the other hand, increased substantially. Un-metered water use actually declined. However, the decline was offset by a corresponding increase in billed water use which suggests that the City's accounting of billed water use has improved (which should have translated to better water revenues). Overall, water production increased more slowly than population over the same time period, suggesting that conservation achieved to date is about 7 percent. That is halfway to the program's total water conservation goal of 14 percent.

Table 3-4 Water Conservation Trends

Water Use	Production Volume (gal)		Increase		
	1997	2007	Amount (gal)	% Total	% Annual
Indoor	781,097,972	800,569,911	19,471,939	2%	0.25%
Outdoor	540,365,894	1,198,816,989	658,451,095	122%	8.29%
Billed	1,321,463,866	1,999,386,900	677,923,034	51%	4.23%
Un-Metered	290,077,434	213,699,700	(76,377,734)	-26%	-3.01%
Production	1,611,541,300	2,213,086,600	601,545,300	37%	3.22%
Population	**1997**	**2007**	**Amount**	**% Total**	**% Annual**
	18,398	26,480	8,082	44%	3.70%

From the trends, it would also appear that much of the savings are attributable to the reduction of indoor water use as well as elimination of some water losses such as leaks or storage tank overflows. It can be concluded that the City's conservation efforts have been very successful. It should be noted however that additional savings could be accomplished in reducing outdoor water use since it grew at much greater rate than the rate of population growth.

RECOMMENDED PROGRAM UPDATES

The same measures recommended in the previous plan are again recommended for this plan update. No additional measures are recommended. While all of the recommended measures have been implemented to one degree or another, not all of the activities associated with each measure have been fully implemented. Conservation efforts should be continued with increased focus on outdoor water use to accomplish the savings goal. All other measures already implemented by the City should be continued. Specific ongoing or improved efforts are detailed in the following paragraphs.

System Water Audits Leak Detection and Repair

UAW is less than 10 percent and leak detection project confirmed that water losses from leaks are insignificant. Thus a leak detection and repair program would not be cost effective. However, the City should continue to perform the annual audit as well as monitor customer billing for extreme changes in individual customer usage as a maintenance measure.

Public Information

The City has a good beginning to a public information program but more could be accomplished. An improved campaign should be developed, focused on areas where greatest conservation can be achieved (like outdoor use). The State has a number of public information documents already prepared that could be used to augment the City's efforts. The City could increase its level of communication to customers through the newsletter by providing more frequent conservation related information. The City could also employ or designate an existing employee (ideally a public information specialist) to devote part of their time to public education *around conservation. And, the City could incorporate a xeriscape demonstration garden into one of its parks or building landscapes.*

Non-Promotional Water Pricing

Rates should be reviewed periodically both to quantify the initial impact as well as to see that the conservation effect continues over time. Some adjustment to the rates may be considered at the time they are up for an increase for financial reasons in response to the results of the monitoring. Additional rate adjustments combined with increased focus through a public information program may be effective in further reducing outdoor water usage.

OTHER IMPLEMENTATION CONSIDERATIONS

In addition to the program update recommendations, the following should be addressed by the City in their conservation plan and program to comply with the State of Utah requirements:

1. *Establishment of a timeline for action and an evaluation process to measure progress for all conservation measures.*
2. *One City Council meeting every 5 years to discuss and adopt the conservation plan with provisions for public comment. A copy of the meeting minutes should be attached to the plan as an appendix.*
3. *Delivery of the plan to City leaders, Iron County and the media.*
4. *The plan should include a drought/emergency element.*

GENERAL

Cedar City's existing culinary water system is comprised of a pipe network, water storage facilities, a transmission system and water supply facilities. Figure 4-1, "Existing Water Distribution System Map" represents the current water system. This section contains detailed discussion of the water distribution system and its operation.

DISTRIBUTION PIPE NETWORK

The Cedar City culinary water distribution system consists primarily of a network of pipes, ranging in size from 1 to 20 inches in diameter. *The majority of pipes are constructed of a variety of materials including ductile or cast iron and galvanized steel, with a few polyvinylchloride (PVC) material.* Table 4-1 summarizes the length of pipe in the distribution system by diameter.

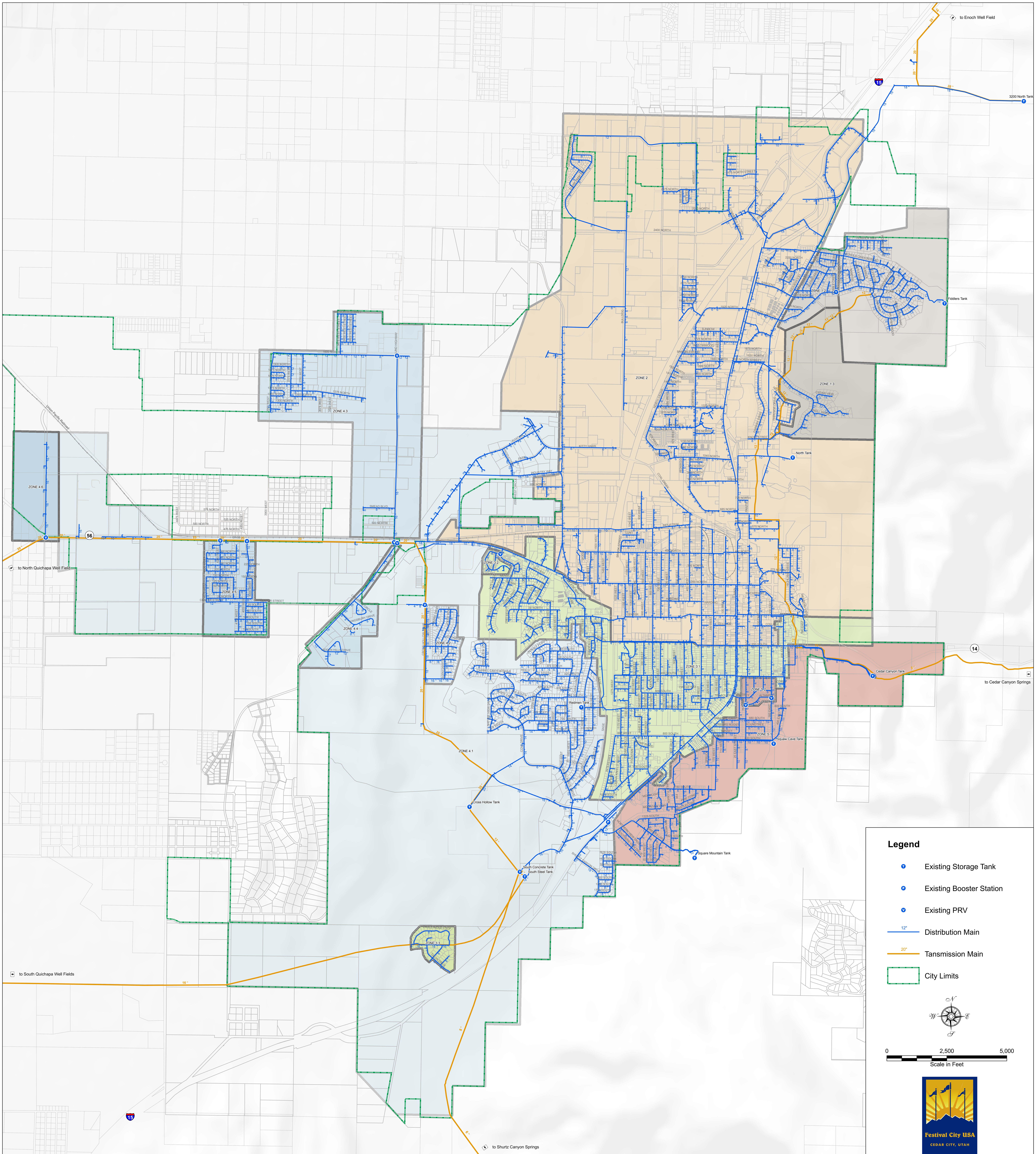
Table 4-1 Existing Water System Pipe Summary

Pipe Diameter (inches)	Total Pipe Length (ft)[1]
1	537
1.5	419
2	12,657
3	4,442
4	80,938
6	276,804
8	260,929
10	115,138
12	111,914
14	18,235
16	89,436
18	42,054
20	64,506
Total	1,078,009

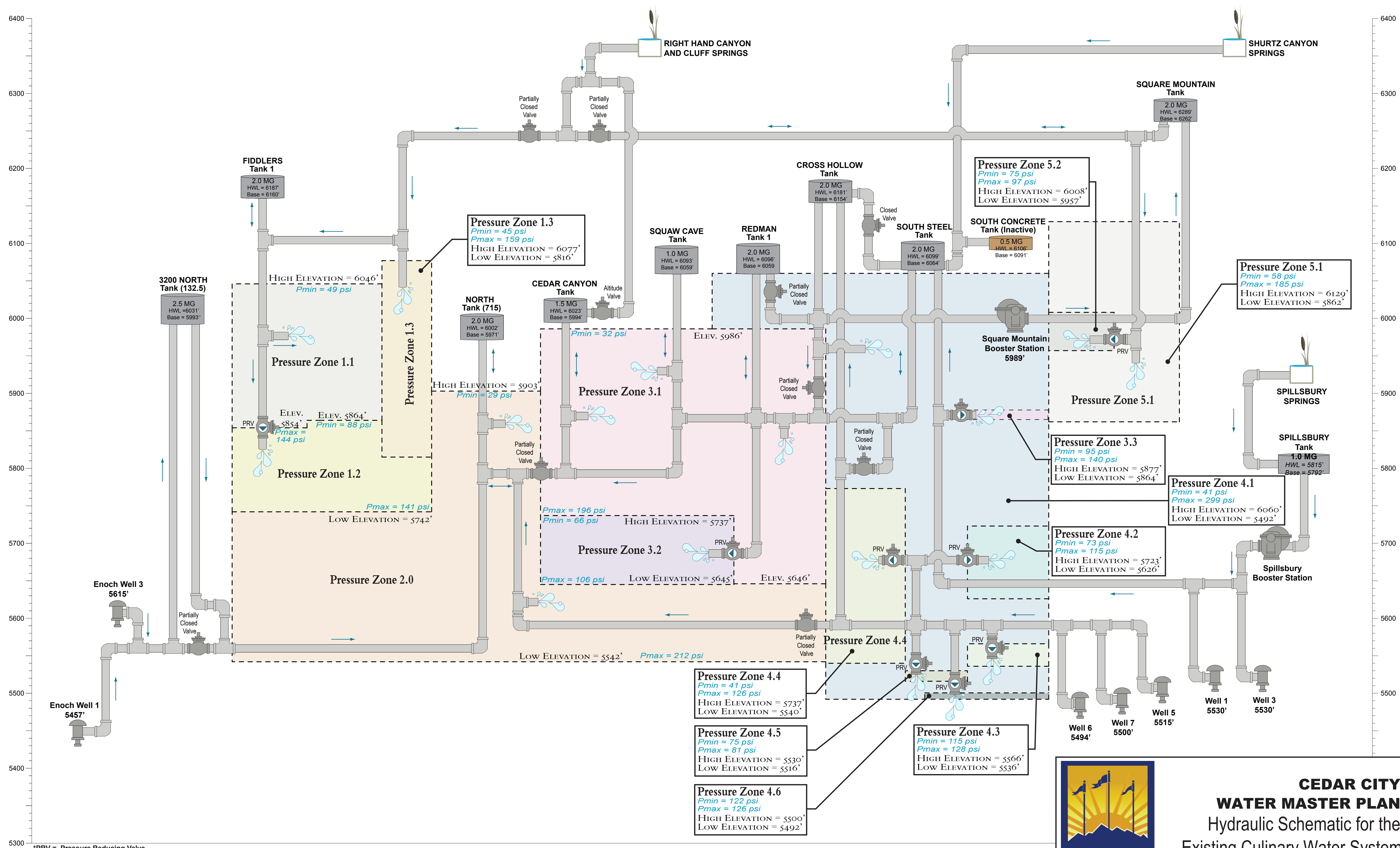
(1) Calculated from GIS. Does not include service connections or hydrant laterals

The current distribution pipe network has five main pressure zones. There are also ten sub-zones within four of the five pressure zones. Figure 4-1 differentiates each pressure zone by color. Pressure zone boundaries are bounded by pressure reducing valves (PRV), isolation valves, and separation of distribution piping. The hydraulic grade in each pressure zone is governed by the water level in the storage tank(s) that serve it.

A *hydraulic* schematic of the culinary distribution system is illustrated in Figure 4-2. The schematic provides comparisons of operating conditions within each pressure zone. The pressures represent static conditions, neglecting headloss due to flow of water in the pipes. High and low pressure ranges are based on minimum and maximum ground surface elevations within pressure zone boundaries and high and low water levels in tanks.



BROWN AND CALDWELL	PROJECT NO. 134355	PROJECT	CEDAR CITY WATER MASTER PLAN UPDATE	Figure
	REVISED DATE 06-19-09	TITLE	Existing Culinary Water System	4-1



BROWN AND CALDWELL

Festival City USA
CEDAR CITY, UTAH

CEDAR CITY
WATER MASTER PLAN
Hydraulic Schematic for the Existing Culinary Water System
Figure 4-2

STORAGE

Cedar City operates and maintains 11 water storage tanks. *Table 4-2 lists each tank and their specifications. The tanks have combined total storage capacity of about 18 million gallons. Most tanks, with the exception of South Concrete Tank,* are of steel construction. *However, one of the 11 storage tanks used to serve the distribution system, South Concrete Tank, is currently not active due to structural damage. Ten storage tanks* are used to serve the distribution system directly, providing operational and emergency storage.

Table 4-2 Existing Storage Facilities Summary

Storage Facility	Capacity[(1)] (gal)	Dimensions		Elevations		Pressure Zone Served	SCADA
		Depth (ft)	Diameter (ft)	Base (ft)	Overflow (ft)		
North Tank	*2,086,858*	*32.0*	105.36	5970.86	*6000.86*	2	Yes
Cedar Canyon Tank	*1,522,468*	*30.0*	92.95	5993.70	*6021.70*	2	Yes
Squaw Cave Tank	*945,189*	*35.0*	67.80	6059.00	*6092.00*	3	Yes
Square Mtn Tank	*2,159,787*	*28.0*	114.59	6262.31	*6288.31*	5	Yes
Fiddlers Tank	*2,159,787*	*28.0*	114.59	6159.78	*6185.78*	1	Yes
Cross Hollow Tank	*2,159,787*	*28.0*	114.59	6154.15	*6180.15*	4	Yes
South Steel Tank	*2,039,439*	*36.0*	98.19	6063.92	*6097.92*	3	Yes
South Concrete Tank	*502,505*	*16.5*	72.00	6090.69	*6105.19*	3	Yes
Redmen Tank	*1,928,325*	*38.0*	92.95	6059.00	*6095.00*	3	Yes
Spillsbury Tank	*105,934*	*24.0*	28.00	5792.00	5815.00	*(2)*	Yes
3200 North Tank	*2,461,238*	*39.5*	*105.00*	*5993.00*	*6031.00*	*2*	*Yes*
Total	**18,071,317**						

(1) Capacity calculated from diameter and depth to overflow
(2) Transmission system storage only. Does not directly serve a specific distribution system pressure zone

Spillsbury Tank does not serve the distribution system directly. Its purpose is to store spring water from the Spillsbury springs located south of the Quichapa well field, west of town. Water is pumped from the Spillsbury reservoir to the South Steel and Concrete Tanks for distribution into the system.

Cross Hollow Tank serves the distribution and transmission systems. It is filled from Quichapa Wells 5, 6 and 7. It distributes water to Pressure Zone No. 4, as well as Redman and Square Mountain Tanks serving Pressure Zones 3 and 5.

Supply Facilities

Water for the culinary distribution system is supplied from springs and wells. There are seven active wells located in two separate well fields. All wells have a combined design production capacity of *10,400* gallons per minute *or 14.98 million gallons per day*. Because of draw-down, headloss and age of equipment, however, only *8300* gpm or *11.95 million gallons per day* can reportedly be delivered. There are also three main spring sources with a combined average flow of *950* gpm.

Table 4-3 represents the summary of well supply sources. More detailed information about each of the pumps can be found in Appendix B, including well logs, pump tests and available pump curves.

Table 4-3 Existing Culinary Well Facility Summary

Well	Pump					Well		
	Current Production (gpm)	Design Capacity (gpm)	Design TDH (ft)	Motor Horse power	Bowl Depth (ft)	Casing Diameter (in)	Depth (ft)	Drawdown (ft) (1)
Quichapa No.1	*658*	*1,300*	*810*	300	*220*	16	336	*175*
Quichapa No.3	*1,098*	*1,300*	*833*	350	*250*	16	697	*200*
Quichapa No.5	*1,329*	*2,000*	*1,050*	600	*250*	16	1,006	*170*
Quichapa No.6	*1,280*	*1,500*	*965*	600	*200*	16	604	*135*
Quichapa No.7	*1,134*	*1,500*	*965*	*450*	*250*	16	1,020	*180*
Enoch No. 1 (South)	*900*	*1,300*	*680*	*400*	*350*	*16*	*875*	*230*
Enoch No. 3 (North)	*1,924*	*1,500*	*590*	*450*	*450*	*16*	*1,030*	*350*
Total	*8,323*	*10,400*						

(1) Approximate drawdown measured from top of casing to water surface in well at design capacity pumping rate.

Quichapa well field *holds five wells* located west of Cedar City. These five wells account for the majority of well water capacity, *approximately 10.9 million gallons per day*. Wells No. 1 and 3 are within close proximity of each other and located south of Wells 5, 6 and 7 also in close proximity to one another.

Enoch well field *hosts three wells* located north of town. Well No. 2 is not currently operational. One of the two operating wells, Enoch Well No. 3, is used frequently. For the most part, the wells in the Enoch well field pump to the 3200 North Tank. However, during peak demand periods, a portion of the water form the Enoch well field bypasses the tank and is pumped directly into the distribution system. In the future, Cedar City would like to be able to utilize the storage capacity in the 3200 North Tank more effectively so that the water does not have to pump directly into the distribution system. This situation will be addressed later in the report.

Table 4-4 summarizes spring sources that supply the Cedar City distribution system. Each source listed is actually a group of springs which are collectively conveyed to the distribution system. The capacities shown in Table 4-4 represent the average annual and maximum monthly flow rates as calculated from daily water supply records maintained by the City *for year 2007*. The maximum month flow rate represents the flow from each of the spring sources during the maximum water use month of the year. Typically this occurs during the month of July.

Table 4-4 Summary of Spring Water Sources

Spring	Average Annual Capacity(1) (gpm)	Maximum Month Capacity(2) (gpm)
Spillsbury Springs	*192*	*222*
Shurtz Canyon Springs	*303*	*490*
Cedar Canyon Springs	*412*	*744*
Total	*907*	*1,456*

(1) Capacities based on average daily records from 2007.
(2) Maximum month refers to the month of highest water use in the distribution system, usually July or August.

TRANSMISSION

The City has an extensive water transmission system which conveys water from the sources to storage or distribution. The transmission facilities have been identified separately in Figure 4-1 from the distribution facilities. Each of the major components of the transmission system is described in the paragraphs that follow.

Two main transmission pipelines transport water to the distribution system from supply sources located to the west of town. A 20-inch diameter pipeline extends from Quichapa Wells 5, 6 and 7, delivering water directly into existing Pressure Zones 2 and 4 and conveying water to the Cross Hollow Tank. A 16-inch diameter pipe also extends from the Quichapa Well Field serving Quichapa Wells 1 and 3 as well as the Spillsbury Springs conveying water to South Steel Tank. These two pipes are interconnected near their source by a 16-inch pipe which is currently closed. The two pipelines operate at different hydraulic grades; thus, the interconnect is opened only under emergency conditions.

The remaining transmission pipelines include an 8-inch pipe from Shurtz Canyon Springs to the South Steel Tank, a 10-inch pipe from Cedar Canyon Springs to the Cedar Canyon Tank, a 20-inch pipe from the Enoch well field to the 3200 North Tank, and a 12-inch pipe which connects the Cedar Canyon Springs pipeline to Fiddlers Tank. Transmission facilities also include two pump stations, Spillsbury and Square Mountain pump stations. Table 4-5 provides basic information about each of the pump stations. Additional information is also contained in Appendix B.

Table 4-5
Existing Booster Pump Stations

Station	Capacity (gpm)	TDH (ft)	Horsepower
Square Mtn. Booster Pump Station	1600	*217*	
Pump 1			*112.5*
Pump 2			*112.5*
Spillsbury Booster Pump Station	400	498	75

GENERAL

A hydraulic computer model of Cedar City water distribution system was redeveloped for the City to bring it up to date with current facilities and to be consistent with the GIS mapping and database. This section describes the features of the rebuilt model. Physical facilities, modeling organization, development of demands and calibration of the model are also discussed. It also serves an important reference document for City staff as they continue to use and maintain the model.

MODEL DESCRIPTION

City records, GIS data and the previous water system model were used to rebuild a hydraulic computer model of the Cedar City water distribution system. City staff was interviewed to understand system operations and clarify questions concerning the available data. H_2OMap Water was used to recreate the model. A copy of the model, converted to EPANET version 2.0, will be delivered to the City with the final report. The conversion actually results in two separate EPANET models simulating existing maximum day operation and build-out demand with fire flow.

PHYSICAL FACILITIES

The new model was rebuilt using available data obtained from City records. Main sources of available data about the water system are City staff, facilities database contained in GIS, and an existing EPANET model created from previous master plan updates.

GIS layers for piping, valves, and hydrants were imported directly into the hydraulic modeling software, H_2OMAP Water. Prior to import, GIS layers were checked to identify any errors or gaps in the data. Identified data problems in the GIS files were reported to City staff for their action. The quality of the GIS data was very high and a few problems were identified and corrected with the aid of City staff and the existing EPANET model. The creation of the facilities is described for each type of facility below.

Pipes

Pipes were created by direct import from GIS data. The existing system shows that there are approximately 5,000 pipes in the model. Initially, GIS pipe IDs were initially used directly as model pipe ID numbers in the model. Pipes in the GIS database are not split at the hydrant locations and do not include hydrant laterals. To accommodate the need to evaluate fire flow at fire hydrants, pipes were split at the location of each hydrant included in the model. While splitting pipes, one segment of the pipe maintained the original identifier and the other segments were assigned suffixes of '_1', '_2' and etc. (i.e. 2457_3). Model IDs were also assigned a new alphanumeric identifier. Pipes were labeled with a prefix of "P" followed by a number, i.e. P-1, P-2, and etc. Pipes added for modeling purposes and not contained in the GIS system were assigned the same identification format. The description field for the additional pipes provides the reason for each additional pipe.

Pipe information includes pipe length, diameter, material, and roughness. Pipe lengths in the model were calculated from the model drawing by H_2OMAP Water. These lengths were verified with the GIS data. Diameters and material type were imported directly from the GIS database.

Where the diameter was not provided in the database, the City was asked to provide the missing information. The description field indicates whether the pipe was missing the pipe diameter or pipe material. If the missing diameters or material were not provided, engineering judgment was used in assuming an appropriate value.

The Hazen-Williams friction or "C" factor was assigned based on the pipe material for each pipe. However, calibration indicated that pipe roughness for each has increased very little over the years, and that a general roughness value of 120 is more appropriate.

Junctions

H_2OMap Water assigned junctions in the model at all changes in pipe diameter (reducers), pipe connections (tees and taps), intersections (crosses), dead ends (plugs), and hydrant locations. H_2OMap Water assigned approximately 4,700 junctions to pipes in the model. Junctions were assigned a new alphanumeric identifier. Identifiers begin with a prefix "J" followed by a number, i.e. J-1, J-2, and etc.

Additional junctions not contained in the GIS system added for modeling purposes were assigned the same identification format. The description field for the additional junctions provides (where possible) some indication as to the reason for the additional junction. Use of this format will prevent conflict between future GIS element IDs and existing model IDs.

Pumps

Pump locations were determined from the existing EPANET model. In a typical model, pump hydraulics are represented by a curve that defines the pump's head versus flow relationship. Manufacturer pump curves for booster stations and well pumps, provided by the City were used for this purpose. Where possible, pump curves were confirmed by field-testing. Pumps that required adjustments are listed in the calibration portion of this section.

Pump curves were entered into the model using the multi-point curve option. This option allows the pump relationship of head versus flow to be entered as a series of points. Operational controls were added to reflect field control settings or the intent of manual operational practices and procedures as provided by the City.

Pump identifiers were manually assigned and are alphanumeric indicating the name of the well or booster station location followed by a numeric value. Pumps were labeled with a prefix "PU" followed by the name of the well or booster station, i.e. PU-ENOCH_1.

Wells and Springs

Wells and springs are represented in the model as fixed head reservoirs. Initially, the water surface elevation of each well was set to the average dynamic water level. The dynamic water level was established by taking the ground elevation from the contour map and subtracting the average dynamic depth provided by the City. The resulting model well production did not match measured field data. This is commonly due to difficulty in accurately measuring dynamic well depths in the field. A correction to the water surface elevations was made to allow the well pumps to discharge at flow rates matching measured field data.

Well ID numbering for existing wells is alphanumeric, containing the name of the well. Spring ID was assigned based on their names only. Wells and springs were labeled with a prefix "W" or "S" followed by the name of the well and a number, i.e. W-ENOCH_1, S-SPILLSBURY.

Storage

All storage tanks were modeled as ground level cylindrical tanks. The City provided the diameters, floor elevations, and maximum water surface (overflow) elevations for each tank. The initial water depth of each tank was set during the calibration process. Because tanks were not included in the GIS layers provided by the City, a separate identifier was used where Tank ID contained the name of the tank. Tanks were labeled with a prefix "TNK" followed by the name of the tank (i.e. TNK-FIDDLERS).

Altitude valves for controlling tank level, pump controls or other controls were modeled to reflect actual tank control settings and operation. The operational controls for each was determined from information provided by the tank level monitoring devices installed on each tank by the City.

Valves

Pressure reducing and flow control valves were assigned an alphanumeric ID number, beginning with the letter 'PRV' or 'FCV' followed by an integer. Flow control valve IDs were started with 9001, i.e. FCV-9001, FCV-9002, and etc. Pressure reducing valve IDs were assigned the same integer of the pipe parallel to it, i.e. PRV-1207, otherwise, PRV-9004. Pressure reducing valves have been given the settings provided by the City except where calibration indicated a different setting from those given. All changed valve settings are listed in the calibration portion of this section.

MODEL ORGANIZATION

H_2OMap Water allows different scenarios to be created and stored within the same model file. Several scenarios were created for this study to simulate system performance with different system demands, facilities and operational settings. The scenarios included in the model are categorized as follows:

6. *Base*
7. *Calibration*
8. *Existing System Conditions*
9. *Short-term Conditions*
10. *Build-out Conditions*

The Base scenario is not used for evaluation purposes; it stores model facility data for all of the other scenarios. The Calibration scenarios were created to simulate the system on the day of field testing. The remaining scenarios were used to evaluate the system at the different planning periods previously discussed in this report. Existing System Condition scenarios were used to determine deficiencies in the existing system and evaluate immediate improvements intended to correct the deficiencies. Long-term or Build-out Condition scenarios were created to evaluate improvements to meet increased demand over the larger service area for build out year, *respectively. For each planning period, the water system was evaluated under average of maximum day demand and fire flow demands.*

DEVELOPMENT OF WATER DEMANDS

Domestic water demand was allocated in the model to accurately represent the distribution of demands in the system. Existing demands are based on the City's billed water use records. Future demands were distributed in the model using unit use rates and land use data for the future service area. Allocation of future demand is discussed in Section 7.

Existing System Demands

The City's 2007 billing records were used for distribution of the existing system demands. An average daily water demand for the maximum month was calculated for each customer from the billing record, which was then assigned to the closest junction node in the model based on the customer address. Three percent of the total billing records could not to be located (geocoded) by address. The three percent non-geocoded records represent only two percent of the average daily water demand for the maximum month and were therefore allocated evenly among the demand nodes.

The highest annual water use to date for the City was recorded in 2007. During 2007, annual water use averaged 6.0 mgd (4,188 gpm). The highest average monthly water use occurred in the month of July. The maximum day water production recorded for the system is 13.85 MGD in 2007. However, tank overflows are estimated at 500 gpm. Therefore, maximum day demand has been adjusted downward to 13.125 mgd (9,115 gpm). Peak hour demand, calculated from SCADA records was determined to be 16,329 gpm.

While not specifically used for modeling, peaking factors were calculated for maximum day and peak hour usage. They are summarized in Table 5-1. The 2007 maximum day peaking factor (the ratio of average maximum day demand to average annual demand) was calculated to be 2.28. This is somewhat less that the 2.62 factor calculated for the previous master plan.

Table 5-1
Model Peaking Factor Summary

Peaking Factor	Value
Average Annual	1.00
Maximum Day	2.28
Peak Hour	4.09

Fire Flow Demands

For both future and existing system hydrants, fire flow demands were assigned in the model based on the land use surrounding each hydrant except where specifically required otherwise by the fire department. The largest of the fire flow rates associated with the neighboring land uses was assigned to the hydrant. Table 5-2 shows the fire flow rates required for land use and site specific recommendations of the City and Fire Department.

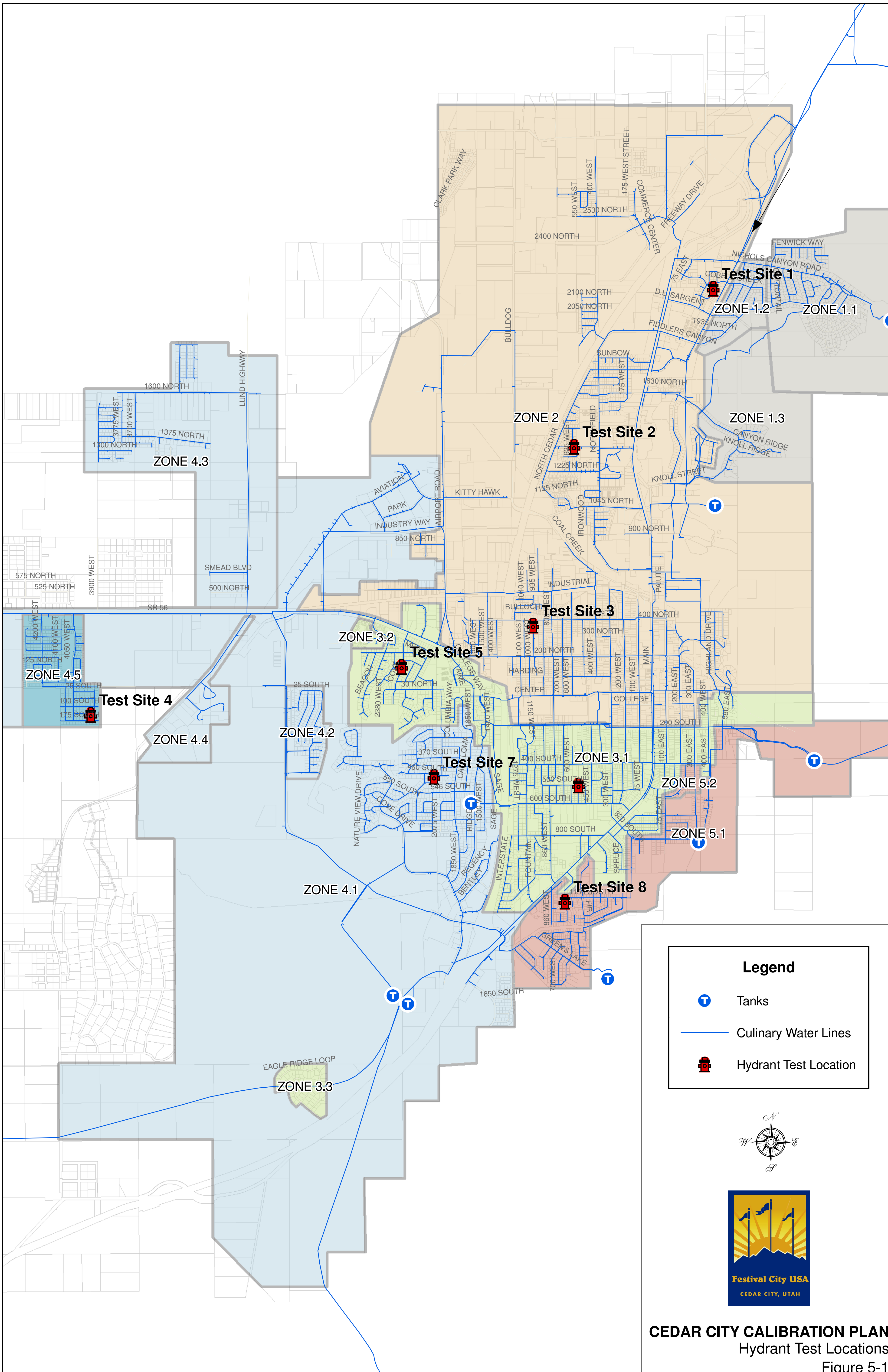
Table 5-2. Fire Flow Requirements

Land Use	Fire Flow (gpm)	Duration (hr)
Agriculture	1,500	2
Highway Service	1,500	2
Parks/Golf Courses	1,500	2
Low Density Residential	1,500	2
Medium Density Residential	1,500	2
High Density Residential	2,500	3
Residential Planned Area (4 D.U. / Acre)	1,500	2
Residential Planned Area (6 D.U. / Acre)	1,500	2
Residential Estate	2,000	3
Neighborhood Commercial	2,000	3
Central Commercial	2,500	3
Downtown Commercial	2,500	3
General Commercial	2,500	3
Industrial & Manufacturing – 1	3,500	3
Industrial & Manufacturing – 2	3,500	3
Industrial & Manufacturing – 3	3,500	3
Public Uses	3,500	3
Lozier (Site Specific)	44,583	3
Cerro Copper (Site Specific)	21,667	3
Charlotte Pipe (Site Specific)	11,667	3
Longview Fiber (Site Specific)	10,000	3
Smead (Site Specific)	26,500	3
Genpack (Site Specific)	29,167	3
Nampac (Site Specific)	7,417	3
Western Quality Foods (Site Specific)	10,833	3

MODEL CALIBRATION

The model was calibrated to ensure that model results are representative of actual system operations. The calibration process includes performing field tests on the system and then making appropriate adjustments to the computer model until the results match the data gathered during testing.

Figure 5-1 shows the eight hydrant test locations that were performed on the system. Tank levels, pumping rates, and pressure fluctuations were monitored during each test. The calibration scenarios in the model were set up to represent the system on the day of testing. Demands for each scenario were scaled to match system demands at the time of each test; tank levels and pumping rates were also matched for each test.



CEDAR CITY CALIBRATION PLAN
Hydrant Test Locations
Figure 5-1

Adjustments were made to the model until pressures in the model matched the recorded field data from before and during the hydrant test. The calibration process revealed some closed isolation valves and connectivity issues that had been overlooked in the model development process. City staff verified the changes that needed to be made to the model. Roughness factors assigned to the pipes in the model are industry accepted values based on pipe material. Some adjustments were needed to the roughness factors.

The model calibrated well. Results were matched to an acceptable degree of accuracy for all but two of the eight tests. Model results at the two un-matched sites (Tests 5 and 8) were significantly different from the field collected test data. In both cases, model results were consistent at static conditions (immediately prior to the hydrant flow test) but were lower than the pressure measured in the field during the flow test. This indicates that there are either additional or different pipe sizes in the distribution system upstream of the tests, or in the case of Test 5, there are additional PRVs supplying the area from a higher pressure zone. Neither could be immediately confirmed through conversations with Staff but should be investigated further by the City. Of the six remaining tests all but one matched the field test pressures within 5 psi. A detailed comparison of field test data to model results is contained in Appendix D.

GENERAL

The existing water distribution system evaluation included an analysis of the distribution piping, pumping, storage, and supply to the system. It was based on criteria established in the Evaluation Criteria Memorandum approved by the City early in the project. These criteria can be found in Appendix E of this report.

The model was used to simulate a maximum demand day scenario as well as fire flow conditions. Evaluation of the system under these demand conditions is important because they represent the critical or worst case conditions for the water distribution network. Such an evaluation will reveal any problems in the system requiring capital improvements. Any problems under minimum-day demand and average-day demand conditions can be remedied with operational changes.

DISTRIBUTION PIPE NETWORK EVALUATION

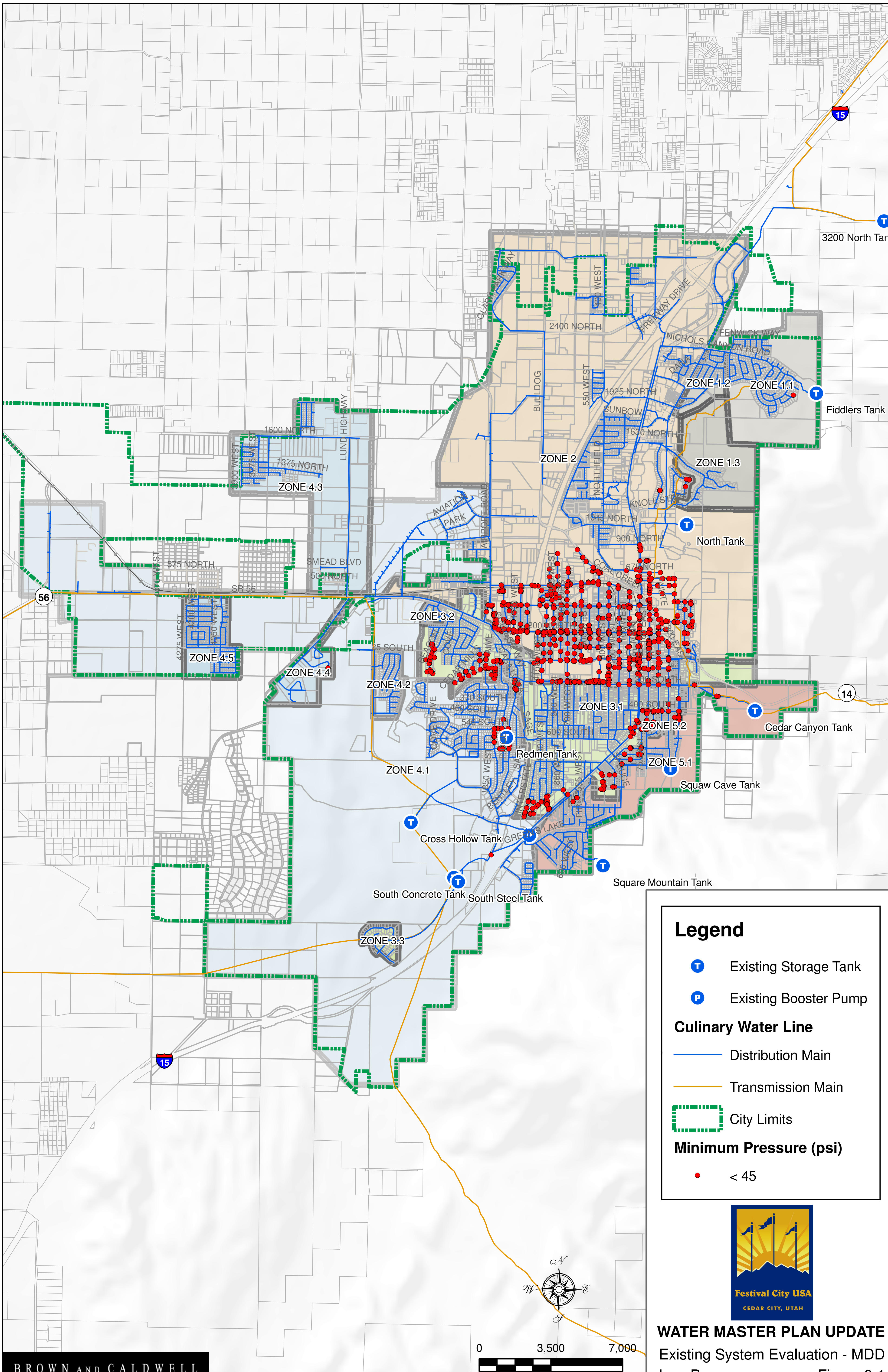
An evaluation of the existing distribution pipe network was performed under normal peak operating and fire flow conditions using the computer model. Peak operating conditions include the annual maximum day water use (maximum day) and the peak hour water use (peak instant). A fire flow evaluation was also performed for the entire distribution pipe network.

Modeling results of peak operating conditions revealed several areas that do not meet the evaluation criteria. These problem areas include low pressures, high pressures, and high head loss. All other criteria, including maximum velocity, were met by the distribution system.

System Service Pressures

Model simulations revealed a number of pressure deficiencies in the water distribution system. Pressures below 45 psi can be expected under maximum day as well as peak instant conditions. Figure 6-1 illustrates low pressure areas located at the highest elevations in some of the pressure zones. Low pressures can be seen at Zone 3 / 5, Zone 3 / 4 and Zone 2 / 3 boundaries. Low pressures in the system are caused by the locations of the pressure zones boundaries. Zone elevations are set too high for the available hydraulic grade of the pressure zone. *Modeling also indicates low pressures exist in Pressure Zone 4 during maximum day simulation*. However, City staff maintain that low pressures are not as wide spread as Figure 6-1 reveals. It is suspected that this is due to partially open valves between zones that City personnel do not know about. City staff reported that when pressures begin to fall too low in Pressure Zone 2, Zone 2 / 3 and 2 / 4 boundaries are breached by allowing water to flow from Zone 3 and 4 into Zone 2 with partially closed valves. Modeling confirms that this action does indeed remedy the problem. Additional pressure problems would be seen in Zone 2 if water was not allowed to flow from Zones 3 and 4 into Zone 2. Low pressure problems increase within Zone 2 when zone boundaries are not breached.

High pressure is a more widespread problem than low pressure. It is less of a concern however, because high pressures do not limit the availability and acceptability of service to the customer. However, high pressure is an undesirable condition because it may result in increased unaccounted water losses, high billed water use and frequent and disastrous pipe failures. It also requires customers to install and maintain pressure reducing valves on their individual service connections.



WATER MASTER PLAN UPDATE
Existing System Evaluation - MDD
Low Pressures Figure 6-1

Pressures above 110 psi were found to exist in all pressure zones. *Figure 6-2 shows the area west of I-15 having significantly high pressures. Most Zones experience pressures greater than 110 psi but not greater than 150 psi. However, Zones 2, 3 and 4 experience pressures beyond 150 psi.* Zone 2 pressures are more serious due to service elevations lower than approximately 5,720 feet. High *pressures in Zone 3 are limited to areas along State Route 56.* Extreme pressures in Zone 4 are of greatest concern. The hydraulic grade of Zone 4 near the airport is the same as the 20-inch transmission pipe from the Quichapa Wellfield where pressures in some cases exceed *240* psi.

System Piping Headloss Rates

Some distribution system piping was found to have headloss rates greater than the suggested seven feet per 1,000 feet under maximum day demand conditions. Figure 6-3 identifies headloss rates above seven feet per 1,000 feet assuming Pressure Zones 2 and 3 boundaries had been breached. *Pipes shown as having high headloss are in the range of 4 – 12-inches in diameter. High headlosses are of concern since they appear to be the cause of low pressures under normal operating conditions, specifically in Zone 2. Thus, it may cause insufficient fire flows under fire or emergency flow conditions.*

System Fire Flow Capacity

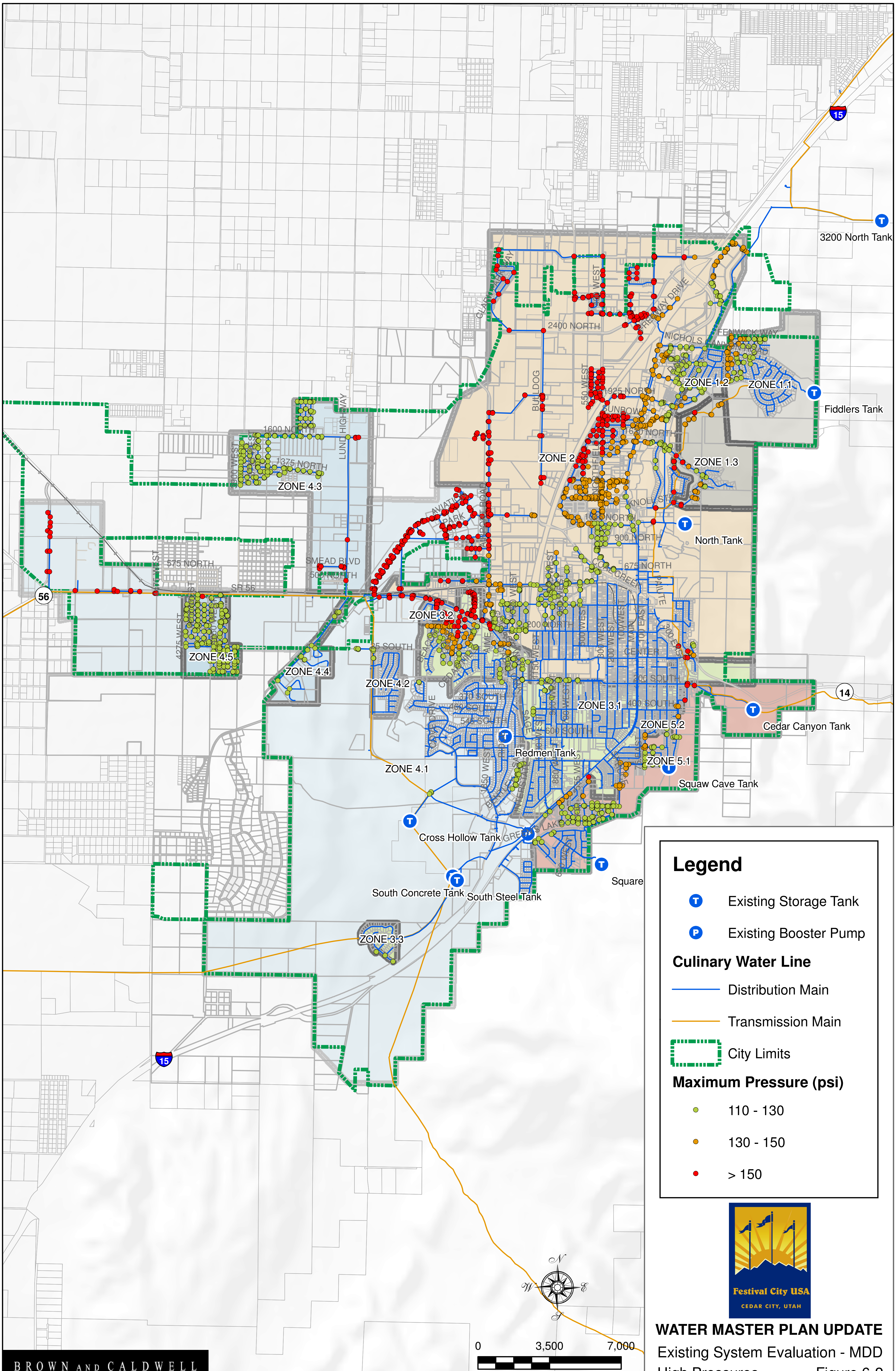
The fire flow capacity analysis was based on maintaining a 20 psi minimum pressure residual at maximum day demand plus fire flows as required by the State Rules for Drinking Water Systems. Modeling assumed the Pressure Zone 2/Zone 3 and Pressure Zone 2/Zone 4 boundaries breached. Site specific fire flow requirements were obtained from the Cedar City Fire Department and distributed accordingly. All other fire flows are based on land use category. All residential areas in Figure 6-2 are required to have no less than 1,500 gpm fire flow requirement because churches are generally located in residential areas.

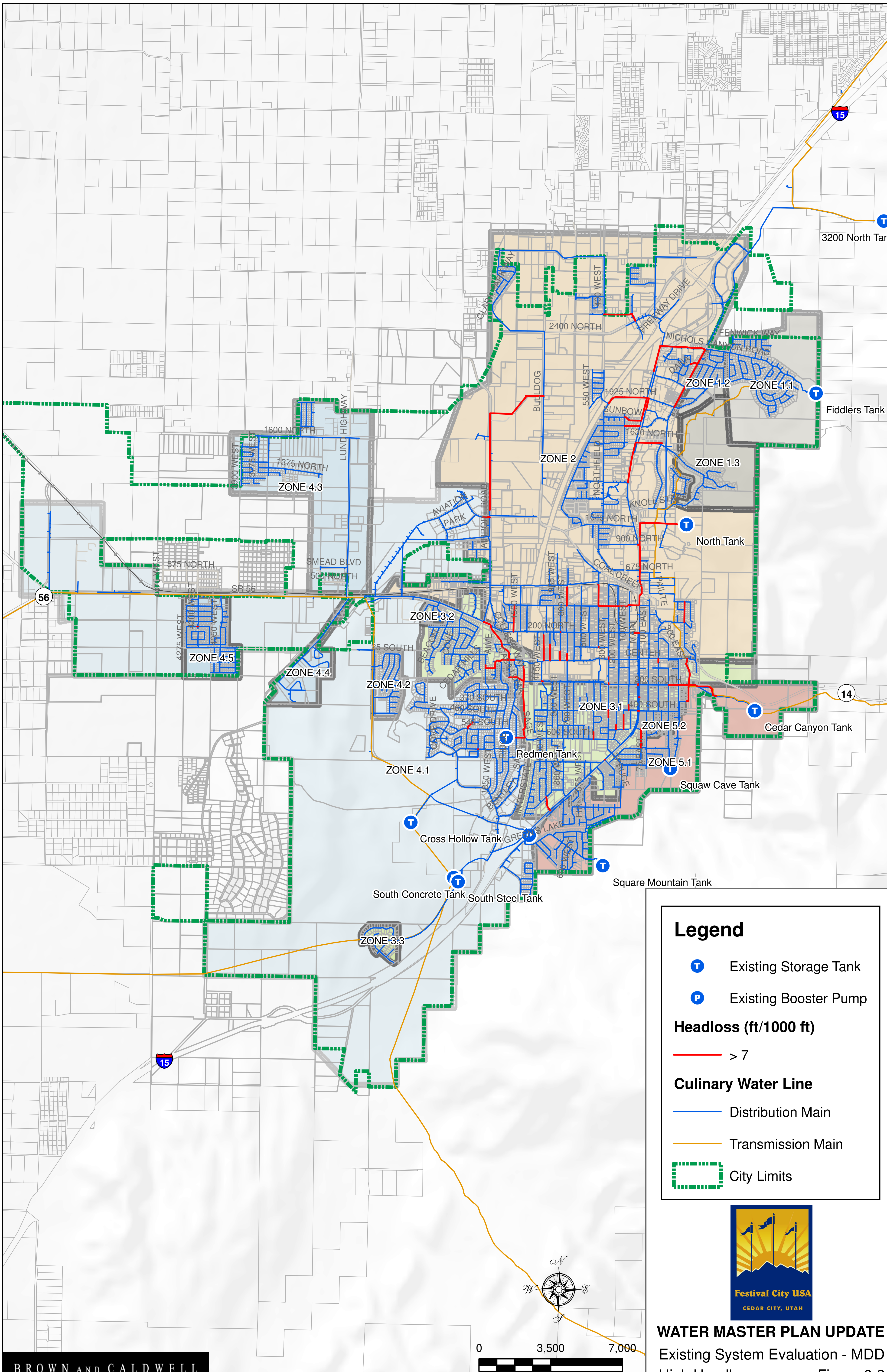
A review of Figure 6-4 indicates significant areas with less than a minimum *1,500 gpm* fire flow capacity. There are also some deficiencies in areas requiring 2,500 and 3,500 gpm. The problem areas are a result of distribution system headloss and insufficient water crossing pressure zone boundaries. *If the Pressure Zone 2/Zone 3 boundary were not breached, insufficient fire flow capacities would increase.* In addition, it was noted that some hydrants are connected to pipes less than 6-inches in diameter. This contributes to the incidence of low fire flow capacity and is in violation of State Rules for Drinking Water Systems. *The capacity of the distribution system was also found to be deficient at the location of most site specific fire flows including Smead, Genpack and Cerro Copper.*

TRANSMISSION SYSTEM EVALUATION

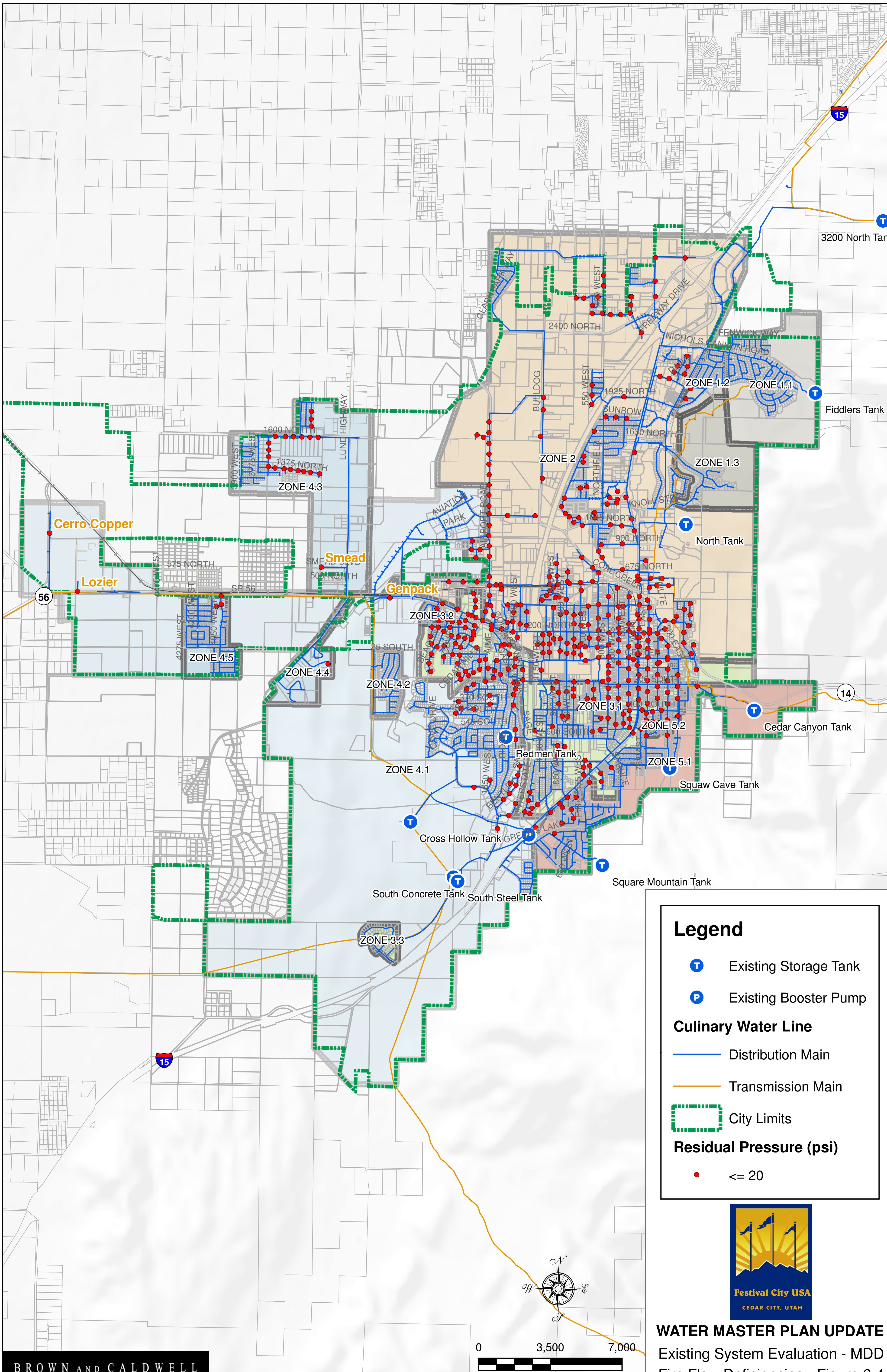
The existing transmission system facilities have sufficient capacity for current flows. All transmission pipes operate at velocities less than 5 fps. Headloss rates are less than 7 ft/l000 ft. in all transmission lines, except the two 10-inch diameter pipes conveying water from Quichapa Wells No. 1 and 3.

A review of transmission system operation revealed that a significant amount of water is being conveyed at unnecessarily high pressures. This increases operation and maintenance costs pumping from the wells. In particular, water from Quichapa Wells 5, 6 and 7 are pumped to both


Legend
Existing Storage Tank
Existing Booster Pump
Culinary Water Line
Distribution Main
Transmission Main
City Limits
Maximum Pressure (psi)
110 - 130
130 - 150
> 150
Festival City USA
CEDAR CITY, UTAH
WATER MASTER PLAN UPDATE
Existing System Evaluation - MDD
High Pressures
Figure 6-2
BROWN AND CALDWELL
0
3,500
7,000
Scale in Feet
3200 North Tank
Fiddlers Tank
North Tank
Cedar Canyon Tank
Squaw Cave Tank
Redmen Tank
Cross Hollow Tank
South Concrete Tank
South Steel Tank
Square
ZONE 1.1
ZONE 1.2
ZONE 1.3
ZONE 2
ZONE 3.1
ZONE 3.2
ZONE 3.3
ZONE 4.1
ZONE 4.2
ZONE 4.3
ZONE 4.4
ZONE 4.5
ZONE 5.1
ZONE 5.2
2400 NORTH
1925 NORTH
900 NORTH
675 NORTH
575 NORTH
1600 NORTH
1375 NORTH
200 NORTH
CENTER
200 SOUTH
400 SOUTH
600 SOUTH
SMEAD BLVD
SR 56
NICHOLS
FENWICK WAY
BULLDOG
550 WEST
LUND HIGHWAY
4275 WEST
56
14
15



WATER MASTER PLAN UPDATE
Existing System Evaluation - MDD
High Headloss Figure 6-3



WATER MASTER PLAN UPDATE
Existing System Evaluation - MDD
Fire Flow Deficiencies Figure 6-4

storage and distribution through a 20- inch pipeline. The total combined flow that can be produced by all three wells together is approximately *5,617* gpm. The water currently serves Pressure Zones 3, 4 and 5. Most of the water is used in Pressure Zone 3 but all is pumped to the Cross Hollow Reservoir at sufficient hydraulic grade to serve Pressure Zone 4.

A Business Case Evaluation (BCE) was conducted on the 16" South Quichapa Transmission Pipeline. A corrosion study conducted by Corrosion Control Technologies, Inc. suggested that the pipe may be near the end of its useful life. A failure in this pipe could have serious consequences in maintaining sufficient water supply, especially during summer months. A portion of the pipeline lies beneath Lake Quichapa making repairs very difficult during certain times of the year. The study indicated that cathodic protection would be sufficient in protection against severe corrosion damage. Several alternatives were analyzed and compared for the probability of pipe failure based on life cycle cost and risk of failure. Results indicated that the risk costs of the "Do Nothing" alternative were slightly higher than the cost to protect the entire segment of the pipe identified to be at risk by the report. A detailed discussion of the assumptions, evaluation and results for each alternative is provided in Appendix F.

STORAGE EVALUATION

Calculations confirm that the Cedar City culinary water system has sufficient total storage capacity. Presently, the City has *18* million gallons of total storage available. *Operational and fire emergency storage needs requires approximately 10.78 million gallons leaving 7.28 million gallons as remaining storage used for emergency. Emergency storage accounts for 40% of total capacity in the system. Approximately 48% of the storage accounts for fire storage for Zone 4, specifically for the Lozier facility requiring 44,583 gpm.* Storage in each pressure zone was found to be sufficient. A summary of this analysis is provided in Table 6-1.

Table 6-1. Water Storage Requirements

Pressure Zone	Total Capacity (MG)	Operational Storage (MG)	Fire Storage (MG)	Emergency Storage (MG)
Zone 1 & 5	4.32	0.27	0.63	3.42
Zone 2, 3 & 4	13.74	1.85	8.02	3.86
Total	18.06	2.13	8.65	7.28

It was noted that Fiddlers Tank and Square Mountain Tank are much larger than required. This may result in difficulty maintaining chlorine residual.

City staff has reported that several storage tanks have operational problems. These tanks include 3200 North Tank, and Cedar Canyon Tank. Both regularly overflow during the summer months when demand is high. Combined water loss is approximately 500 gpm with the majority of the overflow occurring at 3200 North Tank.

The overflow at 3200 North Tank results from the use of the Enoch wells. Full well capacity is needed during the summer to meet demand. However, because of headloss in the pipes that convey water from the tank into and through the distribution system in pressure zone two, not all of the water pumped from the Enoch wells can be used. The bleeding of water from pressure Zones 3 and 4 into Zone 2 is a contributing cause as well.

Overflow occurs at Cedar Canyon Tank because it is sited at a lower elevation than the other reservoirs serving Zone 3. It was actually constructed at an elevation more consistent with Pressure Zone 2. As a result, the hydraulic grades of the other tanks prevent the Cedar Canyon Tank from draining properly. Therefore, some of the water filling the tank from Right Hand Canyon and Cluff Springs simply spills through the overflow pipe.

SUPPLY FACILITIES EVALUATION

The supply facilities evaluation focused on well output and energy costs. Results show that wells are not producing at original design capacity and are able to meet current water demands. The wells had a total design capacity of *10,400* gpm but were only able to deliver about *8,247* gpm. This represents a *22* percent loss in source capacity and this capacity loss is expected to increase as wells are added to the system.

One of the reasons that the City's wells are producing less than design capacity is headloss in the transmission piping. Each time the flow from a new well is added to one of the transmission pipes, velocity and headloss also increase. Since all wells must then pump against a higher pressure to overcome the additional headloss, they each then produce less water. For example, Quichapa Wells 5 and 6, pumping into the 20-inch transmission main produce a combined flow of about *2,847* gpm (*1,502* gpm and *1,345* gpm, respectively). When Quichapa Well No. 7 is online, the flow from Wells 5 and 6 is reduced to approximately *2,591* gpm (*1,316* gpm in Well 5 and *1,275* gpm in Well 6). As total well production increases and system pressures increase, the pumps will be forced to operate at lower efficiencies, which in turn increases the energy cost required to pump the same amount of water. *Enoch Wells 1 and 3 experience the same scenario. Enoch Well 1 operating alone will have a flow of 1,605 gpm. When Enoch Well 3 comes online, Enoch Well 1 flow drops to 826 gpm and Enoch Well 3 pump will function above its operating curve.*

Another reason for reduced well production is the declining groundwater table. Drawdown of wells will likely continue, requiring well pump improvements such as lowering the pump bowls, adding pump stages, and increasing motor horsepower. Production has also been reduced to protect the wells and pumps from over pumping. The production has been reduced to match the yield of the aquifer.

GENERAL

This section presents a summary of the model development and analysis of future scenarios. Two planning horizons were established with the City; one for immediate improvements needed to correct existing problems and another for build-out to the future annexation declaration boundary.

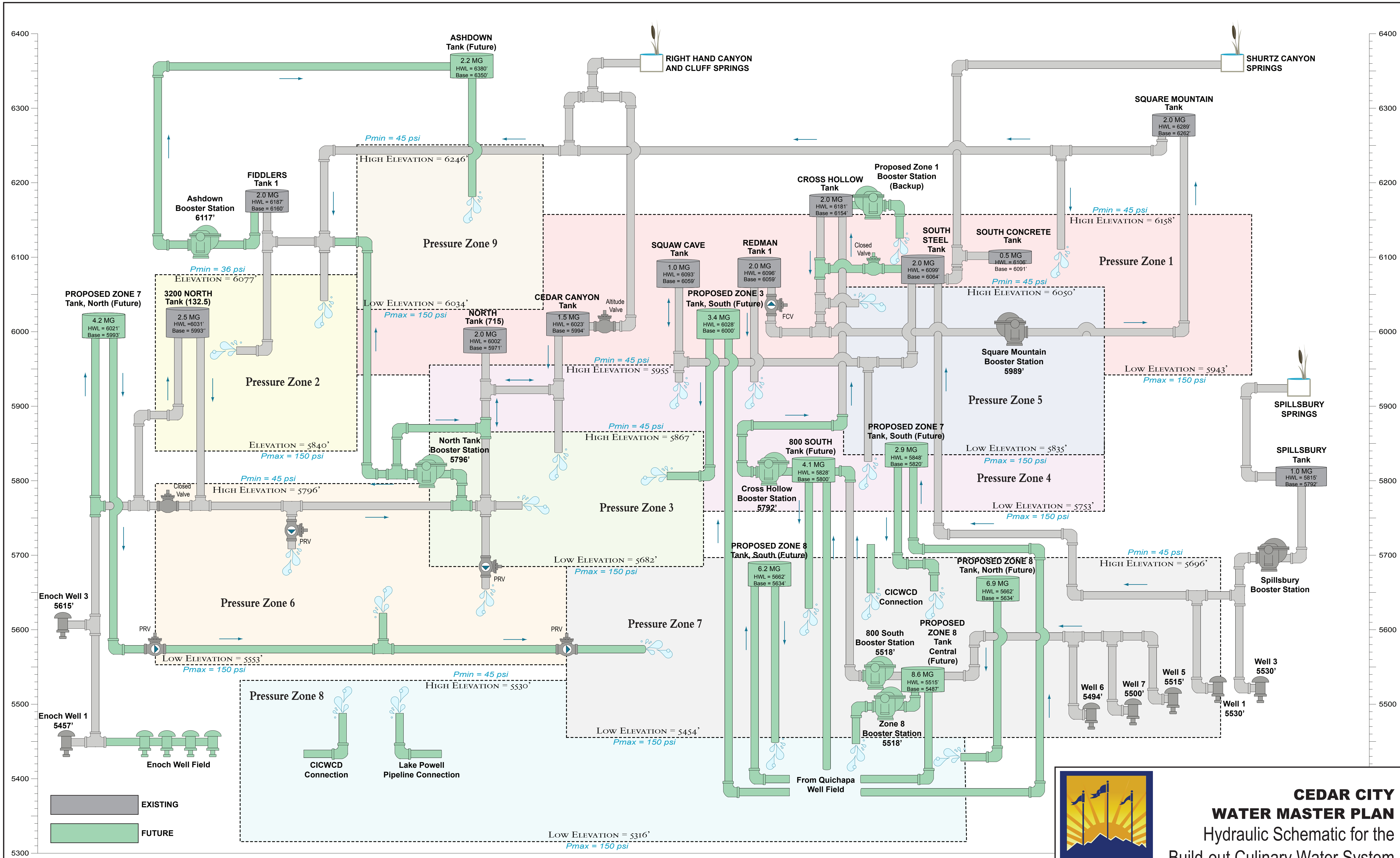
BUILD-OUT MODEL

Future water system improvements were developed through the creation and use of a hydraulic model to simulate build-out development conditions. The existing system hydraulic model was used as the basis for development. Pressure zone boundaries were modified and additional ones established for the undeveloped areas west of town. New piping was laid out along the existing and future transportation corridors established in the City's Transportation Master Plan. Future transmission, storage, supply and pumping facilities were also added. Projected demands were allocated to the model and the proposed facilities were sized to meet the previously established design criteria. These methods used for these activities and the proposed improvements are described in further detail in the paragraphs that follow.

Future Pressure Zones

To facilitate operations and management of the distribution system, considerable effort was placed into reconfiguring the pressure zones. The objective was not necessarily to minimize the number of pressure zones needed but to increase the reliability of each zone. This was done by increasing the number of zones and distributing the sources of supply relative to elevations. As discussed in Section 6, existing pressure zone boundaries have resulted in excessively low and high pressures in some zones of the system. Thus, pressure zones were adjusted to serve a narrower range of elevations and maintain more favorable pressures. A hydraulic schematic, illustrating the pressure zone boundary changes is provided as Figure 7-1. The proposed boundary changes are similar to those recommended in the previous plan but with several important differences.

Some facility improvements are needed to accomplish existing pressure zone reconfiguration. Those improvements are listed and discussed in detail in Section 9 of this report. Figure 7-2 shows the overview of the future distribution system map with the new pressure zone boundaries. Table 7-1 summarizes the new pressure zone elevations and resulting static pressures for the model junctions within the elevation boundary. There are a total of 9 pressure zones in the future system. Comparing the minimum and maximum pressures in Table 7-1 to the existing minimum and maximum pressures shown in Figure 4-2 reveals a significant decrease in maximum pressures. As indicated in Table 7-1, some future minimum pressures remain below the established criteria. These occur in locations where, because of topography, there are no cost effective improvement alternatives.

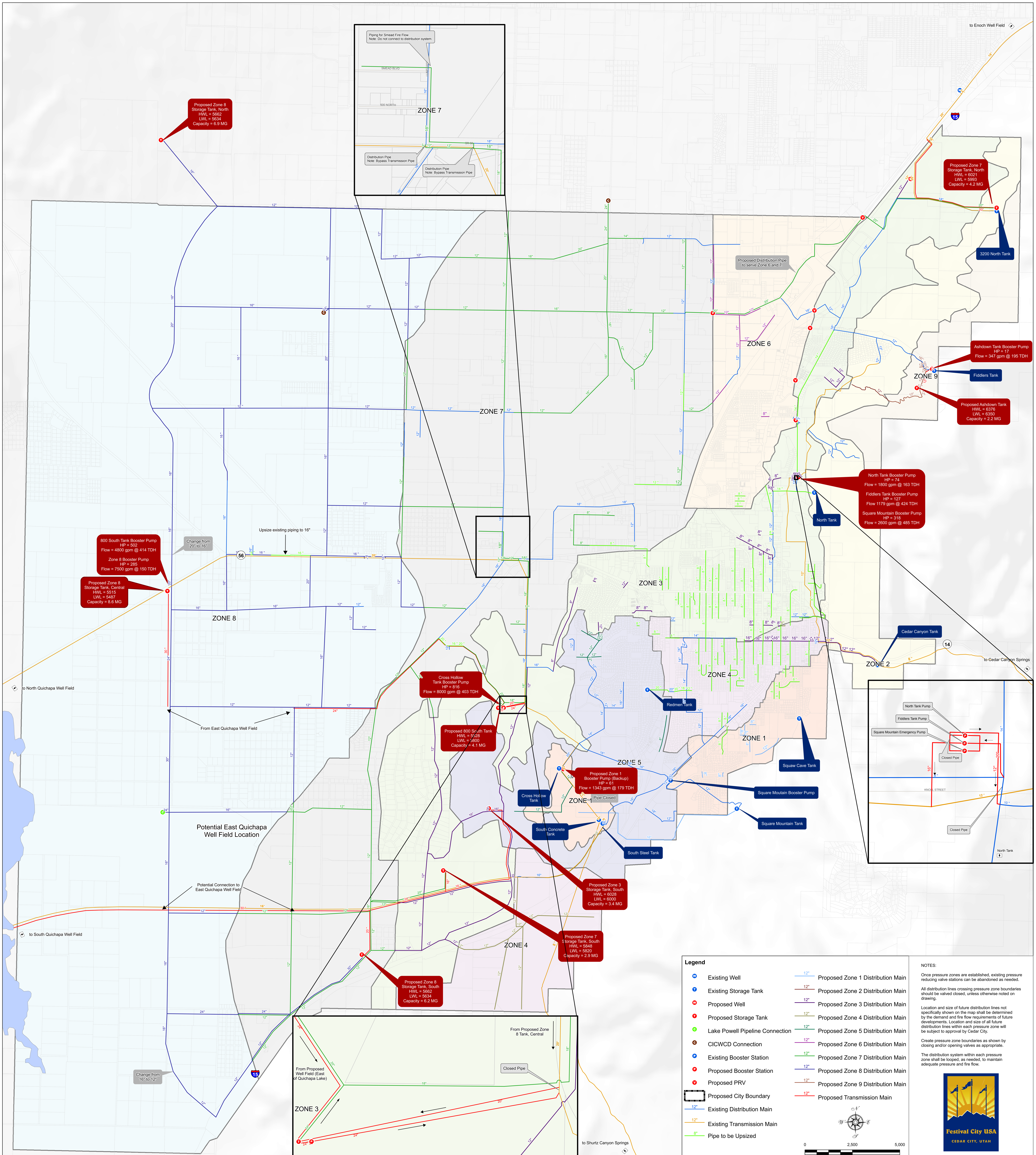


BROWN AND CALDWELL

*PRV = Pressure Reducing Valve

Festival City USA CEDAR CITY, UTAH

CEDAR CITY WATER MASTER PLAN
Hydraulic Schematic for the Build-out Culinary Water System
Figure 7-1



BROWN AND CALDWELL

PROJECT NO. 134355

REVISED DATE 06-19-09

PROJECT: CEDAR CITY WATER MASTER PLAN UPDATE

TITLE: Build-out Culinary Water System Improvement

Figure 7-2

Table 7-1. Future Pressure Zone Summary

Pressure Zone	Minimum Pressure (psi)	Maximum Pressure (psi)	Minimum Elevation (ft)	Maximum Elevation (ft)
Zone 1	45	150	5,943	6,158
Zone 2 (1)	36	150	5,840	6,077
Zone 3	45	150	5,682	5,867
Zone 4	45	150	5,753	5,955
Zone 5	45	150	5,835	6,050
Zone 6	45	150	5,553	5,796
Zone 7	45	150	5,454	5,696
Zone 8	45	150	5,316	5,530
Zone 9	45	150	6,034	6,246

(1)Does not meet the minimum pressure of 45 psi due to the topography of a subdivision.

Build-out Demands

Future demands in the model were calculated on a unit-area basis for currently undeveloped areas and added to the existing model demands. Unit-use rates were developed for each future land use type based on unit use rates for existing development. A summary of the calculated current water use unit rates is provided in Table 7-2. These current use rates were calculated using a representative sample of the water-billing data and the City Planning Department development definitions of each land use type.

Table 7-2. Current Unit Water Use Rates

Land Use Category	Average Day Unit Use Rate (gpm/acre)	Max Day Unit Use Rate (gpm/acre)
Agriculture (1)	--	--
Central Commercial	0.871	1.109
Downtown Commercial	0.951	1.211
General Commercial	0.588	0.749
High Density Residential	3.029	3.856
Highway Services	3.559	4.531
Industrial & Manufacturing – 1	0.042	0.053
Industrial & Manufacturing – 2	0.001	0.002
Industrial & Manufacturing – 3 (1)	--	--
Low Density Residential	3.091	3.936
Medium Density Residential	1.775	2.260
Neighborhood Commercial (1)	--	--
Parks/Golf Courses	0.105	0.133
Public Uses	1.355	1.725
Residential Estates (1)	--	--
Residential Planned Area (4 D.U. per Acre)	1.811	1.033
Residential Planned Area (6 D.U. per Acre)	1.398	1.781

(1) Available data was insufficient to calculate unit use rates for the land use category.

Since future land use categories were somewhat different than for current land use, the current rates were modified to reflect future land use definitions. Table 7-3 contains the future maximum day unit-use rate developed for each future land use type. Brown and Caldwell created a detailed future land use map using aerial photos, zoning maps, and input from City staff. The new land use map details developed and undeveloped land use. A copy of the map is provided in Appendix G.

Table 7-3. Future Unit Water Use Rates

Future Land Use Category	Max Day Unit Use Rate (gpm/acre)	Assumptions
Business/Manufacturing	0.7492	
Corporate Office/Research Campus	0.0277	Average of Industrial/Heavy Manufacturing
Downtown Retail	1.2111	
Industrial	0.0534	
MFR	3.8564	
Mixed Use	0.7492	
Municipal/School/Campus	1.8581	Maximum of Public Uses
Neighborhood/General Commercial	0.7492	
Planned Community Development	1.4067	Average of Residential Planned Area
Regional Commercial	4.5312	
Rural Estate – High	1.1298	Adjusted from the SFR-Medium Land Use Category (4 units/acre)
Rural Estate – Low	1.2299	Adjusted from the SFR-Low Land Use Category (8 units/acre)
SFR – High	3.8564	
SFR – Medium	2.2597	
SFR – Low	3.9357	
Sand, Gravel Mineral Extraction	0.0534	Same as Industrial

In order to get the appropriate distribution of demands for the future model scenario, the initial estimate of build-out demands was made by multiplying the undeveloped land area within the future growth boundary by the appropriate unit use rate. While the project originally anticipated planning for a 2032 horizon, build-out demands (approximate year 2050) for the annexation declaration were used to properly size the water system facilities. Build-out demand estimates were added to the existing demands in the model. Table 7-4 summarizes the total existing and projected future demands in the Cedar City water distribution system.

Table 7-4. Total System Demand

Planning Period	ADD (MGD)	MDD (MGD)
2007	6.06	13.85
2032	15.95	36.42
2050	29.33	66.97

The total build-out demand is summarized by pressure zone in Table 7-5. A complete tabulation of demand calculations can be found in Appendix G.

Table 7-5. Total Build-out Demand by Zone

Pressure Zone	Buildout Demand	
	ADD (gpm)	MDD (gpm)
Zone 1	424.88	970.19
Zone 2	522.28	1,192.60
Zone 3	3,563.99	8,138.11
Zone 4	1,243.08	2,838.50
Zone 5	1,592.96	3,637.42
Zone 6	1,044.77	2,385.66
Zone 7	6,645.95	15,175.55
Zone 8	12,326.18	28,145.94
Zone 9	118.86	271.41

Future Storage Requirements

A storage analysis was completed for the build-out system to identify additional storage required to meet the system criteria. City officials recommended keeping the same ratio of emergency storage to existing storage capacity, 275 gallons/capita. Based on the projected build-out population of 128,078 and emergency storage to total storage capacity ratio, the emergency storage will account for 40% of total capacity. Tanks were added to the water system model for providing additional storage capacity required for 2032 demands. Suggested future tank locations are shown on Figure 7-2.

The results of the storage analysis are presented in Table 7-6. The build-out system evaluation revealed the need for six new tanks in addition to the planned Ashdown and 800 South Tanks (already planned). Future tanks are needed to support demands in all pressure zones and are only planned to support 2032 demands. Table 7-6 also includes constructed storage requirements for zones that need the capacity, totaling 38.6 MG. Proposed tanks to be constructed can also be found in section 9. It was assumed that all remaining required capacity at build-out will be met either by additional storage facilities, not identified in this plan or through joint use capacity of Central Iron County Water Conservancy District (CICWCD) facilities. Proposed tanks, Ashdown and 800 South will support demands in Zones 7 and 9.

Table 7-6. Future (2032) Storage Requirements

Pressure Zone	*Total Capacity (MG)*	*Operational Storage (MG)*	*Fire Storage (MG)*	*Emergency Storage (MG)*	*Constructed Storage Requirements (MG)*
Zone 1	*4.72*	*0.23*	*0.45*	*4.04*	*--*
Zone 2	*8.01*	*0.28*	*0.45*	*7.28*	*--*
Zone 3	*17.10*	*1.89*	*0.63*	*14.58*	*3.4*
Zone 4	*7.58*	*0.66*	*0.63*	*6.29*	*--*
Zone 5	*4.32*	*0.84*	*0.63*	*2.85*	*--*
Zone 6	*4.65*	*0.55*	*0.63*	*3.46*	*--*
Zone 7	*16.08*	*3.52*	*5.25*	*7.31*	*11.2*
Zone 8	*33.01*	*6.53*	*8.02*	*18.46*	*21.8*
Zone 9	*2.2*	*0.06*	*0.45*	*1.65*	*2.2*

Future Transmission System Improvements

New transmission mains will need to be placed along the same corridors as the existing transmission main from Quichapa Well Fields North and South. Transmission main from North Quichapa Well Field will be connected to Proposed Zone 8 Storage Tank, Central. The transmission main from new wells will also connect to Proposed Zone 8 Storage Tank, Central. The Proposed Zone 8 Storage Tank, North will be supplied by Proposed Zone 8 Storage Tank, Central. This will allow the wells to consistently produce to their full capacity, avoiding limitations of pumping against variable heads. Capacity from North Quichapa Well Field will be pumped to Cross Hollow and the remaining capacity from the new wells will be pumped into Zone 8. Wells from the new well field will pump water to 800 South Tank where some water will discharge into Zone 7 and some pumped to Cross Hollow Tank. Additional wells will transmit water to Proposed Zone 3 Storage Tank, South. Similarly, proposed wells will supply Proposed Zone 7 Storage Tank, South, and Proposed Zone 8 Storage Tank, South. Transmission main from Enoch Well Field will transmit water to 3200 North Storage Tank and a capacity of 4,500 gpm will be pumped to the Proposed Zone 7 Storage Tank, North. The future transmission system will accommodate 16 new wells in the Quichapa Well Field and three new wells in Enoch Well Field at full build-out, in addition to connections to Central Iron County Water Conservancy District (CICWCD) service lines.

IMMEDIATE IMPROVEMENTS MODEL

The immediate improvements are a subset of the future build-out improvements. They consist of all future improvements needed to correct the existing problems outlined in the Existing System Evaluation section of this report. Brown and Caldwell created a model of the existing system with the proposed immediate improvements for analysis. Existing system demands were used in this model. All improvements were tested under 24-hour extended period and steady-state fire flow conditions to confirm their effectiveness. Larger diameter piping and additional pipes for increased looping were used to increase available fire flow in deficient areas and to raise low-pressures. Pressure zone boundaries were adjusted in areas of moderately low and excessively high pressures. This was accomplished by adding new PRVs, adjusting existing PRV settings and opening / closing various isolation valves.

Brown and Caldwell determined with the City of existing high-pressure conditions throughout Zone 4 which did not need be addressed. While they are generally higher than desirable and exceed the high pressure guidelines of 110 psi established early in the project, they do not exceed the pressure class of the distribution system piping. Reducing the pressure in this Zone may also have negative consequences to the fire protection capacity of the system in the area.

GENERAL

The purpose of this section is to review the feasibility of implementing a pressurized secondary irrigation system and the impact of such a system on the culinary water system. The following discussion includes a review of existing irrigation system facilities, the evaluation of two improvement alternatives *and the evaluation of wastewater scalping as a source of secondary water supply. The two improvement alternatives were developed during the previous version of the master plan. While they are both still viable considerations, the focus of the effort was to identify cost effective means for extending the existing system in terms of both service and supply.*

EXISTING FACILITIES

The Cedar City secondary irrigation system currently consists of a single transmission main, *two storage facilities, two supply wells, and a booster station*. These are shown in Figure 8-1. The transmission main is a 12-inch diameter pipe that parallels I-15. It extends from the existing pump station at the old wastewater treatment plant site on the north end of town to the existing storage reservoir at the southern end of the City, west of I-15. There are two smaller transmission system branches (6-inch diameter and 10-inch diameter) as shown.

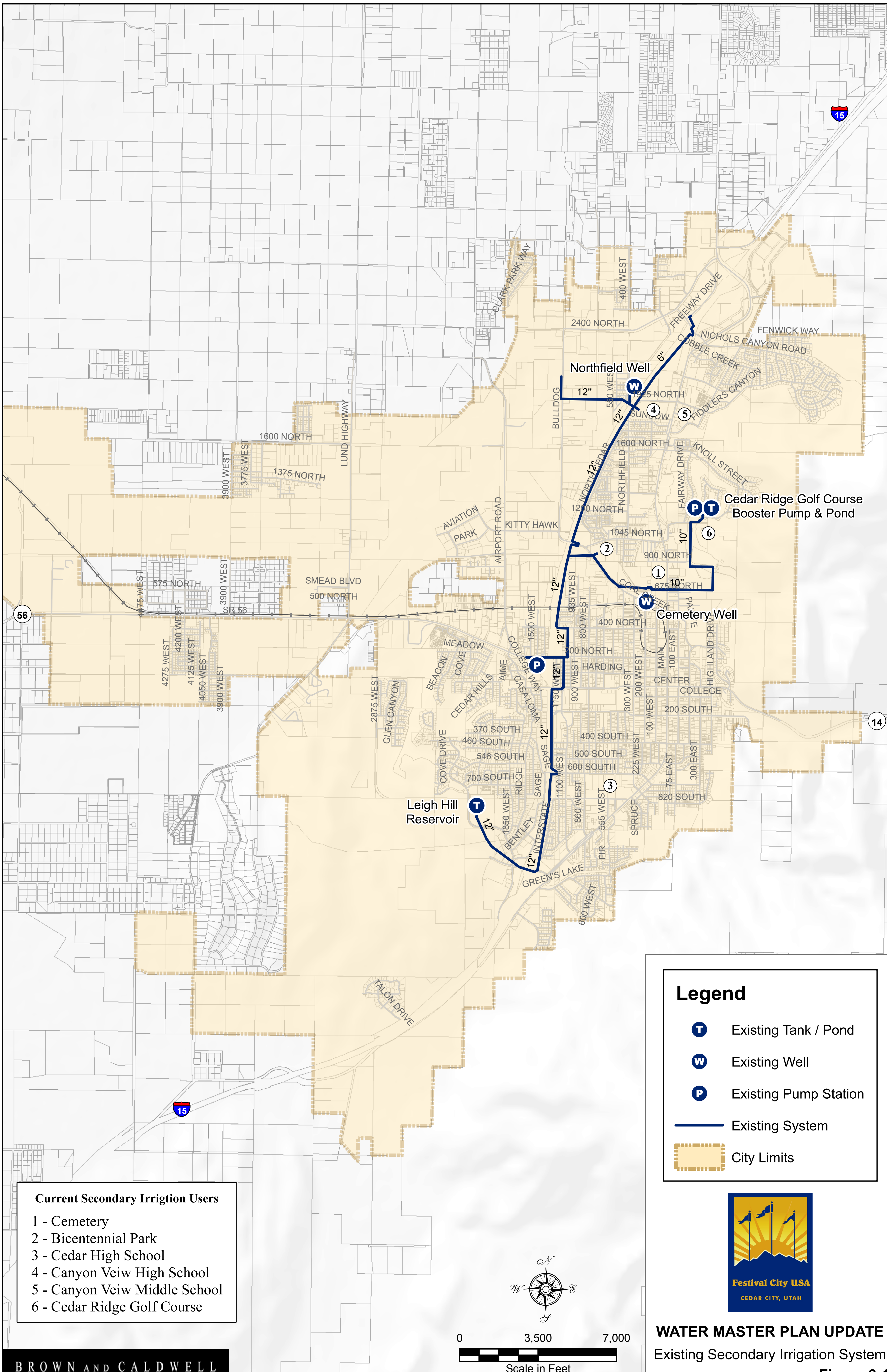
As mentioned, there are two existing water storage facilities. The *existing storage reservoir identified in the previous plan at the south end of the system has been re-constructed; The reservoir will have a finished capacity of approximately 99 acre-feet* (32.3 MG) and is located at about 2090 W. Royal Hunte Drive. *Cedar Ridge Golf Course has a pond with a storage volume of approximately 1.5 MG and a 50 HP booster pump used to supplement flow from the Cemetery Well.*

A pumping station with two 350 HP pumps and a small equalization reservoir is located near the old wastewater treatment plant site. While it is attached to the irrigation system, it is currently not operated. The pumps have been removed and the piping disconnected.

Water Supply

Cedar City currently has water rights for the Cemetery Well, *Northfield Well* and for surface water from Coal Creek that can be used for irrigation purposes. Cedar City also owns shares in five irrigation companies that are supplied by Coal Creek. See Section 2 for information on each of these water rights.

Two sources of water are now being used for the existing secondary irrigation system. The first is a well located near the southwestern corner of the cemetery called the Cemetery Well and has a design capacity of 1,575 gpm at a total dynamic head of 612 feet. The second source is a well located north of town called the Northfield Well and has a design capacity of 900 gpm and a total dynamic head of 635 ft. The wells' maximum production capacities are 1,400 and 900 gpm respectively. Both sources can deliver water to the Leigh Hill Reservoir. The Golf Course and Pond do not use the Northfield Well, only the Cemetery Well. Additional information regarding the well and pumping facilities can be found in Appendix B.



WATER MASTER PLAN UPDATE

Existing Secondary Irrigation System

Figure 8-1

Current Water Use

Based on *2007* water production records received from the City, the Cemetery Well produced *147,252,000* gallons *(451.899* acre-feet) *and Northfield Well produced 80,546,300 gallons (247.187 acre-feet).* The water is supplied to *six* connections: the cemetery, golf course, Bicentennial Park softball and soccer fields, Canyon View High School, Canyon View Middle School, and Cedar City High School. Now that the reservoir is completed, Southern Utah University is connected to the system, but in past years has chosen not to use the water because of the water's high TDS content. *Once the reservoir is completed Southern Utah University will begin to use secondary irrigation water.* Table 8-1 shows the average amount of water being used at each site.

Table 8-1. Current Secondary Irrigation Use Table

Location	Net Area Served (acres)	Average Yearly Use (acre-feet)(1)	Average Demand (acre-feet/acre)
Cemetery & Bicentennial Ball Fields	*50*	*140.2*	*2.8*
Golf Course (including the Pond)	*150*	*381.2*	*2.5*
Cedar High School	*65*	*95.1*	*1.5*
Canyon View High & Canyon View Middle Schools	*40*	*82.3*	*2.1*
Total	*305*	*698.8*	*2.3*

Note: (1) Values taken from Cedar City Corporation Annual Water Report from 2007. Numbers may be slightly reduced since they do not include water discharged into Coal Creek.

DELIVERY ALTERNATIVES

This study evaluated two separate delivery alternatives. The first alternative is a Partial City System that would expand delivery of secondary water to major irrigation water users currently served by the culinary water system and to new developments. The second alternative is a complete City-wide System that would deliver secondary water to all areas within the City limits. Many of the aspects of the Partial City System would be required in the City-wide System. Therefore, it was assumed that the Partial City System would be built first, then the City-wide System would be added.

Secondary Irrigation Design / Evaluation Criteria

Criteria used in this study *are a continuation of those established in the previous master plan and are based on previous experience,* the State of Utah Rules for Public Drinking Water Systems Part II Design and Construction Standards for Systems, and good engineering judgment. A summary of the design criteria is included in Appendix D.

It has been assumed that operational pressure should be a minimum of 45 psi and a maximum of 120 psi. This range provides adequate service without causing pressure related failures to the pipe network and allows sprinkler systems to function properly. However, designs were completed by trying to maintain a working pressure of 65 psi throughout the system.

Computer models were created of the existing distribution system and of each alternative as tools for evaluating existing and future conditions. The models only include the main pipeline backbone distribution systems. They do not include delivery connections to each residential user. Residential users were grouped into larger sub-areas, represented by a single demand. Complete pipeline system layouts were designed for representative residential areas within the City. The designs from these representative areas were used to determine the percent of irrigated areas from gross area, average demands per net acre served, and estimated construction costs per acre for each residential sub-area used in the models.

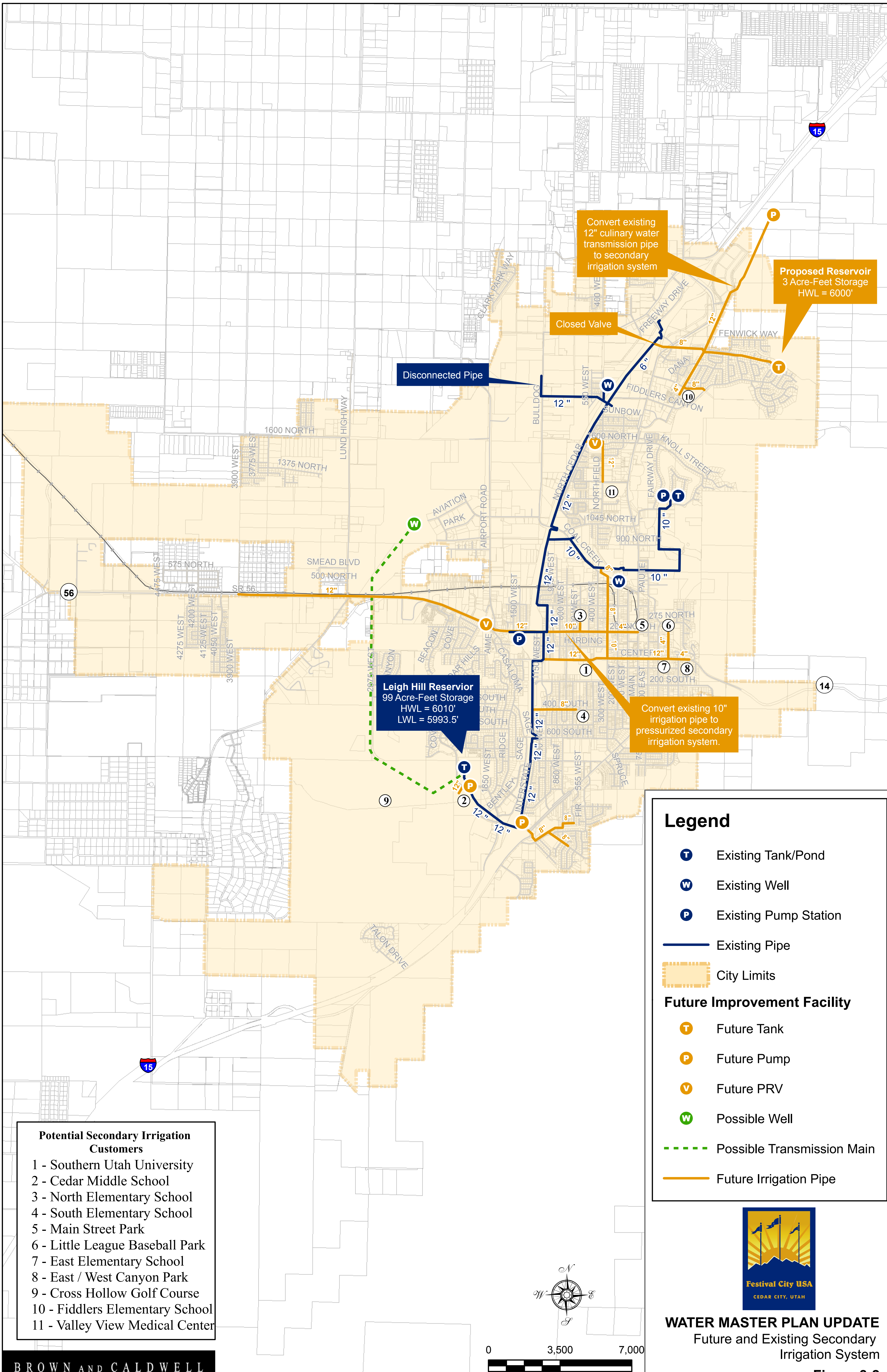
Partial City System

The Partial City System (Partial System) would continue to deliver water to the current users and add several new major water users. The new major users would include all City parks and schools not currently served by the existing system. In addition to the major users, the Partial System *evaluation assumed the City would require* that all new developments construct the necessary infrastructure and use secondary irrigation water. *Figure 8-2* shows the areas served by the Partial System and the proposed backbone distribution system.

There are several improvements which would be required for the operation of the Partial System alternative. These improvements are shown in *Figure 8-2*. The system was modeled using the *newly reconstructed 99* acre-feet reservoir as a storage facility to meet instantaneous peak demands.

There are two areas that cannot be served by gravity flows from this reservoir. Cedar Middle School and *future Cross Hollow Golf Course or Park Area*, would require a dedicated line with a booster pump to provide adequate pressure for an irrigation system. One of the identified undeveloped areas southeast of the reservoir is higher in elevation than the maximum surface elevation of the reservoir. This residential area would also require a booster pump.

Since the City is going ahead with constructing the 200 North Pump Station that will capture excess water from Coal Creek, the City is no longer interested in the option of diverting directly from Coal Creek at the mouth of Cedar Canyon as discussed in the previous Master Plan.



WATER MASTER PLAN UPDATE
Future and Existing Secondary Irrigation System
Figure 8-2

At the north end of the City a new three acre-foot reservoir would need to be built with an overflow elevation of 6,000 feet or higher to meet peak instantaneous demands for potential new residential developments in that area. The supply for the reservoir would be the Enoch South Well. The well would likely require a new pump and motor to provide for the necessary head. The existing 12-inch culinary water transmission pipe, which carries water from the Enoch Well field, is proposed for replacement as part of the culinary water system improvements plan. This pipe could be converted and used for the secondary irrigation system.

In order to maintain service pressures within the recommended design limits, two pressure reducing valves (PRV) would need to be installed. Their locations are shown on *Figure 8-2*. Table 8-2 summarizes the required improvements to the secondary irrigation system for the Partial System alternative.

Table 8-2. Summary of Required Improvements for Partial System

Requirement	Improvement
To service Cedar Middle School	Booster Pump - 10 hp
To service residential area	Booster Pump - 100 hp
Water source - Coal Creek	200 North Pump Station
To meet north end peak demands	Storage reservoir at elevation 6,000 Feet
Water source - north end of City	Re-equip Enoch South Well and convert 12-inch transmission pipeline
To regulate pressures	Install 2 PRV's

Other options were reviewed to help meet system demands and were later eliminated. One option was a pond/storage reservoir on the golf course to meet peak instantaneous demands of the lower pressure zone. In place of this option a pipeline was added that could be used to pump water from the Cemetery Well into the existing storage reservoir. Another option was using the existing Enoch South Well and adding a booster pump rather than a reservoir to serve the higher residential developments. However, the well does not produce a sufficient supply of water to meet peak instantaneous demands for that area. An existing 15-inch pipe from the Coal Creek diversion was also investigated. It was found to provide very little benefit.

City-wide System

The City-wide System would also continue serving the current major users and add all other areas that are within the City limits. Figure 8-2 shows the areas served by this alternative and the proposed backbone distribution system. The City-wide System would require the same improvements as listed under the Partial System. The main difference between the two systems is the need for additional supply sources and storage facilities.

The Leigh Hill Reservoir has sufficient capacity to meet all peak demands of the City-wide System. However, due to the limited capacity of the existing 12" transmission pipe, and the difficulty in filling the reservoir, not all of its capacity can be used and additional storage at the north end of the City is still required.

Additional water sources to meet the increased needs of the City-wide alternative could be obtained by purchasing existing wells and water rights, and/or obtaining additional shares in irrigation company stock that divert water from Coal Creek.

For this study it was assumed that additional water needs would be supplied from Coal Creek. A pump station for this purpose is currently under construction. It is being constructed in the drainage channel along 200 North at approximately 1700 West. It will provide a maximum flow rate of 1,800 gpm and will be able to deliver water to the Leigh Hill Reservoir. The required pump station capacity was determined to be roughly 300 hp.

Several additions and improvements to the distribution piping and appurtenances would also be required. The size of the two proposed booster pumps serving Cedar Middle School and the south east area of the City would need to be increased. Under the Citywide System these pumps would be serving larger areas and/or higher elevations. The pumps would change from 10 hp and 100 hp to 75 hp and 200 hp, respectively. Delivery system piping between the backbone system shown, and individual service connections, would be required in all existing developed areas to be retrofitted. In addition, the existing 12-inch pipe, from Leigh Hill Reservoir to I-15, would need to be replaced with a 16-inch pipeline.

Table 8-3 provides a summary of the required improvements that would be necessary to expand the Partial City system to a full City-wide secondary irrigation system. All other improvements shown on the Partial City system would remain as shown under that alternative.

Table 8-3. Summary of Required Improvements to Expand to City-wide System

Requirement	Improvement
Service to Cedar Middle School and additional residential areas	Increase size of booster pump - 75 hp
Service to all existing individual residences	Delivery system pipe network
Service to south end residential areas	Increase size of booster pump - 200 hp
Additional Water source	200 North Pump Station
Increase pipeline capacity	Replace existing 12-inch pipeline from Leigh Hill Reservoir to the proposed 100 hp booster station with 16-inch pipe and on 200 North from 1150 West to 200 North Pump Station with 18-inch pipe

Future Water Requirements

Table 8-4 shows the water supply requirements for outdoor irrigation. The amount required will depend on the extent to which the secondary irrigation system is developed. The table shows three possible development scenarios as suggested by the City and evaluated for this study. For comparison, the table also includes the same requirements (based on State requirements) for the present system.

Table 8-4. Outdoor Irrigation Requirements

Description	Peak Day Demand (1)	Ave. Yearly Demand (2)	Storage Requirement	Peak Instantaneous Demand (3)
State Requirements	3.39 gpm/acre	3.0 ac-ft/acre	2,528 gal/acre	6.78 gpm/acre
Present System (355 acres)	*1,200 gpm (2.7 cfs)*	*1,065 ac-ft*	*897,440 gal (2.8 ac-ft)*	*2,400 gpm (5.4 cfs)*
• Partial City System (960 acres)	3,250 gpm (7.2 cfs)	2,880 ac-ft	2,427,000 gal (7.4 ac-ft)	6,500 gpm (14.5 cfs)
• City-Wide System without Undeveloped Areas (1640 acres)	5,560 gpm (12.4 cfs)	4,920 ac-ft	4,146,000 gal : (12.7 ac-ft)	11,100 gpm (24.8 cfs)
• City-Wide System with Undeveloped Areas (2,200 acres)	7,460 gpm (16.6 cfs)	6,600 ac-ft .	5,562,000 gal (17.1 ac-ft)	14,900 gpm (33.2 cfs)

(1) Sourcec(s) must be legally and physically capable of meeting demands.
(2) Average yearly demand was changed from the State requirement of 1.66 ac-ft/yr/acre to 3.0 ac-ft/yr/acre. (3.0 ac-ft/yr/acre equals the average evapotranspiration rate less precipitation during the growing season).
(3) For distribution system sizing.

To meet the peak demands for a Partial City System, as shown in the table above, the City must use at least some of its surface water rights from Coal Creek in addition to what is supplied from the *Northfield and* Cemetery Wells. The Cemetery *and Northfield Wells* are designed to produce approximately *5.12* cfs requiring an additional *2.08* cfs from Coal Creek. One alternative groundwater source is the Enoch Well No. 2. It has sufficient capacity to meet the irrigation system demands at the north end of the City and is only used to produce culinary water on an emergency basis.

From the water supply evaluation discussed in Section 2, it appears that another 1.1 cfs of irrigation water supply capacity would need to be acquired to serve a City-wide system including undeveloped areas. However, a more in-depth study of the amount of water available from the irrigation company shares in Coal Creek needs to be completed. After completion of that study, the need for additional water rights to be obtained can be confirmed.

These additional rights could be obtained by change application for existing unused City-owned culinary water rights, purchase of additional surface water rights (Coal Creek rights or irrigation company shares), or purchase of private well(s) with water rights.

Water Quality

Average TDS values from the Cemetery Well have been near 3,000 mg/L. This may require over-irrigating by up to 80 percent to prevent a buildup of salts and resulting damage to plants (water supply records do not confirm this however). Under the Partial City System, assuming 3.5 cfs from the Cemetery Well with a TDS of 3,000 mg/L and 3.7 cfs from other sources with an average TDS of 500 mg/L, the mixed TDS would be approximately 1,715 mg/L. Under the City-wide System, assuming 3.5 cfs from the Cemetery Well with a TDS of 3,000 mg/L and 9.0 cfs from other sources with an average TDS of 500 mg/L, the mixed TDS would be approximately 1,200 mg/L. Each of these scenarios would create a mixed water that is within the range of acceptable TDS levels for irrigation use and reduce or eliminate the need to over-irrigate. The difficulty would be the ability of the system to thoroughly mix the water from all sources. During times of high demand, little or no water would be flowing into the reservoirs, thus there would not be any effective mixing. Some areas would then receive the poor quality water directly from the well.

If irrigation sources are not mixed, the City's intent is to have the Cemetery Well be dedicated to the Golf Course. The Northfield Well, the 200 North Pump Station, and the Leigh Hill Reservoir will provide water to the other customers on the secondary irrigation system. By letting the Golf Course have the Cemetery Well full time, the concerns of poor water quality will be minimized throughout the irrigation system.

Waste Water Scalping Facility

An evaluation was completed to consider the feasibility of using wastewater scalping as a source of secondary water supply. The City currently applies all treated wastewater effluent north of the existing Cedar City Regional Wastewater Treatment Facility (CCRWTF) into open fields, some effluent is used for crop irrigation during summer months.

To implement reuse water for secondary water supply, a wastewater scalping facility would need to be constructed north of the City, near the airport. Approximately 90% of the City's wastewater average daily flow (adf) is conveyed through this location. The location gives the City the largest reuse water quantity for the least amount of pumping. The treated reuse water would be pumped into the City and used to supply the secondary irrigation system directly and/or to assist in aquifer recharge for later withdrawal.

Wastewater records from 2007 indicate the City has a wastewater average daily flow (adf) of 2.5 MGD and by the year 2050 is roughly projected to be 12.1 MGD. The City has the potential with 2007 wastewater flows to produce approximately 1.8 MGD of reuse water and 8.7 MGD by the year 2050.

Appendix H shows the costs of reuse facilities ranging in size from 1 MGD to 5 MGD of treated water. The estimated capital cost for a 1 MGD wastewater scalping facility is approximately $10,000,000 and a 5 MGD wastewater scalping facility is approximately $40,000,000. The respective annualized O&M cost are estimated at $200,000 and $1,000,000. The reclaimed water annualized cost per AF is $775 for the low end of a 1 MGD reuse facility and $642 per AF for the low end cost for the 5 MGD reuse facility.

The considered offset costs for the reuse facilities include the value of water rights and the reduction in flow conveyed to CCRWTF. The cost of water rights in Iron County ranged between $3,500 and $10,000 in 2007. It was assumed that water rights on average would cost $4,500 per acre-ft. The cost of 1.8 MGD of reuse would cost approximately $9,000,000 in water rights and 5.0 MGD of treated reuse would cost approximately $25,200,000. The reduction in flow *conveyed to CCRWTF would decrease, effectively improving the adf capacity of sewer mains giving an added long term value to the sewer pipelines of approximately $5,200,000 for 5 MGD of reuse.*

A scalping faculty would have a positive impact on the nitrate loading at the existing wastewater treatment plant since both flow and pollutants such as nitrogen containing compounds would be removed upstream. An upstream scalping facility could preclude or significantly reduce the need to upgrade or expand the existing wastewater treatment plant to handle future flows and loadings.

We would recommend a more in depth study be conducted to further evaluate and refine the feasibility of scalping including the location of a treatment facility, potential water quantities and quality, aquifer characteristics (including storage volume, water quality, and production capabilities), impacts on the City's Wastewater Treatment Facility (particularly in regards to potential upgrades required for nitrogen removal), regulatory issues (both treatment and ground water), and cost (capital, O&M, per unit volume).

COST ESTIMATE

A brief review of capital and operating costs was completed for each alternative for comparison with each other and other potential water supply options.

Capital Costs

Engineering News-Record (ENR) Construction Cost Index (CCI) numbers where used to update the cost estimates of the two secondary irrigation system alternatives from the last master plan to present day values. A CCI of 5,881 was used for construction costs for October 1998 and 8,361 for August 2008. A break-down of *1998* costs is shown in *Appendix I for both the Partial City System and City-wide Systems.*

The estimated capital cost for the Partial City System would be approximately *$4,500,000*. The additional cost to convert to a City-wide System would be approximately *$21,100,000* (a total cost of *$25,600,000*).

Prioritized Cost for Partial System

Table 8-5 shows the potential users for a Partial System and the estimated cost to add each user to the existing irrigation system. The capital cost in Table 8-5 show the estimated cost to add each user to the existing irrigation system, Cross Hollow Golf Course includes the cost of a booster station. The unit cost per flow rate determines the most cost effective users to add to the system and will help prioritize when the users will be added. Because various users are downstream of one another, a number of users must be added to the Partial System in sequence. The layout of the Partial System is shown in Figure 8-2.

Table 8-5. Estimated Cost to Add User to Existing System

Irrigation User	Irrigation Demand (gpm)	Length of Pipe (ft)	Capital Cost	Unit Cost ($ / gpm)
Cross Hollow Golf Course	763	7800	$2,100,000	$2,800
Cedar Middle School	20	0	$50,000	$2,500
South Elementary School	25	2000	$460,000	$18,400
North Elementary School	15	1500	$340,000	$22,700
Main Street Park	25	1500	$340,000	$13,600
East Elementary School	20	2000	$460,000	$23,000
Little League Baseball Park	102	1500	$340,000	$3,300
East / West Canyon Park	36	2500	$570,000	$15,800
Fiddlers Elementary School	20	2500	$570,000	$28,500

Secondary Irrigation Operation and Maintenance Costs

Annual operation and maintenance costs are estimated to be $90,200 and $205,400 for the Partial City System and City-wide System, respectively. Table 8-6 shows a breakdown of these estimated costs.

Table 8-6. Estimated Annual Operation and Maintenance Cost

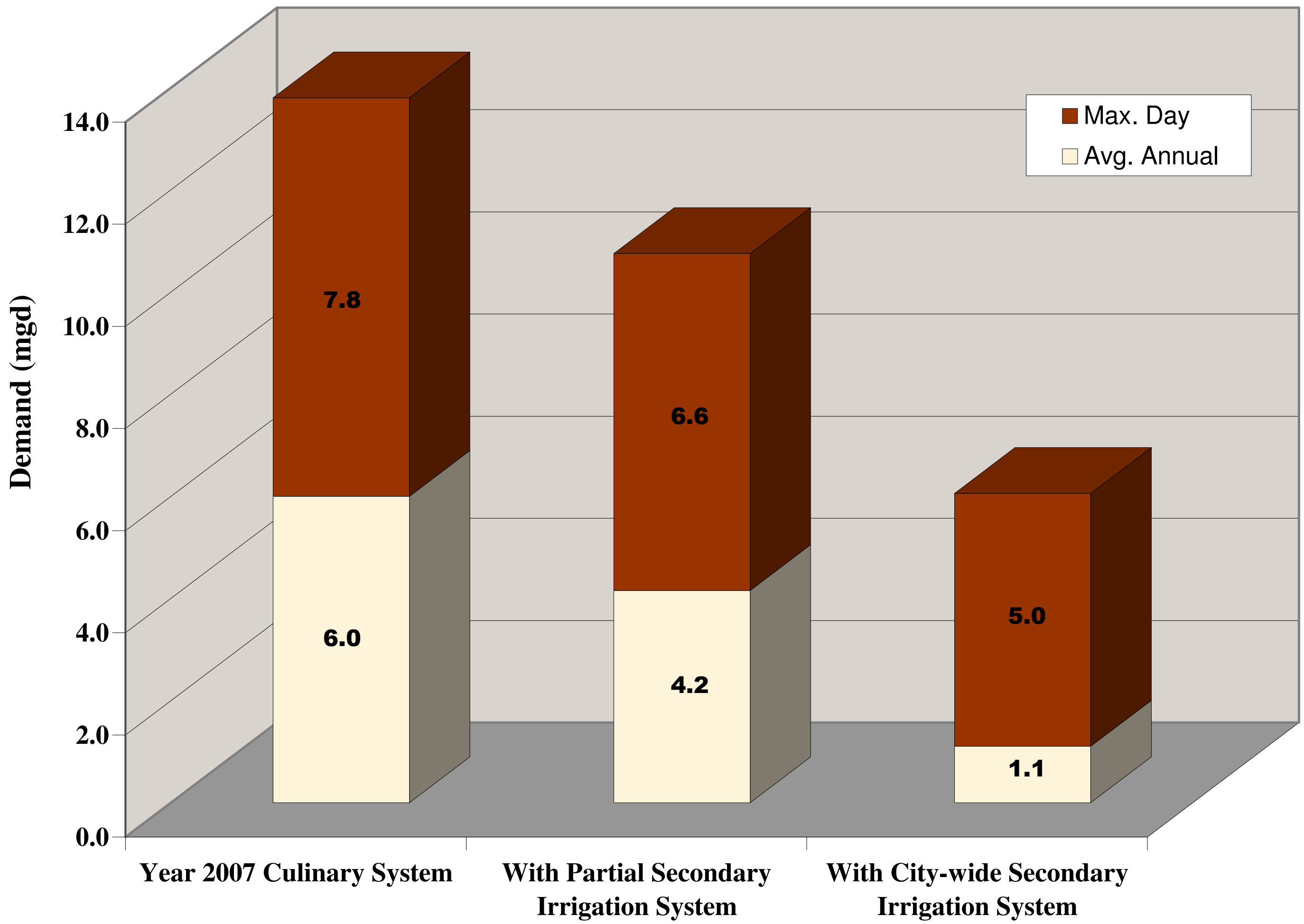
Description	Partial System	City-wide System
Supervisor	$20,600	$41,200
Maintenance Personnel	0	$20,600
Misc. Material, Fuel, Supplies	$3,400	$6,900
Energy:		
Cross Hollow Booster	$800	$6,200
South End Residential Booster	. $6,200	$16,300
Cemetery Well	$16,300	$26,500
Enoch South Well	$26,500	$16,300
200 North Pump Station	$44,900	$0
Total	$118,700	$134,000

CONCLUSIONS

Several conclusions can be drawn from this evaluation of the proposed secondary irrigation system alternatives relating to culinary water system impacts and development costs. These are summarized in the following paragraphs.

Impacts to Culinary System

Construction of a secondary irrigation system would greatly reduce demands on the culinary water system. As an example, Figure 8-3 shows the reduced demands on the culinary water system after implementing each of the proposed secondary irrigation system alternatives



Festival City USA
CEDAR CITY, UTAH

EFFECTS ON CULINARY SYSTEM FLOW DEMAND WITH SECONDARY IRRIGATION SYSTEM IMPROVEMENTS

FIGURE 8-3

(assuming full implementation by the year 2008). The Partial System would reduce the maximum day demands for culinary water by approximately *3.1* mgd. The City-wide System would reduce the maximum day demands for culinary water by approximately *7.5* mgd. The reduced culinary water demands would allow the City to reserve their higher quality water sources for future culinary water needs.

Secondary Irrigation Preferred Alternative

There are several determining factors that can be used to select a preferred alternative. The two main controlling factors for this study are cost and availability of water supply. The cost of the water under the Partial System alternative, including operation and maintenance, would be approximately $123 per acre-ft ($0.38/1,000 gal.). The City-wide System water would cost approximately $256 per acre-ft ($0.78/1,000 gal.). Another very important factor is availability of water supply. The Partial System could be implemented using the water rights and sources already owned by the City. The City-wide System will require the acquisition of additional water rights for either surface water from Coal Creek or for groundwater from an additional well. Another factor would be public acceptance of each alternative. Construction of the Partial System would have very little impact on the general public. However, the City-wide System would greatly disturb or temporarily inconvenience most residents. It would also require a great deal of coordination and scheduling between homeowners and the City, not only during construction but during system startup and operation as well. Based on the above observations, it appears that the Partial City System would be the preferred alternative. The system could be constructed to accommodate future expansion.

GENERAL

This section outlines the recommended plan for Cedar City to guide the continuous development and improvement of its culinary water system. The plan is based on the combined findings of each part of the evaluation. It includes provisions for supply, distribution, transmission and storage needs.

SUPPLY

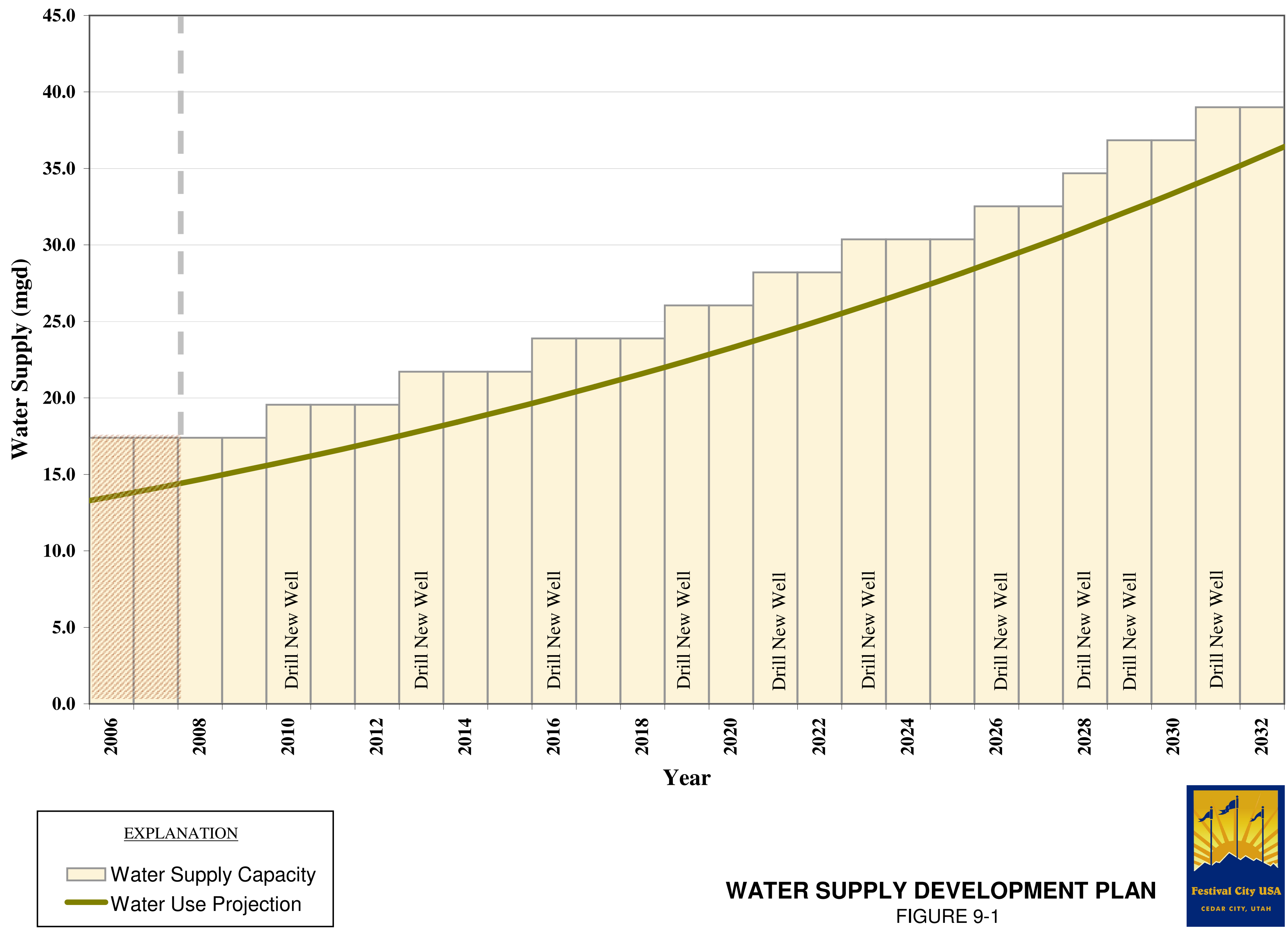
The following water supply improvements are recommended:

- *Develop an additional 22.57 mgd capacity of potable water supply for the water distribution system and an additional 2.08 mgd capacity of non-potable supply for the secondary irrigation system by the year 2032. A portion of that supply should come from connections to CICWCD to provide a redundant source of supply.*
- *Optimize capacity of existing diversions to take full advantage of facilities and water rights. This includes rehabilitation of spring collection and conveyance piping, well casing rehabilitation and re-plumbing of Quichapa Wells 5, 6, and 7 to discharge to the Proposed Zone 8 Storage Tank, Central and pump station.*
- *Acquire additional groundwater rights (approximately 8,000 AF by 2032) through the City's water acquisition ordinance, being careful to retire irrigation uses to offset new groundwater diversions*
- *Site and Drill approximately 10 additional wells as supply for the culinary water distribution system for 2032. One of the wells will need to be constructed in the Enoch well field and Enoch Well #2 will need to be refurbished or re-drilled for 2032. The remainder should be drilled in a new wellfield located south of Route 56 between South Westview Drive and Quichapa Lake or within the existing Quichapa well field. Each well will need to produce 1,500 gpm.*
- *Study and implement aquifer recharge to optimize the available groundwater resource.*
- *Perform supply facilities maintenance to remedy deficiencies noted in the condition assessment summary provided in Appendix B.*

Figure 9-1 illustrates the plan for development of future water supplies. Not shown is the immediate effort needed to restore the existing spring and well production facilities to their design capacity. The first additional well should be constructed and be operational by 2010. The remainders are to be constructed every two or three years and shown. The plan eventually provides and maintains about a 5-year capacity surplus.

SECONDARY IRRIGATION SYSTEM

Recommendations related to the distribution system facilities include provisions for transmission, storage and pumping to meet future needs. There are several determining factors that can be used to select a preferred alternative. The two main controlling factors for this study are cost and availability of water supply. The cost of the water under the Partial System alternative, including operation and maintenance, would be approximately $123 per acre-ft



WATER SUPPLY DEVELOPMENT PLAN

FIGURE 9-1

($0.38/1,000 gal.). The City-wide System water would cost approximately $256 per acre-ft ($0.78/1,000 gal.).

Construction of the Partial System would have very little impact on the general public. However, the City-wide System would greatly disturb or temporarily inconvenience most residents. It would also require a great deal of coordination and scheduling between homeowners and the City, not only during construction but during system startup and operation as well. Based on the above observations and as recommended in the previous master plan, it appears that the Partial City System would be the preferred alternative. The system could be constructed to accommodate future expansion.

CULINARY WATER DISTRIBUTION SYSTEM

Recommendations related to the distribution system facilities include provisions for piping, storage and transmission systems to meet existing and future needs. They were based on modeling of improvement alternatives. *The improvements were grouped into projects and categorized as short-term or long-term projects. Short-term projects address existing problems in the system and long-term projects include improvements for future demands.*

TRANSMISSION SYSTEM

Transmission system recommendations include piping, as well as booster pump improvements. Transmission system recommendations are shown in Figure 7-1. The recommendations were developed specifically to integrate the distribution, storage and supply recommendations. *Implementation of transmission system improvements is integrated with the distribution system implementation plan, provided later in this Section (Table 9-2).*

In addition to the specific projects identified in the implementation plan, it is recommended that full cathodic protection of the 16-inch Quichapa Transmission pipeline be installed in accordance with the recommendations of the Corrosion Control Technologies, Inc. Nov. 2007 Report.

STORAGE

Additional storage will also be required to meet future demands. Future storage needs were evaluated by pressure zones. A total of *38.6* million gallons of additional storage will be required *by year 2032 and 77 million gallons by build-out. The proposed new tanks, Ashdown and 800 South, will serve Pressure Zone 1 and the northern part of Zone 4 in the near future. Beyond the near future, Ashdown will serve the proposed Zone 9 while 800 South will serve the proposed Zone 8. An additional 5.8 MG storage capacity should be constructed to support 800 South Tank to serve Pressure Zone 7. An additional 3.4 million gallon tank should be constructed to serve Pressure Zone 3. Finally, Zone 8 will require a total storage capacity of 21.8 MG. They should be generally located as shown in Figure 7-1. Additional studies should be undertaken to select specific tank sites. All future tanks have been sized to meet water demand projections for year 2032.*

NON-CAPITAL IMPROVEMENT RECOMMENDATIONS

Additional recommendations were developed that are not part of the capital improvements plan. They include:

- *Repair/maintain water supply meters. Not all of the meters were functional at the time data was collected for this study. Some of the water supply numbers are merely estimates based on average production rates. This should be corrected to improve accuracy of documentation and improvement of future updates.*
- *Collect and store hourly flow data for supply meters. Hourly water supply data should be stored indefinitely. The data is valuable in performing future operational analyses and model updates. Data storage space (i.e. backup CDs) is inexpensive but the data cannot be recovered once it is purged.*
- *Make remote level sensor at Cedar Canyon Tank more reliable. The level sensor at Cedar Canyon is solar powered and often fails to read. Improvements should be made to prevent this.*
- *Investigate piping upstream of fire flow tests 5 and 8 to determine cause of discrepancies during calibration. This should be performed prior to design and construction of recommended improvements at these locations (See projects S-7 and S-10).*

IMPLEMENTATION PLAN

The improvements were grouped into projects and categorized as short-term or long-term projects. Short-term projects address existing problems in the system and long-term projects include improvements for future demands.

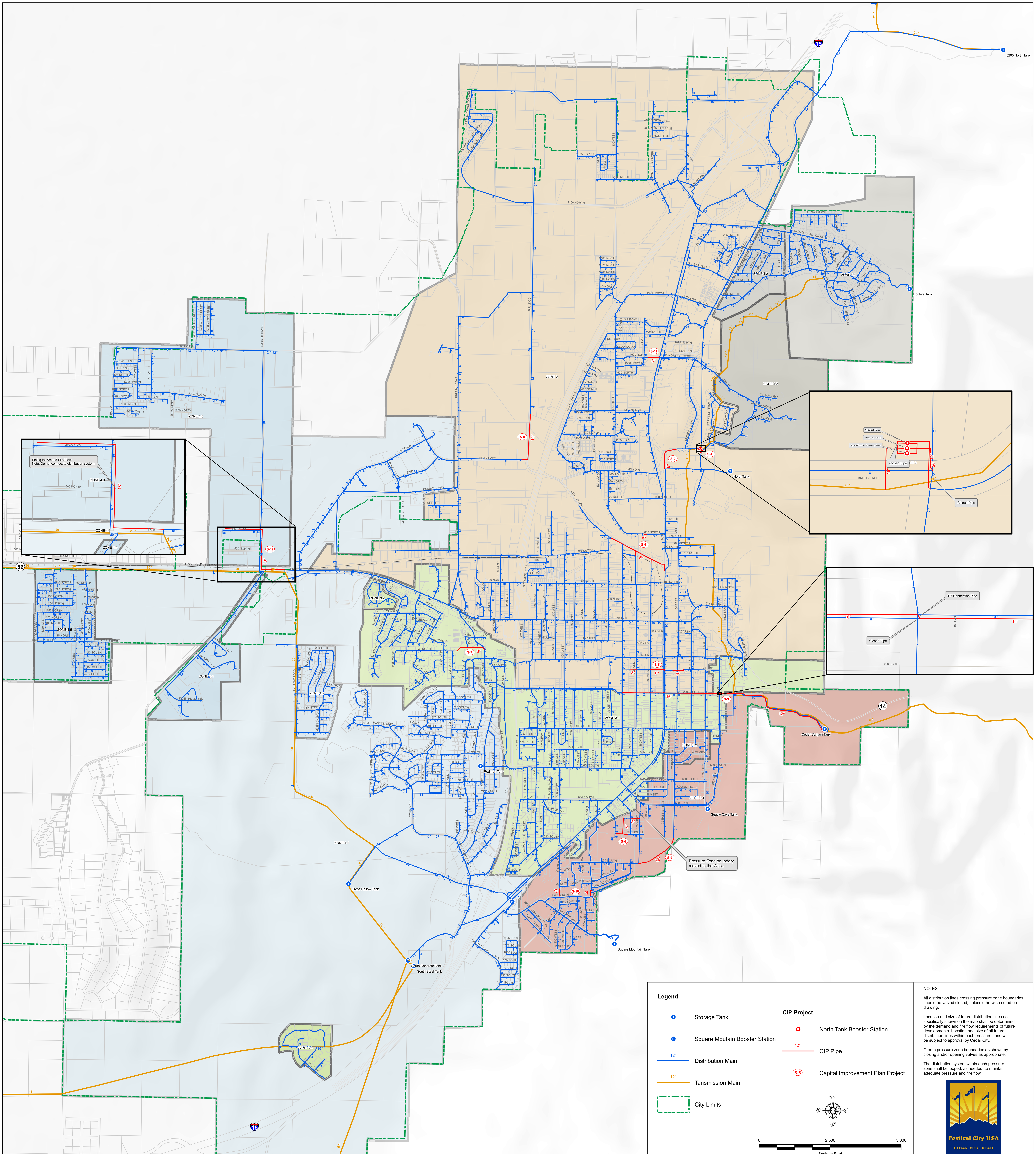
Short-Term Projects

Short-term projects are designed to resolve existing problems in the distribution system. They should be implemented immediately or in the near future. The short-term improvements were sized to meet both existing and future demands. Table 9-1 lists the short-term projects along with the associated Figure 9-2.

Pipe Installation and Replacement Projects

Projects S-1 through S-12 consists of new piping construction to increase capacity to areas where pressures drop below 45 psi under existing demand conditions. The projects were arranged by most important or needs basis.

The existing system model was modified to reflect immediate improvements that will benefit the system. First, overflow problems at 3200 North and Cedar Canyon Tanks were evaluated. After evaluations of identified options, a booster pump positioned along Knoll Street near the Golf Course is recommended to pump water from 3200 North Tank up to Fiddlers Tank, North Tank and Square Mountain Tank for emergency. Boosting water from the distribution line to Fiddlers Tank will utilize the water in 3200 North Tank, preventing overflow and maintaining adequate levels. However, boosting water from the distribution line to North Tank will re-circulate water and may not prevent overflow of water in 3200 North Tank. A benefit for this option does reduce



NOTES:

All distribution lines crossing pressure zone boundaries should be valved closed, unless otherwise noted on drawing.

Location and size of future distribution lines not specifically shown on the map shall be determined by the demand and fire flow requirements of future developments. Location and size of all future distribution lines within each pressure zone will be subject to approval by Cedar City.

Create pressure zone boundaries as shown by closing and/or opening valves as appropriate.

The distribution system within each pressure zone shall be looped, as needed, to maintain adequate pressure and fire flow.

BROWN AND CALDWELL	PROJECT NO. 134355	PROJECT	CEDAR CITY WATER MASTER PLAN UPDATE	Figure
	REVISED DATE 06-17-09	TITLE	Existing Culinary Water System Improvement	9-2

demands from Cross Hollow and Square Mountain Tanks which supplies water to Fiddlers Tank. Another benefit for this option is to allow water transmission between 3200 North to North, Fiddlers, and Square Mountain Tanks. Finally, North Tank has low water level issues but will be maintained with a booster pump connecting to the distribution main within the zone it serves.

Cedar Canyon Tank is currently a supply source to Zone 3. Due to the hydraulic grade and additional capacity of Squaw Cave, Redman and South Steel Tanks, the tank does not get a chance to supply the Zone. Therefore, utilizing its service to Zone 2 will prevent overflow and help mitigate its water level to an acceptable level. This will require a replacement and utilization of the altitude valve at Cedar Canyon Tank. The 10-inch main coming from the tank will need to be activated to help distribute more water into Zone 2. The 6-inch main will need to be replaced to eliminate low pressures in Zone 2 and can be used simultaneously with the 10-inch main. The replaced 6-inch main should be inter-tied into the 10-inch main at200 South and 400 East and closed off from Pressure Zone 3. At the inter-tie location, 200 South and 400 East, the 10-inch main should be replaced with a 16-inch main from 400 East to 300 West for distributing the capacity required from the tank.

Table 9-1. Short-Term Improvement Projects

Project	Description	Total Estimated Cost[1]
S-1	Install Fiddlers, North and Square Mountain Tanks Booster Pumps west of North Tank near Golf Course and Piping to Transmission and Distribution Pipe.	$1,787,000
S-2	Install 8” pipe along Knoll Street for looping	$144,000
S-3	Replace 6” with 12” pipe along 200 South from Cedar Canyon Tank to 400 East, intertie the new 12” with the 10” at 200 South and 400 East, and replace 10” with 16”, west side of intertie, along 200 South from 400 East to 300 West. This will allow sufficient service for Zone 2. In addition, replace the altitude valve for Cedar Canyon Tank.	$1,379,000
S-4	Install 8” piping along 995 South and 895 South for looping and re-establishing pressure zones	$115,000
S-5	Install 8" pipe along College Avenue for looping	$185,000
S-6	Install 8” pipe along Coal Creek Road and install 8” for looping along 100, 200 and 300 West	$388,000
S-7	Install 8” pipe along 30 North for looping	$152,000
S-8	Install 8” pipe along Bulldog Road for looping	$243,000
S-9	Install 12” pipe for distribution/transmission between 820 and 1150 South Street	$286,000
S-10	Install 8" along 860 West and Fir Street for looping	$76,000
S-11	Install 8” along 1600 North for looping from Main St. to dead-end pipe.	$56,000
S-12	Install 20” pipe from Cross Hollow Rd to Smead Facility for Fire Flow purposes	$915,000
Total		$5,726,000

(1) Installation costs include contingency, engineering and administration.

The existing distribution piping network shows pipe networks 6-inchs or smaller. Upsizing these pipes will reduce headloss and eliminate low pressures allowing to separate all pressure zones from one another. Pipes were added as part of the distribution system to improve low pressures areas. Recommendations were not provided for some of the deficiencies identified during the model analysis for various reasons. For example, there are several areas where pressures dip below 40 psi at peak hour demand. These low pressures appear at the highest elevations within the pressure zone, near the boundaries. Fixes for those areas would not be worth the cost to gain a few psi of pressure.

It is important to note that projects S-7 and S-10 are near the two hydrant flow test sites that could not be calibrated. Since the field data would indicate a much greater hydraulic capacity in those locations than indicated by the model, the calibration issues should be fully investigated before proceeding with these two projects to avoid installing un-necessary improvements.

Long-Term Projects

Long-term projects are recommended to enhance performance of the distribution system as the City expands and approaches build-out conditions. Table 9-2 lists the long-term projects and Figure 7-2 shows the improvements to be made in each area. Because the timing of development in the City is uncertain, the projects were listed in order from north to south after project L-3. The City will need to implement the improvement projects as new developments are constructed.

A key part of the Long Term Plan is the development of pressure zones to regulate pressures within recommended limits. The recommended plan contains nine separate pressure zones. Where practical, pressure zone boundaries follow topographic contours at the elevations indicated in the schematic. The hydraulic schematic also shows illustrates the relationship between storage facilities and each pressure zone. The hydraulic grade of each pressure zone is regulated by the water surface of the storage tanks serving the zone, except where supplied solely by PRV.

Figure 7-2 is a map of the recommended water system improvements. Distribution piping was laid out to follow existing or proposed road rights-of-way as shown in the City's Street Master Plan. In the build-out plan, main distribution pipes of 12-inches and larger were included in the plan. The recommendations shown also include existing pipes which require replacement. Pipe replacement was recommended where existing facilities have insufficient capacity to meet current and/or future needs (i.e. pipes less than 6-inches diameter or with high headloss and velocity). The cost estimate schedule of all replacement pipes considered due to insufficient fire flow capacities or high velocities can be viewed in Appendix J. The build-out plan suggests replacing all distribution mains less than 6-inch with 8-inch and larger pipes. Material recommended for the proposed storage tanks presented in Table 9-2 is steel.

Table 9-2. Long-Term Improvement Projects

Project	Description	Total Estimated Cost[1]
L-1	Install 2.2 MG Ashdown Tank, Booster Pump and piping near Fiddlers Tank	$3,449,000
L-2	Install 4.1 MG 800 South Tank Install 24" 800 South Tank Transmission Piping Install 20" 800 South Tank Transmission Piping	$13,058,000

	Install 20" 800 South Tank Distribution Piping Replace 12" with 20” pipe along Hidden Hills Drive Replace 12” with 16” pipe along Hidden Hills Drive Install Cross Hollow Tank Booster Pumps near 800 South Tank	
L-3	Install 4.2 MG Proposed Zone 7 Storage Tank (North) Install 20" Proposed Zone 7 Storage Tank (North) Transmission Piping Install Pressure Reducing Valve on Distribution Piping Install 20" Proposed Zone 7 Storage Tank (North) Distribution Piping	$8,960,000
L-4	Install 6.9 MG Proposed Zone 8 Storage Tank (North) Install 16" Proposed Zone 8 Storage Tank (North) Distribution Piping	$7,677,000
L-5	Install 8.6 MG Proposed Zone 8 Storage Tank (Central) Install 800 South Tank Booster Pumps Install 30" Transmission Piping Install 20" Transmission Piping Install 36" Proposed Zone 8 Storage Tank (Central) Transmission Piping Install 20" Zone 8 Distribution Piping Install Zone 8 Booster Pumps at Proposed Zone 8 Storage Tank (Central)	$16,357,000
L-6	Install 3.4 MG Proposed Zone 3 Storage Tank (South) Install 16" Proposed Zone 3 Storage Tank (South) Transmission Piping Install 16" Proposed Zone 3 Storage Tank (South) Distribution Piping	$5,148,000
L-7	Install 2.9 MG Proposed Zone 7 Storage Tank (South) Install 16" Proposed Zone 7 Storage Tank (South) Transmission Piping Install 16" Zone 7 Distribution Piping from Proposed Zone 7 Storage Tank (South)	$3,898,000
L-8	Install 6.2 MG Proposed Zone 8 Storage Tank (South) Install 20" Proposed Zone 8 Storage Tank (South) Transmission Piping Install 30" Proposed Zone 8 Storage Tank (South) Distribution Piping Install 24" Proposed Zone 8 Storage Tank (South) Distribution Piping Install 16" Proposed Zone 8 Storage Tank (South) Distribution Piping	$9,550,000
L-9	Install Zone 3 Distribution Piping	$5,419,000
L-10	Install Zone 4 Distribution Piping	$2,836,000
L-11	Install Zone 5 Distribution Piping	$1,390,000
L-12	Install Zone 6 Distribution Piping	$1,336,000
L-13	Install Zone 7 Distribution Piping	$21,937,000
L-14	Install Zone 8 Distribution Piping	$28,953,000
Total		$129,968,000

(1) Installation costs include contingency, engineering and administration.

REFERENCES

1. Cedar City Corporation, 1998. Water System Master Plan.
2. U.S. Geological Survey, 2005. Hydrology and Simulation of Ground Water Flow in Cedar Valley, Iron County, Utah.
3. Central Iron County Water Conservancy District, February 2005. Inter-Local Water Supply Feasibility Study.
4. Haested and Walski, 2003. Advanced Water Distribution Modeling and Management.

SUMMARY OF WATER ACQUISITION AND WATER RIGHTS

area.

(b) Underground storage tanks.

(c) Storm water infiltration structures.

(d) Any pollution source as defined herein or in R-113 or the Utah Administrative Code.

(2) Zones 1, 2 and 3. Agriculture industries including, but not limited to, intensive feeding operations such as feed lots, dairies, fur breeding operations, poultry farms, etc.

(3) All Zones.

(a) Surface use, storage, or dumping of hazardous waste or material, expressly including industrial or commercial uses of agricultural pesticides (except when such pesticides are used in farming applications within strict compliance of the manufacturer's recommendations of use, subject to inspection by local officials).

(b) Sanitary landfills.

(c) Hazardous waste or material disposal sites.

(d) Septic tanks/drain field systems.

F. Administration. The policies and procedures or administration of any source protection zone established under this ordinance, including without limitation those applicable to nonconforming uses, exception, enforcement and penalties, shall be the same as provided in the existing zoning ordinance Chapter 26 for Cedar City, Utah, as the same is presently enacted or may from time to time be amended.

(Adopted 4/98)

SECTION 37-32. Water Acquisition.

Section 32-1. Findings.

A. Cedar City has limited water rights. Cedar City provides culinary and irrigation water for residential , commercial, and industrial uses consistent with City ordinance. There are limited water rights in the Cedar City area and these resources are used by Cedar City, Enoch City, the Central Iron County Water Conservancy District, agriculture, private owners, and private water corporations.

B. Cedar City is experiencing sustained residential, commercial, and industrial growth, and growth necessitates acquisition of additional water rights.

C. The City Engineer has conducted an analysis of the City's reasonable water needs. That analysis is incorporated herein and forms the basis for this ordinance. Cedar City contracts for the appraisal of water rights, future appraisals shall be used to determine the amount of special assessment to be charged as an alternative to dedicating water rights.

D. The State of Utah water engineer has determined that the water rights in the Cedar Valley Aquifer have been fully appropriated and has closed the basin to future appropriation of water rights.

Section 32-2. Purpose and policy.

A. Cedar City's primary purpose for establishing this ordinance is to acquire the water rights necessary to serve its expanding population. Therefore, nobody will be allowed to pay the special assessment established herein if the property on which they are filing a land use application has been the point of use for water in the previous three years or since the enactment of this ordinance, whichever is the shorter look back period.

B. In order to carry out the policy stated above, it is hereby ordained that all land within Cedar City, or petitioning for annexation into Cedar City, is wet land if the property has been the point of use for water within the look back period described in section 32-2(A). All wet land must deed all water rights used on the land up to the amount sufficient to satisfy the provisions of this ordinance and may not pay the special assessment for the deeded water.

C. All land that has not been the point of use for water within the look back period described in section 32-2(A) prior to filing of a land use application, that land is ordained to be dry land and the party submitting a land use application may pay the special assessment contained in this ordinance and not be required to deed water rights to the City.

D. All land use applications filed with Cedar City must be accompanied by sufficient documentation from the state engineers office to show if the subject property was or was not the point of use for any water rights within the look back period described in section 32-2(A).

Section 32-3. Time to acquire water rights or pay special assessment.

A. **Annexation.** If the property is wet land pursuant to section 32-2(B), the City shall require the deeding of water rights sufficient to comply with this ordinance at the time of annexation. If, when proposing annexation, the property is dry land pursuant to section 32-2(C), the parties will agree to either acquire water sufficient for the annexation, and deed those rights to the City; or pay the City the special assessment established by this ordinance at the time the of residential subdivision plat per Section 32-3B or at time of building permit per Section 32-3C.

B. **Subdivision.** If real property has annexed into Cedar City prior to the enactment of this ordinance, then prior to a residential subdivision's final plat approval being granted, the developer or owner shall either deed to the City water rights sufficient to comply with this ordinance, if they are subdividing wet land pursuant to section 32-2(B); or pay to the City the special assessment established by this ordinance, if they are subdividing dry land pursuant to 32-2(C).

C. **Building Permit.** If real property has been annexed into Cedar City prior to the effective date of this ordinance and is not in a residential platted subdivision, then prior to receiving a building permit the owner shall either deed to the City sufficient water rights to comply with this ordinance, if the property is wet land pursuant to section 32-2(B); or pay the special assessment set by this ordinance, if the land is dry land pursuant to 23-2(C).

1. Nothing in this ordinance shall require deeding of water rights or payment of the special assessment when a building permit is pulled for repair, remodel, or expansion of a building that has been granted a building permit prior to, or after, the effective date of this ordinance.

Section 32-4. Acquisition of water reserve.

A. Cedar City is an owner of water rights. In providing for culinary, commercial, and industrial uses, the City has been able to determine an appropriate reserve necessary to keep ahead of reasonably foreseeable growth in order to serve the health, safety, and welfare of the Cedar City citizens. This reserve would be water rights that are not being constantly used but would be available for service if necessary. These water rights would be administered pursuant to state law in order to avoid any partial or complete forfeiture. The City has determined the reserve amount necessary to keep ahead of reasonably foreseeable growth to be twenty percent (20%) of the total water rights owned by the City. With the annual Water Report, the City Engineer shall provide information relating to the status of the reserve amount. If at any time the reserve amount of water rights is reached, the City Council shall impose a moratorium on the approval of all annexations, residential platted subdivisions, and building permits not in a residential platted subdivisions until the developer or owner is able to provide, or the City is able to acquire, sufficient water to meet the needs as established by this ordinance.

Section 32-5. Acquisition of excess water rights.

A. If at any time an owner is required to deed water rights to the City, and if that owner owns more water rights in the Cedar Valley Aquifer than the owner is required to deed to the

City, then the City shall request that the owner either sell the excess rights to the City or enter into an agreement with the City giving the City the first right of refusal should the owner decide to sell said water rights in the future.

Section 32-6. Agricultural uses to continue and accounting for water rights.

A. If any owner is required to deed water rights to Cedar City, and at the time of deeding said rights to the City the owners property is dedicated to production of agriculture, then the City shall accept the water rights and the owner shall be allowed to continue the agricultural use of the water until such time as the property, or portions thereof, are removed from the agricultural protection area. If only part of the property is removed from the production of agriculture, then a portion of water rights equal to the acreage removed from the production of agriculture shall be removed from agricultural use.

B. In order to continue to use water rights for agricultural purposes, and in order to account for which properties have deeded water rights or paid fees, City staff shall develop a tracking system. Said system shall indicate which properties have deeded water, which properties have paid fees, and which properties are dedicated to the production of agriculture and using water for agricultural purposes. It is an express purpose of this ordinance that no owner is required to deed water or pay a fee for each parcel of land more than once.

C. For purposes of this section, "agriculture" or "production of agriculture" shall be defined to include any land use wherein corps, plants, trees, or domestic animals are kept and raised with the primary purpose of resale of the finished product. Under no circumstances shall "agriculture" or "production of agriculture" include any use or intended use of land that is secondary to the primary residential use of the property, for example the home garden in a residential neighborhood shall not be considered "agriculture" or "production of agriculture".

Section 32-7. Amount and type of water required – Exception.

A. Amount of water required.

1. If water is deeded at the time of annexation, the property owner will be required to deed 1.2 acre feet of water rights per acre of land annexed into the boundaries of Cedar City.

2. If water is deeded after annexation and at or prior to final residential plat approval, the property owner will be required to deed 1.5 acre feet of water rights per acre of property proposed for a platted residential subdivision.

3. If water is deeded after annexation, but at or prior to acquiring a building permit not in a residential platted subdivision, the owner will be required to deed a minimum of .80 acre feet of water rights per each 50 gallons per minute of the water meter's maximum flow rating.

B. Type of water required.

1. As used in this section the following terms shall have the following meaning:

a. "sub-surface water rights" shall mean all rights to underground water within aquifers that can physically and legally supply water to Cedar City;

b. "class 1 surface rights" shall mean all surface water rights to Coal Creek water adjudicated up to 1870;

c. "class 2 surface rights" shall mean all surface water rights to Coal Creek water on which claims were filed from 1870 through 1880;

d. "class 3 surface rights" shall mean all surface water rights to Coal Creek water on which claims were made from 1880 through 1890;

e. "class 4A surface rights" shall mean all surface water rights to Coal Creek water on which claims were made from 1890 through 1898;

f. "class 4B surface rights" shall mean all surface water rights to Coal Creek water on which claims were made post 1898.

2. The following classifications of water rights shall be deeded to Cedar City in compliance with this ordinance:

a. one third of the required water rights shall be sub-surface water rights;

b. one third of the required water rights shall be class 1,2,or 3, surface rights or additional sub-surface water rights;

c. one third of the required water rights shall be class 4A or 4B surface rights; class 1,2,or 3 surface rights; or additional sub-surface water rights.

d.. if a secondary or supplemental sub-surface water right can be transferred to and used by the City with a primary surface water right then, 50% of the total right shall be credited as a sub-surface water right and 50% of the right credited as a surface water right of the class designated for the primary right.

C. Exception.

1. Open space exception. If at the time of final plat approval, or pulling of a building permit, land is deeded to Cedar City for undeveloped open space, parks and recreation, or placed in a conservation easement that complies with the provisions of Title 57, Chapter 18, Sections 1 through 7, Utah Code Annotated, 1953 as amended, then that acreage is not subject to the requirements of this ordinance that mandate the deeding of water rights or payment of fees. This provision does not apply to annexation as the amount of water required for annexation was adjusted to account for such lands.

2. Public lands exception. If at the time of annexation the annexed property is owned by the Bureau of Land Management or the U.S. Forest Service then that acreage is not subject to the requirements of this ordinance that mandate the deeding of water rights. This exception only applies to annexation and not when the property is platted as a residential subdivision or receives a building permit.

3. Nothing in this ordinance shall require the City to deed water or pay a fee if the City develops land. Furthermore, nothing in this ordinance shall require any person that purchases land from the City, and within the look back period of the purchase develops the land, to deed water to the City. A purchaser of property from the City will have to pay the assessment to the City consistent with this ordinance.

Section 32-8. Establishment of special assessment.

A. There is established a special assessment that owners may pay instead of deeding water rights to the City as required by this ordinance. The special assessment shall be established by the Cedar City Council and adopted in the form of written Resolution duly authorized and approve by said Council. This special assessment may be amended from time to time also by a resolution of the Cedar City Council. Prior to amending the special assessment the City shall have the surface water rights and sub-surface water rights in the Cedar City area appraised and/or use the best available market information. The council may also, by resolution, add costs for reasonable administrative overhead to this special assessment.

Section 32-9. Effective date.

A. This ordinance shall become effective immediately upon passage by the Cedar City Council, and being signed by the Mayor.

(Section 32 adopted 3/06)

Cedar City Corporation Municipal Water Rights - Groundwater

Water Right No.	Source	Source Name(s)	Flow (ac-ft)	Flow (cfs)	Period of Use	Priority Date	Proof Due Date
73-62	Hidden Hills Cove Phase 1 Sycamore Trails PUD		62.44		Mar 15 - Oct 31	10-Jun-1934	
73-131	Enoch Well Field	Enoch Well North (#1) Enoch Well South (#2) Enoch Well #3	61.0		Jan 1 - Dec 31	1918	31-Jan-2012
73-151	Morton's Flat Well	Morton's Flat Well	181.0	0.25	Jan 1 - Dec 31	24-Nov-1950	
73-154	Steve Sevy Annexation	Combined with 73-156			Mar 15 - Oct 31	Feb 1936	
73-155	Steve Sevy Annexation	Combined with 73-156			Mar 15 - Oct 31	1924	
73-156	Steve Sevy Annexation		64.232			Jun 1924	
73-161	Enoch Well Field	Enoch Well North (#1) Enoch Well South (#2) Enoch Well #3	325.6	1.05	Jan 1 - Dec 31	3-Dec-1936	31-Jan-2012
73-172	Joe Burgess		4.2		Jan 1 - Dec 31	1906	
73-189	Steve Sevy Annexation		159.104		Jan 1 - Dec 31	Dec 1934	
73-190	Steve Sevy Annexation		99.12			Mar 1934	
73-361	Quichapa Well Field	Quichapa Wells #1,3,5,6,7	1,905.9		Jan 1 - Dec 31	1900	
73-1023	Irrigation Wells	Cemetery Well Northfield Well	1,200	5.0	Jan 1 - Dec 31	25-Sep-1953	30-Sep-2012
73-1046	Quichapa Well Field	Quichapa Wells #1,3,5,6,7	Combined with 73-361			1900	
73-1076	Enoch Well Field	Enoch Well North (#1) Enoch Well South (#2) Enoch Well #3 Regional WWTP Well	1,447.9	2.0	Jan 1 - Dec 31	26-Jan-1951	31-Jan-2012
73-1088	Cedar Park Townhomes PUD/Joe Burgess		81.2		Mar 15 - Oct 31	10-Jul-1953	
73-1093	Cox Well Field	Warren Cox Well	2.19	0.015	Jan 1 - Dec 31	29-Jul-1947	
73-1770	Joe Burgess		11.6		Mar 15 - Oct 31	1880	
73-1820	Cox Well Field	Cox Well	4.37	0.006	Jan 1 - Dec 31	2-Jun-1949	
73-1831	Cox Well Field	Cox Well	4.37	0.006	Jan 1 - Dec 31	23-Aug-1949	
73-1842	Cedar Park Townhomes PUD		3.0		Mar 15 - Oct 31	18-Jun-1954	
73-1919	Quichapa Well Field	Quichapa Wells #1,3,5,6,7	3,619.8	5.0	Jan 1 - Dec 31	8-Feb-1956	
73-1925	Steve Sevy Annexation		2.498		Jan 1 - Dec 31	31-May-1962	
73-2122	Irrigation Wells	Cemetery Well Northfield Well	24.0		Jan 1 - Dec 31	17-Jul-1944	30-Sep-2012
73-2203	Sage Springs		2.0		Jan 1 - Dec 31	16-Dec-1953	
73-2334	Wallace & Marilyn Heap		2.0			16-Dec-1953	
73-2367	Darla Allen		2.0		Apr 1 - Oct 31	12-Dec-1952	
73-2373	Enoch Well Field	Enoch Well North (#1) Enoch Well South (#2) Enoch Well #3	64.0		Jan 1 - Dec 31	Apr-1912	31-Jan-2012
73-2374	Enoch Well Field	Enoch Well North (#1) Enoch Well South (#2) Enoch Well #3	4.092		Jan 1 - Dec 31	1919	31-Jan-2012
73-2375	Enoch Well Field	Enoch Well North (#1) Enoch Well South (#2) Enoch Well #3	10.408		Jan 1 - Dec 31	23-May-1936	31-Jan-2012
73-2477	Cedar City Industrial Park Well	Cedar City Industrial Park	32.8	0.045	Jan 1 - Dec 31	7-Nov-1963	
73-2944	Quichapa Well Field	Quichapa Wells #1,3,5,6,7	100.77		Jan 1 - Dec 31	23-Apr-1953	
73-3250	Ronald K. Stanley		82.0		Apr 1 - Oct 31	30-Jul-1927	
73-3251	Ronald K. Stanley		79.85		Mar 15 - Oct 31	Feb 1930	
73-3888	Amy Dixie		29.0		Mar 15 - Oct 31	7-Feb-1963	
		Total flow in ac-ft =	9,802.212				

Cedar City Corporation Municipal Water Rights - Springs

Water Right No.	Source	Source Name(s)	Flow (ac-ft)	Flow (cfs)	Period of Use	Priority Date	Proof Due Date
73-888	Spillsbury Springs		Combined w/ 73-990			1929	
73-904	Cedar Canyon Springs	Cliff Spring	609.6	1.28	Apr 1 - Nov 30	1870	
73-905	Shurtz Canyon Springs		Covered by 73-1080, 1081, 1082, 1083			1856	
73-956	Cedar Canyon Springs	Upper Bamson Spring	161.4	0.223	Jan 1 - Dec 31	1856	
73-957	Cedar Canyon Springs	Lower Will Williams Spring	48.5	0.067	Jan 1 - Dec 31	1856	
73-958	Cedar Canyon Springs	Dry Spring	40.5	0.056	Jan 1 - Dec 31	1856	
73-959	Shurtz Canyon Springs	Upper Black Rock Spring	32.6	0.045	Jan 1 - Dec 31	1856	
73-960	Cedar Canyon Springs	Bamson Trail Spring	120.9	0.167	Jan 1 - Dec 31	1856	
73-961	Cedar Canyon Springs	Lower Head House Spring	120.9	0.167	Jan 1 - Dec 31	1856	
73-962	Cedar Canyon Springs	Raspberry Spring	48.5	0.067	Jan 1 - Dec 31	1856	
73-963	Cedar Canyon Springs	White Rock Spring	161.4	0.223	Jan 1 - Dec 31	1856	
73-990	Spillsbury Springs	3 sprgs (Quichapa stream)	1,922.53	20.0	Jan 1 - Dec 31	1880	31-Oct-2008
73-1001	Spillsbury Springs	Duncan Leaches Creek	Combined with 73-990			1893	31-Oct-2008
73-1080	Shurtz Canyon Springs	Upper Posle Spring	Combined w/ 73-2139			1856	
73-1081	Shurtz Canyon Springs	Lower Posle Spring	Combined w/ 73-2139			1856	
73-1082	Shurtz Canyon Springs	West Big Spring	Combined w/ 73-2139			1856	
73-1083	Shurtz Canyon Springs	East Big Spring	Combined w/ 73-2139			1856	
73-1125	Spillsbury Springs	Watson Gulch	Combined w/ 73-990			1856	31-Oct-2008
73-1133	Spillsbury Springs	Willow Spring Stream	Combined w/ 73-990			1856	31-Oct-2008
73-1858	Cedar Canyon Springs	Chatterly Spring	260.6	0.36	Jan 1 - Dec 31	Jun-1856	
73-1896	Shurtz Canyon Springs	Urie Spring	59.0	0.25	Nov 2 - Feb 28	21-Dec-1957	
73-2139	Shurtz Canyon Springs	Birch Spring Three Ledge Spring No. 1 Three Ledge Spring No. 2 Three Ledge Spring No. 3 Upper Posle Spring No. 2	1162.6	1.95	Jan 1 - Dec 31	1856	
		Total flow in ac-ft =	4,769.23				

Cedar City Corporation Municipal Water Rights in Non-Use							
Water Right No.	Source	Source Name(s)	Flow (ac-ft)	Flow (cfs)	Period of Use	Priority Date	Proof Due Date
73-520	Underground Water Well	Iron Mines	696.855	1.46	Jan 1 - Dec 31	5-Apr-1952	31-Oct-201
73-2900	Underground Water Well	Iron Mines	33.32	0.046	Jan 1 - Dec 31	7-Apr-1956	31-Oct-201
73-2901	Underground Water Well	Iron Mines	153.62	0.2164	Jan 1 - Dec 31	7-Apr-1956	31-Oct-201
73-2902	Underground Water Well	Iron Mines	496.575	1.0408	Jan 1 - Dec 31	20-Sep-1951	31-Oct-201
		Total flow in ac-ft =	1,380.37				

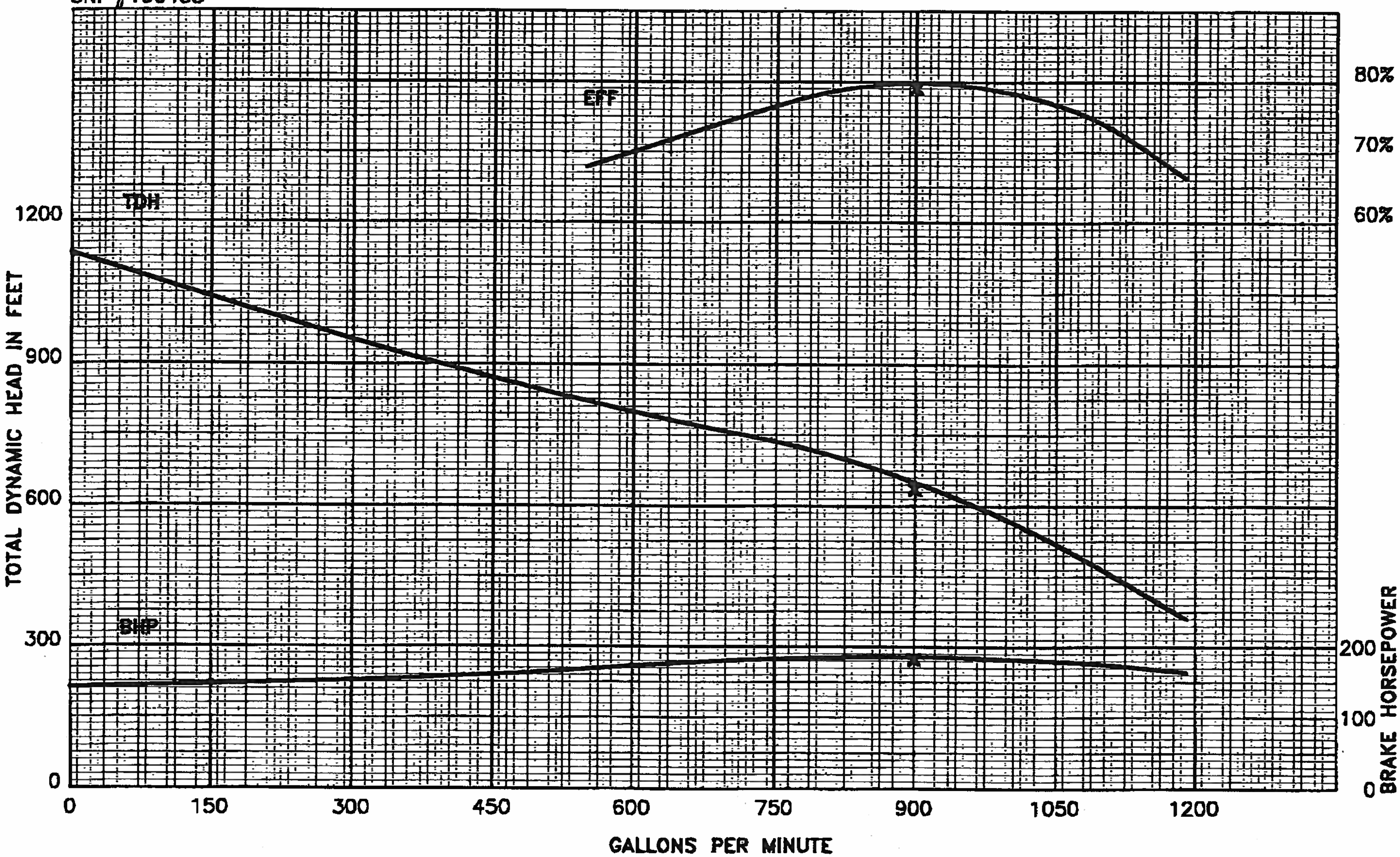
Cedar City Corporation Irrigation Water Rights						
Water Right No.	Source	Source Name(s)	Flow (ac-ft)	Flow (cfs)	Period of Use	Priority Date
73-423	Coal Creek	Coal Creek	118.76	0.36	Apr 1 - Nov 30	1903
73-529	Coal Creek	Coal Creek	*	0.21	Apr 1 - Nov 30	1870
73-1011	Coal Creek	Coal Creek	929.2	1.92	Apr 1 - Nov 30	1870
73-1924	Cox Well Field	2nd Cox Well	*	0.75	Apr 1 - Oct 31	24-Nov-1950
		Total flow in ac-ft =	1,047.96			

* Water rights 73-423, 73-529, and 73-1924 are limited to a total yearly diversion of 118.76 ac-ft.

Cedar City Corporation Irrigation Shares				
Irrigation Company	Shares Owned by Cedar City	Class	Water Yield per Share (ac-ft)	Flow (ac-ft)
North Field	107.16	1	0.75	80.37
	119.75	3 & 4	0.75	89.81
	30.47	A	0.75	22.85
South Field	75.3205	–	0.75	56.49
West Field	93.08325	–	0.75	69.81
East Extension	7.5	1 & 2	0.75	5.63
	2.5	3 & 4	0.75	1.88
Bulldog Ditch	84.027	A	0.75	63.02
Coal Creek	514.2266	B	0.75	385.67
			Total flow in ac-ft =	775.53

WELL PUMPS, WELL LOGS, SITE VISIT NOTES AND FUTURE GROUND WATER MODELING RESULTS

SN: #150433



AMERICAN-MARSH PUMPS

"PUMPS AND PUMPS ONLY SINCE 1873"

185 PROGRESS ROAD
COLLIERVILLE, TN 38017

DATE: 6/14/07

Performance based on pumping clear, fresh water at a temperature not over 85°F., and free of gas, air or abrasives.

Design: 900 GPM @ 635' TDH, 79%

Customer: Nickerson

Northfield Well

PUMP PERFORMANCE

CERTIFIED BY: ____________

PUMP PERFORMANCE

Curve No. 07-156/157

R.P.M. 1760

Pump: 10WCA-18

Quichapa Wells #1 and #3 Spare Pump

Quichapa #1

TEST NUMBER:	TST07-98-1003	DISCHARGE HEAD:	12	COLUMN:	8
SHEET:	1	FLOWMETER:	12	SHAFT SIZE:	1.688
DATE:	10/2/2007	L/S SUB:	L/S	MOTOR HP	350
SERIAL NUMBER:	807270	BOWL TYP	K12HC-14	NO. OF STAG	14
CUSTOMER NAME:	GARDNER BROTHER	IMPELLER D	9.34	POLE:	4
		UNDER FIL	1/8"	WATTMETE	50
		FINISH:	B	THR. K:	11.200
		MATERIAL	D.I./BZ	SP.GR.	1.000

RATED CONDITION: 1300 | Head: 833 | Efficiency: 81.0%

	TEST POINT #:	1	2	3	4	5	6	7	8	9	10
	RPM	1785	1784	1782	1780	1780	1780	1779	1779	1779	1780
	GPM	0.00	605.00	811.00	1005.00	1200.00	1314.00	1483.00	1655.00	1812.00	2051.00
HEAD	VELOCITY HEAD	0.00	0.25	0.46	0.70	1.00	1.20	1.53	1.91	2.29	2.93
	W.S. TO GAUGE	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
	GAUGE	1269.00	1098.00	1036.00	974.00	895.00	849.00	744.00	623.00	476.00	225.00
	ELBOW LOSS										
	COL. LOSS										
	TOTAL HEAD	1276.60	1105.85	1044.06	982.30	903.60	857.80	753.13	632.51	485.89	235.53
HP	WATTMETER READING	4.100	4.496	4.880	5.228	5.478	5.631	5.637	5.659	5.620	5.420
	HORSEPOWER	255.02	279.65	303.54	325.06	340.81	350.26	350.62	351.99	349.56	337.12
	THR. BRG LOSS	1.91	1.66	1.56	1.47	1.35	1.28	1.13	0.95	0.73	0.35
	LAB HP	253.11	277.99	301.97	323.59	339.26	348.97	349.50	351.04	348.84	336.77
	EFFICIENCY	0.00	60.77	70.81	77.04	80.71	81.57	80.70	75.30	63.73	36.22

1780		1	2	3	4	5	6	7	8	9	10
	GALLONS PER MINUTE	0.00	603.64	810.08	1005.00	1200.00	1314.00	1483.83	1655.93	1813.02	2051.00
	HEAD	1269.48	1100.90	1041.72	982.30	903.60	857.80	753.98	633.22	486.43	235.53
	HORSE POWER	250.98	278.13	300.98	323.59	339.26	348.97	350.09	351.84	349.43	336.77
	EFFICIENCY	0.00	80.77	70.81	77.04	80.71	81.57	80.70	75.30	63.73	36.22
	HEAD/STG.	90.68	78.64	74.41	70.16	64.54	61.27	53.86	45.23	34.75	16.82
	HORSEPOWER/STAGE	17.93	19.72	21.50	23.11	24.23	24.93	25.01	25.12	24.96	24.06

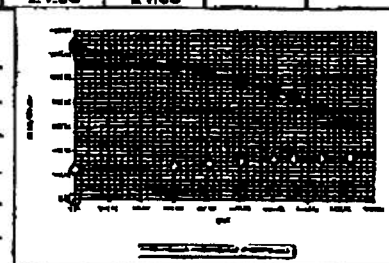
CERTIFIED PERFORMANCE DATE: 10/2/2007

PUMP STATUS:

CERTIFIED BY: BILL GUIN

Bill Guin

PRODUCT ENGINEER



TEST NUMBER: TST07-98-1003

FROM :CEDAR CITY0ENG BUILD PLAN FAX NO. :4355862949 Jan. 30 2008 02:35PM P4/5

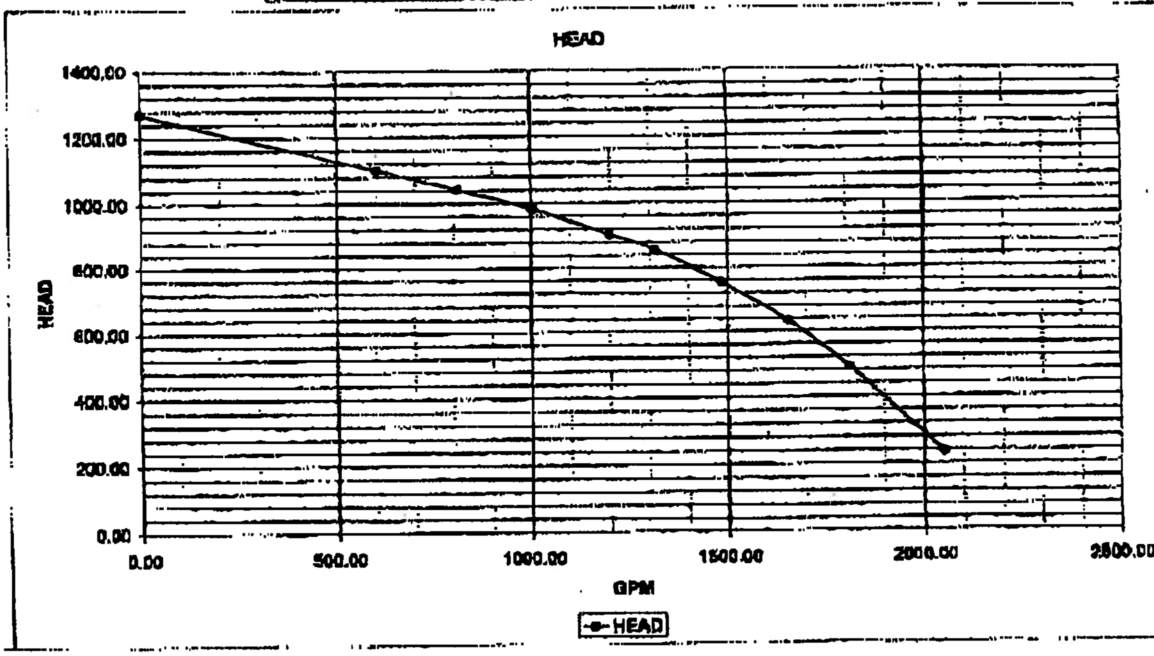
04:00p p.3

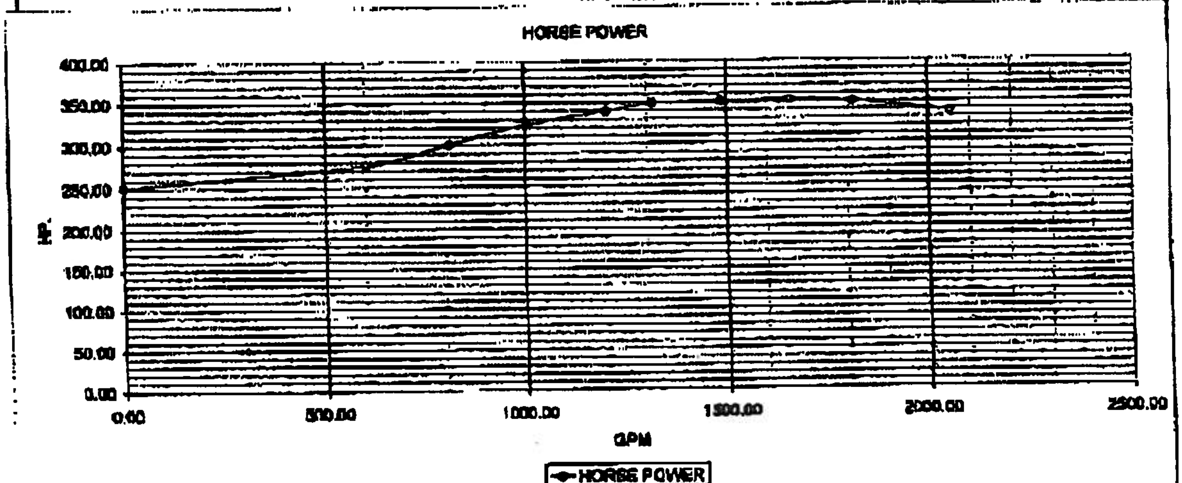
4/07 WED 14:52 FAX 6238792177 M NATL PUMP N

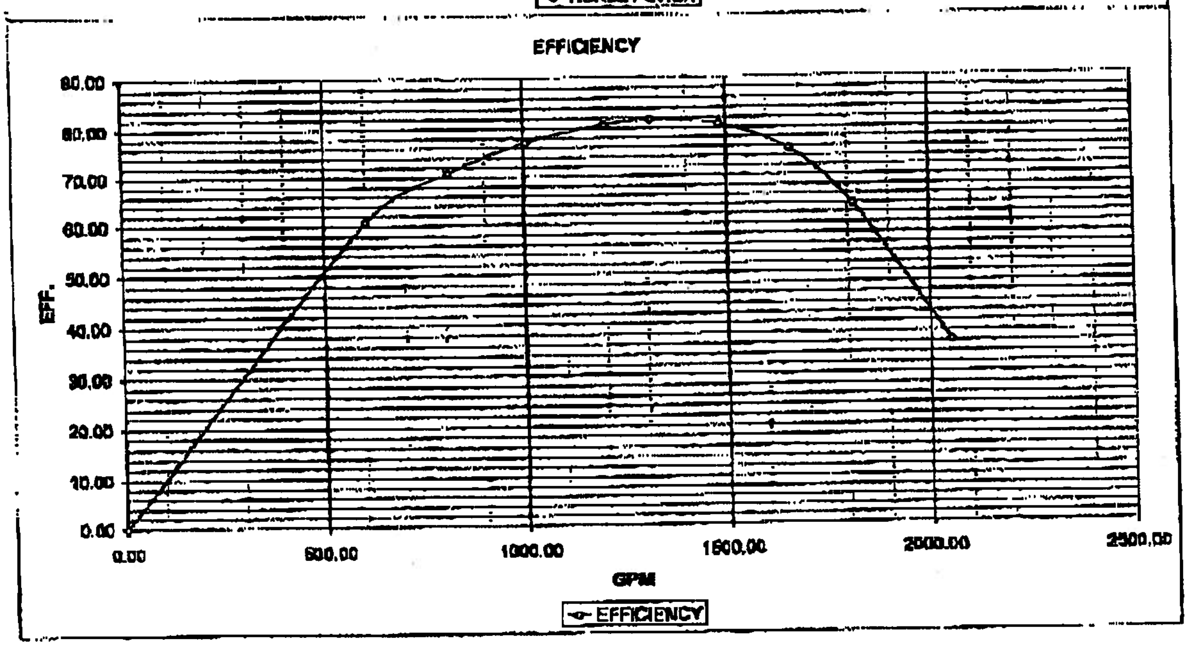
Quichapa Wells #1 + #3 Spare Pump

NATIONAL PUMP COMPANY, LLC

TEST DATA				DESIGN DUTY POINT		CERTIFICATION	
JOB RPM	[illegible]	TEST NO.:	[illegible]	CAPACITY:	[illegible]	BY:	BILL QUIN
CUSTOMER	[illegible]	DATE OF TEST:	[illegible]	TOTAL HEAD:	[illegible]	TITLE:	PRODUCT ENGINEER
SERIAL #	[illegible]	PERFORMED BY:	BILL QUIN	EFFICIENCY	[illegible]	SIGNATURE:	
BOWL TYPE:	[illegible]	IMPELLER TRIM	[illegible]	HP:	[illegible]	MATERIAL:	[illegible]







4510 N. 1170 E.(Mailing)
5[illegible] Airport Road (Shop Address)
Cedar City, UT 84720

ESTIMATE

RHODES BROS.
PUMP SALES and SERVICE Co

Date: Mar. 8, 2005

Phone: (435) 586-8312
FAX:(435) 586-8335

CUSTOMER Cedar City Corp. ATTN: Jonathan Stathis

ADDRESS FAX 435-586-2949

Job Name and Location of Well Well #1 & #3 Quichapa #1 + #3

PUMPING CONDITIONS

Inside Diameter of Well ______ Inches
Depth of Well ______ Feet
Static Water Level ______ Feet
Lift Above ______ Feet
Pump Speed ______ R.P.M.
Probable Drawdown ______ Feet
Friction Head ______ Feet
Pump Capacity ______ G.P.M.
Total Lift Below ______ Feet + Total Lift Above ______ = Total Pumping Head ______ Feet
Size of Pump ______ Type ______ Curve No. ______ Impeller ______ H.P. at Pump Shaft ______
______ Inch I.D. Discharge Flange ______

QUANTITY	DESCRIPTION H.P. R.P.M. MOTOR VOLT PHASE CYCLE	TOTAL
1	12-stage 13 CMC fitted 10" X 3" X 1 15/16" top 2-stages	
	Double bolted & ductile Iron for well #1 & #3	
	1300 GPM @852" TDH	

OTE – Please allow 4 – 6 weeks for delivery

MATERIALS	$ 14,416.00
SALES TAX	
LABOR	
TOTAL	$ 14,416.00

TERMS–50% Down Payment Required and Balance on Delivery

EST NUMBER PC#: 30185 S.O. # : 55644-1-1 DATE: 09-07-2004
ION POINT: GPM= 1500 TDH= 820 RPM =1770
BY: BMT DRAWING No. = 55644-1-1-T2
PE (Bb$): 14 JKM/H
ER CONSTANT (Mc) = 1.0050 IMPELLER TRIM DIA. = 10.228 inch
IGHT (Ght) = 5.270 IMPELLER FINAL DIA. = 10.228 inch
OF STAGES(Stages) = 8 Stages NUMBER OF STAGES TESTED (Ds) = 8
C GRAVITY (SPG) = 1.0000
EMPERATURE = 65 DEGREES (F) SPECIFIC WEIGHT = 62.324 Lbs/Cu Ft.
SIZE = 10
UMBER (Mno) = 7

Enoch Well #1 Pump Curve

PM	GPM	PRESS	GA COR	S LOSS	C-LOS	DH-LOS	VEL HD	HP RDG.	B LOS
95	0.0	188.00	0.00	0.00	0.00	0.00	0.00	72.20	0.00
95	300.0	183.20	0.00	0.00	0.00	0.00	0.02	82.00	0.00
93	600.0	176.50	0.00	0.00	0.00	0.00	0.09	97.50	0.00
92	900.0	166.00	0.00	0.00	0.00	0.00	0.20	116.80	0.00
92	1000.0	160.00	0.00	0.00	0.00	0.00	0.24	122.20	0.00
91	1100.0	150.50	0.00	0.00	0.00	0.00	0.29	126.20	0.00
91	1340.0	125.90	0.00	0.00	0.00	0.00	0.44	130.10	0.00
91	1580.0	98.00	-0.04	0.00	0.00	0.00	0.61	130.00	0.00
91	1820.0	68.20	-0.50	0.00	0.00	0.00	0.80	125.50	0.00

PM	GPM	TDH	TDH/STAGE	BHP	BHP/STAGE	EFF	MTR EFF
70	0.0	964.52	120.57	216.58	27.07	0.00	0.9232
70	446.6	940.24	117.53	247.23	30.90	42.89	0.9278
70	894.6	909.46	113.68	296.92	37.12	69.20	0.9325
70	1343.1	857.74	107.22	358.30	44.79	81.19	0.9369
70	1492.3	827.28	103.41	374.73	46.84	83.20	0.9366
70	1642.9	780.30	97.54	387.86	48.48	83.47	0.9363
70	2001.4	655.08	81.88	399.74	49.97	82.82	0.9361
70	2359.9	512.87	64.11	399.43	49.93	76.52	0.9361
70	2718.3	358.89	44.86	385.73	48.22	63.87	0.9364

The pump has a total of 8 stages, but only 6 stages are currently active. The following table would be the pump curve data for 6 active stages.

RPM	GPM	TDH	TDH/Stage
1770	0	720	120
1770	446	702	117
1770	894	684	114
1770	1342	642	107
1770	1491	618	103
1770	1641	588	98

Enoch Well #1

Existing pump curve data – 6 stages

Ground Elevation at Enoch Well #1 is 5559.0'.

Currently using a 400 HP motor.

If the pump is ever replaced then the spare pump would be installed

Enoch Well #1 Spare Pump

NAME: Enoch #1

TEST NUMBER:	TST07-85-0807	DISCHARGE HEAD:	12	COLUMN:	8
SHEET:	1	FLOWMETER:	12	SHAFT SIZE:	1.688
DATE:	8/7/2007	L/S SUB:	L/S	MOTOR HP:	350
SERIAL NUMBER:	807270	BOWL TYPE:	K12HC-11	NO. OF STAGES:	11
CUSTOMER NAME:	GARDNER BROTHER	IMPELLER DIA:	(6"9.08)+(3" FULL)	POLE:	4
		UNDER FILE:	1/8"	WATTMETER:	50
		FINISH:	8	THR. K:	12.500
		MATERIAL:	C.I EN/BZ	SP.GR.	1.000

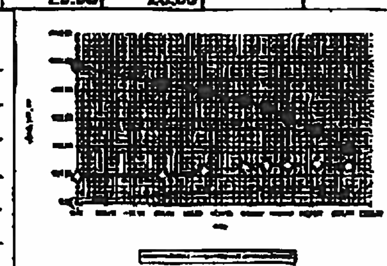
RATED CONDITION: 1300 Head: 680 Efficiency: 81.0%

	TEST POINT #:	1	2	3	4	5	6	7	8	9	10
	RPM	1787	1787	1785	1784	1784	1784	1784	1784	1786	1785
	GPM	0.00	590.00	880.00	1159.00	1305.00	1443.00	1638.00	1851.00	2100.00	2100.00
HEAD	VELOCITY HEAD	0.00	0.24	0.54	0.94	1.19	1.45	1.87	2.39	3.07	3.07
	W.S. TO GAUGE	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
	GAUGE	972.00	846.00	795.00	720.00	675.00	609.00	504.00	374.00	212.00	212.00
	ELBOW LOSS										
	COL. LOSS										
	TOTAL HEAD	979.60	853.84	803.14	728.54	683.79	618.05	513.47	383.99	222.67	222.67
HP	WATTMETER READING	3.136	3.395	3.831	4.218	4.400	4.427	4.458	4.401	4.256	4.258
	HORSEPOWER	195.00	211.17	238.29	262.24	273.68	275.38	277.16	273.74	264.72	264.72
	THR. BRG LOSS	1.64	1.43	1.34	1.22	1.14	1.03	0.86	0.64	0.37	0.37
	LAB HP	193.36	209.74	236.94	261.02	272.54	274.33	276.30	273.10	264.35	264.35
	EFFICIENCY	0.00	60.65	75.32	81.69	82.88	82.10	76.87	65.72	44.67	44.67

1780		1	2	3	4	5	6	7	8	9	10
	GALLONS PER MINUTE	0.00	587.69	877.54	1156.40	1302.07	1439.76	1634.33	1846.85	2094.12	2094.12
	HEAD	971.94	847.17	798.65	725.27	680.72	615.28	511.17	382.27	221.43	221.43
	HORSE POWER	191.09	207.28	234.96	259.28	270.71	272.48	274.45	271.27	262.14	262.14
	EFFICIENCY	0.00	60.66	75.32	81.69	82.88	82.10	76.87	65.72	44.67	44.67
	HEAD/STG.	88.36	77.02	72.60	65.93	61.88	55.93	46.47	34.75	20.13	20.13
	HORSEPOWER/STAGE	17.37	18.84	21.36	23.57	24.61	24.77	24.95	24.66	23.83	23.83

CERTIFIED PERFORMANCE DATE:
8/7/2007

PUMP STATUS:



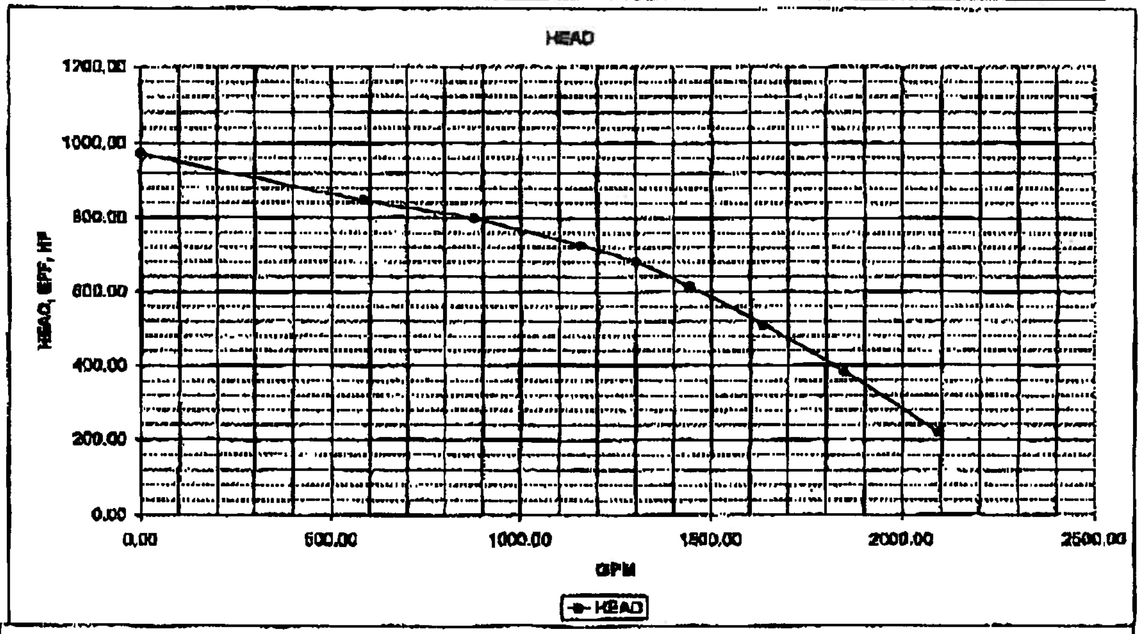
CERTIFIED BY:
BILL GUIN
Bill Guin
PRODUCT ENGINEER

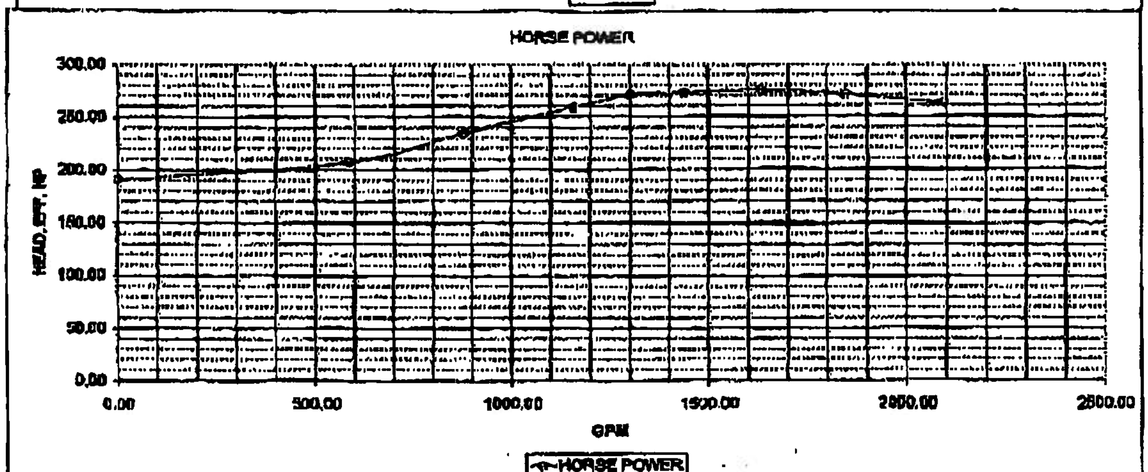
TEST NUMBER: TST07-85-0807

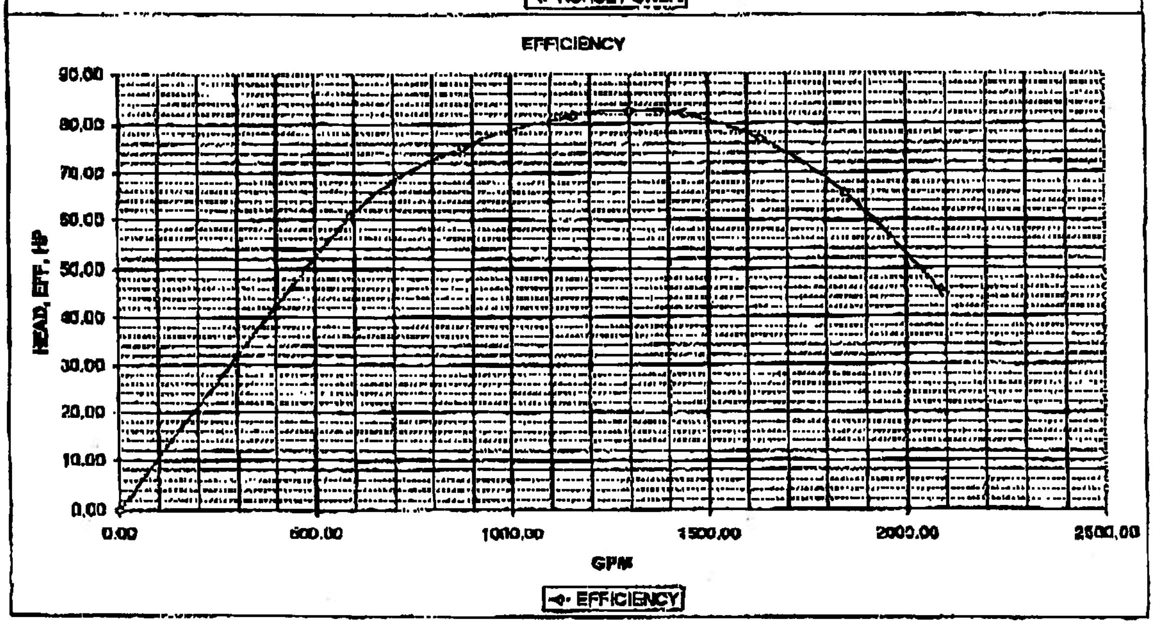
Enoch Well #1 Spare Pump

NATIONAL PUMP COMPANY, LLC

TEST DATA				DESIGN DUTY POINT		CERTIFICATION	
ADJ RPM	[illegible]	TEST NO:	[illegible]	CAPACITY:	[illegible]	BY:	0
CUSTOMER	GARDNER BROTH[illegible]	DATE OF TEST:	[illegible]	TOTAL HEAD:	[illegible]	TITLE:	PRODUCT ENGINEER
SERIAL #	[illegible]	PERFORMED BY:	0	EFFICIENCY	[illegible]	SIGNATURE:	
BOWL TYPE:	[illegible]	IMPELLER TRIM	[illegible] FULL	LIFT:	[illegible]	MATERIAL:	[illegible]







Enoch Well #3 Pump Curve

PERFORMANCE TEST RESULTS

TEST NUMBER:	14EMMR03	BOWL SIZE/TYPE:	14EM
DATE:	2/12/2004	BOWL MATERIAL:	CL40 CI
TESTED BY:	GARY LESPREANCE	IMPELLER TYPE / DIA.:	M 10.69
TESTED FOR:	DELCO WESTERN	IMPELLER MATERIAL:	BRONZE
WITNESSED BY:		IMPELLER SETTING:	0.13
SERIAL NUMBER:	0312CGC77394-1	NUMBER OF STAGES:	10
S.O. NUMBER:	GC77394	DESIGN FLOW, GPM:	1500
CUSTOMER MOTOR HP:	450	DESIGN HEAD, FEET:	950
TEST MOTOR:	200HP @ 1200	THRUST CONSTANT:	8.41

DATA CORRECTED TO 1775 RPM AND 1.00 S.G.

	FLOW (GPM)	HEAD (FT.)	EFF. (%)	POWER (HP)	HEAD/STAGE (FT.)	POWER/STAGE (HP)
	0	1121.1	0.0	258.16	112.1	25.82
	743	1040.8	62.8	310.88	104.1	31.09
	949	1031.5	72.3	341.88	103.2	34.19
	1215	1005.5	79.0	390.69	100.6	39.07
	1518	947.2	85.1	426.32	94.7	42.63
	1635	915.0	86.6	436.13	91.5	43.61
	1818	838.4	86.4	445.28	83.8	44.53
	2054	725.6	83.9	448.39	72.6	44.84
	2345	587.1	77.9	446.55	58.7	44.65
10 stages	2000	751.4	84.5	447.70	75.2	44.77
8 stages	2000	601.1	84.5	358.16	75.2	44.77

358.16 (8 stages)

Enoch Well #3 has a total of 9 stages, but only 7 stages are currently active. The following table is the pump curve for 7 active stages.

RPM	GPM	TDH	TDH/Stage
1775	0	784	112
1775	743	728	104
1775	949	721	103
1775	1215	700	100
1775	1518	658	94
1775	1635	637	91
1775	1818	581	83
1775	2054	504	72
[illegible]	[illegible]	[illegible]	58

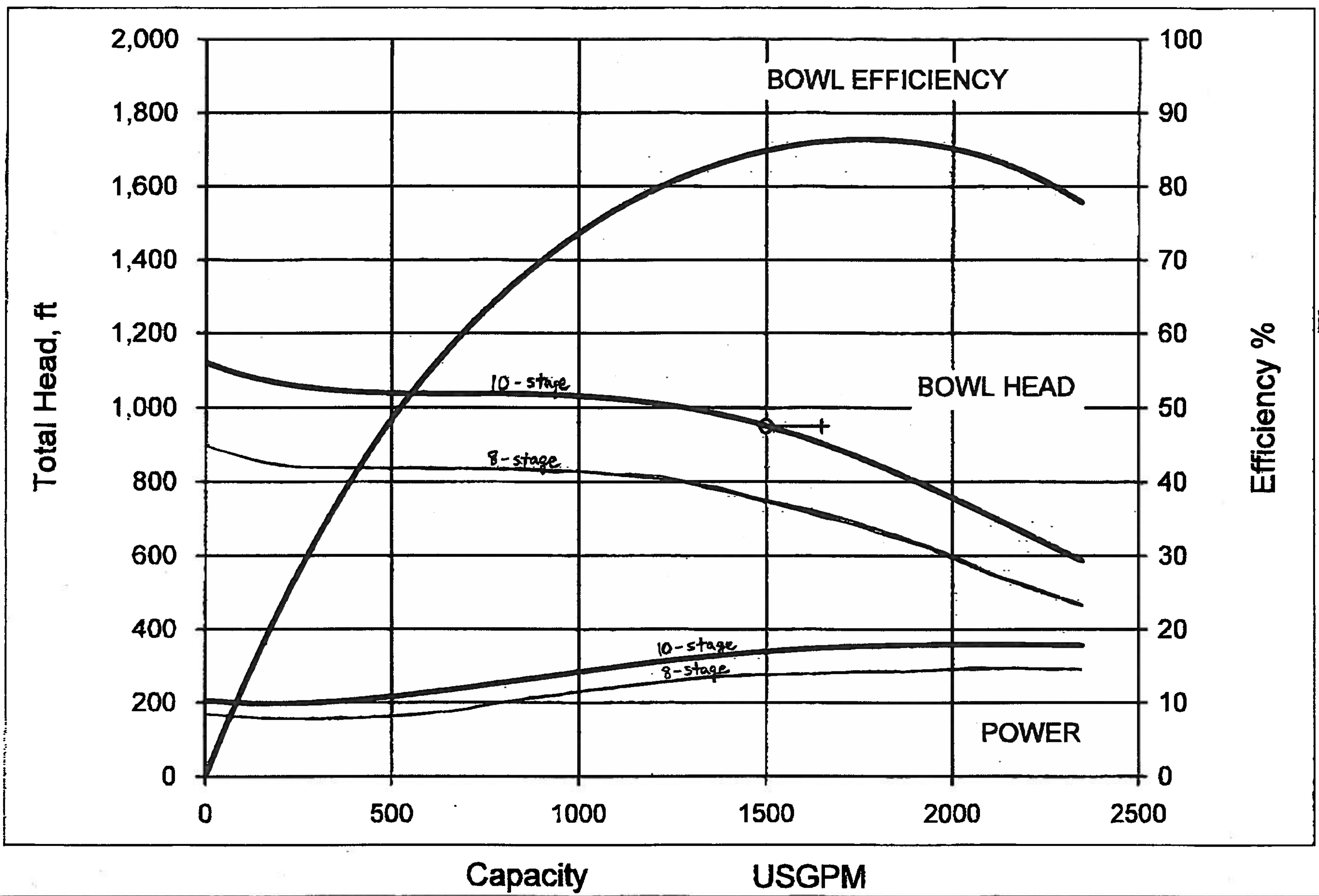
Use this data to model the Enoch Well #3 pump.

Ground elevation at Enoch #3 is 5829.0'.
Currently using a 450 HP motor.
Layne Read

~~— Wasted energy~~
~~— Remove + replace~~
~~Orifice Plate 1/8" thick~~
~~→ Stainless downstream~~
~~→ insulation~~
~~Pull out 2 impellers~~

If the pump is ever replaced then the spare pump would

Enoch Well #3


Total Head, ft
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
BOWL EFFICIENCY
BOWL HEAD
10-stage
8-stage
10-stage
8-stage
POWER
100
90
80
70
60
50
40
30
20
10
0
Efficiency %
BHP
1.00
SpGr
Power
500
250
0
0
500
1000
1500
2000
2500
Capacity
USGPM

FROM :CEDAR CITY0ENG BUILD PLAN FAX NO. :4355862949 Jan. 30 2008 12:03PM P7/10

Aug 13 07 09:07a p.2

08/10/07 FRI 16:08 FAX 6239782177 M NATL PUMP N 002

Enoch Well #3 Spare Pump

NAME: ENOCH #3

TEST NUMBER:	TST07-87-0809	DISCHARGE HEAD:	12
SHEET:	1	FLOWMETER:	12
DATE:	8/9/2007	L/S SUB:	L/S
SERIAL NUMBER:	807270	BOWL TYPE:	M(4XXHC-6
CUSTOMER NAME:	GARDNER BROTHER	IMPELLER DIA:	(5-10.86)+(1-11.563)
		UNDER FILE:	1/8"
		FINISH:	B
		MATERIAL:	D.I /BZ

COLUMN:	10
SHAFT SIZE:	1.688
MOTOR HP:	350
NO. OF STAGES:	6
POLE:	4
WATTMETER:	100
THR. K:	12.500
SP.GR.	1.000

RATED CONDITION: 1650 Head: 590 Efficiency: 81.0%

	TEST POINT #:	1	2	3	4	5	6	7	8	9	10
	RPM	1789	1786	1784	1783	1781	1783	1783	1777	1776	1776
	GPM	0.00	719.00	1037.00	1255.00	1584.00	1854.00	2095.00	2275.00	2554.00	2833.00
HEAD	VELOCITY HEAD	0.00	0.14	0.30	0.43	0.68	0.95	1.21	1.43	1.90	2.21
	W.S. TO GAUGE	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
	GAUGE	766.00	747.00	709.00	674.00	620.00	586.00	538.00	482.00	393.00	276.00
	ELBOW LOSS										
	COL. LOSS										
	TOTAL HEAD	773.60	754.74	716.90	682.03	628.28	594.55	546.81	491.03	402.40	285.81
HP	WATTMETER READING	1.578	1.985	2.196	2.341	2.496	2.754	2.906	2.995	3.091	3.170
	HORSEPOWER	196.30	246.93	273.18	291.22	310.50	342.60	361.51	372.58	384.52	394.35
	THR. BRG LOSS	1.30	1.26	1.20	1.14	1.05	0.99	0.91	0.82	0.67	0.48
	LAB HP	195.01	245.67	271.98	290.08	309.45	341.60	360.69	371.76	383.85	393.87
	EFFICIENCY	0.00	55.78	69.02	74.51	80.19	81.49	80.22	75.88	67.61	51.81

1780		1	2	3	4	5	6	7	8	9	10
	GALLONS PER MINUTE	0.00	716.58	1034.67	1252.89	1583.12	1850.88	2091.48	2278.84	2559.75	2840.98
	HEAD	765.84	749.68	713.69	679.74	627.67	592.55	544.97	492.69	404.21	287.43
	HORSE POWER	192.08	243.20	270.16	288.62	308.93	339.88	368.78	373.65	386.45	397.21
	EFFICIENCY	0.00	55.78	69.02	74.51	80.19	81.49	80.22	75.88	67.61	61.91
	HEAD/STG.	127.64	124.95	118.95	113.29	104.59	98.76	90.83	82.11	67.37	47.90
	HORSEPOWER/STAGE	32.01	40.53	45.03	48.10	51.49	56.65	59.80	62.27	64.41	66.20

CERTIFIED PERFORMANCE DATE:

8/9/2007

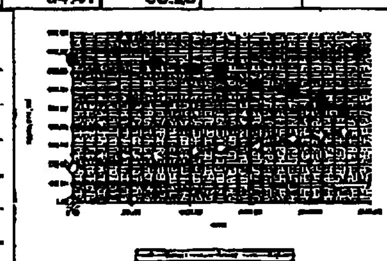
CERTIFIED BY:

BILL GUIN

Bill Guin

PRODUCT ENGINEER

PUMP STATUS:

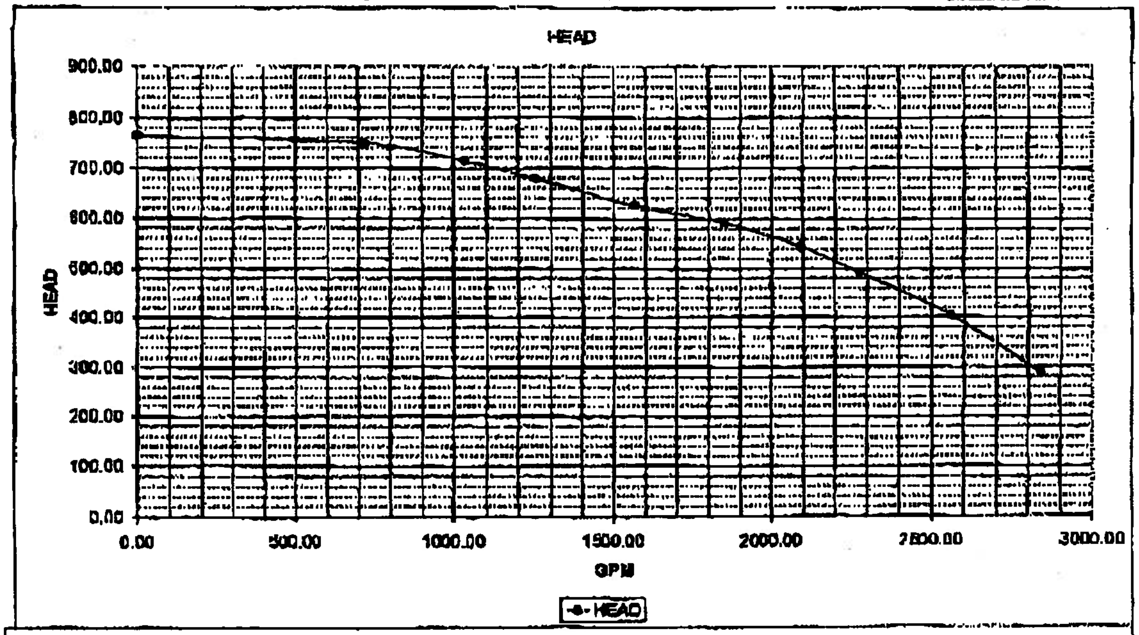


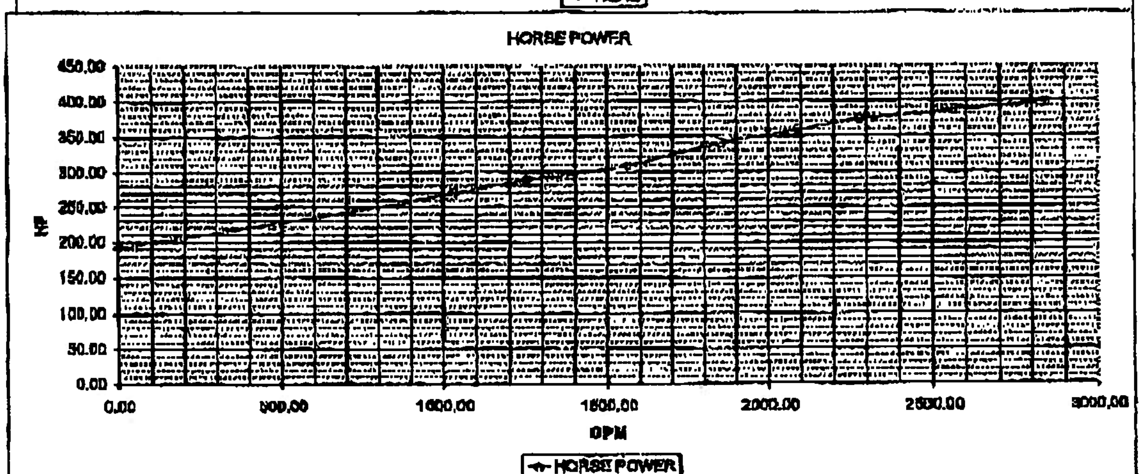
TEST NUMBER: TST07-87-0809

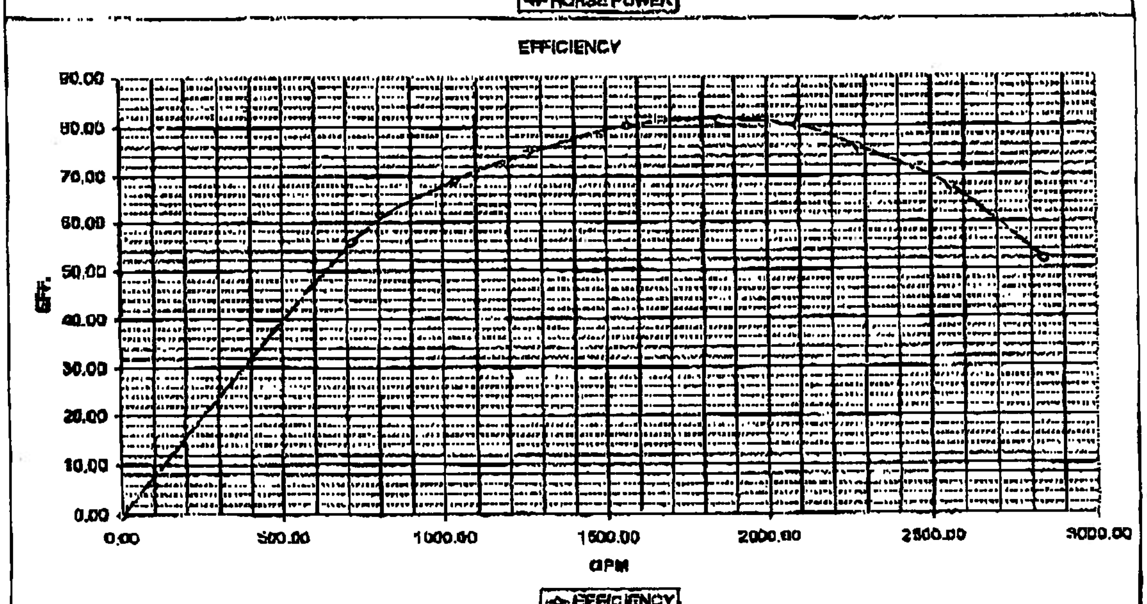
Enoch Well #3 Spare Pump

NATIONAL PUMP COMPANY, LLC

TEST DATA				DESIGN DUTY POINT		CERTIFICATION	
JOB NUM	[illegible]	TEST NO:	[illegible]	CAPACITY:	[illegible]	BY:	
CUSTOMER	GARDNER BROTHERS	DATE OF TEST:	[illegible]/2007	TOTAL HEAD:	[illegible]	TITLE:	PRODUCT ENGINEER
SERIAL #	[illegible]	PERFORMED BY:	[illegible]	EFFICIENCY	[illegible]	SIGNATURE:	
BOWL TYPE:	[illegible]	IMPELLER TRIM	[illegible]	HP:	[illegible]	MATERIAL:	[illegible]







AMERICAN TURBINE PUMP CO., INC.

4229 Adrian Lubbock, Texas 79415

Bowl Assembly Performance Test

Customer:	Rhodes Pump Sales	Test #:	1
User/Contractor:	Rhodes Pump Sales	TEST or CUSTOMER Motor:	TEST
Project:	Cedar City Well #7	Test Motor, hp.:	150
Date:	March 30, 2007	Test Motor RPM:	1175
Sales Order #:	20835	Printed Curve R.P.M.:	1770
Purchase Order #:	6187	Flow Meter Size:	6 in.
Bowl Serial #:	L4764L	Column Pipe Size:	10 in.
Bowl Description:	17 Stg. 12-H-150	Line Shaft Size:	1 1/2 in.
Impeller Trim:	10 9.600 in.	Column Length:	7.0 ft.
Impeller Weight:	14.7 lb.	Complete Pump:	1
Gallons Required:	1500	Gauge Elevation:	(67.1 in.) + 20.0 in. water level
Head Required, ft.:	950	Thrust Constant, (K) Factor:	7.9 lb./ft. head
K.W. Meter Revolutions:	0	Test Voltage:	480
Time (Seconds):	0	Phase:	3
K.W. Reading:	0	Pressure Tap to Bowl:	3 ft.
Specific Gravity:	1		

Point	4in. flow meter gpm	6in. flow meter gpm	8in. flow meter gpm	Total Corrected Flow gpm	meter psi	psi x 2.31 = tdh + gauge elevation, ft.	kw meter reading	corrected kw	tachometer reading rpm	test motor curve rpm	G.P.M. @ 1770 RPM	T.D.H. @ 1770 RPM	Bowl EFF	Bowl H.P.
1	0	0	0	0	296.6	692.5	62.9	62.9	1194	1194	0	1,522.9	0.0%	241.4
2	0	286	0	286	281.2	656.9	75.2	75.2	1192	1192	425	1,448.4	53.8%	288.6
3	0	548	0	548	268.5	627.5	96.0	96.0	1189	1189	816	1,390.9	74.0%	387.3
4	0	660	0	660	261.0	610.2	103.9	103.9	1188	1188	984	1,356.6	79.6%	422.9
5	0	815	0	815	237.4	555.7	111.0	111.0	1186	1186	1,216	1,237.3	83.6%	454.5
6	0	910	0	910	213.8	501.1	112.0	112.0	1186	1186	1,358	1,116.4	83.5%	458.7
7	0	1011	0	1011	186.2	437.3	111.1	111.1	1186	1186	1,508	974.3	81.7%	454.1
8	0	1105	0	1105	158.4	373.1	109.5	109.5	1187	1187	1,648	831.0	77.7%	445.2
9	0	1201	0	1201	128.7	304.5	106.7	106.7	1187	1187	1,791	678.0	71.4%	429.6
10	0	1309	0	1309	91.4	218.3	102.1	102.1	1188	1188	1,950	486.0	59.7%	401.1
11	0	1309	0	1309	91.4	218.3	102.1	102.1	1188	1188	1,950	486.0	59.7%	401.1
12	0	1309	0	1309	91.4	218.3	102.1	102.1	1188	1188	1,950	486.0	59.7%	401.1

Notes:

Tested by: > Troy Fox · Certified Correct by: > Lee Bowron · Witnessed by: > · Date > March 30, 2007

Quichapa Well #7

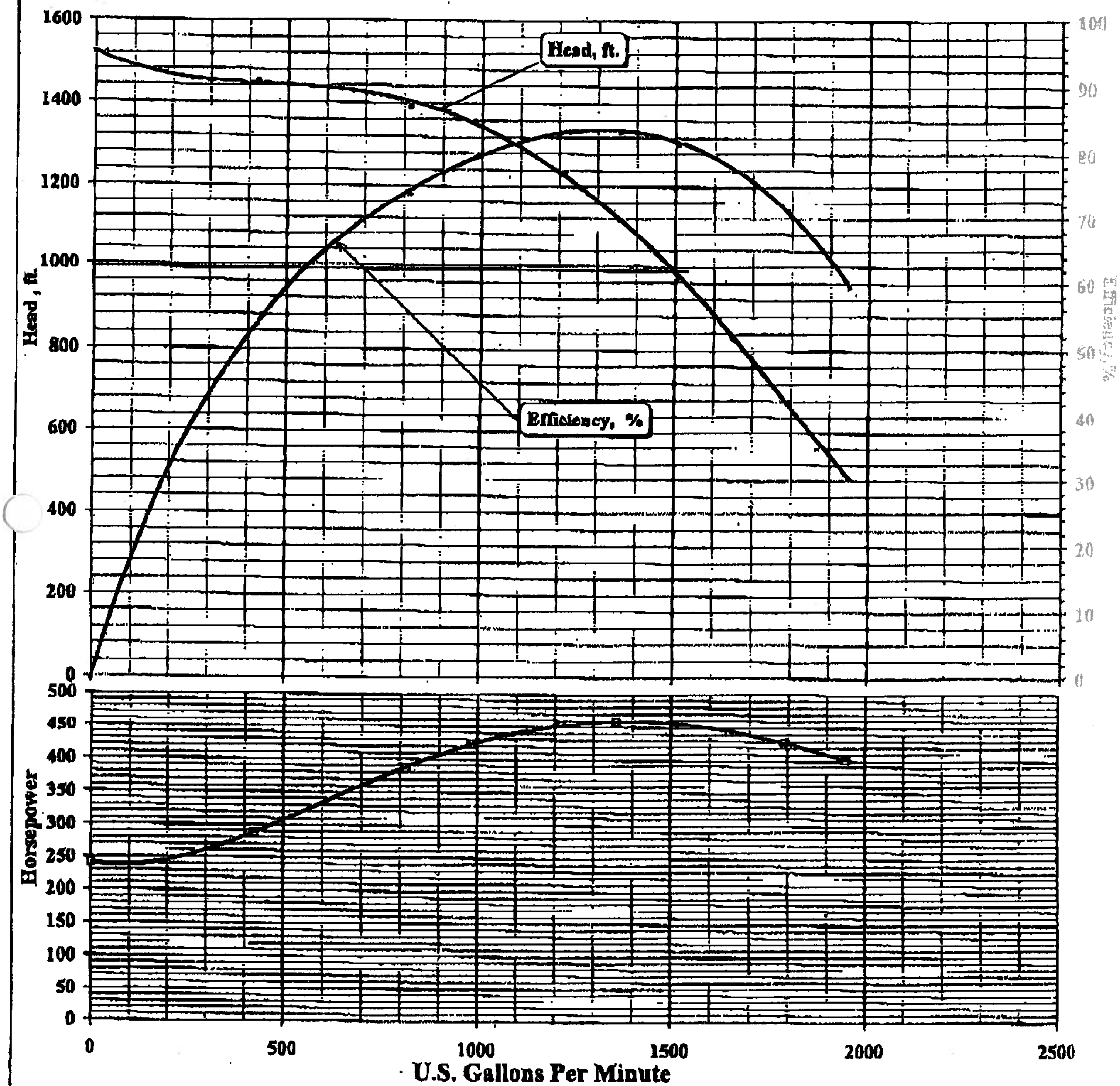
Ground elevation at Quichapa Well #7 is 5477'
Currently using a 500 HP motor, but we may go back to a 600 HP after some repairs are done.

AMERICAN TURBINE PUMP CO., INC.

4229 Adrian Lubbock, Texas 79415

Bowl Assembly Performance Test

Quichapa Well #7



Tested By: Troy Fox		1770 RPM		Certified By: Les Bowron
Customer: Rhodes Pump Sales		Date: March 30, 2007		Witnessed By:
PO #: 6187	Job: Cedar City Well #7	Test #: 1	Serial #: L4764L	
Bowl: 12-H-150	Stages: 17 Stg.	Impeller Trim: 10 @ 9.600 in.		
GPM Req: 1500	Head Req: 950	Tested Head: 759		

AMERICAN TURBINE

Quichapa Well #5

3711 S. Bagley Suite #109 Fresno, CA 93725
Ph:(559)-486-7867 Watts:(800)-435-7867 Fax:(559)-486-2341

Quote Number: 8870 Rev. # 0

Date: 2/21/07
Rev #1 Date:
Attention: Chet Perkins
End User: Cedar City Corporation
Well No: Well # 5

Company: Rhodes Pump Sales
Address: P.O. Box 218
City, State Zip: Cedar City, UT 84721
Phone #: 435-586-8312
Fax #: 435-867-5343

Item #1: Oil Lubricated Pump consisting of;

- A model 14-M-270 bowl assembly • stages - 11 • design gpm - 2000 • design tdh – 1050' • design rpm - 1770 • bowl shaft material – 17-4 ph • upper top (5) bowl material - ductile iron/ non lined and the lower (6) bowl material - cast iron/porcelain lined • bowl wear ring material – 304 stainless steel • impeller material - bronze • impeller wear ring material – 316 stainless steel • impellers to be both statically and dynamically balance • collet material - steel • double bolting with cap screw material - Grade 8 • marine type bowl bearing material –rubber inner / bronze sleeved • suction case bearing material – bronze •

[redacted]

NOTE: The above required castings have been verified and are currently in stock as of 2/21/07!

Total Each for Item # 1	$[redacted]
Total for Quantity 1 of Item # 1	$[redacted]

NOTES AND CLARIFICATIONS:

1.) Option of a 316 stainless steel cone strainer at a cost of $[redacted]
2.) Option of a bronze cone strainer at a cost of $[redacted]
3.) Option of a certified factory performance test on job supplied bowl assemble @ $ 1,001.40
4.) Upper top 5 bowls only will be ductile iron / non-lined, remaining bottom bowls will be porcelain.
5.) Any items not listed above are to be provided by others.
6.) Price above does not include any incoming or out going shipping, freight, fuel or other surcharges.
7.) Estimated cost of freight from Lubbock, TX to Cedar City, UT @ this time would be $ 755.92 and estimated 3 days for delivery.

Quichapa Well #6 Pump Information

AMERICAN TURBINE

3711 S. Bagley #109 Fresno, CA 93725

Ph:(559)-486-7867 Watts:(800)-435-7867 Fax:(559)- 486-2341

FAX TRANSMITTAL

To: Chet @ Fax: 435-867-5343
Rhodes Pump Sales

From: Bruce Smith @
American Turbine Pump, Co.

Date: February 14, 2007

Subject: Bowl Assemble S/N F 4648 L 11 STG 14-M-270

Pages including cover: 3

NOTES: Chet,

As per our phone call this morning, here is the revised curve with the new condition point of 1500 gpm, @ 1000' tdh and the machining sheet for the new shaft length.

As I told you the bottom 6 bowls are regular cast iron and the top 5 bowls are ductile iron. Remove (1) one of the lower standard cast iron bowl, and remove one of the upper impellers from the 11 stage bowl assemble to give the following;

10 Stage 14-M-270 oil lubed bowl assemble
Bottom 5 bowls will be the standard class 30 cast iron
Upper 5 bowls will be ductile class 65-45 cast iron.
Bottom 6 impellers to remain @ full diameter of 11.615" and the upper 4 impellers @ the original diameter of 11.469" will now need to be retrimmed to the new Diameter of 11.035"

Please feel free to contact us if you have any questions!
Thank you,

Bruce Smith

Bruce Smith

AMERICAN TURBINE

Quichapa Well #6

Oil Lube Turbine, Machining Instruction

Customer:	RHODES PUMP SALES
P.O. #	REVISED DESIGN GPM
Date:	February 14, 2007
Bowl Type	14-M-270
Stages:	10
Serial #:	F 4649 L
G.P.M:	1500
T.D.H:	1000
H.P:	?
Tube Projection:	6 in.
Shaft Projection:	16 in.
Bowl Diameter:	Standard
# of Pumps:	1
Blue	Bowl Paint Color

ORIGINAL DESIGN POINT
1500 GPM
1057' TDH
1770 RPM
455 BHP

O-Ring

buna-N

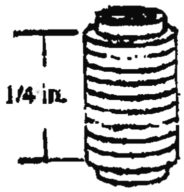
Δ UPPER 5 STAGE BOWLS ARE CL45-65 DUCTILE IRON BOWLS

Lineshaft Bearing

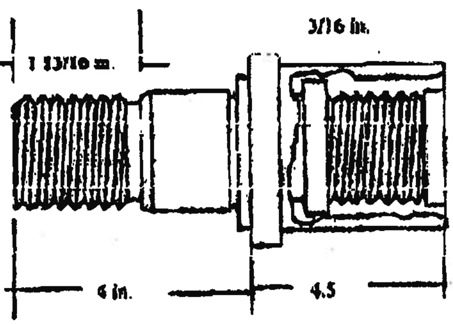
Floway
3 1/2 in.

Thread Pitch
NA

Bearing o.d.
NA



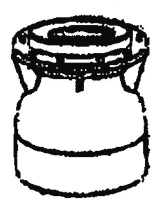
Left Hand Thread, Tube Adapter
cl 65-45-12 di
2.680 thd. dia., 10 thd. per in.



Lineshaft Bearing Type
Floway

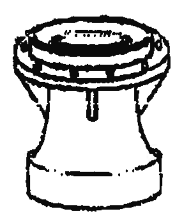
NA	Thread Pitch
NA	Bearing o.d.
#DIV/0!	Tube Bore
NA	Gun Length

Δ **14-M Bowl**
lined with Porcelain
A48-30 cast iron
12 Cap Screws
3/8 X 1 1/2
Standard Bowl Diameter
Standard End Lateral Required



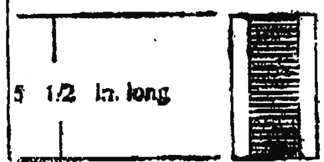
Suction Case (threaded type)

A48-30 cast iron



Grease Plug
cast iron

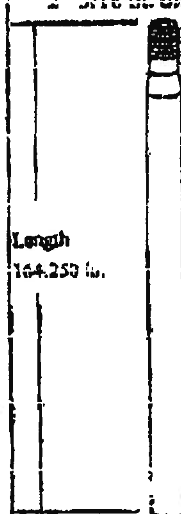
C1215 steel (Shaft Coupling)



2 3/16 in. dia. 10 thd.

Bowl Shaft
5 1/2 in. long
416 stainless steel

2 3/16 in. diameter shaft

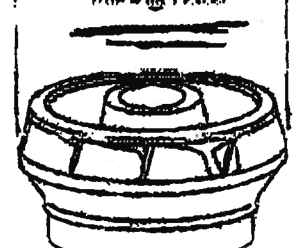


2 3/16 in. diameter bowl shaft

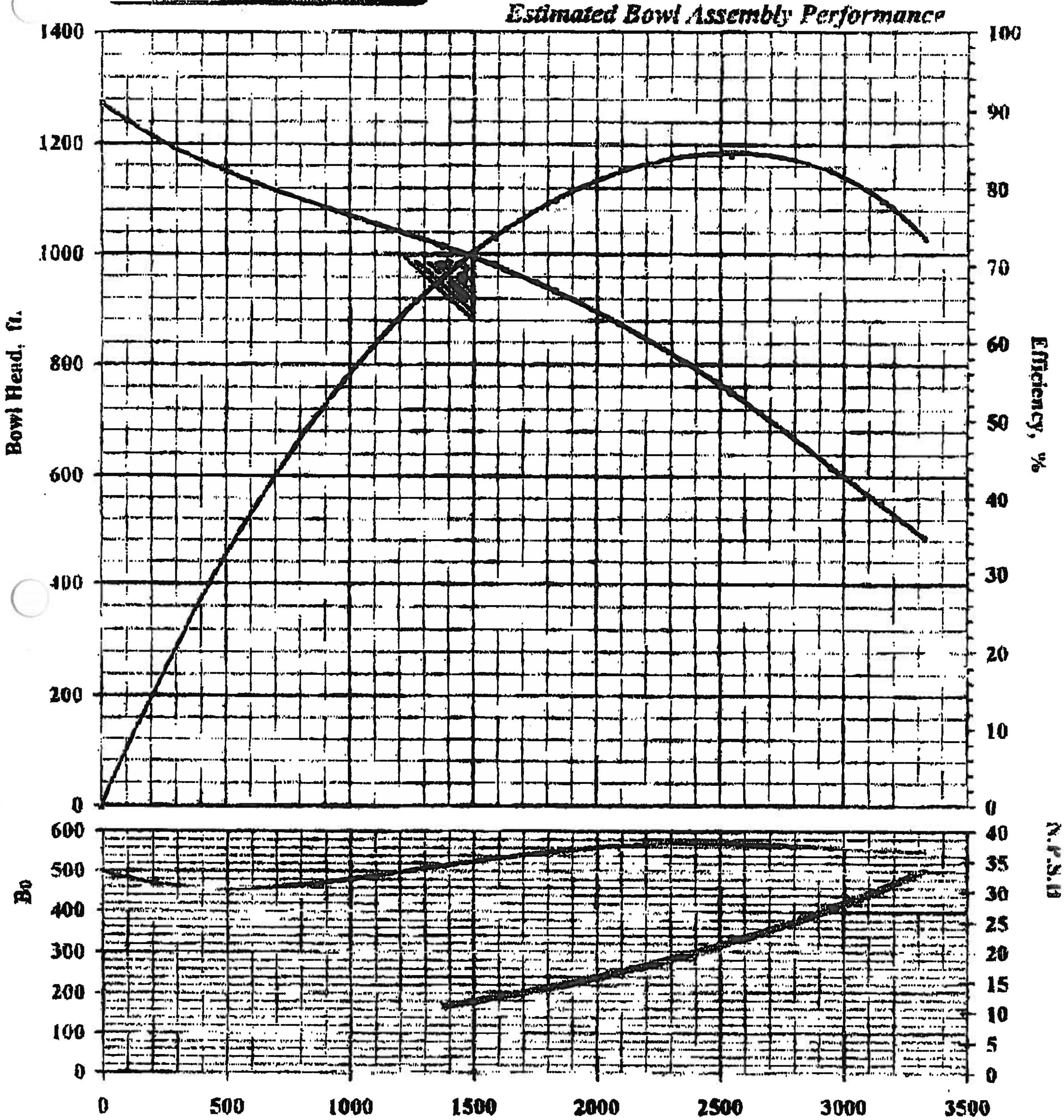
14-M-270 Impeller

C83800 br

14m 4 @ 11.015



Quichapa Well #6 Pump Curve



10 Stage 14-M-270 Bowl Assembly

14-Feb-07

1770 R.P.M.

sg = 1.00

Bowl Material

1500 G.P.M. @ 1,000 T.D.H.

Impeller Material

(TOP) Trim 4 Impellers 11.035 Diameter

C83800 bronze

Bottom 6 impellers @ 11.615 - Full Diameter

Quichapa Well #6 Spare Pump

Spare Pump

GARDNER BROTHER # QUICHAPA # 6

TEST NUMBER:	TST07-084-807
SHEET:	1
DATE:	8/7/2007
SERIAL NUMBER:	807270
CUSTOMER NAME:	

DISCHARGE HEAD:	12
FLOWMETER:	12
L/S SUB:	L/S
BOWL TYPE:	K12HC
IMPELLER DIA:	FULL
UNDER FILE:	0.125
FINISH:	B
MATERIAL:	BZ

COLUMN:	14
SHAFT SIZE:	1.688
MOTOR HP:	450
NO. OF STAGES:	17
POLE:	8
WATTMETER:	20
THR. K:	11.20
SP.GR.	1.000

RATED CONDITION: GPM: 1500 Head 985.0 Efficiency: 81.0%

	TEST POINT #:	1	2	3	4	5	6	7	8	9	10
	RPM	898	898	898	898	898	898	898	898	898	898
	GPM	0.00	212.00	409.00	511.00	622.00	763.00	787.00	821.00	897.00	1055.00
HEAD	VELOCITY HEAD	0.00	0.00	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.08
	W.S. TO GAUGE	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
	GAUGE	399.00	360.00	332.00	315.00	290.00	246.00	232.00	219.00	182.00	100.00
	ELBOW LOSS										
	COL. LOSS										
	TOTAL HEAD	406.60	367.60	339.61	322.62	297.63	253.64	239.64	226.65	189.66	107.68
HP	WATTMETER READ	1.865	1.951	2.156	2.295	2.400	2.491	2.467	2.534	2.592	2.523
	HORSEPOWER	43.40	45.65	51.05	54.81	57.68	60.14	59.52	61.37	62.96	61.05
	THR. BRG LOSS	0.31	0.28	0.26	0.24	0.22	0.19	0.18	0.17	0.14	0.08
	LAB HP	43.09	45.37	50.79	54.57	57.45	59.95	59.33	61.20	62.82	60.97
	EFFICIENCY	0.00	43.37	69.06	76.29	81.37	81.52	80.27	76.78	68.38	47.05

1780		1	2	3	4	5	6	7	8	9	10
	GALLONS PER MIN	0.00	420.22	810.71	1012.90	1232.92	1512.41	1559.98	1627.37	1778.02	2091.20
	HEAD	1597.55	1444.33	1334.35	1267.58	1169.39	996.57	941.57	890.51	745.17	423.07
	HORSE POWER	335.59	353.38	395.59	424.98	447.44	466.89	462.10	476.60	489.26	474.86
	EFFICIENCY	0.00	43.37	69.06	76.29	81.37	81.52	80.27	76.78	68.38	47.05
	HEAD/STG.	93.97	84.98	78.49	74.56	68.79	58.62	55.39	52.38	43.83	24.89

CERTIFIED PERFORMANCE DATE: 8/7/2007

PUMP STATUS:

CERTIFIED BY:

BILL GUIN

Bill Guin

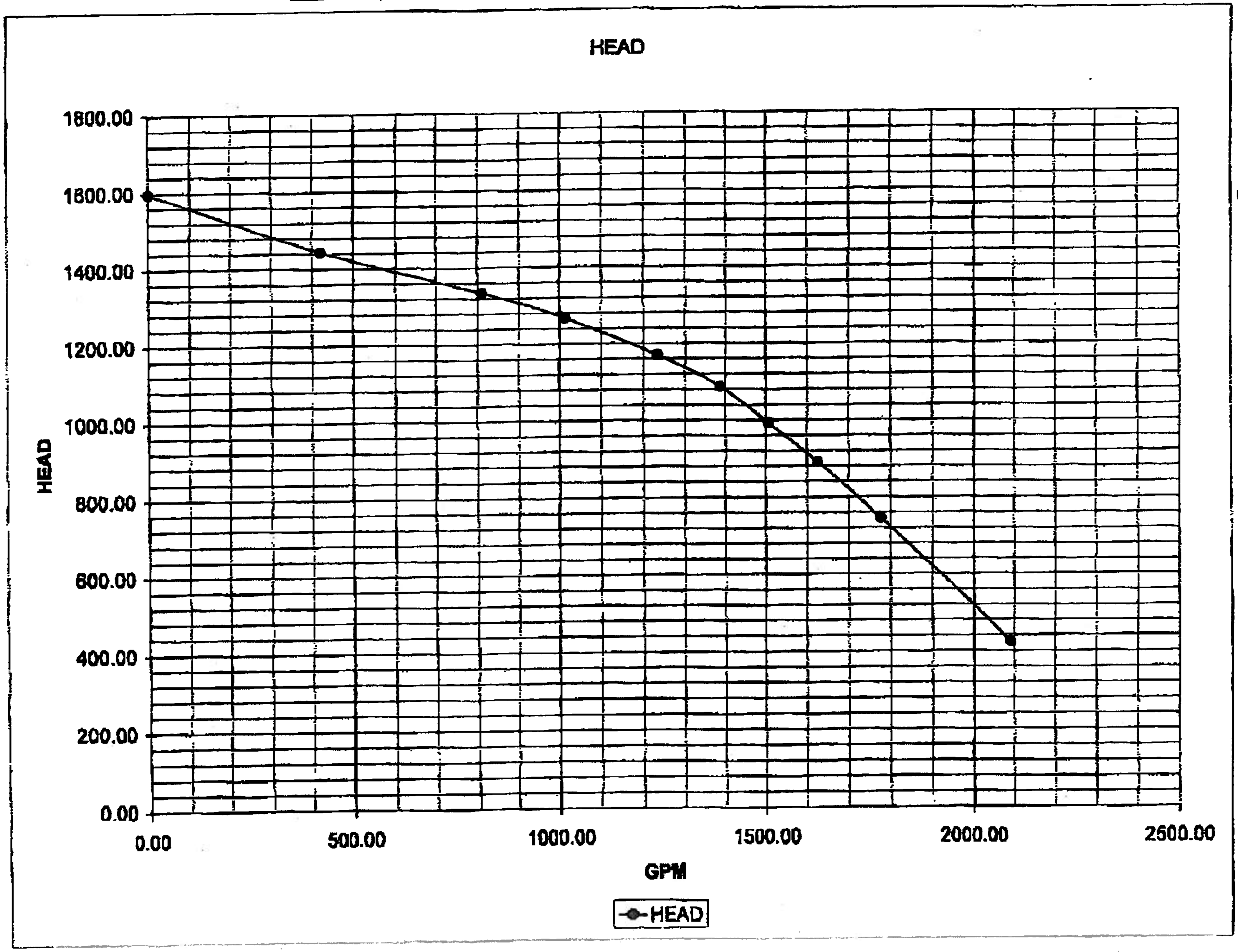
PRODUCT ENGINEER

TEST NUMBER: TST07-084-807

Quichapa Well #6 Spare Pump

NATIONAL PUMP COMPANY, LLC

TEST DATA				DESIGN DUTY POINT		CERTIFICATION	
JOB RPM	1780	TEST NO.:	TST07-094-807	CAPACITY:	1600	BY:	0
CUSTOMER	#REF!	DATE OF TEST:	8/7/2007	TOTAL HEAD:	985	TITLE:	PRODUCT ENGINEER
SERIAL #	0	PERFORMED BY:	0	EFFICIENCY	81.0%	SIGNATURE:	
BOWL TYPE:	K12HC	IMPELLER TRIM	FULL	UFL:	0.125	MATERIAL:	97



AMERICAN TURBINE PUMP CO., INC.

4229 Adrian Lubbock, Texas 79415

Bowl Assembly Performance Test

Customer:	Rhodes Pump Sales	Test #:	1
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Date:	March 30, 2007	Test Motor RPM:	1175
Sales Order #:	10835	Printed Curve R.P.M. :	1770
Purchase Order #:	6187	Flow Meter Size:	6 in.
Bowl Serial #:	L4764L	Column Pipe Size:	10 in.
Bowl Description:	17 Stg. 12-H-150	Line Shaft Size:	1 1/2 in.
Impeller Trim:	10 9.600 in.	Column Length:	7.0 ft.
Impeller Weight:	14.7 lb.	Complete Pump:	1
Gallons Required:	1500	Gauge Elevation:	(67.1 in.) + 20.0 in. water level
Head Required, ft.:	950	Thrust Constant, (K) Factor:	7.9 lb./ft. head
K.W. Meter Revolutions:	0	Test Voltage:	480
Time (Seconds):	0	Phase:	3
K.W. Reading:	0	Pressure Tap to Bowl:	3 ft.
Specific Gravity:	1		

Point	4in. flow meter gpm	6in. flow meter gpm	8in. flow meter gpm	Total Corrected Flow gpm	meter psi	psi x 2.31 = tdh + gauge elevation, ft.	kw meter reading	corrected kw	tachometer reading rpm	test motor curve rpm	G.P.M. @ 1770 RPM	T.D.H. @ 1770 RPM	Bowl EFF	Bowl H.P.
1	0	0	0	0	296.6	692.5	62.9	62.9	1194	1194	0	1,622.9	0.0%	241.4
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12	0	1309	0	1309	91.4	218.3	102.1	102.1	1188	1188	1,950	486.0	59.7%	401.1

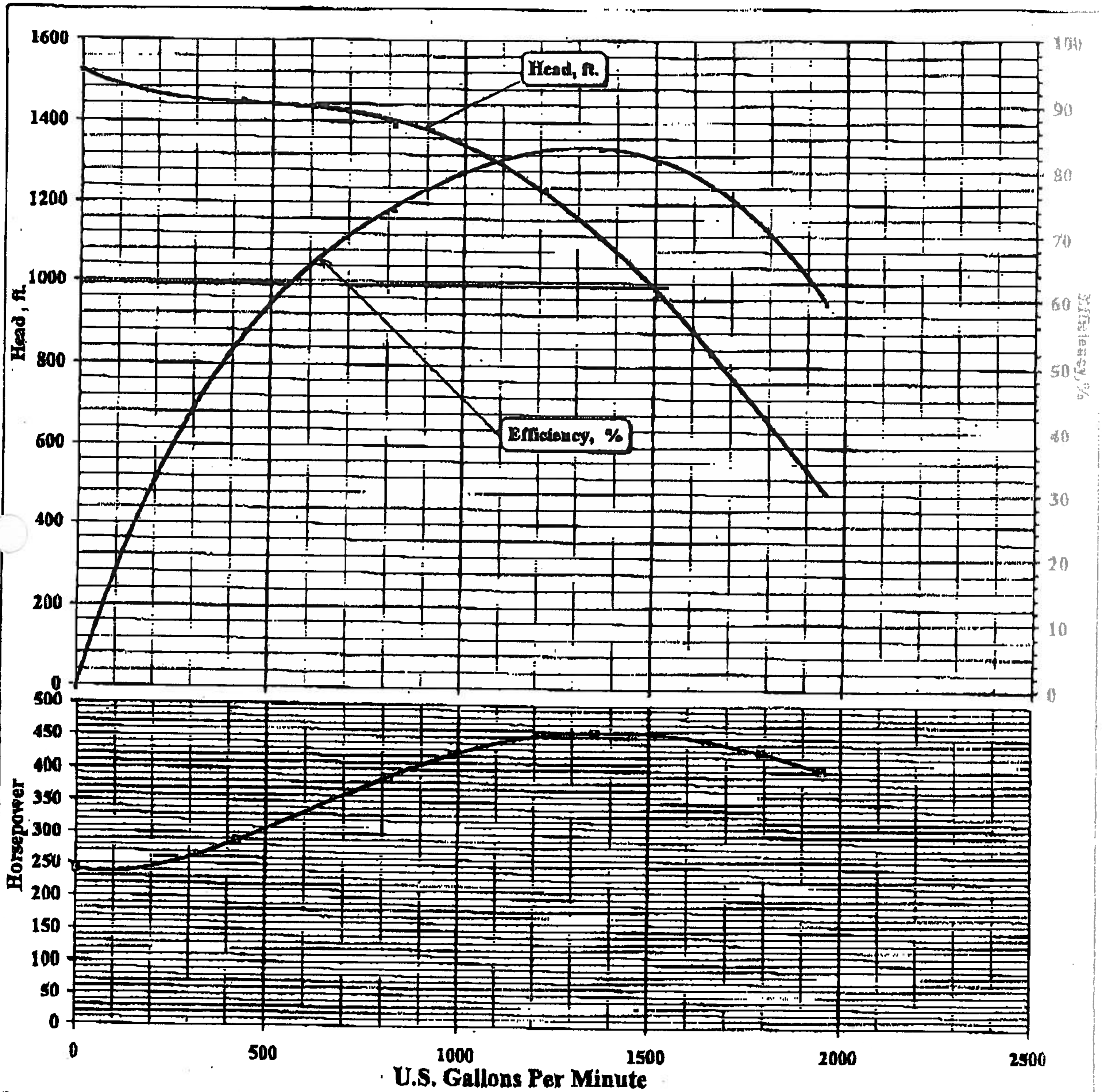
Notes:

Tested by: > Troy Fox Certified Correct by: > Les Bowron Witnessed by: > Date > March 30, 2007

AMERICAN TURBINE PUMP CO., INC.

4229 Adrian Lubbock, Texas 79415

Bowl Assembly Performance Test



...ed By:	Troy Fox	1770 RPM				Certified By: Les Bowron
Customer:	Rhodes Pump Sales		Date:	March 30, 2007		Witnessed By:
PO #:	6187	Job: Cedar City Well #7	Test #: 1	Serial #:	L4764L	
Bowl:	12-H-150	Stages: 17 Stg.	Impeller Trim: 10	@	9.600 in.	
GPM Req:	1500	Head Req: 950	Tested Head:	759		

WLI Quichapa Well #7 COPY

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification CHANGE APPLICATION: a19979(73-2944)

Owner *Note any changes*
Cedar City Corporation
P.O. Box 249
Cedar City, UT 84721-0249

Contact Person/Engineer:

Well Location *Note any changes*
COUNTY: Iron
SOUTH 2364 feet WEST 700 feet from the NE Corner of
SECTION 20, TOWNSHIP 36S, RANGE 12W, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) Cedar City Quichapa Well Field

Drillers Activity Start Date: 9-30-96 Completion Date: 10-8-96
Completion Date Test pump 11-27-96

Check all that apply: [X] New [ ] Repair [ ] Deepen [ ] Abandon [ ] Replace [ ] Public Nature of Use: Please refer to comments.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	40	30"	R. R.	Water
30	~~802~~ 842	25"	" "	"
842 ~~802~~	1020	17"	" "	"

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on water quality if known.)
0	3													Top Soil
3	11												Lt. brown	Hard pan
11	38				X									
38	40				X		X	X						85% clay
40	42				X		X	X						50% Clay 5
42	43				X		X	X						80% Clay
43	64						X	X						85% Sand
64	70				X		X							95% Clay
70	73						X	X						
73	85				X		X							

Static Water Level

Date 10-8-96 Water Level 45 feet Flowing? [ ] Yes [X] No

Method of Water Level Measurement probe If Flowing, Capped Pressure ______ PSI

Point to Which Water Level Measurement was Referenced 2' + ground

Height of Water Level reference point above ground surface 2' feet Temperature Cold [ ] °C [ ] °F

ADDITIONAL WELL DATA FORM

Water Right # a19979 (73-2944)

OWNER NAME Cedar city Corp.

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on water quality if known.)
85	92						X	X						cemented
92	95				X		X	X						50% clay
95	108				X									
108	118				X		X	X						50% clay
118	124				X									
124	130				X		X	X						
130	152				X									
152	159						X	X						good
159	164				X									
164	167						X	X						
167	170				X		X	X						60% Clay
170	172				X									
172	177						X	X						
177	179				X									
179	184				X		X	X						
184	205						X	X						
205	207				X									
207	210						X	X						
210	220						X	X						
220	230						X	X						
230	240						X	X						
240	245				X		X	X						
245	247				X									
247	250						X	X						
250	255						X	X						Wash gravel
255	260				X									
260	268				X		X							
268	271						X	X						Wash Gravel
271	278				X									
278	280						X	X						
280	291				X									
291	294						X	X						Wash Gravel

ADDITIONAL WELL DATA FORM

Water Right # 219979 (73-2944)

OWNER NAME Cedar City Corp.

[illegible]ll Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
294	299				X									
299	302						X	X						Wash gravel
302	312				X									
312	317						X	X						wash gravel
317	338				X									
338	345						X	X						Wash gravel
345	349				X		X							60% Clay
349	355				X									
355	360						X	X						Wash Gravel
360	380				X									
380	382						X	X						Wash gravel
382	384				X									
[illegible]4	408						X	X						Wash gravel
408	444				X									
444	446						X	X						Wash gravel
446	450				X									
450	454						X	X						Wash gravel
454	515				X									
515	519						X	X						
519	525				X									
525	532						X	X						
532	540				X									
540	542						X	X						
542	565				X									
565	569						X	X						
569	584				X									
584	586							X			X			granite
586	590						X	X						
590	594				X									
[illegible]4	602						X	X						
602	605				X									
605	610							X						Decaded granite

ADDITIONAL WELL DATA FORM

Water Right # 819979 (73-2944)

/NER NAME Cedar City Corp.

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (Include comments on *water quality* if known.)
610	625				X									
625	630						X	X						Wash Gravel - decomp. granite
630	635				X									
635	640						X	X						Wash gravel
640	642				X									
642	650						X	X						
650	678				X									
678	679						X	X						90% Sand
679	700				X									Decomposed granite
700	702										X			
702	714				X									
[illegible]	730						X	X						Wash gravel
730	734				X									
734	738						X	X						Wash gravel
738	742				X									
742	750						X	X						
750	754				X									
754	756						X	X						Wash gravel
756	780				X									
780	810						X	X						Wash gravel
810	820				X									
820	825						X	X						
825	834				X									
834	840						X	X						
840	858				X									
858	860						X	X						
860	944				X									
[illegible]4	955						X	X						
955	965				X									
965	975						X	X						
975	980				X									
980	994						X							

ADDITIONAL WELL DATA FORM

Water Right # 219979 (73-2944)

OWNER NAME Cedar City Corp-

Page 5 of 5

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABILITY high	PERMEABILITY low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
994	1005				X						X			Silt
1005	1015						X	X						Granite
1015	1020				X									

Construction Information

DEPTH (feet) FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	SCREEN ☒ PERFORATIONS ☐ SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
21'	162'	Steel	.375	16"					
162'	~~802'~~ 842'	Stainless Steel		16"	162'	~~802'~~ 842'	.50	16"	304 SS

Well Head Configuration: — Access Port Provided? ☒ Yes ☐ No

Casing Joint Type: Weld Perforator Used: Screen

DEPTH (feet) FROM	TO	FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL: ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal., # bag mix, gal./sack etc.)
0	150	~~Cement Grout~~	~~4 yd.~~	~~12 bag sand mix~~
150	1020	Colorado Silica Size 4/9		

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
11/27/96	line shaft turbon	3200	X		200'	200 hr

Pump (Permanent)

Pump Description: N/A Horsepower: ____ Pump Intake Depth: ____ feet

Approximate maximum pumping rate: ____ Well disinfected upon completion? ☐ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Please note the completion date for the well is 10-8-96 and the completion for the test pump is for 11-27-96. We kept the log so we could put the test pump information on before sending it in. Thank you.

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name: Gardner Drilling License No. 492

(Person, Firm, or Corporation – Print or Type)

Signature: Dale Gardner Date: 11/27/96

ATTN: Kit

PUMP YIELD & DRAWDOWN TEST DATA

Well: Quichapa Well #7 Driller: Gardner Well Drilling

Pump Max. Capacity/Head ______ gpm/ ______ Ft.

Depth of test pump 485' Ft.

Date: 11-25-96 Time Starting: 10:00 AM

Drawdown data:

hour	flow (gpm)	#7 Static level (0.10 ft.)	Jones Static Level (0.10 ft.)
0	0	45' 6"	68' 4"
0-1	500	69' 7"	X
1-2	1000	80' 4"	X
2-3	1500	99' 10"	X
3-4	2000	119' 4"	X
4-5	2000	129'	69 (if stable)

Continue hourly readings at 2000 GPM until pumping levels are stabilized then take static level in Jones Well.

5-6	2000	133.3	69.5 (If Stable)
6-7	2000	134	69 7 (If Stable)
7-8	2000	135' 1"	(If Stable)
8-9	2000	138' 9"	(If Stable)
9-10	2000	139' 7"	X
10-11	2500 Maximum Flow	140' 4"	X
11-12	2500 Maximum Flow	161'-2"	X (If Stable)

Continue hourly readings at Maximum flow until pumping levels are stabilized then take static level in Jones Well.

12-13 13-14	2500 Maximum Flow	163-2"	70'-2" (If Stable)
14-15	3100 Maximum Flow	194'-8	(If Stable)

Recovery Data: (Begins at end of Drawdown test)

Hour	#7 Static Level (0.10 Ft.)
1	69-2"
2	62'.7"
3	59'.7
4	58'

Continue recording recovery data hourly until static levels stabilize.

5	56'-10"
6	55-11"
7	55'"
8	53'1"
9	52'5"
10	51-8

Time Ending: 11:00 AM

Tester Gary Gardner
Signature

wpdata\water\well7pmp.txt

WELL #7

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification

Water Right: 73-361 WIN: 123489

Owner *Note any changes*

Cedar City Corporation
10 North Main St
Cedar City UT 84720 ATTN: Jonathan Stathis

Contact Person/Engineer: H. Dewey Petersen or Jonathan Stathis Engineer

Well Location *Note any changes*

S 2364 W 700 from the NE corner of section 20, Township 36S, Range 12W, SL B&M

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) WELL #7: 1 mile west Town

Drillers Activity Start Date: 6-19-06 Completion Date: 6-30-06

Check all that apply: ☐ New ☒ Repair ☐ Deepen ☐ Clean ☐ Replace ☐ Public Nature of Use: ______

If a replacement well, provide location of new well. ______ feet north/south and ______ feet east/west of the existing well.

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	810	16"	No Drilling at This Time	

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE High	PERMEABLE Low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTION AND REMARKS (e.g., relative %, grain size, sorting, angularity, bedding, grain composition density, plasticity, shape, cementation, consistancy, water bearing, ordor, fracturing, minerology, texture, degree of weathering, hardness, water quality, etc.)

Static Water Level

Date 6-26-06 Water Level 95' feet Flowing? ☐ Yes ☒ No

Method of Water Level Measurement Video Camera If Flowing, Capped Pressure ______ PSI

Point to Which Water Level Measurement was Referenced Pump Head Level Elevation ______

Height of Water Level reference point above ground surface ______ feet Temperature ______ degrees ☐ C ☐ F

Construction Information

DEPTH (feet) FROM	TO	CASING: CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	☐SCREEN ☐PERFORATIONS ☐OPEN BOTTOM: SCREEN SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
0	810	w/ V100D			166	810	w/ V100D		

Well Head Configuration: Customers Turbine Pump Access Port Provided? ☑Yes ☐No

Casing Joint Type: ____ Perforator Used: ____

Was a Surface Seal Installed? ☐Yes ☐No Depth of Surface Seal: ____ feet Drive Shoe? ☐Yes ☐No

Surface Seal Material Placement Method: ____

Was a temporary surface casing used? ☐Yes ☐No If yes, depth of casing: ____ feet diameter: ____ inches

DEPTH (feet) FROM	TO	SURFACE SEAL / INTERVAL SEAL / FILTER PACK / PACKER INFORMATION: SEAL MATERIAL, FILTER PACK and PACKER TYPE and DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal., # bag mix, gal./sack etc.)
		N-A		

Well Development and Well Yield Test Information

DATE	METHOD	YIELD	Units Check One: GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
	Done by Peterson Bros. Drilling Co. Inc.					

Pump (Permanent)

Pump Description: ____ Horsepower: ____ Pump Intake Depth: ____ feet

Approximate Maximum Pumping Rate: ____ Well Disinfected upon Completion? ☑Yes ☐No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary Circumstances, abandonment procedures. *Use additional well data form for more space.*

Pump was pulled - Cable tool equip set up with surge block configuration - well surged. Developed in screen area - installed 950 solo sacks 6-9 Colorado Silica Gravel Pack.

Well Driller Statement

This well was drilled and constructed under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name PETERSEN BROTHERS DRILLING CO INC License No. 249

(Person, Firm, or Corporation) (Print or Type)

Signature [signature] Date 7-13-06

(Licensed Well Driller)

Cedar City Water System Master Plan Update

Data Gathering Notes

BROWN AND CALDWELL

Collected By J. Young Date 01/25/08

Summary Notes

I) Supply Condition Assessment

A) Enoch Wells

1) Pump houses, Well Motor and Appurtanances all appear to be in good shape.
2) There are vibrations in the bowls for the Enoch 3 Well. They are scheduled to be replaced in February.
3) There are no sanding or air problems with these wells.
4) The operators are unable to use these wells to their full capacity because:
   1) 3200 N. Tank overflows if all flow is sent there
   2) Throttling Flow to the 3200 N. Tank Results in a very high head at the wells to push water all the way to distribution. ~~With~~ the high head the wells produce ≈ 700 gpm ~~3) 3200 N. Tank~~ below their design flow.
   3) Even with the inflow throttled the 3200 N. Tank overflows contantly throughout the summer.

B) North Field Well

1) Pump house, motor and appurtanances all appear to be in good shape.
2) Used primarily for irrigation; has been used for emergency cullinary supply in the past. Water quality is poor (hard water).
3) Had sanding problems until bowls were downsized.

Cedar City Water System Master Plan Update

Data Gathering Notes

BROWN AND CALDWELL

Collected By J. Young

Date 01/25/08

C) East Canyon Chlorinator

1) Filter method may be outdated. They had ~~a~~ self-cleaning filter but it did not work.
2) Filter is cleaned manually every 30 days.
3) Black, flakey sedimentation under cleanout.
4) May be able to add value by adjusting the PSV here. once the new project is completed.

D) Quichapa Wells 6, 7, 5

1) Each have had sanding issues in the past. Potential causes are:
   a) Screen perforations and gravel pack not sized properly to screen sands.
   b) Nearly the entire well hole was screened including high sand formations.
   c) The pumps are very large constant speed pumps which may result in overpumping of the aquifer.

2) Attempts to mitigate the sanding problem have been moderately successful. They are:
   Well 6 - Downsized bowls.
   Well 7 - Downsized Motor & Column (Not turned on yet)
   Well 5 - Eliminated two bowls.

3) Wells 6 & 5 are the only two wells in the system with back up power.
   Well 6 - has a ~6hr turnover ~~time~~ to convert to the diesel engine drive.
   Well 5 - is an easy switch; only operates on Diesel in the winter once a week to keep the well fresh

Cedar City Water System Master Plan Update

Data Gathering Notes

BROWN AND CALDWELL

Collected By J. Young Date 01/25/08

4) There are taste & odor problems with this water in the winter. This is most likely due to water age without chlorination.

5) Supply HGL with all 3 wells running is extremely high. ~~Ab~~ (300+ psi). Manufactures will not garantee products this high.

6) I need to verify the controls on these wells.

E) Shurtz Springs Chlorinator
1) Small, seems to be new and in good shape.
2) I didn't see any filtration.

Cedar City Water System Master Plan Update

Data Gathering Notes

BROWN AND CALDWELL

Collected By J. Young

Date 01/25/08

F) Quichapa Well 3

1) Well not in operating condition.
   a) Motor was recently replaced but has not been hooked up to electric. b) Expected to be operational by summer.
2) Building needs to be replaced. Pipes had tarps and insulation around them to prevent freezing

G) Quichapa Well 1

1) This well is only used when necessary. It has significant sanding and air problems, even after rehabilitation.
2) Building is partly demolished and has left pump motor exposed all winter
3) Capacity has decreased over time.

H) Spillsburry Pumpstation & Chlorinator

1) Tank, Pump house and equipment are all in great condition.
2) There is no back up pump.
3) I didn't see any filtration.

I) Cemetary Well.

1) Irrigation System work horse
2) Looks old but seems to do the job.
3) Only pump with a VFD

Cedar Valley Groundwater Model Using Future Enoch City and Cedar City Demands

Prepared by:

Nolte Associates

Prepared for:

Central Iron County Water Conservancy District

Date: May 2008

1.0 INTRODUCTION

This study was performed by Nolte for the Central Iron County Water Conservancy District (CICWCD).

All potable water and a large portion of irrigation water used in the Cedar Valley come from an underground lake called an aquifer. This aquifer is replenished by the portion of rain or snow melt that seeps into the ground. The aquifer is depleted by water that is removed by wells located though out the Cedar Valley. To maintain a healthy aquifer, the water that is removed from the aquifer must not exceed the water that enters the aquifer from rain and snow runoff.

Mining the aquifer occurs when more water is removed from the aquifer than is replenished. When the aquifer is mined several problems develop.

- Existing wells have to be abandoned or deepened to reach the lower water table
- Additional energy costs are incurred from pumping the water from deeper wells
- The lower water table causes the soil to subside which results in lost storage capacity in the aquifer and may produce subsidence on the ground surface.
- The total amount of water available for storage and use is reduced

The problems work in combination to damage the aquifer. As the water table is lowered, wells must be drilled deeper. Because the water level begins at a lower level than before, the water level in the aquifer will not reach normal levels during a normal water year. The portion of the aquifer that does not store water dries out. The area of the aquifer that is dry, settles and that portion of the aquifer can no longer store water. Because the storage capacity is lost, the aquifer cannot store water close to the ground surface even when more water is available for underground storage (e.g. a high water year). The result is wells being drilled deeper and cycle continuing.

The USGS completed a study on the aquifer under the Cedar Valley in 2005 (see “Hydrology and Groundwater Simulation Model for the Cedar Valley”). The study examined groundwater data from 1938 to 2000 to determine a “safe yield” of the aquifer. The study concluded that the Cedar Valley is currently using more water from the aquifer than is being replaced or in other words mining the aquifer. As a result, the water level in the aquifer is dropping and the problems described above are starting to occur. In addition, the USGS study projected what the aquifer would look like in the year 2030. The estimates showed the water level dropping 50-100 feet in the areas around Enoch and Cedar City from 2000 to 2030. The future water demands projected in the USGS study are smaller than the water demands predicted by the Enoch and Cedar City water master plans.

The purpose of this study is to predict how the groundwater in the aquifer will change when it must supply current water demands in addition to the future water demands of Cedar City and Enoch. Additionally, this study will make recommendations on how to address the water problems the Cedar Valley will face in the future.

2.0 ASSUMPTIONS

The USGS groundwater and recharge data is used for the basis of the model for this study. In addition, the additional future groundwater demands estimated by the Enoch (December, 2007) and Cedar City water master plans were added to the groundwater model. To accommodate these demands, two new wells were added to the model, one near the city of Enoch and the other near Cedar City. A percentage of the total groundwater demand was added to these wells every ten years based on the water master plans predicted population growth.

The assumptions are as follows:

- The model was calibrated using field data from 1938 to 2000. No additional data was collected to verify results (i.e. 2000 to 2008) and we assumed that current recharge and pumping would continue in the same pattern as the previous 40 years.
- The future demands were placed near Enoch City and Cedar City but actual future wells may be located in different areas of the Valley.
- An increase in average temperature over the next 30 years was not considered.
- This study does not consider agricultural water use conversion to municipal use.
- This study is limited to estimating a future aquifer water surface elevation.
- This study uses the population growth projections from the Enoch and Cedar City water master plans

3.0 RESULTS

A plan view of the modeled area is shown in Figure 1. A three dimensional representation of the water surface for the years 2000 and 2040 is shown in Figure 2. Figure 3 shows the elevation cross section referenced in Figures 1 and 2 for the ground surface, 2000 water surface, and 2040 water surface. The model results show the aquifer water level will drop between 150 to 200 feet from 2000 to 2040 in the Enoch and Cedar City areas. This drop is more than twice as large as the estimate of the USGS study. Additionally, a drop in groundwater level occurs throughout the entire Cedar Valley and is not just limited to the population centers around Cedar City.

4.0 CONCLUSIONS

The results of the model show that over the next 30 years the groundwater aquifer will be depleted significantly if current trends continue. As the population and water demand increases the drawdown occurs more rapidly. If current trends continue, there is a high probability that groundwater in the Cedar Valley aquifer will not meet water demands and a large number of existing wells will not be deep enough to reach the top surface of the aquifer. This will have a tremendous impact on residential, commercial and agricultural water users in the Cedar Valley.

Many things can be done to prevent the scenario predicted by the model including the following five items discussed in this report.

1. Reduce the amount of water being used from the aquifer through conservation.

2. Use infiltration basins to increase the amount of water that replenishes the aquifer.

3. Bring other sources of water to meet the needs of the Cedar Valley.

4. Agricultural water conversion to municipal and industrial uses.

5. The Utah State Engineer enforcing a ground water management plan.

Each of these will play an important role in protecting the aquifer and all of them should be used to meet water demands in the Cedar Valley. These items are discussed in greater detail below.

Reduce the Amount of Water through Conservation

Conservation measures should be made now to reduce the amount of water being used. Even though this will help, alone, it will not be enough to prevent mining of the aquifer. Currently, the Cedar Valley is using more water than is available and with future growth, water demand will only increase. Conservation will delay water reductions in the aquifer and reduce the amount of additional water required to meet demands but, alone it will not allow the aquifer to meet Cedar Valley future water demands.

Use Infiltration Basins to Increase the Amount of Water that Replenishes the Aquifer

Water that is not infiltrated into the aquifer evaporates away and is lost. During very wet years (i.e. 2005 300% of normal runoff) the amount of water that is lost to evaporation is significant. Creating infiltration basins will allow more water to be infiltrated and stored in the aquifer that would otherwise be lost.

Bring Other Sources of Water to Meet the Needs of the Cedar Valley

This includes the possibility of water from areas west of the Cedar Valley and/or Lake Powell Water. In addition, there may be other sources of water that can be brought to the Cedar Valley to meet demands. Bringing additional water to the Cedar Valley will play a vital role in protecting the aquifer and assuring that future water demands are met. The aquifer can supply 35,000 to 43,000 acre-feet of water a year without mining the aquifer. Projected future demands are 60,000 to 68,000 acre-feet per year. This is at least a 25,000 acre-foot shortfall that must be made up through conservation, infiltration, and other water sources.

Agricultural Water Conversion to Municipal and Industrial Uses

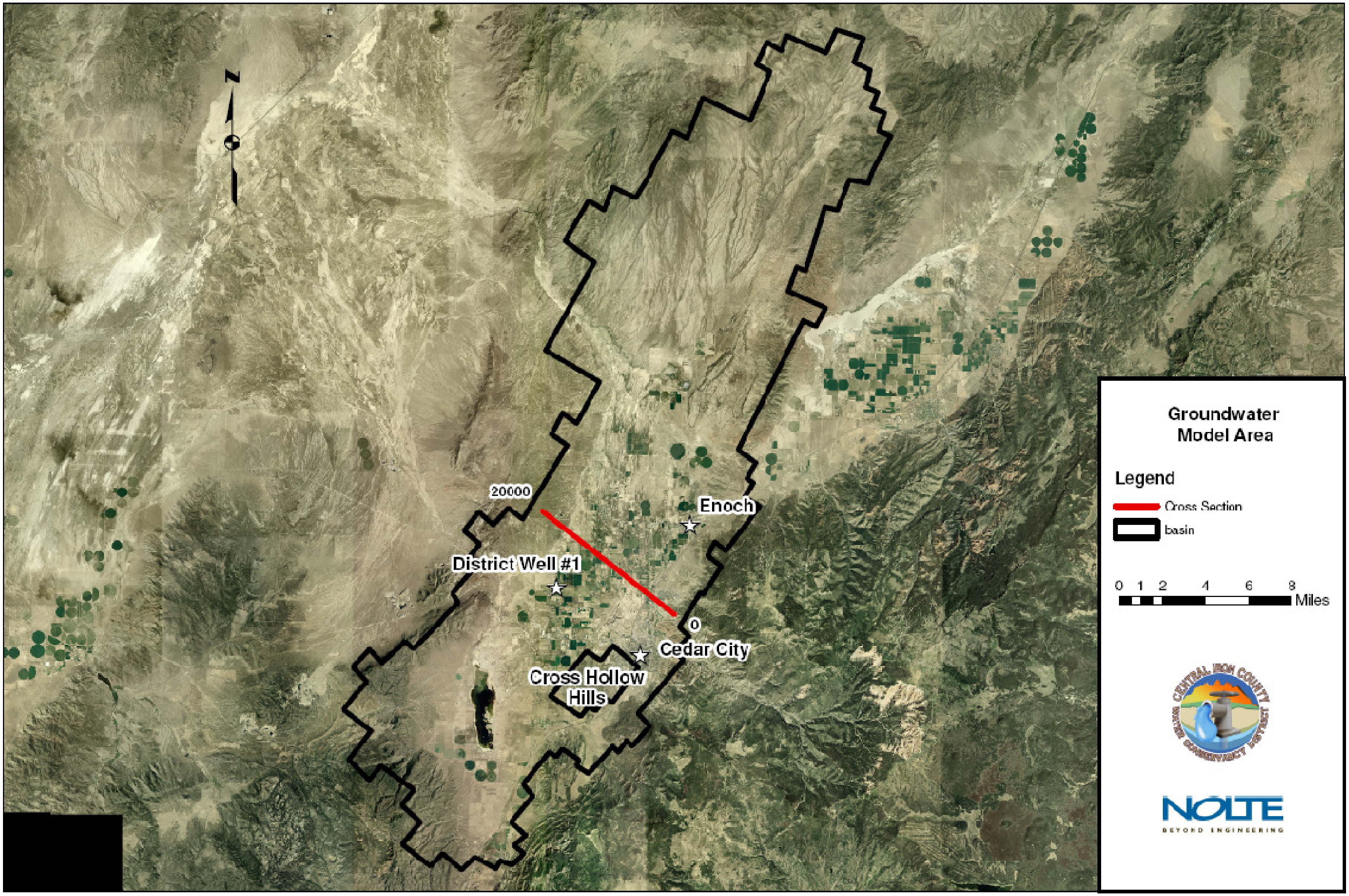
Portions of the land area included in the annexation declaration areas for Cedar City and Enoch City are in agricultural production. This agricultural land has water rights that are associated with it. Both Enoch and Cedar annexation agreements require that water associated with annexed land be transferred to the city and converted to municipal use. Using aerial photographs, the total amount of agricultural land included in the Enoch and Cedar City annexation declaration boundaries was estimated. Each acre of agricultural land was assumed to have 2.8 acres of water available for conversion to municipal use. If all of this water is converted, Enoch will have 3,133 acre-feet and Cedar City will have 7,621 acre-feet of agricultural water that can be converted to municipal use. This converted agricultural water would reduce the total amount of water that is removed from the aquifer for future use.

The Utah State Engineer Enforcing a Ground Water Management Plan

The ground water management plan is a tool the State Engineer can use to reduce the amount of water the removed from an aquifer to a "safe yield." In basic terms, this is accomplished by cancelling water rights with higher priority dates until the remaining water rights are equal to the "safe yield" of the aquifer. Currently the State Engineer is in the process of developing a ground water management plan for the Beryl-Enterprise area and there are indications that he plans to develop a ground water management plan for the Cedar Valley. A ground water management plan will prevent damage to the aquifer but it will also stop all growth in the Cedar Valley by limiting available water. Furthermore, it is likely that current water use will have to be reduced to reach a safe yield for the aquifer.

Based on current growth levels, the Cedar Valley aquifer water level will reduce 150 to 200 feet over the next 30 years. To meet future demands and to prevent failure of the aquifer, the Cedar Valley must start to plan for the future now.

Figure 1



20000
Enoch
District Well #1
0
Cedar City
Cross Hollow
Hills
Groundwater
Model Area
Legend
Cross Section
basin
0 1 2 4 6 8
Miles
NOLTE
BEYOND ENGINEERING

Figure 2

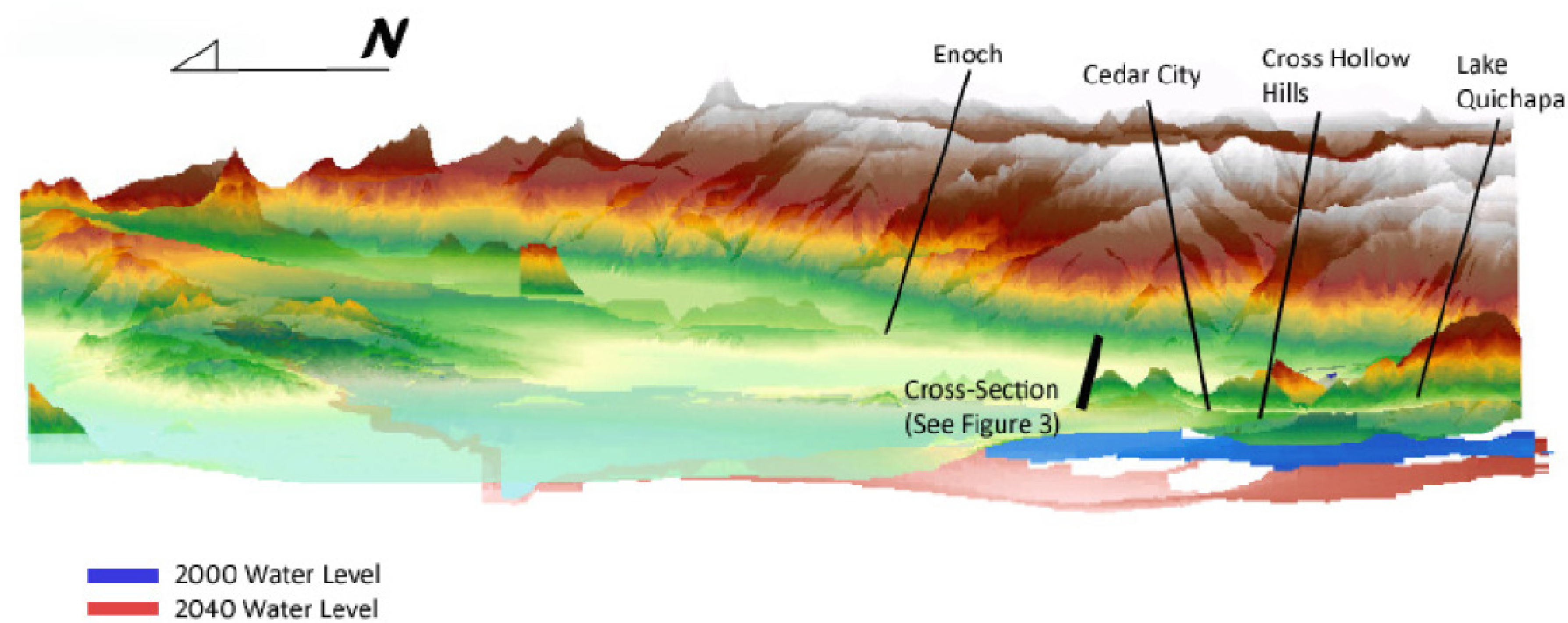
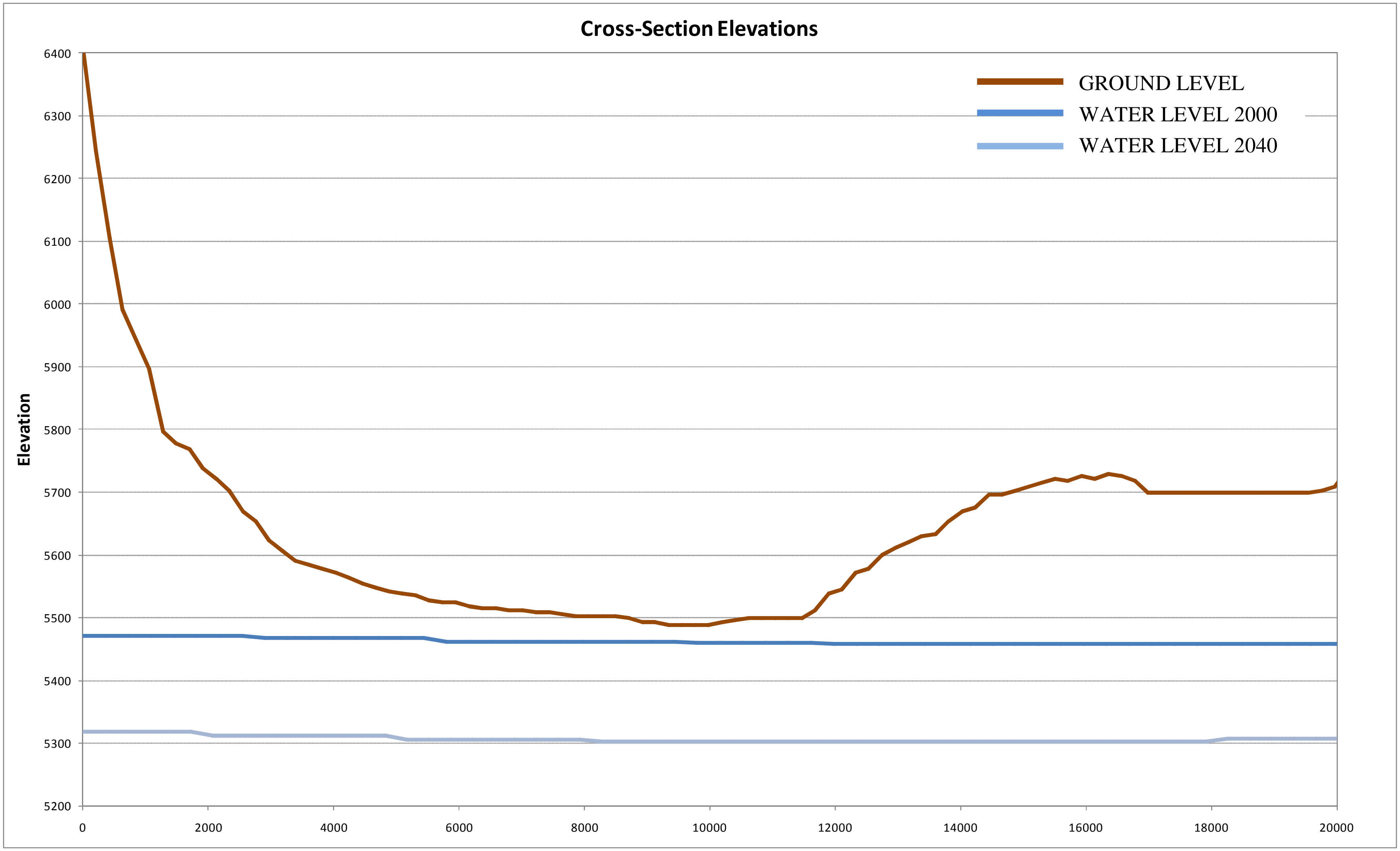

N
Enoch
Cedar City
Cross Hollow
Hills
Lake
Quichapa
Cross-Section
(See Figure 3)
2000 Water Level
2040 Water Level

Figure 3



Cross-Section Elevations
GROUND LEVEL
WATER LEVEL 2000
WATER LEVEL 2040
Elevation
6400
6300
6200
6100
6000
5900
5800
5700
5600
5500
5400
5300
5200
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000

NON-PROMOTIONAL PRICING WATER RATE RESOLUTION

CEDAR CITY CORPORATION

RESOLUTION NO. ______05-0126______

A RESOLUTION GOVERNING CHARGES FOR USE OF CULINARY WATER AND PRESSURIZED IRRIGATION WATER, AND DELINQUENT PENALTY FEE

WHEREAS, it is the policy of the City Council of Cedar City Corporation to provide culinary water and pressurized irrigation water to the inhabitants of the City in such a manner that will best provide for the citizens; and

WHEREAS, the City Council deems it proper and necessary to set rates in order to comply with the pledge of revenue for bond documents and more specifically to conform with the schedule of revenue and debt service coverage; and

WHEREAS, Cedar City Corporation seeks to comply with State initiatives to conserve water in order to maintain the City's future eligibility for State funding and other State-sponsored programs pertaining to water utilities; and

WHEREAS, the City Council deems it proper and necessary to encourage water conservation through the use of pricing incentives and water audits; and

WHEREAS, pursuant to State Statute and City Ordinance, the Cedar City Council is authorized to establish all charges for the use of Cedar City culinary and pressurized irrigation water by and through written resolution;

NOW THEREFORE, BE IT RESOLVED by the Cedar City Council, County of Iron, State of Utah, as follows:

I. FEES FOR WATER USE

A. Fixed Charge

There is a fixed charge each time a bill is rendered as follows:

Monthly Fixed Charge $13.00

B. Quantity Charge for Culinary Water Use

In addition to the fixed charge, there is a charge for all culinary water used for each 1,000 gallons as follows:

Single-family Residential (Monthly Per Account)

Block 1	First 8,000 gallons or any part thereof	$0.48
Block 2	8,001 to 25,000 gallons or any part thereof	$0.60
Block 3	Over 25,000 gallons	$1.20

Multi-family Residential (Monthly Per Occupied Dwelling Unit)

Block 1	First 5,000 gallons or any part thereof	$0.48
Block 2	5,001 to 15,000 gallons or any part thereof	$0.60
Block 3	Over 15,000 gallons	$1.20

Non-residential (Monthly Per Account)

	All Usage	$0.63
	Excess Irrigation Usage*	$1.20

C. Quantity Charge for Pressurized Irrigation Water Use

In addition to the fixed charge, there is a monthly charge for all pressurized irrigation water used for each 1,000 gallons as follows:

All Usage $0.44
Excess Irrigation Usage* $1.20

* Applies to "Large Irrigation Users" as defined herein.

II. LARGE IRRIGATION USERS

A. Definition

A "large irrigation user" shall be defined as any non-residential parcel, or combination of adjacent non-residential parcels under the same ownership, with landscaping in excess of 0.75 acres that is being irrigated with culinary water or pressurized irrigation water.

B. Irrigation Water Meter

After the effective date of this ordinance, all new customers that are deemed to be large irrigation users shall be required to either install a separate water meter that serves the landscaped area only or connect to the pressurized irrigation system.

Any large irrigation user that desires to connect to the City's pressurized irrigation system will be required to make an application to the City for such service. If the application is approved, the customer will be required to install a pressurized irrigation meter according to City standards.

C. Monthly Water Allotment

The City shall assign a monthly water use allotment to each large irrigation user. All water usage in excess of the monthly allotment shall be charged at the higher rate given in Sections I-B and I-C of this resolution.

1. <u>Outdoor Allocation</u>

To determine the outdoor allowance, the average monthly evapotranspiration (ET) rates for turf over a thirty-year period (1961-1990) were calculated. The average precipitation was then subtracted from the ET rates to determine the net irrigation needs. The calculated irrigation needs were then increased by 25% to account for dry years. The results of this analysis are given in Exhibit 1 of this resolution.

The outdoor landscape water allocation for each large irrigation user shall change on a monthly basis according to the monthly irrigation allowances provided in Exhibit 1 of this resolution. The landscape acreage served by an account shall be multiplied by the irrigation allowances to determine the monthly outdoor water use allocation.

2. Indoor Allocation

For large irrigation accounts that have one culinary water meter serving both indoor and outdoor uses, the account shall be provided with an indoor culinary water use allocation in addition to the outdoor culinary water allocation. The indoor culinary water use allocation shall be the average winter flow that is used in calculating the annual sewer rate for the account. The indoor culinary water allocation shall be updated annually in the month of April to correspond with the annual sewer rate adjustment.

3. Total Monthly Allotment

The total monthly culinary water use allotment for each individual large irrigation account that uses culinary water shall be the sum of the outdoor and indoor culinary water allocations.

The outdoor allotment for large irrigation users that use pressurized irrigation water shall be the outdoor allocation without including any indoor use.

4. Appeals

If a large irrigation customer disagrees with the monthly water allotment assigned by the City, the customer may appeal to the City's Public Works Director. The Public Works Director shall then re-examine the allocation and decide whether to keep the original allotment or assign a new allotment. If the customer disagrees with the decision of the Public Works Director, the customer may then make an appeal to the City Manager. The decision of the City Manager regarding the monthly water use allotment shall be final.

D. Classification and Notification

1. Classification of New Large Irrigation Users

New large irrigation users shall be identified and notified during the City's planning and project review process.

2. Adjustments

It shall be the responsibility of large irrigation customers to report any modifications in the amount of landscaped area to the City in order to adjust the monthly water allotment for the account. The City may also initiate an adjustment to the monthly water allotment for a particular account when it is observed that the amount of landscaped area has been modified. When adjustments are made to the amount of landscaped area, the City shall provide the customer with documentation of their new monthly water allotment.

If an existing non-residential customer adds landscaped area to the point that they become a large irrigation user, they shall be provided with a report that defines their monthly water allocation and they shall become subject to the large irrigation user rates. If an existing large irrigation customer removes landscaping to the point that they are no longer considered a large irrigation user, they shall cease to be subjected to the large irrigation user rates.

III. WATER AUDITS

A. Purpose

The City shall provide water audits to culinary and pressurized irrigation water customers as a public service. The goal of a water audit shall be to identify and recommend specific water conservation measures.

B. Procedure

1. Non-residential Customers

For non-residential accounts, the key price incentive for indoor culinary water conservation comes through the sewer rates. Since culinary water and sewer rates are both tied to consumption, it is to the customer's advantage to reduce indoor culinary water usage thereby saving on operating expenses. To provide non-residential customers with the ability to reduce their culinary water and sewer user fees, the City shall provide water audits at the customer's request to help identify potential water saving practices. The City also reserves the right to initiate and conduct water audits on non-residential accounts in accordance with Cedar City Ordinance Section 37-8.

2. Large Irrigation Users

Large irrigation users have an incentive to save culinary water built into the rate structure as given in Section I-B of this resolution. However, if a large irrigation user feels that they need additional help to stay within their monthly allotment, the customer may request that the City perform a water audit on their irrigation system. The City also reserves the right to initiate and conduct water audits on large irrigation users in accordance with Cedar City Ordinance Section 37-8.

3. <u>Residential Customers</u>

For single- and multi-family residential accounts, the incentive for conserving culinary water is provided in the form of an inclining block rate structure given in Section I-B of this resolution. However, if a residential customer feels that they would like specific help in reducing their water usage, the customer may request that the City perform a water audit on their property. The City also reserves the right to initiate and conduct water audits on residential accounts in accordance with Cedar City Ordinance Section 37-8.

C. Water Audit Report

Within thirty-days of completing a water audit, the City shall notify the customer of the findings and results of the audit in the form of a written report. The report shall include the City's recommendations for implementation of water conservation measures. The report shall also include a summary of potential cost savings to the customer for water and sewer user fees, including the payback period on capital costs associated with installing water conservation devices. The goal of the report shall be to encourage the customer to implement specific water conservation measures at their facility or residence. Three months after issuance of the report, the City shall follow-up with the customer to determine which conservation measures were implemented and the success of the measures in reducing water usage.

IV. LATE PAYMENT PENALTY

Failure to make payment for City utilities (water, sewer, garbage, landfill, and storm drain) on or before the due date each month shall result in the imposition of a 5% penalty fee.

V. POLICIES

A. The City Public Works Director may adopt policies, consistent with this resolution, or the waterworks ordinance, and any other resolutions passed by City Council, to assist in the application, administration and interpretation of this resolution, the waterworks ordinance, and any other resolution related to the water utility.

B. If any section, sentence, clause or phrase of this resolution is held to be invalid or unconstitutional by a court of competent jurisdiction, such invalidity or unconstitutionality shall not affect the validity or constitutionality of any other section, sentence, clause or phrase of this resolution.

C. All resolutions or policies in conflict herewith are hereby repealed.

This resolution is considered with full knowledge of any and all disclosures as required by the laws of the State of Utah concerning any actual or potential conflicts of interest.

This resolution, assigned No. 05-0126 shall take effect on the 1st day of February, 2005.

This resolution was made, voted and passed by the Cedar City Council at its regular meeting on the 26th day of January, 2005, by the following vote of its members:

AYES: ______________

NAYS: ______________

ABSTAINED: ______________

DATED this ___________ day of _______________, 2005.

____
GERALD R. SHERRATT, MAYOR

[Corporate Seal]

ATTEST:

____
BONNIE MORITZ, CITY RECORDER

EXHIBIT 1

LARGE IRRIGATION USERS

LANDSCAPE WATER USE ALLOCATION

Month	Landscape Irrigation Allowance (inches)	Landscape Irrigation Allowance (gallons/acre)
January	0	0
February	0	0
March	2.03	55,000
April	3.69	100,000
May	6.01	163,000
June	8.13	221,000
July	8.11	220,000
August	6.54	178,000
September	5.33	145,000
October	3.69	100,000
November	1.84	50,000
December	0	0

STEADY AND DYNAMIC CALIBRATION

STEADY-STATE CALIBRATION FIELD TEST DATA AND RESULTS

This appendix presents the steady-state calibration field test data and model results. The Calibration Testing Plan Memorandum shows the location of each test, with the exception of Test 5 – 8 which were moved to nearby hydrants. Table D – 1 shows a comparison of the field test data to the model results.

Table D – 1. Steady State Calibration Results

Test	Day of Test	Time	Model Results		Field Results		Difference (1)	
			Static Pressure (psi)	Residual Pressure (psi)	Static Pressure (psi)	Residual Pressure (psi)	Static Pressure (psi)	Residual Pressure (psi)
HT1	2/7/2008	14:15	100	80	99	79	1	1
HT2	2/7/2008	13:46	147	104	146	102	1	2
HT3	2/7/2008	13:22	110	85	110	92	0	-7
HT4	2/7/2008	15:00	119	69	108	69	11	0
HT5	2/7/2008	15:23	153	24	154	117	-1	-93
HT6	2/8/2008	10:33	99	50	102	55	-3	-5
HT7	2/8/2008	9:40	76	61	75	63	1	-2
HT8	2/8/2008	10:08	111	8	111	55	0	-47

(1) Difference between model results and field test pressures minus an additional 1 psi to account for height of the hydrant nozzle.

Table D – 2. Steady State Calibration Assumptions and Findings

Test	Comment/Notes
HT1	Test worked well.
HT2	Appears to be a closed valve in this area. Most likely on North Cedar Rd. between 1425 N. and 1600 N. It could also be between 1225 N. and 1325 N. or on 1325 N. between 625 W. and Northfield Rd.
HT3	Used old model diameter for the pipe from the North Tank.
HT4	There is new development in this area which was not included in the demand allocation.
HT5	Appears to be an additional pipe from the East portion of this zone or a PRV from the upper pressure zone serving this area.
HT6	Appears to be a closed valve in this area. Most likely on 400 S. between 450 W. and 350 W.
HT7	Closed inflow to Redmen Tank. Opening it to allow 500 gpm inflow only makes a 1 psi difference.
HT8	Appears to be a pipe diameter issue in this area.

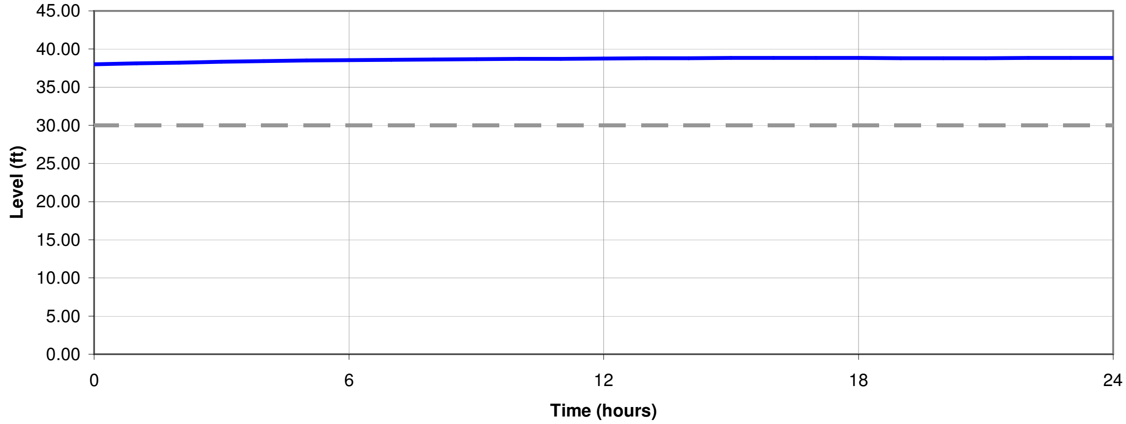
DYNAMIC CALIBRATION RESULTS

The dyanamic calibration results include graphs comparing the model results to SCADA data for the 24 hour periods on July 8, 2008. Graphs are presented in the subsequent pages.

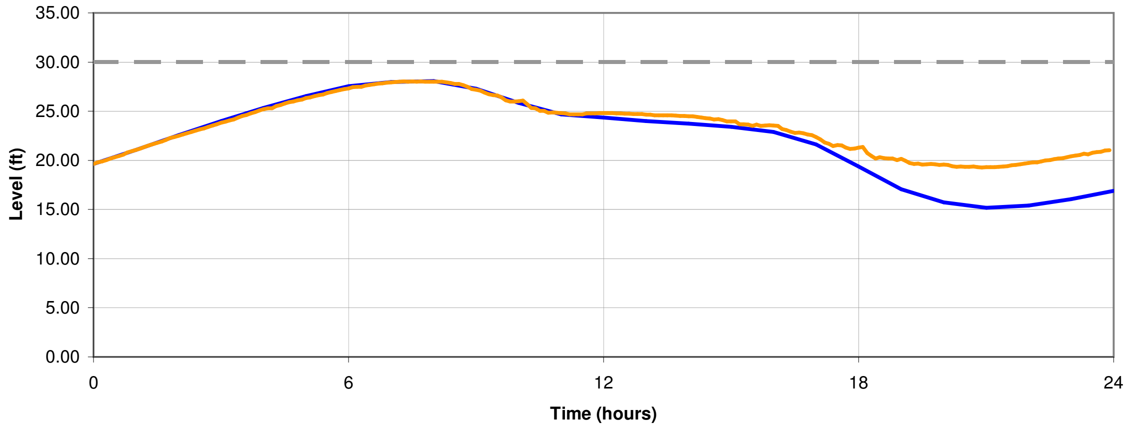
Calibration Results - Test

Model Results
SCADA Data

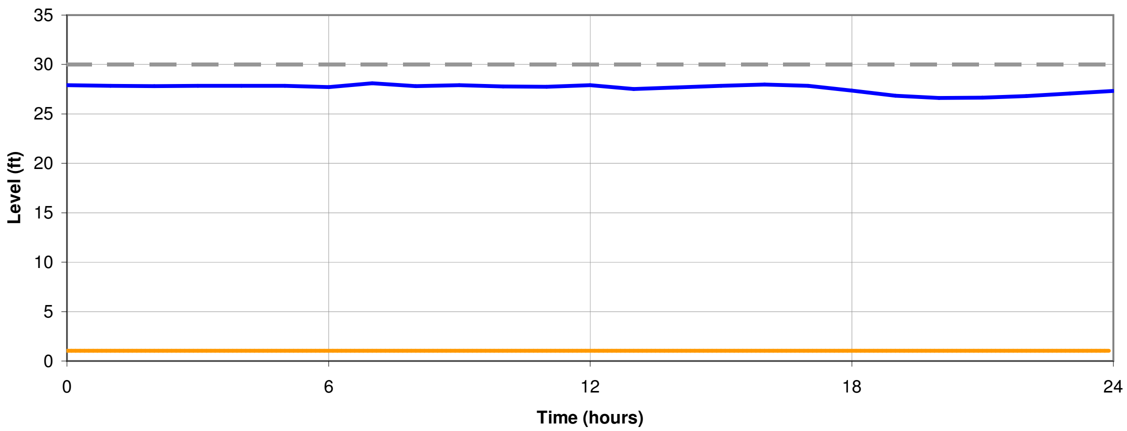
Reservoir 3200 North Tank
Model ID: TNK-3200NORTH (ft)
TANK LEVELS



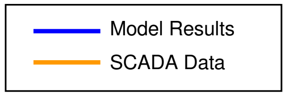
Reservoir North Tank
Model ID: TNK-NORTH (ft)
TANK LEVELS



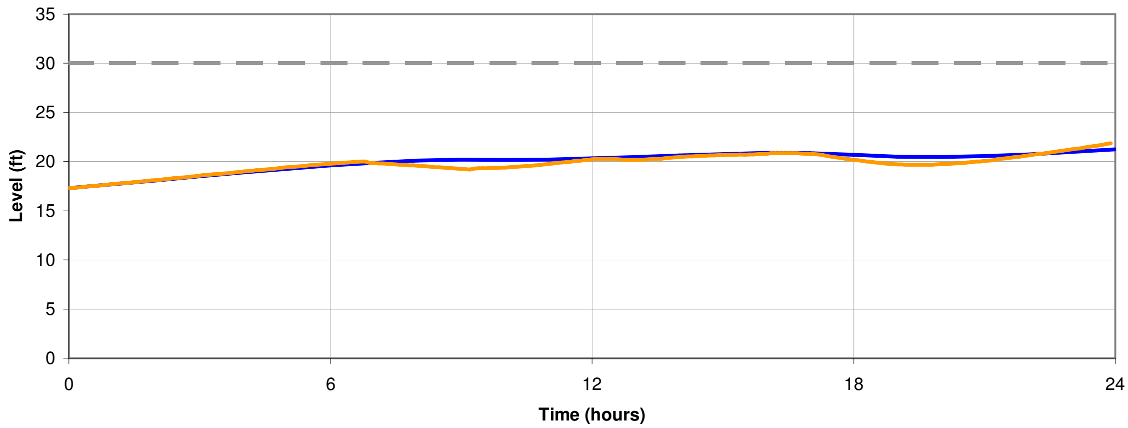
Reservoir Cedar Canyon Tank
Model ID: TNK-CEDARCANYON (ft)
TANK LEVELS



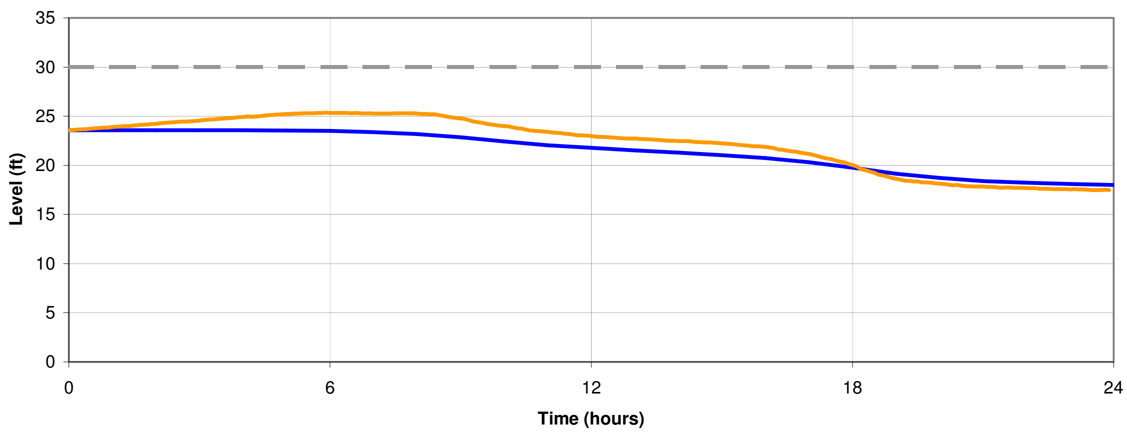
Calibration Results - Test



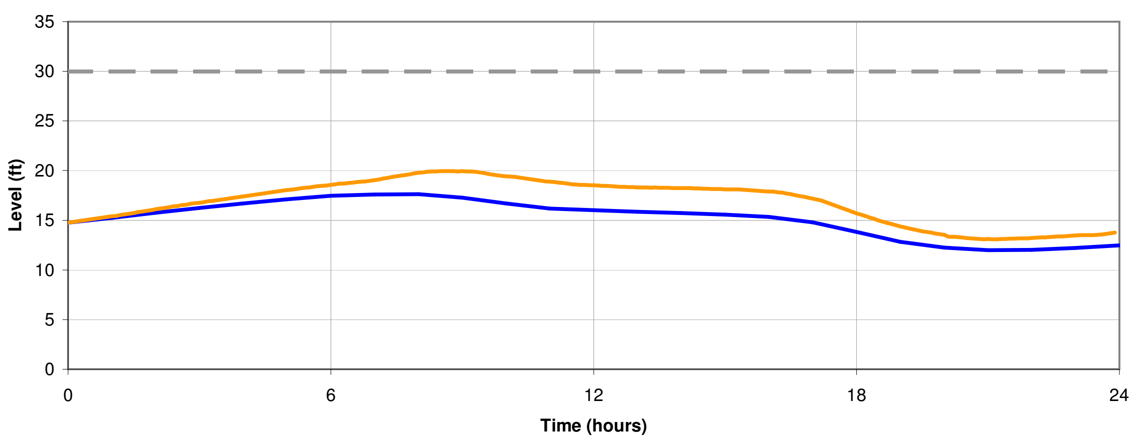
Reservoir Square Mountain Tank
Model ID: TNK-SUAREMTN (ft)
TANK LEVELS



Reservoir Fiddlers Tank
Model ID: TNK-FIDDLERS (ft)
TANK LEVELS



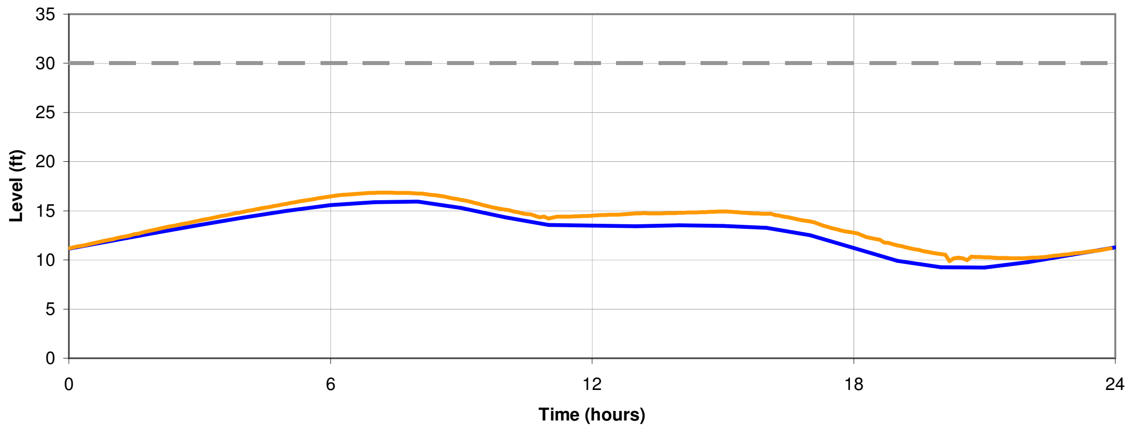
Reservoir Cross Hollow Tank
Model ID: TNK-CROSSHOLLOW (ft)
TANK LEVELS



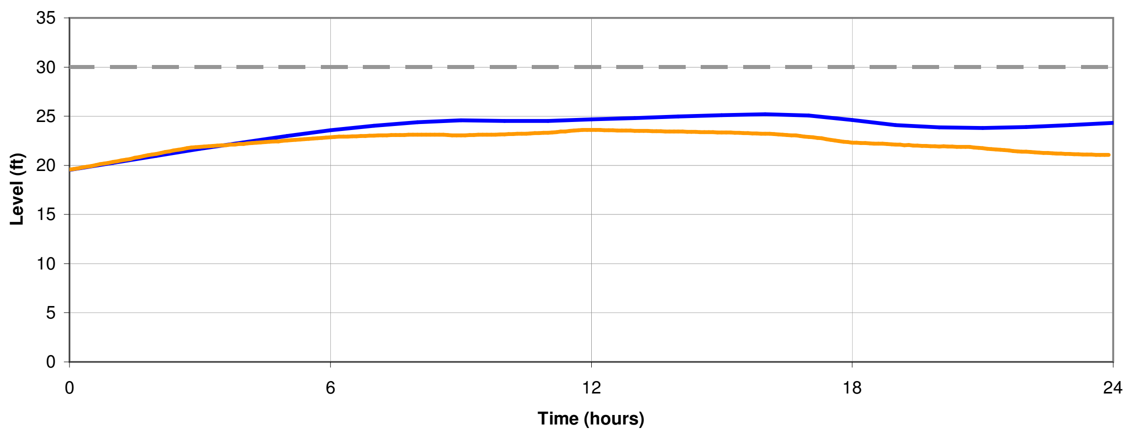
Calibration Results - Test

Model Results
SCADA Data

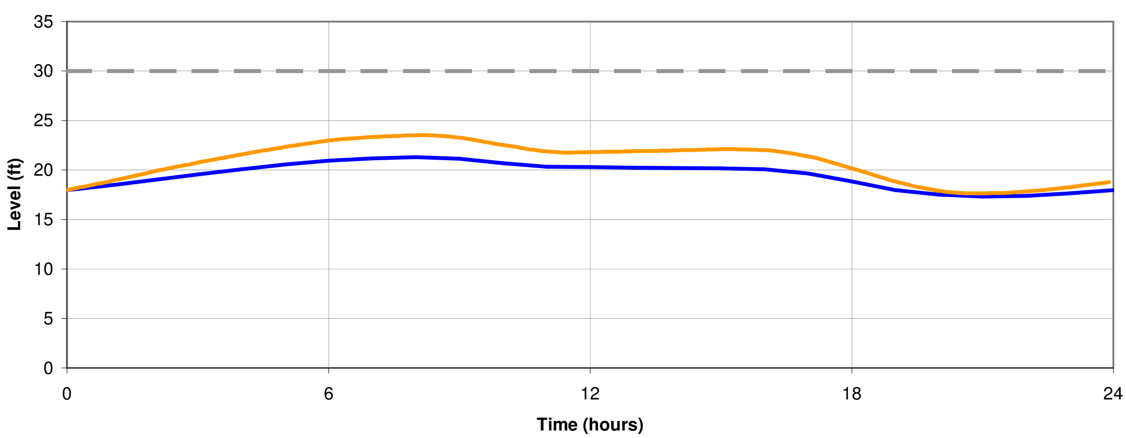
Reservoir Squaw Cave Tank
Model ID: TNK-SQUAWCAVE (ft)
TANK LEVELS



Reservoir South Steel Tank
Model ID: TNK-SOUTHSTEEL (ft)
TANK LEVELS



Reservoir Redmen Tank
Model ID: TNK-REDMEN (ft)
TANK LEVELS



EVALUATION CRITERIA

1. INTRODUCTION

This technical memorandum (TM) describes the criteria to be used in evaluating the water and secondary irrigation systems. This TM also discusses the design criteria to be used in the design of new facilities for the Capital Improvements Plan.

2. EVALUATION CRITERIA

Table 2-1 and 2-2 summarizes the evaluation criteria associated with the water and secondary irrigation systems. The model will be evaluated using the Maximum Day Demand (MDD) scenario according to the evaluation criteria listed in the table. Facilities that do not meet the criteria will be identified as deficiencies. Recommended values shown in parenthesis were derived from Brown and Caldwell's past experiences.

Table 2-1. Water System Evaluation Criteria

Criteria	Value	Reference
Distribution System Pressure (psi)		
Maximum		
Static	(110)	
Minimum		
MDD	45	
Fire Flow Demand	20	
Peak Instant Demand	30	
System Velocity (fps)		
Maximum – MDD	10	
Fire Flows (gpm)		
Site specific, no less than 1500 gpm	1500	
Pumping Capacity	Average of Maximum Day Demand with largest pump out of service.	1
Storage Capacity	Sum of indoor, outdoor water use and fire demand.	Utah Rules for Public Water Drinking Systems
Supply	At a minimum, average of Maximum Day Demand	1
Minimum Pipe Diameter for providing fire protection	6 – inch	Utah Rules for Public Water Drinking Systems

Table 2-2. Secondary Irrigation System Evaluation Criteria

Criteria	Value	Reference
Distribution System Pressure (psi)		
Maximum	(120)	
Minimum	(45)	
System Velocity (fps)		
Maximum – MDD	(7)	
Storage Capacity (gal/acre)	2528	
Supply (gpm/acre)	3.39	

Service Connection size (inch)		
Less than ¾ acre parcel	(1)	
¾ to 1 – ½ acre parcel	(1 – ¼)	
Greater than 1 – ½ acre parcel	Based on flow requirements	
Flow per Connection, Max (gpm)		Irrigation Systems Design Handbook
1 inch service	18	
1 – ¼ inch service	30	
2 inch service and larger	(Based on maximum velocity requirements)	Rainbird
Peak Connections Operating Simultaneously	50	
Irrigation Season	6 months	City
Average Annual Water Use (acre – feet/acre)	3.0	
Irrigation Period	24 hours	City
Minimum Pipe Diameter (inch)	(4)	

3. DESIGN CRITERIA

Recommendations will be created to fix the deficiencies noted during the model evaluation. Recommended improvements and facilities to serve future areas will be sized based on the design criteria listed in **Tables 3-1 and 3-2**.

Table 3-1. Water System Design Criteria

Criteria	Description	Reference
Minimum Pipe Size (inch)	6	Utah Rules for Drinking Water Systems
Peak MDD Velocity (fps)	8	1
Maximum and Minimum Pressures (psi)	Same as evaluation criteria, Table 2-1	1
Pumping Capacity	Same as evaluation criteria, Table 2-1	1
Storage	Same as evaluation criteria, Table 2-1	1
Supply	Same as evaluation criteria, Table 2-1	1

Table 3-2. Secondary Irrigation System Design Criteria

Criteria	Description	Reference
Minimum Pipe Size (inch)	4	
Peak MDD Velocity (fps)	5	1
Maximum and Minimum Pressures (psi)	Same as evaluation criteria, Table 2-2	1
Pumping Capacity	Same as evaluation criteria, Table 2-2	1

Storage	Same as evaluation criteria, Table 2-2	1
Supply	Same as evaluation criteria, Table 2-2	1

REFERENCES

1. AWWA, *Computer Modeling of Water Distribution Systems*, M32, Second Edition, 2005, American Water Works Association, pp. 23.

BUSINESS CASE EVALUATION

BUSINESS CASE EVALUATION OF 16" QUICHAPA TRANSMISSION PIPE

In the worst case scenario, the transmission pipe will break under Quichapa Lake. If there is a small break a diver could go down and repair with a clamp. If the clamp is available the repair would take approximately 8 hours. The service will not be available for another week due to water quality testing.

But how would you notice a small leak beneath the lake? A bigger break that cannot be repaired with a clamp would be more noticeable. Assuming that there is a big break there would be evident of water loss, thus the section of pipe under the lake will have to be replaced. A 16" polyethylene pipe will be paralleled to the worst segment pipe and tied into the system. The system will be out of service to 3 weeks for the installation of pipe.

Table F – 1 represents the alternatives evaluated for the transmission line. Alternative 1, "Do Nothing" alternative does not have a capital cost but has a risk cost associated with it. The risk cost associated with the alternative assumes a probability of consequence or probability of pipe failure of 0.4 within the next year. The probability of pipe failure of 0.4 was assumed due to the installation of the pipe approximately 40 years ago. The 30-year Net Present Value (NPV) indicates the risk cost associated with failure which includes water revenue loss, pipe replacement cost of worst section and repair cost of section break.

Alternative 2 and 3 indicate cathodic protection for the worst and entire sections of the pipe and each alternative has risks associated with pipe failure. Alternative 4 and 5 indicate replacements of the transmission pipe for the entire or worst segment. Alternatives 6 and 7 suggest a replacement of the entire or worst segment and route south of Quichapa Lake. Alternative 8 suggest a tank and pump station installation near Quichapa Wells 5, 6 and 7 where Quichapa Wells 1, 3, 5, 6 and 7 will pump to and have water transmitted into the system thereafter. Finally Alternative 9 suggest a connection to Central Iron County Water Conservancy District's (CICWCD) water system when failure does occur.

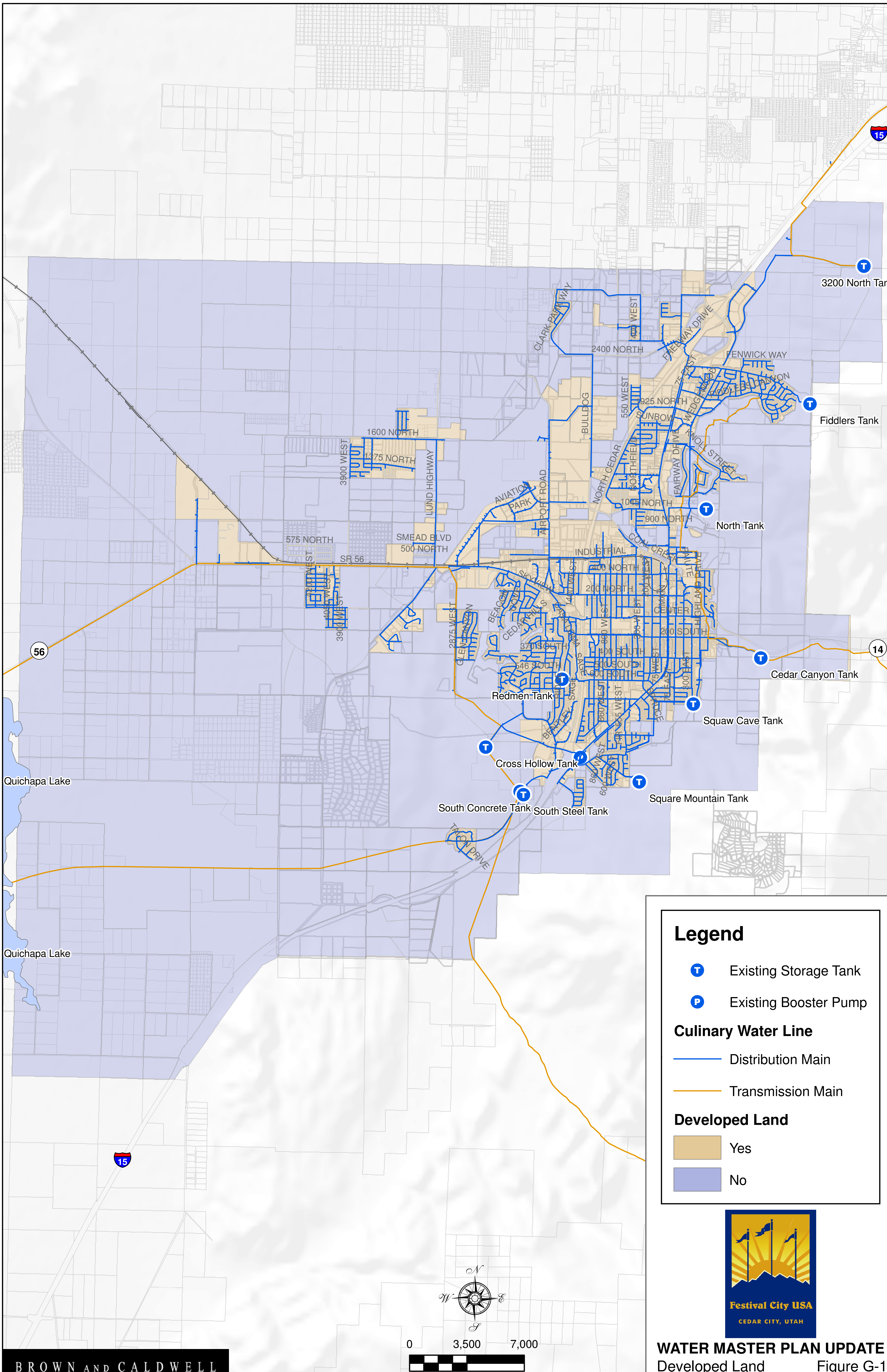
Alternatives 2 thru 9 have risks cost associated with them but only for the duration of the project to be installed or replaced. Probability of pipe failure was assumed to be 0.4, similar to Alternative 1. After installation of the project, the risk cost will have been eliminated. The remaining cost is the capital cost of projects.

Based on the 30-year NPV, Alternative 3, cathodic protection of the entire pipe is recommended over Alternative 1 and Alternative 2. Alternative 2 does have the lowest 30-year NPV but it still has a higher risk cost than Alternative 3. Therefore, Brown and Caldwell's recommendation based on the BCE concurs with the corrosion study done by Corrosion Control Technologies, Inc. prepared November 2007.

Table F – 1. Business Case Evaluation Alternative Comparison

Alternative	Description	Capital Cost	30-year NPV
1	Do Nothing		($227,500)
2	Cathodic Protection - Worst Segment	$50,000	($95,200)
3	Cathodic Protection - Entire Segment	$100,000	($98,200)
4	South Quichapa Transmission Pipe - Entire Segment Replacement	$2,393,000	($2,348,000)
5	South Quichapa Transmission Pipe - Worst Segment Replacement	$1,775,450	($1,742,000)
6	South Quichapa Transmission - Replace entire segment and reroute south of Lake Quichapa	$13,660,930	($13,403,200)
7	South Quichapa Transmission - Replace worst segment and reroute south of Lake Quichapa	$11,103,390	($10,984,000)
8	Install 0.5 MG Quichapa storage tank and booster pumps for Quichapa Wells 1, 3, 5, 6, & 7	$10,309,750	($10,207,500)
9	Connect to CICWCD system	$1,903,180	($1,867,300)

DEVELOPED LAND MAP



WATER MASTER PLAN UPDATE

Developed Land Figure G-1

DEMAND ALLOCATION

ALLOCATION OF DEMANDS PER LAND USE CATEGORY

This appendix presents the allocation of unit water use rates per land use. Unit water use rates were determined from existing land use. Demands (gpm) in each land use were divided by land use areas (acres) for average annual and maximum day demands. Table H – 1 represents existing land use unit water use rates.

Table H – 1. Existing Demand Allocation per Land Category

Existing Land Use	ADD Use/Area (gpm/acre)	MDD Use/Area (gpm/acre)
Agriculture		
Central Commercial	0.871	1.109
Downtown Commercial	0.951	1.211
General Commercial	0.588	0.749
High Density Residential	3.029	3.856
Highway Service	3.559	4.531
Industrial & Manufacturing - 1	0.042	0.053
Industrial & Manufacturing - 2	0.001	0.002
Industrial & Manufacturing - 3		
Low Density Residential	3.091	3.936
Medium Density Residential	1.775	2.260
Neighborhood Commercial		
Parks / Golf Courses	0.105	0.133
Public Uses	1.355	1.725
Residential Estates		
Residential Planned Area (4 D.U. / Acre)	0.811	1.033
Residential Planned Area (6 D.U. / Acre)	1.398	1.781

Allocation for future land use is presented in Table H – 2. Land use descriptions from existing and future land use allowed a direct link to assign unit water use rates per area for the future model.

Table H – 2. Future Demand Allocation per Land Category

Proposed Land Use	ADD Use/Area (gpm/acre)	MDD Use/Area (gpm/acre)
Business/Manufacturing	0.588	0.749
Corporate Office/Research Campus	0.042	0.053
Downtown Retail	0.951	1.211
Industrial	0.042	0.053
MFR	3.029	3.856
Mixed Use	0.588	0.749
Municipal/School/Campus	1.355	1.725
Neighborhood/General Commercial	0.588	0.749
Open Space - Developed		-

Open Space - Natural		-
Planned Community Development	1.105	1.407
Regional Commercial	3.559	4.531
Rural Estate - High	0.887	1.130
Rural Estate - Low	0.966	1.230
SFR - High	3.029	3.856
SFR - Med.	1.775	2.260
SFR - Low	3.091	3.936
Sand, Gravel and Mineral Extraction	0.042	0.053

Table H – 3 represents additional demand allocated to the future model. Non-developed lands and unit water use rates per area were calculated to allocate 53,665 gallons per minute of additional demands.

Table H – 3. Future Max Day Demand per Land Category

Proposed Land Use	Area (acres)	MDD (gpm)
Business/Manufacturing	1,270	951
Corporate Office/Research Campus	167	9
Downtown Retail		
Industrial	1,905	102
MFR	322	1,241
Mixed Use		
Municipal/School/Campus	895	1,543
Neighborhood/General Commercial	419	314
Open Space - Developed	322	
Open Space - Natural	5374	
Planned Community Development	6,405	9,010
Regional Commercial	746	3,380
Rural Estate - High	6,062	6,849
Rural Estate - Low	8,940	10,995
SFR - High	298	1,150
SFR - Med.	2,517	5,688
SFR - Low	3,158	12,429
Sand, Gravel and Mineral Extraction	83	4
Total	38,883	53,665

WASTEWATER REUSE

REUSE FACILTY COSTS

	1 MGD Reuse Facility		2 MGD Reuse Facility		3 MGD Reuse Facility		4 MGD Reuse Facility		5 MGD Reuse Facility	
	Low	High	Low	High	Low	High	Low	High	Low	High
Scalping System Capital Cost, $K[1]	7,990	9,850	15,212	18,654	21,666	26,412	27,352	33,124	32,270	38,790
Misc. Conveyance & ASF Facilities Capital Cost, $K[2]	1,998	2,463	3,803	4,664	5,417	6,603	6,838	8,281	8,068	9,698
Total Estimated Capital Cost, $K	9,988	12,313	19,015	23,318	27,083	33,015	34,190	41,405	40,338	48,488
Present Value of O & M Costs, $K[3]	3,351	4,642	6,257	8,566	9,162	12,490	12,067	16,414	14,973	20,338
Total Present Value of Scalping System, $K	13,339	16,955	25,272	31,884	36,244	45,505	46,257	57,819	55,310	68,825
Estimated O & M Costs, $K/yr[1]	218	302	407	557	596	813	785	1,068	974	1,323
Amortized Capital Cost, $K/yr[4]	520	641	990	1,213	1,409	1,718	1,779	2,155	2,099	2,523
Misc. Conveyance & ASR Facilities, $K/yr[5]	130	160	247	303	352	430	445	539	525	631
Annualized Capital and O & M Cost, $K/yr	868	1,103	1,644	2,074	2,358	2,960	3,009	3,761	3,598	4,477
Annualized Cost, $ / 1000 gal[3,4]	$2.38	$3.02	$2.25	$2.84	$2.15	$2.70	$2.06	$2.58	$1.97	$2.45
Annualized Cost, $ / acre-ft[3,4]	$775	$985	$734	$926	$702	$881	$672	$839	$642	$799

1 - Based on paper, "Cost Trends of MBR System for Municipal Wastewater Treatment", James Decarolis, et. Al. (2007), Proceedings WEFTEC.07
2 - Assumed to be 25% of the Capital Cost
3 - Based on Annual Estimeated O & M Cost using a 30 year project life and 5% interest rate
4 - Based on Scalping System Capital Cost over 30 years with a 5% interest rate
5 - Assumed to be 25% of the Amortized Capital Cost
6 - Assumed that reuse facility treats full capaity year round
7 - Cost does not consider off-set cost for smaller amount of water treated at Cedar WWTP

DETAILED COST ESTIMATE

APPENDIX J

Culinar Water Distribution System Cost Estimate

Short-Term Projects

Project	Description	Quantity	Unit	Diameter (in)	Material	Installed Cost ($/lf)	Cost	Total Estimated Cost
S1	Install 20" Piping from Distribution Piping to Pumps	25	FT	20	DI	$ 272	$ 6,731	**$ 1,787,000**
	Install 20" Piping from Pumps to Transmission Pipe	408	FT	20	DI	$ 272	$ 110,824	
	Install 12" Piping from Pump to Distribution Pipe	84	FT	12	DI	$ 180	$ 15,073	
	Install Fiddlers, North and Square Mountain Tank Booster Pumps	3	EA	-	-	$ 1,654,560	$ 1,654,560	
S2	Install 8" along Knoll Street for looping	1,063	FT	8	DI	$ 136	$ 144,313	**$ 144,000**
S3	Replace 10" Cedar Canyon Tank Distribution Piping	3,421	FT	16	DI	$ 230	$ 786,892	**$ 1,379,000**
	Replace 6" Cedar Canyon Tank Distribution Piping	4,361	FT	12	DI	$ 131	$ 570,718	
	Replace Altitude Valve for Cedar Canyon Tank	1	EA	-	-	$ 21,500	$ 21,500	
S4	Install 8" along 995 South and 895 South	1,298	FT	8	DI	$ 89	$ 115,127	**$ 115,000**
S5	Install 8" along College Avenue for looping	1,363	FT	8	DI	$ 136	$ 185,051	**$ 185,000**
S6	Install 8" along Coal Creek Road	2,373	FT	8	DI	$ 136	$ 322,260	**$ 388,000**
	Install 8" along 685 North	119	FT	8	DI	$ 136	$ 16,224	
	Install 8" for looping along 100, 200 and 300 West	365	FT	8	DI	$ 136	$ 49,515	
S7	Install 8" along 30 North for looping	1,122	FT	8	DI	$ 136	$ 152,346	**$ 152,000**
S8	Install 8" along Bulldog Road for looping	1,793	FT	8	DI	$ 136	$ 243,448	**$ 243,000**
S9	Install 12" for Distribution/Transmission for Square Mountain Line	1,592	FT	12	DI	$ 180	$ 286,054	**$ 286,000**
S10	Install 8" along 860 West and Fir Street for looping	558	FT	8	DI	$ 136	$ 75,781	**$ 76,000**
S11	Install 8" along 1600 North for looping	415	FT	8	DI	$ 136	$ 56,326	**$ 56,000**
S12	Install 18" Piping for Smead fire flow capacity	3,656	FT	18	DI	$ 250	$ 914,932	**$ 915,000**
Total Cost								***$ 5,726,000***

Includes contingency, engineering and administration costs.

Culinary Water Distribution System Cost Estimate

Long-Term Projects

APPENDIX J

Project	Description	Quantity	Unit	Diameter (in)	Pipe Material	Installed Unit Cost ($/lf)	Cost	Total Estimated Cost
L1	Install 2.2 MG Ashdown Tank	1	EA				$ 2,200,000	**$ 3,449,000**
	Install 12" Ashdown Tank Transmission Piping	1,288	FT	12	DI	$ 131	$ 168,514	
	Install Ashdown Tank Booster Pumps	2	EA		PUMPS		$ 1,080,000	
L2	Install 4.1 MG 800 South Tank	1	EA				$ 4,100,000	**$ 13,058,000**
	Install 24" 800 South Tank Transmission Line	14,924	FT	20	DI	$ 220	$ 3,287,173	
	Install 20" 800 South Tank Transmission Line	1,315	FT	20	DI	$ 220	$ 289,596	
	Install 20" 800 South Tank Distribution Piping	4,136	FT	20	DI	$ 220	$ 910,993	
	Instal 24" Cross Hollow Transmission Line	1,294	FT	24	DI	$ 267	$ 345,381	
	Replace 12" along Hidden Hills Drive	558	FT	16	DI	$ 230	$ 128,245	
	Replace 12" along Hidden Hills Drive	896	FT	20	DI	$ 272	$ 243,646	
	Install Cross Hollow Tank Booster Pumps				PUMPS		$ 3,752,280	
L3	Install 4.2 MG Proposed Zone 7 Storage Tank (North)		EA		TANK		$ 4,200,000	**$ 8,960,000**
	Install 20" 3200 Proposed Zone 7 Storage Tank (North) Transmission Piping	4,372	FT	20	DI	$ 220	$ 962,941	
	Install 20" 3200 Proposed Zone 7 Storage Tank (North) Distribution Piping	17,236	FT	20	DI	$ 220	$ 3,796,379	
L4	Install 6.9 MG Proposed Zone 8 Storage Tank (North)		EA		TANK		$ 6,900,000	**$ 7,677,000**
	Install 16" Proposed Zone 8 Storage Tank (North) Distribution Piping	4,523	FT	16	DI	$ 172	$ 776,226	
L5	Install 8.6 MG Proposed Zone 8 Storage Tank (Central)		EA		TANK		$ 8,600,000	**$ 16,357,000**
	Install 800 South Booster Pumps	2	EA		PUMPS		$ 1,854,000	
	Install 30" Transmission Piping	6,082	FT	30	DI	$ 298	$ 1,812,098	
	Install 20" Transmission Piping	2,878	FT	20	DI	$ 220	$ 633,884	
	Install 20" Zone 8 Distribution Piping	821	FT	20	DI	$ 220	$ 180,750	
	Install Zone 8 Booster Pumps at Proposed Zone 8 Storage Tank (Central)	2	EA		PUMPS		$ 3,276,000	
L6	Install 3.4 MG Proposed Zone 3 Storage Tank (South)		EA		TANK		$ 3,400,000	**$ 5,148,000**
	Install 16" Proposed Zone 3 Storage Tank (South) Transmission Piping from Quichapa We	4,480	FT	16	DI	$ 172	$ 768,824	
	Install 16" Proposed Zone 3 Storage Tank (South) Distribution Pipng	5,703	FT	16	DI	$ 172	$ 978,703	
L7	Install 2.9 MG Proposed Zone 7 Storage Tank (South)		EA		TANK		$ 2,900,000	**$ 3,898,000**
	Install 16" Proposed Zone 7 Storage Tank (South) Transmission Piping from 2 New Wells	1,115	FT	12	DI	$ 131	$ 145,968	
	Install 16" Zone 7 Distribution Piping from Proposed Zone 7 Storage Tank (South)	4,960	FT	16	DI	$ 172	$ 851,194	
L8	Install 6.2 MG Proposed Zone 8 Storage Tank (South)		EA		TANK		$ 6,200,000	**$ 9,550,000**
	Install 20" Proposed Zone 8 Storage Tank (South) Transmission Piping	2,493	FT	20	DI	$ 220	$ 549,037	
	Install 30" Proposed Zone 8 Storage Tank (South) Distribution Piping	5,086	FT	30	DI	$ 298	$ 1,515,225	
	Install 24" Proposed Zone 8 Storage Tank (South) Distribution Piping	2,757	FT	24	DI	$ 267	$ 736,111	
	Install 16" Proposed Zone 8 Storage Tank (South) Distribution Piping	3,197	FT	16	DI	$ 172	$ 548,704	
L9	Install Zone 3 Distribution Piping	36,359	FT	12	DI	$ 131	$ 4,758,234	**$ 5,419,000**
		3,848	FT	16	DI	$ 172	$ 660,436	
L10	Install Zone 4 Distribution Piping	21,664	FT	12	DI	$ 131	$ 2,835,074	**$ 2,836,000**
L11	Install Zone 5 Distribution Piping	7,182	FT	12	DI	$ 131	$ 939,902	**$ 1,390,000**
		2,620	FT	16	DI	$ 172	$ 449,659	
L12	Install Zone 6 Distribution Piping	10,206	FT	12	Di	$ 131	$ 1,335,575	**$ 1,336,000**
L13	Install Zone 7 Distribution Piping	4,589	FT	8	DI	$ 89	$ 407,012	**$ 21,937,000**
		119,286	FT	12	DI	$ 131	$ 15,610,603	
		14,460	FT	16	DI	$ 172	$ 2,481,536	
		11,543	FT	20	DI	$ 220	$ 2,542,426	
		1,607	FT	24	DI	$ 267	$ 429,008	
		2,433	FT	18	DI	$ 191	$ 465,753	
L14	Install Zone 8 Distribution Piping	57,245	FT	12	DI	$ 131	$ 7,491,572	**$ 28,953,000**
		67,249	FT	16	DI	$ 172	$ 11,540,596	
		26,774	FT	20	DI	$ 220	$ 5,897,162	
		8,832	FT	24	DI	$ 267	$ 2,358,269	
		5,587	FT	30	DI	$ 298	$ 1,664,460	
Total Cost								***$ 129,968,000***

Includes contingency, engineering and administration costs.

Culinary Water Distribution System Cost Estimate

Replacement Pipe

Project	Project Name	Description	Quantity	Unit	Diameter (in)	Pipe Material	Installed Cost ($/lf)	Cost	Total Estimated Cost
1	100 East Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to Center Street	3,049	FT	8	DI	$ 136	$ 414,037	$ 414,037
2	100 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 200 North to Coal Creek	1,921	FT	8	DI	$ 136	$ 260,847	$ 576,711
		Replace 4" DI Pipe with 8" DI Pipe from 400 South to Center Street	2,326	FT	8	DI	$ 136	$ 315,865	
3	1000 North Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from East of 400 West	313	FT	8	DI	$ 136	$ 42,545	$ 42,545
4	1000 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Harding to 200 North	643	FT	8	DI	$ 136	$ 87,369	$ 87,369
5	1050 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Center Street to 200 North	1,352	FT	8	DI	$ 136	$ 183,597	$ 183,597
6	1150 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Center Street to 200 North	1,350	FT	8	DI	$ 136	$ 183,408	$ 183,408
7	1225 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Harding Avenue to 200 North	619	FT	8	DI	$ 136	$ 84,082	$ 84,082
8	1400 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 200 North to 400 North	1,158	FT	8	DI	$ 136	$ 157,310	$ 157,310
9	150 East Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Monterey Drive to 400 South	620	FT	8	DI	$ 136	$ 84,216	$ 84,216
10	150 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 535 South to 400 South	938	FT	8	DI	$ 136	$ 127,394	$ 127,394
11	1500 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 200 North to 400 North	1,215	FT	8	DI	$ 136	$ 164,978	$ 164,978
12	165 South Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 1650 West to East of South Ridge Road	412	FT	8	DI	$ 136	$ 55,935	$ 55,935
13	200 East Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to 200 South	1,281	FT	8	DI	$ 136	$ 173,933	$ 464,043
		Replace 4" DI Pipe with 8" DI Pipe from College Ave. to 275 North	2,136	FT	8	DI	$ 136	$ 290,110	
14	200 South Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Under I-15	735	FT	8	DI	$ 136	$ 99,857	$ 99,857
15	200 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to Coal Creek	5,964	FT	8	DI	$ 136	$ 810,020	$ 810,020
16	225 East Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Monterey to 400 South	526	FT	8	DI	$ 136	$ 71,417	$ 71,417
17	275 North Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Bulloch Place to Highland Drive	328	FT	8	DI	$ 136	$ 44,550	$ 44,550
18	300 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Center Street to 400 North	2,417	FT	8	DI	$ 136	$ 328,228	$ 607,781
		Replace 4" DI Pipe with 8" DI Pipe from North of 535 South to North of 200 South	2,058	FT	8	DI	$ 136	$ 279,553	
19	400 East Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to 200 South	1,326	FT	8	DI	$ 136	$ 180,132	$ 180,132
20	400 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Intersection of Harding and 400 West	9	FT	8	DI	$ 136	$ 1,268	$ 401,294
		Replace 4" DI Pipe with 8" DI Pipe from Harding Avenue to Industrial Road	2,945	FT	8	DI	$ 136	$ 400,027	
21	450 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 600 South to 400 South	1,400	FT	8	DI	$ 136	$ 190,170	$ 190,170
22	475 South Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Main Street to 800 South	560	FT	8	DI	$ 136	$ 76,103	$ 76,103
23	500 West Replacement & Installation Pipe	Install 8" DI Pipe from 300 South to 200 South	579	FT	8	DI	$ 136	$ 78,699	$ 278,474
		Replace 4" DI Pipe with 8" DI Pipe from 400 South to 300 South	833	FT	8	DI	$ 136	$ 113,156	
		Replace 4" DI Pipe with 8" DI Pipe from Harding Avenue to 200 North	638	FT	8	DI	$ 136	$ 86,618	
24	555 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Main Street to 800 South	810	FT	8	DI	$ 136	$ 110,029	$ 110,029
25	560 North and 1700 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Airport Road to 400 North	1,640	FT	8	DI	$ 136	$ 222,684	$ 222,684
26	580 North Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from West of Airport Road	2,369	FT	8	DI	$ 136	$ 321,710	$ 321,710
27	600 South Replacement Pipe	Replace 10" DI Pipe with 20" DI Pipe from Redman Tank to I-15	1,064	FT	20	DI	$ 272	$ 289,250	$ 289,250
		Replace 10" DI Pipe with 20" DI Pipe from I-15 to 1175 West	366	FT	20	DI	$ 272	$ 99,424	$ 99,424
		Replace 10" DI Pipe with 18" DI Pipe from 1175 West to 1100 West	298	FT	18	DI	$ 250	$ 74,646	$ 74,646
		Replace 10" DI Pipe with 12" DI Pipe from 1100 West to St. James Place	265	FT	12	DI	$ 180	$ 47,558	$ 47,558
28	600 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Center Street to North of 400 North	2,751	FT	8	DI	$ 136	$ 373,629	$ 373,629
29	600 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from North of 400 South	657	FT	8	DI	$ 136	$ 89,274	$ 89,274
30	685 North Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from West of Main Street	179	FT	8	DI	$ 136	$ 24,247	$ 24,247
31	700 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Center Street to 400 North	1,250	FT	8	DI	$ 136	$ 169,804	$ 729,766
		Replace 4" DI Pipe with 8" DI Pipe from 600 South to 200 South	2,770	FT	8	DI	$ 136	$ 376,207	
		Replace 4" DI Pipe with 8" DI Pipe from Center Street to 400 North	1,353	FT	8	DI	$ 136	$ 183,754	
32	75 East Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from North of 670 South	404	FT	8	DI	$ 136	$ 54,857	$ 90,302
		Replace 4" DI Pipe with 8" DI Pipe from Monterey Drive to Altamira Avenue	261	FT	8	DI	$ 136	$ 35,445	
33	800 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 300 South to Industrial Road	5,190	FT	8	DI	$ 136	$ 704,807	$ 704,807
34	90 South Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from West of Columbia Way	126	FT	8	DI	$ 136	$ 17,170	$ 17,170
35	900 West Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to 200 South	1,383	FT	8	DI	$ 136	$ 187,865	$ 543,700
		Replace 4" DI Pipe with 8" DI Pipe from Center Street to 400 North	2,620	FT	8	DI	$ 136	$ 355,835	
36	940 North Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from East of 400 West	216	FT	8	DI	$ 136	$ 29,397	$ 29,397
37	970 North Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from East of 400 West	215	FT	8	DI	$ 136	$ 29,172	$ 29,172
38	Altimira St Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 75 East to 300 East	1,188	FT	8	DI	$ 136	$ 161,287	$ 161,287
39	Bulldog Road Replacement Pipe	Replace 6" DI Pipe with 12" DI Pipe from North of 1600 North	1,976	FT	12	DI	$ 180	$ 355,181	$ 355,181
40	Cedarwood Terrace Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 300 West to 300 West	1,011	FT	8	DI	$ 136	$ 137,370	$ 137,370
41	Center Street Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 300 to 400 East	547	FT	8	DI	$ 136	$ 74,331	$ 74,331

Culinary Water Distribution System Cost Estimate

Replacement Pipe

APPENDIX J

Project	Project Name	Description	Quantity	Unit	Diameter (in)	Pipe Material	Installed Cost ($/lf)	Cost	Total Construction Cost
42	Center Street Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 East to Highland Drive	804	FT	8	DI	$ 136	$ 109,164	$ 109,164
43	Circle Way Dr Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 West to 400 West	958	FT	8	DI	$ 136	$ 130,055	$ 130,055
44	Dewey Avenue Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to 200 South	1,386	FT	8	DI	$ 136	$ 188,288	$ 188,288
45	Fir Street Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 1150 South to South of Main	1,534	FT	8	DI	$ 136	$ 208,392	$ 208,392
46	Hidden Hills Drive Replacement Pipe	Replace 12" DI Pipe with 20" DI Pipe from Westview Drive to Hidden Hills Loop West	727	FT	20	DI	$ 272	$ 197,569	$ 371,892
		Replace 8" DI Pipe with 16" DI Pipe from Hidden Hills Loop West to Hidden Hills Loop East	558	FT	16	DI	$ 230	$ 128,245	
		Replace 8" DI Pipe with 20" DI Pipe from East of Hidden Hills Loop East	169	FT	20	DI	$ 272	$ 46,078	
47	Highland Circle Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from East of Highland Drive	635	FT	8	DI	$ 136	$ 86,234	$ 86,234
48	Highland Dr Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Center Street to Sunrise Avenue	3,099	FT	8	DI	$ 136	$ 420,813	$ 420,813
49	Kayenta Cir Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to 400 South	1,276	FT	8	DI	$ 136	$ 173,347	$ 173,347
50	Kitty Hawk Way Replacement Pipe	Replace 6" DI Pipe with 12" DI Pipe from Airport Road to Bulldog Road	2,222	FT	12	DI	$ 180	$ 399,379	$ 399,379
51	Main Street Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 400 South to 200 South	1,279	FT	8	DI	$ 136	$ 173,644	$ 546,349
		Replace 4" DI Pipe with 8" DI Pipe from 900 North to North of 1045 North	1,474	FT	8	DI	$ 136	$ 200,130	
		Replace 4" DI Pipe with 8" DI Pipe from Center Street to 200 North	1,271	FT	8	DI	$ 136	$ 172,575	
52	North Tank Replacement Pipe	Replace 10" DI Pipe with 14" DI Pipe from East of Knoll Street	2,299	FT	14	DI	$ 203	$ 466,788	$ 466,788
53	Parkway Dr Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from East of Highland Drive	150	FT	8	DI	$ 136	$ 20,372	$ 20,372
54	Skyline Dr Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from Highland Drive to Sunrise Avenue	714	FT	8	DI	$ 136	$ 96,936	$ 96,936
55	SR-56 Replacement Pipe	Replace 4" DI Pipe with 16" DI Pipe from Existing Parallel Pipe to Transmission Pipe	2,195	FT	16	DI	$ 230	$ 504,991	$ 504,991
56	Sunset St Replacement Pipe	Replace 4" DI Pipe with 8" DI Pipe from 670 South to Monterey Drive	879	FT	8	DI	$ 136	$ 119,326	$ 119,326
57	Wedgewood Dr Replacement Pipe	Replace 12" DI Pipe with 14" DI Pipe from Nichols Canyon Road to Knoll Street	8,231	FT	14	DI	$ 203	$ 1,671,092	$ 1,671,092

Includes contingency, engineering and administration costs.