Chapter 9

Looking to the Future

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The purpose of this chapter is to discuss future water use opportunities in the Snake/Salt River Basin. This issue was examined in detail in previous Snake/Salt River Basin Water plans (Sunrise Engineering, 2003; Wyoming Water Development Office , 2014) and the Wyoming Framework Water Plan (WWC Engineering and others, 2007). This study provides the most current information available about the future focus and direction of Snake/Salt River Basin groundwater development projects.

The discussions of technical concepts and geology previously covered in this study provide the background required to understand the practical considerations that shape the conceptualization, design, and successful completion of a water resource development project. **Chapter 5** opened with the definition of several elementary, hydrogeologic concepts that are crucial to understanding basic groundwater science. **Section 5.1.3** introduced the dynamics of groundwater recharge, discharge, and flow and summarized the hydrogeologic characteristics of the complex geologic settings in the Snake/Salt drainage. Future groundwater development in the Snake/Salt River Basin is physically limited by its complex hydrogeology. Specific groundwater development projects are discussed in **section 9.1**, and recommendations for future updates of this Groundwater Determination Technical Memoranda are presented in **section 9.2**.

Additional supporting information for the project assessments contained in this chapter can be found in previous chapters of this study:

- Basin hydrogeology is discussed at length in **chapters 5** through **7** and illustrated in **plates 4, 5**, and **6**.
- Groundwater chemical characteristics are summarized in **chapter 7** and **appendices E** through **F**.
- Recent and historic development patterns specified by beneficial use, obtained from the State Engineer's Office, are examined in **chapter 8**.
- Studies published by the USGS (**chapter 7**) and WWDO (**appendix B**) examine the development potential by specific aquifers.
- The 2003 Water Plan for the Snake/Salt River Basin (Sunrise Engineering, 2003), the 2012 Water Plan (WWDO, 2012) and associated technical memoranda, as well as the 2007 State Water Plan (WWC Engineering and others, 2007), identify potential groundwater development projects considered prior to the completion dates of those studies. Many of the opportunities examined in those publications may be under current development or will become more viable in the future as financial factors and technological improvements allow.
- The Water Resources Data System (WRDS) library, specifically the WWDC Projects and Studies Web page, contains hundreds of water development reports for projects completed over the last forty years for localities throughout Wyoming.

This chapter only discusses development projects that are designed with the primary objective of producing potable groundwater. Projects that may produce groundwater as a value-added byproduct of other activities, such as oil and gas production or in-situ mineral extraction, are not considered.

9.1 Issues affecting future groundwater development

- Water availability – A groundwater resource must be legally, economically, and physically available. In the semi-arid west, the significance of the last two factors cannot be overstated. Large sources of good quality groundwater exist in most Wyoming river basins but in many cases, they are located at such distances from population centers that development is uneconomic. In the Snake/Salt River Basin, there are few legal constraints on groundwater development and availability is controlled primarily by hydrogeology. Fortunately, most of the basin's communities are located in close proximity to productive alluvial aquifers.

- Funding – Groundwater development projects are expensive and most Wyoming municipalities lack the funds required

to plan, carry out, and complete development programs. Funding for some projects, therefore, has to be obtained from other governmental agencies. The primary water development funding agencies in Wyoming are the WWDC, DEQ, and the U.S. Department of Agriculture.

- Stakeholder involvement – The successful completion of any groundwater project requires the involvement of stakeholders who have interests in the development or preservation of a particular water resource. Stakeholders include current and future water users; landowners; business representatives; attorneys; scientists; engineers; environmental groups; sportsmen; holders of competing water rights; municipal, state, and federal regulatory agencies; and others. Stakeholder support for or opposition to a water development project depends on the nature, benefits, costs, and perceived impacts of the particular project. The project will likely incur substantial cost increases and time delays if legal challenges are filed by stakeholders opposed to development.

- Interstate compacts - The Snake River Compact of 1949 regulates surface water use only. The provisions of the compact are primarily administered by the SEO. Currently, there is no interstate regulation of groundwater use in the basin.

- Water quality – The successful completion of a groundwater development project depends on whether the quality of the water produced from the targeted resource meets the requirements of the intended beneficial use(s). State and federal laws may mandate water quality requirements for certain beneficial uses or may, alternately, be used as a reference measures for others. For example, the National Primary Drinking Water Regulations (**table 5-1**) established by the Environmental Protection Agency (EPA) under provisions of the Safe Drinking Water Act, are legally enforceable standards for public water systems (PWS) but do not regulate water quality in private groundwater wells that serve fewer than 25 people. Nevertheless, water quality in private wells is frequently evaluated in comparison to the Maximum Contaminant Levels (MCL) contained in the EPA regulations.

- Environmental regulation – Water development projects in Wyoming are subject to regulation under the provisions of state and federal environmental laws including:
    - Wyoming Environmental Quality Act – the principal state environmental law that created the Wyoming Department of Environmental Quality, repealed the state's existing environmental laws (in 1973) and replaced them with the provisions of the new act.

    - Endangered Species Act – a federal environmental law designed to protect imperiled plant and animal species. The ESA is administered under the Endangered Species Program of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration (NOAA).

    - National Environmental Policy Act (NEPA) – a main federal law that established national environmental policy. It requires federal agencies in the executive branch to write Environmental Impact Statements (EIS) and Environmental Assessments (EA) that examine anticipated impacts to the environment resulting from proposed federal agency actions.

    - Clean Water Act – the principal federal law that governs pollution in the nation's surface waters. The CWA does not regulate groundwater pollution directly. The Water Quality

Division of DEQ regulates the discharge of pollutants to surface waters under the CWA.

- Safe Drinking Water Act – the primary federal law that ensures safe drinking water supplies for the public. The SDWA covers public water supplies but does not apply to private wells that serve less than 25 people. The EPA administers and enforces provisions of the SDWA.

9.1.1 Groundwater development projects in the Snake/Salt River Basin

Appendix B contains a chronological summary of groundwater development related projects sponsored by the WWDC in the Snake/Salt River Basin since 1973. Information contained in many of these studies was used to detail the physical and chemical characteristics of the basin's hydrogeologic units in **chapter 7**. **Appendix B** summarizes the following groundwater development information for WWDC projects in the Snake/Salt River Basin:

- References to the study(s) – full citations are included.
- Location including: town, county, rural area, irrigation district, well site, etc.
- Aquifers involved in the study.
- Descriptions of development project(s) and aquifer development potential.
- Summary of results; and
- Current project status.

9.1.2 Future water use opportunities

Technical Memorandum W of the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003) provides a detailed discussion of future water use opportunities that could expand water supplies to meet current and future demands. These water use opportunities were initially developed by the Snake/Salt River Basin Advisory Group (BAG) in 2002 and can be reviewed online at: http://waterplan.state.wy.us/BAG/snake/meetingrecord.html. The BAG list identifies promising structural and non-structural water development projects. Structural opportunities are projects that involve the design and construction of new water storage and conveyance infrastructure or the modification and improvement of existing infrastructure. Structural opportunities include new or upgraded groundwater development, enlarging reservoirs, trans-basin diversion programs, or improving existing water distribution systems. Non-structural opportunities do not require modifications to infrastructure but instead involve programmatic changes in water use and management such as water conservation programs, improvements in efficiency-of–use, water-banking, and improved reservoir operation.

Most of the opportunities discussed in Technical Memorandum W (Sunrise Engineering, 2003) involve structural improvement projects for surface water bodies. Groundwater projects include:

- Increase natural recharge in the Star Valley by routing spring runoff to existing storage sites such as gravel pits.
- Develop septic system management alternatives that would encourage the creation of regional wastewater systems to prevent groundwater pollution.
- Allow for the expansion of municipal water systems.
- Require metering of municipal and community water systems to encourage water conservation.

This report examines potential new groundwater development in the Snake/Salt River Basin by providing brief discussions of the development potential (**section 9.1.3**) of the basin's major aquifer systems and overviews of recent WWDC groundwater development projects (**section 9.1.4**).

9.1.3 Groundwater development potential by aquifer system

Unlike other Wyoming river basins such as the Platte (Taucher and others, 2013) and the Bear (Taboga and others, 2014), the issue of the hydraulic connection between surface and groundwater resources is not considered in the governing interstate compact. Thus, future groundwater development projects will be designed and completed based on the location and magnitude of future water demands,

Table 9-1. Generalized groundwater development potential for major regional aquifer systems in the Snake/Salt River Basin (modified from WWC Engineering and others, 2007; WWDO, 2014; chapter 7, this report).

Age	Center	Location	Well yields	Major aquifers	General potential for new development
Quaternary	Alluvial	Throughout Snake/ Salt River Basin	Small to large	Unconsolidated deposits	Good to very good
	Non-alluvial	Throughout Snake/ Salt River Basin	Small to moderate	Primarily unconsolidated terrace deposits but locally can include glacial deposits	Good to very good
	Volcanic Rocks	Yellowstone Volcanic Area and Northern Ranges	Small to moderate	Undifferentiated volcanic deposits	Fair to good – deposits generally located distant from population centers
Tertiary	Late	Scattered small outcrops from southern to east central basin	Small to large	Salt Lake, Teewinot	Fair to very good
	Early	Scattered small outcrops eastern basin	Small to moderate	Wind River, Wasatch	Fair - outcrops generally located distant from population centers
Mesozoic	Late Cretaceous	Widespread outcrops throughout basin	Small to moderate	Mesaverde, Frontier	Poor to fair – little yield data
	Early Cretaceous	Widespread outcrops throughout basin	Small to moderate	Thomas Fork	Fair to good - some marginal yields
	Triassic/Jurassic	Outcrops on uplands and flanks of south basin	Small to large	Twin Creek, Nugget	Fair to good –yield data from springs in Snake/Salt Basin
Paleozoic	Late	Widespread outcrops throughout basin	Small to very large	Madison, Tensleep, Wells	Fair to very good – some marginal water quality
	Early	Widespread outcrops throughout basin	Small to large	Flathead, Bighorn, Gallatin	Good – some marginal water quality

groundwater availability and quality, funding, stakeholder involvement, and environmental regulations. **Table 9-1** summarizes further groundwater development potential in the basin's main hydrogeologic units.

Virtually all aquifers and some confining units in the Snake/Salt River Basin have some physical potential for development (**pl. 2** and **table 9-1**), depending on the requirements for quantity, the quality required by the specified beneficial use(s), and technical limitations. The Quaternary Snake/Salt alluvial aquifer remains available for future groundwater development. Additionally, Mesozoic and Late Paleozoic bedrock aquifers are underutilized and may be prime targets for future development especially within or in close proximity to outcrop areas where recharge is actively occurring, residence times are low, and water quality is good. Although well yields could be expected to range from ten to five hundred gpm in these aquifers, water quality and susceptibility

to surface sources of contamination (e.g. irrigation return flows and leachates from septic systems) should be considered in evaluating development prospects.

9.1.4 Recent WWDO groundwater development prospects

An examination of WWDO groundwater development projects conducted since 2003 provides, perhaps, the most realistic evaluation of future groundwater development in the Snake/Salt River Basin. The recent projects are driven by present and expected future needs of municipalities that are likely to experience population adjustments in the coming years as the economy of Wyoming becomes increasingly centered on energy production and continues to focus on the economic development of groundwater resources relative to the issues discussed in **section 9.1**. Recent groundwater projects from the WRDS water library are presented to illustrate viable future prospects for new and additional public-support groundwater development in the Snake/Salt River Basin.

9.1.4.1 Afton

Sunrise Engineering (2006) conducted a Level II hydrogeologic evaluation of the Salt Creek alluvial aquifer. The investigation determined aquifer thickness and the depth to groundwater, installed a test well, and assessed groundwater quality. Subsequently, a new municipal water production well (East Alley Well) was sited and installed to a depth of 315 feet below ground surface in the Salt Creek alluvial aquifer. A constant discharge pump test indicated that the new well was capable of producing 1,230 gpm over a 41 hour period with approximately seven feet of drawdown. Water levels recovered completely within one minute of the cessation of pumping. All water quality constituents were well below EPA Maximum Contaminant Levels for drinking water or were non-detectable. Sunrise Engineering (year) recommended that a subsequent Level III design and construction project be completed to connect the new well to Afton's public water system.

9.1.4.2 Alpine

Rendezvous Engineering (2009) conducted a Level II study under contract to the WWDC to evaluate Alpine's existing water supply, demands, and facilities. At that time, Alpine's municipal water system drew water from two wells completed approximately 270 feet below ground surface in fractured limestone bedrock. A third municipal supply well was installed in the limestone aquifer in 2005 but required final completion. Maximum sustained pumping capacities for all three wells were estimated at 750 – 1,000 gpm. Rendezvous Engineering recommended that Alpine improve the existing public water system by installing larger pumps in the 2 older wells and completing the new well.

9.1.4.3 Alta

Rendezvous Engineering (2007) also completed a Level II study for the town of Alta that evaluated the existing public water system as well as present and future water demands. During the investigation, three test wells were installed and tested. Groundwater evaluations were conducted in the glacial/alluvial aquifer that provided municipal water supplies at that time and the underlying fractured volcanic bedrock aquifer. Recommendations for water system improvements included installing a larger pump in the existing municipal well (Targhee Town #1) and completing two of the test wells as municipal supply wells (Targhee Town #3 and #4).

9.1.4.4 Kennington Springs

Keller Associates (2003) conducted a Level I evaluation of the existing Kennington Springs water system and made recommendations to meet requirements imposed by future growth in the area. In 2003, an improved spring supplied adequate amounts of good quality water to area residents, and the transmission and distribution systems were in good condition. However, future water demands under moderate or high growth scenarios will require installation of at least one well, most likely in the Twin Creek aquifer.

9.1.4.5 North Alpine

Rendezvous Engineering (2009) conducted a Level II study for North Alpine that provided an evaluation of the existing water system, improvement alternatives, cost estimates, financing options and permitting requirements. The study concluded that the existing Salt Lake aquifer municipal wells provided adequate supplies of good quality water and that two new municipal wells could be sited in existing wellfield, as needed. The report noted that the existing transmission/distribution system required improvements and provided cost estimates.

9.1.4.6 Squaw Creek

WWDC funded a Level II study (AVI, 2012) to explore the feasibility of acquiring additional sources of supply for the Squaw Creek Water District. Currently, these water supplies are sourced from two wells completed in the Game Creek alluvium and a spring that discharges from the Squaw Creek Alluvium. The study concluded that the subdivision could construct a new well in the Camp Davis aquifer or purchase an existing well for supplemental supply. The study provided cost estimates for the supplemental well and for construction of a delivery pipeline from the new well to the district water supply system.

9.1.4.7 Star Valley

Sunrise Engineering (2009) investigated the feasibility of developing a regional water system in the Star Valley area. The study evaluated the water transmission and storage systems, water rights, and water quality from 19 existing public water systems in detail. Existing water systems in the valley are supplied by 24 wells and 16 springs sourced from the Madison Limestone, alluvial aquifers, the Salt Lake aquifer, and miscellaneous Paleozoic and Mesozoic aquifers. Sunrise Engineering (2009) suggested that the development of two regional water systems would be the most cost effective alternative.

9.1.4.8 Star Valley Ranch

Forsgren Associates (2008) conducted a Level II study for the Town of Star Valley Ranch. The study provides an evaluation of the existing water system, improvement alternatives, cost estimates, financing options, and permitting requirements. At the time of the study, Star Valley Ranch received its community water supply from two Paleozoic-sourced springs and two Salt Lake Formation wells. Forsgren Associates (2008) recommended that the town develop additional groundwater wells, update its water storage and delivery infrastructure, and install water meters.

9.1.5 Current WWDO and SEO projects

In addition to these recent studies, the WWDO is updating the previous Snake/Salt River Basin Water Plan (Sunrise Engineering, 2003) and constructing a hydrological model for surface flows in the basin. The U.S. Geological Survey (USGS) is currently conducting specific hydrogeologic investigations of Fish Creek near Wilson, Wyoming and the Snake River Alluvial Aquifer in the vicinity of the Jackson Hole Airport. Reports of these investigations can be obtained from the USGS publications website: http://pubs.er.usgs.gov/. Additionally, the USGS continues to collect real time streamflow data and periodic water quality at 16 USGS stream gaging stations located in the basin: http://waterdata.usgs.gov/wy/nwis/current/?type=flow.

9.1.6 Groundwater interference and interconnection with surface water

Other factors that must be considered for new groundwater projects are the potential for interference between wells or well fields completed in the same aquifer, excessive drawdowns in over-utilized aquifers, and interconnections between groundwater and surface water. Wells alone do not necessarily present significant problems to a public water system depending on several factors including, but not limited to, the physical and hydrogeologic properties of the target aquifer, construction of the production wells, and the timing and rate(s) of well production. In aquifers that possess high degrees of secondary (fracture) permeability, well interference may be unavoidable over the scale of several miles. In many cases, municipal water supply personnel, who are aware

of well interference effects in their facilities, effectively manage them by adjusting well pumping times and rates, or periodically switching to other sources of municipal water.

Excessive drawdown, or groundwater depletion, in over-utilized aquifers has become a national concern (Konikow, 2013). Currently, this does not appear to be an issue of regional concern in the Snake/Salt River Basin.

9.2 Recommendations for future updates

The quality of the Wyoming State River Basin water plans is limited by the availability of data and the institutional resources used to develop the compiled information in a readily accessible format that is useful to stakeholders . While some information (e.g., hydrogeology studies, SEO groundwater permits, data from the DEQ and other agencies) is generally available for all basins, other information (e.g. regional groundwater modeling) does not exist. The quantity, accuracy, and completeness of available groundwater information vary between the major drainage basins of Wyoming.

The purpose(s) of updating an Available Groundwater Determination can be to include new information generated since the previous determination, to include older information not initially provided and to utilize continuously improving technology to maximize the value of the relevant information that is presented. While information in some areas will grow slowly (e.g., mapping of geologic and hydrogeologic units), other information (e.g., SEO and other agency data) requires regular updates to maintain its utility.

9.2.1 Data challenges

Computing capabilities will continually improve but will always be limited by the availability and reliability of the input data. The quality of a compilation study such as this relies on the quality of the available data. The development of a comprehensive statewide database for water quality and aquifer physical characteristics would greatly assist Wyoming water professionals to manage and protect the state's valuable water resources. Currently, hydrogeologic and hydrogeochemical data exist that could be integrated into a more comprehensive and evolving groundwater database for Wyoming. For example, DEQ collects copious amounts of groundwater data for site-specific investigations of contaminated sites, for issuing industrial permits (e.g. mining, UIC, waste and wastewater management), and for monitoring for potential impacts. The SEO collects groundwater information from selected wells. The USGS, WOGCC, BLM, EPA, counties, municipalities, other agencies, and private entities all collect hydrologic information for a variety of activities and purposes. However, coordination between the various entities collecting groundwater information is generally lacking, and clearly there is abundant relevant information that was not and is not accessible for this study and groundwater determinations in other basins. While the quality of some of this information may not be consistent with the standards described in **chapter 7**, those data could be qualified. Although, some data (e.g., on contaminated samples) would not be representative of natural groundwater, and some water quality analyses (e.g., for contaminated sites and industrial site monitoring) will be for constituents not commonly used to characterize natural groundwater quality; nevertheless, a comprehensive database would be useful.

Ongoing revision and maintenance of a comprehensive groundwater information database where data are continually being generated by numerous entities would be a substantial project, requiring a continuing commitment of resources by federal, state, and local agencies and is certainly easier described than done. As interest in groundwater resources increases, so will justification for such a program.

9.2.2 Current and future research efforts

This study is a compilation of previous investigations conducted primarily by state and federal agencies and consultants. Any significant advancement in the development of the conceptual model of the hydrogeology of the Snake/Salt River Basin will require further original research, most

likely conducted by academic investigators; USGS water scientists; or by consultants employed by the WWDC, SEO, or Wyoming municipalities. The recent formation of the Wyoming Center for Environmental Hydrology and Geophysics (WyCEHG) should prove to be particularly valuable to a better understanding of groundwater resources in the Snake/Salt River Basin. Funded for a five year period by the National Science Foundation, WyCEHG efforts are specifically targeted to advancing research in western hydrologic systems using advanced geophysics and remote sensing technologies. The stated goals of WyCEHG are:

- **To improve understanding of mountain front hydrology** by characterizing the processes that partition water into streams, soils, plants, rivers, and aquifers in several locations throughout the state.
- **To improve understanding of how disturbances affect water flux** by studying effects on hydrological systems from climate change, bark beetle infestations, and energy extraction.
- **To improve integrated modeling of the fate and transport of water** by creating integrated computer models that will provide the scientific knowledge and tools for improved prediction of hydrological processes.
- **To provide cutting edge resources and tools** for educators and watershed managers in the state. Further information can be obtained from the website for WyCEHG which can be accessed at: http://www.uwyo.edu/epscor/wycehg/.

The recharge calculations based on the surface outcrop area of hydrogeologic units and the SDVC map of recharge (Hamerlinck and Arneson, 1998), contained in **section 6.2**, went beyond summarizing existing information by using the data to estimate the groundwater resource. The recharge evaluation in this study could easily be updated and the results refined as new data is collected, with a relatively low-level commitment of resources. The estimation of recharge can be enhanced by numerical modeling in selected areas that includes additional variables that affect infiltration and recharge (**section 5.1.3**).

Furthermore, there are several areas where additional geologic mapping would develop useful information for future Snake/Salt River Basin Water Plan updates. More detailed geologic mapping would better define the hydrogeologic role of the basin's geology, further identify areas where groundwater and surface water may be interconnected, and determine areas where vertical recharge may be enhanced by fracture permeability.