Hydrogeologic Analysis of the Water Supply for Bancroft, Caribou County, Idaho

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SUMMARY

Elevated levels of nitrate and the presence of fecal coliform bacteria occur in the Bancroft water supply wells. A study was conducted by scientists with the Idaho Water Resources Research Institute's "Technical Assistance for Rural Ground Water Development Within Idaho" project to assist the town in mitigating this problem. The study provides hydrogeologic data that accommodate these specific objectives:

1. Delineate the aquifer that supplies water to the Bancroft wells, and locate the recharge area for this aquifer.
2. Determine possible sources of contamination that may cause water quality problems.
3. Identify possible targets for future ground-water development.
4. Determine the reliability of the new water supply source.

Bancroft lies in northwestern Gem Valley in Caribou County. Sedimentary rocks form the mountains adjacent to the valley. Basalt and unconsolidated fine-grained sediments fill the valley. These fine-grained sediments include sand, silt, and clay deposited by ancient lakes and streams. A clay-rich layer lies between basalt lava flows underneath Bancroft and probably protects the underlying aquifer.

Gem Valley contains a ground-water divide that distinguishes two ground-water flow systems. Ground water south of the divide flows southward and ultimately discharges to the Bear River. Ground water north of the divide flows northwestward and discharges to the Portneuf River. Bancroft is north of the divide, and ground water under the town flows to the northwest.

We compared nitrate levels in nearby U.S. Geological Survey (USGS) monitoring wells with the town's supply wells. This analysis showed localized nitrate contamination in the Bancroft wells. Contamination in the two supply wells likely results from nitrate and fecal-coliform-bearing water traveling above a clay-rich confining layer. These contaminants pass through the confining layer via poorly constructed wells and enter the source aquifer for the town.

The basalt aquifer offers a reliable water supply source for the town. Data from USGS monitoring wells indicate that water levels have remained constant over 74 years; evidence of adequate recharge for a sustained water supply. Well-yield data throughout the valley also show the aquifer is capable of supplying an adequate volume of water to the town.

Rehabilitation of the two supply wells may reduce aquifer contamination. However, insufficient well log data hinder a thorough analysis of this option. The safest course of action, therefore, is to develop new wells and properly abandon the current wells. New wells, if developed south of Bancroft, will eliminate possible sources of contamination within the town. These wells will require proper sealing to a depth below the clay-rich confining layer to prevent surface contamination from entering the aquifer.

INTRODUCTION

Bancroft, located in Gem Valley of southeastern Idaho, obtains domestic water from two wells: City Well No. 1 and Railroad Well No. 2 (Figures 1 and 2). These two wells serve approximately 450 people (IDEQ, 2002). City Well No. 1 is the primary supply of water, while Railroad Well No. 2 serves as a backup. Both wells derive ground water from a basalt aquifer that underlies most of Gem Valley.

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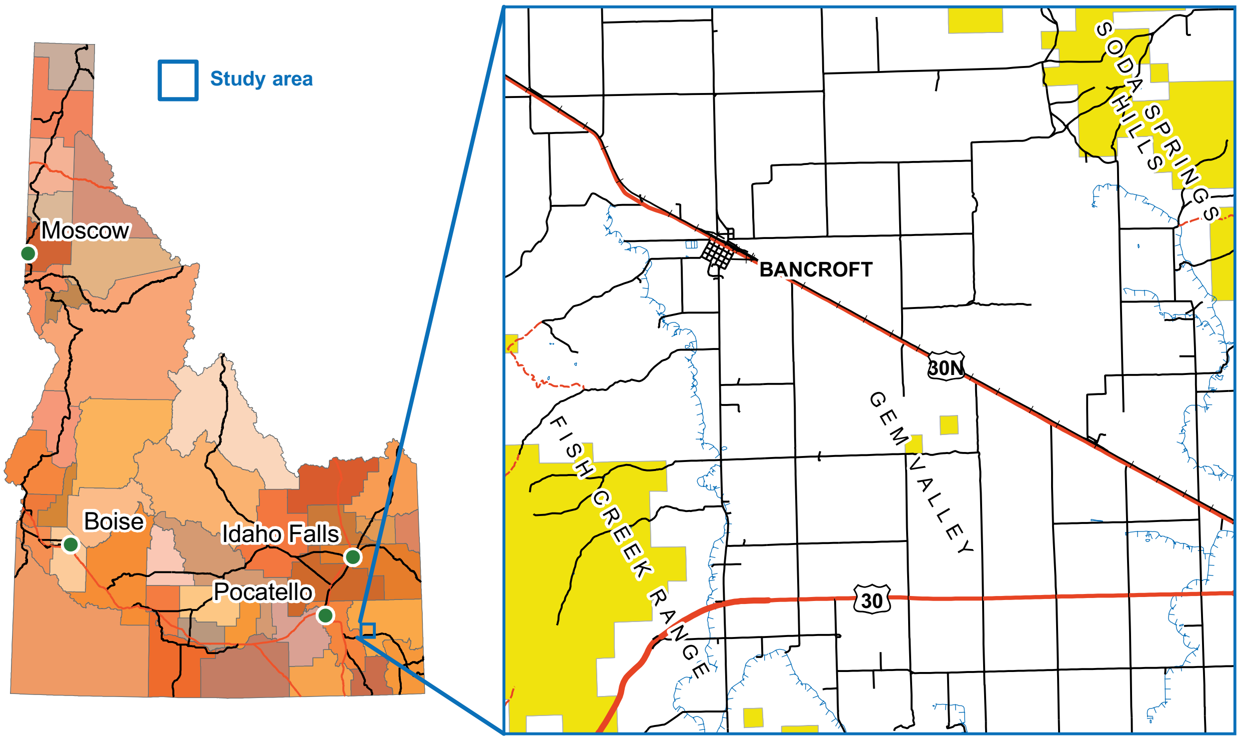

Figure 1. Location map of Bancroft, Caribou County, Idaho.

STATEMENT OF PROBLEM

Fecal coliform bacteria and elevated concentrations of nitrate in both wells cause water quality problems for the town. In addition, town officials are concerned about the location of both wells with respect to the Federal Emergency Management Agency's (FEMA) 100-year floodplain. In 1962 a large precipitation and melt event flooded most of Bancroft. As a result, FEMA defined a 100-year floodplain that includes the town (Figure 2). A well located within the floodplain may increase the risk of contamination from similar surface events.

OBJECTIVES

This project provides hydrogeologic information to Bancroft for future ground-water development. The study consists of two components: (1) an evaluation of the current supply wells and possible contamination sources and (2) a proposal for a new well location and construction techniques intended to minimize the risk of contamination. Specific objectives include the following:

1. Delineate the aquifer supplying water to the Bancroft wells and the location of recharge for the system.
2. Determine possible sources of contamination leading to potential water quality problems.
3. Identify possible targets for future ground-water development.
4. Determine the reliability of the new water supply source.

GENERAL GROUND-WATER CONCEPTS

The main points in understanding the ground-water system for Bancroft 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, called an aquifer, water in the substrate moves under the force of gravity from higher elevations (recharge areas) to lower elevations (discharge areas). Typical discharge areas include springs, streams, and lakes. Most recharge

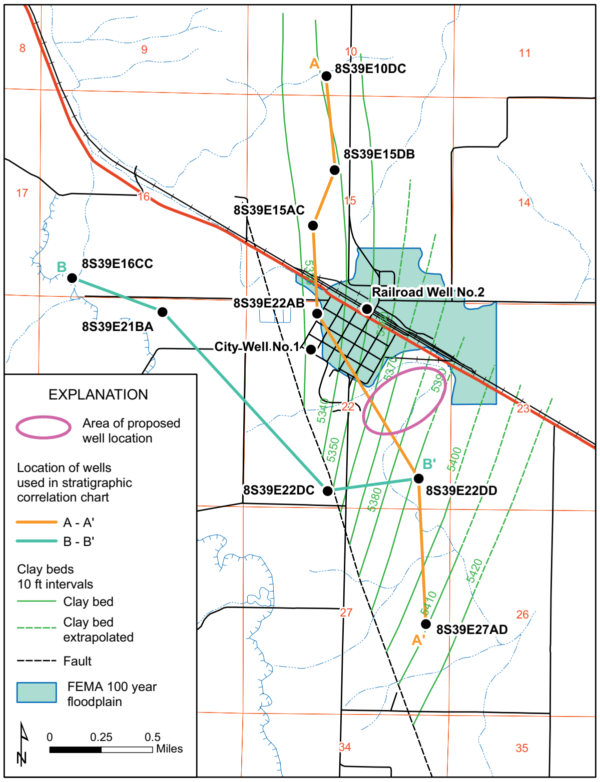

Figure 2. Underlying clay bed, location of wells used in the stratigraphic correlation chart, and proposed well location for Bancroft.

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 downgradient 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

Bancroft lies in northwestern Gem Valley between the Fish Creek Mountain Range and Soda Spring Hills (Figure 1). Deformed Paleozoic and Tertiary-age sedimentary rocks form the mountains, and basalt lava flows and unconsolidated fine-grained sediments fill the valley. These sediments include beds of sand, silt, and clay deposited from ancient lakes and streams.

Gem Valley, one of the many intermountain valleys in southeastern Idaho, formed as the Basin and Range physiographic province developed over the last several million years. Normal faults that formed during this period dropped the valley floor relative to the surrounding mountains, so rocks identical to those in the mountains underlie the valley floor at depth. Geologic and paleontologic studies by Bright (1963) show that Gem Valley contained a lake, named Lake Thatcher, from about 600,000 years to 30,000 years ago. Lake Thatcher predates glacial Lake Bonneville, which filled much of the western Great Basin 12,000 to 15,000 years ago. Clay-rich sediment with interlayered sand and silt settled from Lake Thatcher and now occupies much of the valley. Volcanoes formed contemporaneously and spilled basaltic lava flows into the lake. One of the larger volcanoes formed in Gem Valley due west of Soda Point. This vent, still visible today, provided enough lava to fill the valley above the level of Lake Thatcher. Topography formed by the volcano divides surface waters; northern Gem Valley drains north to the Portneuf River, while the southern part flows south in Bear River to the Great Salt Lake.

PROJECT AREA GEOLOGY

Drill holes and surface rock exposures show that basalt lavas and interlayered clay beds accumulated in the Bancroft area. The basalt flows vary in thickness with some flows over 50 feet thick (Bright, 1963). Shrinkage fractures formed when the lavas cooled and created pathways for ground water. Clay beds, deposited during periods of volcanic quiescence, formed less permeable "confining" layers between the fractured basalt flows.

Well logs reveal a confining layer of clay-rich sediment that may protect the aquifer underneath Bancroft.

Figure 3 correlates the geologic units identified in these wells. Section lines A-A' and B-B' shown in Figure 2 indicate the locations used in Figure 3. Figure 3 shows the correlation of the clay-rich confining layer between the wells, and Figure 2 shows the geographic extent of this bed. Since City Well No. 1 and Railroad Well No. 2 lack adequate data, we omitted these wells from the correlation analysis. These wells lie between wells 8S39E22BA and 8S39E22DD. A correlation of the clay bed between the latter two wells implies that City Well No. 1 should penetrate the bottom of the clay layer approximately 107 feet below ground surface. Railroad Well No. 2 should intercept it approximately 108 feet below ground surface. The clay layer probably protects surface contamination from infiltrating into the underlying basalt aquifer.

REGIONAL HYDROGEOLOGY

City Well No. 1 and Railroad Well No. 2 penetrate a basalt aquifer interbedded with fine-grained sediments. This important basalt aquifer provides drinking water to Bancroft.

Norton (1981) indicates that a ground-water divide, located near the Last Chance Diversion and the Extension Canal, separates Gem Valley into two flow systems (Figure 4). A northwesterly ground-water flow system discharges to the Portneuf River northwest of Bancroft, while a southerly flow system discharges to the Bear River through springs in Black Canyon. Leakage from the Last Chance diversion and Extension canal serve as the primary source of recharge into both systems. Leak-

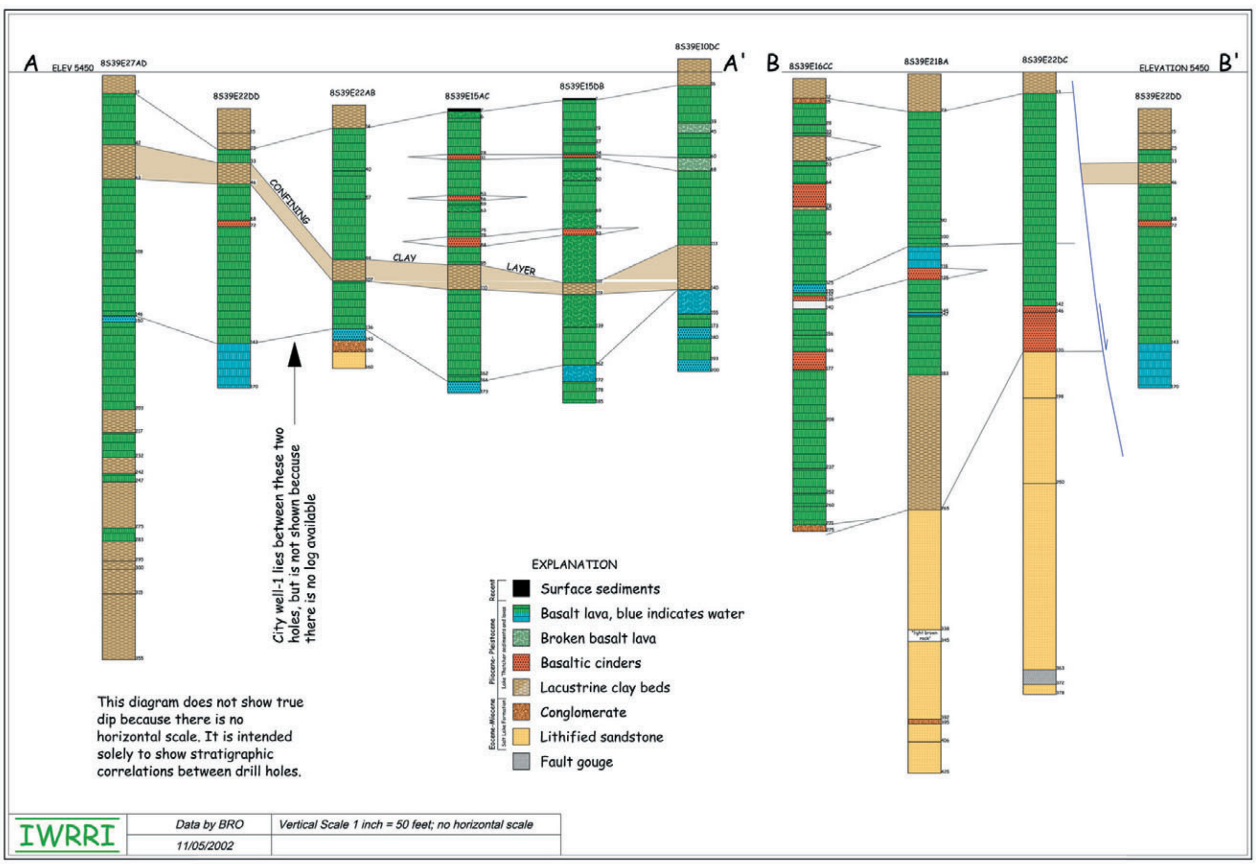

Figure 3. Diagram showing stratigraphic correlations between drill holes along lines A-A' and B-B' in Figure 2.

age from surrounding canals and precipitation falling on the Soda Springs Hills, Fish Creek Range, the Bear River Mountains, and the valley floor provide additional recharge.

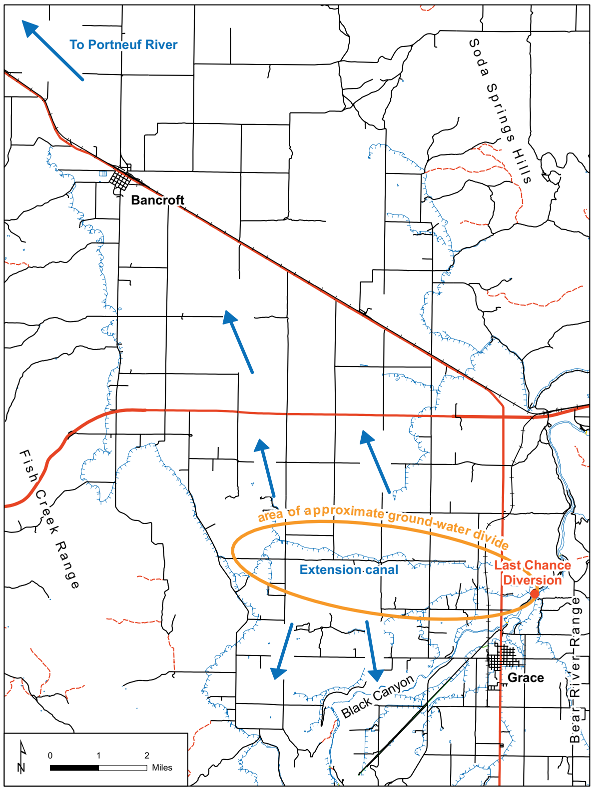

Figure 4. Ground-water flow direction and divide for Gem Valley.

PROJECT AREA HYDROGEOLOGY

Bancroft lies north of the divide where ground water flows to the northwest and discharges to the Portneuf River (Figure 4). Potentiometric contours of water in the basalt aquifer, derived from well log data, demonstrate that water flows north towards the Portneuf River. This supports Norton's (1981) interpretation of a northwestern ground-water flow direction (Figure 5). Leakage from the West Branch, Soda, and Extension canals and the infiltration of precipitation recharges the aquifer in northern Gem Valley. Additional recharge comes from irrigation water unused by vegetation.

A lack of information about well construction and historic water level measurements hinder an analysis of the two Bancroft supply wells. A well log is not available for Railroad Well No. 2; however, the source area delineation report 1 (IDEQ, 2002) indicates the well draws water from the same basalt aquifer as City Well No. 1. The log for City Well No. 1 describes the reconstruction when the town deepened the well in 1993. Information about depth and rock types before this work occurred is not available. Town officials noted that a part of the original well was hand dug. The reconstruction log shows the well was reamed from 6 inches to 7 7/8 inches between depths of 103 feet and 212 feet. The total depth of the well is now 212 feet, and the static water level is 97 feet below ground surface.

Projecting the 97-foot static water level along line A-A' (Figure 3) suggests the aquifer is confined. No wells along A-A' show a static water level above the clay layer. This shows that the aquifer is unconfined but may become confined during periods of increased recharge. In addition, no well logs indicate an aquifer above the clay bed.

Although the two supply wells lack sufficient data for analyzing the aquifer, the Idaho Department of Water Resources (IDWR) and the USGS provide static water levels for other nearby wells in the northern half of Gem Valley. Several wells monitored by the USGS indicate that water levels have remained constant over the past 74 years, thus providing evidence of adequate recharge for a sustained water supply (Figure 6). In addition to adequate recharge, well yields within the basalt aquifer, obtained from IDWR well logs, range from 20 gallons per minute (gpm) for individual domestic use to greater than 1,000 gpm for irrigation use (IDWR records; Figure 5). City Well No. 1 and Railroad Well No. 2 currently yield an adequate volume of water for Bancroft. These data provide evidence that a properly constructed well in the basalt aquifer can supply sufficient water to Bancroft.

WATER QUALITY ANALYSIS IN WELLS

The USGS provides data on water quality and static water levels for wells in Gem Valley. Elevated nitrate levels occur throughout the aquifer. Both City Well No. 1 and Railroad Well No. 2 measure close to the maximum contaminant level (MCL) of 10 mg/L and have higher concentrations than surrounding wells in the northern half of Gem Valley. Figure 5 shows locations of the USGS monitoring wells, the Bancroft wells, and the most recent nitrate concentrations. According to water-table contours, the USGS wells are located upgradient

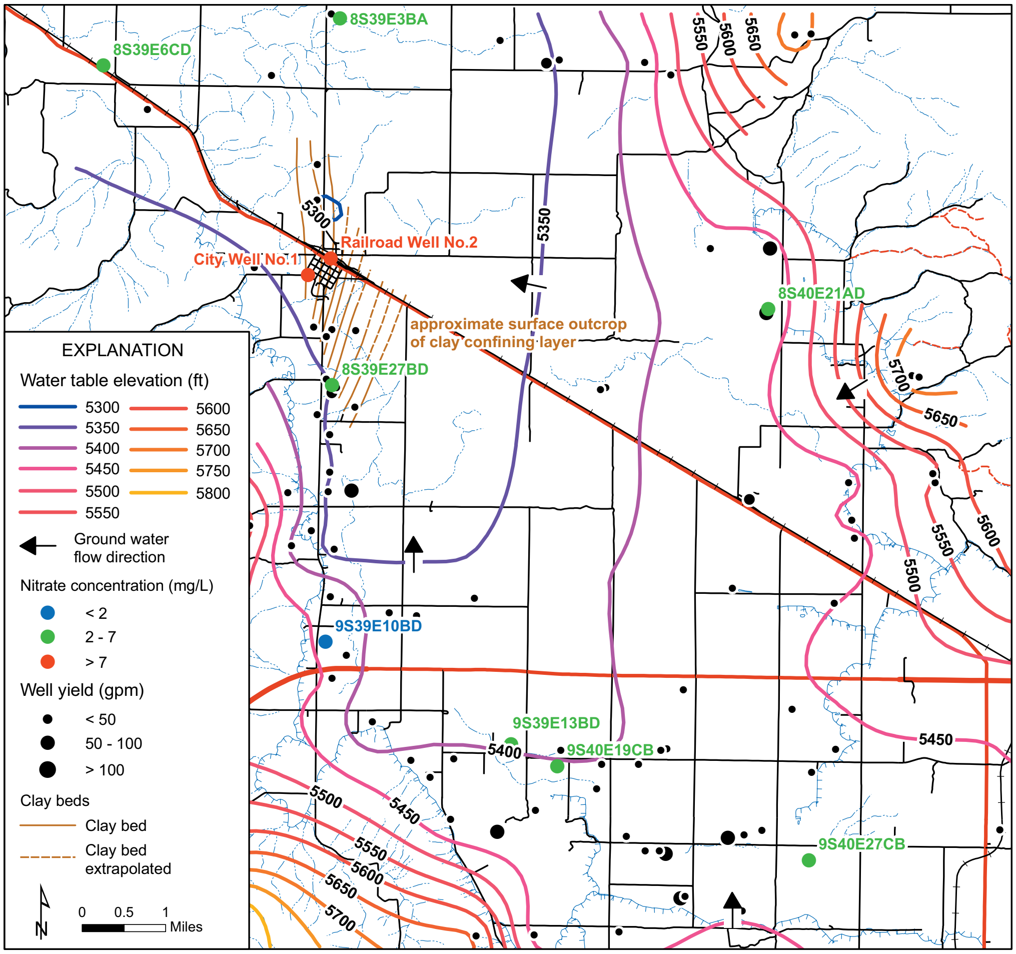

Figure 5. Water table, ground-water flow direction, and most recent nitrate concentrations in the Gem Valley area.

from City Well No. 1 and Railroad Well No. 2, and water flows toward the Bancroft wells. An analysis comparing USGS monitoring wells with those at Bancroft suggests the problem is well construction rather than nitrate contamination in the entire aquifer (Figure 7). Figure 7 suggests that both wells originally contained nitrate concentrations around the elevated background values of the aquifer. In recent years, however, nitrate concentrations increased in the town's wells, while other wells remained relatively constant.

Water quality analyses of the Bancroft water distribution system found fecal coliform present between July 1999 and August 2000. On 18 July 2000, laboratory analysis found fecal coliform in a sample from City Well No. 1. This result, in addition to elevated nitrate concentration, further suggests a well construction problem. Town officials have noted an absence of fecal coliform since the addition and regular use of a chlorination system. However, this recent absence only implies adequate disinfection and nothing regarding a clean water source.

The presence of fecal coliform and elevated nitrate concentrations pose problems to the long-term viability of the existing wells. Figures 2 and 3 show that Bancroft is above a clay-rich confining layer interbedded between basalt flows. This layer probably reduces vertical movement of any locally contaminated water, protecting the underlying ground water by forcing contaminants to migrate horizontally. Poor construction of the two town wells likely explains how contaminants enter the Bancroft water supply system.

Contaminants traveling above the confining layer probably pass through these clay beds via poorly sealed wells. Potential sources of contaminants listed in the source water assessment report (IDEQ, 2002) include underground storage tanks, above ground storage tanks, roads, and railroads. If leaks or spills should occur,

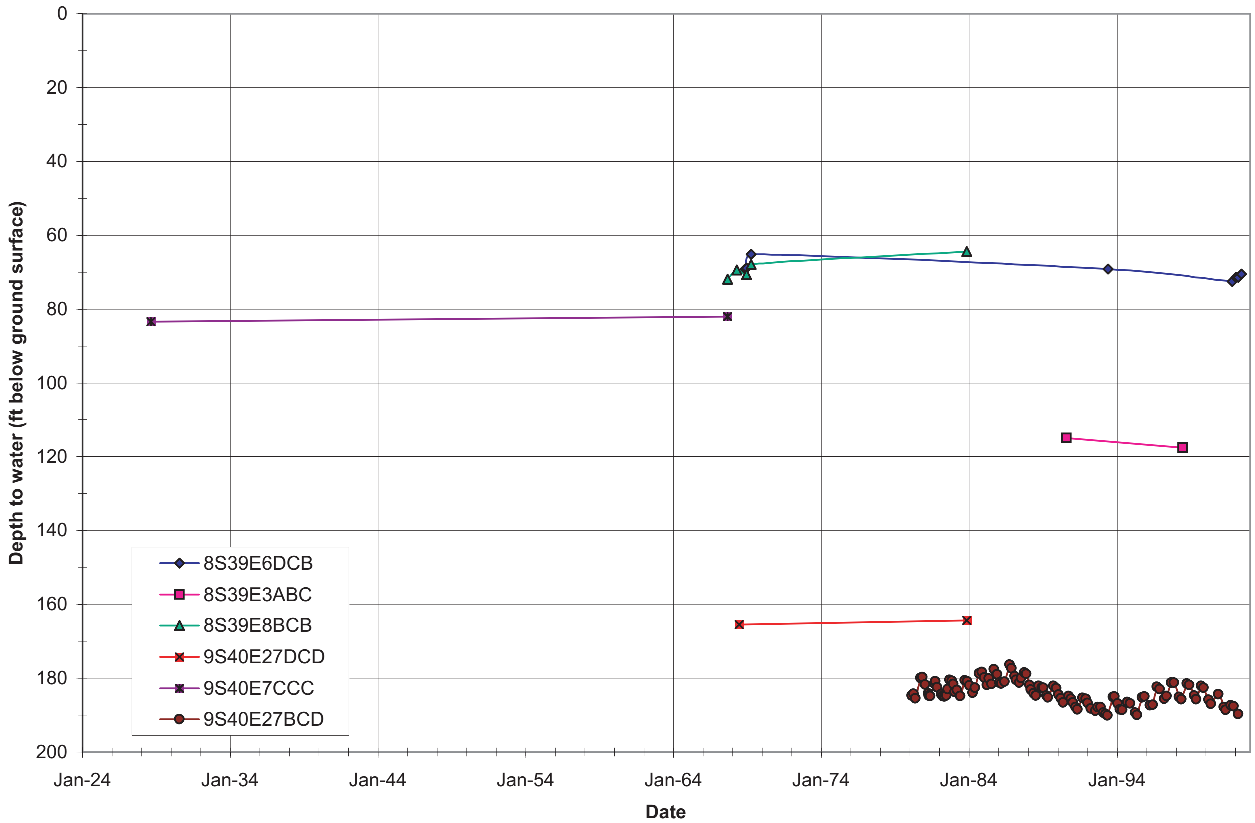

Figure 6. Ground-water levels for USGS monitoring wells within the Gem Valley area <http://idaho.usgs.gov/>.

contaminants could travel down poorly sealed wells through the clay layer and pollute the basalt aquifer. The agrichemical business southeast of town is another potential source of contamination not mentioned in the source water assessment report. Nitrate from this possible source would likely follow the flow path described above. The part of town northeast of the railroad uses septic tanks rather than the municipal sewer system. These septic tanks lie upgradient and may play a role in the nitrate contamination observed in the municipal wells. Contaminants residing southeast of the surface exposure of the clay beds pose concern because they may flow beneath the clay toward the proposed well (Figure 5). These sources include State Highways 30 and 30N, railroads, and agricultural lands.

RESULTS

Recharge and well yield data show that the basalt aquifer is the best available target for ground-water development near Bancroft. Adequate recharge occurs from a variety of sources and provides sufficient water to supply the town. Well-yield measurements obtained from logs of wells throughout Gem Valley show that a properly constructed well can provide the needed quantity of water.

We partitioned the Bancroft region into three potential areas for ground-water development to determine the best location for water from the only viable aquifer. These sites are northwest of town, northeast of the railroad, and south of town (Figure 8).

Contamination from the town that leaks through the confining clay layer, or leakage from sewage lagoons, may impact the quality of water in the aquifer northwest of town. These factors make this a high risk area for maintaining water quality. The extent of the clay-rich confining bed to the northwest is also unknown because of the lack of well data.

An advantage for the northwest area is the proximity to the water tank. This would reduce the cost of a lengthy pipeline compared to the other two potential drilling areas. Most of the area is outside the 100-year

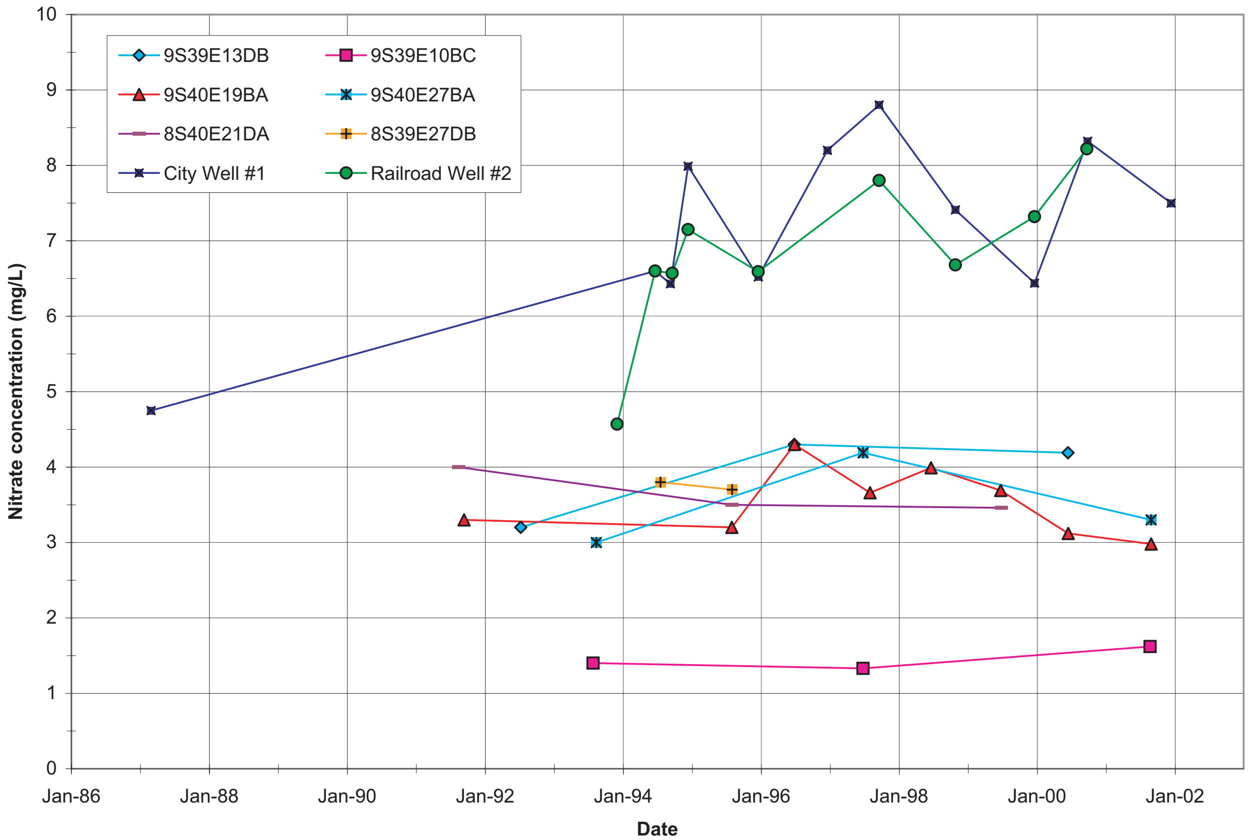

Figure 7. Nitrate concentrations for the Bancroft supply wells and USGS monitored wells <http://idaho.usgs.gov/>.

floodplain, thereby greatly reducing the risk of contamination by flood events.

A well located northeast of town may encounter several problems. This unincorporated part of town lacks central water or sewage lines, and residents there use septic tanks. Drain fields from the septic tanks may leach contaminants that could enter the aquifer. Most of the area is within the FEMA 100-year floodplain. Locations within the floodplain are more susceptible to contamination by surface water. The cost of constructing a pipeline under the railroad grade and Idaho highway 30N may be a major drawback.

An advantage for this area is the northwestward ground-water flow direction, which reduces the risk of any contamination coming from Bancroft. Potential contamination sources to the east and southeast of this area include only agricultural fields, the railroad, and roads.

The area south of town has one distinct disadvantage. The location will require an additional pipeline to connect the well to the water tank. Compared with the other two sites, the distance from the water tank may be the furthest, yet it does not require crossing the railroad grade.

There are several advantages to this area. Any contamination generated in town will have minimal influence because of the northwestward ground-water flow direction. The new well location is outside of the FEMA 100-year floodplain, reducing the impact of contamination from surface events. The town already owns and plans to develop a park in this area, so there is no cost associated with purchasing the land.

CONCLUSIONS AND RECOMMENDATIONS

The town should abandon the current supply wells following proper abandonment procedures. Proper abandonment is essential for minimizing on-going surface contamination to the aquifer via poorly constructed wells.

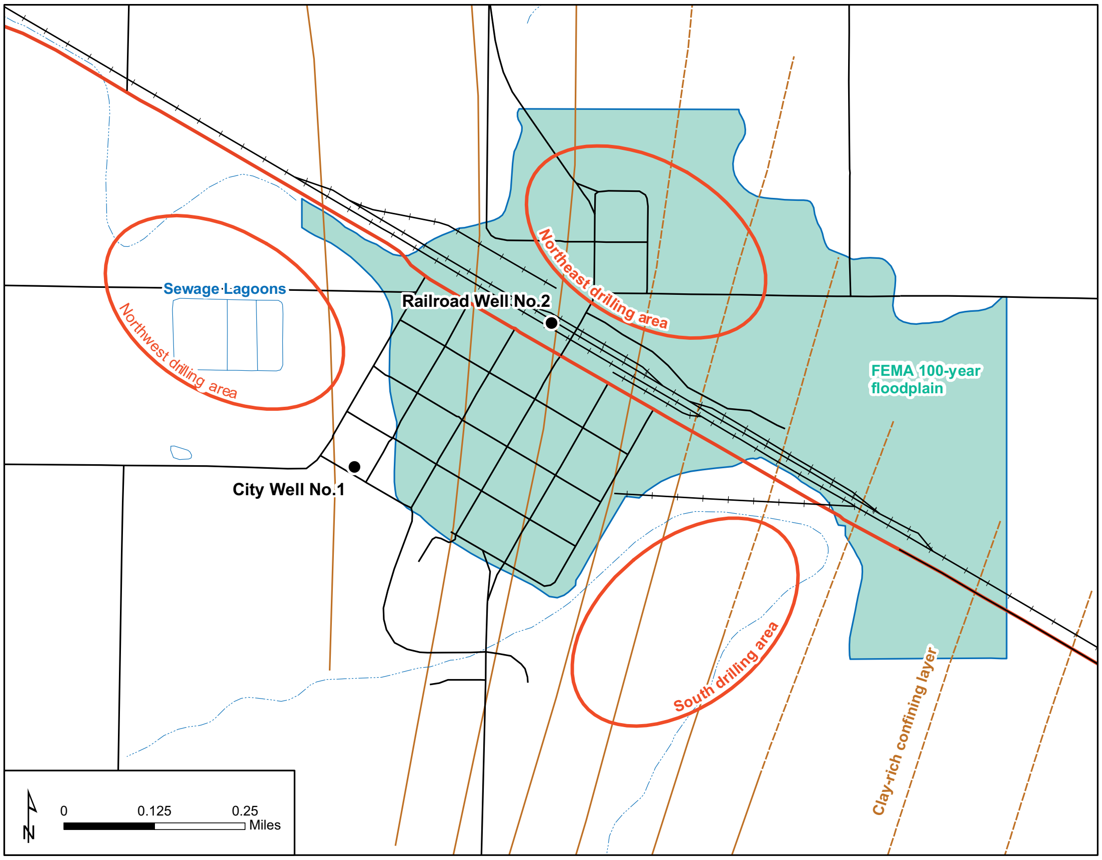

Figure 8. Three potential drilling areas for Bancroft.

We recommend the town drill south of town within the area of the new park (Figure 2). The clay-rich confining layer overlying the aquifer will provide protection from contamination if the town adopts proper well construction techniques. A high-solids bentonite grout or hydrated bentonite chips and pellets will provide the best seal and prevent ground-water contamination (Christman and others, 2002). The sealant must reach a depth below the confining layer to prevent contamination. In the recommended target area, the projected depth onto line A-A' (Figure 2 and 3) to the bottom of the clay-rich confining layer is 68 feet. The specific depth, however, should be determined by the depth to the clay layer when drilled.

ACKNOWLEDGMENTS

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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 Bancroft.

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