DRINKING WATER MASTER PLAN AND CAPITAL FACILITY PLAN

(HAL Project No.: 415.02.100)

DRAFT

January 2021

SANTAQUIN CITY

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Steven C. Jones, P.E.
Project Manager

HANSEN
ALLEN
& LUCE INC
ENGINEERS

January 2021

ACKNOWLEDGEMENTS

Hansen, Allen & Luce thanks the following individuals for their contributions to this project:

Santaquin City Government

Kirk Hunsaker, Mayor
Nicholas Miller, Councilperson
Betsy Montoya, Councilperson
Lynn Mecham, Councilperson
Jennifer Bowman, Councilperson
Dave Hathaway, Councilperson

Santaquin City Staff

Benjamin Reeves, City Manager
Norm Beagley, Assistant City Manager/Engineer
Jon Lundell, City Engineer

Jason Callaway, Public Works Operations Manager
Shannon Hoffman, Admin Service Director/Treasurer
Aaron Shirley, Finance Director/Recorder

Hansen, Allen & Luce, Inc.

Steven C. Jones, P.E., Vice President, Project Manager
Richard M. Noble, Vice President
Ridley J. Griggs, Staff Engineer

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GLOSSARY OF TECHNICAL TERMS

Average Daily Flow: The average yearly demand volume expressed in a flow rate.

Average Yearly Demand: The volume of water used during an entire year.

Buildout: When the development density reaches maximum allowed by planned development.

Demand: Required water flow rate or volume.

Distribution System: The network of pipes, valves and appurtenances contained within a water system.

Drinking Water: Water of sufficient quality for human consumption. Also referred to as Culinary or Potable water.

Equivalent Residential Connection: A measure used in comparing water demand from non-residential connections to residential connections.

Fire Flow Requirements: The rate of water delivery required to extinguish a particular fire. Usually it is given in rate of flow (gallons per minute) for a specific period of time (hours).

Head: A measure of the pressure in a distribution system that is exerted by the water. Head represents the height of the free water surface (or pressure reduction valve setting) above any point in the hydraulic system.

Head loss: The amount of pressure lost in a distribution system under dynamic conditions due to the wall roughness and other physical characteristics of pipes in the system.

Peak Day: The day(s) of the year in which a maximum amount of water is used in a 24-hour period.

Peak Day Demand: The average daily flow required to meet the needs imposed on a water system during the peak day(s) of the year.

Peak Instantaneous Demand: The flow required to meet the needs imposed on a water system during maximum flow on a peak day.

Pressure Reducing Valve (PRV): A valve used to reduce excessive pressure in a water distribution system.

Pressure Zone: The area within a distribution system in which water pressure is maintained within specified limits.

Service Area: Typically, the area within the boundaries of the entity or entities that participate in the ownership, planning, design, construction, operation and maintenance of a water system.

Static Pressure: The pressure exerted by water within the pipelines and other water system appurtenances when water is not flowing through the system, i.e., during periods of little or no water use.

Storage Reservoir: A facility used to store, contain and protect water until it is needed by the customers of a water system. Also referred to as a Storage Tank.

Transmission Pipeline: A pipeline that transfers water from a source to a reservoir or from a reservoir to a distribution system.

Water Conservation: Planned management of water to prevent waste.

ABBREVIATIONS AND UNITS

ac	acre [area]
ac-ft	acre-foot (1 ac-ft = 325,851 gal) [volume]
CIP	Capital Improvement Plan
CFP	Capital Facilities Plan
CUWCD	Central Utah Water Conservancy District
CWP	Central Water Project
DIP	Ductile Iron Pipe
DBP	disinfection byproduct
EPA	U.S. Environmental Protection Agency
EPANET	EPA hydraulic network modeling software
ERC	Equivalent Residential Connection
ft	foot [length]
ft/s	feet per second [velocity]
gal	gallon [volume]
gpd	gallons per day [flow rate]
gpm	gallons per minute [flow rate]
HAL	Hansen, Allen & Luce, Inc.
hp	horsepower [power]
hr	hour [time]
IFA	Impact Fee Analysis
IFC	International Fire Code
IFFP	Impact Fee Facilities Plan
in.	inch [length]
kgal	thousand gallons [volume]
kW	kilowatt [power]
kWh	kilowatt hour [energy]
MG	million gallons [volume]
MGD	million gallons per day [flow rate]
mg/L	milligram per liter [concentration]
µg/L	microgram per liter [concentration]
mi	mile [length]
psi	pounds per square inch [pressure]
s	second [time]
SCADA	Supervisory Control and Data Acquisition
THM	trihalomethane
UV	ultraviolet radiation (disinfection method)
wsfu	water supply fixture unit
yr	year[time]

EXECUTIVE SUMMARY

PURPOSE OF STUDY

The purpose of this study is to help Santaquin City provide safe, efficient and reliable drinking water service to its customers, both now and into the future, at the lowest cost.

PLANNING HORIZONS

The ultimate planning horizon for this study is the year 2060. However, this report provides guidance applicable at various time intervals:

1. Near future: low-cost actions and best practices the City can implement to reduce costs and improve operations.
2. 10-year: system improvements needed within 10 years to provide capacity for anticipated new development. The cost of these improvements will be used to set impact fees and guide the formulation of near-term budgets.
3. 20-year: system improvements needed within 20 years for anticipated new development. These improvements are included in the capital facility plan to guide the formulation of longer-term budgets.
4. Future: all system improvements necessary to serve the City at year 2060, when it is developed at the density defined by the City's current general plan and zoning ordinances (except for remaining agricultural lands). These recommendations will help the City secure key pieces of land and work with developers to properly plan for infrastructure that is compatible with the future system.

COMPONENTS OF A WATER DISTRIBUTION SYSTEM

The following three components of a water distribution system were analyzed to determine the capacity and ability of the water system to meet existing and future water demands:

1. Source – the water used to supply the system
2. Storage – a location to store water between the time it is delivered to the system and the time it is used by a customer
3. Distribution – pipelines used to deliver water from sources or storage locations to the customer

Each of these components must have enough capacity and capability to serve existing and future customers. To ensure adequate capacity, this study proposes a level of service as a design standard for new development (as discussed in the following section).

METHODS

Water usage and water system data were used to develop a responsible level of service for each component (source, storage, distribution) of the water system. The level of service was used to evaluate the existing system, identify existing deficiencies, and develop a computer model of the existing system.

The land use element of the general plan, population projections, development concept plans, and the proposed level of service were used to forecast the magnitude and locations of future water demands in the City. Computer modeling and other tools were used to determine what infrastructure is necessary to best meet these demands.

LEVEL OF SERVICE

Level of service is the standard to which the drinking water system is designed to meet. The level of service is based on three years of historical water billing and water production data provided by the City. The level of service is based on Equivalent Residential Connections (ERCs). One ERC is defined as the average water demand of an average residence in Santaquin.

Table ES-1 shows the levels of service used for this study. Pressure requirements are expressed in units of pounds per square inch (psi). Other requirements are expressed in units of demand (gallons per minute [gpm]) or volume (gallons [gal] or acre-feet [ac-ft]) per ERC. Because some areas are irrigated by the drinking water system, a level of service for outdoor use has also been defined, using an irrigable acre (irr-ac) as a standard of measurement.

Table ES-1
Level of Service Parameters

Parameter	Proposed Level of Service - Indoor Use	Proposed Level of Service - Outdoor Use
Minimum system pressure	40 psi	40 psi
Maximum system pressure	125 psi	125 psi
Maximum daily pressure variation	20 psi	20 psi
Peak Day Demand	500 gpd/ERC	8.0 gpm/irr-ac
Average Yearly Demand	0.336 ac-ft/ERC	4.0 ac-ft/irr-ac
Storage	360 gal/ERC	9,200 gal/irr-ac

These level of service parameters were used to quantify system demand and compare it to system capacity. This allowed the project team to identify vulnerabilities in the water system and make plans for future growth.

DISTRIBUTION SYSTEM VULNERABILITIES

The system was analyzed to identify vulnerabilities in the existing system and areas which need improvements in order to support future growth. Table ES-2 contains a summary of system vulnerabilities. Further information about these vulnerabilities is described in subsequent sections.

Table ES-2
System Vulnerabilities

ID	Description	Notes
V1	**Zone 11W Source and Storage**	The Zone 11W drinking water tank and the Summit Ridge pump station are rapidly approaching capacity. There is heavy development pressure in this area, and these facilities will not have sufficient capacity after year 2021.
V2	**System Source Redundancy**	Because drinking water sources can go out of service for a variety of reasons, the drinking water system should have sufficient capacity to meet peak demands with the largest source (Summit Ridge Well) out of service. Redundant capacity is available as of this writing, but will be exhausted by year 2022.
V3	**Zone 10 Storage**	The limited amount of storage in Zone 10 makes it difficult for the City to operate the Summit Ridge Well. The resulting operational scheme used by the City leads to high electrical demand charges and spillage of spring water.
V4	**Source Water Loss**	Approximately 30 – 40% of the water Santaquin produces is ultimately non-revenue water. This is higher than average and is most likely indicative of leakage problems.
V5	**Limited Fire Flow Capacity**	Several hydrants in Santaquin cannot provide the desired 1,500 gpm of flow.
V6	**Lack of Separate PI Source**	The drinking water system supplies irrigation water to substantial portions of the pressurized irrigation system. This mode of operation puts additional stress on the drinking water distribution system and sources.

Recommended solutions to these vulnerabilities are shown in Table ES-3 and described in further detail in Chapter 7.

Table ES-3
Proposed Solutions to System Vulnerabilities

Description	Notes	Vulnerabilities Addressed
Zone 10 Western Tank (2021)	Construct an additional tank in Zone 10 (in the Summit Ridge area) to provide adequate storage for future users and help to improve the operation of the Summit Ridge Well and City pump stations. Connect the tank to the Zone 10 portion of the Summit Ridge development.	V1, V3
Zone 10 Well (2021)	Drill and equip an additional well in Zone 10 to provide continued redundant capacity.	V2
Leak Detection Study	Commission a leak detection study to reduce non-revenue water, save energy, and save money	V4
Fire flow distribution projects	Depending on available funding and City priorities, replace existing undersized pipelines to resolve fire flow deficiencies.	V5
PI Projects	Construct several projects in the PI system to provide source and storage capacity (see the Santaquin PI Master Plan for details).	V6

DISTRIBUTION SYSTEM – GENERAL RECOMMENDATIONS

The following subsections contain general recommendations for Santaquin to follow to ensure continued water service into the future.

General Source Recommendations

The following are recommended actions for Santaquin to take to ensure adequate source capacity into the future:

1. Take all actions necessary to preserve groundwater quality and supply. For the foreseeable future, groundwater will be the only drinking water supply for Santaquin City.
2. Drill new wells to support future growth and provide redundancy.

General Storage Recommendations

The following are recommended actions for Santaquin to take to ensure adequate storage capacity into the future:

1. Construct additional storage tanks to support growth.
2. Use building permit data to track remaining capacity in existing drinking water tanks.

General Distribution Recommendations

The following are recommended actions for Santaquin to take to ensure adequate distribution capacity into the future:

1. Upsize pipes to master plan size as development occurs. Master plan pipe sizes are shown on the master plan map in Appendix A.
2. Keep a record of the age of system pipes. Replace pipes which are beyond their service life or are experiencing frequent leaks. Recommendations for the service life of system components are discussed in Chapter 7.

CAPITAL FACILITY PLAN

Projects necessary to support growth over the next 20 years are identified and described in the Capital Facility Plan. Conceptual-level cost estimates were prepared for each project. Costs were classified as either (1) A project to correct an existing deficiency or maintain the system; or (2) A project attributable to new growth. This distinction is important because projects attributable to new growth are eligible to be repaid with impact fees.

Table ES-4 briefly summarizes the estimated costs of projects that the City may opt to implement (depending on available funds and City priorities). Figure 7-4 in the report shows each proposed fire flow project.

Table ES-4
Maintenance/Deficiency Projects

Project	Estimated Cost
Fire Flow Projects	$1,039,000
Leak Detection Study	$40,000
Total	**$1,079,000**

System growth will necessitate three major capital projects within the next 20 years. These projects have an estimated cost of **$10,263,000** (see Table ES-5). These costs are eligible to be paid for by impact fees.

Table ES-5
System Growth-Related Capital Projects (0 – 20 Years)

Type & Phasing Year	Map ID[1]	Recommended Project	Growth Cost
Storage, Distribution, Efficiency – **2021**	3	Construct a 2.5 MG tank in Zone 10W, a 1,500 gpm pump station to supply Zone 11W, a 16-inch diameter pipe to improve distribution capacity, and reconfigure the Summit Ridge Well to improve operations and save energy and money.[2]	$4,431,000
Source – **2021**	4	Drill an additional well to provide redundant source capacity and support growth.	$1,584,000
Storage, Distribution – **10 – 20 Years**	10	Replace the existing Zone 10 tank with a 2.5 MG tank and construct 20-inch diameter pipeline to connect it to the distribution system.[2]	$4,248,000
Total			**$10,263,000**

1. The Map ID corresponds to the project number on the Capital Facility Plan map. Refer to Figures 7-3 and 7-4.
2. Projects 3 and 10 both address a need for more storage in Pressure Zone 10. It is recommended that construction on one of these projects be scheduled for 2021; however, project 3 does not necessarily need to take precedence over Project 10. Either will meet the City's needs. See Chapter 4 for further discussion

Development will require additional distribution pipelines and booster stations to be installed or upsized throughout the 20-year capital facility planning project period. A brief summary of these costs is included in Table ES-6. These costs are also eligible to be paid by impact fees.

Table ES-6
Development-Driven Projects (0 – 20 Years)

Project	Estimated Cost
Zone 12E Foothill Village Booster Station (2021)	$600,000
Pipe Upsizing (0 – 10 Years)	$52,000
Pipe Upsizing and Installation (10 – 20 Years)	$1,821,000
Zone 11 NE Booster Station (10 – 20 Years)	$1,200,000
Total	**$3,673,000**

CONCLUSIONS

It is recommended that the City take the following actions within the next year to ensure safe, reliable, and cost-effective water service:

1. Immediately begin planning and budgeting for the projects outlined in the Capital Facility Plan.
2. Begin design work on the above-mentioned Zone 10W tank and pipeline, with intentions to construct these facilities in 2021.
3. Use the master plan to review each new development, to ensure properly sized and located infrastructure is constructed as development progresses. Doing so will eliminate the need for guesswork, help the City use its resources most efficiently, and ensure excellent performance of the drinking water system, both now and in the future.

CHAPTER 1 INTRODUCTION

PURPOSE AND SCOPE

The purpose of this master plan is to provide direction to the City of Santaquin regarding decisions that will be made now and into the future to provide an adequate drinking water system for its customers at the most reasonable cost. Recommendations are based on demand data, growth projections, standards of the Utah Division of Drinking Water (DDW), city zoning, the Santaquin City general plan, known planned developments, and standard engineering practices.

The master plan is a study of the City's drinking water system and customer water use. The following topics are addressed herein: general planning, growth projections, water rights, water loss, water rates, impact fees, source requirements, storage requirements, and distribution system requirements. Operational parameters for the City's drinking water system were reviewed, and recommendations were made to optimize the system based on stability, ease of use, and cost. Based on this study, needed capital improvements have been identified with conceptual-level cost estimates for the recommended improvements.

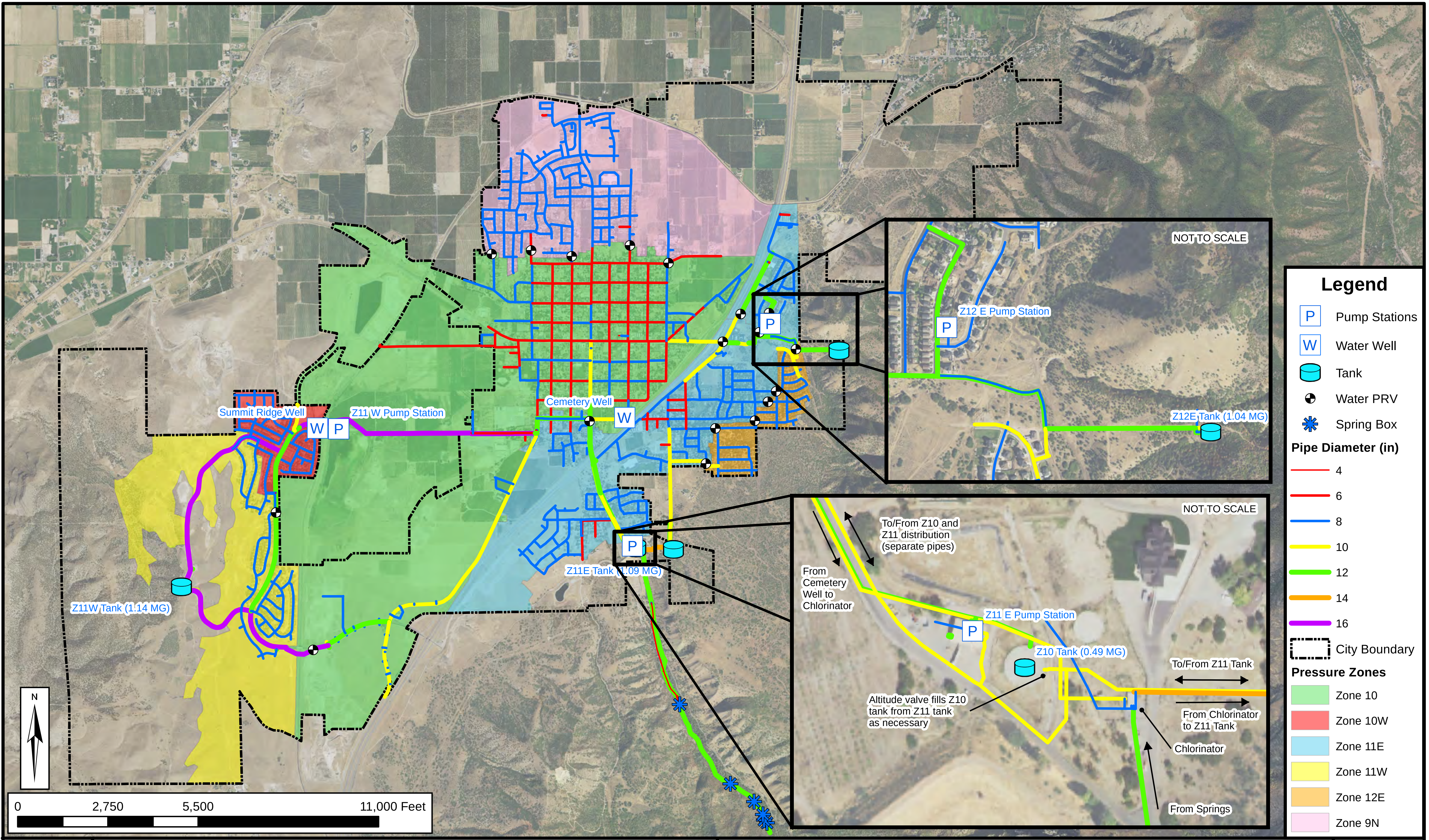
The results of the study are limited by the accuracy of growth projections, data provided by the City, and other assumptions used in preparing the study. It is expected that the City will review and update this master plan every 5–10 years as new information about development, system performance, or water use becomes available.

BACKGROUND

Santaquin City was first settled in late 1851 and is located about 70 miles south of Salt Lake City in Utah County. Although its history lies mostly in agriculture, its population today also has a substantial number of commuters who work in Provo, Spanish Fork, and other nearby cities. Utah County has experienced rapid growth in recent decades, and this growth has extended to Santaquin as population centers have expanded and property values have increased. From 2010–2018, Santaquin grew at a rate of 34.1% from a population of 9,128 to an estimated 12,274 (U.S. Census Bureau). In June 2020, the City provided drinking water service to 3,796 connections.

The existing drinking water system includes four storage tanks, three pump stations, five pressure zones, and about 78 miles of pipe with diameters ranging from 4 inches to 16 inches. Figure 1-1 shows existing drinking water infrastructure. The City recognizes that its continued growth necessitates proactively planning additional drinking water facilities to maintain an acceptable level of service for both indoor and outdoor water use.

Santaquin's drinking water system is master planned to be separate from the City's pressurized irrigation system, but it currently supplements the pressurized irrigation system in several areas. Separate drinking water and pressurized irrigation water pipelines exist in these developments; however, pressurize irrigation source and storage facilities are not yet constructed in some areas. As the excess capacity in the drinking water system is needed for future growth, pressurized irrigation water system facilities will be constructed to increase the capacity of the pressurized irrigation water system, thus freeing up capacity for future drinking water demands. The pressurized irrigation water system is addressed in a separate master plan document.



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SANTAQUIN DRINKING WATER MASTER PLAN

EXISTING DRINKING WATER SYSTEM

FIGURE
1-1

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COMPLIANCE WITH PERTINENT LEGISLATION

Santaquin City intends to comply with all requirements in Utah House Bill 31, *Water Supply and Surplus Water Amendments* (2019 General Session), including the requirement to define a water service area and post a map showing it. Figure 1-2 shows the service area for the Santaquin City drinking water system, the Santaquin City municipal boundary, and customer connections outside of the City boundary.

This master plan will also assist Santaquin in complying with Utah House Joint Resolution 1, *Proposal to Amend Utah Constitution* (2019 General Session), which directs municipalities to protect and preserve water rights and water supply.

LEVEL OF SERVICE

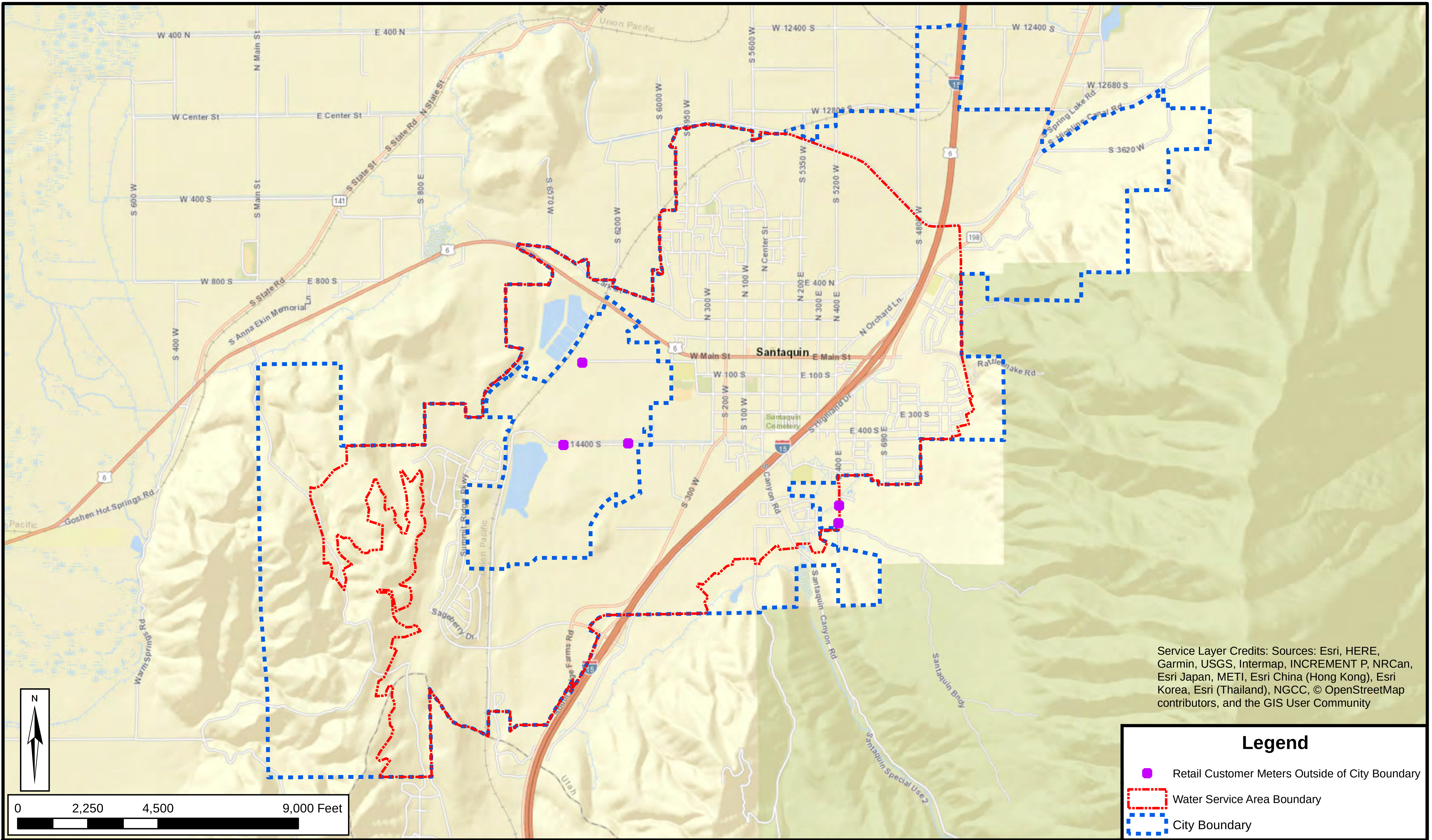
The level of service (LOS) is the water volume and pressure standards that the drinking water system is designed to meet. Level of service is regulated by Utah Administrative Rule 309, which is administered by the Utah Division of Drinking Water (DDW). In the past, the DDW set standard sizing requirements which each water utility was required to meet, based on equivalent residential connections or ERCs. In 2018, the DDW revised this approach to set system-specific sizing requirements. The Division of Drinking water is currently in the process of defining these system-specific requirements for Santaquin. As such, the level of service in this master plan is based on *anticipated* sizing requirements. Slight adjustments may be required if the DDW imposes minimum sizing requirements which are more restrictive than anticipated.

The level of service for this master plan is based on production and meter data collected and reported by Santaquin City over several years. It incorporates appropriate safety factors and is intended to produce a design which is responsible without being unnecessarily expensive. It considers both indoor use and areas which are irrigated using the drinking water system.

The LOS parameters used for this study are summarized in Table 1-1. The development of each LOS parameter is described in later chapters.

Table 1-1
Level of Service Parameters

Parameter	Former DDW Standard	Proposed Level of Service - Indoor Use	Proposed Level of Service - Outdoor Use
Minimum system pressure	30 psi	40 psi	40 psi
Maximum system pressure	N/A	125 psi	125 psi
Maximum daily pressure variation	N/A	20 psi	20 psi
Peak Day Demand	800 gpd/ERC	500 gpd/ERC	8.0 gpm/irr-ac
Average Yearly Demand	0.45 ac-ft/ERC	0.336 ac-ft/ERC	4.0 ac-ft/irr-ac
Storage	400 gal/ERC	360 gal/ERC	9,200 gal/irr-ac
Minimum Fire Flow	-	1,500 gpm for 2 hours	-



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HANSEN ALLEN & LUCE INC ENGINEERS	SANTAQUIN DRINKING WATER MASTER PLAN	SANTAQUIN CITY WATER SERVICE AREA	FIGURE 1-2

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MASTER PLANNING METHODOLOGY

Drinking water systems consist of water sources, storage facilities, distribution pipes, pump stations, valves, and other components. Design and operation of the individual components must be coordinated so that they operate efficiently under a range of demands and conditions. The system must be capable of responding to daily and seasonal variations in demand while simultaneously providing sufficient capacity for firefighting and other emergency situations.

Identifying present and future water system needs is essential in the management and planning of a water system. Existing water demands were calculated from SCADA data and billed water use. Existing water use data, together with planned land uses in the City General Plan (and proposed development concepts), were used to project future water use.

This report follows the DDW requirements of Rule R309-510 (“Facility Design and Operation: Minimum Sizing Requirements”) and Rule R309-105 (“Administration: General Responsibilities of Public Water Systems”) of the Utah Administrative Code. The report addresses sources, storage, distribution, minimum pressures, hydraulic modeling, capital improvements, funding, and other topics pertinent to Santaquin’s drinking water system.

Computer models of the City’s drinking water system were prepared to simulate the performance of facilities under existing and future conditions. System improvement recommendations were prepared from the analysis and are presented in this report.

DESIGN AND PERFORMANCE CRITERIA

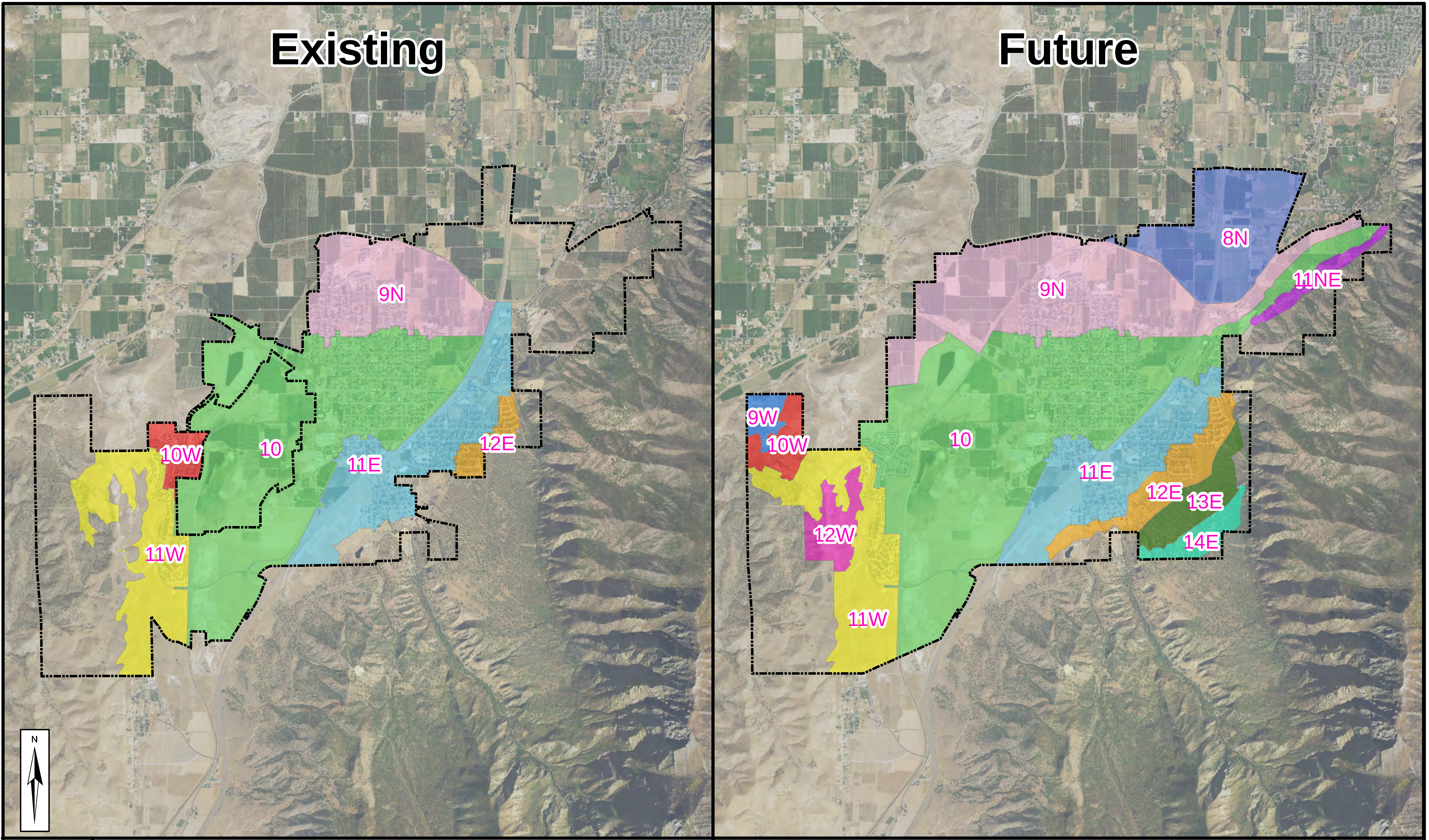
Summaries of the key design criteria and demand requirements for the drinking water system are included in Table 1-2. The design criteria were used in evaluating system performance and in recommending future improvements. Criteria development is described in later chapters.

Table 1-2: System Design Criteria

	Criteria	**Existing Requirements**	**Estimated Future Requirements**
Equivalent Residential Connections	Billing data/LOS	5,380 ERC	18,630 ERC
Irrigable Acreage	Billing data/LOS	125 irr-ac	185 irr-ac
Source			
Peak Day Demand	Section R309-510-7/LOS	2,868 gpm	7,949 gpm
Average Yearly Demand	Section R309-510-7/LOS	2,308 ac-ft	7,000 ac-ft
Storage			
Equalization	Section R309-501-8/LOS	2.76 MG	7.29 MG
Emergency	City preference	0.32 MG	1.12 MG
Fire Suppression	IFC/ Fire Marshall	0.36 MG	1.44 MG
Total		3.45 MG	9.85 MG
Distribution			
Peak Instantaneous	Meter data/LOS	5,736 gpm	15,898 gpm
Minimum Peak Day Fire Flow	IFC/ Fire Marshall/LOS	1,500 gpm @ 20psi	1,500 gpm @ 20psi
Max. Operating Pressure	LOS	125 psi	125 psi
Max. Pressure fluctuation	LOS	20 psi	20 psi
Min. Pressure:			
Peak Day	Section R309-510-9/LOS	40 psi	40 psi
Peak Instantaneous	Section R309-510-9/LOS	30 psi	30 psi

PRESSURE ZONE REVISIONS

This master plan proposes revisions to the City’s existing pressure zones (see details in Chapter 5). Tables which explain existing conditions are organized based on existing pressure zones. Tables which explain future conditions are organized based on proposed future pressure zones. Figure 1-3 shows the difference between existing and proposed pressure zones. The master plan map in Appendix A shows additional proposed infrastructure.



SANTAQUIN DRINKING WATER MASTER PLAN

EXISTING AND FUTURE PRESSURE ZONES

FIGURE
1-3

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CHAPTER 2 SYSTEM GROWTH

GROWTH PROJECTIONS

The development of impact fees requires growth projections over the next ten years. In addition to impact fee projects, this report will also highlight anticipated projects 10-20 years out in the "Capital Facilities Plan" section of this report. Growth projections for Santaquin were evaluated as a part of this master planning effort.

City input and growth projections made by the Governor's Office of Management and Budget (GOMB), Mountainland Association of Governments (MAG), and a market-driven growth analysis prepared for Envision Utah were considered in the development of growth projections used for this study. Detailed information is included in Appendix B. Figure 2-1 and Table 2-1 show the historic and projected population for Santaquin through 2060.

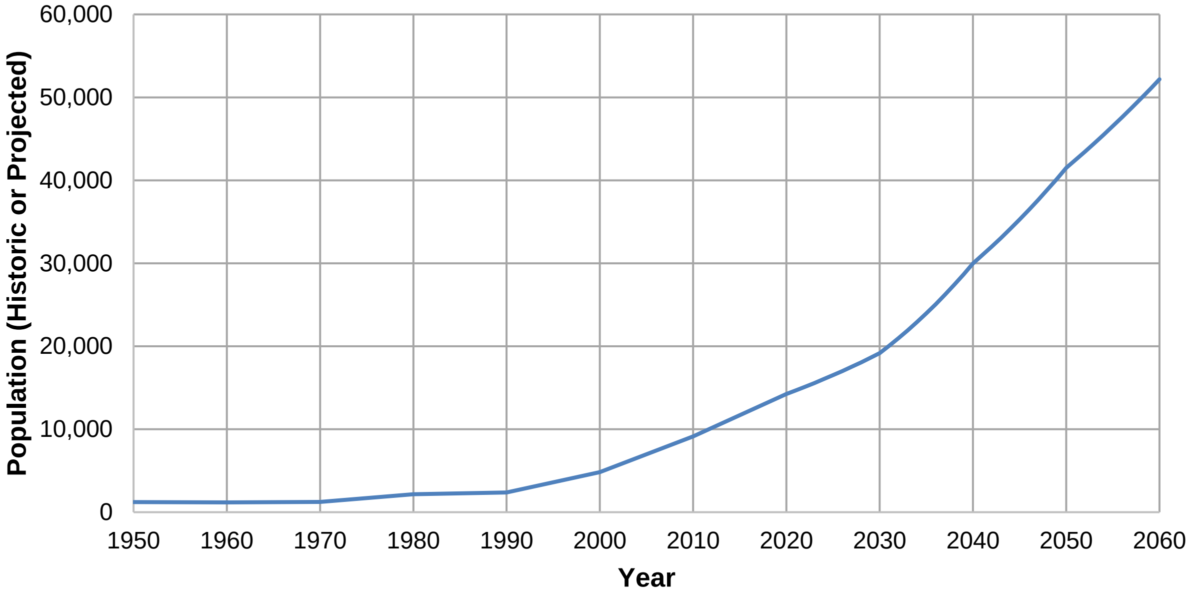


Figure 2-1: Santaquin Historic and Projected Population

EQUIVALENT RESIDENTIAL CONNECTIONS

Drinking water demands are expressed in terms of equivalent residential connections (ERCs). The use of ERCs is a standard engineering practice to describe the entire system in a common unit of measurement. One ERC is equal to the average demand of an average single-family, detached residential connection. Non-residential demands are converted to ERCs for planning purposes. For example, a commercial building requiring six times as much water as a typical single-family, detached residential connection is assigned an ERC count of 6.

EXISTING AND FUTURE CONNECTIONS

HAL analyzed the City's water use data from years 2017 through 2019 to determine the existing ERCs served by each pressure zone. HAL also used growth projections and land use plans to project the ERCs each zone in the system will serve in 2060. A breakdown of the existing and future ERCs by pressure zone is shown in Table 2-1. Figure 2-2 shows the projected future land use and corresponding density of ERCs.

Table 2-1
Existing and Future ERCs

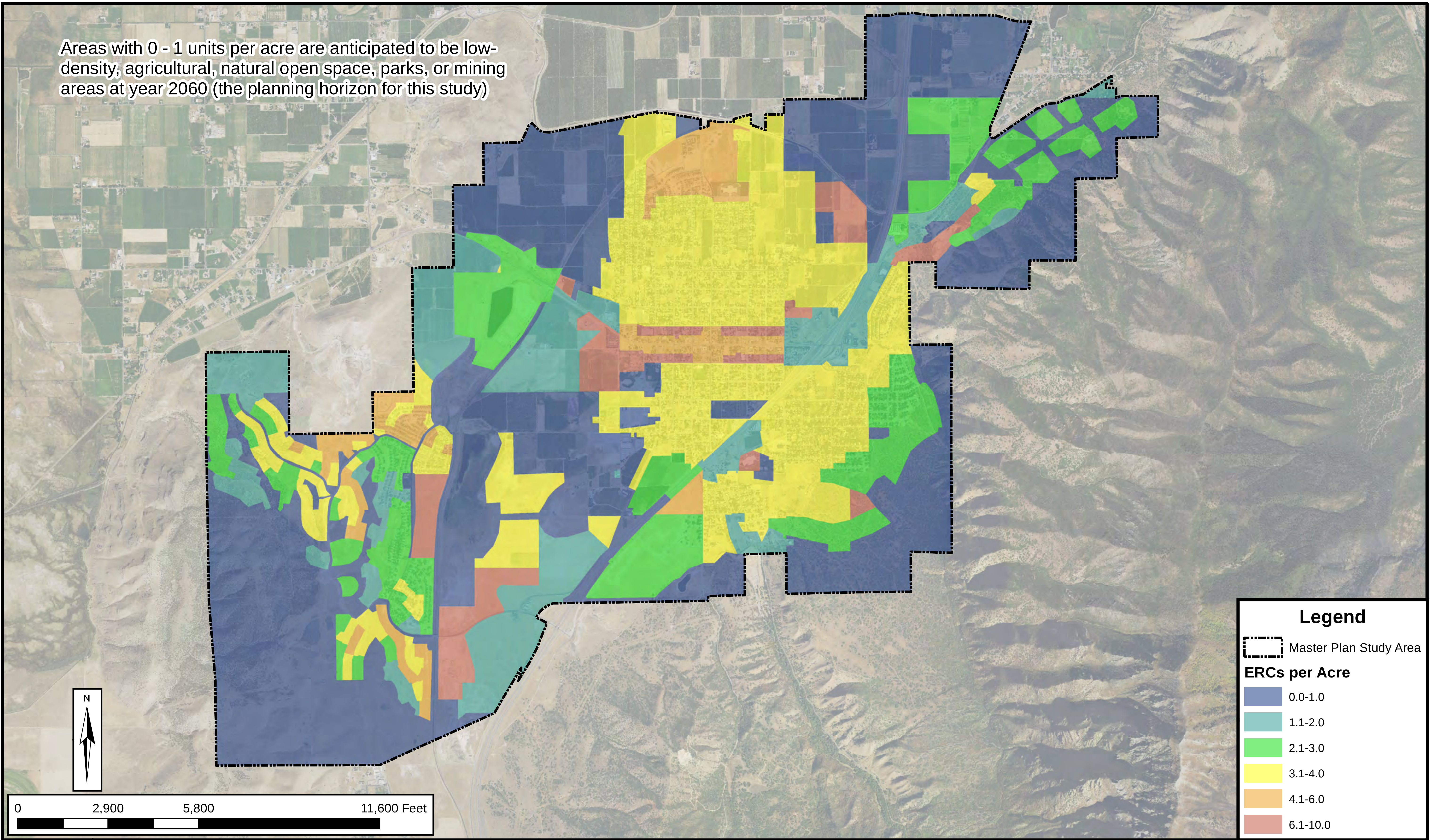
Zone	Existing ERCs	Future ERCs
8N	0	340
9N	810	3,470
9W	0	140
10	2,910	8,780
10W	300	310
11W	260	1,400
11E	870	2,420
11NE	0	140
12W	0	210
12E	230	920
13E	0	420
14E	0	80
Total	**5,380**	**18,630**

Data used to calculate the ERCs are included in Appendix C along with water usage and connection data.

EXISTING AND FUTURE IRRIGABLE ACREAGE

The Santaquin drinking water system supplies water for outdoor irrigation in certain areas of the City. This master plan will also consider the demands imposed on the drinking water system by outdoor irrigation. Outdoor water demands are based on irrigable acreage (irr-ac). The existing irrigable acreage served by the drinking water system was determined based on an analysis of aerial imagery, the layout of the drinking and P.I. systems, and discussions with City personnel.

Future irrigable acreage was forecasted for pressure zones not planned to be served with a separate PI system. These areas are located at high elevations and will have demands small enough that a separate irrigation system is not financially justified. Table 2-2 provides a breakdown of the existing and future irrigable acreage served by the drinking water system, by pressure zone.



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Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Figure 2-2 ERC density by area.mxd

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SANTAQUIN DRINKING WATER MASTER PLAN

ERC DENSITY BY AREA

FIGURE 2-2

Table 2-2
Existing and Future Irrigable Acreage

Zone	Existing Irrigable Acreage	Future Irrigable Acreage
8N	0	0
9N	0	0
9W	0	0
10	0	0
10W	40	0
11W	55	0
11E	0	0
11NE	0	30
12W	0	40
12E	30	0
13E	0	85
14E	0	30
Total	**125**	**185**

Table 2-3 contains the projected population and ERC count through 2040. These projections are used to develop the Capital Facility Plan in Chapter 7.

Table 2-3
Growth Projections

Year	Projected Population	Projected ERCs	Annual Growth
2020	14,242	5,380	3.0%
2021	14,671	5,560	3.0%
2022	15,113	5,750	3.0%
2023	15,568	5,940	3.0%
2024	16,037	6,140	3.0%
2025	16,520	6,340	3.0%
2026	17,017	6,550	3.0%
2027	17,530	6,770	3.0%
2028	18,058	6,990	3.0%
2029	18,602	7,220	3.0%
2030	19,162	7,460	3.0%
2031	20,039	7,700	4.6%
2032	20,957	7,950	4.6%
2033	21,916	8,210	4.6%
2034	22,920	8,480	4.6%
2035	23,969	8,770	4.6%
2036	25,066	9,070	4.6%
2037	26,214	9,380	4.6%
2038	27,414	9,700	4.6%
2039	28,669	10,050	4.6%
2040	29,982	10,400	4.6%

While growth projections are an essential component of this master plan, it should be noted that system capacity is dependent on the number of ERCs in the system. Infrastructure improvements should be made when certain ERC counts are reached – which may occur in a different year than is projected in this plan. Timing for capital improvement projects should be determined based on the development that actually occurs in the system, rather than a target date which is not known with certainty.

CHAPTER 3 WATER SOURCES AND DEMAND

This chapter presents an overview of existing and future source requirements and makes recommendations that will help the City meet these requirements as it grows. Water rights are covered in detail in the Santaquin 40-year water rights plan (in a separate document), and as such, are not discussed in detail in this chapter.

EXISTING WATER SOURCES

The Santaquin drinking water system currently has a series of springs and two wells that provide the system with a total peak day capacity of 4,555 gpm and an annual source capacity of 4,238 ac-ft. A summary of the capacity of these sources is shown in Table 3-1.

Table 3-1
Capacity of Existing Drinking Water Sources

Source	Existing Zone	Physical Flow Capacity (gpm)	Peak Day Source Capacity (gpm)[1]	Annual Source Capacity[2] (ac-ft)
Cemetery Well	11E	850	740	597
Center Street Well[3]	10	560	490	395
Springs 2-5	11E	700	700	1,129
Summit Ridge Well	11W	3,000	2,625	2,117
Total		**5,110**	**4,555**	**4,238**

1. Peak Day Well capacity assumes the well runs 21 hours per day.
2. Annual Source Capacity assumes the well runs an average of 12 hours per day.
3. The Center Street Well is currently used in the PI system. It can be used in the drinking water system in the event of an emergency.

Springs 2 - 5

The City owns five springs in Santaquin Canyon. Spring 1 is used in the PI system. The remainder supply the drinking water system. Water from the springs is chlorinated and then supplied to the Zone 11E tank. From there, it can be pumped to higher zones or fed to lower zones as needed. Because the springs are the lowest-cost source of water in the system, they are used to the maximum extent possible.

In recent years, production from the springs has been lower than average. As a part of this master planning effort, HAL analyzed the springs to determine whether actions could be taken to increase their yield. A summary of this analysis is included in Appendix D. Based on available hydrologic data, it appears that flows from Springs 2 and 3 typically increase if annual precipitation increases, and vice versa. No redevelopment actions are recommended at this time. However, if Springs 2 and 3 do not increase production following several wet years, redevelopment may be needed.

Cemetery Well

Santaquin uses the Cemetery Well to provide source to Pressure Zone 11E. Water from the Cemetery Well can be fed down to lower zones or pumped up to higher zones as needed.

Center Street Well

The Center Street Well was used as a drinking water supply for many years. However, it was connected to the PI system in 2012 to provide additional source to that system. Should the need arise, it can be connected to the drinking water system. For purposes of this plan, it is only considered an emergency source.

Summit Ridge Well

Summit Ridge Well is the largest drinking water source for the City, and plays a key role in meeting peak summer demands. During the summer season, water from Summit Ridge Well is pumped into Zone 10, where it can be consumed, fed down, or pumped up to other pressure zones as needed. During the winter season, valving and controls in the Summit Ridge Wellhouse are changed to enable the well to pump directly to the Zone 11W (and feed down to Zones 10W and 10 as necessary). This mode of operation can also be used at times when the Summit Ridge pump station is not operating. The Summit Ridge Well experiences limited use in the winter, because the City typically prioritizes other sources during periods of lower demand.

EXISTING WATER SOURCE DEMAND

In 2018, House Bill 303 amended Title 19, Chapter 4 of the Utah Code (the Safe Drinking Water Act). Section 19-4-114 of the new code directs the Utah Division of Drinking Water (DDW) to establish system-specific water source and storage minimum sizing requirements (rather than prescribing statewide sizing standards) based on at least three years of actual water use data and/or an engineering study. Historical data for the last three years was used to calculate the peak day drinking water demand as shown in Table 3-2. The requirement was calculated following guidance provided by the DDW.

Table 3-2
Historic Drinking Water Use

Water Use Variable	Year		
	2017	2018	2019
ERCs	4,236	5,022	5,366
Average Yearly Demand			
Total (ac-ft)	1,089	1,110	1,271
Per ERC (ac-ft/ERC)	0.257	0.221	0.237
Per ERC (gpd/ERC)	230	197	211
Per ERC (gpm/ERC)	0.16	0.14	0.15
Peak Day Demand			
Total (gpm)[1]	1,270	1,563	1,557
Per ERC (gpd/ERC)	432	448	418
Per ERC (gpm/ERC)	0.30	0.31	0.29

1. Peak day demand shown is the demand attributable to use within the drinking water system. Water supplied to the PI through crossovers or wholesaled to Genola City is not accounted for in the listed number. Development of the outdoor level of service is described in detail in the City's 2020 Pressurized Irrigation Master Plan report.

Analysis

Variation factors were computed according to DDW guidance and as shown in Table 3-3.

Table 3-3
Water Use Variation

Water Use Variable	Calculation	Calculated Factor[1]	Proposed Factor	Proposed Level of Service[2]
Average Yearly Demand (gpd/ERC)	(230 – 197) / (197)	17%	30%	300
Peak Day Demand (gpd/ERC)	(448 – 418) / (418)	7%	12%	500

1. Calculated as (Maximum – Minimum) / (Minimum) from Table 3-2.
2. Calculated as (Maximum) * (1 + Proposed Factor), with Maximum from Table 3-2.

The City has chosen level of service parameters greater than the calculated minimum for the following reasons:

1. Leakage and water main breaks are likely to increase over time as pipes age and more length of pipe is installed.
2. Santaquin City pressurized irrigation sources produce vastly different amounts of water from year to year, and in some years, there is a greater reliance on the drinking water system for irrigation than is typical.
3. Santaquin City desires a responsible level of drought contingency protection in the event that flows from the springs diminish and/or groundwater levels decrease.

EXISTING WATER SOURCE REQUIREMENTS

According to DDW standards (Section R309-510-7), water sources must be able to meet both the expected water demand on the peak day (flow requirement) and the average demand over the course of one year (volume requirement).

Existing Peak Day Demand

Peak day demand is the water demand on the day of the year with the highest water use. Peak day demand must be considered for both indoor use and all irrigable acreage served by the drinking water system.

Table 3-4 shows the computed peak day demand by pressure zone. The City's pump stations and PRVs enable water to be transferred among pressure zones.

Table 3-4
Existing Peak Day Demand by Pressure Zone

Existing Zone(s)	ERCs	Irrigable Acres	Existing Demand (gpm)	Existing Supply (gpm)	Transfers in (+) or out (-)	Surplus (+) or Deficit (−)
9N	810	0	281	0	+281	+0
10	2,910	0	1,010	2,625	-1,235	+380
10W	300	40	424	0	+424	+0
11W	260	55	530	0	+530	+0
11E	870	0	302	1,440	-320	+818
12E	230	30	320	0	+320	+0
Total	**5,380**	**125**	**2,868**	**4,065**	**+0**	**+1,198**

As demonstrated in Table 3-4, there is surplus capacity available in the system as a whole and in all pressure zones. However, the City experiences some difficulty operating the system efficiently. System inefficiencies is discussed somewhat in the following section and again in more detail in Chapter 6.

Existing Pump Stations

Santaquin City operates three drinking water pump stations. These pump stations are summarized in Table 3-5. All pump stations have capacity remaining.

Table 3-5
Existing Drinking Water Pump Stations

Name	From Zone	To Zone	Pumps	Rated Capacity (gpm)	Peak Day Demand (gpm)	Surplus (+) or Deficit (−) (gpm)
Summit Ridge Booster	10	11W/10W	1 @ 1000 gpm	1,000 gpm	954	+46
Canyon Road Booster	10	11E/12E	2 @ 1,200 gpm	1,200 gpm	622	+578
Zone 12E Booster	11E	12E	3 @ 500 gpm	1,000 gpm	320	+680

The Summit Ridge Booster is the sole source of water to zones 11W and 10W during normal peak day operation. The Summit Ridge Well can be configured to pump to Zone 11W directly if needed. While this is very energy-inefficient due to a greater static lift, it provides redundancy despite there being only one pump in the Zone 11W pumphouse.

During typical summertime operations, the City leaves the Cemetery Well off and instead uses the Canyon Road Booster to move water from Zone 10 (produced by Summit Ridge Well) to Zone 11E. This enables the City to more effectively operate Summit Ridge Well. Capacity in the booster station is limited.

The Zone 12E booster is the only source of water to Zone 12E.

Existing Average Yearly Demand

Average yearly demand is the volume of water used during an entire year, and is used to ensure the sources can supply enough volume to meet demand under existing and future conditions. Average yearly demand must be considered for both indoor use and all irrigable acreage served by the drinking water system.

At the proposed level of service of 0.336 ac-ft per ERC and 4.0 ac-ft per irrigable acre, the existing average yearly demand requirement is **2,308 ac-ft/yr**. A comparison to the annual source capacity listed in Table 3-1 shows that there is capacity remaining for average yearly demand.

SOURCE REDUNDANCY

At times, water sources fail to produce. Possible reasons for this include contamination, drought, decreasing groundwater levels, pump failure, etc. For this reason, Santaquin City has included source redundancy as a component of their LOS, which specifies that the indoor level of service of 500 gpd/ERC must be able to be met if the largest water source (Summit Ridge Well) is out of commission.

If the Summit Ridge Well were to fail, Santaquin personnel would shut off the backflow preventers that serve the PI system and connect the Center Street Well to the drinking water system. Table 3-6 contains a comparison of the peak day demand and capacity of each pressure zone of the drinking water system, assuming these actions have been taken.

Table 3-6
Supply and Demand by Pressure Zone, Assuming Source Failure

Existing Zone(s)	ERCs	Irrigable Acres[1]	Demand (gpm)[2]	Supply (gpm)[3]	Transfers in (+) or out (-)	Surplus (+) or Deficit (−)
9N	810	0	281	0	+281	+0
10	2,910	0	1,010	490	+520	+0
10W	300	0	104	0	+104	+0
11W	260	0	90	0	+90	+0
11E	870	0	302	1,440	-1,076	+62
12E	230	0	80	0	+80	+0
Total	**5,380**	**0**	**1,868**	**1,930**	**+0**	**+62**

1. This analysis assumes that the backflow preventers serving the PI system would be shut off
2. Demand listed is at the level of service of 500 gpd/ERC
3. Assumes that Center Street Well is being used in the drinking water system

Conclusions from this source redundancy analysis (assuming Summit Ridge Well were to fail on a peak day) are as follows:

- There are no existing deficiencies for source redundancy. However, remaining capacity is limited.

Based on these conclusions, the following are recommended:

1. Complete a source protection plan for the Center Street Well to ensure that it is available for use in the drinking water system. Ensure there is sufficient equipment and in-house knowledge to quickly switch it to the drinking water system if needed.
2. Establish a method to quickly contact customers in the event of source failure. This could be used to encourage conservation and reduce peak demands.
3. Plan to drill another well to provide redundancy for future growth (details will be provided in the Capital Facility Plan in Chapter 7).

FUTURE WATER SOURCE REQUIREMENTS

As with existing water source requirements, future water source requirements were evaluated on criteria for both peak day and average yearly demand (Section R309-510-7).

Future Peak Day Demand

Following the methodology described for existing conditions, the peak day source requirement for each pressure zone is shown in Table 3-7.

Table 3-7
Future Peak Day Demand by Pressure Zone

Future Zone	ERCs	Irr-ac	Demand (gpm)	Existing Supply (gpm)	Surplus (+) or Deficit (−)
8N	340	0	118	0	-118
9N	3,470	0	1,205	0	-1,205
9W	140	0	49	0	-49
10	8,780	0	3,049	2,625	-424
10W	310	0	108	0	-108
11W	1,400	0	486	0	-486
11E	2,420	0	840	1,440	+600
11NE	140	30	289	0	-289
12W	210	40	393	0	-393
12E	920	0	319	0	-319
13E	420	85	826	0	-826
14E	80	30	268	0	-268
Total	**18,630**	**185**	**7,949**	**4,065**	**-3,884**

As shown in Table 3-7, the existing system does not have sufficient source capacity to meet projected peak day water demands in 2060. Additional sources will be needed.

Future Average Yearly Demand

Following the methodology described for existing conditions, the future average yearly demand requirement is projected to be **7,000 ac-ft/yr**. A comparison to the annual source capacity listed in Table 3-1 shows that there is not sufficient existing source capacity to meet this demand. More average yearly source capacity will be needed.

Comparison to Former DDW Standards

Appendix C contains a comparison of the requirements calculated at the proposed level of service to the requirements as calculated according to former DDW standards. For both existing and future conditions, the proposed level of service results in a lower calculated requirement than former DDW standards.

SOURCE - CONCLUSIONS

Key conclusions from this analysis are as follows:

- Existing drinking water sources are adequate for both peak day demand and average yearly demand at the level of service.
- Existing pump stations adequately meet peak day demands at the level of service.
- If the Summit Ridge Well were to fail during the period of peak demand, the City would need to shut off the backflow preventers that supply the PI system and use the Center Street Well in the drinking water system in order to meet peak day demands at the level of service of 500 gpd/ERC.
- Additional drinking water pump stations will be needed to support anticipated future growth.
- Additional drinking water sources will be needed to support anticipated future growth. Wells are the recommended future drinking water source for Santaquin City.

SOURCE - RECOMMENDATIONS

Future Pump Stations

Recommended future pump stations are shown in Table 3-8.

Table 3-8
Recommended Future Drinking Water Pump Stations

Name	From Zone	To Zone	Peak Day Flow Served (gpm)	Fire Flow Requirement (gpm)	Recommended Pumping Configuration[1]
Zone 11NE	10	11NE	290	1500	1 @ 100 gpm 2 @ 300 gpm 1 @ 1500 gpm VFD
Zone 11W	10	11W	1,040	0	1 @ 500 gpm 2 @ 1000 gpm
Zone 12W	11W	12W	400	0	2 @ 500 gpm
Zone 13E	11E	13E	830	0	3 @ 500 gpm
Zone 14E	13E	14E	270	0	2 @ 300 gpm

1. Prior to construction, each pump station must be re-evaluated to ensure that the listed size is adequate for the proposed developments being constructed and consistent with the latest general plan land use concept.

Water Dedication Policy

Santaquin City Code 8-1-10 requires developers to convey a minimum of three acre-feet of water rights per gross acre of developed land. This requirement was analyzed and compared to the water usage level of service in this study to ensure that the City is collecting an appropriate amount of water for developments being constructed.

Except for high-density residential zoning, the City water rights requirement of three acre-feet per gross acre was found to provide sufficient water rights to meet demands at the level of service. The following approach is recommended for high-density residential areas:

1. Compute the indoor requirement by multiplying the number of ERCs by the level of service of 0.336 ac-ft/ERC
2. Reduce the indoor requirement by 20% as an allowance to the developer, considering that multi-family developments tend to use less water per connection than single-family homes
3. Compute irrigable acreage based on the site plan and assess water rights for irrigable acreage at the level of service of 4.0 ac-ft/irr-ac.

For example, a multi-family development on a 5-acre parcel with 50 units and 1.8 irrigable acres would have a calculated water requirement as follows:

(50 ERC) * (0.336 ac-ft/ERC) * (80%) + (1.8 irr-ac) * (4.0 ac-ft/irr-ac) = 20.64 ac-ft.

Note that this requirement is greater than the 15 ac-ft that would be calculated using the current City code.

General Source Recommendations

The following are recommended actions to take to ensure adequate source capacity is available for existing and future customers:

1. Complete a source protection plan for the Center Street Well so it can be used as a backup source if needed.
2. Establish a method to quickly contact customers in the event of source failure. This could be used to encourage conservation and reduce peak demands.
3. Plan to drill future wells to secure additional source capacity and redundancy.

CHAPTER 4 WATER STORAGE

EXISTING WATER STORAGE

The City's existing drinking water system includes four storage facilities with a total capacity of 3.76 MG. Their locations are shown on the City's Drinking Water Master Plan Map in Appendix A. Table 4-1 summarizes the capacity of each storage tank.

Table 4-1
Capacity of Existing Storage Tanks

Tank and Zone	Volume (MG)
Zone 10	0.49
Zone 11E	1.09
Zone 11W	1.14
Zone 12E	1.04
Total	**3.76**

EXISTING WATER STORAGE REQUIREMENTS

According to DDW standards outlined in Section R309-510-8, storage tanks must be able to provide: 1) fire suppression storage to supply water for firefighting; 2) emergency storage, as deemed necessary; and 3) equalization storage volume to make up the difference between source and demand. Each of the requirements is addressed below.

Fire Suppression Storage

Fire suppression storage is required for water systems that provide water for firefighting (Subsection R309-510-8(3)). The local fire authority determines the need for fire suppression storage. The policy for Santaquin City is to provide 1,500 gpm of fire flow at all areas of the system. Buildings must be designed to require no more than 1,500 gpm.

Contact information for the Santaquin Fire department is as follows:

Fire Chief: Ryan Lind

Phone: 801-754-1941

Address: 275 West Main Street
Santaquin, Utah

Storage was allocated to each tank according to simulations of fire flow during peak day conditions, considering that fire flow may be supplied by storage in higher zones. Fire suppression storage was determined with the following assumptions:

- All pressure zones have a maximum fire flow requirement of 1,500 gpm for two hours. This equates to a fire storage of 180,000 gallons.
- 180,000 gallons of fire storage must be stored in Zone 12E, because it is the highest zone on the eastern bench and does not have access to other storage through PRVs.
- 180,000 gallons of fire storage must be stored in Zone 11W, because it is the highest zone on the western side of town and does not have access to other storage through PRVs.
- Fire storage in Zones 12E and 11W can be fed down to lower zones through PRVs. No dedicated fire storage is assumed in the tanks in Zones 11E and 10.

Table 4-2 summarizes the fire suppression storage reserved in each storage facility.

Table 4-2
Existing Fire Suppression Storage by Tank

Tank and Zone	Fire Suppression Storage (gallons)
Zone 10	0
Zone 11E	0
Zone 11W	180,000
Zone 12E	180,000
Total	360,000

Equalization Storage

The proposed level of service for equalization storage in the drinking water system is equivalent to the proposed average yearly demand level of service of 300 gal/ERC for indoor use (calculated based on R309-510-8(2)). See Chapter 3 for source calculations. The City also plans for 9,200 gallons of storage per irrigable acre served by the drinking water system. This is equal to the irrigation level of service as calculated in the Santaquin 2020 Pressurized Irrigation Master Plan report.

With 5,380 ERCs and 125 irrigable acres under existing conditions, Santaquin needs 2.76 MG of equalization storage in its drinking water system.

Emergency Storage

While there are no specific DDW requirements for emergency storage (Subsection R309-510-8(4)), water systems can choose to maintain emergency storage to mitigate risks, provide system reliability, and protect public health and welfare. Emergency storage may be used in case of pipeline failures, equipment failures, power outages, source contamination, and natural disasters.

For the above listed reasons, Santaquin City has chosen an emergency storage requirement equal to 20% of the equalization storage requirement, or 60 gal/ERC. Table 4-3 lists the equalization storage requirement by pressure zone, as well as total storage requirements.

Table 4-3
Existing Drinking Water Storage Requirements by Zone

Zone	ERCs	Irrigable Acreage	Equalization (MG)	Fire (MG)	Emergency (MG)	Total Required Storage (MG)	Existing Storage (MG)	Remaining Capacity (MG)
9N	810	0	0.24	0	0.05	0.29	0	-0.29
10	2,910	0	0.87	0	0.17	1.05	0.49	-0.56
10W	300	40	0.46	0	0.02	0.48	0	-0.48
11W	260	55	0.58	0.18	0.02	0.78	1.14	+0.36
11E	870	0	0.26	0	0.05	0.31	1.09	+0.78
12E	230	30	0.35	0.18	0.01	0.54	1.04	+0.50
Total	**5,380**	**125**	**2.76**	**0.36**	**0.32**	**3.45**	**3.76**	**+0.31**

1. Equalization storage requirements under the former DDW standard would be 2.51 MG.

It is important to note that the storage in a zone is only useful within that zone, or the zones below it. Zones 9, 10, and 10W draw upon the storage in Zones 11E and 11W, so these zones meet level of service storage requirements, despite showing a deficit in Table 4-3. However, storage in Zone 11 is not useful to zone 12.

Conclusions about the City’s existing storage capacity are as follows:

- The system is nearly out of storage capacity. The Zone 10 and Zone 11W tanks are most stressed.
- The Zone 10 tank relies heavily on storage from higher zones. Storage demands for the zones it serves are much higher than its existing capacity.
- Much of the capacity in the Zone 11E tank serves lower zones.
- The Zone 12E tank has capacity remaining.

SUMMARY OF EXISTING STORAGE

A summary of selected attributes of existing storage tanks is shown in Table 4-4.

Table 4-4
Attributes of Existing Storage Tanks

Name and Zone	Type	Diameter (ft)	Volume (MG)	Outlet Level (ft)	Emergency Storage Level (ft)	Fire Suppression Level (ft)	Overflow / Equalization Level (ft)
10	Concrete	80	0.49	0.0	5.9	0.0	13.0
11E	Concrete	89	1.09	0.5	1.1	0.0	23.3
11W	Concrete	92	1.14	0.0	3.7	3.6	23.0
12E	Concrete	88	1.04	0.0	4.3	4.0	23.1

FUTURE WATER STORAGE REQUIREMENTS

Table 4-5 presents the future drinking water storage requirements by pressure zone. These are then discussed below. A total of 9.85 MG is needed at year 2060.

Table 4-5
Future Drinking Water Storage Requirements

Zone	ERCs	Irr-ac	Equalization (MG)	Fire (MG)	Emergency (MG)	Total Required Storage (MG)	Existing Storage (MG)	Surplus / Deficiency (MG)
8N	340	0	0.10	0.00	0.02	0.12	0	-0.12
9N	3,470	0	1.04	0.18	0.21	1.43	0	-1.43
9W	140	0	0.04	0.00	0.01	0.05	0	-0.05
10	8,780	0	2.63	0.18	0.53	3.34	0.49	-2.85
10W	310	0	0.09	0.00	0.02	0.11	0	-0.11
11W	1,400	0	0.42	0.18	0.08	0.68	1.14	0.46
11E	2,420	0	0.73	0.18	0.15	1.05	1.09	0.04
11NE	140	30	0.32	0.00	0.01	0.33	0	-0.33
12W	210	40	0.43	0.18	0.01	0.62	0	-0.62
12E	920	0	0.28	0.18	0.06	0.51	1.04	0.53
13E	420	85	0.91	0.18	0.03	1.11	0	-1.11
14E	80	30	0.30	0.18	0.00	0.48	0	-0.48
Total	**18,630**	**185**	**7.29**	**1.44**	**1.12**	**9.85**	**3.76**	**-6.09**

Equalization Storage

Following the methodology described for existing conditions, and calculating 18,630 ERCs and 185 irrigable acres at year 2060, the projected indoor equalization storage requirement is 7.29 MG.

Fire Suppression Storage

For the 2060 scenario, fire storage has been assumed for all zones except those zones fed only through PRVs. This will become necessary as the system grows, because the wider spatial extent of the system (and consequent long distribution mains) will limit the amount of water that can be fed through PRVs from higher zones. The total projected fire storage requirement is 1.44 MG.

Emergency Storage

Emergency storage was evaluated at 60 gal/ERC, as discussed previously. The total emergency storage requirement at year 2060 is projected to be 1.12 MG.

WATER STORAGE RECOMMENDATIONS

Several additional storage facilities are recommended to meet the needs of the City through year 2060. Table 4-6 contains a summary of key attributes of these facilities. In all cases, a detailed review of existing and proposed development concepts will be needed prior to construction.

Table 4-6
Recommended Future Storage Facilities

Zone	Combined Minimum Size[1] (MG)	Approximate HGL when Full (ft)	Notes
10	5.0	5180[2]	Two Zone 10 tanks are recommended (they will also serve Zone 9N). The westernmost tank is recommended at 2.5 MG. It is also recommended that the existing Zone 10 storage be replaced or augmented to a total capacity of 2.5 MG. See the Capital Facility Plan in Chapter 7 for recommendations on the timing of these improvements.
12W	1.0	5416	Sizing is based upon the development concept for the Summit Ridge master planned development. The size of the tank must be re-evaluated if this concept plan changes significantly.
13E	1.25	5586	The development concept for Zone 13E is presently not well-defined. A detailed review will be needed prior to the construction of this tank, to ensure adequate size.
14E	0.5	5746	The development concept for Zone 14E is presently not well-defined. A detailed review will be needed prior to the construction of this tank, to ensure adequate size.

1. The volume listed is the minimum requirement for the zone. This may be accomplished with multiple tanks in some instances.
2. Precise survey elevations of the Zone 10 tank were not available for this study. Detailed analysis should be done to confirm this elevation before any design work occurs.

There is a need to construct additional storage to support growth. Zone 10 is the recommended location for the City's next storage tank. Projects 3 and 10 in the Capital Facility Plan both address this need, and there are advantages and disadvantages to each. The Capital Facility Plan in Chapter 7 lists the westernmost tank as the first priority for the following reasons:

- Minimal new transmission would be required (thus, initial cost would likely be lower)
- The timing of construction coincides with the necessary timing of construction for the Zone 11W pump station and the recommended Zone 10 to Zone 10W connection, both in that area of the City
- It is necessary to secure land for this facility, which is typically easier done sooner rather than later

However, there are several compelling reasons to instead construct additional storage at the site of the existing Zone 10 tank, including the following:

- Most projected growth in Zones 9N and 10 occurs toward the eastern side of town
- Land for the tank is already owned by the City

The main disadvantage of this option is that it would likely have a higher upfront cost due to a required 20-inch diameter transmission pipeline. However, the City should consider growth patterns and long-term priorities when weighing these options. Either would be acceptable. Chapter 7 includes more details on the location and timing of these proposed storage projects.

CHAPTER 5 WATER DISTRIBUTION

HYDRAULIC MODEL

Development

A computer model of the City’s drinking water distribution system was developed to analyze the performance of the existing and future distribution system and to prepare solutions for existing facilities not meeting the distribution system requirements. The model was developed with the software EPANET 2.0, published by the U.S. Environmental Protection Agency (EPA 2014; Rossman 2000). EPANET simulates the hydraulic behavior of pipe networks. Sources, pipes, tanks, valves, controls, and other data used to develop the model were obtained from GIS data of the city’s drinking water system and other information supplied by the City.

HAL developed models for two phases of drinking water system development. The first phase was a model representing the existing system (existing model). This model was used to calibrate the model and identify deficiencies in the existing system. Calibration was performed using fire hydrant tests and by comparing model results to the City’s SCADA output. Calibration data is included in Appendix E. The second phase was a model representing future conditions and the improvements necessary to accommodate growth (future model).

Model Components

The two basic elements of the model are pipes and nodes. A pipe is described by its inside diameter, length, minor friction loss factors, and a roughness value associated with friction head losses. A pipe can contain elbows, bends, valves, pumps, and other operational elements. Nodes are the endpoints of a pipe and can be categorized as junction nodes or boundary nodes. A junction node is a point where two or more pipes meet, where a change in pipe diameter occurs, or where flow is added (source) or removed (demand). A boundary node is a point where the hydraulic grade is known (a reservoir, tank, or PRV). Other components include tanks, reservoirs, pumps, valves, and controls.

The model is not an exact replica of the actual water system. Pipeline locations used in the model are approximate and not every pipeline may be included in the model, although efforts were made to make the model as complete and accurate as possible. Moreover, it is not necessary to include all of the distribution system pipes in the model to accurately simulate its performance.

Pipe Network

The pipe network layout originated from GIS data provided by the City. Elevation information was obtained from LIDAR data. Pipes in the system are generally PVC. Darcy-Weisbach roughness coefficients for pipes in this model ranged from 0.4 – 1.0, which is typical for these pipe materials in EPANET (Rossman 2000, 31).

Water Demands

Water demands were allocated in the model based on billed usage and billing addresses. Demand was determined for each billing address, and the addresses were geocoded in order to link the demands to a physical location. The geocoded demands were then assigned to the closest model node. With the proper spatial distribution, demands were scaled to reach the peak day demand determined in Chapter 3. For the future model, future demands were estimated according to the zoning and density shown in the City’s general plan, and development concepts with approval. Future demands were assigned to new nodes representing the expected location of new development in each pressure zone.

The pattern of water demand over a 24-hour period is called the diurnal curve or daily demand curve. There was not sufficient data to determine an indoor diurnal curve for the system, so a typical indoor curve with a peaking factor of 2.0 was selected for this study. A diurnal curve for outdoor demands was determined from SCADA data. These diurnal curves were put into the model to simulate changes in water demand throughout the day.

In summary, the spatial distribution of demands followed geocoded water use data; the flow and volume of demands followed the proposed level of service described in Chapter 3; and the temporal pattern of demand followed typical diurnal curves.

Water Sources and Storage Tanks

The sources of water in the model are the two wells and springs. A well is represented by a reservoir and pump. A spring is represented by a reservoir and a flow control valve. Tank location, height, diameter, and volume are represented in the model. The extended-period model predicts water levels in the tanks as they fill from sources and as they empty to meet demand in the system.

ANALYSIS METHODOLOGY

HAL used extended-period and steady-state modeling to analyze the performance of the water system with current and projected future demands. An extended-period model represents system behavior over a period of time: tanks filling and draining, pumps turning on or off, pressures fluctuating, and flows shifting in response to demands. A steady-state model represents a snapshot of system performance. The peak day extended period model was used to set system conditions for the steady-state model, calibrate zone to zone water transfers, analyze system controls and the performance of the system over time, and to analyze system recommendations for performance over time. The steady-state model was used for analyzing the peak day plus fire flow conditions.

Four operating conditions were analyzed with the extended period model: Static conditions, peak day conditions, peak instantaneous conditions, and peak day plus fire flow conditions. Each of these conditions is a worst-case situation so the performance of the distribution system may be analyzed for compliance with DDW standards and City preferences.

EXISTING WATER DISTRIBUTION SYSTEM

Santaquin's drinking water distribution system consists of all pipelines, valves, fittings, and other appurtenances used to convey water from sources and storage tanks to water users. The existing water system contains approximately 78 miles of pipe with diameters of 4 inches to 16 inches. Figure 5-1 presents a summary of pipe length by diameter.

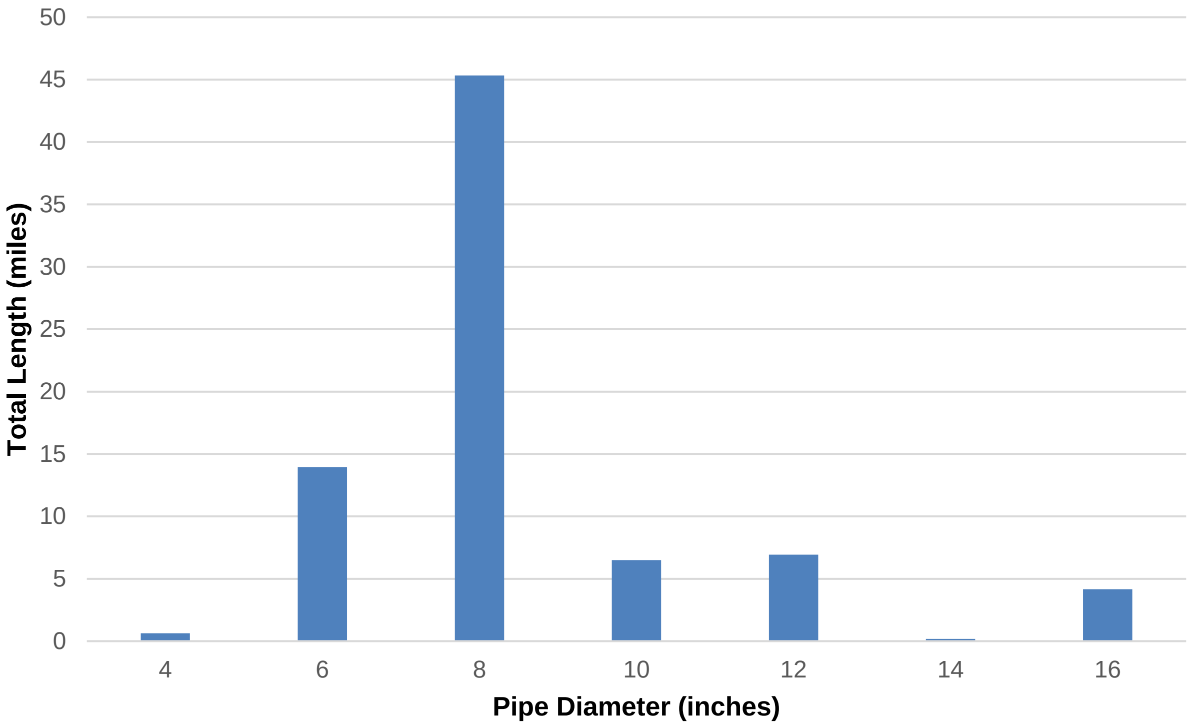


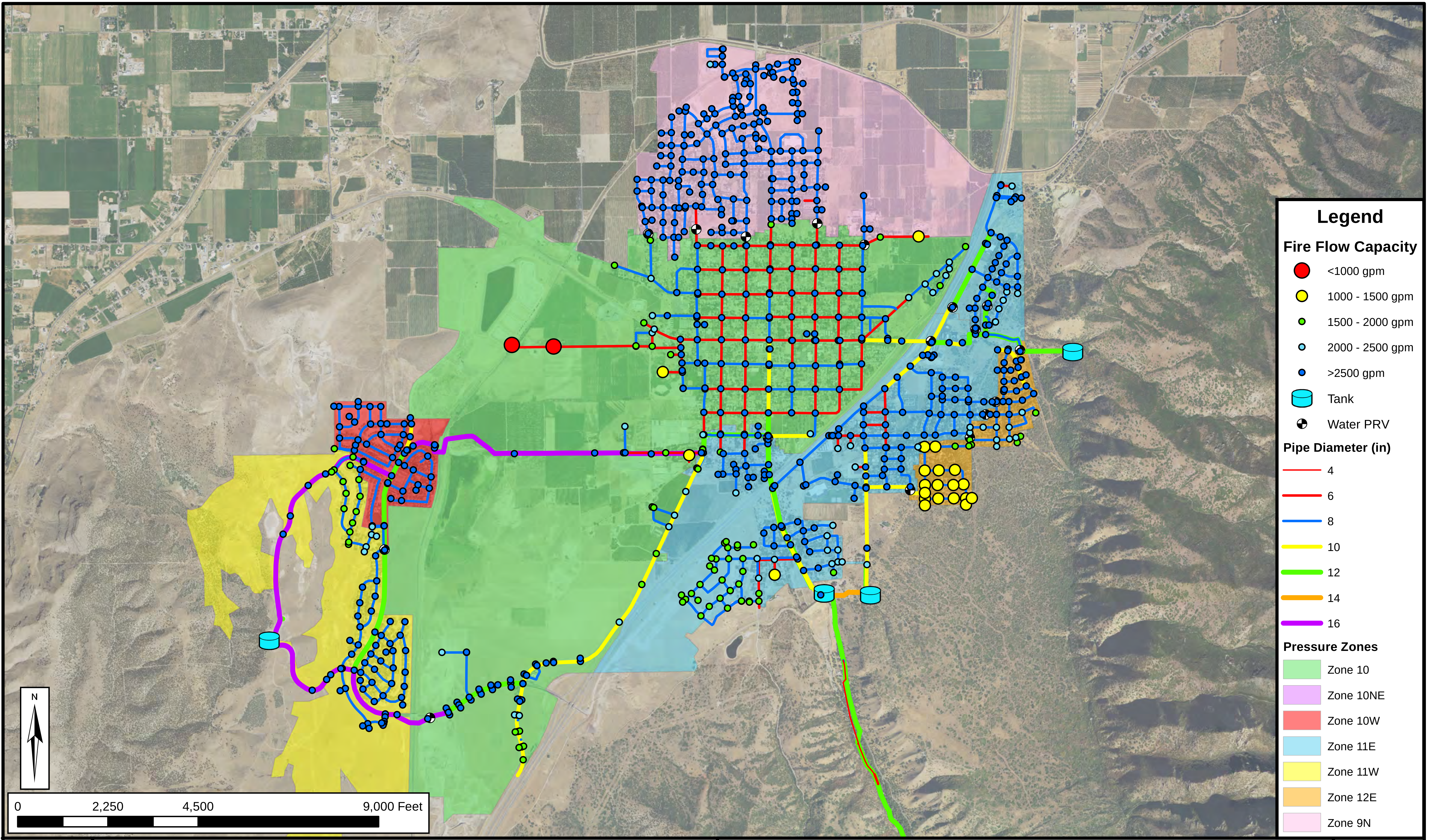
Figure 5-1: Summary of Pipe Length by Diameter

Performance of the drinking water system was evaluated according to the requirements listed in Table 5-1.

Table 5-1
Compliance of Existing
Distribution System with Utah Rule

Condition	Requirement[1]	System Design Flow[2]	Compliance Status
Peak Day	Minimum 40 psi service pressure	2,868 gpm	All connections comply.
Peak Instantaneous	Minimum 30 psi service pressure	5,736 gpm	All connections comply.
Peak Day plus Fire Flow[3]	Minimum 20 psi service pressure	2,868 gpm (system) Plus 1,500 gpm fire	All areas comply except as shown on Figure 5-2.

1. Requirements are as stated in Utah Code R309-105-9(2). The requirement for connections prior to 2007 is a minimum of 20 psi under all conditions.
2. Peak day system flows are discussed in Chapter 3. Peak day flow was multiplied by a factor of 2.0 to produce peak instantaneous flow.
3. Fire flow is discussed in Chapter 4. The maximum fire flow requirement in Santaquin is 1,500 gpm.



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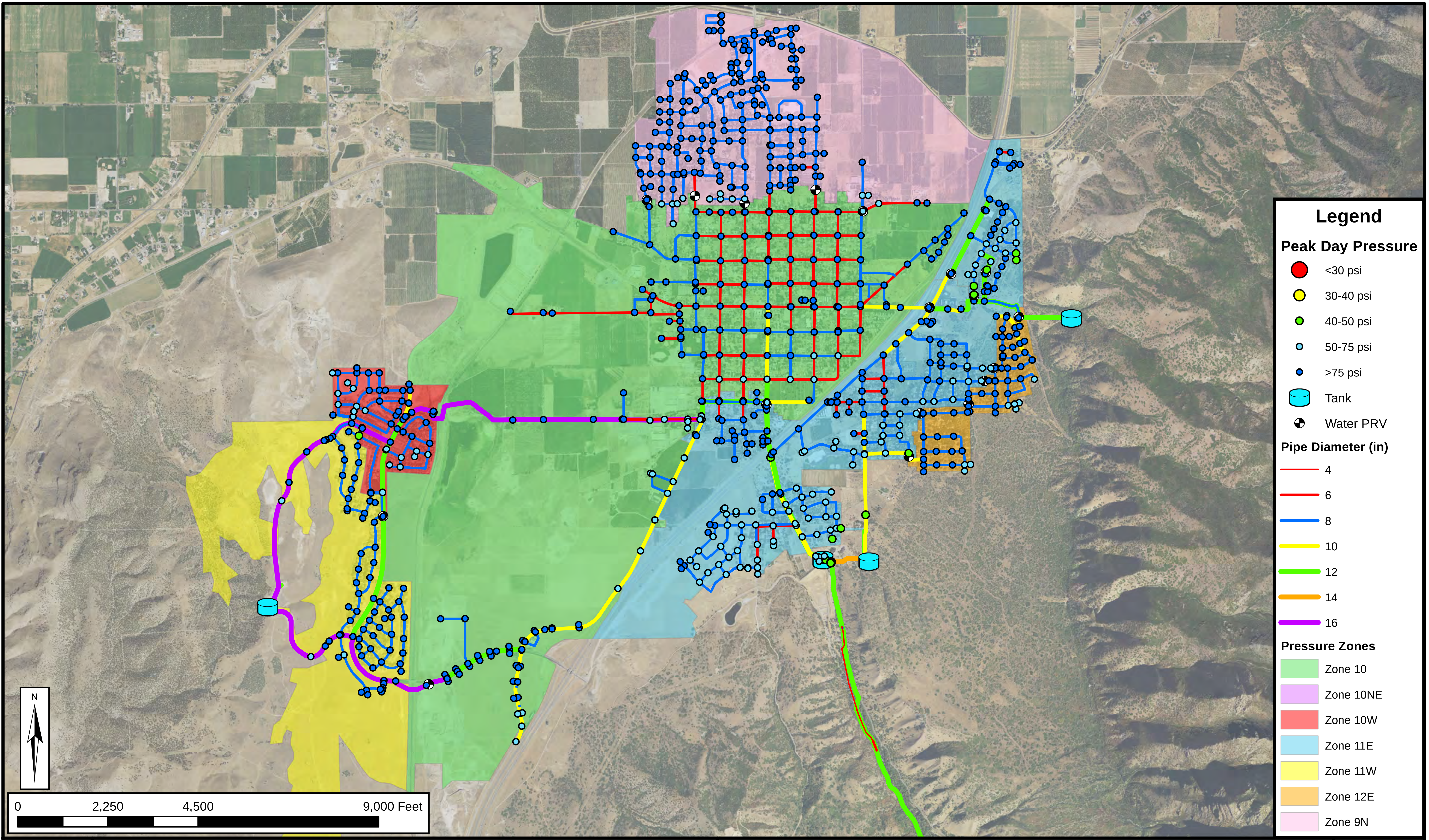
SANTAQUIN DRINKING WATER MASTER PLAN

MODELED EXISTING FIRE FLOW CAPACITY

FIGURE
5-2

Date: 7/29/2020
Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Figure 5-2 Existing Fire Flow.mxd



Date: 7/29/2020
Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Figure 5-3 Existing Peak Day.mxd

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SANTAQUIN DRINKING WATER MASTER PLAN

MODELED EXISTING PEAK DAY PRESSURE

FIGURE
5-3

Fire Flow Deficiencies

A brief description of each area with modeled flow deficiencies is included below:

- The dead end 6-inch pipe in 14000 S (County coordinates), near the City's winter storage ponds, is not able to provide 1,000 gpm of fire flow capacity.
- The dead end 6-inch pipe in 13600 S (County coordinates) cannot provide 1,500 gpm of fire flow.
- The pipes south of 425 S in Zone 12E cannot provide 1,500 gpm of fire flow.
- The dead end 6-inch pipe in Center Street cannot provide 1,500 gpm of fire flow.

The City is aware of these deficiencies, and several were approved either because they are in rural areas where development of full fire flow requirements is not practical, they were constructed before the International Fire Code required 1,500 gpm, or they were granted approval with the understanding that fire flow capacity would be limited until a future time when looping would increase fire flow capacity.

Modeling should not replace physical hydrant testing as the primary means of determining available fire flow. Testing hydrants is recommended in each of these areas to more precisely determine the existence and the extent of any flow deficiencies.

FUTURE WATER DISTRIBUTION SYSTEM DEMANDS

Demands in the future water distribution model are shown in Table 5-2. The buildout system was designed to meet all regulatory requirements.

Table 5-2
Design Parameters for
Future Distribution System

Condition	Requirement[1]	System Design Flow[2]
Peak Day	Minimum 40 psi service pressure	7,949 gpm
Peak Instantaneous	Minimum 30 psi service pressure	15,898 gpm
Peak Day plus Fire Flow[3]	Minimum 20 psi service pressure	7,949 gpm (system) Plus 1,500 gpm fire

1. Requirements are as stated in Utah Code R309-105-9(2)
2. Peak day system flows are discussed in Chapter 3. Peak day flow was multiplied by a factor of 2.0 to produce peak instantaneous flow.
3. Fire flow is discussed in Chapter 4. The maximum fire flow requirement in Santaquin in 1,500 gpm.

WATER DISTRIBUTION SYSTEM RECOMMENDATIONS

The model output primarily consists of the computed pressures at nodes and flow rates through pipes. The model also provides additional data related to pipeline flow velocity and head loss to help evaluate the performance of the various components of the distribution system. Results from the model are available on a CD in Appendix E. Due to the large number of pipes and nodes in the model, it is impractical to prepare a figure which illustrates pipe numbers and node numbers. The reader should refer to the CD to review model output.

Recommendations for distribution improvement projects were based on modeling, as outlined above, and guidance provided by Santaquin personnel. Because they will provide distribution to and from future sources and tanks, the alignments of these projects may need to change as the locations of tanks and sources are more precisely determined.

Several revisions to existing pressure zones are proposed in order to preserve supply in tanks, reduce required pumping, and save energy. Revised pressure zone boundaries are shown in Fig 1-2 of this report and in the master plan map in Appendix A. Elevations of the proposed pressure zones are included in Appendix C.

The locations and lengths of future distribution pipelines will vary depending on the final location of future streets. Anticipated future pipes 10 inches in diameter and larger have been located according to zone demand following proposed road alignments. The locations of these pipes are illustrated on the Drinking Water Master Plan Map in Appendix A.

CHAPTER 6 SYSTEM OPTIMIZATION

ENERGY AND SYSTEM PERFORMANCE

Energy costs typically account for a substantial portion of a water utility's operating budget. The evaluation presented in this section provides guidance to Santaquin on how to operate its water system in the most efficient way.

Source Energy Costs

Producing, treating, and delivering high-quality water requires energy, which is usually a water utility's largest operational expense and can account for 30%–40% of municipal energy consumption (EPA 2015). Efforts to increase energy efficiency bring financial savings and can facilitate improvements in water quality and hydraulic performance. As part of the optimization analysis, HAL estimated the energy intensity associated with each source in the distribution system.

To analyze well performance, the estimated energy intensity of each well was calculated based on its total dynamic head. This value was then compared to the observed energy intensity calculated based on three years of meter and billing data. The results for each of the City's sources are presented in Figure 6-1. Modeling had to be used to infer the performance of the winter operation of Summit Ridge well, due to limited available data.

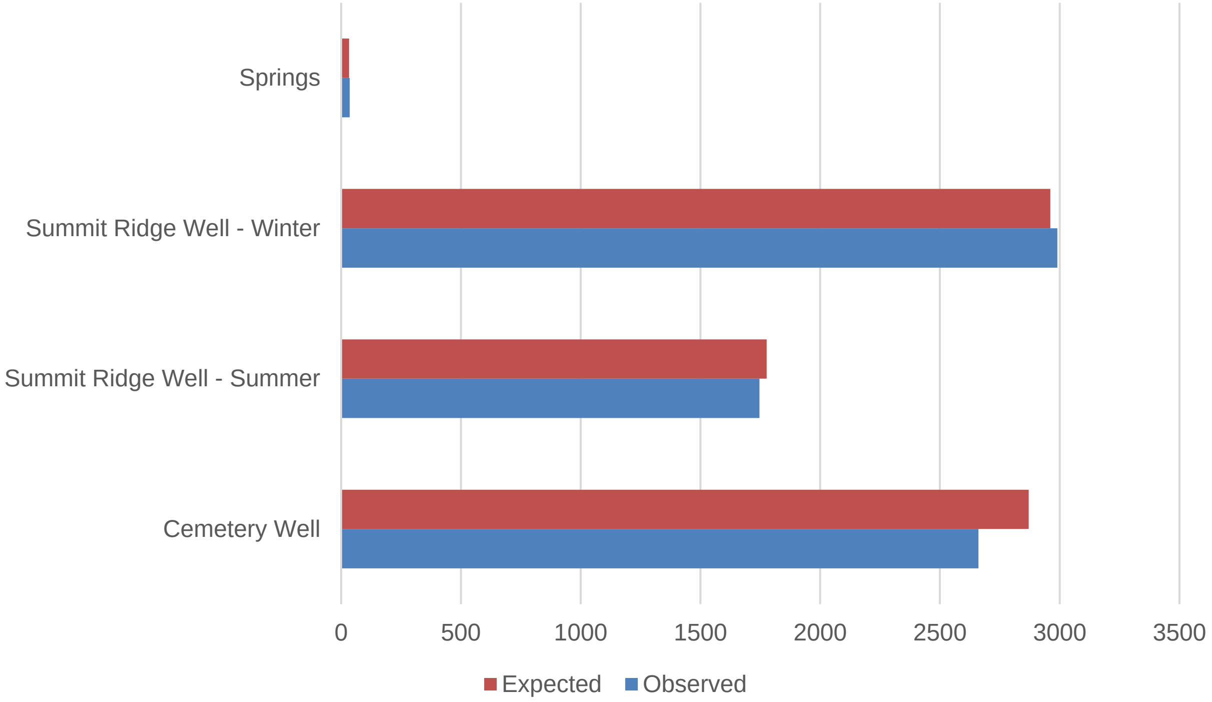


Figure 6-1: Expected vs. Observed Source Energy Intensity (kWh/MG)

Conclusions from this analysis are as follows:

- The City's wells are operating within expected limits for efficiency.
- Springs 2-5 are the most efficient water source for the system, and should be used to their maximum extent.
- Summit Ridge Well is a more efficient source of water than the Cemetery well due to a lower total dynamic head across the pump. It is a preferable source for Zones 10 and 9N. Because water from Summit Ridge Well must be pumped again to reach Zone 11E, it is comparable to the Cemetery Well from an energy perspective.

Pumping Operation

Some pump operation schemes are more efficient than others. "Loading" is a common inefficiency HAL has observed in water systems throughout the United States. Loading occurs when pumps are oversized or storage facilities are undersized. An example schematic of loading is shown in Figure 6-2.

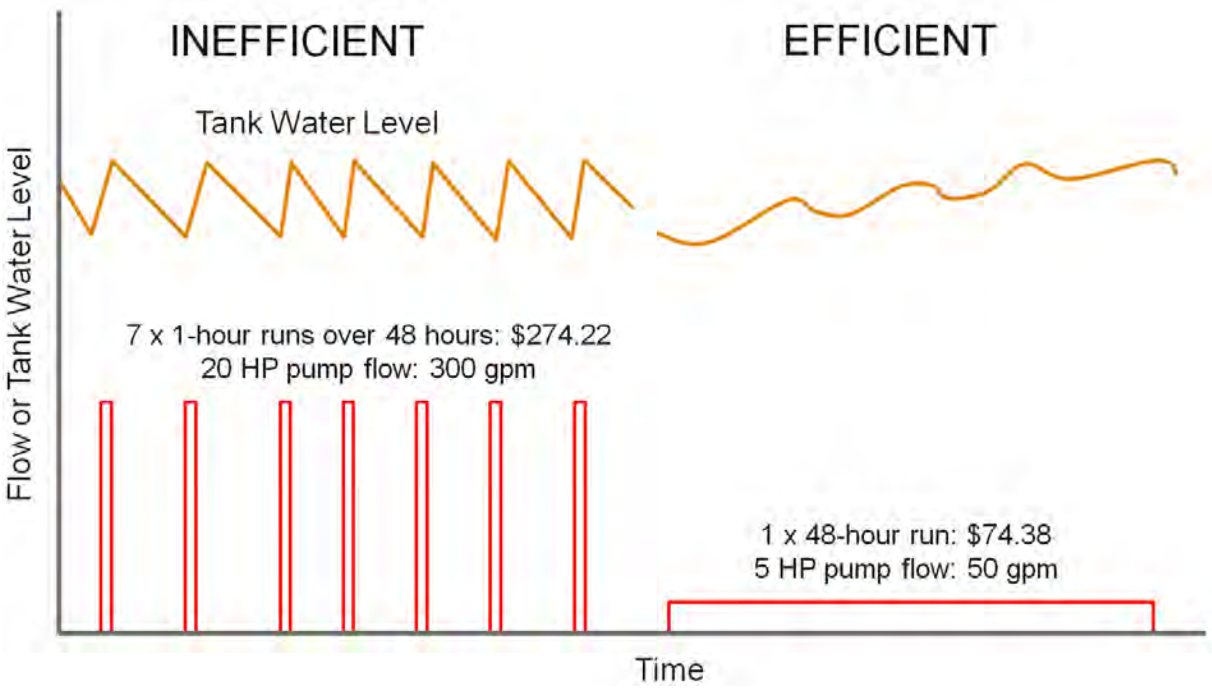


Figure 6-2: Pump Loading (example)

Loading can substantially increase head loss, which amounts to wasted energy. It also leads to a much higher electrical demand charge than may be necessary.

The Summit Ridge Well is prone to loading both because of its high flow capacity and because the tank in Zone 10 is undersized. To prevent rapid cycling of the Summit Ridge Well, the City has programmed their booster stations to work in conjunction with the Summit Ridge Well to fill all tanks simultaneously. This control scheme has operational benefits, but also causes some of the City's spring water to overflow to the PI system via the bypass. When this occurs, the least expensive water (from Springs 2-5) is replaced by more expensive water from the Summit Ridge Well. This water must then be pumped to Zone 11E, which adds additional expense. A more energy- and cost-efficient approach would be to take full advantage of the inexpensive spring water, and supplement with wells only as necessary.

Typically, HAL recommends the installation of a VFD to reduce loading. However, the Summit Ridge Well is currently equipped with a VFD, and runs on the lowest possible setting when pumping into Zone 10. Higher settings are used if pumping to Zone 11W.

The following actions would decrease loading, thereby saving energy and money:

- Construct additional storage in Zone 10.
- Modify the Summit Ridge well pump so it can pump into Zone 10 at a range of flows (using a VFD).
- Reconfigure the pumping control scheme for the Zone 11E pump station so that the full flow of the springs can always be used. To do so, the pump station would need to shut off before completely filling the tank. This would allow spring flow to continue to fill the tank, rather than spill.

WATER USE PRIORITY

Considering the energy intensity of each source, and all other information presented in this report, HAL recommends prioritizing the use of drinking water sources according to the following rules:

1. Springs 2-5 should always be the preferred source. They are much less expensive than either of the wells. They should be used to their maximum capacity.
2. At this time, it makes sense to use the Cemetery Well as the first supplemental source to the springs during periods of lower demand (winter, spring, and fall). This is due to the small amount of storage in Zone 10, which makes it difficult to operate the Summit Ridge Well.
3. During the peak summer demand period, Summit Ridge Well should be used as the first source to supplement the springs. Cemetery Well generally should not be needed during the summer period.
4. When more storage is constructed in Zone 10, Summit Ridge Well should be the preferred year-round source of water for the zone. Cemetery Well should function chiefly as a backup supply.

NON-REVENUE WATER

Every water system loses some water or at least cannot account for the fate of all water produced. This water, which is not billed for, is commonly known as non-revenue water. Mechanisms for non-revenue water include the following:

- Leaks from pipes or at tanks
- Water line breaks
- Hydrant flushing
- Construction water use
- Pumping to waste
- Unmetered users

Water production data and billing data for years 2017 through 2019 was analyzed to quantify the non-revenue water produced in the Santaquin City drinking water system. Results are summarized in Table 6-1.

Table 6-1
Non-Revenue Water in the Santaquin Drinking Water System

Year	Water Supplied (ac-ft)	Water Billed	Non-Revenue Water (ac-ft)	**Non-Revenue Percentage**
2017	1,426.0	936.5	489.5	**34%**
2018	1,484.3	861.7	622.6	**42%**
2019	1,270.9	886.49	384.4	**30%**

The United States Environmental Protection Agency reports a typical national rate of non-revenue water of 16% (EPA 2013). HAL often sees non-revenue water percentages of 15-30% in Utah. Based on data from the last three years, it appears that non-revenue water is a persistent problem in Santaquin.

Each year, Santaquin increases their metering capabilities and improves the accuracy of their water metering and tracking data. This may explain why the reported non-revenue water in 2019 is less than the previous two years.

The most likely explanation for the high percentage of non-revenue water in Santaquin is leakage. Accordingly, HAL makes the following recommendations:

1. Plan and budget for a leak detection program. Finding and repairing even one or two leaks can result in substantial water and cost savings over time.
2. Plan for and fund a pipeline replacement program. Routine pipe replacement is a recommended best practice for any water systems, as pipes have a finite service life. However, proactive pipeline replacement has the added benefit of reducing water main line breaks and leaks, which tend to increase as pipes age. See Chapter 7 for recommendations on facility replacement.

A water loss audit was performed as a part of this master planning effort. More detailed information on water loss is included in Appendix C.

CHAPTER 7 CAPITAL FACILITY PLAN

INTRODUCTION

The purpose of this section is to identify the drinking water facilities that are required, for the 20-year planning period, to meet the demands placed on the system by future development. Proposed facilities were sized to meet master plan requirements and located to accommodate 20-year growth projections. Each capital facility plan project will require a detailed design analysis before construction to ensure that the location and sizing is appropriate for the actual growth that has taken place since this capital facility plan (CFP) was developed. Specific projects with estimated costs are presented at the end of this chapter.

GROWTH PROJECTIONS

Areas of expected growth within 10 years and within 20 years were identified based on existing development patterns, population projections, and discussions with City personnel. These areas are shown on Figure 7-1.

Most development pressure in Santaquin is occurring in the Summit Ridge Development, on the East Bench, and on the northern end of the City. Growth in each of these areas is expected to continue for more than 20 years. Scattered infill and redevelopment within the main town are also expected.

Changes to Expected Growth Areas

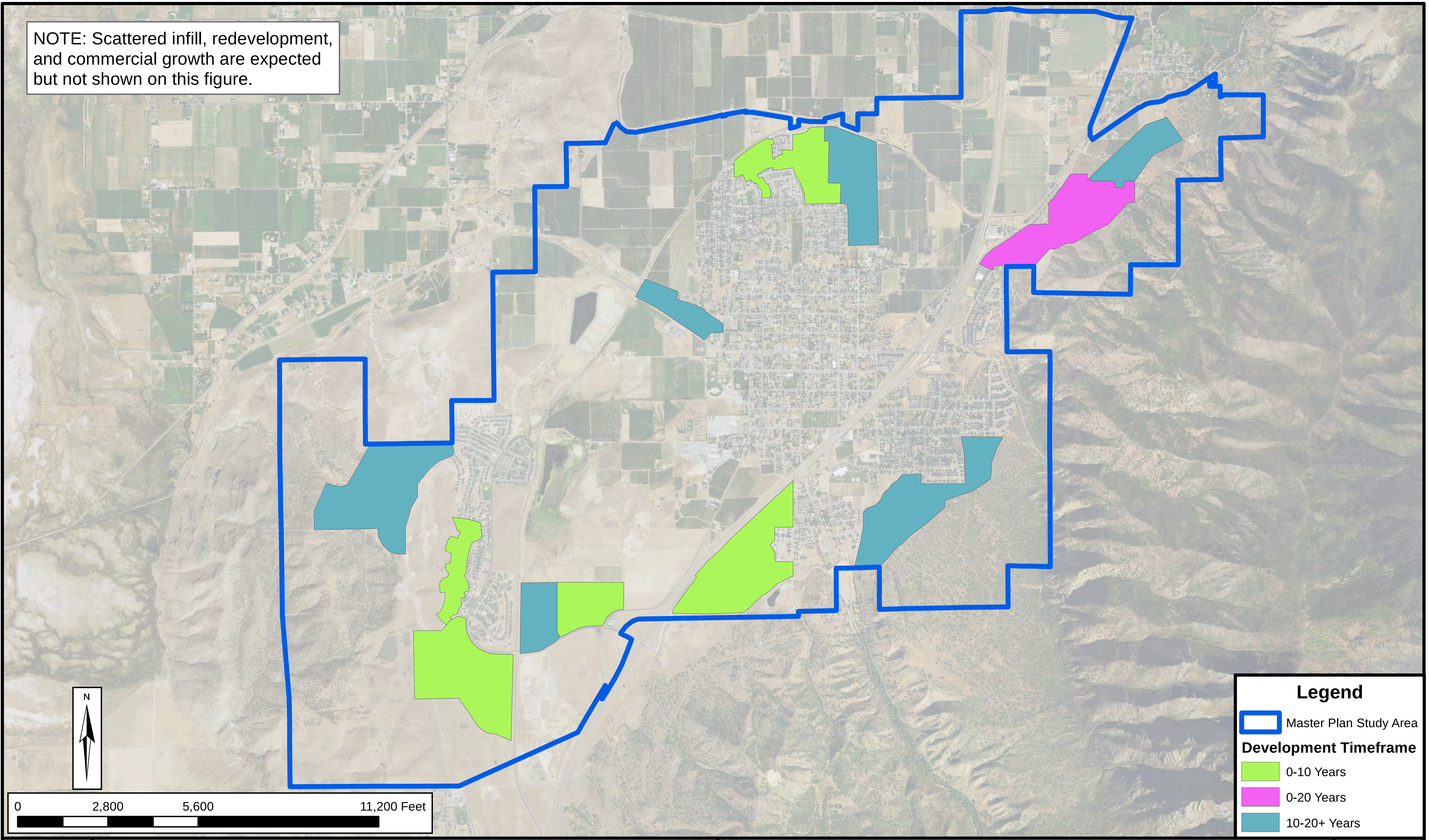
The Master Plan is intended to incorporate a reasonable degree of flexibility. Minor developments or infill developments not anticipated in the City’s growth projections can generally be served after a site-level evaluation, without substantial changes to the master plan. If growth patterns change substantially from those predicted, however, it is recommended that the assumptions in this master plan be re-evaluated to ensure the City is planning properly for the growth that actually occurs.

Large Developments

For large developments that will be constructed in a number of phases over a number of years, it is recommended that the City require a utilities phasing plan as part of the development agreement. A utilities phasing plan clearly defines when and how key infrastructure will be constructed within the development. The utilities phasing plan should be negotiated in such a way that it will protect the City’s financial interests and hold the developer responsible for supporting growth in that development – even if ownership changes.

In Santaquin, it is recommended that utilities phasing plans be required for the following types of developments:

- Developments larger than 10 acres
- Developments that will be constructed in multiple phases or issue multiple plats
- Areas being evaluated for annexation



NOTE: Scattered infill, redevelopment, and commercial growth are expected but not shown on this figure.

Legend

▭ Master Plan Study Area

Development Timeframe

🟩 0-10 Years

🟪 0-20 Years

🟦 10-20+ Years

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CAPITAL FACILITY PLAN (0 - 20 YEARS)
PROJECTED AREAS OF DEVELOPMENT

FIGURE
7-1

Date: 8/21/2020
Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Figure 7-1 growth areas.mxd

In a typical utilities phasing plan, the construction of infrastructure is tied directly to the number of residential units (or square footage of nonresidential space) permitted to be constructed within the development. An example utilities phasing agreement for drinking water might include the following components:

- Additional drinking water storage capacity must be provided before more than [#] units are permitted to be constructed within the development.
- Separate PI source and storage must be provided before more than [#] units are permitted to be constructed within the development.

METHODOLOGY

Growth projections were used to forecast future water demands on a year-by-year basis, which were then compared to the capacity of existing source and storage facilities. When this analysis showed that existing facilities would not have capacity for the 20-year planning period, solutions were identified to ensure that the City can meet demands at the proposed level of service.

A hydraulic model was developed for the purpose of assessing the system operation and capacity with future demands added to the system. The model was used to identify problem areas in the system and to identify the most efficient way to make improvements to distribution pipelines, sources, pumps, and storage facilities. Solutions and alternatives were discussed with City staff.

The drinking water system supplements the PI water system in certain areas of the City. In several cases, the most efficient approach to maintain capacity in the drinking water system will be to provide PI source to an area currently served by drinking water sources, rather than build additional capacity into the drinking water system. **This drinking water capital facility plan assumes that all projects listed herein and in the pressurized irrigation capital facility plan (presented in a separate document) will be constructed in a timely manner, as identified in their respective master plans.** If this is not the case, the drinking water projects in this chapter need to be re-evaluated.

The future system was evaluated in the same manner as the existing system, by modeling (1) peak instantaneous demands and (2) peak day demands plus fire flow conditions.

RECOMMENDED PROJECTS AND COSTS

As discussed in previous chapters, source, storage and distribution system capacity expansion will be needed to meet the demands of future growth. Cost estimates have been prepared for the recommended projects and are summarized in following tables and included in detail in Appendix F.

Unit costs for the construction cost estimates are based on conceptual level engineering. Sources used to estimate construction costs include:

1. “Means Heavy Construction Cost Data, 2019"
2. Price quotes from equipment suppliers
3. Recent construction bids for similar work

All costs are presented in 2020 dollars.

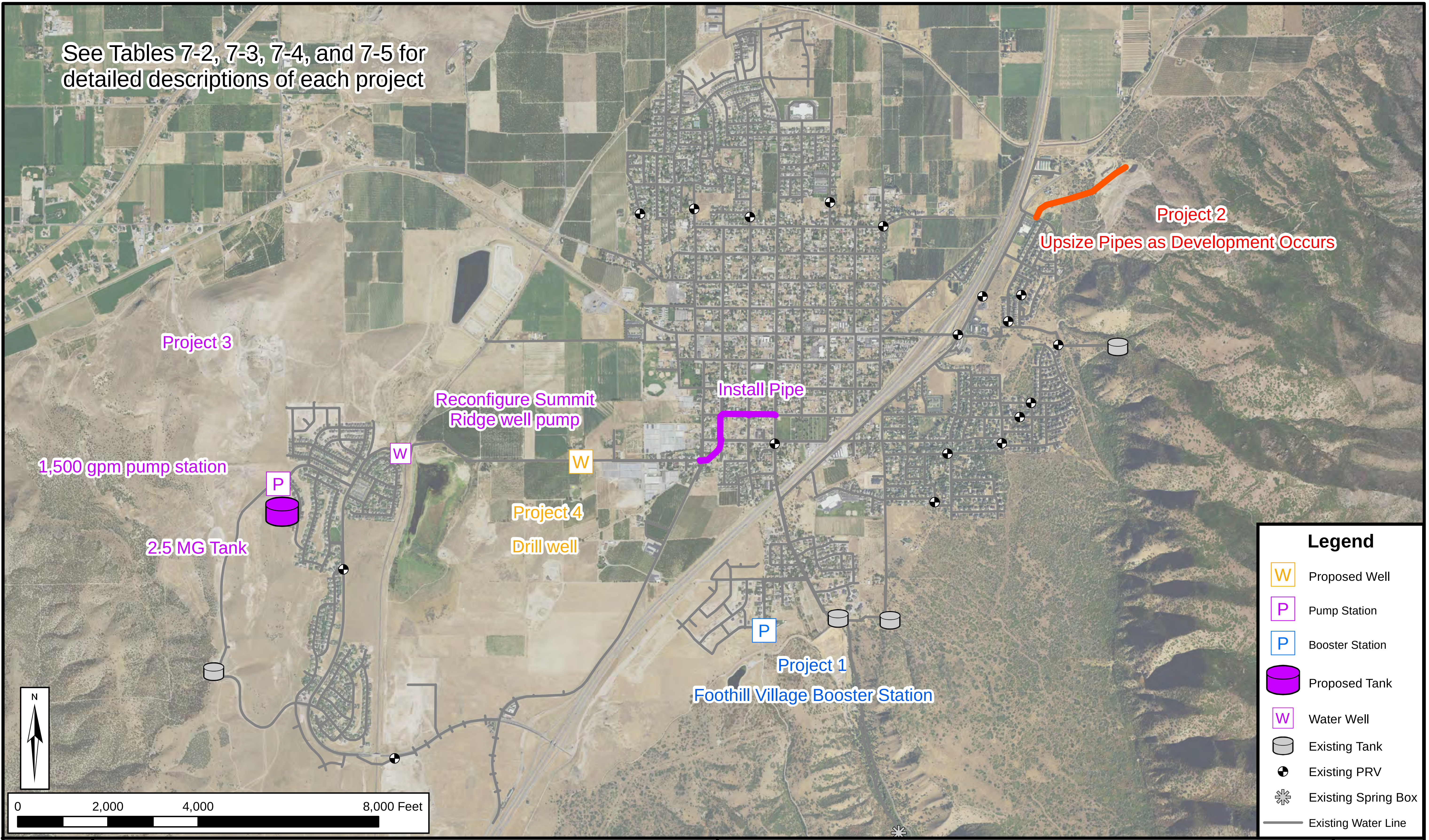
Precision of Cost Estimates

Master plan projects are a high-level representation of the infrastructure the City will need to construct in order to correct deficiencies or meet growth. However, due to the many unknown factors at this stage of design (such as alignment and depth of pipelines, utility conflicts, the cost of land and easements, construction methodology, types of equipment and material to be used, interest and inflation rates, permitting requirements, etc.), there is a significant level of uncertainty in estimated costs.

Every effort has been made to produce cost estimates which will help the City prepare a responsible budget that will meet the City's needs without being excessive or unreasonable. However, it is recommended that the City plan additional contingency into the budget when preparing to complete individual projects.

GROWTH-RELATED PROJECTS

A summary of the estimated cost of each growth-related project is included in Table 7-1. Projects are shown on Figures 7-2 and 7-3. Tables 7-2 through 7-5 include more detailed descriptions of the recommended projects, organized by project type (source, storage, distribution, or efficiency).



See Tables 7-2, 7-3, 7-4, and 7-5 for detailed descriptions of each project

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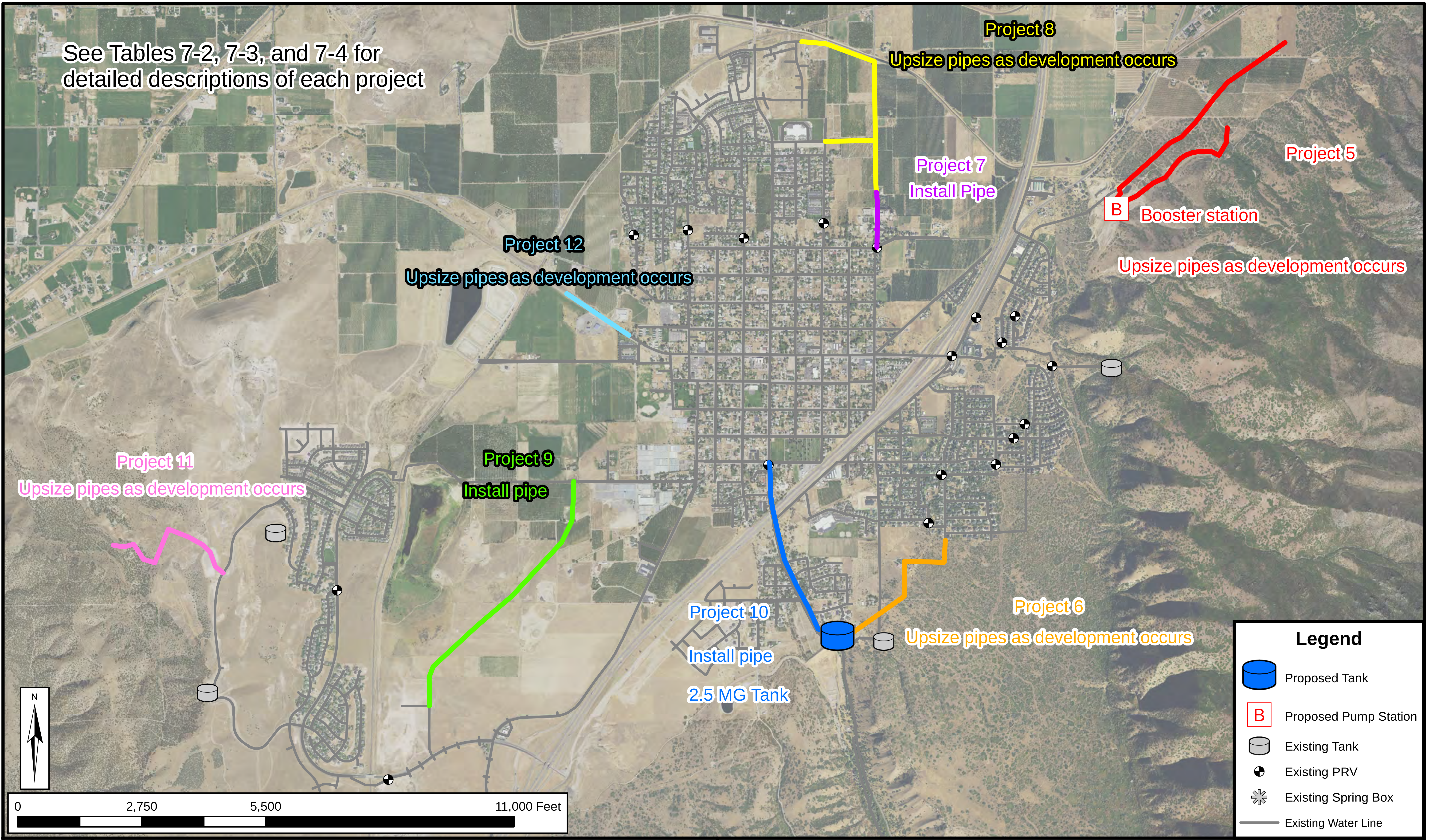
RECOMMENDED GROWTH PROJECTS
0-10 YEAR TIMEFRAME

FIGURE
7-2

Date: 9/16/2020
Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Figure 7-2 CFP Projects 0-10 yr.mxd



See Tables 7-2, 7-3, and 7-4 for detailed descriptions of each project

Date: 8/28/2020
Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Figure 7-3 CFP Projects 10-20 yr.mxd

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SANTAQUIN DRINKING WATER MASTER PLAN

RECOMMENDED GROWTH PROJECTS
10-20 YEAR TIMEFRAME

FIGURE
7-3

Table 7-1
Estimated Costs for Growth-Related Projects

Trigger	Figure Number	Figure ID[1]	Project Type(s) Included[2]	Estimated Phasing Year[3]	Cost
Development	7-2	1	Source	**2021**	$600,000
Development	7-2	2	Distribution	**0-5 Years**	$52,000
System Growth	7-2	3	Source, Storage, Distribution, Efficiency	**2021**	$4,431,000
System Growth	7-2	4	Source	**2021**	$1,584,000
Development	7-3	5	Source, Distribution	**10-20 Years**	$1,403,000
Development	7-3	6	Distribution	**10-20 Years**	$80,000
Development	7-3	7	Distribution	**10-20 Years**	$234,000
System Growth	7-3	8	Distribution	**10-20 Years**	$198,000
Development	7-3	9	Distribution	**10-20 Years**	$968,000
System Growth	7-3	10	Storage, Distribution	**10-20 Years**	$4,248,000
Development	7-3	11	Distribution	**10-20 Years**	$99,000
Development	7-3	12	Distribution	**10-20 Years**	$39,000
				Subtotal 0 – 10 Years	$6,667,000
				Subtotal 10 – 20 Years	$7,269,000
				Total	**$13,936,000**

1. ID refers to the ID numbers shown on Figures 7-2 and 7-3.
2. See Tables 7-2 for source projects, 7-3 for storage projects, 7-4 for distribution projects, and 7-5 for efficiency projects.
3. The phasing year for development-driven projects is estimated, but development-driven projects are not necessary until the area develops. This may occur earlier or later than listed in this document.

Recommended source projects are shown in Table 7-2 and on Figure 7-2.

Table 7-2
Recommended Source Projects

Type & Phasing Year	Figure Number	Map ID	Recommended Project	Cost
Source – Growth Project **2021**	7-2	1	Construct a booster pump station to serve the Zone 12E portion of the Foothill Village development.	$600,000
Source – Growth Project **2021**	7-2	3	Construct a 1,500 gpm booster station to serve Zone 11W. Must be constructed along with the storage and distribution components of this project (Tables 7-3 and 7-4).	$1,200,000
Source – Growth Project **2021**	7-2	4	Drill a well to provide redundant source for new growth.[1]	$1,584,000
Source – Growth Project **Development-Driven**	7-3	5	Construct a booster station to serve Zone 11NE. This will be required only when development occurs in this area.	$900,000
Total				**$4,284,000**

1. It is assumed that the well will have sufficient yield to provide source capacity through the 20-year window (considering that some drinking water demands will be replaced when additional irrigation source water is available from the planned ULS pipeline). See Chapter 3 of the Pressurized Irrigation Master Plan report for further discussion on this pipeline. If yield on the planned well is poor, an additional well may be necessary.

Recommended storage projects are shown in Table 7-3 and on Figures 7-2 and 7-3.

Table 7-3
Recommended Storage Projects

Type & Phasing Year	Figure Number	Map ID	Recommended Project	Cost
Storage – Growth Project **2021**	7-2	3	Construct a 2.5 MG tank to serve Zone 10, including the Zone 10W portion of Summit Ridge. Includes associated piping. Connect the Zone 10 portion of the Summit Ridge development to the 16-inch pipeline supplying the tank. Must be constructed along with the source and distribution components of this project (Tables 7-2 and 7-4).	$3,036,000
Storage – Growth Project **10 – 20 Years**	7-3	10	Replace the existing Zone 10 tank with a 2.5 MG tank to provide capacity for future growth. Must be constructed along with the distribution component of this project (Table 7-4).	$3,000,000
Total				**$6,036,000**

Projects 3 and 10 both address the City's need for additional storage capacity in Zone 10. Each has advantages and disadvantages, as discussed in Chapter 4, and either would meet the near-term needs of the City if constructed. It is recommended that one of these projects be constructed beginning in year 2021.

Recommended distribution projects (including PRVs) are shown in Table 7-4 and on Figures 7-2 and 7-3.

Table 7-4
Recommended Distribution Projects

Type & Phasing Year	Figure Number	Map ID	Recommended Project	Cost
Distribution – Growth Project **Development -Driven**	7-2	2	Upsize approximately 2300 ft of pipe to 10-inch diameter in SR 198 to serve growth and provide capacity for future growth in the northeastern portion of the City.	$52,000
Distribution – Growth Project **2021**	7-2	3	Install approximately 700 ft of 16-inch diameter pipe and 1800 ft of 12-inch diameter pipe to provide distribution capacity from the western portion of Zone 10 to the eastern portion of Zone 10. Must be constructed along with the source and storage components of this project (Tables 7-2 and 7-3).	$459,000
Distribution – Growth Project **Development -Driven**	7-3	5	Upsize approximately 8900 ft of pipe to 10-inch diameter in Zones 10 and 11NE to serve growth and provide future capacity in the northeastern portion of the City.	$203,000
Distribution – Growth Project **Development -Driven**	7-3	6	Upsize approximately 3500 ft of pipe to 10-inch diameter in Zone 12E to serve growth and provide future capacity.	$80,000
Distribution – Growth Project **10-20 yrs**	7-3	7	Install approximately 1200 ft of 12-inch diameter pipe and a PRV to serve growth and provide future capacity in Zone 9N.	$234,000
Distribution – Growth Project **Development -Driven**	7-3	8	Upsize approximately 5700 ft of pipe to 12-inch diameter in Zone 9N to serve growth and provide future capacity.	$198,000
Distribution – Growth Project **10-20 yrs**	7-3	9	Install approximately 6300 ft of 10-inch diameter pipeline in a planned future road to serve the western portion of Zone 10.	$968,000

Type & Phasing Year	Figure Number	Map ID	Recommended Project	Cost
Distribution – Growth Project **10-20 yrs**	7-3	10	Install approximately 4200 ft of 20-inch diameter pipeline in Center Street and Canyon Road to provide increased capacity to the Z10 tank site and the Z11E booster. Must be constructed along with the storage component of this project (Table 7-3).	$1,248,000
Distribution – Growth Project **Development -Driven**	7-3	11	Upsize approximately 1900 ft of pipe to 10-inch diameter and 1600 ft of pipe to 12-inch diameter to serve growth and provide future capacity in Zone 11W.	$99,000
Distribution – Growth Project **Development -Driven**	7-3	12	Upsize approximately 1700 ft of pipe to 10-inch diameter to serve the northwestern portion of Zone 10.	$39,000
Total				**$3,579,000**

Recommended efficiency projects are shown in Table 7-5 and on Figure 7-2. Costs in Table 7-5 are not impact fee-eligible, but will provide the City with long-term energy savings. Incentives from Rocky Mountain Power may be available to assist the City with paying the initial cost.

Table 7-5
Recommended Efficiency Projects

Type & Phasing Year	Map ID	Recommended Project	Cost
Efficiency Project **2021**	3 (Fig 7-2)	Remove a bowl from the Summit Ridge Well pump to enable the well to pump to Zone 10 head with better VFD control (this is recommended after the new Zone 10 tank is constructed). This will allow the City to reduce the monthly demand charge, reduce overflow of spring water, and improve the operation of the well. This cannot be accomplished until the source, storage, and transmission components of this project (Tables 7-2, 7-3, and 7-4) are complete.	$36,000
Efficiency Project **0-5 Years**	N/A	Commission a leak detection and repair program in order to save energy, money, and water.	$40,000
Total			**$76,000**

The leak detection study revealed that the value of unaccounted-for water produced each year in Santaquin has a value of approximately $23,000 (see Appendix C). The budget for the leak detection project was formulated by assuming unaccounted-for water could be reduced by approximately 25% ($5,000 per year), with a desired payback of 8 years. The City is free to spend more or less money on leak detection depending on available resources and City priorities.

MAINTENANCE OR DEFICIENCY PROJECTS

This section contains maintenance or deficiency-related projects for the City's consideration. These projects would not be impact fee-eligible and are not required to be implemented, but will provide certain benefits that the City may find worthwhile. These projects should be considered and implemented as resources allow and as priority dictates.

Fire Flow Projects

As discussed in Chapter 5, several areas of the City cannot provide the recommended fire flow of 1,500 gpm. Construction in these areas was approved with this understanding. However, projects to provide a minimum of 1,500 gpm of fire flow were identified in order to inform the City what would be required if it becomes a priority to increase fire flow capacity in these areas. A brief description of each project is listed in Table 7-6. Projects are shown on Figure 7-4.

Table 7-6
Fire Flow Projects Required to Provide 1,500 gpm

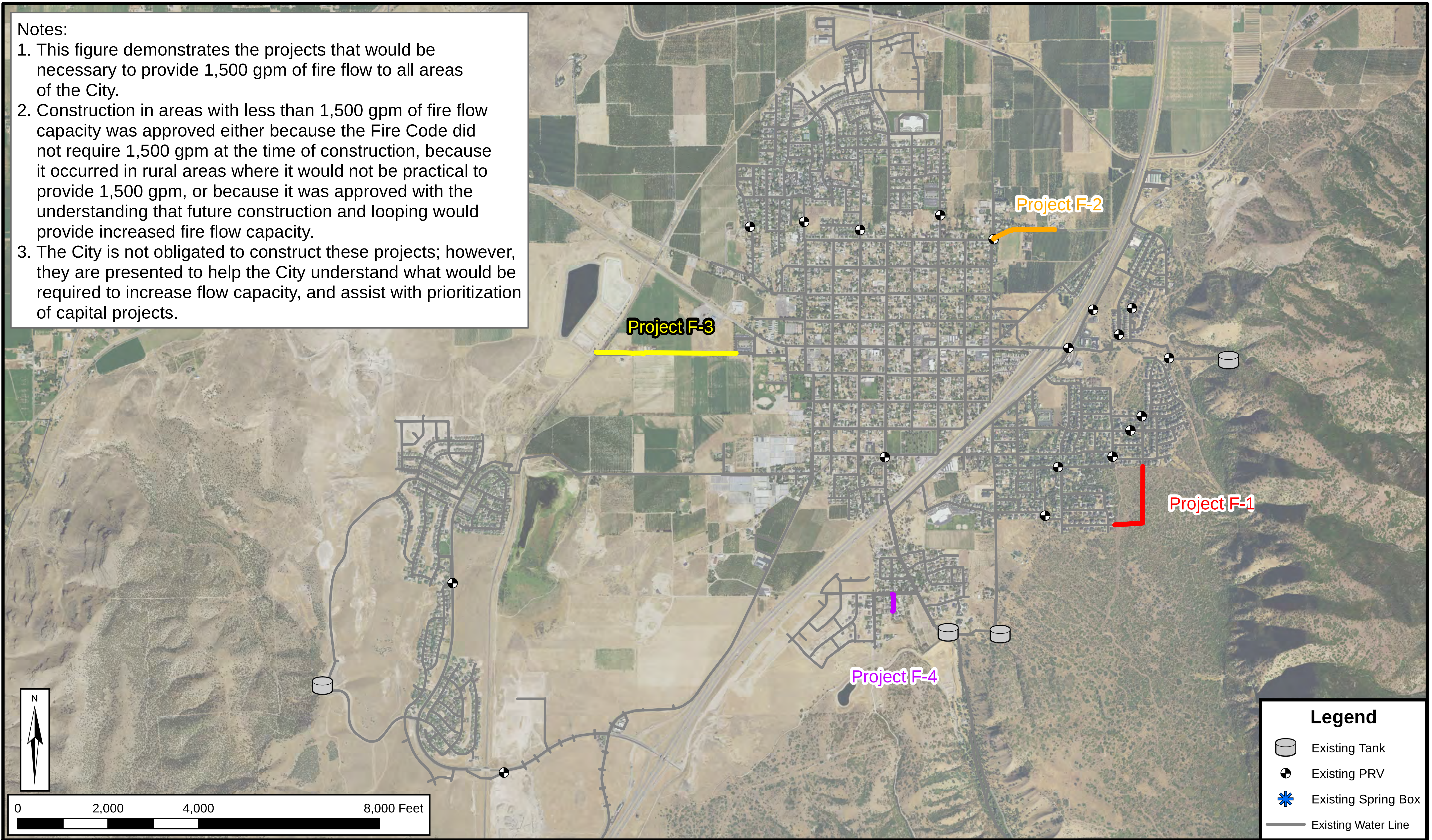
Type & Phasing Year	Map ID	Recommended Project	Cost
Distribution – Fire Flow Project **0-5 Years**	F-1	Install approximately 1900 ft of 8-inch diameter distribution pipe to create a loop and solve existing fire flow deficiencies in Zone 12E.	$249,000
Distribution – Fire Flow Project **0-5 Years**	F-2	Install approximately 1400 ft of 12-inch diameter distribution pipe in 400 N from 400 E to the easternmost existing hydrant in the street. The cost of an 8-inch pipe is attributable to correcting the fire deficiency; an upsize to 12-inch would be attributable to growth.	$183,000 (Deficiency) $49,000 (Growth)
Distribution – Fire Flow Project **0-5 Years**	F-3	Install approximately 3100 ft of 10-inch diameter distribution pipe in 14000 S (County) from 500 W to the Winter Storage Ponds to solve existing fire flow deficiencies along that road.	$506,000
Distribution – Fire Flow Project **0-5 Years**	F-4	Install approximately 400 ft of 8-inch diameter distribution pipe in Center Street to solve the existing fire flow deficiency.	$52,000
Total			**$1,039,000**

Facility Replacement

Water system components have a finite service life. It is recommended that the City establish an annual budget for replacement of facilities which are beyond their useful service life or are experiencing problems (breaks, leakage, etc.). The typical service life of water system components is shown in Table 7-7, along with a calculation showing a recommended long-term annual depreciation budget for the City.

Notes:

1. This figure demonstrates the projects that would be necessary to provide 1,500 gpm of fire flow to all areas of the City.
2. Construction in areas with less than 1,500 gpm of fire flow capacity was approved either because the Fire Code did not require 1,500 gpm at the time of construction, because it occurred in rural areas where it would not be practical to provide 1,500 gpm, or because it was approved with the understanding that future construction and looping would provide increased fire flow capacity.
3. The City is not obligated to construct these projects; however, they are presented to help the City understand what would be required to increase flow capacity, and assist with prioritization of capital projects.



Legend

- Existing Tank
- ● Existing PRV
- ✱ Existing Spring Box
- — Existing Water Line

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SANTAQUIN DRINKING WATER MASTER PLAN

PROJECTS REQUIRED TO PROVIDE 1,500 GPM FIRE FLOW CAPACITY

FIGURE
7-4

Date: 8/28/2020
Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Figure 7-4 Fire Flow projects.mxd

Table 7-7
Recommended Long-Term Annual Replacement Budget

Component	Service Life (Years)	Unit Cost ($)	Quantity	Replacement Value ($)	Recommended Annual Budget ($)
Storage Tank	75	$1.00/gal	3.76 MG	$3,760,000	$50,000
Well	50	$1.5M/well	3 Wells	$4,500,000	$90,000
Pipeline	60	$60/ft	410,000 ft	$24,600,000	$410,000
			Total	**$32,860,000**	**$550,000**

Because many facilities in Santaquin are quite new, it may be appropriate for the City to begin with a lower budget than is listed in Table 7-7.

FUNDING OPTIONS

Funding options for the recommended projects, in addition to water use fees, include: general obligation bonds, revenue bonds, State/Federal grants and loans, and impact fees. In reality, the City may need to consider a combination of these funding options. The following discussion describes each of these options.

General Obligation Bonds

This form of debt enables the City to issue general obligation bonds for capital improvements and replacement. General Obligation (G.O.) bonds would be used for items not typically financed through the Water Revenue Bonds (for example, the purchase of water source to ensure a sufficient water supply for the City in the future). G.O. bonds are debt instruments backed by the full faith and credit of the City which would be secured by an unconditional pledge of the City to levy assessments, charges, or ad valorem taxes necessary to retire the bonds. G.O. bonds are the lowest-cost form of debt financing available to local governments and can be combined with other revenue sources such as specific fees, or special assessment charges to form a dual security through the City’s revenue-generating authority. These bonds are supported by the City as a whole, so the amount of debt issued for the water system is limited to a fixed percentage of the real market value for taxable property within the City. G.O. bonds must be approved by a citizen vote.

Revenue Bonds

This form of debt financing is also available to the City for utility-related capital improvements. Unlike G.O. bonds, revenue bonds are not backed by the City as a whole, but constitute a lien against the water service charge revenues of a Water Utility. Revenue bonds present a greater risk to the lender than do G.O. bonds, since repayment of debt depends on an adequate revenue stream, legally defensible rate structure, and sound fiscal management by the issuing jurisdiction. Due to this increased risk, revenue bonds generally require a higher interest rate than G.O. bonds, although current interest rates are quite low. This type of debt also has very specific coverage requirements in the form of a reserve fund specifying an amount, usually expressed in terms of average or maximum debt service due in any future year. This debt service is required to be held as a cash reserve for annual debt service payment to the benefit of bondholders. Typically, voter approval is not required when issuing revenue bonds.

State or Federal Grants and Loans

Historically, both local and county governments have experienced significant infrastructure funding support from state and federal government agencies in the form of block grants, direct grants in aid, interagency loans, and general revenue sharing. Federal expenditure pressures and virtual elimination of federal revenue sharing are clear indicators that local government may be left to its own devices regarding infrastructure finance in general. However, state or federal grants and loans should be further investigated as a possible funding source for needed water system improvements.

It is also important to assess likely trends regarding state or federal assistance in infrastructure financing. Future trends indicate that grants will be replaced by loans through a public works revolving fund. Local governments can expect to access these revolving funds or public works trust funds by demonstrating both the need for and the ability to repay the borrowed monies, with interest. As with the revenue bonds discussed earlier, the ability of infrastructure programs to wisely manage their own finances will be a key element in evaluating whether many secondary funding sources, such as federal/state loans, will be available to the City.

Impact Fees

The Utah Impact Fees Act, codified in Title 11, Chapter 36a, of the Utah Code, authorizes municipalities to collect impact fees to fund public facilities. An impact fee is “a payment of money imposed upon new development activity . . . to mitigate the impact of the new development on public infrastructure” (Subsection 11-36a-102(8)). Impact fees enable local governments to finance infrastructure improvements without burdening existing development with costs that are exclusively attributable to growth.

Impact fees can be applied to water-related facilities under the Utah Impact Fees Act. The Act is designed to provide a logical and clear framework for establishing new development assessments. It is also designed to establish the basis for the fee calculation which the City must follow in order to comply with the statute. The fundamental objective for the fee structure is the imposition on new development of only those costs associated with providing or expanding water infrastructure to meet the capacity needs created by that specific new development. Impact fees cannot be applied retroactively.

An impact fee analysis has taken place as part of the 2020 master planning effort. It is described in a separate document.

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APPENDIX A

Drinking Water Master Plan Map

Date: 9/5/2020
Document Path: H:\Projects\415 - Santaquin\02.100 - Culinary Water Master Plan\GIS\Working\DW Appendix A Buildout system 2020_09_05.mxd

HANSEN ALLEN & LUCE INC
ENGINEERS

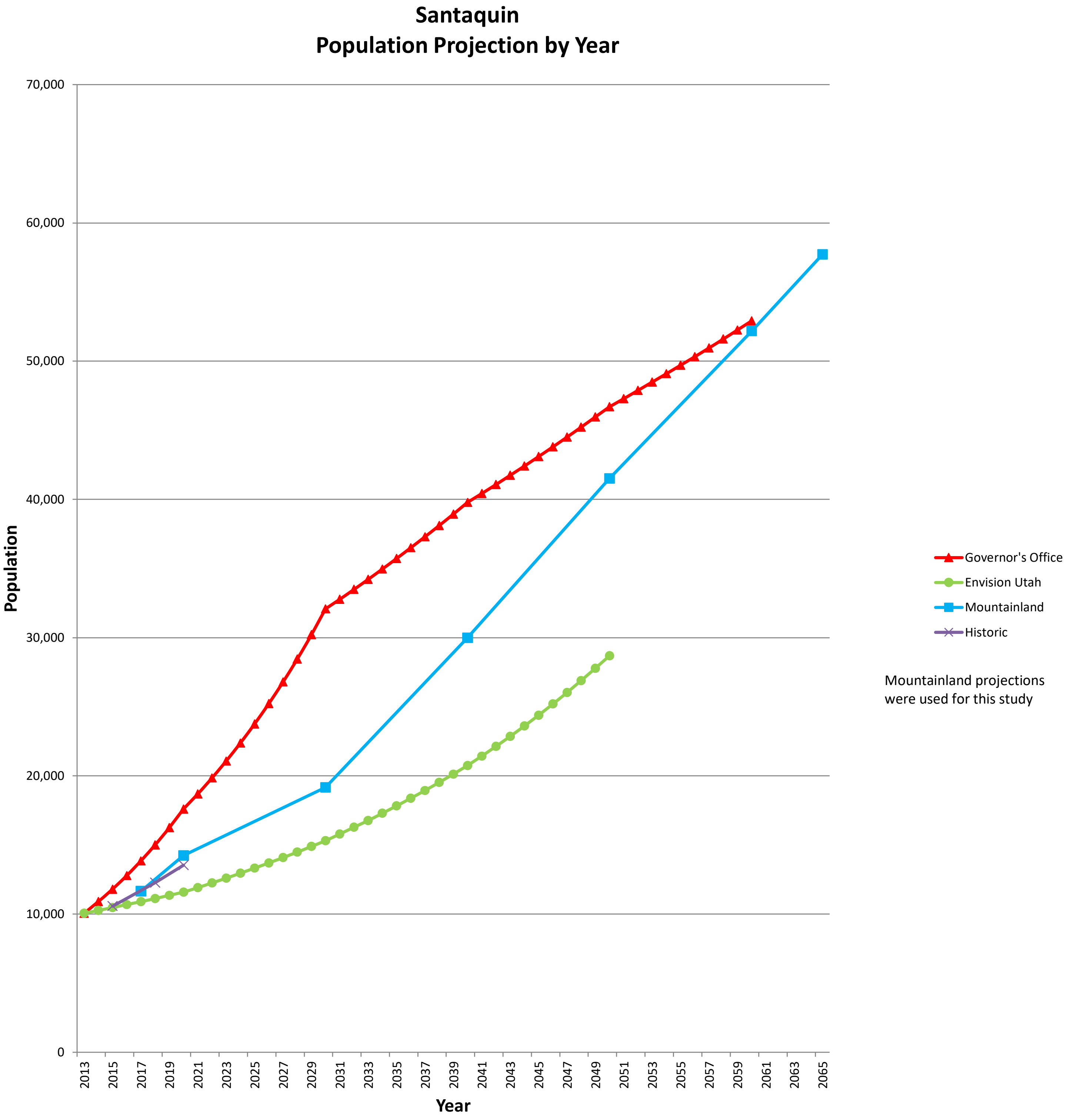
SANTAQUIN DRINKING WATER MASTER PLAN

2060 SYSTEM CONCEPT MAP

APPENDIX
A

APPENDIX B

Population Projections



Mountainland projections
were used for this study

APPENDIX C

Water System Data and Calculations

Santaquin City
2020 Drinking Water System Master Plan
Existing and Future Requirements
09/16/2020 RJG

Level of Service Parameter	Per ERC	Per irr-ac
Peak Day Source (gpm)	0.35	8
Average Yearly Source (ac-ft)	0.45	4
Storage (gal)	360	9200

Service (ERCs and irr-ac)

	Existing		10-yr		20-yr		2060	
Pressure Zone	**ERC**	**Irr-ac**	**ERC**	**Irr-ac**	**ERC**	**Irr-ac**	**ERC**	**Irr-ac**
8N	0	0	0	0	0	0	341	0
9N	812	0	1128	0	1821	0	3469	0
9W	0	0	0	0	0	0	141	0
10	2905	0	3970	0	4963	0	8778	0
10W	296	40	296	0	296	0	307	0
11W	256	55	652	0	1302	121	1403	0
11E	871	0	1128	0	1279	0	2416	0
11NE	0	0	0	0	88	21	143	30
12W	0	0	0	0	0	0	210	40
12E	226	30	226	30	591	96	856	0
12S	0	0	62	16	62	16	65	20
13E	0	0	0	0	0	0	420	85
14E	0	0	0	0	0	0	82	30
Totals	**5366**	**125.0**	**7462**	**46.0**	**10402**	**254.0**	**18631**	**205.0**

Peak Day Demand (gpm)

Pressure Zone	Existing	10-yr	20-yr	2060
8N	**0**	**0**	**0**	**118**
9N	**282**	**392**	**632**	**1205**
9W	**0**	**0**	**0**	**49**
10	**1009**	**1379**	**1723**	**3048**
10W	**423**	**103**	**103**	**107**
11W	**529**	**226**	**1420**	**487**
11E	**302**	**392**	**444**	**839**
11NE	**0**	**0**	**199**	**290**
12W	**0**	**0**	**0**	**393**
12E	**318**	**318**	**973**	**297**
12S	**0**	**150**	**150**	**183**
13E	**0**	**0**	**0**	**826**
14E	**0**	**0**	**0**	**268**
Totals	**2863**	**2959**	**5644**	**8109**

Average Yearly Demand (ac-ft)

Pressure Zone	Existing	10-yr	20-yr	2060
8N	**0.00**	**0.00**	**0.00**	**153.45**
9N	**365.40**	**507.60**	**819.45**	**1561.05**
9W	**0.00**	**0.00**	**0.00**	**63.45**
10	**1307.25**	**1786.70**	**2233.55**	**3950.30**
10W	**293.20**	**133.20**	**133.20**	**138.15**
11W	**335.20**	**293.40**	**1069.90**	**631.35**
11E	**391.95**	**507.60**	**575.55**	**1087.20**
11NE	**0.00**	**0.00**	**123.60**	**184.35**
12W	**0.00**	**0.00**	**0.00**	**254.50**
12E	**221.70**	**221.70**	**649.95**	**385.20**
12S	**0.00**	**91.90**	**91.90**	**109.25**
13E	**0.00**	**0.00**	**0.00**	**529.00**
14E	**0.00**	**0.00**	**0.00**	**156.90**
Totals	**2914.70**	**3542.10**	**5697.10**	**9204.15**

Storage (MG)

Pressure Zone	Existing	10-yr	20-yr	2060
8N	**0.00**	**0.00**	**0.00**	**0.12**
9N	**0.29**	**0.41**	**0.66**	**1.25**
9W	**0.00**	**0.00**	**0.00**	**0.05**
10	**1.05**	**1.43**	**1.79**	**3.16**
10W	**0.47**	**0.11**	**0.11**	**0.11**
11W	**0.60**	**0.23**	**1.58**	**0.51**
11E	**0.31**	**0.41**	**0.46**	**0.87**
11NE	**0.00**	**0.00**	**0.22**	**0.33**
12W	**0.00**	**0.00**	**0.00**	**0.44**
12E	**0.36**	**0.36**	**1.10**	**0.31**
12S	**0.00**	**0.17**	**0.17**	**0.21**
13E	**0.00**	**0.00**	**0.00**	**0.93**
14E	**0.00**	**0.00**	**0.00**	**0.31**
Totals	**3.08**	**3.11**	**6.08**	**8.59**

Recommended Drinking Water Pressure Zone Elevations

Zone	Recommended Maximum Service Elevation (ft)	Recommended Minimum Service Elevation Elevation (ft)	Recommended HGL (ft)
14E	5630	5470	5745
13E	5470	5300	5585
12E	5300	5150	5415
12W	5300	5150	5415
11NE	5150	5030	5265
11E	5150	5030	5265
11W	5180	5020	5295
10W	5020	4890	5135
10	5030	4890	5145
9N	4890	4800	5005
9W	4890	4700	5005
8N	4800	4640	4915

Notes:

1. HGL is approximate and intended to represent the static HGL when a tank is three-quarters full.
2. The elevation reference datum is as follows:

Projection:	UTM Zone 12
Vertical Datum:	NAVD88 (GEOID12B)
Horizontal Datum:	NAD83 (2011)
WKID:	6341

2018 LiDAR data was used. See:
https://gis.utah.gov/data/elevation-and-terrain/2018-lidar-central-utah/

Comparison of Proposed Level of Service to Former DDW Standards

This document shows a comparison of the former DDW drinking water standards with the proposed level of service standards.

This table summarizes the former DDW standards and the proposed level of service standards.

	Former DDW		Level of Service	
Level of Service Parameter	**Indoor (per ERC)**	**Outdoor (per irr-ac)**	**Indoor (per ERC)**	**Outdoor (per irr-ac)**
Peak Day Demand (gpd)	800	5702	500	11,520
Average Yearly Demand (ac-ft)	0.45	1.87	0.336	4

This table shows the calculated peak day demand and average yearly demand requirements under both the former DDW standard and the proposed level of service. The proposed level of service results in lower water requirements for both peak day demand and average yearly demand, for both existing and future scenarios.

	ERCs		Irrigated Acreage		Peak Day Demand (gpm)		Average Yearly Demand (ac-ft)	
Method	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**
Former DDW standard	5380	18630	125	185	3484	11083	2655	8729
Level of service	5380	18630	125	185	2868	7949	2308	7000
Difference	**0**	**0**	**0**	**0**	**-616**	**-3134**	**-347**	**-1730**

AWWA Free Water Audit Software:
Reporting Worksheet

WAS v5.0

? Click to access definition
\+ Click to add a comment

Water Audit Report for: Santaquin
Reporting Year: 2019 | 1/2019 - 12/2019

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

All volumes to be entered as: ACRE-FEET PER YEAR

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

<----------- Enter grading in column 'E' and 'J' ---------->

WATER SUPPLIED

Master Meter and Supply Error Adjustments

		Grade	Value	Unit	Grade	Pcnt:		Value:	Unit
Volume from own sources:	+ ?	7	1,955.810	acre-ft/yr	+ ?		● ○		acre-ft/yr
Water imported:	+ ?	n/a	0.000	acre-ft/yr	+ ?		● ○		acre-ft/yr
Water exported:	+ ?	7	684.890	acre-ft/yr	+ ?		● ○		acre-ft/yr
WATER SUPPLIED:			**1,270.920**	acre-ft/yr					

Enter negative % or value for under-registration
Enter positive % or value for over-registration

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

		Grade	Value	Unit	Pcnt:		Value:	Unit
Billed metered:	+ ?	7	886.490	acre-ft/yr				
Billed unmetered:	+ ?	n/a	0.000	acre-ft/yr				
Unbilled metered:	+ ?	n/a	0.000	acre-ft/yr				
Unbilled unmetered:	+ ?		15.887	acre-ft/yr	1.25%	● ○		acre-ft/yr

Default option selected for Unbilled unmetered - a grading of 5 is applied but not displayed

AUTHORIZED CONSUMPTION:	?		**902.377**	acre-ft/yr

Use buttons to select percentage of water supplied
OR
value

WATER LOSSES (Water Supplied - Authorized Consumption)

368.544 acre-ft/yr

Apparent Losses

		Grade	Value	Unit	Pcnt:		Value:	Unit
Unauthorized consumption:	+ ?		3.177	acre-ft/yr	0.25%	● ○		acre-ft/yr

Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

		Grade	Value	Unit	Pcnt		Value	Unit
Customer metering inaccuracies:	+ ?	7	0.000	acre-ft/yr	🟥	● ○		acre-ft/yr
Systematic data handling errors:	+ ?		2.216	acre-ft/yr	0.25%	● ○		acre-ft/yr

Default option selected for Systematic data handling errors - a grading of 5 is applied but not displayed

Apparent Losses:	?		**5.394**	acre-ft/yr

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses:	?		**363.150**	acre-ft/yr
WATER LOSSES:			**368.544**	acre-ft/yr

NON-REVENUE WATER

NON-REVENUE WATER:	?		**384.430**	acre-ft/yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

		Grade	Value	Unit
Length of mains:	+ ?	8	77.7	miles
Number of active AND inactive service connections:	+ ?	8	3,688	
Service connection density:	?		47	conn./mile main
Are customer meters typically located at the curbstop or property line?			Yes	
Average length of customer service line:	+ ?			(length of service line, beyond the property boundary, that is the responsibility of the utility)

Average length of customer service line has been set to zero and a data grading score of 10 has been applied

		Grade	Value	Unit
Average operating pressure:	+ ?	5	90.0	psi

COST DATA

		Grade	Value	Unit
Total annual cost of operating water system:	+ ?	6	$1,420,841	$/Year
Customer retail unit cost (applied to Apparent Losses):	+ ?	8	$2.11	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	+ ?	4	$33.04	$/acre-ft

☐ Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 65 out of 100 ***

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION:

Based on the information provided, audit accuracy can be improved by addressing the following components:

1: Volume from own sources

2: Variable production cost (applied to Real Losses)

3: Billed metered

AWWA Free Water Audit Software:
System Attributes and Performance Indicators

WAS v5.0

Water Audit Report for: Santaquin
Reporting Year: 2019 1/2019 - 12/2019

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 65 out of 100 ***

System Attributes:

Apparent Losses:	5.394	acre-ft/yr
+ Real Losses:	363.150	acre-ft/yr
= Water Losses:	368.544	acre-ft/yr
? Unavoidable Annual Real Losses (UARL):	98.14	acre-ft/yr
Annual cost of Apparent Losses:	$3,708	
Annual cost of Real Losses:	$11,998	Valued at Variable Production Cost

Return to Reporting Worksheet to change this assumpiton

Performance Indicators:

Financial:	Non-revenue water as percent by volume of Water Supplied:	30.2%	
	Non-revenue water as percent by cost of operating system:	1.1%	Real Losses valued at Variable Production Cost
Operational Efficiency:	Apparent Losses per service connection per day:	1.31	gallons/connection/day
	Real Losses per service connection per day:	87.91	gallons/connection/day
	Real Losses per length of main per day*:	N/A	
	Real Losses per service connection per day per psi pressure:	0.98	gallons/connection/day/psi

From Above, Real Losses = Current Annual Real Losses (CARL):	363.15	acre-feet/year
? Infrastructure Leakage Index (ILI) [CARL/UARL]:	3.70	

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

AWWA Free Water Audit Software:
User Comments

WAS v5.0

Use this worksheet to add comments or notes to explain how an input value was calculated, or to document the sources of the information used.

General Comment:	

Audit Item	Comment
Volume from own sources:	https://waterrights.utah.gov/asp_apps/viewEditPWS/pwsView.asp?SYSTEM_ID=1268
Vol. from own sources: Master meter error adjustment:	
Water imported:	
Water imported: master meter error adjustment:	
Water exported:	https://waterrights.utah.gov/asp_apps/viewEditPWS/pwsView.asp?SYSTEM_ID=1268
Water exported: master meter error adjustment:	
Billed metered:	https://waterrights.utah.gov/asp_apps/viewEditPWS/pwsView.asp?SYSTEM_ID=1268
Billed unmetered:	
Unbilled metered:	
Unbilled unmetered:	

Audit Item	Comment
Unauthorized consumption:	
Customer metering inaccuracies:	
Systematic data handling errors:	
Length of mains:	As reported in Master Plan report.
Number of active AND inactive service connections:	3,688 active connections. The City reported that they have very few or no inactive connections.
Average length of customer service line:	
Average operating pressure:	Provided by the model.
Total annual cost of operating water system:	Provided by the City.
Customer retail unit cost (applied to Apparent Losses):	https://www.santaquin.org/government/fee_schedule
Variable production cost (applied to Real Losses):	Calculated from City's energy billing data. Calculations made by Ridley.

AWWA Free Water Audit Software: Water Balance

WAS v5.0

Water Audit Report for: **Santaquin**
Reporting Year: **2019** **1/2019 - 12/2019**
Data Validity Score: **65**

Own Sources **(Adjusted for known errors)** *1,955.810*	**Water Exported** *684.890*			**Billed Water Exported**	
	Water Supplied *1,270.920*	**Authorized Consumption** *902.377*	**Billed Authorized Consumption** *886.490*	**Billed Metered Consumption (water exported is removed)** *886.490*	**Revenue Water** **886.490**
				Billed Unmetered Consumption *0.000*	
			Unbilled Authorized Consumption *15.887*	**Unbilled Metered Consumption** *0.000*	**Non-Revenue Water (NRW)** **384.430**
				Unbilled Unmetered Consumption *15.887*	
		Water Losses *368.544*	**Apparent Losses** *5.394*	**Unauthorized Consumption** *3.177*	
				Customer Metering Inaccuracies *0.000*	
				Systematic Data Handling Errors *2.216*	
Water Imported *0.000*			**Real Losses** *363.150*	**Leakage on Transmission and/or Distribution Mains** *Not broken down*	
				Leakage and Overflows at Utility's Storage Tanks *Not broken down*	
				Leakage on Service Connections *Not broken down*	

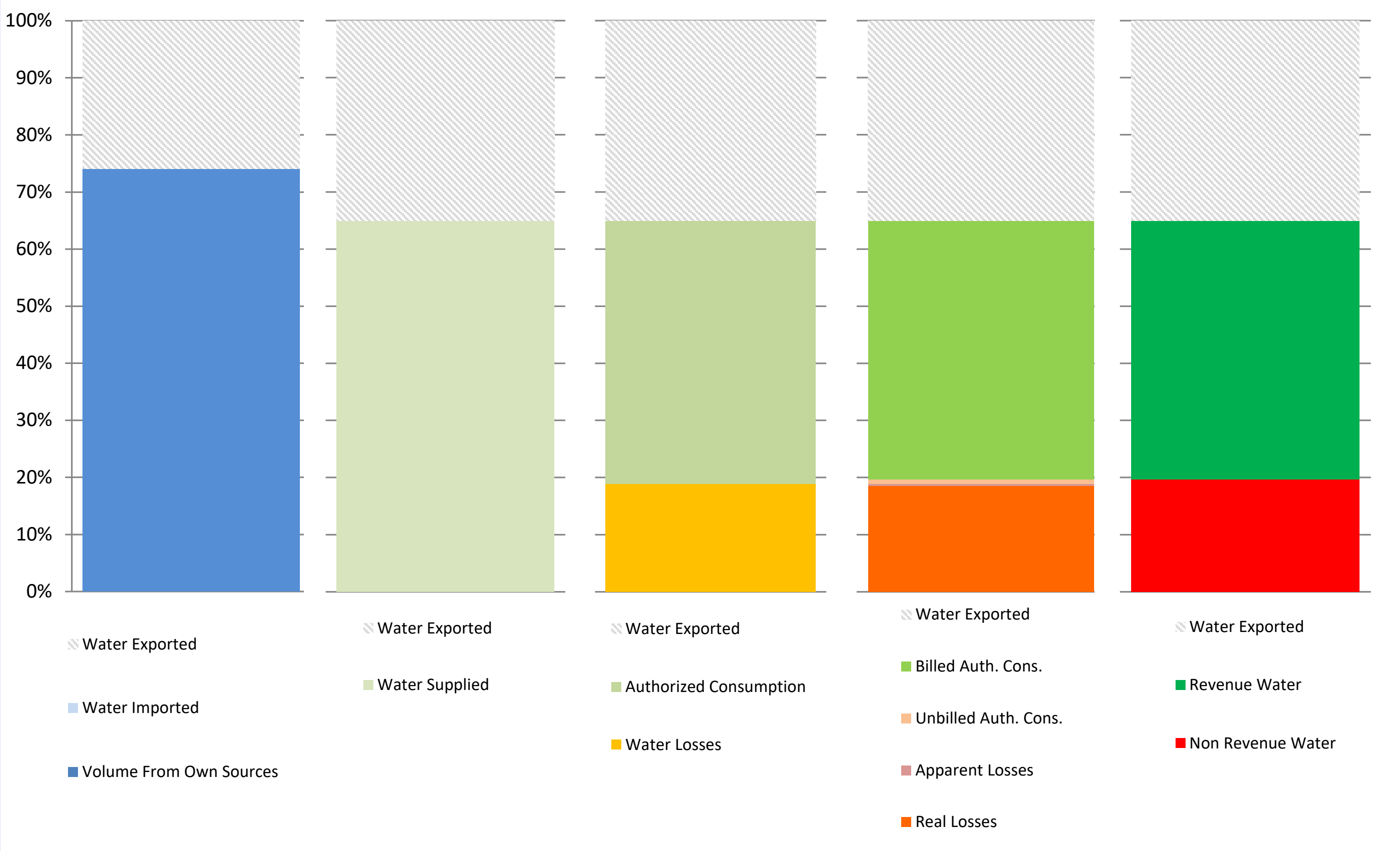
AWWA Free Water Audit Software:
Dashboard

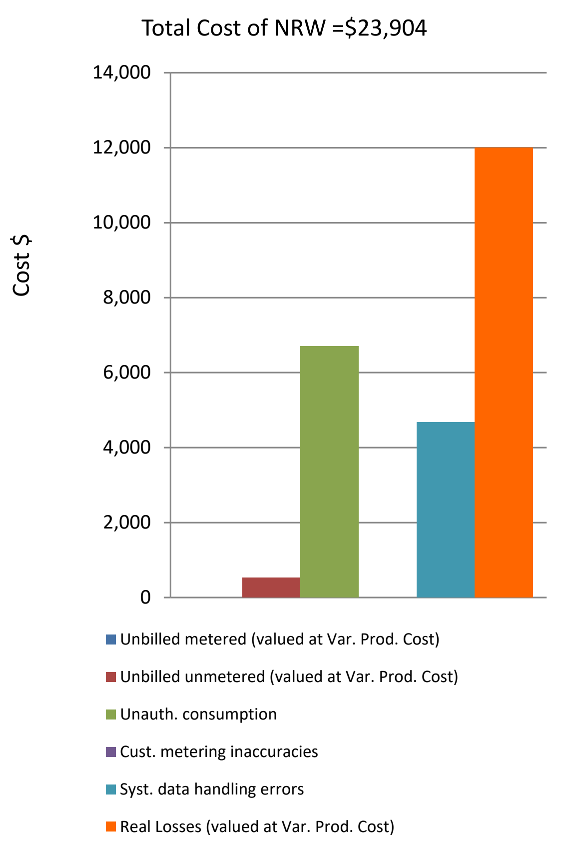
WAS v5.0

The graphic below is a visual representation of the Water Balance with bar heights propotional to the volume of the audit components

Water Audit Report for: Santaquin
Reporting Year: 2019 | 1/2019 - 12/2019
Data Validity Score: 65

○ Show me the VOLUME of Non-Revenue Water
● Show me the COST of Non-Revenue Water





AWWA Free Water Audit Software: Grading Matrix

WAS 5.0

The grading assigned to each audit component and the corresponding recommended improvements and actions are highlighted in yellow. Audit accuracy is likely to be improved by prioritizing those items shown in red

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
WATER SUPPLIED											
Volume from own sources:	Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)	Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing or electronic calibration conducted.	25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing or electronic calibration conducted.	Conditions between 2 and 4	50% - 75% of treated water production sources are metered, other sources estimated. Occasional meter accuracy testing or electronic calibration conducted.	Conditions between 4 and 6	At least 75% of treated water production sources are metered, or at least 90% of the source flow is derived from metered sources. Meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of treated water production sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually, with less than 10% found outside of +/- 3% accuracy. Procedures are reviewed by a third party knowledgeable in the M36 methodology.
Improvements to attain higher data grading for "Volume from own Sources" component:		to qualify for 2: Organize and launch efforts to collect data for determining volume from own sources	to qualify for 4: Locate all water production sources on maps and in the field, launch meter accuracy testing for existing meters, begin to install meters on unmetered water production sources and replace any obsolete/defective meters.		to qualify for 6: Formalize annual meter accuracy testing for all source meters; specify the frequency of testing. Complete installation of meters on unmetered water production sources and complete replacement of all obsolete/defective meters.		to qualify for 8: Conduct annual meter accuracy testing and calibration of related instrumentation on all meter installations on a regular basis. Complete project to install new, or replace defective existing, meters so that entire production meter population is metered. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing and calibration of related instrumentation for all meter installations. Repair or replace meters outside of +/- 3% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to further improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.
Volume from own sources master meter and supply error adjustment:	Select n/a only if the water utility fails to have meters on its sources of supply	Inventory information on meters and paper records of measured volumes exist but are incomplete and/or in a very crude condition; data error cannot be determined	No automatic datalogging of production volumes; daily readings are scribed on paper records without any accountability controls. Flows are not balanced across the water distribution system: tank/storage elevation changes are not employed in calculating the "Volume from own sources" component and archived flow data is adjusted only when grossly evident data error occurs.	Conditions between 2 and 4	Production meter data is logged automatically in electronic format and reviewed at least on a monthly basis with necessary corrections implemented. "Volume from own sources" tabulations include estimate of daily changes in tanks/storage facilities. Meter data is adjusted when gross data errors occur, or occasional meter testing deems this necessary.	Conditions between 4 and 6	Hourly production meter data logged automatically & reviewed on at least a weekly basis. Data is adjusted to correct gross error when meter/instrumentation equipment malfunction is detected; and/or error is confirmed by meter accuracy testing. Tank/storage facility elevation changes are automatically used in calculating a balanced "Volume from own sources" component, and data gaps in the archived data are corrected on at least a weekly basis.	Conditions between 6 and 8	Continuous production meter data is logged automatically & reviewed each business day. Data is adjusted to correct gross error from detected meter/instrumentation equipment malfunction and/or results of meter accuracy testing. Tank/storage facility elevation changes are automatically used in "Volume from own sources" tabulations and data gaps in the archived data are corrected on a daily basis.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically balances flows from all sources and storages; results are reviewed each business day. Tight accountability controls ensure that all data gaps that occur in the archived flow data are quickly detected and corrected. Regular calibrations between SCADA and sources meters ensures minimal data transfer error.
Improvements to attain higher data grading for "Master meter and supply error adjustment" component:		to qualify for 2: Develop a plan to restructure recordkeeping system to capture all flow data; set a procedure to review flow data on a daily basis to detect input errors. Obtain more reliable information about existing meters by conducting field inspections of meters and related instrumentation, and obtaining manufacturer literature.	to qualify for 4: Install automatic datalogging equipment on production meters. Complete installation of level instrumentation at all tanks/storage facilities and include tank level data in automatic calculation routine in a computerized system. Construct a computerized listing or spreadsheet to archive input volumes, tank/storage volume changes and import/export flows in order to determine the composite "Water Supplied" volume for the distribution system. Set a procedure to review this data on a monthly basis to detect gross anomalies and data gaps.		to qualify for 6: Refine computerized data collection and archive to include hourly production meter data that is reviewed at least on a weekly basis to detect specific data anomalies and gaps. Use daily net storage change to balance flows in calculating "Water Supplied" volume. Necessary corrections to data errors are implemented on a weekly basis.		to qualify for 8: Ensure that all flow data is collected and archived on at least an hourly basis. All data is reviewed and detected errors corrected each business day. Tank/storage levels variations are employed in calculating balanced "Water Supplied" component. Adjust production meter data for gross error and inaccuracy confirmed by testing.		to qualify for 10: Link all production and tank/storage facility elevation change data to a Supervisory Control & Data Acquisition (SCADA) System, or similar computerized monitoring/control system, and establish automatic flow balancing algorithm and regularly calibrate between SCADA and source meters. Data is reviewed and corrected each business day.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flowmeters. Continue to replace or repair meters as they perform outside of desired accuracy limits. Stay abreast of new and more accurate water level instruments to better record tank/storage levels and archive the variations in storage volume. Keep current with SCADA and data management systems to ensure that archived data is well-managed and error free.
Water Imported:	Select n/a if the water utility's supply is exclusively from its own water resources (no bulk purchased/ imported water)	Less than 25% of imported water sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of imported water sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of imported water sources are metered, other sources estimated. Occasional meter accuracy testing conducted.	Conditions between 4 and 6	At least 75% of imported water sources are metered, meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually for all meter installations. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of imported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of imported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually for all meter installations, with less than 10% of accuracy tests found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Water Imported Volume" component: *(Note: usually the water supplier selling the water - "the Exporter" - to the utility being audited is responsible to maintain the metering installation measuring the imported volume. The utility should coordinate carefully with the Exporter to ensure that adequate meter upkeep takes place and an accurate measure of the Water Imported volume is quantified.)*		to qualify for 2: Review bulk water purchase agreements with partner suppliers; confirm requirements for use and maintenance of accurate metering. Identify needs for new or replacement meters with goal to meter all imported water sources.	To qualify for 4: Locate all imported water sources on maps and in the field, launch meter accuracy testing for existing meters, begin to install meters on unmetered imported water interconnections and replace obsolete/defective meters.		to qualify for 6: Formalize annual meter accuracy testing for all imported water meters, planning for both regular meter accuracy testing and calibration of the related instrumentation. Continue installation of meters on unmetered imported water interconnections and replacement of obsolete/defective meters.		to qualify for 8: Complete project to install new, or replace defective, meters on all imported water interconnections. Maintain annual meter accuracy testing for all imported water meters and conduct calibration of related instrumentation at least annually. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Conduct meter accuracy testing for all meters on a semi-annual basis, along with calibration of all related instrumentation. Repair or replace meters outside of +/- 3% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Continue to conduct calibration of related instrumentation on a semi-annual basis. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Water imported master meter and supply error adjustment:	Select n/a if the Imported water supply is unmetered, with Imported water quantities estimated on the billing invoices sent by the Exporter to the purchasing Utility.	Inventory information on imported meters and paper records of measured volumes exist but are incomplete and/or in a very crude condition; data error cannot be determined Written agreement(s) with water Exporter(s) are missing or written in vague language concerning meter management and testing.	No automatic datalogging of imported supply volumes; daily readings are scribed on paper records without any accountability controls to confirm data accuracy and the absence of errors and data gaps in recorded volumes. Written agreement requires meter accuracy testing but is vague on the details of how and who conducts the testing.	Conditions between 2 and 4	Imported supply metered flow data is logged automatically in electronic format and reviewed at least on a monthly basis by the Exporter with necessary corrections implemented. Meter data is adjusted by the Exporter when gross data errors are detected. A coherent data trail exists for this process to protect both the selling and the purchasing Utility. Written agreement exists and clearly states requirements and roles for meter accuracy testing and data management.	Conditions between 4 and 6	Hourly Imported supply metered data is logged automatically & reviewed on at least a weekly basis by the Exporter. Data is adjusted to correct gross error when meter/instrumentation equipment malfunction is detected; and to correct for error confirmed by meter accuracy testing. Any data gaps in the archived data are detected and corrected during the weekly review. A coherent data trail exists for this process to protect both the selling and the purchasing Utility.	Conditions between 6 and 8	Continuous Imported supply metered flow data is logged automatically & reviewed each business day by the Importer. Data is adjusted to correct gross error from detected meter/instrumentation equipment malfunction and/or results of meter accuracy testing. Any data errors/gaps are detected and corrected on a daily basis. A data trail exists for the process to protect both the selling and the purchasing Utility.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically records data which is reviewed each business day by the Exporter. Tight accountability controls ensure that all error/data gaps that occur in the archived flow data are quickly detected and corrected. A reliable data trail exists and contract provisions for meter testing and data management are reviewed by the selling and purchasing Utility at least once every five years.
Improvements to attain higher data grading for "Water imported master meter and supply error adjustment" component:		to qualify for 2: Develop a plan to restructure recordkeeping system to capture all flow data; set a procedure to review flow data on a daily basis to detect input errors. Obtain more reliable information about existing meters by conducting field inspections of meters and related instrumentation, and obtaining manufacturer literature. Review the written agreement between the selling and purchasing Utility.	to qualify for 4: Install automatic datalogging equipment on Imported supply meters. Set a procedure to review this data on a monthly basis to detect gross anomalies and data gaps. Launch discussions with the Exporters to jointly review terms of the written agreements regarding meter accuracy testing and data management; revise the terms as necessary.		to qualify for 6: Refine computerized data collection and archive to include hourly Imported supply metered flow data that is reviewed at least on a weekly basis to detect specific data anomalies and gaps. Make necessary corrections to errors/data errors on a weekly basis.		to qualify for 8: Ensure that all Imported supply metered flow data is collected and archived on at least an hourly basis. All data is reviewed and errors/data gaps are corrected each business day.		to qualify for 10: Conduct accountability checks to confirm that all Imported supply metered data is reviewed and corrected each business day by the Exporter. Results of all meter accuracy tests and data corrections should be available for sharing between the Exporter and the purchasing Utility. Establish a schedule for a regular review and updating of the contractual language in the written agreement between the selling and the purchasing Utility; at least every five years.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flowmeters; work with the Exporter to help identify meter replacement needs. Keep communication lines with Exporters open and maintain productive relations. Keep the written agreement current with clear and explicit language that meets the ongoing needs of all parties.
Water Exported:	Select n/a if the water utility sells no bulk water to neighboring water utilities (no exported water sales)	Less than 25% of exported water sources are metered, remaining sources are estimated. No regular meter accuracy testing.	25% - 50% of exported water sources are metered; other sources estimated. No regular meter accuracy testing.	Conditions between 2 and 4	50% - 75% of exported water sources are metered, other sources estimated. Occasional meter accuracy testing conducted.	Conditions between 4 and 6	At least 75% of exported water sources are metered, meter accuracy testing and/or electronic calibration conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.	Conditions between 6 and 8	100% of exported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted annually, less than 10% of meters are found outside of +/- 6% accuracy	Conditions between 8 and 10	100% of exported water sources are metered, meter accuracy testing and electronic calibration of related instrumentation is conducted semi-annually for all meter installations, with less than 10% of accuracy tests found outside of +/- 3% accuracy.
Improvements to attain higher data grading for "Water Exported Volume" component: *(Note: usually, if the water utility being audited sells (Exports) water to a neighboring purchasing Utility, it is the responsibility of the utility exporting the water to maintain the metering installation measuring the Exported volume. The utility exporting the water should ensure that adequate meter upkeep takes place and an accurate measure of the Water Exported volume is quantified.)*		to qualify for 2: Review bulk water sales agreements with purchasing utilities; confirm requirements for use & upkeep of accurate metering. Identify needs to install new, or replace defective meters as needed.	To qualify for 4: Locate all exported water sources on maps and in field, launch meter accuracy testing for existing meters, begin to install meters on unmetered exported water interconnections and replace obsolete/defective meters		to qualify for 6: Formalize annual meter accuracy testing for all exported water meters. Continue installation of meters on unmetered exported water interconnections and replacement of obsolete/defective meters.		to qualify for 8: Complete project to install new, or replace defective, meters on all exported water interconnections. Maintain annual meter accuracy testing for all exported water meters. Repair or replace meters outside of +/- 6% accuracy.		to qualify for 10: Maintain annual meter accuracy testing for all meters. Repair or replace meters outside of +/- 3% accuracy. Investigate new meter technology; pilot one or more replacements with innovative meters in attempt to improve meter accuracy.		to maintain 10: Standardize meter accuracy test frequency to semi-annual, or more frequent, for all meters. Repair or replace meters outside of +/- 3% accuracy. Continually investigate/pilot improving metering technology.
Water exported master meter and supply error adjustment:	Select n/a only if the water utility fails to have meters on its exported supply interconnections.	Inventory information on exported meters and paper records of measured volumes exist but are incomplete and/or in a very crude condition; data error cannot be determined Written agreement(s) with the utility purchasing the water are missing or written in vague language concerning meter management and testing.	No automatic datalogging of exported supply volumes; daily readings are scribed on paper records without any accountability controls to confirm data accuracy and the absence of errors and data gaps in recorded volumes. Written agreement requires meter accuracy testing but is vague on the details of how and who conducts the testing.	Conditions between 2 and 4	Exported metered flow data is logged automatically in electronic format and reviewed at least on a monthly basis, with necessary corrections implemented. Meter data is adjusted by the utility selling (exporting) the water when gross data errors are detected. A coherent data trail exists for this process to protect both the utility exporting the water and the purchasing Utility. Written agreement exists and clearly states requirements and roles for meter accuracy testing and data management.	Conditions between 4 and 6	Hourly exported supply metered data is logged automatically & reviewed on at least a weekly basis by the utility selling the water. Data is adjusted to correct gross error when meter/instrumentation equipment malfunction is detected; and to correct for error found by meter accuracy testing. Any data gaps in the archived data are detected and corrected during the weekly review. A coherent data trail exists for this process to protect both the selling (exporting) utility and the purchasing Utility.	Conditions between 6 and 8	Continuous exported supply metered flow data is logged automatically & reviewed each business day by the utility selling (exporting) the water. Data is adjusted to correct gross error from detected meter/instrumentation equipment malfunction and any error confirmed by meter accuracy testing. Any data errors/gaps are detected and corrected on a daily basis. A data trail exists for the process to protect both the selling (exporting) Utility and the purchasing Utility.	Conditions between 8 and 10	Computerized system (SCADA or similar) automatically records data which is reviewed each business day by the utility selling (exporting) the water. Tight accountability controls ensure that all error/data gaps that occur in the archived flow data are quickly detected and corrected. A reliable data trail exists and contract provisions for meter testing and data management are reviewed by the selling Utility and purchasing Utility at least once every five years.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Improvements to attain higher data grading for "Water exported master meter and supply error adjustment" component:		to qualify for 2: Develop a plan to restructure recordkeeping system to capture all flow data; set a procedure to review flow data on a daily basis to detect input errors. Obtain more reliable information about existing meters by conducting field inspections of meters and related instrumentation, and obtaining manufacturer literature. Review the written agreement between the utility selling (exporting) the water and the purchasing Utility.	to qualify for 4: Install automatic datalogging equipment on exported supply meters. Set a procedure to review this data on a monthly basis to detect gross anomalies and data gaps. Launch discussions with the purchasing utilities to jointly review terms of the written agreements regarding meter accuracy testing and data management; revise the terms as necessary.		to qualify for 6: Refine computerized data collection and archive to include hourly exported supply metered flow data that is reviewed at least on a weekly basis to detect specific data anomalies and gaps. Make necessary corrections to errors/data errors on a weekly basis.		to qualify for 8: Ensure that all exported metered flow data is collected and archived on at least an hourly basis. All data is reviewed and errors/data gaps are corrected each business day.		to qualify for 10: Conduct accountability checks to confirm that all exported metered flow data is reviewed and corrected each business day by the utility selling the water. Results of all meter accuracy tests and data corrections should be available for sharing between the utility and the purchasing Utility. Establish a schedule for a regular review and updating of the contractual language in the written agreements with the purchasing utilities; at least every five years.		to maintain 10: Monitor meter innovations for development of more accurate and less expensive flowmeters; work with the purchasing utilities to help identify meter replacement needs. Keep communication lines with the purchasing utilities open and maintain productive relations. Keep the written agreement current with clear and explicit language that meets the ongoing needs of all parties.
AUTHORIZED CONSUMPTION											
Billed metered:	n/a (not applicable). Select n/a only if the entire customer population is not metered and is billed for water service on a flat or fixed rate basis. In such a case the volume entered must be zero.	Less than 50% of customers with volume-based billings from meter readings; flat or fixed rate billing exists for the majority of the customer population	At least 50% of customers with volume-based billing from meter reads; flat rate billing for others. Manual meter reading is conducted, with less than 50% meter read success rate, remaining accounts' consumption is estimated. Limited meter records, no regular meter testing or replacement. Billing data maintained on paper records, with no auditing.	Conditions between 2 and 4	At least 75% of customers with volume-based, billing from meter reads; flat or fixed rate billing for remaining accounts. Manual meter reading is conducted with at least 50% meter read success rate; consumption for accounts with failed reads is estimated. Purchase records verify age of customer meters; only very limited meter accuracy testing is conducted. Customer meters are replaced only upon complete failure. Computerized billing records exist, but only sporadic internal auditing conducted.	Conditions between 4 and 6	At least 90% of customers with volume-based billing from meter reads; consumption for remaining accounts is estimated. Manual customer meter reading gives at least 80% customer meter reading success rate; consumption for accounts with failed reads is estimated. Good customer meter records exist, but only limited meter accuracy testing is conducted. Regular replacement is conducted for the oldest meters. Computerized billing records exist with annual auditing of summary statistics conducted by utility personnel.	Conditions between 6 and 8	At least 97% of customers exist with volume-based billing from meter reads. At least 90% customer meter reading success rate; or at least 80% read success rate with planning and budgeting for trials of Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) in one or more pilot areas. Good customer meter records. Regular meter accuracy testing guides replacement of statistically significant number of meters each year. Routine auditing of computerized billing records for global and detailed statistics occurs annually by utility personnel, and is verified by third party at least once every five years.	Conditions between 8 and 10	At least 99% of customers exist with volume-based billing from meter reads. At least 95% customer meter reading success rate; or minimum 80% meter reading success rate, with Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) trials underway. Statistically significant customer meter testing and replacement program in place on a continuous basis. Computerized billing with routine, detailed auditing, including field investigation of representative sample of accounts undertaken annually by utility personnel. Audit is conducted by third party auditors at least once every three years.
Improvements to attain higher data grading for "Billed Metered Consumption" component:	If n/a is selected because the customer meter population is unmetered, consider establishing a new policy to meter the customer population and employ water rates based upon metered volumes.	to qualify for 2: Conduct investigations or trials of customer meters to select appropriate meter models. Budget funding for meter installations. Investigate volume based water rate structures.	to qualify for 4: Purchase and install meters on unmetered accounts. Implement policies to improve meter reading success. Catalog meter information during meter read visits to identify age/model of existing meters. Test a minimal number of meters for accuracy. Install computerized billing system.		to qualify for 6: Purchase and install meters on unmetered accounts. Eliminate flat fee billing and establish appropriate water rate structure based upon measured consumption. Continue to achieve verifiable success in removing manual meter reading barriers. Expand meter accuracy testing. Launch regular meter replacement program. Launch a program of annual auditing of global billing statistics by utility personnel.		to qualify for 8: Purchase and install meters on unmetered accounts. If customer meter reading success rate is less than 97%, assess cost-effectiveness of Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) system for portion or entire system; or otherwise achieve ongoing improvements in manual meter reading success rate to 97% or higher. Refine meter accuracy testing program. Set meter replacement goals based upon accuracy test results. Implement annual auditing of detailed billing records by utility personnel and implement third party auditing at least once every five years.		to qualify for 10: Purchase and install meters on unmetered accounts. Launch Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) system trials if manual meter reading success rate of at least 99% is not achieved within a five-year program. Continue meter accuracy testing program. Conduct planning and budgeting for large scale meter replacement based upon meter life cycle analysis using cumulative flow target. Continue annual detailed billing data auditing by utility personnel and conduct third party auditing at least once every three years.		to maintain 10: Continue annual internal billing data auditing, and third party auditing at least every three years. Continue customer meter accuracy testing to ensure that accurate customer meter readings are obtained and entered as the basis for volume based billing. Stay abreast of improvements in Automatic Meter Reading (AMR) and Advanced Metering Infrastructure (AMI) and information management. Plan and budget for justified upgrades in metering, meter reading and billing data management to maintain very high accuracy in customer metering and billing.
Billed unmetered:	Select n/a if it is the policy of the water utility to meter all customer connections and it has been confirmed by detailed auditing that all customers do indeed have a water meter; i.e. no intentionally unmetered accounts exist	Water utility policy does not require customer metering; flat or fixed fee billing is employed. No data is collected on customer consumption. The only estimates of customer population consumption available are derived from data estimation methods using average fixture count multiplied by number of connections, or similar approach.	Water utility policy does not require customer metering; flat or fixed fee billing is employed. Some metered accounts exist in parts of the system (pilot areas or District Metered Areas) with consumption read periodically or recorded on portable dataloggers over one, three, or seven day periods. Data from these sample meters are used to infer consumption for the total customer population. Site specific estimation methods are used for unusual buildings/water uses.	Conditions between 2 and 4	Water utility policy does require metering and volume based billing in general. However, a liberal amount of exemptions and a lack of clearly written and communicated procedures result in up to 20% of billed accounts believed to be unmetered by exemption; or the water utility is in transition to becoming fully metered, and a large number of customers remain unmetered. A rough estimate of the annual consumption for all unmetered accounts is included in the annual water audit, with no inspection of individual unmetered accounts.	Conditions between 4 and 6	Water utility policy does require metering and volume based billing but established exemptions exist for a portion of accounts such as municipal buildings. As many as 15% of billed accounts are unmetered due to this exemption or meter installation difficulties. Only a group estimate of annual consumption for all unmetered accounts is included in the annual water audit, with no inspection of individual unmetered accounts.	Conditions between 6 and 8	Water utility policy does require metering and volume based billing for all customer accounts. However, less than 5% of billed accounts remain unmetered because meter installation is hindered by unusual circumstances. The goal is to minimize the number of unmetered accounts. Reliable estimates of consumption are obtained for these unmetered accounts via site specific estimation methods.	Conditions between 8 and 10	Water utility policy does require metering and volume based billing for all customer accounts. Less than 2% of billed accounts are unmetered and exist because meter installation is hindered by unusual circumstances. The goal exists to minimize the number of unmetered accounts to the extent that is economical. Reliable estimates of consumption are obtained at these accounts via site specific estimation methods.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Improvements to attain higher data grading for "Billed Unmetered Consumption" component:		to qualify for 2: Conduct research and evaluate cost/benefit of a new water utility policy to require metering of the customer population; thereby greatly reducing or eliminating unmetered accounts. Conduct pilot metering project by installing water meters in small sample of customer accounts and periodically reading the meters or datalogging the water consumption over one, three, or seven day periods.	to qualify for 4: Implement a new water utility policy requiring customer metering. Launch or expand pilot metering study to include several different meter types, which will provide data for economic assessment of full scale metering options. Assess sites with access difficulties to devise means to obtain water consumption volumes. Begin customer meter installation.		to qualify for 6: Refine policy and procedures to improve customer metering participation for all but solidly exempt accounts. Assign staff resources to review billing records to identify errant unmetered properties. Specify metering needs and funding requirements to install sufficient meters to significant reduce the number of unmetered accounts		to qualify for 8: Push to install customer meters on a full scale basis. Refine metering policy and procedures to ensure that all accounts, including municipal properties, are designated for meters. Plan special efforts to address "hard-to-access" accounts. Implement procedures to obtain a reliable consumption estimate for the remaining few unmetered accounts awaiting meter installation.		to qualify for 10: Continue customer meter installation throughout the service area, with a goal to minimize unmetered accounts. Sustain the effort to investigate accounts with access difficulties, and devise means to install water meters or otherwise measure water consumption.		to maintain 10: Continue to refine estimation methods for unmetered consumption and explore means to establish metering, for as many billed remaining unmetered accounts as is economically feasible.
Unbilled metered:	select n/a if all billing-exempt consumption is unmetered.	Billing practices exempt certain accounts, such as municipal buildings, but written policies do not exist; and a reliable count of unbilled metered accounts is unavailable. Meter upkeep and meter reading on these accounts is rare and not considered a priority. Due to poor recordkeeping and lack of auditing, water consumption for all such accounts is purely guesstimated.	Billing practices exempt certain accounts, such as municipal buildings, but only scattered, dated written directives exist to justify this practice. A reliable count of unbilled metered accounts is unavailable. Sporadic meter replacement and meter reading occurs on an as-needed basis. The total annual water consumption for all unbilled, metered accounts is estimated based upon approximating the number of accounts and assigning consumption from actively billed accounts of same meter size.	Conditions between 2 and 4	Dated written procedures permit billing exemption for specific accounts, such as municipal properties, but are unclear regarding certain other types of accounts. Meter reading is given low priority and is sporadic. Consumption is quantified from meter readings where available. The total number of unbilled, unmetered accounts must be estimated along with consumption volumes.	Conditions between 4 and 6	Written policies regarding billing exemptions exist but adherence in practice is questionable. Metering and meter reading for municipal buildings is reliable but sporadic for other unbilled metered accounts. Periodic auditing of such accounts is conducted. Water consumption is quantified directly from meter readings where available, but the majority of the consumption is estimated.	Conditions between 6 and 8	Written policy identifies the types of accounts granted a billing exemption. Customer meter management and meter reading are considered secondary priorities, but meter reading is conducted at least annually to obtain consumption volumes for the annual water audit. High level auditing of billing records ensures that a reliable census of such accounts exists.	Conditions between 8 and 10	Clearly written policy identifies the types of accounts given a billing exemption, with emphasis on keeping such accounts to a minimum. Customer meter management and meter reading for these accounts is given proper priority and is reliably conducted. Regular auditing confirms this. Total water consumption for these accounts is taken from reliable readings from accurate meters.
Improvements to attain higher data grading for "Unbilled Metered Consumption" component:		to qualify for 2: Reassess the water utility's policy allowing certain accounts to be granted a billing exemption. Draft an outline of a new written policy for billing exemptions, with clear justification as to why any accounts should be exempt from billing, and with the intention to keep the number of such accounts to a minimum.	to qualify for 4: Review historic written directives and policy documents allowing certain accounts to be billing-exempt. Draft an outline of a written policy for billing exemptions, identify criteria that grants an exemption, with a goal of keeping this number of accounts to a minimum. Consider increasing the priority of reading meters on unbilled accounts at least annually.		to qualify for 6: Draft a new written policy regarding billing exemptions based upon consensus criteria allowing this occurrence. Assign resources to audit meter records and billing records to obtain census of unbilled metered accounts. Gradually include a greater number of these metered accounts to the routes for regular meter reading.		to qualify for 8: Communicate billing exemption policy throughout the organization and implement procedures that ensure proper account management. Conduct inspections of accounts confirmed in unbilled metered status and verify that accurate meters exist and are scheduled for routine meter readings. Gradually increase the number of unbilled metered accounts that are included in regular meter reading routes.		to qualify for 10: Ensure that meter management (meter accuracy testing, meter replacement) and meter reading activities for unbilled accounts are accorded the same priority as billed accounts. Establish ongoing annual auditing process to ensure that water consumption is reliably collected and provided to the annual water audit process.		to maintain 10: Reassess the utility's philosophy in allowing any water uses to go "unbilled". It is possible to meter and bill all accounts, even if the fee charged for water consumption is discounted or waived. Metering and billing all accounts ensures that water consumption is tracked and water waste from plumbing leaks is detected and minimized.
Unbilled unmetered:		Extent of unbilled, unmetered consumption is unknown due to unclear policies and poor recordkeeping. Total consumption is quantified based upon a purely subjective estimate.	Clear extent of unbilled, unmetered consumption is unknown, but a number of events are randomly documented each year, confirming existence of such consumption, but without sufficient documentation to quantify an accurate estimate of the annual volume consumed.	Conditions between 2 and 4	Extent of unbilled, unmetered consumption is partially known, and procedures exist to document certain events such as miscellaneous fire hydrant uses. Formulae is used to quantify the consumption from such events (time running multiplied by typical flowrate, multiplied by number of events).	Default value of 1.25% of system input volume is employed	Coherent policies exist for some forms of unbilled, unmetered consumption but others await closer evaluation. Reasonable recordkeeping for the managed uses exists and allows for annual volumes to be quantified by inference, but unsupervised uses are guesstimated.	Conditions between 6 and 8	Clear policies and good recordkeeping exist for some uses (ex: water used in periodic testing of unmetered fire connections), but other uses (ex: miscellaneous uses of fire hydrants) have limited oversight. Total consumption is a mix of well quantified use such as from formulae (time running multiplied by typical flow, multiplied by number of events) or temporary meters, and relatively subjective estimates of less regulated use.	Conditions between 8 and 10	Clear policies exist to identify permitted use of water in unbilled, unmetered fashion, with the intention of minimizing this type of consumption. Good records document each occurrence and consumption is quantified via formulae (time running multiplied by typical flow, multiplied by number of events) or use of temporary meters.
Improvements to attain higher data grading for "Unbilled Unmetered Consumption" component:		to qualify for 5: Utilize the accepted default value of 1.25% of the volume of water supplied as an expedient means to gain a reasonable quantification of this use. to qualify for 2: Establish a policy regarding what water uses should be allowed to remain as unbilled and unmetered. Consider tracking a small sample of one such use (ex: fire hydrant flushing).	to qualify for 5: Utilize accepted default value of 1.25% of the volume of water supplied as an expedient means to gain a reasonable quantification of this use. to qualify for 4: Evaluate the documentation of events that have been observed. Meet with user groups (ex: for fire hydrants - fire departments, contractors to ascertain their need and/or volume requirements for water from fire hydrants).		to qualify for 5: Utilize accepted default value of 1.25% of the volume of water supplied as an expedient means to gain a reasonable quantification of all such use. This is particularly appropriate for water utilities who are in the early stages of the water auditing process, and should focus on other components since the volume of unbilled, unmetered consumption is usually a relatively small quantity component, and other larger-quantity components should take priority.	to qualify for 6 or greater: Finalize policy and begin to conduct field checks to better establish and quantify such usage. Proceed if top-down audit exists and/or a great volume of such use is suspected.	to qualify for 8: Assess water utility policy and procedures for various unmetered usages. For example, ensure that a policy exists and permits are issued for use of fire hydrants by persons outside of the utility. Create written procedures for use and documentation of fire hydrants by water utility personnel. Use same approach for other types of unbilled, unmetered water usage.		to qualify for 10: Refine written procedures to ensure that all uses of unbilled, unmetered water are overseen by a structured permitting process managed by water utility personnel. Reassess policy to determine if some of these uses have value in being converted to billed and/or metered status.		to maintain 10: Continue to refine policy and procedures with intention of reducing the number of allowable uses of water in unbilled and unmetered fashion. Any uses that can feasibly become billed and metered should be converted eventually.
APPARENT LOSSES											

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Unauthorized consumption:		Extent of unauthorized consumption is unknown due to unclear policies and poor recordkeeping. Total unauthorized consumption is guesstimated.	Unauthorized consumption is a known occurrence, but its extent is a mystery. There are no requirements to document observed events, but periodic field reports capture some of these occurrences. Total unauthorized consumption is approximated from this limited data.	conditions between 2 and 4	Procedures exist to document some unauthorized consumption such as observed unauthorized fire hydrant openings. Use formulae to quantify this consumption (time running multiplied typical flowrate, multiplied by number of events).	Default value of 0.25% of volume of water supplied is employed	Coherent policies exist for some forms of unauthorized consumption (more than simply fire hydrant misuse) but others await closer evaluation. Reasonable surveillance and recordkeeping exist for occurrences that fall under the policy. Volumes quantified by inference from these records.	Conditions between 6 and 8	Clear policies and good auditable recordkeeping exist for certain events (ex: tampering with water meters, illegal bypasses of customer meters); but other occurrences have limited oversight. Total consumption is a combination of volumes from formulae (time x typical flow) and subjective estimates of unconfirmed consumption.	Conditions between 8 and 10	Clear policies exist to identify all known unauthorized uses of water. Staff and procedures exist to provide enforcement of policies and detect violations. Each occurrence is recorded and quantified via formulae (estimated time running multiplied by typical flow) or similar methods. All records and calculations should exist in a form that can be audited by a third party.
Improvements to attain higher data grading for "Unauthorized Consumption" component:		to qualify for 5: Use accepted default of 0.25% of volume of water supplied. to qualify for 2: Review utility policy regarding what water uses are considered unauthorized, and consider tracking a small sample of one such occurrence (ex: unauthorized fire hydrant openings)	to qualify for 5: Use accepted default of 0.25% of system input volume to qualify for 4: Review utility policy regarding what water uses are considered unauthorized, and consider tracking a small sample of one such occurrence (ex: unauthorized fire hydrant openings)		to qualify for 5: Utilize accepted default value of 0.25% of volume of water supplied as an expedient means to gain a reasonable quantification of all such use. This is particularly appropriate for water utilities who are in the early stages of the water auditing process.	to qualify for 6 or greater: Finalize policy updates to clearly identify the types of water consumption that are authorized from those usages that fall outside of this policy and are, therefore, unauthorized. Begin to conduct regular field checks. Proceed if the top-down audit already exists and/or a great volume of such use is suspected.	to quality for 8: Assess water utility policies to ensure that all known occurrences of unauthorized consumption are outlawed, and that appropriate penalties are prescribed. Create written procedures for detection and documentation of various occurrences of unauthorized consumption as they are uncovered.		to qualify for 10: Refine written procedures and assign staff to seek out likely occurrences of unauthorized consumption. Explore new locking devices, monitors and other technologies designed to detect and thwart unauthorized consumption.		to maintain 10: Continue to refine policy and procedures to eliminate any loopholes that allow or tacitly encourage unauthorized consumption. Continue to be vigilant in detection, documentation and enforcement efforts.
Customer metering inaccuracies:	select n/a only if the entire customer population is unmetered. In such a case the volume entered must be zero.	Customer meters exist, but with unorganized paper records on meters; no meter accuracy testing or meter replacement program for any size of retail meter. Metering workflow is driven chaotically with no proactive management. Loss volume due to aggregate meter inaccuracy is guesstimated.	Poor recordkeeping and meter oversight is recognized by water utility management who has allotted staff and funding resources to organize improved recordkeeping and start meter accuracy testing. Existing paper records gathered and organized to provide cursory disposition of meter population. Customer meters are tested for accuracy only upon customer request.	Conditions between 2 and 4	Reliable recordkeeping exists; meter information is improving as meters are replaced. Meter accuracy testing is conducted annually for a small number of meters (more than just customer requests, but less than 1% of inventory). A limited number of the oldest meters are replaced each year. Inaccuracy volume is largely an estimate, but refined based upon limited testing data.	Conditions between 4 and 6	A reliable electronic recordkeeping system for meters exists. The meter population includes a mix of new high performing meters and dated meters with suspect accuracy. Routine, but limited, meter accuracy testing and meter replacement occur. Inaccuracy volume is quantified using a mix of reliable and less certain data.	Conditions between 6 and 8	Ongoing meter replacement and accuracy testing result in highly accurate customer meter population. Testing is conducted on samples of meters of varying age and accumulated volume of throughput to determine optimum replacement time for various types of meters.	Ongoing meter replacement and accuracy testing result in highly accurate customer meter population. Statistically significant number of meters are tested in audit year. This testing is conducted on samples of meters of varying age and accumulated volume of throughput to determine optimum replacement time for these meters.	Good records of all active customer meters exist and include as a minimum: meter number, account number/location, type, size and manufacturer. Ongoing meter replacement occurs according to a targeted and justified basis. Regular meter accuracy testing gives a reliable measure of composite inaccuracy volume for the customer meter population. New metering technology is embraced to keep overall accuracy improving. Procedures are reviewed by a third party knowledgeable in the M36 methodology.
Improvements to attain higher data grading for "Customer meter inaccuracy volume" component:	If n/a is selected because the customer meter population is unmetered, consider establishing a new policy to meter the customer population and employ water rates based upon metered volumes.	to qualify for 2: Gather available meter purchase records. Conduct testing on a small number of meters believed to be the most inaccurate. Review staffing needs of the metering group and budget for necessary resources to better organize meter management.	to qualify for 4: Implement a reliable record keeping system for customer meter histories, preferably using electronic methods typically linked to, or part of, the Customer Billing System or Customer Information System. Expand meter accuracy testing to a larger group of meters.		to qualify for 6: Standardize the procedures for meter recordkeeping within an electronic information system. Accelerate meter accuracy testing and meter replacements guided by testing results.		to qualify for 8: Expand annual meter accuracy testing to evaluate a statistically significant number of meter makes/models. Expand meter replacement program to replace statistically significant number of poor performing meters each year.		to qualify for 9: Continue efforts to manage meter population with reliable recordkeeping. Test a statistically significant number of meters each year and analyze test results in an ongoing manner to serve as a basis for a target meter replacement strategy based upon accumulated volume throughput.	to qualify for 10: Continue efforts to manage meter population with reliable recordkeeping, meter testing and replacement. Evaluate new meter types and install one or more types in 5-10 customer accounts each year in order to pilot improving metering technology.	to maintain 10: Increase the number of meters tested and replaced as justified by meter accuracy test data. Continually monitor development of new metering technology and Advanced Metering Infrastructure (AMI) to grasp opportunities for greater accuracy in metering of water flow and management of customer consumption data.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Systematic Data Handling Errors:	Note: all water utilities incur some amount of this error. Even in water utilities with unmetered customer populations and fixed rate billing, errors occur in annual billing tabulations. Enter a positive value for the volume and select a grading.	Policies and procedures for activation of new customer water billing accounts are vague and lack accountability. Billing data is maintained on paper records which are not well organized. No auditing is conducted to confirm billing data handling efficiency. An unknown number of customers escape routine billing due to lack of billing process oversight.	Policy and procedures for activation of new customer accounts and oversight of billing records exist but need refinement. Billing data is maintained on paper records or insufficiently capable electronic database. Only periodic unstructured auditing work is conducted to confirm billing data handling efficiency. The volume of unbilled water due to billing lapses is a guess.	Conditions between 2 and 4	Policy and procedures for new account activation and oversight of billing operations exist but needs refinement. Computerized billing system exists, but is dated or lacks needed functionality. Periodic, limited internal audits conducted and confirm with approximate accuracy the consumption volumes lost to billing lapses.	Conditions between 4 and 6	Policy and procedures for new account activation and oversight of billing operations is adequate and reviewed periodically. Computerized billing system is in use with basic reporting available. Any effect of billing adjustments on measured consumption volumes is well understood. Internal checks of billing data error conducted annually. Reasonably accurate quantification of consumption volume lost to billing lapses is obtained.	Conditions between 6 and 8	New account activation and billing operations policy and procedures are reviewed at least biannually. Computerized billing system includes an array of reports to confirm billing data and system functionality. Checks are conducted routinely to flag and explain zero consumption accounts. Annual internal checks conducted with third party audit conducted at least once every five years. Accountability checks flag billing lapses. Consumption volume lost to billing lapses is well quantified and reducing year-by-year.	Conditions between 8 and 10	Sound written policy and procedures exist for new account activation and oversight of customer billing operations. Robust computerized billing system gives high functionality and reporting capabilities which are utilized, analyzed and the results reported each billing cycle. Assessment of policy and data handling errors are conducted internally and audited by third party at least once every three years, ensuring consumption lost to billing lapses is minimized and detected as it occurs.
Improvements to attain higher data grading for "Systematic Data Handling Error volume" component:		to qualify for 2: Draft written policy and procedures for activating new water billing accounts and oversight of billing operations. Investigate and budget for computerized customer billing system. Conduct initial audit of billing records by flow-charting the basic business processes of the customer account/billing function.	to qualify for 4: Finalize written policy and procedures for activation of new billing accounts and overall billing operations management. Implement a computerized customer billing system. Conduct initial audit of billing records as part of this process.		to qualify for 6: Refine new account activation and billing operations procedures and ensure consistency with the utility policy regarding billing, and minimize opportunity for missed billings. Upgrade or replace customer billing system for needed functionality - ensure that billing adjustments don't corrupt the value of consumption volumes. Procedurize internal annual audit process.		to qualify for 8: Formalize regular review of new account activation process and general billing practices. Enhance reporting capability of computerized billing system. Formalize regular auditing process to reveal scope of data handling error. Plan for periodic third party audit to occur at least once every five years.		to qualify for 10: Close policy/procedure loopholes that allow some customer accounts to go unbilled, or data handling errors to exist. Ensure that billing system reports are utilized, analyzed and reported every billing cycle. Ensure that internal and third party audits are conducted at least once every three years.		to maintain 10: Stay abreast of customer information management developments and innovations. Monitor developments of Advanced Metering Infrastructure (AMI) and integrate technology to ensure that customer endpoint information is well-monitored and errors/lapses are at an economic minimum.
SYSTEM DATA											
Length of mains:		Poorly assembled and maintained paper as-built records of existing water main installations makes accurate determination of system pipe length impossible. Length of mains is guesstimated.	Paper records in poor or uncertain condition (no annual tracking of installations & abandonments). Poor procedures to ensure that new water mains installed by developers are accurately documented.	Conditions between 2 and 4	Sound written policy and procedures exist for documenting new water main installations, but gaps in management result in a uncertain degree of error in tabulation of mains length.	Conditions between 4 and 6	Sound written policy and procedures exist for permitting and commissioning new water mains. Highly accurate paper records with regular field validation; or electronic records and asset management system in good condition. Includes system backup.	Conditions between 6 and 8	Sound written policy and procedures exist for permitting and commissioning new water mains. Electronic recordkeeping such as a Geographical Information System (GIS) and asset management system are used to store and manage data.	Conditions between 8 and 10	Sound written policy exists for managing water mains extensions and replacements. Geographic Information System (GIS) data and asset management database agree and random field validation proves truth of databases. Records of annual field validation should be available for review.
Improvements to attain higher data grading for "Length of Water Mains" component:		to qualify for 2: Assign personnel to inventory current as-built records and compare with customer billing system records and highway plans in order to verify poorly documented pipelines. Assemble policy documents regarding permitting and documentation of water main installations by the utility and building developers; identify gaps in procedures that result in poor documentation of new water main installations.	to qualify for 4: Complete inventory of paper records of water main installations for several years prior to audit year. Review policy and procedures for commissioning and documenting new water main installation.		to qualify for 6: Finalize updates/improvements to written policy and procedures for permitting/commissioning new main installations. Confirm inventory of records for five years prior to audit year; correct any errors or omissions.		to qualify for 8: Launch random field checks of limited number of locations. Convert to electronic database such as a Geographic Information System (GIS) with backup as justified. Develop written policy and procedures.		to qualify for 10: Link Geographic Information System (GIS) and asset management databases, conduct field verification of data. Record field verification information at least annually.		to maintain 10: Continue with standardization and random field validation to improve the completeness and accuracy of the system.
Number of active AND inactive service connections:		Vague permitting (of new service connections) policy and poor paper recordkeeping of customer connections/billings result in suspect determination of the number of service connections, which may be 10-15% in error from actual count.	General permitting policy exists but paper records, procedural gaps, and weak oversight result in questionable total for number of connections, which may vary 5-10% of actual count.	Conditions between 2 and 4	Written account activation policy and procedures exist, but with some gaps in performance and oversight. Computerized information management system is being brought online to replace dated paper recordkeeping system. Reasonably accurate tracking of service connection installations & abandonments; but count can be up to 5% in error from actual total.	Conditions between 4 and 6	Written new account activation and overall billing policies and procedures are adequate and reviewed periodically. Computerized information management system is in use with annual installations & abandonments totaled. Very limited field verifications and audits. Error in count of number of service connections is believed to be no more than 3%.	Conditions between 6 and 8	Policies and procedures for new account activation and overall billing operations are written, well-structured and reviewed at least biannually. Well-managed computerized information management system exists and routine, periodic field checks and internal system audits are conducted. Counts of connections are no more than 2% in error.	Conditions between 8 and 10	Sound written policy and well managed and audited procedures ensure reliable management of service connection population. Computerized information management system, Customer Billing System, and Geographic Information System (GIS) information agree; field validation proves truth of databases. Count of connections recorded as being in error is less than 1% of the entire population.
Improvements to attain higher data grading for "Number of Active and Inactive Service Connections" component:	**Note: The number of Service Connections does not include fire hydrant leads/lines connecting the hydrant to the water main**	to qualify for 2: Draft new policy and procedures for new account activation and overall billing operations. Research and collect paper records of installations & abandonments for several years prior to audit year.	to qualify for 4: Refine policy and procedures for new account activation and overall billing operations. Research computerized recordkeeping system (Customer Information System or Customer Billing System) to improve documentation format for service connections.		to qualify for 6: Refine procedures to ensure consistency with new account activation and overall billing policy to establish new service connections or decommission existing connections. Improve process to include all totals for at least five years prior to audit year.		to qualify for 8: Formalize regular review of new account activation and overall billing operations policies and procedures. Launch random field checks of limited number of locations. Develop reports and auditing mechanisms for computerized information management system.		to qualify for 10: Close any procedural loopholes that allow installations to go undocumented. Link computerized information management system with Geographic Information System (GIS) and formalize field inspection and information system auditing processes. Documentation of new or decommissioned service connections encounters several levels of checks and balances.		to maintain 10: Continue with standardization and random field validation to improve knowledge of system.
	Note: if customer water	Gradings 1-9 apply if customer properties are unmetered, if customer meters exist and are located inside the customer building premises, or if the water utility owns and is responsible for the entire service connection piping from the water main to the customer building. In any of these cases the average distance between the curb stop or boundary separating utility/customer responsibility for service connection piping, and the typical first point of use (ex: faucet) or the customer meter must be quantified. Gradings of 1-9 are used to grade the validity of the means to quantify this value. (See the "Service Connection Diagram" worksheet)									Either of two conditions can be met for a grading of 10:

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
Average length of customer service line:	meters are located outside of the customer building next to the curb stop or boundary separating utility/customer responsibility, then the auditor should answer "Yes" to the question on the Reporting Worksheet asking about this. If the answer is Yes, the grading description listed under the Grading of 10(a) will be followed, with a value of zero automatically entered at a Grading of 10. See the Service Connection Diagram worksheet for a visual presentation of this distance.	Vague policy exists to define the delineation of water utility ownership and customer ownership of the service connection piping. Curb stops are perceived as the breakpoint but these have not been well-maintained or documented. Most are buried or obscured. Their location varies widely from site-to-site, and estimating this distance is arbitrary due to the unknown location of many curb stops.	Policy requires that the curb stop serves as the delineation point between water utility ownership and customer ownership of the service connection piping. The piping from the water main to the curb stop is the property of the water utility; and the piping from the curb stop to the customer building is owned by the customer. Curb stop locations are not well documented and the average distance is based upon a limited number of locations measured in the field.	Conditions between 2 and 4	Good policy requires that the curb stop serves as the delineation point between water utility ownership and customer ownership of the service connection piping. Curb stops are generally installed as needed and are reasonably documented. Their location varies widely from site-to-site, and an estimate of this distance is hindered by the availability of paper records of limited accuracy.	Conditions between 4 and 6	Clear written policy exists to define utility/customer responsibility for service connection piping. Accurate, well-maintained paper or basic electronic recordkeeping system exists. Periodic field checks confirm piping lengths for a sample of customer properties.	Conditions between 6 and 8	Clearly worded policy standardizes the location of curb stops and meters, which are inspected upon installation. Accurate and well maintained electronic records exist with periodic field checks to confirm locations of service lines, curb stops and customer meter pits. An accurate number of customer properties from the customer billing system allows for reliable averaging of this length.	Conditions between 8 and 10	a) Customer water meters exist outside of customer buildings next to the curb stop or boundary separating utility/customer responsibility for service connection piping. If so, answer "Yes" to the question on the Reporting Working asking about this condition. A value of zero and a Grading of 10 are automatically entered in the Reporting Worksheet . b). Meters exist inside customer buildings, or properties are unmetered. In either case, answer "No" to the Reporting Worksheet question on meter location, and enter a distance determined by the auditor. For a Grading of 10 this value must be a very reliable number from a Geographic Information System (GIS) and confirmed by a statistically valid number of field checks.
Improvements to attain higher data grading for "Average Length of Customer Service Line" component:		to qualify for 2: Research and collect paper records of service line installations. Inspect several sites in the field using pipe locators to locate curb stops. Obtain the length of this small sample of connections in this manner.	to qualify for 4: Formalize and communicate policy delineating utility/customer responsibilities for service connection piping. Assess accuracy of paper records by field inspection of a small sample of service connections using pipe locators as needed. Research the potential migration to a computerized information management system to store service connection data.		to qualify for 6: Establish coherent procedures to ensure that policy for curb stop, meter installation and documentation is followed. Gain consensus within the water utility for the establishment of a computerized information management system.		to qualify for 8: Implement an electronic means of recordkeeping, typically via a customer information system, customer billing system, or Geographic Information System (GIS). Standardize the process to conduct field checks of a limited number of locations.		to qualify for 10: Link customer information management system and Geographic Information System (GIS), standardize process for field verification of data.		to maintain 10: Continue with standardization and random field validation to improve knowledge of service connection configurations and customer meter locations.
Average operating pressure:		Available records are poorly assembled and maintained paper records of supply pump characteristics and water distribution system operating conditions. Average pressure is guesstimated based upon this information and ground elevations from crude topographical maps. Widely varying distribution system pressures due to undulating terrain, high system head loss and weak/erratic pressure controls further compromise the validity of the average pressure calculation.	Limited telemetry monitoring of scattered pumping station and water storage tank sites provides some static pressure data, which is recorded in handwritten logbooks. Pressure data is gathered at individual sites only when low pressure complaints arise. Average pressure is determined by averaging relatively crude data, and is affected by significant variation in ground elevations, system head loss and gaps in pressure controls in the distribution system.	Conditions between 2 and 4	Effective pressure controls separate different pressure zones; moderate pressure variation across the system, occasional open boundary valves are discovered that breech pressure zones. Basic telemetry monitoring of the distribution system logs pressure data electronically. Pressure data gathered by gauges or dataloggers at fire hydrants or buildings when low pressure complaints arise, and during fire flow tests and system flushing. Reliable topographical data exists. Average pressure is calculated using this mix of data.	Conditions between 4 and 6	Reliable pressure controls separate distinct pressure zones; only very occasional open boundary valves are encountered that breech pressure zones. Well-covered telemetry monitoring of the distribution system (not just pumping at source treatment plants or wells) logs extensive pressure data electronically. Pressure gathered by gauges/dataloggers at fire hydrants and buildings when low pressure complaints arise, and during fire flow tests and system flushing. Average pressure is determined by using this mix of reliable data.	Conditions between 6 and 8	Well-managed, discrete pressure zones exist with generally predictable pressure fluctuations. A current full-scale SCADA System or similar realtime monitoring system exists to monitor the water distribution system and collect data, including real time pressure readings at representative sites across the system. The average system pressure is determined from reliable monitoring system data.	Conditions between 8 and 10	Well-managed pressure districts/zones, SCADA System and hydraulic model exist to give very precise pressure data across the water distribution system. Average system pressure is reliably calculated from extensive, reliable, and cross-checked data. Calculations are reported on an annual basis as a minimum.
Improvements to attain higher data grading for "Average Operating Pressure" component:		to qualify for 2: Employ pressure gauging and/or datalogging equipment to obtain pressure measurements from fire hydrants. Locate accurate topographical maps of service area in order to confirm ground elevations. Research pump data sheets to find pump pressure/flow characteristics	to qualify for 4: Formalize a procedure to use pressure gauging/datalogging equipment to gather pressure data during various system events such as low pressure complaints, or operational testing. Gather pump pressure and flow data at different flow regimes. Identify faulty pressure controls (pressure reducing valves, altitude valves, partially open boundary valves) and plan to properly configure pressure zones. Make all pressure data from these efforts available to generate system-wide average pressure.		to qualify for 6: Expand the use of pressure gauging/datalogging equipment to gather scattered pressure data at a representative set of sites, based upon pressure zones or areas. Utilize pump pressure and flow data to determine supply head entering each pressure zone or district. Correct any faulty pressure controls (pressure reducing valves, altitude valves, partially open boundary valves) to ensure properly configured pressure zones. Use expanded pressure dataset from these activities to generate system-wide average pressure.		to qualify for 8: Install a Supervisory Control and Data Acquisition (SCADA) System, or similar realtime monitoring system, to monitor system parameters and control operations. Set regular calibration schedule for instrumentation to insure data accuracy. Obtain accurate topographical data and utilize pressure data gathered from field surveys to provide extensive, reliable data for pressure averaging.		to qualify for 10: Annually, obtain a system-wide average pressure value from the hydraulic model of the distribution system that has been calibrated via field measurements in the water distribution system and confirmed in comparisons with SCADA System data.		to maintain 10: Continue to refine the hydraulic model of the distribution system and consider linking it with SCADA System for real-time pressure data calibration, and averaging.

Grading >>>	n/a	1	2	3	4	5	6	7	8	9	10
COST DATA											
Total annual cost of operating water system:		Incomplete paper records and lack of financial accounting documentation on many operating functions makes calculation of water system operating costs a pure guesstimate	Reasonably maintained, but incomplete, paper or electronic accounting provides data to estimate the major portion of water system operating costs.	Conditions between 2 and 4	Electronic, industry-standard cost accounting system in place. However, gaps in data are known to exist, periodic internal reviews are conducted but not a structured financial audit.	Conditions between 4 and 6	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited periodically by utility personnel, but not a Certified Public Accountant (CPA).	Conditions between 6 and 8	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited at least annually by utility personnel, and at least once every three years by third-party CPA.	Conditions between 8 and 10	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited annually by utility personnel and annually also by third-party CPA.
Improvements to attain higher data grading for "Total Annual Cost of Operating the Water System" component:		to qualify for 2: Gather available records, institute new financial accounting procedures to regularly collect and audit basic cost data of most important operations functions.	to qualify for 4: Implement an electronic cost accounting system, structured according to accounting standards for water utilities		to qualify for 6: Establish process for periodic internal audit of water system operating costs; identify cost data gaps and institute procedures for tracking these outstanding costs.		to qualify for 8: Standardize the process to conduct routine financial audit on an annual basis. Arrange for CPA audit of financial records at least once every three years.		to qualify for 10: Standardize the process to conduct a third-party financial audit by a CPA on an annual basis.		to maintain 10: Maintain program, stay abreast of expenses subject to erratic cost changes and long-term cost trend, and budget/track costs proactively
Customer retail unit cost (applied to Apparent Losses):	Customer population unmetered, and/or only a fixed fee is charged for consumption.	Antiquated, cumbersome water rate structure is used, with periodic historic amendments that were poorly documented and implemented; resulting in classes of customers being billed inconsistent charges. The actual composite billing rate likely differs significantly from the published water rate structure, but a lack of auditing leaves the degree of error indeterminate.	Dated, cumbersome water rate structure, not always employed consistently in actual billing operations. The actual composite billing rate is known to differ from the published water rate structure, and a reasonably accurate estimate of the degree of error is determined, allowing a composite billing rate to be quantified.	Conditions between 2 and 4	Straight-forward water rate structure in use, but not updated in several years. Billing operations reliably employ the rate structure. The composite billing rate is derived from a single customer class such as residential customer accounts, neglecting the effect of different rates from varying customer classes.	Conditions between 4 and 6	Clearly written, up-to-date water rate structure is in force and is applied reliably in billing operations. Composite customer rate is determined using a weighted average residential rate using volumes of water in each rate block.	Conditions between 6 and 8	Effective water rate structure is in force and is applied reliably in billing operations. Composite customer rate is determined using a weighted average composite consumption rate, which includes residential, commercial, industrial, institutional (CII), and any other distinct customer classes within the water rate structure.	Conditions between 8 and 10	Current, effective water rate structure is in force and applied reliably in billing operations. The rate structure and calculations of composite rate - which includes residential, commercial, industrial, institutional (CII), and other distinct customer classes - are reviewed by a third party knowledgeable in the M36 methodology at least once every five years.
Improvements to attain higher data grading for "Customer Retail Unit Cost" component:		to qualify for 2: Formalize the process to implement water rates, including a secure documentation procedure. Create a current, formal water rate document and gain approval from all stakeholders.	to qualify for 4: Review the water rate structure and update/formalize as needed. Assess billing operations to ensure that actual billing operations incorporate the established water rate structure.		to qualify for 6: Evaluate volume of water used in each usage block by residential users. Multiply volumes by full rate structure.	Launch effort to fully meter the customer population and charge rates based upon water volumes	to qualify for 8: Evaluate volume of water used in each usage block by all classifications of users. Multiply volumes by full rate structure.		to qualify for 10: Conduct a periodic third-party audit of water used in each usage block by all classifications of users. Multiply volumes by full rate structure.		to maintain 10: Keep water rate structure current in addressing the water utility's revenue needs. Update the calculation of the customer unit rate as new rate components, customer classes, or other components are modified.
Variable production cost (applied to Real Losses):	Note: if the water utility purchases/imports its entire water supply, then enter the unit purchase cost of the bulk water supply in the Reporting Worksheet with a grading of 10	Incomplete paper records and lack of documentation on primary operating functions (electric power and treatment costs most importantly) makes calculation of variable production costs a pure guesstimate	Reasonably maintained, but incomplete, paper or electronic accounting provides data to roughly estimate the basic operations costs (pumping power costs and treatment costs) and calculate a unit variable production cost.	Conditions between 2 and 4	Electronic, industry-standard cost accounting system in place. Electric power and treatment costs are reliably tracked and allow accurate weighted calculation of unit variable production costs based on these two inputs and water imported purchase costs (if applicable). All costs are audited internally on a periodic basis.	Conditions between 4 and 6	Reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Pertinent additional costs beyond power, treatment and water imported purchase costs (if applicable) such as liability, residuals management, wear and tear on equipment, impending expansion of supply, are included in the unit variable production cost, as applicable. The data is audited at least annually by utility personnel.	Conditions between 6 and 8	Reliable electronic, industry-standard cost accounting system in place, with all pertinent primary and secondary variable production and water imported purchase (if applicable) costs tracked. The data is audited at least annually by utility personnel, and at least once every three years by a third-party knowledgeable in the M36 methodology.	Conditions between 8 and 10	Either of two conditions can be met to obtain a grading of 10: 1) Third party CPA audit of all pertinent primary and secondary variable production and water imported purchase (if applicable) costs on an annual basis. or: 2) Water supply is entirely purchased as bulk imported water, and unit purchase cost serves as the variable production cost.
Improvements to attain higher data grading for "Variable Production Cost" component:		to qualify for 2: Gather available records, institute new procedures to regularly collect and audit basic cost data and most important operations functions.	to qualify for 4: Implement an electronic cost accounting system, structured according to accounting standards for water utilities		to qualify for 6: Formalize process for regular internal audits of production costs. Assess whether additional costs (liability, residuals management, equipment wear, impending infrastructure expansion) should be included to calculate a more representative variable production cost.		to qualify for 8: Formalize the accounting process to include direct cost components (power, treatment) as well as indirect cost components (liability, residuals management, etc.) Arrange to conduct audits by a knowledgeable third-party at least once every three years.		to qualify for 10: Standardize the process to conduct a third-party financial audit by a CPA on an annual basis.		to maintain 10: Maintain program, stay abreast of expenses subject to erratic cost changes and budget/track costs proactively

AWWA Free Water Audit Software:

Determining Water Loss Standing

Water Audit Report for: Santaquin
Reporting Year: 2019 1/2019 - 12/2019
Data Validity Score: **65**

Water Loss Control Planning Guide

	Water Audit Data Validity Level / Score				
Functional Focus Area	**Level I** (0-25)	**Level II** (26-50)	**Level III** (51-70)	**Level IV** (71-90)	**Level V** (91-100)
Audit Data Collection	Launch auditing and loss control team; address production metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs. Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)	Performance Benchmarking - ILI is meaningful in comparing real loss standing	Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.

Once data have been entered into the Reporting Worksheet, the performance indicators are automatically calculated. How does a water utility operator know how well his or her system is performing? The AWWA Water Loss Control Committee provided the following table to assist water utilities is gauging an approximate Infrastructure Leakage Index (ILI) that is appropriate for their water system and local conditions. The lower the amount of leakage and real losses that exist in the system, then the lower the ILI value will be.

Note: this table offers an approximate guideline for leakage reduction target-setting. The best means of setting such targets include performing an economic assessment of various loss control methods. However, this table is useful if such an assessment is not possible.

General Guidelines for Setting a Target ILI
(without doing a full economic analysis of leakage control options)

Target ILI Range	Financial Considerations	Operational Considerations	Water Resources Considerations
1.0 - 3.0	Water resources are costly to develop or purchase; ability to increase revenues via water rates is greatly limited because of regulation or low ratepayer affordability.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.
>3.0 -5.0	Water resources can be developed or purchased at reasonable expense; periodic water rate increases can be feasibly imposed and are tolerated by the customer population.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management, water conservation) are included in the long-term planning.
>5.0 - 8.0	Cost to purchase or obtain/treat water is low, as are rates charged to customers.	Superior reliability, capacity and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Water resources are plentiful, reliable, and easily extracted.
Greater than 8.0	Although operational and financial considerations may allow a long-term ILI greater than 8.0, such a level of leakage is not an effective utilization of water as a resource. Setting a target level greater than 8.0 - other than as an incremental goal to a smaller long-term target - is discouraged.		
Less than 1.0	If the calculated Infrastructure Leakage Index (ILI) value for your system is 1.0 or less, two possibilities exist. a) you are maintaining your leakage at low levels in a class with the top worldwide performers in leakage control. b) A portion of your data may be flawed, causing your losses to be greatly understated. This is likely if you calculate a low ILI value but do not employ extensive leakage control practices in your operations. In such cases it is beneficial to validate the data by performing field measurements to confirm the accuracy of production and customer meters, or to identify any other potential sources of error in the data.		

APPENDIX D

Springs Evaluation

MEMORANDUM

DATE: October 30, 2020

TO:
Norm Beagley, P.E.
Jon Lundell, P.E.
Santaquin City
275 West Main Street
Santaquin, UT 84655

FROM:
Roy B. McDaniel, P.E.
Hansen, Allen & Luce, Inc. (HAL)
859 West So. Jordan Pkwy – Suite 200
South Jordan, Utah 84095

SUBJECT: Analysis of Existing Culinary Water Springs

PROJECT NO.: 415.02.100 **DRAFT**

INTRODUCTION

Purpose and Scope

The purpose of this memo is to provide direction to the City of Santaquin regarding the question to redevelop its culinary water springs located in Santaquin Canyon. Santaquin City has seen a decline in the volume of water produced from its spring sources. Hansen, Allen & Luce (HAL) evaluated the springs to determine whether the decline is related to the recent dry period that the region has been experiencing or by deterioration of the spring collection pipes and boxes, thus requiring replacement.

As part of this evaluation, HAL has reviewed and analyzed record drawings of the springs, historic spring flow data, and precipitation records. Dennis Barnes, a City employee, and former Public Works Director with over 37 years of experience managing the City's water systems and springs, guided the inspection of the springs and provided valuable historical information.

Background

Santaquin City's culinary water springs are located on the west side of Summit Creek in Santaquin Canyon. The Town of Santaquin began using the springs for culinary water between 1911 and 1914. According to the "Proof of Appropriation of Water" filed in April 1921, the construction consisted of "cement or concrete pipe laid with open joints two to three feet below creek bed in channel of stream" with the purpose of collection water from "springs in the bed of Summit Creek."

Summit Creek experienced massive floods in 1983 that washed out the bank of the stream channel and the collection works, requiring the collection works to be reconstructed. Due to Spring 1 being reconstructed at a lower elevation and having poorer water quality, it is no longer used in the culinary water system. The City most recently reconstructed Springs 2 through 5 in 1993, with engineering plans being prepared by Sunrise Engineering.

Figure D-1 shows the location of Springs 2 – 5 in relation to the City and Summit Creek.

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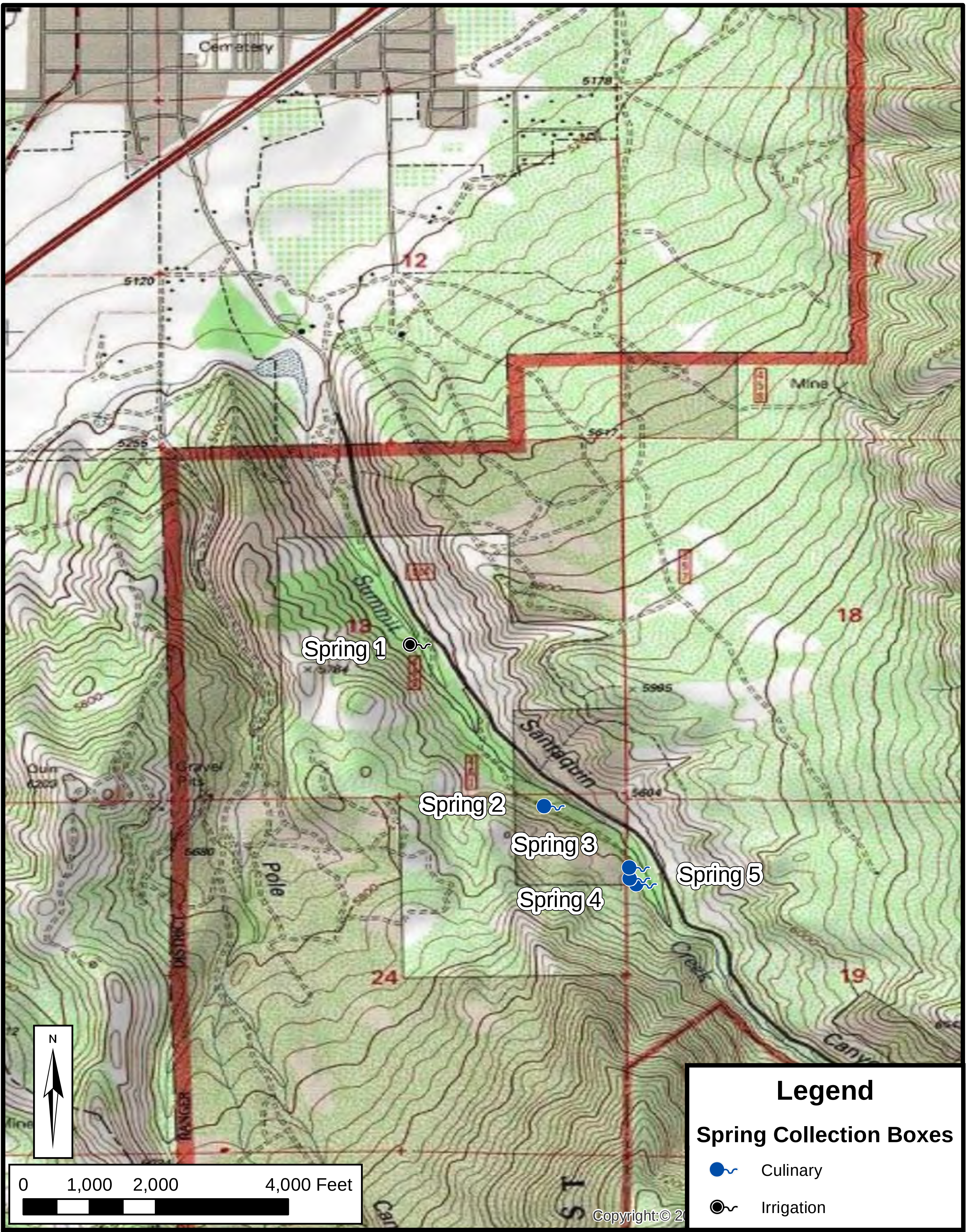
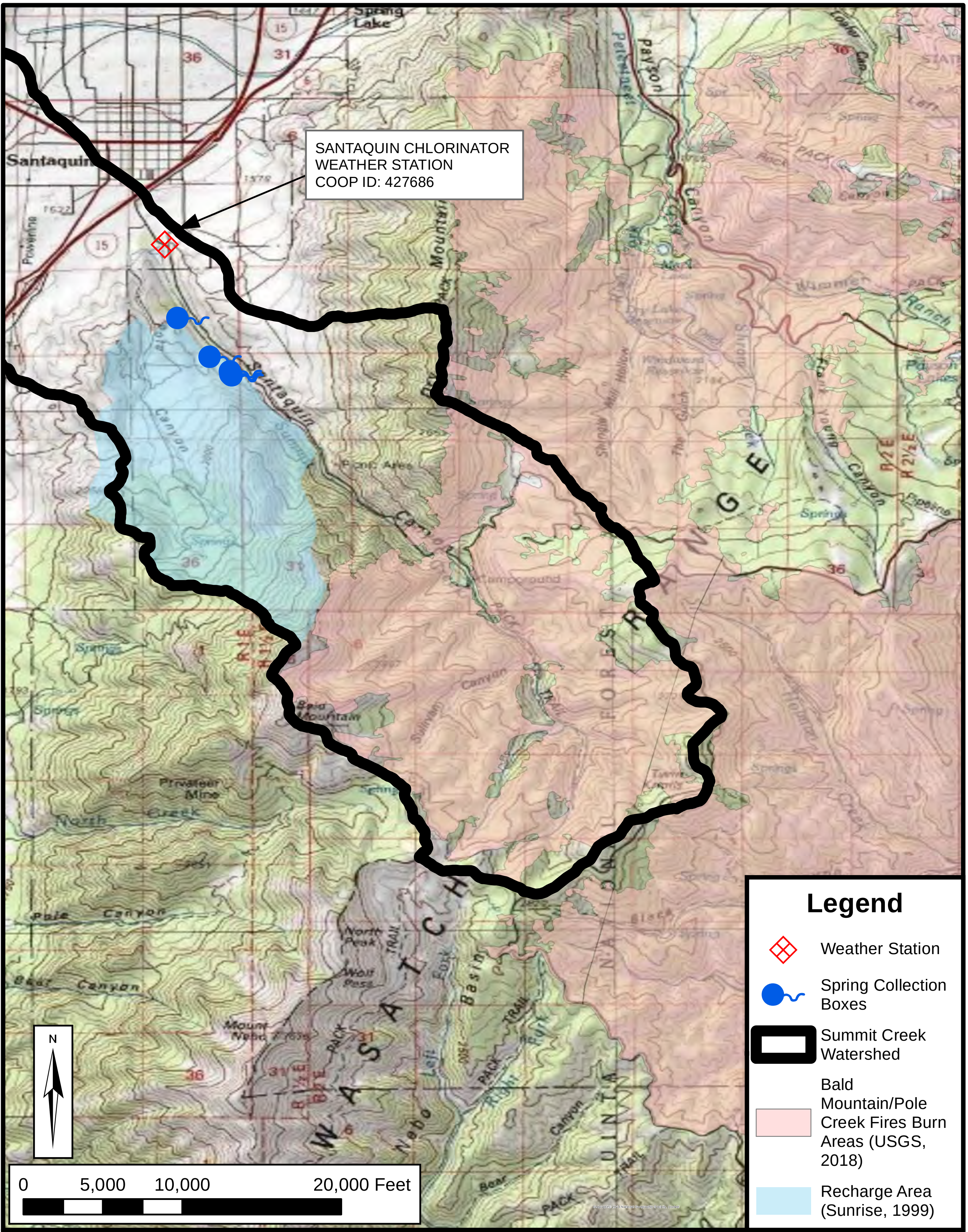


HANSEN ALLEN & LUCE INC
ENGINEERS

SANTAQUIN CITY
ANALYSIS OF CULINARY WATER SPRINGS
SPRING LOCATIONS

FIGURE
D-1



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HANSEN ALLEN & LUCE INC
ENGINEERS

SANTAQUIN CITY
ANALYSIS OF CULINARY WATER SPRINGS
SPRING LOCATIONS

FIGURE
D-2

ANALYSIS OF HYDROLOGY AND SPRING FLOW DATA

Figure D-2 shows the springs, the weather station used in the analysis, and the recharge area defined in the Drinking Water Source Protection plan (Sunrise, 1999). Spring flow data was analyzed to determine if there is a correlation between the reduction in spring flow and the precipitation patterns in Santaquin Canyon.

Weather Data

The Utah Climate Center maintains a weather station at Santaquin City's chlorination building, named "Santaquin Chlorinator". The weather station is at the mouth of Santaquin Canyon, approximately 1.3 miles from Spring 2, and 1.7 miles from Springs 3, 4, & 5. According to the Drinking Water Source Protection Plan (Sunrise, 1999), the watershed that recharges the spring extends approximately 5 miles to the south and east of the weather station.

Figure D-3 shows a graph of the annual precipitation from 1993 to 2020, and the average annual precipitation value of 18.82 inches. The graph shows that the periods of 1999-2003, 2007, 2010, and 2012-2017 saw below average precipitation. The linear trendline calculated for the precipitation data shows that precipitation values have been decreasing since 1993.

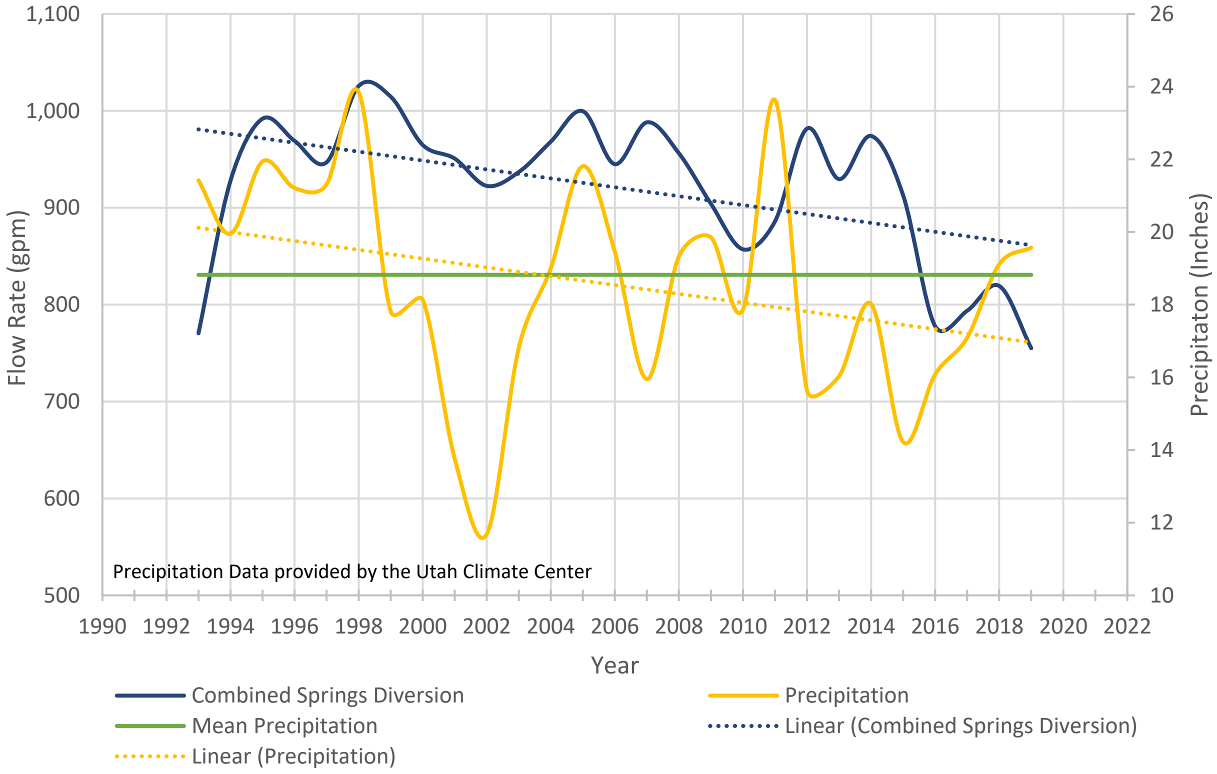


Figure D-3: Annual Precipitation vs Annual Metered Spring Flow

The total spring flow from Springs 2 – 5 are also metered and the volume of water being diverted is reported to the Utah Division of Water Rights. The annual diversions, converted to gallons per minute (gpm), are also plotted on Figure D-3.

Figure D-3 shows correlation between the peaks and valleys of both the precipitation graph and the metered discharge graph. Like the precipitation graph, the trendline shows the metered discharges have been decreasing. This indicates that the decrease in water coming from the springs is being influenced by the decrease in precipitation that is happening in the Santaquin area.

Individual Spring Flows

Santaquin City has recorded the flow rate of each spring several months each year since 1993. The flow rate is measured using a rectangular weir and staff gauge located in the box. Normally the flow rate is taken at each spring several times of the year, with January being the most consistent month of spring flow measurement. One difficulty in analyzing the readings over the weir is that the measurements were not taken consistently, so it was difficult to determine individual patters of each spring. This could be resolved by installing transducers in each spring that would measure the depth of water over the weir on a daily, weekly, or monthly basis, and downloaded at regular intervals.

Figure D-4 shows that both Springs 2 and 3 have seen a decline in production since 1993, with Spring 3 seeing the biggest drop. This appears to follow a similar downward trend as the annual metered flows and precipitation.

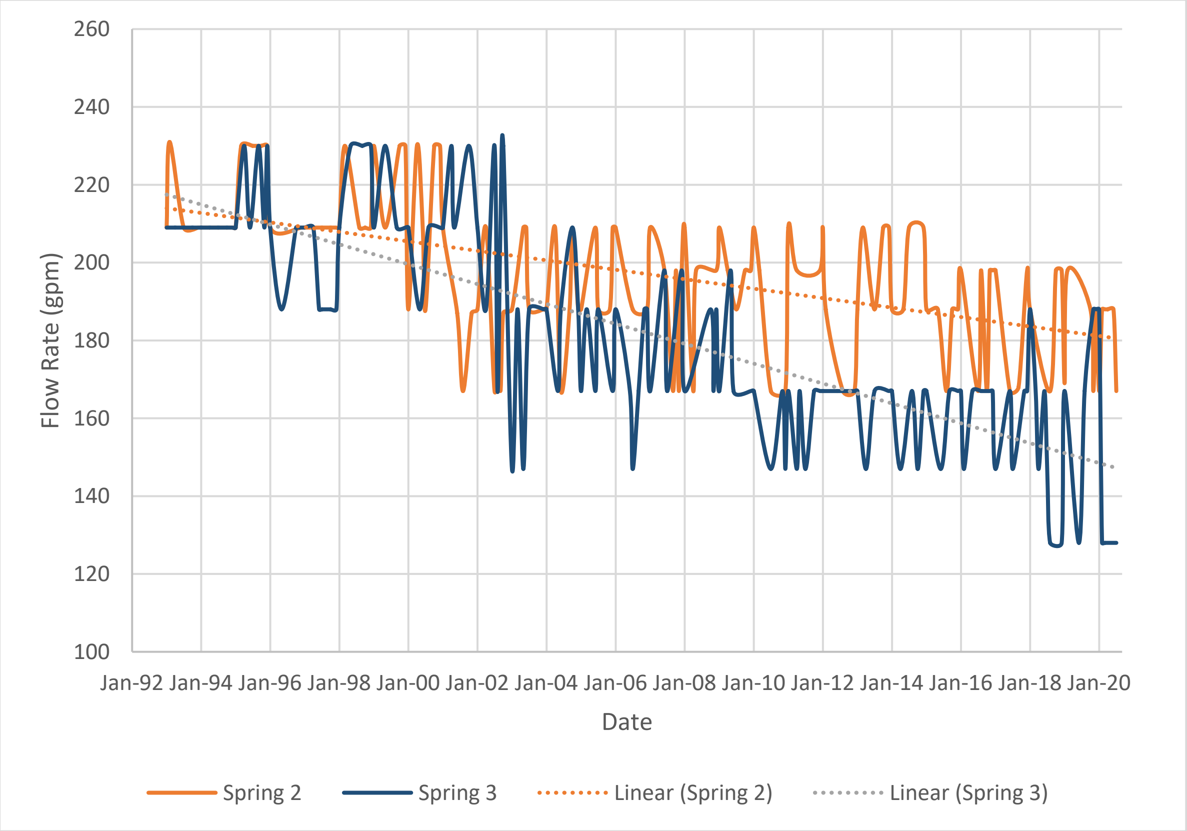


Figure D-4: Monthly Flow Measurements Springs 2 and 3 - January 1993 to July 2020

Figure D-5 shows that the flows from Springs 4 and 5 have been consistently steadier until January 2020, when production started to drop. Spring 5 is the largest, and most consistent producer of water of all the springs, seeing very little variation until 2020. Spring 4 fluctuates more than Spring 5 but has not seen a pattern of significant decrease in flow over the past 27 years.

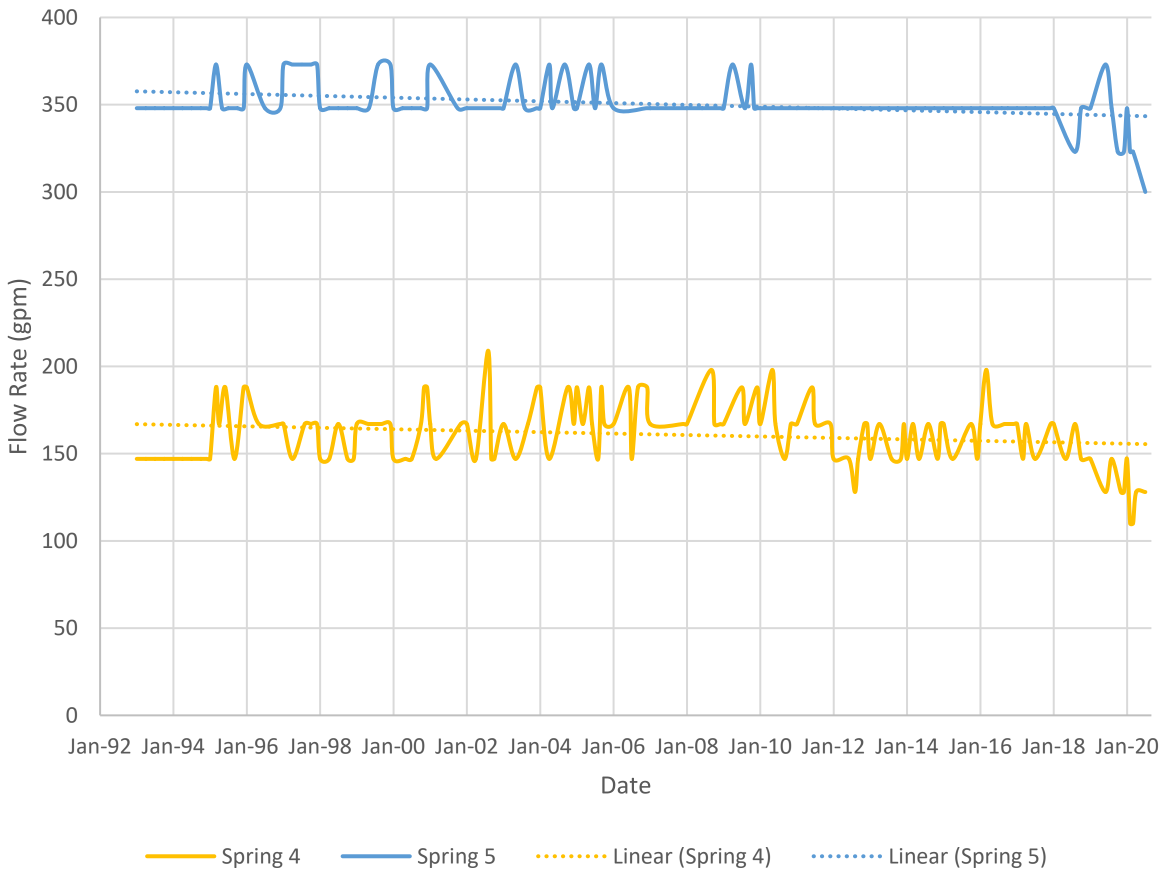


Figure D-5: Monthly Flow measurements springs 4 & 5 – January 1993 to July 2020

An analysis of the spring flows shows that Springs 2 and 3 are seeing the longest decline in spring flow with sharp decreases seen between 2000 and 2003, soon after a period when annual precipitation fell significantly below the average annual precipitation. Annual precipitation fell significantly below average beginning in 2012, and not improving until 2018. This same period saw further decrease in spring flow production, indicating that Springs 2 and 3 are influenced quickly by precipitation.

Springs 4 and 5 have produced constant flows from 1993 through 2019 and have only seen decreases in flow since the beginning of 2020. This may indicate that these springs are influenced by a much larger regional aquifer that is not directly influenced by yearly precipitation patterns.

Hydrologic Implications of the Bald Mountain and Pole Creek Fires

The Bald Mountain and Pole Creek fires began separately on August 24 and September 6, 2018 and combined into one larger fire that burned areas within the Summit Creek watershed (See Figure D-2). The fires caused increased flows in the Summit Creek watershed, which have deposited increased silt and debris in the debris basin at the mouth of Santaquin Canyon. This has led to the question of whether the forest fires have affected the production of the springs.

There are numerous scholarly articles and papers that discuss the hydrologic effects of forest fires, giving examples of snow melting earlier in the season, increased runoff, and decrease of infiltration due to damaged soil (USDA, 2005). Forest fires can also increase the snowpack and snow water equivalent in burn areas (Maxwell, 2019). On the other hand, these papers discuss the complicated issues that make the results of each forest fire behave differently.

Springs 4 and 5 have exhibited constant flows until January 2020. Since then, the flows have uncharacteristically decreased. The recharge area identified as part of the Drinking Water Source Protection plan does not include any of the burn areas identified in the forest fires, but bedrock aquifers are complex, and difficult to understand, and the area may not be delineated accurately. Additionally, ash may have migrated into the recharge area, changing the snowmelt and recharge characteristics of the aquifer. The fire could be a cause for the decreases seen in 2020 but would need further investigation to confirm the cause.

A study of forest fires in New Mexico that studied the hydrologic effects of wildfires observed that arid watersheds recover in 3 to 5 years following a forest fire (Wine and Cadol, 2016). If that is the case, one could expect to see decreased flows from the springs through 2021 through 2023.

INSPECTION OF SPRINGS

The springs were inspected on the morning of August 4, 2020, and were attended by Dennis Barnes, representing Santaquin City, and Roy McDaniel, P.E., representing HAL. Photographs of the inspection are included at the end of this report. The inspection of the springs did not reveal any obvious problems that may indicate that the reduction in spring flow is caused by a failure of the springs.

The purpose of the inspection was to look for signs of failure of the spring collection devices, such as deep rooted vegetation growing in the spring collection area and evidence of roots or other debris in the spring collection box and drains, and evidence of water seeping past the spring collection pipes.

Rocks, sand and gravel in the spring collection box or drain would indicate a failure in the collection pipe that may need to be repaired. Hard water deposits could indicate plugging of the gravel collection. Roots could indicate failure of the liner, clay cut-off wall, or just that trees are consuming a large portion of water. The site visit did not reveal any of these problems. There was some gravel and rocks in the bottom of the spring collection boxes, but it was minor, and reportedly has been there since the boxes were installed.

Springs 2 and 3 did not have any trees closer than 15 feet on the downhill side, or 50 or more feet on the uphill side of the collection pipes. The dominant tree species appeared to be the Canyon Maple, also known as Bigtooth Maple. In many cases, the trees were growing up against the barbed wire fences. There was no evidence that the trees or other vegetation were causing problems along the main collection areas.

As mentioned earlier, Dennis Barnes reported that Spring 2’s collection pipe extended into a small, buried cave on the south side of the canyon. The location of the pipe was not apparent, and it could be possible that some roots could be reducing flow.

The overflow/drainpipe for Spring 2 was not available for inspection due to it being buried. The assumed location of the outlet is marked by a black metal pipe placed as a marker sticking out of the ground.

ANALYSIS OF SPRING PLANS

Description of Design

Marvin J. Wilson, P.E., of Sunrise Engineering, sealed and signed the “Santaquin City CDBG Spring Redevelopment Project” on September 9, 1993, providing information on the construction of Springs 2 & 3. Figure D-6 shows a cross section of the spring collection design.

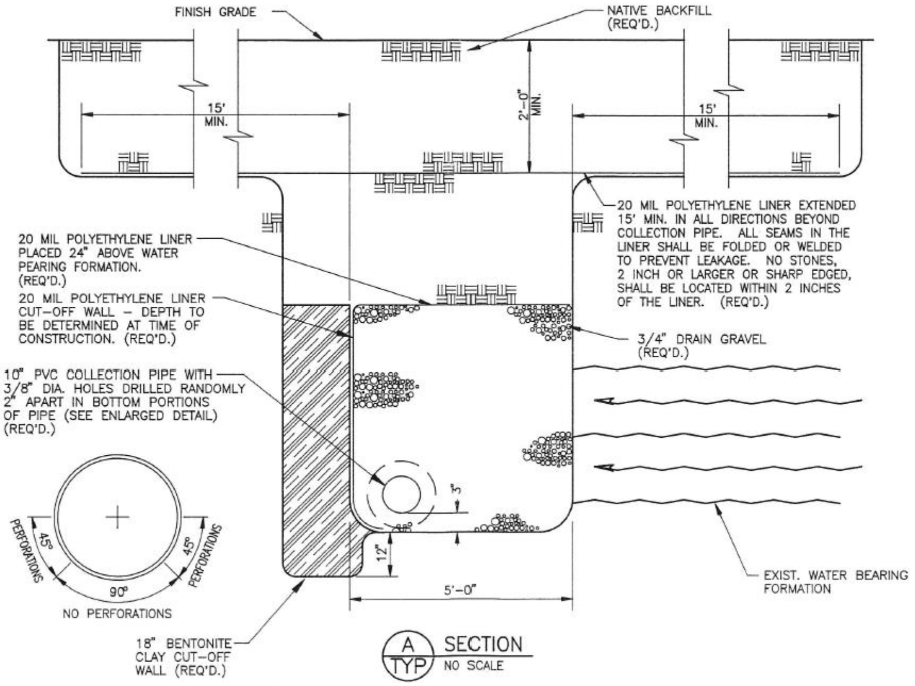
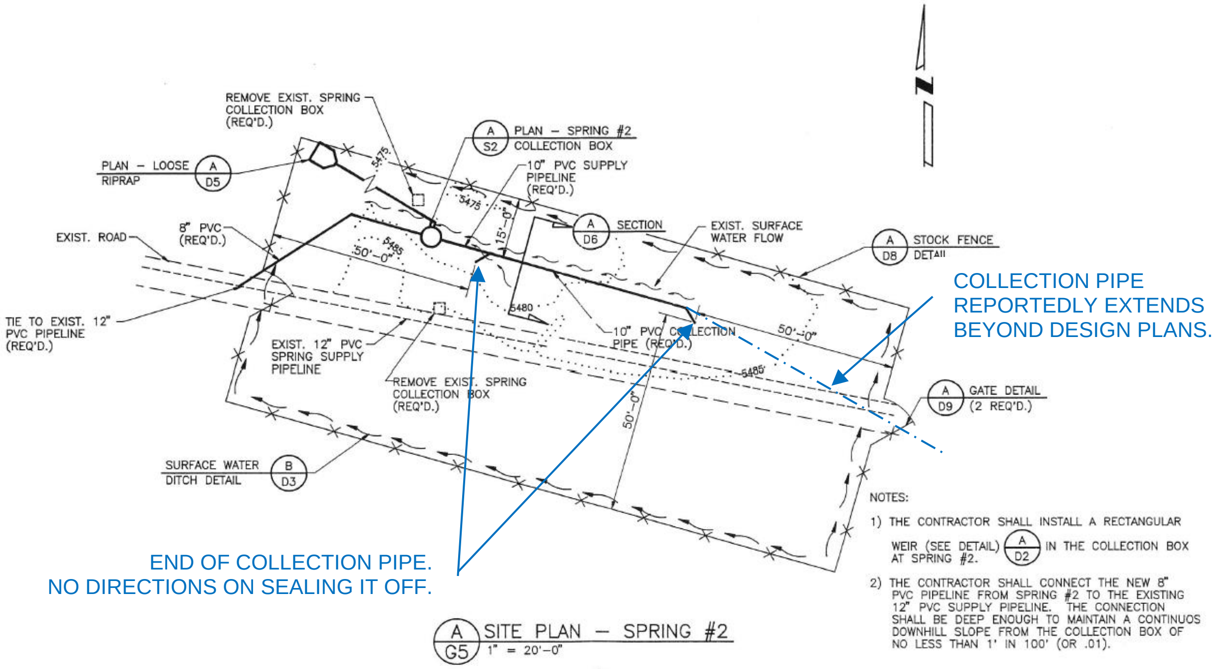


FIGURE D-6: SPRING COLLECTION DESIGN FOR SPRINGS 2 & 3 (SUNRISE, 1993)

The gravel, bentonite wall, and 20-mil liner were to be placed 2 feet higher than the top of the water bearing formation to minimize the risk of water flowing over the top of the collection gravel. The perforations were placed on the bottom half of 10” pipe, reducing the risk of sand and gravel falling into the pipe by gravity.

The trench was to be backfilled with native material, with no stones larger than 2 inches within 2 inches of the liner. At a depth of 2 feet, the ground was excavated 15 feet in all directions, covered with another 20-mil polyethylene liner and backfilled with native material.

Figure D-7 shows the plan view of Spring 2 & 3.The plans call for the spring area to be mounded to prevent ponding and to direct surface water away from the spring collection area, along with the construction of diversion channels to be constructed next to a barbed-wire fence. The fence is a minimum of 15 feet away from the downhill side of the spring collection pipes, and 50 feet away from the uphill side of the spring collection pipes.



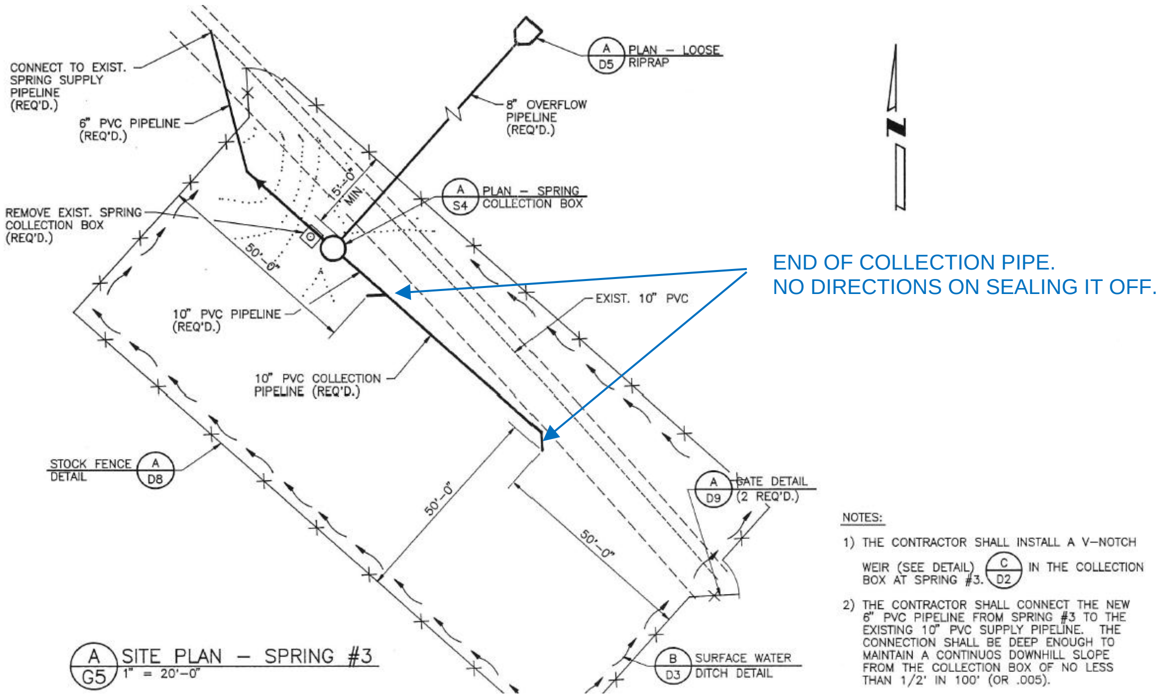
COLLECTION PIPE REPORTEDLY EXTENDS BEYOND DESIGN PLANS.

END OF COLLECTION PIPE.
NO DIRECTIONS ON SEALING IT OFF.

NOTES:

1) THE CONTRACTOR SHALL INSTALL A RECTANGULAR WEIR (SEE DETAIL) A/D2 IN THE COLLECTION BOX AT SPRING #2.

2) THE CONTRACTOR SHALL CONNECT THE NEW 8" PVC PIPELINE FROM SPRING #2 TO THE EXISTING 12" PVC SUPPLY PIPELINE. THE CONNECTION SHALL BE DEEP ENOUGH TO MAINTAIN A CONTINUOS DOWNHILL SLOPE FROM THE COLLECTION BOX OF NO LESS THAN 1' IN 100' (OR .01).



END OF COLLECTION PIPE.
NO DIRECTIONS ON SEALING IT OFF.

NOTES:

1) THE CONTRACTOR SHALL INSTALL A V–NOTCH WEIR (SEE DETAIL) C/D2 IN THE COLLECTION BOX AT SPRING #3.

2) THE CONTRACTOR SHALL CONNECT THE NEW 6" PVC PIPELINE FROM SPRING #3 TO THE EXISTING 10" PVC SUPPLY PIPELINE. THE CONNECTION SHALL BE DEEP ENOUGH TO MAINTAIN A CONTINUOS DOWNHILL SLOPE FROM THE COLLECTION BOX OF NO LESS THAN 1/2' IN 100' (OR .005).

FIGURE D-7: PLAN VIEW OF SPRINGS 2 & 3 DESIGN

Analysis of Spring Plan Drawings

The plans show the locations of six springs but only five collection boxes could be identified in the field. The plans only contain designs for Springs 2 & 3, but Dennis Barnes indicated that the City followed the designs to reconstruct the other springs as much as possible.

Between the depth of the spring collection pipes, the setbacks, and the liners, Springs 2 and 3 appear to have multiple barriers to preventing tree roots from causing problems with the springs. Based on the site inspection, the spring collection pipe for Spring 2 appears to be about 8 to 10 feet below ground, and the collection pipe for Spring 3 appears to be 6 to 8 feet deep.

As shown on Figure D-7, the plans do not specify what happens at each end of the perforated pipe and trench. The plans called for extending the gravel 2 feet above the water bearing formation in order to prevent water from traveling over the top of the gravel, but they do not specify if the gravel was extended horizontally beyond the water bearing zone to reduce the chance of the water flowing horizontally around the collection pipe.

The plans call out the extent of the perforated pipe but failed to specify how the clay wall and liner terminate at these locations. It is assumed the end of the perforated pipe is capped. The plans show a line drawn at a 45-degree angle to the collection line at the end of the collection lines and where the pipe transitions from a perforated pipe to a fully enclosed pipe. Ideally this would indicate that the bentonite wall and liner wrap around to the opposite side of the 5-foot wide trench.

Because the spring collection areas are flat, and Springs 2 & 3 are 6 to 10 feet deep, any water that bypasses the springs would likely surface a significant distance from the collection pipes. The groundwater flow appears to be directed to Summit Creek, which is separated from the spring collection system by a small ridge that rises in elevation to the north/northeast of the collection boxes. Any water that bypasses the springs will most likely surface in Summit Creek, making it difficult to determine if it is happening.

The Utah Division of Drinking Water would have approved the use of a 20-mil liner in 1993, but Utah State Administrative Rules R309-515-7(7)(b) required the liner to have a minimum thickness of 40-mil (DDW, 2014). Part of the reason for the increase in liner thickness is because 20-mil thickness material is easily torn, causing a potential for the native material to be carried into the gravel, introducing contamination, but also possibly plugging the gravel and reducing flow.
The site visit did not reveal any sink holes or other indications that this has happened.

The backfill on top of the spring would ideally have 2 feet of impermeable material, but the plans did not specify anything except for screened native material. Dennis Barnes recalled during the site visit that clay material was used on top of the liner to seal off the springs.

As Figure D-7 shows, Dennis Barnes reported that spring collection line for Spring #2 extends beyond the location shown in the plans to an outcrop on the south side of the canyon where water seeped into a cave. Figure D-8 shows that the vegetation changes in the soil covering the 35-foot-wide liner. This pattern extends beyond the area shown on the plans, supporting Dennis's claim.

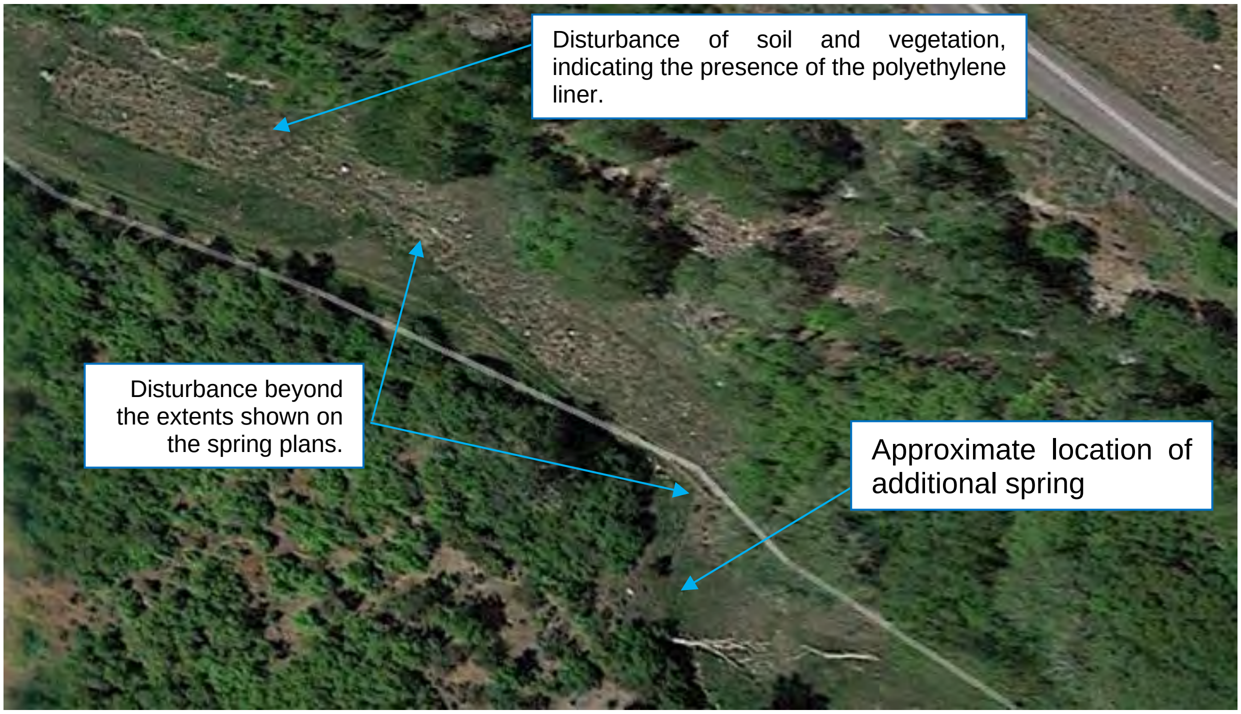


FIGURE D-8 – COLLECTION AREA FOR SPRING 2, MAY 2013 AERIAL PHOTOGRAPH FROM MAY 2013

CONCLUSIONS AND RECOMMENDATIONS

Considerations

The analysis of Springs 2 through 5 indicate that the greatest correlation to reduced spring flows is the below average precipitation for 14 of the past 22 years. A review of the spring construction plans, and site inspection did not reveal any obvious defects in the spring that could be corrected through reconstruction of the springs.

The greatest decrease in spring production is evident in the Springs 2 and 3, which appear to be affected more by local weather patterns. Springs 2 and 3 are in the bottom of the canyon near Summit Creek and were reported to be developed in boggy areas that could experience local recharge. Springs 4 and 5 are located closer to canyon walls and are likely influenced by an aquifer that is much larger and deeper and does not respond as quickly to weather pattern changes.

There appears to be a correlation to decreased spring flows in Springs 4 and 5 that may be related to the Pole Creek/Bald Mountain fires, but further investigation would need to be performed to validate the effect. It is expected as precipitation increases the flows from Springs 2 and 3 would increase, and as precipitation decreases, it would decrease.

Recommendations

HAL makes the following recommendations concerning Springs 2 – 5.

- Consider installing transducers in Springs 2 – 5 collection boxes to measure the flow over the weir on a consistent basis, to have a better understanding of each spring’s flow patterns.
- Continue to monitor spring flow in relation to precipitation data for the next 5 years. If annual precipitation increases without an increase in spring flow, consider performing additional investigations and redeveloping the springs.
- Consider sending a camera in the 10-inch collection pipe to see if there are signs of pipe failure, roots, or clogging of the gravel pack.
- Consider increasing the buffer around the spring collection area by cutting down trees that are closest to the spring collection lines.
- Consider developing other springs along Summit Creek, with the understanding that a water rights change application may be protested by other water right holders.
- Uncover the drain/outfall for Spring 2, to provide a 12-inch air gap

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Attachment A
Photographs from the Inspection of Santaquin's Culinary Water Springs
August 4, 2020


Photo 1 - Spring 2 Collection Box, looking northwesterly down the canyon, perpendicular to groundwater flow.


Photo 2 - Spring #2 Collection Box, looking northeasterly, toward Summit Creek, in the direction of groundwater flow. The land rises before the creek.


Photo 3 – Spring 2 collection area, looking east toward Summit Creek.


Photo 4 – Spring 2 collection area, looking south easterly up the canyon. The spring collection area is located on the left.


Photo 5 – Spring 2 Collection Box


Photo 6 – Location of Spring 2 overflow and drain line outlet. The outlet is buried, and marked by the black pipe.

Photo 7 – Reported location of undocumented spring that is tied into Spring 2's collection box. The spring was originally located in a small Cave.

Photo 8 – Reported location of undocumented spring that is tied into Spring 2's collection box.

Photo 9 – Collection area for Spring 3, looking northwesterly down the canyon at the spring collection box.

Photo 10 – Drain/Overflow outlet for Springs 3 – 5. No signs of sand, gravel, or hard water deposits.

Photo 11- Spring 3 Collection box and weir

Photo 12- Spring 3 collection area, with Spring 4 on the right and Spring 5 on the left. Looking up the canyon.

Photo 13 – Spring 4 collection box with the collection area on the left, into the slope of the mountain.

Photo 14- Spring 4 collection box.

Photo 15 – Spring 5 collection area, looking up the canyon from the collecton box.

Photo 16 – Spring 5 collection box

Photo 17 – Spring 5, looking toward Summit Creek.

Photo 18 – Spring 5, looking down the canyon from the collection box.

APPENDIX E

EPANET 2.0 Hydraulic Models and
Model Calibration Data
(see disk)

APPENDIX F

Capital Facility Plan Cost Estimates

Santaquin City Capital Facility Plan
Drinking Water Recommended Improvements
Preliminary Engineers Cost Estimates

	Item	Unit	Unit Price	Quantity	Total Price
DW 1.	***Foothill Village Booster Station***				
	Booster Station	LS	$ 500,000	1	$ 500,000
	Engineering & Admin. (10%)				$ 50,000
	Contingency (10%)				$ 50,000
	Total to Foothill Village Booster Station				**$ 600,000**
DW 2.	***Northeast Zone 10 transmission***				
	Upsize water line from 8" to 10"	LF	$ 19	2300	$ 43,700
	Engineering & Admin. (10%)				$ 4,370
	Contingency (10%)				$ 4,370
	Total to Northeast Zone 10 transmission				**$ 52,000**
DW 3.	***Zone 10 tank/Zone 11W source***				
	2.5 MG tank	GAL	$ 1.00	2500000	$ 2,500,000
	Connections to 16" Pipeline	LS	$ 10,000	3	$ 30,000
	Reconfigure Summit Ridge Well	LS	$ 30,000	1	$ 30,000
	16" Water Line	LF	$ 173	700	$ 121,100
	12" Water Line	LF	$ 145	1800	$ 261,000
	Pump Station	LS	$ 750,000	1	$ 750,000
	Engineering & Admin. (10%)				$ 369,210
	Contingency (10%)				$ 369,210
	Total to Zone 10 tank/Zone 11W source				**$ 4,431,000**
DW 4.	***Well for redundant source***				
	Well drilling and development (2,000 gpm)	LS	$ 770,000	1	$ 770,000
	Well equipment and well house	LS	$ 550,000	1	$ 550,000
	Engineering & Admin. (10%)				$ 132,000
	Contingency (10%)				$ 132,000
	Total to Well for redundant source				**$ 1,584,000**
DW 5.	***Zone 9N Transmission***				
	VFD and Fire Flow Pump Station	LS	$ 1,000,000	1	$ 1,000,000
	Upsize water line from 8" to 10"	LF	$ 19	8900	$ 169,100
	Engineering & Admin. (10%)				$ 116,910
	Contingency (10%)				$ 116,910
	Total to Zone 9N Transmission				**$ 1,403,000**
DW 6.	***Zone 12E Transmission***				
	Upsize water line from 8" to 10"	LF	$ 19	3500	$ 66,500
	Engineering & Admin. (10%)				$ 6,650
	Contingency (10%)				$ 6,650
	Total to Zone 12E Transmission				**$ 80,000**
DW 7.	***Zone 9N Transmission***				
	12" Water Line	LF	$ 145	1200	$ 174,000
	PRV	LS	$ 25,000	1	$ 25,000
	Engineering & Admin. (10%)				$ 17,400
	Contingency (10%)				$ 17,400
	Total to Zone 9N Transmission				**$ 234,000**
DW 8.	***Zone 9N Transmission***				
	Upsize water line from 8" to 12"	LF	$ 29	5700	$ 165,300
	Engineering & Admin. (10%)				$ 16,530
	Contingency (10%)				$ 16,530
	Total to Zone 9N Transmission				**$ 198,000**
DW 9.	***Western Zone 10 Transmission***				
	10" Water Line	LF	$ 128	6300	$ 806,400
	Engineering & Admin. (10%)				$ 80,640
	Contingency (10%)				$ 80,640
	Total to Western Zone 10 Transmission				**$ 968,000**

Santaquin City Capital Facility Plan
Drinking Water Recommended Improvements
Preliminary Engineers Cost Estimates

	Item	Unit	Unit Price	Quantity	Total Price
DW 10.	***Zone 10 tank and transmission***				
	20" Water Line	LF	$ 200	4200	$ 840,000
	Interstate crossing and utility work	LS	$ 200,000	1	$ 200,000
	Tank	GAL	$ 1.00	2500000	$ 2,500,000
				Engineering & Admin. (10%)	$ 354,000
				Contingency (10%)	$ 354,000
				Total to Zone 10 tank and transmission	**$ 4,248,000**
DW 11.	***Zone 11W Transmission***				
	Upsize water line from 8" to 10"	LF	$ 19	1900	$ 36,100
	Upsize water line from 8" to 12"	LF	$ 29	1600	$ 46,400
				Engineering & Admin. (10%)	$ 8,250
				Contingency (10%)	$ 8,250
				Total to Zone 11W Transmission	**$ 99,000**
DW 12.	***Northwestern Zone 10 Transmission***				
	Upsize water line from 8" to 10"	LF	$ 19	1700	$ 32,300
				Engineering & Admin. (10%)	$ 3,230
				Contingency (10%)	$ 3,230
				Total to Northwestern Zone 10 Transmission	**$ 39,000**
FF 1.	***Zone 12E Fire Flow***				
	8" Water Line	LF	$ 109	1900	$ 207,100
				Engineering & Admin. (10%)	$ 20,710
				Contingency (10%)	$ 20,710
				Total to Zone 12E Fire Flow	**$ 249,000**
FF 2.	***Zone 9N 400 N Fire Flow***				
	8" Water Line for Fire Deficiency	LF	$ 109	1400	$ 152,600
	Upsize water line from 8" to 12"	LF	$ 29	1400	$ 40,600
				Engineering & Admin. (10%)	$ 19,320
				Contingency (10%)	$ 19,320
				Total to Zone 9N 400 N Fire Flow	**$ 232,000**
FF 3.	***Zone 10 14000 S Fire Flow***				
	10" Water Line	LF	$ 136	3100	$ 421,600
				Engineering & Admin. (10%)	$ 42,160
				Contingency (10%)	$ 42,160
				Total to Zone 10 14000 S Fire Flow	**$ 506,000**
FF 4.	***Center Street Fire Flow***				
	8" Water Line	LF	$ 109	400	$ 43,600
				Engineering & Admin. (10%)	$ 4,360
				Contingency (10%)	$ 4,360
				Total to Center Street Fire Flow	**$ 52,000**

Growth-Related Project Costs: $ 13,936,000

Fire Flow Project Costs: $ 1,039,000

Total Costs $ 14,975,000

AVERAGE WATER PIPE COST PER FOOT

Diameter (in)	Diameter (ft)	Outside Diameter (ft)	Pipe Material & Installation (1)	Excavation	Imported Bedding Installed	Hauling Excess Native Mat'l	Trench Backfill Installed (3)	Trench Box per Day (2)	Average Daily Output	Trench Box Cost	Top Trench Width (ft)	Road Repair Width (ft)	Asphalt Cost	Service Lateral Cost	Fire Hydrant Cost	Valves & Fittings Cost	Pipeline Connection Costs	Conflicts (9)	Trench Dewatering (4)	Total Cost per Foot of Pipe	Adjusted Cost per foot	Cost Out of Street (3)	Diameter (in)
4	0.3	0.39	26.00	2.84	9.61	1.20	3.83	210.00	400	0.53	2.99	6.99	28.94	18.11	2.37	0.34	1.20	0.00	8.48	103	90	77	4
6	0.5	0.58	30.50	3.17	11.19	1.43	4.11	210.00	333	0.63	3.18	7.18	29.59	18.11	2.37	0.46	1.36	0.00	9.51	112	98	86	6
8	0.7	0.78	48.00	3.52	12.81	1.68	4.40	210.00	200	1.05	3.38	7.38	30.25	18.11	2.37	0.72	1.53	0.00	12.27	137	119	109	8
10	0.8	0.97	61.50	3.88	14.45	1.95	4.69	210.00	182	1.15	3.57	7.57	30.91	18.11	2.37	1.13	2.23	0.00	13.31	156	136	128	10
12	1.0	1.17	67.00	4.26	16.14	2.24	4.98	210.00	160	1.31	3.77	7.77	31.57	18.11	2.37	0.73	2.94	0.00	14.63	166	145	138	12
14	1.2	1.36	71.00	4.65	17.86	2.55	5.27	210.00	133	1.58	3.96	7.96	32.23	18.11	2.37	1.27	3.22	0.00	16.52	177	154	148	14
16	1.3	1.56	77.00	5.07	19.61	2.88	5.56	210.00	114	1.84	4.16	8.16	32.89	18.11	2.37	1.63	3.52	9.44	18.42	198	173	159	16
18	1.5	1.75	86.50	5.50	21.40	3.23	5.84	210.00	100	2.10	4.35	8.35	33.55	18.11	2.37	2.04	3.80	10.24	20.32	215	187	175	18
20	1.7	1.94	93.00	5.95	23.23	3.60	6.13	210.00	89	2.36	4.54	8.54	34.21	18.11	2.37	2.65	4.10	10.90	22.21	229	200	188	20
24	2.0	2.33	112.00	6.89	26.99	4.41	6.71	210.00	77	2.73	4.93	8.93	35.52	18.11	2.37	4.10	4.68	12.48	25.14	262	229	218	24

Reference: 2018 RS Means Heavy Construction Cost Data Updated by: JKN

Costs:

$ 20.85	/CY Native Trench backfill - sec. 31 23 23.16 (0200): Fill by borrow [sand, dead or bank x 1.21 O&P] w/o materials (27.94-18.6) and convert from loose to compacted volume. $11.20/LCY * 1.39 LCY/ECY (see Note 5)
$ 59.08	/CY Imported Select Fill - sec. 31 23 23.16 (0200), 31 23 23.20 (4266), 31 23 23.23 (8050): Sand, dead or bank w/ hauling and compaction. ($33.50/LCY + $5.10/LCY)*1.39 LCY/ECY + $5.50/ECY (see Note 5)
$ 6.10	/CY Excavation - sec. 31 23 16.13 (6372): 10-14 ft deep, 1 CY excavator, Trench Box.
$ 30.49	/SY 4" Asphalt Pavement - sec. 32 11 23.23 (0390), 31 23 23.20 (4268), 32 12 16.13 (0120), 32 12 16.13 (0380): 9" Bank Run GravelBase Course ($7.10/SY), 2" Binder ($9.30/SY), 2" Wear ($10.40/SY [4"=$19.80/SY]) and Hauling [Item 4268] ($7.35/LCY * 1.39LCY/ECY * 0.361CY/SY) (see Note 5)
$ 2.63	/LF 4" Asphalt cutting - sec. 02 41 19.25 (0015, 0020): Saw cutting asphalt up to 3" deep ($1.68/LF), each additional inch of depth ($0.95/LF)
$ 1,811.32	/EA Service Lateral Connection (see Note 7)
$ 4,734.51	/EA Fire hydrant assembly including excavation and backfill (see Note 8)
$ 7.16	/CY Hauling - sec. 31 23 23.20 (4262): 20 CY dump truck, 6 mile round trip and conversion from loose to compacted volume. $4.13/LCY * 1.39 LCY/ECY (see Note 5)
$ 210.00	/day Trench Box - sec. 31 52 16.10 (4500): 7' deep, 16' x 8'
$ 63.32	/CY Stabilization Gravel - sec. 31 23 23.16 (0050), 31 23 23.20 (4266), 31 23 23.23 (8050): Bank Run Gravel ($36.50/LCY * 1.39 LCY/ECY) plus compaction ($5.50/ECY) and hauling ($5.10/LCY * 1.39 LCY/ECY) (see Note 5)
$ 1,152.00	/day Dewatering - sec. 31 23 19.20 (1000, 1020): 4" diaphram pump, 8 hrs attended ($1,025/day). Second pump ($127/day)

NOTES:

(1) Assumes: class 50, 18' lengths, tyton push-on joint for DIP (33 11 13.15 3000-3180); Pressure Pipe class 150, SDR 18, AWWA C900 for PVC <14" & AWWA C905, PR 100, DR 25 for 14" and larger (33 11 13.25 4520-4550 3030-3200); butt fusion joints SDR 21, 40' lengths for HDPE ().
DIP and HDPE costs only go up to 24". PVC costs only go up to 48". All costs for pipe larger than 48" are Prestressed Concrete pipe (PCCP), 150 psi, 24' length (Pg 315).

(2) 7' deep trench box (16' x 8') - on page 263

(3) Backfill Material & Installation assumes in street. For out of street unit costs, the backfill material cost has been added in place of base course and asphalt.

(4) Dewatering assumes 1' stabilization gravel at the bottom of the trench plus dewatering pumps

(5) Conversion from loose to compacted volumes assumes 125 PCF for compacted density and 90 PCF for loose density. Or (125 PCF/ECY)/(90 PCF/LCY) = 1.39 LCY/ECY

(6) Conversion from cubic yards to square yards for hauling of asphalt paving assumed a total thickness of 13". 3 ft x 3 ft x (13 in)/(12 in/ft) = 0.361 CY/SY

(7) Service Lateral costs are based on Beaver Dam short and long service connections average ($1,660.98/connection), with 45.40 for curb replacement, 40.20 for sidewalk replacement, and 158.19 for additional asphalt all added to the short service connection. Used historical cost index to update to current dollars.

(8) Fire Hydrant assembly costs are based on Beaver Dam Water Projects plus 45.40 for curb replacement and 158.19 for additional asphalt ($4341.55 per FH). Used historical cost index to update to current dollars.

(9) Conflicts amounted to be 2% of the cost on the Springville 400 South Pipeline project. Use 5% of total cost per ft.

(10) Joint Restraint has NOT been included in this spreadsheet.

Abbreviations:

VLF	vertical lineal foot
PCF	pounds per cubic foot
LCY	loose cubic yard
ECY	embankment cubic yard

Utah City Cost Indices

SLC	88.5
Ogden	85.8
Logan	87
Price	85
Provo	87.2

APPENDIX G

Checklist for Hydraulic Model Design Elements Report

Content for this appendix will be provided in a subsequent draft.