

Chapter 1

Introduction

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The Wyoming State Engineer's Office (SEO) published the first State Framework Water Plan in 1973 under the Wyoming Water Planning Program (1973). The publication presented a framework plan for the entire state of Wyoming and included summary water plans for each of the state's seven major river drainages. In 1975, the Wyoming Legislature established the Wyoming Water Development Commission (WWDC) and Wyoming Water Development Office (WWDO) to coordinate planning, development and project management efforts for the state's water and related land resources. Between 1979 and 1995, the WWDO completed several major river basin planning studies.

The development of the present State Water Planning Process began in 1997 when the state Legislature directed WWDC to conduct a water planning feasibility study in collaboration with the University of Wyoming (UW) and the SEO that included public input and compilation of a statewide water data inventory. Based on the feasibility study, the Legislature accepted the recommended planning framework and funded the Statewide Water Planning Process in 1999 to update the original 1973 State Framework Water Plan, and specifically to:

- inventory the state's water resources and related lands,
- summarize the state's present water uses and project future water needs,
- identify alternatives to meet projected future water needs, and
- provide water resource planning direction to the state of Wyoming for a 30-year time-frame.

The Wyoming Framework Water Plan (WWC Engineering, and others, 2007a) summarized the separate water plans for Wyoming's seven major river basins (**Figure 1-1**) compiled between 2001 and 2006. The Platte River Basin plan (Trihydro Corporation and others, 2006a, 2006c; Trihydro Corporation, 2006b) summarized technical memoranda on its water resources and use, including the initial Available Groundwater Determination for the Platte River Basin (Lidstone and Associates, 2005b). This Available

Groundwater Determination updates, revises, and expands the 2005 Technical Memorandum with a new compilation of available information and represents the most current assessment of the groundwater resources of the Platte River Basin. The data contained in this memorandum is a compilation of existing data obtained by several state and federal agencies. While original maps and tables were developed, and existing maps and tables were updated and modified, no original investigations or research were conducted for this memorandum.

The format of this update follows the general layout of recently completed groundwater determination updates co-authored by the Wyoming State Geological Survey (WSGS) and U.S. Geological Survey (USGS) for the Wind/Bighorn River Basin (Taucher and others, 2012) and Green River Basin (Clarey and others, 2010); much of the content of these two previous studies is found in this memorandum, frequently without citation.

I.1 Interagency agreement and scope

The WWDC and the Wyoming State Geological Survey (WSGS) entered into an Interagency Agreement in June 2009 to review and compile existing information, to update the 2005 Available Groundwater Determination Technical Memorandum. A downloadable file containing the 2005 Memorandum is available online at the WWDC website at <http://waterplan.state.wy.us/plan/platte/techmemos/techmemos.html>. The Agreement outlined the following tasks for this update of the Platte River Basin Available Groundwater Determination:

- **Identify the major (most widely used) aquifers in the Platte River Basin.** To make this determination the U.S. Geological Survey (USGS) defined all of the aquifers and confining units in geologically distinct areas of the Platte River Basin and presented the information on hydrostratigraphic nomenclature charts (**Plates J, K, M, S, T, and U; Figure 7-2**). Based on these detailed analyses, the digital Geographic Information System (GIS) geologic units mapped on **Plate 1** and

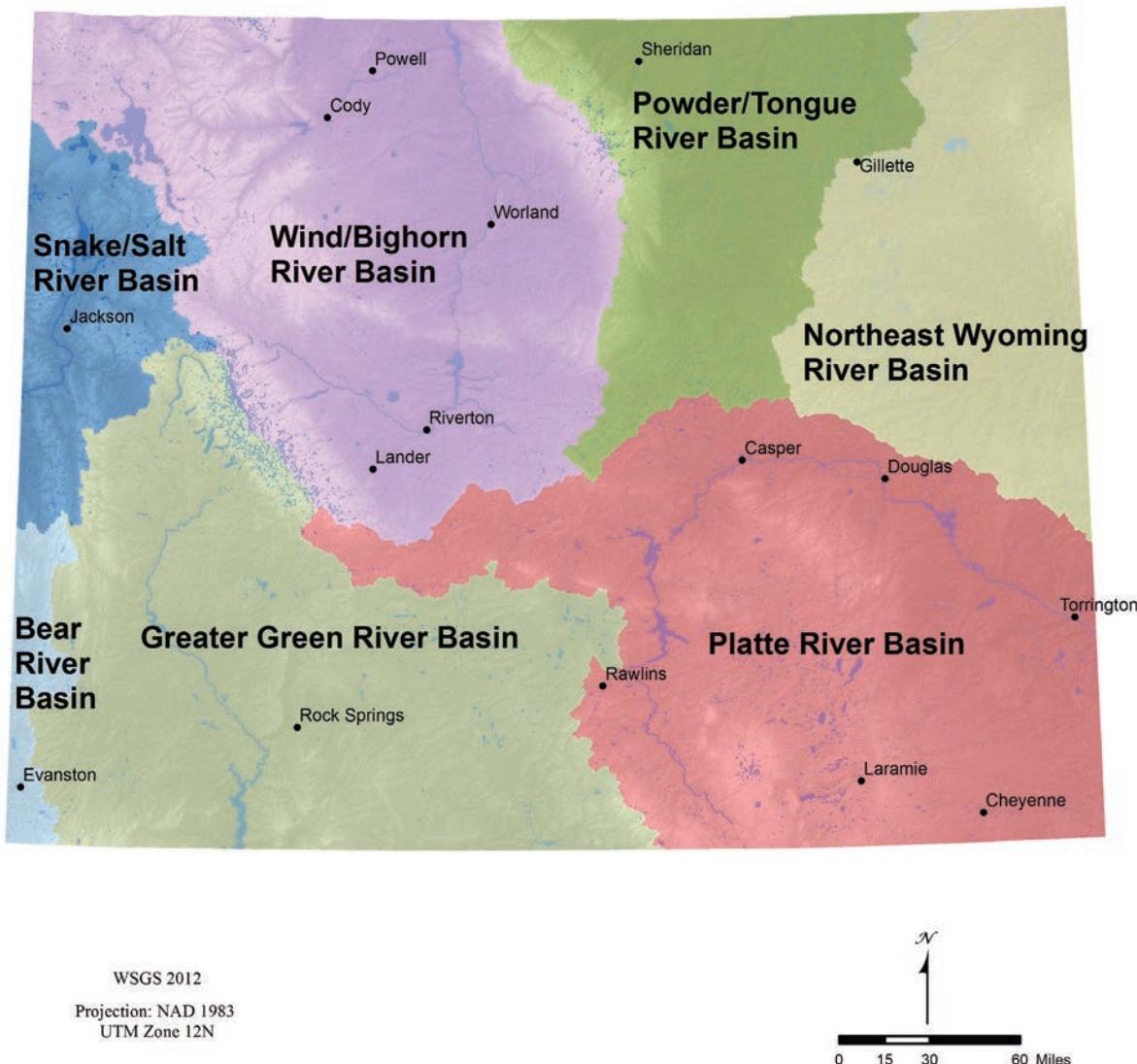


Figure 1-1. Major drainage basins, Wyoming.

described in **Appendix A** were organized into comprehensive hydrostratigraphic charts and a surface hydrogeology map for the Platte River Basin (**Plate 2**). In some cases, two or more minor aquifers that are hydrologically connected have been grouped together and treated as a single combined hydrogeologic unit. The physical geology of the major landforms within the Platte River Basin is discussed in **Chapter 4**. The geology and hydrogeology of individual Platte River Basin geologic units are discussed in detail in **Chapter 7**.

- **Define the three-dimensional extent of the aquifers.**

Plate 2 is a map of the outcrop areas for the basin's aquifers and confining units in the Platte River Basin. Nineteen cross sections (**Figures. 9-2–9-20**) illustrate the subsurface configuration of the geologic units that constitute the hydrogeologic units at selected areas within the Platte River Basin. Isopach maps with substantial coverage of the major aquifers in the Platte River Basin are not available.

- **Describe the following hydraulic, hydrogeologic and hydrogeochemi-**

- cal properties of the aquifers and confining units:**

 - Physical characteristics - **Chapter 7** describes the lithologic and hydrogeologic characteristics of the hydrogeologic units identified in **Plate 2**.
 - Water chemistry with comparisons to applicable state and federal regulatory standards by class of use – **Chapters 5** and **7** contain extensive discussions of basin water quality with comparisons to regulatory standards, statistical analyses of water chemistry are presented in **Appendices E1 - F6** and **Chapter 5** and trilinear diagrams are provided in **Appendices G1 – H4**.
 - Principal potential pollutants - **Section 5.7** contains a discussion of potential sources of pollution and maps of these facilities are provided in **Figures 5-4** through **5-10**,
- **Estimate the quantity of water in the aquifers.**

Data sufficient for a basin-wide aquifer-specific assessment of groundwater quantity is not available and is unlikely to ever be developed. The complex geology of most of the Platte River Basin does not lend itself to the general assumptions about aquifer properties, geometry, and saturated thickness that would be required for a plausible estimate of total and producible groundwater resources. Important aquifers in the Platte River Basin, such as the High Plains, Casper, and Split Rock aquifers, have been described in numerous specific studies that are more comprehensive and relevant than a summary estimate. Groundwater resource estimates are addressed in this Technical Memorandum by analysis of recharge (**Chapter 6**) and a basin-wide water balance (**Chapter 8**).
- **Describe the aquifer recharge areas.**

Plate 2 is a map of the outcrop areas of aquifers and confining units in the Platte River Basin. Maps that depict the outcrop areas used to calculate the annual rate of recharge for specific aquifers and logical groups of aquifers throughout the Platte River Basin are provided in **Figures. 6-1 – 6-6**. Recharge is discussed in **Section 5.1** and **Chapter 6**.
- **Estimate aquifer recharge rates.**

Existing maps depicting average annual precipitation (**Figure 3-3**) and estimated recharge rates (**Figure 5-2**) over the entire Platte River Basin were adapted for presentation in this Technical Memorandum. Existing annual recharge rates were multiplied by aquifer outcrop areas (**Figures 6-1 – 6-6**) to estimate a range of annual recharge volumes for individual and combined aquifers. The results of these estimates are summarized in **Tables 6-1** through **6-3** and discussed in **Section 6-2**.

Figure 6-7 represents recharge as a percentage of precipitation and **Section 6-2** describes how recharge efficiency varies by individual and combined aquifers overall within the Platte River Basin.
- **Estimate the “safe yield” potential for the aquifers and describe implications of hydrologically connected groundwater and surface water.**

The difficult and controversial concept of “safe yield” has been discussed at length by many authors. Originally, the concept was defined as the volume of water that could be pumped, “regularly and permanently without dangerous depletion of the storage reserve” (Lee, 1915). Meinzer (1923) defined safe yield as, “the rate at which water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that withdrawal at this rate is no longer economically feasible.” By these definitions, safe yield

- is determined solely on the basis of storage depletion and does not directly consider recharge or natural discharges to springs, to surface water bodies and to deep basins. Ideally, however, new groundwater development projects would not decrease surface water flows but would capture water that would otherwise flow deeper into a basin where production is precluded by economic or water quality limitations. Lacking accurate data for either recharge or total discharge (which are rarely known), it is difficult to derive a meaningful value for safe yield. Adequate data does not exist and will probably never be developed for an accurate basin-wide aquifer-specific estimate of safe yield in the Platte River Basin; however, total (average annual) recharge for the various aquifers and groups of aquifers is estimated in **Chapter 6**, and these estimates can be used as upper limits of safe yield for the Platte River Basin aquifers. In some cases, rational estimates of safe yield can be calculated for specific well-delineated prospects. Safe yield is further discussed in **Section 5.1.4**. Areas where groundwater uses may impact surface water flows, as defined by the 2001 Modified North Platte Decree, and where development may be restricted by other institutional constraints are shown on **Figure 9-1** and discussed in **chapters 8 and 9** and **Appendix D**.
- **Describe and evaluate existing groundwater studies and models:** Existing groundwater models are identified and evaluated; and recommendations for future groundwater modeling in the Platte River Basin are discussed in **Chapter 7**. Existing groundwater studies are discussed in **Chapter 7** and **Appendix B** and are cited throughout this report.
 - **Identify future groundwater development opportunities to satisfy projected agricultural, municipal,**

and industrial demands:

Several approaches to address future groundwater development potential are discussed in **Chapter 9**. General and aquifer-specific hydrogeology relative to groundwater development potential is discussed in **Chapters 4, 5, 6, and 7**.

- **Figures 8-1 through 8-34** show wells permitted in the Platte River Basin sub-regions (**Chapter 2**) by the SEO through February 14, 2011. These figures contain selected groundwater permit statistics and illustrate historic groundwater development patterns relative to sub-region hydrogeologic unit outcrop patterns. SEO permits issued for the period from January 1, 2005 through February 14, 2011, shown on inset tables contained within these figures, illustrate the focus of recent groundwater development efforts. Existing groundwater development in the Platte River Basin is discussed in **Chapters 7, and 8**.
- A summary of groundwater development studies and projects in the Platte River Basin, sponsored by the WWDC, is included in **Appendix B**. The development potential of specific aquifers based on information compiled from these and other previous studies is described in **Chapter 7** and summarized in **Chapter 9**.
- Groundwater development prospects for the Platte River Basin, identified in the 2005 Available Groundwater Determination (Lidstone and Associates, Inc., 2005b) and areas where groundwater development may be restricted by groundwater control districts or the Decree are shown in **Figure 9-1** and briefly

- discussed in **Chapter 9**.
- Current WWDC and SEO projects related to groundwater development in the Platte River Basin are discussed in **Chapter 9**.

1.2 Agency participation

This Technical Memorandum is the result of a cooperative effort by the WWDC/WWDO, WSGS, USGS, and the Water Resources Data System (WRDS). The WSEO and the Wyoming Department of Environmental Quality (DEQ) contributed significant resources for developing some of the data presented in this Technical Memorandum.

- The WWDO and WRDS provided the WSGS with overall program guidance and standards, software, and format requirements for deliverables (maps, databases, metadata, tables, graphs, etc.).
- The WSGS was the primary compiler of the information developed in **Chapters 1, 2, 3, 4, 5, 6, 8, and 9**.
- The USGS, under contract with the WSGS, compiled the information used in **Chapter 7**, and associated **Section 5.6.1**.
- The WSGS and USGS cooperated on sections of **Chapter 5**.
- The WRDS provided assistance by providing hard copies of the final Technical Memorandum and will feature the associated deliverables on its website at <http://www.wrds.uwyo.edu> on behalf of WWDC/WWDO.

The WWDC, the water development planning agency for Wyoming, administers publicly-funded development, construction, rehabilitation, and related groundwater projects through its professional, legal, and support staff at the WWDO.

The WSGS is a separate operating agency under the executive branch of state government (W.S. 9-2-801, 9-2-803 through 9-2-810). The WSGS' purposes are:

- To study, examine, and understand the geology, mineral resources, and physical features of the state;
- To prepare, publish, and distribute (free or for sale) reports and maps of the state's geology, mineral resources, and physical features; and,
- To provide information, advice, and services related to the geology, mineral resources, and physical features of the state.

The agency's mission is to "promote the beneficial and environmentally sound use of Wyoming's vast geologic, mineral, and energy resources while helping protect the public from geologic hazards." By providing accurate information and expanding knowledge through the application of geologic principles, the WSGS contributes to the economic growth of the state and improves the quality of life of Wyoming's residents.

The USGS provides data, maps, reports, and other scientific information to help individuals, local and state governments to manage, develop, and protect America's water, energy, mineral, and land resources. The agency's mission is to "provide reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life." To meet these goals, the USGS employs experienced scientists and support staff from a wide range of earth and life science disciplines.

The WRDS is a clearinghouse for hydrological data. The WRDS is funded by the WWDO to provide a variety of services, including the online provision of groundwater resources information, maps, and publications.

The WSEO and WWDO cooperate on many projects. WSEO personnel attend meetings on river basin planning and other WWDC projects. WWDC-funded groundwater development projects generally require permits from both the WSEO and WDEQ (K. Clarey, WWDC, personal communication).

1.3 Legal and Institutional Framework

Wyoming laws that govern the appropriation, development, and beneficial use of water resources

are based on the doctrine of prior appropriation, commonly stated as “*first in time is first in right.*” This means that the first party to put a source of water to beneficial use has a “priority” water-right that will be honored prior to those of other users with later water-rights during periods of limited supply. A special provision is that municipalities can obtain water-rights from earlier priority uses through eminent domain under specific conditions. Because all waters within Wyoming are property of the state, a water-right does not grant ownership, but only the right to use water for beneficial purposes. Use of water resources for domestic and livestock purposes customarily take precedence over other uses. In Wyoming, water-rights are attached to the land but can be transferred. The laws and regulations pertaining to the appropriation, development, and beneficial use of groundwater are administered by the SEO and Board of Control comprised of the superintendents of the four state water divisions and the State Engineer. The entire Platte River Basin area is included in Water Division 1. Comprehensive discussions of the laws that govern Wyoming water resources are provided online at:

<http://seo.state.wy.us/PDF/b849r.pdf> and <http://seo.state.wy.us/PDF/b-969r.pdf>

1.3.1 Wyoming water law – groundwater appropriation, development, and use

Groundwater within the state is owned and controlled by the state of Wyoming. Under Wyoming law, groundwater includes any water (including geothermal waters) under the land surface or under the bed of any body of surface water. The SEO is responsible for the permitting and orderly development of groundwater in Wyoming and for protecting groundwater resources from waste. The updated Wind/Bighorn River Basin Water Plan (MWH, and others, 2010) provides the following discussion of Wyoming water law specific to groundwater:

“Wyoming’s groundwater laws were originally enacted in 1945 and amended in 1947. These laws were replaced by new groundwater laws on March 1,

1958, which were then amended in 1969. Groundwater is administered on a permit basis. The acquisition of groundwater rights generally follows the same permitting procedures as surface water rights, except that a map is not required at the time of permit application. Applications are submitted to and approved by the WSEO prior to drilling a well. With the completion of the well and application of the water to a beneficial use, the appropriation can then be adjudicated. The issuance of well permits carries no guarantee of a continued water level or artesian pressure.”

“As with surface water rights, groundwater rights are administered on a priority basis. For all wells drilled prior to April 1, 1947, a statement of claim process was followed to determine the priority date of the well. For wells drilled between April 1, 1947 and March 1, 1958, the priority date is the date the well was registered. For wells drilled after March 1, 1958, the priority date is the date the application was received at the WSEO.”

“Domestic and stock wells are those wells used for non-commercial household use, including lawn and garden watering that does not exceed one acre in aerial extent, and the watering of stock. The yield from these wells cannot exceed 25 gallons per minute (gpm). ... The Groundwater Division also issues permits for spring developments where the total yield or flow of the spring is 25 gpm or less and where the proposed use is for stock and/or domestic purposes.”

1.3.2 Interstate agreements

Flows are generally subject to strict water rights. Surface water resources of Wyoming are subject to interstate agreements that generally limit how much streamflow can be depleted before leaving the state.

Tributary interconnection between groundwater and surface water is a prominent water-rights issue in the Platte River Basin and conflicts among users within the state or across state lines can occur where groundwater extraction affects surface flows. In the Platte River Basin there are significant judicial and regulatory constraints on the development of groundwater pursuant to the “Modified North Platte Decree” and the “Platte River Recovery Implementation Program.”

In 2001 the Modified North Platte Decree between the states of Wyoming and Nebraska resolved decades of litigation over the water resources of the North Platte River Basin. In specific areas of the Platte River Basin, the Modified North Platte Decree restricts Wyoming diversions of groundwater with priority dates later than 1945 that are hydrologically connected to surface water. Criteria were developed under the North Platte Decree for identifying areas where groundwater is hydrologically connected. Based on these criteria, the SEO developed “green area” maps for the Modified North Platte Decree Committee; groundwater in the designated areas or which otherwise meets the Decree criteria is considered to be not hydrologically connected to surface water (**Figure 9-1**) for purposes of Decree enforcement. Groundwater prospects identified in previous studies (Lidstone and Associates, 2005b; Trihydro Corporation, 2004 and Trihydro Corporation, 2007a) that focused on developing potentially large-volume non-connected groundwater sources to augment surface flows are shown on the map inset on **Plate 2**.

In 1997, the states of Wyoming, Colorado, and Nebraska, and the U.S. Department of the Interior developed the Platte River Recovery Implementation Program (PRRIP) to address several issues under the Endangered Species Act (ESA) related to the current use and future development of Platte River Basin water resources. The PRRIP has two primary objectives:

1. To maintain, improve, and conserve water-dependent habitat on behalf of four threatened and endangered species, with populations located along the Platte River in central Nebraska.
2. To allow current use and future

development of water resources in the Platte River Basin to proceed without additional ESA requirements related to these threatened and endangered species.

Because the depletion of surface water resources through the use of hydrologically connected groundwater would impact habitats of concern, the parties to the PRRIP adopted the hydrological connection criteria from the North Platte Decree.

Appendix D (Hinckley, 2011) describes the background and history of the Decree and the PRRIP, and the criteria used for determining whether groundwater is hydrologically connected to surface water under these programs. Groundwater prospects located outside of the designated areas (in areas where groundwater and surface water “have not been” determined to be not hydrologically interconnected) may be developed depending on the results of site-specific hydrogeologic investigations performed consistent with the criteria outlined in the Modified North Platte Decree.

Furthermore, there are additional criteria used by the SEO to assess the depletive quantity of groundwater wells that are hydrologically connected to the surface water flows in the North Platte River Basin. If projected depletions from these wells are less than benchmarks specified by the SEO, the wells are approved to permit status if the State of Wyoming agrees to cover the depletions as described in the Wyoming Depletion’s Plan.

1.3.3 Wyoming water law – groundwater quality

The Denver office of the U.S. Environmental Protection Agency (EPA) Region 8 has primary control (primacy) over Wyoming’s public drinking water supplies. Wyoming is the only state in which EPA has primacy over drinking water systems. The EPA monitors water quality for the several hundred public water systems in Wyoming. Information on Wyoming’s public drinking water systems is available on the EPA Wyoming Drinking Water website:

<http://www.epa.gov/safewater/dwinfo/wy.htm>

Except on the Wind River Indian Reservation, the DEQ enforces groundwater quality regulations under the Wyoming Environmental Quality Act, with guidance from the Wyoming Environmental Quality Council. The DEQ administers provisions of the Federal Clean Water Act Amendment of 1972 (Section 208) that provide for water quality management by state and local governments, as well as provisions of the Federal Water Pollution Act, by developing a State Water Quality Plan approved by the EPA. In general, operations under the jurisdiction of the Wyoming Oil and Gas Conservation Commission (WOGCC), U.S. Bureau of Land Management (BLM), EPA, or U.S. Forest Service that cause groundwater contamination are referred to the DEQ; The WOGCC has jurisdiction over Class II underground injection wells dedicated to disposal of produced water from state and federal oil and gas leases, respectively.

1.3.4 Other agencies

The U.S. Bureau of Reclamation (BOR), an agency under the U.S. Department of the Interior, oversees and manages water resources specifically related to the operation of numerous water diversion, delivery, storage, and hydroelectric power generation projects built by the federal government throughout the western United States. The BOR cooperates with the SEO and the WWDC (primarily through the SEO), but as a federal agency has autonomy to execute some programs unilaterally. The BOR coordinates releases from Wyoming's reservoirs with the SEO. (K. Clary, WWDC, personal communication). Although not a primary area of concern, the BOR and the following other agencies are occasionally involved in groundwater resource issues:

- Wyoming Department of Agriculture
- U.S. Department of Agriculture
- U.S. National Park Service
- U.S Army Corps of Engineers
- U.S National Resources Conservation Service
- USDA Soil Conservation Service
- U.S. Office of Surface Mining, Reclamation and Enforcement
- U.S Bureau of Ocean Energy Management and the Bureau of Safety and

- Environmental Enforcement
- U.S Department of Energy
- U.S. Nuclear Regulatory Commission

1.3.5 Authorship

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