Chapter 9

Looking to the Future

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Chapter 1, Part 2 introduces the groundwater regime of the WBRB and gives an overview of future development prospects. Elements of specific groundwater development potential are discussed below in Section 9.1, and recommendations for future updates of this Available Groundwater Determination Technical Memorandum in Section 9.2.

9.1 Future groundwater development

The prospects for future development of specific groundwater resources in the WBRB are described in this section using information developed for this study:

- Hydrogeology **(Chapters 5, 6, and 7)**
- Current and historic development patterns based on groundwater permitting information **(Chapter 8)**
- Development potential of specific aquifers based on information compiled from previous studies **(Chapter 7)**
- Specific potential groundwater development projects identified in the 2003 Water Plan for the WBRB (BRS, Inc. et al., 2003), the 2007 State Water Plan (WWC Engineering et al., 2007b), and the current (2010) Update Plan (MWH et al., 2010a) and their associated Technical Memoranda

Only development of fresh groundwater for supply purposes is addressed in this chapter. The development potential of groundwater produced as a byproduct of industrial activities (e.g. oil and gas operations) is not addressed.

9.1.1 Aquifer-specific development potential

Information concerning the potential for new or additional groundwater development of specific hydrogeologic units in the WBRB was compiled from a variety of sources for **Chapter 7** of this study. The development potential of specific units discussed in **Chapter 7** is summarized in **Appendix D**, along with a brief discussion of the various factors that affect the viability of developing groundwater resources in these units. Table 2 of the WWDC 2003 Available Ground Water Determination Technical Memorandum (Lidstone and Associates, 2003) provides similar tabulated aquifer-specific information.

Appendix B presents a summary, in chronological order, of all WWDC-sponsored studies relevant to groundwater development in the WBRB since 1982. Many of these studies were used in compiling the aquifer-specific information presented in **Chapter 7;** therefore, these data are also generally summarized in **Appendix D**. **Appendix B** summarizes the following information relevant to developing new or additional groundwater resources in the WBRB:

- References to the study(s) – full citations are included in the References
- Location, including as appropriate: town, county, rural area, irrigation district, well site, etc.
- Aquifers involved in the study
- Project descriptions:
    - Studies of development potential of area(s and aquifer(s)
    - Development drilling project(s)
    - Study results
- Project status

9.1.2 Aquifers and specific projects

Numerous hydrogeological investigations have been performed in the WBRB. Previous Water Plans (BRS, Inc. et al., 2003; WWC Engineering et al., 2007a) provide general conclusions regarding the groundwater development potential of the major aquifers of the WBRB, summarized below:

Virtually all aquifers and some confining units have some potential for development, depending on quantity and quality requirements and technical considerations.

Quaternary alluvial subaquifers have local development potential. Depending on local hydrogeologic conditions, well yields are expected to range from 10 to 500 gpm. Water quality and susceptibility to surface sources of contamination (e.g. irrigation) should be considered in evaluating development prospects.

The Lower Tertiary Wind River aquifer is developed in several areas in the Wind River Basin, especially in the vicinity of Riverton. Opportunities for additional groundwater development, including high-capacity wells, exist mostly in areas near major surface drainages, primarily the Wind River. Water quality may constrain development in some areas.

The Paleozoic aquifers, primarily the Madison–Bighorn aquifer in the Bighorn Basin (the Madison aquifer in the Wind River Basin), probably have the best potential for developing high-yield wells, depending on site-specific hydrogeologic conditions. Yields up to 14,000 gpm under flowing artesian conditions have been measured from the Madison–Bighorn along the west side of the Bighorn Basin. Because Paleozoic aquifers are confined in most places, lowered hydraulic head associated with large withdrawals, great drilling depth, and poor water quality may constrain development in some areas. Large variations in structure- and solution-controlled permeability will necessitate site-specific investigations to evaluate new development prospects.

The Flathead aquifer also has potential for developing high-yield wells, but is limited to areas where the sandstone formation can be accessed at economic depth, generally not far from outcrop. The Flathead is generally characterized by high artesian pressure, and it has produced large artesian flows

as great as 3,000 gpm. As with the Madison–Bighorn aquifer, drilling depth and water quality will constrain development in the WBRB.

Previous Water Plans (BRS, Inc. et al., 2003; WWC Engineering et al., 2007a) included lists of groundwater opportunities (by category), developed by the Wind/Bighorn Basin Planning Team (WWDC, other agencies, and consultants) and Basin Advisory Group (BAG) for use by individuals and organizations that will require some level of public support for groundwater development projects to meet specific existing and anticipated withdrawal requirements. The previous Water Plans discuss in detail the categories, screening criteria, and other considerations under which a "long list" of groundwater development opportunities was developed and evaluated to produce a "short list" of opportunities perceived to be most beneficial and feasible over a 30-year period, based on the screening criteria below:

1. Need – the capacity of a successful project to meet specific existing and anticipated water needs
2. Water availability – the likelihood that an aquifer can provide sustainable yield adequate to meet anticipated demand
3. Financial feasibility – the combined technical considerations and construction costs compared with the economic benefits of the project
4. Public acceptance – the degree to which the public supports or opposes the project
5. Number of sponsors/beneficiaries/participants – the beneficial aspects of a project relative to the population to be served
6. Legal/institutional concerns – the likelihood that a project would be authorized and permitted under applicable state and federal laws
7. Environmental/recreational benefits – the potential for a project to have a positive or negative impact on recreation or the environment (e.g., a groundwater project's potential for decreasing stream flows)

The previous WBRB Water Plans (BRS, Inc. et al., 2003; WWC Engineering et al., 2007a) also noted that because of treatment requirements for surface waters under the Safe Drinking Water Act and recent drought conditions, many municipalities and other public water supply systems are increasingly interested in developing groundwater resources.

The current 2010 Update Water Plan for the WBRB (MWH et. al, 2010a) presents an updated list of specific groundwater project opportunities to address existing and future use requirements based on the lists presented in the previous Water Plans, supplemented by studies completed since 2003 and additional recommendations from the BAG and the Basin Planning Team. The following potential groundwater projects from the 2010 Plan are presented to illustrate the prospects, some of which have been identified for several years, that reflect a general consensus on the foremost opportunities for new and additional public-support groundwater development in the WBRB.

- Flathead aquifer near Lander
- Paleozoic aquifers (Madison–Bighorn, Flathead) near Thermopolis and Hyattville
- Madison–Bighorn aquifer in the southern Bighorn Basin
- Shallow to deep aquifers in the upper Bighorn Basin
- Tensleep aquifer near Big Trails
- Paleozoic aquifers in the Mud Creek Basin
- Wind River aquifer in the Gas Hills area

As of late 2010, current and planned WWDC-funded groundwater projects the WBRB include (Keith Clarey, pers. comm., 2010):

- The **Arapahoe Water Supply Level II Study** (2006-2010) funded the construction of a test/production well with a depth of 1,041 feet and a yield of 300 gpm and other wells. A series of shallow test wells constructed into alluvial deposits along the Little Wind River were also evaluated for use as a back-up supply for the local Ethete public water system on the Wind River Indian Reservation. An alluvial well field system is planned to be connected to the Northern Arapahoe Utilities Organization public surface water system during the Level III construction project, 2010-2011.

- The **Bighorn Regional Groundwater Level II Study** (2005-2010) is a study for the Big Horn Regional Joint Powers Board (BHRJPB). The BHRJPB is supplied with groundwater from the City of Worland well field. Four deep test/production wells have been constructed to find a new well to serve as a redundant source of supply for the regional system. The fourth well is considered a potential production supply well for connection to the regional public water system.

- The **Pavillion Area Water Supply Level I Study** (Fall 2010) is a study to investigate a long-term alternative water supply for the rural residents living east of the Town of Pavillion to replace their contaminated private water wells. In August 2010, the USEPA Region 8 office issued an advisory to these Fremont County rural residents to not drink their private well water due to contamination by dissolved hydrocarbon and inorganic compounds.

9.1.3 Groundwater interference and interconnection with surface water

The potential for interference between wells or well fields and associated areas of high drawdown over initial conditions, and interconnections between groundwater and surface water, should be considered in assessing the potential for developing groundwater resources. These issues are discussed in **Section 8.4** and briefly in **Section 1.**

9.2 Recommendations for future updates

The Wyoming State Water Plan Available Groundwater Determinations for the WBRB (and other major drainage basins of Wyoming) are limited by the availability of data and the institutional resources that can be marshaled to compile and develop the information in a form that is accessible and useful to stakeholders in groundwater development. While some information (e.g., hydrogeology, WSEO groundwater permit, other agency data) is available for all basins, other information (e.g. regional groundwater modeling) may not exist. The quality, quantity, accuracy, and completeness of available groundwater information vary between and within the major drainage basins of Wyoming.

The purpose of updating an Available Groundwater Determination can be to include information generated since the previous determination, to include older information not initially provided, and to utilize our continuously improving technology to maximize the value of compiling, developing, and presenting the full body of relevant information. While some information will grow slowly (e.g., mapping of geologic and hydrogeologic units), other information will need to be continuously updated to maintain its utility (e.g., WSEO and other agency data).

9.2.1 Data Challenges

Computing capabilities will continuously improve but will always be limited by data availability and reliability. The quality of a study that relies substantially on data processing may, therefore, be substantially enhanced through improved data. Specific areas for data improvement in the WBRB include:

- WSEO and WDEQ database issues (**Appendix C**), primarily:
    - consistency between the various databases
    - accessibility of databases
    - definition of how current, complete, and accurate the information is; what information has been excluded, and why
    - the uniqueness of the data and the need for common identifiers to distinguish data duplicated in different databases
- development of a comprehensive database for water quality and aquifer physical characteristics.

Hydrogeologic and hydrogeochemical data exist that could be integrated into a more comprehensive and evolving groundwater database for Wyoming. For example, WDEQ collects copious groundwater information from site-specific investigations of contaminated sites, for issuing industrial permits (e.g. mining, UIC, waste and wastewater management), for monitoring for potential impacts, and other activities. The WSEO collects groundwater information from selected wells. The USGS, WOGCC, BLM, EPA, TWE, counties, municipalities, other agencies, and private entities all collect groundwater 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 the WBRB and other Available Groundwater Determinations. While the quality of some of this information may not be consistent with the standards described in **Chapter 7**, those data could be qualified. In addition, 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 updating and maintenance of a comprehensive groundwater information database where data are being generated by several entities would be a substantial project, requiring a continuing commitment of resources by Federal, State, and local agencies – and is likely easier described than done. As interest in groundwater resources increases, so will justification for such a program.

9.2.2 Future Efforts

This study is substantially more comprehensive than the previous groundwater determination. For the most part, no original investigations were performed for this study; however, additional information is summarized to the extent that significant advancement of the conceptual model of WBRB groundwater resources would require original efforts on a basin-wide scale. Ideally, numeric modeling of aquifer performance and three-dimensional models of groundwater basin geology and hydrogeology including the areal extent, thickness, continuity, structure, hydraulic characteristics, groundwater quality, and total and available groundwater resources of the hydrogeologic unit components of the WBRB would be the basis of better definition of the groundwater resource. Developing numeric and 3-D models of the groundwater basin would require extensive subsurface data collection and processing.

The **Section 6.2** evaluation of groundwater volume and recharge based on the surface outcrop area of hydrogeologic units and the SDVC map of recharge (Hamerlinck and Arneson, 1998) went beyond summarizing existing information by using the data for estimating the groundwater resource. The evaluation

of recharge implemented 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 could be enhanced by updated numeric modeling that includes the additional variables that affect infiltration and recharge (**Section 5.1.3**).

Other areas where useful information could be developed for the Available Groundwater Determination for the WBRB include:

- more detailed geologic mapping to better define the function of hydrogeologic units as aquifers or confining units based on lithology, stratigraphic position, and structural relationships

- priority ranking of areas where numerical modeling would be most useful

- identification of any additional areas where interference between wells and well fields should be considered in evaluating future groundwater development

- identification of areas where groundwater and surface water may be interconnected

- inclusion on the surface hydrogeology map (**Plate IV**) of shallow anticlinal axes that may affect groundwater flow

- mapping linear segments of surface-water drainages, primarily where Tertiary geologic units are exposed or thinly covered by Quaternary deposits in the basin interiors, to identify areas where vertical recharge may be enhanced by fracture permeability

- mapping irrigation drain systems and sampling the discharge points to provide spatially-averaged water quality of the shallowest groundwater in local irrigated areas

- mapping areas covered by WWDC studies listed in **Appendix B**

- developing an on-line site where stakeholders can submit information and comments relevant to the Available Groundwater Determination

- developing additional and specific information on institutional, legal, and cultural issues that could affect groundwater development in the WBRB