State of Utah

Water Use
Data Collection Program

Prepared for:

UTAH DNR WATER RESOURCES

Prepared by:

BOWEN COLLINS & ASSOCIATES Celebrating 20 Years

HANSEN ALLEN & LUCE inc ENGINEERS

STATE OF UTAH
WATER USE DATA COLLECTION PROGRAM REPORT

January 2018

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LIST OF ACRONYMS

BC&A	Bowen Collins & Associates
DNR	Division of Natural Resources
DWRe	Division of Water Resources
DWRi	Division of Water Rights
ERU	Equivalent Residential Unit
ET	Evapotranspiration Rate
GOMB	Governor's Office of Management and Budget
HAL	Hansen, Allen & Luce
JVWCD	Jordan Valley Water Conservancy District
M&I	Municipal and Industrial
MWDSLS	Metropolitan Water District of Salt Lake & Sandy

LIST OF ACRONYMS
continued

NAIP	National Agriculture Imagery Program
NDVI	Normalized Difference Vegetation Index
PCWS	Public Community Water Systems
PPH	Persons per Household
WBWCD	Weber Basin Water Conservancy District
WUF	Water Use Forms

EXECUTIVE SUMMARY

PROJECT PURPOSE

The State of Utah (State), through the Department of Natural Resources (DNR), has been involved in regulating, assisting, and providing funding to local water agencies for decades. This has been accomplished primarily through work by the Division of Water Resources (DWRe) and Division of Water Rights (DWRi). Recently, as the demand for water across the state has intensified, these divisions have come under criticism for not accurately determining water usage by the public water systems across the state. The purpose of this study is to evaluate the State's method of collecting water use data, estimate the overall accuracy of the results, and make recommendations for further improvements.

PROJECT METHODOLOGY

With more than 500 separate water systems reporting data to the State, it is not feasible to prepare a detailed audit of each system as part of this study. To overcome this challenge, this study focused on two tasks: (1) meeting with the large water providers that provide the majority of water across the state and evaluating their water usage and source data in detail, and (2) auditing a cross section of several dozen smaller water providers to determine overall data gaps, issues, needs, etc. This approach allowed us to determine the accuracy of overall water usage estimates in the state and develop recommendations for improving the existing program.

MAJOR FINDINGS

Based on the analysis completed, the project team has reached the following major conclusions:

1. **Despite its limitations, the data collection process has resulted in accurate estimations of potable water use.** In the process of conducting this study, the authors of this report were impressed by the magnitude of the task facing State of Utah personnel in preparing estimates of statewide water use. Having prepared dozens of water system master plans for systems across the State, we are familiar with the time and effort required to obtain and evaluate water use data. The sheer volume of water sales data makes it vulnerable to error and almost every system has one or more unique characteristics that require special consideration and analysis. With these challenges, we were pleasantly surprised to find that overall error associated with potable water use numbers is small as summarized in Table ES-1.

Table ES-1
Comparison of State Compiled Data to System Data - Potable Water

	Individual Water Systems	Large Water Districts
Year	Absolute Error	Absolute Error
2015	0.3%	0.8%
2010	3.3%	6.5%
2005	3.7%	-1.6%

With an absolute error of less than one percent in 2015 for the sample systems examined, it appears the overall numbers generated for potable water use by the State are very representative of statewide water use. While errors in individual systems may be larger, the overall numbers still appear to be an acceptable compilation of potable use.

2. **The data collection process and resulting data accuracy have improved over time.** Also apparent in the data is a clear improvement in accuracy over time, especially for the small systems sampled. Efforts to improve the process are improving the quality of data. Additionally, observed improvements since 2015, including increased support staff, improved training for system operators, and the development of a new data entry portal appear to have great promise for further improving the process.

3. **Secondary water use and supply estimates are less accurate.** The DWRi data collection form has not historically collected any information regarding actual secondary water use since most of the systems do not meter individual deliveries. Thus, information available to even estimate secondary use is difficult to obtain. As a result, estimates of secondary use have been far less accurate than compiled results for potable use as summarized in Table ES-2. It appears that the State numbers underestimate the amount of water being used in secondary systems.

Table ES-2
Comparison of State Estimates to System Data - Secondary Water

	Individual Water Systems	Large Water Districts
Year	Absolute Error	Absolute Error
2015	-24.8%	-34.4%
2010	-30.9%	-32.3%
2005	-32.6%	-10.7%

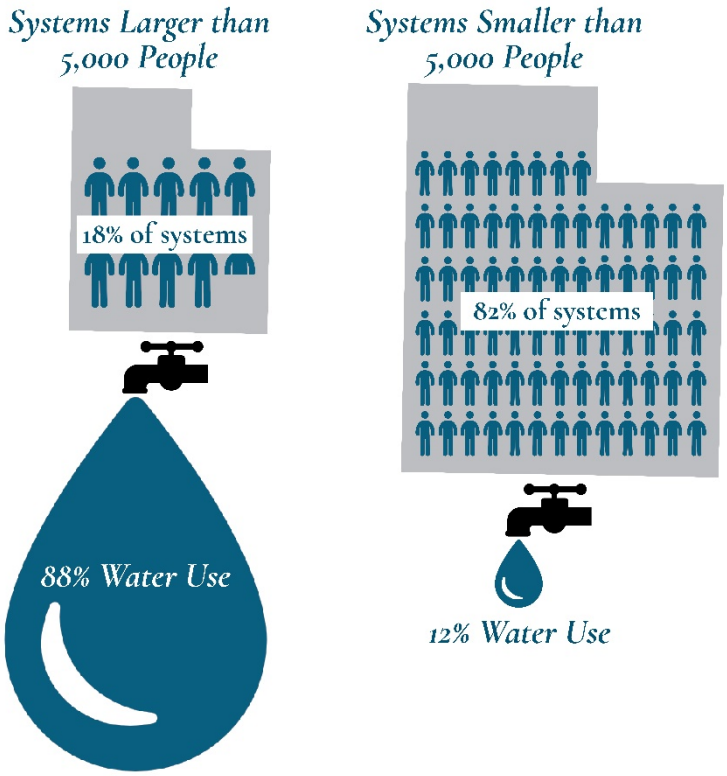
Similarly, defining available supply is more complex than can be adequately represented based on the data available through the data collection process. Required simplifications in estimating potable supply and the absence of any reliable projections of secondary supply are a major hurdle to future planning. We summarize the current accuracy of supply estimates in Table ES-3. Much like water use estimates, error for secondary supply is much higher than potable supply.

Table ES-3
Comparison of State Estimates to System Data - Supply

	% Difference
Potable	-11.0%
Secondary	-64.0%
Total	-29.6%

4. **Time and effort spent trying to perfect data entry for small systems may not be cost effective or necessary.** Regardless of the best efforts of the State, accuracy of any estimates prepared will ultimately be dependent on the quality of data entered by the system operators. A common theme heard over and over from small system operators during the course of this study was that limited resources (human, financial, technological) are a significant challenge to accomplish comprehensive data reporting. Achieving a "perfect" data set may not be a reasonable goal given these conditions.

With this in mind, the State may want to reconsider the amount of time it spends on data collection for small systems. Our observations indicate that the data collection process begins to fail with water systems serving fewer than 5,000 people. Based on 2015 water use statistics, 82% of systems in the State fall into this category. Much of the effort to collect data, follow up, and revise data is spent on these small systems. However, these smaller systems account for only 12% of total potable water use in the state. Furthermore, most of these small systems are isolated from population centers and each other and correspondingly have little influence on major water planning decisions. Given these statistics, it may not be necessary to spend the same amount of time on these systems as is spent on the larger systems.

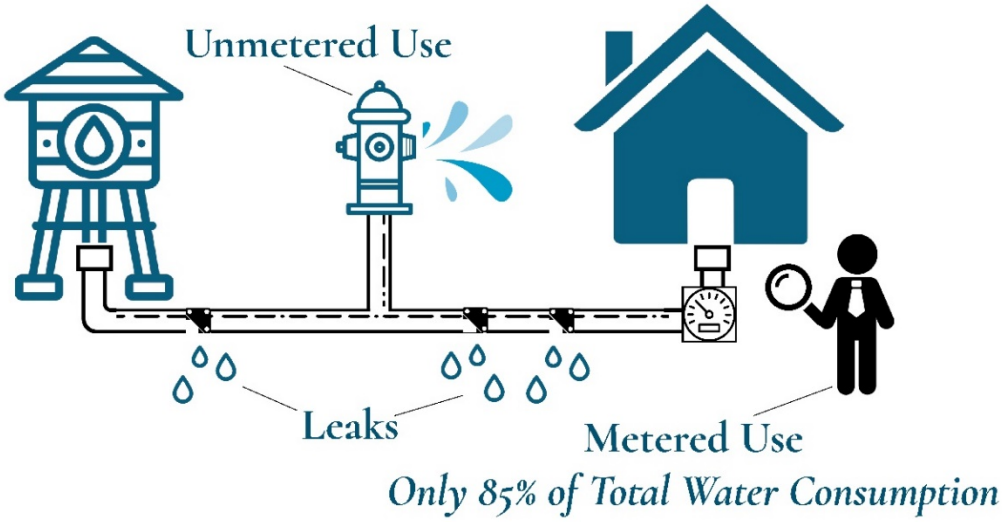


RECOMMENDATIONS

Although much progress has been made and potable use numbers appear to be accurate, there are still several ways in which the data collection process could be improved. To continue to improve the data collection process, the project team would recommend the following actions:

1. **Continue Current Trajectory of Improvement in Data Collection Process.** While major improvements have been observed in the data collection process since 2015, there are still opportunities for additional improvement. Recommended remaining changes include additional functionality of the data entry portal and improved collection of secondary water use and system loss data.
2. **Add consideration of system losses into calculation of water demands.** As it currently stands, the definition of water use in the data collection process includes metered sales only. This does not include consideration of system losses such as leakage and unmetered consumption. If water demands used for future planning do not include consideration of system losses, insufficient water will be projected for future needs. Analysis of sample systems in this report results in a recommended planning value for future losses of 15 percent. Components should be added to the data

collection process to improve consideration of system losses. This may include requirements for periodic AWWA M36 water audits to assess the magnitude and nature of system losses.



3. **Improve estimates of secondary water use including the expanded use of secondary metering.** There is currently a large gap between the State's ability to estimate potable water use and secondary water use. Starting in 2016, the State began requesting additional data on secondary demands and supplies as part of the data collection process. This is a good first step. In the long-term, however, the ideal solution to improve accuracy in this area is to require secondary metering at each customer connection. Secondary metering has the added benefit of reducing water use. For these reasons, it is recommended that the State continue to explore options to encourage broad implementation of secondary metering.

4. **Improve efforts to evaluate supply at the system level.** Much like water use estimates, error for secondary supply is much higher than potable supply. Much of the reason for the reduced error in potable supply is the fact that the State has refined their potable supply estimates using area specific supply studies prepared by some of the larger water districts. Because of the complexities associated with supply planning, it appears that this is the only way in which supply can be estimated accurately.

5. **To best utilize available resources, a separate approach to data collection is recommended for small systems.** Based on the considerations as documented above, it is recommended that the State consider modifying its data collection program to treat water systems differently based on size:

    a. **Large Systems.** For systems serving greater than 5,000 persons, it is recommended the State continue with its current program and pursue the full menu of improvements identified in this report including:

i. Detailed reporting and data verification through the State's new, improved data collection portal. Of special focus will be improved reporting of secondary water use.

ii. Pursuit of secondary metering for all M&I connections.

iii. Periodic AWWA M36 water audits to assess the magnitude and nature of system losses.

iv. A detailed water supply evaluation prepared by a professional engineer and submitted as part of system conservation plans.

b. **Small Systems.** For systems serving fewer than 5,000 persons, it is recommended the State consider simplified reporting requirements:

i. Small system will still be required to provide reporting and data verification through the State's new, improved data collection portal. However, it is expected that recent improvements in the system will simplify data entry for small systems.

ii. Other available information from larger systems will then be used to fill in the gaps for any missing information.

iii. Instead of trying to perfect data entry for all small systems every year, detailed review and verification of data by DWRi and DWRe staff can be limited to a rotating portion of small systems (approximately 20 percent per year) without compromising overall data accuracy.

6. **Use revised 2015 estimates as the baseline for future planning and conservation goals.** For future planning and evaluation of conservation goals, it is recommended that 2015 be used as a baseline. The year 2015 is recommended because it is both the most recent and most accurate year for which data is available. Because of the minimal error observed in DWRe's overall potable water use numbers, no changes are recommended to the data compiled for potable use. It is recommended that secondary use estimates be revisited using infrared aerial imaging to calculate irrigated acreage and updated, area specific water application rates. Although the exact effect of the updated secondary estimates will not be known until the revised analysis is completed, expected total use numbers have been summarized in Table ES-4.

Table ES-4
Recommended Baseline Water Use

	DWRe 2015 Draft Use (AF)	Recommended Baseline Water Use (AF)	Absolute Difference
Potable	557,083	557,083	0.0%
Secondary	181,647	255,774	40.8%
Total	738,730	812,857	10.0%

Notes

Recommended secondary use for individual water systems is for comparison purposes only and was derived by multiplying by the calculated absolute error.

See report for recommended method for calculating secondary use.

7. **Work with the Legislature to Accomplish the Goals Above.** Most of the recommendations contained in this study can be implemented through changes to the internal processes of DWRi or DWRe. However, legislative action will be needed on three specific recommendations:

   - Required customer metering for secondary water use
   - Required periodic AWWA M36 water audits
   - Required reliable supply evaluation to be submitted with conservation plans

   It is recommended that DWRe work with the legislature to pursue these recommended changes for systems serving populations greater than 5,000.

CHAPTER 1
PURPOSE, SCOPE, AND AUTHORIZATION

INTRODUCTION

The State of Utah (State), through the Department of Natural Resources (DNR), has been involved in regulating, assisting, and providing funding to local water agencies for decades. This has been accomplished primarily through work by the Division of Water Resources (DWRe) and Division of Water Rights (DWRi). Recently, as the demand for water across the state has intensified, these divisions have come under criticism for not accurately determining water usage by the public water systems across the state. The State retained the engineering firms of Bowen Collins & Associates (BC&A) and Hansen, Allen & Luce (HAL) to evaluate the State's method of collecting water use data and estimate the overall accuracy of the results.

BACKGROUND

Utah is a dry state. As such, access to water is key to long-term growth across the state. The importance of quantifying water supply and use, and improving the data collection and planning processes is underscored by the following facts.

- ✓ Utah is one of the driest states in the United States (National Weather Service, Average Annual Precipitation by State). On average, Utah has about 300 sunny days a year.
- ✓ In 2016, the U.S. Census Bureau estimated that Utah had the fastest-growing population of any state.
- ✓ From 2010 to 2015, the U.S. Census Bureau estimates that 76.8% of the state's population growth occurred in four Wasatch Front counties: Weber County, Davis County, Salt Lake County, and Utah County.
- ✓ St. George was the fastest-growing metropolitan area in the United States from 2000 to 2005, and according to the U.S. Census Bureau; this growth rate continued through 2010. Per 2015 U.S. census estimates, St. George was declared the fifth fastest-growing metropolitan area in the United States.
- ✓ A 2012 Gallup national survey found Utah overall to be the "best state to live in" based on 13 forward-looking metrics including various economic, lifestyle, and health-related outlook, which included the availability of clean, safe water.

Over the past 50 years, DWRe has developed procedures to obtain municipal and industrial (M&I) water use data. In recent years, these procedures have evolved and have become more comprehensive. Before 1960, available data consisted of mainly supplies and uses statewide as a whole. M&I water use was calculated simply by multiplying estimated per-capita water use rates by census population data.

In 1960, DWRi began sending out questionnaires to municipal water suppliers to collect water use data. The data was collected as-is with no attempt to assess accuracy. In 1977, DWRi entered into an agreement with the United States Geological Survey (USGS) to collect water use in Utah for a national database and prepare reports documenting the data. In 1979, DWRi began developing a water use database of supply facilities and sources related to water use to store and analyze the information collected for creating reports detailing current water use and projections of future water requirements. Today, the DWRi collects water use data annually from roughly 500 Public Community Water Systems (PCWS) in Utah.

The raw data collected by DWRi have served as the basis for further analysis of water use and supply patterns by DWRe. Through 2015, DWRe evaluated the data every five years. The water use data collected in 2000 serve as the baseline and subsequent data collected are used for comparison. Coupled with anticipated population growth, DWRe projects future supplies and demands for the purposes of planning the state's water resources.

In 2015, the Office of the Legislative Auditor General issued a report entitled "A Performance Audit of Projections of Utah's Water Needs" (no. 2015-01). The report raised several concerns about the quality of data used to project the state's future water demand, namely:

- ✓ DWRe does not have reliable local water use data.
- ✓ DWRe needs a better process for collecting and evaluating water use data.
- ✓ DWRe's 2000 study of baseline water use, from which future water needs are projected, may not be reliable.

The audit recommended the following actions to improve the reliability of water use data:

- ✓ DWRe review water use data annually to perform trend analysis
- ✓ Department of Natural Resources work with State water agencies to develop an efficient and effective system of collecting accurate water use data for public water providers
- ✓ Give statutory authority to the Division of Water Resources to validate the annual water use reported by public water providers
- ✓ Make local water managers responsible for submitting accurate water use data more accountable by requiring them to sign their report and identify their position and credentials
- ✓ Incorporate a routine data check feature in the online data collection form that is used to validate the accuracy of the data submitted by the public water providers
- ✓ Validate the accuracy of the water use data by comparing it to other sources with similar information
- ✓ Conduct data validity checks, periodic audits, and training for local water systems to verify the accuracy of water supply and data use
- ✓ Committing additional staff and resources to improving the State's water use database

These findings prompted DWRe to reconsider its practices in collecting, estimating, validating, and reporting water use data. This study addresses some of the deficiencies noted in the audit.

PROJECT PURPOSE

The purpose of this study was to evaluate the State's method of collecting water use data and to estimate the overall accuracy of the results. The analysis yielded recommendations to improve the State's program to more accurately and efficiently characterize Utah's M&I water demands.

SCOPE OF SERVICES

The scope of this project included the following four major tasks:

Task 1 – Stakeholder Coordination with DWRe and DWRi

The project team met with State personnel to discuss the goals for this project. Discussion topics included finalizing the overall project purpose, methods, historic data collection practices, supply reliability, and study assumptions. As part of this meeting, sources of needed data were identified and discussed along with types of analysis necessary for stakeholders, both internal and external to State agencies, to accept the results of this study as an accurate portrayal of the Utah's water use and the State's data collection process.

The project team then met with each of the major water districts in the State along with a selected cross-section of smaller water systems to collect data and discuss the historic data collection process. These conversations also gathered insights on each entity's available water use data, available supply data, and experience in reporting data to the State.

Task 2 – Evaluation of State's Current Water Use Data Collection Program

The purpose of this task was to determine how accurately the State's existing data collection program is representing demands. Activities under this task included:

- ✓ Evaluation of Large Water Providers – The majority of municipal water use in the State comes from a limited number of large water districts with detailed water use and supply records. The project team met with each and gathered detailed information where available regarding water use and supply. In addition, the project team also reviewed each provider's data collection and planning process. The data received from the large providers was reviewed and analyzed for completeness and accuracy, and then compared against other available data sources to assess consistency and correctness.
- ✓ Audit of a Cross Section of Small Water Providers – The project team reviewed existing water use data contained in the State water use database for small water providers. The project team met with State personnel to identify and select a sample group of small water providers for further analysis. Independent data were collected and a detailed evaluation of water use and supply was completed.
- ✓ Probable Magnitude of Potential Error in Data – Based on the analysis of large and small water providers, the project team estimated the error between DWRe's data and the consultant's data. This exercise provided a measure of how accurate the State's data are and informed recommendations for improvement.
- ✓ Recommendations for Improvement in State's Data Collection Process – Based on the data and analyses just discussed, the project team developed several recommendations for improving the State's water use data collection program. We summarize the results and final recommendations in Chapter 5.

Task 3 – Verification of State's Water Use and Supply Data

BC&A/HAL evaluated water use and supply data contained in the State's database for Calendar Years 2005, 2010, and 2015 and compared them with independent data collected during this project. Comparison tables provided in this report compare historic projections against the consultant's water use numbers. Data are organized by provider service area for both potable and secondary uses.

- ✓ Existing Water Resource Data – The project team evaluated and verified existing water supplies using both State data and their own data. This evaluation included wells, springs, and surface water sources for both potable and secondary use. As part of this evaluation, the project team considered the annual yield of each source along with limitations associated with peak production capacity and seasonal availability.
- ✓ Consistency of Supply Data as a Whole – To ensure the State has an accurate assessment of available water supply, the project team compared the supply information provided by each water provider against each other and against available overall supply numbers provided during the evaluations. This was compared against future population projections and resulting demand.

Task 4 – Base Water Use for Future Planning

BC&A/HAL has compiled a base water use according to the following subtasks to assist the State with future planning:

- ✓ Water Use Rates for 2005, 2010, and 2015 – Utilizing the new data, the project team estimated water use for 2005, 2010, and 2015. These rates are available for comparison against reported rates in 2000 (the base year used for the State's current conservation goal).
- ✓ Factors that May Affect Water Use Patterns – Based on the collected data and professional experience, the project team identified factors affecting indoor and outdoor water use in Utah and related them to national trends identified by the USGS and others.
- ✓ Base Water Use for Future Planning – Based upon data compiled in preparation of this study, the project team has developed a recommended approach for base water use to be used with future planning and conservation goals.

AUTHORIZATION

The Utah State Legislature provided authorization for this Study. The study is being administered through DWRe, and appropriations from the Utah State Legislature are funding this effort. The timeframe for completion of this study was four months after contract signature.

To obtain this authorization, the project team met with State personnel to identify and discuss the need for this study along with potential goals. Topics reviewed during the authorization process included project purpose, overall need for the study, and assumptions and estimates required to complete the study.

PROJECT STAFF

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Brandon Ashcroft	Jacob K. Nielsen	**Utah Division of Water Rights**
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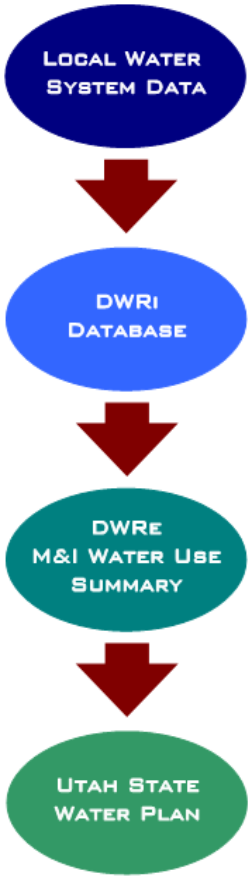
CHAPTER 2
WATER USE DATA COLLECTION PROCESS

The purpose of this chapter is to document the State of Utah's process of collecting water use data. The process documented here primarily reflects how data has been collected through 2015; changes to the process since then will be discussed at the end of the chapter.

SUMMARY OF PROCESS PRIOR TO 2016

Collection of water use data prior to 2016 occurred in two separate steps and involved two State divisions:



✓ **Division of Water Rights -** The Utah Division of Water Rights (DWRi) is responsible for collecting primary data regarding water production and use. Data requested includes service population, retail potable use, secondary water use, source inventory, and wholesale delivery. Each public water system throughout the state is to provide its own data, which is then combined into a publicly available database maintained by DWRi. The database is used for the internal purposes of DWRi but is also made available to other water agencies such as the Division of Water Resources.

✓ **Division of Water Resources -** Since the first publication of the Utah State Water Plan in 1990, the Utah Division of Water Resources (DWRe) has prepared a detailed summary of Utah's Municipal and Industrial (M&I) water use every five years. This effort includes the quantification of both potable and secondary M&I water supplies and uses for Public Community Water Systems (PCWS) in the state. DWRe uses the raw data collected by DWRi as the basis for its analysis. Prior to 2016, the raw data were reviewed by DWRe staff, corrected or augmented from other sources, stored in a separate database, and then assembled into a report of estimated water use.

Beginning in 1990, DWRe's analysis focused on one hydrologic basin each year. Beginning in 2005, DWRe began evaluating water use and supply data for all PCWS every five years. Thus, even though DWRi collects water use data from all PCWS each year, DWRe statewide M&I water use estimates have typically been published in five-year increments (2005, 2010, and 2015). These statewide water use estimates are subsequently used in DWRe statewide and basin-level planning documents.

WATER RIGHTS COLLECTION OF RAW DATA

Water use data is collected annually by DWRi for each public water system. While many State agencies are interested in water use data, DWRi is the agency specifically given authority by the State legislature to collect the data.

Initial Data Collection

There are several ways that the data have been collected. Originally, all systems submitted data by hand. DWRi would mail or email data collection forms at the beginning of each year. The forms were to be completed by each system and returned to DWRi.

When all the reports were submitted by hand, the work to receive and verify the data was tedious. DWRi often had to deal with errors in reports or a lack of reporting altogether. It was not uncommon for contact information to become outdated, requiring DWRi to track down the correct address, email, or phone number of the person responsible for submission. Follow-up conversations were needed when systems did not submit complete data, or if DWRi noticed discrepancies or errors in the data. For each report filled out by hand, the data had to be manually entered into the database.

Because of these challenges, DWRi created an option for the systems to submit data using an online portal beginning in 2000. While some systems still prefer to submit hard copies, the popularity of the online portal has grown steadily. Data submitted online is much easier to compile, reducing the amount of time needed to input the data. Because of this, the DWRi has tried to improve the online portal over time and make it easier to use. More training and support has also recently become available to improve response rate and accuracy.

Historic Data Verification

Once the data are received, they are reviewed by DWRi staff for completeness and accuracy. Prior to 2016, there had been only one employee designated to do this review. With the volume of data received, review by this employee was necessarily limited. Major outliers and missing data were often identified, but more detailed analysis was not possible.

Once suspected errors were identified, the systems providing the suspect data were contacted by phone and a request was made to investigate and correct the data. Follow up phone calls occurred through about July of each year. At that point, data entry by DWRi was closed for the year, regarding of the status of the data.

This process has resulted in incomplete and less-than-perfect data. DWRi reports that, at the end of the process, approximately 20% to 25% of systems failed to report any data at all for various reasons. These reasons included general lack of data, limited staff resources, excessive cost or effort to compile the data, past misunderstandings regarding water rights, and water system emergencies.

TRANSFER OF DATA TO WATER RESOURCES

DWRi's water use database is the starting point for DWRe's analysis. Prior to 2016, DWRe did most of its work in a relational database separate from the DWRi raw data. The data retrieved by DWRe were organized into several tables. Code developed by DWRe allowed it to query individual water systems and correct the data as necessary. The code also tracked which user made changes and provided space for comments and assumptions. Because DWRe pulled down DWRi data at one time, the annual database represented a snapshot of DWRi data and missed any updates and corrections submitted to DWRi thereafter.

WATER RESOURCES EVALUATION AND DATA VERIFICATION

Once the data had been pulled from DWRi, DWRe began a more detailed review of the data and the production of a report estimating M&I water use. DWRe has historically had a staff of five or six individuals involved in the process. While these individuals are not working on this task exclusively, it does represent more resources than DWRi has historically been able to dedicate to data review. This, combined with the fact that DWRe estimates of use are developed only once every five years, means that DWRe estimates should represent a notable improvement in accuracy over the raw data collected by DWRi.

DWRe's process to review data and produce a report of estimated M&I water use has historically included several components. These components are summarized in the following bulleted list with additional detail regarding some of specifics of each component in the sections that follow:

- ✓ **System Verification –** DWRe first determined which PCWS had been removed or added since the last review. This was determined by comparing a list of current PCWSs provided by the Division of Drinking Water with information provided by DWRi based on Utah Water Use Forms (WUF).
- ✓ **Water Use Review –** The targeted year's information submitted on the WUFs was critically reviewed by DWRe for accuracy and completeness. If errors were found, or data were determined to be unreasonable or incomplete, DWRe contacted the system and asked them to review and update the data in the DWRi database. Common errors encountered included not properly categorizing water use data by type of use, using incorrect units for data entry, and confusing municipal populations for service area populations.
- ✓ **Estimation of Missing Water Use Data –** For PCWS that failed to provide water use data, DWRe contacted water agency representatives and attempted to obtain the required data via telephone, email, or in-person meetings. During these contacts, assistance was provided to the PCWS on how to properly complete the WUF. The reason for these contacts was to obtain the most accurate water data available from each PCWS. After these efforts were made, if water use data was still determined to be insufficient, for all or part of the system, estimates were made by DWRe. The estimated data was then uploaded by DWRe into the water use database with supporting documentation.
- ✓ **Development of Estimates for Unreported Water Use Categories –** While the DWRi dataset includes much useful water use data, it has not historically contained information in all the categories necessary for planning water resources in the state. A prime example of this is secondary water use. Prior to 2016, no information was collected on secondary water use in the DWRi database. Another example is reliable water supply. While the DWRi database includes information on historic production from system sources, it does not specifically contain information on how these sources can or will be used to meet future demands. To accomplish its comprehensive planning mandate, DWRe used available information to estimate values for these categories where DWRi data was insufficient.
- ✓ **Final M&I Report -** Information developed through the steps above was compiled into a comprehensive report of M&I water use that became the basis for future DWRe planning efforts.

A detailed discussion of the process is grouped by type of water use in the following sections.

POTABLE DEMAND DATA

Residential Potable Demand

For residential water use, DWRe collected data regarding the number of residential connections and the amount of water used by those connections. Water use in the residential category was then divided into three subcategories: potable indoor, potable outdoor, and secondary outdoor. Due to the fact that most systems meter only total potable residential water use, indoor and outdoor use were rarely metered separately and secondary

water use was rarely metered at all. As a result, DWRe estimated the subcategory totals:

- ✓ ***Indoor Potable -*** DWRe typically estimated indoor potable water use first. One of the methods used was to review residential meter reading totals for the winter months, if this data was available. Since outdoor water typically does not occur during the winter months, it was assumed that water use during this period would be for indoor use only. If this method did not produce reasonable values, the per-capita indoor water use for a system was estimated by using equations developed in the *2009 Residential Water Use* study, a broad study of water use for communities across the state prepared by DWRe. Part of the analysis involved determining the average Persons per Household (PPH). DWRe obtained this data from county records where the PCWS is located.
- ✓ ***Outdoor Potable -*** Once potable indoor use was estimated, potable outdoor use could be estimated by simply subtracting indoor use from the total.
- ✓ ***Outdoor Secondary -*** Secondary outdoor use was estimated separately and will be discussed in a subsequent section.

Care was taken in this process to make sure all residential water was included, including homes, apartments, condominiums, and second homes.

Commercial Potable Water Demand

For most PCWS, system operators could separate metered commercial water use data from total water use using water billing customer classes. In cases where this information was not available or difficult to obtain, DWRe estimated commercial potable water use through conversations with system operators.

Institutional Potable Water Demand

Institutional water use is water used for city, county, state, and federal facilities. These include public parks, municipal golf courses, schools, hospitals, recreation centers, churches, cemeteries, and military facilities. The water system operator was asked by DWRe to provide information about institutional facilities, such as the number of public facilities and the size of irrigated acreage of parks, schools, and municipal golf courses. DWRe also used GIS maps and aerial photos of these properties to calculate irrigated acreage. After this information was gathered, the WUF was reviewed to ensure that all institutional water use was included.

When the property owner is the same entity providing the water (as often occurs in cities), water use is sometimes not metered or billed. Where this occurs, the process to gather accurate water use data was often difficult. For large unmetered irrigated areas, DWRe utilized GIS (geographic information systems) mapping to digitize these areas for more refined estimates. For unmetered services, water use was estimated by analyzing information gathered about indoor water use, irrigated areas, and how often those areas were irrigated. These estimates included the use of water right duty and/or evapotranspiration (ET) to calculate the amount of water necessary to irrigate these areas.

Industrial Potable Water Demand

DWRe has historically classified industrial water use as water used in the production of a product. Commercial establishments such as dairies, mink farms, greenhouses, and stock-watering, provided they are served by a PCWS, have traditionally been included in this category. Industrial water use within community water systems was calculated in the same manner as commercial water use. DWRe reviewed the WUF to determine if all industrial water use was included. Through meetings,

DWRe determined if any industrial water use came from self-supplied sources. DWRe used the DWRi website to obtain this self-supplied source information.

Public Non-Community Water Systems

For all public non-community water systems, DWRe attempted to contact or make a personal visit to each of these systems. Non-community water systems are rarely metered, so DWRe made estimates of water use in most cases. DWRe analyzed the number and types of facilities included within these systems, the population served, water source information and outside irrigation use. The data gathered, along with information located in water-related publications, were used to estimate this water use.

Private Domestic Water Systems

Private domestic water systems are residences that are not connected to any public community or non-community water system. The vast majority of these systems consist of one or two individual homes connected to a well.

To determine water use for this category, the population served by these private domestic systems was estimated by subtracting the population served by community water systems from the total population for each county. The remainder was assumed to be the population that was served by private domestic water systems. Population estimates were acquired from the Governor's Office of Management and Budget (GOMB) and from information self-reported by the water suppliers. To determine total water use, the estimated population was multiplied by the per-capita water use rate calculated for residential use in public community water systems in that county.

Secondary Demand Data

Estimating secondary water use presents at least three major challenges:

- ✓ Most secondary systems do not include individual customer meters. Thus, the only data that is available for most systems comes from source meters.
- ✓ Many secondary systems still include a mixture of both M&I as well as agricultural demands. As a result, even in systems where good source production data exists, it can be difficult to segregate M&I and agricultural demands.
- ✓ Many secondary systems include at least some portion of their service area that is supplied from private irrigation companies. Because private irrigation companies have not historically been required to report water use information to the DWRi, few data are available.

Because of these challenges, estimates for secondary water use prepared by DWRe have not historically been based on actual meter data. Instead, this use has been estimated by multiplying the estimated irrigated acreage in each system by the estimated water application rate for that system. These two components have historically been estimated as follows:

- ✓ ***Irrigated Acreage*** **-** To estimate irrigated acreage, the DWRe obtained general layouts from master plans for secondary water distribution systems serving potable areas. Additional mapping was also obtained from the secondary water providers as well as

the total number of secondary service providers for the particular area being analyzed. DWRe studied this mapping to determine if any secondary water was being diverted for cropland irrigation in lieu of lawns, shrubs, and gardens. Each water system was also asked to provide an estimate of the percent of users served by secondary irrigation. Using these various data sources, the DWRe estimated irrigated acreage in the system. Estimates varied by type of user:

- Residential irrigated acreage was usually estimated by multiplying the number of connections served by secondary water by an average lot size and an average percent irrigated. It appears that most of the estimates contained in the DWRe water use numbers assumed an average lot size of 0.25 acres with 50 percent irrigated.
- Commercial and institutional irrigated acreage was estimated based on a more detailed assessment of individual properties. System operators were asked to provide information on the irrigated acreage of parks, schools, churches, and golf courses. In some cases, these estimates were augmented by DWRe using visible irrigation from aerial photography.
- Industrial irrigated acreage was usually assumed to be zero.

- ✓ ***Application Rate -*** The application rate is the amount of water applied to a property over the course of the year, usually measured in inches. Estimates of application rate by the DWRe have varied over time. In 2010, application rates were estimated based on the water right duty for each area of the state. For example, in Davis County, the application rate was estimated as 48 inches (water right duty for irrigation in Water Right Area 31). In 2015, application rates were estimated as the evapotranspiration rate (ET) times an assumed application efficiency percentage. ET represents the amount of water, in inches, necessary to produce green, healthy turf. ET values are obtained from the DWRe ET network. Unfortunately, it is very difficult to apply the exact amount of water needed at the exact time and place it is needed to achieve the optimal ET. Application efficiency represents how effective water is applied in order to satisfy the ET. This is expressed in terms of the percent of total water applied that satisfies ET. In 2015, DWRe used an estimated application efficiency of 50 percent.

Reliable Water Supply Data

In addition to water use estimates, the DWRe M&I water report estimates the reliable water supply of each PCWS. Reliable water supply is defined as the capacity of community water systems sources (e.g. wells, springs, etc.) to meet projected demands and is expressed as an annual volume. For planning purposes, the reliable potable water supply is essential for estimating what population base each system can theoretically support with current demand patterns. It is also a guideline to help predict the approximate timing of future system improvements in order to meet the increased demand.

In developing water supply estimates, DWRe has historically considered two different numbers:

- ✓ The maximum developed potable water supply under present conditions
- ✓ The reliable potable water supply

Maximum Supply. The maximum developed potable water supply under present conditions is a theoretical annual volume based upon constant production at a maximum daily flow rate. This maximum production rate is limited by the following constraints:

- ✓ Physical production capacity of a source considering pump capacities, pipe sizes, etc.
- ✓ Hydrologic limitations such as reliable stream flows or groundwater safe yield
- ✓ Legal constraints such as limited water rights

The lesser amount of water supply, due to these three constraints, is considered to be the maximum developed potable water available under present conditions.

Reliable Supply. In assembling estimates of supply, DWRe has recognized that expecting supply to be produced at its theoretical maximum, year round is not realistic. Systems with significant irrigation demand see significant changes in demand over the course of the year. This means that sources sized to produce water during the peak demand periods of the year will need to be turned off during the periods of lower demand. As a result, the portion of maximum supply that is actually useable to the system is almost always less than 100 percent.

To account for this reality, the values used for supply planning by DWRe have been based on a reduced supply number referred to as reliable supply. Based on input from PCWS's, DWRe developed a method of estimating reliable potable water supply by adding together the following:

- ✓ 100 percent of the maximum developed potable water supply capacity of surface sources
- ✓ 50 percent of the maximum yield of wells
- ✓ A percentage of the average annual flow of spring sources. The assigned percentage of spring capacity used for reliable supply estimates ranged from 50% and 100%. The assigned percentage was dependent upon whether or not the springs were used as a first priority for base water deliveries, or used only as a supplement during high use summer months.

Both maximum and reliable potable water supplies were based upon current supplies and current demand conditions. These estimates did not include additional supply that may be made available by the following:

- ✓ Lowering and/or increasing the size of the existing well pumps
- ✓ Pumping existing wells for longer durations
- ✓ Increasing the storage capacity and/or distribution pipe sizes
- ✓ Developing new sources

OBSERVATIONS REGARDING THE DATA COLLECTION PROCESS

A primary focus of this report was to review the State's water use data collection process and determine what, if any, problems actually exist. To accomplish this task, the project team first met with DWRe and DWRi personnel to develop an understanding of the process. The team then began meeting with several water providers throughout the State. This included both in-person meetings and telephone interviews in an effort to solicit feedback regarding DWRi's water use database and the overall data collection process. We compiled this feedback and common themes among these various providers developed.

Based on our understanding of the data collection process prior to 2016 as described above, as well as feedback we received, it does appear that there have been some challenges within the State's Water Use Collection Program in the past. What we discovered is that all providers interviewed for this report do need, or have needed assistance, in one form or another. As a result, the project team has identified a number of areas where the historic process (through 2015) may have been inadequate to capture accurate, consistent water use data. The following observations provide insight to where inaccuracies and inconsistencies could occur.

"IT WOULD BE HELPFUL FOR US, AS A DATA PROVIDER, TO BETTER UNDERSTAND THE WAYS THAT THE DATA WE ARE PROVIDING ARE BEING USED. IF WE HAD THIS UNDERSTANDING, WE MAY BE ABLE TO PROVIDE INSIGHT INTO WHETHER THE DATA THAT WE PROVIDE IS APPROPRIATE FOR WHAT IT IS BEING USED FOR."

1. **Unclear Purpose –** Some water system personnel do not understand the purpose or importance of the data collection and therefore are not motivated to provide accurate information and question whether the data are being used properly. Comments received from water providers expressing this sentiment include the following:
   - ✓ *"It would be helpful for us, as a data provider, to better understand the ways that the data we are providing are being used. If we had this understanding, we may be able to provide insight into whether the data that we provide is appropriate for what it is being used for."*
   - ✓ *"No. I don't really know what this data is used for, but I did hear that our results go to the State Engineer and I think he publishes a report. I think it helps the people at the state level. That's just what I heard."*
   - ✓ *"I attended a conference recently where a representative, I believe from the State, explained this data is used to calculate water use throughout the State."*
   - ✓ *"I have no idea what the data is used for."*

2. **Unclear Definitions –** Based on our interviews with survey respondents and review of reported data, it is clear that the 2015 WUF does not sufficiently define what information is being requested. Areas of potential confusion include the following:
   - ✓ ***Population Served* –** For those paying attention, this is clearly defined as "Retail Population Served"; however, it appears that some entities may be responding with populations based on municipal boundaries instead of actual service area.

     Data from the 2010 Census was analyzed for a few water systems to evaluate if water system were reporting municipal boundary populations instead of service area population. Population data was both clipped to the municipal boundary and water system service area boundary. The resultant populations were compared to what each water system reported to the state in 2010. The results confirmed that, while some entities clearly understand they are reporting population for their service area, many others are clearly reporting population for their municipal boundary instead of their service area.
   - ✓ ***Water Diverted* –** Some confusion may exist on the definition of diverted.
     - o Because there is no definition or guidance given, there is inconsistency across water systems as to how water "diverted" is measured. For example, one system

reports the total amount of water diverted off a certain surface water source even though only a portion of this is actually used at the system's water treatment plant. A second system reports water diverted at the head of its treatment plant, but includes a large amount of water that is lost through the backwash process. A third system only reports the treated water that leaves the treatment plant and is delivered to the customers. These several systems could report identical numbers for water diverted but have very different amounts of water that are actually available to satisfy system demands.

- Quite a few systems do not even measure the water produced by their sources individually, but only measure at a master meter downstream where the water produced by the various sources is combined.

✓ ***Source Type –*** No definition is provided.

- Throughout the data collection and analysis, there have been no perceived errors associated with misclassification of source type; however, defining a standard group of acceptable source types (e.g. wells, springs, treatment plant, untreated surface water diversion, reuse, etc.) will aid in future analysis help avoid future misunderstanding.

✓ ***Water Use –*** "Water Use" is a very ambiguous term. Does water use refer to:

- Metered water sales?
- Actual water use at metered connections (meter sales plus underreads resulting from inaccurate meters)?
- Water use at metered connections plus unmetered uses such as fire flow?
- Total system use including leaks and other losses?

  These various numbers can be different in some systems. Based on interviews with DWRe personnel, it appears that the intended definition of "water use" is metered sales and unmetered use. However, this is not clear to many system operators.

- For example, multiple systems were identified that are reporting water use numbers as the sum of the production from their sources. The report then reflects an inaccurate picture that the water systems have no losses. Differences in production versus sales average around 16 percent nationally and were as high as 31 percent in systems surveyed for this study. This highlights the importance of understanding the definition of use so everyone is reporting the same information under this category.

✓ ***Water Use Categories –*** While the current water use categories (residential, commercial, institutional, and industrial) are generally understood, no specific definitions are provided and individual interpretations may lead to inconsistent reporting. Specific areas of concern include:

- Does Residential include multifamily housing, second homes, and apartments? Some water systems have reported such connections under Commercial because the account owners are businesses (not residents), the meters are large and serve multiple units, and/or the account was categorized as "Commercial" in the billing system.

- How are overnight accommodations outside of traditional hotels represented (i.e. timeshare condos, rentals, etc.)? The data examined in this study reveal that such water uses are not categorized consistently.
- How should golf courses be categorized? Depending on whether the owner is a municipality or a business, it appears that golf course may be categorized as either institutional or commercial. Regardless of ownership, it would be preferable that common types of use are all in the same category.
- Is there a category for water loss? Some water systems appear to be attempting to report unmetered water consumption like leakage, theft, and flushing under Institutional use, while most system do not report water loss at all.

- From year to year, many water systems change the categories in which they report certain water uses. What is reported as a commercial use one year may be reported as industrial the next. While some changes are to be expected as water systems refine their reporting, the frequency of these types of changes suggest that water systems clearly do not understand the definitions of these water use categories.

✓ ***Secondary Water Use Definition*** **–** Difference between M&I secondary water use and agricultural use needs to be clearly defined so that reported results are consistent with subsequent DWRe planning assumptions.

- The delivery of non-potable secondary water is an important component of M&I water use within the boundaries of a PCWS. However, many of the secondary water systems are part of a larger agricultural irrigation system. As a result, demands on the overall secondary system include both M&I and agriculture. Separating M&I secondary water use from agricultural use is mostly estimated due to lack of metering.

✓ ***Secondary Water Use Percent Coverage*** – "% of your potable customers" using secondary water is not defined. Reported values could be based on percent of connections, percent of indoor Equivalent Residential Units (ERUs), percent of irrigated area, etc.

2. **Process Not User Friendly –** Several entities view the data collection process as burdensome and complicated. They report that education, training, and support relative to providing data have historically been inadequate. We reference comments received during interviews from providers below.

✓ *"Prior to 2015, we always had difficulty with the categories: municipal, industrial, institutions etc. and how to separate this water. We also had trouble identifying and assigning the different types of connections. We were not comfortable uploading data*

into the State's database. There was always confusion as to where to put numbers; in fact, there was several years of confusion."

- ✓ *"Sometimes after uploading the State's water use database, the State contacts us and tells us it's wrong. We have to go back and try to find our mistakes. It's usually unit conversions or our water use is in the wrong category. We have a lot of trouble with unit conversions. Our flow meters are read in gallons and the State wants these numbers in ac-ft. We also have difficulty with time –when I have an hour, it ends up taking three hours. It's just painful."*
- ✓ *"We don't have any difficulty with the State's Water Use Database. We believe it's very straightforward; however, for everyone involved with data assembly and input, we've all been in our respective jobs for the past 20 years. I will admit, it took me about 10 years to really understand the City's water report and learn how to input this information into the State database, such that I knew it was correct. We always had difficulty understanding the different categories but we believe we understand them now."*

While operators of many different sized systems reported having trouble with the data collection process in the past, this sentiment was especially prevalent among smaller systems:

- ✓ *"The most difficult item for us is reporting our production. Our city staff is very small, and we're very busy. It's difficult to get someone out to read the flow meters. Sometimes we just forget, or the reading is put off because of other more pressing issues."*
- ✓ *"Sometimes we have and hour to spend uploading the State's water use database and we get pulled away due to an emergency. We may not get back to uploading data for two weeks, or even longer."*
- ✓ *"If we provided all the information the state requires, we'd need to hire another full-time person and we can't do that."*
- ✓ *"We received a notification from the State that threatened to cut off our state funding unless we immediately uploaded the water use database."*

3. **Perceived Conflict of Interest –** Some entities may perceive a conflict of interest between the goals of reporting accurate water use data, showing water conservation progress, and preserving water rights. To show conservation or to not exceed a water right, they might report only certain types of usage, or none at all. To preserve excess water rights, they might report inflated numbers to show full use of the right ("use it or lose it"). While conflict of interest concerns appear to be rare, this issue was raised by at least one water system surveyed as part of this study:
   - ✓ *"We're in a water rights dispute with the State, and there's no way we'll participate in this study. We don't want to give them any additional ammunition to come after our water rights."*
4. **Insufficient Data on Water Loss –** The process does not currently collect sufficient information to understand and plan for water loss. Once all systems are correctly reporting both water sales and water

"IF YOU CAN WORK WITH THE STATE AND MAKE UPLOADING THE DATABASE EASIER AND LESS TIME CONSUMING, YOU'LL BE MY NEW BEST FRIEND."

production, it will be possible to calculate total system loss. However, there will still be no way for DWRe to understand what this loss consists of (e.g. unmetered use vs. leakage) and correspondingly be able to accurately account for it in planning activities. On occasion, losses in the municipal water system (e.g., flushing, fire flows, etc.) are reported in the Institutional category, but this practice is inconsistent.

5. **Lack of Secondary Water Data –** The process does not currently collect sufficient secondary water use/production information for planning purposes, especially pertaining to irrigation providers separate from potable water providers. The majority of the water systems that were examined did not have detailed information concerning their secondary water use. This is largely a result of most systems not metering their secondary water and cities having multiple sources of secondary water. It is also evident in many of the communities that were examined that multiple sources of water are being used for outdoor watering purposes (private well use, third party water providers, etc.).

RECOMMENDED CHANGES TO THE 2015 DATA COLLECTION PROCESS

Based on the observations and conclusions summarized above, we would recommend the following actions regarding the data collection process:

1. **Clearly articulate, both internally and externally, the purpose of collecting water use data.** Clarity of purpose will improve the overall the data collection process and minimize perceived conflicts of interest. Safe, reliable water supplies are vital to public health and welfare. The Utah Code (Sections 73-10-20 and 73-10-18) declares that constructing and expanding public water systems must be "based on proper planning and sound engineering" to help ensure efficient water use and, for this purpose, designates the Division of Water Resources as "the water resources authority for the state." The Division's mission is to "plan, conserve, develop, and protect" Utah's water resources, and to fulfill that mission, it needs adequate water use data.

   Beyond their value to the State, the data are passed on to the U.S. Geological Survey's National Water-Use Science Project. The USGS aggregates water use data at county, state, and national levels and publishes the data in a report every five years. The series characterizes current and historic conditions of the country's water use, which are essential to understanding "how future water demands will be met while maintaining adequate water quality and quantities for human and ecosystem needs" (Maupin et al. 2014). The series is one of few sources of information on regional and national trends in water use.

   Water systems that struggle to provide data, for whatever reason, may not understand either purpose and may not be motivated to report accurately.

2. **Improve instructions in data entry process.** Based on feedback received from water system operators, it is clear that not everybody understands what they should be reporting and how to report it. One easy step to improve the data collection process is to improve the instructions and training associated with the data collection form. Specific suggestions for improvement include the following:

   a. **Clearly define all water use types and include guidance within the data entry form.** Consistency among the data provided by water providers is more important than which category each type of user ultimately ends up in. To facilitate federal reporting, follow the USGS definitions where possible (https://water.usgs.gov/watuse/wuglossary.html). Where specific potential areas

of confusion exist, make a decision and clearly document it. Some specific suggestions:

i. Define all living units other than hotels as Residential (USGS term: Domestic). This includes single-family homes, apartments, duplexes, condominiums, etc., regardless of whether or not some are used as vacation rentals or second homes or whether they are commercially or privately owned.

ii. Define hotels as Commercial. While the USGS no longer estimates commercial water use nationally, it is an important category for the State's water conservation efforts.

iii. Define all golf courses as Institutional (USGS term: Public) regardless of ownership. Golf courses, where most water use is for irrigation, are very similar to city parks and recreation facilities categorized as Institutional.

b. **Request "metered sales" for water end use.** The outreach of this study confirmed that what the State is requesting in terms of "water use" may be misinterpreted. "Metered sales" or "billing data" are terms water system and accounting personnel understand since sales is how they normally record end-use. This would help eliminate a lot of misreported numbers as some users in the past have not known what to report here and report production or some volume other than customer metered use. Most water systems bill their customers monthly and can easily report this information.

c. **Request raw water use data and units.** Errors have been introduced through attempted unit conversions, averaging, and other manipulations when system operators try to report data in a format different than what the water system actually has. Requesting raw data, units, and supporting comments will minimize the potential for such errors before data entry.

   It should be noted that our understanding is that the DWRi online data entry portal has allowed for entering data in different units prior to 2015. However, training in how to use the portal and limitations in how the data is ultimately recorded and stored has led to continued data entry and unit conversion errors by system operators. Additional clarification in this area beyond what was available in 2015 is needed.

d. **Add instructional components to data collection form.** While the issues highlighted above appear to be the most common sources of misunderstanding in the process, there is potential that any one of the different components could be misinterpreted at some point. To improve clarity, the water use form should be equipped with a help button that provides definitions and instructions for every entry field on the form, along with a "best practices" manual or similar guidance. This would give those who enter the data a source to turn to for definitions and procedures, resulting in more conformity and consistency in the reported data. The State might also consider adding a video tutorial or other training tool to assist water system personnel in learning the data entry process.

e. **Provide opportunity for feedback regarding data entry from users.** Actively solicit additional feedback and implement to achieve continual improvement.

3. **Simplify and Automate the Data Collection and Evaluation Process.** Based upon in-person meetings and interviews with providers, different ideas were discussed that would make the reporting process less time consuming, easier to understand, improve repeatability from year to year, and eliminate confusion. Recommendations resulting from these discussions include:

    a. **Seek to minimize requested data to maximize participation rate and response accuracy.** Clearly, a balance must be reached between obtaining useful data and overburdening water providers. This means revisiting the data request form and limiting the request to information water suppliers already have and can provide easily and accurately. While most of the existing data requested on the form is needed for one reason or another, the State should eliminate anything not absolutely essential and minimize what it adds to the data request form in the future.

    b. Pre-Populate Data Entry Fields to Save Time and Increase Consistency. Past data entry forms have required most information to be re-entered every year. Multiple system operators interviewed as part of this study requested that the data collection portal be updated to pre-populate as many fields as possible to minimize the time and effort required to submit the information. This could include contact information, information on system sources (type, location, water right numbers, method of measurement, past unit of measurement), and historic metered sales information.

    c. **Meet with billing software providers to understand how the software could help fulfill data requests.** Most of the systems in the state currently use some kind of billing software to collect and organize metered water use data. Since these programs are already involved in the data collection process, there seems to be potential to coordinate with these software providers to help accomplish the State's purpose. One particular provider, Caselle, is locally owned and operated. Because of its location and popularity with communities throughout the State, our team contacted them to discuss the possibilities on how their software could help improve the process. While their response represents just one company, similar concepts could likely be applied through any of the billing software providers.

    Capabilities that do or could exist in the billing software include:

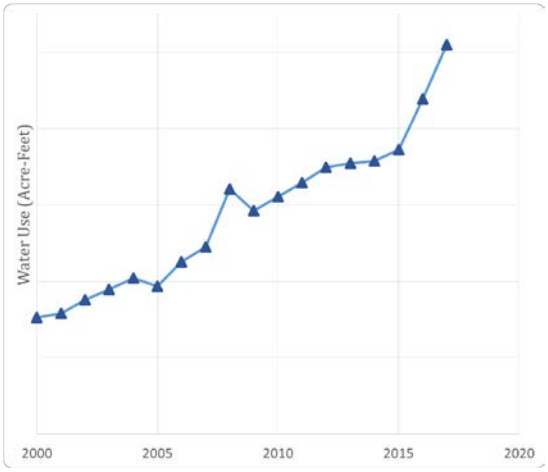
    - Data Entry - To mitigate human error, billing software can interface directly with the meter reading software and collecting usage data electronically.
    - Data Verification - Based upon prior metered usage, inaccurate readings for individual meters can be "flagged" to alert the entity that investigation into water usage is required
    - Water Use Type Categorization - The software includes an option for organizing customers into the same water use categories requested for reporting to the State (residential, commercial, institutional, and industrial). Once set up, these types can be assigned and tracked independent of how the system groups customers for actual billing.
    - Output Reports - The software can export customizable reading files providing metering data in any format desired. Caselle reports that they have actually already created a report specific to State water use reporting that can be printed out and user by systems to respond to the State's data request. While this is

useful in providing the numbers needed, the next step may be to automate the process such that data from the reports can be directly imported into the State's data collection portal. This feature was requested by a couple of the system operators interviewed. One provider interviewed stated:

"The software generates the metered sales report, and I receive this report on a spreadsheet from the billing department. From the spreadsheet, I upload the water use data to the state's database. It would really save time, and prevent input errors, if this billing data was somehow linked to the water use database. I'm retiring in a couple of years, and I don't have any idea who will take over uploading this data after I leave. It took me about 10 years to understand how to do this."

d. **Provide the ability to report monthly, rather than annual, billing data.** Some water providers do not have a very good system for storing water use data. Providing a way for them to use the State database as their primary location for data storage may assist them with data storage along with providing additional information for analysis. Having monthly water use resolution would match that of the production data, help identify seasonal patterns, and enable calculation of water loss and indoor/outdoor use. While we caution against adding any new mandatory reporting requirements, allowing the option of reporting monthly billing data would probably be an intuitive and easy way for entities to report their meter sales data.

e. **Increase water providers' interest in the data entry process by making the data collection form more of a tool.** As it currently stands, the State data entry process is viewed as tedious chore by operators, with little if any benefits to their systems. Participation rates and interest in providing quality data would increase if water systems could see the value of collecting the data. One way to do this would be to make the data collection portal into a useful water use analysis tool. This could occur if the portal not only took data, but also gave back information in the form of data analysis.



This would likely consist of displaying water use and production graphs and trends within the portal. These graphics would likely include a display of historic data reported from previous years as well as a comparison to other similar water users throughout the State (where applicable). Some specific output information that may be of interest to water users would be as follows:

- ✓ Number of connections
- ✓ Total water sales
- ✓ Total water production
- ✓ Calculated system loss
- ✓ Production by individual sources
- ✓ Overall use per connection and/or production per connection

- ✓ Indoor vs. outdoor use
- ✓ Indoor use per connection
- ✓ Outdoor use per irrigated acre (i.e. application rate)
- ✓ Comparison to other similar water systems

System operators will be able to use this analysis to track conservation, understand system losses, and help with future supply and demand planning. In addition to improving interest in the data collection process, these types of tools will also improve data accuracy as past trends will allow systems to see if new information is reasonable and consistent.

4. **Collect additional information regarding water loss.** Understanding water loss is a very important component in water planning. For example, as it currently stands, the DWRe definition of water use includes metered sales only. If this is used as the basis for water demands in future planning, insufficient water will be projected for future needs since unmetered use and other losses add additional demand on the system. Water production is a more conservative and accurate basis for future planning, as it accounts for the total water needed so there is enough end use water delivered to customers after losses occur. To properly account for system losses, the following actions are recommended:

   a. **Account for system losses in DWRe planning activities.** The DWRi data collection process does include an area for reporting system production. However, this information has not been used historically as part of DWRe demands projections. It is recommended that DWRe begin to take into account system production and estimate losses as part of its evaluation of total demand. As part of this process, the State could consider requiring each entity to balance water produced with water sales plus system loss. This would help entities understand the relationship between the several numbers and force them to consider if the data being entered is reasonable.

   b. **Collect information regarding type of losses.** While collecting water production and metered sales data will give an overall picture of water loss, this is only so useful. There are many types of losses in a water system that, when quantified and understood, make water planning much more effective and efficient. Broadly speaking, system losses can be grouped into two categories: real and apparent.

      - ✓ Apparent losses are the non-physical losses that occur in a system. These can include customer meter inaccuracies, data errors in customer billing systems, and unmetered or unauthorized consumption. In other words, this is water that is consumed but is not properly measured, accounted, or paid for. These losses impact the system financially and underrepresent the water resources required to satisfy end uses.

- ✓ Real losses are the physical losses of water from the distribution system, including leakage and storage overflows. They represent water that is extracted and treated, yet never reaches beneficial use.

It is recommended that the data collection process be modified to collect data on categories of system loss such as unmetered use, meter error, leaks, backwash, etc. This will help DWRe to better understand the nature of these loses and whether they are actual demands (e.g. meter error) or could be eliminated to provide new source (e.g. system leaks). Some systems already do measure and categorize losses in their systems, but there are no fields in the state form to report those amounts.

As part of the effort to secure information about system loss, the State might consider requiring some systems to complete detailed water audits. A recommended methodology for this type of audit is contained in AWWA Manual M36. This type of audit details the variety of supply, consumption, and loss components that exist in each system. This allows the entity and the State to look at the water balance, which summarizes those components mentioned above and provides accountability for the water that enters the system.

There are many benefits to controlling losses. Reducing real losses saves water and operating costs such as power, maintenance, and treatment. By reducing real losses, expansion of water supply infrastructure may be deferred and equipment and facility lifetime increased. Reducing apparent losses increases knowledge of the customer metering and billing systems and recovers lost revenues from customers who have been undercharged or have gained water in an unauthorized manner. Understanding and controlling both types of losses will improve the accuracy and integrity of water system input volumes and customer consumption. Knowing true water consumption patterns promotes better water resources management, confirms water conservation benefits, and aids long-term planning. Because of these benefits, understanding and quantifying losses should be an important goal for water systems and a state with rapid population growth and limited water supplies.

5. **Improve secondary water reporting and encourage secondary metering.** The DWRi data collection form has not historically collected any information regarding actual secondary water use. To improve planning, better understand potential for conservation, and increase confidence in estimates of secondary water use, the following actions are recommended:

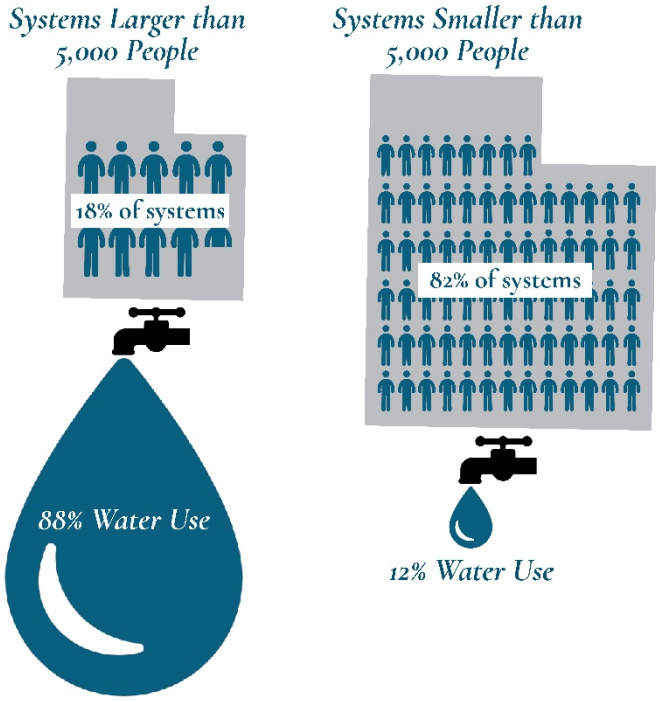
   a. **Require customer metering of secondary water use.** In the long-term, the ideal solution to this problem is secondary metering at each customer connection. With customer meters in place, secondary use data could be gathered for at the same level as currently collected for potable use. Secondary metering has the added benefit of reducing the actual demand for water by providing feedback to customers on their water use and allowing water to be charged for based on actual consumption.

   b. **Add data collection categories for secondary use and production.** While comprehensive customer metering is the ultimate goal, implementation of this solution will take some time. In the meantime, it is recommended that the data collection process be expanded to collect information on secondary use. Because of the challenges of secondary systems noted previously, the accuracy of data may initially be questionable. However, many secondary supplies are metered or can be

estimated more accurately by the personnel operating the system than by State personnel.

6. **Focus detailed data evaluation activities on large water suppliers (service population over 5,000).** The majority of M&I water statewide, both potable and secondary, is provided by a limited number of larger cities and water districts. These systems are in business to provide water, with large staffs focused on this single task. Large wholesale providers and water districts, for the most part, have resources available, are adequately staffed, and already collect the data the State is requesting. Large cities are likewise capable of providing good data.

   However "one size fits all" approach does not work well for all systems. The situation portrayed for large systems is in stark contrast to the smallest providers who are responsible not only for providing water but also for managing many other components of their cities or districts. Our observations indicate that the data collection process begins to fail with smaller water systems serving fewer than 5,000 people. There were several common sentiments expressed by the smallest providers including comments that the State's water use database is cumbersome and confusing; however, the theme consistent among all the smallest providers interviewed was simply the lack of resources. Small cities have small staffs who run everything from water distribution to snow removal to building inspections. As a result, uploading complete and accurate water use data into the State's water use database in a timely fashion is often a lower priority.



Simplifying data entry through the other recommendations identified here will go a long way to lightening the load for small systems. However, given the challenges small systems face, achieving a "perfect" data set for the more than 500 PCWS's in the state may not be a reasonable goal. With this in mind, the State may want to reconsider the amount of time it spends on data collection for small systems. Based on 2015 water use statistics, 82% of systems in the state serve populations of less than 5,000 people. Much of the effort to collect data, follow up, and revise data is spent on these small systems. However, these smaller systems account for only 12% of total potable water use in the state. Furthermore, most of these small systems are isolated from population centers and each other and correspondingly have little influence on major water planning decisions. Given these statistics, it may not be necessary to spend the same amount of time on these systems as is spent on larger systems.

To best utilize available resources, we would recommend that small systems be treated slightly different from their larger counterparts in two ways:

a. **Reduced data reporting requirements -** Once DWRi has improved its data collection process, it may not be practical or necessary to maintain separate data collection forms for large and small systems relative to basic water use data. However, there are some recommendations contained in this report where the cost and effort of obtaining additional data to improve DWRe estimate accuracy is not justified for smaller systems. We would recommend not requiring small systems to submit any advanced data analysis such as AWWA M36 water audits, detailed supply studies, etc. Any deficiencies in the data resulting from not requiring this information from small systems could be filled using estimates from applicable studies in larger systems. This simplification would relieve the burden felt by many of the smallest water providers without compromising the accuracy of final planning estimates.

b. **Limited data evaluation/verification –** As the State prioritizes its efforts, we would recommend a shift in emphasis away from data evaluation and verification in small systems. In short, it may not be necessary to meet with every system in the state each year. It may be sufficient to meet with only a portion of small systems to provide training and oversight and then rotate through the small systems over time. Perhaps a minimum standard could be to meet with at least 20 percent of the small systems each year. Systems could also be added to this list if their data looked suspect. This would allow a contact with each system at least once every 5 years. While this would not guarantee perfect data every year, it would be often enough to correct the course for each system from time to time such that overall data quality would be good. And for the reasons discussed above, errors in any individual years would not have a significant effect on the overall accuracy of the planning data.

CHANGES CURRENTLY BEING IMPLEMENTED IN THE DATA COLLECTION PROCESS

As noted at the beginning of this chapter, all the comments contained here are based on the process used to gather and process data up through 2015. Since 2015, a number of changes have already been implemented by DWRi and DWRe to improve the process.

1. **Increased effort from DWRi to help systems complete and submit data.** As a result of the 2015 Legislative Audit, DWRi has made a conscious effort to reach out to all systems and assist with the data entry process. Specific focus has been made on systems that appear to be struggling with the requested data. Specific efforts in this regard include:

    a. The DWRi now has two full-time employees that travel to 10-15 systems per week to train and help fill out forms.

    b. An interactive map has been created that shows which systems have or have not reported, as well as those systems that have reported but need to change or finish incomplete sections.

    c. Increased emphasis has been put on using the online portal. By making the online portal easier to use and of better help to each system, the DWRi aims to reduce its effort to manually enter in data and decrease human error. Improvements associated with the data entry portal will be discussed in detail subsequently.

    The efforts of DWRi appear to be paying off in terms of participation rate. Figure 2-1 below shows a summary of yearly reports. The last few years have seen a major rise in both the number of systems reporting and the number of systems using the online portal.

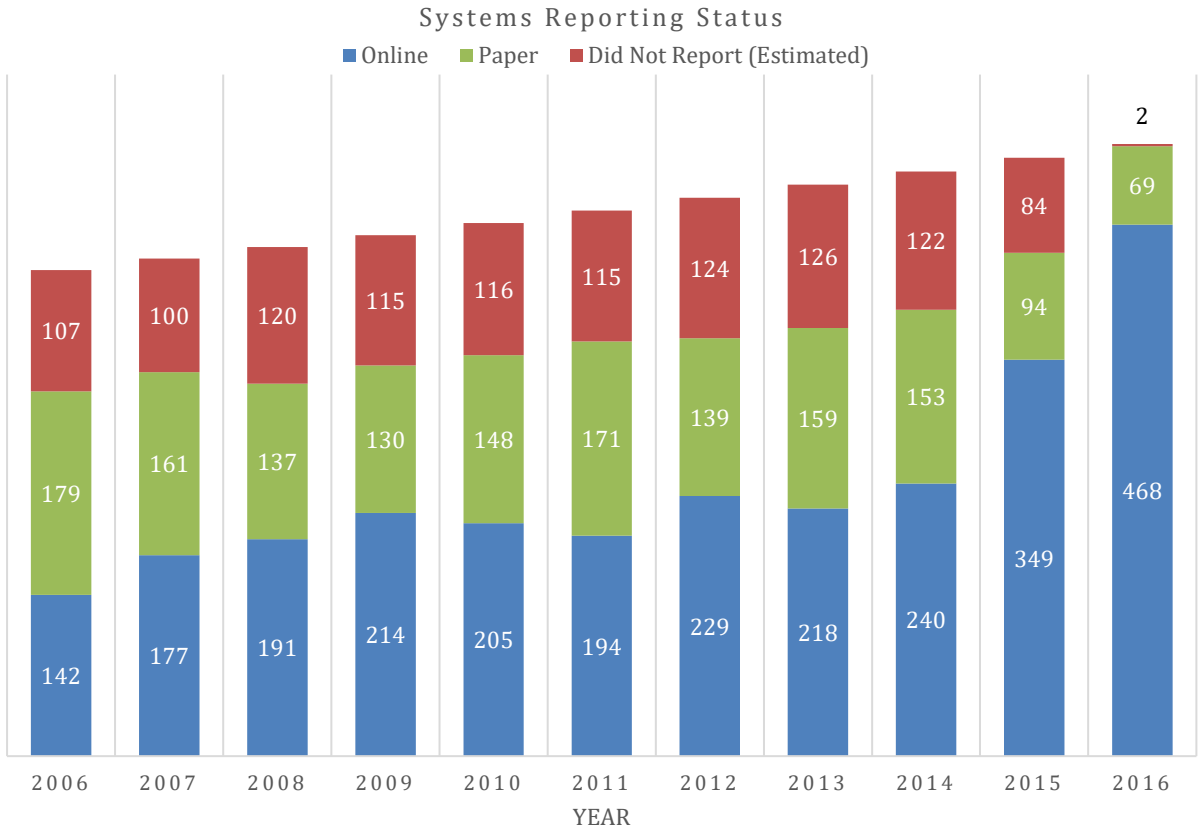


Figure 2-1: Systems Reporting by Year

2. **Improved coordination between DWRi and DWRe**. Prior to 2015, much of the work done by DWRi and DWRe was independent of each other. After DWRi handed off the raw data to DWRe, there was minimal interaction between the departments while DWRe completed their work. As a result, efforts spent by DWRe in analyzing and correcting the data did not result in corrections to the original DWRi database or improvements. In recent years, coordination between DWRi and DWRe has improved by moving to a single database used by both entities. Now, when DWRe identifies some sort of issue in the data, they contact DWRi who then works with the system operator to correct the data in the common database. In addition to improving the quality of the data, this has the added benefit of helping DWRi's field team understand where common errors are occurring and improve training with system operators.
3. **Revised Data Portal to be Released in 2018.** The changes noted above have been implemented and in place for the past few years. One additional improvement in the data collection process is not set to begin until early in 2018. This is the development of a new online data entry portal. Although no system operators have yet been able to use the portal, DWRi provided our project team with access to the beta version of the portal. Overall we were very impressed in the progress made to improve the ease and accuracy of the system. Some of the key features of the new portal are as follows:
    a. **Improved User-Interface makes online portal easier to use.** A new design of the online portal allows the new user to see each category that needs to be completed (See figure 2-2 below).

i. Data entry is broken into simple steps that are easier to follow.

ii. A check mark appears next to each step once all of the required data is filled out.

iii. Detailed instructions are provided with each step and are easily accessible.

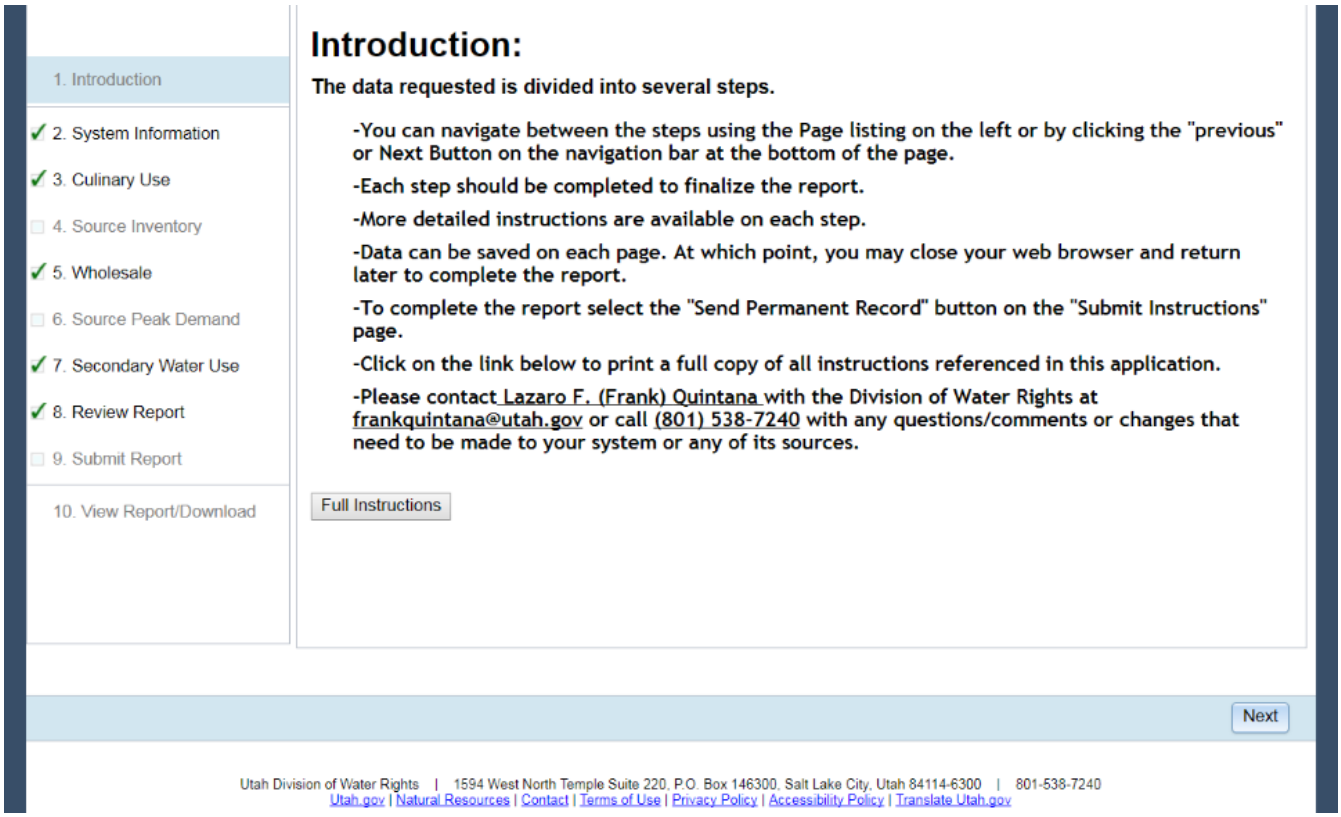


Figure 2-2: Screenshot of New Online Portal

4. **Error Minimization.** Several improvements have been made to directly address several concerns regarding data accuracy.

   a. **Improved instructions and definitions in data entry process.** In addition to the full step-by-step instructions given of how to fill out the form, definition icons have been placed next to each requested item. When clicked on, a definition box will pop-up further explaining exactly what should be entered. For example, if someone is unsure to which retail potable use class something belongs (residential, commercial, industrial, or institutional), they could click on the icon next to each class until they see their use identified in the definition of the class.

   b. **Requests raw water use data and units.** Drop-down menus have been included to avoid error in unit conversions. Systems can enter in raw data and choose the units in which they track their data. There is also a drop-down menu to allow the system to select the method of measurement - whether the data was taken off a meter, estimated, etc.

c. **Historical Data Comparison.** This tool was designed specifically to reduce human-error data input. When data is entered into any line, it is automatically compared with the previous year's data. If the data differs by more than a specified percentage, a message automatically pops up indicating that the data entered differs from past data. The user can then decide if the data is right, or if a number or unit was erroneously entered. There is also an icon next to each item that if clicked on, will bring up a bar graph showing historical data, as shown in Figure 2-3 below. This is useful to confirm whether the data is being input correctly.

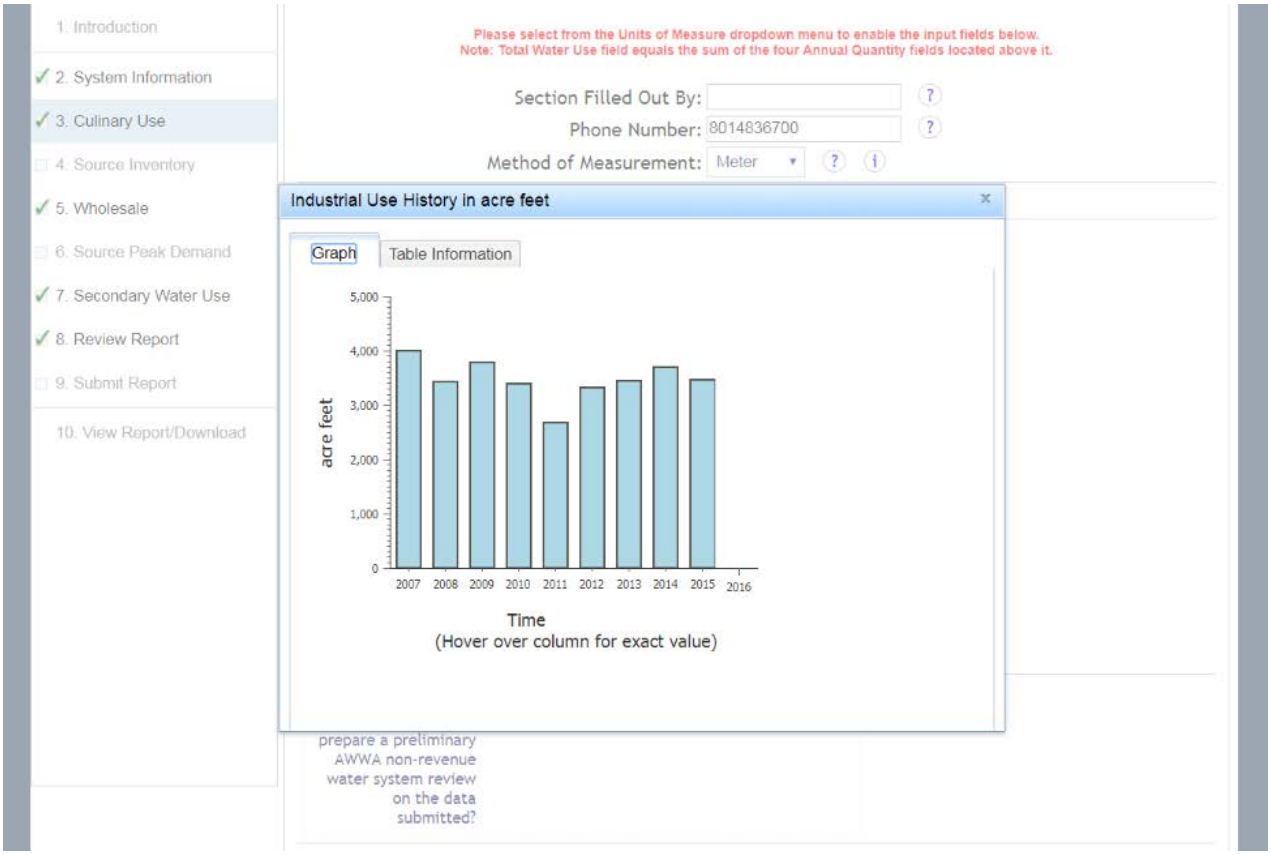


Figure 2-3: Screenshot of Typical Graph Showing Historical Data

5. **Pre-Populated System Data.** Source inventory and wholesale delivery information often has several sources or entities that must be created filled out. These inventories are now saved automatically from year-to-year so that the user does not need to re-create them. Data saved includes the name, location, WR numbers, and type (well, spring, etc) for each source or entity.

   Population data is also automatically populated based on what the DWRe has calculated based on census information and system service area boundaries. The system has the option to say whether the population is accurate. If it is not, there is an option to input the correct population.

6. **Automatic calculation of system losses.** A report review has been added as a step in the online portal. This review automatically calculates non-revenue water (system loss or unaccounted), as displayed in Figure 2-4 (numbers used in this particular figure are not

from an actual system). This is done by subtracting the total use (including wholesale deliveries) from the sum of all sources (diversions and purchased water). This function serves as both an error check, as well as a way to encourage systems to reduce their losses to avoid losing revenue.

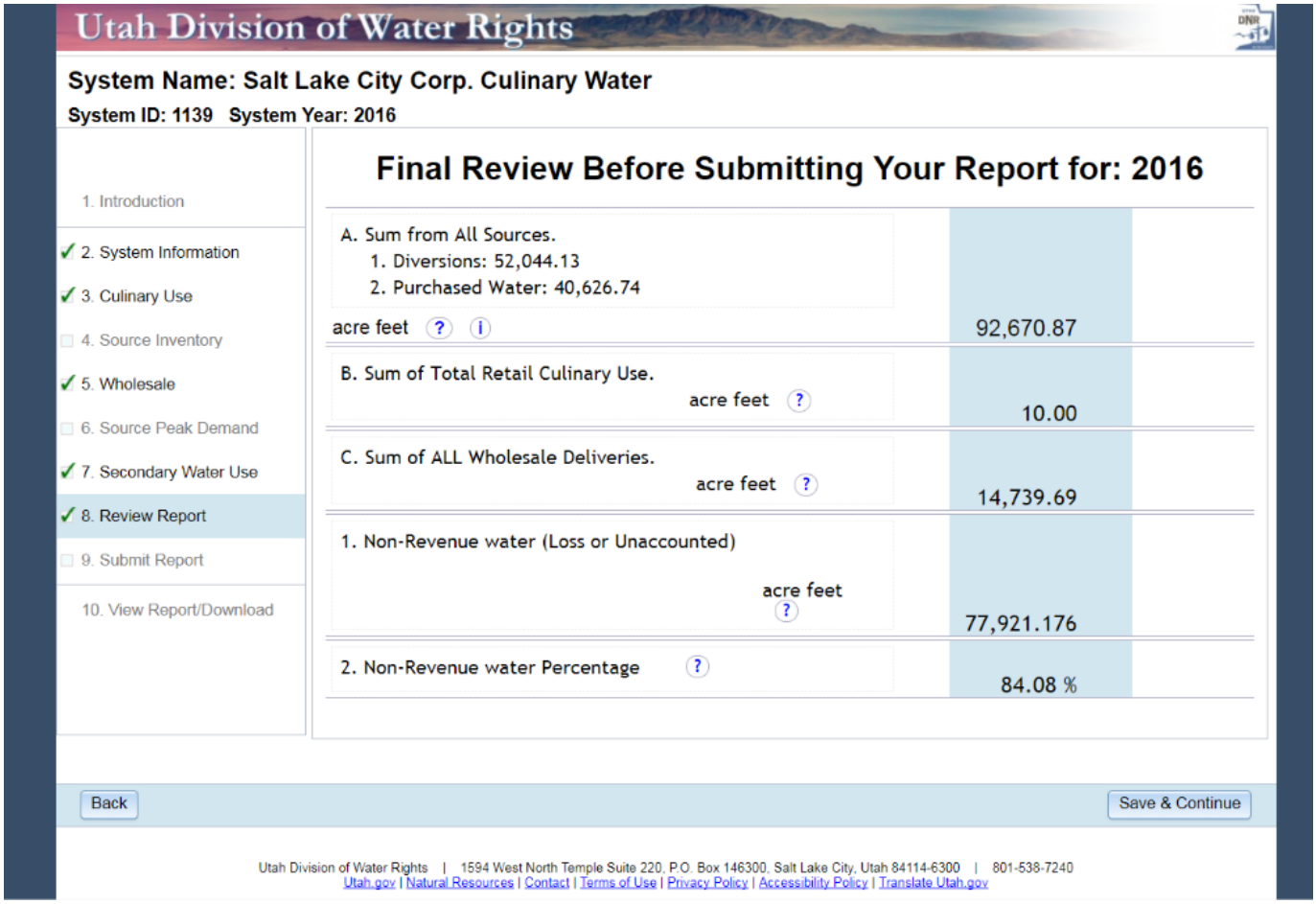


Figure 2-4: Screenshot of Automated System Loss Tab in New Online Portal

7. **Option to Download PDF copy of Report.** After submitting the report, there is an option to download a pdf to keep for their records.

SYSTEM FEEDBACK REGARDING RECENT CHANGES

Although system operators have not yet seen the new data entry portal, they are already reporting marked improvement in the data collection process based on changes seen over the last few years:

- ✓ *"We met with a State representative prior to reporting our 2016 data in order to discuss the reporting process. This meeting was helpful for us to better understand what the State is asking for and for us to better describe the data that is being provided. We feel like this was a step towards a better reporting process."*
- ✓ *"We have a pretty good understanding of the state's water use collection program and database; however, we've only had this good understanding for the past 2 years or so. Prior to*

2015, we always had difficulty…We don't have any difficulty now with the State's data collection system."

- ✓ *"The State's database is now much easier since they deleted some of the information previously required. Previously, the State required 5-year projections and we would spend weeks, or longer trying to compile this information for inclusion. Now they just want water totals and so it's much easier."*
- ✓ *"We like the revisions that State has made in the database for data input that is more closely tailored to our own system. We don't need to go back each year and re-enter all of our water sources. Our sources are now saved from year to year so we simply put in the numbers."*

SUMMARY OF REMAINING RECOMMENDED CHANGES

As documented in the sections above, many of the recommended changes to the 2015 process for both DWRi and DWRe have already been accomplished through improvements made over the last few years. Table 2-1 summarizes the recommendations made previously in this chapter and the status of their completion based on the observations of the project team.

Table 2-1
Status of Data Collection Process Recommendations

Data Collection Process Recommendations	Status
Articulate Purpose of Collecting Data	In Progress
Improve Instructions in the Data Entry Process	
Define water use types	Complete
Move from "water use" to "metered sales"	In Progress
Request raw water use data and units	Complete
Add instructional components to collection form	Complete
Provide opportunity for feedback	Complete
Simplify & Automate Data Collection and Evaluation	
Minimize requested data	Complete
Pre-populate data entry fields	Complete
Coordinate how billing software could improve data requests	In Progress
Allow monthly reporting of metered sales data	Still Needed
Make data collection form tool for water providers	In Progress
Collect Additional Water Loss Info	
Account for losses in DWRe planning	Still Needed
Collect info on type of losses	In Progress
Improve Secondary Water Reporting & Encourage Secondary Metering	
Require metering of secondary water	Still Needed
Add categories for secondary use and production	Complete
Focus Detailed Data Evaluation on Large Water Suppliers	
Reduce data reporting requirements for small systems	In Progress
Limited data evaluation/verification for small systems	In Progress

Thus, the list of remaining recommended changes can be shortened to the following:

- ✓ **Ongoing education regarding data collection purpose.** This recommendation will likely never be "Complete". There will always be an ongoing need to educate system providers of the purpose for this data collection.
- ✓ **Verification of data entry definitions in the new portal.** Because the new portal was still in development, not all of its features could be reviewed in detail as part of this study. It is recommended that data entry definitions in the final portal be reviewed relative to the issues identified in this report.
- ✓ **Clarification of water "use".** The new data portal still uses the ambiguous term "water use". We would recommend replacing this with the term "metered sales" or providing very clear and visible instructions regarding what the term "use" means.
- ✓ **Continued coordination with billing software providers.** Some work has already been accomplished to coordinate billing software with the data collection process. Continued collaboration is recommended as new ideas are identified and as technology evolves.
- ✓ **Allow Monthly Reporting.** Consider including this feature in future iterations of the data entry portal.
- ✓ **Additional water trend and analysis output.** The new portal currently includes the ability to look at historic connections, water use, and production by year. It also includes the ability to look at historic production by month for the previous year. We would recommend adding the additional categories as identified in this report.
- ✓ **Additional simplified water use report.** The portal also includes the ability to print a pdf of the overall water use data report. While useful for record keeping purposes, the pdf as constituted includes more information than might be of interest to many non-technical individuals. We would suggest adding a second pdf output that is designed specifically for city councils, residents, and other non-technical audiences. The goal of this pdf output would be to create an attractive, easy to understand visual summary of the most useful information on water use for the system and how it relates to system goals such as conservation, minimizing system leaks and other non-revenue water, etc.
- ✓ **Provide typical or statewide average values for comparison purposes.** The new portal provides a tool for data verification by flagging any data entries that are substantially different from previous years. It is recommended that another data verification tool be added that flags data entries that result in values that are substantially different from typical or statewide averages. Recommended values for comparison of this type would include indoor flow per residential connection. Typical values might also be used to help entities understand where they fall relative to the rest of the state to encourage conservation or system maintenance.
- ✓ **Additional loss categories.** Consideration of overall system losses has been added to the data portal. It is recommended that the State consider also adding additional categories to report information of types of loss, consistent with AWWA M36 water audit results.
- ✓ **Encourage secondary metering.** Despite the best efforts of DWRi and DWRe to improve the data collection process, secondary water use estimates will be of limited accuracy until secondary use is metered at the customer level.
- ✓ **Review process performance over the next few years to identify additional improvement opportunities and simplify process, especially for small systems.** We are confident that the data collection process will improve as the recommendations in this

report are implemented. However, it is not reasonable to expect that this report has captured 100 percent of the possible data collection issues that exist now or will surface in the future. It is recommended that the State continually look for opportunities to improve the process. Part of this will include continuing to collect feedback from system operators and then acting on the suggestions received.

CHAPTER 3
EVALUATION OF WATER USE AND RELIABLE SUPPLY DATA

PURPOSE

One of the goals of this study was to compare data collected by the project team with data from the State's water use database to determine the overall differences in both potable and secondary water use and to recommend improvements to the process.

METHOD

To evaluate water use and supply data, the project team collected independent data from a number of Utah water systems to compare with the State's data. To maximize our understanding of the data in the limited time available, we focused our data gathering efforts in two areas:

- **Large Water Districts** – Much of the data collection needed for this study has already been happening in the large, primarily wholesale water districts throughout the state. Since these districts account for much of the overall M&I water use in Utah, focusing on data gathering in these district's provides a good way to quickly understand overall accuracy for a large portion of the state. The large water districts examined in this study include Jordan Valley Water Conservancy District (JVWCD), Weber Basin Water Conservancy District (WBWCD), and Metropolitan Water District of Salt Lake and Sandy (MWDSLS). We contacted each to discuss the purpose of the study and to initiate a data request. Each supplied various degrees of water production and use data based on previously completed studies within their districts.
- **Sample of Individual Water Systems** – Although data from the larger districts is good for looking at overall accuracy of water use numbers, they do not provide much insight into the data collection process at the individual system level. While surveying all of the individual systems in the state would not be practical for this study, it was possible to survey a representative sample from across the state. With input from the DWRe, a sample of individual water systems, representing each of Utah's major river basins, was proposed. Each of these systems was contacted by either telephone or in person. Follow up data questionnaires were sent via email. In cases where providers declined to respond, substitutes were selected and several willingly participated.

Ultimately, the new data collected were sufficient to illustrate the process and outcomes of the State's water use data collection program and provide a measure of error.

SUMMARY OF DATA COLLECTION PROCESS FOR SAMPLE GROUP

Potable Water Use Data

Most potable water systems meter customer deliveries and bill them monthly, so this information was readily available. Data originated from each water system's billing program and, after receipt, were evaluated for accuracy. Several follow-up calls were needed to clarify units, billing categories, and any major discrepancies and to resolve any known issues.

Secondary Water Use Data

Most providers of secondary water—whether municipal water systems or private irrigation companies—do not meter customer deliveries. As such, this type of data was largely unavailable. A further complication is that irrigation in municipal settings may occur with either potable or secondary water, and the extent of the latter is usually not known, making a complete characterization almost impossible.

With these limitations in mind, data were received from several pressurized irrigation systems, irrigation companies, and water master plans where available. This included full-metered use data for just a few systems where secondary meters exist. It also included collection of secondary production data (i.e. water into the system) for several more systems where adequate source metering was available. This effort was supplemented by the collection of potable water use data as described above and was sufficient to characterize irrigation use when combined with other methods.

In the absence of complete secondary water use data, relevant irrigated area was estimated. The team employed a remote-sensing approach using National Agricultural Imagery Program (NAIP) four-band aerial imagery and a method known as the Normalized Difference Vegetation Index (NDVI), which detects vegetated (irrigated) areas. Appendix D describes how the data were prepared and analyzed for this study.

Saratoga Springs and Spanish Fork were selected as case studies due to the project teams' familiarity with these systems and the availability of outdoor water use data. (Both have complete, metered pressurized irrigation systems.) Several of the conclusions about outdoor water use elsewhere in the report were drawn from these case studies.

Water Supply Data

Determining reliable annual supply of sources is unique to each water system. It depends on the types of sources (e.g., stream, reservoir, spring, well, wholesale) and how they are used. Surface water sources depend on precipitation and storage. Reliable supply also depends on available water rights. Another dependency is water treatment plant capacity for surface water sources and pump capacity for wells. Water availability in aquifers is a constraint that is difficult to quantify and account for with any single method. Wholesale supply agreements, which constitute much of Utah's deliveries, further complicate matters since the supply may or may not be double-counted by the wholesaler and customer. There is also the difficulty in some systems of separating potable supply from secondary supply when they come from the same sources.

Reliable supply can then be categorized as existing or future, as well as average or dry year. For this report, the reliable annual supply was calculated based on the projected potential supply of existing sources for a dry year. Therefore, new, undeveloped sources and agricultural conversion were not included. Only further future development of existing sources was considered. For the water systems sampled, reliable supply was either extracted from existing master plan reports or calculated based on data provided independently. The majority of the supply numbers provided were taken from master plan reports. For data provided independently, the following assumptions were made in estimating reliable annual supply from data provided by sampled water systems. For surface water sources, the minimum yield was taken from available historical data. For wells, 80% of total groundwater rights was assumed. Finally, 100% of wholesale deliveries to the system were added.

COMPARISON OF STATE DATA TO ACTUAL VALUES

The summary tables below compare the State's data to data collected by the project team. More detailed tables are found in Appendix C. For simplicity, data collected by the project team is referred to as "Consultant Data" in the several tables. The categories compared are: potable, secondary, and total water use; indoor residential, outdoor residential, and total residential water use; potable and secondary reliable supply; and water loss. The relationship between these several pieces of information is shown in Figure 3-1.

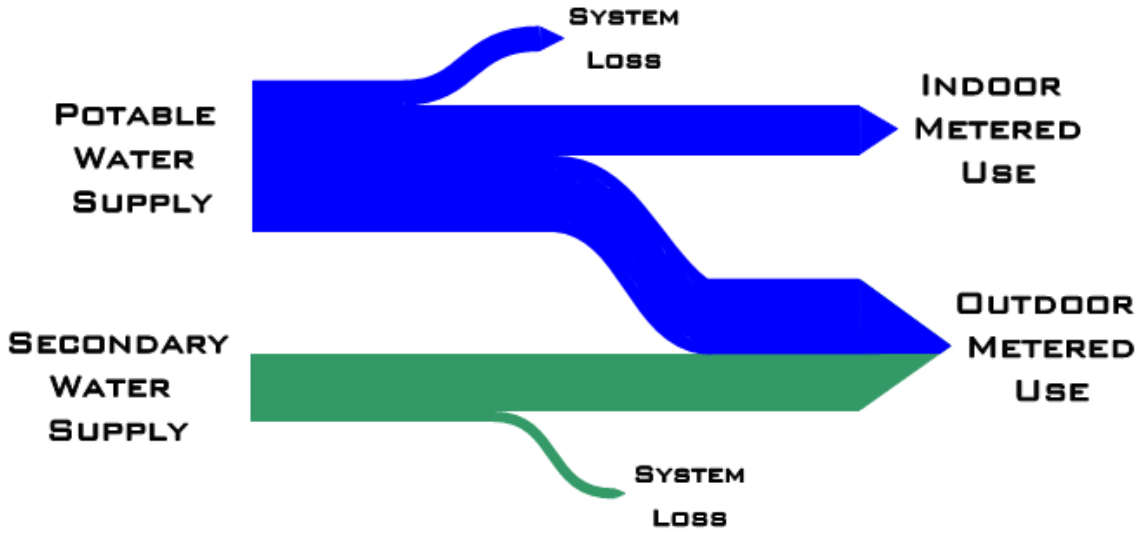


Figure 3-1: Relationship Between Different Types of Water Use and Supply

Tables 3-1 and 3-2 summarize potable, secondary, and total water use for individual water systems and large districts, respectively.

Table 3-1
Individual System Water Use Summary

	Year		
	2005	2010	2015
Potable Use			
State	130,111	113,070	131,532
Consultant	125,457	109,452	131,099
% Difference	3.7%	3.3%	0.3%
Secondary Use			
State	43,857	38,071	52,708
Consultant	65,103	55,058	70,117
% Difference	-32.6%	-30.9%	-24.8%
Total Use			
State Use	173,968	151,141	184,240
Consultant Use	190,560	164,510	201,216
% Difference	-8.7%	-8.1%	-8.4%

Notes: These numbers represent totals of a sample of water systems examined as part of this study, not totals for the entire state.

Table 3-2
Large District Water Use

Year	Provider	State Potable Use (AF)	Consultant Potable Use (AF)	Potable % Error	State Secondary Use (AF)	Consultant Secondary Use (AF)	Secondary % Error	State Total Use (AF)	Consultant Total Use (AF)	Total % Error
	JVWCD	125,650	113,923	10.3%	21,457	21,171	1.3%	147,106	135,094	8.9%
2015	MWDSLS	95,100	97,431	-2.4%	1,620	--	--	96,720	99,051	-2.4%
	WBWCD	69,106	76,164	-9.3%	54,546	94,600	-42.3%	123,652	170,764	-27.6%
	TOTAL	**289,856**	**287,518**	**0.8%**	**76,003**	**115,771**	**-34.4%**	**367,478**	**404,909**	**-9.2%**
	JVWCD	118,865	108,303	9.8%	12,913	15,941	-19.0%	131,778	124,244	6.1%
2010	MWDSLS	96,171	96,929	-0.8%	2,220	2,220	0.0%	98,391	99,149	-0.8%
	WBWCD	81,383	73,040	11.4%	62,472	96,500	-35.3%	143,855	169,540	-15.1%
	TOTAL	**296,419**	**278,272**	**6.5%**	**77,605**	**114,661**	**-32.3%**	**374,024**	**392,933**	**-4.8%**
	JVWCD	102,998	94,416	9.1%	12,588	11,908	5.7%	115,585	106,324	8.7%
2005	MWDSLS	90,758	94,245	-3.7%	2,130	2,130	0.0%	92,888	96,375	-3.6%
	WBWCD	67,250	76,472	-12.1%	78,450	90,350	-13.2%	145,700	166,822	-12.7%
	TOTAL	**261,006**	**265,133**	**-1.6%**	**93,168**	**104,388**	**-10.7%**	**354,173**	**369,521**	**-4.2%**

Notes
"--" represents missing data. Where state totals are compared to consultant totals with missing data, the state's total excludes the data for which the consultant field is found missing.
Data reflects the total use within the service areas of the districts. Thus it includes use of member agency and district water supplies.
JVWCD use is estimated by applying an average loss percentage (10.7%) to production data. Loss percentage applied to all member agencies was averaged using loss data from some of the member agencies.

Table 3-3 breaks out indoor and outdoor use for the residential water use category. Analysis has been limited to this category because it is the only category for which DWRe includes a detailed breakdown between indoor and outdoor use.

Table 3-3
Individual System Potable Residential Water Use Summary

	Year		
	2005	2010	2015
Potable Residential Indoor Use			
State	32,776	39,464	48,353
Consultant	38,335	41,666	47,970
% Difference	-14.5%	-5.3%	0.8%
Potable Residential Outdoor Use			
State	20,040	15,337	11,755
Consultant	13,791	14,026	13,233
% Difference	45.3%	9.3%	-11.2%
Total Potable Residential Use			
State	65,726	67,712	104,516
Consultant	61,244	71,163	103,294
% Difference	7.3%	-4.8%	1.2%

Notes These numbers represent totals of a sample of water systems examined as part of this study, not totals for the entire state.

Table 3-4 summarizes reliable supply estimates.

Table 3-4
Summary of 2015 Annual Reliable Supply of Sources

	Potable (AF)	Secondary (AF)	Total (AF)
State	454,464	97,268	551,732
Consultant	510,513	270,285	783,870
% Difference	-11.0%	-64.0%	-29.6%

Notes
State assumes secondary supply equals current use.
Consultant numbers are based on future dry year based on development of current sources.
These numbers represent totals of a sample of 30 water systems examined as part of this study, not totals for the entire state.

Table 3-5 summarizes water loss estimates, computed as the difference between production and use. Not all water is beneficially used; water loss may include leakage, theft, flushing, firefighting, unmetered uses, and metering errors. This is an important point since production must be adequate to meet total use (including system loss).

Table 3-5
2015 System Loss

# of Water Systems	Potable Production (AF)	Potable Use (AF)	Loss (AF)	% Loss
28	231,487	203,299	28,189	12.2%

Notes

All data in the table is consultant derived.
These numbers represent totals of a sample of water systems examined as part of this study, not totals for the entire state.

PROBABLE MAGNITUDES OF ERROR

From this data, it is possible to estimate probable magnitudes of error in DWRe's planning values. While not all water systems in Utah were studied here, the samples are representative enough (in terms of size, location, and water source type) to draw conclusions about the overall accuracy of the State's water use data.

The following sections discuss the comparison. For comparison and discussion purposes, the data assembled by the project team are assumed to be entirely accurate and all error is attributed to the State's data. In reality, both sets of numbers are only estimates of actual use. However, several factors contribute to the increased level of confidence in the new data against which the State's data are to be compared. One is the receipt of original, raw data rather than summaries reported to the State. The project team aimed to acquire "the data behind the data," as close to the original source as possible. Beginning with raw data (e.g., billing data, source meter records, and SCADA systems)

bypasses many of the errors that are introduced when a water system attempts to summarize and report the data to the State, as will be discussed later. Another factor is the project team's long professional experience with many of the respondents, which offers insights and quality control not available to State personnel. The project team's regular engineering work requires validation of water production and use data from multiple perspectives (historic patterns, hydraulic models, SCADA, etc.), leading to an ability to resolve discrepancies and improve the overall quality of the data.

Tables 3-6 through 3-8 summarize calculated error in the various datasets. Because they each provide a little different insight into the data, three types of error are presented in each table:

- ✓ **Absolute error:** The net difference between the State value and the Consultant value, expressed as a percentage of the Consultant value. Positive indicates overestimation by the State; negative indicates underestimation by the State. Absolute error represents error in the sum total of water use or supply, regardless of individual observations within the sample. It is useful in understanding how representative the overall number is, but does not provide any insight into the accuracy for individual systems. In some cases inaccuracy in different directions can offset each other to make the results look more accurate than they really are.
- ✓ **Mean weighted error:** The absolute value of the difference between the State value and the Consultant value, weighted by the Consultant value. This metric is useful because it represents the typical distance (positive or negative) of the State value from the Consultant value.
- ✓ **Root mean square error (RMSE):** The square root of the sum of the squares of individual differences between the State value and the Consultant value, expressed as a percentage of the Consultant value. This metric is a common statistical representation of accuracy. It is useful in that, similar to the mean weighted error, it provides an indication of relative accuracy for individual systems, but provides added weighting for outliers in the data set.

Table 3-6
Overall Water Use Error

		Potable Use			Secondary Use			Total Use		
Year	Water Provider	Absolute Error	Mean Weighted Error	Root Mean Square Error	Absolute Error	Mean Weighted Error	Root Mean Square Error	Absolute Error	Mean Weighted Error	Root Mean Square Error
2015	Individual Systems	0.3%	±3.2%	±1.2%	-24.8%	±25%	±12.3%	-8.4%	±9.1%	±3.6%
	Large District	0.8%	±7.3%	±4.8%	-34.4%	±34.8%	±52.7%	-9.2%	±15.2&	±13.2%
2010	Individual Systems	3.3%	±7.3%	±2.6%	-30.9%	±31%	±18.4%	-8.1%	±12.7%	±4.9%
	Large District	6.5%	±7%	±4.5%	-32.3%	±32.3%	±44%	-4.8%	±8.6%	±7.2%
2005	Individual Systems	3.7%	±9.9%	±3.7%	-32.6%	±32.6%	±16.5%	-8.7%	±13.6%	±5%
	Large District	-1.6%	±8%	±5%	-10.7%	±12.1%	±12.8%	-4.2%	±9.2%	±6.6%

Note: Errors based on the sample of water system analyzed in the study

Table 3-7
Residential Potable Use Error

	Indoor Use			Outdoor Use			Total Use		
Year	Absolute Error	Mean Weighted Error	Root Mean Square Error	Absolute Error	Mean Weighted Error	Root Mean Square Error	Absolute Error	Mean Weighted Error	Root Mean Square Error
2015	0.8%	±10.9%	±4.5%	-11.2%	±17.7%	±10.1%	1.2%	±7.8%	±3.5%
2010	-5.3%	±10.2%	±5.5%	9.3%	±15.1%	±9.3%	-4.8%	±11.5%	±7.4%
2005	-14.5%	±22.9%	±17.8%	45.3%	±56.1%	±28.7%	7.3%	±10.6%	±4.1%

Notes
Errors based on the sample of water systems analyzed in the study.

Table 3-8
2015 Water Supply Error

	Absolute Error	Mean Weighted Error	Root Mean Square Error
Culinary	-11.0%	±16.6%	±5.1%
Secondary	-64.0%	±65%	±81.5%
Total	-29.6%	±32%	±15.7%

Notes
Errors based on a sample of water systems analyzed in the study.

Potable Water Use Data

Potable water use estimates by the DWRe increase in accuracy from 2005 to 2015. The root mean square error of the individual water systems improved from 3.7% to 1.2%, and the absolute error in 2015 was 0.3%. This suggests that improvements made to the State's program are effectively capturing accurate water use from individual systems. For large water districts, the root mean square error is about 4.5%–5.0% and has not varied much since 2005. The absolute error in 2015 was 0.8%. It should be noted that these water districts regularly review their historic data and make corrections as necessary, which account for some of the internal differences. This suggests that these water districts have been reporting accurate data for some time and that the State's numbers accurately capture a large portion of Utah's total potable water use supplied by these districts. Overall, the State's potable water use data have been improving and are acceptably accurate.

Secondary Water Use Data

DWRe's estimates of secondary water use are improving but are consistently low. Among individual water systems, the root mean square error decreased from 16.5% in 2005 to 12.3% in 2015. Among the water districts, the result is mixed. DWRe appears to be relatively accurate for JVWCD. However, secondary use for WBWCD is increasingly underestimated, skewing the overall trend in the wrong direction. In 2015, the absolute error was -34.4%.

Water Supply Data

The absolute error in reliable potable supply is small (-11.0%) compared to individual systems, as results vary from –82% to 239% (see Appendix C). The error is much larger for the individual water systems than for the large water districts, -27% and 2.6%, respectively.

The State severely underestimates secondary supply. From the completed analysis, the State underrepresents secondary supplies by 64%. This is to be expected from the assumption that secondary use equals supply, and secondary use is also underreported, compounding the problem.

The error in the secondary water supply estimates increases the total water supply error to -30%.

OBSERVED OR SUSPECTED SOURCES OF ERROR

1. **Errors Occurring before or during Reporting –** Many errors were traced to actions that occurred before the State even received the data. Since the State requests data in summary form (e.g., by category and month), these summaries must first be produced from raw data. Errors in exporting, units, categorizing, and aggregation were observed, as well as apparent mistakes during data entry. Many of the data submitters, especially those representing small communities, do not understand the process, have no training on how or why to submit the data, and have little incentive to do so accurately.
2. **Errors in Service Area Boundaries –** Some of the public water supplier service area boundaries examined in this study differed from actual conditions. The boundaries are the basis for determining population, irrigated area, and other parameters and may introduce error in subsequent calculations if not properly characterized. For example, a portion of JVWCD's retail service area in Midvale was recently transferred to Midvale but the boundary dataset was not updated, and a portion of Midvale served by Sandy's water system was mistakenly attributed to Midvale's water system.
3. **Assumptions for Indoor/Outdoor Water Use Division –** Assumptions regarding division of indoor vs. outdoor use presents a potential source of error. For most connections there are many ways that water is used. Trying to split the indoor and outdoor use can be problematic for several reasons: water meters not being read every month, atypical seasonal patterns (i.e. ski resorts have a spike in the winter for snowmaking), and differences in how each connection is using water.
4. **Estimation of Institutional Leakage –** Documentation indicates that "estimates of leakage and water use for testing" are included in the institutional category. However, it is unclear how this value is estimated or why it is only included in institutional use.
5. **Oversimplification of Secondary Water Use Assumptions –** In the absence of better data, estimation of secondary use contains several simplifying assumptions that can add to potential error in the reported numbers. Observed instances of this include:

    a. Irrigated acreage – Irrigated acreage is currently estimated based on number of connections, average lot size, and average percent irrigated. Our experience suggests lot size and percent irrigated can vary among entities (and within entities) depending on location and zoning.

    This was apparent in the analysis of NDVI data for Saratoga Springs and Spanish Fork. An appropriate cutoff pixel value was selected for each city and merged with ARGC parcel data. This allowed for the calculation of percent irrigated for each parcel. Only the parcels that had a matching address from the billing records

received from the cities were used in the analysis. Therefore, the analysis includes various parcel types (Residential, Commercial, Institutional) and are all located within the water system boundaries. The tables below illustrate some of the variations in lot size and percentage of irrigated land for a sampling of parcels in Saratoga Springs and Spanish Fork.

Table 3-9
Distribution of Percent Irrigated in Saratoga Springs

		Percent Irrigated			
Parcel Size (acres)	# of Parcels	Min	Max	Average	Standard Dev.
Less than 0.1	69	2%	60%	32%	13%
0.1–0.18	996	0%	96%	43%	13%
0.18–0.25	2,435	0%	77%	43%	15%
0.25-0.5	1,361	0%	84%	47%	16%
Greater than 0.5	174	0%	98%	40%	23%

Notes
Parcels analyzed were of various types (residential, commercial, institutional) and were all located within the water system boundaries.

Table 3-10
Distribution of Percent Irrigated in Spanish Fork

		Percent Irrigated			
Parcel Size (acres)	# of Parcels	Min	Max	Average	Standard Dev.
Less than 0.1	86	5%	90%	28%	14%
0.1-0.18	2,046	0%	95%	31%	12%
0.18-0.25	2,854	0%	94%	35%	12%
0.25-0.5	1,885	0%	100%	35%	14%
Greater than 0.5	267	0%	95%	24%	20%

Notes
Parcels analyzed were of various types (residential, commercial, institutional) and were all located within the water system boundaries.

In these examples, it is clear that there is a fair amount of variation in what percentage of the parcel is being irrigated. The smaller lots and larger lots show a decrease in the percent irrigated as compared to the more typical lot sizes. Comparing the two datasets shows a similar pattern, but on average Saratoga Springs residents tend to irrigate a larger percentage of their lot than those in Spanish Fork. A one-size-fits-all approach could lead to misrepresentation. The NDVI dataset can provide clarity to what people are actually doing rather than making assumptions about what they might do.

b. Application rate – The rate that water is applied to irrigated acreage is currently estimated based on evapotranspiration rate and the assumed percentage of application efficiency. Our experience suggests application rates can vary between entities depending on the status of metering, the cost of water, and the communities' view of conservation. However, when some of the variables are accounted for, the data from this study suggest there is a fairly consistent pattern of irrigation application rates (e.g., acre-feet per irrigated acre) among Utah communities. For systems that meter outdoor water use (either potable or secondary), the application rate is consistently between 3 and 4 ac-ft/ac with an average of 3.5 ac-ft/ac for the population centers along the Wasatch Front. A few of the desert communities in the southern portion of the state showed higher values due to the higher summer temperatures and longer irrigation season. Similarly, a few of the higher elevation communities along the Wasatch Back and elsewhere in the state showed lower values. Detailed data for a sample of Utah communities is summarized in Table 3-11.

Table 3-11
Irrigation Application Rates

City	Irrigated Area[1] (ac)	Outdoor Use[2] (ac-ft)	Application Rate (ac-ft/ac)
Saratoga Springs	995	2,547	2.6
Clinton	1,012	3,086	3.0
North Salt Lake	680	2,668	3.9
Midvale	680	2,408	3.5
Herriman	990	3,338	3.4
Roy	1,306	4,594	3.5
Washington Terrace	302	1,048	3.5
Kearns	1,210	3,922	3.2
West Jordan	3,206	10,283	3.2
Spanish Fork	1,290	5,004	3.9
Springville	1,269	5,058	4.0
Orem	2,759	11,729	4.3
Ivins	198	957	4.8
Hurricane	896	4,327	4.8

1. Irrigated area computed by NDVI analysis described earlier.
2. Outdoor use estimated by project team (see Appendix C).

It should be emphasized that the values contained in the table are all for metered outdoor water systems. Application rates for unmetered systems are expected to be significantly higher. Two detailed studies of the difference between metered and unmetered water use for a large group of customers have been conducted in the Weber Basin Water Conservancy District during the last several years. The District's 2011 Supply and Demand Study identified a 32 percent difference in outdoor water use between unmetered secondary and metered potable water customers. A more recent study in 2017 identified a decrease in water use of 33.7 percent for secondary customers once a meter was added to their connection. From these results, it appears reasonable to approximate unmetered secondary application rates by increasing calculated rates for metered connections by about 50 percent.

c. In summary, defining secondary use appears to be more complex than can be adequately represented based on the current data available to the DWRe. Additional

information on irrigated acreage and application rates will be needed if increased accuracy is desired.

6. **Inadequate Assumptions of Potable Supply –** In calculating supply, it should be noted that data available to DWRe is limited. It has access to historic production records and some physical parameters for sources such as well pump capacity. It also has access to water rights information. However, it rarely has access to information regarding some of the more complicated aspects of water supply such as exchange contracts, water quality limitations, seasonal availability of supply, etc. In the absence of better data, evaluation of reliable supply contains several simplifying assumptions that can add to error in the reported numbers:

    a. Demand constraints on supply – The method notes three constraints on supply (mechanical, hydrologic, and legal) and then defines a maximum supply as the most water that can be produced given these three constraints. The method then represents the concept of demand constraints through the definition of a reliable supply. This represents the most water that can actually be used under typical demand conditions. The reliable supply is then estimated based on 100% of surface water, 50% of groundwater, and between 50% and 100% of spring water depending on how spring water is used in the system. For many systems, these are not unreasonable assumptions. However, for other systems (especially those with secondary water), actual numbers can be significantly different.

    b. Drought considerations – The term "reliable supply" might seem to suggest that reported values include consideration of drought. However, as noted above, "reliable source capacity" has been defined with demand constraints and does not include the potential impact of drought. Hydrologic constraints may include some consideration of drought, but if that is the case, it has not been well defined or described in the method.

    c. Source redundancy and reliability – Most water providers are uncomfortable running their system at the very edge of capacity. They often design their systems with some supply flexibility to account for potential loss of source to mechanical failure, contamination, climate change, etc. This does not appear to be reflected in the current method.

    d. Contractual limitations – As noted in the documentation provided by DWRe, "a detailed search of water right limitations associated with each entity is not within the scope of this study." While this is understandable, it introduces another potential source of error.

    e. In summary, defining reliable supply appears to be more complex than can be adequately represented based on the data available to the DWRe. Definition of "reliable supply" is highly individual for each water system (e.g., according to master plans or city preferences) and is difficult to generalize.

7. **Inadequate Assumptions of Secondary Supply –** As noted in the documentation provided by DWRe, secondary water supply is even less certain than potable supply. It is simply assumed to be equal to use or production. Secondary supply is difficult to estimate due to the fact that it is often coming from shared sources with potable water. For example, Weber Basin Water Conservancy District's (WBWCD) supply is mainly surface water that is used as a potable and secondary source. The Weber Basin Project (WBWCD's primary source) has an annual reliable yield of 206,914 acre-ft. This water can be treated for potable water or

used untreated as secondary. Also, several irrigation and canal companies each have rights in the same sources and they provide water to different systems and customers, with the majority going to agricultural use. All of this makes it difficult to distinguish what is reserved for potable, M&I secondary, and agricultural uses.

8. **Underrepresentation of Losses –** Existing and future water demands appear to be based on reported use numbers. Most entities appear to be reporting this information based on metered sales only. Where this is the case, this neglects losses between production and delivery resulting in total demand on the system being underrepresented.

    a. Reporting has been very inconsistent due to lack of clarity on the term "use." Some entities report metered sales while others report production from an arbitrary point in their system. Thus, losses are not consistently accounted for.

    b. Where production and sales are appropriately reported, losses have been as high as 30%. Where entities do not report production and sales, no loss is represented.

9. **Inadequate Secondary Demand Projections –** Projected secondary demands are based on many of the same simplifying assumptions used to estimate historic secondary demands. This means projected demands are vulnerable to the same potential sources of error previously noted.

10. **Future Planning Hampered by Inadequate Total Supply Data –** Required simplifications in estimating potable supply and the absence of any reliable projections of secondary supply are major hurdles to future planning. The error in secondary supply is greater than that of potable supply, therefore, better secondary supply and use data would improve planning efforts.

WATER USE AND RELIABLE SUPPLY DATA RECOMMENDATIONS

The foregoing analysis suggests the following recommendations to improve quantification of water use and reliable water supply in Utah:

1. **Consider water loss between production and use.** Some water (about 15% average in this analysis) is lost between production and use due to leaks, theft, flushing, firefighting, unmetered uses, and metering errors. This means that more water must be provided than is beneficially consumed. The State's planning efforts should therefore consider this important difference. The approach is more conservative and assures that the State is planning adequate water resources to meet the demand. Consider AWWA M36, *Water Audits and Loss Control Programs*, to gather more granular information about water loss from individual water systems and help them mitigate losses. This also has conservation benefits.

2. **Continue to review and update water supplier service area boundaries.** Such boundaries are the starting point for calculating service area population, irrigated area, and other values for estimating water use. While service area boundaries change constantly with new development, infrastructure, and agreements, every effort should be made to assure that the boundaries are current and correct before proceeding with the analysis. This will require verification by a knowledgeable person in each water system. The boundary dataset also serves local engineers, water managers, and planners who can benefit from better accuracy.

3. **Continue interagency cooperation and data sharing.** Coordinate data collection and avoid duplicate work among DWRi, DWRe, and DDW. One example is population, where multiple parties are computing service populations with different results. As much as

possible, update and correct the original DWRi database instead of maintaining separate DWRi and DWRe databases with different numbers. Share data with relevant State agencies, the local water community, and the public.

4. **Continue documenting assumptions for calculations and sources for corrections.** This practice helps identify recurring problems in data submission and deficiencies in the review process that need to be addressed. It also documents how and why the process is changing over time so assumptions and corrections can be evaluated for their impact on accuracy.

5. **Have each water system provide its own information on reliable supply.** Quantifying reliable supply involves many intricacies and complexities unique to each water system, and no one method accurately captures them for the hundreds of water systems in Utah. It is also demanding in terms of both time and effort. Many water systems already have master plans that either they or their engineers have prepared that contain information about reliable supply. These may be requested during DWRe's review process. Another option is to encourage water systems to report reliable supply as part of their water conservation plans every five years.

6. **Estimate outdoor water use with remote sensing of irrigated areas and observed application rates**. DWRe's current method of estimating outdoor water use by lot size, irrigated percentage, number of connections, and evapotranspiration rate is only situationally accurate. A better approach, as demonstrated here, would be as follows:

   - **Irrigated Area –** It is recommend that irrigated area be computed from four-band aerial imagery after excluding agricultural areas. While this approach requires some calibration and interpretation, it can be largely automated to cover large areas consistently. With statewide imagery updated every two years, the analysis can reveal growth or decline in irrigated area, providing a useful dataset on development patterns.

   - **Application Rates –** It is recommended that application rates be calibrated to those observed for similar locations or system types (e.g., metered vs. unmetered). While this study includes only a limited sample size, it appears that application rates for sampled systems can be approximated as follows:

     - Application Rate (Metered System) = ET Rate/Efficiency Rate of 60%
     - Application Rate (Unmetered System) = ET Rate/Efficiency Rate of 40%

     This would result in the sample application rates as documented in Table 3-12 and shown in Figure 3-2:

Table 3-12
Estimated Application Rates
(Acre-feet/Acre/Year)

	ET Rate for Turf	Application Rate-Metered System	Application Rate-Unmetered System
Wasatch Front	2.1	3.4	5.1
Wasatch Back	1.8	2.9	4.4
St. George Area	2.8	4.7	7.0

Notes
1. ET rates taken from Hill, R.W. and K.L. Kopp. 2002. Turfgrass water use in Utah. Utah St. Univ. Ext. Pub. ENGR/ BIE/WM-36.

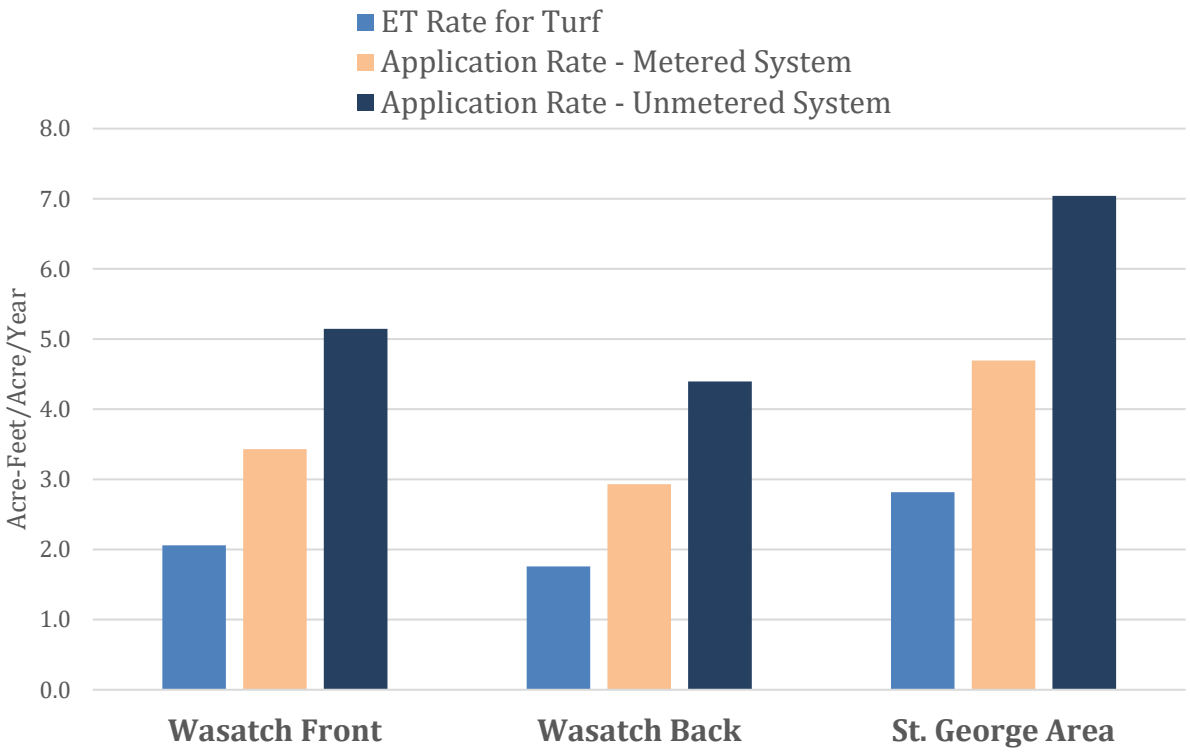


Figure 3-2: Estimated Application Rates

7. **Promote secondary water metering (both production and use) to better characterize outdoor water demands.** Most of the error discussed earlier, for both water systems and water districts, is associated with the lack of adequate data on secondary water production and use. This is perhaps the biggest hole in the dataset. Where irrigation practices vary so much with weather, location, water quality, user behavior, landscape choices, and other factors, metering can improve confidence in the magnitude of outdoor water demands. Secondary metering will also help local water systems manage and conserve their water resources by providing data on outdoor water use and decision-relevant scales.
8. **Encourage each water system to use a professional engineer in its own data collection, management, and reporting processes.** Many of the sources of error discussed earlier could be eliminated if the activities were overseen by someone who understands the water system, the data, and the State's reporting process and who can provide quality control throughout. Most water systems have a consulting engineer or staff engineer who could fill this role as a credentialed, accountable individual.
9. **Encourage each water system to use a professional engineer in its own planning and design decisions.** Rather than relying on the State's aggregated data, each water system should base decisions on site-specific local data where possible and enlist the help of a professional engineer. This would improve the relevance and effectiveness of planning decisions by considering actual conditions of water use, water production, and water supply, along with the hydrologic, infrastructural, and legal constraints. Nearly all of the large water systems and some of the small water systems already do this.

OTHER RELEVANT STUDIES OF WATER USE AND RELIABLE SUPPLY DATA IN UTAH

The following resources may further inform DWRe's water use data collection program and planning efforts.

- ✓ **Bear River Water Conservancy District Drinking Water System Master Plan**

  Hansen, Allen & Luce, Inc., September 2017

  This plan addresses water supply, use, and infrastructure in portions of Box Elder County. Individual water suppliers and the District contributed data and participated in a public outreach process. The plan considers the impacts of population growth, water conservation, and the proposed Bear River Project.

- ✓ **Mt. Nebo Water Agency Regional Water Supply Study (Draft)**

  Hansen, Allen & Luce, Inc., In Progress

  This study, currently in draft stage, will characterize municipal and agricultural water demands, average and dry year supplies, and water rights for 13 study sub-areas in southern Utah County. With a planning horizon of 2060, it will guide the Mt. Nebo Water Agency in its mission to coordinate local water resources for these growing communities.

- ✓ **Utah's Water Future: Perspectives on Water Issues in Utah's Wasatch Range Metropolitan Area**

  Joanna Endter-Wada, Andria Hall, Douglas Jackson-Smith, and Courtney Flint

  Utah State University, July 2015

  A household survey gathered data from over 2,300 adults to capture the views, experiences, and priorities of household water users in Salt Lake City, other parts of Salt Lake Valley, Cache Valley, and Heber Valley. This report presents the 12 key findings and overarching themes that are relevant to water policy, planning, and management at local and state levels.

- ✓ **Water Use Trends in the United States**

  Kristina Donnelly and Heather Cooley

  Pacific Institute, April 2015

  This report reviews USGS data and explains the factors contributing to the observed decline in water use across all sectors.

- ✓ **Estimated Use of Water in the United States in 2010**

  Molly A. Maupin, Joan F. Kenny, Susan S. Hutson, John K. Lovelace, Nancy L. Barber, and Kristin S. Linsey

  U.S. Geological Survey, November 2014

  This is the latest in a series of comprehensive five-year reports in the U.S. Geological Survey's National Water-Use Science Project. Aggregated data are reported for all sectors and historic trends are identified. The report also defines water use categories.

- ✓ **Drivers of Urban Water Use**

  Philip Stoker and Robin Rothfeder

  Sustainable Cities and Society, July 2014

  Using detailed water use data, this study identifies climate, demographics, parcel size, and turf coverage as important factors affecting urban water use. The variables are applied to water demand prediction to suggest conservation strategies.

- ✓ **Weber Basin Water Conservancy District Supply and Demand Study**

  Bowen Collins & Associates, Inc., April 2011

  Population growth models indicate the Northern Utah counties of Davis, Weber, Morgan and Summit face many challenges over the next several decades. This study addresses future water demands for both potable and secondary along with recommendations for additional supply development which include; new well development, wastewater reuse, aquifer storage and recovery, and development of the Bear River.

- ✓ **Residential Water Use Trends in North America**

  Thomas D. Rockaway, Paul A. Coomes, Joshua Rivard, and Barry Kornstein

  Journal – American Water Works Association, February 2011

  This study investigates trends in residential water use over a 30-year period and suggests the magnitude and causes of its decline. The study focuses on understanding the trends, assessing their impact to water system operations, and providing new data to help water systems adapt.

- ✓ **North America Residential Water Usage Trends Since 1992**

  Paul Coomes, Tom Rockaway, Josh Rivard, and Barry Kornstein

  Water Research Foundation, 2010

  This is the full report of the study listed above.

- ✓ **Salt Lake County Demand and Supply Study**

  Bowen Collins & Associates, Inc., September 2007

  Demand projections, annual and seasonal supply evaluations, and cooperative use between providing entities was reviewed and analyzed in this study. Existing and future water sources were also evaluated and identified for four major water suppliers located in Salt Lake County.

CHAPTER 4
WATER USE FOR FUTURE PLANNING

HISTORIC USE OF DATA FOR FUTURE PLANNING

The Utah Division of Water Resources (DWRe), has the overall responsibility for completing studies, investigations, and plans to assist with the responsible development and utilization of water resources in the State of Utah. The State Water Plan, developed and published by the DWRe, provides the foundation and overall direction to establish and implement the State's policy and framework for water management.

As part of the State's water planning process, and overall preparation of the State Water Plan, the DWRe prepares detailed plans for each of the 11 river basins within the State. Each individual Basin Water Plan identifies potential conservation and development projects and describes alternatives to sufficiently satisfy the water needs for that particular basin. In establishing the foundation for the State Water Plan and all basin water plans, two background data reports are necessary:

- ✓ A water related land use report
- ✓ The Municipal and Industrial Water Supply and Use Report

As documented in previous chapters, the M&I Water Supply and Use Report prepared by DWRe is assembled from the water use forms prepared by each of the community water systems. In order to develop an accurate State Water Plan, or any of the 11 river basin plans, it's critical that water use data assembled by community water systems be compiled and submitted accurately to the State. For future planning based upon the State Water Plan, it all begins with accurate water use data assembled by the community water systems.

HISTORIC DWR ESTIMATES OF WATER USE IN 2005, 2010, AND 2015

The historic M&I water use estimates prepared by the DWRe are presented in Tables 4-1 through 4-3 for the years 2015, 2010, and 2005, respectively. The data is summarized by basin and categorized into potable, secondary, and total use. Totals for state are shown for each category. Potable reliable supply is also shown for 2015 to represent the most current estimates of the state's potable water supply. The data was retrieved from the State's published M&I Water Supply and Use Studies for the years 2005 and 2010, and the draft report for 2015.

Table 4-1
DWRe M&I Water Use 2015 (Draft)

Basin	Potable Use (AF)	Secondary Use (AF)	Total Use (AF)	Potable Reliable Supply (AF)
Columbia River & West Desert	11,410	2,503	13,913	27,691
Bear River	41,494	11,282	52,776	140,012
Weber River	81,969	59,351	141,320	195,746
Utah Lake	92,124	46,976	139,101	259,638
Jordan River	234,795	27,071	261,866	276,599
Sevier River	14,909	6,421	21,330	43,536
Cedar/Beaver	11,400	3,932	15,332	24,753
Uintah	12,237	2,926	15,163	52,100
West Colorado River	6,698	7,240	13,938	26,357
Southeast Colorado	4,114	1,178	5,292	12,331
Kanab Creek/Virgin River	45,934	12,767	58,701	66,076
TOTAL	**557,083**	**181,647**	**738,730**	**1,124,838**

Note: Data published by Utah Division of Water Resources in Community Water Systems Water Use and Supply Study

Table 4-2
DWRe M&I Water Use 2010

Basin	Potable Use (AF)	Secondary Use (AF)	Total Use (AF)
Columbia River & West Desert	13,147	3,274	16,421
Bear River	39,375	9,859	49,234
Weber River	93,982	68,018	162,001
Utah Lake	90,601	44,369	134,970
Jordan River	229,475	18,096	247,571
Sevier River	14,328	4,078	18,407
Cedar/Beaver	12,461	3,174	15,636
Uintah	13,674	2,441	16,115
West Colorado River	7,985	7,908	15,893
Southeast Colorado	4,993	1,476	6,470
Kanab Creek/Virgin River	44,309	8,900	53,209
TOTAL	**564,330**	**171,594**	**735,925**

Note: Data published by Utah Division of Water Resources in State of Utah Municipal and Industrial Water Supply and Utah Study Summary 2010.

Table 4-3
M&I Water Use 2005

Basin	Potable Use (AF)	Secondary Use (AF)	Total Use (AF)
Columbia River & West Desert	10,847	2,927	13,774
Bear River	35,450	12,497	47,947
Weber River	92,263	101,121	193,384
Utah Lake	94,768	29,418	124,186
Jordan River	205,954	18,066	224,020
Sevier River	14,963	6,683	21,646
Cedar/Beaver	10,705	2,891	13,596
Uintah	13,102	2,911	16,013
West Colorado River	7,415	3,518	10,933
Southeast Colorado	4,401	1,478	5,879
Kanab Creek/Virgin River	38,111	8,002	46,113
TOTAL	**527,979**	**189,512**	**717,491**

Note: Data published by Utah Division of Water Resources in State of Utah Municipal and Industrial Water Supply and Utah Study Summary 2005.

RECOMMENDED REVISIONS TO ESTIMATES OF WATER USE IN 2005, 2010, AND 2015

Based on the results of our analysis as discussed in previous chapters, the project team was asked to generate updated values of water use for 2005, 2010, and 2015. These numbers are necessary to compare against reported water use rates in 2000 (the base year used for the State's current conservation goal).

Because of the limited sample size examined for this study, it is not possible to make any detailed corrections of water use in any specific systems outside the sample or even in any specific regions. However, the data does contain enough information to make some conclusions regarding overall water use across the state. Based on the conclusions contained in Chapter 3, we would recommend the following revisions to overall water use estimates in 2005, 2010, and 2015.

- ✓ ***Potable Water Use -*** The DWRe's estimates of potable use appear to be reasonably close to actual use for the systems sampled as part of this project. In 2015, the absolute error is less than 1 percent and even the mean weighted error is barely over 3 percent (see Chapter 3). Accuracy appears to decrease as you get further back in time, but even in 2005 absolute error is still no more than 5 percent. Because the observed error is so small, it appears that any changes that might be applied to systems outside those individual systems sampled as part of this report are within the expected range of uncertainty associated with a sample of this size. Thus, it is recommended that no revisions be made to the 2015 potable water use numbers, but that the DWRe estimates be used as they are.
- ✓ ***Secondary Water Use -*** In contrast to potable estimates, the DWRe's estimates of secondary use appear consistently lower than observed use for the systems sampled as part of this project. Based on these overall conclusions, the following approach is recommended for revising estimates of secondary water use:

- Large Districts Evaluated as Part of this Study: For the large water districts evaluated as part of this study (JVWCD, MWDSLS, and WBWCD), it is recommended that the secondary use be modified to match the total use calculated as part of this analysis as documented in Chapter 3. This will result in a significant increase to secondary use estimates but represents the best information available for these entities.
- Individual Systems Outside Evaluated Large Districts: From the information gathered, it is clear that DWRe's overall estimates of secondary water use are lower than observed use. However, the sample size for which data is available is small and the range of accuracy appears to vary widely between systems. As a result, it is recommended that DWRe update its estimates of secondary water use for individual systems using some of the remote sensing infrared technology and area specific application rates as discussed in Chapter 3. This will be more accurate than trying to apply a statewide adjustment to secondary use based on the limited data available. Unfortunately, making this adjustment will take more time and effort than allowed within the scope of this project. Thus, this report increased the overall existing DWRe estimate by the calculated absolute error in each sample year to approximate actual use for comparison and discussion purposes only.

The revised water use for 2015, 2010, and 2005 based on the recommended revisions discussed above are shown in Table 4-4. It should be emphasized that the revised values published here have been produced strictly for the purpose of comparison against reported historic water use rates. We are not suggesting that DWRe needs to go back and alter any historic projections or documents. DWRe will want to update its baseline for future projections, but that will be discussed subsequently.

Included in Table 4-4 is a summary of both the revised water use volumes and the percent difference from the State's numbers. As can be seen, the recommended changes in secondary estimates results in an overall recommended increase of about 8-10% in all years.

Table 4-4
Revised Water Use Estimates

Provider	Potable Use (AF)	Recommended Potable Use (AF)	Potable % Difference	Existing Secondary Use (AF)	Recommended Secondary Use (AF)	Secondary % Difference	Existing Total Use (AF)	Recommended Total Use (AF)	Total % Difference
2015									
Large Water Districts	289,856	289,856	0.0%	77,623	117,391	51.2%	367,478	407,247	10.8%
Individual Water Systems	267,227	267,227	0.0%	104,025	138,383	33.0%	371,252	405,610	9.3%
TOTAL	**557,083**	**557,083**	**0.0%**	**181,647**	**255,774**	**40.8%**	**738,730**	**812,857**	**10.0%**
2010									
Large Water Districts	296,419	296,419	0.0%	77,605	114,661	47.8%	374,024	411,080	9.9%
Individual Water Systems	267,911	267,911	0.0%	93,989	135,927	44.6%	361,900	403,837	11.6%
TOTAL	**564,330**	**564,330**	**0.0%**	**171,594**	**250,588**	**46.0%**	**735,924**	**814,918**	**10.7%**
2005									
Large Water Districts	261,006	261,006	0.0%	93,168	104,388	12.0%	354,173	365,394	3.2%
Individual Water Systems	266,973	266,973	0.0%	96,344	143,017	48.4%	363,318	409,990	12.8%
TOTAL	**527,979**	**527,979**	**0.0%**	**189,512**	**247,404**	**30.5%**	**717,491**	**775,383**	**8.1%**

Notes

Potable and secondary use for the large water districts examined (MWSLS, WBWCD, JVWCD) is recommended to match use calculated in consultant's analysis.
Potable use for individual water systems is recommended to remain the same, due to the small sample to compare to and the very small observed error.
Recommended secondary use for individual water systems is for comparison purposes only and was derived by multiplying by the calculated absolute error.

FACTORS AFFECTING WATER USE PATTERNS

Total public (M&I) water use in the state has been matching national trends. As shown in Figure 4-1, per capita use increased from 1950, peaked in 1990, and has been trending down ever since. In general, this peak and subsequent downward trend have been attributed to conservation and efficiency, although different factors are affecting water use patterns in municipal indoor and outdoor water use, and industrial water use.

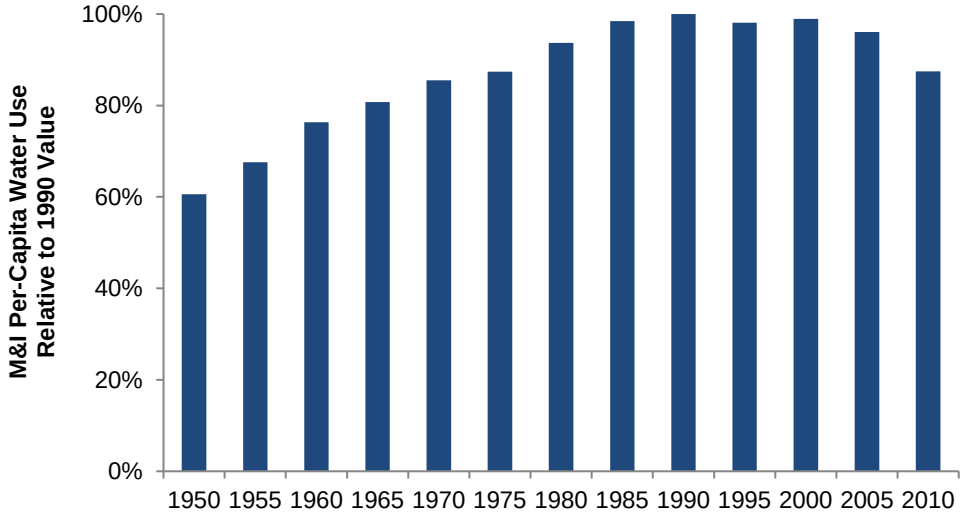


Figure 4-1: Per-Capita Public Water Use in the United States (USGS data normalized to 1990 peak value)

INDOOR WATER USE PATTERNS

Indoor water use is consistent across the state and across the nation. The largest factor affecting indoor water use appears to be the age of appliances and water fixtures. With more water-efficient fixtures, newer buildings use less, and older ones are improving as old fixtures are replaced. In Utah water systems with newer development, single-family residential indoor use averages about 170 gpd; those with older development average about 280 gpd. It is anticipated that indoor water use in water systems with older development will trend toward the lower water use of systems with newer development over time. Water production necessary to meet indoor water demands is less consistent across the state due to factors affecting water loss. On average it takes 10 to 20 percent more water produced than water delivered, but some systems require up to 30 percent.

OUTDOOR WATER USE PATTERNS

Outdoor water use is more sensitive to many factors. As seen by data from multiple water systems in the state, adding meters on a previously unmetered secondary water system can reduce water use by more than 30% in some cases. Other factors affecting outdoor water use in Utah are lot size, landscaping type, climate, soil type, water rates, conservation education, irrigation system type, irrigation system controller type, water quality, conveyance system quality and type, water losses, weather patterns, and climate change. For water users in Utah's population centers on the Wasatch Front, end user application rates vary between 2.6 and 4.8 ac-ft/ac for metered systems. Again, water production necessary to deliver the outdoor water to the end user is not consistent due to factors related to water loss. Supply water used to deliver outdoor water for the same group of users varies from 3.13 to over 6.0 ac-ft/ac.

Outdoor water use has the most opportunity for conservation. Some of the lowest application rates and supply rates are for water systems with below average water quality and soil conditions. Some of the higher rates are from water systems that use potable water for outdoor irrigation. This would suggest that outdoor water use could trend toward an application rate and supply rate closer to 2.8 and 3.0 ac-ft/ac respectively. Again, these values are for water users in Utah's population centers on the Wasatch Front. Rates will be slightly higher in the southern parts of the state and lower for higher elevation communities.

Industrial water use unrelated to indoor and outdoor use has followed the same national downward trend. This has been attributed to efficiency advances in technology. There is a financial incentive for industry to use less water, especially with the rising cost of water.

IMPACTS OF WATER USE TRENDS ON SELECTION OF A BASELINE FOR WATER PLANNING AND CONSERVATION

The State used water use data from the year 2000 to measure conservation goals. Although the water use data is less accurate than the data collected in subsequent years, it accurately indicates the downward per capita water use that is occurring in the State and nationwide. Looking at the factors affecting water use indicate that the trend will continue. Utah has one of the highest M&I water use per capita rates in the nation because of outdoor watering. Even if the amount of irrigated acreage per home remains the same, data show less water could be used. If changes in landscaping practices are considered, even more room for conservation is possible. Therefore, using the most current and accurate estimates of water use data without including conservation in projecting future water use would be conservative.

RECOMMENDED BASE WATER USE FOR FUTURE PLANNING

For future planning purposes, the scope of this project includes developing a recommended base water use for future planning and conservation goals. Based on the analysis contained in this report, it is recommended that 2015 be the base year for planning for the following reasons:

- ✓ The 2015 data are more accurate than 2010, 2005, or 2000 data.
- ✓ The 2015 data are more recent than 2010, 2005, or 2000 data.
- ✓ Recent improvements to the reporting process are producing better data.
- ✓ Per-capita water use in Utah will follow declining national trends; 2015 levels will be conservative relative to future water use.

For Conservation Calculations

As discussed above, this recommendation means that no change is required to the DWRe estimates for potable use. For secondary use, it is recommended that the DWRe estimates be updated based on remote sensing to calculate irrigated areas and updated application rates as discussed in Chapter 3. Although the exact effect of the updated secondary estimates will not be known until the revised analysis is completed, expected total use numbers have been summarized in Table 4-5.

Table 4-5
Recommended Baseline Water Use Estimates for Conservation

	DWRe 2015 Draft Use (AF)	Recommended Baseline Water Use (AF)	Absolute Difference
Potable	557,083	557,083	0.0%
Secondary	181,647	255,774	40.8%
Total	738,730	812,857	10.0%

Notes

Recommended secondary use for individual water systems is for comparison purposes only and was derived by multiplying by the calculated absolute error.

See report for recommended method for calculating secondary use.

In making this recommendation, it should be noted that Table 4-5 reflects current water use as historically defined in the DWRi database. This means metered water sales (end use). Because of this, actual demand for water is underrepresented because water loss, discussed in Chapter 3, is not considered. Thus, while Table 4-5 is a good baseline for conservation calculations and comparisons, it should not be used when planning future water supply.

For Water Supply Planning

When considering demand for the planning of future water supply, water loss should be included in the baseline. DWRe has not historically analyzed production data. However, taking potable production as reported by the DWRi and total potable metered sales as summarized by DWRe results in an estimated statewide average system water loss of 33%. Because this project did not include detailed consideration of production data, it is difficult to say how accurate this estimate is. However, it seems apparent that water loss is a large part of overall water demands. The nationwide average is 16% and the average loss calculated from the sample data collected here is 12.1%. Until improved water loss information is collected, it is recommended that the State include 15% losses in future demand planning numbers. While this is a little higher than the observed losses for the limited sample examined here, it is consistent with the national average and significantly lower than what would be suggested by existing DWRi production data. Thus, it seems a reasonable planning value until additional data can be collected.

RECOMMENDED RELIABLE SUPPLY FOR FUTURE PLANNING

As with system use, the scope of this project included developing a recommended reliable water supply for future planning. Based on analysis as documented in Chapter 3, the recommended approach for supply planning is as follows:

- ✓ ***Potable Water Supply -*** As reported in Chapter 4, the State's estimates for annual reliable potable supply have large amounts of error, both positive and negative for individual systems. The State's estimates for WBWCD and MWDSLS supplies are quite close to actuals because these numbers come from supply studies done in master planning for those districts. For all other systems, there does not seem to be any consistent pattern that could help us update the estimates based on the analysis contained in this report alone. This highlights the recommendation that an individual reliable supply study needs to be done for each system to get an accurate picture of supply.

Due to the range and inconsistency of error associated with supply estimates, we cannot recommend any specific revision to the number for overall potable water supply in the state. DWRe will likely need to live with its current estimates until it can implement the recommendation for each system to complete its own supply evaluation.

- ✓ ***Secondary Water Supply -*** The State's estimates for secondary supply appear to be falling consistently short of the actual supply. This is likely due to the assumption of secondary supply simply being equal secondary use. Since secondary use has been consistently underestimated, secondary supply has similarly been underestimated.

  In the short-term, we would recommend updating the secondary supply within the WBWCD service area to 117,123 acre-feet. For the rest of the individual systems in the state, we would recommend updating the secondary supply to equal the revised secondary demand as discussed previously. While this will get closer to an accurate number, this is not the recommended long-term approach to estimating secondary supply. As with potable supply, reliable secondary supply will be unique to each system based its sources and circumstances. Thus, current estimates should be replaced as individual systems complete their own supply evaluations.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

Detailed conclusions and recommendations regarding the data collection process, the accuracy of existing DWRe estimates, and the use of the data for future planning have been discussed in Chapters 2, 3, and 4, respectively. The purpose of this chapter is to summarize the overall major conclusions and recommendations of this report.

MAJOR CONCLUSIONS

Based on the analysis completed, the project team has reached the following major conclusions:

1. **Despite its limitations, the data collection process has resulted in accurate estimations of potable water use.** In the process of conducting this study, we were impressed by the magnitude of the task facing State of Utah personnel in preparing estimates of statewide water use. Having prepared dozens of water system master plans for systems across the State, we are familiar with the time and effort required to obtain and evaluate water use data. The sheer volume of water sales data makes it vulnerable to error and almost every system has one or more unique characteristics that require special consideration and analysis. With these challenges, we were pleasantly surprised to find that overall error associated with potable water use numbers is small as summarized in Table 5-1.

Table 5-1
Comparison of State Compiled Data to System Data - Potable Water

	Individual Water Systems			Large Water Districts		
Year	Absolute Error	Mean Weighted Error	Root Mean Square Error	Absolute Error	Mean Weighted Error	Root Mean Square Error
2015	0.3%	±3.2%	±1.2%	0.8%	±7.3%	±4.8%
2010	3.3%	±7.3%	±2.6%	6.5%	±7%	±4.5%
2005	3.7%	±9.9%	±3.7%	-1.6%	±8%	±5%

Notes

Errors based on a sample of water systems analyzed in the study.

With an absolute error of less than one percent in 2015 for the sample systems examined, it appears the overall numbers generated for potable water use by the State are very representative of statewide water use. While the average error for individual systems is larger, the numbers still generally appear to be an acceptable compilation of potable use.

2. **The data collection process and resulting data accuracy have improved over time.** Also apparent in the data is a clear improvement in accuracy over time. Especially for the small systems sampled, efforts to improve the process are improving the quality of data. Additionally, observed improvements since 2015, including increased support staff, improved training for system operators, and the development of a new data entry portal appear to have great promise to further improve the process.

3. **Secondary water use and supply estimates are less accurate.** The DWRi data collection form has not historically collected any information regarding actual secondary water use since most of the systems do not meter individual deliveries. Thus, information available to even estimate secondary use is difficult to obtain. As a result, estimates of secondary use have been far less accurate than complied results for potable use as summarized in Table 5-2. In general, it appears that the State numbers underestimate the amount of water being used in secondary systems.

Table 5-2
Comparison of State Estimates to System Data - Secondary Water

	Individual Water Systems			Large Water Districts		
Year	Absolute Error	Mean Weighted Error	Root Mean Square Error	Absolute Error	Mean Weighted Error	Root Mean Square Error
2015	-24.8%	±25%	±12.3%	-34.4%	±34.8%	±52.7%
2010	-30.9%	±31%	±18.4%	-32.3%	±32.3%	±44%
2005	-32.6%	±32.6%	±17.6%	-10.7%	±12.1%	±12.8%

Notes

Errors based on a sample of water systems analyzed in the study.

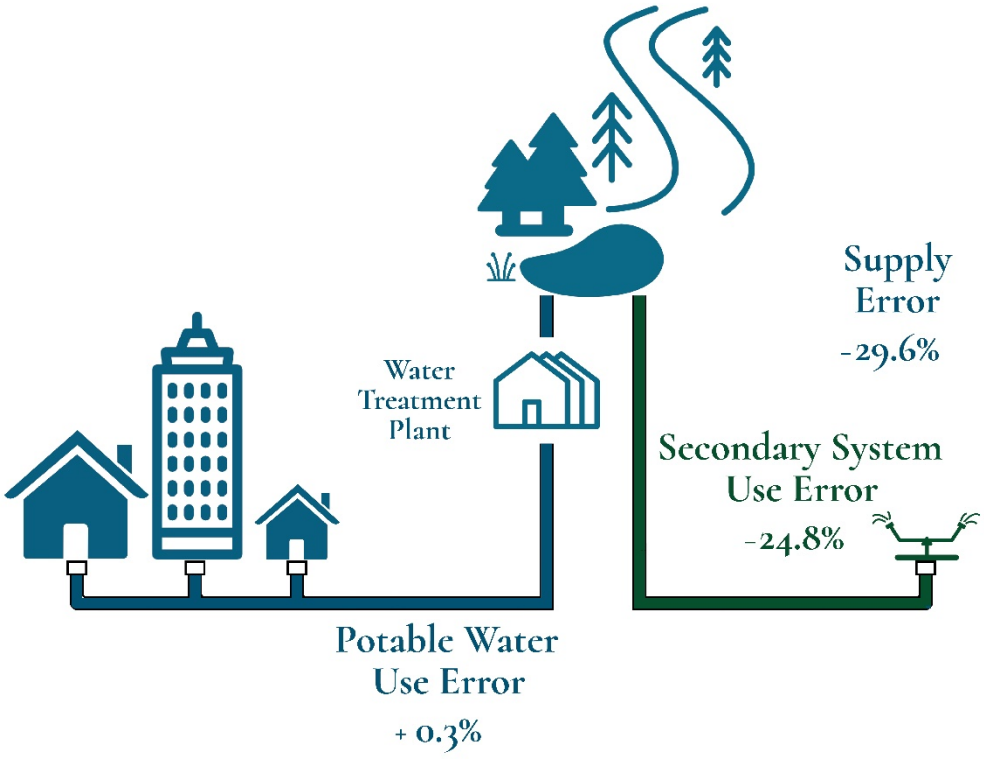
Similarly, defining available supply appears to be more complex than can be adequately represented based on the data available through the data collection process. Required simplifications in estimating potable supply and the absence of any reliable projections of secondary supply are major hurdles to future planning. We summarize the current accuracy of supply estimates in Table 5-3. Much like water use estimates, error for secondary supply is much higher than potable supply.

Table 5-3
Comparison of State Estimates to System Data - Supply

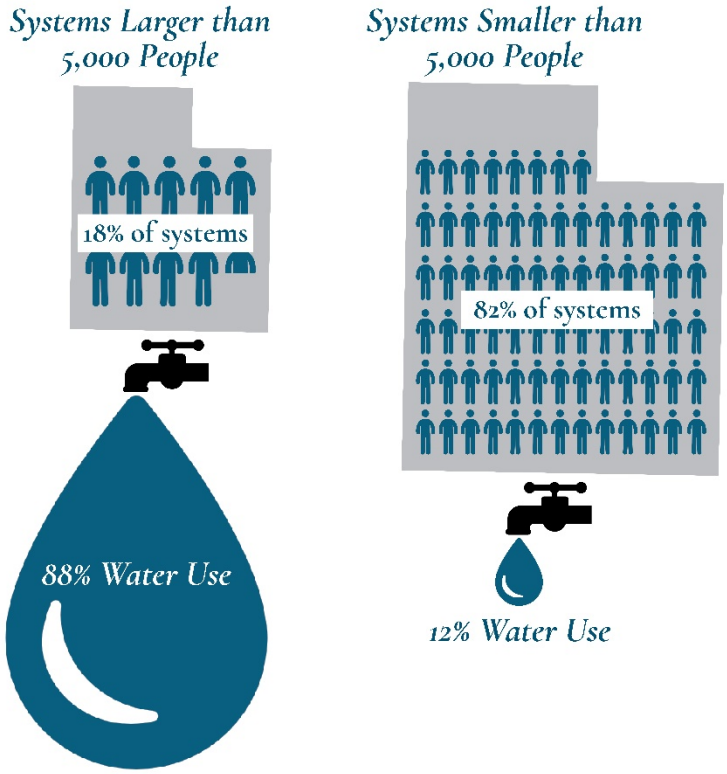
	Absolute Error	Mean Weighted Error	Root Mean Square Error
Potable	-11.0%	±16.6%	±5.1%
Secondary	-64.0%	±65%	±81.5%
Total	-29.6%	±32%	±15.7%

Notes

Errors based on a sample of water systems analyzed in the study.



4. **Time and effort spent trying to perfect data entry for small systems may not be cost effective or necessary.** Regardless of the best efforts of the State, accuracy of any estimates prepared will ultimately be dependent on the quality of data entered by the system operators. A common theme heard over and over from small system operators during the course of this study was that limited resources (human, financial, technological) are a significant challenge to accomplish comprehensive data reporting. Achieving a "perfect" data set may not be a reasonable goal given these conditions.



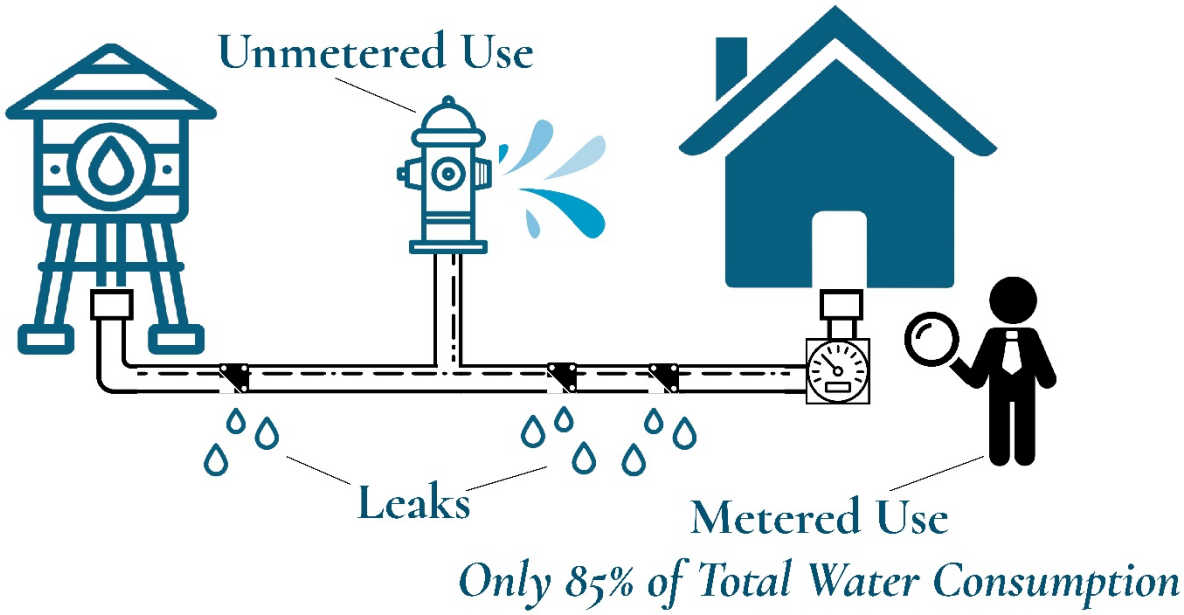
With this in mind, the State may want to reconsider the amount of time it spends on data collection for small systems. Our observations indicate that the data collection process begins to fail with water systems serving fewer than 5,000 people. Based on 2015 water use statistics, 82% of systems in the State fall into this category. Much of the effort to collect data, follow up, and revise data is spent on these small systems. However, these

smaller systems account for only 12% of total potable water use in the state. Furthermore, most of these small systems are isolated from population centers and each other and correspondingly have little influence on major water planning decisions. Given these statistics, it may not be cost effective or necessary to spend the same amount of time on these systems as is spent on larger system.

RECOMMENDATIONS

Although good progress has been made and potable use numbers appear to be accurate, there are still several ways in which the data collection process could be improved. To continue to improve the data collection process, the project team would recommend the following actions:

1. **Continue Current Trajectory of Improvement in Data Collection Process.** While major improvements have been observed in the data collection process since 2015, there are still opportunities for additional improvement. Recommended remaining changes include additional functionality of the data entry portal and improved collection of secondary water use and system loss data.
2. **Add consideration of system losses into calculation of water demands.** As it currently stands, the definition of water use in the data collection process includes metered sales only. This does not include consideration of system losses such as leakage and unmetered consumption. If water demands used for future planning do not include consideration of system losses, insufficient water will be projected for future needs. Analysis of sample systems in this report results in a recommended planning value for future losses of 15 percent. Components should be added to the data collection process to improve consideration of system losses. This may include requirements for periodic AWWA M36 water audits to assess the magnitude and nature of system losses.



3. **Improve estimates of secondary water use including the expanded use of secondary metering.** There is currently a large gap between the State's ability to accurately estimate potable water use and secondary water use. Starting in 2016, the State began requesting additional data on secondary demands and supplies as part of the data collection process.

This is a good first step. In the long-term, however, the ideal solution to improve accuracy in this area is to require secondary metering at each customer connection. Secondary metering has the added benefit of reducing water use. For these reasons, it is recommended that the State continue to explore options to encourage broad implementation of secondary metering.

4. **Improve efforts to evaluate supply at the system level.** Similar to water use estimates, error for secondary supply is much higher than potable supply. Much of the reason for the reduced error in potable supply is the fact that the State has refined their potable supply estimates using area specific supply studies prepared by some of the larger water districts. Because of the complexities associated with supply planning, it appears that this is the only way in which supply can be estimated accurately.
5. **To best utilize available resources, a separate approach to data collection is recommended for small systems.** Based on the considerations as documented above, it is recommended that the State consider modifying its data collection program to treat water systems differently based on size:
    a. **Large Systems.** For systems serving greater than 5,000 persons, it is recommended the State continue with its current program and pursue the full menu of improvements identified in this report including:
        i. Detailed reporting and data verification through the State's new, improved data collection portal. Of special focus will be improved reporting of secondary water use.
        ii. Pursuit of secondary metering for all M&I connections.
        iii. Periodic AWWA M36 water audits to assess the magnitude and nature of system losses.
        iv. A detailed water supply evaluation prepared by a professional engineer and submitted as part of system conservation plans.
    b. **Small Systems.** For systems serving fewer than 5,000 persons, it is recommended the State consider simplified reporting requirements:
        i. Small systems will still be required to provide reporting and data verification through the State's new, improved data collection portal. However, it is expected that recent improvements in the system will simplify data entry for small systems.
        ii. Other available information from larger systems will then be used to fill in the gaps for any missing information.
        iii. Instead of trying to perfect data entry for all small systems every year, detailed review and verification of data by DWRi and DWRe staff can be limited to a rotating portion of small systems (approximately 20 percent per year) without compromising overall data accuracy.
6. **Use revised 2015 estimates as the baseline for future planning and conservation goals.** For future planning and evaluation of conservation goals, it is recommended that 2015 be used as a baseline. The year 2015 is recommended because it is both the most recent and most accurate year for which data is available. Because of the minimal error observed in DWRe's overall potable water use numbers, no changes are recommended to the data compiled for potable use. It is recommend that secondary use estimates be

revisited using infrared aerial imaging to calculate irrigated acreage and updated, area specific water application rates. Although the exact effect of the updated secondary estimates will not be known until the revised analysis is completed, expected total use numbers have been summarized in Table 5-4.

Table 5-4
Recommended Base Water Use

	DWRe 2015 Draft Use (AF)	Recommended Baseline Water Use (AF)	Absolute Difference
Potable	557,083	557,083	0.0%
Secondary	181,647	255,774	40.8%
Total	738,730	812,857	10.0%

Notes

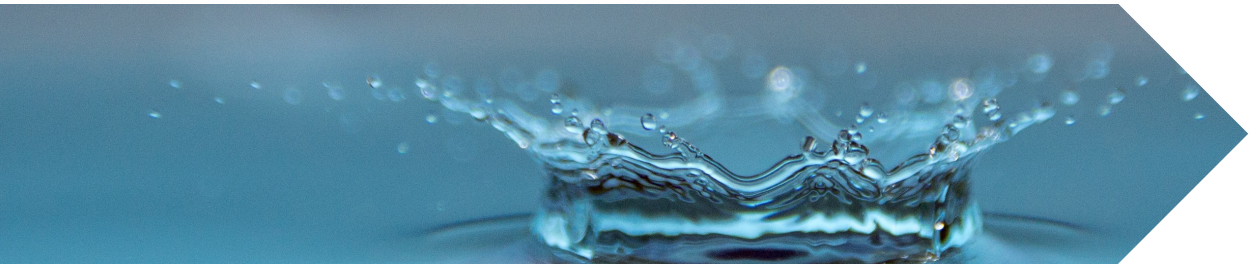
Recommended secondary use for individual water systems is for comparison purposes only and was derived by multiplying by the calculated absolute error.

See report for recommended method for calculating secondary use.

7. **Work with the Legislature to Accomplish the Goals Above.** Most of the recommendations contained in this study can be implemented through changes to the internal processes of DWRi or DWRe. However, legislative action will be needed on three specific recommendations:

    - Required customer metering for secondary water use
    - Required periodic AWWA M36 water audits
    - Required reliable supply evaluation to be submitted with conservation plans

    It is recommended that DWRe work with the legislature to pursue these recommended changes for systems serving populations greater than 5,000.



APPENDIX A
STATE OF UTAH HISTORIC DATA COLLECTION FORMS

UTAH WATER USE DATA FORM

DATA FOR 2015

Information jointly requested by:
Utah Division of Water Rights, 801-538-7223
Utah Division of Water Resources, 801-538-7264
Utah Division of Drinking Water, 801-536-4200

Return completed form to:
Utah Division of Water Rights
PO Box 146300
Salt Lake City, UT 84114-6300

System Name:

Public Water System ID:

Address:

,

Retail Population Served: 0 If different, please specify _____
County:

I. SUMMARY INFORMATION:

E-Mail Address: If different, please specify _____

Contact Person:

Phone Number: ()--

To the best of my knowledge all information is accurate and complete:

Name: _____ Signature _____

[ ] Drinking Water Operator Number: _____
[ ] Professional Engineer Number: _____
[ ] Water Manager

Data must be completed and signed by Drinking Water Qualified Operator, Professional Engineer or Water Manager.

II. SOURCE INVENTORY:

Enter the volume of water diverted from each source by month

** If you are using other sources which are not shown above, please enter the appropriate data in the space provided below. **

---

1 Source Name: _____

Type: _____ Location: _____

WR Number(s): _____

Method of Measurement: [ ] Master Meter, [ ] Estimate, [ ] Other - Specify _____

Units of Measurement: [ ] Gallons, [ ] Thousand Gallons, [ ] Million Gallons, [ ] Acre-feet, [ ] Other - Specify _____

FOR SPRINGS, Are there any spills/overflow? [ ] Yes, [ ] No Are spills/overflow included in the quantities reported? [ ] Yes, [ ] No

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL

---

2 Source Name: _____

Type: _____ Location: _____

WR Number(s): _____

Method of Measurement: [ ] Master Meter, [ ] Estimate, [ ] Other - Specify _____

Units of Measurement: [ ] Gallons, [ ] Thousand Gallons, [ ] Million Gallons, [ ] Acre-feet, [ ] Other - Specify _____

FOR SPRINGS, Are there any spills/overflow? [ ] Yes, [ ] No Are spills/overflow included in the quantities reported? [ ] Yes, [ ] No

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL

Source Comments: Water supply conditions were: [ ] Above normal, [ ] Below normal

III. WHOLESALE DELIVERY:

If you wholesale water please call Frank Quintana with the Division of Water Rights at 801-538-7223.

IV. RETAIL CULINARY WATER USE BREAKDOWN: **(Only retailers need to fill out this section.)**

The Utah Division of Water Resources (DWRe) needs each culinary water system to breakout customer level water use. This helps the DWRe greatly in its missions to provide future water planning. This Section IV should be filled out by the person in your organization that is most familiar with customer level billing

This section filled out by: _____ Phone Number: _____

Method of Measurement: [ ] Residential Meters, [ ] Estimate, [ ] Other - Specify _____

Units of Measurement: [ ] Gallons, [ ] Thousand Gallons, [ ] Million Gallons, [ ] Acre-feet, [ ] Other - Specify _____

Culinary Water Use Category	Annual Quantity	Number of Active Connections
Residential Use		
Commercial Use		
Institutional Use		
Industrial Use		
TOTAL		

1) Is there unmetered culinary institutional water use for irriagtion purposes of churches, schools, city owned property including city office, parks, cemeteries, etc.? **YES NO**

2) If **YES**, please provide an estimate of total unmetered institutional acreage that is irrigated: _____ **ACRES**

3) Would you like to have DWRe prepare a preliminary AWWA non-revenue water system review on the data submitted? **YES NO**

V. UNTREATED OR SECONDARY WATER USE BREAKDOWN:

The Urban Secondary Water use breakdown is equally important to the DWRe in its water planning efforts. Although this secondary water use is usually not delivered by your culinary water system, it does represent additional water use within your service area boundary. Although secondary water use is rarely metered at the customer level, it would be helpful if you could provide at least an estimate to some of the information requested below.

1) Do you provide separate urban secondary irrigation (untreated) water to your culinary customers? **YES NO**
If YES, please contact Eric Klotz with the Division of Water Resources at 801-510-0348 to report your secondary water use information.

2) Do other secondary districts and/or irrigation companies provide urban secondary irrigation (untreated) water within the boundary of your culinary water service area? **YES NO** If YES, please provide the information below:

3) What percentage (%) of your culinary customers utilize a separate pressurized irrigation system for their landscapes? _____ **%**
Please list the separate systems here:

Name of Separate Irrigation Company Providing Pressurized Secondary Water (Please give the Name of Company, Contact Person & Number)
1
2
3
4
5

4) What percentage (%) of your culinary customers utilize a separate ditch irrigation system for their landscapes? _____ **%**
Please list the separate systems here:

Name of Separate Irrigation Company Providing Ditch Secondary Water (Please give the Name of Company, Contact Person & Number)
1
2
3
4
5

APPENDIX B
MEETING NOTES

Evaluation of Current Water Use Data Collection Program
State of Utah-Division of Water Resources

Meeting Notes
Project Kickoff Meeting
August 31, 2017

1. Attendees:

   DWRe, Todd Adams, Rachel Shilton, Candace Hasenyager, Eric Millis
   HAL, Steve Jones, Rob Sowby
   BCA, Mike Collins, Keith Larson
   State Legislative Auditor, Tim Bereece, Jim Benhunin

2. Project Goals
   a. Todd, goal is to not just improve DWR data, but make the system better for all agencies
   b. Jim, new baseline for conservation planning moving forward, expressed concern about 2000 baseline containing multiple years data
   c. Discussed unmetered secondary as a challenge
   d. Rachel, we want every water system to know more about their own water system
   e. Need good numbers to justify need for future projects (legislature)
   f. 3rd party review of entire process
   g. Define water conservation goals by region is not included in this contract

3. Meeting Purpose. The purpose of this meeting is to develop a strategy for completing this project and to begin the process of completing the study.

4. Review of project objectives. (Overall: develop confidence in State's planning numbers)

   a. Evaluate state water use collection program
   b. Verify water use by categories (residential, commercial, institutional, and industrial) and reliable supply data
   c. Determine reliable base year for planning purposes, either 2000, 2005, or 2010

5. Review of scope of services (attached)

6. State of Utah Background and Input, discussed audit and recommendations for improvements, data has been better last couple of years.

7. Review of project schedule

   a. December 22, 2017 completion

8. Communication, Keith will be project manager for team, Rachel for state, but communicate as needed between staffs.

9. Specific Project Issues

    a. Proposed water provider audit entities, we handed out and reviewed our proposed map of small water providers to be audited
    b. Large water district planning vs. water use records (essentially a big chunk of our scope is to look at the large water districts in detail, but they don't have any recorded water use in the database. Do we want to discuss our strategy here?) We discussed examining customers of the large water users to gather data on water use.
    c. History of water use database (How did this come about? Does having it under water rights create a conflict for reporting entities who are worried about showing beneficial use?) Discussed two data bases, one for water rights, and the modified data by the DWR
    d. Supply reliability (This was a specific topic for the kick off meeting listed in our scope of work.) It is limited, based on published reports. We will have better data for the entities we have worked with. Focus is on reliable annual yield. Discussed need to deal with planning for agriculture conversion.
    e. Project stakeholders (Who is our audience?)
        i. Legislature
        ii. Environmental groups
        iii. Public
        iv. Division
        v. Water providers

10. Data Needs

    a. Water use data files
    b. Water Source data files
    c. Water Use Questionnaire
    d. Protocols for Data Gathering Process, work with Craig Miller on programming

11. Set date for next regular progress meeting
    a. Set time next week for teams to meet, data gather 9/6 at 8:30 a.m.
    b. Next progress meeting, 10/4, 2:00 p.m.

Evaluation of Current Water Use Data Collection Program
State of Utah-Division of Water Resources

Meeting Notes
Progress Meeting
October 4, 2017

1. Attendees:

   DWRe, Todd Adams, Rachel Shilton, Candace Hasenyager, Laura Haskell
   HAL, Steve Jones, Rob Sowby
   BCA, Mike Collins, Keith Larson
   State Legislative Auditor, Jim Benhunin
   State Water Rights, James Hatch

2. Review of project objectives. (Overall: develop confidence in State's planning numbers)

   a. Evaluate state water use collection program
   b. Verify water use and supply data
   c. Determine reliable base year for planning purposes
   d. (Jim discussed fact that data is needed to satisfy planning mandate for future projects, possible funding from legislature)

3. Discussion Topics

   a. Summary of progress to date
   b. Review proposed data collection worksheets – Verify data collection categories, we handed out draft tables, had a long discussion about the worksheets, columns to add or subtract.
      i. Discussed why break out use into four groups, residential, commercial, industrial, and institutional. Important because they are concerned about outdoor water use, specifically with institutional.
      ii. We will follow up to see if new form for data collection from water rights will be out on October 10th,
      iii. Emphasis has shifted from the numbers to the methodology, both Jim and DWRe want specific critique of methodology,, use the numbers to show why(for example .25 acre lot size assumption)
   c. Review proposed report outline, handed out the report outline for review by the team by next meeting.
   d. Discussed the need for validation of the baseline year for conservation planning
   e. Jim discussed his desire to review methodology of obtaining and collecting data

4. Additional Data Needs

    a. Need drinking water separated into residential, commercial, institutional, and industrial
    b. Add percent irrigated with a secondary systems
    c. Need secondary out of drinking water numbers separated at least into residential/non-residential
    d. DWRe will send 2015 outdoor use data
    e. 2000 baseline data does not need to be on data comparison table, just analyze and quantify separately (295gpd/connection)

5. Set date for next regular progress meeting
    a. Next progress meeting, 11/1, 2:00 p.m.

Evaluation of Current Water Use Data Collection Program
State of Utah-Division of Water Resources

Agenda
Project Progress Meeting
November 1, 2017

1. Attendees:

   DWRe, Todd Adams, Rachel Shilton, Candace Hasenyager
   HAL, Steve Jones
   BCA, Mike Collins, Keith Larson
   State Legislative Auditor, Tim Bereece, Jim Benhunin

2. Welcome and introductions
   a. Project Team, BC&A and HAL
   b. State

3. Status/Progress Report on Data Collection and Analysis, reviewed progress to date.

4. Review of Data Collection Observations Document. (we reviewed the document and went through several of the observations, Keith)

   a. Water Rights Raw Data Collection
      i. Report on meeting with James Greer to review new data entry portal
   b. Water Resources Data Review and Correction
   c. Water Resources Planning

5. Discussion Topics

   - Is system loss represented? If so, where and how?, No, they use sales as water usage, because their historic primary use was for conservation monitoring, not overall water planning. Source capacity is going to be needed for long term planning

   - How can we improve your secondary water use numbers?

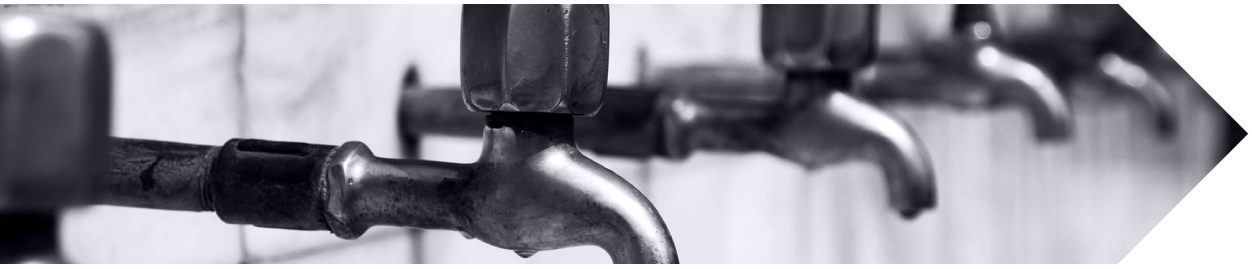
     a. Infrared evaluation of irrigated acreage, we will make this a recommendation in the report
     b. Strive to make reporting a tool for the users, if it benefits them then they will utilize it more

   - How can we improve your estimates of water supply?

6. Additional Data Needs
   a. Steve, share google drive

b. Rachel, coordinate review of questions on observations document (item 4)
c. Keith, Steve, work hard
d. Jim, review with our staff draft of his document, in person if need be
e.

7. Set date for next regular progress meeting, December 19, 2017, 10:00 a.m.



APPENDIX C
DATA TABLES

APPENDIX C - DATA TABLES

The results of the analysis are presented elsewhere in the report in summary form. The tables below, used to produce the summaries, contain more detail on individual water systems.

2015 Individual System Potable, Secondary and Total Water Use

Provider	State Potable Use (AF)	Consultant Potable Use (AF)	Potable % Error	State Secondary Use (AF)	Consultant Secondary Use (AF)	Secondary % Error	State Total Use (AF)	Consultant Total Use (AF)	Total % Error
ACME Water Company	201	201	0.0%	172	229	-24.8%	373	430	-13.2%
Blanding City Municipal Water	678	648	4.6%	217	289	-24.8%	895	937	-4.4%
Bluffdale Water System	1,912	1,878	1.8%	1,780	2,368	-24.8%	3,692	4,246	-13.0%
Bothwell Town Water System	61	45	35.6%	39	52	-24.8%	100	97	3.2%
Bountiful City	4,493	4,497	-0.1%	3,853	9,398	-59.0%	8,346	13,895	-39.9%
Brigham City Corp.	5,740	5,835	-1.6%	1,778	2,365	-24.8%	7,518	8,200	-8.3%
BRWCD - Beaver Dam	11	11	0.0%	0	0	0.0%	11	11	0.0%
BRWCD - Harper Ward	57	57	0.0%	0	0	0.0%	57	57	0.0%
BRWCD - Tremonton 2	49	45	8.9%	15	20	-24.8%	64	65	-1.5%
Cedar City	5,898	5,947	-0.8%	933	2,091	-55.4%	6,831	8,038	-15.0%
City of South Jordan	13,737	13,752	-0.1%	5,365	7,137	-24.8%	19,102	20,889	-8.6%
Clinton City	1,515	1,200	26.3%	3,298	4,387	-24.8%	4,813	5,587	-13.9%
Deweyville Town	106	92	15.2%	67	89	-24.8%	173	181	-4.5%
Granger-Hunter ID	21,391	22,761	-6.0%	513	682	-24.8%	21,904	23,443	-6.6%
Grantsville Municipal Water System	1,602	1,369	17.0%	907	1,207	-24.8%	2,509	2,576	-2.6%
High Valley Water Co.	90	81	11.1%	0	0	0.0%	90	81	0.0%
Holliday Water Company	4,127	3,859	6.9%	102	102	0.0%	4,229	3,961	6.8%
Honeyville Town Water System	804	804	0.0%	77	102	-24.8%	881	906	-2.8%
Hurricane	3,270	3,270	0.0%	2,705	3,846	-29.7%	5,975	7,116	-16.0%
Ivins	1,578	1,578	0.0%	114	102	11.8%	1,692	1,680	0.7%
Kanab	1,111	1,111	0.0%	288	277	4.0%	1,399	1,388	0.8%
Kearns ID	7,297	7,227	1.0%	548	729	-24.8%	7,845	7,956	-1.4%
Lehi	3,723	3,723	0.0%	10,980	10,959	0.2%	14,703	14,682	0.1%
Logan City	8,565	8,856	-3.3%	2,477	3,295	-24.8%	11,042	12,151	-9.1%
Midvale City Water System	5,048	4,815	4.8%	6	8	-24.8%	5,054	4,823	4.8%
Riverside - North Garland Water Co.	299	298	0.3%	114	152	-24.8%	413	450	-8.2%
Saratoga Springs Municipal	1,236	1,295	-4.6%	2,575	2,547	1.1%	3,811	3,842	-0.8%
South Ogden City	1,260	1,205	4.6%	3,387	4,506	-24.8%	4,647	5,711	-18.6%
South Salt Lake Culinary Water	2,266	2,077	9.1%	212	282	-24.8%	2,478	2,359	5.0%
Spanish Fork	2,913	2,914	0.0%	5,004	5,004	0.0%	7,917	7,918	0.0%
Springville City	8,060	7,765	3.8%	1,131	1,505	-24.8%	9,191	9,270	-0.8%
Twin Creeks	465	181	156.9%	289	1,383	-79.1%	754	1,564	-51.8%
Ukon Water Co.	186	186	0.0%	69	92	-24.8%	255	278	-8.2%
Wendover	337	337	0.0%	0	0	0.0%	337	337	0.0%
West Jordan City Water	19,775	19,775	0.0%	935	1,244	-24.8%	20,710	21,019	-1.5%
West Point City Water System	536	269	99.3%	1,490	1,982	-24.8%	2,026	2,251	-10.0%
Woods Cross City Water System	1,135	1,135	0.0%	1,268	1,687	-24.8%	2,403	2,822	-14.8%
TOTAL	**131,532**	**131,099**	**0.3%**	**52,708**	**70,117**	**-24.8%**	**184,240**	**201,216**	**-8.4%**
Mean Weighted Error			**±3.2%**			**±25%**			**±9.1%**
Root Mean Square Error			**±1.2%**			**±12.3%**			**±3.6%**

2010 Individual System Potable, Secondary and Total Water Use

Provider	State Potable Use (AF)	Consultant Potable Use (AF)	Potable % Error	State Secondary Use (AF)	Consultant Secondary Use (AF)	Secondary % Error	State Total Use (AF)	Consultant Total Use (AF)	Total % Error
ACME Water Company	179	179	0.0%	50	72	-30.9%	229	251	-8.9%
Blanding City Municipal Water	806	843	-4.4%	200	289	-30.9%	1,006	1,132	-11.1%
Bluffdale Water System	1,553	1,427	8.8%	254	367	-30.9%	1,807	1,794	0.7%
Bothwell Town Water System	61	31	96.8%	47	68	-30.9%	108	99	9.1%
Bountiful City	4,587	4,664	-1.7%	5,500	11,595	-52.6%	10,087	16,259	-38.0%
BRWCD - Harper Ward	55	55	0.0%	0	0	0.0%	55	55	0.0%
BRWCD - Tremonton 2	37	31	19.4%	2	3	-30.9%	39	34	15.1%
Cedar City	5,889	5,926	-0.6%	1,527	2,810	-45.7%	7,416	8,736	-15.1%
City of South Jordan	11,984	10,079	18.9%	1,100	1,591	-30.9%	13,084	11,670	12.1%
Deweyville Town	101	101	0.0%	35	51	-30.9%	136	152	-10.3%
Granger-Hunter ID	24,266	24,266	0.0%	310	448	-30.9%	24,576	24,714	-0.6%
Holliday Water Company	4,014	3,752	7.0%	185	185	0.0%	4,199	3,937	6.7%
Honeyville Town Water System	258	258	0.0%	78	113	-30.9%	336	371	-9.4%
Hurricane	3,020	2,966	1.8%	2,161	3,811	-43.3%	5,181	6,777	-23.6%
Ivins	1,441	1,435	0.4%	81	98	-17.3%	1,522	1,533	-0.7%
JVWCD (Retail)	8,919	8,974	-0.6%	330	477	-30.9%	9,249	9,451	-2.1%
Kanab	1,361	1,361	0.0%	80	449	-82.2%	1,441	1,810	-20.4%
Kaysville City	2,273	2,273	0.0%	4,540	6,566	-30.9%	6,813	8,839	-22.9%
Kearns ID	6,231	7,662	-18.7%	500	723	-30.9%	6,731	8,385	-19.7%
Lehi	3,531	3,107	13.6%	10,249	10,442	-1.8%	13,780	13,549	1.7%
Manila Municipal Water System	1,324	80	1555.0%	0	0	0.0%	1,324	80	1555.0%
Midvale City Water System	4,450	4,911	-9.4%	0	0	0.0%	4,450	4,911	-9.4%
North Salt Lake Water System	4,196	4,199	-0.1%	383	554	-30.9%	4,579	4,753	-3.7%
Saratoga Springs Municipal	1,280	837	52.9%	2,659	3,845	-30.9%	3,939	4,682	-15.9%
South Salt Lake Culinary Water	2,364	2,364	0.0%	0	0	0.0%	2,364	2,364	0.0%
South Weber City	719	531	35.4%	950	1,374	-30.9%	1,669	1,905	-12.4%
Spanish Fork	2,625	2,646	-0.8%	3,650	3,617	0.9%	6,275	6,263	0.2%
Springville City	7,107	6,926	2.6%	600	868	-30.9%	7,707	7,794	-1.1%
Tooele Municipal Water System	6,788	5,832	16.4%	875	1,265	-30.9%	7,663	7,097	8.0%
Twin Creeks	80	114	-29.8%	225	1,207	-81.4%	305	1,321	-76.9%
Ukon Water Co.	175	216	-19.0%	180	260	-30.9%	355	476	-25.5%
Wendover	357	357	0.0%	0	0	0.0%	357	357	0
Woods Cross City Water System	1,039	1,049	-1.0%	1,320	1,909	-30.9%	2,359	2,958	-20.2%
TOTAL	**113,070**	**109,452**	**3.3%**	**38,071**	**55,058**	**-30.9%**	**151,141**	**164,510**	**-8.1%**
Mean Weighted Error			**±7.3%**			**±31%**			**±12.7%**
Root Mean Square Error			**±2.6%**			**±18.4%**			**±4.9%**

2005 Individual System Potable, Secondary and Total Water Use

Provider	State Potable Use (AF)	Consultant Potable Use (AF)	Potable % Error	State Secondary Use (AF)	Consultant Secondary Use (AF)	Secondary % Error	State Total Use (AF)	Consultant Total Use (AF)	Total % Error
ACME Water Company	206	184	12.0%	57	85	-32.6%	263	269	-2.1%
Blanding City Municipal Water	509	747	-31.9%	93	138	-32.6%	602	885	-32.0%
Bluffdale Water System	1,153	1,062	8.6%	256	380	-32.6%	1,409	1,442	-2.3%
Bountiful City	4,671	4,669	0.0%	12,050	17,887	-32.6%	16,721	22,556	-25.9%
Brigham City Corp.	4,593	5,683	-19.2%	404	600	-32.6%	4,997	6,283	-20.5%
BRWCD - Beaver Dam	27	14	92.9%	0	0	0.0%	27	14	92.9%
Cedar City	6,246	5,563	12.3%	765	3,073	-75.1%	7,011	8,636	-18.8%
City of South Jordan	9,088	8,768	3.6%	530	787	-32.6%	9,618	9,555	0.7%
Granger-Hunter ID	20,592	20,592	0.0%	310	460	-32.6%	20,902	21,052	-0.7%
Holliday Water Company	3,695	3,455	6.9%	185	185	0.0%	3,880	3,640	6.6%
Hurricane	2,692	3,760	-28.4%	1,078	2,274	-52.6%	3,770	6,034	-37.5%
Ivins	1,262	1,262	0.0%	81	93	-12.9%	1,343	1,355	-0.9%
JVWCD (Retail)	9,199	8,876	3.6%	250	371	-32.6%	9,449	9,247	2.2%
Kanab	1,519	1,519	0.0%	66	359	-81.6%	1,585	1,878	-15.6%
Kaysville City	2,640	2,388	10.6%	3,589	5,328	-32.6%	6,229	7,716	-19.3%
Kearns ID	7,690	7,777	-1.1%	500	742	-32.6%	8,190	8,519	-3.9%
Lehi	2,395	1,937	23.6%	6,942	7,078	-1.9%	9,337	9,015	3.6%
Logan City	8,753	10,058	-13.0%	6,711	9,962	-32.6%	15,464	20,020	-22.8%
Manila Municipal Water System	1,390	246	465.0%	0	0	0.0%	1,390	246	465.0%
Riverside - North Garland Water Co.	208	239	-13.0%	134	199	-32.6%	342	438	-21.9%
Saratoga Springs Municipal	850	898	-5.3%	1,050	1,559	-32.6%	1,900	2,457	-22.7%
South Salt Lake Culinary Water	2,987	2,988	0.0%	0	0	0.0%	2,987	2,988	0.0%
Spanish Fork	6,595	2,546	159.0%	3,200	4,750	-32.6%	9,795	7,296	34.2%
Springville City	6,682	6,682	0.0%	600	891	-32.6%	7,282	7,573	-3.8%
Tooele Municipal Water System	5,746	4,907	17.1%	1,366	2,028	-32.6%	7,112	6,935	2.6%
Twin Creeks	59	58	1.7%	100	620	-83.9%	159	678	-76.5%
Ukon Water Co.	276	256	7.8%	320	475	-32.6%	596	731	-18.5%
Wendover	312	312	0.0%	0	0	0.0%	312	312	0.0%
West Jordan City Water	17,021	17,021	0.0%	1,220	1,811	-32.6%	18,241	18,832	-3.1%
Woods Cross City Water System	1,055	990	6.6%	2,000	2,969	-32.6%	3,055	3,959	-22.8%
TOTAL	**130,111**	**125,457**	**3.7%**	**49,657**	**73,712**	**-32.6%**	**173,968**	**190,560**	**-8.7%**
Mean Weighted Error			**±9.9%**			**±32.6%**			**±13.6%**
Root Mean Square Error			**±3.7%**			**±16.5%**			**±5%**

2015 Individual System Potable Water Use

Provider	State Potable Use (AF)	Consultant Potable Use (AF)	Potable % Error
ACME Water Company	201	201	0.0%
Blanding City Municipal Water	678	648	4.6%
Bluffdale Water System	1,912	1,878	1.8%
Bothwell Town Water System	61	45	35.6%
Bountiful City	4,493	4,497	-0.1%
Brigham City Corp.	5,740	5,835	-1.6%
BRWCD - Beaver Dam	11	11	0.0%
BRWCD - Harper Ward	57	57	0.0%
BRWCD - Tremonton 2	49	45	8.9%
Cedar City	5,898	5,947	-0.8%
City of South Jordan	13,737	13,752	-0.1%
Clinton City	1,515	1,200	26.3%
Deweyville Town	106	92	15.2%
Granger-Hunter ID	21,391	22,761	-6.0%
Grantsville Municipal Water System	1,602	1,369	17.0%
High Valley Water Co.	90	81	11.1%
Holliday Water Company	4,127	3,859	6.9%
Honeyville Town Water System	804	804	0.0%
Hurricane	3,270	3,270	0.0%
Ivins	1,578	1,578	0.0%
Kanab	1,111	1,111	0.0%
Kearns ID	7,297	7,227	1.0%
Lehi	3,723	3,723	0.0%
Logan City	8,565	8,856	-3.3%
Midvale City Water System	5,048	4,815	4.8%
Riverside - North Garland Water Co.	299	298	0.3%
Saratoga Springs Municipal	1,236	1,295	-4.6%
South Ogden City	1,260	1,205	4.6%
South Salt Lake Culinary Water	2,266	2,077	9.1%
Spanish Fork	2,913	2,914	0.0%
Springville City	8,060	7,765	3.8%
Twin Creeks	465	181	156.9%
Ukon Water Co.	186	186	0.0%
Wendover	337	337	0.0%
West Jordan City Water	19,775	19,775	0.0%
West Point City Water System	536	269	99.3%
Woods Cross City Water System	1,135	1,135	0.0%
TOTAL	**131,532**	**131,099**	**0.3%**
Mean Weighted Error			**±3.2%**
Root Mean Square Error			**±1.2%**

2010 Individual System Potable Water Use			
Provider	**State Potable Use (AF)**	**Consultant Potable Use (AF)**	**Potable % Error**
ACME Water Company	179	179	0.0%
Blanding City Municipal Water	806	843	-4.4%
Bluffdale Water System	1,553	1,427	8.8%
Bothwell Town Water System	61	31	96.8%
Bountiful City	4,587	4,664	-1.7%
BRWCD - Harper Ward	55	55	0.0%
BRWCD - Tremonton 2	37	31	19.4%
Cedar City	5,889	5,926	-0.6%
City of South Jordan	11,984	10,079	18.9%
Deweyville Town	101	101	0.0%
Granger-Hunter ID	24,266	24,266	0.0%
Holliday Water Company	4,014	3,752	7.0%
Honeyville Town Water System	258	258	0.0%
Hurricane	3,020	2,966	1.8%
Ivins	1,441	1,435	0.4%
Jordan Valley Water Conservancy District (Retail)	8,919	8,974	-0.6%
Kanab	1,361	1,361	0.0%
Kaysville City	2,273	2,273	0.0%
Kearns ID	6,231	7,662	-18.7%
Lehi	3,531	3,107	13.6%
Manila Municipal Water System	1,324	80	1555.0%
Midvale City Water System	4,450	4,911	-9.4%
North Salt Lake Water System	4,196	4,199	-0.1%
Saratoga Springs Municipal	1,280	837	52.9%
South Salt Lake Culinary Water	2,364	2,364	0.0%
South Weber City	719	531	35.4%
Spanish Fork	2,625	2,646	-0.8%
Springville City	7,107	6,926	2.6%
Tooele Municipal Water System	6,788	5,832	16.4%
Twin Creeks	80	114	-29.8%
Ukon Water Co.	175	216	-19.0%
Wendover	357	357	0.0%
Woods Cross City Water System	1,039	1,049	-1.0%
TOTAL	**113,070**	**109,452**	**3.3%**
Mean Weighted Error			**±7.3%**
Root Mean Square Error			**±2.6%**

2005 Individual System Potable Water Use

Provider	State Potable Use (AF)	Consultant Potable Use (AF)	Potable % Error
ACME Water Company	206	184	12.0%
Blanding City Municipal Water	509	747	-31.9%
Bluffdale Water System	1,153	1,062	8.6%
Bountiful City	4,671	4,669	0.0%
Brigham City Corp.	4,593	5,683	-19.2%
BRWCD - Beaver Dam	27	14	92.9%
Cedar City	6,246	5,563	12.3%
City of South Jordan	9,088	8,768	3.6%
Granger-Hunter ID	20,592	20,592	0.0%
Holliday Water Company	3,695	3,455	6.9%
Hurricane	2,692	3,760	-28.4%
Ivins	1,262	1,262	0.0%
Jordan Valley Water Conservancy District (Retail)	9,199	8,876	3.6%
Kanab	1,519	1,519	0.0%
Kaysville City	2,640	2,388	10.6%
Kearns ID	7,690	7,777	-1.1%
Lehi	2,395	1,937	23.6%
Logan City	8,753	10,058	-13.0%
Manila Municipal Water System	1,390	246	465.0%
Riverside - North Garland Water Co.	208	239	-13.0%
Saratoga Springs Municipal	850	898	-5.3%
South Salt Lake Culinary Water	2,987	2,988	0.0%
Spanish Fork	6,595	2,546	159.0%
Springville City	6,682	6,682	0.0%
Tooele Municipal Water System	5,746	4,907	17.1%
Twin Creeks	59	58	1.7%
Ukon Water Co.	276	256	7.8%
Wendover	312	312	0.0%
West Jordan City Water	17,021	17,021	0.0%
Woods Cross City Water System	1,055	990	6.6%
TOTAL	**130,111**	**125,457**	**3.7%**
Mean Weighted Error			**±9.9%**
Root Mean Square Error			**±3.7%**

2015 Individual System Secondary Water Use

Provider	State Secondary Use (AF)	Consultant Secondary Use (AF)	Secondary % Error
Bountiful City	3,853	9,398	-59.0%
Cedar City	933	2,091	-55.4%
Holliday Water Company	102	102	0.0%
Hurricane	2,705	3,846	-29.7%
Ivins	114	102	11.8%
Kanab	288	277	4.0%
Lehi	10,980	10,959	0.2%
Saratoga Springs Municipal	2,575	2,547	1.1%
Spanish Fork	5,004	5,004	0.0%
Twin Creeks	289	1,383	-79.1%
Wendover	0	0	0.0%
SUB TOTAL	**26,843**	**35,709**	**±21.9%**
Estimated Consultant Secondary Use			
ACME Water Company	172	229	-24.8%
Blanding City Municipal Water	217	289	-24.8%
Bluffdale Water System	1,780	2,368	-24.8%
Bothwell Town Water System	39	52	-24.8%
Brigham City Corp.	1,778	2,365	-24.8%
BRWCD - Beaver Dam	0	0	0.0%
BRWCD - Harper Ward	0	0	0.0%
BRWCD - Tremonton 2	15	20	-24.8%
City of South Jordan	5,365	7,137	-24.8%
Clinton City	3,298	4,387	-24.8%
Deweyville Town	67	89	-24.8%
Granger-Hunter ID	513	682	-24.8%
Grantsville Municipal Water System	907	1,207	-24.8%
High Valley Water Co.	0	0	0.0%
Honeyville Town Water System	77	102	-24.8%
Kearns ID	548	729	-24.8%
Logan City	2,477	3,295	-24.8%
Midvale City Water System	6	8	-24.8%
Riverside - North Garland Water Co.	114	152	-24.8%
South Ogden City	3,387	4,506	-24.8%
South Salt Lake Culinary Water	212	282	-24.8%
Springville City	1,131	1,505	-24.8%
Ukon Water Co.	69	92	-24.8%
West Jordan City Water	935	1,244	-24.8%
West Point City Water System	1,490	1,982	-24.8%
Woods Cross City Water System	1,268	1,687	-24.8%
TOTAL	**52,708**	**70,117**	**-24.8%**
Mean Weighted Error			**±25%**
Root Mean Square Error			**±12.3%**

Notes

The average loss of systems with data was used to estimate use for systems with no collected data

2010 Individual System Secondary Water Use

Provider	State Secondary Use (AF)	Consultant Secondary Use (AF)	Secondary % Error
Bountiful City	5,500	11,595	-52.6%
Cedar City	1,527	2,810	-45.7%
Holliday Water Company	185	185	0.0%
Hurricane	2,161	3,811	-43.3%
Ivins	81	98	-17.3%
Kanab	80	449	-82.2%
Lehi	10,249	10,442	-1.8%
Spanish Fork	3,650	3,617	0.9%
Twin Creeks	225	1,207	-81.4%
Wendover	0	0	0.0%
SUB TOTAL	**23,658**	**34,214**	**±27.6%**
Estimated Consultant Secondary Use			
ACME Water Company	50	72	-30.9%
Blanding City Municipal Water	200	289	-30.9%
Bluffdale Water System	254	367	-30.9%
Bothwell Town Water System	47	68	-30.9%
BRWCD - Harper Ward	0	0	0.0%
BRWCD - Tremonton 2	2	3	-30.9%
City of South Jordan	1,100	1,591	-30.9%
Deweyville Town	35	51	-30.9%
Granger-Hunter ID	310	448	-30.9%
Honeyville Town Water System	78	113	-30.9%
Jordan Valley Water Conservancy District (Retail)	330	477	-30.9%
Kaysville City	4,540	6,566	-30.9%
Kearns ID	500	723	-30.9%
Manila Municipal Water System	0	0	0.0%
Midvale City Water System	0	0	0.0%
North Salt Lake Water System	383	554	-30.9%
Saratoga Springs Municipal	2,659	3,845	-30.9%
South Salt Lake Culinary Water	0	0	0.0%
South Weber City	950	1,374	-30.9%
Springville City	600	868	-30.9%
Tooele Municipal Water System	875	1,265	-30.9%
Ukon Water Co.	180	260	-30.9%
Woods Cross City Water System	1,320	1,909	-30.9%
TOTAL	**38,071**	**55,058**	**-30.9%**
Mean Weighted Error			**±31%**
Root Mean Square Error			**±18.4%**

Notes

The average loss of systems with data was used to estimate use for systems with no collected data

2005 Individual System Secondary Water Use			
Provider	**State Secondary Use (AF)**	**Consultant Secondary Use (AF)**	**Secondary % Error**
Cedar City	765	3,073	-75.1%
Holliday Water Company	185	185	0.0%
Hurricane	1,078	2,274	-52.6%
Ivins	81	93	-12.9%
Kanab	66	359	-81.6%
Lehi	6,942	7,078	-1.9%
Twin Creeks	100	620	-83.9%
Wendover	0	0	0.0%
SUB TOTAL	**9,217**	**13,682**	**±29%**
Estimated Consultant Secondary Use			
ACME Water Company	57	85	-32.6%
Blanding City Municipal Water	93	138	-32.6%
Bluffdale Water System	256	380	-32.6%
Bountiful City	12,050	17,887	-32.6%
Brigham City Corp.	404	600	-32.6%
BRWCD - Beaver Dam	0	0	0.0%
City of South Jordan	530	787	-32.6%
Granger-Hunter ID	310	460	-32.6%
Jordan Valley Water Conservancy District (Retail)	250	371	-32.6%
Kaysville City	3,589	5,328	-32.6%
Kearns ID	500	742	-32.6%
Logan City	6,711	9,962	-32.6%
Manila Municipal Water System	0	0	0.0%
Riverside - North Garland Water Co.	134	199	-32.6%
Saratoga Springs Municipal	1,050	1,559	-32.6%
South Salt Lake Culinary Water	0	0	0.0%
Spanish Fork	3,200	4,750	-32.6%
Springville City	600	891	-32.6%
Tooele Municipal Water System	1,366	2,028	-32.6%
Ukon Water Co.	320	475	-32.6%
West Jordan City Water	1,220	1,811	-32.6%
Woods Cross City Water System	2,000	2,969	-32.6%
TOTAL	**43,857**	**65,103**	**-32.6%**
Mean Weighted Error			**±32.6%**
Root Mean Square Error			**±17.6%**

Notes

The average loss of systems with data was used to estimate use for systems with no collected data

2015 Individual System Total Water Use			
Provider	**State Total Use (AF)**	**Consultant Total Use (AF)**	**Total % Error**
ACME Water Company	373	430	-13.2%
Blanding City Municipal Water	895	937	-4.4%
Bluffdale Water System	3,692	4,246	-13.0%
Bothwell Town Water System	100	97	3.2%
Bountiful City	8,346	13,895	-39.9%
Brigham City Corp.	7,518	8,200	-8.3%
BRWCD - Beaver Dam	11	11	0.0%
BRWCD - Harper Ward	57	57	0.0%
BRWCD - Tremonton 2	64	65	-1.5%
Cedar City	6,831	8,038	-15.0%
City of South Jordan	19,102	20,889	-8.6%
Clinton City	4,813	5,587	-13.9%
Deweyville Town	173	181	-4.5%
Granger-Hunter ID	21,904	23,443	-6.6%
Grantsville Municipal Water System	2,509	2,576	-2.6%
High Valley Water Co.	90	81	0.0%
Holliday Water Company	4,229	3,961	6.8%
Honeyville Town Water System	881	906	-2.8%
Hurricane	5,975	7,116	-16.0%
Ivins	1,692	1,680	0.7%
Kanab	1,399	1,388	0.8%
Kearns ID	7,845	7,956	-1.4%
Lehi	14,703	14,682	0.1%
Logan City	11,042	12,151	-9.1%
Midvale City Water System	5,054	4,823	4.8%
Riverside - North Garland Water Co.	413	450	-8.2%
Saratoga Springs Municipal	3,811	3,842	-0.8%
South Ogden City	4,647	5,711	-18.6%
South Salt Lake Culinary Water	2,478	2,359	5.0%
Spanish Fork	7,917	7,918	0.0%
Springville City	9,191	9,270	-0.8%
Twin Creeks	754	1,564	-51.8%
Ukon Water Co.	255	278	-8.2%
Wendover	337	337	0.0%
West Jordan City Water	20,710	21,019	-1.5%
West Point City Water System	2,026	2,251	-10.0%
Woods Cross City Water System	2,403	2,822	-14.8%
TOTAL	**184,240**	**201,216**	**-8.4%**
Mean Weighted Error			**±9.1%**
Root Mean Square Error			**±3.6%**

2010 Individual System Total Water Use			
Provider	**State Total Use (AF)**	**Consultant Total Use (AF)**	**Total % Error**
ACME Water Company	229	251	-8.9%
Blanding City Municipal Water	1,006	1,132	-11.1%
Bluffdale Water System	1,807	1,794	0.7%
Bothwell Town Water System	108	99	9.1%
Bountiful City	10,087	16,259	-38.0%
BRWCD - Harper Ward	55	55	0.0%
BRWCD - Tremonton 2	39	34	15.1%
Cedar City	7,416	8,736	-15.1%
City of South Jordan	13,084	11,670	12.1%
Deweyville Town	136	152	-10.3%
Granger-Hunter ID	24,576	24,714	-0.6%
Holliday Water Company	4,199	3,937	6.7%
Honeyville Town Water System	336	371	-9.4%
Hurricane	5,181	6,777	-23.6%
Ivins	1,522	1,533	-0.7%
ordan Valley Water Conservancy District (Retail)	9,249	9,451	-2.1%
Kanab	1,441	1,810	-20.4%
Kaysville City	6,813	8,839	-22.9%
Kearns ID	6,731	8,385	-19.7%
Lehi	13,780	13,549	1.7%
Manila Municipal Water System	1,324	80	1555.0%
Midvale City Water System	4,450	4,911	-9.4%
North Salt Lake Water System	4,579	4,753	-3.7%
Saratoga Springs Municipal	3,939	4,682	-15.9%
South Salt Lake Culinary Water	2,364	2,364	0.0%
South Weber City	1,669	1,905	-12.4%
Spanish Fork	6,275	6,263	0.2%
Springville City	7,707	7,794	-1.1%
Tooele Municipal Water System	7,663	7,097	8.0%
Twin Creeks	305	1,321	-76.9%
Ukon Water Co.	355	476	-25.5%
Wendover	357	357	0%
Woods Cross City Water System	2,359	2,958	-20.2%
TOTAL	**151,141**	**164,510**	**-8.1%**
Mean Weighted Error			**±12.7%**
Root Mean Square Error			**±4.9%**

2005 Individual System Total Water Use			
Provider	**State Total Use (AF)**	**Consultant Total Use (AF)**	**Total % Error**
ACME Water Company	263	269	-2.1%
Blanding City Municipal Water	602	885	-32.0%
Bluffdale Water System	1,409	1,442	-2.3%
Bountiful City	16,721	22,556	-25.9%
Brigham City Corp.	4,997	6,283	-20.5%
BRWCD - Beaver Dam	27	14	92.9%
Cedar City	7,011	8,636	-18.8%
City of South Jordan	9,618	9,555	0.7%
Granger-Hunter ID	20,902	21,052	-0.7%
Holliday Water Company	3,880	3,640	6.6%
Hurricane	3,770	6,034	-37.5%
Ivins	1,343	1,355	-0.9%
Jordan Valley Water Conservancy District (Retail)	9,449	9,247	2.2%
Kanab	1,585	1,878	-15.6%
Kaysville City	6,229	7,716	-19.3%
Kearns ID	8,190	8,519	-3.9%
Lehi	9,337	9,015	3.6%
Logan City	15,464	20,020	-22.8%
Manila Municipal Water System	1,390	246	465.0%
Riverside - North Garland Water Co.	342	438	-21.9%
Saratoga Springs Municipal	1,900	2,457	-22.7%
South Salt Lake Culinary Water	2,987	2,988	0.0%
Spanish Fork	9,795	7,296	34.2%
Springville City	7,282	7,573	-3.8%
Tooele Municipal Water System	7,112	6,935	2.6%
Twin Creeks	159	678	-76.5%
Ukon Water Co.	596	731	-18.5%
Wendover	312	312	0.0%
West Jordan City Water	18,241	18,832	-3.1%
Woods Cross City Water System	3,055	3,959	-22.8%
TOTAL	**173,968**	**190,560**	**-8.7%**
Mean Weighted Error			**±13.6%**
Root Mean Square Error			**±5%**

2015 Individual System Potable Residential Water Use									
Provider	**State RES Indoor Use (AF)**	**Consultant RES Indoor Use (AF)**	**RES % Error**	**State RES Outdoor Use (AF)**	**Consultant RES Outdoor Use (AF)**	**RES % Error**	**State Total RES Use (AF)**	**Consultant Total RES Use (AF)**	**Total RES % Error**
ACME Water Company	59.85	59.00	1.4%	82.28	83.13	-1.0%	142	142	0.0%
Bluffdale Water System	624.33	670.00	-6.8%	788.75	438.00	80.1%	1,413	1,108	27.5%
Bothwell Town Water System							54	45	19.6%
Bountiful City	2,664.17	3,793.20	-29.8%				3,793	3,793	0.0%
BRWCD - Beaver Dam	5.50	6.00	-8.3%	5.82	5.00	16.3%	11	11	2.9%
BRWCD - Harper Ward	21.33	27.00	-21.0%	35.29	30.00	17.6%	57	57	-0.7%
BRWCD - Tremonton 2	10.26	11.16	-8.1%	33.62	33.53	0.3%	44	45	-1.8%
Cedar City Waterworks	2,251.91	1,981.00	13.7%				3,866	3,862	0.1%
City of South Jordan							9,531	9,531	0.0%
Clinton City	1,227.30	1,060.00	15.8%				1,227	1,060	15.8%
Deweyville Town							70	92	-24.5%
Granger-Hunter ID	8,217.11	8,125.00	1.1%	7,542.89	7,816.00	-3.5%	15,760	15,941	-1.1%
Grantsville Municipal Water System							952	952	0.0%
High Valley Water Co.	57.82	59.57	-2.9%	25.98	21.00	23.7%	84	81	4.0%
Hurricane City Water System							2,313	2,599	-11.0%
Ivins City	566.68	530.56	6.8%	553.32	648.47	-14.7%	1,120	1,179	-5.0%
Kearns ID							5,329	5,273	1.1%
Lehi							2,880	3,595	-19.9%
Logan City	3,553.38	2,717.56	30.8%	1,793.32	2,744.60	-34.7%	5,347	5,462	-2.1%
Midvale City Water System	2,226.35	1,152.00	93.3%	602.54	1,152.00	-47.7%	2,829	2,304	22.8%
Murray City Water System							5,220	5,310	-1.7%
Orem City							14,797	16,739	-11.6%
Riverside - North Garland Water Co.	82.56	90.00	-8.3%	161.00	99.00	62.6%	244	189	28.9%
Riverton City Water System							3,160	316	899.9%
Salt Lake City Corp. Culinary Water	21,877.18	23,109.69	-5.3%						
Saratoga Springs Municipal	1,174.43	1,150.00	2.1%				1,174	1,150	2.1%
South Ogden City	991.30	968.00	2.4%				991	968	2.5%
South Salt Lake Culinary Water							1,028	947	8.5%
Spanish Fork	2,085.86	2,086.00	0.0%				2,086	2,086	0.0%
Springville City							5,080	5,080	0.0%
Twin Creeks SSD							457	169	170.4%
Ukon Water Co.	79.12	85.00	-6.9%	103.10	92.00	12.1%	182	177	3.0%
Wendover Municipal Water System	73.28	29.81	145.8%	26.69	70.16	-62.0%	100	100	0.0%
West Jordan City Water							12,039	12,039	0.0%
West Point City Water System	503.30	259.00	94.3%				503	259	94.3%
Woods Cross City Water System							634	634	0.0%
TOTAL	**48,353**	**47,970**	**0.8%**	**11,755**	**13,233**	**-11.2%**	**104,516**	**103,294**	**1.2%**
Mean Weighted Error			**±10.9%**			**±17.7%**			**±7.8%**
Root Mean Square Error			**±4.5%**			**±10.1%**			**±3.5%**

2010 Individual System Potable Residential Water Use

Provider	State RES Indoor Use (AF)	Consultant RES Indoor Use (AF)	RES % Error	State RES Outdoor Use (AF)	Consultant RES Outdoor Use (AF)	RES % Error	State Total RES Use (AF)	Consultant Total RES Use (AF)	Total RES % Error
ACME Water Company	59	64	-8.1%	100	105	-4.6%	159	169	-5.9%
Bluffdale Water System	517	510	1.5%	659	332	98.3%	1,176	842	39.7%
Bothwell Town Water System							54	31	73.5%
Bountiful City	2,544	3,899	-34.7%				3,859	3,899	-1.0%
BRWCD - Harper Ward	16	32	-48.8%	37	21	75.7%	53	53	0.6%
BRWCD - Tremonton 2	10	6	61.1%	27	25	8.4%	37	31	19.1%
Cedar City Waterworks	1,792	1,939	-7.6%				3,915	3,915	0.0%
Deweyville Town							65	101	-36.1%
Granger-Hunter ID	7,987	7,986	0.0%	10,089	10,090	0.0%	18,076	18,076	0.0%
Hurricane City Water System							1,481	2,357	-37.2%
Kearns ID							5,513	5,512	0.0%
Midvale City Water System							2,389	2,413	-1.0%
North Salt Lake Water System	1,075	804	33.8%	918	1,023	-10.3%	1,993	1,827	9.1%
Orem City							13,791	18,527	-25.6%
Salt Lake City Corp. Culinary Water	20,210	21,751	-7.1%						
Saratoga Springs Municipal	1,069	411	160.1%	155	368	-58.0%	1,224	779	57.1%
South Salt Lake Culinary Water							1,132	1,132	0.0%
Spanish Fork	1,875	2,017	-7.0%				1,974	2,017	-2.1%
Springville City							4,525	4,536	-0.2%
Tooele Municipal Water System	2,125	2,124	0.0%	3,331	1,958	70.1%	5,457	4,082	33.7%
Twin Creeks SSD	80	102	-20.8%				80	102	-20.8%
Wendover Municipal Water System	103	21	401.5%	20	103	-80.4%	124	123	0.0%
Woods Cross City Water System							637	637	0.0%
TOTAL	**39,464**	**41,666**	**-5.3%**	**15,337**	**14,026**	**9.3%**	**67,712**	**71,163**	**-4.8%**
Mean Weighted Error			**±10.2%**			**±15.1%**			**±11.5%**
Root Mean Square Error			**±5.5%**			**±9.3%**			**±7.4%**

2005 Individual Potable Residential Water Use

Provider	State RES Indoor Use (AF)	Consultant RES Indoor Use (AF)	RES % Error	State RES Outdoor Use (AF)	Consultant RES Outdoor Use (AF)	RES % Error	State Total RES Use (AF)	Consultant Total RES Use (AF)	Total RES % Error
ACME Water Company	74	62	19.8%	110	122	-10.0%	184	184	0.0%
Bluffdale Water System	103	413	-75.0%	855	214	300.3%	959	627	53.0%
Bountiful City	2,573	3,694	-30.4%				3,694	3,694	0.0%
Brigham City Corp.	1,365	1,186	15.1%	2,285	2,702	-15.4%	3,651	3,888	-6.1%
BRWCD - Beaver Dam	6	13	-57.7%	21	1	2000.0%	27	14	89.3%
Cedar City Waterworks							4,130	3,550	16.4%
Granger-Hunter ID	1,602	7,278	-78.0%	14,328	8,652	65.6%	15,930	15,930	0.0%
Grouse Creek							17	33	-48.5%
Honeyville Town Water System	106	153	-30.7%	493	143	244.7%	599	296	102.3%
Hurricane City Water System							2,049	2,699	-24.1%
Kearns ID							5,523	5,468	1.0%
Logan City							5,156	5,040	2.3%
Manila Municipal Water System							1,340	218	514.8%
Riverside - North Garland Water Co.							115	157	-26.9%
Riverton City Water System							2,371	2,370	0.0%
Salt Lake City Corp. Culinary Water	21,693	21,371	1.5%						
Saratoga Springs Municipal	764	525	45.5%	36	328	-89.0%	800	853	-6.2%
Spanish Fork	1,986	1,656	19.9%				3,746	1,656	126.2%
Tooele Municipal Water System	2,352	1,859	26.6%	1,882	1,576	19.4%	4,234	3,435	23.3%
Twin Creeks SSD	59	54	8.5%				59	54	8.5%
Wendover Municipal Water System	93	70	32.3%	30	53	-43.0%	123	123	0.0%
West Jordan City Water							10,367	10,367	0.0%
Woods Cross City Water System							654	589	11.0%
TOTAL	**32,776**	**38,335**	**-14.5%**	**20,040**	**13,791**	**45.3%**	**65,726**	**61,244**	**7.3%**
Mean Weighted Error			**±22.9%**			**±56.1%**			**±10.6%**
Root Mean Square Error			**±17.8%**			**±28.7%**			**±4.1%**

2015 Annual Reliable Supply of Sources

Provider	State Potable (AF)	Consultant Potable (AF)	Potable % Error	State Secondary (AF)	Consultant Secondary (AF)	Secondary % Error	State Total (AF)	Consultant Total (AF)	Total % Error
Cedar City	11,388	10,289	10.7%	933	2,554	-63.5%	12,321	12,843	-4.1%
Bluffdale	0	0	0.0%	1,780	2,482	-28.3%	1,780	2,482	-28.3%
Granger-Hunter Improvement District	9,393	21,266	-55.8%	513	568	-9.7%	9,906	21,834	-54.6%
Herriman City	3,101	3,205	-3.2%	466	525	-11.2%	3,567	3,730	-4.4%
Holliday Water Company	5,779	4,725	22.3%	102	--	--	5,881	4,827	21.8%
Hurricane	4,482	6,595	-32.0%	2,705	3,883	-30.3%	7,187	10,478	-31.4%
Ivins	393	393	0.0%	114	449	-74.6%	507	842	-39.8%
Kearns Improvement District	1,816	1,530	18.7%	548	544	0.7%	2,364	2,074	14.0%
Layton	7,557	8,000	-5.5%	2,061	2,894	-28.8%	9,618	10,894	-11.7%
Maeser WID	848	1,338	-36.6%	195	290	-32.8%	1,043	1,628	-35.9%
Magna	4,309	4,431	-2.8%	555	721	-23.0%	4,864	5,152	-5.6%
Midvale City	2,800	5,310	-47.3%	6	6	0.0%	2,806	5,316	-47.2%
MWDSLS	136,534	132,524	3.0%	1,620	--	--	138,154	134,144	3.0%
Orem	18,369	21,264	-13.6%	450	--	--	18,819	21,714	-13.3%
Payson	4,855	10,160	-52.2%	2,703	41,141	-93.4%	7,558	51,301	-85.3%
Provo	49,135	48,485	1.3%	900	--	--	50,035	49,385	1.3%
Riverton City	5,040	12,100	-58.3%	10,877	19,400	-43.9%	15,917	31,500	-49.5%
Salem	4,426	7,430	-40.4%	814	12,278	-93.4%	5,240	19,708	-73.4%
Santequin	3,900	9,350	-58.3%	1,595	15,822	-89.9%	5,495	25,172	-78.2%
South Jordan	0	0	0.0%	5,365	15,185	-64.7%	5,365	15,185	-64.7%
South Salt Lake	3,157	12,900	-75.5%	212	329	-35.6%	3,369	13,229	-74.5%
Spanish Fork	10,115	18,850	-46.3%	5,004	23,641	-78.8%	15,119	42,491	-64.4%
Taylorsville-Bennion Improvement District	1,690	7,833	-78.4%	503	1,122	-55.2%	2,193	8,955	-75.5%
Twin Creeks	248	1,409	-82.4%	289	1,383	-79.1%	537	2,792	-80.8%
WaterPro	6,266	5,588	12.1%	1,477	6,630	-77.7%	7,743	12,218	-36.6%
WBWCD	147,256	144,173	2.1%	54,546	117,123	-53.4%	201,802	261,296	-22.8%
Wendover	4,184	1,236	238.5%	0	0	0.0%	4,184	1,236	238.5%
West Jordan	3,000	4,678	-35.9%	935	1,315	-28.9%	3,935	5,993	-34.3%
White City Water Improvement District	4,052	3,401	19.1%	0	0	0.0%	4,052	3,401	19.1%
Woodland Hills	371	2,050	-81.9%	0	0	0.0%	371	2,050	-81.9%
TOTAL	**454,464**	**510,513**	**-11.0%**	**97,268**	**270,285**	**-64.0%**	**551,732**	**783,870**	**-29.6%**
Mean Weighted Error			**±16.6%**			**±65%**			**±32%**
Root Mean Square Error			**±5.1%**			**±81.5%**			**±15.7%**

Notes

State assumes secondary supply equals current use.

Consultant supply numbers are based on future dry year based on development of current sources.

MWDSLS and WBWCD data includes member agency plus district supply.

Supplies of Orem and Layton do not reflect water provided by wholesale providers.

"--" represents missing data. Where state totals are compared to consultant totals with missing data, the state's total excludes the data for which the consultant field is found missing.

2015 System Loss				
Provider	**Potable Production (AF)**	**Potable Use (AF)**	**Loss (AF)**	**% Loss**
Bluffdale Water System	2,134	1,878	256	12.0%
Bountiful City	5,094	4,497	597	11.7%
BRWCD - Tremonton 2	45	40	5	11.1%
Cedar City Waterworks	6,855	5,947	908	13.2%
Clinton City	1,588	1,200	388	24.4%
Eagle Mountain Town	5,545	4,571	974	17.6%
Granger-Hunter ID	23,900	22,761	1,139	4.8%
Grantsville Municipal Water System	1,621	1,369	252	15.6%
High Valley Water Co.	91	81	10	11.1%
Holliday Water Company	4,127	3,859	268	6.5%
Hurricane City Water System	4,701	3,270	1,432	30.5%
Ivins City	1,638	1,578	60	3.6%
Kanab Municipal Water System	1,301	1,111	190	14.6%
Kearns ID	8,284	7,227	1,057	12.8%
Logan City	12,275	8,856	3,419	27.9%
Midvale City Water System	5,355	4,815	540	10.1%
Mountain Regional Water SSD	3,141	2,583	558	17.8%
Orem City	27,641	22,930	4,711	17.0%
Park City	5,005	3,244	1,761	35.2%
Riverside - North Garland Water Co.	332	298	34	10.2%
Salt Lake City Corp. Culinary Water	79,760	73,305	6,455	8.1%
Saratoga Springs Municipal	1,404	1,295	109	7.8%
South Ogden City	1,499	1,205	294	19.6%
South Salt Lake Culinary Water	2,842	2,077	765	26.9%
Spanish Fork	3,853	2,914	939	24.4%
Twin Creeks SSD	261	181	80	30.5%
Wendover Municipal Water System	492	337	154	31.4%
West Jordan City Water	20,705	19,870	835	4.0%
TOTAL	**231,487**	**203,299**	**28,189**	**12.2%**

Notes

All data in the table is consultant derived.

APPENDIX D
SECONDARY WATER USE INFORMATION

Appendix D
Estimation of Irrigated Area and Application Rates

In thinking about outdoor water use, it is useful to consider two parameters:

- Irrigated acreage – This refers to the total amount of area that is actively irrigated.
- Application rate – This refers to the amount of water applied to an area over a period of time. It can be expressed in units of volume (i.e. acre-ft per acre per year) or simply as a depth (i.e. inches per year).

When estimating outdoor use for systems without individual meters, it is common for estimates to be developed for these two parameters independently with the results multiplied to arrive at a final estimate of water consumption. As discussed in the body of the report, this is essentially the approach that was used by DWRe to estimate secondary use. In order to improve upon the DWRe estimates, this appendix looks at available information on each of these parameters and how aerial imagery might be used to help estimate their values.

AERIAL IMAGERY AND IRRIGATED ACREAGE

To estimate irrigated area around the state, the team employed a remote-sensing approach using National Agricultural Imagery Program (NAIP) data from the Utah Automated Geographic Reference Center (ARGC). The dataset is delivered in four bands (red, green, blue, and near infrared) at 1-meter resolution. A method known as the Normalized Difference Vegetation Index (NDVI) was used to detect vegetated areas. Healthy vegetation with more chlorophyll reflects higher levels of near-infrared and green light. The NDVI can distinguish between areas of thick, healthy plant life vs. unhealthy and/or sparse plant life.

To accomplish this goal, the NDVI utilizes the red light band (RED) from an image and the near-infrared light band (NIR) of the same image to isolate areas of vegetation. The typical formula for the NDVI is:

$$NDVI = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED})}$$

This formula produces values between –1 and 1. For this study, a commonly applied scaling factor was selected as follows:

$$Scaled\ NDVI = (\mathrm{NDVI} + 1) * 127.5$$

The scaling factor removes negative values and establishes higher pixel values with broader ranges that are easier to work with in a geographic information system (GIS).

To correlate vegetated area to irrigated area, each water system was evaluated individually and an appropriate cutoff pixel value was selected based on aerial imagery. The pixel value threshold that represented irrigated area varied somewhat by location, ranging from 150 to 175. As a result, cutoff points needed to be selected individually for each water system. Pixel values below the selected

cutoff point were excluded from any of the calculations for irrigated acreage. The results this analysis for an area of one of the systems analyzed is shown as Figure 1.

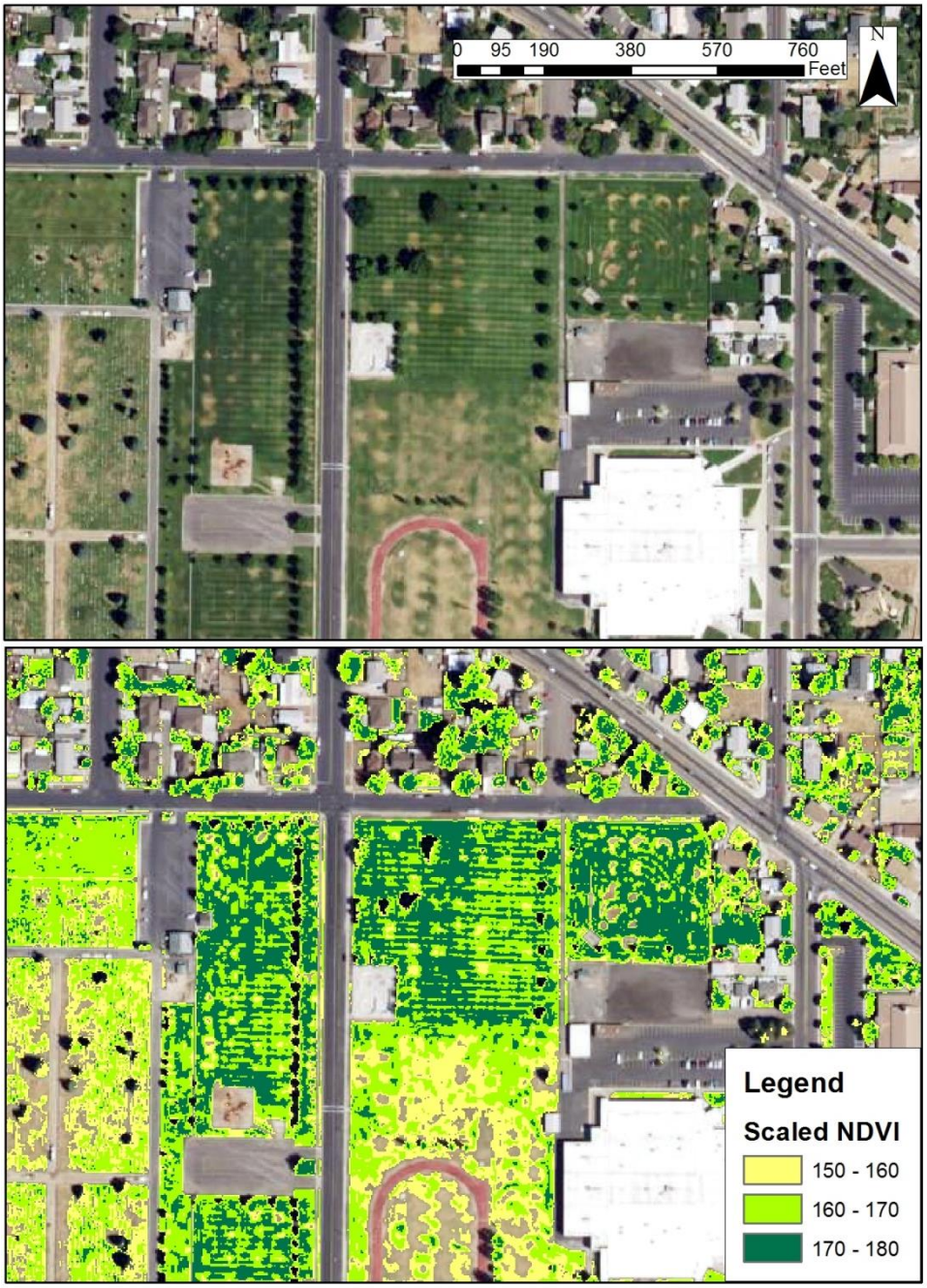


Figure 1. Imagery vs Scaled NDVI ranges (Spanish Fork, UT)

Comparing the imagery and the ranges of the NDVI it is clear that areas that are drier and have a yellow tint fall into the lower ranges, while areas that appear lush and green fall into the higher ranges. The imagery is a raster dataset that includes pixels that are 1 meter square. GIS tools are capable of computing how many pixels there are in a given boundary. This allows for calculating irrigated acres based on a pixel count of the NDVI grid over a specified area.

For the purposes of this study, all vegetated, non-agricultural areas within a public water supplier's service area were assumed to be irrigated. Studies have shown that NDVI data is useful in determining the location and coverage of irrigated area even in urban settings (Johnson and Belitz 2012). This method was tested on a few select cities and found to be very accurate in delineating areas that appeared to be irrigated. Based on this finding, a script was written to process the NAIP imagery and compute a NDVI grid for each of the water systems that were examined in this study. The same method could be applied to any water system in the entire state.

Application Rate

The cities of Spanish Fork and Saratoga Springs have complete pressurized irrigation (PI) systems that are metered and billed. Billing records for the month of August 2016 (same period the 2016 NAIP imagery was taken) were collected to examine the relationship between water application and the average NDVI pixel value (higher values correspond to greener and healthier plant life) for the same location. A shapefile of the parcel data for Spanish Fork and Saratoga Springs was obtained from the ARGC website to define the shape and size of each address. The addresses from the billing records along with the usage from August 2016 were matched with the corresponding parcel data. A statistical analysis was performed using the parcel shapefile data as a boundary to compute the number of NDVI pixels in each parcel (i.e., the irrigated area of each parcel) as well as the mean pixel value in each parcel.

The volume of water at each address could then be converted to a depth of water applied over the computed irrigated area for each parcel. This was accomplished by dividing the volume of water registered by the meters in the billing records by the irrigated area computed based on the NDVI pixel count. For this analysis the necessary conversions were performed to obtain the depth of water in inches that were applied to the computed irrigated area for each parcel.

Variation in Application Rates

Initially, the team's hypothesis was that there would be a direct relationship between the amount of water applied and the corresponding average pixel value. However, a scatter plot of the amount of water applied and the average pixel value for all the available data was produced for each city including a linear trend line which showed an R^2 of nearly zero for both cities.

Further investigation revealed some interesting information. Both datasets contained outliers and were pared down to only include data for parcels that showed an application rate of 4–24 inches of water in the month of August. These datasets included approximately 70% (Spanish Fork) and 75% (Saratoga Springs) of all the connections in the respective PI systems and therefore represents typical conditions while ignoring outliers.

The data were then put into bins of 1-inch increments to generate a histogram showing the how many connections fell into each bin. The histograms for each of the cities showed a shape that is similar to a bell curve indicating that most people apply about the same amount of water to their yards, while smaller groups water more or less than average. The results for each city are shown in Figures 2 and 3.

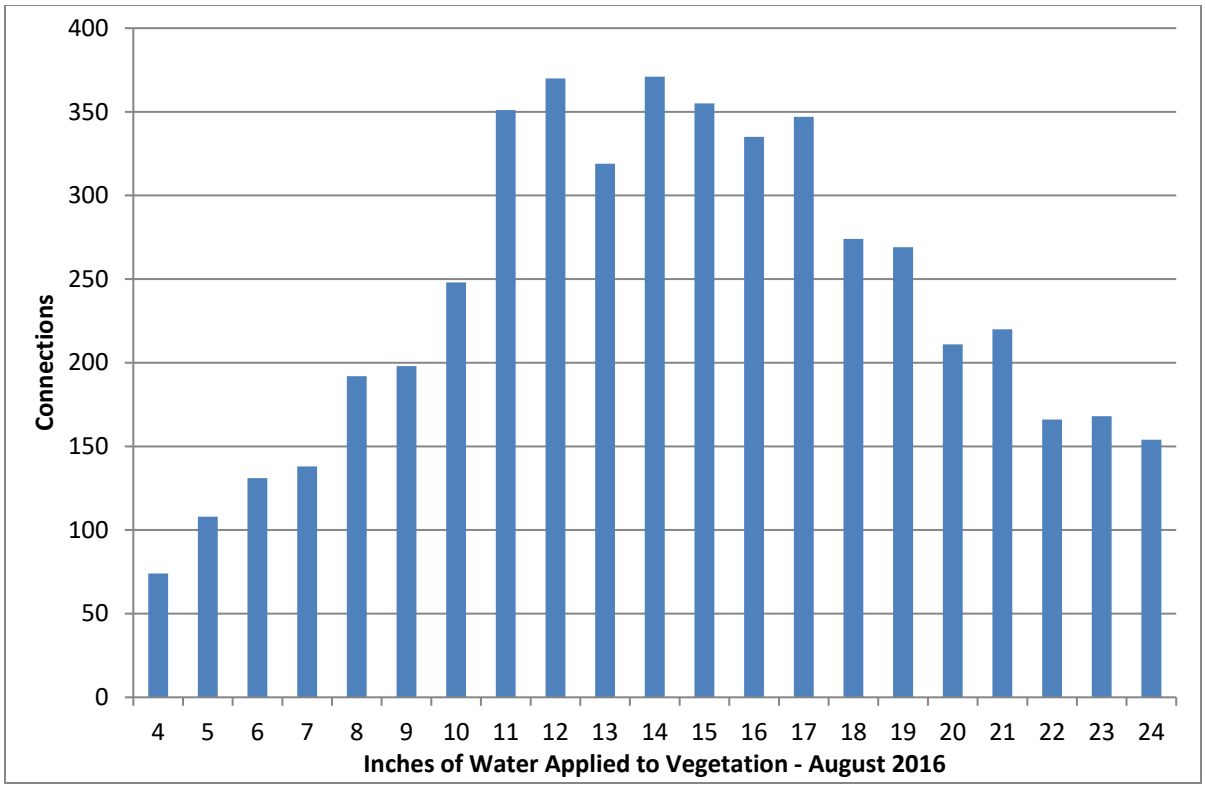


Figure 2. Inches of Water Applied (Spanish Fork)

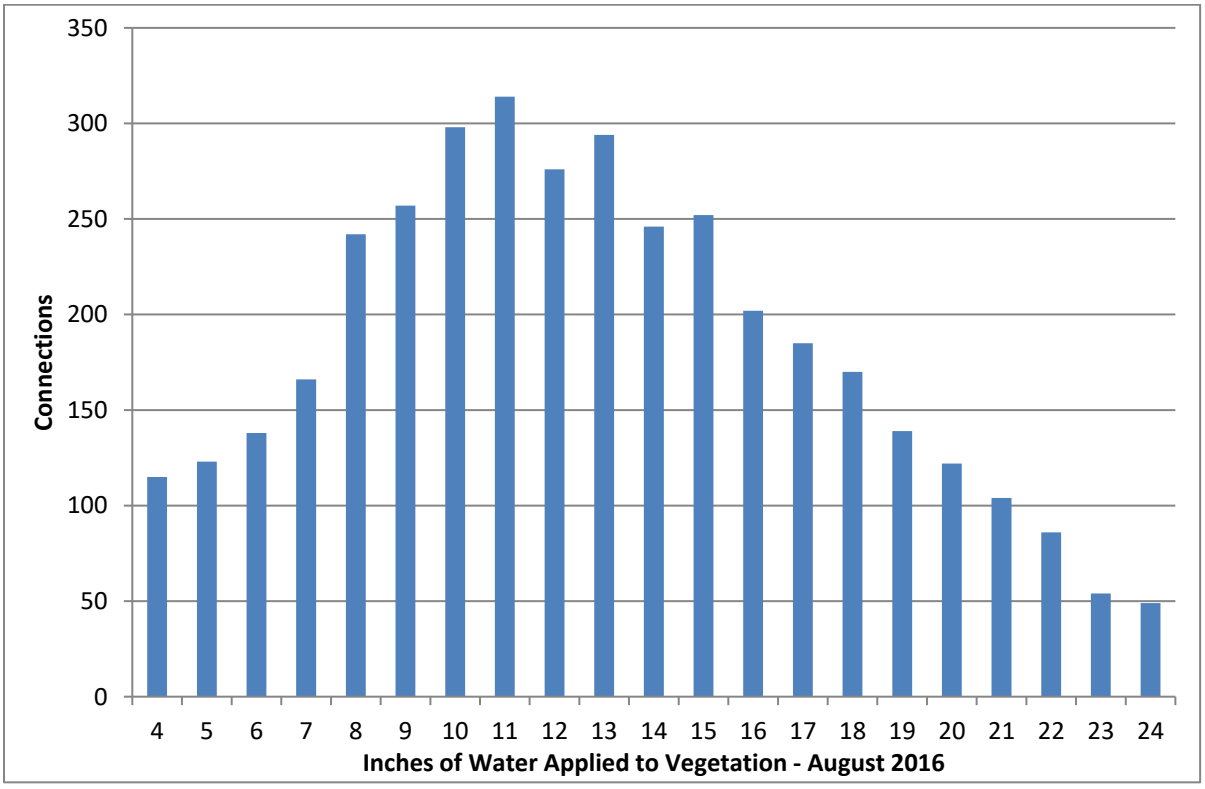


Figure 3. Inches of Water Applied (Saratoga Springs)

Influence of Water Rates

While the general pattern in Spanish Fork and Saratoga Springs is similar, it appears that Saratoga Springs has a larger percentage of their connections watering less than what Spanish Fork is doing. An examination of their respective rate structure may help explain why this is the case. Figure 4 compares the monthly bill for each of the cities per 1,000 gallons used (based on a typical quarter-acre lot size). Saratoga Springs rate payers are penalized with a much higher bill if they use too much water. The rate structure in Saratoga Springs also accounts for lot size and is adjusted as lot sizes increase in an effort to encourage users to apply the correct amount of water to their yards. This appears to have influenced the watering behavior of the residents in Saratoga Springs. This test case provides strong evidence that a tiered billing structure which also accounts for lot size can be effective in reducing outdoor water use.

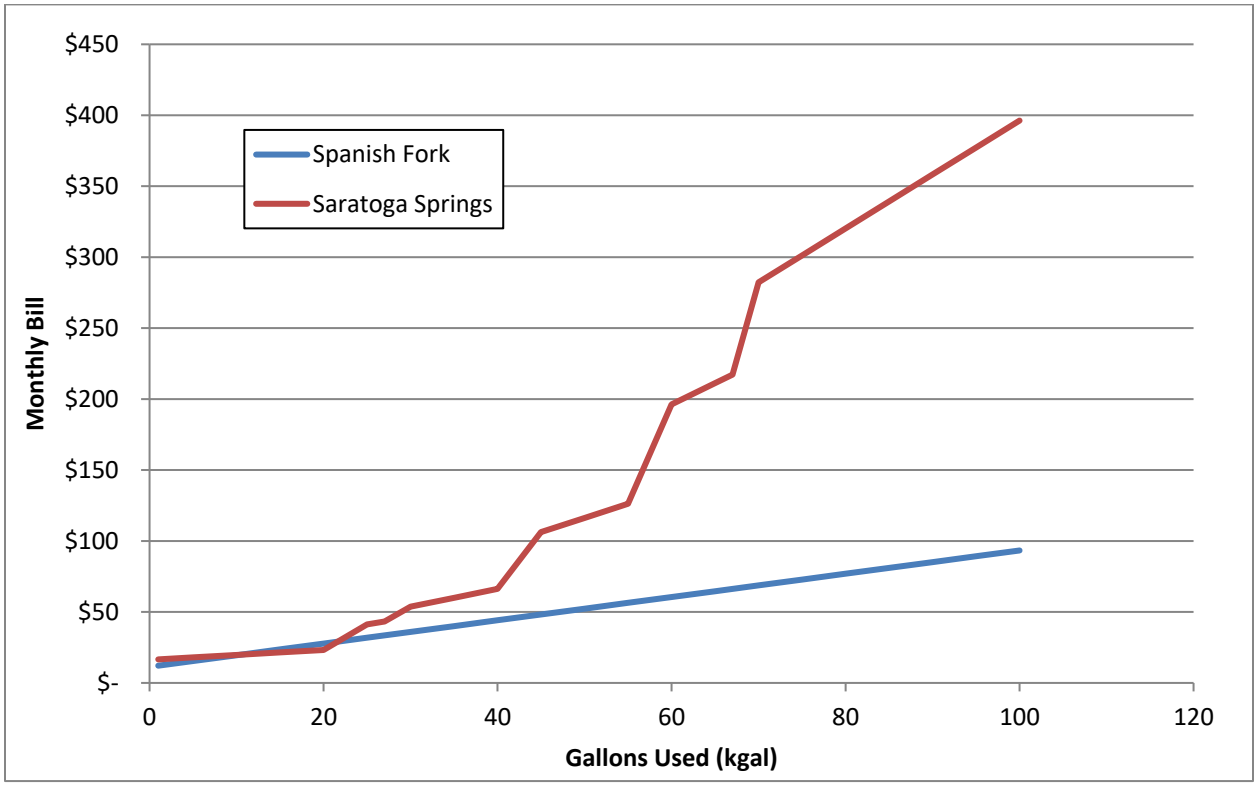


Figure 4. Monthly Bill vs Gallons Used for Typical Quarter Acre Lot

Relationship Between NDVI Imagery And Application Rates

After dividing application rates into bins, the average pixel value was computed for each of the same bins. The results of this analysis are shown for each of the cities in Figures 5 and 6.

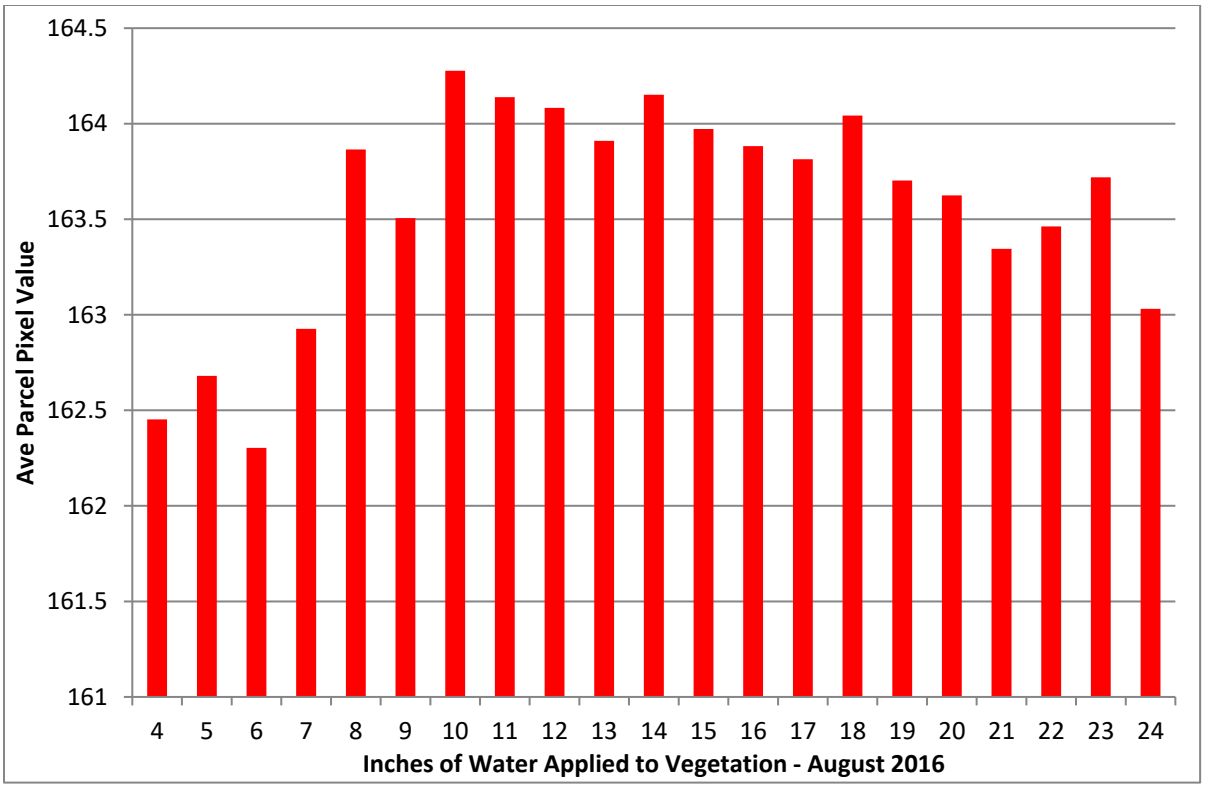


Figure 5. Average NDVI Pixel Value of Parcels with Similar Water Application (Spanish Fork)

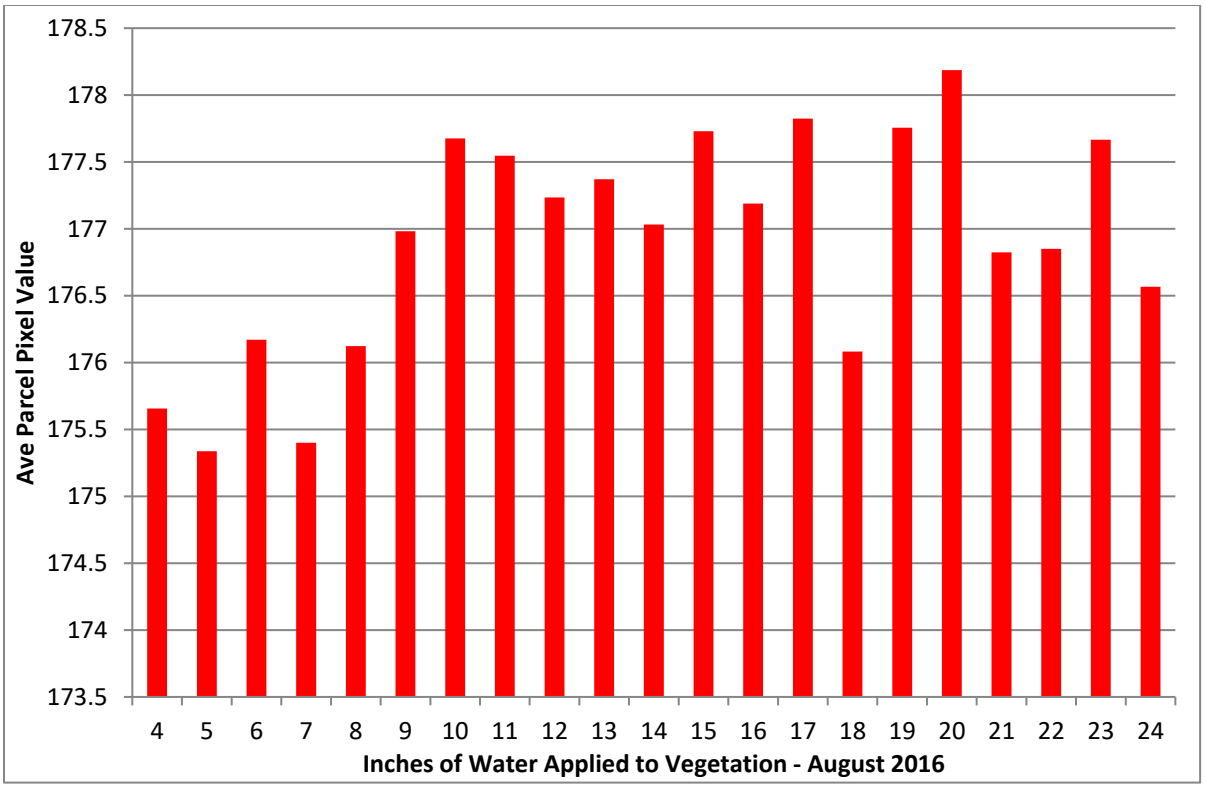


Figure 6. Average NDVI Pixel Value of Parcels with Similar Water Application (Saratoga Springs)

As can be seen in the figures, there is a clear increase in pixel value as the amount of water applied increases up to a hinge point that occurs at around 8 to 10 inches. Beyond 8 to 10 inches, connections applying more water are not seeing an increase in average pixel value. In others words, there is no additional benefit in making one's lawn greener by watering more than what is required to keep the lawn green. A report by Utah State University confirms this assertion, indicating that in the month of August, a typical Utah lawn needs about 2 inches of water per week or about 8 inches in a month (USU, website accessed Nov. 2017).

Once again the overall patterns for both of the cities are similar. The average pixel values for Saratoga Springs are higher overall, but the patterns are still very similar and tell the same story.

Application To DWRE Water Use Data Collection Process

The difficulty in collecting reliable outdoor water use has been well documented. The process of using NDVI data as described in this appendix is an alternative way for the DWRe to estimate outdoor water use. Data collection using this method would be an accurate, repeatable, and consistent approach that would likely require less effort from both the DWRe and the reporting water systems. Not only does this approach provide a relatively fast and simple way to estimate irrigated acreage and outdoor water use, but it also provides a basis for how much water should be applied for municipal irrigation purposes. As shown in the highlighted case studies of this appendix, significant reductions to outdoor water use could be achieved through reductions to water application rates while still maintaining healthy landscapes.

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