Hydrogeologic Analysis of the Water Supply for Challis, Custer County, Idaho

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Information Circular 60
ISBN 1-55765-114-0
2005

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SUMMARY

A hydrogeologic study of the Challis water supply was conducted by geoscientists with the Idaho Water Resources Research Institute's "Technical Assistance for Rural Ground Water Development Within Idaho" project. This study provides the town with hydrogeologic information to aid in the expansion of its water supply. It includes bedrock geologic mapping and analyses of the ground-water system and the three community wells.

Geologic mapping shows that gently inclined volcanic strata in combination with an extensive network of faults impose strong controls on how and where ground water flows. The volcanic rocks form a three-part stratigraphy. The lowest unit consists of basaltic lava flows. These lavas are covered by two successive accumulations of volcanic ash. The lava flows form a better aquifer because of abundant fractures and relatively low clay content. Abundant faults cut the volcanic strata and inhibit water flow along the original depositional layering, creating isolated fault-bound aquifers.

We recommend the following actions for Challis. Closely monitor upstream water use to assess potential sources of contamination and any infringement on the town's water right. Install water-level measuring devices in West Well No. 2 to routinely monitor water levels over time. Deepen West Well No. 2. The additional water likely gained by the deeper well may deplete the aquifer, but there will be enough time to monitor water levels in the aquifer and to assess the viability of using it for the long term.

The Challis domestic water supply is derived from four independent sources: surface water from Garden Creek and three partitioned ground-water aquifers. The two ground-water aquifers developed by West Well No. 1 and West Well No. 2 have low recharge volumes owing to the dry climate. Two water-level measurements collected from West Well No. 2 (1980 and 2002) suggest the possibility that water in the aquifer is depleting over time. Installing a monitoring device in this important well will address this possibility. West Well No. 1 produces reduced volumes owing to poor well design and high clay content in the aquifer. Relocating or redrilling this well to a deeper level will likely enhance yield. East Well No. 1, developed in unconsolidated river gravel, is productive and will likely remain a viable source.

Two factors impact the quality and quantity of Garden Creek surface water: upstream domestic or agricultural development, and the amount of annual precipitation. Monitoring new upstream water use will develop an accurate understanding of impacts to this fragile supply. Upstream contamination probably travels rapidly downstream because of clay-rich, paleo lake-bed sediments that provide a natural lining along much of the Garden Creek drainage.

INTRODUCTION

The incorporated town of Challis, the seat of Custer County, lies in the Salmon River valley at an elevation of approximately 5,000 feet (Figure 1). The town presently derives domestic water from a combination of surface water from Garden Creek and ground water from three wells (Figure 2). The quantity received from these sources marginally accommodates present needs, but cannot sustain future growth.

Our report summarizes results of a hydrogeologic study of the Challis water system undertaken by IWRRI

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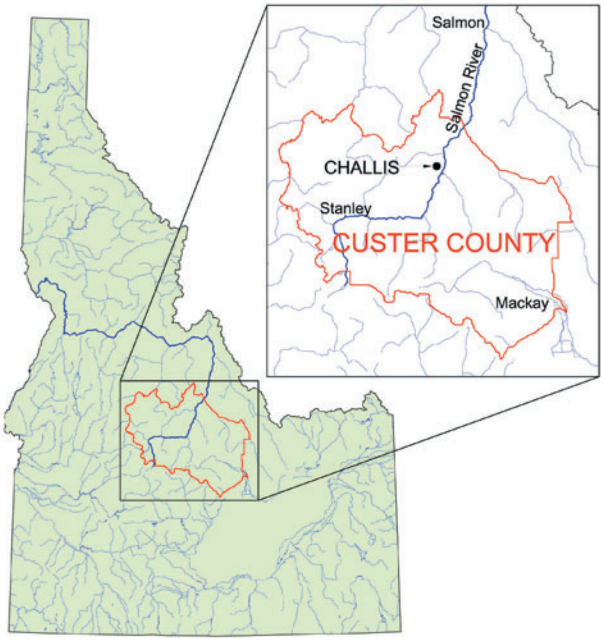

Figure 1. Location map of the Challis study area, Custer County, Idaho.

and the Technical Assistance for Rural Ground Water Development Within Idaho project to provide the town with information that could lead to the development of additional sources of water. To accomplish this goal, we mapped the geology surrounding the town, studied the geologic, hydrologic, and engineering aspects of the three municipal wells, and integrated this information with existing climatic data.

STATEMENT OF PROBLEM

Challis may experience growth in future years, due largely to increased tourism, and sustained growth will need a viable water supply. During certain times of an average year, the community uses its entire available capacity. Additionally, one well may be experiencing a declining static level, though incomplete historic water production data do not allow an accurate understanding of this possibility.

OBJECTIVES

This study provides Challis with technical information about its water supply so that the town can foster improvements to alleviate an apparent water supply deficiency. Additionally, recommendations provided herein will enhance the community's ability to collect accurate water usage data for future planning.

GENERAL GROUND-WATER CONCEPTS

The main points in understanding the ground-water system for Challis include the composition of the subsurface rocks that make up the water source or aquifer, the locations of recharge and discharge areas for the aquifer, and the sustainability of the aquifer.

Ground water collects and moves between individual grains of sand and gravel in an aquifer and through cracks and fractures in solid rocks. One of the keys to exploiting a ground-water resource is locating a zone where the spaces between grains or fractures are large and interconnected. In such a saturated subsurface zone, water moves under the force of gravity from higher elevations (recharge areas) to lower elevations (discharge areas). Most recharge comes from precipitation (rain and snow) that infiltrates the ground. Some recharge occurs from streams and lakes at elevations higher than the ground-water table. Generally, ground water moves down gradient less than 10 feet per day.

Understanding subsurface geology improves our knowledge of ground-water systems. Aquifers occur where ancient streams deposited sand or gravel or where an extensive network of fractures cut solid rock. Geologists study aquifers and ground-water flow patterns by mapping surface rock outcrops and reviewing well-drillers' logs of material penetrated by wells. This leads to identifying the potential areas for well construction and the recharge areas critical for good water quality and sustainability.

Sustainable development requires that ground-water use be less than aquifer recharge. Removing water from wells results in some water level decline in the ground and an associated reduction in natural discharge. Characterizing natural ground-water discharge from springs and seeps, estimating the discharge of interconnected streams, and defining the quantity and location of annual aquifer recharge provide the fundamental data for sustainable ground-water exploitation.

REGIONAL GEOLOGY

Several regional geologic features influence the hydrogeology of the Challis area. The town lies near the eastern margin of the Idaho batholith, near the northern margin of basin and range extension, and within the Eocene-age Challis volcanic field. This diverse assemblage

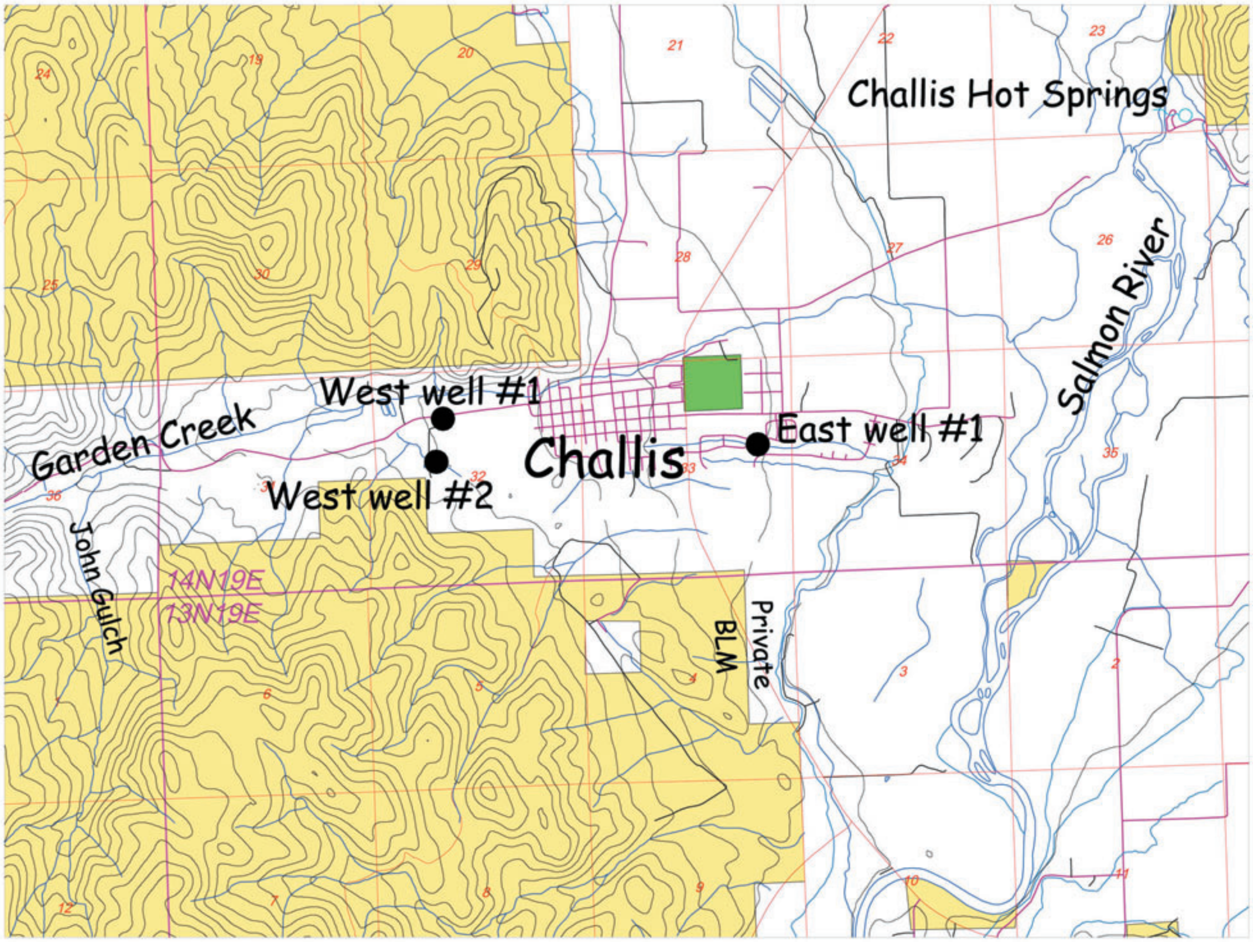

Figure 2. Location map of the Challis municipal wells.

of geologic environments provides a challenge to understanding the influence that structure and rock type play on the local area hydrogeology.

East-central Idaho lies in a geologic terrain dominated by Eocene-age volcanic strata. These rocks erupted 51-40 million years ago (McIntyre and others, 1982) onto a steep mountainous topography, similar to today's. The volcanic strata emanated primarily from stratovolcanoes and large calderas. Geologic mapping by McIntyre and Hobbs (1987) and Fisher and others (1992) shows the regional distribution of these strata.

Challis resides in a structural basin bounded on the east by the northern extension of the Borah Peak fault and on the west by a series of smaller parallel faults. Eocene-age volcanic strata near Challis were deposited in a proto-Salmon River canyon deeply incised into Proterozoic-age quartzite, suggesting that the Challis basin formed at least 50 million years ago.

PROJECT AREA GEOLOGY

Paleo-erosional patterns and the distribution of volcanic strata along the Salmon River near Challis show that the canyon formed by a combination of faulting and stream erosion during and before the eruption of the Challis Volcanics. Faults active at the time of volcanism, indicated by the distribution of vent-proximal facies, helped form the topography that largely controlled the thickness of volcanic strata blanketing the area. These volcanic rocks now tilt gently to the east, reflecting rotation during renewed faulting (Figure 3). The thickness, the distribution of strata, and the geometry of faults largely control the location, flow volume, and flow direction of ground water. Plate 1, constructed from original field mapping by the IWRRI project team, shows these relationships, and the following section discusses how they relate to the hydrogeology of the Challis area.

Figure 3. Photograph showing east-dipping pyroclastic strata immediately north of Challis. City Well No. 2 is in bottom left of picture; City Well No. 1 is just below left center.

STRATIGRAPHY

Strata of the Challis volcanic field in the study area include a lower unit of lava flows and two upper units of pyroclastic material. The lower unit of the pyroclastic strata includes deposits of unwelded to poorly welded volcanic ash (white beds in Figure 3). The upper unit consists of densely welded ash-flow tuff (reddish beds in Figure 3). Exposures of the basaltic lava flows occur along much of the Garden Creek drainage (Figure 4). The lower lava flow units are dark brown to gray; the middle ash unit is brilliant white to pastel green, and the upper welded tuff unit is typically bright orange to crimson red. Color, though generally not a reliable indicator of rock type, works well to identify the volcanic rocks in the Challis area.

Figure 4. Photograph showing an exposure of basaltic lava flows in Garden Creek.

Basaltic Lava Flows

Basaltic lava flows form the lowest unit exposed in the study area (Plate 1, unit *Tb*). The flow sequence has a varied thickness with an unknown maximum; based on map distribution, it is at least 1,000 feet thick in the Garden Creek drainage. Volcanic textures exposed in outcrops, such as pyroclastic spatter and spindle bombs incorporated into lavas, show that the flows emanated from nearby sources (Figure 5). This part of the sequence erupted approximately 50.3 million years ago (McIntyre and others, 1982).

The generally aphanitic lavas range from aphyric to plagioclase porphyritic. Colonnades and entablatures are generally not well developed, though outcrops show abundant cooling fractures, particularly in flow-brecciated parts. Flow boundaries are generally not visible, probably due to poor exposure. A dark brownish gray to black color on weathered surfaces distinguishes these rocks from the overlying pyroclastic strata. The basaltic lavas form most of the canyon of Garden Creek west of town.

Figure 5. Close-up photograph of mafic lava unit. The feature in center of photograph is a spindle bomb that was ejected from a nearby volcanic vent.

Dacitic Lava Flows

Dacitic lava flows occur locally above the basalts and form a subunit of unit *Tb*. Outcroppings of these lava flows are shown in Plate 1 by a distinct color. Their highly varied thickness ranges from less than 20 feet to an unknown maximum. They are thickest southwest of Challis where they erupted from fissure vents localized along normal faults. We mapped this unit separately from the basaltic lavas of unit *Tb* to better define the distribution of faults that pass beneath the town of Challis and to aid in determining the amount and direction of offset across these structures.

The basalt and dacite lavas underlie much of the recharge area for the aquifers that Challis uses. The joints that were formed during cooling and the fractures that were caused by post-depositional deformation occur throughout these units and provide avenues for entry and migration of ground water. West Well No. 2 is collared and terminated in unit *Tb* and is one of Challis's most important sources of water. The well is 605 feet deep and supplies an average of 450-500 gallons per minute.

Air-Fall Rhyolite Ash

The tuff of Penal Gulch, a white to pastel-green volcanic ash erupted from the large Van Horn Peak caldera complex northwest of Challis (Plate 1, unit *Tp*; McIntyre and others, 1982), lies depositionally above the basaltic lava sequence. When erupted, the ash was composed of very fine-grained shards of volcanic glass. Later, the glass devitrified and now forms an aggregate with abundant interstitial clay. The ash probably blanketed the area evenly immediately following eruption but was redeposited into topographically low areas, so its thickness varies as a function of the paleo land surface. Exposures in the Garden Creek drainage 3 miles west of town are less than 50 feet thick. The unit thickens progressively to the east, where immediately north of town it is over 200 feet thick (Figure 3). This change in thickness may indicate that the faults bounding the Challis Valley were active during the eruptive cycle, about 45 million years ago.

The ash section provides important controls on the distribution of ground water in the Challis valley. It has few open fractures or fluid pathways in outcrop and contains an abundance of clay, so it likely impedes groundwater flow. Erosion has stripped the unit away from most of the aquifer recharge area for the Challis water supply. Recharge water infiltrates the basalt aquifer, and as it travels down gradient, it likely flows beneath the ash section. The unit underlies much of the community and the Salmon River canyon near Challis, so it inhibits surface water from entering the underlying basalt aquifer in these areas. West Well No. 1 penetrates 92 feet of unconsolidated gravels and then cuts 125 feet of altered Penal Gulch tuff before entering the lower basalt lava unit (cross section BB', Plate 1).

Welded Rhyolite Ash-Flow Tuff

The uppermost volcanic unit in the study area is a distinctly red, cliff-forming unit named the tuff of Challis Creek (McIntyre and others, 1982; Plate 1, unit *Trt*). It erupted from the Twin Peaks caldera, a 12-mile diameter feature centered on Twin Peaks, west of town. The densely welded vitreous rock has a varied thickness, with a maximum of approximately 200 feet.

The unit commonly has abundant fractures in outcrop, so depending on location, it could be a viable aquifer. West of Challis, exposures generally occur on ridge tops, out of reach of recharge areas, or have been eroded away. The tuff underlies much of the Salmon River valley east of Challis, so it could potentially be recharged through overlying saturated gravel.

Unconsolidated Sediments

Unconsolidated sediments in the study area include landslide deposits, clay beds deposited from lakes, alluvial-fan gravels derived from nearby sources, and gravels deposited by flowing streams.

Landslides are common in the study area but generally do not influence the distribution or flow of ground water (Plate 1, unit *Qls*). One prehistoric slide, however, flowed into Garden Creek from the north, blocked the drainage, and formed a lake. Though the landslide dam has since eroded away, clay beds deposited at the bottom of the lake still occur along much of the Garden Creek drainage ("area of clay-rich soil" on Plate 1). The clay beds greatly impede the capability of Garden Creek water to enter the substrate and recharge the bedrock aquifer. Additionally, any contaminants entering Garden Creek upstream of the clay beds will tend to flow overland a greater distance rather than percolate and filter into the substrate.

The Salmon River has flowed through the Challis valley since at least middle Tertiary time based on the distribution of volcanic strata relative to older rocks. Basalt lavas and ash flows between Challis and Salmon fill an ancestral canyon carved into Precambrian-age strata and mark the course of the paleo Salmon River (unpublished mapping by B.R. Otto). Sand and gravel deposited from ancestral rivers occur below and interbedded with the volcanics, and similar deposits from contemporary river channels fill the valley above the volcanics. The Salmon River provides water to the gravels, recharging the aquifer used by Challis East Well No. 1 and numerous other wells in the central part of the valley. Similar gravels underlie tributary streams such as Garden Creek (Plate 1, unit *Qsg*).

Cone-shaped alluvial fans accumulate along mountain fronts in dry climates and are generally thickest along the range front near where streams emerge from incised canyons. They are composed of angular rock fragments embedded in a matrix of sand, clay, and fine-grained rock particles. Internally, the stratigraphy can be discontinuous, sinuous, and compositionally varied due to the temporal interplay of gravel deposited from flowing streams versus erosion and deposition from flash floods. These complicated stratigraphic patterns create an equally complex regime for ground-water flow. Challis lies on the upper end of an alluvial fan emanating from the mouth of Garden Creek (Plate 1, unit *TQfg*).

STRUCTURE

Faulting is principally responsible for landforms visible in the Challis area, including the Salmon River valley. Beyond these landforms, faulting also formed the present distribution and geometry of volcanic rock units underlying the area. The Challis basin is a half graben (Plate 1, Section AA'), bound on the east side by the northern extension of the Borah Peak fault (east of the area shown on Plate 1), which last moved in 1983. The Borah Peak fault and subsidiary structures drop rocks on the west side of the faults down relative to the east side. This relationship is visible in the strata exposed on the bluffs north of town, where the beds are gently inclined from west to east (Figure 3; Plate 1).

Mapped faults in the study area are numerous and conform to two general orientations. Most of the faults strike north-northwest and dip steeply to the west (Plate 1). A subsidiary set of faults strikes northeastward and dips northward. The pattern created by the intersection of these two sets of faults is rectilinear. The broken or gouge zones that occur in fault planes are commonly rich in clay and act to reduce or prevent the flow of water.

The migration of ground water down gradient, along the dip of the volcanic beds from west to east, may be interrupted by faults. The fault geometry defines a set of rectilinear blocks in which ground water cannot easily flow into strata of adjacent blocks. The concentration of lake-deposited clay beds along the floor of Garden Creek in combination with the presence of faults suggests that surface water in this segment of Garden Creek may not recharge strata adjacent to West Well No. 1.

HOT SPRINGS ACTIVITY

Water that resides at depth generally has an elevated temperature owing to the natural geothermal gradient of the earth, which averages 25°C/km (14°F/1,000 feet). For example, assuming the ambient temperature of water charging the thermal area is 54°F, water emanating from a thermal spring with a temperature of 100°F would have come from a depth below surface of about 3,300 feet. Hot springs occur where pathways through the rock, generally along faults, allow hot water to rapidly migrate to the surface. The hot and commonly corrosive water will interact with and alter rock exposed along the fluid pathway, changing the mineralogy of the rock. One of the most common styles of alteration from this process is the destruction of original minerals and, in their place, the development of clay.

We mapped several areas of hydrothermally altered rock from ancient hot springs activity. These areas contain an abundance of clay, a rock constituent that commonly impedes the flow of ground water. One altered area of note occurs northwest of West Well No. 1 north of Garden Creek. The drill log of this well indicates that these altered clay-rich strata extend beneath Garden Creek and into the well area. The presence of abundant clay in the well is likely part of the reason that it does not maintain a high rate of flow.

REGIONAL HYDROGEOLOGY

Rock composition and the type of occurrence of volcanic strata greatly influence a rock's capability to store and transmit ground water. Most volcanic strata have little intercrystalline porosity, so fractures probably host most fluid flow. Lava rock commonly contains abundant cooling fractures formed when the rock crystallizes from molten magma. Cooling fractures are less likely to form in low-temperature, air-fall ash deposits. At Challis, an aquifer in basaltic lava flows provides much of the community's water supply.

Three primary factors influence ground water hydrology of the Challis basin: climate; rock characteristics, including fracture density, porosity, and permeability; and the distribution of faults.

Challis lies in an arid part of the state and receives less than 10 inches of precipitation annually; greater amounts fall on the higher terrain west of town (Figure 6). Therefore, remote, higher elevation sources largely supply the water used by Challis.

Fractures created during deformation form preferentially in hard, brittle rocks. Three types of volcanic rocks in the Challis area fall into this category: basaltic lava flows, dacitic lava flows, and welded rhyolite ash-flow tuff. Ash-flow tuff fuses into a dense, vitreous rock after deposition. Low-temperature air-fall ash deposits commonly devitrify to clay, which helps the rock to deform without developing through-going fractures. Lava flows and densely welded ash-flow tuff generally create the best aquifers in volcanic rocks because they contain the greatest fracture permeability. The terrain surrounding Challis has an abundance of faults, which influence ground-water distribution and flow.

PROJECT AREA HYDROGEOLOGY

Our geologic mapping suggests that the gently inclined volcanic strata in combination with a rectilinear

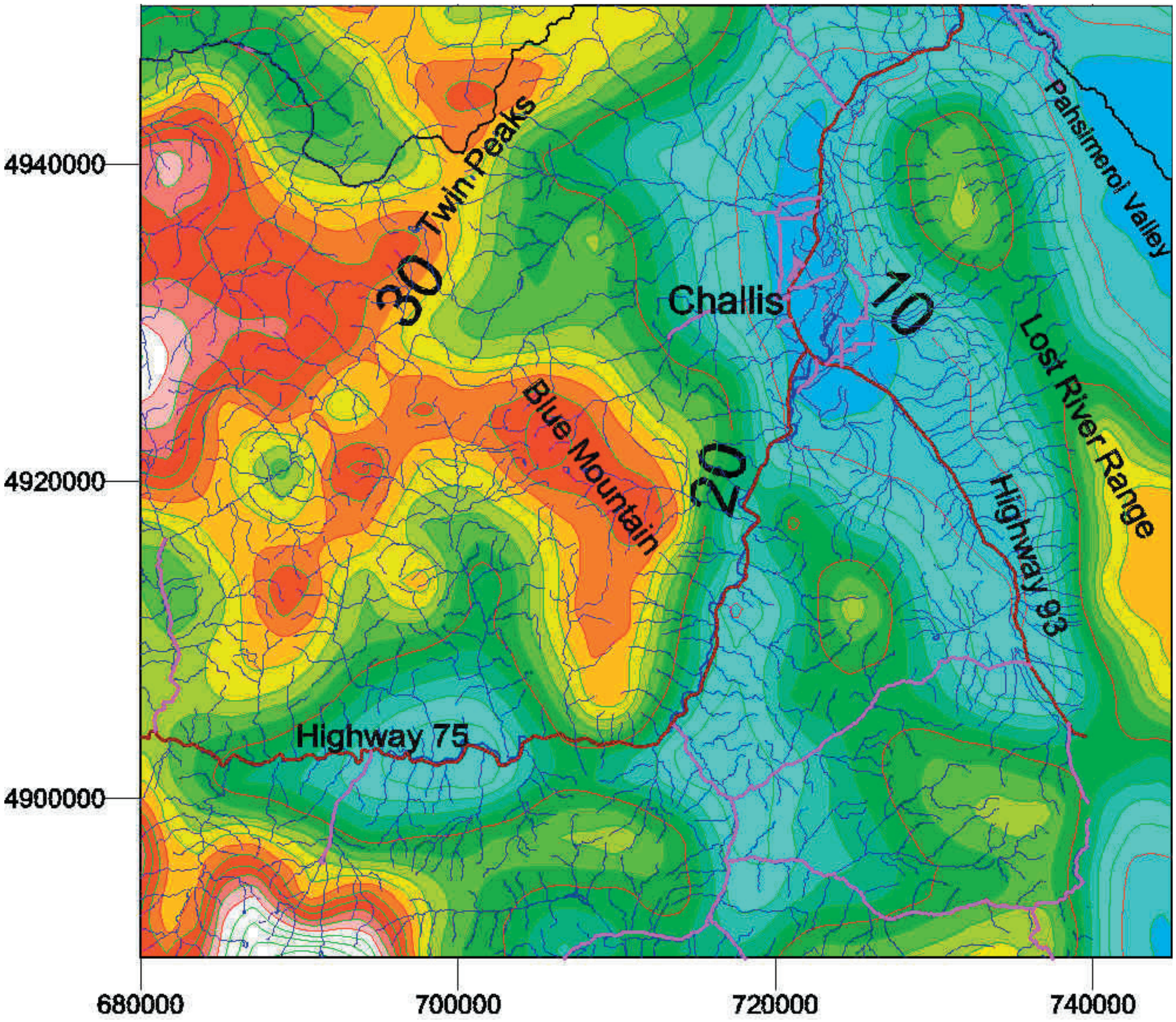

Figure 6. Annual precipitation in the Challis area (after Daly and Taylor, 2001). Values shown are in inches per year; coordinates are in UTM NAD27-11.

network of faults exerts strong controls on how and where ground water flows in the Challis basin. This, coupled with low recharge volumes due to the dry climate, provides a unique challenge in locating a sustainable source of water.

The town's water supply is derived from three independent sources: surface water from Garden Creek and two ground-water aquifers. Challis West Wells No. 1 and No. 2 penetrate an aquifer within fractured basaltic lavas. The second ground-water system, tapped by Challis East Well No. 1, occurs in unconsolidated sands and gravels that fill the Salmon River valley. A third ground-water system, not presently utilized, lies within shallow sand and gravel zones that underlie Garden Creek valley. The following section outlines each of these systems.

GROUND-WATER FLOW SYSTEMS IN VOLCANIC ROCK

The depth to water in West Well No. 2 when drilled in 1980 was about 317 feet below the surface. This measurement places the water level about 300 feet lower than in any surrounding well and suggests isolation from the surrounding aquifers (Figure 7). To check the water level, we collected a new measurement in West Well No. 2. We ran 450 feet of water level measurement tape down West Well No. 2 without finding any water. This suggests two possibilities: the water level could have dropped from 317 feet below the surface when the well was drilled to below 450 feet, or our tape hung on an obstacle in the well. The fact that the original static water level in West Well No. 2 was much lower than in the surrounding wells suggests this well taps a different

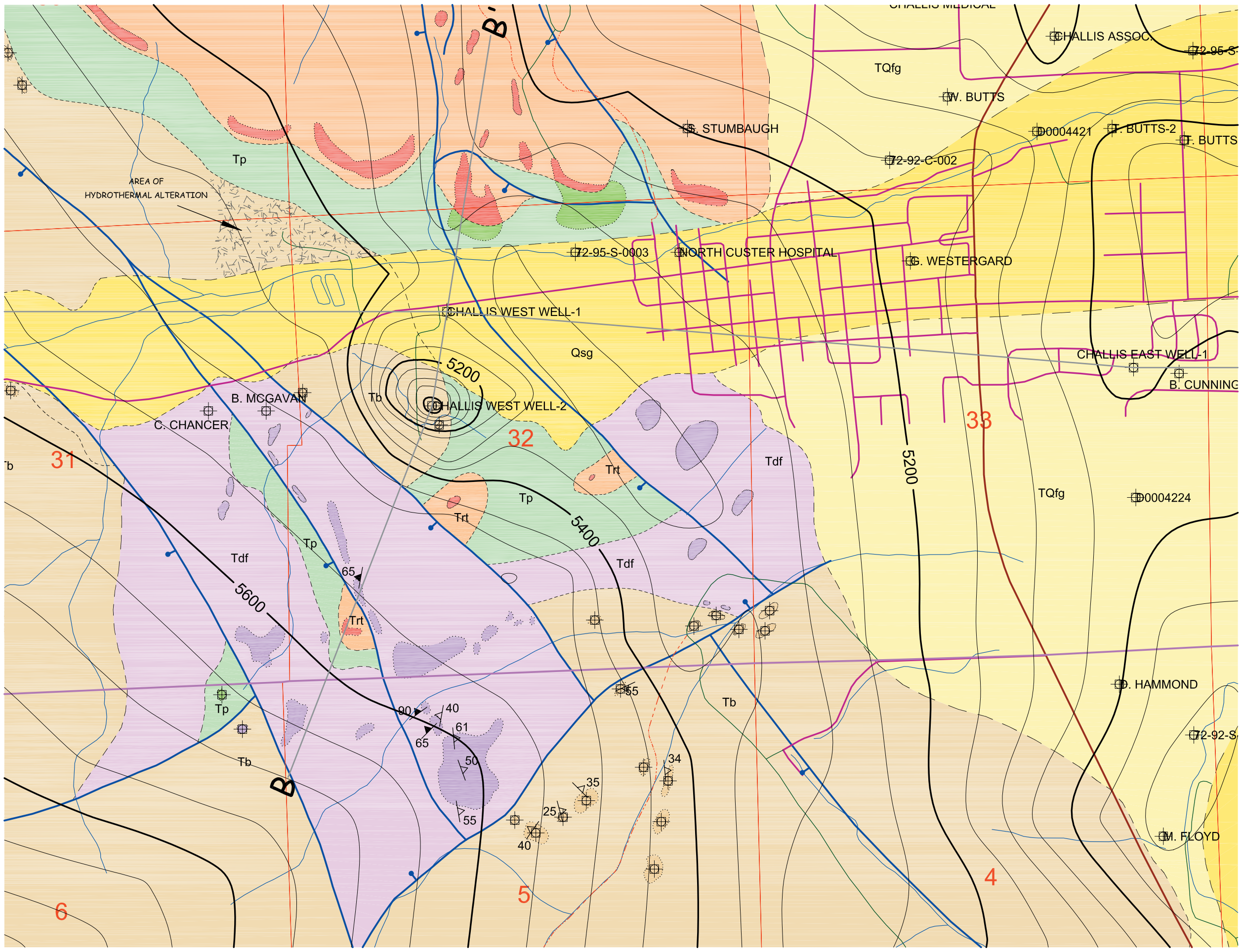

Figure 7. Water-table map of the Challis area. Contours indicate water table surface in feet; constructed from static water levels in wells and from elevations of perennial streams. See Plate 1 for explanation of map units.

aquifer than the surrounding wells. The relevant questions then are two: does this aquifer receive adequate recharge to supply Challis's demands, and from where does this aquifer receive recharge?

In the absence of supporting water level data, pumping rates can be used in a rather crude way to infer significant changes in water level. For a simple pumping system, when the pump turns on, some of the energy applied to the pump goes toward lifting the water from the aquifer to land surface, the rest of the energy goes toward maintaining the pumping rate. If the aquifer level does not fully recover because of inadequate recharge, then the next time the well pumps, a higher percentage of the energy must be used to lift the water from the aquifer to land surface, leaving less to maintain the pumping rate. These types of changes are often insidious and only observable over long periods. For example, a pump may pump at about 500 gallons per minute (gpm) today and tomorrow, but in five years it may only pump 450 gpm and in 10 years only 400 gpm.

Analysis of pumping records from West Well No. 2 failed to reveal evidence of long-term water level decline. Figure 8 shows pumping rate versus time for West Well No. 2 as recorded by Challis's municipal workers. The graph does not show a consistent decline in pumping rate commonly associated with declining water levels. In fact, current pumping rates occasionally exceed the rates recorded when the well was first put on line. These observations suggest that the aquifer penetrated by West Well No. 2 does receive some recharge.

Two significant sources of recharge exist in the Challis area: the Salmon River and Garden Creek. However, the graph of pumping rate in Figure 8 is inconsistent with an aquifer receiving recharge from spring runoff. If this were the case, water levels (pumping rates) would

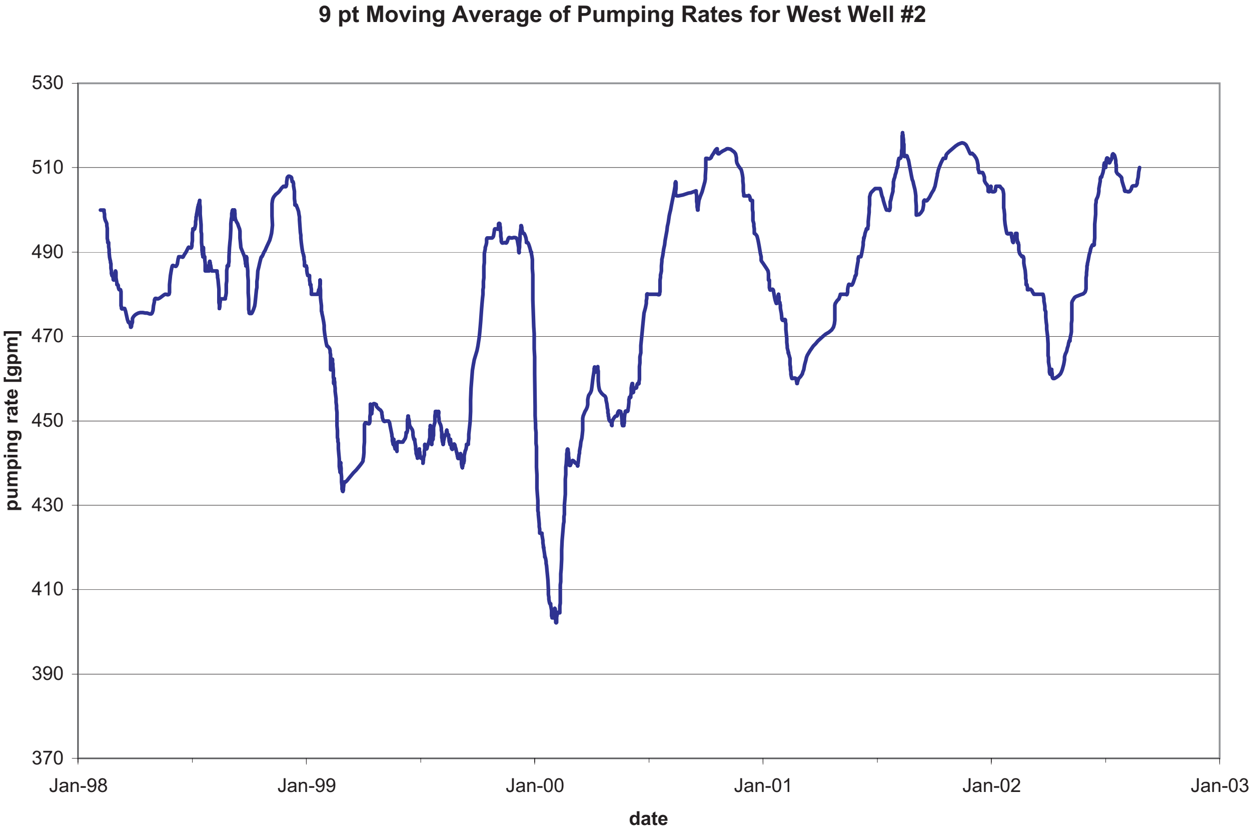

Figure 8. Graph showing pumping rate in gpm over time for West Well No. 2; constructed using data collected by employees of Challis.

peak in the spring. However, water levels expressed by pumping rates tend to peak during October or November rather than May or June, perhaps indicating that demand affects pumping rate.

Figure 9 shows pumping rate versus time and daily pumping volume versus time for West Well No. 2. Pumping volume peaks twice a year, in mid summer and mid winter. The annual peak for the pumping rate curve tends to occur between the midsummer and midwinter peak of daily pumping volume. The annual March minimum on the pumping rate curve also occurs at a minimum on the daily pumping volume curve. If the aquifer were not receiving recharge, the pumping rate curve would have two peaks opposite the minimums in the daily pumping volume curve. This analysis indicates that the aquifer tapped by West Well No. 2 receives recharge. If the aquifer received inadequate recharge to meet demand, there would be an overall declining trend in the pumping rate curve. Therefore, the available evidence fails to support the notion that the West Well No. 2 aquifer does not receive adequate recharge. However, this analysis hinges on using pumping rates as a proxy for real water level observations.

The source of recharge for the West Well No. 2 aquifer remains unclear. Since the static water level elevation in this well when drilled exceeds the elevation of the Salmon River (see cross-section B-B', in Figure 1), the Salmon River cannot act as the source of water for the well because water will not flow uphill. The Garden Creek drainage remains the only other possible recharge source (Figure 10).

GROUND-WATER FLOW SYSTEM IN THE SALMON RIVER VALLEY ALLUVIUM

No evidence exists suggesting that water level decline presents a major problem in the alluvial aquifer

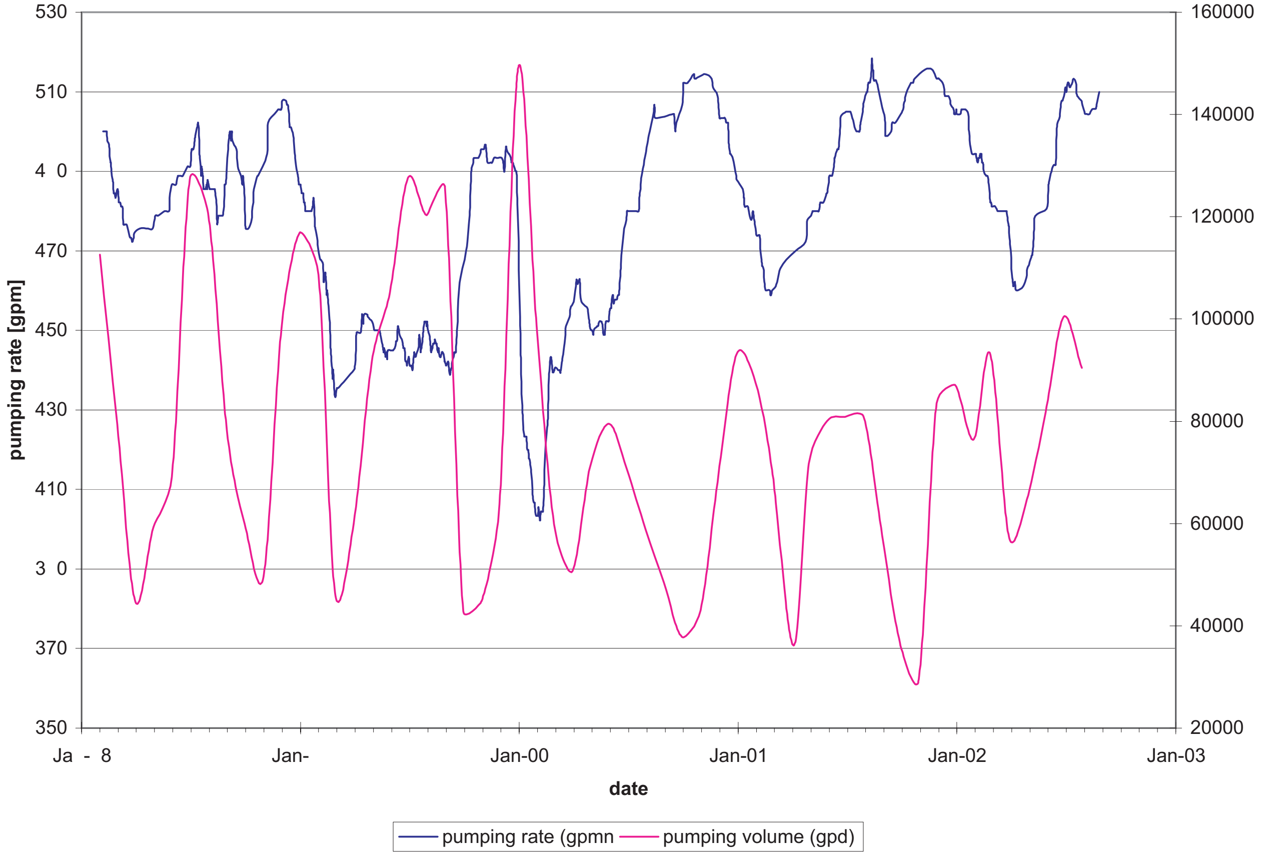

Figure 9. Graph showing pumping rate in gpm over time and daily pumping volume versus time for West Well No. 2; constructed using data collected by employees of Challis.

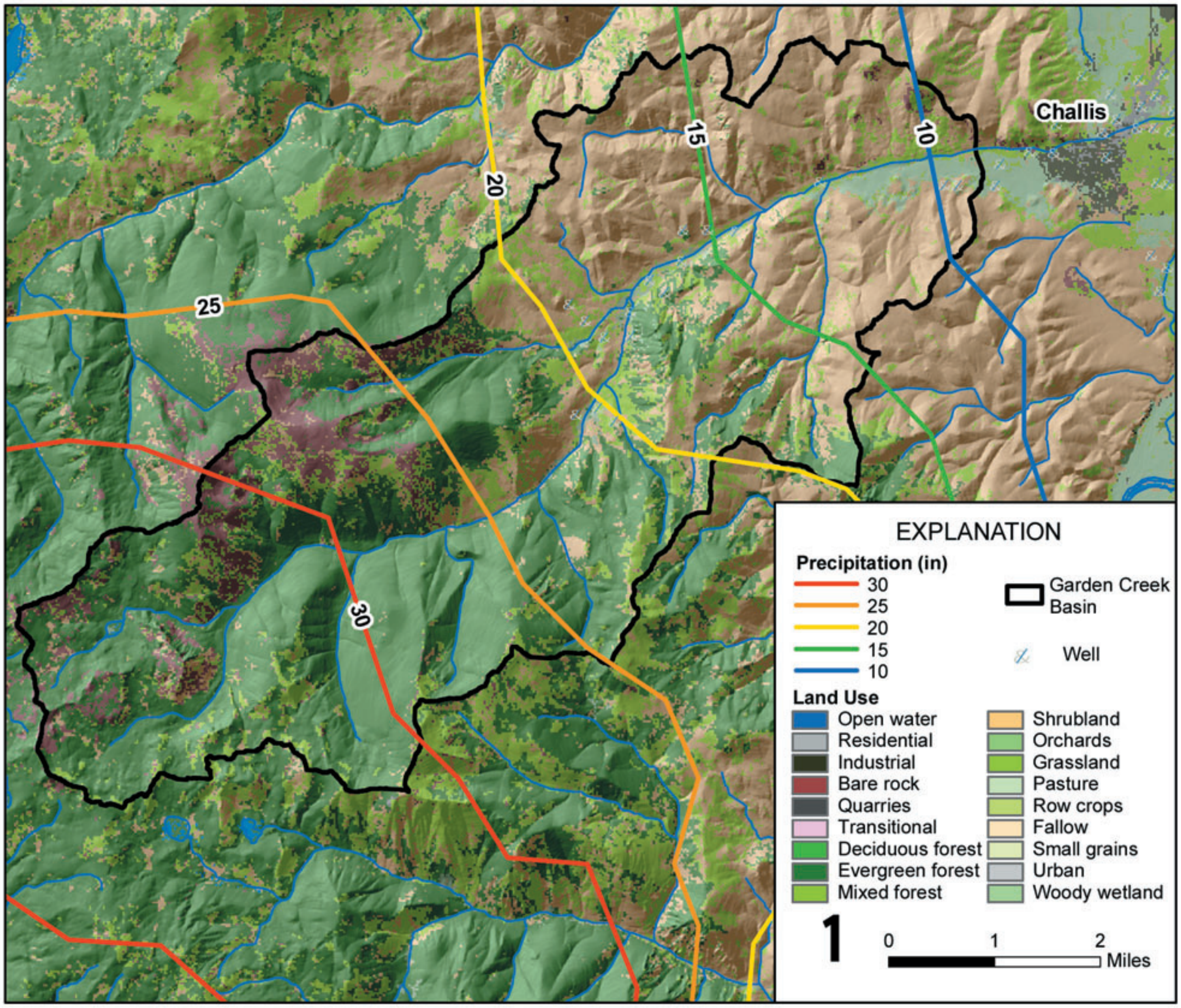

Figure 10. Recharge map for the Garden Creek drainage.

tapped by East Well No. 1. Figure 11 contains a hydrograph showing depth to water in East Well No. 1. Note the consistency between water levels in April and May of 2001 and those in April and May of 2002. In addition, the depth to water observed when the well was drilled in December of 1980 was 157 feet below land surface. The water level observed by Challis municipal workers in December of 2001 ranged between 159 and 165 feet below surface. This suggests that declining water levels pose no problems in the Salmon River Valley alluvium. Comparable historic and present water levels suggest that the Salmon River is the probable source of recharge. The elevation of the East Well No. 1 aquifer is nearly the same as the elevation of the Salmon River.

GROUND-WATER FLOW SYSTEM IN THE GARDEN CREEK VALLEY ALLUVIUM

Alluvial gravels underlie Garden Creek near West Well No. 1. The cross section along line B-B' in Plate 1 shows Garden Creek, West Well No. 1, and West Well No. 2. Garden Creek flows directly above a 90-foot-thick gravel aquifer in this area, indicating a direct hydraulic communication with Garden Creek. The viability of obtaining water from this alluvial aquifer depends on the amount of water in storage and the annual recharge received from Garden Creek. Potential exists to use this aquifer with a new shallow well or by modifying West Well No. 1.

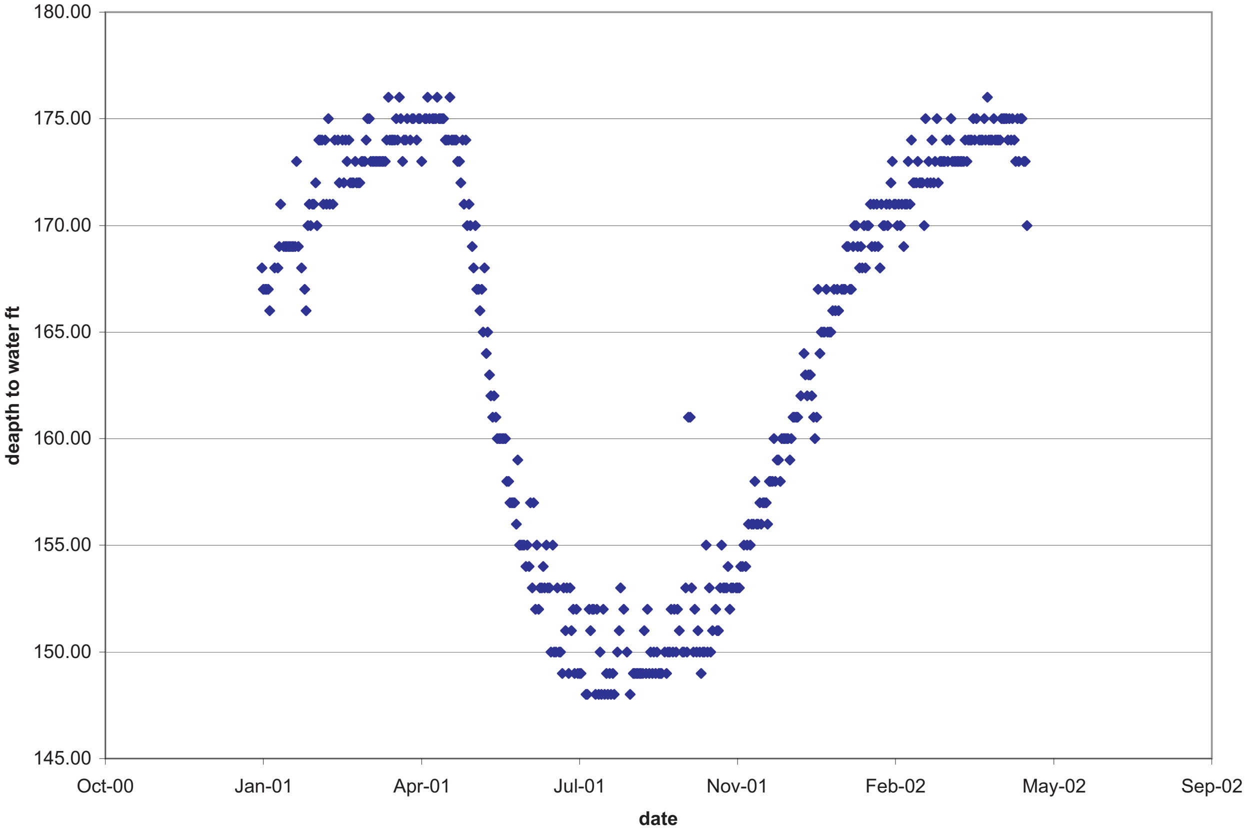

Figure 11. Hydrograph from East Well No. 1.

SURFACE-WATER FLOW SYSTEM

Garden Creek flows into Challis from the west (Plate 1; Figure 2). Diverted surface water flows from the stream through sand filters, is chlorinated, and then flows into the town's distribution system. Two factors impact the quality and quantity of this water: (1) upstream domestic or agricultural development and the use of Garden Creek water that reaches the town diversion, and (2) the amount of annual precipitation, particularly winter snowpack.

Figure 6 shows the annual precipitation of the Challis area. The map indicates that most of the water that flows through the Garden Creek drainage entered the hydrological system from higher elevation terrains to the west.

ANALYSIS OF WELL DEVELOPMENT

West Well No. 2

West Well No. 2, a reliable producer of quality water, penetrates an unaltered part of the lower basaltic lava unit. Long-term use of this well depends on present pumping rates in relation to average annual recharge rates. Available information gives conflicting evidence on this. First, based on one attempt to measure depth to water in this well, the water level may be in decline. If the water level actually lies below 450 feet in West Well No. 2, then water level decline poses a major problem. However, pumping rate measurements do not show a drop, which would be expected during water level decline. Accurate measurement of the static water levels in

West Well No. 2 will resolve this issue and should be a high priority for Challis.

West Well No. 1

West Well No. 1 is collared in stream gravels of Garden Creek and penetrates bedrock at a depth of 92 feet. Geologic mapping and a review of the drill log indicate that the well passes through welded tuff, air-fall tuff, and clay-altered basalt of the lower lava unit and ends in unaltered basalt. Though the lavas generally provide good flow rates, the presence of abundant clay in the altered basalt section may inhibit water flow into this well. The log indicates that a fault occurs at a depth of 520 feet, below which the well is in unaltered lava.

West Well No. 1 as presently constructed fails to produce adequate water. Plugging the lower part of the well and perforating the casing adjacent to the bottom 30 feet of alluvial material should significantly increase the yield. This option will increase the risk of contamination from surface sources.

Recharge for the West Wells

Collectively, the hydrologic systems (volcanic rock, Salmon River valley alluvium, and Garden Creek) supply adequate water to meet the town's current demands. Future development upstream of Challis on Garden Creek or within the town could upset the balance. Garden Creek remains the most likely source of recharge for the wells on the west side of Challis. This means that the maximum available recharge is the difference between precipitation in the Garden Creek drainage basin and evapotranspiration (ET), i.e., the water used by plants and lost to evaporation.

Figure 10 contains an outline of the Garden Creek drainage basin, land use, and precipitation contours. Total recharge, determined by summing the precipitation that falls in the basin, minus ET, determined by climate, ET coefficients, and acreage from the land use map, yields the available water. The available water for the Garden Creek basin is 4,738 acre-feet per year. The available unappropriated water, found by subtracting the amount of diverted water (municipal, domestic, and agricultural) from the basin yield, is about zero. This implies that nearly all water in the basin is appropriated. New upstream water use within the Garden Creek drainage will likely impact Challis. Accuracy of these types of calculations in mountainous terrains tends to be highly uncertain. Nonetheless, these calculations indicate that the volume of surplus water in the Garden Creek drainage is small.

East Well No. 1

Challis's East Well No. 1 penetrates 240 feet of alluvial fan gravel and then 50 feet of gravel deposited by the ancestral Salmon River. Water from the Salmon River recharges this aquifer. This large hydrologic system contains abundant storage and has a large recharge capacity. Although East Well No. 1 taps this robust system, we recommend continuing to monitor water levels to make sure demand does not exceed recharge.

RESULTS

The following discussion outlines possible options for Challis to develop additional ground water in these locations: gravels that underlie Garden Creek, the Salmon River gravel aquifer, and one of the other mapped compartments similar to that of West Well No. 1.

A shallow well (ground water diversion) from the Garden Creek gravel aquifer could probably replace the existing surface water system. As such, the resource would be available throughout the year and under fewer regulatory restrictions than the current surface water system. Pumping from this aquifer would directly deplete Garden Creek, so perhaps Challis could transfer its water right to a well or series of wells along Garden Creek. This strategy would enable the town to use this resource during the winter as well as summer, provided Garden Creek adequately recharges the aquifer. Treatment requirements for a shallow well near a stream depend on Idaho Department of Environmental Quality designations of whether the well is "under the influence of surface water" or "under the direct influence of surface water." These issues should be investigated in detail before any development of the shallow Garden Creek alluvial aquifer. This strategy could diminish recharge to the aquifer supplying West Well No. 2, so that the necessity to monitor water levels in West Well No. 2 will increase if this approach is adopted.

Drilling a new well along the east edge of the town should tap the Salmon River gravels. East Well No. 1 penetrates about 250 feet of unproductive fan gravels before intersecting the more productive Salmon River stream gravels. We recommend investigating IDWR requirements regarding water rights along the Salmon River before exploiting new targets in the Salmon River valley.

Targeting a new compartment within the volcanic rock aquifer will limit direct competition between West Well No. 2 and the new well. Locating the new well at least 500 feet east of West Well No. 1 should place it in a different structural compartment. This new compartment aquifer may or may not receive recharge, so monitoring water levels in such a new well must be a high priority.

RECOMMENDATIONS

The town of Challis should closely monitor upstream water use to assess potential sources of contamination or infringement on its water right. Additionally, the community should install water-level measuring instruments in each well and routinely monitor water levels.

The best approach for Challis to supply additional water in the 3- to 5-year period would be to deepen West Well No. 2. The town could also accomplish this by redesigning West Well No. 1 to tap water from the unconsolidated gravels in the upper 92 feet of the well. This would provide the time necessary to monitor well water levels in West Well No. 2 in order to create a long-term solution.

ACKNOWLEDGMENTS

This work was funded through grant number X97008601 from the U.S. Environmental Protection Agency (Region 10) to the Idaho Water Resources Research Institute at the University of Idaho. We thank the representatives of Challis for their contributions, and the Idaho Geologic Survey for providing peer reviews and publishing this work. The representatives from Challis include the town clerk, Betty Horn, and the water system operator, Jerry Moss.

The authors are alone responsible for the interpretations expressed in this document. These do not necessarily reflect those of the University of Idaho and IWRRI, the U.S. Environmental Protection Agency, or any other institution. Rather, they are observations shaped by our experiences in the field, study of the scientific and technical literature, and discussions with colleagues and the representatives of Challis.

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