HYDROGEOLOGIC ASSESSMENT OF THE INGOMAR WATER DISTRICT WATER SUPPLY SYSTEM FOR GROUND WATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

Open-File Report MBMG 401-K

INGOMAR WATER DISTRICT
PWSID #03078
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Prepared
for
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Water Quality Division

by
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INTRODUCTION AND PURPOSE

This report summarizes the results of a hydrogeologic assessment for the Ingomar Water District (PWSID #03078) located in east-central Montana, between Melstone and Forsyth, Montana on Highway 12. The Montana Bureau of Mines and Geology (MBMG) is under contract with the Montana Department of Environmental Quality (DEQ) to conduct preliminary assessments and hydrogeologic assessments for selected community water supplies. The project was funded under DEQ contract number 430007 task order number 7.

The purpose of conducting this hydrogeologic assessment is to determine if the water supply source used by the Ingomar Water District is under the direct influence of surface water as defined in 40 CFR part 141. A field inspection was completed on June 18, 1998 with Mr. Erik Erickson, the water system operator. **The results of the assessment indicate that the Ingomar Water District may be under the direct influence of surface water as defined in 40 CFR part 141, due to system construction which includes an infiltration gallery to collect shallow ground water.** This report summarizes information obtained during the field inspection that was used to make the above determination. Information on system location, construction, geology, hydrology, and water quality are summarized. Conclusions and recommendations are presented at the end of the report. Site-access maps and photographs taken during the site inspection are provided as appendixes.

BACKGROUND

The Surface Water Treatment Rule (SWTR) of the Federal Safe Drinking Water Act of 1986 requires each state to examine public water supplies using ground water, to determine if there is a direct surface-water influence. In Montana, the Water Quality Division (WQD) of DEQ is evaluating public water supplies for the SWTR. This project is known as the **Ground Water Under the Direct Influence of Surface Water (GWUDISW) program**. The SWTR defines ground water under the direct influence of surface water as:

Any water beneath the surface of the ground with:

i) significant occurrence of insects or other macroorganisms, algae, or large diameter pathogens such as *Giardia lamblia*, or *Cryptosporidium*; or

ii) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity or pH, which closely correlate to climatological or surface water conditions.

The evaluation begins with a preliminary assessment (PA). If the PA indicates that the ground-water supply may be under the direct influence of surface water, further study is required. Further study may include conducting a hydrogeologic assessment (HA) (this report) a water quality assessment, and/or conducting microscopic particulate analysis (MPA) sampling.

PRELIMINARY ASSESSMENT

Montana Department of Environmental Quality (DEQ) records show the Ingomar water supply source is a spring. During the HA investigation it was discovered that the spring site was reconstructed in 1984 and is now a 30 foot deep cased well. In about 1993, an infiltration gallery was connected to the well to provide an additional source of water. The well is the only water supply source for the Ingomar water system. The water system was assigned a total score of 95 points on the preliminary assessment. A completed preliminary assessment form is included in appendix A along with a well-head protection inventory sheet. The system was assigned 40 points because an infiltration gallery is attached to the well. Another 15 points were added for three acute Maximum Contaminant Level (MCL) violations of the coliform bacteria standard from samples collected from the water-supply system, 10 points were added for 5 non-acute MCL violations of the total coliform rule over the last 3 years and 5 points were added for verified turbid conditions detected in two samples over the last 3 years. The open interval of the well begins at 23 feet below the land surface (the casing is opened at the bottom) adding 15 points because the open interval is less than 25 feet below the land surface. An additional 10 points were added because the static water level in the well is less than 50 feet below the land surface. **The score of 95 points out of a possible total of over 200 indicates the system is at moderate risk of being under the direct influence of surface water**. Because the score is above 40 points additional evaluation is required under DEQ guidelines.

SYSTEM DESCRIPTION

Location

The town of Ingomar, Montana is located in northwestern Rosebud County along Highway 12, 40-miles northwest of Forsyth, Montana. The town site is located in section 31, T. 10 N., R. 35 E., on the Ingomar East and Ingomar West 7.5-minute U.S. Geological Survey (U.S.G.S.) topographic quadrangle maps (USGS 1960 and 1980) (Appendix D, map 1). The water supply well is located 2½ miles northwest of town at the NE¼ NE¼ NE¼ SE¼ section 23, T. 10 N., R. 34 E. on the Ingomar West 7.5-minute USGS topographic quadrangle map (USGS, 1980)and at 46° 36' 20", 107° 23' 55". The well is M:1746 in the Ground-Water Information Center (GWIC) database at the Montana Bureau of Mines and Geology (MBMG).

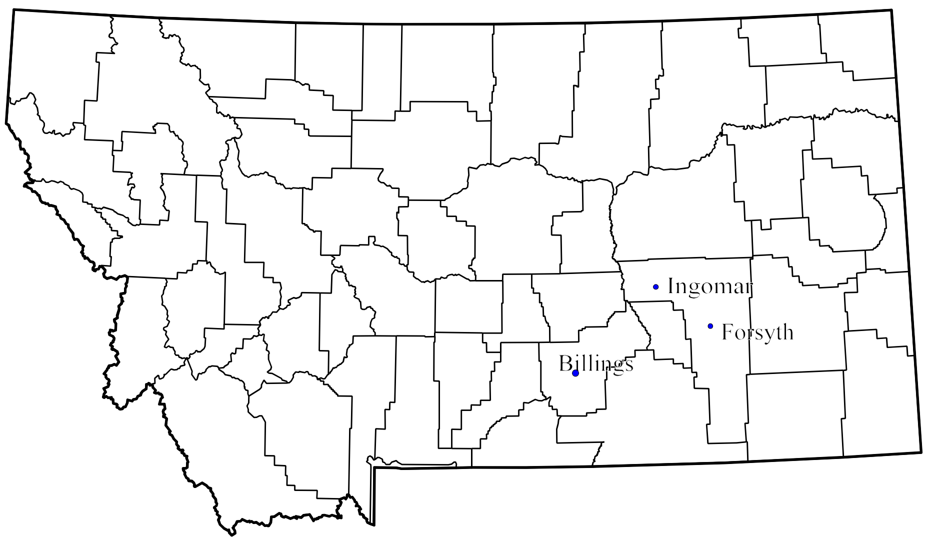


Figure 1. Montana state map showing the location of Ingomar, Forsyth and Billings.

Source History

Ingomar was founded as a sheep shearing and shipping center along the Milwaukee Railroad in the early 1900's. For a short time Ingomar was the largest sheep shipping center in the world. Sheep ranching declined in the early 1930's and the town became a small residential and school center for the surrounding ranches.

Historically, locating ground water of tolerable mineral content and adequate quantity has been difficult in the Ingomar area. For many years the town’s water was supplied from a water tender maintained by the Milwaukee Railroad. The railroad line is now abandoned. Mr. Eric Erickson, the system operator, noted that during the 1920's a series of shallow wells with good water production were dug just west of the present water district well. At one time the wells were being considered to supply water to the town but for some reason that was never done. The wells are now abandoned and no sign of them exists.

The Ingomar water-system well is located on land formerly owned by the Northern Pacific Railroad, the Milwaukee Railroad, and later the Burlington Northern Railroad, and is presently owned by the Sun Coulee Ranch Corporation. The well site was originally a spring developed by the Northern Pacific Railroad to water livestock. A shallow, hand-dug well was completed to 7 ft below ground level (BGL) at the spring discharge site in the early 1900's and was used for stock water until the 1980's. In the early 1980's the town of Ingomar purchased the water rights for the well for the town's public-water supply. In 1984 the town contracted a Billings engineering firm (name unknown) to design and construct a water distribution system from the well to town. During water system construction the old, hand-dug well was deepened to 30 feet BGL and cased to a depth of 23 feet. Recharge to the well from the sandstone bedrock in the bottom of the well ranges from about 500 gpd (gallons per day) to a maximum of 1200 gpd during peak flow periods.

The Ingomar Water District water-supply system has had a history of bacterial contamination problems (McNenny 1995; Rosa 1987a, 1987b). Mr. Erik Erickson, the water system operator, reported that water samples analyzed in the last 2 years (1997 and 1998) have been clean with no problems detected. Montana Department of Environmental Quality (DEQ) records also show no violations in the last 2 years.

Well and water distribution system

The spring/well site is located at 3,250 feet elevation along the south slope of a shallow coulee in hills about 2½ miles northwest of Ingomar (Appendix D, map 1). The land surface at the well is covered by colluvium, which overlies bedrock of the Fox Hills Formation (Appendix B, photo 1). The well is accessed by using the Sun Coulee Ranch manager's driveway. Donald John Cameron is the ranch manager; the Cameron house is located about one-quarter mile below the water-system storage tank and is the first house connected to the water-supply system (Appendix D, map 1) (Appendix B, photo 2).

A backhoe was used to dig the present well and to install a corrugated 60-inch galvanized-steel casing vertically to a depth of 23 feet. The top of the casing is only 0.9 feet above the land surface and is covered by a heavy steel lid with a lip that covers the top of the casing. The Montana Board of Water Well Contractors Annotated Codes (1997) requires that the well casing stick up no less than 1.5 feet (18 inches) above the ground surface. The casing was placed through the colluvial material at the land surface and lowered approximately 8 feet into the Fox Hills Sandstone bedrock. The bottom of the casing is open, allowing ground water to seep into the well casing from pore spaces, fractures and partings within the sandstone formation at the bottom of the well. Sandy and silty clay dug from the well was used as backfill around the well casing. During the site inspection no cracks or gaps were seen in the backfill material.

In 1993 an infiltration gallery was connected to the well. The gallery was attached to the well 15 feet below the land surface and was laid in the colluvium on top of the underlying bedrock. The gallery is constructed from 4-inch diameter, perforated, PVC pipe laid to the west toward the center of the coulee for a distance of 150 to 200 feet (Appendix B, photo 3). The pipe was designed to capture drainage water flowing through the colluvium in the bottom of the coulee and seepage from the near-surface bedrock to supplement ground-water recharge to the well. Water draining into the infiltration gallery is probably from the same source that supplied the old spring at the well site. The system operator reported that he has not observed water flowing into the well from the infiltration gallery for the past 3 to 4 years. At the time of the HA no water was observed flowing from the infiltration gallery and it was not determined whether the infiltration gallery contributes water to the well. The infiltration gallery may be obstructed or the gallery may have drained the available ground water from the coulee and water is no longer available to flow into the well. For the HA it was assumed that the gallery is open and functional and could contribute water to the well. The spring is recharged from drainage of the colluvium and from the bedrock below. After the well was constructed the spring did not flow at the surface. The ground water recharging the spring now flows to the well.

Ground water is pumped from the well through a 1½-inch galvanized steel pipe to the adjacent pump house by a ¾-horsepower submersible pump. Electronic water-level sensors are located inside the well casing to control the submersible pump. The highest sensor probe is placed 17.5 feet below the land surface and is used to detect when the water level in the well has adequately recharged. The deeper probe is located at approximately 21 feet below ground level. The system is designed so that when ground water rises in the casing to contact the upper probe the pump is switched on and pumps until the water drops below the lower probe at which time the circuit is broken and the pump is switched off. The volume of casing storage between the two probes is approximately 500 gallons. Mr. Erickson reports that ground-water recharge to the well is slow and the water level in the well may require an entire day to recover from the low probe to the high probe elevation. Mr. Erickson reported that recharge to the well typically ranges between 500 gpd and 1,200 gpd based on daily readings from a flow meter in the pump house (no written records are available). According to the operator, the higher recharge rates are rare and short term, and occur following periods of high precipitation or the infiltration of snowmelt during the springtime and early-summer. The seasonal high well recharge rates could be from drainage into the well from the infiltration gallery.

The pumped water is chlorinated by a liquid chlorination system in the pump house located at the well site (Appendix B, photo 1). From the pump house the water is pumped for a distance of about 2,000 feet to a 20,000 gallon steel storage tank located on a hilltop (Appendix B, photo 4). The operator reports that all water pumped from the well to the storage tank is chlorinated although no records have been kept of chlorine use or meter settings. The elevation rise from the well to the storage tank is approximately 115 feet. The type and size of the pipe from the pump house to the tank is unknown but is thought to be 1½-inch diameter black, flexible, PVC pipe buried along the access road. The steel storage tank is located about 2 miles from town at an elevation of 3,310 feet. Water flows by gravity from the water tank to town through a 4-inch diameter, PVC pipe (Appendix B, photo 2). Water pressure for the system is supplied by gravity flow from the water tank. The main distribution line drops 285 feet in elevation from the water tank to town (at 3,025 feet elevation).

Mr. Erickson reported at the time of the site investigation that the main water line is broken and leaks somewhere near town. These leaks cause water to drain from the main line and from the water tank at a relatively fast rate. At present the leaks are large enough that the water tank can be drained dry in 2 to 3 days, even with the well at full production, because ground-water recharge to the well is not fast enough to keep up with the leakage loss. Because of the low well production rate, the water users contract Mr. Erickson to haul water from the Forsyth treatment plant to the Ingomar water-storage tank. In the past the water has been hauled from Forsyth in a 7,700 gallon tanker truck at least once every 1 to 2 weeks. From discussions with the system operator it appears that the leaks are getting worse, causing the water storage tank to run dry more frequently and requiring more water haulage from Forsyth. Currently water is being hauled from Forsyth 2 to 3 times per week. At the time of the HA inspection the tank was one-third to one-fourth full even though for several days the pump had been cycling as much as the well recharge would allow. This situation was reported as typical of the system by Mr. Erickson. On many occasions in the past the water tank and upper portion of the main distribution line have run dry creating a back flow from the Cameron house near the water tank into the main water line (Appendix B, photo 2). Often this is the first indication that the tank has run dry.

There are about 16 active service connections on the system and 8 to 10 year-round residents. Most of the connections are in town, except for the Cameron house, which is located near the storage tank. One grade school, serving 10 to 20 students, is connected to the system and only one public business operates in Ingomar, the Jersey Lilly Bar. Assuming each of the 10 users on the system consumes an average of 150 gallons of water per day (gpd) (Solley and others, 1993), the system would be required to supply at least 1,500 gallons/day. The present estimated well production rate of 500 gpd to 1,200 gpd is minimal for the population of Ingomar and may not be adequate to supply all of the town's water needs. Even at the highest production rates the well water may have to be supplemented by other water sources. Because of the slow well recharge rate and the existing leak problems the users are very conservative with water use. The well water is used only for household needs, none of the system water is used for irrigation.

GEOLOGY

Local Topography and Land Use

The town of Ingomar is located at 3,025 feet elevation southeast of a northwest trending ridge that forms a local topographic high. The topography around town consists of broad, nearly flat plains and gently rolling hills occasionally cut by narrow, shallow drainages typical of regions where the upper-Cretaceous Bearpaw Shale is exposed at the land surface (Appendix B, photo 2). The topography at the well site in the hills northwest of town is steep to gently rolling with rock ledges of resistant, cross-bedded sandstone of the Lance Formation common along hilltops (Appendix B, photos 1, 3 and 4). Small creeks and coulees drain runoff water from the hills to the southeast and east (Appendix D, map 1). The coulees are usually dry except during brief periods of runoff following storms. Near the well site the topographic relief from the drainage bottoms to the hilltops is moderately steep with elevation changes ranging between 50 feet and 200 feet (Appendix B, photo 1).

The well is surrounded for several miles by native grassland historically used for grazing sheep and cattle. The Bearpaw Shale, which immediately underlies much of the land surface around Ingomar, forms a poor soil for crops. Sparse native grass and sagebrush grow on the land and it is likely that very little of the land has ever been tilled. Cattle ranching on large ranches is the primary industry in the area. Livestock are no longer grazed in the well section and land is unused because the water district well does not have sufficient production capacity to supply water to the town and to livestock.

Regional Geology

Bedrock exposures around Ingomar consist of upper-Cretaceous sedimentary rocks that were deposited in an oceanic or near-shore setting. Thin, narrow layers of Quaternary alluvium cover the drainage bottoms. Table 1 shows the estimated thickness and relative stratigraphic positions of the geologic formations in the Ingomar area.

Table 1. Estimated thickness of geologic formations in the Ingomar area (Edith Wilde, MBMG, personal communication, 1999 and Bowen, 1920).

Geologic unit	Geologic age	Thickness, feet
alluvium	Quaternary	0-30
Lance Formation	Upper Cretaceous	400-450
Fox Hills Formation		80-120
Bearpaw Shale		900 - 1,100
Judith River Formation		300 - 350
Claggett Formation		600-700
Colorado Group Shales		2,300

Ingomar lies on the axis of the Sumatra Syncline, a regional structural feature explored for oil in the 1920's and 1930's (Appendix D, map 1). The axis of the Sumatra Anticline runs parallel to the syncline and passes about 1½ miles to the south of Ingomar (Vuke and others, 1994). The Sumatra Syncline and Sumatra Anticline are regional northwest-southeast trending structures that bend to a westerly strike for a short distance at Ingomar. Both structures are late-Paleocene or younger in age and fold all of the rock formations in the area, with the exception of the Quaternary units. The folds are a result of regional compression following Laramide uplift to the west and are part of the Cat Creek Lineament, a series of en-echelon folds extending from the Bearpaw Mountains to the northwest, to the Black Hills in the southeast (Nelson, 1993 and Thomas, 1974). The Ingomar Dome is located along the trend of these structures southeast of Ingomar.

The Cretaceous Judith River Formation is the oldest geologic formation exposed in the area. The formation has been uplifted along the Ingomar Dome and crops out about 1¼ miles southeast of town (Heald, 1926). In eastern and central Montana the formation is composed of fresh-water deposits that grade eastward into marine-deposited sediments more typical of the formation (Bowen, 1920). Near Ingomar the Judith River Formation is described as grading from a massive brown, poorly cemented sandstone at the base, into an ash-grey shale intermediate layer, to a greyish-white to brown massive to heavy bedded sandstone near the top (Bowen, 1920).

The Bearpaw Shale, overlying the Judith River Formation, is a thick, fine-grained, semi-consolidated, grey, marine shale, and crops out throughout much of eastern Montana, including the areas north, east and south of Ingomar. The upper part of the formation often contains layers of sandy shale and some sandstones that form a transition to the overlying Fox Hills Sandstone. The land surface underlain by the Bearpaw Shale is typically gently rolling with broad gradual slopes into shallow drainages (Appendix B, photo 2).

In the Ingomar area hills and ridges rise above the Bearpaw Shale surface. The hills are composed of Upper Cretaceous Fox Hills Sandstone which directly overlies the Bearpaw Shale, and sandstones and shales of the Upper Cretaceous Lance Formation. The layers of the Bearpaw Shale, Fox Hills Sandstone and Lance Formation sediments form a regressive sequence of deposition developed during retreat of an inland sea. Thin, narrow unconsolidated layers of alluvium and colluvium cover the bedrock along drainage bottoms and are composed of silt, clay and shale eroded from the underlying Cretaceous sediments.

Local Geology

The Ingomar water-supply well is located in hills northwest of town that rise above the nearly flat to gently rolling terrain of the Bearpaw Shale. The hills are composed of Fox Hills Sandstone overlain by Lance Formation bedrock that lies along the axis of the Sumatra Syncline. The hills form a prominent, narrow, 2- to 3-mile-wide ridge that is one of only a few locations where the Fox Hills and Lance Formations are preserved near Ingomar. The total topographic relief of the hills, from the Bearpaw Shale plains to the hilltops, is 350 feet. In the hills the sedimentary beds of the Fox Hills and Lance Formation dip gently inward toward the synclinal axis from the east and from the west at 3 degrees to 10 degrees (Appendix D, map 1). The water-supply well is located in a dry coulee cut into the bedrock. The well is collared in colluvium near the bottom of the drainage just below the Lance-Fox Hills contact. The colluvium is estimated to range from less than 1 foot thick to 15 feet thick along the coulee bottom.

The Fox Hills Formation, often described as the lower Lance Formation in this region of Central Montana, is composed of alternating layers of sand and shale (mud or silty layers) deposited in a near-shore environment or as channel deposits. The sandstone layers have thin, shaley partings (Edith Wilde, MBMG, personal communication, 1999 and Bowen, 1920). Fragments of the Fox Hills Sandstone removed during construction of the water-supply well are friable, tan to buff-yellow, semi-consolidated, well-sorted, medium-grained sandstone with shaley partings at 0.8 to 1.6 inch spacing. Small 0.8 to 2 inch, rust-red, sub-rounded concretions are scattered throughout the fragments. Fragments of the sandstone can be seen scattered on the ground around the well. A lithology log on file with the MBMG, Montana Ground Water Information Center (GWIC) for a stock well in section 33, T. 10 N., R. 35 E. (GWIC i.d. number M:23483), the same township and range as the water district well, shows a 57-foot thick interval of interlayered clay with brown sandstone (Fox Hills Formation) underlain by a hard shale (Bearpaw Shale) (GWIC, 1998). The well is situated at nearly the same elevation as the water district well along the west slope of the hills, suggesting that the bottom of the public water-supply well may be 25 to 30 feet above the base of the Fox Hills Formation (approximately 60-foot-thick Fox Hills Formation minus the 30 foot total well depth).

The overlying Lance Formation originated as fluvial channel and shallow lake deposits. The Lance Formation has many stream-channel deposits. The Lower Lance Formation is composed of massive sandstone layers and interbedded shales and local fossiliferous limestone. The Lance

Formation is identified in outcrop by massive brownish-grey, to dirty-white, arkosic sandstones with ripple marks and cross-bedding common (Bowen, 1920). Some of the sandstone layers are heavily consolidated and form protective capping layers in outcrop. Many of the outcrops have rusty-brown staining and rusty-brown concretions. Thin-bedded layers of shale are found in the lower Lance Formation as are local thin limestone layers. Mapping by MBMG geologists shows the contact between the Fox Hills Formation and the Lance Formation is located at approximately 3,270 to 3,280 feet elevation in the coulee above the well site (Vuke and others, 1994).

HYDROLOGY

Information collected during the site investigation, reports published by the USGS and the MBMG, and data available from GWIC were used to evaluate the hydrogeology of the site. Most of the wells that have been developed in the area are abandoned. Only five other wells are on record with GWIC in the same township and range as the water-supply well (Appendix C, Table C-1). Some of these wells are very old and may no longer exist.

The climate at Ingomar is semiarid. Between 1953 and 1998 Ingomar received an average annual precipitation of 11.29 inches (WRCC, 1999). Ingomar receives 51 percent of its annual precipitation in May, June and July as rainfall.

Surface Water

Ingomar is located between the Musselshell River, 23 miles to the west, and the Yellowstone River, 24 miles to the south. No significant bodies of surface water exist in the Ingomar region. Most creeks are intermittent and only flow when draining surface runoff during periods of intense precipitation. Some ground water flows into the drainages from seeps and springs, but the creeks and coulees are dry most of the year. No defined channel was evident in the coulee (Appendix B, photo 3). The east fork of Froze-To-Death Creek, located just east of Ingomar is the largest drainage in the area, but it is also dry most of the year. Surface water flows to the south with the exception of drainages located approximately 2 miles north of town, which flow east, away from the hills. Water retention dams have been constructed along some of the drainages to capture and store runoff water. One of these dams is located in the coulee about 50 yards below the water-supply well. Following a relatively wet spring and several days of heavy rain prior to the site inspection there was no water behind the dam and the coulee bottom was dry. No established channel exists in the drainage bottom at the well site.

Regional Ground-Water Flow

Ground water in the Ingomar area is recharged by precipitation. Some of the precipitation infiltrates into the land surface, but a large portion is lost to surface runoff and evapotranspiration, especially on the shales. Ground water that infiltrates below the land surface flows through sandy layers of the formations and may be directed laterally by low permeability silt and shale layers common in the Cretaceous formations. Ground water is discharged along hillsides and low lying areas where the water-bearing layers intercept the land surface.

Few geologic formations in the Ingomar area supply water of adequate volume or quality to be useful. The Bearpaw Shale in most parts of Montana is considered an aquitard. Occasionally quantities of water adequate to supply wells are found in thin sandy layers within the upper portion of the formation. Water that is available from the shale typically contains very high concentrations of total dissolved solids (TDS) and is too saline to be drinkable. The dissolved minerals are derived from primary mineralization in the marine shales. Water in the Cretaceous Judith River Formation is also typically high in dissolved mineral content. Water quality is generally poor in the Judith River Formation in this part of Montana but can vary by location (GWIC, 1998).

The Fox Hills Formation and the overlying Lance Formation were deposited in near-shore or fluvial fresh water environments. Ground water in these formations typically contains lower TDS concentrations and has better quality water than the marine sediments.

Most of the wells in the area are located along drainages or in low-lying areas and are shallow. These wells draw water from unconsolidated alluvial deposits along drainage bottoms which rely on surface runoff and seepage from the bedrock of the surrounding hillsides for recharge. Because most of the water that recharges the alluvial material has come in contact with the marine Bearpaw Shale and because most of the alluvial material itself is derived from the underlying Cretaceous marine bedrock the ground water is high in total dissolved mineral content.

Local Ground-Water Flow

A long-term problem in the Ingomar area has been in finding a good-quality water source. Outcrops of the Fox Hills Sandstone and the Lance Formation in the hills northeast of town provide better quality, lower-TDS, water, but the hills are narrow and have a relatively small surface area, so the potential for significant recharge to these formations is low. In the hills around the well the useable ground water moves through the sandstone layers of the Fox Hills and Lance Formations. Movement through these formations may be facilitated by secondary fractures in the bedrock formed by folding along the syncline. The occurrence and orientation of fractures were not determined. Ground water discharges to the land surface as springs along the hillsides where the water-bearing layers intercept the land surface, such as in low-lying areas along coulee and creek bottoms. Several springs were observed discharging from the Fox Hills Formation at the base of the hills at the Bearpaw Shale contact. Ground-water movement within the Lance and Fox Hills Formations in the hills is probably generally to the southeast; some movement may be directed from the margins of the hills toward the center along the dip slope of the folded formations. The spring at the well location was a discharge site for ground water draining from the colluvium along the coulee bottom. Some of the ground water in the colluvium is seepage from sandstone layers in the underlying Lance Formation. The new well draws ground water primarily from the sandstone bedrock but also from drainage in the colluvium.

WATER QUALITY

No water samples were collected for the hydrogeologic assessment of the Ingomar Water District water-supply system. Field water-quality measurements for pH, temperature, specific conductivity and redox (an indication of the reducing or oxidizing potential of the water) were measured from a hose faucet inside the pump house. The faucet was located on the main distribution line to the water-storage tank and was located after the chlorinator**.** The water temperature measured at the pump house was 11.0 ºC, pH was 7.74, specific conductivity was 1616 µmhos/cm and redox was 203.9 mv. Eh was calculated at 416.9 mv using the redox potential measurement corrected for temperature. Water-quality data from 39 water samples collected from Fox Hills or Hell Creek wells in Rosebud County on record in GWIC have reported pH values ranging from 7.65 to 8.94, and specific conductance ranging from 682 to 4,964 µmhos/cm (1998). The water quality at the Ingomar water system pump house is on the low end of the range of values reported for the Fox Hills ground water in the region.

A water-sample analysis record is on file with GWIC (sample 23Q0109 and GWIC well number M:1746) for the Ingomar well. The sample was collected for a USGS ground water study when the well was reported to be 7.7 feet deep (Renick, 1929). The sample source was identified as Lance Formation gravel. Ion-analysis results indicate that the water is calcium-sodium-bicarbonate rich. GWIC records for Fox Hills water quality data in southeastern Montana indicates that most Fox Hills ground water is sodium-bicarbonate type (GWIC, 1998). No specific conductance or pH data were recorded for the well sample. The estimated total dissolved solids concentration was reported to be 370 ppm in the 1923 water sample (Appendix C, Table C-2). The specific conductance measured from the well during the HA (1616 µmhos/cm) suggests a TDS closer to 1000 ppm. The lower TDS in the shallow-well sample and the higher calcium content are probably the result of shallow ground-water circulation recharging the spring. The higher relative TDS in the well indicates ground water from deeper circulation, with longer retention time in the ground, is recharging the well.

Microbiological Water Quality

Monthly bacteria water-quality samples were collected from the water system by the operator between January 11, 1993 and October 3, 1998, the date of the latest record on file with the Montana Department of Environmental Quality (DEQ). The submitted samples have, at times, contained fecal-coliform bacteria, non-coliform growths, or have been turbid (Table 2). According to Mr. Erickson water quality samples are collected from taps in Ingomar. Actual sampling practices are not known. It was also not determined whether the aerators were removed from the tap faucets prior to sampling. The system condition and operation could be contributors to the potential contamination. The bacteria could originate from several sources: From the ground water in the well, from the storage tank, from the water hauled to the tank from Forsyth, from the haul truck or from the break in the main water line. All of these areas are potential pathways for bacteria to enter the system.

No bacteria were detected in samples submitted in 1997 or 1998 (Mike Brayton, DEQ, personal communication, 1999). No explanation for this improvement is known because the system still operates in much the same way as it has for the previous years.

Table 2. Water quality samples in which violations of the water quality standards were detected. The last five sample results are greater than 3-years old. No exceedances have been noted since September 1996.

Sample date	water quality analysis result
9/11/96	excessive turbidity
7/25/96	acute, 1-sample coliforms present
5/23/96	acute, 5 fecal coliforms present
5/15/96	non-acute, coliforms present
2/29/96	non-acute, coliforms present
2/12/96	non-acute, coliforms present
2/5/96	acute, fecal coliform present
7/25/96	non-acute, heavy growth non-coliforms present (3-samples)
5/13/96	non-acute, heavy growth non-coliforms
2/9/95	turbid
9/14/94	3@ 4+ total coliform
9/14/94	2@3+ total coliform
9/8/94	TNTC (too numerous to count) with coliform
4/19/94	turbid
10/18/93	TNTC non-coliform

Turbid water conditions detected in the water samples may be caused by agitation of silt at the bottom of the well caused by frequent pumping, or from rust or sediment in the water tank that is drawn into the water lines when the water level in the tank is low. Turbidity may limit the effectiveness of the chlorinator.

An undated notification memo from the DEQ to the Ingomar Water District stated that the town of Forsyth water-treatment plant has been in violation of state treatment-technique requirements for adequate contact time for treated water and for chlorination in the treatment plant (DEQ files). Because the Ingomar Water District often uses water from the Forsyth water-treatment plant, the DEQ determined that the Ingomar Water District is also in violation of the treatment-technique requirements.

Prior Sanitary Survey Results

A 1991 inspection of the Ingomar water system by personnel from the DHES (Montana Department of Health and Environmental Sciences, the name was changed to the DEQ in 1992) reported that the tank-fill lid on the tanker truck was opened making the tank susceptible to contamination. In a letter from the DHES to the Ingomar Water District, dated September 21,1994 (Schultz, 1994), the DHES recommended that the Ingomar Water District make sure the lid of the haul-truck tank remains closed, the truck tank and the system storage tank be inspected for sediment content, chlorine residuals are regularly measured in the water system, and the results documented. The DHES also recommended that the water-truck filling and unloading procedure be reviewed to ensure no contamination can get into the water system as a result of poor water transfer practices. In the letter the DHES offered assistance to the Ingomar Water District through an MRW (Montana Rural Water Systems) Contract. The DHES asked for clarification of chlorinator operation, no response was noted in their files.

In a letter from the Montana DHES dated December 1994 (Cottingham, 1994), the water system was cited for other violations of state law. The letter was written after questioning of a water district representative by the DHES following detection of coliform bacteria in monthly water samples taken on September 8, 1994 and in a second round of confirmation samples collected on September 14, 1994. In the letter the DHES determined that the Ingomar Water District was in violation of state public water system codes in the following areas:

1) no evidence that a chlorine residual is maintained in the system,

2) no records are kept of daily chlorine residual measurements from the water system,

3) no records are kept of chlorine residual measurements from water hauled by truck from the town of Forsyth water treatment system to the Ingomar water system,

4) concern was expressed over the sanitation of the truck tank used to haul water,

5) the system operator, Mr. Erickson was not a certified public water-system operator.

CONCLUSIONS

Determination of Direct Surface-water Influence

The Ingomar Water District water supply source may be under the direct influence of surface water because a shallow infiltration gallery is connected to the water-supply well, the well casing is less than 25 feet deep and the casing sticks up less than 1.5 feet above the ground surface. The infiltration gallery attached to the well may periodically drain water from the colluvial material overlying the Fox Hills Formation bedrock at the well site. The shallow depth and design of the infiltration gallery suggests that near surface ground water could flow into the well from the gallery. The primary source of water to the well comes from ground water in the Fox Hills Formation. Ground water in the Fox Hills aquifer does not appear to be directly influenced by surface water.

The presence of fecal coliform bacteria, coliform bacteria and turbidity in the Ingomar public water supply may be from surface water influences or the result of handling practices with refill water, water system integrity or system design. Vulnerable portions of the water supply system and possible sources of coliform and fecal-coliform bacteria include:

a) shallow ground water from the infiltration gallery flowing into the well,
b) contamination of the well by small animals getting into the casing,
c) back flow from the Cameron house,
d) water main leaks,
e) the water-storage tank,
f) water truck or water transfer processes from the truck to the storage tank,
g) a secondary water source (Forsyth water treatment plant).

The risk of potential contamination to the well from surface source appears minimal because the section around the well is not used for grazing and has no other signs human activity.

Repairing the breaks in the main water line would solve a lot of the water shortage problems, reduce the need for hauled water and reduce the occurrences of system back flow currently experienced. The leakage causes back flow to occur from the Cameron house near the water tank into the water system's mainline when the water level is drawn down to the house elevation. Installation of a back-flow preventer on the Cameron house would protect the water system from back flow from the house, which occurs frequently.

The main line of the water distribution system leaks through breaks in the pipe at a rate faster than the water-supply well can replenish the system. The leakage requires the water district to truck water from the Forsyth municipal water-treatment plant to the storage tank 2 to 3 time per week. The mainline leaks could be a possible source of contamination of the water system. Because of the low production rate of the well, the water-supply system may not produce enough water to meet the communities daily needs even if the leaks are prepared. A long-term alternate water source may be necessary to ensure an adequate water supply is available for the water system users.

Other observations noted during the HA study include:

1) The water-system operator is not state certified.

2) A chlorinator is installed on the water-supply system and appears to be in constant use, however no records of chloride residual in the water system are recorded.

3) Repeated, past, acute-MCL violations of the water quality standards in samples from the water system suggest chlorination may not be adequate or other problems may exist.

4) Concerns have been noted by the DEQ during previous site inspections about the sanitation of the water truck tank used to haul water from Forsyth to Ingomar.

5) The DEQ has not received water quality samples from Ingomar since October 3, 1998. The current status of the MCL values in the water-supply system is not known.

6) The Ingomar Water District is supported by 8 full-time and 12 part-time users. Funds for the system are probably very low. In order to make the proper repairs to the system the water district may need to obtain additional funds from grants or loans.

RECOMMENDATIONS

Because the well system as constructed **could be under the direct influence of surface water** several recommendations for further study have been included. The recommendations include system improvements to insure good water quality.

1. Obtain and analyze water samples from the water system for coliform bacteria and turbidity. Samples have not been collected since October 3, 1998.

2. Conduct an MPA at the well to determine if the well water is influenced by surface water.

3. Plug the infiltration gallery to ensure that shallow colluvial ground water does not flow into the well. Doing so could classify the well source as ground water.

4. Conduct a review of the integrity of the water system in an effort to determine the source of the turbidity and the coliform bacteria.

5. Repair leaks in pipeline system to ensure that the water in distribution system is isolated from potential contamination sources and the potential influence by surface water. Repairing the leaks will also improve the chances that an adequate storage capacity can be maintained in the storage tank.

6. Install a back-flow-preventer check valve on the Cameron house water line (near the water tank) to prevent back flow into the distribution line from the house when the water tank runs dry.

7. Install a low water alarm system for water tank to detect low water levels before the tank runs dry.

8. Install a tighter, more secure sanitary seal on the well. Installing a rubber gasket and latch system on the present lid may be adequate to seal the top against rodents and potential surface water infiltration.

9. Check chlorinator for proper operation.

10. Keep records of measured chlorine residual in the water system.

11. Review water hauling procedures, ensure a sanitary, secondary-water source, a sanitary truck tank, sanitary and proper handling and water transfer procedures.

12. Acquire grant or low interest loan funding to repair the broken water lines.

13. Locate additional/supplemental water supply sources:

    a) continue to haul water from the Forsyth water-treatment plant.

    b) Evaluate whether deepening the present well would improve ground-water recharge to the well. Interception of additional sandstone layers within the Fox Hills Formation could provide additional sources of water and improve the rate of recharge to the well. The bottom of the Fox Hills Formation is typically composed of a thick sandstone that usually contains water of acceptable quality and quantity for wells. Deepening the well would increase the water storage capacity of the casing. The bottom of the well should not be deepened into the Bearpaw Shale due to the high TDS of water in the shale.

    c) Consider drilling additional well(s) to supplement the water supply. The best location for a new well would be in the Fox Hills Formation in another coulee near the present well site. Locating the well in an area that would drill through the thickest possible section of the Fox Hills Formation would allow for the potential to intercept the most water-bearing layers within the formation and produce the greatest yield. The additional well(s) could be piped into the present pump house and chlorinator.

REFERENCES

Bowen, C. F., 1920, Gradations From Continental to Marine Conditions of Deposition in Central Montana During the Eagle and Judith River Epochs, U. S. Geological Survey Professional Paper 125, U. S. Geological Survey, Washington, pg. 11-21.

Ground-Water Information Center, 1998, Montana Ground-Water and well database, Montana Bureau of Mines and Geology, Butte, Montana.

Heald, K. C., 1926, The Geology of the Ingomar Anticline Treasure and Rosebud Counties Montana, U. S. Geological Survey Bulletin 786-A, U. S. Geological Survey, Washington, 37 p.

Montana Department of Natural Resources and Conservation, 1997, Montana Board of Water Well Contractors, Montana Codes Annotated, Administrative Rules of Montana, March, 1997; Montana Department of Natural Resources and Conservation, Helena, Montana, 40 p.

Nelson, J. A., 1993, Structural Geology of the Cat Creek Anticline and Related Features, Central Montana, Montana Bureau of Mines and Geology Memoir 64, Butte, Montana, 38 p.

Renick, B. C.,1929, Geology and Ground-Water Resources of Central and Southern Rosebud County Montana, U.S. Geological Survey Water-Supply Paper 600, U. S. Geological Survey, Washington, 138 p.

Solley, W.B., Pierce, R.R., and Perlman, H.A., 1993, Estimated use of water in the United States in 1990: U.S. Geological Survey Circular 1081, 76 p.

Thomas, G. E., 1974, Lineament-Block Tectonics: Williston-Blood Creek Basin, The American Association of Petroleum Geologists Bulletin, Vol. 58, no. 7, July 1974, pp. 1305-1322.

U. S. Geological Survey, 1960, Ingomar East topographic quadrangle map, U. S. Geologic Survey, Denver, Colorado, 1:24,000 scale map.

U. S. Geological Survey, 1960 (photo revised 1980), Ingomar West topographic quadrangle map, U. S. Geologic Survey, Denver, Colorado, 1:24,000 scale map.

Vuke, S. M., Wilde, E. M., and Bergantino R. N. (compilers),1994, Preliminary geologic map of the Melstone 30 X 60-minute quadrangle, MBMG 292, Montana Bureau of Mines and Geology, Butte, Montana, 1:100,000 scale map.

Western Regional Climate Center, 1999, Western U. S. Climate Historical Summaries, Internet address: www.wrcc.dri.edu.

Appendix A

A-1. DEQ Preliminary Assessment Form
A-2. Well Head Protection Inventory Form

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Metcalf Building
1520 E. 6th St.
Helena, MT 59620-0901

Preliminary Assessment of Ground water Sources that may be under the Direct Influence of Surface water

SYSTEM NAME <u>**Ingomar Water District**</u> **PWS ID #** <u>**03078**</u>
SOURCE NAME <u>**Ingomar Water District** well / old BN spring</u> COUNTY <u>Rosebud</u>
DATE <u>6/18/98</u> NC NTNC C POPULATION <u>12</u>

		Index Points
A.	**TYPE OF STRUCTURE (Circle One)**	
	Well	GO TO SECTION B
	Spring	40
	Infiltration Gallery/Horizontal Well	40
B.	**HISTORICAL PATHOGENIC ORGANISM CONTAMINATION**	
	History or suspected outbreak of *Giardia,* or other pathogenic organisms associated with surface water with current system configuration	40
	No history or suspected outbreak of *Giardia* .	0
C.	**HISTORICAL MICROBIOLOGICAL CONTAMINATION (Circle all that apply)**	
	Record of acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
	No violations	0
	One violation	5
	Two violations	10
	Three violations	15
	Record of non-acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
	One violation or less	0
	Two violations	5
	Three violations	10
	DHES-verified complaints about turbidity . . .	5
D.	**HYDROLOGICAL FEATURES**	
	Horizontal distance between a surface water and the source	
	greater than 250 feet	0
	175 - 250 feet	5
	100 - 175 feet	10
	less than 100 feet	15
	unknown	15

E. WELL CONSTRUCTION

Poorly constructed well (uncased, or casing not sealed to depth of at least 18 feet below land surface), or casing construction is unknown .	15
In wells tapping unconfined or semiconfined aquifers, depth below land surface to top of perforated intervals or screen	
greater than 100 feet	0
50 - 100 feet	5
25 - 50 feet	10
0 - 25 feet	15
unknown	15

F. WELL INTAKE CONSTRUCTION

In wells tapping unconfined or semiconfined aquifers, depth to static water level below land surface	
greater than 100 feet	0
50 - 100 feet	5
0 - 50 feet	10
unknown	10
Poor sanitary seal, seal without acceptable material, or unknown sanitary seal type . . .	15

TOTAL SCORE 95

PRELIMINARY ASSESSMENT DETERMINATION (Circle the one that applies)

i) PASS: Well is classified as ground water.
ii) FAIL:. Well must undergo further GWUDISW determination.
iii) FAIL: Spring or Infiltration Gallery; must undergo further GWUDISW determination.
iv) FAIL: Well will PASS if well construction deficiencies (section E or F) are repaired.
v) FAIL: Well may PASS if well construction details (section E or F) become available.

ANALYST James Rose ANALYST AFFILIATION MBMG

COMMENTS: Formerly a hand dug well owned by the Northern Pacific Railroad and the Burlington Northern Railroad. The well produces about 500 gallons per day most of the year. An infiltration gallery is connected to the well. The water main line leaks and water is hauled by truck from Forsyth to supplement the water supply.

Public Water Supply Number 03078
WHP Region ____________

Source Number ____________
Inventory Person James Rose/M.3.?
Attached Map Number ____________

INVENTORY FORM

Occupant's Name: Town of Ingomar - Erik Erickson
Site Address: P. O. Box 65
City: Ingomar
Zip Code: 59039-0065
County: Rosebud
T/R/S: 10N 34E 23
Phone Number: 406-358-2356
Lat/Long: ____________

Name, address and phone number of property owner if different from above
Sun Coulee Ranch   Donald John Cameron (manager)
Ingomar, MT

NATURE OF PROPERTY

Residential ___   Retail Business ___   Agricultural /Livestock X
Industrial ___   Government ___   Other (describe on back) ___

POTENTIAL SOURCES OF CONTAMINATION

Circle the number or letter of each source found at this site. Under quantity, indicate how many. Place the number or letter on the attached map to indicate the location of the source. List the chemicals used or stored on back of the form.

POTENTIAL SOURCE	QUANTITY	POTENTIAL SOURCE	QUANTITY
(1) Water well in use	___	(I) Above ground storage tank	___
(2) Water well abandoned	___	(J) Chemical storage facility	___
(3) Chemigation well	___	(K) Fertilizer/pesticide use	___
(4) Oil/gas well	___	(L) Chemical mixing/loading site	___
(5) Exploration bore hole	___	(M) Land application of waste	___
(6) Injection well	___	(N) Grain storage bin	___
(7) Mine/Quarry	___	(O) Animal feedlot	___
(A) Septic tank/privy	___	(P) Auto salvage yard	___
(B) Landfill/dump	___	(Q) Irrigated land	___
(C) Pipeline	___	(R) Artificial recharge project	___
(D) Wastewater lagoon	___	(S) Drainage canal	___
(E) Brine pit	___	(T) Highway/interstate frontage	___
(F) Service station dry well	___	(U) Railroad frontage	___
(G) Stormwater drain	___	(V) Stream, river, lake, pond	X/
(H) Underground storage tank	___	(W) ____________	___

intermittent stream drainage

Appendix B

Photo 1. Pump house and well cover
Photo 2. View south from storage tank towards Ingomar
Photo 3. View west up coulee above well site
Photo 4. Water storage tank

Photo 1. View looking north across coulee showing pump house and well cover. The fence in the distance is on the north section line. A water retention dam crosses the coulee to the right, just out of view; the pond was dry. The outcrops on the hilltops are Lance Formation sandstone.

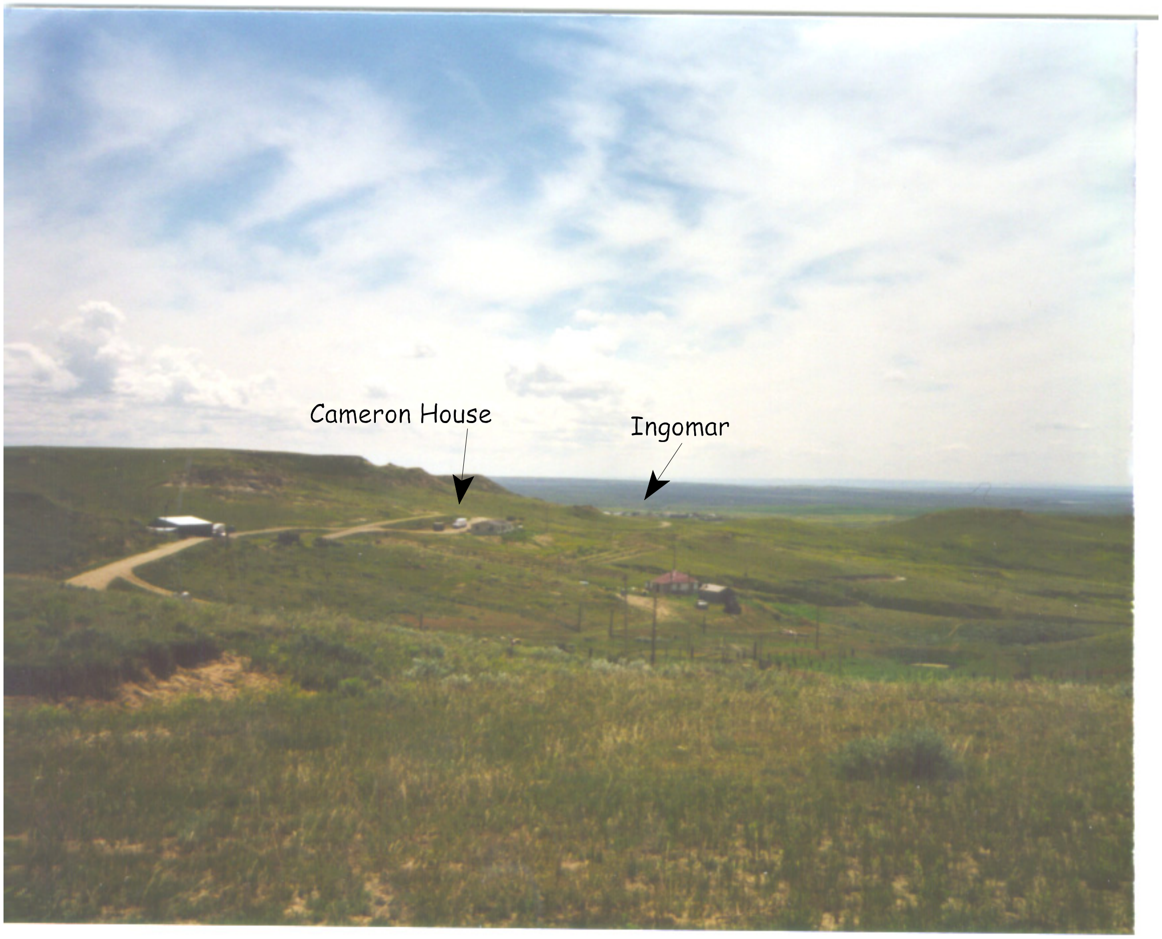


Photo 2. View looking south from the water-storage tank showing Ingomar in the distance and the Cameron house in the middle foreground. The Cameron house is the first house on the Ingomar water-distribution system. Hills in foreground are Lance Formation, the lower part of the hills are Fox Hills Formation bedrock. The flat terrain beyond Ingomar is typical of geomorphology developed on the Bearpaw Shale.

Photo 3. Looking west up coulee showing well in foreground and pump house. Colluvium covers the coulee bottom, the well is in the Fox Hills Sandstone, the hills in the background are Lance Formation bedrock. The infiltration gallery is buried behind the well and extends about 150 to 200 feet west, directly into the photo view.

Photo 4. Looking east along a ridge showing the water-storage tank. Lance Formation sandstone forms the caprock on the hilltops. Ingomar is to the right, the well is to the left.

Appendix C

Table C-1. Well completion data for wells near the water supply site
Table C-2. Water Quality report for the former spring located at the well site

Table C-1. Other wells located near the Ingomar public water supply well on record with GWIC (1998). Many of these wells are old and may be abandoned.

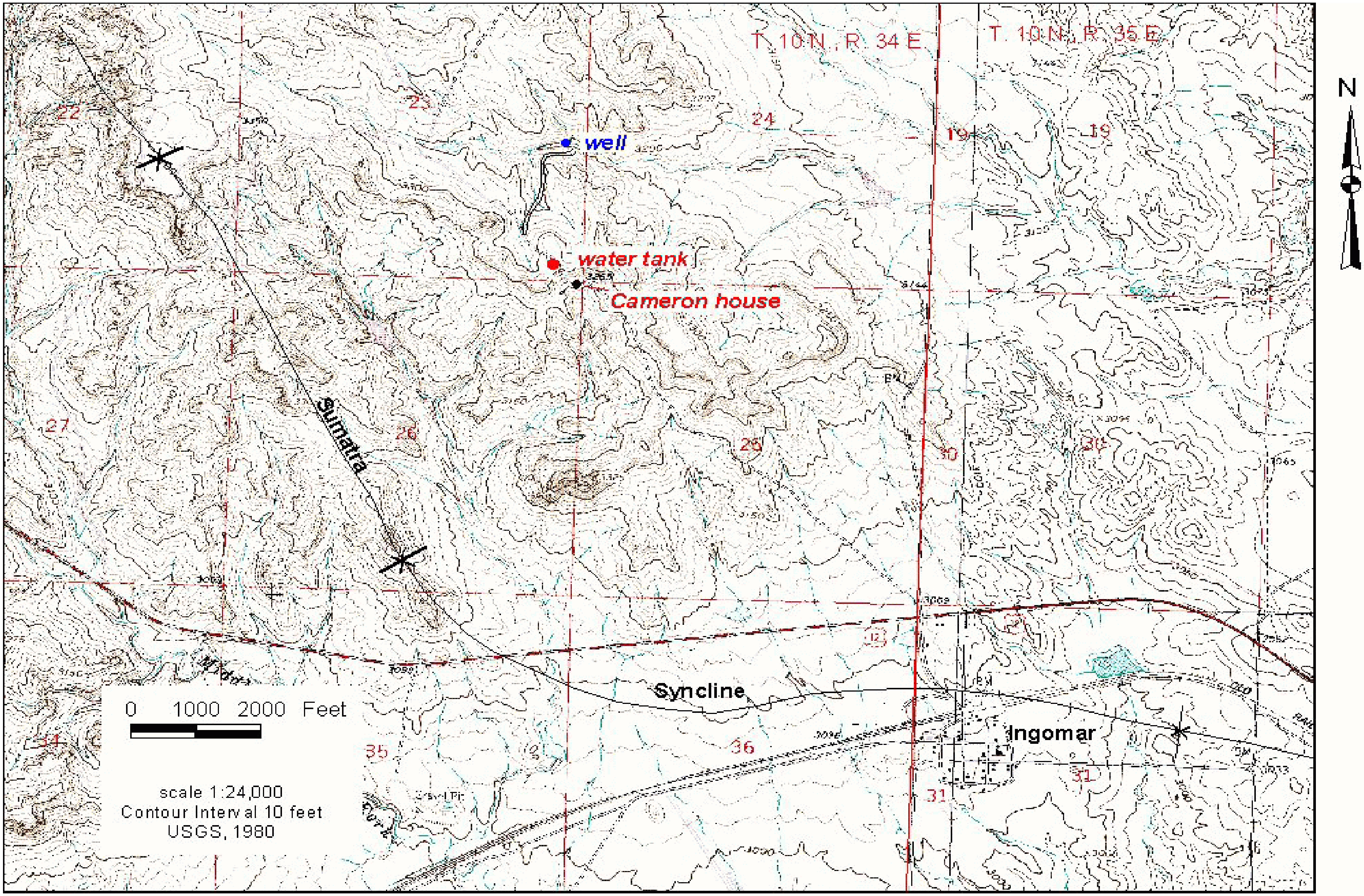
Well number	T	R	S	tract	Site owner name	Aquifer	Total depth feet	Depth water enters feet	Land surface elevation feet	Static water level feet	completion date	water use
M:23482	10N	34E	19	DDC	KLUK ELIAS					16	1-Jan-52	stockwater
M:1747	10N	34E	26	AA	MRS. A. HENDERSON	Fox Hills-Hell Creek	53	53	3220	51		domestic
M:23483	10N	34E	33	BAD	FRANK KANTA	Bearpaw	95	20		42	1-Jan-74	stockwater
M:145253	10N	34E	33	ACA	ETAL JOE KANTA		115	70		58	12-Jun-81	domestic
M:23484	10N	34E	34	DAB	LUCIN SCHOESSLER	Bearpaw	54	54		50	1-Jan-16	stockwater

Table C-2. Water quality record for the Ingomar water supply well from a 1923 sample (GWIC, 1998).

Water quality sample number	Well number	Site owner name	Aquifer	Sample source	Sample date	calcium mg/L	magnesium mg/L	iron mg/L	silica mg/L	CO3 mg/L	HCO3 mg/L	chloride mg/L	sulfate mg/L	nitrate as N mg/L	Dissolved solids mg/L	Dissolved constituents mg/L	alkalinity **X**	Hardness **X**	PROJ ID.
23Q0109	M:1746	Northern Pacific Railroad	Hell Creek	WELL	8-Oct-23	57	27	0.4	16	0	366	2	40	0.34	369.04	508.74	300.18	253.46	WSP-600

Appendix D

Map 1. Location and topographic map of water supply site



Map 1. Topographic map of Ingomar area showing the location of the water supply well, water storage tank, Cameron house and Ingomar (Ingomar East and Ingomar West, USGS Topographic Quadrangle maps, 1980).