Final Report

City of Rawlins Operations Level I Study

A Wyoming Water Development Commission Project
Consultant Contract for Services 05SC0294568

June 2013

PMPC
Saratoga, Wyoming

In association with:

Hinckley Consulting
Laramie, Wyoming

and

TST Inc. of Denver
Denver, Colorado

FINAL REPORT

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INTRODUCTION

INTRODUCTION

Located in south-central Wyoming, Rawlins is the largest city in Carbon County and the thirteenth largest city in Wyoming. With more than 9,000 residents and a strong economy, supported by energy and extraction industries, the city is planning for growth in the foreseeable future.

Operation of the City of Rawlins water system requires balancing three water supply sources, three reservoirs, numerous pump stations, storage tanks, miles of distribution and transmission lines, not to mention treatment and pretreatment plants, see Figure A1-1. The three supply sources have separate treatment requirements and varying outputs depending on the time of year and climatic conditions. The reservoirs' water quality fluctuates with the supply source and the pretreatment plant has a production limit half that of the primary treatment plant.

The three separate water sources for Rawlins are the Sage Creek Basin Springs, Nugget Wellfield and the North Platte River; and each have unique quality, quantity and operational constraints associated with their use. City water use is also limited by Wyoming water law and interstate agreements such as the Platte River Recovery Implementation Program (PRRIP).

There have been numerous studies over the years regarding the City of Rawlins water supply and storage. The past studies have focused on deficient components of the supply and collection system such as: the leaking Atlantic Rim Reservoir, outdated Platte River pumping system, and various transmission line components. The studies were followed up with construction projects that addressed these deficiencies and the City now has a water supply that can meet current and future needs with proper operation and maintenance.

Section 8 of this report has several operational scenarios that describe improvements and changes that can be done to the Rawlins system. These operational scenarios will help manage as well as improve supply and treatment systems that will meet future demands. Section 9 provides costs estimates for implementing the various scenarios and the impact of these costs on user fees.

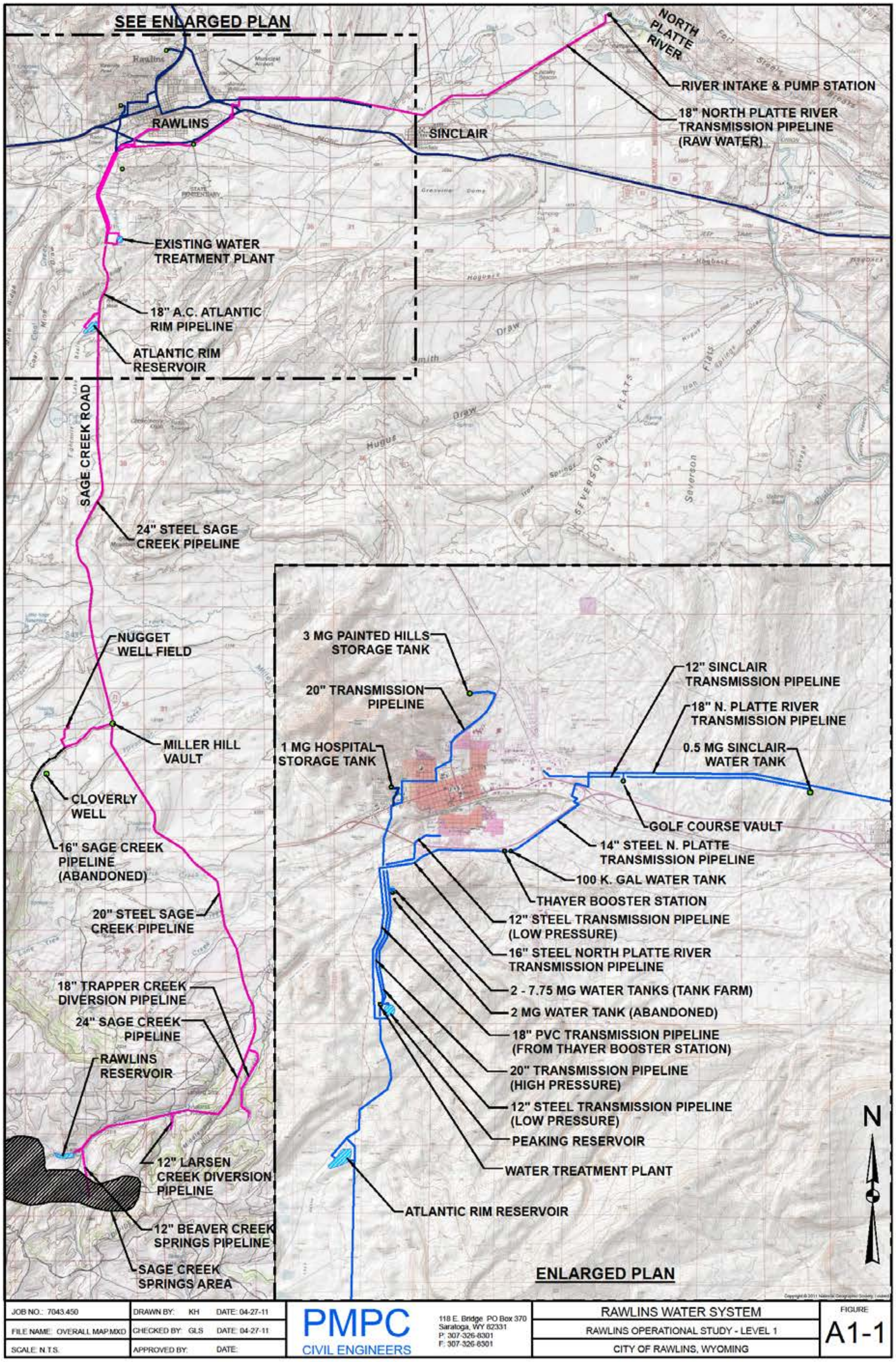


Figure A1-1. Rawlins Water System

Intent

This study is anticipated to be used as a tool by the City of Rawlins to maximize the supply, storage, treatment and distribution of their municipal water. This study is intended as a complement to previous master plans, storage and supply studies completed in recent years.

Goals

The goals and objectives of this Level I study are:

- Review and update previous studies' population and water demand projections.
- Identify development scenarios and their effects on the City's ability to supply, treat, store and distribute water.
- Identify operational scenarios and make recommendations on the best practices for management of the raw water supply to maintain quantity, quality and legal obligations mandated by the State of Wyoming.

Acknowledgements

An operations study of this magnitude would not be possible without the contribution and cooperation of many competent professionals. In no particular order, we would like to thank the following for their contribution to and involvement with this project:

Mike Besson, Wyoming Water Development Commission Project Manager
Danny Rodriguez, Rawlins Water Treatment Plant Superintendent
Dan Izzo, Rawlins Director of Finance
Chris Jones, BLM Rawlins Field Office Recreation Department
Matt Hoobler, Wyoming State Engineer's Office North Plate River Coordinator
Bern Hinckley, Bern Hinckley Consulting Professional Geologist
David Waterstreet, Wyoming DEQ Watershed Program Manager
Stephanie Elliot, P.E. TST Denver Inc.
Eric J. Jenkins, P.E. TST Denver Inc.
Jodi Preston, Water Resources Data System Senior Office Assistant

1 PROJECT MEETINGS

To assess the project as well as define goals and outcomes, meetings were held at several milestones during the project. A scoping meeting was held early in the project schedule to familiarize the City of Rawlins with the planned project and obtain input from City officials. Progress meetings were also completed to refine project direction and overall development. The PMPC team was also in constant communication with City staff and project subcontractors to maintain and define project progress as new information was developed.

1.1 SCOPING MEETING

The scoping meeting was held in the City of Rawlins on July 7th, 2011. Those in attendance: From the City - Danny Rodriquez, Superintendent of Water Treatment, Steve Golnar, City Manager, Blane Frandsen, Director of Public Works and Spencer Ellingson, City Engineer; From the Wyoming Water Development Commission - Mike Besson, Project Manager; From TST Denver Inc. - Bob Takeda; and, from PMPC, - Gary Steele, Project Manager and Seth Tourney, Project Engineer.

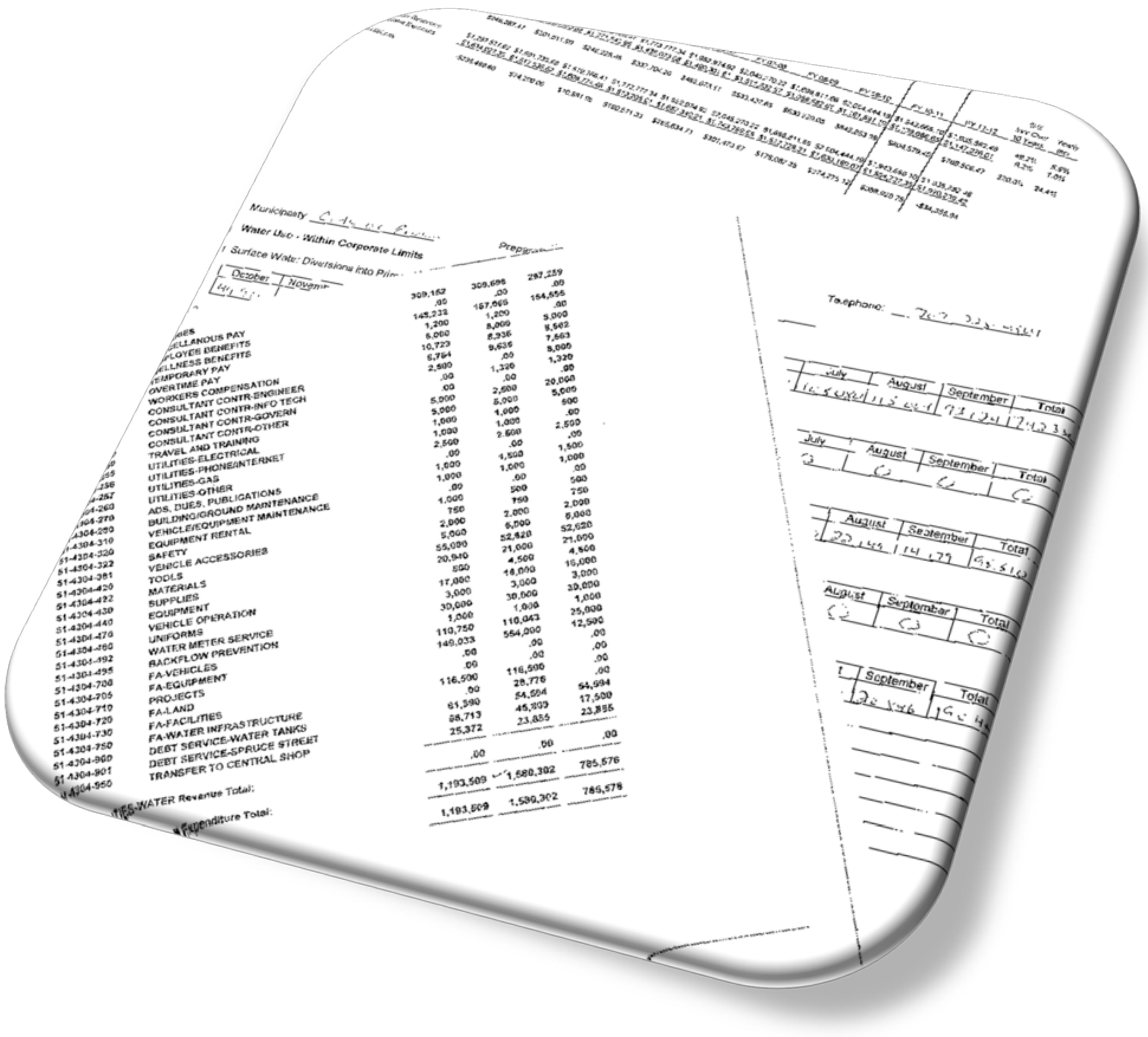
1.2 PROGRESS MEETING 1

A progress meeting was held in the City of Rawlins on March 3rd, 2012. From the City - Danny Rodriquez, Superintendent of Water Treatment, Steve Golnar, City Manager, Blane Frandsen, Director of Public Works and Spencer Ellingson, City Engineer; From TST Denver Inc. - Eric J. Jenkins, P.E., and Stephanie Elliot, P.E.; and from PMPC - Gary Steele, Project Manager.

1.3 PROGRESS MEETING 2

A progress meeting was held at the WWDC office in Cheyenne on February 15th, 2013. From the Wyoming Water Development Commission - Mike Besson, Project Manager; and, from PMPC - Gary Steele, Project Manager.

2 REVIEW OF EXISTING INFORMATION



2.1 INTRODUCTION

Existing data and information was collected from numerous sources including: previous reports and master plans, weather observations, population records, the City's records of water supply and meter billings. Wyoming water law and interstate agreements were also reviewed for their impact on City's water use.

Over the past 30 years a number of important reports and studies have identified the strengths and weakness of the Rawlins water supply and transmission system. The Water Development Master Plan produced by James M. Montgomery, Consulting Engineers, dated 1983, promoted development of groundwater resources as supplement to the Sage Creek Basin Springs in the event of severe drought. Most recently, a Wester-Wetstein & Associates report identified an aging pipeline and leaking reservoir as system weaknesses. The existing reports identified past areas of concern and documented the condition of the water system.

The City gets the bulk of its water supply from a series of springs in the Sage Creek Basin, 30 miles south of Rawlins. These springs are subject to variations in production based on available snowmelt and overall precipitation; so any discussion of the springs output must include a review of regional climate data. Climate data for this report was collected from several sources. Snotel sites, maintained by the National Resource Conservation Service (NRCS) provided invaluable information on seasonal snowpack in the Sage Creek Basin. Precipitation data for the City of Rawlins was taken from the High Plains Climate Center website, records from station C487533 (Rawlins Airport) were used. Further discussion of the limitations of the precipitation data can be found in Section 2.3 of this report.

The State of Wyoming has a number of agencies that collect climate and water-use data. For this report, data from Water Resources Data System (WRDS) and Wyoming State Engineers Office (SEO) were collected and reviewed. Section 2.4 discusses topics framed by the data acquired from these State agencies. Also there has been recent development in the water use picture for the Platte River basin is attributable to the Platte River Recovery Implementation Program (PRRIP), which began operations in the spring 2007.

Population and expected population growth are important components of estimating future water demand; consequently, records from the US Census, Wyoming Department of Administration and Information, previous studies' population projections and City estimates were compiled and reviewed. Population data and projections are discussed further in Section 2.6 of this report.

The City of Rawlins provided water supply and use data from several sources that included operations data from the water treatment plant and the water transmission system. The City's finance office provided data on the water billings and water use by categories such as residential, commercial and the Town of Sinclair. A more complete discussion of the City of Rawlins Data can be found in Section 2.5.

2.2 PAST REPORTS

Table 2-1 is a list of studies in chronological order that were completed to help identify the strengths and weaknesses of the Rawlins water supply and transmission systems.

Table 2-1. Past Rawlins Water Studies

1977	Howard, Needles, Tammen, and Bergendoff	Hydrologic Analysis of the Sage Creek Basin
1982	James M. Montgomery	Wyoming Hydrogeologic and Water Supply Study Task Report No. 1 Phase I
1982	James M. Montgomery	Wyoming Hydrogeologic and Water Supply Study Task Report No. 2 Phase II III IV
1983	James M. Montgomery	Water Development Master Plan VI
1983	James M. Montgomery	Water Development Master Plan VII Background Data and Reports
1984	Anderson & Kelly Inc	Hydrogeologic Evaluation of the Nugget Aquifer Near Rawlins Wyoming Level II Feasibility Study
1984	Black and Veatch	Water Supply Needs Assessment for the North Platte and Little Snake River Drainages
1986	James M. Montgomery	Rawlins Groundwater Project Level III Summary of Interim Report and Nugget Aquifer Report
1986	James M. Montgomery	Rawlins Groundwater Project Level III Interim Report
1986	James M. Montgomery	Rawlins Groundwater Project Level III Nugget Aquifer Report
1986	Jeffrey L. Hauff	Report of a Class III Cultural Resource Inventory, Rawlins Groundwater Project Lower Sage Creek Transmission Line
1986	James M. Montgomery	Wyoming Sage Creek Water Transmission Pipeline and Wellfield Facilities Legislative Executive Summary
1997	Western Water Consultants	City of Rawlins Water Supply Project Level II Phase I Report
1998	Western Water Consultants	City of Rawlins Water Supply Project Level II Phase II Report
2006	Wyoming Water Development Office	Platte River Recovery Implementation Program
2006	Western Water Consultants	Rawlins Raw Water Storage Level II Phase I and II Report
2010	Wester-Wetstein & Associates	City of Rawlins Water Master Plan Level I Final Report

The Water Development Master Plan produced by James M. Montgomery in 1983 promoted development of groundwater resources as an alternative to the Sage Creek Basin Springs in the event of a severe drought. The report was written during an energy industry boom-cycle and a period of rapid development. The memory of a severe drought in 1977 prompted the City to locate back-up groundwater resources to supplement the spring water from the Sage Creek Basin. The report also identified an original wooden stave transmission line from the springs to the City as a weakness.

The 1983 report was followed by studies which eventually led to developing the Nugget Wellfield near Miller Hill. The Nugget Wellfield came online in the mid-1980’s and now is an important part of the Rawlins water supply. During the summer season, free flowing artesian wells contribute as much as 700 gpm to the water supply. Also the wooden stave pipeline was replaced with steel pipe in the mid-1980’s.

The most recent report, the 2010 City of Rawlins Master Plan - Level l, by Wester-Wetstein & Associates, identified several system weaknesses. The most serious being the limited operational capacity of Atlantic Rim Reservoir and a failing Atlantic Rim to water treatment plant transmission line.

The Atlantic Rim reservoir, completed in 1978, has never been fully operational until repairs were completed in late 2012. Leakage through the native soils and bedrock required the reservoir to be completely rehabilitated before the full storage capacity of 644.5 acre feet could be realized. In addition, the failing transmission line between Atlantic Rim Reservoir and the water treatment plant was replaced.

More than thirty years of studies and continuous infrastructure improvements have provided Rawlins with a sustainable water supply capable of meeting current demands. With responsible operation and maintenance, all of the resources are in place to meet the City’s foreseeable future demands.

2.3 CLIMATE AND WATER RESOURCES DATA

The 24 mountain springs 30 miles south of the City are subject to variations in production based on available precipitation; so a review of this mountain basin's climate data was done.

The demand for City water is driven by local climate conditions independent of seasonal mountain snowpack. Climate data for the City was reviewed to identify trends in water use driven by seasonal conditions and was collected from several different sources. Treated water is used for the majority of lawn watering, so a dry summer will increase demand on the City's water treatment plant to meet the seasonal irrigation needs.

Two Snotel sites, maintained by the National Resource Conservation Service (NRCS), provide invaluable information on seasonal snowpack in the Sage Creek Basin area. Sage Creek Basin Site Number 1015 is within the watershed adjacent to the eastern most City springs. Divide Peak Site Number 449, while not in the basin, provides additional data points for comparison with the Sage Creek Basin site.

Sage Creek Basin Site #1015, shown in Figure 2-1, is located at Latitude 41º 24' N, Longitude 107º 15' W at an elevation of 7,850 feet.

Figure 2-1 Sage Creek Basin Snotel Site

The Sage Creek Basin Snotel has been collecting data since 2001. Its location, under the northeast lee of the nearby mountain, which is surrounded by trees, may not be representative of the overall precipitation and prevailing wind distribution of Sage Creek Basin in the area of the City springs. As can be seen from Figure 2-1, the area around the Snotel site is forested as opposed to open sage brush around the City springs, as seen in Figure 2-2. From the protected Snotel location, data would underestimate wind velocity and obscure prevailing wind direction (See Section 5 Snow Fences)

Figure 2-2 Spring Collection Box in Sage Creek Basin

The second Snotel site, Divide Peak #449, is shown in Figure 2-3. The site is located at Latitude 41° 18' N, Longitude 107° 9' W at an elevation of 8,880 feet.

Figure 2-3. Divide Peak Snotel Station

The Divide Peak Snotel is not in Sage Creek Basin but has been collecting data since 1979. The data from Divide Peak has more history and could be representative of long term overall regional snowfall. As can be seen from the photo, the area around this Snotel site is forested and has the same limitations as the Sage Creek Basin Snotel. The available snowpack and precipitation data from both sites is included in Appendix A.

Precipitation data for the City of Rawlins was requested from the High Plains Regional Climate Center (HPRCC). The HPRCC is recognized as the center of expertise in the use of automated weather stations to obtain near-real time climate data. HPRCC also includes in its archive all relevant data from National Weather Service surface weather networks. The Water Resources Data System (WRDS) provided a complete record for station C487533 (Rawlins Airport) in Rawlins for the years from 1998 through 2012 and is included in Appendix B.

2.4 STATE AGENCIES AND RESOURCES:

The State of Wyoming has a number of agencies that collect climate and water use data. For this report data from WRDS, State Climate Office, Wyoming State Engineers Office (SEO), and the Wyoming Department of Environmental Quality (WDEQ) were collected and reviewed.

The Wyoming State Climate Office (SCO) is a branch of the WRDS. Together, WRDS and the SCO are the single largest providers of water and climate-related data in the state.

The Wyoming State Engineer's Office (SEO) is charged with the regulation and administration of water rights in Wyoming as well as compliance with interstate agreements such as the PRRIP. The SEO was consulted to ascertain compliance and reporting responsibilities required by the PRRIP and whether Rawlins' operations appropriately limited the chance of overruns of Rawlins' depletion baseline, a measure of Rawlins historical depletions that occurred between 1992 and 1996. From a basin-wide perspective, the State of Wyoming is required to address depletions that exceed the baseline, this requires accounting of overruns and underruns of each depletion category and may eventually require depletion replacement by the state whenever basin overruns cannot be offset by basin underruns. Matt Hoobler, with the SEO, provided documentation and advice on the City's water rights and obligations under the PRRIP.

An additional resource that was used was the Environmental Protection Agency (EPA), which is responsible for enforcing federal drinking water laws in Wyoming. The EPA has numerous guidelines for drinking water supply. It is the objective of the City to use the "best available" water for customer satisfaction including full compliance with the EPA's Safe Drinking Water Act (SDWA), Long Term 1 and Long Term 2 Enhanced Surface Water Treatment Rules (LT1 and LT2 ESWTR), Stage 1 and Stage 2 Disinfectant/Disinfection By-Products Rules (Stage 1 and Stage 2 D/DBPR) and the Lead and Copper Rule (LCR).

2.5 CITY OF RAWLINS DATA:

The City of Rawlins provided data for this study from several departments. The Public Works Water Department staff provided operational data on metered water supply and treatment quantities. The Finance Department provided meter reading records for City and the Town of Sinclair customers, as well as a summary budget, which profiled operating expenses and revenues. The collected City data is a reasonably complete picture of water production and consumption, which is matched with operating revenues and expenses that have some qualifications or limitations.

The limitations in the City of Rawlins data included gaps in the operational data, meter discrepancies and changes to the meter installations. There is currently no calibration, maintenance, or replacement policy in effect for the City water meters.

The City water supply data provided by the Water Department consisted of monthly report sheets that list the following metered flows:

- Raw Water: all of the water brought into the water treatment plant (WTP) from all sources and storage in millions of gallons.
- Treated Water Production: the total water leaving the WTP and entering the water distribution system.
- Sage Creek Basin Springs Production: the major source of high quality water for the City.
- Nugget Wells Production: a deep well water source not hydrologically connected to the Platte River.

- Platte River Production: the water pumped from the Platte River used to fill Peaking and Atlantic Rim reservoirs as well as for irrigation of the golf course.
- Bypass Flow: water not required to meet demand and returned to the river.
- Sinclair Consumption: water provided to the Town of Sinclair.

The report sheets are completed by Water Department staff on a monthly basis. The records reviewed, with some gaps, cover the years 1997 through 2012, copies of the report sheets are in Appendix C. The gaps in information were filled with the best estimates to complete calculations and some information is not reconcilable. For example, the Town of Sinclair billings do not match the Water Department's supply records. This may be a result of the billing cycle not matching the Water Department record cycle.

The City provided meter billing records from January 2008 through December 2012. As recommended by the 2010 Rawlins Master Plan, the City installed meters on City services and began tracking water use by city facilities: including irrigation for city parks and green areas. Regular tracking of City consumption started in 2008 and full year water records are complete beginning with the 2008-09 fiscal year.

For the Economic analysis, ten years of water enterprise fund financials were provided by the Finance Department. The records cover the fiscal years 2002-03 through 2011-12. Water fund expenses and revenues were combined with sewer funds until 2008 when they were divided into separate departments; the records are in Appendix D.

Some of the water supply data may be questionable. In testing the Nugget Wells there were concerns over the accuracy of the meters used to monitor the wellfield's flows. The behavior of the individual flow meters on the wellheads was questioned due to:

1) Observed large differences between the needle-indicated flow rates and flow rates calculated by totalizer readings and a stopwatch.

2) Inability of the meters to consistently respond to flows below approximately 100 gpm. (The meters sporadically cease to measure any flow at all, while it is obvious that water is passing through the meter.)

3) Visibly poor condition of the individual well flow meters and inoperability of the wellfield master meter.

Water meters are not 100 percent accurate and can lose their sensitivity over time and fail to accurately monitor water volumes. Inaccuracy in water measurements are also the result of outdated meters in poor repair. This report is based on data provided by the City with little allowance made for meter or record keeping discrepancies.

2.6 POPULATION DATA:

Population estimates for this study came from a number of sources and agencies. The US Census, Wyoming Department of Administration and Information (WDA&I), City of Rawlins records, the latest Rawlins Economic Development Plan (dated October 2, 2012) and population projections from previous reports have all been compared to estimate population and projected growth. As can be expected, the estimates vary widely.

The WDA&I uses US Census data to estimate state population and create population projections. According to the WDA&I's most recent report, Wyoming has grown an estimated 2.3 percent since the 2010 Census, which outpaces the national average of 1.7 percent. The currently published growth projections for Rawlins and Carbon County predict a period of relatively flat growth through 2022 followed by negative growth through 2030. Figure 2-4 represents the WDA&I population projection for the City of Rawlins.

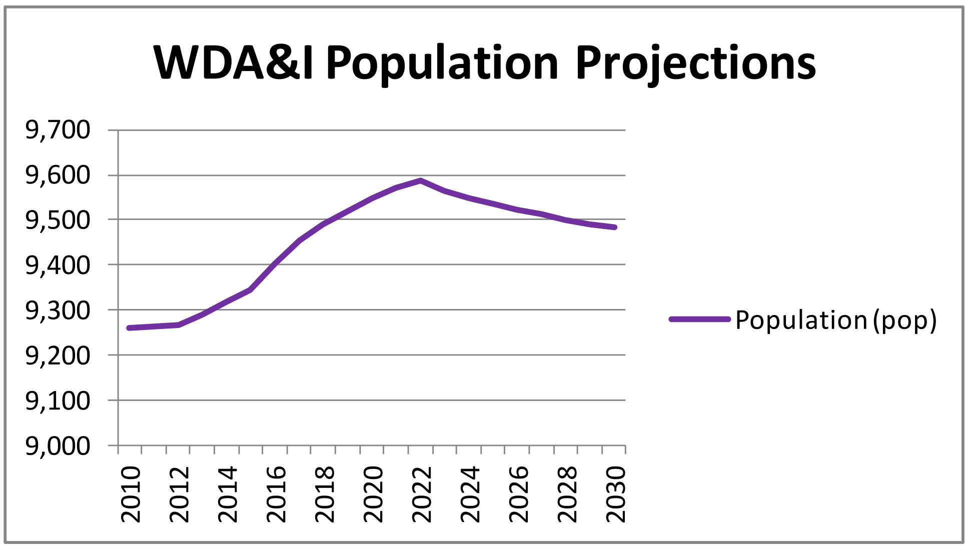


Figure 2-4. City of Rawlins WDA&I Population Projection

Rawlins experienced substantial growth between the 2000 and the 2010 census, which was not reflected in the WDA&I estimates. This bump in the City population was not captured by the census counts nor was the continuous influx of transient energy development workers. However, this transient population is a significant part of the water system demand and it should be included within population counts.

City officials suggest correcting Census estimates by the addition of 210 people each year from 2001 through 2008. The City's correction is based on indicators such as driver's license applications, building permits and water and sewer use.

Figure 2-5 is a graph of the census estimates provided by the WDA&I and City estimates of population from 1998 through 2012.

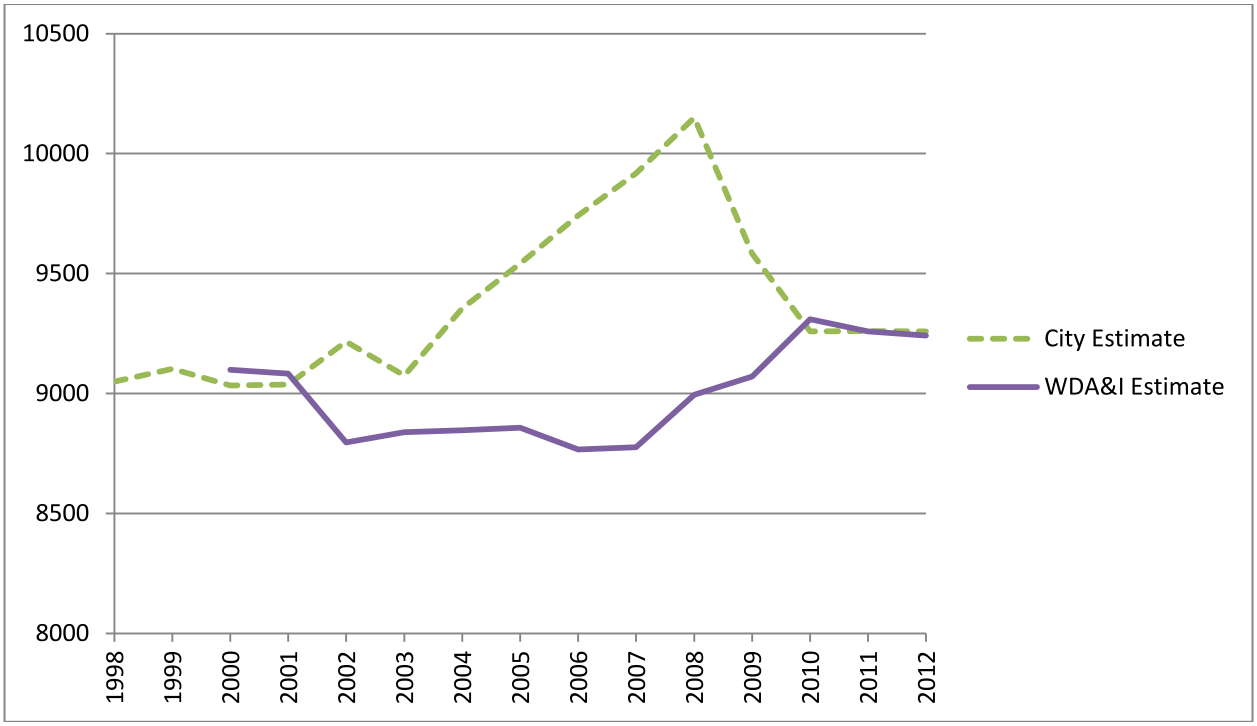


Figure 2-5. Population Estimates

The 2010 Water Master Plan recognized that there is a great deal of uncertainty in projecting the populations of Rawlins and Carbon County. The area has seen periods of growth followed by rapid declines. A single energy project, starting up or shutting down, has the potential to significantly change the course of any population projection. Population projections and impacts to water planning will be further discussed in Section 3.5 of this report.

2.7 WATER RIGHTS AND THE PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

2.7.1 Introduction

From its earliest history, Wyoming has adhered to the doctrine of prior appropriation to allocated water rights. Rawlins has secured senior water rights to both Sage Creek Basin Springs and the Platte River. However, a recent development in the water use picture for the Platte River basin is attributable to the Platte River Recovery implementation Program (PRRIP), which began operations in the spring of 2007.

The City of Rawlins has a variety of direct-flow, storage and groundwater rights as shown in Table 2-2 below.

Table 2-2. Water Rights

Water Rights				
Source	**Permit #**	**Priority**	**CFS**	**Remarks**
North Platte River	2860	10/4/1900	2.010	Fort Steele Pipeline
Big Sage Creek	2947	1/25/1900	3.920	Rawlins Pipeline (5.25 CFS)
Sage Creek	11509	5/27/1912	3.000	Rawlins Pipeline (5.25 CFS)
Sage Creek Springs	16721-			
	16744	3/27/1923	6.920	Rawlins Pipeline (5.25 CFS)
Rawlins Springs	80736	9/14/1989	0.011	
Rawlins Reservoir	6271R	1/28/1955		624.00 Acre-Feet
Peaking Reservoir	7185R	6/7/1966		346.66 Acre-Feet
Atlantic Rim Reservoir	8016R	7/20/1978		644.50 Acre-Feet
Groundwater	306G	9/27/1954	0.268	1,000' Deep, Flowing*
Groundwater	26776	5/3/1974	0.004	650' Deep, Flowing*
Groundwater	26777	1/25/1974	0.004	305' Deep, Flowing*
Groundwater	37510	2/7/1977	0.557	320' Deep, Cemetery*
Groundwater	70332	5/24/1985	0.780	NWF***, 1,730 Feet**
Groundwater	70333	5/24/1985	1.114	NWF***, 1,743 Feet**
Groundwater	70334	5/24/1985	1.114	NWF***, 1,625 Feet**

* These wells are located outside the PRRIP exclusion area and are therefore considered potentially hydrologically connected. Well specific analyses may be warranted.

** These wells are located inside the PRRIP exclusion area and are therefore considered non-hydrologically connected groundwater wells.

*** Nugget Wellfield

2.7.2 Surface water Rights

The Sage Creek Basin water is an important water supply for the City. The Springs have (1923) water rights, which renders the municipal use of water junior to other surface rights in the Sage Creek Drainage. The city has also purchased earlier irrigation rights, 1900 and 1912, which have been converted to municipal use. In total, the City has 13.84 CFS of water rights to Sage Creek and Sage Creek Springs.

The City has a 2.01 CFS water right to the North Platte River with an October 4, 1900 priority which was obtained from the Union Pacific Railroad. In 2002 the City entered into a 50-year joint powers agreement with the Town of Sinclair. The Town of Sinclair has 4.21 CFS of territorial rights that pre-date the City's North Platter River diversion. Under the terms of this agreement, 1 CFS of right was transferred to the City for a 50 year period in exchange for treated water from the Rawlins treatment system. Sinclair pays Rawlins a negotiated rate for their treated water under this agreement. Sinclair's water right is further reduced 2.0 cfs through a lease agreement with the Sinclair Refinery. The water consumed by Sinclair comes under the 1.21 cfs remainder of the original 4.21 cfs territorial right.

2.7.3 Ground Water Rights

The City's groundwater rights include the Rawlins Nugget Wells, the City of Rawlins Well No. 2 (Cloverly Well) near Miller Hill, the Cemetery Well No. 1 and the Penitentiary Well No. 2. The priority of these water rights are junior to the City's surface rights but, being in the PRRIP exclusion zone, they could be key to the City's supply in times of reduced surface flows.

The City of Rawlins Well No. 2, completed in the Cloverly formation, produces approximately 70 gallons per minute (GPM) at the surface. This well was connected to the old wooden stave pipeline from the Sage Creek Basin and was allowed to flow freely into the drainage for an extended time period. The well however, is not connected to the new Sage Creek Pipeline. With the current back pressure on the Sage Creek Pipeline, Well No. 2 has little potential to produce without the installation of booster pumps in the Miller Hill Vault.

The Nugget Formation wells are artesian wells that have a shut-in pressure of approximately 140-PSI. The yield from these wells is limited by back pressure on the Sage Creek Pipeline. With the installation of booster pumps in the Miller Hill Vault, total yields could be improved to approximately 1,000 GPM. The well water has the added advantage of being non-hydrologically connected to the North Platte River, under the terms of the PRRIP. The wells are also independent of seasonal variation or short-term drought conditions.

The Cemetery Well No. 1 and Penitentiary Well No. 2 are situated within the City limits and could provide irrigation water if pumping equipment were installed. Each well has a reported capacity of 250 GPM and could reduce water treatment plant demand during the summer irrigation season.

2.7.4 Water Storage Rights

The City has storage rights on Rawlins, Peaking and Atlantic Rim Reservoirs amounting to 1,615.16 Acre Feet. Rawlins Reservoir is filled by Sage Creek and can be accessed through the Sage Creek Basin Pipeline. Atlantic Rim and Peaking Reservoir can store water from the Sage Creek Basin pipeline or be filled by pumping from the North Platte River. The total water right of 6.15 CFS from the Sage Creek Springs can be used for filling Atlantic Rim and Peaking Reservoirs, also there is an allowable diversion rate from Sage Creek of 5.25 CFS. The Sage Creek Pipeline has an estimated capacity of 11.8 CFS (1986, James M. Montgomery).

2.7.5 Platte River Recovery Implementation Program

In 1997, Colorado, Wyoming, Nebraska and the Department of Interior formed a unique partnership with the goal of sharing responsibilities for addressing endangered species issues within the Platte River Basin. Water users from the three states as well as local and national conservation groups joined the effort.

The PRRIP was implemented to recover habitat for four threatened and endangered species in the Central Platte River basin in Nebraska. Jeopardy biological opinions, by the U.S. Fish and Wildlife Service beginning in the 1970's, were rendered for virtually all water projects (existing and new water related activities) that would deplete flows in the Platte River Basin. The barrage of jeopardy opinions, along with the cost of mitigation, served as the catalyst for creating the PRRIP.

The PRRIP provides a "reasonable and prudent alternative" for addressing the jeopardy condition of the target species by creating or restoring habitat in the Central Platte River, Nebraska. Measures undertaken by the PRRIP provide Endangered Species Act (ESA) protection for all existing water related activities, which allow them to operate as they have historically. Historical municipal depletions were based upon the maximum Platte River Basin water use in a five year period, ranging from 1992 through 1996, for each North Platte River municipality in Wyoming. However, depending on circumstances, the State of Wyoming may incur water replacement obligations if these historical maximum municipal depletions are exceeded and if the municipal under-runs are not sufficient to offset over-runs to the depletion baseline. Therefore, it is important for the State to work closely with each municipality to encourage or change operations that either prevent or delay triggering such replacement obligations.

On January 1, 2007, the State of Wyoming entered into the Platte River Recovery Implementation Program (PRRIP) with the U.S. Department of the Interior, the State of Colorado, the State of Nebraska, representatives from environmental interests and water users' interests throughout the Platte River Basin. The purpose of the PRRIP is to provide ESA coverage for water uses that existed on or before July 1, 1997. The PRRIP also provides a means for the development of Wyoming's water in the Platte River basin while maintaining compliance under the ESA. The State of Wyoming developed a Wyoming Depletion Plan to allow new uses to occur in the North Platte River basin in Wyoming without adversely impacting the targeted endangered Platte River Basin species. This depletion plan is referenced in the PRRIP "Program Documents."

In the Wyoming Depletions plan municipal water use is measured against a depletion baseline that consists of the highest annual water use (depletions) that occurred during the irrigation season and non-irrigation season from 1992 through 1996. Under the PRRIP, Wyoming must measure and compare current annual depletions against the allowable annual depletion thresholds that were quantified for each municipality during this 1992-1996 period. Annual depletions for the City of Rawlins were established at 1,341 Acre Feet in the irrigation season, from May 1 through September 31, and 462 Acre Feet during the non-irrigation season, October 1 through April 31.

The City provides a completed "Platte River Depletion Report-Municipal Water Use" form annually to the SEO's office. City water use is itemized under the following headings:

- Surface Water Diversions into Primary Treatment
- Ground Water Deliveries into Primary Treatment
- Surface Water Diversions into Raw Water Irrigation
- Groundwater Diversions into Raw Water Irrigation
- Measured Effluent through Waste Water Treatment Facilities
- Surface Water Sales, Ground Water Sales
- Waste Water Effluent Treated from Water Sales
- Waste Water Effluent Treated from Non-Municipal Water Supplies and other diversions.

Since PRRIP implementation in 2007, water accounting has been undertaken by the State Engineer's office and is based on reports that are provided by the City. The accumulated data, for the Upper Platte Basin, has shown the municipal use is either meeting or under allowable municipal depletions thresholds and agricultural use is regularly under the allotted irrigation depletion amounts. These under-runs are expected to continue into the foreseeable future. In the event of the City exceeding their depletions thresholds, the State engineer will put them on notice.

Once notice has been provided that depletions have been exceeded, the City will provide the State Engineer's Office with a plan to meet the benchmark in the water year. The City's plan to reduce depletions could include conservation measures or purchase agreements. The City has recently made plans to reserve and purchase Pathfinder Modification water; see the next section for more details of the agreement.

2.7.6 Pathfinder Modifications

In 1995, the Wyoming Water Development Commission (WWDC) requested that the U.S. Department of the Interior, Bureau of Reclamation - Wyoming Area Office (Reclamation) evaluate the Pathfinder Modification Project (Project). The Project is an alternative to the Deer Creek Dam and Reservoir, which was embroiled in the Nebraska v. Wyoming lawsuit.

The purpose of the project is to provide the same municipal water supply benefits as the Deer Creek Project and assist in the resolution of the endangered species issues that have plagued water management and development in the Platte River Basin since the early 1970s.

The Project recaptures approximately 54,000 acre-feet of storage space lost to sedimentation in Pathfinder Reservoir. The recaptured storage space will store water under the existing 1904 storage right for Pathfinder Reservoir; however, with the exception of Seminoe Reservoir, the Project cannot be the cause of any requests for water rights administration in the North Platte Basin above Pathfinder Reservoir.

In November, 2001, the operation of the Pathfinder Modification Project was prescribed and authorized in Appendix F to the Final Settlement Stipulation to the Nebraska v. Wyoming law suit. The Pathfinder Modification Project consists of two storage accounts, the Wyoming Account and the Environmental Account.

The Wyoming Account includes 20,000 acre-feet of storage space. The U.S. Bureau of Reclamation, through an agreement with the State of Wyoming, will operate the 20,000 acre-foot Wyoming Account to provide a yield of 9,600 acre-feet annually. The first priority for the Wyoming Account is to serve as a supplemental supply for North Platte municipalities if and when their water rights are subjected to administration (priority regulation). Until the municipal demand reaches 9,600 acre-feet per year, the State of Wyoming may utilize the Pathfinder water to meet replacement water obligations specified in the modified North Platte Decree and/or for depletion replacements needed to comport with the Platte River Recovery Implementation Program. In years that the yield is not needed for these purposes, water may be leased to the Platte River Recovery Implementation Program through annual temporary water use agreements to help the state defray its share of project operation and maintenance costs for the Pathfinder Modification Project.

Water from the Environmental Account is the State of Wyoming's and Reclamation's water contribution to the PRRIP on behalf of Wyoming's water users including the federal storage water contractors in Wyoming and Nebraska. This water contribution ensures that clearances required under the ESA will be provided for existing uses as well as for certain specified new uses and that these water-related activities will continue to beneficially use Wyoming's water well into the future.

The Environmental Account has a capacity of approximately 34,000 acre feet. Water from the account will be released for fish, wildlife and environmental purposes to develop habitat in Nebraska per the PRRIP.

3 WATER USE: EXISTING AND PROJECTED

3.1 INTRODUCTION

Municipal water use is a function of both population and precipitation. Population-driven use is obvious; more people equals more water consumption. Precipitation-driven use is more subtle and responds to variations in precipitation, especially during the irrigation season. Use is also impacted by system losses and inefficiencies such as unmetered consumption and leakage.

Quantifying water use is by nature inexact and must be approached systematically. The water use numbers come from City departments with separate operational goals. While the public works department is interested in the big picture of keeping water in the pipes, the Finance Department is more interested in getting paid for delivered water. The Public Works Department provided meter readings from the supply sources and Water Treatment Plant output. The Finance Department provided meter readings from billings. The two sets of numbers usually do not coincide, without making several assumptions about water use.

The WTP output volume is recorded monthly and represents the treated water made available to the distribution system. This total output satisfies municipal demands from metered customers, including public irrigation needs. The total also includes system leakage and losses. Finished water output accounts for the majority of revenue production through metered water sales. However, total water treatment plant (WTP) output alone is not a clear picture of City use. To understand water use trends, output must be separated into components including baseline demand, water losses and irrigation use. Existing data from the City of Rawlins and the Town of Sinclair was reviewed to identify historical supply and usage trends. The historical supply data comes from WTP records and climate data from the sources listed in Section 2.3 of this report.

The Finance Department provided monthly meter readings that were divided into user groups. The residential meter numbers were used to identify sold water and the difference between produced and sold water. The residential meter numbers were also used to identify per capita demand. Estimated per capita demand will help define Water Department plans for future growth.

Population-driven demand is a major concern as the City develops. The reliability of the water supply is also an important consideration in planning for growth and development. The City has to understand the production limits of their water sources and the costs of delivering quality water to customers. Rising population and the resultant demand increases will necessitate ongoing water system improvements to maintain quantity and quality of water service.

While population increases require long term facilities improvement, climate variations create short term stress, especially during the irrigation season. In a normal precipitation year, irrigation demand increases the overall baseline consumption by more than 300%: from 40 million gallons to more than 120 million gallons per month. A dry summer can exceed baseline uses by more than 325%. This irrigation demand may also coincide with seasonally stressed supply sources as well. The City's supply and usage data as well as climate data was reviewed to identify historical long and short term weather patterns and their impact on usage and supply.

The following sections will analyze the current water use patterns from the perspective that seasonal drought conditions have a greater impact on water use than short term changes in population.

Figure 3-1 Sage Creek Basin Springs Collection Box.

3.2 EXISTING WATER DEMAND

To quantify water demand for trends related to population growth and seasonal variation, an analysis of the City's water records was completed. Total Water Treatment Plant (WTP) production records from 1998 through 2012 were compared with meter billings from 2008 through 2012, see Appendix C. WTP output was broken into components which included baseline demand, irrigation use and water losses. The meter billings for domestic and City metered consumption were reviewed and compared to the WTP numbers to validate estimated in-house use and help identify potential loss mechanisms. The City's per capita water use was then compared to national consumptive use averages.

3.2.1 Baseline Demand

Baseline demand is in-house use; it's the water people use to cook, clean, flush toilets and serve other necessary home functions. System losses, such as unmetered consumption and leakage are also associated with baseline demand. System losses constitute a hidden cost of delivering water to customers. System losses are attributable to a combination of distribution line leaks, water service leaks (before the meter), by-passed meters, unmetered taps, faulty or un-calibrated meters and meter reading errors.

To identify baseline demand, non-irrigation season WTP production numbers were extended over the full year and assumed to be a composite of in-house metered use and system losses. Overall baseline demand should marginally follow population trends. When the City's baseline demand is plotted with the Rawlins population estimates in Figure 3-2, there is a strong correlation between changes in population and baseline demand. When the City's water consumption is subtracted from the baseline demand; per capita consumption is calculated to be 130 gallons per capita day (GPCD) of in-home use.

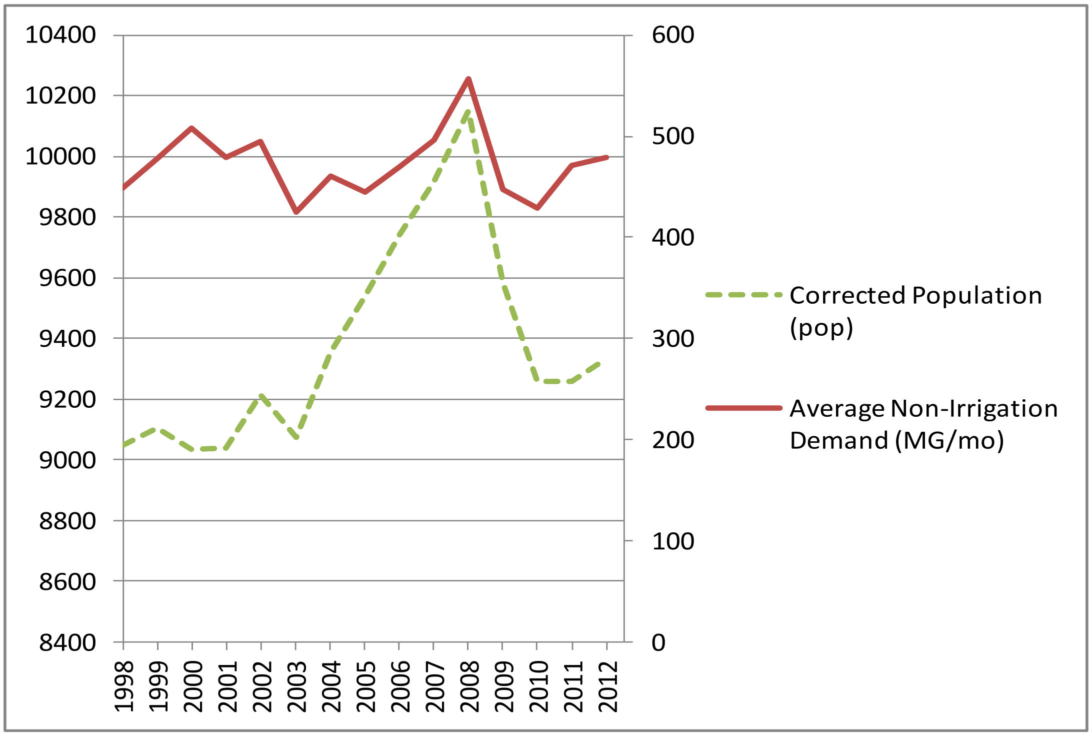


Figure 3-2. Non-irrigation Season Demand and Population

Meter billings are a more direct way to estimate GPCD and substantiate overall WTP estimates. In Figure 3-3, average residential non-irrigation season monthly meter volumes are plotted against City estimates of population for the years 2008 through 2012. Once again there is a direct correlation between baseline demand and population. From the meter volume monthly totals, average baseline demand is approximately 100 GPCD.

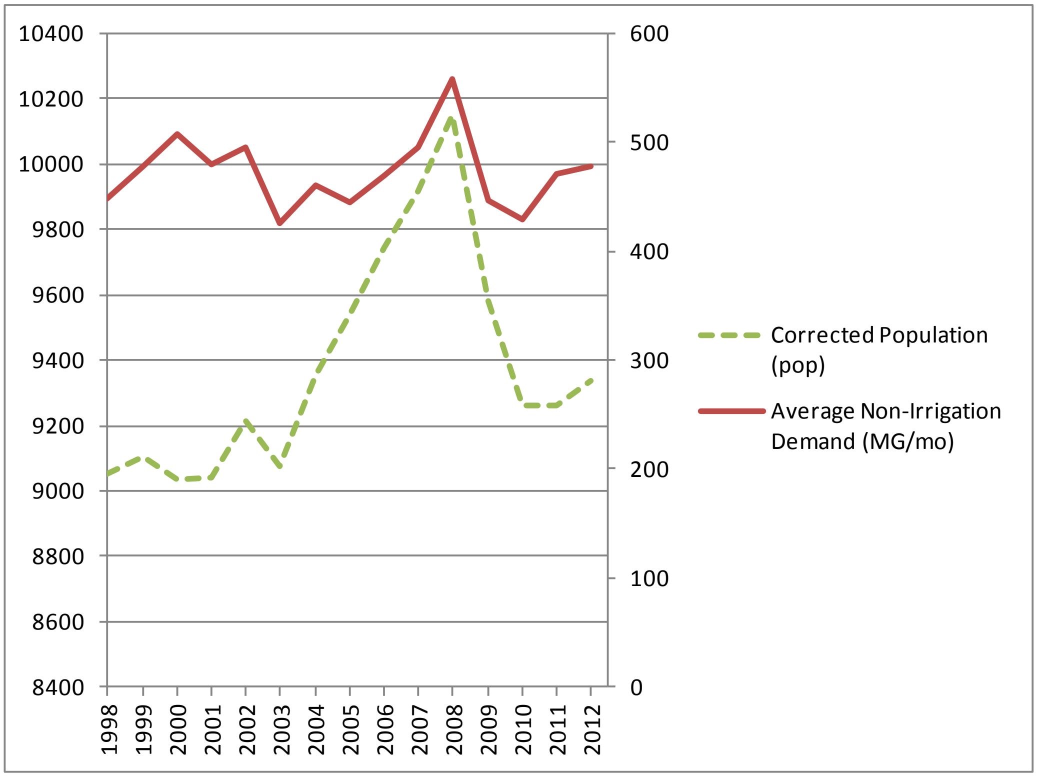


Figure 3-3: Metered Average Baseline Demand and Population.

3.2.2 National Average Baseline Demand

Average water use in the United States can be estimated from many data sources ranging from specific community data to federal sources. Previous reports for the City of Rawlins have divided WTP production by population to arrive at an average per capita usage of 200 GPCD. Two hundred gallons GPCD is consistent with a 1990 U.S. EPA report, which estimated water use in the United States averaged 183 GPCD. In 1995 the U.S. Geological Survey estimated water use to be 179 GPCD. This is total average in-house and outside use; not necessarily baseline use. It is important to identify in-house use for the City of Rawlins, because in-house use is directly impacted by population trends while outdoor demands are driven by seasonal precipitation variations and irrigation requirements.

In 1996, the American Water Works Association (AWWA) estimated in-house water use as follows: "Daily indoor per capita water use in the typical single family home with no water-conserving fixtures is 73 gallons. Table 3-1 shows how the AWWA breaks down in-house water use.

Table 3-1. AWWA In-House Water Use

Use	Gallons Per Capita	Percentage of Total
Showers	12.6	17.3%
Clothes Washers	15.1	20.9%
Dishwashers	1.0	1.3%
Toilets	20.1	27.7%
Baths	1.2	2.1%
Leaks	10.0	13.8%
Faucets	11.1	15.3%
Other Domestic Uses	1.5	2.1%
Total Daily Water Use	**72.6**	**100%**

The AWWA water use value represents average “in-house” use. When Rawlins average loss of 20% is added to the AWWA total, 91 GPCD would be the expected in-house use for a city resident.

Both the WTP numbers and the meter billings estimate the City’s average in-house water use to be approximately 100 GPCD. This is a little more than the national average but not out of the ordinary.

3.2.3 Irrigation Demand

As discussed, demand is dependent on population and irrigation. From a review of the City’s data, it’s apparent that water demand goes up in the summer as outside use and irrigation increases, see Figure 3-4.

Demand is relatively flat at approximately 40 million gallons per month during the non-irrigation months. In the summer, demand averages 55 million gallons per month over the baseline. If the same ratio of loss is applied to the irrigation water as baseline demand, 44 million gallons of treated water per month goes to irrigation and other outside uses. From the City records, 10 million gallons a month is used by the city for watering public spaces such as parks, ball fields and the cemetery. So municipal watering represents 25 percent of the City’s annual water use.

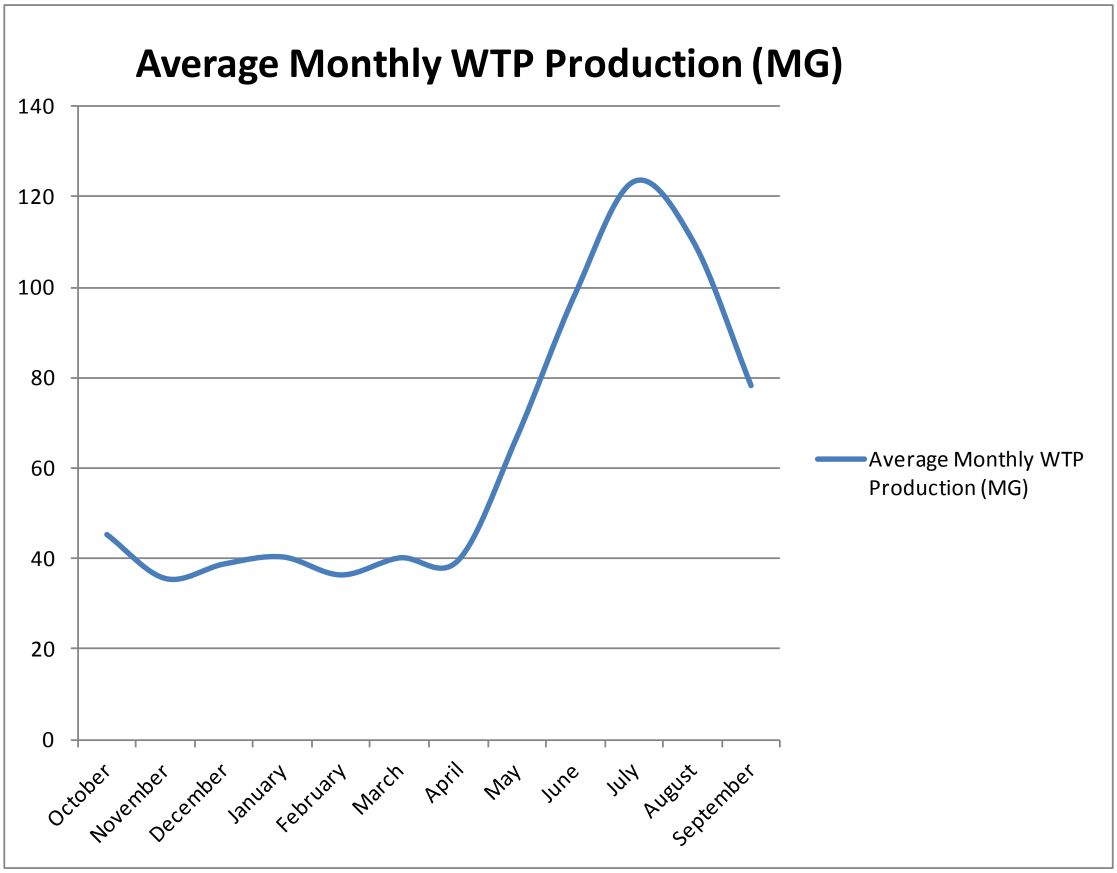


Figure 3-4. Average WTP Production by Month (1997-2011)

Residential irrigation would follow increases in population, if the additional population were increasing irrigated acreage. Irrigation consumption is less driven by changes in population than changes in seasonal precipitation. The City is the largest single consumer of irrigation water. Although the population may have increased, the City has not recently increased irrigated acres. From Figure-3-5, it does not appear that residential irrigation follows major population trends as much as it inversely follows seasonal precipitation levels. Combining residential in-house demand of 100 GPCD with the average irrigation demand of 125 GPCD; the average residential demand is 225 GPCD.

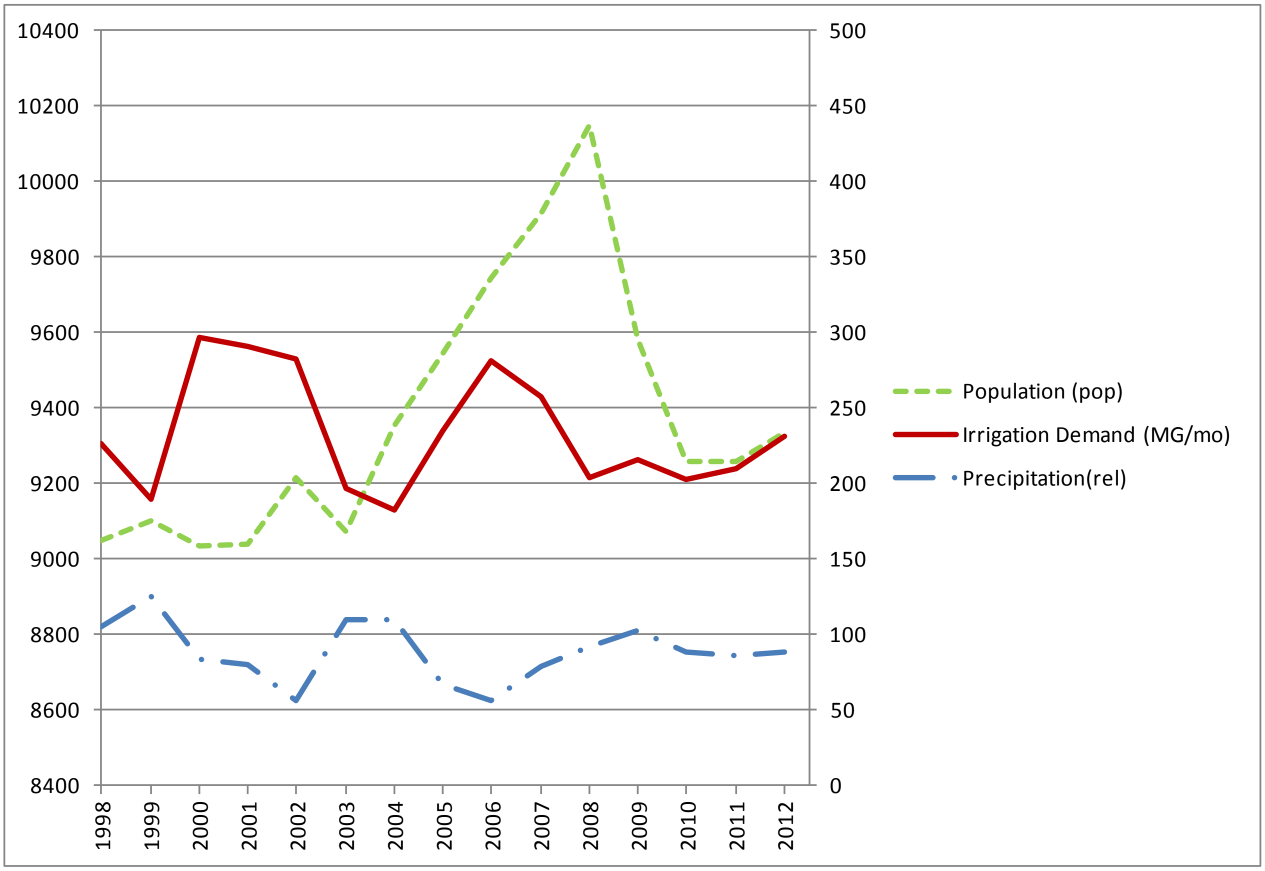


Figure-3-5: Irrigation Demand and Precipitation vs. Population.

A simplistic assessment of per capita use would be 'average finished water production' divided by a population estimate. Based on population and water usage from 2009 through 2012, per capita use averaged 212 GPCD. This coincides well with the figures reported in previous master plans. WWC reported usage at 206 GPCD (WWC, 1997), JMM reported 202 GPCD (JMM, 1983) and Wester-Wetstein & Associates reported use of 201 GPCD (WWA, 2010).

3.3 WATER SUPPLY

As previously identified, the water supply system for the City of Rawlins is complex with three raw water sources, three reservoirs, as well as pretreatment and treatment systems. The maximum population that can be served is determined by a combination of treatment capacity and supply under severe drought conditions. This section describes this complex system and the limits of population that can be served.

3.3.1 Raw Water Sources

The Sage Creek Basin water supply varies depending on the current and previous season's precipitation. For this study, precipitation conditions from water years 1997 through 2011 were analyzed. The fifteen years of data were separated into three categories; dry, 5.8" to 7.5"; average, 7.5" to 9.7"; wet 9.7" to 12.6" of precipitation. The monthly precipitation was averaged over the five dry years, five average years and five wet years to identify the effects of seasonal variation on supply trends.

Figure 3-6 is a graphical representation of the water supplied by the Sage Creek Basin categorized by wet, average and dry water years.

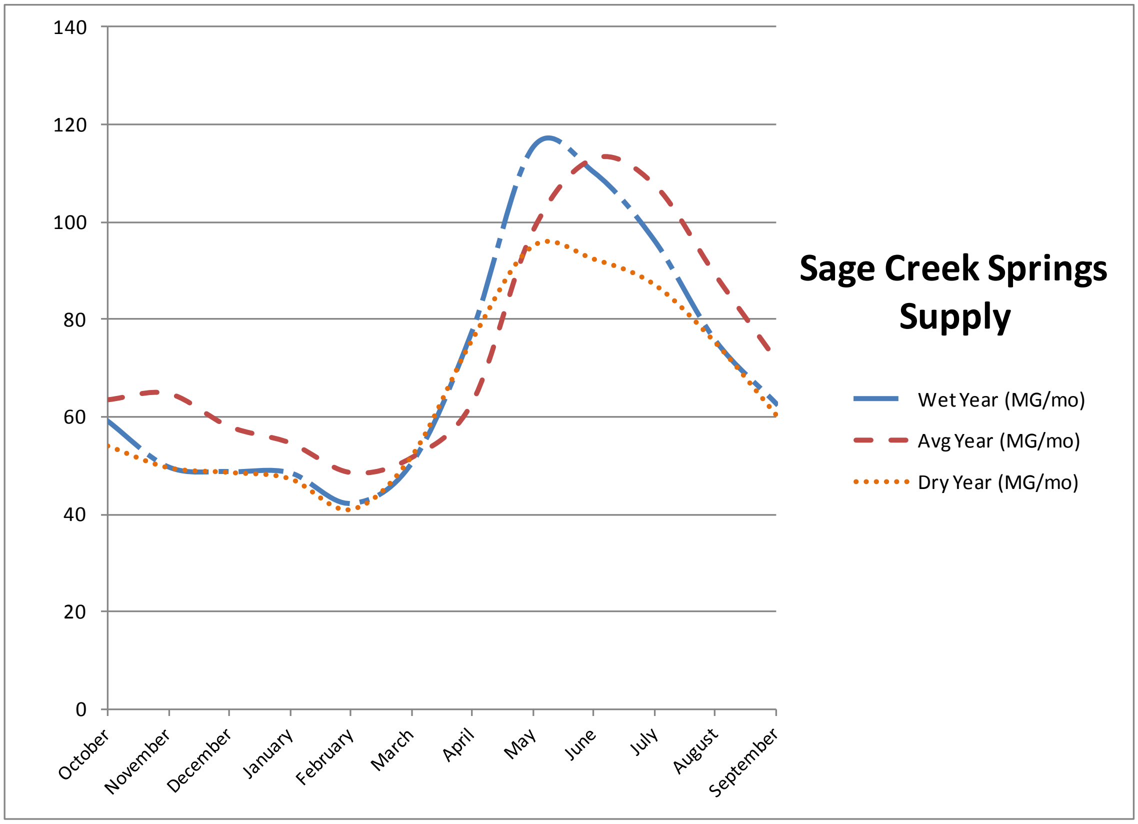


Figure 3-6. Monthly Average Sage Creek Springs Water Supply 1997-2011.

As can be seen from the graph, the Sage Creek Basin Springs water supply is directly dependent on the seasonal precipitation; so in wet years the Springs produce more water. While this may be obvious, what is not so obvious is the water supplied during the wet years is only slightly more than the water supplied in the average years. This may be a result of the Springs' collection system being optimized for an average year and excess water bypassing the collection system during the wet years. Total dry year production can average 112.9 million gallons less than an average water year's production of 884.2 million gallons.

Water use data from the Nugget Wells also shows variation from wet years to dry years but there are some inconsistencies in the data. The short term water production of the wells is not impacted by seasonal precipitation but is impacted by long term use, as discussed in Section 4 of this report. Figure 3-7 shows the wells get less use during average and wet years and increased use in the dry years; establishing their important role as supplemental water for the Springs. The water from the wells has the added advantage of decreasing PRRIP depletions. The graph shows more demand for well water in wet years than average years; which may be a result of the small data set analyzed for this study. The wells had zero use from November of 2007 through June of 2012. These years were all average or wet years. When the data from the nonuse years is normalized, Nugget well use appears to peak at 21.6 million gallons a month in dry, average and wet years. The wells output is more influenced by management decisions than what the wells can potentially produce in any given water year.

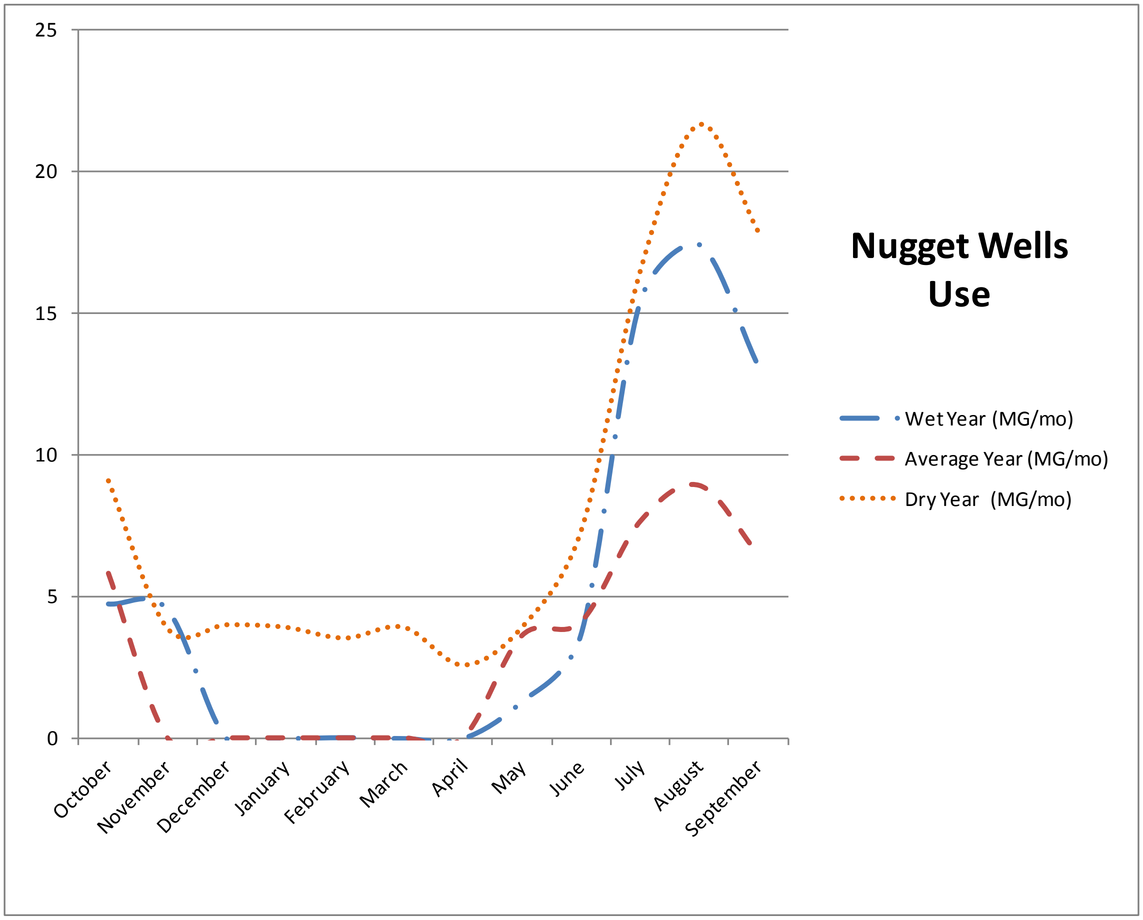


Figure 3-7. Monthly Average Nugget Wells Water Supply 1997-2011.

Platte River water is introduced into the water supply mainly for irrigation of the Rochelle Ranch Golf Course; although it can be treated and used for potable supply as well. The Platte River water efficiently meets golf course irrigation needs as it does not require treatment before use. From Figure 3-8, it's apparent there is more water taken from the river during dry precipitation years. The demand for irrigation water is greater during the dry precipitation years when the Springs supply is reduced. The City supplements the water supply by pumping raw, untreated water from the river to the golf course as well as to Peaking and Atlantic Rim reservoirs, which can then either be used by the golf course or serve as a supplemental supply for the Water Treatment Plant.

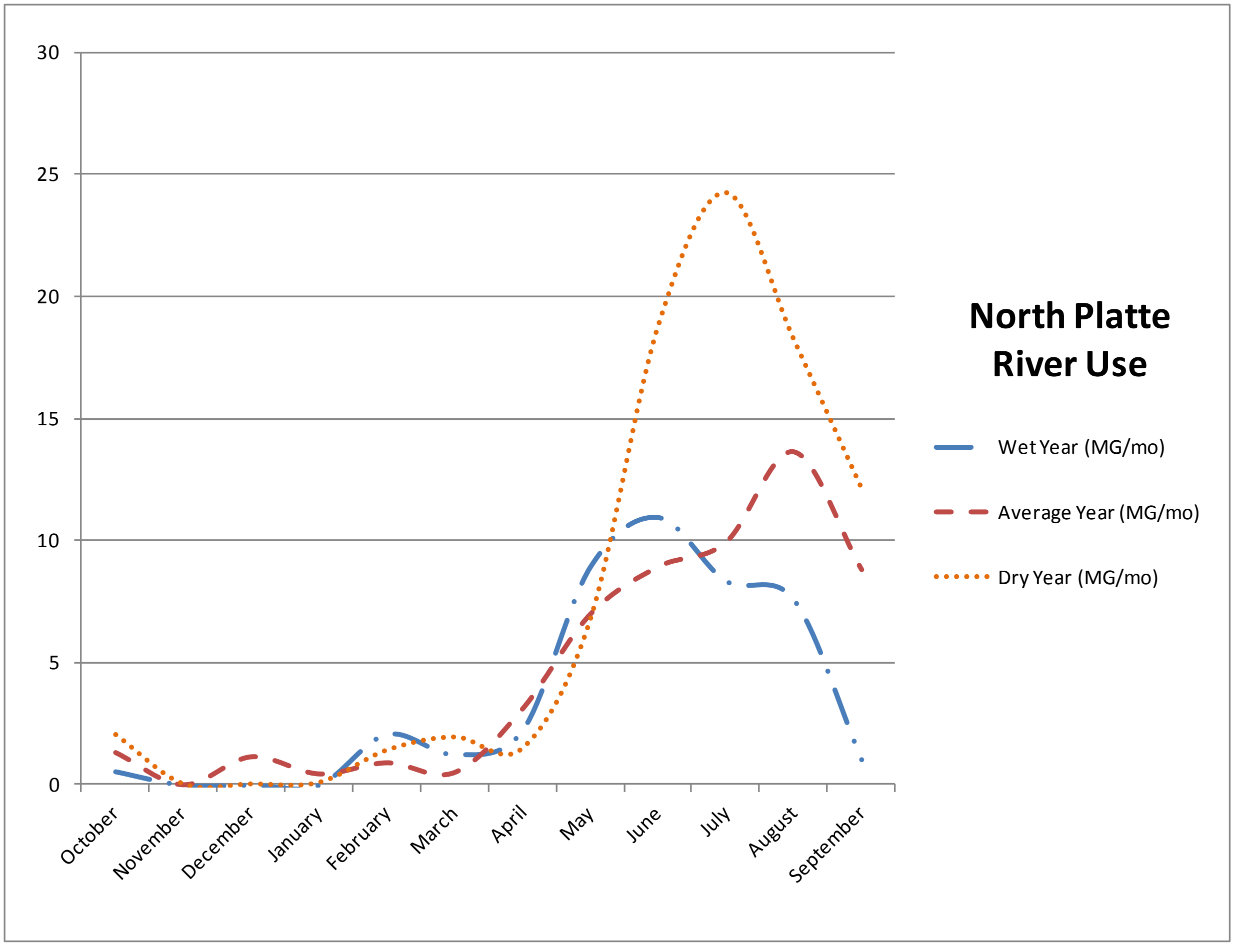


Figure 3-8. Monthly Average North Platte River Supply 1997-2011

3.3.2 Reservoir Storage

The City has storage in the Peaking, Atlantic Rim and Rawlins reservoirs. Peaking and Atlantic Rim reservoirs can be filled with Springs water and accessed by the Sage Creek Basin pipeline. Rawlins Reservoir is filled with surface flows in the upper Sage Creek. In addition, the Atlantic Rim and Peaking reservoirs can be filled with Platte River water via the Thayer Booster Station, see Figure 3-9.

Peaking reservoir, with 346.66 acre feet of storage, was permitted in 1966 under permit No. 7185. Peaking is also closest to the water treatment plant and the first reservoir accessed when the Springs supply does not meet demand. Water stored in Peaking Reservoir is typically supplied by the Springs.

Atlantic Rim Reservoir, with 644.5 acre feet of storage, was permitted in 1978 under permit No. 8016. From its construction in 1978, Atlantic Rim Reservoir has experienced reliability and usability problems. Leakage through the foundation had prevented the Reservoir from operating at full capacity. A liner was installed in the summer of 2012 and, at the writing of this report, the reservoir is being filled.

Rawlins Reservoir, with 624.0 acre-feet of storage, was permitted in 1955 under permit No. 6271. Rawlins Reservoir is the highest reservoir in the system and closest to the Sage Creek Basin Springs source. The reservoir is reported to have poor water quality and sediments accumulate in the Sage Creek Basin pipeline when water from this reservoir is used. However, releases from Rawlins Reservoir satisfy senior water rights when Sage Creek is under regulation.

Peaking and Atlantic Rim reservoirs should provide adequate operational storage capacity for the City’s municipal supply. With recent rehabilitation work completed, Atlantic Rim can generally meet water demands. The maximum accessible storage in Peaking and Atlantic Rim, with 10% allowance for water below intakes, is 290 million gallons. The design minimum storage stage occurs when Atlantic Rim is 10% full and Peaking 90% full. This operational range maintains intake head in Peaking for Water Treatment Plant operation and results in 188.6 million gallons of storage capacity.

In total, the City has 1,615.16 acre-feet of permitted storage. Of this permitted storage, 578.7 acre-feet are readily accessible and are of acceptable water quality. This is enough water for 3 months of peak summer demand or 7.5 months of winter baseline demand, when combined with nominal flow from the Springs.

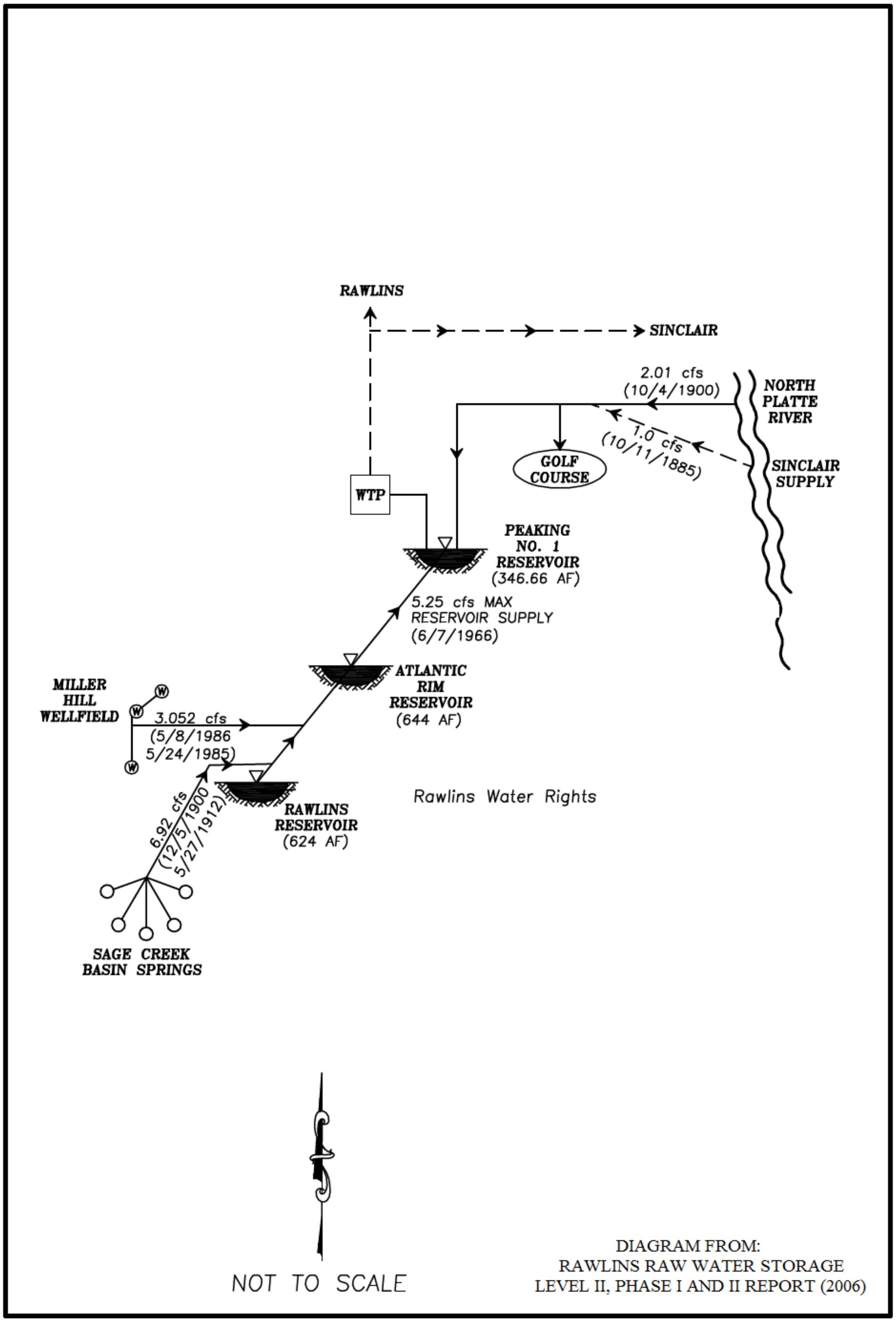


Figure 3-9. Reservoir Diagram

3.3.3 Operational Planning Limit

The operational planning limit is a theoretical lowest potential water supply available to the City for distribution to customers. The total raw water supply from the three sources is impacted by a number of factors. As previously discussed, seasonal snowpack and summer precipitation directly impact the Springs supply as well as overall demand. Each water source has different treatment requirements, which creates issues that may adversely affect Water Treatment Plant capacities. The water from the Springs requires little treatment; the Nugget Well water must be blended and the North Platte River water is subject to seasonal turbidity issues that require pretreatment. See Section 6.0 for a full discussion of source water quality and water treatment process.

The water treatment plant is rated for 8 million gallons a day when processing high quality Springs water. As the Nugget Well water is added, total dissolved solids and sodium create blending constraints that limit the well water to 20% of the total supply. Whenever the North Platte River or reservoir water is used for municipal supply, additional pretreatment is required. The pretreatment plant is limited to 4 million gallons per day while the treatment plant has a capacity of 8 million gallons per day. With the pretreatment plant limit and factoring in limited springs production, 5.5 million gallons per day is the operational planning limit of the water supply system, see Table 3-2 below.

Table 3-2. Operational Planning Limits

Water Season	Springs (mg/day)	Wells (mg/day)	North Platte (mg/day)	Total (mg/day)	20% Loss (mg/day)	City Use (mg/day)	Planning Limit (mg/day)
Wet	2.50	0.63	4.00	7.13	-1.425	-0.15	5.55
Average	1.20	0.30	4.00	5.50	-1.1	-0.15	4.25
Dry	0.85	0.21	4.00	5.06	-1.0125	-0.10	3.95

For planning purposes, the dry water season limit of 5.06 million gallons a day should be used. This would be the amount of water comfortably available for the City's use. This limit anticipates reduced flows from the Springs combined with an optimal blending ratio for the wells. This lower limit also anticipates the 4 million gallon limit of the pretreatment plant when using the Platte River or reservoir water as supplemental municipal supplies.

3.4 ACCOUNTING FOR WATER LOSS

Maintaining system infrastructure to deliver clean and safe drinking water to customers is a significant challenge for municipal water departments everywhere. Much of the estimated 880,000 miles of drinking water infrastructure in the United States has been in service for decades and can be a significant source of water loss. In addition to physical loss of water from the distribution system, water can be "lost" through unauthorized consumption (theft), administrative errors, data handling errors and meter reading inaccuracies or failure.

Neither the term "unaccounted-for-water" nor the use of percentages as measures of water loss is sufficient to completely describe the nature and extent of distribution system water loss. "Lost water" is an appropriate term that captures the multifaceted nature of unaccounted for water treatment plant (WTP) production. Water is the commodity produced by a water department and lost water can be directly equated to lost revenue.

Lost water, expressed as a percentage, is calculated as the amount of water produced by the water department minus the metered customer use divided by the amount of water produced by the water department. Although this percentage provides a rough idea of how much water is unaccounted for, it does not help answer questions such as: Is the water really being lost? If so where? Is it water used for firefighting or City street cleaning? What about inaccurate or misread meters, theft or billing errors? These situations can all contribute to lost water but do not necessarily mean there is excessive leakage in the distribution system. Accounting for lost water and where losses are occurring in a distribution system can be a difficult task.

3.4.1 Water Accounting

Water accounting attempts to meter and track water from supply through the treatment and distribution system to an end user. Metering occurs at several points in the City system beginning with the Sage Creek Springs supply line, Nugget wells and Platte River intake. Water is also metered as it leaves the water treatment plant on its way to nearly 4,000 city and residential customers. Due to unavoidable system losses from evaporation, leakage, meter calibration, etc., water accounting is less precise than financial accounting.

Meters require periodic calibration and are subject to mechanical failure. In addition, there are a number of known unmetered uses such as line flushing, firefighting and leakage, which may be of either a slow or catastrophic nature. Systematic water accounting can help the City become aware of and consequently locate chronic leak conditions and water losses within the system. Rawlins currently takes customary measures to identify and remedy most correctable system losses, but the implementation of a systematic water loss prevention program may be worthwhile.

The City of Rawlins currently has a significant difference in the volume of water produced by the WTP and the volume of water metered and billed to end users. This lost water was identified as 31% of overall production in the 2010 Master Plan. The 2010 Master Plan recommended that the city start metering its own domestic and irrigation use and tighten its water accounting.

Metering of City use was initiated in 2009 and by 2010 water meters had been installed on most of the City's parks and municipal facilities. The tightening of water accounting reduced overall unmetered use from 31% in 2009 to 24% in 2011.

Figure 3-10 shows the average unmetered water use over the course of a year. The majority of water loss occurs during the summer irrigation season when monthly losses average 26.5 million gallons. There are substantial losses over the non-irrigation season as well that average 9.5 million gallons/month. The non-irrigation season losses may be the result of unmetered domestic use in addition to water lost to leakage, data handling errors or misread meters.

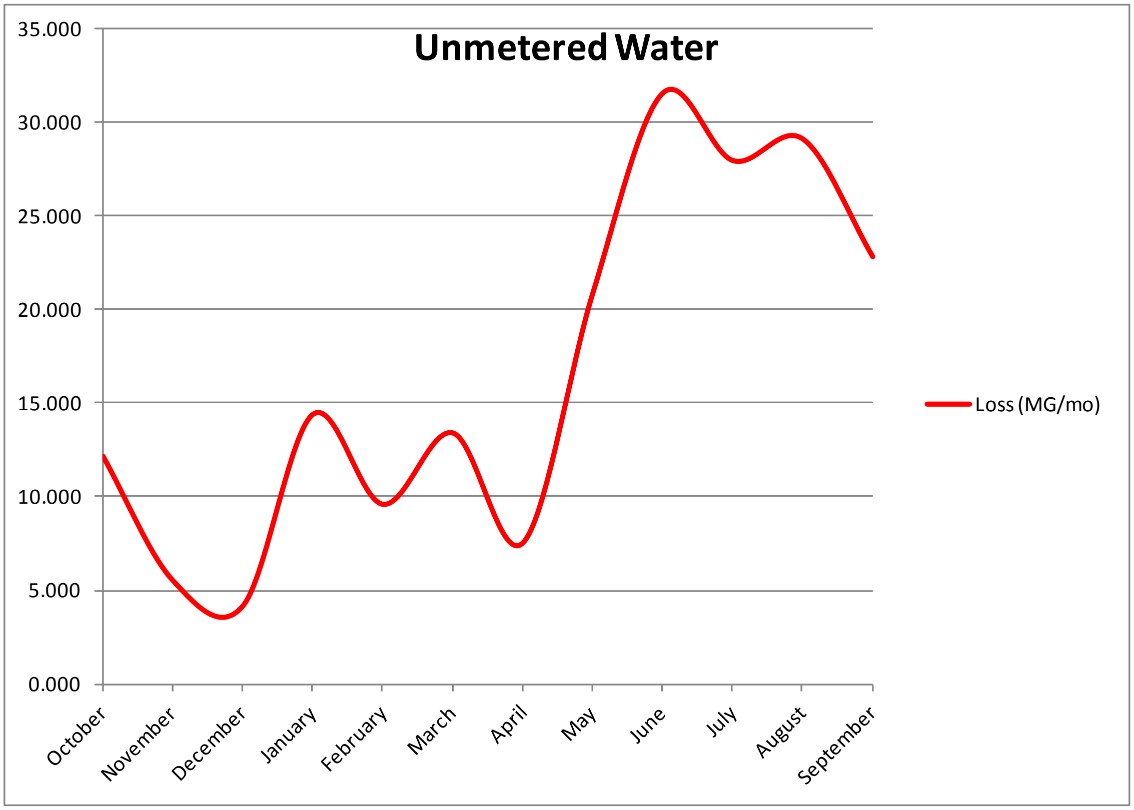


Figure 3-10. Average WTP Production Minus Metered Water, 2008 -2011.

There is an acceptable amount of water loss for typical municipal distribution systems. The American Water Works Association (AWWA) standard for leakage in jointed ductile and iron pipe is 10.5 gallons per day per mile per nominal inch of pipe diameter. The City has approximately 80 miles of various-sized distribution pipes; primarily consisting of jointed PVC and ductile iron pipe. Based on an average pipe diameter of 6 inches; the total acceptable system leakage is approximately 153,000 gallons a month or less than 1% of water treatment plant production.

The yearly total of lost water, with the acceptable leakage factored in, is 197 million gallons. The potential lost return on this water, if metered and sold, is $394,000 (computed at $2.00 per thousand gallons). The operational cost of providing this lost water is $311,260 (computed at $1.58 per thousand gallons).

Further evaluation of the system is needed to identify the source of these discrepancies and how to remedy them. Along with ensuring proper design and installation of new distribution components, the implementation of proper maintenance and operation measures; such as system flushing, valve exercising, meter assessment testing, system replacement programs, system modeling and pressure management programs are recommended to improved efficiencies and reduce system losses; which would also reduce operational costs.

Developing a complete water loss prevention program requires careful consideration of the City's water loss reduction goals. From a records review, it is possible to spot losses through billing data discrepancies or abrupt changes in amounts of water that have been historically used. Sudden increases in meter readings may be a sign of leakage, theft or an open valve that should be closed. Accounts that have been estimated but not read for several billing periods should also be reviewed since the estimated usage may be quite different from the actual usage. It is prudent to re-calculate assumed estimates periodically to ensure that water usage patterns in the area have not changed when meters are not available to correlate the data.

While beyond the scope of this study, preparing a water loss plan should be addressed by the City as soon as possible. The Environmental Protection Agency (EPA) provides resources and advice for preparing water loss programs. A brief description of a typical EPA plan is presented in Appendix F.

3.5 POPULATION ESTIMATES, TRENDS AND PROJECTIONS

Population estimates and projections come from a variety of sources that will be put into perspective in this section. Growth can be limited by available water resources which will be discussed in Section 3.6.

For the purposes of this study there are three service areas: the City of Rawlins, the Rochelle Ranch Golf Course and the Town of Sinclair. Since the construction of the new North Platte Supply Pipeline, the golf course has been using raw water pumped from the North Platte River for its irrigation requirements. The North Platte Supply Pipeline project also provides Sinclair with treated water from the City of Rawlins for its domestic water supply.

3.5.1 Population estimates

Population data, from the 2010 Census, shows a population of 9,259 for Rawlins and 433 for Sinclair, see Figure 3-11 This represents a ten year increase of 8.4% for the city of Rawlins and a 7.5% increase for the total Rawlins water system service area. While the number of people in Rawlins has increased the past few years, it is less than was projected by previous studies.

	CITY OF RAWLINS				TOWN OF SINCLAIR				CARBON COUNTY			
YEAR	POP.	POP INCREASE	% CHANGE	% ANNUAL CHANGE	POP.	POP INCREASE	% CHANGE	% ANNUAL CHANGE	POP.	POP INCREASE	% CHANGE	% ANNUAL CHANGE
1900	2,317	--	--	--	--	--	--	--	9,589	--	--	--
1910	4,256	1,939	84%	8.4%	--	--	--	--	11,282	1,693	18%	1.8%
1920	3,969	-287	-7%	-0.7%	--	--	--	--	9,525	-1,757	-16%	-1.6%
1930	4,868	899	23%	2.3%	--	--	--	--	11,391	1,866	20%	2.0%
1940	5,531	663	14%	1.4%	604	--	--	--	12,644	1,253	11%	1.1%
1950	7,415	1,884	34%	3.4%	775	171	28%	2.8%	15,742	3,098	25%	2.5%
1960	8,968	1,553	21%	2.1%	621	-154	-20%	-2.0%	14,937	-805	-5%	-0.5%
1970	7,855	-1,113	-12%	-1.2%	445	-176	-28%	-2.8%	13,354	-1,583	-11%	-1.1%
1980	11,547	3,692	47%	4.7%	586	141	32%	3.2%	21,896	8,542	64%	6.4%
1990	9,380	-2,167	-19%	-1.9%	500	-86	-15%	-1.5%	16,659	-5,237	-24%	-2.4%
2000	9,006	-374	-4%	-0.4%	423	-77	-15%	-1.5%	15,639	-1,020	-6%	-0.6%
2010	9,259	253	3%	0.3%	433	10	2%	0.2%	15,885	246	2%	0.2%

Figure 3-11. 2010 US Census – Rawlins, Sinclair, Carbon County

3.5.2 Projected Growth

The City experienced substantial growth between 2000 and 2008, followed by a population decrease prior to the 2010 census. The WDA&I data does not take energy development projects into account, however, the transient construction population is a significant part of the water system demand that must be recognized.

The most recent Economic Development Plan, dated October 2, 2012, combined the WDA&I projections with planned projects in the Rawlins area to arrive at an expected growth rate of 0.31% through 2020 and a slightly negative growth rate from 2020 through 2030. The report goes on to note that Rawlins is subject to the boom and bust cycles that come with energy development; so any discussion of population projections must consider the potential for energy development on the planning horizon.

There are several ongoing or planned projects in the Rawlins area that could have a significant influence on population. Construction employment is expected to surge in 2014 and 2015, largely due to the DKRW coal project near Medicine Bow and construction of the Sierra Madre/Chokecherry wind project. Smaller projects (in terms of employment) that have been included in the projections include the Lost Creek in-situ uranium mining recovery project and construction of the Gateway West TransWest Express power transmission line project. Employment projections and years of impact are presented in Table 3-3.

Table 3-3. Projected Worker Needs by Project.

Proposed Project	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Chokecherry/Sierra Madre wind project	1644	1403	1184	1215	136	136	136	136
Gateway West/TransWest transmission lines	262	718	1093	858	53	53	53	53
DKRW coal-to-liquids (CTL) project	935	2157	2307	850	450	450	450	450
Lost Creek Uranium	94	183	89	89	89	89	89	89
Totals	**2935**	**4461**	**4673**	**3012**	**728**	**728**	**728**	**728**

These projects have the potential to increase population to a temporary high of 14,260 residents in 2014 and a planning horizon population high of 12,895 in 2040. Timing of employment for these projects is difficult due to reliance on fluctuating conditions in the energy industry, availability of financing, government approvals and regulatory processes. If all four projects proceed as scheduled, Carbon County could see an additional 1,000 to 6,000 construction employees annually between 2014 and 2018.

Using this data and extrapolating out to a 17-year planning horizon, the population rises irregularly to a 2030 population of 10,200. This is a growth rate of 3.0% over ten years or an annual growth rate of a little less than 0.3%. The population estimates and projections through 2030 are presented in Figure 3-12.

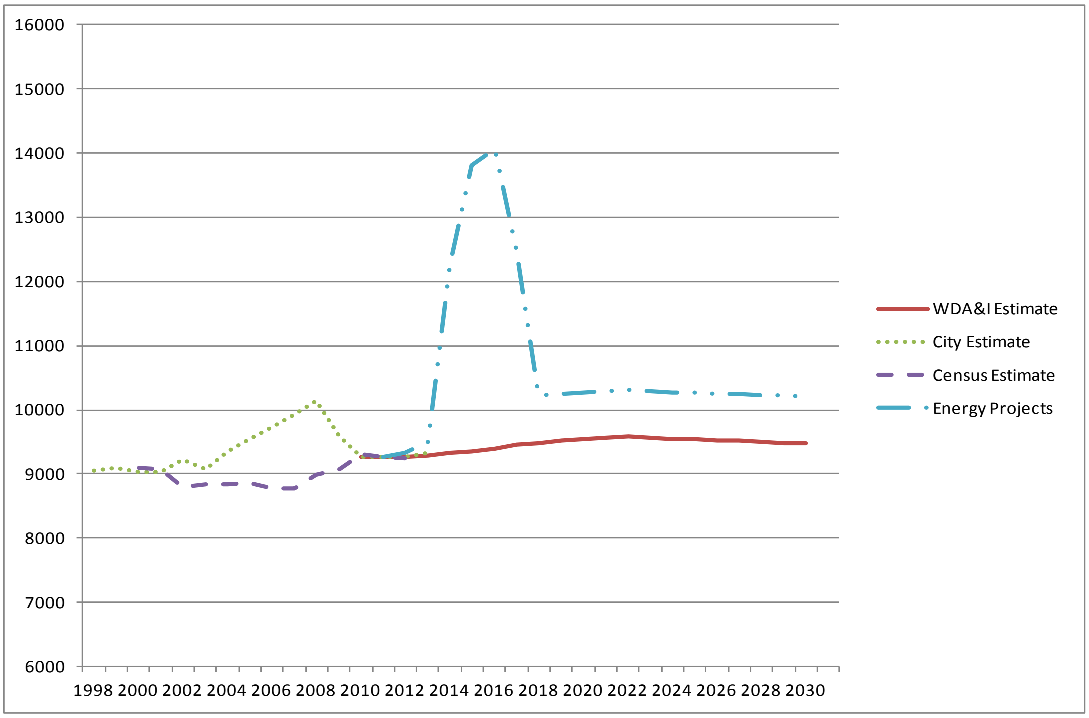


Figure 3-12. Population Projections through 2030

3.5.3 Growth and Demand

From the discussion above, population growth will be a combination of transient construction workers as well as permanent families. Permanent families are assumed to be moving into housing units with outside water usage while the transient population will be living in more temporary accommodations, such as an apartment, man-camp or RV and less likely to be doing outside irrigation.

As far as water demand is concerned, transient construction workers pose an interesting problem. As a water consumer, transient workers are less likely to consume as much water as permanent residents. This is apparent when seasonal water use is plotted against the transient population bump experienced by Rawlins from 2003 through 2010. As previously demonstrated (see Figure 3-2), non-irrigation season water use closely tracks the population increases, while (see Figure-3-5) irrigation season water usage inversely tracks precipitation.

This indicates that the City supply can handle fairly large increases in temporary population with the current water supply resources. The operational limits of the water supply are discussed in the next section of this report.

3.6 OPERATIONAL WATER SUPPLY GROWTH LIMITS

The population projections and limits of supply were identified in previous sections. From a comparison of per capita demand to potential supply, a City growth limit based on current resources can be identified. As the growth limit is approached, additional water resources and operations efficiencies will need to be identified and implemented.

The growth limit is a theoretical limit on population that can be served by the current water supply sources. A conservative limit would be the lowest available supply, less City use, divided by the average per capita use. The low limit of what the City supply can comfortably produce is 5.06 million gallon per day, from Section 3.3. The average per capita consumption ranges from 100 gallon per day, for in-house use, to 225 gallons per day including outdoor use. Conservative water supply limits in wet, average and dry years are presented in Table 3-4.

Table 3-4. Conservative Water Supply Limits

Water Season	Springs mg/day	Wells mg/day	River mg/day	Total mg/day	Loss mg/day	City Use mg/day	Sinclair mg/day	Residential Use mg/day	Max @225 GPD	Max @200 GPD	Max @100 GPD
Wet	2.50	0.63	4.00	7.13	-1.43	-0.33	-0.11	5.26	23369	26290	52580
Avg	1.20	0.30	4.00	5.50	-1.10	-0.33	-0.11	3.96	17591	19790	39580
Dry	0.85	0.21	4.00	5.06	-1.01	-0.20	-0.11	3.74	16613	18690	37380

The average per capita use for Rawlins does not take into account the transient construction population and their lower demand rate. In Section 3.4, demand has been divided into per capita in-house and irrigation use. As the large construction and energy projects come online, in-house demand can be assumed to rise immediately as temporary population increases.

Population is supposed to peak with the planned projects at 14,266 persons in 2014. This is an increase of 4,932 persons in two years. Of the 4,932 people, 90% could be temporary residents and 10% full time. At 100 GPCD for the temporary and 225 GPCD for the permanent, the total increased demand would peak at an additional 0.5 million gallons a day. This temporary population peak is estimated to last 4 years through the construction of the projects, which coincides with the additional demand associated with temporary construction workers. Once the projects are constructed, demand will fall to the full time resident growth projections.

From Section 3.3.3, an operational planning limit of 5.06 million gallons a day was identified. This represents maximum treatment plant production and is the sum of Platte River water, reservoir water, spring water and Nugget wells water at their minimum operational limits.

From the 5.06 million gallons per day, 20% is the expected loss and 0.2 million gallons is the expected City demand, which leaves 4.15 million gallons for City residents. Based on an adjusted per capita consumption of 225 GPCD the system can potentially serve 16,600 full time residents at these minimum operational limits.

4 GROUNDWATER PRODUCTION

4.1 NUGGET WELLFIELD

4.1.1 Introduction

The aquifer supplying the Rawlins Nugget wellfield is the Triassic-age Nugget Sandstone. Although the fine grained Nugget Sandstone formation is only 100 ft. thick in this area, fracturing has greatly increased formation permeability. Combined with wellhead pressures of over 100 psi, an abundant, free-flowing groundwater resource is available.

Figure 4-1 shows the location of the three wells of the Rawlins Nugget wellfield. Figure 4-2 is a geologic block diagram of the wellfield area. Figure 4-3 provides a stratigraphic and completion diagram for Well No. 1. All three wells are virtually identical.

Well Name	Permit No.	Well Depth (ft)
Rawlins Nugget Well #1	P70332W	1730
Rawlins Nugget Well #2	P70333W	1743
Rawlins Nugget Well #3	P70334W	1625

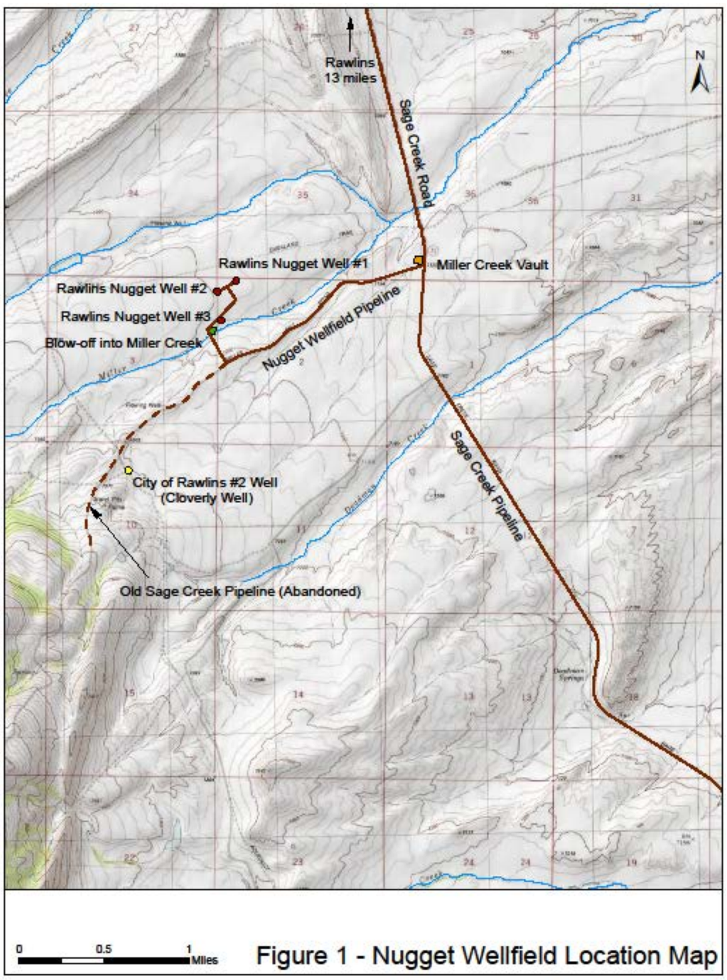
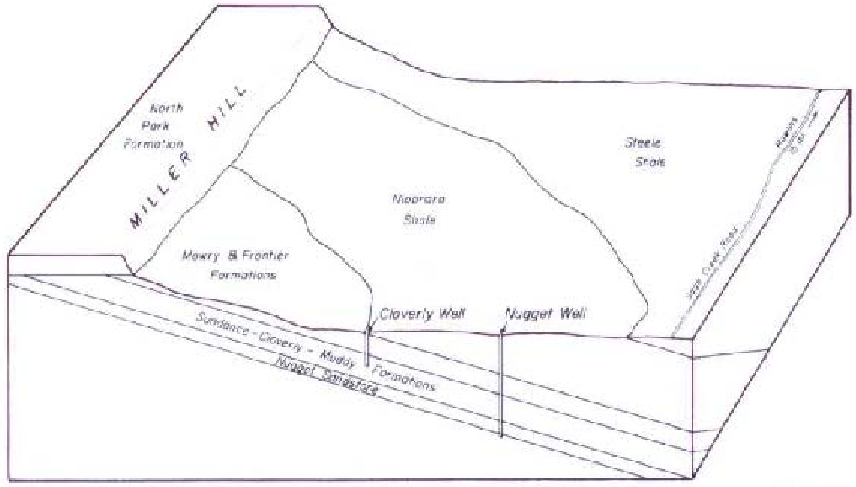
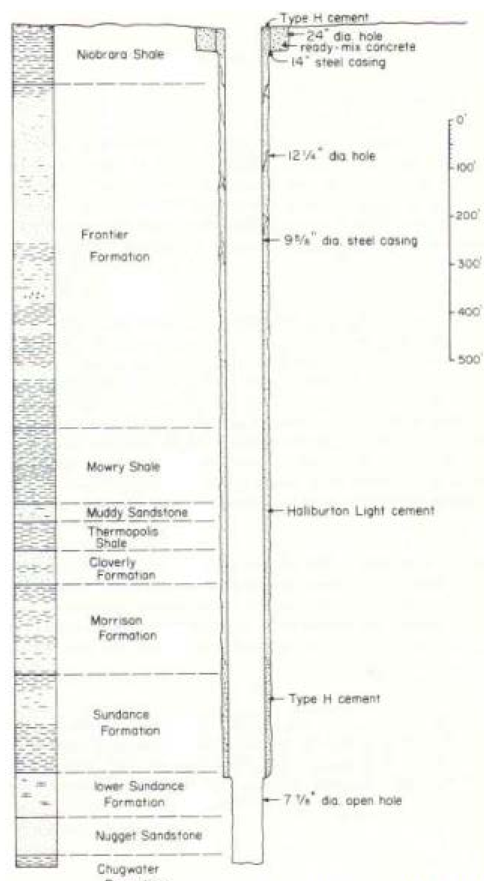


Figure 4-1. Nugget Wellfield Location Map



Source: Anderson and Kelly, 1984

Figure 4-2. Geologic Block Diagram of the Wellfield Area



Source: Anderson and Kelly, 1984

Figure 4-3. Stratigraphic Column and Nugget Well No. 1 Completion Diagram

Well No. 1 was drilled in 1984 following an unsuccessful attempt to recover the large reported production from an unsuccessful oil exploration well at this location. Well Nos. 2 and 3 were drilled the following year as offsets. The initial production from Well No. 3 was only 85 gpm, but flow-test results clearly showed the near proximity of much higher permeability and production was increased to 900 gpm following a modest hydraulic stimulation ("sand frac").

Aquifer testing associated with the completion of these wells (JMM, 1986) indicated a wellfield aquifer transmissivity of approximately 15,000 gpd/ft, a storage coefficient of 5×10^{-5}, and the presence of a negative aquifer boundary which drops the long-term effective transmissivity to approximately 8,000 gpd/ft. The boundary was probably a fault which severs the aquifer approximately 2,000 feet east of the wellfield.

Due to the abundance of higher-quality water from the city spring collection system 12 miles south of the Nugget wellfield, the wells have not been heavily used since their construction. Table 4-1 presents the Nugget wellfield water production from 1997 - 2012.

Table 4-1. Rawlins Nugget Wellfield Water Production

Year	Production (million gal/yr)	Production (ac-ft/yr)
1997	0.073	0.2
1998	5.958	18.3
1999	6.748	20.7
2000	8.342	25.6
2001	7.199	22.1
2002	17.919	55.0
2003	7.633	23.4
2004	4.767	14.6
2005	5.452	16.7
2006	4.072	12.5
2007	6.262	19.2
2008	1.428	4.4
2009	0	0
2010	0	0
2011	0	0
2012	15.642	48.0

4.1.2 Well/Aquifer Testing

4.1.2.1 Data Collection

Testing of the Nugget wells, for this project, began on Feb. 7, 2012 with step testing of each well, proceeded to a 29-day constant-drawdown test of Well No. 2 with Well No. 3 serving as an observation well, and concluded with monitoring of wellfield pressure recovery at Well No. 2 for two months.

Flow was monitored by sequential reading of the installed flow-meter totalizer in each well vault[1]. The free-flow of the wells was used for production in all cases; no pumping equipment was needed. Drawdown was measured with an In-Situ "Hermit" datalogger pressure transducer installed at the wellhead; "drawdown" was calculated as the reduction in shut-in pressure for these flowing wells. Flow was discharged directly to Miller Creek (WDEQ discharge permit WYG720293) through the existing blow-off facility for the wellfield.

None of the three wells had been significantly produced for several years prior to testing. The initial shut-in pressures, as measured in the individual well vaults approximately 4 ft. below ground surface:

Well No. 1	115.0 psi	265.7 ft.
Well No. 2	114.5 psi	264.5 ft.
Well No. 3	125.5 psi	289.9 ft.

The Well No. 3 shut-in pressure is somewhat higher due to its lower ground-surface elevation. Converted to the elevation to which groundwater would rise in a pipe extending up from the surface, all three wells have approximately the same "head".

Table 4-2 provides summary data from the step tests, for the 2012 tests and, for comparison, for the 1986 tests. Figure 4-4 makes the comparisons graphically.

Well Nos. 1 and 3 were tested at higher maximum rates in 1986. This was possibly due to the somewhat higher shut-in pressure providing more available drawdown. The shut-in pressure of Well No. 1 was monitored for 260 days in 1984/85. During that time, it varied between 131 and 135 psi. We have found no pressure data collected between then and now. We assume the present shut-in pressures are a function of long-term fluctuations in recharge, e.g. related to the 2000s drought.

[1] See later section for discussion of flow meter issues.

Although Figure 4-4 suggests Well Nos. 1 and 2 may have performed somewhat better in 1986 than in 2012 (i.e. in terms of flow at a given pressure drawdown), these differences are likely within the flow-measurement errors. We see little reason to conclude there has been any significant deterioration in the basic performance of these wells.

Table 4-2. Nugget Wells Step Test Summary and Comparison

2012 Step-Tests								
Well No. 1			Well No. 2			Well No. 3		
Flow Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Flow Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Flow Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)
38.6	29.22	1.32	59.5	5.30	11.23	50	8.10	6.17
100.3	48.88	2.05	104.9	8.80	11.92	79.6	10.76	7.40
147.0	76.83	1.91	174.5	19.02	9.17	166.3	23.61	7.05
196.8	118.69	1.66	341.4	48.16	7.09	326.8	61.25	5.34
303.1	218.17	1.39	486.0	93.90	5.18	493.6	115.48	4.27
341.9	258.05	1.32	636.3	148.87	4.27	702.9	213.17	3.30
			863.7	255.67	3.38	805.6	268.03	3.01
1986 Step-Tests (Calculated drawdown not in original table)								
Well No. 1			Well No. 2			Well No. 3b*		
Flow Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Flow Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Flow Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)
16	2.4	6.80	23	1.3	18.4	5.5	0.8	6.8
32	5.5	5.80	50	3.0	16.7	9.3	1.2	7.8
76	13.6	5.60	75	4.7	16.0	19	2.0	9.5
150	46.9	3.20	100	9.3	10.8	36.6	3.3	11.0
225	97.8	2.30	200	23.0	8.7	50	4.9	10.2
300	176.5	1.70	300	40.5	7.4	76	7.2	10.6
375	288.5	1.3	400	62.5	6.4	126	14.8	8.5
			500	90.9	5.5	200	23.8	8.4
			700	142.9	4.9	300	49.2	6.1
			900	236.8	3.8	400	78.4	5.1
						920	306.7	3.0

*3b refers to Nugget Well No.3 after fracturing treatment.

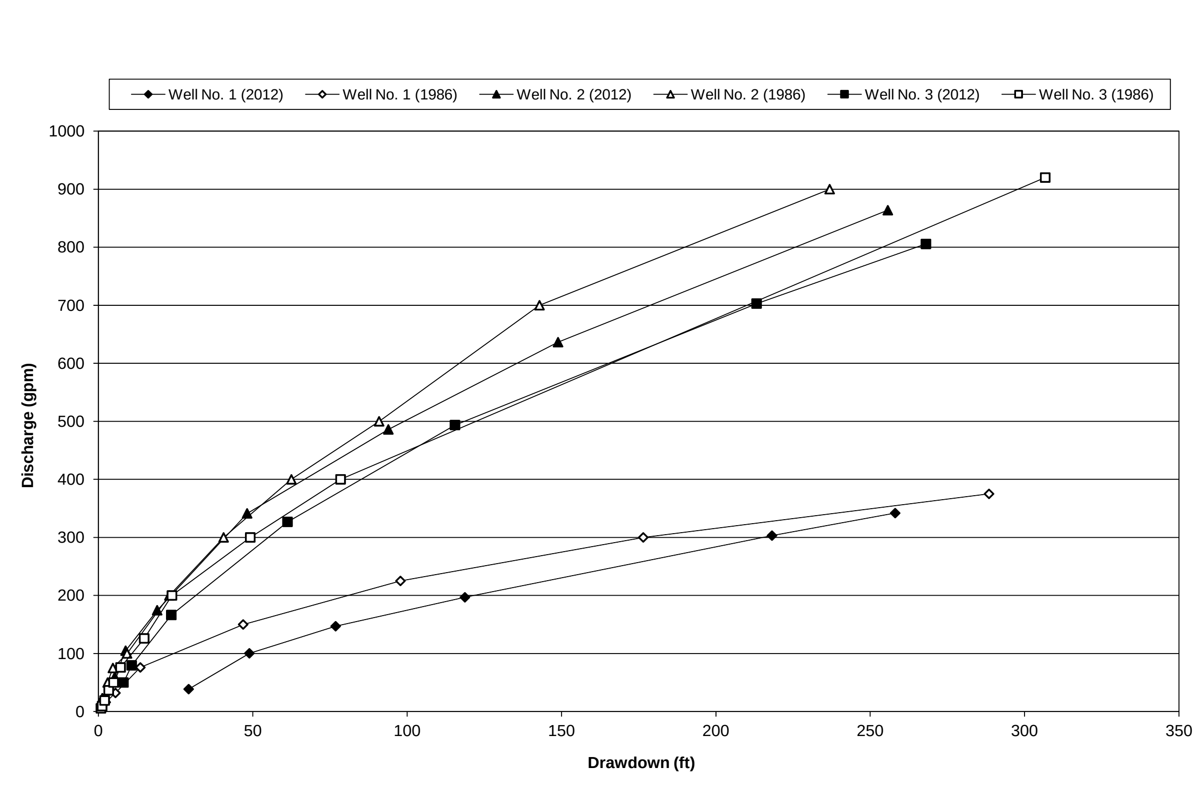


Figure 4-4. Rawlins Nugget Wells Discharge/Drawdown Comparison of Step-Testing

Basically, the curves of Figure 4-4 demonstrate that while each well performs differently, there have been no large changes since they were first constructed. Because the wells are all completed identically – all are simply open-hole through the aquifer – productivity differences are due to the nature of the immediately surrounding aquifer. The critical importance of fracturing in this thin sandstone aquifer was well demonstrated by Well No. 3, which originally produced only 85 gpm, but increased to 900 gpm following hydraulic stimulation.

The specific capacities listed on Table 4-2 decline with flow. In an ideal aquifer, the specific capacity would not change with flow rate, i.e. if a 100 ft of drawdown would produce 50 gpm, 200ft. would produce 100 gpm. Indicated here is an increasing component of "well loss", likely due to the occurrence of turbulent flow into the wellbore through the fractures known to be important in this relatively thin aquifer.

Following a 103-minute recovery period from the step-test, Well No. 2 was allowed to flow to open discharge (near-zero wellhead pressure) via the wellfield blow-off facility at Miller Creek (see Figure 4-1). This was a constant-drawdown test, i.e. the drawdown was held at the difference between the original shut-in pressure of the well and atmospheric pressure, and the change in discharge rate over time was recorded to assess the aquifer's hydraulic characteristics.

Figure 4-5 provides flow data over the course of a one-month period of open discharge of Well No. 2 – constant drawdown of 264 ft. Well No. 2 flow data were logged with a "webcam" attached to a laptop computer installed in the well vault. The camera was programmed to take an image of the meter face every 10 minutes and to log the time of each image. Totalizer values were manually extracted from these images at select intervals to reconstruct the flow history of the test.

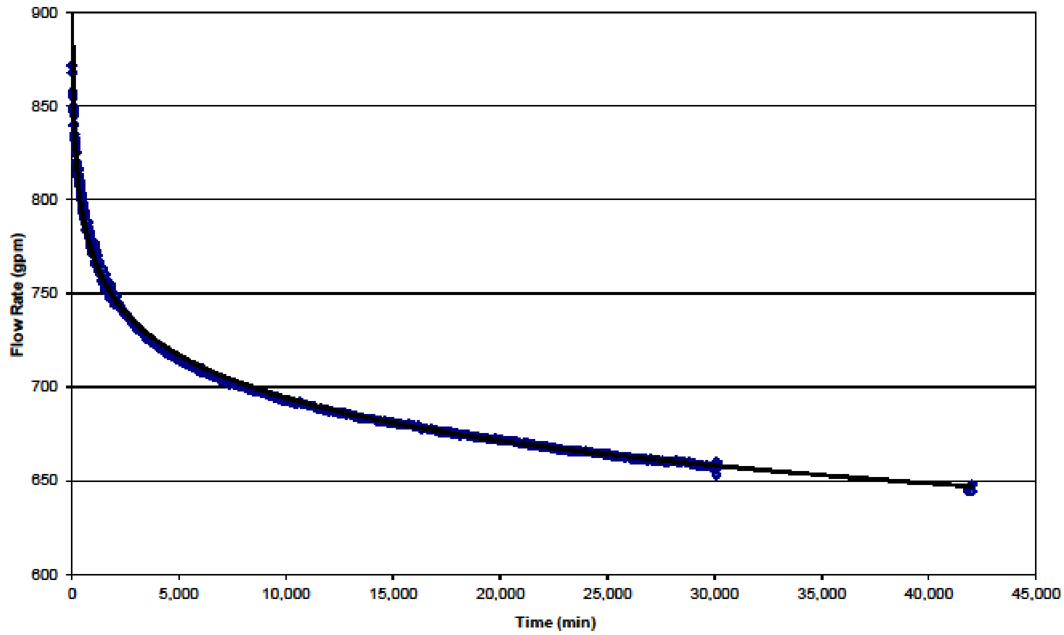


Figure 4-5. Nugget Well No. 2 Flow Test

Figure 4-6 provides companion drawdown data collected at Well No. 3, a distance of 980 ft. from Well No. 2. While drawdown was constant at Well No. 2, i.e. the difference between the full shut-in pressure and atmospheric pressure, Well No. 3 monitored the gradual loss of aquifer pressure throughout the wellfield as flow from Well No. 2 proceeded. Pressure readings were collected from Well No. 3 with a datalogger transducer installed on the sampling tap at the wellhead vault.

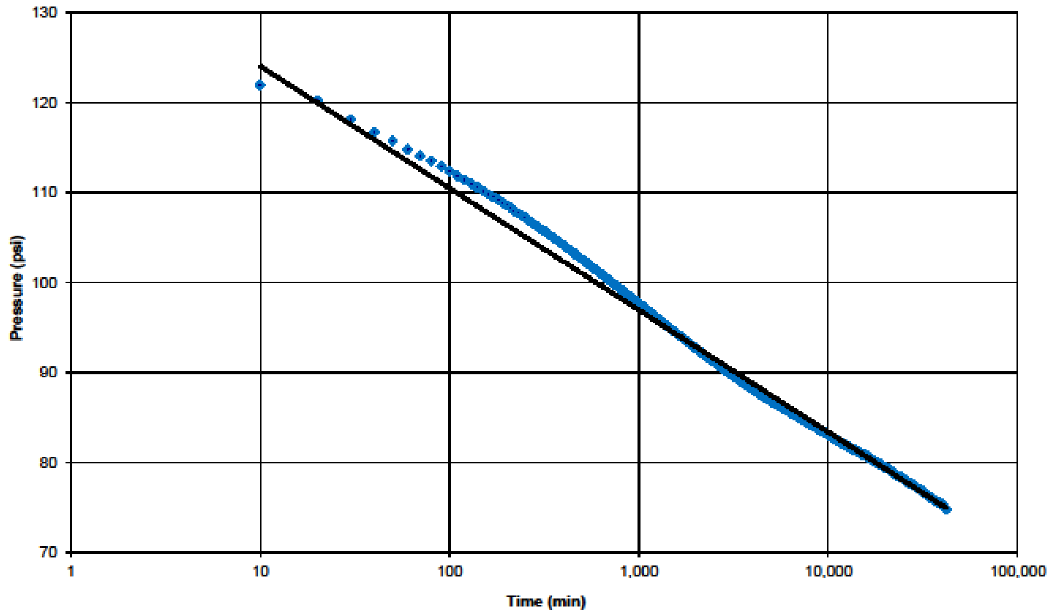


Figure 4-6. Nugget Well No. 3 Pressure (Flow Test on Nugget Well No. 2)

At the conclusion of flow testing, a datalogger and pressure transducer were installed on the No. 2 wellhead and the recovery in wellfield pressure was monitored for 54 days. Figure 4-7 provides a plot of the recovery data. 75% recovery was achieved within 9 hours; 90% in 4 ½ days; 95% in 15 days; and 99% in 43 days. These values are generally consistent with the aquifer characteristics estimated from the flow-test data.

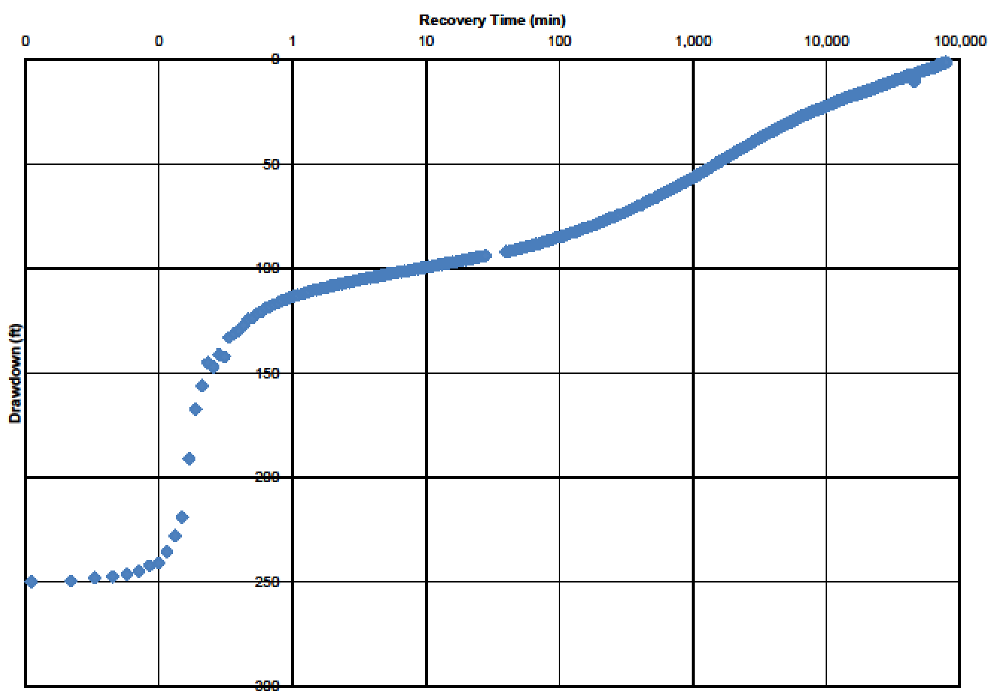


Figure 4-7. Nugget Well No. 2 Recovery

4.1.2.2 Analysis

The Well No. 2 data were analyzed using the program, AQTESOLVE, simulating the confined aquifer using the Hurst-Clark-Brauer (1969) Solution for a Constant-Head Test in a Confined Aquifer. This analysis produces an estimate of 7,900 gpd/ft for aquifer transmissivity and an aquifer "skin" factor, representing wellbore damage, of 1.7. As shown on Figure 4-8, the curve match is best beyond 100 minutes. We believe this reflects the aquifer boundary identified in the original testing.

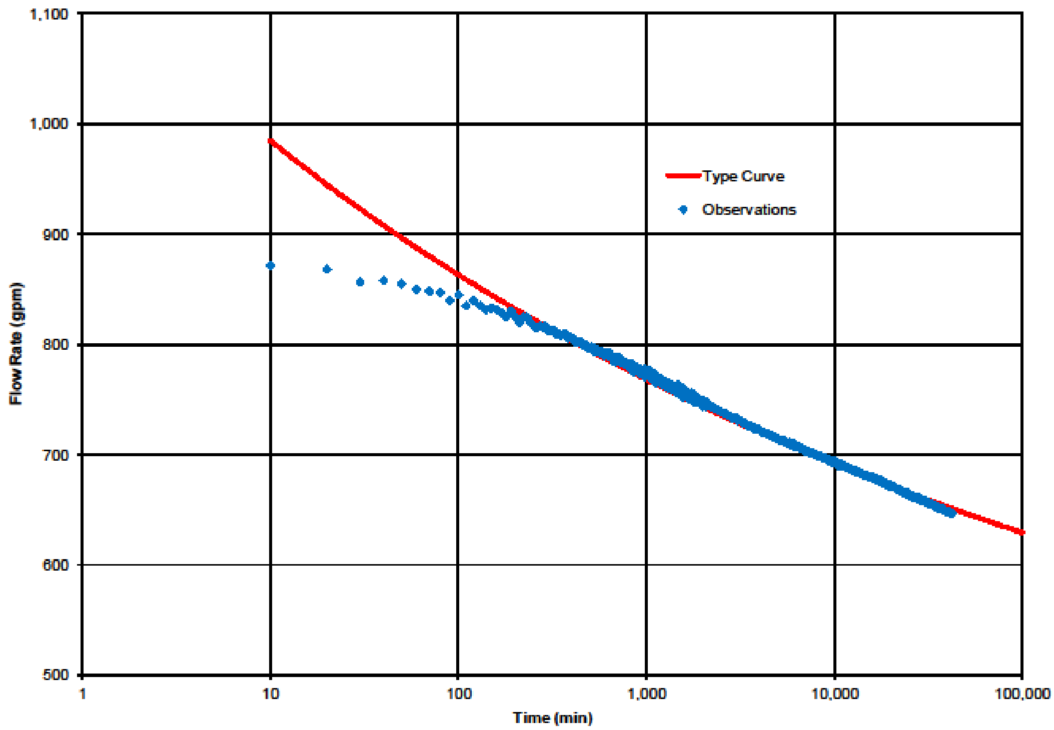


Figure 4-8. Nugget Well No. 2 Constant Drawdown Test

Analysis of the Well No. 2 flow data is complicated by the large well losses to which these wells are subject. Rather than being a constant term, or even a term that varies linearly with flow, the well loss appears to be a non-linear function of flow rate. Thus, the measured change in flow over time – the basis for the test analysis – is a function of the decline in aquifer pressure, but also the changing addition of well loss. This element is not present in the data from Well No. 3 which was simply passively monitoring aquifer pressure as that pressure responded to the production at Well No. 2. Regardless of the hydraulics at Well No. 2, the aquifer simply "sees" a quantity of water being removed, and Well No. 3 monitors the aquifer response.

The pressure response data from Well No. 3 were also analyzed using AQTESOLVE, simulating the aquifer using the Theis solution, explicitly including a boundary at 2,000 ft. In this case, because the boundary is explicit in the modeling, a transmissivity of 9,100 gpd/ft provides the best theoretical match to the pressure observations, with the distance to Well No. 2 of 980 ft. and a storage coefficient of 3.3 x 10^{-5} (see Figure 4-9). This is interpreted as the actual, local aquifer transmissivity, which is effectively reduced across the larger aquifer by the presence of the boundary. Because the Theis solution does not accommodate a constant-drawdown test, the measured production data were incremented into successively smaller rates (gpm) and the analysis was conducted as a 610-step constant-rate test.

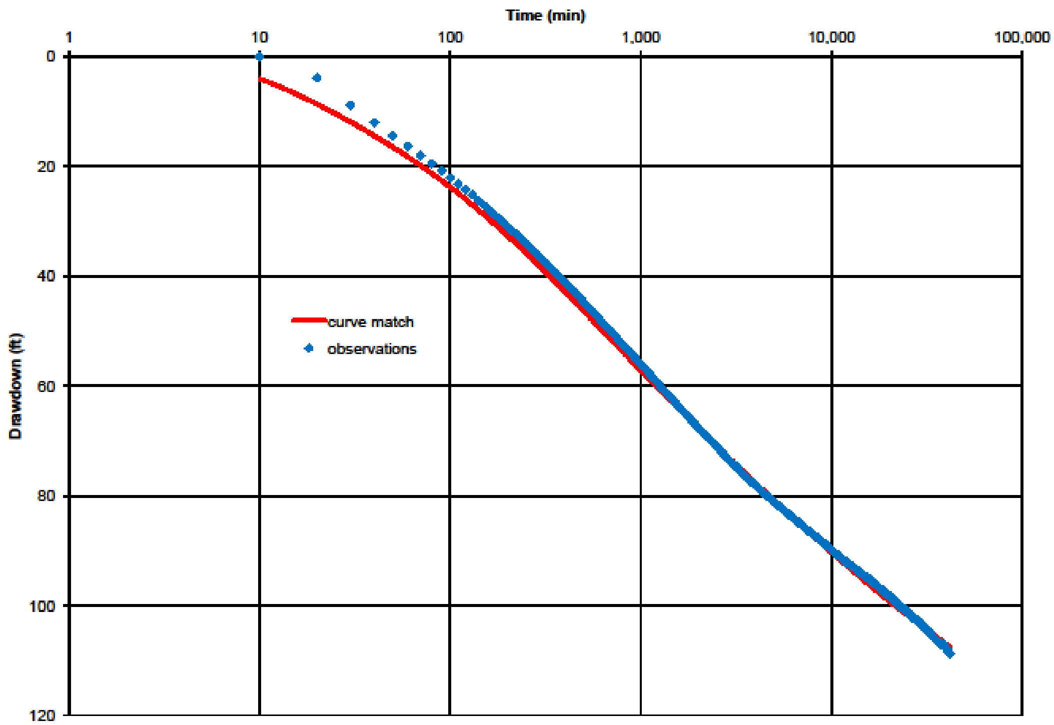


Figure 4-9. Nugget Well No. 3 (Observation Well)

No other aquifer boundaries are apparent in the production data from Well No. 1 or the pressure data from Well No. 3. It was anticipated that the edges of the aquifer could be encountered in a test of this duration. The Nugget subcrops beneath North Park Formation at a distance of approximately 4 miles to the southwest, but there is no indication of this in the test data. Perhaps the overlying North Park Formation reacts similarly to the Nugget, effectively extending the aquifer. Perhaps the combination of the change in water production characteristics accompanying the subcrop/outcrop change in storage coefficient and other boundaries encountered in the aquifer to the north and east simply combine to eliminate discernible discontinuity in test data. In any case, indications are that the aquifer is performing in a predictable manner, loosely confirmed by the much longer "test" described below.

4.1.3 2012 Production Period

Following the testing of the wells in February - March, the City decided to use the wells at maximum production rate through the summer of 2012. Data collection during and following this flow period was minimal and inconsistent, but as the most significant use of the wells in 10 years, it provided a rare opportunity to evaluate the wells in full-scale production.

Groundwater production began May 7, was continuous throughout the summer, and ended approximately September 28. Based on "before" and "after" totalizer readings by Hinckley Consulting (verified by independent PMPC readings) from the three individual wells (i.e. the in-vault meters used for testing) and the length of the pumping period:

Well No.	Total Gallons	Avg. Discharge Rate
1	25.3 million	122 gpm
2	69.8	337
3	60.3	290
Total	155.4	749

An initial flow of 987 gpm was reported by city personnel. An intermediate set of totalizer readings reported for approximately June 27 (i.e. after 51 days of discharge) indicate average flows of 100, 326, and 279 gpm, for a combined average flow of 705 gpm at that point. (This is clearly at odds with the full-period average flow of 749 cited above, as the average flow almost certainly declined over the course of the flow period. Reporting errors for the intermediate observations are suspected.)

This is qualitatively consistent with an initial flow considerably higher than average, falling off over the first few weeks, then maintaining with little additional decline.

Once-a-month flows were estimated by city personnel based on the well-vault, flow-rate indicators: June - 750 gpm; July - 700 gpm; August - 700 gpm; September - 700 gpm. The general observation by the City in 2012 was that after the initial decrease in discharge in the first few weeks of production, all three wells flowed without further reduction for the duration of the period.

Groundwater production throughout the period was accomplished by opening all three wells fully, providing the maximum possible discharge within the constraints of wellhead and wellfield piping, the transmission line from the wellfield to the main transmission line, and most importantly, the entry pressure to push water into the main transmission line. Main pipeline entry pressure was measured at 78 psi by City personnel in mid-June.

The contemporaneous wellhead pressures were 47, 45, and 54 psi for Well Nos. 1, 2, and 3, respectively[2]. That difference is consistent with the lower elevation of the main pipeline, and indicates that the wellhead pressures could be reduced to near zero through installation of a booster pump at the main pipeline to force well water into the pipeline (rather than needing booster pumps in the wellfield).

4.1.4 Meter Issues

All three wells were tested with the installed, in-vault meters, none of which are operating entirely satisfactorily. The Well No. 1 vault has many water leaks, the electrical panel is extensively rusted out, and the flow meter has water droplets beneath the face plate. The vaults at Well Nos. 2 and 3 are in much better shape, although the Well No. 2 meter also condenses fog beneath the face plate. There is no indication any of the flow meters have received service since their original installation.

These flow meters provide both an instantaneous display of gpm production and an odometer-style totalizer. The two were checked against one another by calculating the flow rate from sequential totalizer readings over a stopwatch-timed period. For Well No. 1, there was good correspondence between the flow-rate indicator and the totalizer-based flow (although the meter workings are audibly uneven).

For Well Nos. 2 and 3, the flow-rate indicator readings were consistently higher than the totalizer-based values. At maximum discharge:

Well No.	Totalizer Flow	Flow-Rate Indicator Flow	Indicator/Totalizer
2	636 gpm	800 gpm	126%
3	701	800	114%

Similarly, city personnel reported a combined flow rate on June 27 of 725 gpm, summing the flow-rate indicator, whereas the totalizer readings provided an average of only 677 gpm since the beginning of the flow period 51 days earlier. Since the June 27 flow was surely less than the average flow due to the gradual decline in flow over the period, the discrepancy was in excess of this 7% difference.

At Well No. 2, repeated short-period measurements with a stopwatch (100 gallons) produced calculated flows varying between 672 and 727 gpm. Given the characteristics of the aquifer/well system, real variations of this magnitude are unlikely.

Also, at Well No. 3, the meter is dead below 50 gpm, and between 50 and 100 gpm, operates only intermittently (both flow-rate indicator and totalizer).

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[2]Unlike the considerable ambiguity in flow measurement, the well-vault pressure gages were found to be consistent with transducer measurements logged during testing.

A relatively new flow meter at the point at which the wellfield pipeline enters the main pipeline was considered as a backup to the well-vault meters, but was found to be inoperable.

City personnel expressed general confidence in the well-vault flow meters based on the general concurrence with the volumes measured elsewhere downstream. Given the difficulty of flow measurement elsewhere in the system, the apparent consistency of the totalizer-based flow measurements at the higher flows of most interest, and the understanding that these meters could be calibrated against other meters in the system at a later date, our testing proceeded using totalizer-based flows measured over at least 1,000-gallon periods.

Unfortunately, the planned calibration never took place. Thus, all flow data reported herein should be understood to be based on totalizer-based measurements from the installed meters, which are as much as 20% lower than the city-preferred flow-rate indicators, and of undetermined absolute accuracy. At such time as these meters are calibrated or confirmed by comparison metering elsewhere in the system, the quantities cited herein should be re-scaled as appropriate.

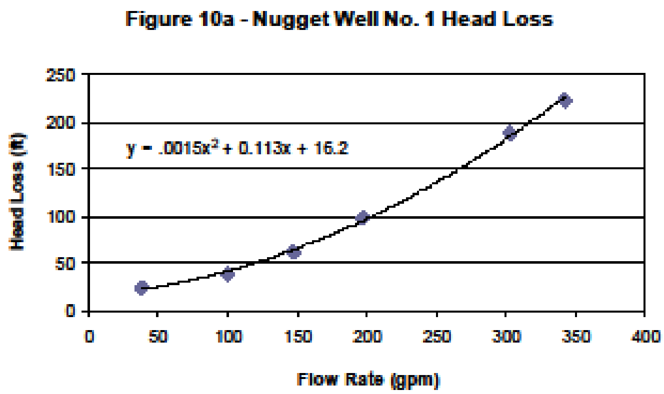
For consistency with the testing, we adopted the individual-well timed-totalizer flow rates for our analysis, but we repeat our strong recommendations that flow measurement be improved and caution that our results may be subject to errors on the order of 10 - 15%.

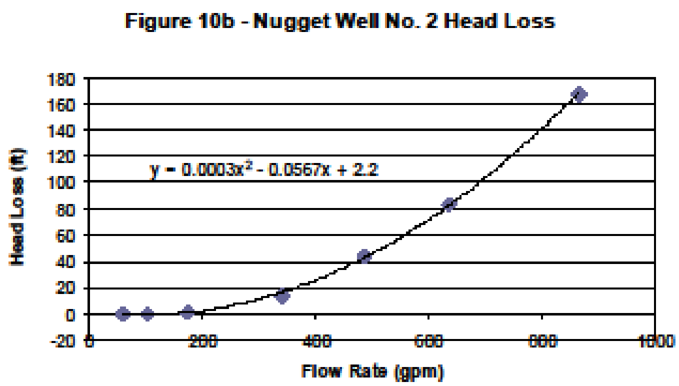
4.1.5 Production Projections

Application of the indicated wellfield aquifer parameters allows estimation of the idealized drawdown at each well at the various rates of the step tests. This allows isolation of the "extra" drawdown due to hydraulic losses near the wellbore for each step, i.e. the difference between the ideal and estimated values. These losses are plotted on Figure 4-10 and a polynomial curve is fit to allow estimation of intermediate values.

The wellfield production projections of interest are based on two operational scenarios: 1) flow into the pressurized main pipeline, i.e. wide open well valves, with a wellhead pressure sufficient to overcome the pressure where the wellfield pipeline joins the main pipeline along the Sage Creek Road; and 2) flow into the main pipeline via a booster pump that accepts wellfield flow at atmospheric pressure and forces it into the main pipeline. Obviously, the latter production will be greater than the former, but would require the installation (and provision of power) to a booster pump that does not now exist. Because the city experienced the first of these two scenarios in the summer of 2012, the relevant pressures were directly measured by city personnel in mid-June:

Main pipeline pressure at Miller Creek vault (end of wellfield pipeline) = 78 psi
Wellhead No. 1 = 47 psi (i.e. drawdown = 157 ft.)
Wellhead No. 2 = 45 psi (i.e. drawdown = 161 ft.)
Wellhead No. 3 = 54 psi (i.e. drawdown = 165 ft.)





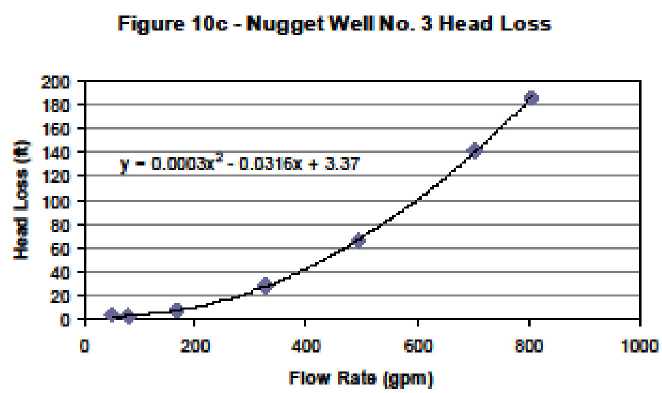


Figure 4-10. Nugget Well Nos. 1,2,3 Head Loss

Theoretical flow rates at various durations of pumping and wellhead pressures have been estimated by application of the Theis Equation for confined aquifers to calculate the drawdown in each well due to its own production and the drawdown in each well due to its neighbors' production, with additional drawdown due to well losses estimated using the equations developed above. Flow rates from each of the three wells were adjusted to match the available drawdown based on shut-in pressures. For example, one-day production at Well No. 2 of 430 gpm, while Well No. 1 is flowing 180 gpm and Well No. 3 is flowing 420 gpm, is estimated to produce aquifer drawdown at the well of 110 ft. due to its own production, subject to a well loss of 33 ft., and an additional 7 ft. of drawdown due the production at Well No. 1 and 11 ft. due to the production at Well No. 3. These increments consume the available drawdown of 161 ft., the difference between the well shut-in pressure and the entry pressure to the main pipeline.

The combined discharge estimated after one day of production by this method is 1037 gpm, in reasonable agreement with the 987 reported by city personnel. Similarly, projections to the 144 days of the summer, 2012 flow period provide an estimate of 746 gpm, which compares with the average discharge of 749 gpm for the entire flow period based on "before" and "after" well-vault totalizer readings. Our projections are based on constant discharge rather than constant drawdown, but over extended periods the higher initial flows will tend to be averaged out by the lower sustained flows across the bulk of the flow period.

Application of this methodology to a 24-month period of continuous flow suggests a combined wellfield discharge rate of approximately 675 gpm at main pipeline discharge pressure.

Application of this methodology to a 24-month period of continuous flow to atmospheric pressure, i.e. with a booster facility to push water into the main pipeline, increases the combined wellfield discharge estimate to 1070 gpm. Note that the elevation drop between the wellfield and the main pipeline appears to be more than sufficient to overcome wellfield and wellfield transmission line head losses, i.e. booster facilities at the main pipeline should be able to reduce the wellhead pressures to near-zero.

Maximum production from these wells could be achieved through the installation of submersible pumps. That would require overhaul of the wellheads and bringing in power supplies that do not presently exist. Theoretically, the available drawdown would be increased by another 1,000 ft. in this manner, although examination of Figure 10 indicates that well losses may become very large at substantially higher discharge rates. This alternative is not recommended if there are any reasonable alternatives.

4.1.6 Groundwater Quality

Table 4-3 compiles water quality information for the Rawlins Nugget wells.

Table 4-3. Rawlins Nugget Wellfield Groundwater Quality Analysis

Parameter	Rawlins Nugget Well #1		Rawlins Nugget Well #2						Rawlins Nugget Well #3			"Cloverly" Well	Wellfield Pipeline Discharge	EPA Drinking Water Standards	
Source	JMM (1986)	Hinckley Consulting	JMM (1986)	Hinckley Consulting					JMM (1986)	Hinckley Consulting					
Sample Date	10/4/1984	2/7/2012	7/5/1985	2/15/2012	2/23/2012	2/29/2012	3/8/2012	4/24/2012	10/24/1985	2/7/2012	11/17/2012	5/2/2012	11/17/2012	Primary	Secondary
pH (lab)	8.8		8.9	8.77	8.8	8.78		8.92	8.7	8.85					6.5-8.5
Temperature (^oC)				24.4	24.4	24.2	24.4	9.3							
Corrosivity															
Conductivity (umhos/cm)	1000	1207	1000	1133	1131	1131	1131	1163	1050	1027	1112	440	1097		
Ryznar Stability Index[1]	8.7		8.7						9.1						
TDS	648		698	736	751	719		760	596	710					500
TSS				<4	<4	<4				<4					
Acidity															
Alkalinity as CaCO3	390		420	450	448	446		460	360	393					
Hardness as CaCO3	9		9						9						
Gross Alpha (pCi/L)[2]	0		10.8				ND		10					15	
Gross Beta (pCi/L)[2]	1.6		<1.5				ND		7.9						
Radium 226 (pCi/L)	0.8		<0.7						0.3					5 (226 & 228)	
Radium 228 (pCi/L)	1.5		<4.5						0.5						
Uranium							0.0005							0.03	
Total Coliform															
E-Coli Coliform															
Bacteria, Iron Related (CFU/ml)															
Bicarbonate	378		439						415						
Carbonate	0		36						12						
Chloride	6		8			4	3		7						250
Fluoride	1		1.1						1.6					4.0	2.0
Nitrate + Nitrite as N															
Nitrate as N	<0.01		<0.01						0.1					10.0	
Nitrite as N															
Sulfate	160		163			168		168	160						250
Calcium	2		2			3	2		2						
Magnesium	1		1			<1	<1		1						
Potassium	2		2			2	2		2						
Sodium[3]	249			299	308	310	275	292		235					
Silica	9.8		11.9						1.5						
Aluminum															
Antimony															
Arsenic	<0.004		<0.004				<0.001		<0.004					0.05 (0.01)	
Barium	<0.01		0.03						0.02					2	
Beryllium															
Boron	0.4		0.3						0.4						
Cadmium	<0.01		<0.01						<0.01					0.005	
Chromium	<0.04		<0.05						<0.05					0.1	
Copper	<0.01		<0.01						<0.01					1.3	1
Iron	0.12		<0.03				<0.03		0.07						0.3
Lead	<0.05		<0.05				<0.001		<0.05					0.015	
Manganese	0.03		<0.01				0.002		<0.01						0.05
Mercury	<0.0004		<0.0004						<0.0002					0.002	
Nickel															
Selenium	<0.004		<0.001						<0.001					0.05	
Silver	0.04		<0.02						<0.02						0.1
Zinc	0.46		<0.01						<0.01						5

[1]Ryznar Stability Index = 2(K - Log10(Ca) - Log10(total alkalinity)) - pH, where K is a factor based on TDS.

[2]ND - not detected at minimum detectable concentration.

[3]EPA's non-enforceable guidance level for sodium is 20 mg/l, developed for individuals restricted to a total sodium intake of 500 mg/day and should not be extrapolated to the entire population.

As in the 1986 testing, the 2012 data demonstrate that all three wells are essentially the same in terms of water-quality parameters. The 2012 data provide a temporal dimension to this similarity as well, demonstrating little change in water quality over the course of the test. Although not monitored over the course of the subsequent production period, conductivity measurements from the standing water in the No. 3 wellhead and in the combined wellfield pipeline, following the summer flow period, were the same as during the test period, indicating no significant change over this extended period as well. Sodium concentrations, while high in all three wells, are highest in Well No. 2, but show no significant change during the test period.

Groundwater from the Nugget wellfield is of a sodium bicarbonate type, quite soft, but high in sodium. The water meets all Primary EPA Drinking Water Standards. These standards are enforced for a Public Water Supply. They are based on human health impacts.

The EPA also promulgates Secondary Standards, which are advisory standards (not enforceable) based on aesthetic characteristics such as taste, odor, and color. Groundwater from the Nugget wellfield exceeds secondary standards only for Total Dissolved Solids (TDS). Although there is no secondary standard for sodium, EPA suggests concentrations above 20 mg/l are of concern for those on limited-sodium diets (500 mg/day), e.g. to control high blood pressure.

4.1.7 Conclusions

1. The Rawlins Nugget wells produce water meeting all EPA Primary Drinking Water Standards, but have sodium and total dissolved solids concentrations that may be objectionable if delivered without benefit of blending with higher-quality sources.

2. Water quality from the Nugget wells is the same between wells and over sustained pumping periods.

3. The wells exhibit production characteristics not significantly different from when they were first constructed. Although periodic flushing to atmospheric pressure (e.g. at the existing Miller Creek blow-off) is recommended, there is no evidence for rehabilitation needs[3].

4. Based on the experience with Well No. 3, it is likely that the productivity of Well No. 1 could be improved with hydraulic stimulation should additional flow be desired in the future.

[3]City personnel had earlier reported that a previous year's experience with Well No. 1 was that it declined to approximately 10 gpm after 30 days' production, but that was clearly not the case over the 2012 flow period.

5. The Nugget wellfield is capable of making a sustained contribution to the Rawlins municipal water supply on the order of 600 gpm in its present configuration, and its sustained contribution could likely be increased to over 900 gpm with installation of booster pump to lower the necessary wellhead discharge pressure.

4.2 IN-TOWN WELLS

Over our several decades of experience with the Rawlins-area groundwater investigations, we have conducted and become aware of various studies in search of suitable groundwater closer to town than the springs (25 miles away) or the Nugget wellfield (13 miles away). In all cases, groundwater supplies have been determined to be either of insufficient quantity or unacceptable quality from the basis of a municipal water supply. For the present study, the possibility of developing useful groundwater supplies within the city for selective application to landscape irrigation needs was investigated.

Based on previous reports, SEO permit files, and interviews with Town staff and local residents, eight wells within the City of Rawlins were investigated for potential contribution to localized raw-water landscape irrigation systems. These wells vary from the “South Penitentiary” well, which is currently being rehabilitated as a 60 gpm landscape-irrigation supply by the Joint Powers Board, to the “Brack” wells near the City shops just south of the railroad tracks which are of too poor quality and are too far from current irrigation needs to be useful beyond their present application.

Each of these wells received preliminary evaluation with respect to quantity, quality, and location relative to identified areas of potential application, and recommendations were made for further study as appropriate. An interim report was prepared for city review and response. That report is attached as Appendix F.

4.3 “CLOVERLY” AQUIFER

As part of the 1984 exploration of the Nugget Formation, the overlying Cloverly Formation was also investigated. Like the Nugget, the Cloverly produces flowing wells in the Miller Hill area, one of which is owned by the City of Rawlins. That well, known as the “Rawlins-Cloverly Well”, is approximately 1 mile southwest of the Nugget wellfield, along the alignment of the original Sage Creek Springs pipeline, to which it contributed flow. (See Figure 4-1 for location.)

Testing of the well in 1984 (Anderson & Kelly, 1984) documented a shut-in pressure of 126 psi (291 ft.). A 20-day constant-drawdown test with surface discharge saw production fall from 150 gpm to 84 gpm over the course of the test. A long-term effective aquifer transmissivity of 1200-1500 gpd/ft was interpreted from the test data, with a somewhat lower transmissivity in the immediate vicinity of the well.

Although groundwater from the Cloverly Fm. at this location is of a sodium bicarbonate type, like that from the Nugget Fm., the Cloverly has lower concentrations of sodium (75 mg/l) and of Total Dissolved Solids (200 mg/l). Iron and manganese concentrations are higher, however, approaching EPA Secondary Drinking Water Standards.

The formation pressure in the Cloverly Fm. would be sufficient to force water into the main pipeline, particularly given that the Cloverly well is 180 ft. higher in elevation than the pipeline entry point. The Cloverly Fm. was not explored or developed beyond the 1984 studies due to the relatively small free-flow of the existing well, which would be considerably smaller against pipeline pressure.

The Rawlins-Cloverly well was investigated for the present study only to the extent of verifying its continued existence and measuring a groundwater conductivity of 440 umhos/cm (5/2/2012). Conductivity of 350 umhos/cm was measured from this well during the 1984 investigation. The potential contribution of the Cloverly Fm. to the Rawlins municipal system remains the same as evaluated in 1984: the formation could provide some blending mitigation of high sodium and TDS levels from the Nugget Fm., but would only become usefully productive with installation of a booster pump to overcome main pipeline pressure or of submersible pumps at the well, and with construction of additional wells. (See the 1984 report for additional hydrogeologic and development-plan details.)

REFERENCES

Anderson & Kelly; November, 1984; Hydrogeologic Evaluation of the Nugget Aquifer near Rawlins, Wyoming - Level II Feasibility Study; Wyoming Water Development Commission.

Hurst, W., J.D. Clark and E.B. Brauer, 1969; The skin effect in producing wells, Journal of Petroleum Technology, November 1969, pp. 1483-1489.

JMM; February, 1986; Rawlins Groundwater Project - Level III Nugget Aquifer Report; Wyoming Water Development Commission.

5 SNOW FENCES

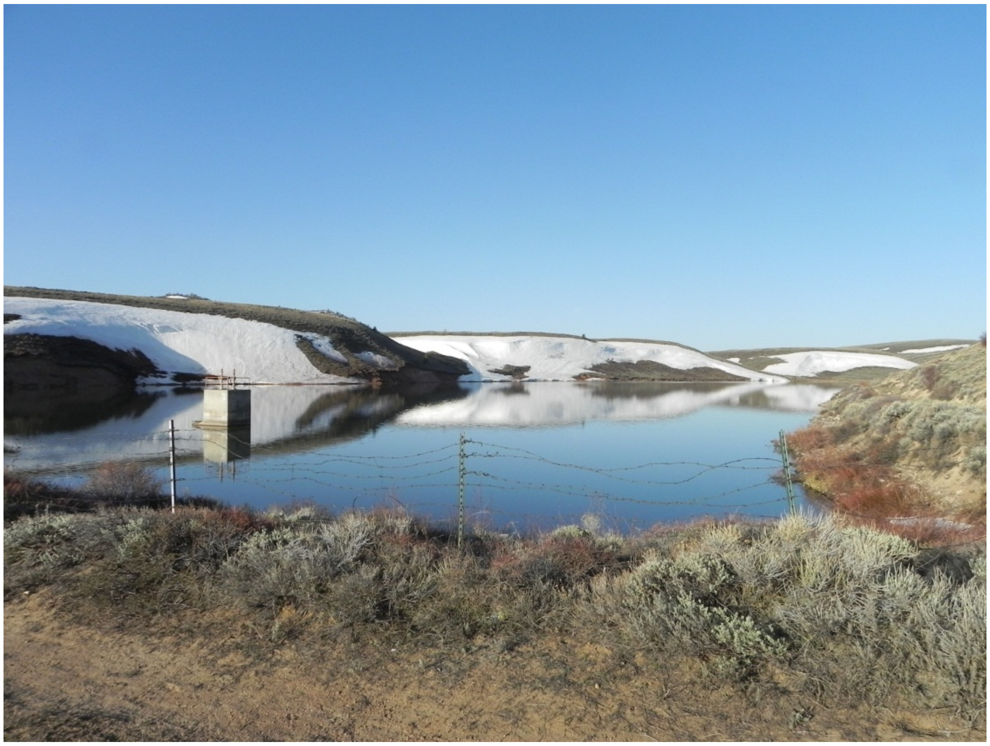
5.1 INTRODUCTION

Snow accumulation contributes to surface flow and recharge of groundwater in the Sage Creek Basin. A portion of the snowfall that occurs annually in the basin is lost to sublimation (evaporation) and not available for groundwater recharge. Snow fence installation would improve snow accumulation at specific design locations, lengthen the spring season melt period and increase the amount of water available for beneficial use.

Studies have shown that installation of snow fence improved surface flow volume, groundwater recharge and extended the snow melt season. Research conducted in the Stratton Sagebrush Study Area approximately 11 miles east of the Sage Creek Basin documented average increased surface water yields of 129% and prolonged runoff duration by 17 days with the installation of snow fence (Sturges, 1992).

The installation of snow fence improves basin water production by reducing sublimation of windblown snow. Water recovered by reducing sublimation can be identified as "new water" and may not be hydrologically connected to the Platte River. A formal submittal to the Wyoming State Engineer regarding this "new water" has not been done so a determination of priority use has not been made.

This snow fence report includes an investigation of the climate data and documents site visits which were made to verify design data and to determine proposed fence heights and layouts. The effectiveness of the proposed snow fence will be quantified by specific site conditions and volume of "new water" added to the basin.



5.2 SITE CLIMATE INVESTIGATION

5.2.1 Introduction

For snow fence to be effective and cost efficient, it must be properly aligned to the prevailing transport wind direction and sized for the seasonal snow conditions. As part of the investigation, wind speed and prevailing direction were measured. Wind speed is a factor in determining fence height and prevailing direction defines the fence layout. Seasonal snow conditions are more than inches of snowfall. Snow must be investigated to determine snow water equivalency and to define the limits of the accumulation season. The climate investigation makes use of collected weather data in order to determine prevailing wind transport direction and average snow conditions.

The Sage Creek Basin Snotel weather station data was used to determine average temperature, snow accumulation season, snow accumulation (as water equivalent), prevailing wind direction, snow transport direction and storm wind direction. Near the eastern boundary of Sage Creek Basin, this SNOTEL site is within the study area and has been reporting data since October 2001. Snotel Data is presented in Appendix A.

Site visits were also completed to verify the accuracy of the data and to observe the effectiveness of previously installed snow fence.

5.2.2 Snow Accumulation Season

The snow accumulation season is the period of snow drift growth beginning with the first blowing snow event that causes drifts, persisting throughout winter and ending whenever the snowdrifts reach their maximum seasonal volume. Snow that falls during the snow accumulation season is the only snow available for relocation by the proposed snow fence. The snow accumulation season can be delineated by the dates when average air temperature falls below 0° C in the fall and rises above 0° C in the spring, as computed from mean monthly temperatures (Tabler, 1988).

The daily temperatures recorded by the Sage Creek Basin Snotel site from 2001 through 2011 were averaged on a monthly basis as shown below in Table 5-1. From the data, a snow accumulation season of November 11th through March 20th was interpolated for the study area. From the snow accumulation season results, a total seasonal snowfall average was determined for further snow fence calculations.

Table 5-1. Average Monthly Temperatures During Snow Accumulation Season

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
°F	56	45	29	27	21	19	32	35
°C	13	7	-1	-3	-6	-7	0	2

5.2.3 Prevailing Wind & Transport Direction

Prevailing wind is the trend in direction of wind with the highest probability measured in a true heading. When estimating prevailing wind direction, it is important to recognize that wind direction at the design site can vary from recorded anemometer data because of local terrain and vegetation. The remote data is useful for preliminary design until a site inspection can verify design assumptions.

Prevailing transport direction relates the prevailing wind direction with the threshold wind speed for a blowing snow event to occur. The prevailing transport direction is needed to orient the snow fences for the greatest efficiency. Snow fence is most effective when constructed perpendicular to the prevailing snow transport direction.

Wind direction and wind speed data for the 2009-2010 snow accumulation season was examined to determine prevailing wind direction, prevailing transport direction and storm wind direction. After review of the available wind data from the Sage Creek Basin Snotel site, a prevailing southerly wind direction of 179° TN was determined. A prevailing southerly transport direction of 185° TN and north-northeasterly storm wind direction of 31°TN were also identified.

5.2.4 Snow Fence Height Design Constraints

Potential snow fence heights are calculated independently from two design constraints, i.e., the potential for snow transport and the volume of precipitation during the snow accumulation season. The first constraint assumes wind is the limiting factor and the second assumes total snowfall is the limiting factor.

The wind constraint assumes there is an infinite amount of snow to fill the fence to capacity. The total snowfall constraint assumes there is sufficient wind to relocate all of the available snow. The method determined to be the limiting factor is used for snow fence height calculation.

5.2.5 Wind Transport Speed

Threshold transport speed is the minimum wind speed that will transport snow. This varies with snow condition, particle size, elevation and temperature. Based on the typical snow and elevation in Sage Creek Basin, a threshold wind speed of 13.4 mph (6 m/s) is appropriate for calculating potential snow transport and recommended snow fence heights. From the 13.4 mph (6 m/s) wind speed a potential fence height of 1.3 feet (0.4 m) was calculated using equations developed by Dr. R.D. Tabler (Tabler, 2003).

5.2.6 Precipitation and Snow Water Equivalency

Snow Water Equivalent (S_{WE}) is the amount of water contained within the snowpack. It can be thought of as the depth of water that would theoretically result if the entire snowpack melted instantaneously. The NRCS measures S_{WE} at many remote SNOTEL sites and uses the data for streamflow forecasting.

To determine snow depth from S_{WE} you need to approximate the snow water density of the snow. The snow water density of fresh snow has water contents that range from about 5% when the air temperature is 14° F to about 20% when the temperature is 32° F. Most snow that falls in Wyoming’s southern mountains is relatively low in water content; typical values of 10-20% in the winter and 20-40% in the spring. After the snow falls its density increases due to gravitational settling, wind packing, melting and recrystallization (NRCS).

Precipitation data, compiled from the 2002-2011 snow accumulation seasons, was used to determine an average Snow Water Equivalent (S_{WE}) of 11.52 inches (292.61mm) per season, see Table 5-2. Using the precipitation and resultant Potential Snow Transport as the design constraint, a snow fence height of 18.8 feet (5.7 M) was calculated (Tabler, 2003).

Table 5-2. Historical Precipitation Data 2001-12 (inches S_{WE})

YEAR(S)	JAN (in)	FEB (in)	MAR (in)	APR (in)	MAY (in)	JUN (in)	JUL (in)	AUG (in)	SEP (in)	OCT (in)	NOV (in)	DEC (in)	ANNUAL (in)	SNOW ACCUMULATION SEASON (in)
2001	-	-	-	-	-	-	-	-	-	-	2.7	2.5	-	-
2002	1.4	0.9	5	0.7	0.7	0.3	0.6	0.7	1.2	2.4	1.8	2.6	18.3	11.7
2003	1.4	1.8	2.3	2.4	2	0.8	0.2	0.2	1.5	0.6	4.3	3.6	21.1	13.4
2004	1.9	1.6	0.6	1.8	1.2	1.9	0.8	2.2	2.4	5.2	1.6	2.3	23.5	8
2005	3	1.8	1.3	2	2.4	2.4	0.3	0.3	2	2.2	2.9	3.4	24	12.4
2006	2.8	1.2	2	2.2	0.6	0.5	1.2	1.1	2.6	3.9	1.8	1.6	21.5	9.4
2007	1.3	2.1	1.7	1.3	1.7	1.1	0.4	1.7	2.6	2.7	1	5.1	22.7	11.2
2008	4.3	2.7	2	1.5	1.8	1.5	0.3	1.4	2.4	1	1.4	3.5	23.8	13.9
2009	2.9	3	2.4	4.2	1.7	3	1.1	1.9	0.1	3.4	1	2.5	27.2	11.8
2010	1	1.4	1.5	4.2	3.3	2.5	0.4	2	0.3	3	3	5	27.6	11.9
2011	2.1	2.6	3.3	4.9	2	2.2	0	0.3	0.1	2	2.6	0.9	23	11.5
2012	1.6	2.6	0.5	1.1	0.8	0	1	0.4	0.4	-	-	-	-	-
														AVERAGE = 11.52

5.2.7 Design Comparison

Using wind as the design constraint, a recommended snow fence height of 1.3 feet was calculated, while a recommended snow fence height of 18.8 feet was calculated with snow accumulation as the design constraint. Usually the lower of the two would be the recommended design height, but wind data for the specific sites of the Springs is not available.

The analysis of the Sage Creek SNOTEL site data implies that wind is the limiting factor, but this conclusion is not realistic for the specific area around the Springs. As can be seen from Figure 5-1 below, the Sage Creek Basin Snotel site is surrounded by trees and somewhat protected from the wind.

Figure 5-1. Sage Basin Snotel Site in the Trees Protected from the Wind

This protected location would significantly reduce measured wind speeds, resulting in the small snow fence height. While equations can be applied to remotely recorded data to estimate recommended snow fence heights, site observations should be completed and site specific wind data should be collected to verify these conclusions.

5.2.8 Site Visits

Two site visits were conducted to assess field conditions in the Sage Creek Springs Basin. The first was to verify prevailing wind direction and to observe snow accumulation at potential snow fence locations. The second documented site conditions, like vegetation and topography. The onsite field investigation also observed local features for evidence of wind direction and velocity, and evaluated the existing snow fence for effectiveness and orientation.

5.2.9 Winter Season Visit

The first site visit was accomplished, via snowmobile, in March of 2011 and verified existing snow fence operation and assessed the basin's topography. According to the Sage Creek Basin Snotel site, the yearly snow pack was above average at the time of the visit. Figure 5-2 is an overview of Sage Creek basin in the area of the existing snow fence.

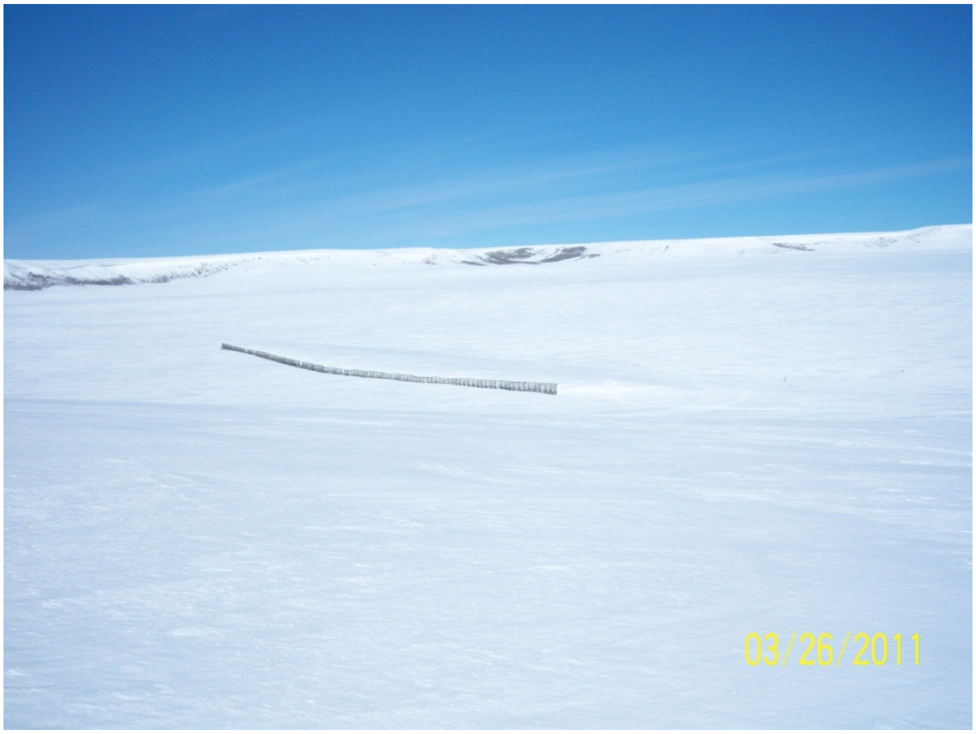


Figure 5-2: Sage Creek Basin, March 2011.

The snowpack was consistent and heavy across the basin. The existing snow fence was observed to be at equilibrium which indicates that a 12-foot snow fence height may be appropriate for this site. Existing terrain in the vicinity of the Springs effectively traps snow in many locations but the snow-trapping efficiency can be improved by addition of snow fences in several locations.

5.2.10 Fall Visit

The second field visit occurred on October 20th, 2012. The road access was open and the site was visited via automobile. Basin soil conditions, vegetative cover for transport wind direction data and potential snow fence sites were evaluated.

The Springs lie in a north facing basin approximately 30 miles south of the City. The undulating topography is sparsely forested and mainly covered in low sage brush and grasses. On the date of the field visit, the wind was from the south southwest at 10 to 15 miles an hour.

The vegetative growth patterns were observed for signs of predominant wind direction. It was noted that the sage leans to the north and east. These growth patterns indicate a predominant wind direction of 210°. Site features such as fence posts and exposed rocks also displayed wind scour on the same 210° aspect.

Figure 5-3. Sage Leaning Away from the Prevailing Wind

At the southeast end of Sage Creek Basin, there is approximately 700 feet of 12 foot high Wyoming wood snow fence. The fence is immediately upstream of the Springs 14A, 14B and 14C. The existing snow fence is in fair condition and the exact age is unknown.

Examination of existing features scattered throughout the landscape, such as fence posts, vegetation, rocks, etc., indicate a transport wind direction of 205° magnetic north to be more suitable for snow fence design than the prevailing wind direction of 179° TN identified by review of the Snotel site data. A wind direction of 195° TN is recommended for design orientation of any proposed snow fence. Snow fence layout is further discussed in Section 5.3 of this report.

5.3 SNOW FENCE DESIGN

A site-specific snow fence design includes proposed height and horizontal layout recommendations. As previously mentioned, the lower calculated height of the two design constraints; available transport wind and seasonal snowfall, is usually recommended when backed by site observations. Horizontal Layout is a function of wind direction and snow fence should be installed perpendicular to the prevailing transport wind direction.

A 12-foot high snow fence with a design wind direction of 195° TN is recommended as the most efficient design for the Sage Creek Basin conditions. The recommendations are based on the observed data including seasonal snow amounts and prevailing transport winds. As previously stated wind data should be collected at the specific site locations of the Springs to verify the results give in this report.

Specific location within the Basin is dependent on topography, location of the City's collection system and available fetch. Fetch is the upwind distance from the fence to any boundary across which there is no snow transport, such as forest margins, deep gullies, stream channels, rows of trees or bodies of unfrozen water.

Various locations in Sage Creek Basin for new snow fence were investigated. The area with the most potential for improving the City's water supply portfolio is near the existing snow fence on the western boundary of the Springs area. The undulating topography, in the central and eastern portions of the basin already trap snow effectively. Also, the closer the fence is to the collection system, the faster water enters the system with less time for infiltration and evaporation losses.

Three snow fence layouts are proposed in Figure 5-4. These locations were chosen for their greatest potential benefit to the Rawlins springs. Snow Fence 1 (SF1) is located approximately 400 feet upstream of springs 9B and 9D. Snow Fence 2 (SF2) is an extension of the existing 12 foot snow fence, upstream of springs 14A, 14B and 14C. Snow Fence 3 (SF3) is located to the north and upstream of springs 14A, 14B and 14C.

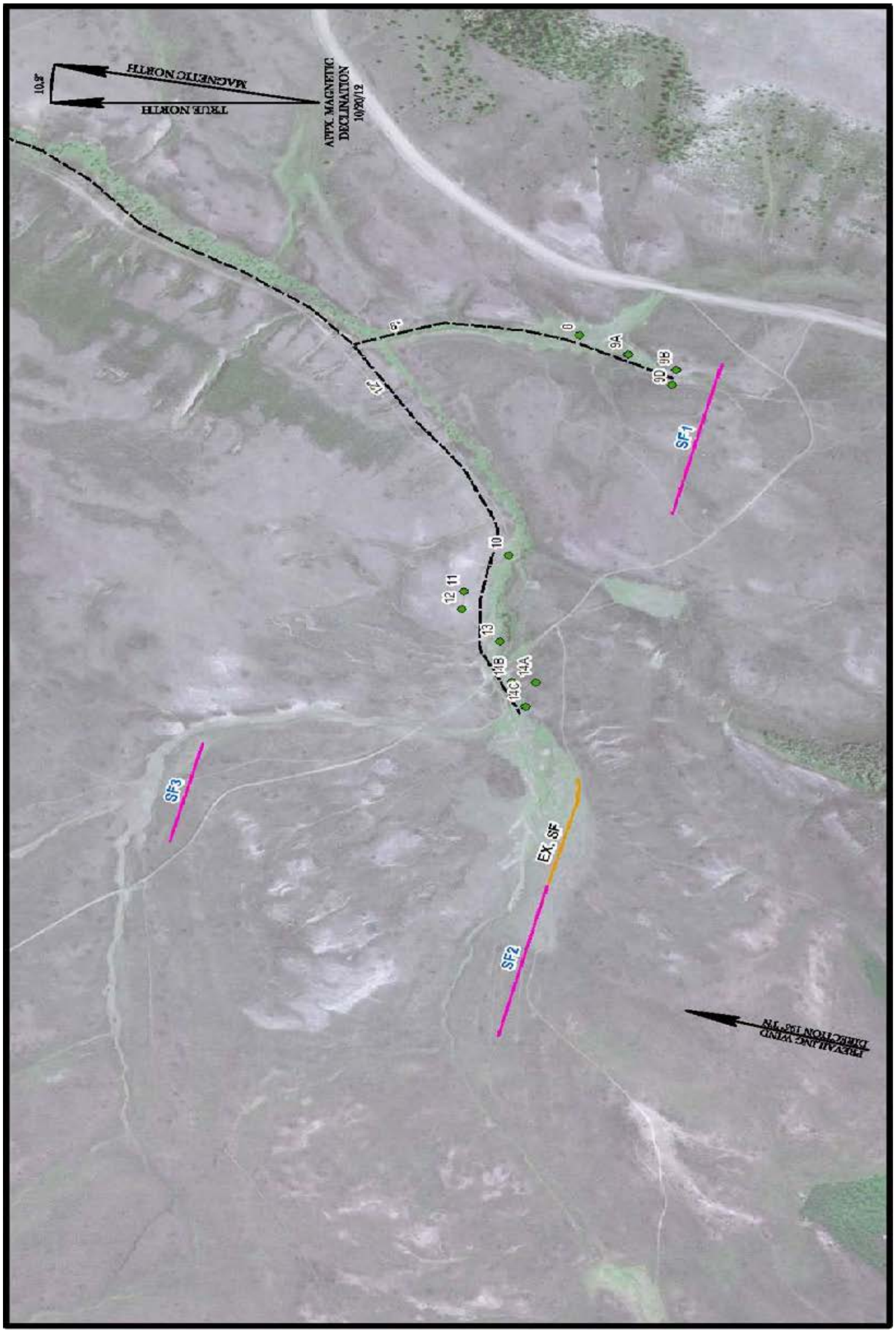


Figure 5-4. Snow Fence Layout

5.4 WATER VOLUME

This section provides information supporting the idea that installation of snow fence improves basin water production by reducing sublimation of windblown snow. The effectiveness of these existing and proposed snow fences can be theoretically quantified by site conditions and expressed as a volume of additional "new water" that may potentially accrue to the basin. The addition of "new water" to a basin is a function of relocated snow trapped by the snow fence and the reduction in sublimation of the snow pack.

The calculation of "new water" is based on a number of assumptions developed from previous studies and research. The research conducted in the Stratton Sagebrush Study Area documented increased surface runoff water yields and prolonged runoff duration. The Stratton Study area shares similar characteristics with the Sage Creek Basin, which include soil type, topography, aspect and snow conditions.

The calculated overall volume of water trapped by a 12-foot Wyoming wood snow fence at equilibrium is 1,380 ft^3/ lineal foot of snow fence (10,323 gal/ft), See Table 5-3.

Table 5-3. Snow Fence Overall Water Quantity Calculations

Snow Fence Height		Avg. Drift Height		Avg. Snow Density		Cross Sectional Area*		Volume of Water	
H (ft)	H (m)	y (ft)	y (m)	ρ (lb/ft^3)	ρ (kg/m^3)	area (ft^2)	area (m^2)	ft^3/ft of Snow Fence	m^3/m of Snow Fence
12	3.7	4.0	1.2	23.8	381.5	3614.4	335.8	1379.4	128.1

* All calculations are based on a snow drift at equilibrium conditions.

In order to get a more accurate representation of additional water trapped by the proposed snow fence, the quantity of water currently being trapped by the vegetation must be estimated. For the assumed vegetation height of 18 inches, the quantity of water currently being trapped is approximately 155 ft^3/lineal ft of snow fence (1,160 gal/ft).

Subtracting the volume of water trapped by vegetation from the total water trapped by the fence results in 1,224 ft^3 (9,156 gal) of additional water per lineal foot of snow fence, see Table 5-4.

Table 5-4. Snow Fence Additional Water Quantity Calculations

Vegetative Cover		Avg. Snow Density		Cross Sectional Area*		Volume of Water		Additional Water	
h (ft)	h (m)	ρ (lb/ft^3)	ρ (kg/m^3)	area (ft^2)	area (m^2)	ft^3/ft of Snow Fence	m^3/m of Snow Fence	ft^3/ft of Snow Fence	m^3/m of Snow Fence
1.5	0.5	16.5	264.2	588	179.2	155	47	1224	81

Sublimation is a significant source of water loss that occurs throughout the snow accumulation season. Figure 5-5 illustrates that relocated snow evaporates as it travels further. The proposed snow fences will concentrate the snow, reducing the amount lost to sublimation, which potentially increases supply and lengthens the period of runoff/infiltration. This "new water" is water that would have otherwise been lost and not available for infiltration or runoff and could be viewed as non-hydrologically connected.

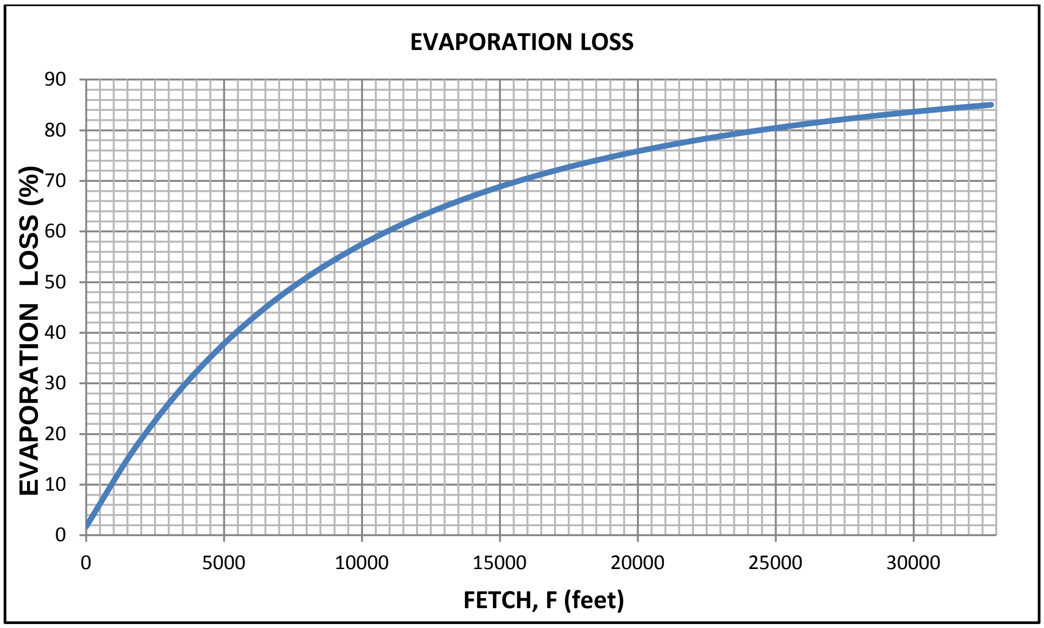


Figure 5-5. Evaporation of Relocated Snow as a Function of Fetch (Tabler 1994)

The following equation estimates sublimation quantities (Tabler, 2003):

$$Q_{evap} = 1000S_{rwe}F - 500TS_{rwe}(1 - 0.14^{F/T})$$

where: Q_{evap} = evaporation loss (kg/m of width across the wind)
S_{rwe} = relocated snow water equivalent (meters)
F = fetch distance (m)
T = maximum transport distance (m), assumed to be 3,000 meters (10,000 feet)

Calculations resulting in "new water" quantities obtained with the addition of 12-foot snow fence in the southeastern corner of the Sage Creek Basin are shown in Table 5-5 . It should be noted that this estimated quantity of "new water" is pre-melt, and the site-specific evaporation and transpiration rates during the spring melt are not accounted for. The total volume of "new water" that is potentially available for collection and use by the City of Rawlins is calculated to be 40.5 acre-feet.

Table 5-5. Snow Fence "New" Water Quantity Calculations

Snow Fence	Length	Height	Fetch	Down-Wind Distance	Total Transport Distance	Evaporation Loss	Volume of Water				Notes
							Total	Additional	"NEW" Water		
	(ft)	(ft)	(ft)	(ft)	(ft)	(%)	(ft^3)	(ft^3)	(ft^3)	ac-ft	
SF1	996	12	1,500	6,000	7,500	48.9	457,960	406,350	198,720	4.6	<---west 1/3 of SF1
			3,000	6,000	9,000	54.3	915,910	812,710	440,940	10.1	<---east 2/3 of SF1
SF2	996	12	2,400	8,000	10,400	58.5	1,373,870	1,219,060	713,370	16.4	
SF3	660	12	2,000	6,000	8,000	50.9	910,400	807,810	410,890	9.4	
						TOTALS	3,658,140	3,245,930	1,763,920	40.5	

5.5 CONCLUSION

The City of Rawlins springs in the Sage Creek Basin are significantly impacted by seasonal snowpack for water production. The snowpack, accumulating in the mezzo topography of the basin, is subject to seasonal variations of wind and snowfall. The Springs collection system takes advantage of the natural basin topography to collect ground water and runoff for City use. Changes to the snow pack directly impact ground water levels, runoff in the basin and total water production available for City use.

In an open basin, such as Sage Creek Basin, snow fence installation would alter the mezzo topography of the basin and relocate snowpack to more directly benefit the spring's water collection. The increased snowpack adjacent to the Springs collection would increase the length of the runoff season and total amount of water available. The increased depth of relocated snow pack would also reduce the amount of water lost to sublimation and yield "new water" for City use.

The three proposed snow fence layouts, from section 5.3 of this report, take advantage of the basin topography and Springs collection system to improve spring water yield. Snow Fence 1, located 400 feet upstream of springs 9B and 9D, is 996 feet long and relocates approximately 9 million gallons of water. Snow Fence 2, 600 feet upstream of springs 14A, 14B, and 14C, is a 996 foot extension of the existing snow fence and relocates another 9 million gallons of water. Snow Fence 3, located 2,000 feet upstream of springs 14A, 14B, and 14C, is 660 feet long and relocates approximately 6 million gallons of water. The total theoretical volume of water relocated by the snow fence is 24 million gallons; of which 13.2 million gallons is "new water".

Due to collection factors such as evaporation, infiltration and distance from the Springs, not all of the relocated water is available for City use. If a conservative collection factor of 50% is used for the relocated water close to the Springs collection system Snow Fence 1 and 2) and an even more conservative factor of 30% used for the more distant snow fence (Snow Fence 3), 10.8 million gallons of additional water may be available for City use.

This additional water would be most beneficial in a dry year after a below average snow season. Figure 5-6 shows the theoretical addition to the Springs supply monthly totals. The longer melt period and increased flows would be most noticeable in a dry season and would probably go unnoticed in an average or wet season unless the Springs collection system was optimized for increased flows.

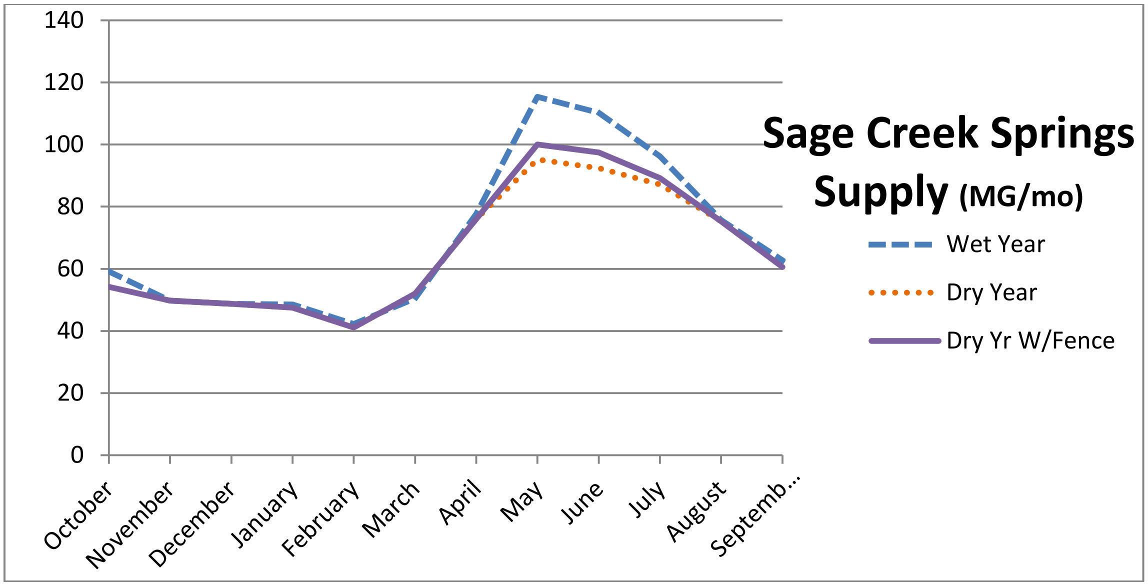


Figure 5-6. Sage Creek Springs Water Supply

Section 9 further discusses cost of snow fence installation and maintenance along with the cost benefit of the additional water to the City of Rawlins.

REFERENCES

Sturges, D.L. (1992), Streamflow and sediment transport responses to snow fencing a rangeland watershed, Water Resources Research, 28(5), 1347-1356.

Tabler, R.D. (1988), Estimating dates of the snow accumulation season. *Western Snow Conference (Kalispell, Montana; April 19-21, 1988) Proceedings 56:35-42.*

Tabler, R.D. (2003), Controlling Blowing and Drifting Snow with Snow Fences and Road Design, NCHRP Project 20-7(147), Transportation Research Board of the National Academies, Washington, D.C.

6 SOURCE WATER QUALITY

6.1 INTRODUCTION

A raw water quality assessment was conducted on the City's three sources of water supply: the Sage Creek Basin Springs (Springs), the Nugget Wells (Wells) and the North Platte River (river). The assessment also included two of the City's reservoirs: Rawlins and Peaking Reservoir. The City's third reservoir, Atlantic Rim, was under construction and not available for testing.

The assessment developed a sampling program to determine the baseline water quality and develop potential source water blending methods to optimize the blend of water for the City's use. It is the objective of the City to use the "best available" water for customer satisfaction and especially for compliance with the Environmental Protection Agency's (EPA) Safe Drinking Water Act (SDWA). The City also considers it a high priority to produce aesthetically pleasing water that is enjoyed by its customers and is in compliance with the secondary standards of EPA's SDWA.

The main source of water for the City is the Springs. This quality source provides adequate water supply for most of the year. During the summer irrigation season, the Spring's supply may require supplemental supply from other sources, such as the Nugget Wells, storage reservoirs and the North Platte River. Blending of these sources will impact the City's water quality.

The three main contaminants of concern for blending are total dissolved solids (TDS), sodium and corrosivity. The source water blending analysis is based on these contaminants and impacts to the source water quality compared to the established baseline.

6.2 REGULATION REVIEW

6.2.1 Long-Term 1 Enhanced Surface Water Treatment Rule

The LT1ESWTR was established to increase public health by reducing potential of adverse health effects by assuring that measures, including microbial control, are implemented for public water systems that serve fewer than 10,000 customers. Essentially, LT1ESWTR establishes a removal requirement of Cryptosporidium for filtered and unfiltered water systems and establishes combined filter effluent (CFE) turbidity performance standards that are dependent on the type of filtration used by the system:

<u>Conventional and direct filtration:</u>

- ≤ 0.3 nephelometric turbidity unit (NTU) in at least 95% of measurements taken each month
- Maximum level of turbidity: 1 NTU

<u>Slow sand and diatomaceous earth (DE) filtration:</u>

- Continue to meet CFE turbidity limits specified as the following:
    - 1 NTU at least 95% of measurements taken each month
    - Maximum level of turbidity: 5 NTU

<u>Alternative technologies (other than conventional, direct, slow and, or DE):</u>

- Turbidity levels are established by the EPA based on filter demonstration data submitted by the system.
    - EPA-set limits must not exceed 1 NTU (in at least 95% of measurements) or 5 NTU (maximum).

6.2.2 Long-Term 2 Enhanced Surface Water Treatment Rule

The LT2ESWTR adds additional public protection against Cryptosporidium and other water borne microbial pathogens. Cryptosporidium is a protozoan parasite that is common in surface water supplies and highly resistant to common chemical disinfectants typically used for water treatment, causing additional concern.

The LT2ESWTR required the City to begin a first-round source water monitoring program to determine if the sources are at risk of contamination. This first-round monitoring program began April 2010. The results from the source water monitoring determined the extent of additional treatment that will be required to mitigate potential health threats. If additional treatment is needed the City will be required to provide additional treatment no later than October 1, 2014.

6.2.3 Stage 1 Disinfectants/Disinfections By-Product Rule

The Stage 1 D/DBPR established seven new standards for total trihalomethanes (TTHMs), haloacetic acids (HAA_5), and a number of other contaminants that result from using specific oxidants/disinfectants. The maximum contaminant level (MCL) for the regulated constituents are as follows:

Regulated Contaminants	MCL (mg/L)
• TTHMs	0.080
• HAA_5	0.060
• Bromate (plants that use ozone)	0.010
• Chlorite (plants that use chlorine dioxide)	1.0

Regulated Disinfectants	MCL (mg/L)
• Chlorine	4 as Cl_2
• Chloramines	4 as Cl_2
• Chlorine Dioxide	0.5

TTHM's and HAA_5 occur by the reaction between dissolved organics and residual chlorine; therefore, the presences of organic compounds, expressed as concentrations of total organic carbon (TOC) are indicators that DBP formation during the disinfection process will likely occur. The Stage 1 D/DBPR establishes a treatment technique of enhanced coagulation or enhanced softening to further reduce TOC. The removal requirements for TOC for conventional plants consist of the following:

Source Water TOC	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0 – 60	<60 – 120	>120
	Percent Removal		
>2.0 – 4.0 mg/L	35	25	15
> 4.0 – 8.0 mg/L	45	35	25
> 8.0 mg/L	50	40	30

6.2.4 Stage 2 Disinfectants/Disinfection By-Products Rule

The Stage 2 D/DBPR further regulates DBP formation by focusing on distribution systems. In fact, the Stage 2 D/DBPR requires utilities to identify locations in their distribution systems that represent the highest DBP levels using either modeling, sampling tools, historical data or a combination of these. The identified locations will be required to meet TTHM and HAA5 compliance based on a running annual average. Utilities must complete the monitoring plan and begin complying with monitoring requirements no later than October 1, 2013. The monitoring requirements stated in Stage 2 D/DBPR include the following:

Source Water Type	Population by Size	Monitoring Frequency	Total Distribution System Monitoring Location per Monitoring Period
Subpart H (Filtration and Disinfection)	< 500	per year	2
	501 – 3,300	per quarter	2
	3,301 – 9,999	per quarter	2
	10,000 – 49,999		4
	50,000 – 249,999		8
	250,000 – 999,999		12
	1M – 4.9M		16
	≥5M		20
Groundwater	< 500	per year	2
	501-9,999		2
	10,000 – 99,999	per quarter	4
	100,000 – 499,999		6
	≥ 500,000		8

6.2.5 Lead and Copper Rule

The Lead and Copper Rule (LCR) was promulgated to specifically address the problems associated with mobilizing lead and copper in water distribution systems. It acknowledges that acceptable quality water leaving the treatment plant could potentially impact materials in the distribution system and corrode system components resulting in the solution of metals. The LCR establishes an action level of 0.015 mg/L of lead and 1.3 mg/L of copper based on a 90^{th} percentile level of tap water samples. A utility that exceeds these action levels is subject to further requirements that include water quality parameter monitoring, corrosion control treatment, source water monitoring/treatment, public education and lead service line replacement.

6.2.6 Secondary Drinking Water Standards

The City also considers it a high priority to produce aesthetically pleasing water that is enjoyed by customers and is in compliance with the secondary standards of the SDWA. Secondary standards are not enforced by EPA. However, the City is still concerned with maintaining compliance with secondary standards, such as sulfate (MCL of 250 mg/L), total dissolved solids (TDS) (MCL of 500 mg/L) and taste and odor (T/O) (MCL of 3 threshold number). The City is also concerned with addressing high sodium and hardness concentrations, which have no EPA standards.

High sodium concentrations create a health threat for persons with hypertension, diabetes or kidney diseases. In the event soils in the area possess a high sodium adsorption ratio (SAR), high sodium concentrations will likely adversely impact the ability to grow vegetation, including grass species used in residential lawns and parks. The SAR is determined by the concentrations of dissolved solids in the water, specifically sodium, calcium and magnesium. The sodium in the water, especially with a high SAR of over 12, can displace the calcium and magnesium in the soil which affects the soils structure and may cause a decrease in the infiltration and permeability of the soil, and thus, adversely affecting crop/grass production. The EPA's recommended sodium level is 30 mg/L to 60 mg/L. Hardness has both positive and negative effects.

Hardness is thought to decrease corrosion through contributing ions of calcium and magnesium; however, high concentrations of these ions result in increased scale formation on typical household items such as water heaters and plumbing fixtures. Hardness is classified as follows: water with concentrations of calcium and magnesium ions of less than 75 mg/L is soft; water with concentrations ranging from 75 mg/L to 150 mg/L is moderately hard, concentrations ranging from 150 mg/L to 300 mg/L is considered hard and concentrations greater than 300 mg/L is considered to be very hard. The EPA provides no policy on the control of hardness but the City's goal is soft to moderately hard.

6.2.7 Sampling Program

A water quality sampling program was conducted on the City's water supply sources to measure specific water quality parameters. The program consisted of sampling each source bimonthly during the time of year when water quality has been known to change. The sample months when water quality is expected to improve are October, November and February. The months when water quality is expected to deteriorate are April, June and August. Samples were analyzed for the following water quality parameters: pH, turbidity, TOC, TDS, alkalinity, sulfate, total hardness, calcium, magnesium, chloride, and sodium. Samples were analyzed both in the field and at a laboratory except for the month of November when only field analyses were performed. Table 6-1 is an example of April 9, 2012's water quality results for each of the water sources. The complete sampling program's water quality results are provided in Appendix A. Table 6-2 shows the City's typical historical water quality results sample date July 31, 2008, except for Peaking Reservoir which was not included in the analysis.

Table 6-1. Water Quality Results (April 9, 2012)

Parameter (mg/L) unless otherwise stated	Sage Creek Basin Springs	Nugget Wells	North Platte River	Rawlins Reservoir	Peaking Reservoir
pH	8	8	8	9	8
Turbidity (NTU)	0.3	0.4	10.5	7.8	3.5
TOC	1.1	0.8	4.6	3.3	1.8
TDS	238	693	142	188	227
Total Alkalinity (mg/L as $CaCO_3$)	138	406	72	109	136
Sulfate	28	161	59	31	33
Total Hardness (mg/L as $CaCO_3$)	162	9	82	139	159
Calcium	58	2	23	44	56
Magnesium	4	ND	6	7	3
Chloride	2	3	5	3	2
Sodium	3	253	11	5	3

Table 6-2. Historical Water Quality Sampling Results

Parameter (mg/L) unless otherwise stated	Sage Creek Basin Springs	Nugget Wells	North Platte River Typical Range	Rawlins Reservoir
pH	7.6	8.8	7.6-8.3	8.8
Turbidity (NTU)			2-20	
TDS	180	648	200-340	11
Total Alkalinity (mg/L as $CaCO_3$)	150	390	100-140	95
Sulfate	28	160	50-110	16
Total Hardness (mg/L as $CaCO_3$)	140	9	150-200	93
Calcium	50	2	30-60	30
Magnesium	4.2	1	6-19	4.5
Chloride	2.3	7	3-15	1.6
Sodium	3.2	260	13-36	3

Although sampling results between dates are similar, the springs and wells experience relatively low turbidities while the river exhibits elevated turbidities. In addition, the wells experience relatively high concentrations of sodium and sulfate but low hardness, while the springs have low sodium and sulfate concentrations and moderate levels of hardness. The river also has a moderate level of hardness and exhibits low sulfate levels.

In comparing the three sources, the springs produce the best water quality with low concentrations in most of the parameters. The sampling results indicated the river and reservoirs have elevated turbidity above the acceptable limit for the City's DE filters, which is less than 5 NTU.

The reservoirs water quality is dependent on the sources of supply and the percentage that each source contributes to the reservoir's storage volume. Peaking reservoir can be supplied by all three sources where Rawlins reservoir is only supplied by Sage Creek.

7 EXISTING WATER TREATMENT PLANT EVALUATION

7.1 INTRODUCTION

The treatment plant typically draws water directly from the Sage Creek Basin Springs Pipeline and adds water from Peaking Reservoir when the pipeline cannot meet instantaneous demand. Water from Atlantic Rim Reservoir may also be diverted into the pipeline, if necessary, to meet demand. North Platte River water can be pumped to either Atlantic Rim or Peaking Reservoirs to augment these supplies as well.

The Spring's water quality is such that a Diatomacious Earth (DE) filter and chlorine gas disinfection is sufficient treatment to meet current EPA standards. When reservoir or Platte River water is introduced, turbidity levels are such that pretreatment is necessary.

The City's treatment includes a pre-treatment plant consisting of powdered activated carbon (PAC) and an ACTIFLO system. Treatment downstream of the pre-treatment system employs diatomaceous earth (DE) filters and a chlorine gas disinfection system. The pre-treatment plant systems remove T/O with PAC. The ACTIFLO system was constructed to remove high levels of turbidity and TOC prior to DE filtration. DE filtration operates very well with low turbidity water (less than 5 NTU).

The operation of the ACTIFLO system utilizes an aluminum sulfate polymer and sand to achieve turbidity removal. As a result of operational incompatibility with the DE filters, the City's pre-treatment plant is currently not utilized. With the pre-treatment plant not in operation, the City is limited to water sources that exhibit turbidities and TOC concentrations of less than 5 NTUs and 2 mg/L, respectively.

The City's treatment plant is also not equipped with processes to remove sulfate, TDS, sodium and hardness; therefore, sources that exhibit low concentration levels of these constituents in the raw water are ideal. Raw water sources with low levels in turbidity and TOC are also ideal. For each constituent the recommended limit needed to achieve the "best available" raw water for the City is shown in Table 7-1.

Table 7-1. Raw Water Limits

Parameter	Desired Raw Water Limits
Turbidity	< 5 NTU
TOC	< 2 mg/L
Sodium	< 60 mg/L
Hardness	< 150 mg/L
TDS	< 500 mg/L
Sulfate	< 250 mg/L
T/O	No odor

One of the City's primary responsibilities is to provide drinking water that is safe and compliant with the SDWA. To determine the best water quality, an analysis was performed and scenarios were developed that will provide the City with options to assist them with their source water management plan.

7.1.1 Water Treatment Plant Assessment

The City is required to meet EPA LT1&2ESTWTR, Stage 1&2 D/DBPR and lead and copper rule (LCR) of the SDWA. The City's treated water turbidity limit is 1 NTU under LT1&2ESWTR for DE filters. The City's compliance objective for Stage 1&2 D/DBPR is a TOC concentration of 2 mg/L, which will constitute a 35% reduction in the TOC concentration when the objective is achieved. The City's LCR compliance objective is to provide customers with non-corrosive water, which will ensure that lead and copper limits are met. An assessment of the City's existing treatment plant was performed to determine if the treatment processes are able to treat the different blended sources while continuing to provide safe, EPA compliant water to the City's customers.

7.1.2 Existing Plant

The City currently operates the diatomaceous earth (DE) filters and chlorine gas disinfection system to treat water from the springs and wells. DE filtration is a type of precoat filtration where water is passed through a layer of filter media (DE) that has been precoated on a septum, which is a permeable material that supports the filter media. As the water passes through the DE filter media and the septum, suspended particles of 2 microns or larger are removed (AWWA, 1999). DE filters are limited by the quality of the water that is to be treated; highly turbid waters clog the DE pore sites, which leads to supplying additional media to extend filter runs. Without exception, pore clogging requires frequent backwashing of the DE filters and recoating of the filter's septum, which increases operating costs. DE filters are also not typically able to reduce TOC and T/O without additional pre-treatment.

In 2000, the City added a pre-treatment system that employed powdered activated carbon (PAC) and a proprietary system (the ACTIFLO system) to be able to utilize and treat water from the City's reservoirs. The PAC system was intended to be used for T/O issues when the reservoirs are in use. ACTIFLO is a compact treatment process that relies on polymers and coagulants in combination with microsand, which acts as a seed for floc formation. The microsand provides surface area to enhance flocculation and act as a ballast or weight to encourage rapid settlement in the settling tubes. Aluminum sulfate (alum) is used as a coagulant, which forms the floc, and a polymer is applied to link the floc with the sand. As a result of the rapid settling, the hydraulic resident time is shortened, resulting in a smaller footprint. The main target for ACTIFLO is turbidity and TOC. Unfortunately, due to polymer carry-over onto the DE filters and because of the subsequent clogging of the DE filters, use of this pre-treatment system was discontinued in 2002.

Since 2002, the City has had ample supply of water from the Sage Creek Springs to meet demand, which only requires treatment by the DE filters: therefore, there has been little interest in re-commissioning the pretreatment system. The City is currently facing drought conditions, which may require the City to utilize all of their water supply sources. Use of all water sources will likely require re-commissioning and changes to the pretreatment system to assure compatibility with the DE filters. The current treatment processes were evaluated to determine the applicability to reliably meet regulations independent of the water source.

7.1.3 Treatment Process Evaluation

The raw water quality assessment results indicated that when the City draws from the springs or the wells the DE filters provide sufficient treatment for turbidity and TOC without the addition of any pretreatment process. However, the raw water quality assessment results indicated that most blends involving the river resulted in higher turbidity and TOC concentrations. Historical operations indicate that the DE filters alone are not able to efficiently remove elevated concentrations of turbidity and TOC to their respective compliance limits. Therefore, the City will need to initially remove these elevated concentrations of turbidity and TOC prior to filtration. The ACTIFLO process is capable of removing elevated concentrations of turbidity and TOC. The operation of ACTIFLO with DE filters will be discussed in another section of this report.

The raw water quality assessment results from the corrosivity analysis indicated that treatment of the Springs and well water at any blend ratio is corrosive, which will require the addition of caustic to remedy the corrosive nature of the blended water sources. The amount of caustic needed will vary depending on the raw water quality and the chemical dosages used. When the pretreatment system is operational the need to add caustic is higher than when not in operation.

The current treatment facility has no treatment processes available for removal of the dissolved salts like hardness, sulfate and sodium. These Secondary Drinking Water Act constituents are non-life threatening and not subject to regulation, but they are rather aesthetically unpleasing. It is the City’s discretion as to the level of treatment provided to reduce these constituents. These constituents require high level of treatment, like a reverse osmosis system; however, the City has the option to control the concentration through source water blending. The optimal source water blends for secondary standards are 80% Springs water, 20% North Platte water or 10% North Platte water, 72% Springs water, and 18% Nugget Well water.

The City's current operation of the DE filters and disinfection are not capable of treating water supplied from all of their sources and continue to be in compliance with the SDWA. Based on the City's current operations, the recommended blend is 80% Springs water and 20% Nugget Well water. The City is considering re-commissioning the pretreatment system in order to provide the flexibility to utilize any source when needed. Otherwise, the City is vulnerable to water shortages and compromised effluent quality during times of drought.

7.1.4 Operation of Pre-Treatment Plant

The pre-treatment plant use was discontinued as a result of operational incompatibility with the DE filters where the DE filters saw polymer carry-over that blinded the filters (shorter filter runs were observed). The operation of the ACTIFLO process should be optimized to reduce polymer carry-over and improve filter run times in order to be compatible with the DE filters. This optimization involved conducting additional analyses to determine the ideal combination of coagulants, polymers and pH necessary to assure compatibility with the DE filters.

The additional studies conducted were bench-scale studies and a full-scale pilot study with CLEARLOGX and ACTIFLO. CLEARLOGX is a controlling process that measures temperature, pH and streaming current (ionization) to determine the adequate coagulant dosage and pH adjustment required for optimal floc formation. Depending on the raw water's pH, an acid or base can be injected to bring the pH within the optimal range for flocculation. This control system is dependent on the type of coagulant used. Typical ranges for pH with these various coagulants are as follows:

- Alum pH = 6.0 - 6.5
- Ferric pH = 5.5 - 6.5 or 8.8 - 9.2 (ferric provides multiple optimal points)
- ACH pH = 7.5 - 8.1
- PACL pH = 7.0-7.5

First, bench-scale studies were performed on the raw water supply sources. The intent of the study, performed in November of 2011 and repeated in June of 2012, was to demonstrate that ACTIFLO with CLEARLOGX is a viable pretreatment technology. The November analysis took water samples from the Peaking and Rawlins reservoirs using three different coagulants: alum (existing coagulant), low manganese ferric chloride (LMF) and aluminum chlorohydrate (ACH). All of the coagulants were dosed at 25 mg/L and a polymer feed of 0.3 mg/L for each source. Additional runs were conducted for alum and ferric at a dose of 50 mg/L and polymer of 0.3 mg/L.

The jar tests showed LMF at a concentration of 50 mg/L and ACH at a concentration of 25 mg/L each using 0.3 mg/L of polymer provided the best conditions for turbidity and TOC removal. Alum was a marginal performer for TOC removal but achieved results similar to the other two coagulants for turbidity.

The June analysis took water samples from the Peaking reservoir and used two different coagulants: alum and polyaluminum chloride (PACL). Two parallel jar tests were run with each coagulant. In one, the coagulant was dosed at 25 mg/L without pH control. In the second, the coagulant was dosed at 25 mg/L while controlling the pH.

The test was then repeated using the pH control, 25 mg/l of coagulant, 0.125 mg/L of polymer and microsand, simulating the ACTIFLO process. The results showed that the PACL provided the best conditions for turbidity removal; however, alum achieved similar results to the test performed in November.

Based on the bench-scale results, a full-scale pilot study using the ACTIFLO plant, CLEARLOGX control system and DE filters was conducted in the fall of 2012. This study ran 1 MGD from Peaking Reservoir through the ACTIFLO plant and one DE filter and then mixing with 3 MGD from Sage Creek Springs treated with the other three DE filters. This pilot test used a pilot CLEARLOGX control system to control the plant under two conditions: the first uses alum, sulfuric acid (pH control), and anionic (LT 25) polymer; the second uses PACL as the coagulant, sulfuric acid and anionic (LT 25) polymer.

At the time of this report, preliminary pilot study results show that ACTIFLO with CLEARLOGX is a viable pre-treatment system. Preliminary study results for both Alum and PACL show zero chemical carry-over onto the filters. The filter run results are twelve (12) hours and eighteen (18) hours for alum and PACL respectively, which have increased when compared to the three (3) hour filter runs observed in 2002. Pilot results also show that PACL is the more effective coagulant for turbidity removal. Based on these initial pilot results, ACTIFLO with CLEARLOGX is a viable pre-treatment technology.

7.2 SOURCE WATER BLENDING ANALYSIS

One of the City's primary responsibilities is to provide drinking water that is safe and compliant with the SDWA. To determine the best water quality an analysis was performed to provide the City with options that will assist them with their source water management plan.

The blending analysis used the month with the poorest quality water to provide the City with a good quality blend during spring runoff (the runoff season typically exhibits the poorest water quality). The blended scenarios analyzed are the following: (1) springs and river; (2) springs and wells; (3) river and wells and (4) all three. Since blending already occurs from the three sources in the reservoirs, the reservoirs were not considered in the blending analysis; but their usage will be further discussed in a later section of this report. It was also assumed that blending occurs in the pipeline prior to discharge into the reservoirs.

The blending analysis was performed using the AWWA/RTW Corrosion Blending model. The model is a tool devised to assist with evaluating water chemistry associated with chemical addition processes (coagulation/softening) and the potential for corrosion. It was also used to predict the water's stability as a result of any chemical addition from a single sources or blended sources. The blended model calculates a blended water quality from the different sources at specific blended ratios.

The model determines the water's corrosivity based on the water quality parameters TDS, sulfate, calcium, alkalinity and pH, and considers chemical processes from the source waters that ultimately increases or decreases the water's pH, which in turn influences the water's corrosivity. If corrosive water is predicted then the model can predict chemical dosages of a corrosion inhibitor that will provide non-corrosive water.

7.2.1 Sage Creek Basin Springs and North Platte River

The Sage Creek Springs (SC) and North Platte River (NP) blend occurs in Peaking Reservoir. The main parameters of concern with respect to this specific blending analysis were turbidity, TOC, TDS, alkalinity and hardness because the source concentrations are vastly different; some source waters contain concentrations of constituents greater than the desired raw water limits. The predicted blended water quality should see an increase in turbidity and TOC concentrations and a decrease in TDS, alkalinity and hardness concentration. Results of using different percentages of river water in the NP/SC blend were previously shown in Table 6-1. Figure 7-1 shows the blended water quality results for specific parameters

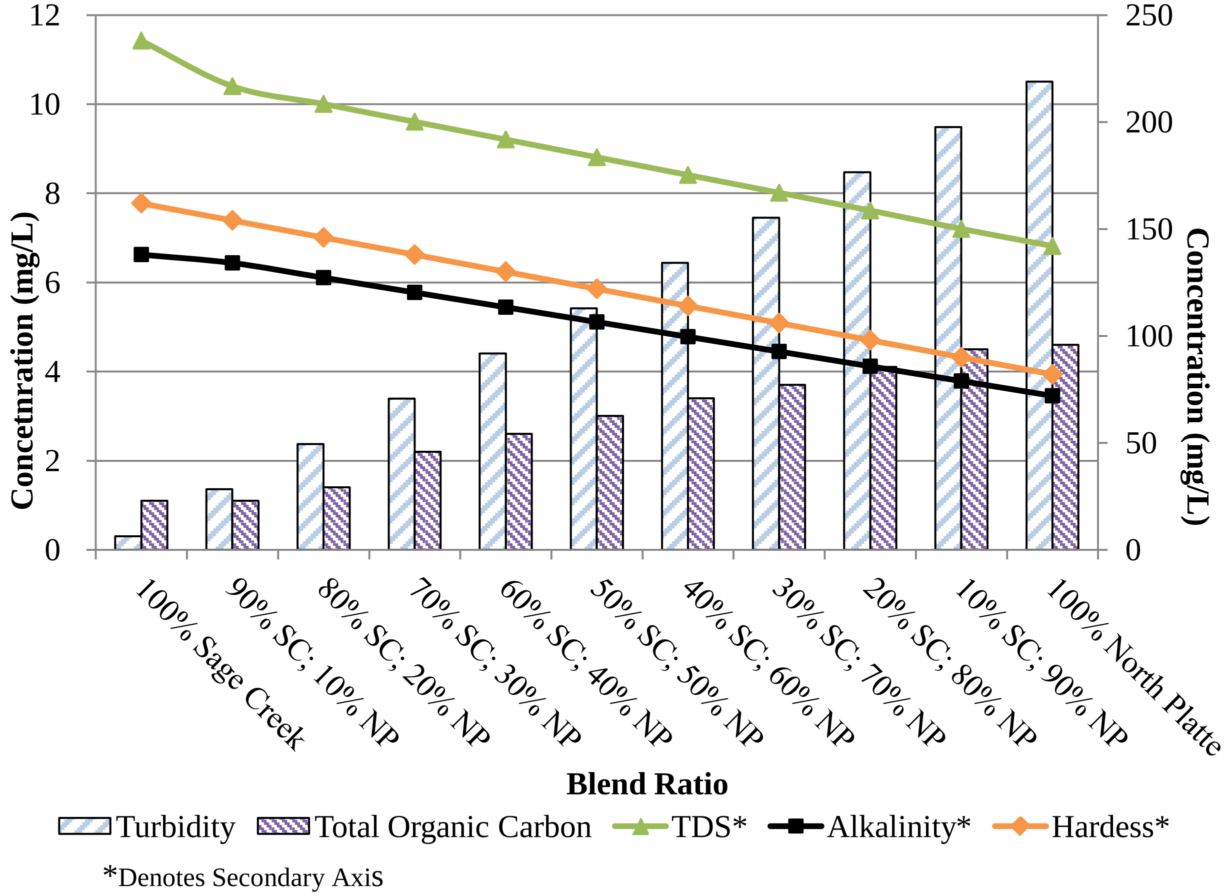


Figure 7-1. Blended Water Quality Results – Sage Creek Springs and North Platte River

The resulting water quality meets expectations concerning the decrease of TDS, alkalinity and hardness concentrations and an increase in TOC and turbidity when the NP water constitutes a larger share of the blend ratio. The sodium concentrations for both the SC and NP are low, so the SAR were not determined.

The model indicates a blend consisting of 70% SC/ 30% NP to 10% SC/ 90% NP that the TOC is higher than 2 mg/L, which requires the City to remove TOC under Stage 1 &2 D/DBPR. The results for blended ratios 80% SC/ 20% NP to 100% NP provides a turbidity concentration above the City's finished water turbidity limit of 1 NTU; therefore, the City will be required to remove turbidity to less than 1 NTU for compliance with LT1 & LT2 ESWTR. In order for the City to meet both TOC and turbidity removal, the City will need to operate the pretreatment plant. The optimal blend is 80% SC/ 20% NP; but because the TOC and turbidity are below the desired raw water limits, the City would need to operate the main plant (DE filter and disinfection) to continue to produce safe, SDWA compliant and aesthetically pleasing water to its customers.

The blended water quality was further modeled for corrosivity at each blend ratio. Based on the blended water quality analysis, use of the pretreatment plant with the filters is required. The plant's chemical dosages would include aluminum sulfate and sodium hypochlorite. The model was run using the plant's typical dosages for aluminum sulfate of 45 mg/L and chlorine gas of 1.5 mg/L. The resulting sodium hydroxide dosage was in the range of 19 mg/L to 21 mg/L depending on the blend ratio. The City currently does not add sodium hydroxide, so there are no typical dosage rates available for comparison.

7.2.2 Sage Creek Basin Springs and Nugget Wells

The SC and Nugget Wells (NW) blend would occur in the Sage Creek Pipeline. The main parameters of concern with respect to this specific blending analysis were TDS, alkalinity, sulfate, hardness, calcium and sodium. Because the source concentrations were vastly different, some of which were greater than the desired raw water limits additional analyses were conducted. According to results shown previously in Table 6-1, the predicted blended water quality should see an increase in TDS, alkalinity, sulfate and sodium and a decrease in hardness and calcium concentrations.

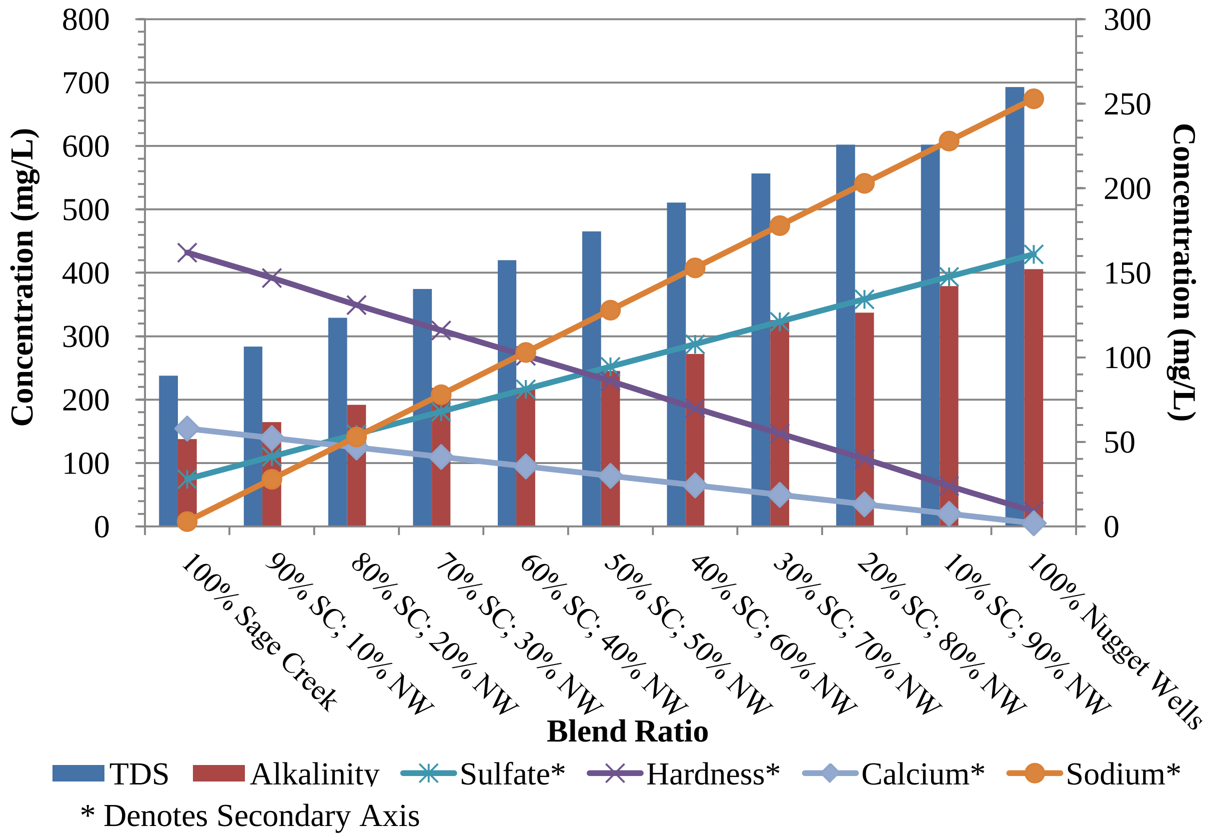


Figure 7-2. Blended Water Quality Results – Sage Creek Springs and Nugget Wells

The resulting water quality is as expected. The TDS, alkalinity, sulfate and sodium concentrations increased while hardness and calcium concentrations decreased. Since turbidity and TOC concentrations are below the desired raw water limit for all blend ratios, the City meets the LT1 and LT2 ESWTR and Stage 1 & 2 D/DBPR and will continue to provide safe, SDWA compliant drinking water to its customers.

Table 7-2. Sodium Adsorption Ratio – SC and NW

	SAR
100% SC; 0% NW	0.24
90% SC; 10% NW	2.43
80% SC; 20% NW	4.99
70% SC; 30% NW	8.21
60% SC; 40% NW	12.29
50% SC; 50% NW	17.63
40% SC; 60% NW	24.92
30% SC; 70% NW	35.48
20% SC; 80% NW	48.98
10% SC; 90% NW	75.44
100% Nugget Wells	133.15

← Objective SAR <12

As a result of the high sodium concentration in the wells, the sodium adsorption ratio (SAR) was determined for each blend ratio. The results are shown in Table 7-2. The SAR limit was reached at a blend ratio of 60% SC/ 40% NW. From Figure 2, a sodium concentration of less than 60 mg/L was reached using the blend ratio of 80% SC/ 20% NW, which was determined to be the optimal blended ratio. This ratio meets both the SAR and EPA suggested concentration limits. The usage of the wells is limited due to their high sodium concentrations.

The blend ratio of 80% SC/ 20% NW also meets the water quality objective limits for TDS, sulfate and hardness concentrations. Therefore, the optimal blend ratio for the springs and wells is 80% SC/ 20% NW.

Water quality was further modeled for corrosivity at each blend ratio. The blended water quality analyses indicate that only the filters are required to meet water quality standards. In addition, the plant's chemical dosages would be limited to chlorine gas applied before the filters for disinfection purposes and applied after the filters for maintaining chlorine residuals within the City's distribution system. The model was run using the plant's current chlorine gas dosage of 1.5 mg/L, which indicated that the blended water quality was non-corrosive. The wells are very high in alkalinity which provides a strong buffer to pH shifts. The City historically has not had an issue with corrosion when using these water sources; therefore the addition of sodium hydroxide is not required.

7.2.3 North Platte River and Nugget Wells

The NP and NW blend would occur within Peaking Reservoir. The main parameters of concern, due to water quality differences between the two sources, involve a wide range of constituents including turbidity, TOC, TDS, alkalinity, sulfate, hardness and sodium. According to Table 6-1, as the percentage of well water increases, the blended water quality should exhibit an increase in TDS, alkalinity and sodium with a decrease in turbidity and TOC concentrations. Figure 7-3 which shows the blended water quality results for these specific parameters.

The resulting water quality is as expected; concentrations of TDS, alkalinity and sodium increase while the concentrations of turbidity and TOC decreased. The results utilizing 100% NP water to 10% NP/ 90%NW water indicate a turbidity concentration above the City's turbidity effluent limit of 1 NTU; therefore, the City will be required to remove turbidity to less than 1 NTU for compliance with LT1 & LT2 ESWTR. The TOC results show that at a 100% NP to 30% NP/ 70% NW, the TOC is higher than the maximum allowable 2 mg/L, which requires removal of TOC to be compliant with the SDWA's Stage 1 & 2 D/DBPR. In order for the City to meet both TOC and turbidity removal, the City will need to operate both the pretreatment plant and treatment plant. In regards to turbidity and TOC the optimal blend ratio is 10% NP/ 90% NW, which would only require operation of the treatment plant with pre- and post-treatment applications of chlorine gas for disinfection purposes.

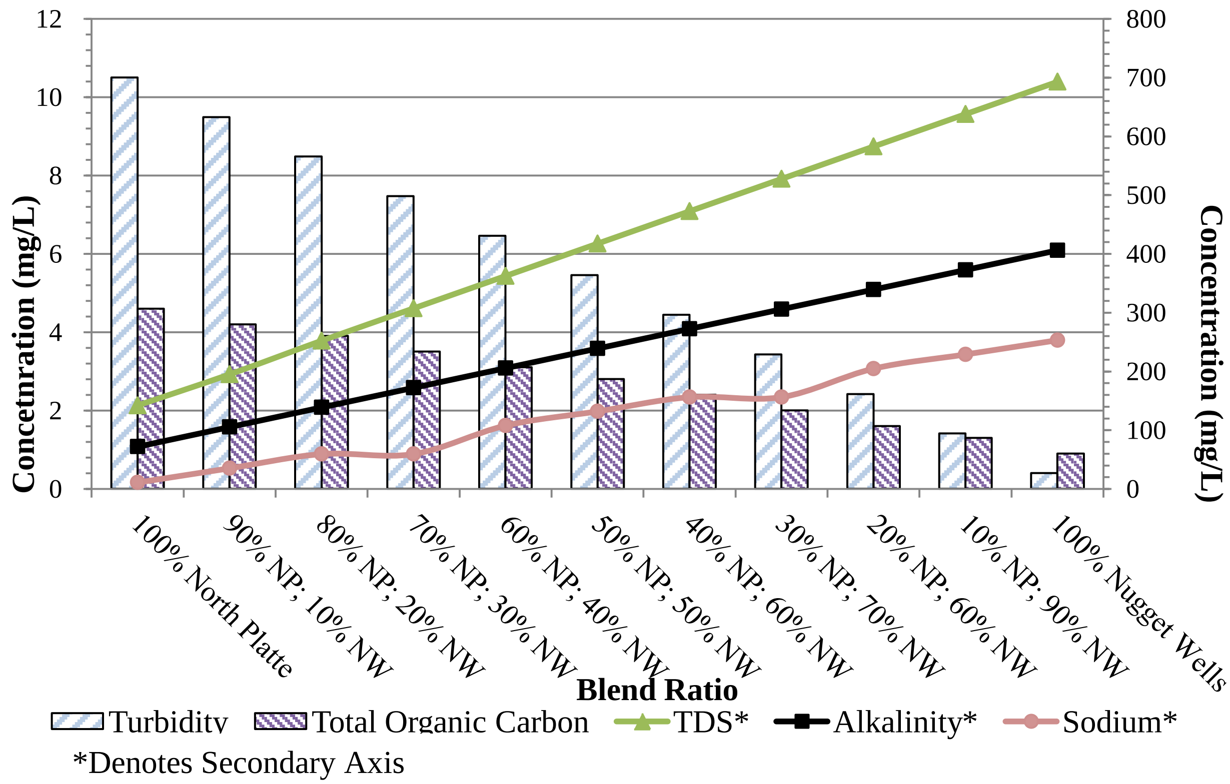


Figure 7-3. North Platte River and Nugget Wells - Blending Ratio Results

As a result of the increasing sodium concentration with use of the NW water, the SAR was calculated for different blend ratios and is shown in Table 7-3. The SAR goal of less than 12 was reached at the blend ratio of 70% NP/30% NW. From Figure 3, the blended sodium concentration less than 60 mg/L was also reached at 70% NP/30% NW. Therefore, the usage of the wells is limited by the sodium concentration.

Table 7-3. Sodium Adsorption Ration - NP and NW

	SAR
100% North Platte	0.84
90% NP/10% NW	2.94
80% NP/20% NW	5.53
70% NP/30% NW	6.18
60% NP/40% NW	12.97
50% NP/50% NW	18.18
40% NP/60% NW	26.21
30% NP/70% NW	31.83
20% NP/60% NW	56.74
10% NP/ 90% NW	70.64
100% Nugget Wells	388.81

← Objective SAR <12

The water quality of these two sources does not allow for an optimal blend ratio that meets all the desired limits. A blend ratio of 60% NP/40% NW is considered the best because the concentrations for turbidity and TOC are moderately greater than the desired raw water limits while the sodium concentration and SAR are slightly greater than their respective objective limits.

The blended water quality was further modeled for corrosivity at each blend ratio. The blended water quality requires the operation of the pretreatment plant with the DE filters; thereby, the plant's chemical dosages would be similar to the springs and river corrosivity analysis. The resulting sodium hydroxide dosage was in the range of 13 mg/L to 22 mg/L depending on the blend ratio.

7.2.4 Springs, North Platte River and Nugget Wells

The spring/wells sources are blended prior to conveyance to Peaking Reservoir. The analysis considered that the springs and wells were optimally blended (80%SC/20%NW) before the water was again blended with water from the North Platte River. This spring/wells optimal blend ratio was selected based on water quality and SAR ratio. The main parameters of concern, due to water quality differences between the two sources, involve a wide range of constituents including turbidity, TOC, TDS, alkalinity, sulfate, hardness and sodium concentrations. Based on Table 6-1, the predicted blended water quality indicates an increase in TDS, alkalinity and sodium and a decrease in turbidity and TOC concentrations with use of a higher spring/well percentages in the overall blend of water sources. Figure 7-4 shows the blended water quality results for these specific parameters.

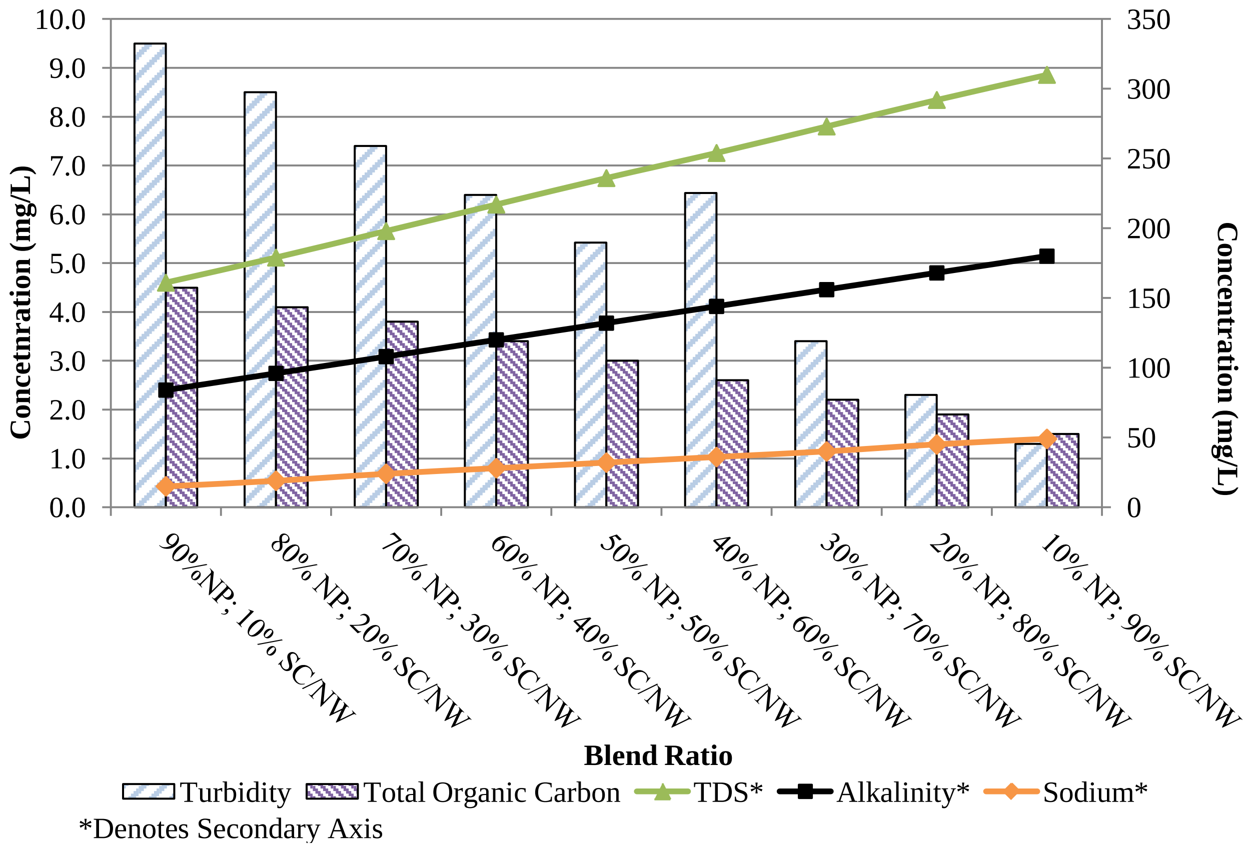


Figure 7-4. Springs, North Platte River and Nugget Wells - Blending Ratio Results

The resulting water quality is as expected. TDS, alkalinity and sodium concentrations increased while turbidity and TOC concentrations decreased. The turbidity results for all of the blend ratios are above the City's 1 NTU limit, which follows the trend of the other blended water quality results when the river was a source. Similarly, results indicate, at high river blend ratios (greater than 20% NP/80 SC/NW), a TOC concentration of 2 mg/L, requires additional treatment to meet the SDWA's Stage 1 & 2 D/DBPR. In order for the City to meet both turbidity and TOC removal, the City will need to operate the pretreatment plant for most of the blend ratios. In regards to turbidity and TOC, the optimal blend ratio is 10% NP/ 90% SC/NW in order to meet the desired raw water limits, which would only require operation of the treatment plant.

Because sodium concentrations increase with a higher usage of the NW water (on a percentage basis), SARs were calculated for different blend ratios. The SAR goal of less than 12 was reached at the blend ratio of 60% NP/40% SC/NW. From Figure 4, the blended sodium concentration of less than 60 mg/L was reached at all blended ratios. The sodium concentration will change whenever a springs/well blend ratio other than 80% SC/ 20% NW is used.

Table 7-4. Sodium Adsorption Ratio - NP, SC and NW

	SAR
90%NP/10% SC/NW	6.0
80% NP/20% SC/NW	7.6
70% NP/30% SC/NW	9.6
60% NP/40% SC/NW	11.2
50% NP/50% SC/NW	12.8
40% NP/60% SC/NW	14.4
30% NP/70% SC/NW	16.0
20% NP/80% SC/NW	18.0
10% NP/90% SC/NW	19.6

← Objective SAR <12

The optimal blend ratio consists of 10% NP; 72% SC and 18% NW. This blend meets all the desired raw water quality limits.

The blended water quality was further modeled for corrosivity at each blend ratio. The blended water quality requires treatment from the pretreatment plant and the filters; accordingly, the plant's chemical dosages would be similar to the springs and river corrosivity analysis. The resulting sodium hydroxide dosage was in the range of 1 mg/L to 17 mg/L depending on the blend ratio. This indicates a similar level of corrosivity to the springs/river blend ratio's corrosivity.

7.2.5 Reservoir Water Quality Analysis

The two reservoirs in operation are the Peaking Reservoir and the Rawlins Reservoir. No water samples were taken from the third reservoir, Atlantic Rim, because it is under construction. The reservoirs are filled using a combination of the three supply sources so the water quality is affected by the sources used. The water quality is also affected by sediment re-entrainment, water usage and algal blooms. Table 7-5 shows one month's results from the sampling program.

Table 7-5. Water Quality Results (April 9, 2012)

Parameter (mg/L) unless otherwise stated	Sage Creek Springs	Nugget Wells	North Platte River	Rawlins Reservoir	Peaking Reservoir
pH	8	8	8	9	8
Turbidity (NTU)	0.3	0.4	10.5	7.8	3.5
TOC	1.1	0.8	4.6	3.3	1.8
TDS	238	693	142	188	227
Total Alkalinity (mg/L as $CaCO_3$)	138	406	72	109	136
Sulfate	28	161	59	31	33
Total Hardness (mg/L as $CaCO_3$)	162	9	82	139	159
Calcium	58	2	23	44	56
Magnesium	4	ND	6	7	3
Chloride	2	3	5	3	2
Sodium	3	253	11	5	3

Peaking Reservoir can be supplied by all three sources, but recently it has been supplied mainly by the Springs. The water quality results for both Peaking Reservoir and the Springs are very similar in most of the parameters except turbidity where the reservoir has higher turbidity. The higher turbidity is probably a result of sediment re-entrainment. The Peaking Reservoir water quality would change dramatically and exhibit higher turbidity levels and an increased TOC concentration, if the river was conveyed directly to the reservoir, especially during peak run-off where turbidity and TOC spikes are common.

The Rawlins Reservoir is supplied solely by Sage Creek, and exhibits similar water quality results for a majority of the parameters. Rawlins Reservoir has higher turbidity levels and TOC concentrations than the Springs, which is likely attributable to sediment re-entrainment that may cause an increase in turbidity and organics. This reservoir was drained pretty low during a previous dry year and has yet to fully recover to its original water quality state.

Additionally, the reservoirs are prone to algal blooms that result in taste and odor issues. Taste and odor samples were not taken during this sampling program; however, the City has experienced taste and odor problems in previous years. As a result of its water quality, both reservoirs would require the operation of the pretreatment plant, treatment plant as well as the chlorine disinfection system to be in compliance with the SDWA.

7.2.6 Summary

The City's raw water supply consists of three source waters: Sage Creek Basin Springs, North Platte River and Nugget Wells, and three reservoirs: Peaking, Rawlins and Atlantic Rim. A water quality sampling program was conducted on the City's water supply sources to measure specific water quality parameters. The program consisted of sampling each source bi-monthly during the time of year when water quality has been known to drastically change. These water quality results were used to determine an optimal source water blend for each of the following blending scenarios: (1) springs and river; (2) springs and wells; (3) river and wells and (4) all three. The optimal blend from each scenario was chosen based on meeting the raw water limits in Table 7-6 below.

Table 7-6. Raw Water Optimal Blending Limits

Parameter	Desired Raw Water Limits
Turbidity	< 5 NTU
TOC	< 2 mg/L
Sodium	< 60 mg/L
Hardness	< 150 mg/L
TDS	< 500 mg/L
Sulfate	< 250 mg/L
T/O	No odor
SAR	< 12

A summary of the optimal blends for the blending scenarios are presented in Table 7-7.

Table 7-7. Summary of Optimal Blend

Blending Scenario	**Optimal Blend**
Springs and North Platte	80% SC/20% NP
Springs and Nugget Wells	80% SC/20% NW
North Platte and Nugget Wells	60% NP/40% NW
North Platte, Springs and Nugget Wells	10% NP/72% SC and 18% NW

8 IDENTIFICATION AND SELECTION OF OPERATIONAL SCENARIOS

8.1 INTRODUCTION

Operational scenarios are fixed views of a dynamic system which are largely influenced by source water quality, demand, climate, the Platte River Basin endangered species issues and mandates of the SDWA. The following operational scenarios were developed from various components of this study including: system demands, environmental factors, water sources, system depletions versus the allowable PRRIP depletion baseline and water quality. They are based on two simple premises: 1. the system will be most stressed by reductions in supply due to climatic conditions, and 2. an increasing population will drive up the demand for water. Furthermore, dry cycles or drought heavily influence the raw water volume supplied by the Springs (the City's primary source) and also increases the demand for finished water. During below average precipitation years, the reduced Springs output is stressed by increased irrigation demands. Operational triggers associated with climatic conditions include Snotel site data, reservoir levels and Springs production.

The source water quality changes as the water year develops. During dry cycles, the relatively pure Spring water may be blended with well water in the spring, which influences water quality by increasing the overall sodium concentration. During the mid- to late-summer, due to a continued decline of Springs production, water quality is further influenced by an increase in turbidity and total organic compounds (TOC) via introduction of reservoir and river water to the system. The river and reservoir water require pretreatment which further limits overall production. The operational triggers, with respect to source water, will be based on optimal blending ratios identified in the water quality section of this report.

While the water sources are limited by output constraints and the priority administration of water rights, there are a number of ways to increase the amount of water available for City use. Using less treated water for irrigation would increase the water available for City consumption and could easily be accomplished by exploiting in-town wells. As discussed previously, snow fences have been used successfully to improve water yields from mountain watersheds.

8.2 RESERVOIR LEVEL AND WATER SOURCE MANAGEMENT

Managing the Atlantic Rim and Peaking reservoir levels is an important operational component of managing the City's water supply. The Springs produce their greatest volume of water over a three-month period in the spring and effectively using this resource requires storing excess production for later use. Storing this excess is accomplished in the Atlantic Rim and Peaking reservoirs and maintaining adequate reservoir levels is crucial to maintaining water supply and quality while controlling cost.

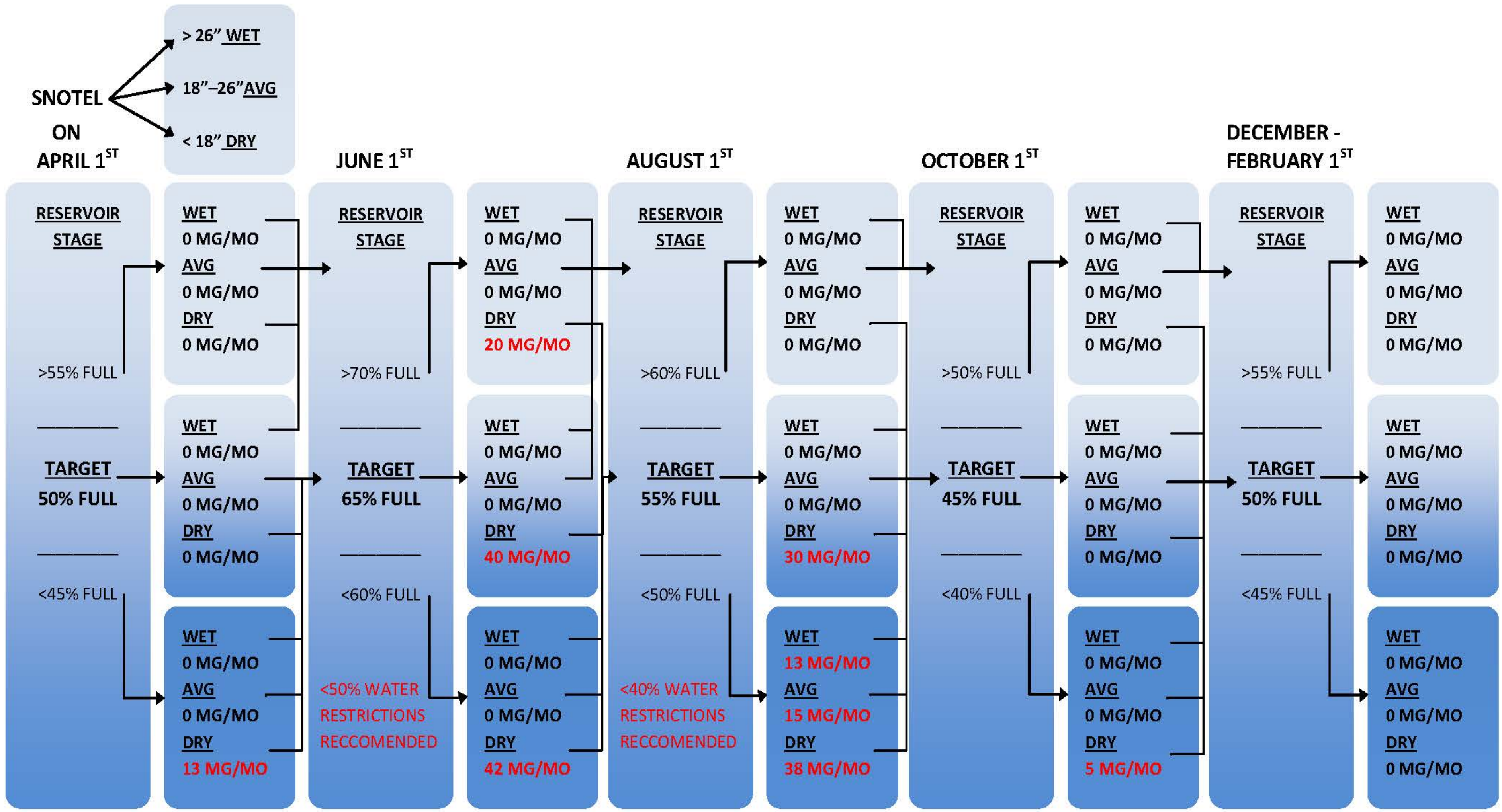
Figure 8-1 is an operational flow chart for managing reservoir levels based on predicted Springs production and irrigation demand. The flowchart tracks expected system storage levels by applying past usage and production rates based on observed climate parameters. On April 1st of each year the following guidelines are recommended to be followed in conjunction with referring to the flowchart to properly operate the reservoirs:

1. Estimate the seasonal snowpack by visiting the NRCS website for the Sage Creek Basin Snotel at: (www.wcc.nrcs.usda.gov/nwcc/site?sitenum=1015&state=wy).
2. If the April 1st snowpack is below 18", the season can be characterized as Dry and reduced springs production can be expected. If the snowpack is between 18 and 26 inches, the season is considered Average and normal production can be expected. If the snowpack is over 26 inches, it is a Wet year and above average production can be expected.
3. Identify the existing reservoir storage levels. The target is 50% full on April 1st; this level allows for storage of spring runoff. If the reservoirs levels are below 45%, additional water from other sources may be required in a dry year to meet June targets. If the reservoirs are above 55%, there may not be enough storage for all the spring flows.
4. As the benchmark months of June, August, October and December approach, the reservoirs should be reviewed for the target levels on the flowchart. Depending on the level, additional water may have to be pumped from the river or added from the wells to meet targets.

The recommended April 1st Reservoir levels are based upon historical supply volumes and demands. Irrigation demand is estimated from past data on total use and precipitation in Rawlins. For dry seasons, the flowchart anticipates an increased irrigation demand of 120 million gallons per month. For wet seasons, the flowchart anticipates reduced irrigation demand of 100 million gallons a month. The estimated demands are generally overstated, so meeting reservoir targets may not require the full flows recommended in the flow chart.

The following example illustrates how the flow chart can be used: Suppose on April 1st the snowpack is less than 18”, which would be characterized as a dry season. If the reservoirs are at 50% full, it can be expected that the reservoirs would be 65% full by June 1st. If, for some reason, the reservoirs were less than 60% full on June 1st, the flowchart indicates that during a dry season, starting in June, 42 million gallons of water per month would have to be added to the reservoir to meet demand targets for August. The 42 million gallons could come from the river and/or the Nugget Wells. If the reservoir target is met in August, 30 million gallons per month would have to be added to the reservoirs to meet the October target. If the October target is met, no additional water will be required to meet the December target, even in a dry year.

The current policy of filling the Atlantic Rim and Peaking reservoirs to 100% of capacity by April 1st does not allow for any storage of the peak runoff flows in the Sage Creek Basin pipeline. In the past, peak flows have been diverted to the Platte River. While there is some assurance in keeping the reservoirs full (from an ability to meet demand perspective), using the Nugget Wells and River sources to fill them is costly and not recommended.



- Nugget Well and North Platte water should be brought online to supplement Sage Creek production and meet reservoir stage targets based on seasonal Snotel snowpack data and reservoir stage.
- Design minimum storage reached when Atlantic Rim is 10% full and Peaking 90% full.
- Design minimum storage occurs at 41.5% of total storage available.

Figure 8-1. Operational Flow Chart

8.3 IN-TOWN WELL USE FOR IRRIGATION DEMAND

Future growth in Rawlins will likely require the development of additional domestic water supplies. While the sources of raw water are limited, there are options for reducing the demands on treated water by bringing in-town wells online for irrigation use.

Alternative irrigation water sources would free up treated water for residential consumption and reduce water system costs. Three in-town wells have the potential to contribute a significant volume of raw water for landscape irrigation: the South Penitentiary well (60 gpm potential), the Wyoming Penitentiary Well No. 2 (250 gpm potential; with new well) and the Cemetery Well No. 1 (250 gpm potential).

The Old Penitentiary Joint Powers Board has plans to redevelop the South Penitentiary well for their irrigation needs. Installation of a new pump and controls should provide the Board with irrigation water for approximately 5 ½ acres of grass and trees around the penitentiary. The well should be permitted through the State Engineer's Office as part of the redevelopment.

The Wyoming Penitentiary Well No. 2 has been vandalized and is no longer an option (unless it is re-drilled and re-developed). It does, however, possess a state water right and could be re-drilled to its original 384 foot depth. The well's proximity to the cemetery makes it an attractive source of irrigation water. Redevelopment for this purpose would require re-drilling the well, installation of a pump and controls along with a raw water distribution network.

The Cemetery Well No. 1 has the greatest potential to provide irrigation water to the City. With the installation of a pump and controls, the well would provide water for cemetery irrigation. To irrigate the entire 25-acre cemetery, a well would need to provide 675,000 gallons each week, or approximately 67 gpm. To put one inch of water on 25 acres in a week; irrigating 8 hours per day (presumably at night) would require approximately 202 gpm. If the cemetery were increased in size to 31 acres, a 250 gpm well irrigating 8 hours per day each week would be required.

8.4 SOURCE WATER BLENDING AND PRETREATMENT

Section 7.2 describes the water quality sampling program that was conducted on the City's water supply sources and reservoirs to measure specific water quality parameters. These water quality results were used to determine an optimal water blend for each of the source waters. A summary of the acceptable blends for the blending scenarios are presented in Table 8-1.

Table 8-1. Summary of Acceptable Blend Ratios

Blending Scenario	Optimal Blend
Springs and North Platte	80% SC/ 20% NP
Springs and Nugget Wells	80% SC/ 20% NW
North Platte and Nugget Wells	60% NP/ 40% NW
North Platte, Springs and Nugget Wells	10% NP/ 72% SC and 18% NW

The City operates the water treatment plant to treat water from the Springs and wells directly. Use of the DE filters is limited by the quality of the raw water to be treated. In late summer the Springs production diminishes and additional water must be supplied from the City's reservoirs, river or the Nugget Wellfield. Without additional treatment, the highly turbid waters of the reservoirs and river clog the DE pore sites.

The City added a powdered activated carbon (PAC) and ACTIFLO® system as a pretreatment process to be able to treat water supplied by the river and/or the City's reservoirs. The effluent from the pretreatment process would then be filtered by the existing DE treatment plant. Actiflo® is a compact treatment process that uses polymers and coagulants in combination with microsand to assist the flocculation and settlement process.

Blending of the three water sources has numerous implications for the operation of the water system and the cost of treated water. Water treatment and pretreatment operations are both affected by source water quality. Water from the North Platte River must be pumped and undergo pretreatment, which are not required whenever demand can be met solely by water produced by the Springs. The ability to use surface water is also dependent upon the limitation imposed by the PRRIP and annual depletion accounting procedures. Sound operational blending decisions will assure sustainable water quantity and quality at an efficient price.

8.5 DEPLETIONS, ACCRETIONS AND WATER ACCOUNTING

Under the Platte River Recovery Implementation Plan (PRRIP), allowable annual depletions thresholds/benchmarks for the City of Rawlins were established at 1,341 acre-feet in the irrigation season, from May 1 through September 31, and 462 acre-feet during the non-irrigation season, October 1 through April 31. Annual depletions in excess of the City's benchmark values are not necessarily out of compliance if sufficient underruns are available to offset the City's overruns during either the irrigation or non-irrigation season. However, the City should have plans in place to assist the state with mitigation/depletion replacement efforts in the event that sufficient underruns are not available to mitigate depletions in excess of the benchmark values.

To comply with PRRIP accounting procedures, the City provides a completed "Platte River Depletion Report-Municipal Water Use" form annually to the State Engineer's Office (SEO). During the water year ending in 2012, the City's depletions were 704.4 acre feet and 1,267.8 acre feet during the non-irrigation and irrigation season, respectively. The City exceeded their non-irrigation season depletions by 242.4 acre feet, but underran the irrigation season depletions by 73.2 acre feet. However, the underruns during the irrigation season currently cannot be used to offset overruns during the non-irrigation season. Fortunately, there were sufficient underruns elsewhere in the basin during the non-irrigation season to offset the City's overruns in water year 2012.

The City's plan to reduce depletions could include water accounting modifications, conservation measures and purchase agreements. Water accounting could effectively reduce depletions by documenting the use of non-hydrologically connected water not currently applied to annual accretion amounts and documenting the return of surface flows that presently may not be credited when comparing with the allowable depletion benchmarks. For example, due to the assumption that one-half of the water diverted from the river returns to the river, the City currently receives a 50% reduction in depletions for water used to irrigate the City golf course. The theory is that a portion of the irrigation water returns to the river system and the remainder either evaporates or is consumed by crop production (grass) and is not available to the river system.

Using the same logic, additional irrigation water may be available as an accretion to the City's account if the use of in-city wells are proven to be non-hydrologically connected. If the City were to replace North Platte basin surface water currently used to irrigate City parks and greenways with non-hydrologically connected groundwater sources, the majority of the volume applied to the parks and greenways would be an accretion. This occurs because surface water, i.e. the North Platte River and the Springs would no longer be used to irrigate parks and greenways; and 50% of the non-hydrologically connected groundwater irrigation source could then be considered an accretion to the North Platte River. The City would not be able to claim a 100 % accretion since some of the water presently applied to irrigate parks and greenways occasionally comes from the Nugget Wellfield, which is not hydrologically connected to the North Platte River and would have already been given accretion credits.

An expanded use of the Nugget Wellfield would also enable the City to stay within the allowable depletion baselines developed for the PRRIP. By using this water source in lieu of surface water (particularly during the non-irrigation season, which is the time period most likely to experience a overrun to the allowable depletions threshold), the City would be able to accommodate a measure of additional growth or development and still stay within the allowable PRRIP depletion baseline. Furthermore, a large percentage of the water supplied by the Nugget Wellfield would return to the river either through runoff, groundwater infiltration or through returns via the City's wastewater treatment system; these returns would constitute an accretion to flows of the North Platte River.

The City uses finished water to irrigate the cemetery and parks. During the irrigation season the City uses approximately 27 million gallons of treated water on these two areas. The City could receive up to a 50% accretion and a reduction in surface water depletions for this irrigation water by using non-hydrologically connected sources, which could amount to 13.5 million gallons or 41.4 acre feet during the irrigation season. The reductions in surface water use and accretions that come with using non-hydrologically connected water sources have the net effect of increasing the City's allowable depletion benchmarks.

Another potential reduction in surface water use would be to account for the return flow attributable to waste water discharge from the City's sewage treatment works to Sugar Creek. Sugar Creek is a Class 4 waterway adjacent to the City's treatment facility. Effluent is already recorded and discussions with Matt Hoobler, at the State Engineer's Office, have indicated he is willing to review the situation and make a determination on the potential for accretion. In the 2012 water year, approximately 150.2 million gallons of water was returned to the river system during the irrigation season. If this water were credited during the non-irrigation season it would cover the depletion overruns. Further discussion with the SEO is recommended to whether these return flows may be applied to reduce the City's current non-irrigation season depletion overruns. With these accretions the City could reduce dependence on purchasing Pathfinder Modification water and overall water system costs.

The City currently reserves 700 acre-feet of water from the Wyoming Account of the Pathfinder Modification Project. The reserved water can be used to offset depletions, if the State Engineer were to put the City on notice. The water has been reserved at a cost of $5.00 per acre foot. In the event of a depletion over-run and request for offset plans from the State engineer, the water can be purchase for an additional $25.00 an acre-foot. The Pathfinder Modification water must be reserved by February 15th of each year.

8.6 WATER SYSTEM OPERATION UNDER PRIORITY REGULATION

In February of 2013, intensifying drought has prompted the first wintertime call for administration of water rights on the North Platte River drainage in Wyoming since 2005. Specifically, the call applies to rights upstream of Pathfinder Reservoir with priorities junior to Dec. 6, 1904. The City's water rights on Sage Creek and the North Platte River are affected by this call. The call remains in effect until May 1 unless there is a dramatic increase in precipitation. Under the terms of the Modified North Platte Decree, the water supply for the basin is assessed the first week of February, March and April. An automatic call for regulation to 1904 is issued if a combination of available storage and forecasted run off volumes fall short of the amounts stipulated by the Modified North Platte Decree.

During water rights administration the City can continue to utilize its surface rights that are senior to Pathfinder. The City has senior rights for 3.01 cubic feet per second (CFS), of North Platte water that includes a portion of the Town of Sinclair's senior water right (1.00 CFS). 2.00 CFS of the senior rights were obtained from the Union Pacific railroad (Permit No. 2860, 1900 Priority, Fort Steele Pipeline). In addition, the City can utilize water from the Nugget Wells, as production from these wells does not impact flows in the North Platte River. River water use over the 3.01 CFS, not including well water, must come from the reserved Pathfinder Modification water.

The City needs to make a couple of updates to their 2.00 CFS Union Pacific water rights from the North Platte River. The point of diversion for this right needs to be moved to the recently construction North Platte Pipeline. There also needs to be an enlargement of the pipeline supply to include filling Peaking and Atlantic Rim Reservoirs.

The City has the ability to pump river water at 4.00 million gallons per day, approximately 6.19 CFS. If the City were to pump at this rate it would be exceeding its water right by 3.18 CFS or .84 acre feet per day. Seven hundred (700) acre-feet of Pathfinder water has been reserved by the City at a cost of $5.00 per acre-foot and is available for diversion from the North Platte River upstream of the reservoir by exchange whenever priority regulation would curtail the diversion of natural flow by the City. The City will be charged $25.00 an acre-foot for use of this water. Whenever the City operates the pumping plant at capacity (the 4 million gallons a day), the pumping cost is approximately $650 a month.

The City's spring rights are also subject to calls for regulation by downstream seniors on Sage Creek. During the non-irrigation season there is little conflict with irrigators on Sage Creek, however, during the irrigation season senior rights may be impacted by the City's diversions. In the summer of 2003 the City paid a senior appropriator a fee for lost hay production or for crops that would have been grown if the Sage Creek Basin were strictly regulated in accordance with the Priority Doctrine. Payment of this fee allowed the City to continue to divert under its Sage Creek water rights. Releases from Rawlins Reservoir should be sufficient to cover a downstream call from irrigators. Also during the call period of 2013 the City was required to use Pathfinder water to replace the spring water used.

8.7 WATERSHED STUDY AND PROTECTION AREA

Ninety percent (90%) of City's water usage is supplied by the Springs. During normal hydrologic cycles the Springs provide an adequate amount of good quality water. A hydrologic analysis, performed by HNTB in 1977, determined the potential annual yield from the Springs flow to be 2.02 billion gallons. However, due to storage limitations and competing senior water rights within the basin, the entire production is not available to the City. The City currently diverts 1.00 billion gallons of high quality water a year for their municipal supply.

The 24 springs could be monitored on an individual basis to identify any changes in production and to recommend appropriate methodologies that may improve production. Identifying the current condition and possible improvements to the collection system should also be part of an ongoing maintenance program. Watersheds can be threatened by activities such as private development, road building, stock grazing and energy extraction. It is recommended that the City initiate a watershed study to identify present and future risks to the Sage Creek Basin.

The Wyoming Department of Environmental Quality administers a Watershed Protection Program and is actively involved in a variety of planning and water quality project implementation activities. The major functions include Water Quality Standards, Non-point Source Planning and Grant Administration, Water Quality Assessment, Water Quality Monitoring, Water Quality Laboratory, 401 Certifications and Wetlands Protection, TMDL Coordination and Data Quality Assurance. The primary staff contact for this program is David Waterstreet at 307-777-6709.

There is a history of watershed management in Sage Creek Basin. In 1997, Saratoga-Encampment-Rawlins Conservation District (SERCD), in cooperation with land owners, BLM, NRCS and WGFD, began the Sage Creek Watershed Section 319 projects, which together included the entire Sage Creek watershed. The resulting Best Management Practices (BMPs) consisted of recommending short duration grazing programs, installation of riparian and drift fencing, development of off channel stockwater facilities, implementation of improved road management practices, installation of grade control structures, water diversions and vegetation filtering to reduce sediment loading from Sage Creek to the North Platte. Monitoring data collected as part of the project showed reduced sediment loading to the North Platte River as well as improved riparian and range condition.

The recommended Sage Creek Basin Watershed study should place particular emphasis on identifying current and future risks to the basin above Rawlins Reservoir: such as energy development, road improvements, use changes, private development and climate change. The study should identify and possibly put in place some permanent protections for the basin. Improving data collection with the installation of water meters on the individual springs or spring areas would greatly increase understanding of the Springs function and possibly lead to other improvements. Depending upon the water year's hydrology, the Springs are capable of providing adequate water and exhibit the best water quality of the City's three raw water sources. Evaluating the current physical condition of the Springs and identifying improvements to the collection system should also be part of an ongoing maintenance program.

8.8 INSTALLATION OF SNOW FENCE

The City of Rawlins Springs in the Sage Creek Basin are dependent on seasonal precipitation for water production. The snowpack accumulating in the mezzo topography of the basin is subject to seasonal variations of wind and snowfall. In an open basin, such as Sage Creek, snow fence installation would alter the mezzo topography of the basin and relocate snow pack to more directly benefit the Springs water collection.

The three proposed snow fence layouts, from Section 5.3 of this report, take advantage of basin topography and the Springs collection system to improve annual water yield. The total theoretical volume of water relocated by the proposed snow fence is 24 million gallons; of which 13.3 million gallons is “new water”. If a conservative collection factor is used for the theoretical additional volume, approximately 10.8 million gallons per year of additional water may be available for City use.

This additional water would be particularly important during the low precipitation seasons when the Springs produce approximately 50.0 million gallons less than average years. Typically the shortfall is supplemented with Nugget wells or river water. Both the wells and river have additional costs over the Springs supply. The river water has additional cost in pumping and pretreatment; while the well water may require installation of booster pumps to increase capacity and to overcome the pressure effects of the Sage Creek transmission line. Reliably improving the Springs supply will yield sustainable benefits.

8.9 NUGGET WELLFIELD BOOSTER PUMPS

The three Nugget wells are the main groundwater source and the Cloverly is a known but currently unexploited resource. The Nugget Wells are artesian or flowing wells that flow into the Sage Creek Basin pipeline at the Miller Hill Vault. These ground water resources could provide an important supplement to the City supply in the event of a Sage Creek Basin Springs failure in production.

The Nugget Wells have the potential to produce 1,000 gpm. Although the current layout/configuration of the wellfield is capable of producing up to 700 gpm to the City, the head pressure at the vault connection prevents the Nugget wells from realizing their maximum production potential. Installing booster pumps would increase the production of the Miller Hill wellfield. Installation of a booster pump within the existing Miller Hill vault (there is sufficient room within the vault for installation) was recommended in the 2010 Master Plan report to improve the volume of well water.

Maximum production from these wells could be achieved through the installation of submersible pumps. Installation of the submersible pumps would require overhauling the wellheads and bringing in a power supply. Theoretically, the available drawdown would be increased by another 1,000 foot and head losses for the well bore would become large at higher discharge rates.

8.10 IMPLEMENTATION

The operational recommendations from this report should be implemented in phases. Following are the recommended implementation priorities.

1. Reservoir Level Management
2. Cemetery Well Development
3. Prison Well Development
4. ClearLogx Pretreatmen
5. Nugget Well Booster Pumps
6. Watershed Study/Springs Collection Upgrade
7. Snow Fence Installation

Population is supposed to peak, with the planned projects, at 14,266 persons in 2014. This is an increase of 4,932 persons in two years. Of the 4,932 people, 90% could be classified as temporary residents and 10% as full time residents. Total increased demand for these temporary projects would peak at an additional 0.5 million gallons a day and may last an estimated 4 years. The area may experience a temporary drop in population before it begins to grow more slowly under full time resident growth projections.

From the available data, Rawlins has adequate water supply, treatment and storage for the anticipated growth. Population growth in the City is not limited, at this time, by available water sources. There are measures the City can take to insure this supply even further. Snow fence could make more than 10.8 million gallons of additional water and development of in-town wells could free up as much as 100 million gallons of treated water during the irrigation season.

9 ECONOMIC AND FINANCIAL ANALYSIS UPDATE AND PRELIMINARY COST ESTIMATES

9.1 INTRODUCTION

Operational scenarios have been identified in the previous section based on the current state of the City's water supply system. Implementation of preferred operational scenarios should improve system efficiency and lead to cost savings. Cost estimates for infrastructure investment recommendations are compared to expected returns based on water or cost savings.

This section is a review of the City's water enterprise finances and includes recommended management changes to improve efficiencies. The City's water revenue structure was reviewed and rate recommendations were developed to generate sufficient revenue to support the existing water system as well as fund proposed improvements and operating scenario costs.

9.2 RESERVOIR LEVEL MANAGEMENT

The flow chart in Section 8.2 is based on keeping no less than a 60-day supply in storage at any time. The flowchart recommends a 50% target on April 1st and to be no more than 65% full by June 1st. Additional water over the recommended levels in the reservoirs is acceptable but could come at an unnecessary cost.

Filling the reservoirs with the Springs water is the lowest cost alternative. Pretreatment of the lower quality river water adds an additional $417 in costs per million gallons of treated water. The cost of pumping water up to the City reservoirs was identified in the 2010 Wester-Wetstein & Associates 2010 Master Plan. In the report, water from the North Platte River can be pumped to the Thayer Booster Station (TBS) for $190.84 per million gallons. From the TBS, the cost of pumping water up to Peaking Reservoir is $170.48 per million gallons. Lifting water from the River to Atlantic Rim Reservoir, 108 feet higher than Peaking, would cost $617.13 per million gallons.

Storage should be maintained at a level to accommodate any excess Springs flows during the peak flow months of May, June and early July to effectively utilize all of the high quality Sage Creek Basin spring water. The Springs production exceeds the City's demand for water by 100 million gallons during the peak runoff months. If this water were bypassed (not stored), the value lost could be calculated based upon the cost of pumping and pretreating 100 million gallons of North Platte River water which equates to a total cost (or value) of $103,400.

9.3 IN-TOWN WELL USE FOR IRRIGATION

As previously mentioned in Section 8.3, the Wyoming Penitentiary Well No. 2 has been vandalized and is no longer operational. However, it possesses a valid water right and could be re-drilled and re-developed to its original 384 foot depth. Table 9-1 is an engineer's opinion of probable cost which includes re-drilling the well and installation of distribution pipelines to deliver water to the cemetery.

Table 9-1. Engineer's Opinion of Probable Cost for the Prison Well Development.

Description	Quantity	Unit	Unit Cost	Cost
Contractor Mobilization	1	ea	$10,800.00	$10,800.00
Re-Drill Well No. 2	400	lf	$75.00	$30,000.00
Pump and Controls	1	ea	$15,000.00	$15,000.00
4" PVC Raw Water Pipe Network	1000	ft	$40.00	$40,000.00
Road Boring	40	lf	$200.00	$8,000.00
Irrigation Controls and Misc.	1	ea	$15,000.00	$15,000.00
			Sub Total	$118,800.00
Design Engineering				$11,880.00
Construction Engineering				$11,880.00
			Sub Total	$142,560.00
20% Contingency				$28,512.00
			Total	$171,072.00

The Cemetery Well No. 1 has the greatest potential to provide irrigation water to the City. With the installation of a pump and controls, the well would provide water for cemetery irrigation. Table 9-1 is an engineer's opinion of probable cost to install the pump and controls in the Cemetery Well.

Table 9-2. Engineer's Opinion of Probable Cost for the Cemetery Well Development.

Description	Quantity	Unit	Unit Cost	Cost
Contractor Mobilization	1	ea	$4,550.00	$4,550.00
Pump with Variable Frequency Drive	1	ea	$4,500.00	$4,500.00
Well Controls Building	1	ea	$15,000.00	$15,000.00
Pump Controls and Interior Plumbing	1	ea	$4,500.00	$4,500.00
2-1/2" Pitless Adapter W/install	1	ea	$3,500.00	$3,500.00
Well Pump and Controls Installation	1	ea	$18,000.00	$18,000.00
4" PVC Distribution Line	250	lf	$34.00	$8,500.00
			Sub Total	$58,550.00
Design Engineering				$5,855.00
Construction Engineering				$5,855.00
			Sub Total	$70,260.00
20% Contingency				$14,052.00
			Total	$84,312.00

From Section 9.8.3 of this report, treated water cost are $1.58 per thousand gallons delivered. At this rate, the gross savings in treatment costs by switching the cemetery to raw-water irrigation during the summer months would be approximately $9,400 per month, or $10,400 per month when the cemetery reaches full expansion. Further savings could be realized if nearby parks (e.g., old penitentiary, old Outlaw Bowl, etc.) are also converted to raw water. A portion of the treatment cost-savings would be offset by the development and operations costs of a raw water system.

9.4 SOURCE WATER BLENDING AND PRETREATMENT

There are different costs and scenarios associated with blending water from the three water sources and reservoirs that supply the City's raw water.

The Springs water has the lowest cost with little treatment required other than filtering and disinfection in the WTP and is the source most relied upon by the City. This water can either be conveyed directly to the WTP or stored in the City's reservoirs for later use.

As the Springs production fades late in the summer, Nugget Wellfield water is brought online. Past reports have suggested that booster pumps in the wellfield vault may improve the yield from these wells. However, use is not limited by production potential but by the high concentrations of TDS and sodium exhibited by the wells. The ideal blending ratio of the source water is four parts spring water to one part well water. The pipeline back pressure limits well production to approximately 700 gpm; so further reduction in flow to 200 gpm, the recommended blending ratio, with the Springs is required.

River and reservoir water are important to the City's supply whenever spring flows cannot meet water service demands. However, both the river and reservoir water require pretreatment at additional expense before it can enter the WTP. In a pilot study conducted during the summer of 2012 the cost of pretreatment was estimated to be $475.60 per million gallons. This estimate is based on monthly operation cost assuming 4 million gallons a day is run through the pretreatment plant. Table 9-3 is an engineer's estimate of probable cost for installation and full time operation.

Table 9-3. Engineer's Opinion of Probable Cost for the ClearLogx Pre-treatment System.

Installation	Quantity	Unit	Unit Cost	Cost
ClearLogx Pilot Study	1	LS	$53,230.00	$53,230.00
ClearLogx Purchase	1	LS	$125,000.00	$125,000.00
ClearLogx Installation (estimate)	1	LS	$75,000.00	$75,000.00
Engineering	1	LS	$29,564.00	$29,564.00
		Total		$282,794.00
Cost of Operation				
Chemicals (per month)	4	MO	$47,175.00	$188,700.00
Electricity (per month)	4	MO	$10,660.00	$42,640.00
		Total		$231,340.00

It was further assumed that the pretreatment plant would operate 4 months every year for yearly operations cost of $231,340. This may be a little excessive based on system demands and operational history. The Springs still produce between 1,000 and 1,200 gpm late in the season. With an additional 200 gpm from the Nugget Wells 1,400 gpm could be expected in the Sage Creek Basin pipeline. This 2 million gallons per day of production, along with 2 million gallons per day from the pretreatment plant could reliably meet peak monthly demands of 120 million gallons.

Estimating the operational costs of the pretreatment plant is also complicated by seasonal variation. Pretreatment plant operation may not be required during wet and average water years because of reduced demand and increased production from the Springs. The historic data shows the pretreatment plant can expect to operate at 50% of capacity for 30% of the water years. When these numbers are applied to the full time operational cost described above, a nominal cost of $34,700 per year is identified.

9.5 WATERSHED STUDY AND PROTECTION AREA

Ninety percent (90%) of the City's water comes from the Springs. During normal or wet hydrologic cycles, the Springs provide adequate quantities of the best quality water (when compared to either the North Platte River or Nugget Wellfield). The City currently diverts 1.00 billion gallons of Springs water a year for their municipal supply.

The Springs are a million-dollar per-year asset based on retail value of the water delivered to the City's customers. The cost to replace the Springs water from the North Platte River, which includes cost for pumping and for pretreatment, is more than $600,000 per year. NPR water would cost $1.29 more per thousand gallons than spring water; which would increase overall water system cost to $2.87 per thousand gallons The initial cost for undertaking the watershed study and for subsequently implementing protection and Sage Creek Basin Springs improvement projects is $261,360 as shown in Table 9-4.

Table 9-4. Engineer's Opinion of Probable Cost for the Watershed Study

Description	**Quantity**	**Unit**	**Unit Cost**	**Cost**
Contractor Mobilization	1	ea	$16,500.00	$16,500.00
Watershed Study	1	ea	$45,000.00	$45,000.00
Meter Installation	24	ea	$2,500.00	$60,000.00
Spring Collection Upgrade	24	ea	$2,500.00	$60,000.00
		Sub Total		$181,500.00
Design Engineering				$18,150.00
Construction Engineering				$18,150.00
		Sub Total		$217,800.00
20% Contingency				$43,560.00
		Total		$261,360.00

9.6 SNOW FENCE COST

From Section 5, there is potentially 3,245,930 cubic feet of additional water or 24.3 million gallons that would accrue to the Sage Creek basin with the installation of snow fence. Anticipating conservative recovery rates there could be an additional 10.8 million gallons added to the City's supply every year. The cost to acquire this relocated water involves construction and maintenance of 2,652 lineal feet of snow fence.

There are two types of snow fence suitable for permanent installation; vertical post and Wyoming snow fence. Both systems are appropriate for trapping snow, but differ in initial price, ease of installation and maintenance.

Vertical post installation requires heavy equipment to set large treated timbers directly into the ground. The installation of these vertical posts may have unintended consequences for the movement of groundwater through the basin. Wyoming snow fence construction consists of assembled wooden crib work fixed in place with site driven rebar. The site driven rebar generate minimal impacts to the movement of ground water.

Material choices also affect initial cost and long term maintenance. The material for posts and slats can vary from wood and steel to fiberglass and plastic. There are also package systems sold under trademark names such as Snow Predator™ by Perma-Rail. Costs vary from one snow fence-type to another and can also vary due to on site constraints and quantity to be installed. Wyoming wood snow fence, with its tilt-up wooden crib construction and low cost of installation, is the preferred alternative and has historically been proven to be the "go to" snow fence in southern Wyoming.

Wyoming snow fence prices, from WYDOT Weighted Average Bid Price are presented in Table 9-5. The cost estimate includes material, delivery, installation and engineering in the Sage Creek Basin.

Table 9-5. Engineer's Opinion of Probable Cost for Snow Fence Installation

Description	Quantity	Unit	Unit Cost	Cost
Mobilization	1	EA	$3,447.60	$3,447.60
Wyoming Snow Fence	2,652	LF	$26.00	$68,952.00
		Sub Total		$72,399.60
Design Engineering				$3,619.98
Construction Engineering				$3,619.98
		Total		$79,639.56

Wyoming wood snow fence maintenance typically starts after two seasons of service. Typical maintenance requires tightening fasteners where the panels connect and periodic replacement of the wooden slats after several years of operation. An annual maintenance budget for Wyoming wood snow fence could be estimated at two days of labor and 1% of initial material cost for every thousand feet of installed fence. For the Sage Creek Basin snow fence maintenance would be approximately $930 per year for each thousand feet of fence or approximately $2,500 per year averaged over the life of the fence.

Installation of snow fence in the Sage Creek Basin has measurable benefits to the City's water portfolio. The cost to acquire this water is the construction and maintenance of 2,652 lineal feet of 12-foot high Wyoming Wood Snow Fence. The estimated construction cost of 2,652 feet of fence is approximately $80,000.00. Regular maintenance would add up to an additional $69,000 over the thirty-year life of the fence.

With the initial investment and regular maintenance, the City could realize 10.8 million gallons (33 acre-feet) of additional water each year the fence is operational. The additional water would require an initial investment of $6.48 per thousand gallons and yearly maintenance costs of $0.22 per thousand gallons. When the initial investment is amortized over the 30-year service life of the snow fence, the total cost of the additional water is approximately $0.45 per thousand gallons.

As a comparison: using North Platte River water to supplement the Springs, the more expensive alternative due to pretreatment and pumping requirements. For 10.8 million gallons of river water to be conveyed to the water treatment plant it would first have to be pumped to Peaking reservoir at a cost of $360 per million gallons and then pretreated for another $417 per million gallons. Therefore, the combined cost is calculated to be $7,800 or $0.77 per thousand gallons.

9.7 NUGGET WELLFIELD BOOSTER PUMPS

The main City groundwater resources include the Nugget Wells and the Cloverly Well. The three Nugget Wells are the main groundwater source and the Cloverly is a known but currently unexploited resource. The Nugget Wells have the potential to produce 1,000 gpm, if head pressure at the vault connection could be reduced. An existing vault was initially constructed to accommodate the addition of booster pumps, which would overcome the head pressure of the Sage Creek pipeline and increase wellfield production.

Installation of electric booster pumps in the wellfield vault could be accomplished; but power must first be brought to the site. Powering the booster pumps with a portable diesel generator may be a viable option when compared to the cost of electric transmission facilities. Fifty horsepower pumps would require an externally regulated 175 Kilowatt generator to operate effectively. Generators must be sized to deliver at least 65% of the rated voltage during pump start-up to ensure adequate starting torque.

Generator frequency is an important factor when considering pump selection, as the motor speed varies with the frequency (Hz). Due to pump affinity laws, a pump running at 1 or 2 Hz below nameplate frequency design will not meet its performance curve. Conversely, a pump running at 1 to 2 Hz above may trip overloads. When selecting a generator, the engineer should follow the generator manufacturer's recommendations for de-rating output at higher elevations and when using natural gas.

Typical 175KW Diesel Generator rental rates are: daily $610, weekly $1,300 and monthly $2,800. Fuel consumption for a 175KW diesel generator, at 75% load, may be 10 gallons an hour. Based on the figures above, the cost to pump water from the Nugget Wells would be approximately $0.73 per 1,000 gallons with the pumps running 24 hours a day at 1,000 gpm. This cost for diesel fuel was assumed to be $4.00 per gallon.

A rational for using more Nugget Wellfield water is reducing depletions. Depletions accrue as the North Platte River, which includes the Sage Creek Basin, water is used. Water from the Nugget Wells is not hydrologically connected so, using this source would not negatively influence the City’s allowable depletion threshold. In fact, the City would enjoy accretions due to return flows to the North Platte River that would stem from using water from the Nugget Wellfield. In fact at least 50% of the City’s Nugget

Well water (usually municipal depletions are less than 50% of the water diverted; therefore, with documentation the accretions would likely exceed the standard 50% return flow volume) would generate accretions to the North Platte River. This accretion would allow City customers to consume additional water without debiting the City's allowable depletions under the PRRIP agreement. In-other-words, use of the Nugget Wells increases the likelihood that the City would stay within the PRRIP's allowable depletion benchmarks.

Depletions can also be offset with purchased water from the Pathfinder Modification Project, as discussed in Section 2.7.6 of this report. Table 9-6 is a comparison between the well-field booster pump cost of operation and purchasing Pathfinder water to meet depletions. The well-field booster pump operation assumes that a generator would have been installed.

Table 9-6. Engineer's Opinion of Depletion Cost

	WATER DELIVERY GPM	HR/DAY OF OPERATION	DAYS OF OPERATION	FUEL USE GPH	DOLLARS /GALLON	FUEL TOTAL GALLONS	RENTAL /MONTH	TOTAL MONTHLY COST	COST PER 1000 GAL
Wellfield Booster Pump Operation W/175KW Generator	1000	24	31	10	$4.00	$29,760.00	$2,800.00	$32,560.00	$0.73
	RESERVE WYOMING ACCOUNT /AF	PURCHASE /AF	PUMPING COST $/MG	PRE-TREAT COST $/MG	MONTHLY EQUIVILANT MG			TOTAL MONTHLY COST	
Pathfinder Purchase	$5.00	$25.00	$360.00	$417.00	44.64			$35,121.86	$0.79

The operations cost per thousand gallons are relatively close at $0.73 for the pumped water and $0.79 for the purchased water. The purchased water would come at no additional equipment cost while the pumped water would require $200,000 in additional installation costs.

9.8 WATER ENTERPRISE FUND

For budgeting purposes, the water enterprise fund is divided into two departments: the Water Treatment Department and the Distribution Department. The Water Treatment Department operates and maintains the treatment plant, pump stations, reservoirs and transmission lines from the City's water sources. The Distribution Department operates and maintains the storage tanks and distribution lines up to and including the City's water meters. Major replacement or new installation projects are accounted for on a capital improvements project basis.

The City's financial information from the fiscal year beginning July 2010 through June 2011 was reviewed to identify operational expenses and revenues. The data was reviewed to identify the cost per 1,000 gallons of water delivered to customers and to determine whether the revenues received from the delivered water adequately recover the costs. The cost per 1,000 gallons, from the reviewed data, will be used as a baseline to quantify the recommended operational scenarios discussed in Section 8.

9.8.1 System Expenses

The City's Finance Director provided a summary statement of revenues and expenses for the Water Fund. Since 2009, water enterprise expenses and sewer enterprise expenses have been separated in the budget. Table 9-7 lists expenses for fiscal years 2008 thru 2011.

Table 9-7. Revenue Fund Expenses

	FY 08-09	FY 09-10	FY 10-11
Water Plant Operating	$556,339.37	$567,875.15	$575,016.30
Water Distribution Operating	$512,243.24	$593,715.95	$564,070.35
Operating Water Expenses	$1,068,582.61	$1,161,591.10	$1,139,086.65

The financial year 2010-11 was singled out as the most recent year with complete records. The summary statement provided both total and operating expenses which were compared with budget numbers and water treatment plant production numbers.

The operating expenses are the cost of system operations, including personnel wage or salary expenses, equipment costs, utility expenses and other day to day costs. The operating expenses are a combination of both the Treatment and Distribution departments. Debt service, although a part of total expenses, was not included in the operating expenses. Operating expenses were used to identify cost of water produced.

9.8.2 Revenues

The City generates water enterprise revenues from a number of sources. Revenue sources are divided into, interest and miscellaneous income, water usage and tap fees. The fees are set by the City council under recommendations from the water department.

Interest income is generated by water fund deposits in interest bearing accounts. Miscellaneous income is derived from revenues such as Low Income Energy Assistance Program (L.E.A.P) funds, late payments, charges for corral usage and assorted other miscellaneous services that are provided to City residents. The late fees are a significant source of income for the water enterprise fund. The late fees apply to all City service billings such as sewer and landfill as well as water service. However, the late fees are only applied to water enterprise revenue. Late fees generate more than $100,000 a year for the water revenue fund. Corral users pay a flat $10.00 per month fee for use of the corrals with water for six months a year.

Water usage fees are a combination of the flat monthly availability fee and volume usage charge. Domestic users pay a monthly availability fee of $14.00 per month. The availability fee is designated for debt service on capital improvement projects. The availability fee was raised from $10.00 to $14.00 in April of 2009 with an anticipated increase in revenue of approximately $190,000 per year to address increased debt payments. A comparison of the water fund revenues from 2010, the first full year of the fee increase, with the revenues from 2011 show a decrease in total revenue of $60,778.00. The number of users actually increased from 2010 thru 2011, so it can be assumed that increased fees for water use decreased overall per-capita consumption. The volume usage charge is currently set at $2.00 per thousand gallons.

Water users are also categorized into eight types: Domestic, Volume, Fire, Out of Town, City, Construction, Corral and Town of Sinclair. Domestic users pay the monthly access fee. Volume, Construction and Out of Town users do not pay the availability fee but do pay a higher commodity/per gallon rate. The Town of Sinclair purchases treated water from Rawlins under a negotiated agreement, Sinclair pays 62.5% of the commodity rate for metered use. All water usage revenue is combined into a single line item in Table 9-8.

New construction and development create additional demands on the City's water system. These additional demand costs are partially offset by tap fees. The tap fee for a standard ¾" residential service is $1,000.00; a 2" tap is $7,000.00. The water tap fees are typical for a Wyoming city the size of Rawlins.

Table 9-8. Water Fund Revenues

Revenues	FY 08-09	FY 09-10	FY 10-11
Interest Income	$21,449.33	$9,621.40	$7,550
Miscellaneous	$105,824.53	$242,421.82	$190,220
Water Usage Fees	$1,569,550.60	$1,699,426.41	$1,739,230
Water Tap Fees	$1,987.20	$52,974.56	$6,650.00
TOTAL	$1,698,811.66	$2,004,444.19	$1,943,660

Operational revenue is the share of total revenue used to cover the costs of providing water to users. Operational revenue can be separated from total revenue by subtracting the estimated monthly availability fee, earmarked for debt service, from the total revenue. The monthly availability fees were estimated to be $559,048, based on 3,328 users for the fiscal year ending in 2011. Therefore, the estimated annual operational revenue is $1,384,616.

9.8.3 Cost of Water Produced

From June of 2010 through July of 2011 the Water Treatment Plant produced 721.952 million gallons of water for an average return of $1.92 for each 1,000 gallons at a cost of $1.58 per thousand. Table 9-9 is a summary of the revenue, expenses and WTP production. The operational revenue is comfortably covering the operational cost of producing water.

Table 9-9. Fiscal Year 2010-11 Cost of Water Comparison Summary

Revenue	Number	Availability	Usage charge	Gallons Used	Revenue
Interest Income					$7,555
Misc. Income					$190,226
Domestic Users	3328	$14.00	$2.00	452,862,700	$1,547,781
Volume Users	24	$0.00	$2.00	6,284,200	$12,568
Sinclair	1	$0.00	$1.25	38,980,000	$48,725
City Use	1	$0.00	$0.00	41,387,900	$0
Other Metered	1		$10.00	13,015,848	$130,158
Tap Fees					$6,650
Total Revenue					$1,943,660
Estimated Monthly Access Fees					-$559,048
Operational Revenue					**$1,384,612**
Operational Expenses					**$1,139,086**
WTP Production	**721.95**	Million Gallons			
				Expense Per 1,000 Gallons	**$1.58**
				Revenue Per 1,000 Gallons	**$1.92**

The $1.58 per thousand gallon cost identified in this report contrasts with the 2010 Rawlins Master Plan in which water cost were calculated to be $2.49 per thousand based on $2,005,500 in operating cost and 805 million gallons of production. It is unclear how the operating costs were calculated in the 2010 Master Plan.

The costs in Table 9-9 do not reflect the cost of pre-treatment. In the summer of 2012 the pretreatment plant was brought online for a pilot study to treat river water for the City supply. The pretreatment pilot study showed that the system was successful in reducing total turbidity of the river water. The cost of pretreatment, at full capacity, for 5 months is estimated to be $231,000. When the cost of pretreatment is factored in, total operational cost goes from $1.58 to $1.90 per thousand gallons. At $1.90 per thousand gallons, operational costs are approaching the $2.00 per thousand gallon consumption charge and may impact overall water revenue fund sustainability.

9.9 CURRENT AND PLANNED WATER SYSTEM DEBT

Rawlins currently pays debt service on eight water system related loans as shown in Table 9-10.

Table 9-10. Water Projects Loan Summary

Project	Loan Balance	Payment	Interest Rate	Lender
Atlantic Rim Reservoir	$1,970,797.08	$131,849.59	4.00%	WWDC
Sage Creek Water Line	$2,378,568.00	$150,278.00	4.00%	WWDC
DWSRF #69	$342,990.00	$25,077.00	2.50%	SLIB
DWSRF #80	$344,998.00	$17,302.00	2.50%	SLIB
Rawlins Pipeline Rehabilitation	$864,997.00	$50,023.00	4.00%	WWDC
Sage Creek Water Line	$2,482,560.30	$150,278.84	4.00%	WWDC
Water Storage Tanks	$851,070.00	$25,076.51	2.50%	DWSRF
Spruce Street Water Line	$714,120.00	$17,302.27	2.50%	DWSRF
Totals	$9,950,100.38	$567,187.21		

Debt service is generally paid with a monthly availability fee charged to users. The City raised water availability fees to $14.00 per month. The debt service, in 2012 was $435,337 per year. With the completion of the Atlantic Rim Reservoir Project, debt service will total $567,187 per year. With an average of 3,300 users the water availability fee should realize $554,400 per year. The unfunded debt service totals $12,787 per year. The unfunded shortfall could be funded by raising availability fees $0.32 per month to cover unfunded debt service or use other water enterprise funds.

Further debt is expected as the City continues to improve water system infrastructure and operations. It is the City's intention to improve their water system by utilizing available grant and loan programs offered through State and Federal Agencies. Debt service on any loans shall be kept at conservative levels that can be paid for within revenue constraints.

This study has identified several projects that may require the City to incur additional debt. Funding options that have been considered for these improvements include: WWDC Grants, SLIB Mineral Royalty Grants, Rural Utility Service (RUS) loans and grants, Drinking Water State Revolving Fund (DWSRF) loans, County 1% Specific Purpose Tax and water user fees. A brief description of each funding program follows.

Wyoming Water Development Commission (WWDC)
WWDC eligible grant and loan funding includes water source development, storage and transmission. The typical grant/loan mix is 67% grant, 33% loan. However the loan portion of the WWDC funding portfolio can be replaced with funding from other state or non-state sources. WWDC present loan rate is 4% with no origination fee. Variable loan periods are available.

State Land and Investments Board (SLIB)
SLIB eligible grant and loan funding project types include water treatment, distribution and projects that install water meters and service lines. SLIB Criteria is currently changing with reduced revenues available for 2012 and 2013. Additional loan costs include a 1% loan origination fee.

Wyoming State Revolving Fund (SRF)
This program is intended to provide low interest loans, presently at 2 ½%, to finance water system improvements with a ½% loan origination fee. Variable loan periods are available.

User Fees
The City of Rawlins water system is metered using a base availability rate with a block rate per volume of water consumed. The availability fee is currently $14.00 per month with a commodity use fee of $2.00 per thousand gallons.

Carbon County 1% Specific Purpose Tax
Not utilized in the economic analysis due to the variable nature of the funding.

USDA Rural Utilities Service (RUS)
From 2006-2010, Wyoming's median household income is $53,802. Rawlins' median household income is $59,357, above the state median.

RUS Funding
Use of the RUS loan/grant combination yields a 25% savings in cost when compared to DWSRF loan. General funds and American Recovery and Reinvestment Act (ARRA) funds are available through the RUS. General funds are typically available only to very small communities that do not have qualified staff available to provide administration and reporting necessary for ARRA funding. Based on the extensive application requirements for RUS funding and ARRA requirements, RUS funding should be considered for improvement projects on a case by case basis. As such, economic analyses have been performed utilizing the more conservative DWSRF loan scenario.

State requirements (SLIB and WWDC) are well known to the sponsor. Requirements for RUS fund application are more involved. Requirements were reviewed and a checklist was developed for use by grant writing personnel. Application Requirements for each funding source are outlined in Table 9-11.

Table 9-11. Funding Source Form Requirements

	AGENCIES		
REQUIREMENT	**SLIB**	**WWDC**	**RUS**
Standard Form 424, “Application for Federal Assistance”			X
Standard Form 424A, “Budget Information – Non-Construction Programs”			X
Standard Form 424B, “Assurances – Non-Construction Programs”			X
Standard Form LLL, “Disclosure of Lobbying Activity”			X
Form RD 400-1, “Equal Opportunity Agreement”			X
Form RD 400-4, “Assurance Agreement (Under Title VI, Civil Rights Act of 1964)”			X
Evidence of Legal Existence	X	X	X
List of Directors and Officers			X
IRS Tax Exempt Status			X
Debarment and Suspension Rules	X		X
Drug-Free Workplace Requirements			X
Audit			X
Financial Statements	X	X	X
DUN's Number			X
Entity Information	X	X	
Requested Financing Plan	X	X	
Existing Water Supply System		X	
Financial Information	X	X	
Project Description, Summary, Goals and Objectives	X	X	X
Engineer's Rate Study Report	X		
DEQ permit to construct	X	X	X
Property Assessments	X		
Needs Assessment			X

9.10 WATER RATES

Currently, Rawlins availability fees are among the lowest in the state. With usage fees, water rates approach average levels. There is a single rate for all in-town metered customer use: $2.00 per thousand gallons. The City's water fund is self-supporting at the current levels of debt, operational cost and rate structure.

If the City were to move forward with the recommendations outlined in this report without funding assistance, sinking funds would have to be built up with increased user fees or with additional loans provided by private sector funding institutions. Table 9-12 is a list of recommended projects and an estimation of the impact to user fees if the improvements were made with loans amortized over thirty years at 4% interest. The estimate is based on 3,500 users and a current user availability fee of $14.00 per month.

Table 9-12. Impact to User Availability Fees with no Outside Funding.

Recommendations	Cost	Year	Annual Payment	Change in Base Rate
Reservoir Level Management	$0.00	2013	$0.00	$0.00
Cemetery Well Development	$84,312.00	2013	$4,824.00	$0.11
Prison Well Development	$171,072.00	2013	$9,792.00	$0.23
ClearLogx Pretreatment	$231,340.00	2013	$13,248.00	$0.32
Watershed Study/Springs Collection Upgrades	$261,360.00	2013	$14,976.00	$0.36
Snow Fence Installation	$79,639.56	2013	$4,560.00	$0.11
Total	$827,723.56		$47,400.00	$1.13

As shown in the table, the recommended improvements total $827,723. With no outside funding, user availability fees would increase $1.13 to $15.13.

The planned improvements were reviewed for impacts to water rates assuming WWDC funding is provided. WWDC project funding typically includes a 67% grant and a 33% loan, with interest at 4%. The loan portion of the project could be sourced through the Wyoming State Revolving Fund at 2.5% interest and ½% origination fee. The increase to user fees is shown in Table 9-13.

Table 9-13. Impact to User Availability Fees with Outside Funding

Recommendations	Cost	67% WWDC Grant	33% City Match New Loan	Annual Payment	Change in Base Rate
Reservoir Level Management	$0.00	$0.00	$0.00	$0.00	$0.00
Cemetery Well Development	$84,312.00	$56,489.04	$27,822.96	$1,764.00	$0.04
Prison Well Development	$171,072.00	$114,618.24	$56,453.76	$3,588.00	$0.09
ClearLogx Pretreatment	$231,340.00	$154,997.80	$76,342.20	$4,854.00	$0.12
Watershed Study/Springs Collection Upgrades	$261,360.00	$175,111.20	$86,248.80	$5,484.00	$0.13
Snow Fence Installation	$79,639.56	$53,358.51	$26,281.05	$1,670.00	$0.04
Total	$827,723.56			$17,360.00	$0.41

If the recommended improvements were completed with outside funding assistance, there would be $86,248 in additional debt and user availability fees would increase to $14.41.

Re-drilling of the Prison Well No. 2 may qualify for specific funding through the WWDC. The WWDC has funds set aside for the drilling of wells only. These funds would cover 75% of the $30,000 direct drilling cost for the well with a 25% City match. While the well drilling is a small portion of the total well development cost, the grant share reduces the City's portion to $7,500.

9.11 WATER LOSS, TIERED RATES AND CITY POLICY

Decisions at the City policy level could have major impacts on the water system's operational and cost efficiency. Water loss policies could be implemented that may add revenue and reduce production cost. Tiered rates have a proven history of success and provide an alternative to across the board rate increases, which may be needed to develop new water sources or to improve yields from existing sources. With the Atlantic Rim Reservoir online, the City's watering restrictions should also be reviewed.

Currently there is a significant difference between the volume of water produced versus the volume of water metered and billed to end users. The tightening of water accounting reduced overall unmetered use from 31% of WTP production in 2009 to 24% in 2011. In 2011 the lost water, with acceptable leakage factored in, was 197 million gallons. The potential return on this water if it had been metered and sold was $197,000 at $2.00 per thousand. The operational cost of providing this lost water was $156,000 at $1.58 per thousand gallons.

City policy could be used as a tool to maximize the return on delivered water and promote water conservation as well. Effective pricing of water to communicate its true value, and the cost of wasting it, is one of the most powerful tools water managers have to ensure a long term supply. Effective pricing rewards conservation, discourages gross wasteful use and, when correctly implemented, results in affordable water for the majority of consumers over the long run. Evidence from across the West indicates that when water is priced correctly, water usage is reduced 16-37% over time.

In the past, when the City has raised rates to generate more revenue, the City actually lost revenue. A tiered plan could be more effective in raising revenue. In a tiered pricing structure, the rate charged for water consumption each month resembles a set of stairs; which are called tiers or blocks. Water used within the first tier is the least expensive. If a customer's water use exceeds the limit of the first tier, subsequent water use is charged at a higher, second tier rate. As consumption continues into higher tiers, the price for water consumed continues to rise. Typically, the more dramatic the rise in cost, the greater the incentive is to conserve water. Table 9-14 is a sample tiered rate structure that may be applicable to Rawlins.

Table 9-14. Typical Tiered Rate Structure

Tiers	Old Rate	New Rate
First Tier: 0 - 10,000 gallons	$2.00 per 1,000 gallons	$2.00 per 1,000 gallons
Second Tier: 10,001 - 20,000 gallons	$2.00 per 1,000 gallons	$4.00 per 1,000 gallons
Third Tier: Above 20,000 gallons	$2.00 per 1,000 gallons	$8.00 per 1,000 gallons

Based on the 2012 City water revenue fund billings and the sample tiers above, there would be approximately $300,000 in additional revenue with a tiered rate structure. The majority of additional revenue would be generated 10% of users in the top tier. 35% of current users, now in the first tier, would see no change in their water bill and the middle tier would realize nominal increases between 10% and 25%. Water use would adjust to the new pricing and increased revenue would fade over time. The operational savings created by water conservation would be a long term benefit.

APPENDIX A
Combined Snotel Data

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1		0	2.7	5.2	6.6	8.2	13.2	13.9	14.6	14.9	15.5	16.2
2		0	3.2	5.2	6.8	8.2	13.2	13.9	14.6	14.9	15.5	16.2
3	0	0	3.5	5.4	6.9	8.3	13.3	14.2	14.6	14.9	15.5	16.2
4	0	0	3.5	5.4	6.9	9	13.3	14.2	14.7	14.9	15.5	16.2
5	0	0	3.7	5.4	6.9	9.1	13.3	14.2	14.7	14.9	15.5	16.2
6	0	0	3.8	5.4	6.9	9.1	13.3	14.2	14.8	14.9	15.5	16.2
7	0	0	3.9	5.6	7.3	9.1	13.3	14.2	14.8	14.9	15.5	16.2
8	0	0	3.9	5.6	7.3	9.9	13.3	14.2	14.8	14.9	15.5	16.5
9	0	0	3.9	5.6	7.4	9.9	13.3	14.3	14.8	15	15.6	16.6
10	0	0	3.9	5.6	7.4	9.9	13.3	14.3	14.8	15	15.7	16.7
11	0	0	4	5.6	7.5	9.9	13.3	14.4	14.8	15	15.8	16.7
12	0	0	4	5.6	7.5	10.5	13.3	14.4	14.8	15	15.8	16.8
13	0	0	4.2	5.6	7.5	10.6	13.3	14.4	14.8	15	15.8	16.8
14	0	0	4.2	5.6	7.5	11.7	13.3	14.4	14.8	15	15.8	16.8
15	0	0	4.2	5.6	7.5	12.9	13.3	14.5	14.8	15	15.9	16.8
16	0	0	4.2	5.6	7.5	12.9	13.3	14.5	14.8	15	15.9	16.9
17	0	0	4.2	5.6	7.5	12.9	13.4	14.5	14.8	15	15.9	16.9
18	0	0	4.2	5.7	7.5	13.1	13.4	14.5	14.8	15	15.9	17.3
19	0	0	4.3	5.8	7.5	13.1	13.4	14.5	14.8	15	15.9	17.3
20	0	0	4.6	5.9	7.5	13.1	13.4	14.6	14.8	15	15.9	17.3
21	0	0	4.6	6	7.5	13.1	13.4	14.6	14.8	15	15.9	17.3
22	0	0	4.6	6.1	7.5	13.1	13.4	14.6	14.8	15	15.9	17.3
23	0	0.2	4.7	6.2	7.5	13.2	13.4	14.6	14.9	15.1	15.9	17.3
24	0	1	4.7	6.2	7.5	13.2	13.4	14.6	14.9	15.1	15.9	17.3
25	0	1.4	4.7	6.2	7.5	13.2	13.6	14.6	14.9	15.1	15.9	17.3
26	0	1.9	4.7	6.3	7.5	13.2	13.6	14.6	14.9	15.1	15.9	17.4
27	0	2.1	4.7	6.3	7.5	13.2	13.7	14.6	14.9	15.2	15.9	17.4
28	0	2.7	4.7	6.3	7.5	13.2	13.9	14.6	14.9	15.3	15.9	17.4
29	0	2.7	5.1	6.4	---	13.2	13.9	14.6	14.9	15.4	15.9	17.4
30	0	2.7	5.1	6.4	---	13.2	13.9	14.6	14.9	15.5	16.2	17.4
31	0	---	5.2	6.6	---	13.2	---	14.6	---	15.5	16.2	---
	0	**2.7**	**2.5**	**1.4**	**0.9**	**5**	**0.7**	**0.7**	**0.3**	**0.6**	**0.7**	**1.2**
mean	0	0.5	4.2	5.8	7.3	11.5	13.4	14.4	14.8	15	15.8	16.9
max	0	2.7	5.2	6.6	7.5	13.2	13.9	14.6	14.9	15.5	16.2	17.4
min	0	0	2.7	5.2	6.6	8.2	13.2	13.9	14.6	14.9	15.5	16.2

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2003 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2002	2002	2002	2003	2003	2003	2003	2003	2003	2003	2003	2003
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	2.4	4.2	6.8	8.2	10	12.3	14.7	16.7	17.5	17.7	17.9
2	0.1	2.4	4.2	6.9	8.2	10	12.3	14.7	16.7	17.5	17.7	17.9
3	0.7	2.5	4.2	6.9	8.2	10	12.4	14.7	16.7	17.5	17.7	17.9
4	1.3	2.5	4.2	6.9	8.4	10.2	12.6	14.7	16.8	17.5	17.7	17.9
5	1.4	2.5	4.2	6.9	8.5	10.7	12.7	14.9	16.8	17.5	17.7	17.9
6	1.4	2.5	4.2	7	8.5	10.8	12.7	14.9	16.8	17.5	17.7	18
7	1.4	2.5	4.2	7	8.5	10.9	12.8	14.9	16.9	17.5	17.7	18.2
8	1.4	2.5	4.2	7	8.5	10.9	12.9	15.3	16.9	17.5	17.7	18.2
9	1.4	3	4.2	7	8.6	10.9	12.9	15.6	17	17.5	17.7	18.5
10	1.4	3.2	4.2	7	8.6	10.9	12.9	16.1	17.1	17.5	17.7	18.8
11	1.4	3.5	4.2	7.1	8.6	10.9	12.9	16.1	17.2	17.5	17.7	18.9
12	1.4	3.5	4.3	7.1	8.6	10.9	12.9	16.1	17.2	17.5	17.7	18.9
13	1.4	3.5	4.4	7.1	8.7	10.9	12.9	16.1	17.2	17.5	17.7	18.9
14	1.4	3.7	4.4	7.1	9.1	10.9	12.9	16.1	17.2	17.5	17.7	18.9
15	1.4	3.9	4.4	7.1	9.1	10.9	12.9	16.1	17.2	17.5	17.7	18.9
16	1.4	4	4.4	7.3	9.2	10.9	12.9	16.4	17.2	17.6	17.7	19
17	1.4	4	4.7	7.3	9.3	11.2	12.9	16.4	17.2	17.6	17.7	19
18	1.4	4	4.9	7.3	9.3	11.4	13	16.4	17.2	17.6	17.7	19.4
19	1.4	4.1	5.3	7.3	9.3	11.6	13.1	16.6	17.2	17.6	17.7	19.4
20	1.4	4.1	5.3	7.3	9.3	11.6	13.2	16.6	17.3	17.6	17.7	19.4
21	1.4	4.1	5.5	7.3	9.3	11.6	13.2	16.6	17.3	17.6	17.7	19.4
22	1.4	4.1	5.6	7.3	9.4	11.6	13.2	16.6	17.3	17.6	17.7	19.4
23	1.8	4.1	5.7	7.4	9.6	11.6	13.3	16.6	17.4	17.6	17.8	19.4
24	1.9	4.1	5.7	7.8	9.9	11.8	14.3	16.6	17.4	17.6	17.8	19.4
25	2	4.1	5.8	7.8	9.9	11.8	14.4	16.7	17.5	17.6	17.8	19.4
26	2.1	4.2	5.8	7.8	9.9	11.8	14.4	16.7	17.5	17.6	17.8	19.4
27	2.1	4.2	5.9	7.8	9.9	12	14.4	16.7	17.5	17.6	17.8	19.4
28	2.1	4.2	5.9	7.8	9.9	12.2	14.4	16.7	17.5	17.7	17.8	19.4
29	2.2	4.2	5.9	8.2	---	12.3	14.4	16.7	17.5	17.7	17.8	19.4
30	2.3	4.2	5.9	8.2	---	12.3	14.5	16.7	17.5	17.7	17.8	19.4
31	2.4	---	5.9	8.2	---	12.3	---	16.7	---	17.7	17.9	---
	2.4	**1.8**	**2.6**	**1.4**	**1.8**	**2.3**	**2.4**	**2**	**0.8**	**0.2**	**0.2**	**1.5**
mean	1.5	3.5	4.9	7.3	9	11.2	13.2	16	17.2	17.6	17.7	18.9
max	2.4	4.2	5.9	8.2	9.9	12.3	14.5	16.7	17.5	17.7	17.9	19.4
min	0	2.4	4.2	6.8	8.2	10	12.3	14.7	16.7	17.5	17.7	17.9

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2004 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2003	2003	2003	2004	2004	2004	2004	2004	2004	2004	2004	2004
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	0.7	5	8.6	10.5	12.1	12.7	14.5	15.7	17.6	18.4	20.6
2	0	1.3	5	8.7	10.6	12.1	12.7	14.5	15.7	17.6	18.4	20.6
3	0.5	1.4	5	9	10.6	12.2	12.7	14.5	15.7	17.6	18.4	20.6
4	0.5	2.3	5	9	10.7	12.2	12.7	14.5	15.7	17.6	18.4	20.8
5	0.5	2.5	5	9.1	10.8	12.2	12.7	14.5	15.7	17.6	18.4	20.8
6	0.5	2.6	5	9.1	10.9	12.2	12.7	14.5	15.7	17.6	18.4	20.8
7	0.5	2.6	5	9.1	10.9	12.2	12.7	14.5	15.7	17.6	18.4	20.8
8	0.5	2.6	5.1	9.6	11	12.3	12.7	14.5	15.7	17.6	18.4	20.8
9	0.5	2.6	5.2	9.6	11.2	12.3	13.1	14.5	15.7	17.6	18.4	20.8
10	0.5	2.7	5.2	9.6	11.2	12.3	13.1	14.5	15.7	17.6	18.4	20.8
11	0.5	2.8	5.5	9.6	11.3	12.3	13.2	14.6	15.7	17.6	18.4	20.8
12	0.5	2.8	5.6	9.6	11.3	12.3	13.2	14.9	15.8	17.7	18.4	20.8
13	0.5	2.8	5.7	9.6	11.3	12.3	13.2	15	15.8	17.8	18.4	20.9
14	0.5	3.1	5.7	9.6	11.3	12.3	13.2	15.1	15.8	17.8	18.4	21.1
15	0.5	3.3	5.9	9.6	11.3	12.3	13.2	15.1	15.8	17.9	18.4	21.1
16	0.5	3.3	6.1	9.6	11.4	12.3	13.2	15.2	15.8	17.9	18.5	21.1
17	0.5	3.4	6.1	9.6	11.4	12.3	13.2	15.2	15.8	17.9	18.5	21.1
18	0.5	4	6.1	9.6	11.4	12.3	13.2	15.2	16.1	17.9	18.5	21.2
19	0.5	4	6.1	9.6	11.4	12.3	13.7	15.2	16.3	17.9	19.6	21.2
20	0.5	4	6.1	9.6	11.4	12.3	13.8	15.2	16.3	17.9	19.6	21.2
21	0.5	4	6.1	9.6	11.4	12.3	13.9	15.2	16.6	17.9	19.9	22.2
22	0.5	4.4	6.5	9.6	11.5	12.3	14.3	15.2	17.1	17.9	19.9	22.6
23	0.5	4.6	6.5	9.6	11.5	12.3	14.3	15.5	17.1	17.9	19.9	22.6
24	0.5	4.7	6.5	9.6	11.5	12.3	14.3	15.5	17.1	17.9	19.9	22.6
25	0.5	4.7	6.5	9.6	11.6	12.5	14.4	15.6	17.4	18.2	20	22.6
26	0.5	4.9	6.8	9.9	11.7	12.5	14.4	15.6	17.6	18.2	20.1	22.6
27	0.5	5	7.1	10.1	11.7	12.5	14.4	15.6	17.6	18.3	20.5	22.6
28	0.6	5	7.7	10.1	11.8	12.6	14.4	15.6	17.6	18.3	20.5	22.7
29	0.6	5	8	10.2	12.1	12.7	14.4	15.6	17.6	18.3	20.5	22.7
30	0.6	5	8.2	10.3	---	12.7	14.5	15.6	17.6	18.4	20.5	23
31	0.6	---	8.6	10.5	---	12.7	---	15.7	---	18.4	20.5	---
	0.6	**4.3**	**3.6**	**1.9**	**1.6**	**0.6**	**1.8**	**1.2**	**1.9**	**0.8**	**2.2**	**2.4**
mean	0.5	3.4	6.1	9.6	11.3	12.3	13.5	15	16.3	17.9	19.1	21.5
max	0.6	5	8.6	10.5	12.1	12.7	14.5	15.7	17.6	18.4	20.5	23
min	0	0.7	5	8.6	10.5	12.1	12.7	14.5	15.7	17.6	18.4	20.6

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2005 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2004	2004	2004	2005	2005	2005	2005	2005	2005	2005	2005	2005
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	5.7	7.3	9.6	12.6	14.4	15.7	17.7	20.1	22.5	22.8	23.1
2	0.1	5.7	7.4	9.9	12.6	14.4	15.7	17.7	20.2	22.5	22.8	23.2
3	0.1	5.7	7.4	9.9	12.6	14.4	15.7	17.7	20.2	22.7	22.9	23.2
4	0.1	5.7	7.4	10	12.6	14.4	15.7	17.7	20.2	22.7	22.9	23.3
5	0.1	5.7	7.4	10	12.7	14.4	15.8	17.8	20.5	22.7	22.9	23.3
6	0.1	5.7	7.5	10.2	12.7	14.4	15.9	17.8	20.5	22.7	22.9	23.3
7	0.1	5.7	7.5	10.4	12.7	14.4	15.9	17.9	20.5	22.7	22.9	23.4
8	0.4	5.7	7.8	10.4	12.8	14.4	16	18.5	20.5	22.7	22.9	23.4
9	0.4	5.7	8.3	10.5	12.9	14.4	16	18.5	20.5	22.7	22.9	23.4
10	0.4	5.7	8.5	11.1	12.9	14.4	16.1	18.6	20.6	22.7	22.9	24.4
11	0.4	5.7	8.5	11.8	12.9	14.4	16.1	18.7	20.6	22.7	22.9	24.5
12	0.4	5.8	8.5	12.4	13	14.4	16.1	18.9	20.8	22.7	22.9	24.5
13	0.9	5.8	8.5	12.4	13.3	14.4	16.1	19.2	20.8	22.7	22.9	24.5
14	1	5.8	8.5	12.4	13.3	14.4	16.1	19.2	20.8	22.7	22.9	24.5
15	1	5.8	8.5	12.4	13.8	14.5	16.1	19.2	20.8	22.7	22.9	24.5
16	1	5.8	8.6	12.4	13.9	14.5	16.1	19.3	20.9	22.7	23	24.5
17	1	5.8	8.6	12.5	13.9	14.6	16.1	19.3	20.9	22.7	23	24.5
18	1.1	5.8	8.6	12.5	13.9	14.7	16.1	19.4	20.9	22.7	23	24.5
19	1.1	5.8	8.6	12.5	14	14.7	16.1	19.4	20.9	22.7	23	24.5
20	1.8	5.9	8.6	12.5	14.2	14.7	16.1	19.4	20.9	22.7	23	24.6
21	1.8	5.9	8.6	12.5	14.4	15	16.1	19.4	20.9	22.7	23.1	24.6
22	2.3	5.9	8.6	12.5	14.4	15	16.1	19.4	20.9	22.7	23.1	25
23	2.7	5.9	8.7	12.5	14.4	15.1	16.1	19.4	22.3	22.7	23.1	25
24	3	5.9	8.7	12.5	14.4	15.3	16.1	19.4	22.3	22.7	23.1	25
25	3.6	6	8.7	12.5	14.4	15.4	16.2	19.4	22.3	22.7	23.1	25
26	3.8	6.6	8.7	12.5	14.4	15.4	16.2	19.4	22.3	22.7	23.1	25
27	3.9	6.8	8.7	12.5	14.4	15.4	16.2	19.4	22.3	22.7	23.1	25
28	4.1	7.1	8.7	12.5	14.4	15.4	16.7	19.4	22.3	22.7	23.1	25
29	4.5	7.2	8.7	12.5	---	15.6	17.4	19.4	22.5	22.7	23.1	25
30	5.1	7.3	9.4	12.5	---	15.6	17.5	19.6	22.5	22.7	23.1	25.1
31	5.2	---	9.6	12.6	---	15.7	---	19.9	---	22.7	23.1	---
	5.2	**1.6**	**2.3**	**3**	**1.8**	**1.3**	**2**	**2.4**	**2.4**	**0.3**	**0.3**	**2**
mean	1.7	6	8.4	11.7	13.5	14.8	16.1	18.9	21.1	22.7	23	24.3
max	5.2	7.3	9.6	12.6	14.4	15.7	17.5	19.9	22.5	22.7	23.1	25.1
min	0	5.7	7.3	9.6	12.6	14.4	15.7	17.7	20.1	22.5	22.8	23.1

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2006 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2005	2005	2005	2006	2006	2006	2006	2006	2006	2006	2006	2006
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	2.2	5.1	8.5	11.3	12.5	14.5	16.7	17.3	17.8	19	20.1
2	0	2.2	5.2	8.7	11.5	12.5	14.7	16.7	17.4	17.8	19	20.1
3	0	2.2	5.7	8.8	11.5	12.5	14.7	16.7	17.4	17.9	19	20.1
4	0	2.2	5.8	8.9	11.5	12.5	14.7	16.7	17.4	17.9	19	20.1
5	0.5	2.3	5.9	9	11.6	12.5	14.8	16.8	17.4	18	19.1	20.1
6	0.6	2.4	5.9	9	11.8	12.5	14.9	16.8	17.4	18	19.4	20.1
7	0.6	2.5	6	9	11.8	12.5	15.4	16.8	17.5	18.3	19.4	20.1
8	0.6	2.5	6	9	11.8	12.6	15.4	16.9	17.5	18.3	19.4	20.1
9	1.2	2.5	6	9.2	11.8	12.8	15.5	17	17.5	18.4	19.4	20.6
10	1.3	2.6	6	9.2	11.8	13	15.5	17	17.6	18.5	19.4	21.1
11	1.5	2.6	6	9.2	11.8	13.1	15.5	17	17.7	18.5	19.4	21.1
12	1.6	3.1	6	9.4	11.8	13.2	15.6	17	17.7	18.5	19.5	21.1
13	1.6	3.3	6	9.4	11.8	13.3	15.6	17.1	17.7	18.5	19.6	21.1
14	1.6	3.5	6.1	9.5	11.8	13.4	15.6	17.1	17.7	18.5	19.6	21.1
15	1.6	3.8	6.1	9.5	11.8	13.4	15.6	17.1	17.7	18.5	19.6	21.1
16	1.6	3.9	6.1	9.6	11.8	13.4	15.7	17.1	17.7	18.5	19.6	21.9
17	1.6	4	6.2	9.6	11.9	13.5	15.7	17.1	17.7	18.5	19.6	22.1
18	1.6	4.1	6.3	9.8	11.9	13.6	16.3	17.1	17.7	18.5	19.6	22.1
19	1.7	4.1	6.5	9.9	11.9	13.6	16.6	17.1	17.7	18.6	19.6	22.1
20	1.8	4.1	6.6	9.9	12	13.6	16.6	17.1	17.7	18.6	19.6	22.1
21	1.8	4.1	6.6	9.9	12	13.6	16.6	17.2	17.7	18.6	19.6	22.1
22	1.8	4.1	6.6	10.2	12.1	13.7	16.6	17.3	17.7	18.6	19.6	22.4
23	1.8	4.1	6.6	10.2	12.3	13.7	16.6	17.3	17.7	18.6	19.6	22.5
24	1.8	4.1	6.6	10.2	12.3	13.7	16.6	17.3	17.7	18.6	19.6	22.6
25	1.8	4.1	6.6	10.2	12.3	13.7	16.6	17.3	17.7	18.6	19.6	22.6
26	1.8	4.1	6.6	10.2	12.3	13.8	16.6	17.3	17.7	18.7	19.9	22.7
27	1.8	4.3	7	10.4	12.3	14.2	16.6	17.3	17.7	18.7	20.1	22.7
28	1.9	4.6	7	10.5	12.3	14.2	16.6	17.3	17.7	18.7	20.1	22.7
29	2.2	4.7	7.3	10.8	---	14.2	16.6	17.3	17.7	18.7	20.1	22.7
30	2.2	5	7.7	10.8	---	14.4	16.7	17.3	17.8	18.8	20.1	22.7
31	2.2	---	7.9	11	---	14.4	---	17.3	---	18.8	20.1	---
	2.2	**2.9**	**3.4**	**2.8**	**1.2**	**2**	**2.2**	**0.6**	**0.5**	**1.2**	**1.1**	**2.6**
mean	1.4	3.4	6.3	9.7	11.9	13.3	15.8	17.1	17.6	18.4	19.6	21.5
max	2.2	5	7.9	11	12.3	14.4	16.7	17.3	17.8	18.8	20.1	22.7
min	0	2.2	5.1	8.5	11.3	12.5	14.5	16.7	17.3	17.8	19	20.1

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2007 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2006	2006	2006	2007	2007	2007	2007	2007	2007	2007	2007	2007
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	3.9	5.7	7.3	8.6	10.7	12.4	13.7	15.4	16.5	16.9	18.6
2	0	3.9	5.8	7.3	8.8	10.8	12.5	13.7	15.4	16.5	17	18.6
3	0.3	4	5.8	7.3	8.8	10.8	12.8	13.7	15.4	16.5	17.1	18.6
4	0.3	4	5.8	7.3	8.8	10.8	12.8	14	15.4	16.5	17.8	18.6
5	0.4	4	5.8	8	8.8	10.8	12.8	14.3	15.4	16.5	17.8	18.6
6	0.5	4	5.8	8	8.8	10.8	12.8	14.8	15.5	16.5	17.8	19.1
7	0.8	4	5.8	8.1	8.8	10.8	12.8	15	15.8	16.5	17.8	19.1
8	1	4	5.8	8.1	8.8	10.8	12.8	15	16.4	16.5	17.8	19.1
9	1	4	5.8	8.1	8.8	11	12.8	15	16.4	16.5	17.8	19.1
10	1.4	4.1	5.8	8.2	8.8	11.1	13	15	16.4	16.5	17.8	19.1
11	1.5	4.1	5.8	8.2	8.9	11.2	13.1	15	16.4	16.5	17.8	19.1
12	1.5	4.5	5.8	8.2	9.4	11.2	13.1	15	16.5	16.5	17.8	19.1
13	1.5	4.5	6	8.2	9.4	11.2	13.1	15.1	16.5	16.5	17.8	19.1
14	1.5	4.7	6.1	8.3	9.4	11.2	13.1	15.1	16.5	16.5	17.8	19.1
15	1.5	5.2	6.1	8.3	9.4	11.2	13.1	15.1	16.5	16.6	18.1	19.1
16	1.5	5.2	6.1	8.3	9.7	11.2	13.1	15.1	16.5	16.7	18.3	19.1
17	1.7	5.2	6.7	8.3	9.8	11.2	13.1	15.1	16.5	16.7	18.4	19.2
18	1.9	5.2	6.8	8.3	9.8	11.2	13.1	15.1	16.5	16.7	18.5	19.3
19	2	5.2	6.8	8.3	9.9	11.2	13.2	15.1	16.5	16.7	18.5	19.3
20	2.2	5.2	6.8	8.3	10.1	11.2	13.3	15.1	16.5	16.7	18.5	19.3
21	3.2	5.2	6.8	8.3	10.1	11.2	13.3	15.1	16.5	16.7	18.5	19.3
22	3.4	5.2	6.9	8.5	10.1	11.3	13.3	15.2	16.5	16.7	18.5	19.3
23	3.4	5.2	6.9	8.5	10.2	11.3	13.4	15.2	16.5	16.7	18.5	19.3
24	3.4	5.2	6.9	8.5	10.2	11.3	13.5	15.2	16.5	16.7	18.5	20
25	3.4	5.2	7.1	8.5	10.3	11.3	13.7	15.2	16.5	16.7	18.5	20.6
26	3.8	5.2	7.1	8.5	10.5	11.3	13.7	15.2	16.5	16.8	18.5	20.6
27	3.9	5.2	7.1	8.5	10.5	11.3	13.7	15.2	16.5	16.9	18.5	20.6
28	3.9	5.4	7.1	8.5	10.7	11.3	13.7	15.2	16.5	16.9	18.6	20.6
29	3.9	5.7	7.1	8.5	---	12.2	13.7	15.4	16.5	16.9	18.6	20.7
30	3.9	5.7	7.3	8.5	---	12.2	13.7	15.4	16.5	16.9	18.6	21.2
31	3.9	---	7.3	8.6	---	12.3	---	15.4	---	16.9	18.6	---
	3.9	**1.8**	**1.6**	**1.3**	**2.1**	**1.7**	**1.3**	**1.7**	**1.1**	**0.4**	**1.7**	**2.6**
mean	2	4.7	6.4	8.2	9.5	11.2	13.2	14.9	16.2	16.6	18.1	19.4
max	3.9	5.7	7.3	8.6	10.7	12.3	13.7	15.4	16.5	16.9	18.6	21.2
min	0	3.9	5.7	7.3	8.6	10.7	12.4	13.7	15.4	16.5	16.9	18.6

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2008 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2007	2007	2007	2008	2008	2008	2008	2008	2008	2008	2008	2008
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	2.8	3.8	8.9	13.2	15.9	17.9	19.4	21.2	22.7	23	24.4
2	0.2	2.8	4.5	9	13.7	16.2	18	19.6	21.2	22.7	23	25.1
3	0.3	2.8	4.5	9	13.7	16.4	18.1	19.7	21.2	22.8	23	25.1
4	0.3	2.8	4.5	9	14	16.4	18.1	19.8	21.4	22.8	23	25.1
5	0.3	2.8	4.6	9	14	16.5	18.1	19.8	22	22.8	23	25.1
6	0.3	2.8	4.6	9.4	14.1	16.5	18.2	19.8	22.2	22.8	23	25.1
7	0.8	2.8	4.6	9.6	14.5	16.5	18.4	19.8	22.2	22.8	23.4	25.1
8	1	2.8	5.3	9.6	14.7	16.5	18.4	19.8	22.3	22.8	23.4	25.1
9	1	2.8	5.6	9.7	14.9	16.5	18.5	19.9	22.3	22.8	23.6	25.1
10	1	2.8	5.8	10	15.1	16.6	18.5	19.9	22.3	22.8	23.7	25.2
11	1	2.8	5.8	10.1	15.1	16.6	18.8	20	22.4	22.8	23.7	25.4
12	1	2.9	5.9	10.3	15.2	16.6	19	20	22.7	22.8	23.7	26.1
13	1	2.9	5.9	10.4	15.2	16.6	19	20.3	22.7	22.8	23.7	26.2
14	1.3	2.9	5.9	10.4	15.2	16.7	19	20.4	22.7	22.8	23.7	26.2
15	1.4	2.9	6	10.5	15.2	16.8	19	20.6	22.7	22.8	23.7	26.2
16	1.4	2.9	6	10.5	15.3	16.8	19	20.6	22.7	22.8	24.4	26.2
17	1.4	2.9	6	10.6	15.3	16.8	19	20.6	22.7	22.8	24.4	26.2
18	1.4	2.9	6	10.8	15.5	16.8	19	20.6	22.7	22.8	24.4	26.3
19	1.5	2.9	6.1	10.9	15.5	16.8	19	20.6	22.7	22.8	24.4	26.3
20	1.5	2.9	6.4	11.1	15.5	16.8	19	20.6	22.7	22.8	24.4	26.3
21	1.9	2.9	7	11.2	15.5	16.8	19	20.6	22.7	22.8	24.4	26.4
22	2.1	3	7.2	11.3	15.5	16.8	19	20.6	22.7	22.9	24.4	26.4
23	2.1	3	7.3	11.3	15.6	16.8	19.1	20.8	22.7	22.9	24.4	26.8
24	2.1	3	7.6	11.4	15.6	16.9	19.2	21.1	22.7	23	24.4	26.8
25	2.1	3	8	11.6	15.6	16.9	19.2	21.2	22.7	23	24.4	26.8
26	2.1	3	8.2	11.7	15.8	16.9	19.2	21.2	22.7	23	24.4	26.8
27	2.1	3.1	8.2	11.8	15.8	16.9	19.3	21.2	22.7	23	24.4	26.8
28	2.1	3.2	8.3	12	15.9	17	19.3	21.2	22.7	23	24.4	26.8
29	2.1	3.2	8.4	12.6	15.9	17.1	19.3	21.2	22.7	23	24.4	26.8
30	2.1	3.3	8.6	12.8	---	17.1	19.3	21.2	22.7	23	24.4	26.8
31	2.7	---	8.9	13	---	17.7	---	21.2	---	23	24.4	---
	2.7	**1**	**5.1**	**4.3**	**2.7**	**2**	**1.5**	**1.8**	**1.5**	**0.3**	**1.4**	**2.4**
mean	1.3	2.9	6.3	10.6	15	16.7	18.8	20.4	22.4	22.9	23.9	26
max	2.7	3.3	8.9	13	15.9	17.7	19.3	21.2	22.7	23	24.4	26.8
min	0	2.8	3.8	8.9	13.2	15.9	17.9	19.4	21.2	22.7	23	24.4

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2009 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2008	2008	2008	2009	2009	2009	2009	2009	2009	2009	2009	2009
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	1	2.4	5.9	8.8	11.8	14.2	18.4	20.1	23.1	24.2	26.1
2	0	1	2.4	5.9	8.8	11.8	14.5	18.5	20.7	23.2	24.2	26.1
3	0	1.3	2.4	6	8.8	11.8	14.6	19.2	20.9	23.3	24.2	26.1
4	0	1.4	2.5	6.2	8.8	11.8	14.9	19.4	21	23.3	24.2	26.1
5	0.2	1.6	2.6	6.2	8.8	11.8	14.9	19.4	21	23.3	24.2	26.1
6	0.2	1.8	2.6	6.2	8.8	11.9	15	19.4	21	23.3	24.2	26.1
7	0.2	1.8	2.6	6.3	8.9	12.1	15	19.4	21	23.3	24.9	26.1
8	0.2	1.8	2.6	6.4	8.9	12.1	15	19.4	21.2	23.3	25.2	26.1
9	0.2	1.8	2.7	6.5	9.2	12.1	15.1	19.4	21.7	23.3	25.2	26.1
10	0.3	1.8	2.7	6.6	9.7	12.3	16.2	19.4	21.9	23.3	25.2	26.1
11	0.5	1.9	2.7	6.6	9.7	12.4	16.2	19.4	22.5	23.3	25.2	26.1
12	0.7	2	2.7	6.7	9.8	12.4	16.3	19.4	22.6	23.3	25.2	26.1
13	0.8	2.2	2.7	6.8	9.8	12.4	16.6	19.4	22.6	23.3	25.2	26.1
14	0.8	2.2	3.2	6.8	9.8	12.4	16.6	19.4	22.6	23.3	25.2	26.1
15	0.8	2.3	3.3	6.8	10.1	12.4	16.6	19.4	22.6	23.3	25.2	26.1
16	0.8	2.3	3.4	6.8	10.1	12.4	16.6	19.4	22.7	23.3	25.7	26.1
17	0.8	2.3	3.6	6.8	10.2	12.4	16.8	19.4	22.7	23.3	25.8	26.1
18	0.8	2.3	3.6	6.8	11.3	12.4	17	19.4	22.7	23.3	25.8	26.1
19	0.8	2.3	4	6.8	11.5	12.4	17	19.4	22.7	23.3	25.8	26.1
20	0.8	2.3	4.2	6.8	11.5	12.4	17	19.4	22.7	23.3	25.8	26.1
21	0.8	2.3	4.2	6.8	11.5	12.4	17	19.5	22.8	23.3	25.8	26.2
22	0.9	2.3	4.3	6.8	11.5	12.4	17	19.6	23	23.3	25.8	26.2
23	1	2.3	5	6.9	11.6	12.4	17	19.6	23	23.3	25.8	26.2
24	1	2.3	5.1	7.5	11.6	12.7	17	19.7	23	23.3	26	26.2
25	1	2.3	5.2	7.8	11.6	12.7	17	20.1	23.1	23.3	26.1	26.2
26	1	2.3	5.3	8.4	11.6	13.4	17.6	20.1	23.1	23.3	26.1	26.2
27	1	2.3	5.8	8.6	11.6	13.4	18.4	20.1	23.1	23.3	26.1	26.2
28	1	2.3	5.9	8.6	11.7	13.5	18.4	20.1	23.1	23.4	26.1	26.2
29	1	2.3	5.9	8.7	---	13.5	18.4	20.1	23.1	23.9	26.1	26.2
30	1	2.3	5.9	8.8	---	13.8	18.4	20.1	23.1	24.1	26.1	26.2
31	1	---	5.9	8.8	---	13.9	---	20.1	---	24.2	26.1	---
	1	**1.4**	**3.5**	**2.9**	**3**	**2.4**	**4.2**	**1.7**	**3**	**1.1**	**1.9**	**0.1**
mean	0.6	2	3.8	7	10.2	12.5	16.4	19.5	22.2	23.4	25.4	26.1
max	1	2.3	5.9	8.8	11.7	13.9	18.4	20.1	23.1	24.2	26.1	26.2
min	0	1	2.4	5.9	8.8	11.8	14.2	18.4	20.1	23.1	24.2	26.1

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2010 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2009	2009	2009	2010	2010	2010	2010	2010	2010	2010	2010	2010
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	3.4	4.4	6.9	7.9	9.3	10.8	15	18.3	20.8	21.2	23.2
2	0.3	3.4	4.4	7	8	9.3	11.4	15.1	18.4	20.8	21.8	23.2
3	0.3	3.4	4.5	7	8	9.3	11.7	15.2	18.4	20.9	21.8	23.2
4	0.3	3.4	4.5	7.1	8	9.3	11.8	15.2	18.4	20.9	21.8	23.2
5	1	3.4	4.5	7.1	8.1	9.3	12	15.5	18.4	20.9	21.8	23.2
6	1.1	3.4	4.5	7.1	8.1	9.6	12.2	15.6	18.4	20.9	21.8	23.2
7	1.1	3.4	4.5	7.2	8.2	9.6	13.8	15.7	18.5	20.9	21.9	23.2
8	1.1	3.4	4.9	7.2	8.2	9.6	13.9	15.7	18.6	20.9	21.9	23.3
9	1.2	3.4	5	7.2	8.2	9.6	13.9	15.7	18.8	20.9	21.9	23.3
10	1.4	3.4	5.1	7.2	8.2	9.6	13.9	15.7	18.9	20.9	21.9	23.3
11	1.4	3.4	5.1	7.2	8.3	9.8	13.9	15.7	19.1	20.9	21.9	23.3
12	1.6	3.4	5.1	7.2	8.4	9.8	13.9	15.9	19.3	20.9	21.9	23.3
13	1.6	3.9	5.4	7.2	8.6	9.8	13.9	16.1	19.8	21	21.9	23.3
14	1.7	4.1	6	7.2	8.7	9.8	13.9	16.1	20.6	21	21.9	23.3
15	2	4.1	6	7.2	8.7	9.8	13.9	16.1	20.6	21	21.9	23.3
16	2	4.1	6	7.2	8.7	9.8	13.9	16.1	20.6	21	21.9	23.3
17	2	4.1	6	7.2	8.8	9.8	14	16.1	20.7	21	21.9	23.3
18	2	4.1	6.1	7.2	8.9	9.8	14	16.1	20.7	21	22	23.3
19	2	4.1	6.1	7.2	9	9.8	14	16.2	20.7	21	22.2	23.3
20	2	4.1	6.1	7.3	9	9.8	14	17.2	20.7	21	22.3	23.3
21	2.1	4.1	6.1	7.3	9.1	9.9	14	17.3	20.7	21	22.3	23.3
22	2.1	4.1	6.1	7.4	9.1	9.9	14	17.4	20.7	21	22.3	23.3
23	2.1	4.3	6.1	7.6	9.1	10	14	17.6	20.7	21	22.4	23.4
24	2.2	4.4	6.2	7.7	9.1	10.2	14.4	17.7	20.7	21	22.4	23.5
25	2.3	4.4	6.2	7.7	9.1	10.2	14.4	18.3	20.7	21	22.4	23.5
26	2.4	4.4	6.4	7.8	9.3	10.2	14.4	18.3	20.7	21	22.4	23.5
27	2.4	4.4	6.4	7.8	9.3	10.4	14.4	18.3	20.7	21	22.4	23.5
28	2.5	4.4	6.4	7.8	9.3	10.4	14.4	18.3	20.7	21	22.4	23.5
29	3.2	4.4	6.4	7.8	---	10.5	14.8	18.3	20.7	21.2	22.5	23.5
30	3.2	4.4	6.6	7.8	---	10.5	14.9	18.3	20.8	21.2	22.6	23.5
31	3.4	---	6.9	7.8	---	10.5	---	18.3	---	21.2	23.2	---
	3.4	**1**	**2.5**	**1**	**1.4**	**1.5**	**4.2**	**3.3**	**2.5**	**0.4**	**2**	**0.3**
mean	1.7	3.9	5.6	7.3	8.6	9.8	13.6	16.6	19.8	21	22.1	23.3
max	3.4	4.4	6.9	7.8	9.3	10.5	14.9	18.3	20.8	21.2	23.2	23.5
min	0	3.4	4.4	6.9	7.9	9.3	10.8	15	18.3	20.8	21.2	23.2

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2011 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011	2011
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	3	6	11	13.1	15.7	19	23.9	25.9		28.1	28.4
2	0	3	6	11.2	13.2	15.7	19	23.9	25.9		28.1	28.4
3	0	3	6	11.2	13.2	15.7	19	24	25.9		28.1	28.4
4	0	3	6.2	11.2	13.2	15.8	19.6	24.1	25.9		28.2	28.4
5	0	3	6.7	11.3	13.2	15.8	19.6	24.1	25.9		28.2	28.4
6	0.1	3	6.8	11.5	13.4	15.8	19.8	24.2	25.9		28.2	28.4
7	0.2	3	7	11.5	13.4	16.5	20	24.2	25.9		28.2	28.5
8	0.5	3	7.1	11.5	13.7	16.5	20.1	24.2	25.9		28.2	28.5
9	0.9	3	7.1	11.5	13.7	16.6	20.2	24.2	25.9		28.2	28.5
10	1.1	3.2	7.1	11.6	13.8	16.6	20.6	24.2	25.9		28.2	28.5
11	1.1	3.2	7.2	11.7	13.8	16.6	21.2	24.2	25.9		28.2	28.5
12	1.1	3.3	7.3	11.7	13.8	16.6	21.2	24.3	25.9		28.2	28.5
13	1.1	3.3	7.3	11.8	13.9	16.7	21.2	24.3	25.9		28.2	28.5
14	1.1	3.5	7.3	11.8	13.9	16.7	21.3	24.3	25.9	27.7	28.2	28.5
15	1.1	3.6	7.3	11.9	13.9	16.7	21.3	24.3	25.9	27.7	28.2	28.5
16	1.1	3.7	7.5	11.9	13.9	16.8	21.3	24.3	25.9	27.7	28.3	28.5
17	1.1	4.3	7.5	12	14.1	17.1	21.6	24.3	26.1	27.7	28.3	28.5
18	1.1	4.4	7.5	12	14.2	17.2	21.7	24.8	26.1	27.8	28.3	28.5
19	1.1	4.4	7.7	12	14.3	17.2	22.9	25.1	26.2	27.8	28.3	28.5
20	1.1	4.4	8.4	12.5	14.5	17.2	22.9	25.3	26.3	27.8	28.3	28.5
21	1.1	4.4	9.1	12.6	14.9	17.2	23	25.6	26.6	27.8	28.3	28.5
22	1.1	5.3	9.5	12.6	15	17.5	23.4	25.7	26.6	27.8	28.3	28.5
23	1.9	5.3	9.7	12.7	15	17.8	23.4	25.7	26.6	27.8	28.3	28.5
24	2.3	5.5	9.9	12.8	15.1	17.9	23.4	25.8	26.6	27.8	28.3	28.5
25	2.5	5.7	9.9	12.9	15.4	17.9	23.4	25.8	26.6	27.8	28.3	28.5
26	2.9	5.7	10	13	15.7	18.3	23.5	25.8	26.6	27.8	28.3	28.5
27	2.9	5.7	10	13	15.7	18.4	23.7	25.8	26.6	28.1	28.3	28.5
28	2.9	5.7	10	13	15.7	18.5	23.7	25.8	26.6	28.1	28.3	28.5
29	2.9	5.9	10	13	---	18.9	23.8	25.9	26.6	28.1	28.3	28.5
30	2.9	6	10.9	13	---	19	23.9	25.9	28.1	28.3	28.5	
31	2.9	---	10.9	13.1	---	19	---	25.9	---	28.1	28.3	---
	3	**3**	**5**	**2.1**	**2.6**	**3.3**	**4.9**	**2**	**2.2**	**0**	**0.3**	**0.1**
mean	1.3	4.1	8.1	12.1	14.2	17.1	21.6	24.8	26.2	27.9	28.2	28.5
max	2.9	6	10.9	13.1	15.7	19	23.9	25.9	26.6	28.1	28.3	28.5
min	0	3	6	11	13.1	15.7	19	23.9	25.9	27.7	28.1	28.4

/cdbs/wy/snot56 2002 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2001	2001	2001	2002	2002	2002	2002	2002	2002	2002	2002	2002
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep

/cdbs/wy/snot56 2012 Accumlated Precipitation - Since Oct. 1
Station: WY07H06S, SAGE CREEK BASIN
Unit = inches

	2011	2011	2011	2012	2012	2012	2012	2012	2012	2012	2012	2012
day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0	2	4.6	5.5	7.1	9.7	10.2	11.3	12.1	12.1	13.1	13.5
2	0	2.3	4.8	5.5	7.1	9.7	10.2	11.5	12.1	12.1	13.1	13.6
3	0	2.5	4.9	5.5	7.1	9.7	10.3	11.7	12.1	12.1	13.1	13.6
4	0	2.5	5	5.5	7.1	9.8	10.3	11.7	12.1	12.1	13.1	13.6
5	0.1	2.5	5	5.5	7.1	9.8	10.3	11.7	12.1	12.1	13.1	13.6
6	0.1	2.8	5	5.5	7.1	9.8	10.3	11.7	12.1	12.1	13.1	13.6
7	0.5	2.8	5	5.5	7.1	9.8	10.3	11.7	12.1	12.1	13.1	13.6
8	0.5	2.8	5	5.6	7.1	9.8	10.3	11.7	12.1	12.1	13.1	13.6
9	0.9	2.8	5	5.6	7.2	9.8	10.3	11.7	12.1	12.1	13.1	13.6
10	0.9	2.8	5	5.6	7.3	9.8	10.3	11.7	12.1	12.1	13.1	13.6
11	1	2.8	5	5.6	7.5	9.8	10.3	11.7	12.1	12.1	13.3	13.6
12	1.3	2.8	5	5.6	7.5	9.8	10.3	11.7	12.1	12.1	13.3	13.6
13	1.3	3.1	5	5.6	7.6	9.8	10.6	11.7	12.1	12.1	13.3	13.6
14	1.3	3.7	5.1	5.6	7.7	9.8	10.6	11.7	12.1	12.2	13.3	13.6
15	1.3	3.7	5.2	5.6	7.8	9.8	10.8	11.7	12.1	12.2	13.3	13.6
16	1.3	3.8	5.2	5.6	7.8	9.8	11.1	11.7	12.1	12.3	13.3	13.6
17	1.4	3.8	5.2	5.8	7.8	9.8	11.1	11.7	12.1	12.3	13.3	13.6
18	1.6	3.8	5.2	5.8	7.9	9.8	11.2	11.7	12.1	12.3	13.3	13.6
19	1.6	4	5.2	5.8	7.9	10	11.2	11.7	12.1	12.3	13.3	13.6
20	1.6	4.2	5.2	5.8	8.2	10.2	11.2	11.7	12.1	12.3	13.3	13.6
21	1.6	4.3	5.2	5.8	8.4	10.2	11.2	11.7	12.1	12.4	13.3	13.6
22	1.6	4.5	5.3	6.4	8.8	10.2	11.2	11.7	12.1	12.7	13.3	13.6
23	1.7	4.5	5.5	6.6	9	10.2	11.2	11.8	12.1	12.8	13.3	13.6
24	1.7	4.5	5.5	6.8	9.1	10.2	11.2	12.1	12.1	12.8	13.3	13.8
25	1.7	4.5	5.5	6.9	9.1	10.2	11.2	12.1	12.1	13	13.3	13.8
26	1.9	4.6	5.5	6.9	9.2	10.2	11.3	12.1	12.1	13	13.3	13.8
27	2	4.6	5.5	7	9.2	10.2	11.3	12.1	12.1	13	13.3	13.9
28	2	4.6	5.5	7.1	9.2	10.2	11.3	12.1	12.1	13	13.3	13.9
29	2	4.6	5.5	7.1	9.6	10.2	11.3	12.1	12.1	13	13.3	13.9
30	2	4.6	5.5	7.1	---	10.2	11.3	12.1	12.1	13	13.3	13.9
31	2	---	5.5	7.1	---	10.2	---	12.1	---	13.1	13.4	---
	2	**2.6**	**0.9**	**1.6**	**2.6**	**0.5**	**1.1**	**0.8**	**0**	**1**	**0.4**	**0.4**
mean	1.2	3.6	5.2	6	8	10	10.8	11.8	12.1	12.4	13.2	13.7
max	2	4.6	5.5	7.1	9.6	10.2	11.3	12.1	12.1	13.1	13.4	13.9
min	0	2	4.6	5.5	7.1	9.7	10.2	11.3	12.1	12.1	13.1	13.5

APPENDIX B
Rawlins Precipitation Data

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
1/1/2006	--		--		--
1/2/2006	--		--		--
1/3/2006	--		--		--
1/4/2006	--		--		--
1/5/2006	--		--		--
1/6/2006	--		--		--
1/7/2006	0		0		--
1/8/2006	0		0		--
1/9/2006	0.26		T		--
1/10/2006	T		0.01		--
1/11/2006	0		0		--
1/12/2006	0.12		T		--
1/13/2006	0		T		--
1/14/2006	0		0		--
1/15/2006	0		0		--
1/16/2006	--		--		--
1/17/2006	T		0		--
1/18/2006	0		T		--
1/19/2006	0.1		T		--
1/20/2006	0		0		--
1/21/2006	T		0		--
1/22/2006	--		0		--
1/23/2006	--		0		--
1/24/2006	--		0		--
1/25/2006	--		0		--
1/26/2006	--		0		--
1/27/2006	--		T		--
1/28/2006	--		T		--
1/29/2006	T		T		--
1/30/2006	0		0		--
1/31/2006	0.05		0		--
2/1/2006	0		T		--
2/2/2006	T		T		--
2/3/2006	0		0		--
2/4/2006	0		0		--
2/5/2006	0.27		T		--
2/6/2006	T		T		--
2/7/2006	0		0		--
2/8/2006	0		0		--
2/9/2006	0		0		--
2/10/2006	0.02		T		--
2/11/2006	0		0		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
2/12/2006	0		0		--
2/13/2006	0		0		--
2/14/2006	0		0		--
2/15/2006	0.19		T		--
2/16/2006	0.29		0.35		--
2/17/2006	0.02		0.02		--
2/18/2006	0.05		T		--
2/19/2006	0.04		T		--
2/20/2006	T		T		--
2/21/2006	0		0		--
2/22/2006	T		T		--
2/23/2006	T		T		--
2/24/2006	0		0.01		--
2/25/2006	--		--		--
2/26/2006	--		0		--
2/27/2006	0		0		--
2/28/2006	0		0		--
3/1/2006	T		0.01		--
3/2/2006	0		0		--
3/3/2006	0		0		--
3/4/2006	0		0.01		--
3/5/2006	0		0		--
3/6/2006	0		0		--
3/7/2006	0		0		--
3/8/2006	0.16		T		--
3/9/2006	T		0.18		--
3/10/2006	0.04		T		--
3/11/2006	0.07		0.05		--
3/12/2006	0.04		0.03		--
3/13/2006	T		0.05		--
3/14/2006	T		T		--
3/15/2006	T		0.01		--
3/16/2006	T		T		--
3/17/2006	0		0		--
3/18/2006	T		T		--
3/19/2006	0.13		0.11		--
3/20/2006	--		0.03		--
3/21/2006	T		T		--
3/22/2006	0.19		0.02		--
3/23/2006	0		0		--
3/24/2006	0		0		--
3/25/2006	0		0		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
3/26/2006	0.06		T		--
3/27/2006	0.09		T		--
3/28/2006	0		0		--
3/29/2006	0		0		--
3/30/2006	T		0.01		--
3/31/2006	T		T		--
4/1/2006	0		--		--
4/2/2006	--		--		--
4/3/2006	0		--		--
4/4/2006	0		--		--
4/5/2006	0		--		--
4/6/2006	0.13		--		--
4/7/2006	0.13		--		--
4/8/2006	0.05		--		--
4/9/2006	0		--		--
4/10/2006	0		--		--
4/11/2006	0		--		--
4/12/2006	0.02		--		--
4/13/2006	0		--		--
4/14/2006	0		--		--
4/15/2006	--		--		--
4/16/2006	0		--		--
4/17/2006	0		--		--
4/18/2006	0.12		--		--
4/19/2006	0		--		--
4/20/2006	0		--		--
4/21/2006	0		--		--
4/22/2006	0		--		--
4/23/2006	0		--		--
4/24/2006	--		--		--
4/25/2006	--		--		--
4/26/2006	--		--		--
4/27/2006	--		--		--
4/28/2006	--		--		--
4/29/2006	--		--		--
4/30/2006	--		--		--
5/1/2006	--		--		--
5/2/2006	--		--		--
5/3/2006	--		--		--
5/4/2006	0.04		--		--
5/5/2006	0.06		--		--
5/6/2006	0		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
5/7/2006	--		--		--
5/8/2006	--		--		--
5/9/2006	--		--		--
5/10/2006	--		--		--
5/11/2006	--		--		--
5/12/2006	--		--		--
5/13/2006	--		--		--
5/14/2006	--		--		--
5/15/2006	--		--		--
5/16/2006	--		--		--
5/17/2006	--		--		--
5/18/2006	--		--		--
5/19/2006	--		--		--
5/20/2006	0.01		--		--
5/21/2006	0.02		--		--
5/22/2006	0		--		--
5/23/2006	0.34		--		--
5/24/2006	0.01		--		--
5/25/2006	0		--		--
5/26/2006	0		--		--
5/27/2006	0		--		--
5/28/2006	0		--		--
5/29/2006	T		--		--
5/30/2006	0		--		--
5/31/2006	0		--		--
6/1/2006	0		--		--
6/2/2006	0		--		--
6/3/2006	--		--		--
6/4/2006	--		--		--
6/5/2006	--		--		--
6/6/2006	--		--		--
6/7/2006	--		--		--
6/8/2006	0		--		--
6/9/2006	T		--		--
6/10/2006	0.31		--		--
6/11/2006	0.05		--		--
6/12/2006	0		--		--
6/13/2006	0		--		--
6/14/2006	0		--		--
6/15/2006	0		--		--
6/16/2006	--		--		--
6/17/2006	0		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
6/18/2006	--		--		--
6/19/2006	--		--		--
6/20/2006	--		--		--
6/21/2006	--		--		--
6/22/2006	--		--		--
6/23/2006	0		--		--
6/24/2006	0		--		--
6/25/2006	--		--		--
6/26/2006	0		--		--
6/27/2006	0		--		--
6/28/2006	T		--		--
6/29/2006	0		--		--
6/30/2006	0		--		--
7/1/2006	T		--		--
7/2/2006	T		--		--
7/3/2006	T		--		--
7/4/2006	T		--		--
7/5/2006	0		--		--
7/6/2006	T		--		--
7/7/2006	0.02		--		--
7/8/2006	0		--		--
7/9/2006	0.16		--		--
7/10/2006	0.03		--		--
7/11/2006	T		--		--
7/12/2006	0		--		--
7/13/2006	0.01		--		--
7/14/2006	0		--		--
7/15/2006	--		--		--
7/16/2006	--		--		--
7/17/2006	0		--		--
7/18/2006	0		--		--
7/19/2006	0		--		--
7/20/2006	0		--		--
7/21/2006	0		--		--
7/22/2006	0		--		--
7/23/2006	--		--		--
7/24/2006	T		--		--
7/25/2006	0.03		--		--
7/26/2006	0.04		--		--
7/27/2006	0.01		--		--
7/28/2006	--		--		--
7/29/2006	0		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
7/30/2006	0		--		--
7/31/2006	0.25		--		--
8/1/2006	0.08		--		--
8/2/2006	0.02		--		--
8/3/2006	0		--		--
8/4/2006	0		--		--
8/5/2006	--		--		--
8/6/2006	0		--		--
8/7/2006	0.03		--		--
8/8/2006	0		--		--
8/9/2006	0		--		--
8/10/2006	0		--		--
8/11/2006	0		--		--
8/12/2006	0		--		--
8/13/2006	0.05		--		--
8/14/2006	0		--		--
8/15/2006	0		--		--
8/16/2006	T		--		--
8/17/2006	0		--		--
8/18/2006	T		--		--
8/19/2006	--		--		--
8/20/2006	0.02		--		--
8/21/2006	0		--		--
8/22/2006	0		--		--
8/23/2006	0		--		--
8/24/2006	0		--		--
8/25/2006	0		--		--
8/26/2006	0.15		--		--
8/27/2006	0.39		--		--
8/28/2006	0.08		--		--
8/29/2006	0		--		--
8/30/2006	0		--		--
8/31/2006	0		--		--
9/1/2006	--		--		--
9/2/2006	0		--		--
9/3/2006	--		--		--
9/4/2006	0		--		--
9/5/2006	--		--		--
9/6/2006	0		--		--
9/7/2006	T		--		--
9/8/2006	0		--		--
9/9/2006	0.11		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
9/10/2006	T		--		--
9/11/2006	0		--		--
9/12/2006	0		--		--
9/13/2006	0		--		--
9/14/2006	0		--		--
9/15/2006	T		--		--
9/16/2006	0.76		--		--
9/17/2006	0		--		--
9/18/2006	0		--		--
9/19/2006	0		--		--
9/20/2006	0		--		--
9/21/2006	T		--		--
9/22/2006	0.08		--		--
9/23/2006	0.12		--		--
9/24/2006	--		--		--
9/25/2006	--		--		--
9/26/2006	--		--		--
9/27/2006	--		--		--
9/28/2006	--		--		--
9/29/2006	--		--		--
9/30/2006	--		--		--
10/1/2006	--		--		--
10/2/2006	0		--		--
10/3/2006	0		--		--
10/4/2006	0		--		--
10/5/2006	0.04		--		--
10/6/2006	0.02		--		--
10/7/2006	0.02		--		--
10/8/2006	0.02		--		--
10/9/2006	T		--		--
10/10/2006	0.31		--		--
10/11/2006	0.01		--		--
10/12/2006	0		--		--
10/13/2006	0		--		--
10/14/2006	0		--		--
10/15/2006	--		--		--
10/16/2006	--		--		--
10/17/2006	--		--		--
10/18/2006	--		--		--
10/19/2006	--		--		--
10/20/2006	NA		--		--
10/21/2006	0.16		--		--

Data from CoCo RaHS Website, Station Report Summary

	Rawlins 1 NW		Rawlins Airport		Sinclair 0.1 N
DATE	WY-CR-2		WY-CR-3		WY-CR-9
10/22/2006	0.13		--		--
10/23/2006	0		--		--
10/24/2006	0		--		--
10/25/2006	0		--		--
10/26/2006	0.49		--		--
10/27/2006	0		--		--
10/28/2006	0		--		--
10/29/2006	0		--		--
10/30/2006	0		--		--
10/31/2006	0		--		--
11/1/2006	0		--		--
11/2/2006	0		--		--
11/3/2006	0		--		--
11/4/2006	0		--		--
11/5/2006	--		--		--
11/6/2006	0		--		--
11/7/2006	0		--		--
11/8/2006	0		--		--
11/9/2006	0		--		--
11/10/2006	0.07		--		--
11/11/2006	0		--		--
11/12/2006	0.01		--		--
11/13/2006	0.02		--		--
11/14/2006	--		--		--
11/15/2006	0.11		--		--
11/16/2006	--		--		--
11/17/2006	0.01		--		--
11/18/2006	0		--		--
11/19/2006	--		--		--
11/20/2006	0		--		--
11/21/2006	0		--		--
11/22/2006	0		--		--
11/23/2006	0		--		--
11/24/2006	0		--		--
11/25/2006	0		--		--
11/26/2006	0		--		--
11/27/2006	0		--		--
11/28/2006	0.09		--		--
11/29/2006	0.03		--		--
11/30/2006	0		--		--
12/1/2006	0		--		--
12/2/2006	0.01		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
12/3/2006	0		--		--
12/4/2006	0		--		--
12/5/2006	0		--		--
12/6/2006	--		--		--
12/7/2006	--		--		--
12/8/2006	0		--		--
12/9/2006	0		--		--
12/10/2006	0		--		--
12/11/2006	T		--		--
12/12/2006	T		--		--
12/13/2006	0.03		--		--
12/14/2006	0		--		--
12/15/2006	0.01		--		--
12/16/2006	0.21		--		--
12/17/2006	0.33		--		--
12/18/2006	0.13		--		--
12/19/2006	T		--		--
12/20/2006	0		--		--
12/21/2006	0.01		--		--
12/22/2006	0		--		--
12/23/2006	--		--		--
12/24/2006	--		--		--
12/25/2006	--		--		--
12/26/2006	--		--		--
12/27/2006	--		--		--
12/28/2006	--		--		--
12/29/2006	0.15		--		--
12/30/2006	T		--		--
12/31/2006	T		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
1/1/2007	0		--		--
1/2/2007	0		--		--
1/3/2007	0		--		--
1/4/2007	0.01		--		--
1/5/2007	0.1		--		--
1/6/2007	0		--		--
1/7/2007	0		--		--
1/8/2007	T		--		--
1/9/2007	0		--		--
1/10/2007	0		--		--
1/11/2007	0		--		--
1/12/2007	0.24		--		--
1/13/2007	0.13		--		--
1/14/2007	T		--		--
1/15/2007	0		--		--
1/16/2007	0		--		--
1/17/2007	0		--		--
1/18/2007	0.07		--		--
1/19/2007	0		--		--
1/20/2007	0		--		--
1/21/2007	0.14		--		--
1/22/2007	0.02		--		--
1/23/2007	0		--		--
1/24/2007	0		--		--
1/25/2007	0		--		--
1/26/2007	0		--		--
1/27/2007	T		--		--
1/28/2007	0		--		--
1/29/2007	0		--		--
1/30/2007	0		--		--
1/31/2007	0.03		--		--
2/1/2007	T		--		--
2/2/2007	0.07		--		--
2/3/2007	T		--		--
2/4/2007	0		--		--
2/5/2007	0		--		--
2/6/2007	0		--		--
2/7/2007	0		--		--
2/8/2007	0		--		--
2/9/2007	T		--		--
2/10/2007	0		--		--
2/11/2007	0		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
2/12/2007	T		--		--
2/13/2007	T		--		--
2/14/2007	0.01		--		--
2/15/2007	0.01		--		--
2/16/2007	T		--		--
2/17/2007	0		--		--
2/18/2007	0		--		--
2/19/2007	T		--		--
2/20/2007	0.03		--		--
2/21/2007	0		--		--
2/22/2007	0		--		--
2/23/2007	0		--		--
2/24/2007	0.12		--		--
2/25/2007	T		--		--
2/26/2007	0.01		--		--
2/27/2007	0.01		--		--
2/28/2007	0.01		--		--
3/1/2007	0.01		--		--
3/2/2007	T		--		--
3/3/2007	T		--		--
3/4/2007	0		--		--
3/5/2007	0		--		--
3/6/2007	0		--		--
3/7/2007	0		--		--
3/8/2007	0		--		--
3/9/2007	T		--		--
3/10/2007	0.03		--		--
3/11/2007	0.09		--		--
3/12/2007	0		--		--
3/13/2007	0		--		--
3/14/2007	0		--		--
3/15/2007	0		--		--
3/16/2007	0		--		--
3/17/2007	0		--		--
3/18/2007	0		--		--
3/19/2007	0		--		--
3/20/2007	0		--		--
3/21/2007	0		--		--
3/22/2007	0		--		--
3/23/2007	0		--		--
3/24/2007	0		--		--
3/25/2007	0		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
3/26/2007	0		--		--
3/27/2007	T		--		--
3/28/2007	0.51		--		--
3/29/2007	0.78		--		--
3/30/2007	0.14		--		--
3/31/2007	--		--		--
4/1/2007	--		--		--
4/2/2007	T		--		--
4/3/2007	0.04		--		--
4/4/2007	0		--		--
4/5/2007	0		--		--
4/6/2007	0		--		--
4/7/2007	0		--		--
4/8/2007	0		--		--
4/9/2007	T		--		--
4/10/2007	0.09		--		--
4/11/2007	0		--		--
4/12/2007	0		--		--
4/13/2007	--		--		--
4/14/2007	--		--		--
4/15/2007	--		--		--
4/16/2007	T		--		--
4/17/2007	T		--		--
4/18/2007	0		--		--
4/19/2007	0.07		--		--
4/20/2007	0		--		--
4/21/2007	0		--		--
4/22/2007	0		--		--
4/23/2007	T		--		--
4/24/2007	T		--		--
4/25/2007	--		--		--
4/26/2007	--		--		--
4/27/2007	--		--		--
4/28/2007	--		--		--
4/29/2007	0		--		--
4/30/2007	0		--		--
5/1/2007	0		--		--
5/2/2007	T		--		--
5/3/2007	T		--		--
5/4/2007	0.07		--		--
5/5/2007	0.31		--		--
5/6/2007	0.69		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
5/7/2007	0.01		--		--
5/8/2007	0		--		--
5/9/2007	0		--		--
5/10/2007	0		--		--
5/11/2007	0		--		--
5/12/2007	0		--		--
5/13/2007	0		--		--
5/14/2007	T		--		--
5/15/2007	T		--		--
5/16/2007	0		--		--
5/17/2007	0		--		--
5/18/2007	--		--		--
5/19/2007	0.05		--		--
5/20/2007	T		--		--
5/21/2007	T		--		--
5/22/2007	0.13		--		--
5/23/2007	0		--		--
5/24/2007	0		--		--
5/25/2007	--		--		--
5/26/2007	--		--		--
5/27/2007	--		--		--
5/28/2007	--		--		--
5/29/2007	0.14		--		--
5/30/2007	0		--		--
5/31/2007	0.01		--		--
6/1/2007	0.08		--		--
6/2/2007	0.03		--		--
6/3/2007	0		--		--
6/4/2007	--		--		--
6/5/2007	--		--		--
6/6/2007	--		--		--
6/7/2007	--		--		--
6/8/2007	--		--		--
6/9/2007	--		--		--
6/10/2007	--		--		--
6/11/2007	--		--		--
6/12/2007	--		--		--
6/13/2007	0.03		--		--
6/14/2007	0		--		--
6/15/2007	0		--		--
6/16/2007	0		--		--
6/17/2007	0.01		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
6/18/2007	T		--		--
6/19/2007	0		--		--
6/20/2007	0		--		--
6/21/2007	--		--		--
6/22/2007	0		--		--
6/23/2007	0		--		--
6/24/2007	0		--		--
6/25/2007	0		--		--
6/26/2007	0		--		--
6/27/2007	0		--		--
6/28/2007	0.02		--		--
6/29/2007	0		--		--
6/30/2007	0		--		--
7/1/2007	0		--		--
7/2/2007	0		--		--
7/3/2007	0		--		--
7/4/2007	0		--		--
7/5/2007	0.04		--		--
7/6/2007	0.03		--		--
7/7/2007	0		--		--
7/8/2007	--		--		--
7/9/2007	0		--		--
7/10/2007	0		--		--
7/11/2007	0.02		--		--
7/12/2007	0.21		--		--
7/13/2007	0		--		--
7/14/2007	0		--		--
7/15/2007	T		--		--
7/16/2007	0		--		--
7/17/2007	--		--		--
7/18/2007	--		--		--
7/19/2007	--		--		--
7/20/2007	--		--		--
7/21/2007	0.09		--		--
7/22/2007	--		--		--
7/23/2007	0.04		--		--
7/24/2007	--		--		--
7/25/2007	0		--		--
7/26/2007	0.65		--		--
7/27/2007	0.13		--		--
7/28/2007	0.02		--		--
7/29/2007	0		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
7/30/2007	0		--		--
7/31/2007	T		--		--
8/1/2007	0		--		--
8/2/2007	0.34		--		--
8/3/2007	0.1		--		--
8/4/2007	T		--		--
8/5/2007	0		--		--
8/6/2007	0.01		--		--
8/7/2007	0		--		--
8/8/2007	0.07		--		--
8/9/2007	--		--		--
8/10/2007	--		--		--
8/11/2007	--		--		--
8/12/2007	--		--		--
8/13/2007	--		--		--
8/14/2007	--		--		--
8/15/2007	--		--		--
8/16/2007	--		--		--
8/17/2007	--		--		--
8/18/2007	--		--		--
8/19/2007	--		--		--
8/20/2007	0.01		--		--
8/21/2007	0		--		--
8/22/2007	0		--		--
8/23/2007	0.04		--		--
8/24/2007	--		--		--
8/25/2007	--		--		--
8/26/2007	--		--		--
8/27/2007	0.02		--		--
8/28/2007	T		--		--
8/29/2007	T		--		--
8/30/2007	--		--		--
8/31/2007	--		--		--
9/1/2007	0.04		--		--
9/2/2007	0		--		--
9/3/2007	T		--		--
9/4/2007	0		--		--
9/5/2007	0		--		--
9/6/2007	0.19		--		--
9/7/2007	0		--		--
9/8/2007	0		--		--
9/9/2007	0		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
9/10/2007	T		--		--
9/11/2007	0		--		--
9/12/2007	0		--		--
9/13/2007	0		--		--
9/14/2007	0		--		--
9/15/2007	0.1		--		--
9/16/2007	0		--		--
9/17/2007	0.03		--		--
9/18/2007	0.05		--		--
9/19/2007	T		--		--
9/20/2007	0		--		--
9/21/2007	0		--		--
9/22/2007	0		--		--
9/23/2007	0.01		--		--
9/24/2007	0.07		--		--
9/25/2007	0.03		--		--
9/26/2007	0		--		--
9/27/2007	0		--		--
9/28/2007	0		--		--
9/29/2007	0		--		--
9/30/2007	--		--		--
10/1/2007	--		--		--
10/2/2007	--		--		--
10/3/2007	--		--		--
10/4/2007	--		--		--
10/5/2007	0		--		--
10/6/2007	0		--		--
10/7/2007	0.11		--		--
10/8/2007	0.01		--		--
10/9/2007	0		--		--
10/10/2007	0		--		--
10/11/2007	0		--		--
10/12/2007	0		--		--
10/13/2007	0		--		--
10/14/2007	0.03		--		--
10/15/2007	--		--		--
10/16/2007	0		--		--
10/17/2007	0		--		--
10/18/2007	0.02		--		--
10/19/2007	0		--		--
10/20/2007	0		--		--
10/21/2007	0.32		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
10/22/2007	--		--		--
10/23/2007	--		--		--
10/24/2007	--		--		--
10/25/2007	--		--		--
10/26/2007	--		--		--
10/27/2007	--		--		--
10/28/2007	0		--		--
10/29/2007	0		--		--
10/30/2007	0		--		--
10/31/2007	0.21		--		--
11/1/2007	--		--		--
11/2/2007	--		--		--
11/3/2007	0		--		--
11/4/2007	0		--		--
11/5/2007	0		--		--
11/6/2007	0		--		--
11/7/2007	0		--		--
11/8/2007	0		--		--
11/9/2007	0		--		--
11/10/2007	0		--		--
11/11/2007	0		--		--
11/12/2007	--		--		--
11/13/2007	0		--		--
11/14/2007	T		--		--
11/15/2007	0		--		--
11/16/2007	0		--		--
11/17/2007	0		--		--
11/18/2007	T		--		--
11/19/2007	0		--		--
11/20/2007	--		--		--
11/21/2007	--		--		--
11/22/2007	--		--		--
11/23/2007	--		--		--
11/24/2007	--		--		--
11/25/2007	--		--		--
11/26/2007	0		--		--
11/27/2007	0		--		--
11/28/2007	0.02		--		--
11/29/2007	0		--		--
11/30/2007	0		--		--
12/1/2007	0.58		--		--
12/2/2007	0.2		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
12/3/2007	0		--		--
12/4/2007	0.02		--		--
12/5/2007	0		--		--
12/6/2007	0		--		--
12/7/2007	0.16		--		--
12/8/2007	0.42		--		--
12/9/2007	0.12		--		--
12/10/2007	T		--		--
12/11/2007	0.13		--		--
12/12/2007	T		--		--
12/13/2007	0		--		--
12/14/2007	0.11		--		--
12/15/2007	0		--		--
12/16/2007	0		--		--
12/17/2007	0		--		--
12/18/2007	0		--		--
12/19/2007	--		--		--
12/20/2007	0		--		--
12/21/2007	0.06		--		--
12/22/2007	0.21		--		--
12/23/2007	0		--		--
12/24/2007	T		--		--
12/25/2007	0.4		--		--
12/26/2007	0.04		--		--
12/27/2007	0.02		--		--
12/28/2007	0		--		--
12/29/2007	--		--		--
12/30/2007	--		--		--
12/31/2007	--		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
1/1/2008	--		--		--
1/2/2008	--		--		--
1/3/2008	--		--		--
1/4/2008	--		--		--
1/5/2008	--		--		--
1/6/2008	--		--		--
1/7/2008	--		--		--
1/8/2008	--		--		--
1/9/2008	0		--		--
1/10/2008	0.04		--		--
1/11/2008	0.02		--		--
1/12/2008	T		--		--
1/13/2008	0		--		--
1/14/2008	0		--		--
1/15/2008	0		--		--
1/16/2008	0.06		--		--
1/17/2008	0.03		--		--
1/18/2008	0.18		--		--
1/19/2008	0.05		--		--
1/20/2008	0.05		--		--
1/21/2008	0.09		--		--
1/22/2008	0.11		--		--
1/23/2008	T		--		--
1/24/2008	0		--		--
1/25/2008	0.19		--		--
1/26/2008	0.04		--		--
1/27/2008	0		--		--
1/28/2008	0.02		--		--
1/29/2008	0.1		--		--
1/30/2008	0		--		--
1/31/2008	0.08		--		--
2/1/2008	0.04		--		--
2/2/2008	0		--		0
2/3/2008	0		--		0
2/4/2008	0.04		--		0.02
2/5/2008	0.06		--		0.03
2/6/2008	0.08		--		0
2/7/2008	0.05		--		0.01
2/8/2008	0.03		--		**
2/9/2008	0.02		--		T *
2/10/2008	0		--		0
2/11/2008	0		--		0

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
2/12/2008	0.06		--		0
2/13/2008	0		--		0
2/14/2008	0.31		--		0.21
2/15/2008	0.06		--		0.03
2/16/2008	0		--		T
2/17/2008	0.14		--		0.04
2/18/2008	0.02		--		0
2/19/2008	0		--		0
2/20/2008	0		--		0
2/21/2008	T		--		0
2/22/2008	T		--		0
2/23/2008	T		--		T
2/24/2008	T		--		0
2/25/2008	0.01		--		0
2/26/2008	0.11		--		0.02
2/27/2008	0		--		0
2/28/2008	0		--		0
2/29/2008	0		--		0
3/1/2008	0		--		0
3/2/2008	0.21		--		0.09
3/3/2008	0.07		--		T
3/4/2008	T		--		--
3/5/2008	0.16		--		**
3/6/2008	0.01		--		0.10 *
3/7/2008	0		--		0
3/8/2008	0		--		0
3/9/2008	0		--		0
3/10/2008	0		--		0
3/11/2008	0		--		0
3/12/2008	0		--		0
3/13/2008	0		--		0
3/14/2008	0.02		--		T
3/15/2008	T		--		0
3/16/2008	--		--		T
3/17/2008	--		--		0
3/18/2008	--		--		0
3/19/2008	--		--		0
3/20/2008	--		--		0
3/21/2008	0.03		--		T
3/22/2008	0.01		--		T
3/23/2008	T		--		0
3/24/2008	0		--		0

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
3/25/2008	0		--		0
3/26/2008	T		--		T
3/27/2008	0.06		--		0.01
3/28/2008	T		--		0
3/29/2008	--		--		0
3/30/2008	--		--		0.02
3/31/2008	--		--		0.49
4/1/2008	--		--		0.02
4/2/2008	NA		--		0
4/3/2008	0.02		--		0
4/4/2008	T		--		0
4/5/2008	T		--		T
4/6/2008	T		--		0
4/7/2008	T		--		0
4/8/2008	T		--		0
4/9/2008	0		--		0
4/10/2008	0.12		--		0.04
4/11/2008	0.46		--		0.22
4/12/2008	--		--		T
4/13/2008	--		--		0
4/14/2008	0		--		0
4/15/2008	0		--		0
4/16/2008	0		--		0
4/17/2008	T		--		0
4/18/2008	0		--		0
4/19/2008	0		--		0
4/20/2008	0		--		0
4/21/2008	0		--		0
4/22/2008	0		--		0
4/23/2008	0		--		--
4/24/2008	T		--		0
4/25/2008	0.11		--		0.04
4/26/2008	0.06		--		0.01
4/27/2008	T		--		0
4/28/2008	0		--		0
4/29/2008	0		--		0
4/30/2008	0		--		0
5/1/2008	--		--		T
5/2/2008	--		--		0.03
5/3/2008	--		--		T
5/4/2008	--		--		0
5/5/2008	NA		--		0

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
5/6/2008	0		--		0
5/7/2008	--		--		0
5/8/2008	--		--		T
5/9/2008	--		--		**
5/10/2008	--		--		0.05
5/11/2008	--		--		0.15
5/12/2008	--		--		0
5/13/2008	--		--		0.31
5/14/2008	--		--		T
5/15/2008	0.08		--		0.02
5/16/2008	0.02		--		0
5/17/2008	0		--		0
5/18/2008	0		--		0
5/19/2008	0		--		0
5/20/2008	0		--		0
5/21/2008	0		--		0
5/22/2008	0.17		--		0.27
5/23/2008	--		--		0.65
5/24/2008	--		--		--
5/25/2008	--		--		--
5/26/2008	--		--		--
5/27/2008	NA		--		0.09
5/28/2008	T		--		0
5/29/2008	0		--		0
5/30/2008	T		--		0
5/31/2008	0		--		0
6/1/2008	0.01		--		0
6/2/2008	0		--		0
6/3/2008	0		--		0
6/4/2008	0.18		--		0.1
6/5/2008	0.1		--		0.06
6/6/2008	0.06		--		0.05
6/7/2008	0.03		--		0.02
6/8/2008	0.09		--		0.03
6/9/2008	0		--		0
6/10/2008	0		--		0
6/11/2008	0.09		--		0.08
6/12/2008	0.1		--		0.04
6/13/2008	0		--		0
6/14/2008	0		--		0
6/15/2008	0		--		0
6/16/2008	0		--		0

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
6/17/2008	0.01		--		T
6/18/2008	T		--		0
6/19/2008	0		--		0
6/20/2008	0		--		0
6/21/2008	T		--		0
6/22/2008	0		--		0
6/23/2008	0.04		--		T
6/24/2008	0.03		--		T
6/25/2008	0.03		--		0.06
6/26/2008	0.02		--		0.01
6/27/2008	0		--		0
6/28/2008	0		--		0
6/29/2008	0		--		0
6/30/2008	0		--		0
7/1/2008	0.01		--		0
7/2/2008	0.03		--		T
7/3/2008	0.25		--		0.25
7/4/2008	0		--		0
7/5/2008	0		--		--
7/6/2008	T		--		--
7/7/2008	0.36		--		0.37
7/8/2008	0		--		0
7/9/2008	0		--		0
7/10/2008	0		--		0
7/11/2008	0		--		0
7/12/2008	0		--		0
7/13/2008	0		--		0
7/14/2008	0		--		0
7/15/2008	0		--		0
7/16/2008	0		--		0
7/17/2008	0.01		--		0
7/18/2008	0		--		0
7/19/2008	T		--		0
7/20/2008	0		--		0
7/21/2008	T		--		0
7/22/2008	0.01		--		T
7/23/2008	0.02		--		0
7/24/2008	T		--		0
7/25/2008	0.04		--		0.03
7/26/2008	0		--		0
7/27/2008	0		--		0
7/28/2008	0		--		0

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
7/29/2008	T		--		0
7/30/2008	0		--		0
7/31/2008	0		--		0
8/1/2008	0		--		0
8/2/2008	0		--		0
8/3/2008	T		--		0
8/4/2008	T		--		0.02
8/5/2008	0		--		0
8/6/2008	0		--		0
8/7/2008	0.06		--		0.05
8/8/2008	0.21		--		0.08
8/9/2008	0.05		--		0.12
8/10/2008	0		--		0
8/11/2008	0.03		--		T
8/12/2008	0		--		0
8/13/2008	0		--		0
8/14/2008	0		--		0
8/15/2008	--		--		0.04
8/16/2008	--		--		0.28
8/17/2008	--		--		0
8/18/2008	NA		--		0
8/19/2008	0		--		0
8/20/2008	0		--		0
8/21/2008	0		--		0
8/22/2008	0		--		0
8/23/2008	0		--		0
8/24/2008	0		--		0
8/25/2008	0		--		0
8/26/2008	0		--		0
8/27/2008	0		--		0
8/28/2008	0		--		0
8/29/2008	0		--		0
8/30/2008	0		--		0
8/31/2008	0		--		0
9/1/2008	0.04		--		0.06
9/2/2008	0.57		--		0.5
9/3/2008	0		--		0
9/4/2008	0		--		0
9/5/2008	0		--		T
9/6/2008	0		--		0
9/7/2008	0		--		0
9/8/2008	0		--		0

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
9/9/2008	0		--		0
9/10/2008	0.05		--		0
9/11/2008	0.46		--		0.28
9/12/2008	0.06		--		0.02
9/13/2008	0.07		--		0.13
9/14/2008	0		--		0
9/15/2008	--		--		0
9/16/2008	--		--		0
9/17/2008	--		--		0
9/18/2008	--		--		0
9/19/2008	--		--		0.03
9/20/2008	NA		--		0
9/21/2008	0.13		--		0.08
9/22/2008	T		--		0
9/23/2008	0.26		--		0.11
9/24/2008	0		--		0
9/25/2008	0		--		0
9/26/2008	0		--		0
9/27/2008	0		--		0
9/28/2008	0		--		--
9/29/2008	0		--		0
9/30/2008	0		--		0
10/1/2008	0		--		0
10/2/2008	0		--		0
10/3/2008	--		--		0
10/4/2008	--		--		0
10/5/2008	--		--		0.02
10/6/2008	--		--		0
10/7/2008	0		--		0
10/8/2008	0		--		0
10/9/2008	0		--		0
10/10/2008	0.36		--		0.14
10/11/2008	0.1		--		0.04
10/12/2008	0.22		--		--
10/13/2008	0		--		--
10/14/2008	0		--		--
10/15/2008	0		--		--
10/16/2008	0		--		--
10/17/2008	0		--		--
10/18/2008	0		--		--
10/19/2008	0		--		--
10/20/2008	T		--		--

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
10/21/2008	T		--		0
10/22/2008	0.07		--		0.05
10/23/2008	T		--		T
10/24/2008	0		--		0
10/25/2008	0		--		0
10/26/2008	0		--		0
10/27/2008	0		--		0
10/28/2008	--		--		0
10/29/2008	--		--		0
10/30/2008	0		--		0
10/31/2008	0		--		0
11/1/2008	0		--		0
11/2/2008	0		--		0
11/3/2008	0.11		--		0.05
11/4/2008	0		--		0
11/5/2008	0.05		--		T
11/6/2008	--		--		T
11/7/2008	--		--		0
11/8/2008	--		--		T
11/9/2008	--		--		--
11/10/2008	--		--		0.03
11/11/2008	--		--		T
11/12/2008	--		--		0
11/13/2008	NA		--		0
11/14/2008	0.15		--		0.14
11/15/2008	T		--		0
11/16/2008	0		--		0
11/17/2008	0		--		0
11/18/2008	0		--		0
11/19/2008	0		--		0
11/20/2008	0		--		0
11/21/2008	--		--		0
11/22/2008	0		--		0
11/23/2008	0		--		0
11/24/2008	0		--		0
11/25/2008	0		--		0
11/26/2008	0		--		0
11/27/2008	0.01		--		0
11/28/2008	0		--		T
11/29/2008	0		--		T
11/30/2008	0.02		--		0.02
12/1/2008	0.03		--		0.02

Data from CoCo RaHS Website, Station Report Summary

DATE	Rawlins 1 NW WY-CR-2		Rawlins Airport WY-CR-3		Sinclair 0.1 N WY-CR-9
12/2/2008	0		--		0
12/3/2008	0.01		--		T
12/4/2008	0.08		--		0.09
12/5/2008	0.03		--		0.01
12/6/2008	0		--		0
12/7/2008	0		--		0
12/8/2008	0		--		0
12/9/2008	0.04		--		T
12/10/2008	0		--		0
12/11/2008	0		--		0
12/12/2008	0		--		0
12/13/2008	0.02		--		T
12/14/2008	0.07		--		0.01
12/15/2008	0		--		0
12/16/2008	0		--		0
12/17/2008	0.03		--		T
12/18/2008	0.11		--		0.01
12/19/2008	0.15		--		0.2
12/20/2008	0.08		--		0.02
12/21/2008	0.02		--		0.01
12/22/2008	--		--		0
12/23/2008	--		--		T
12/24/2008	--		--		0
12/25/2008	--		--		0
12/26/2008	--		--		T
12/27/2008	--		--		0.05
12/28/2008	--		--		0
12/29/2008	NA		--		0
12/30/2008	0		--		0
12/31/2008	0		--		0

APPENDIX C
Water Department Records

RAWLINS WATER OPERATIONAL STUDY

Data from Rawlins Master Plan and Raw Water Storage Level I & II Notebooks Jun-97 12-Dec

MONTH-YEAR	WTP RAW WATER MG	WTP PRODUCTION MG	SPRINGS PRODUCTION MG	WELLS PRODUCTION MG	NP RIVER	TOTAL SUPPLY	SUPPLY MINUS DEMAND
Jun-97	88.465	84.224	139.048	0.015		139.063	54.839
Jul-97	125.643	120.488	121.266	0.075		121.341	0.853
Aug-97	85.492	82.311	89.745	0.128		89.873	7.562
Sep-97	58.860	55.437	69.155	0.072		69.227	13.790
Oct-97	60.210	58.054	64.000	0.000		64.000	5.946
Nov-97	20.740	18.946	56.000	0.000		56.000	37.054
Dec-97	38.080	37.000	52.000	0.000		52.000	15.000
Jan-98	37.180	35.683	52.000	0.000		52.000	16.317
Feb-98	33.100	32.055	40.449	0.159		40.608	8.553
Mar-98	40.060	38.832	49.501	0.000		49.501	10.669
Apr-98	43.140	41.328	69.499	0.000		69.499	28.171
May-98	80.230	79.761	135.915	0.000		135.915	56.154
Jun-98	83.220	81.770	128.586	0.000		128.586	46.816
Jul-98	128.300	124.554	114.765	31.022		145.787	21.233
Aug-98	99.010	95.567	87.447	21.678		109.125	13.558
Sep-98	82.920	78.343	67.788	18.640		86.428	8.085
Oct-98	40.820	38.573	71.863	0.000		71.863	33.290
Nov-98	40.650	37.888	60.989	22.713		83.702	45.814
Dec-98	41.100	37.233	59.233	0.000		59.233	22.000
Jan-99	44.440	42.441	56.105	0.000		56.105	13.664
Feb-99	33.260	32.511	48.384	0.000		48.384	15.873
Mar-99	54.040	51.490	60.283	0.000		60.283	8.793
Apr-99	39.120	38.890	99.082	0.000		99.082	60.192
May-99	53.010	50.477	135.378	0.000		135.378	84.901
Jun-99	88.390	84.687	133.882	0.000		133.882	49.195
Jul-99	135.240	131.461	113.871	24.552		138.423	6.962
Aug-99	105.570	101.323	90.055	23.219		113.274	11.951
Sep-99	71.930	67.729	74.775	10.486		85.261	17.532
Oct-99	59.790	57.669	72.100	0.000		72.100	14.431
Nov-99	40.690	38.803	63.376	0.000		63.376	24.573
Dec-99	47.230	45.918	61.815	0.000		61.815	15.897
Jan-00	41.180	39.096	58.790	0.000		58.790	19.694
Feb-00	36.720	35.760	57.507	0.000		57.507	21.747
Mar-00	41.240	39.122	50.403	0.000		50.403	11.281
Apr-00	42.560	39.978	77.841	0.000		77.841	37.863
May-00	86.310	83.946	89.524	18.045		107.569	23.623
Jun-00	125.180	120.935	83.254	20.476		103.730	-17.205
Jul-00	144.442	139.267	72.756	21.337		94.093	-45.174
Aug-00	136.823	131.730	70.078	20.891		90.969	-40.761
Sep-00	80.500	79.642	59.971	19.353		79.324	-0.318
Oct-00	40.020	38.465	54.928	19.284		74.212	35.747
Nov-00	35.302	34.389	51.059	0.000		51.059	16.670

Data from Rawlins Master Plan and Raw Water Storage Level I & II Notebooks Jun-97 12-Dec

MONTH-YEAR	WTP RAW WATER MG	WTP PRODUCTION MG	SPRINGS PRODUCTION MG	WELLS PRODUCTION MG	NP RIVER	TOTAL SUPPLY	SUPPLY MINUS DEMAND
Dec-00	40.354	39.576	49.711	0.000		49.711	10.135
Jan-01	43.746	40.670	49.238	0.000		49.238	8.568
Feb-01	43.414	43.363	43.263	0.000		43.263	-0.100
Mar-01	38.130	37.142	48.491	0.000		48.491	11.349
Apr-01	46.858	45.593	75.318	0.000		75.318	29.725
May-01	78.796	79.461	116.803	0.000		116.803	37.342
Jun-01	123.222	123.834	104.945	18.000		122.945	-0.889
Jul-01	124.135	133.735	85.928	18.600		104.528	-29.207
Aug-01	113.921	118.051	73.349	15.500		88.849	-29.202
Sep-01	82.718	82.233	63.005	15.000		78.005	-4.228
Oct-01	49.935	49.315	58.114	14.260		72.374	23.059
Nov-01	40.132	40.190	51.267	19.440		70.707	30.517
Dec-01	42.220	41.872	50.829	20.088		70.917	29.045
Jan-02	40.235	39.973	48.682	19.642		68.324	28.351
Feb-02	36.761	36.963	42.879	17.741		60.620	23.657
Mar-02	41.099	40.533	47.718	19.642		67.360	26.827
Apr-02	39.892	40.070	45.718	12.999		58.717	18.647
May-02	66.457	68.891	63.479	19.642		83.121	14.230
Jun-02	121.173	123.030	76.077	18.576		94.653	-28.377
Jul-02	143.911	144.180	119.226	17.856		137.082	-7.098
Aug-02	118.634	117.396	113.100	17.856		130.956	13.560
Sep-02	86.703	82.332	52.032	17.280		69.312	-13.020
Oct-02	43.765	38.737	45.090	8.640		53.730	14.993
Nov-02	35.086	34.673	43.220	0.000		43.220	8.547
Dec-02	34.669	33.719	44.000	0.000		44.000	10.281
Jan-03	36.100	34.737	41.000	0.000		41.000	6.263
Feb-03	32.127	31.954	37.000	0.000		37.000	5.046
Mar-03	36.706	35.354	47.000	0.000		47.000	11.646
Apr-03	44.168	38.839	85.000	0.000		85.000	46.161
May-03	61.873	57.234	83.500	6.500		90.000	32.766
Jun-03	93.044	83.104	66.960	18.360		85.320	2.216
Jul-03	131.060	119.427	60.700	21.400		82.100	-37.327
Aug-03	107.876	106.710	52.060	19.900		71.960	-34.750
Sep-03	55.518	54.392	46.760	16.800		63.560	9.168
Oct-03	49.485	48.580	46.160	15.100		61.260	12.680
Nov-03	33.416	32.264	45.150	0.000		45.150	12.886
Dec-03	40.296	39.183	44.530	0.000		44.530	5.347
Jan-04	40.267	39.529	41.410	0.000		41.410	1.881
Feb-04	36.910	35.832	38.300	0.000	10.39	48.690	12.858
Mar-04	37.977	37.349	43.470	0.000	6.26	49.730	12.381
Apr-04	36.789	36.212	65.150	0.000	11.16	76.310	40.098
May-04	60.066	60.732	82.400	0.000	40.43	122.830	62.098

Data from Rawlins Master Plan and Raw Water Storage Level I & II Notebooks Jun-97 12-Dec

MONTH-YEAR	WTP RAW WATER MG	WTP PRODUCTION MG	SPRINGS PRODUCTION MG	WELLS PRODUCTION MG	NP RIVER	TOTAL SUPPLY	SUPPLY MINUS DEMAND
Jun-04	97.639	98.070	86.400	0.000	53.58	139.980	41.910
Jul-04	99.893	100.715	74.920	0.011	35.15	110.081	9.366
Aug-04	101.489	99.850	59.320	22.320	33.12	114.760	14.910
Sep-04	63.461	61.813	51.022	19.772	5.23	76.024	14.211
Oct-04	37.191	35.784	48.642	11.887	0.00	60.529	24.745
Nov-04	34.561	33.432	46.021	0.000	0.00	46.021	12.589
Dec-04	36.666	37.797	44.682	0.000	0.00	44.682	6.885
Jan-05	38.296	37.280	44.441	0.000	0.00	44.441	7.161
Feb-05	35.732	34.761	37.115	0.000	6.95	44.065	9.304
Mar-05	40.748	39.468	44.468	0.000	0.00	44.468	5.000
Apr-05	42.029	41.133	77.831	0.000	0.00	77.831	36.698
May-05	55.014	55.532	120.846	0.000	4.46	125.306	69.774
Jun-05	93.625	92.759	116.544	0.000	15.69	132.234	39.475
Jul-05	93.625	128.892	93.764	16.848	32.95	143.562	14.670
Aug-05	93.625	108.050	71.259	23.652	49.73	144.641	36.591
Sep-05	93.625	81.432	59.386	13.038	26.48	98.904	17.472
Oct-05		41.630	56.500	0.000	4.57	61.070	19.440
Nov-05		35.597	50.764	0.000	0.00	50.764	15.167
Dec-05		39.383	50.211	0.000	0.00	50.211	10.828
Jan-06		38.855	48.295	0.000	0.32	48.615	9.760
Feb-06		34.631	42.211	0.000	0.00	42.211	7.580
Mar-06		44.224	45.355	0.000	0.00	45.355	1.131
Apr-06		39.632	88.150	0.000	0.00	88.150	48.518
May-06		91.133	101.965	0.000	17.41	119.375	28.242
Jun-06		120.855	98.313	0.000	43.62	141.933	21.078
Jul-06		123.847	79.326	1.141	41.91	122.377	-1.470
Aug-06		109.881	63.153	26.164	19.40	108.716	-1.165
Sep-06		77.803	54.954	21.558	18.62	95.132	17.329
Oct-06		45.479	52.719	0.000	5.55	58.269	12.790
Nov-06		34.328	49.495	0.000	0.00	49.495	15.167
Dec-06		35.478	48.334	0.000	0.00	48.334	12.856
Jan-07		44.179	46.602	0.000	0.00	46.602	2.423
Feb-07		50.482	40.303	0.000	0.00	40.303	-10.179
Mar-07		39.106	74.101	0.000	9.63	83.731	44.625
Apr-07		40.075	92.979	0.000	7.35	100.329	60.254
May-07		78.259	72.797	0.000	11.94	84.737	6.478
Jun-07		105.358	66.376	0.000	34.67	101.046	-4.312
Jul-07		130.147	57.773	27.809	46.41	131.992	1.845
Aug-07		113.955	55.768	24.942	22.01	102.720	-11.235
Sep-07		82.997	73.298	22.398	15.49	111.186	28.189
Oct-07		44.130	46.942	17.141	0.18	64.263	20.133
Nov-07		42.541	43.266	0.000	0.00	43.266	0.725

RAWLINS WATER OPERATIONAL STUDY

Data from Rawlins Master Plan and Raw Water Storage Level I & II Notebooks Jun-97 12-Dec

MONTH-YEAR	WTP RAW WATER MG	WTP PRODUCTION MG	SPRINGS PRODUCTION MG	WELLS PRODUCTION MG	NP RIVER	TOTAL SUPPLY	SUPPLY MINUS DEMAND
Dec-07		46.415	44.664	0.000	5.73	50.394	3.979
Jan-08		51.352	43.686	0.000	2.22	45.906	-5.446
Feb-08		45.754	38.361	0.000	45.11	83.471	37.717
Mar-08		48.243	40.821	0.000	2.53	43.349	-4.894
Apr-08		46.489	42.589	0.000	5.77	48.359	1.870
May-08		58.481	110.183	0.000	6.67	116.853	58.372
Jun-08		94.726	143.531	0.000	15.47	159.001	64.275
Jul-08		127.546	143.548	0.000	19.63	163.178	35.632
Aug-08		125.116	109.304	0.000	20.94	130.244	5.128
Sep-08		76.684	77.661	0.000	6.80	84.461	7.777
Oct-08		46.745	68.574	0.000	2.76	71.334	24.589
Nov-08				0.000			
Dec-08				0.000			
Jan-09	39.446	38.275	52.059	0.000		52.059	13.784
Feb-09	35.211	34.201	46.998	0.000		46.998	12.797
Mar-09	38.232	37.257	51.992	0.000		51.992	14.735
Apr-09	37.378	35.908	69.794	0.000		69.794	33.886
May-09	60.274	61.844	139.764	0.000	4.200	143.964	82.120
Jun-09	74.175	74.796	135.329	0.000	1.2	136.529	61.733
Jul-09	111.467	113.631	116.634	0.000	6.610	123.244	9.613
Aug-09	105.405	105.577	89.525	0.000	4.854	94.379	-11.198
Sep-09	85.189	93.105	73.302	0.000		73.302	-19.803
Oct-09	41.358	39.577	72.762	0.000		72.762	33.185
Nov-09	33.631	32.979	56.093	0.000		56.093	23.114
Dec-09	40.746	40.545	56.318	0.000		56.318	15.773
Jan-10	37.563	37.269	52.105	0.000		52.105	14.836
Feb-10	30.524	29.523	47.053	0.000		47.053	17.530
Mar-10	39.306	38.038	53.162	0.000		53.162	15.124
Apr-10	33.728	32.028	79.728	0.000		79.728	47.700
May-10	49.199	48.060	123.794	0.000		123.794	75.734
Jun-10	71.378	72.626	130.817	0.000		130.817	58.191
Jul-10	118.786	117.706	114.226	0.000	17.800	132.026	14.320
Aug-10	106.983	104.963	87.135	0.000	10.800	97.935	-7.028
Sep-10	86.504	84.322	72.049	0.000	14.900	86.949	2.627
Oct-10	49.910	49.409	67.219	0.000	4.128	71.347	21.938
Nov-10	34.687	34.123	60.692	0.000		60.692	26.569
Dec-10	37.351	36.912	58.830	0.000		58.830	21.918
Jan-11	49.696	48.184	55.329	0.000		55.329	7.145
Feb-11	34.072	33.407	44.352	0.000		44.352	10.945
Mar-11	37.423	36.769	51.657	0.000		51.657	14.888
Apr-11	37.587	36.117	62.460	0.000	3.689	66.149	30.032
May-11	52.718	47.675	88.763	0.000	9.302	98.065	50.390

Data from Rawlins Master Plan and Raw Water Storage Level I & II Notebooks Jun-97 12-Dec

MONTH-YEAR	WTP RAW WATER MG	WTP PRODUCTION MG	SPRINGS PRODUCTION MG	WELLS PRODUCTION MG	NP RIVER	TOTAL SUPPLY	SUPPLY MINUS DEMAND
Jun-11	92.637	92.365	137.225	0.000	8.425	145.650	53.285
Jul-11	108.080	108.151	146.800	0.000		146.800	38.649
Aug-11	115.064	113.966	125.471	0.000		125.471	11.505
Sep-11	93.124	91.478	98.342	0.000	14.179	112.521	21.043
Oct-11	47.485	48.094	58.801	0.000	2.285	61.086	12.992
Nov-11	36.083	35.584	100.749	0.000		100.749	65.165
Dec-11	39.702	38.756	68.818	0.000		68.818	30.062
Jan-12	40.289	38.616	63.762	0.000		63.762	25.146
Feb-12	36.389	35.366	55.991	0.000		55.991	20.625
Mar-12	41.199	40.105	62.496	0.000		62.496	22.391
Apr-12	44.488	42.660	52.557	0.000	6.094	58.651	15.991
May-12	83.702	81.081	78.862	0.000	18.999	97.861	16.780
Jun-12	106.276	109.276	69.968	32.400	20.790	123.158	13.882
Jul-12	108.394	105.448	60.561	31.248	12.301	104.110	-1.338
Aug-12	103.740	102.568	53.568	31.248	36.502	121.318	18.750
Sep-12	79.808	78.963	50.475	30.240	38.712	119.427	40.464
Oct-12	41.822	42.005	50.314		8.220	58.534	16.529
Nov-12	42.537	41.395	47.111		46.838	93.949	52.554

APPENDIX D
Water Meter Billing

Date	Domestic Water	# of Users	Volume Charge only	# of Users	Fire Protection	# of Users	Out of Town Users	# of Users	City Usage	# of Users	Construction Water	# of Users	Sinclair Total Consupmtion	Corral Water (Irrigation)	# of Users	Rawlins Total Consumption	Total Users
	x 100		x 100		x 100		x 100		x 100		x 100		x 1000	x 100			
Jan-08	314689	3095	6984	3			2089	14					4350			32376200	3112
Feb-08	310243	3296	858	5			2391	14	526	2			2630			31401800	3317
Mar-08	370263	3378	8203	12			3796	13					2255			38226200	3403
Apr-08	259124	3338	58	6			5406	18	3129	1			2454			26771700	3363
May-08	370263	3378	8203	12	0	0	3796	13	0	0	0	0	2255	0	0	38226200	3403
Jun-08	568184	3451	13982	29	0	0	6033	17	0	0	22550	2	4161	0	0	61074900	3499
Jul-08	793608	3443	5287	31	0	0	6808	15	0	0	19810	1	7700	0	0	82551300	3490
Aug-08	819988	3459	15926	34	0	0	8017	16	0	0	1917	2	5940	0	0	84584800	3511
Sep-08	600363	3403	8718	32	0	0	5468	17	0	0	0	0	4400	0	0	61454900	3452
Oct-08	306848	3431	4759	29	0	0	3546	21	0	0	0	0	2550	0	0	31515300	3481
Nov-08	308870	3393	1665	7	0	0	3222	16	0	0	0	0	2760	0	0	31375700	3416
Dec-08	256372	3356	336	5	0	0	2654	19	0	0	0	0	2930	0	0	25936200	3380
Jan-09	209534	3306	134	4	0	0	1298	18	14	1	0	0	2270	0	0	21098000	3329
Feb-09	247611	3240	173	3	0	0	3009	15	25	1	0	0	2260	0	0	25081800	3259
Mar-09	1072062	2134	137	3	0	0	93141	14	2539	3	0	0	2380	0	0	116787900	2154
Apr-09	313880	3274	227	3	0	0	2778	14	48	2	0	0	2480	0	0	31693300	3293
May-09	270762	3238	44036	12	0	0	3124	15	28	1	0	0	3860	0	0	31795000	3266
Jun-09	394828	2168	7472	18	0	0	4160	14	2463	5	0	0	3100	0	0	40892300	2205
Jul-09	718298	3341	23988	50	0	0	13747	17	93	1	0	0	8700	0	0	75612600	3409
Aug-09	683070	3379	27811	51	0	0	9988	18	45995	11	0	0	6120	0	0	76686400	3459
Sep-09	757419	3342	30611	54	0	0	7702	18	987697	34	20674	5	6440	0	0	180410300	3453
Oct-09	398345	3333	7464	36	0	0	4776	21	864252	31	11202	7	3570	0	0	128603900	3428
Nov-09	260702	3305	17729	5	0	0	4455	20	33	2	8093	6	1700	0	0	29101200	3338
Dec-09	424089	3254	95	4	0	0	3720	20	1290	11	2758	6	1790	0	0	43195200	3295
Jan-10	266942	3207	100	2	0	0	3629	19	7207	6	3918	5	2270	0	0	28179600	3239
Feb-10	243791	3301	1460	3	10	1	3927	20	133710	28	1710	3	1700	0	0	38460800	3356
Mar-10	222253	3292	132	3	0	0	3247	19	3360	11	2865	4	1710	0	0	23185700	3329
Apr-10	279020	3304	92	4	0	0	3710	20	326	3	393	4	1850	0	0	28354100	3335
May-10	248046	3317	84	6	10	1	10124	23	756	11	8950	5	3380	0	0	26797000	3363
Jun-10	341005	3353	4569	43	0	0	4482	25	33309	37	3262	5	2900	0	0	38662700	3463
Jul-10	646575	3349	19630	53	0	0	7185	25	90955	37	8954	4	7250	0	0	77329900	3468
Aug-10	662725	3366	22633	54	0	0	9213	25	118813	41	13520	4	3970	0	0	82690400	3490
Sep-10	592515	3359	1977	54	0	0	565	25	94625	39	8727	5	3980	0	0	69840900	3482
Oct-10	474387	3385	10462	49	0	0	6511	24	3465	11	14860	4	1720	0	0	50968500	3473
Nov-10	249850	3339	1249	10	0	0	4061	24	41452	37	6876	5	1590	0	0	30348800	3415
Dec-10	260912	3317	80	3	10	1	4695	24	3540	7	8211	3	3250	0	0	27744800	3355
Jan-11	250861	2976	57	5	0	0	4153	23	3215	10	2890	2	920	0	0	26117600	3016
Feb-11	219695	2810	45	2	11	2	1288	17	1959	9	710	1	2390	0	0	22370800	2841
Mar-11	262553	3268	294	3	0	0	3764	22	6335	12	936	2	2340	0	0	27388200	3307
Apr-11	244465	3286	94	4	0	0	3287	23	2104	13	669	3	1870	0	0	25061900	3329

Date	Domestic Water	# of Users	Volume Charge only	# of Users	Fire Protection	# of Users	Out of Town Users	# of Users	City Usage	# of Users	Construction Water	# of Users	Sinclair Total Consupmtion	Corral Water (Irrigation)	# of Users	Rawlins Total Consumption	Total Users
	x 100		x 100		x 100		x 100		x 100		x 100		x 1000	x 100			
May-11	236155	3300	371	6	0	0	2960	24	4224	18	999	3	1830	0	0	24470900	3351
Jun-11	427934	3321	5950	41	0	0	3600	23	43171	18	15550	2	7870	0	0	49620500	3405
Jul-11	650485	3345	19895	53	0	0	7488	24	234491	41	3119	2	4540	0	0	91547800	3465
Aug-11	630671	3348	21811	53	0	0	7045	23	13812	16	7554	4	5120	0	0	68089300	3444
Sep-11	701557	3337	23922	49	0	0	8360	24	4730	14	17432	3	4620	0	0	75600100	3427
Oct-11	373406	3315	11723	47	0	0	5014	23	3764	15	9359	3	2490	0	0	40326600	3403
Nov-11	176265	1952	479	8	0	0	7326	22	2489	15	9464	3	1690	0	0	19602300	2000
Dec-11	304396	3317	77	3	10	1	6530	22	2502	13	6647	2	0	0	0	32016200	3358
Jan-12	284642	3309	138	4	9	1	9050	43	40838	43	14021	2	1260	0	0	34869800	3402
Feb-12	231753	3297	99	4	1	1	8149	42	41739	42	14589	2	7760	0	0	29633000	3388
Mar-12	216188	3287	90136	5	0	0	8904	23	41694	41	10702	2	3710	0	0	36762400	3358
Apr-12	244551	3329	88793	9	0	0	7711	23	42466	42	10686	2	2690	0	0	39420700	3405
May-12	333675	3352	3645	32	0	0	7277	23	37977	43	6239	3	3210	0	0	38881300	3453
Jun-12	611181	3401	16689	50	0	0	14136	23	35005	44	7746	4	4440	0	0	68475700	3522
Jul-12	792644	3409	24124	58	0	0	15677	23	202438	47	13543	2	6050	0	0	104842600	3539
Aug-12	623730	3426	19026	59	0	0	11233	21	201833	46	13227	3	4350	0	0	86904900	3555
Sep-12	630403	3417	20828	60	0	0	8891	22	201406	47	15322	2	4090	0	0	87685000	3548
Oct-12	405592	3426	1159	59	1	1	5862	22	306608	47	8892	5	2460	0	0	72811400	3560
Nov-12	297214	3380	882	14	0	0	5757	22	33329	41	8939	5	1870	0	0	34612100	3462
Dec-12	239738	3341	367	5	10	1	5782	22	41463	40	6647	2	3250	0	0	29400700	3411

APPENDIX E
Bern Hinckley Interim Report

APPENDIX A

Town Wells Investigations Interim Report
July 3, 2012

HINCKLEY
CONSULTING P.O. Box 452 ⊄ Laramie, WY 82073 ⊄ 307-745-0066 (-0499 FAX)

MEMORANDUM

TO: Ken Schwerdt DATE: July 3, 2012

FROM: Todd Schmidt, Bern Hinckley PROJECT: Rawlins Operations Project

SUBJECT: Town Wells Investigations Interim Report

Introduction

The purpose of this memo is to provide interim results from our on-going investigations into individual wells around the Town of Rawlins that were thought could possibly be used as sources of raw water, whether commingled with Town water or sole-source, for irrigation use in the cemetery, the old penitentiary, parks, etc. Currently, the cemetery, old penitentiary, and all the town parks are hooked up to the town water system. Wester-Wetstein & Associates (2010) reported that the Town uses much finished water to irrigate the cemetery and parks, and noted that the largest irrigated areas are the cemetery (20 acres) and new ball fields (30 acres). Based on the National Gardening Association's recommendation of 1 inch per week for lawn and turf, Wester-Wetstein estimated that the Town uses 1.35 MG of finished water every week to irrigate these two facilities alone. Blane Frandsen (Public Works Director, pers. comm., 5/7/12) said that the cemetery currently has 25 acres cultivated with another 6 acres to develop for expansion. Adding 5 acres to the Wester-Wetstein total of 50 irrigated acres increases the estimated weekly water usage to 1.49 MG, and to 1.65 MG if the cemetery reaches full expansion. Wester-Wetstein assumed a water treatment cost of $1.25 per thousand gallons treated. At this rate, the gross savings in treatment costs by switching to raw-water irrigation during the summer months would be approximately $7,500 per month, or $8,250 per month when the cemetery reaches full expansion. Further savings could be realized if nearby parks (e.g., old penitentiary, old Outlaw Bowl, etc.) also converted to raw water. Of course, some of this treatment-cost savings would be offset by the development and operations costs of a raw water system.

One option proposed by Wester-Wetstein (2010) was to use the Cemetery #1 and Wyoming Penitentiary #2 wells (see Figure 1 for locations), permitted at 250 gpm apiece, to irrigate the cemetery, north ball fields, and Rawlins High School landscaping. They also considered bringing in raw water via the North Platte River pipeline and booster station, but concluded that the pumping and installation costs for using local wells were significantly less.

Our investigations began with local interviews and review of past reports to identify potential candidate wells. We ultimately identified eight potential raw-water-supply wells for further investigation, including field work on October 10, 2011 and May 2 and 9, 2012, permit reviews, and various local contacts. Investigations, conclusions, and recommendations for each well are provided below. Figure 1 shows the locations of all the wells. Results are summarized in the final section of this memo. Available well logs are attached.

SISSIE #3 WELL

Investigations

The Sissie #3 well (P513W; domestic use) is owned by Rick and Shelly Seldomridge and was considered a possible candidate for raw water supply due to its State Engineer's Office (SEO) permitted flow rate of 100 gpm and its location, on the north side of Town near the Rawlins Parks and Recreation building and near four baseball fields. The Seldomridges also own the Sissie #1 well (P344W; domestic use) which is located in the basement of their house (pers. comm., Rick Seldomridge, 5/22/12). Rick did not know the names of his wells but SEO data show those two to be his wells. He purchased the property from Mrs. O'Melia, wife of Theodore O'Melia (both of whom are now deceased). Mr. O'Melia is named as applicant for the wells.

The Seldomridges own about 30 acres around their place and use the Sissie #3 well to irrigate the area within his fence. He didn't say how much he irrigates but doesn't irrigate the whole 30 acres. Sissie #1 is used for domestic use in the home. He doesn't know what the pumped flow rate is for Sissie #3 but indicated that it produces pretty well. He also indicated that there seems to be very little drawdown in Sissie #3 when he irrigates (but we don't know how hard he pumps the well). The Seldomridges indicated that their wells produce "excellent water" that tastes good and is "crystal clear" in a glass. Both Mr. and Mrs. Seldomridge, while very cordial, are not interested in having their well(s) tested nor in providing raw water for Town irrigation use. Their contact information: 1509 N. 3rd Street, Rawlins, WY 82301; phone: 307-328-0537.

The Seldomridges stated that the subdivision to the east and the small subdivision to the west are both hooked up to the Town's water system. The SEO wells database shows the nearest permitted wells are about ½ mile away to the southeast: a group of seven DEQ miscellaneous wells all permitted for 1 gpm at the south end of the east subdivision. This may become relevant should we consider siting and drilling a new well on Town property near the Sissie #3 to tap into the same aquifer.

Conclusion

No potential contribution for raw water supply at this time, although the reports from the Sissie #3 suggests the presence of at least a local aquifer potentially capable of producing useful quantities of good-quality water.

Recommendation

Keep this well in mind for the future, e.g. should the situation ever develop to the point of bringing this parcel into the City. Include the data from this well in any future evaluation of drilling additional, local raw-water supply wells in the area.

WYOMING PENITENTIARY WELL #2 (NORTH WELL)

Investigations

“Wyoming Penitentiary Well No. 2" (P726G) is owned by the Old Penitentiary Joint Powers Board and is located just outside the penitentiary wall near the northeast corner (T21N, R87W, Sec. 17, SWNE). The SEO well registration reports the well is 384 ft. deep with an “estimated yield of water per minute” of 250 gpm. The static water level was reported as 65 ft. and the main source of water as encountered at 105 ft. An electric 15-hp pump, with a 300-gpm capacity was installed. Well registration shows remarks: “Well tested 250 gallons per minute with no appreciable drawdown. Test was limited by pumping equipment available.”

The log for this well includes lithologic descriptions which place the bottom of the well in “granite”. This is not inconsistent with the location of the well and, along with the cuttings log, suggests the Cambrian-age section as the water-producing strata. (We have not investigated the the geology of this location further.)

Tina Hill (pers. comm. 11/8/11; 307-324-4422) is the director for the Rawlins Historic Penitentiary and the contact person for the prison’s wells. (The prison has another well, discussed below, that it is trying to rehabilitate.) Ms. Hill confirmed that the penitentiary has two wells and described the locations of both wells. Her description of the north well matches the location shown on the SEO well registration. She also described the vandalism of the well by throwing cement blocks, rebar, etc. into the well, plugging the well. Leroy Graham (with the Rural Water Association at the time; pers. comm., 11/8/11) says he was there when a “Glenrock outfit” performed a pump test on this north well in 2000 or 2001. He remembers that it produced approximately 2-3 gpm and that after about 1 ½ hours of pumping it was sucking air. However, Ms. Hill, who has been there since 1991 and has been the director since 2000, recalls no such testing. Mr. Graham’s remarks don’t correspond to the well registration pump test remark, nor with the installed pump. We conclude Mr. Graham’s memory was mistaken.

Scott Blakeley (Pronghorn Pump & Repair, Glenrock, WY; pers. comm. 11/9/11) did not mention any testing, but said he pulled an inoperable 15-hp pump out of the well, which matches the well registration. He planned to test the well but before he came back with a test pump, the vandals had destroyed the well. Mr. Blakeley said he ran a camera down the well and spent most of a day trying to clear out the debris, but was unsuccessful. He suggested it would be easier to drill a new well than to rehabilitate this one, but he had never gotten any idea (beyond the size of the pump he removed) of its production. Ms. Hill was disappointed because she wanted to use this well for irrigation of a proposed baseball field in the north half of the walled-in area of the prison since the well is so close. Ms. Hill indicated no plans by the penitentiary board to drill another well.

We visited the old penitentiary and spoke with Ms. Hill (and Ron Bjork, a coworker) on May 2, 2012. She reiterated some of the above story but we did not visit this well. Ms. Hill (pers. comm., 5/3/12) said this well used to irrigate the acreage on the west side of the penitentiary along 7th Street.

Dan Mica (currently works for the Town of Rawlins, managed cemetery from 1989-99, pers. comm., 11/1/11) also indicated that this well was used for irrigation until sometime in the 2000s. He remembers the north well not producing as well as the south well, but did not indicate a specific production amount.

Conclusion

Available evidence makes a good case for this having been a productive well, producing water acceptable for irrigation, but it has been destroyed beyond rehabilitation. Its potential contribution to a raw-water supply is in having identified a favorable location for construction of a new well. The water-bearing strata indicated by the lithologic log outcrops and subcrops extensively along the east side of the Rawlins Uplift, providing recharge opportunity.

Recommendation

If a 250 gpm well at this location would make a cost-effective contribution to the Rawlins water supply, a replacement well should be constructed. Given the vagaries of the geology in this area, an elaborate siting study is not indicated. A limited hydrogeologic investigation focused on recovering a "known" resource would be appropriate.

SOUTH PENITENTIARY WELL

Investigations

This well is owned by the Old Penitentiary Joint Powers Board and is located in T21N, R87W, Sec. 17, SWNE. Tina Hill (pers. comm. 11/8/11) is the director for the Rawlins Historic Penitentiary and the contact person for the prison's wells. No permit data exist for this well. According to a letter dated April 25, 1988 from Carol Lacy (SEO) to the Old Penitentiary Joint Powers Board, "a search of the records of our office indicates that this is the only well [Wyoming Penitentiary Well No. 2, P726G] serving the penitentiary registered with the State Engineer's Office and therefore, it is the only water source for which a valid water right exists. It is our understanding that two wells have served the institution for some time. If you plan to continue to use the second well, you should register it with this office to establish the water right.

Absent a permit, there is no record of the strata penetrated or any past assessments of aquifer productivity.
The well is located outside the penitentiary walls east of the southeast corner, in a pump house just south of the maintenance buildings. Ms. Hill stated that this well was used for irrigation of approximately 5 ½ acres of grass and trees around the front of the penitentiary until about five years ago. At that time the penitentiary was hooked up to city water and the well has remained unused. (We are unsure why the well was no longer used.) Ms. Hill's current plans are to rehabilitate the well and use it for the proposed baseball field they had hoped to irrigate with the north well..

Scott Blakeley (Pronghorn Pump & Repair, Glenrock, WY; pers. comm. 11/9/11) has been working on the rehabilitation of this well. Mr. Blakeley reported that they ran a short test with the existing pump at 60 gpm, but then came back, pulled the existing pump and ran a 2 hour test with a 120-gpm test pump "with hardly any drawdown". Pronghorn agreed to share the results from their pump test and emailed us the results and some well data on 11/29/11. The well's total depth is 385.2 ft., static water level is 58 ft., and the well casing is 8 in. steel. The well was tested for 2 hours at 120 gpm with a drawdown of 83 ft. (This suggests an aquifer transmissivity of approximately 1400 gpd/ft.) Mr. Blakeley is planning to install a pump that produces 60 gpm for irrigation purposes.

Ms. Hill has secured funding for a new pump and said Pronghorn and CPS (an irrigation company out of Casper) are working together on specifications for pump size, piping, etc. to complete the project. She said that the quality of the water was not really suitable for drinking; it's very hard. Years ago the inmates complained about the water so the State had the water tested and the results showed that the water was not good for drinking. The well water has apparently been used satisfactorily for irrigation.

We visited the old penitentiary and spoke with Ms. Hill (and Ron Bjork, a coworker) on May 2, 2012. The well rehabilitation project is still in progress. She indicated that the main grounds of the penitentiary will stay on Town water but that the well is being developed for the new use on the baseball field. Ms. Hill reiterated how hard the well water is, saying that it left deposits on their outside lights. Mr. Bjork showed us the well. Fifteen, 20-ft. joints (300 ft. total) of steel pipe are lying on the ground outside the well house. The well is currently just an open casing inside a secure building.

Conclusion

This well is currently physically available to contribute raw water for irrigation. With appropriate arrangements with the prison management, a pump, power supply, and appropriate plumbing may be all that is needed.

Recommendation

The well should be properly permitted to make its use fully legal. Because a sample could be easily obtained with a bailer, a sample should be collected and analyzed for irrigation suitability. (Energy Labs' "irrigation classification" analysis costs $55 and sample size is a 250-ml unpreserved sample (1 250-ml plastic bottle).)

OLD OUTLAW BOWL WELL

Investigations

The "Old Outlaw Bowl Well" is named such because Dan Mica (Town of Rawlins employee; pers. comm. 11/2/11) alerted us to this well at the old "Outlaw Bowl", the arena in which the Rawlins High School (nickname "Outlaws") played football until the mid-1980s. The "Outlaw Bowl" is located in T21N, R87W, Sec. 17, SENE, and has an oval-shaped field which used to be the football field with the track running around it. The well is thought to be located outside of the oval-shaped field in the southeast corner of the grounds next to the east-side tree line (near the Walnut and 1st St. corner, see discussion below). We could find no permit for this well. The "Bowl" is just east of the old penitentiary grounds, just across 3rd St. (see Figure1).

Mr. Mica said the well water was tested at some point and the results indicated that the water is not good for irrigation because of salinity. When in use, the turf on the field was replaced every year or so due to the salinity. Mr. Mica thinks the well is only about 50 ft. deep and that this shallow aquifer contains higher salt content. The well had sufficient production for irrigation and was used up until the early-1990s, at which time the irrigation system was tied into the Town system. Mr. Mica said the well has remained unused but there were no other problems with the well, and the pump, wires, etc. are hooked up and accessible; so it should be fully operational.

On 5/2/12, we visited what we thought was the location of the well, 3-inch plastic piping coming out of the ground and going back into the ground within a small, locked chainlink fence at the southeast corner of the ball field area. However, Adolf Bernal (Utilities Superintendent, pers. comm., 5/21/12) said that this facility is a backflow prevention device for the Town's water system. They have one on nearly all Town parks to prevent contamination. He thinks the well is near the backflow prevention area, but we did not see it. If the well is near the backflow prevention area, there is a power meter/service near the well. The Town owns this well since it acquired the land from the school district. The County Assessor's map for Carbon County (http://gis.carbonwy.com/CarbonCountyMap/default.aspx) shows that the Town owns the land where the well is located. Blane Frandsen (Public Works Director, pers. comm., 7/3/12) indicated the Town acquired the well when it acquired the land from the public school, and welcomed the idea of a pump test and water quality sample for the well. Mr. Frandsen does not know where the well is located and neither Mr. Bernal nor Mr. Frandsen knows where the water comes out from the ground.

Conclusion

This well is reported to be currently physically available to contribute raw water for irrigation, including an installed pump. However, the high salinity may render it useful only in combination with higher-quality water from another source, and the production rate is unknown.

Recommendation

The current condition of the well (location, access, operability, sampling opportunity) should be verified and a sample taken for analysis of irrigation suitability. (Energy Labs' "irrigation classification" analysis costs $55 and sample size is a 250-ml unpreserved sample (1 250-ml plastic bottle). The well should be properly permitted to make its use fully legal.

If water quality is not suitable for irrigation, blending opportunities should be evaluated. If water quality is suitable or can be blended to suitability, a pump test should be conducted on the well to determine productivity.

CEMETERY #1 WELL

Investigations

The Cemetery #1 well (P37510W) is 320 ft. deep and permitted for 250 gpm. It was completed with 6-inch Schedule 40 PVC casing to 260 ft., with "cut vertical slots - 1/8 inch X 14 inches; 20 perforations" from 200 to 260 ft., and apparently open-hole from 260 to 320 ft. The pump test reported with the Statement of Completion states 150 gpm for 6 hours produced "0" drawdown. It is owned by the Town of Rawlins and is located in T21N, R87W, Sec. 17, NENE, just across 3rd St. to the northeast of the old penitentiary, and approximately 620 ft. due north of the "Outlaw Bowl" well.

Dan Mica (pers. comm. 11/2/11) was a seasonal employee at the Rawlins cemetery in the 1980s and was in charge of cemetery operations from 1989-1999. He said the well was used only for cemetery irrigation and last used in 1982. He knows nothing about the depth of the well or the flow rate, but said there is no filtration on the pipe coming out of the ground and it was "sucking junk into the system and plugging the irrigation system." Mr. Mica thinks they were also sucking salamanders into the system. Therefore they quit using the well and tied into the Town system. He thinks the pump is still there and works since they just shut it off and left it and it has remained unused.

During our site inspection, we discovered there is no access into the wellhead and no power currently accessible, although there is a nearby power pole. Mr. Frandsen (pers. comm., 5/7/12) said the Town owns this well and it was taken out of service because it did not produce enough to effectively irrigate the whole cemetery. He doesn't think the permitted 250 gpm is enough to irrigate the entire cemetery – currently 25 acres – in one night (with 6 acres waiting to be developed). In the introduction we cited estimates that the Town uses approximately 1.35 MG of water each week to irrigate 50 acres to a depth of one inch. Thus, to irrigate 25 acres the Town would need 675,000 gallons each week, or approximately 67 gpm. To put one inch of water on 25 acres in a week irrigating 8 hours per day (presumably at night) would require approximately 202 gpm. With a 250 gpm well, the cemetery could be irrigated satisfactorily each week. If developed to 31 acres, adequate irrigation of the cemetery would require approximately 250 gpm, irrigating 8 hours per day each week.

Pochop et al. (1992) reports mean, maximum, and minimum monthly and seasonal (April - September) consumptive irrigation requirements (CIR) for crops and turf for 67 locations in Wyoming. The maximum seasonal CIR estimate for lawn grass in Rawlins is approximately 30 inches. The average weekly irrigation requirement using Pochop's estimates is approximately 1.15 inches. Irrigating 25 and 31 acres of cemetery lawn 8 hours per day translates into a production requirement of 232 gpm and 287 gpm, respectively, suggesting a 250 gpm supply may be inadequate for full development of the cemetery. Pochop et al. (1992) estimated the peak monthly (June) demand for lawn grass to be 8.25 inches. This is approximately 1.9 inches per week, which would require 389 gpm for 25 acres and 482 gpm for 31 acres, irrigating 8 hours per day each week.

Mr. Frandsen also confirmed the salamander story although he thought the salamanders were breeding in the Town reservoirs and slipping through the filtration system. He welcomed the idea of a pump test on this well.

A 1978 chemical analysis for the Cemetery #1 well water was obtained by Wester-Wetstein & Associates (2010). From the sodium, calcium, and magnesium measured in the analysis, we calculated the sodium adsorption ratio (SAR) to be 3 meq/l. The SAR is a measure of the suitability of water for agricultural irrigation. According to the CSU Cooperative Extension (http://www.ext.colostate.edu/pubs/crops/00504.html), a SAR value below 13 is desirable. If the SAR is above 13, sodium can cause soil structure deterioration and water infiltration problems.

Conclusion

While this well may have serious sediment-production issues, the productivity and water quality appear to be suitable for raw-water irrigation.

Recommendation

If a 250 gpm well at this location is of interest, a contractor should be mobilized to pull existing pump and install temporary test pump and run a short pump test to verify productivity and assess "sediment" issues. If the well is inoperable, additional investigations would likely require downhole video log, re-development of the well, etc. (It appears that the chemical suitability of the water is not an issue.)

CIRCLE CROSS #1 WELL

Investigations

The Circle Cross #1 well (P41389W) is 190 ft. deep with 6-inch casing and a permitted yield of 25 gpm. It is located in T21N, R87W, Sec. 16, NENW, about a ½ mile to the east of the cemetery, at the west end of McMicken St. in the Circle Cross Trailer Court, on the east edge of the tree row that separates the baseball fields to the west from the trailer court.. The SEO permit applicants are Vernon and Grace Brodsho but the well location is owned by “Circle Cross Trailer Court” according to the Carbon County Assessor’s property listing.

Circle Cross #1 is a flowing well and during our site visit 5/2/12, we were able to measure the shut-in pressure and flow rate of the well, and the conductivity of the water. We measured 24.42 ft. (10.6 psi = 24.42 ft. / 2.31 ft/psi) shut-in pressure using a pressure transducer, and approximately 5 gpm flow rate using a bucket and stopwatch. After the flow rate test, which took about three minutes total, we measured the shut-in pressure again, which had dropped to 23.7 psi. Conductivity of the water measured 805 umhos/cm and the temperature was 8.8 ^{o}C.

This small “pump test” indicates a specific capacity of approximately 0.2 gpm/ft (5 gpm / 24.42 ft.). Since the total depth of the well is 190 ft., the most this well could produce at the indicated specific capacity is approximately 36 gpm, i.e., 0.2 gpm/ft x 180 ft. of drawdown (leaving 10 ft. of water for pump setting and margin of error).

The water rights database shows an enlargement permit (P54123W) was filed for this well for yield (175 gpm) and expanded use, with no physical enlargement to the well, but the permit was subsequently cancelled per request of the Brodshos (maybe because they realized that the well could not produce 175 gpm without deepening the well).

With a conductivity of 805 umhos/cm, the TDS should be approximately 500-550 mg/l (the secondary drinking water standard for TDS is 500 mg/l). Hinckley (2007) reported this well as having “drinking-water quality” and estimated a “conductivity-based TDS of 530 mg/l”. Hinckley (2007) also conveyed an anecdotal report that the well initially flowed a 3-ft. high fountain of water from the 6-inch casing, a report dramatically at odds with our observations of pressure and flow.

Hinckley (2007) concluded that, “it appears that the basal conglomerate beds of the Miocene deposit may be the source of the flowing ‘Brodsho’ well”, i.e., the Circle Cross #1 well. Directly underneath the Miocene conglomerates are Cambrian-age rocks which are “590 ft. of predominantly sandstone (lower) and shale (upper)”. These deposits “produce small springs form local recharge, but have not been significantly developed for groundwater.” Based on the location of the well, were it to be deepened, it would likely penetrate the Cambrian section.

Conclusion

This investigation suggests little potential for this well contributing significantly to a raw water irrigation system, due to a lack of productivity.

Recommendation

If a well of modest production at this location is of interest, the ownership and potential availability of the well should be investigated in the context of setting a pump to increase production beyond that available at free flow and to provide pressure for irrigation sprinklers. If favorable potential is identified, the well should be sampled for irrigation suitability and a pump test conducted. If additional drilling is contemplated to provide a raw-water system, there may be value in this well location with respect to adjacent irrigation demand and with respect to a fully-saturated section of Cambrian-age strata.

"BRACK" WELLS

Investigations

Dan Mica (pers. comm., 11/2/11) alerted us to this well, which he said is located near the Town's old sewer shop. He called it the "Brack" well because he described its water as "brackish – not drinkable" (i.e., too salty). Mr. Mica says people drive under the standpipe and get water for construction, etc. We found the standpipe located in T21N, R87W, Sec. 16, SWSW, just outside the chainlink fence surrounding the Town shop grounds on the north side of East Railroad St. where it intersects with Jefferson St.

SEO water rights database shows two wells in this qtr-qtr – "Old City #1" (P26776W) and "New City #1A" (P26777W) – both of which are flowing wells permitted for municipal use for 2 gpm. Permit status for each is "incomplete".

These wells were not on our radar because of the low flow rates of each. However, maybe they could be pumped for greater production.

During our 5/9/12 field investigations, Ralph Hughes (Water Treatment Plant employee) said that the "old" city well (Old City #1) is located just inside the fenced area near the gate at the city sewer shop but is no longer used. He said a piece of sheet metal was placed over the well and covered with dirt but at some point he and another man used a metal detector and found the well. Mr. Hughes said the big standpipe along the street, previously used for filling water trucks, is no longer used. He said the "new" city well (New City #1A) is located inside the city sewer shop and described it as a "brack" well also. He said it is used to fill the city's sewer jet truck, which is at least 1,000 gallons and only takes a few minutes to fill, indicating a much greater pumped discharge than 2 gpm. We found a small standpipe with a water pump handle just inside the fence near the drive-through gate on the west side, but it produced no water when the handle was lifted. We never found the "old" city well Mr. Hughes described. Closer to the west side of the shop, we found a well hole, covered with wood but with casing extending above ground in the middle of the hole. It has power hooked up to it. Even though a "brack" well, this well may be worth looking into since it apparently produces much more than 2 gpm.

The Town owns both wells and Adolf Bernal (Utilities Superintendent, pers. comm., 5/21/12) confirmed that the "new" city well is outside, on the west side of the shop. Mr. Bernal said the well has a pump in it to pump water into the building. The small standpipe with a water pump handle is connected to the Town water system. He said he would check on the pumping rate of the well and on 6/29/12 he called to say the Town's sewer jet truck holds 1,300 gallons and fills in a little over 10 minutes indicating the pumped well produces approximately 120 gpm. He also looked for water quality data in their records but found none.

Conclusion

The Old City #1 well appears to be beyond recovery. The New City #1A well appears to have modest production, but may be of poor water quality and is not well located to serve the City's raw water irrigation demands.

Recommendation

Given the availability of sampling with installed equipment, it would be informative to sample the New City #1A well for irrigation suitability.

THAYER #1 WELL

Investigations

The Thayer #1 well (P114106W) is 380 ft. deep and permitted for 450 gpm. The principal water bearing formation is from 373-380 ft. It is owned by the Wyoming Department of Transportation and is located in T21N, R87W, Sec. 21, SWNE. The well is between I-80 and the Higley Blvd. off-ramp. Thayer #1 is a flowing well, equipped with a stand pipe for water trucks to drive under to fill their tanks. During our 5/2/12 site visit, the stand pipe was draining down and we took a sample from a leak in the stand pipe; the conductivity measured 1960 umhos/cm, suggesting a TDS of approximately 1274 mg/l (1960 umhos/cm x 0.65).

Aaron Spenny (Rawlins DOT, pers. comm., 5/22/12; 307-328-4144) said the water from this well is "pretty nasty water" and "stains the ground red", but he doesn't have any water quality analyses. The water is used for road construction and watering some trees. He doesn't know the flow rate of the well. Jake Lonn (Rawlins DOT Supervisor, pers. comm., 5/29/12) said we could do a flow test but to let him know a week or two ahead of time. He also said a water-use agreement with the Town is a possibility; DOT just wants to be involved in the process.

Conclusion

Although this well is known to be highly productive, it is also known to have significant water-quality issues. Those issues, combined with its remote location relative to the City's irrigation demands, render it of marginal interest to this project.

Recommendation

Given the ready availability of sampling, it would be informative to sample this well for irrigation suitability. If engineering considerations, e.g. piping costs, blending opportunities, suggest potential utility for a raw-water irrigation system, DOT should be contacted to arrange a flow test of the well. A flow test for this well was scoped and budgeted in a short proposal to DOT in January, 2005. The estimated cost, including test analysis and reporting, was $4500.

NEW WELL(S)

Drilling a new well (or wells) may be a viable alternative in which well location could be optimized for raw-water irrigation. The success of the various wells discussed above demonstrates that groundwater production on the order of 100 - 200 gpm is potentially available in the general area of the identified irrigation demand. A hydrogeologic investigation integrating the results of this investigation so far, the additional investigations suggested above, consideration of hydrogeologic conditions in the area, and the engineering constraints of piping and power, would be desirable in directing exploratory drilling.

SUMMARY

Based on previous reports, SEO permit files, and interviews with Town staff and local residents, eight wells within the City of Rawlins were investigated for potential contribution to a raw water landscape irrigation system. Based on present condition, expected groundwater quality and location with respect to the irrigation needs in the north part of the City, the most favorable are:

1. South Penitentiary well (60 gpm potential)
2. Cemetery #1 well (250 gpm potential)
3. Circle Cross #1 well (36 gpm potential)
4. Old Outlaw Bowl well (50 gpm potential)
5. Wyoming Penitentiary Well No. 2 (250 gpm potential; new well)

Potential total yield is approximately 650 gpm;
Potential quality: suitable without blending (with the exception of the Old Outlaw Bowl well).
Recommended next steps: 1) provide a reconnaissance-level evaluation of the engineering/operational/financial aspects of a raw-water irrigation system to identify the potential service area, raw-water demand and opportunities for blending to suitable water quality; 2) complete water-quality analyses for wells of interest (south Penitentiary well, Circle

Cross #1 and Old Outlaw Bowl well; 3) contract for and conduct pump test on Cemetery #1 and Old Outlaw Bowl wells, 4) secure funding to redrill Wyoming Penitentiary Well No. 2.

WWC (1997) estimated a total of 114 acres irrigated by the Town, but did not include the "Outlaw Bowl" which is approximately 2 acres. Assuming irrigation of 116 acres, Rawlins would need approximately 1,804 gpm to satisfy the peak demand of 1.9 inches per week, irrigating 8 hours per day each week. Assuming a potential yield of 650 gpm, the Town could reach peak demand on approximately 42 acres, irrigating 8 hours per day each week. At average demand (1.15 inches per week), 650 gpm could irrigate approximately 70 acres, watering 8 hours per day each week.

Wells investigated but judged to have little potential at this point.

1. Thayer #1 well
2. "Brack" wells

REFERENCES

Pochop, Larry, et al.; 1992; Consumptive Use and Consumptive Irrigation Requirements in Wyoming; Wyoming Water Resources Center (WWRC) publication #92-06.

Wester-Wetstein & Associates; 2010; City of Rawlins Water Master Plan - Level I, Final Report; Wyoming Water Development Commission.

Western Water Consultants; 1997; City of Rawlins Water Supply Project, Level II, Phase I Report; Wyoming Water Development Commission.

APPENDIX F
Comprehensive EPA Water Loss Prevention Program

Comprehensive EPA Water Loss Prevention Program

From the EPA Guidance Document *Control and Mitigation of Drinking Water Losses in Distribution Systems* (http://water.epa.gov/type/drink/pws/smallsystems/upload/Water_Loss_Control_508_FINALDEc.pdf)

A water loss control program must be flexible and tailored to the specific needs and characteristics of the water department. There are three major components to an effective program:

1. Audit.
2. Intervention.
3. Evaluation.

Each of these major components consists of additional steps and options. The *Audit* is an assessment of the distribution, metering, and accounting operations of the water utility and uses accounting principles to determine how much water is being lost and where. The American Water Works Association (AWWA) recommends that an annual water audit be compiled by the water utility as a standard business process. Through the water audit process, options will become apparent as to how to proceed with further identifying where losses are occurring or where efforts to control or eliminate the losses should be concentrated. These options should be compared and evaluated not only economically but with consideration of all other issues and concerns the water department faces. Typical steps in an audit include:

- Gathering information,
- Determining flows into and out of the distribution system based on estimates or metering,
- Calculating the standard performance indicator values and assessing water loss standing by comparing these values with ranges of values from audits from other water utilities,
- Assessing where water losses appear to be occurring based on available metering and estimates,
- Analyzing data gaps (e.g., determining if more information is necessary to make comparisons and an informed decision),
- Considering options and making economic and benefit comparisons of potential actions
- Selecting the appropriate interventions.

The *Intervention* process puts the selected options into action. More than one action may be selected as beneficial to the water department and the public. For example, the water management administrator may decide that the PWS has three high priority items including adding additional metering in one neighborhood, precisely locating and repairing a leak in a specific section of main, and replacing a one-mile section of pipe.

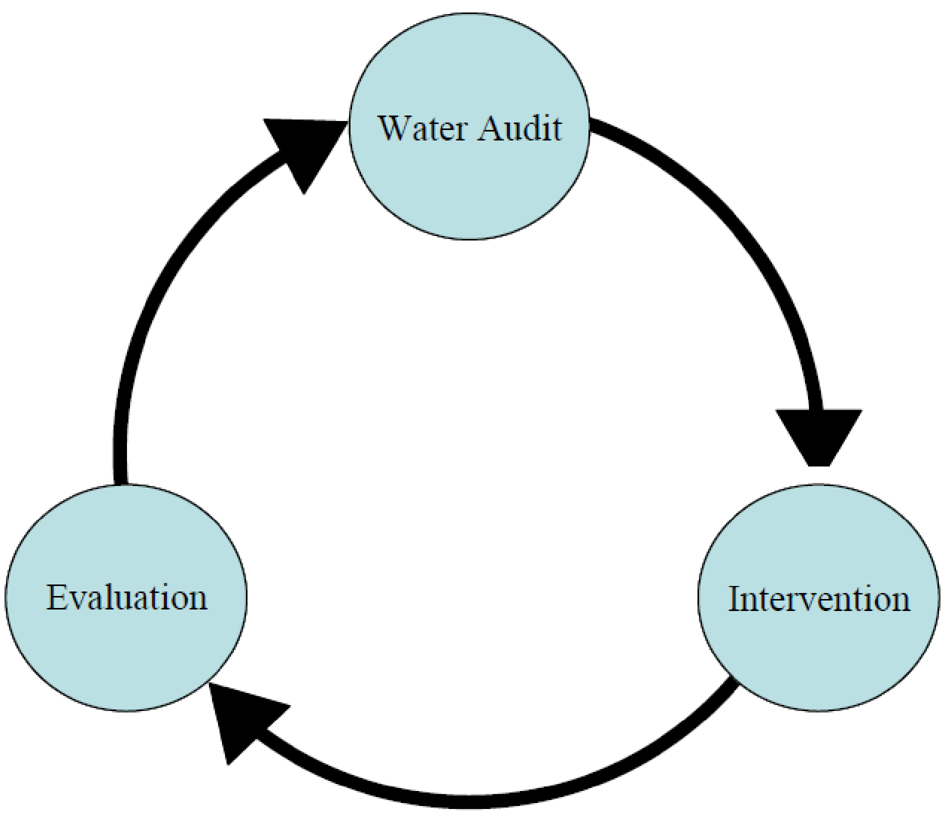
Selecting the order of these actions should be based on budget constraints, public benefit, and priority of other scheduled capital improvements. Intervention can include:

- Gathering further information
- Metering assessment, testing, or a metering replacement program,
- Detecting and locating leaks,
- Repairing or replacing pipe,
- Operation and maintenance programs and changes,
- Administrative processes or policy changes
- No further action is necessary.

The *Evaluation* portion of the program consists of assessing the success of the audit and intervention actions. The evaluation will answer questions such as:

- Were the goals of the intervention met? If not, why not?
- Where do we need more information?
- How often should we repeat the Audit, Intervention, and Evaluation process?
- Is there another performance indicator we should consider?
- How did we compare to the last Audit, Intervention, and Evaluation process?
- How can we improve performance?

A major portion of evaluation is benchmarking. The audit establishes performance indicators, which serve as benchmarks. The intervention action should improve performance in some way. Evaluation is necessary to ensure that whatever the intervention was, it succeeded in its goal. If the goal of the intervention was not met, the evaluation process seeks to determine why and what can be done about it.



Physical	Exist	New	Performance	Exist	New	Commercial/Service	Exist	New
Year of Installation	Y	Y	Complaint Frequency	A	Y	Critical Customer	Y	Y
Diameter	Y	Y	Type of Complaint AY	A	Y	Affect on Community	Y	Y
Material	Y	Y	Break Frequency	A	Y	No. People Served	A	A
Length	Y	Y	Type of Break	A	Y	Length of Shutdown	A	A
Location	Y	Y	Reason for Break	A	Y	Coordination w/Other	A	A
Interior Lining	A	Y	Service (Hydraulic Adequacy)					
Exterior Protection	A	Y	Fire Flow Adequacy	Y	Y			
Joint A Y	A	Y						
Wall Thickness	A	Y						
Soil Conditions	A	A						
Internal Condition	A							
External Condition	A							
Y = yes, in all cases A = as needed, or as available								
Source: Based on (USEPA, 2002) Deteriorating Buried Infrastructure Management Challenges and Strategies								

In addition to piping information, data should be maintained for other components within the water system including: meters, valves, storage tanks, fire hydrants, pumping and pressure boosting stations, and distribution system controls and monitoring equipment. EPA has developed the *Check-Up Program for Small Systems (CUPSS)* to assist with water system component inventory as well as with system asset management activities. CUPSS is a free, easy-to-use asset management tool for small drinking water and wastewater utilities.

It is recommended that a water loss program based be initiated at the water department managerial level. The program should be based on the following three components:

Audit
Intervention
Evaluation

The *Audit* is an assessment of the distribution, metering, and accounting operations of the water utility and uses accounting principles to determine how much water is being lost and where.

The *Intervention* process puts the selected options into action. When there is more than one proposed action, during the *Intervention* process is when priorities are set.

The *Evaluation* portion of the program consists of assessing the success of the audit and intervention actions.

A major portion of the *Evaluation* is benchmarking. The *Audit* establishes performance indicators, which serve as benchmarks. The *Intervention* action should improve performance. *Evaluation* is necessary to ensure that whatever the intervention was, it succeeded in its goal. If the goal of the intervention was not met, the evaluation process seeks to determine why and what can be done about it.

The process should be repeated until acceptable levels of loss are reached. EPA guidance document *Control and Mitigation of Drinking Water Losses in Distribution Systems (2010)* can be consulted for more specific details and recommendations.