Final Report

Frannie Well Rehabilitation Level II Study

(Kirk #1)
Frannie Wyoming

Prepared for
The Wyoming Water Development Commission
The Town of Frannie WY

By
Falcon Consulting Services L.L.C.
and
JayHawk Water Consulting

October 2005

Cover Photo courtesy Town of Frannie Circa 1955
Monday, October 31, 2005

Mr. Kevin Boyce  
Project Coordinator  
WWDC  
Cheyenne WY

RE: Final Report LEVEL II Rehabilitation of Frannie Well

Kevin,

Please attached 15 copies bound, and one unbound, along with the log CD’s, and electronic files required for this project. The cost estimates are included, however due the uncertainty created by recent events in conjunction with the Hurricanes Katrina and Wilma we are not able to warrant that these cost will not vary. They are based on our best available information as of this date. Two copies have been forwarded to Frannie, and one to the DEQ, Lander office to evaluate.

Should you have any questions, or require us to do anything else, please do not hesitate to call.

Sincerely,

Bret H. Wolz  
Principal Engineer  
Falcon Consulting Services

John Kaughman  
Principal Geologist  
Jayhawk Water Consulting

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Executive Summary

At the request of the Town of Frannie Wyoming, a Level 2 investigation of the Frannie Well was conducted to determine the feasibility of rehabilitating it to a productive status for beneficial use. The project was coordinated by the Wyoming Water Development Commission (WWDC) and funded by the Wyoming Legislature. The Frannie Well (once an oil exploration well) is located next to Sage Creek near the northeast corner of the Town of Frannie.

The Frannie Well (Kirk#1) is an artesian warm-water supply well that has served the municipal needs of the town for almost 50 years. Over time, the well deteriorated and the artesian flow diminished substantially. Several attempts were made by others to rehabilitate the well, but without lasting or substantial success.

Falcon Consulting Services L.L.C., and Jayhawk Water Consulting were contracted to prepare the Level 2 Study to investigate alternatives for rehabilitating the well for backup supply in the event the flow in the Shoshone Rural/Municipal pipeline is interrupted, to enhance opportunities for economic development, and as a nonpotable irrigation supply.

A forensic analysis of the well was conducted using traditional and cutting-edge geophysical technology to determine the feasibility of rehabilitating the Frannie Well to a productive status for beneficial use. The geophysical logs indicate the Frannie Well has significantly deteriorated and should be plugged and abandoned or reconstructed.
From the geophysical data is was discovered that the steel well casing and steel casing liner are partly missing and where present are corroded, pitted, worn, and punctured from prior well maintenance/rehabilitation events. (see digital optical photos of casing). The well bore is deviated substantially from vertical, there is little or no cement in the annular spaces behind the casing and liner strings, and there is cement in the open-hole (aquifer) section of the well. Much of the ground water from the aquifer is flowing up the well behind the well casing and casing liner and into permeable overlying sandstone units, which reduces the both the yield and artesian pressure at the wellhead.

From this analysis, five rehabilitation alternatives were identified along with estimates of probable cost and alternatives for funding. The preferred and least-cost alternative is to rehabilitate the well in two major steps: intervention and reconstruction. Well intervention would involve removal of the deteriorated steel casing liner, steel casing, and cement from the well. Well reconstruction would include well bore reaming, new casing installation, cementing, development, and testing.

The cost to rehabilitate the Frannie Well is approximately $630,000. Under the assumption that the Frannie Well is a secondary water source, the restoration project should be eligible for WWDC, RUS, EPA and/or possibly SLIB funds for completion.

Copies of this report have been provided to the Wyoming Department of Environmental Quality, Water Quality, for evaluation on the feasibility of re-permitting the well as a municipal source.
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OBI – ABI Comparisons and Sample Exhibits 4 Pages
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Pipeline Exhibit 4 Page
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Proposed Well Design 1 Page

Attached CD with WellCAD Reader and all Logs
   Insert CD to load WellCAD Reader Program, then you can access and review the OBI and ABI logs in their entirety.
Section 1.0

Introduction

This report presents the findings of an investigation of the Frannie Well to determine the feasibility of rehabilitating it to a productive status for beneficial use. The Wyoming Legislature authorized work on this project as a Level II Study in 2005. The project was coordinated by the Wyoming Water Development Commission (WWDC). The study was conducted from July to October, 2005, by Falcon Consulting Services, Inc. and Jayhawk Water Consulting. Colog, Inc. provided geophysical logging services. Woodcraft Inc. provided backhoe services to prepare the well site for the logging activities.

The Frannie Well (once called the Kirk No. 1 Well) is located in the Town of Frannie near the northeast corner of the community. Frannie is the northernmost incorporated town in Wyoming, about two miles south of the Wyoming – Montana state line on US Highway 310. Geographically, the Frannie is situated in the northern Big Horn Basin within the drainage basin of Sage Creek (a tributary of the Shoshone River), which flows south from Montana. The well site is on the east side of Sage Creek (near the center of the northwest quarter (SW¼, of the SW¼, of the NE¼, of the NW¼) of Section 31 in Township 59 North and Range 97 West).

The Frannie Well is an artesian warm-water supply well that has served the municipal needs of the town for almost 50 years. Over this period of time, the well has deteriorated and the artesian flow has diminished substantially. Beginning in the 1980’s several attempts were made by others to rehabilitate the well, but without success.

Potable water is now delivered to the Town of Frannie through the regional Shoshone Rural/Municipal Pipeline. Frannie is the last water-delivery point along the pipeline. If flow in the line is interrupted, then Frannie would be without water service until the flow is reestablished. The Town of Frannie requested a Level II Study to investigate alternatives for rehabilitating the well for nonpotable irrigation use and as a backup supply in the event the flow in the regional pipeline is interrupted.

The purpose of the investigation was to determine, through forensic analysis, whether or not the Frannie Well can be rehabilitated and, if feasible, develop rehabilitation alternative plans along with estimates of probable cost. If rehabilitation of the well is not feasible, then an alternative source of supply would be identified and evaluated.
Section 2.0  History of Frannie Well

2.1 CONSTRUCTION

The Frannie Well is an artesian municipal water-supply well. The well was drilled and constructed in 1955 to a reported depth of 4,500 feet as an oil exploration well. The well was drilled by Carroll Kirk, an oil producer, and was known originally as the Kirk No. 1 Well. The well did not produce oil, but it did encounter warm artesian ground water in the Madison Limestone.

The Madison Limestone is a major Mississippian-age regional aquifer that is typically vuggy and densely fractured from pre-Laramide erosional and tectonic stresses. These attributes make both the aquifer transmissivity and storativity high as compared to neighboring rock formations. As a consequence, most Madison Limestone wells in northern Wyoming yield large volumes of water for municipal use. In the Sage Creek Basin area, numerous impermeable overlying rock strata (or aquitards) confine the top of the aquifer. The Madison Limestone aquifer outcrops at higher elevations (hundreds of feet up-slope) several miles to the northeast where snowmelt is plentiful. This geometry and opportunity for significant recharge likely created and perpetuates the artesian conditions at the Frannie well site.

To construct the Kirk No. 1 oil exploration well, a 17.25-inch diameter borehole was drilled to a depth of 196 feet. A nominal 12-inch diameter steel surface (or conductor) casing was installed to this depth and cement grout was placed in the annual space. Beginning at 196 feet of depth, the borehole diameter was 8.75 inches, which was probably drilled by the direct mud-rotary method – it being the oil exploration drilling technology of the day in 1955.

When constructed, the well was completed with 7-inch OD steel well casing to a reported depth of 4,360 feet, or to about the middle of the Madison Limestone. The inside-casing diameter was not reported, but is believed at present to be 6.276 inches owing to the depth of the well and a caliper log of the well in 1984. The casing wall thickness and weight were likely 0.362 inches and 26 pounds per foot (lb/ft), respectively. A 7-inch ID / 7.625-inch OD steel casing is possible but not likely because the corresponding collar diameter is 8.5 inches. Such a casing (even without collars) would have been difficult if not impossible to install in the 4,500-foot deep, 8.75-inch diameter borehole. A 7-inch ID casing is not consistent with the caliper log developed in 1984. Below the casing depth to 4,500 feet below the ground surface, the Madison Limestone interval is an open-hole completion. Whether or not the Madison Limestone was fully penetrated by the borehole is also not known at the present time.
The annular space between the casing and the borehole wall, which was only 0.875 inches, was grouted with cement by positive displacement (the “Halliburton” method). This was done to prevent borehole collapse and the migration of borehole fluids (ground water, oil, and gas) up the annular space of the well and into other permeable rock strata or onto the ground surface. However, there is no record that centralizers were used to center the steel casing in the borehole prior to cementing to ensure the cement grout was placed evenly and completely around the well casing. The bedrock formations in the Frannie area dip steeply from northeast to southwest. Because of the steeply-dipping bedrock, the borehole probably deviates substantially from vertical to the northeast, or in the up-slope direction. Some “cork-screwing” of the borehole likely occurred, as well. In 1955, centralizers that would center the casing in the borehole were not commonly used in oil exploration wells. Therefore, the well casing would have been in contact with the borehole wall along most of the casing interval of the well, and the cement grout would not have completely filled the annual space between the casing and the borehole wall. This condition would have allowed ground water to seep into the open void spaces behind the casing. In time, oxidation or deterioration of the steel well casing and cement grout would have resulted.

2.2 INITIAL YIELD AND PRESSURE

Reported 1955 artesian yields from the well were as high as 2,000 gpm. However, initially-measured artesian water production from the well through a 3-inch diameter line at the wellhead produced 21,000 barrels per day (bbls/day), which is equal to 0.882 million gallons per day (mgd), or nearly 613 gallons per minute (gpm). The back pressure was 85 pounds per square inch (psi) or 196 feet of water. The estimated unrestricted artesian yield from the 7-inch diameter casing was 60,000 bbls/day, 2.52 mgd, or about 1,750 gpm. However, no record was found that substantiates this estimate.

The reported initial shut-in pressure at the wellhead was 150 psi, or about 346 feet above the ground surface. Historically, the water temperature has been about 94°F, which may be due to the normal geothermal gradient within the earth’s crust and not to an anomalous heat source. A laboratory report from 1956 by Chemical and Geological Laboratories indicates the Madison Limestone ground water flowing from the well was calcium-sulfate-bicarbonate type water. The total dissolved solids content was 994 mg/L and the pH was 7.8.

2.3 TRANSFER OF WELL OWNERSHIP

The Kirk No. 1 Well was sold to the Town of Frannie in 1955 and permitted under Well Registration No. U.W. 406 for municipal, irrigation, and domestic use. The well was also
adjudicated for municipal use at 500 gpm with a priority date of October 18, 1955. The well was the Town's water supply for many years until Frannie connected its water system to the Shoshone Rural/Municipal Pipeline.

2.4 WELL DETERIORATION AND REHABILITATION EFFORTS

2.4.1 First Report of Casing Oxidation (1961)

By 1961 (only six years after the well was constructed), oxidation of the well casing was evident, but not yet ascertained directly by experts. On April 29, 1961, Consulting Engineer Robert Streeter prepared a letter report to Arthur Becker, the Town Mayor, on a water-quality investigation of the well. The report stated the water is “scale-forming”, but the data do not explain the “red-water” problem and rapid buildup of ferrous hydroxide or “rust” in the Town's water within a few days after the water mains were flushed. He further reported that microscopic analysis of the water showed “flocculent mass of iron bacteria of “filamentous type”. The letter report did not mention possible corrosion of the well casing.

2.4.2 First Remediation Efforts (1984)

By 1984, well-casing corrosion was observed directly and the artesian yield from the well was reduced sufficiently to warrant remedial action by the occurring Town. On April 19, 1984, the well casing was scraped with a nominal 7-inch scraper and 6.125-inch diameter tricone rock bit, presumably to remove accumulated iron oxidation deposits and calcium scale from the inside casing wall. Following on April 21, 1984, Strata Data developed temperature, caliper, natural gamma, cement-bond, and sonic logs of the well. These logs revealed the following about the condition of the well at the time:

- The temperature log indicated the water temperature changed gradually and nearly evenly from 94.3°F at the bottom of the well (4,495 feet of depth) to 93.5°F at the ground surface, which shows a loss of only 0.8°F. No cool water inflows to the well were detected on the temperature log.

- The caliper log shows the inside well casing diameter is about 6.25 inches. Therefore, if the well casing OD is 7 inches, then the true casing ID is 6.276 inches (consistent with J-55 type, 26-pound well casing. Likewise, the casing wall thickness was likely 0.362 inches, and the annual space between the borehole wall and the outside casing wall was just 0.875 inches (or just 0.547 inches at the casing. Numerous pits and large holes in the casing are visible on the caliper log. Some of the holes likely represent casing separation/disintegration, particularly at depths of 3,942 to 3946 feet, 4,099 to
4,103 feet, 4,130 to 4,131 feet, and 4,346 to 4,370 feet below the ground surface.

- The natural gamma log indicates the presence of thick and interbedded sandstone units above the Madison Limestone into which water could flow from the Madison Limestone aquifer. Some of these sandstone units occur at depths ranging from about 2250 to 2400, 2560 to 2650, 2800 to 2940, 2970 to 3330, 3540 to 3700 feet of depth. Other more shallow sandstone sequences are also evident on the borehole log. According to the log, the top of the Madison Limestone aquifer is about 4180 feet below the ground surface at the well site.

- According to the cement-bond and sonic logs, there is little or no cement grout behind the casing, except from about 4240 to 4320 feet below the ground surface. This cement interval is only about 60 feet thick.

Curtis L. Talbot, Consulting Geologist, wrote a report (not dated) to Western Water Consultants about the remedial work that was completed in April 1984. His comments are summarized below. Commentary for the purpose of this report is provided in italic.

- The well was drilled to a depth of 1,000 feet in just three hours using a power swivel and a 6.125-inch diameter drilling bit. Drilling was soon completed to the total well depth of 4,500 feet. (Thus, no major obstructions to artesian flow were encountered in the well.)

- Drilling removed about 6 cubic yard of debris from the casing and open-hole portion of the well. The “worst” deposits were encountered at the bottom of the open hole. (This suggests that some caving and/or travertine deposition was occurring in the open portion of the well. Travertine deposition can reduce the artesian yield of the well.)

- The bottom of the well casing was encountered at 4,370 feet (not 4,360 feet, as previously reported). However, the casing was found to be “rotting away” below 4,350 feet of depth.

- The well casing was scraped to a depth of 4,200 feet using the 7-inch scraper. Increased flow occurred while “washing out” the hole below the casing. The total volume of artesian flow from the well and pressure were “greatly increased by the drilling and scraping.” (This washing was likely accomplished by circulating clean water into the well through the drill bit or by airlifting.)

- The hole was “coated with deposits from the formation” (as evidenced by the drilling and scraping debris). (These deposits were likely calcium scale similar in composition to travertine or simply calcium carbonate.)

- Holes in the well casing were found at 3,946 feet to 3,950 feet and at 4,102 to 4,106 feet of depth. Minor holes were also found elsewhere in the well casing.

- The logs “did not solve the problem of the source the radioactivity” in the well. (Curtis L. Talbot’s report is the first indication that radioactivity in the water has been observed.)

Western Water Consultants, Inc. reported later in a letter to Mayor Bryon Lee on May 8, 1984, that the gamma log shows “high radioactive zones” between 3,930 feet and 3,961 feet of depth, and that this should represent a problem. They also noted the well casing
is badly deteriorated and the cement grout seal is “poor”. They further recommended that a casing liner be installed in the well. On May 14, 1984, Dowell recommended to the Town that a 5.5-inch diameter casing liner be cemented inside the “old 7-inch casing” to a depth of 4,360 feet of depth. The bottom-hole temperature was presumed to be 130°F. However, the water-temperature indicates the temperature is 94°F.

The Madison Limestone is not a typical source of dissolved radionuclides (generally uranium, radium-226, radium-228) and radon gas. A likely source of the radionuclides in the ground water flowing from the Frannie Well under artesian head is lower Paleozoic formations and Precambrian-age crystalline rock formations that directly underlie the Madison Limestone Formation. Ground water from these lower geologic deposits can easily flow into the overlying Madison Limestone by vertical leakage through pre-Laramide joints, fractures, and permeable fault lines. A similar condition exists near Fairplay, Colorado at the London Mine, where the Madison Limestone is called the Leadville Limestone and the radon gas concentration is 500 pc/L. Recent gamma logging of the well also indicates that possible uranium roll-front deposits may be present in the following depth intervals: 190 to 250 feet, 880 to 995 feet, 3,139 to 3,141 feet, and 3,210 to 3,215 feet. Due to the poor condition of the well casing and lack of cement grout behind the well casing, radioactive ground water from one or more of these possible roll-front deposits may be seeping into the well. Removing and replacing the old well casing and proper cement grouting will eliminate these possible roll-front deposits as sources of radioactive ground water. If the radioactivity is due to radon gas, then simply aerating the water before distribution will eliminate the radioactivity.

2.4.3 First Observation of Flow Behind the Well Casing (1989)

In 1989, a leak of ground-water flow behind the 7-inch diameter casing was observed at the well head. An inflatable packer hung from a 4.5-inch diameter steel column of pipe was installed at a depth of 1,000 feet in the well. However, this solution failed to stop the leak indicating the water was seeping behind the casing below 1,000 feet of depth and/or around the packer. The packer was pulled and the 7-inch casing was again scraped.

2.4.4 Installation of Casing Liner and Cement Grout (1990)

In 1990, a Class B cementing shoe was placed on the end of 4,200 feet of used 4.5-inch OD steel casing liner and set in the well at a depth of 4,190.68 feet. The casing liner was purchased from Marathon Oil Company and consisted of 3,200 feet of 9.5 lb/ft and 1,001 feet of 15.1 lb/ft steel pipe. The 9.5 lb/ft casing wall thickness is 0.205 inches and the ID is 4.090 inches. The 15.1 lb/ft casing wall thickness is 0.337 inches and the ID is 3.826 inches. The average annular space between the well casing and the casing liner was about 0.888 inches, which is too small to ensure effective cement grouting inside
the already deteriorated 7-inch diameter well casing. Whether or not rigid centralizers were attached to the 4.5-inch casing liner to facilitate grout placement is not presently known.

A packer was set at the base of the casing-liner string with 800 psi pressure after dropping a ball down the casing. Cement grout (about 7 barrels or 1.46 cubic yards) was pumped into annular space. However, circulation was lost and not regained. The contractor estimated the cement rose only 600 feet in the annular space. The rest of the cement apparently flowed to the bottom of the well.

Using a 3.75-inch diameter drill bit, the cementing shoe was drilled and removed from the well. However, cement grout was found below the cementing shoe to a depth of about 4,360 feet, or the bottom of the well casing. Drilling progressed to near the bottom of the well (4,495 feet). During the drilling process, metal shavings (presumably from the 4.5-inch casing liner and packer) were found on the drill bit. After drilling was completed artesian production from the well resumed, but only to about 50 gpm. The well was subsequently acidized with to remove residual cement grout from the open Madison Limestone interval of the well.


In 1995, a 3.75-inch diameter drill bit and a 4.5-inch diameter scraper were used to remove accumulated scale and debris from the casing liner. The well was scraped from 3,300 feet to 4,190 feet of depth, or the bottom of the casing liner. From 4,190 feet to 4,370 feet of depth, cement was encountered in casing liner. From 4,370 feet to 4,495 feet of depth the well was found to be open to the Madison Limestone aquifer. The casing liner was then acidized. Again in May 1996 and May 1998, the drilling and scraping process was repeated inside the 4.5-inch casing liner.

2.4.6 Shot Perforations and Scraping (1998 and 2002)

In May 1998, the open portion of the well was shot-perforated below the casing depth (at 4,380 feet to 4,386 feet and at 4,430 to 4,450 feet) to increase the rate of artesian production. After setting a packer in the well at 3,380 feet of depth and installing a mud pump, the flow from the well increased to only about 84 gpm.

The casing liner was again scraped in June 1998. However, blocks were used to push the scraper for a distance of 180 feet, which may have damaged the casing liner. The process was again repeated in June 2002.

2.4.7 Wellhead Remediation and Bridge Plugs (2002)
In June 2002, 12 bls (about 18.7 cubic yards) of Class G cement was pumped into the annular space between the 7-inch well casing and the 4.5-inch casing liner at the well head to plug the ground leak. The seal worked, but only temporarily as the ground seepage soon continued unabated.

The casing liner was again scraped to 400 feet of depth. A retrievable bridge plug (RBP) was set in the casing liner at 490, 980, 1,480, 1,990, and 2,490 feet of depth. Flow from the annulus stopped when the RBP was set at 2,490 feet of depth. However, the seepage from the annulus soon continued. Two sacks of sand were then placed on the bridge plug followed by 6 cubic yards of Class G cement grout. Three days later the cement plug was removed with a 3.875-inch diameter beveled blade bit. The top of the cement was tagged at 2,455 feet of depth, or 35 feet above the bridge plug. However, the cement did not set as it was still in a slurry form. The cement, sand, and plug were removed from the well by drilling and scraping. Formation cuttings were encountered at 2,490 feet of depth where the RBP had been placed. The following day, a 3.75-inch diameter drill bit was tripped into the well to a depth of 4,500 feet to ensure the no blockage remained in the casing liner.
Section 3.0  Current Well Status

Over the years, the artesian yield from the Frannie Well has steadily declined to less than 100 gpm (according to the WWDC) due largely to deterioration of the well casing and cement grout. Much of the ground water entering the well from the Madison Limestone likely flows up the well behind the 7-inch well casing where the cement grout is absent and into permeable overlying rock formations above the aquitard strata. The wellhead pressure is likely reduced substantially from the original 85 psi measured in 1955 because of this short-circuiting and the continuous withdrawal of ground water from the well over 50 years.

Much of the ground water from the Madison aquifer also flows up the well between the 7-inch well casing and the 4.5-inch casing liner. This water is dark red color from casing oxidation and discharges directly into Sage Creek. The 4.5-inch diameter casing liner is probably deteriorated.

According to Town officials, much of the artesian flow from inside the 4.5-inch diameter casing liner of the well is captured and is directed into the Town's nonpotable irrigation system.

Over the years, the Frannie well has been an economic asset to the community. Because of its degraded condition, recent economic opportunities that could have developed from use of the well water have been missed. An operationally sound well, through either a successful rehabilitation or a new well, would provide Frannie with a viable supply for economic development and restoration of a dependable raw water source for the town.
Section 4.0   Methods of Investigation

A forensic analysis of the well was conducted using traditional and cutting-edge geophysical technology to determine the feasibility of rehabilitating the Frannie Well to a productive status for beneficial use. From this analysis, rehabilitation alternatives were identified along with estimates of probable cost and alternatives for funding. Alternative sources of supply were also identified and evaluated. No attempt was made to rehabilitate the well.

4.1    FORENSIC ANALYSIS BY GEOPHYSICAL LOGGING

Traditional geophysical logs (single-arm caliper, three-arm caliper, 3-D caliper, natural gamma, spontaneous potential, sonic density, and spinner) of the Frannie Well were developed and analyzed. A color video log of the well was attempted, but was not successful because of buoyancy created by the camera diameter and artesian flow of water in the narrow casing liner. The spinner tool proved ineffective because the flow velocities were beyond the calibration range of the spinner-logging tool.

Cutting-edge color optical borehole image (OBI) and acoustic borehole image (ABI) logs and the well were also developed. An OBI log is a color digital, optical side view of the casing and well bore in 360 degrees, but presented in 2 dimensions. It is analogous to splitting the casing vertically down the side and pealing it open to a flat position. Dark areas on the image represent pits and scratches in the casing. Large dark areas are holes in the casing. Light-colored areas are where minimal or no casing damage has occurred. A red line on the image is a reference line on the casing liner or open borehole. Its position is the high side of the casing and variability is due to the borehole deviation and turbulence of the up-flowing water.

An ABI log is a 3-dimensional digital caliper graphical image of the inner diameter of the casing and well-bore wall (where it is exposed). The scale progresses from black to white to red corresponding to smaller to larger diameters. For oxidized areas or holes in the casing, a larger inner diameter will be evident. The caliper-max and caliper-min logs of the ABI suit are another way of viewing the same data, as they represent the maximum and minimum value of the inner diameter at that depth. The casing image log contains a graphical representation of the thickness of the casing. The scale is from red to white to black to blue, which correspond to thinner and thicker casing. The color red represents the thinnest areas of the casing. The thickness-min and thickness-mean logs of the ABI suit are another way of viewing these same data, as they represent the minimum and mean value of the thickness at that depth. Anomalies at the bottom of the ABI log correspond to the bottom of the deteriorated casing liner and well casing. These images are not oriented and may not align perfectly with the OBI data set.

The complete ABI and OBI data sets are too large to include in this report. Typical ABI and OBI images are presented in the Appendix. Instead, the complete ABI and OBI data sets are contained on a computer disk (CD), which is attached to this report. The
program “WellCAD” is required to access the data sets and is also included on the CD. Instructions on installation of the program are found on the sleeve containing the CD.

The forensic field investigation of the Frannie Well began upon receipt of a notice to proceed from the Wyoming Water Development Commission. First, the well site was prepared for logging activities. The well building was removed and 20 cubic yards of “pit-run” rock base placed and compacted around the well to build a pad for the logging equipment. The construction of the pad began on June 20, 2005. The well site was fenced and a “no trespassing” sign was posted for security.

Geophysical logging began on June 24, 2005 and was completed on July 23, 2005. Logging was accomplished in stages in response to scheduling, specialized equipment availability, equipment malfunction due possibly to borehole obstructions, and interim analysis of the logs. The well condition was initially investigated using a three-arm caliper tool to document the casing and open-hole diameter, ensure that other geophysical tools would fit into the well, and to identify any obstructions. Several obstructions were identified and noted before the bottom of the well was reached. A significant blockage was found a depth of 1516 below the ground surface, which took considerable time and effort to overcome. As a consequence, the three-arm caliper tool was damaged during the initial logging of the well. The density tool was also damaged and flooded. Consequently, only the bottom portion of the well was logged with this tool.

\section*{4.2 Examination of Options and Costs}

As part of the investigation, the following five options were identified and examined in terms of feasibility and cost:

1. Continue to capture the available artesian flows from the Frannie Well for beneficial use and take no other action to rehabilitate the well.
2. Rehabilitate the Frannie Well;
3. Plug and abandon the Frannie Well, and construct a replacement well under the existing water right;
4. Plug and abandon the Frannie Well and abandon the water right; and
5. Plug and abandon the Frannie Well and transfer or create a new water right using an existing oil exploration well west of the town.

Abandonment of the water right without properly plugging and abandoning the well in accordance with State Engineer’s Office rules and regulations is not a viable option that was considered in this investigation.

\section*{4.3 Examination of Available Funding Mechanisms}

For the alternatives identified above, available funding mechanisms were examined and include the following:

- Wyoming Water Development Commission (WWDC);
- Rural Utility Services (RUS) of the Federal Farm Home Administration;
• Environmental Protection Agency (EPA);
• State Loan and Investment Board (SLIB); and
• Community Development Block Grant (CDBG) Program.

4.3.1 WWDC Funding

The Wyoming Water Development Program was established in 1975 to promote the optimal development of the state's human, industrial, mineral, agricultural, water and recreational resources. In 1979 the Wyoming Water Development Commission (WWDC) was established to implement the water development program and to conduct water and related resource planning.

Project planning and development are broken down into three levels. Project planning is covered in Levels 1 and 2, and project construction is covered in Level 3. Level 1 studies carry out necessary reconnaissance work, while Level II studies determine the projects' feasibility. Levels 1 and 2 are 100 percent grant funded. Project ideas originate with the sponsoring entities and come to the WWDC through applications. Applications for new projects must be received by WWDC by September 15th of each year.

The Wyoming legislature must authorize each project and approve funding before a project proceeds to final design and construction. Once this occurs, the staff of the Construction Division works with project sponsors to establish the legal documentation required to make the state funds available and to insure that the project constructed complies with the description, intent, and budget as specified in the enabling legislation. One of the professional staff is assigned to each construction project from design through construction and warranty acceptance. The Construction Division coordinates design engineer selection, plan and specification review, and award of construction contract and approves all project payments. Commission policy allows for grants of 50 percent of the eligible portions of new development projects, and 50 percent of the eligible portions of rehabilitation projects. The remainder of funding for eligible portions can be loaned at an interest rate equal to the rate set by the State Loan and Investment Board, currently 7.25 percent for new development and 6 percent for agricultural rehabilitation projects. Sponsors may choose to fund the loan portion from local or federal sources.

The WWDC can offer funding for the Town's consideration under Level 2 (for rehabilitation) and Level 3 (for re-connection to the water system). Each funding level is described below:

• Level 2 Funding: A Level 2 Project is initially funded 100 percent by the WWDC, in cooperation with the Town objectives. The WWDC assumes the risks inherent in exploratory projects or other projects involving certain risks. Upon successful completion of the Level 2 project and if the Town desires to place the project in operation, then the Town would be responsible for 50 percent of the construction costs (excluding engineering) of the Level 2 portion. Level 2 projects do not include construction required to connect the project to the water system.

• Level 3 Funding: A Level 3 project would be developed pursuant to a Level 2 project to connect the rehabilitated well to the Town system. The WWDC has historically funded as much as 75 percent of these costs in the form of grants.
The maximum grant funding available 50 percent of the project cost. The WWDC also offers loans for the balance of funding for both levels of projects. Specifics of Funding for WWDC projects may be found on the WWDC website: http://wwdc.state.wy.us/about/about.html. The funding deadline is on or about the 15th of October of each year.

4.3.2 RUS Funding

RUS funding is managed through federal program administered by the USDA and is available for small water projects such as the Frannie Well. The grants available, and loans vary by type, and dollars allocated each year. Application deadlines are in the latter part of May for the year the monies are required. Eligible funding grant levels and loan interest rates are based on economic conditions at the project site, and funding levels established by the congressional budgeting process for the fiscal year. Specifics of funding RUS projects may be found on the RUS website: http://www.usda.gov/rus/water/revolving%20fund.htm.

4.3.3 EPA Funding

Federal funds are available for certain projects through a program administered by the EPA. Funding varies by project. Eligible funding grant levels and loan interest rates are based on economic conditions at the project site, and funding levels established by the congressional budgeting process for the fiscal year. Specifics of funding may be found on the EPA website: http://www.epa.gov/ogd/grants/funding_opportunities.htm.

4.3.4 SLIB Funding

The Grants and Loan Section of SLIB is responsible for the administration and coordination of numerous statutory programs. The SLIB provides capital construction and infrastructure development assistance in the form of loans and grants to cities, counties, school districts, and other political subdivisions of the state. The available government grant and loan programs are used primarily for public water and sewer projects; streets, roads, and bridges; public health, safety, and medical facilities; jails and law enforcement facilities; and school districts. Five funding programs are administered under the SLIB:

- Clean Water State Revolving Fund (Loan)
- Drinking Water State Revolving Fund (Loan)
- Abandoned Mine land (Grant)
- Mineral Royalty Grants
- Joint Powers Act Loan

Monies from one or more of these programs may be available for the Frannie Well project. In general, available funding from these programs is not as attractive as WWDC program monies. Specifically one cannot use grants from the SLIB program to offset the
local investment required with the WWDC programs. Loans may be created and interest rates are established each year, which are similar to the WWDC rates. Specifics of funding may be found on the SLIB website:

http://slf-web.state.wy.us/grants/grants.htm

4.3.5 CDBG Funding

The Wyoming Business Council (WBC) administers the Community Development Block Grant (CDBG) Program for economic and community development projects, and its board of directors approves grant recipients. The CDBG Program is a federally funded pass through grant program from the U.S. Department of Housing and Urban Development (HUD). Wyoming has received an annual allocation from a low of $2.2 million, to a high of $3.7 million. For the 2005 program, the state has received $3,571,002.

Only counties and incorporated cities and towns are eligible to apply for CDBG funds. However, local governments may apply on behalf of other units of government, non-profit and for-profit businesses, and special interest groups. Applications for Community Development projects under Chapter 4 are due in the Wyoming Business Council (WBC) office on or about July 1st of each year. Applications for Economic Development planning only, technical assistance, job training, downtown development, Economic Development infrastructure projects, convertible loan, float loan, and Section 108 loans under Chapter 2 are due in the WBC office on February 1, 2006, and May 1, 2006.

Under the community development component of the program, public infrastructure includes projects such as water and sewer lines, streets, curb, gutter and storm drainage, and water supply and storage. CDBG funding is based on economic conditions within the Project site. Frannie would appear to be eligible for CDBG funding. The project must benefit economic development. Supplying a second source of water for Frannie, could spur development and make them eligible for this program. Specifics of the funding may be found on the DDBG website:

http://www.wyomingbusiness.org/cdc/cdbg/index.cfm
4.4 EXAMINATION OF ABILITY TO PAY

The following data has been provided by the Town of Frannie on the current indebtedness and ability to pay of the town.

Town of Frannie
General Financial Information

Prepared by: Diane Wagner, Clerk/Treasurer

Date: September 27, 2005

Entity: Town of Frannie

Assessed Valuation, FY2005:

Big Horn: 295,182          Park: 55,625

Assessed Valuation, FY2004:

Big Horn: 274,161          Park: 51,869

Assessed Valuation, FY2003:

Big Horn: 291,334          Park: 52,550

Total Mills levied - Frannie: 8 mills
Total Mills levied - County: 65.5 mills

Total Indebtness as of:
06/30/05: $220,500.00 Water Loan
06/30/05: $130,500.00 Sewer Loan

Residential Utility Information

1. Water Rate - basic........................................ $ 27.50
   (a) Usage Rate per 1000 gals............................. $ 2.50
2. Sewer Rate.................................................. $ 15.00
3. Garbage Rate................................................ $ 12.50
4. Telephone - basic.......................................... $ 45.00
5. FDU - Natural Gas - basic.............................. $ 8.00
   (b) Usage Rate per mcf.................................$ 5.95
6. Pacific Power - Electric - basic ................. .... $ 8.89
   (c) Usage Rate per kWh............................3.650¢

According to the town a project that adds monthly assessments in excess of $20.00 a month will most likely be beyond the ability of the majority of the residents to pay.
Section 5.0 Results of Investigation

5.1 PHYSICAL CONDITION OF THE FRANNIE WELL

The geophysical logs indicate the Frannie Well is significantly deteriorated and should be plugged and abandoned or reconstructed. The 7-inch diameter steel well casing and 4-inch diameter steel liner are partly missing and where present are corroded, pitted, worn, and punctured from prior well maintenance/rehabilitation events. There is little cement in the annular spaces behind the casing and liner strings, the well bore is deviated substantially from vertical, and there is cement in the open-hole (aquifer) section of the well.

Much of the ground water from the Madison Limestone aquifer (open section of the well) is flowing up the well behind the well casing and casing liner. Some of the water then seeps into permeable overlying sandstone units (such as the Dakota Sandstone), which reduces the both the yield and artesian pressure at the wellhead. The wellhead is also deteriorated because water is escaping the well as essentially uncontrolled pipe and diffuse flow at the ground surface from around the well casing and casing liner.

At the present time, none of the flow from the well is metered and all of the flow discharges directly into Sage Creek. The status of the well surface casing is not known, but will likely deteriorate in time. The geophysical logs and examples of the OBI and ABI logs are presented in the Appendix.

5.2 REHABILITATION ALTERNATIVES

A summary of the alternatives for this project follows. Specific cost estimates are developed with the alternatives and follow:
### Summary of Cost Estimates Frannie Well Level II

<table>
<thead>
<tr>
<th>Option</th>
<th>Estimated Project Costs</th>
<th>Estimated WWDC Grant Funding</th>
<th>Estimated Local Funding</th>
<th>Annual Loan Payment (30yr@4.5%)</th>
<th>Sinking Fund (10% of Loan)</th>
<th>O&amp;M Costs</th>
<th>Total Annual Costs</th>
<th>Cost per EDU (Monthly)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1 Maintain Status Quo</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>92</td>
<td>$0.00 dollars now, much greater costs, and no benefits later</td>
</tr>
<tr>
<td>Option 2 Rehab Frannie Well</td>
<td>$629,913.75</td>
<td>$389,038.75</td>
<td>$240,875.00</td>
<td>$14,059.31</td>
<td>$1,405.93</td>
<td>$4,200.00</td>
<td>$19,665.24</td>
<td>92</td>
<td>$17.81, Prefered Alternative</td>
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<tr>
<td>Option 3 Abandon Existing and Construct replacement Well</td>
<td>$1,106,946.75</td>
<td>$689,971.75</td>
<td>$416,975.00</td>
<td>$23,606.46</td>
<td>$2,360.65</td>
<td>$12,000.00</td>
<td>$37,967.11</td>
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<td>$34.39</td>
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<tr>
<td>Option 4 Plug and Abandon Well and Water Right</td>
<td>$381,687.00</td>
<td>$0.00</td>
<td>$381,687.00</td>
<td>$21,669.15</td>
<td>$2,166.92</td>
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<td>$23,836.07</td>
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<td>$21.59</td>
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<tr>
<td>Option 5 Abandon and use an alternate existing Well</td>
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<td>$49,209.50</td>
<td>$812,583.50</td>
<td>$46,631.32</td>
<td>$4,663.13</td>
<td>$25,000.00</td>
<td>$76,294.45</td>
<td>92</td>
<td>$69.11</td>
</tr>
</tbody>
</table>

Copyright © 2005 by Falcon Consulting Services, LLC and Jayhawk Water Consulting.
5.2.1 Maintain the Status Quo (Alternative 1)

Under this alternative, the Town of Frannie would continue to capture the available artesian flows from the Frannie Well for beneficial use and take no other action to rehabilitate the well. There is no immediate cost for this alternative. A small-diameter, low-yield submersible pump could be installed at a shallow depth is the well to prolong the yield. However, in time, the well condition will continue to deteriorate and all artesian flows may cease. A small submersible pump would be subject to damage or loss. The well bore may even collapse due to the lack of lateral support once provided by the well casing and cement grout when the well was constructed in 1955.

This alternative merely delays taking action in favor of one of the other alternatives at potentially higher capital cost. The State Engineer may not allow any uncontrolled and non-metered flow from the well. All flows from the well should be put to beneficial use so as not to risk forfeiture of some or all of the water right.

5.2.2 Rehabilitate the Frannie Well (Alternative 2)

This alternative would involve the rehabilitation of the Frannie Well to a productive status for beneficial use by the Town of Frannie. Whether or not the well can be rehabilitated to its original flow and pressure condition is not certain at this time. Due to the deteriorated nature of the well, this alternative would involve:

- Removal of the wellhead works;
- Complete removal of the existing steel casing liner and well casing;
- Reaming the well bore to a large diameter (such as 10 to 12 inches);
- Installing new well casing and cement grout; and
- Replacing the wellhead works to adequately control and measure the flows from the well.

The preferred rehabilitation work would be conducted in two major steps: intervention and reconstruction. Well intervention would involve removal of the deteriorated steel casing liner, steel casing, and cement from the well. Well reconstruction would include well bore reaming, new casing installation, cementing, development, and testing.

5.2.2.1 Well Intervention

Well intervention services would be provided by a firm and experienced staff that specialize in such work and should not be attempted by others. Tubing, casing, and cement remove would be analogous to the removal of pipe that is stuck in a well by cement. However, the deteriorated condition of the steel tubing and casing could require considerable milling to achieve removal, which could be both time-consuming and costly. The general pipe recovery process would proceed as follows:

- Review the well configuration, conditions, and geophysical logs.
- Work the pipe string and determine the estimated free point.
- Run a free-point tool to determine the uppermost stuck point.
- Select the best method and tools to separate the pipe.
• Back off, cut or sever the pipe.
• Remove the free portion of the pipe from the well.

The anticipated free-point tendency (stretch and torque readings) will drop over a short interval because of the remaining cement in the annular spaces. The freepoint is the deepest point at which the pipe can be recovered by a given method. Most freepoint tools are strain gauges to measure the stretch or torque of the pipe between a top anchor and a bottom anchor. Stuck pipe will not move in response to applied stretch or torque. Therefore, a freepoint tool can determine whether the pipe is stuck or free at a given point in the well.

A backoff or cut can be used to recover the uncemented portion of the pipe. Jarring operations will be successful only if the cemented sections are short. Where the pipe is centered in the well bore, a washover tool can be used to free the pipe. Where the pipe is not centered in the well bore, milling may be necessary to remove the pipe and cement.

A backoff is accomplished using a shot string. It relies on the impact provided by the detonation of a string to loosen a pipe connection. The string shot does not free pipe or unscrew a threaded connection; it simply provides extra energy to the torqued connection, which aids in unscrewing the connection. The rig-provided torque actually unscrews the pipe connection; the string shot determines which pipe connection will be unscrewed by the torque. A successful backoff will depend on the following conditions:

• Free pipe at the point of backoff;
• Sufficient left-hand torque at the point of backoff;
• Proper weight of the pipe string at the point of backoff; and
• A string shot of adequate strength for the specific pipe.

Cutting the pipe will necessary where the geometry of the well bore makes transmission of the torque down to the point of backoff impossible or for welded pipe joints. Cutting the pipe may also be an economical method of pipe recovery, since it typically takes less time than the backing-off step. Cutting may be accomplished using a combination of tools such as chemical cutters, jet cutters, radial cutting torches, split cutters, severing tools, and mechanical cutters.

5.2.2.2 Well Reconstruction

Following the successful completion of well intervention activities, a large drilling rig would be mobilized to the site to ream the well bore to approximately 12 to 14 inches. Drilling would be accomplished using the reverse-circulation method so as not to damage the aquifer with drilling fluid. Following drilling the well bore will be logged using gamma, density, resistivity, caliper, deviation, and spontaneous potential geophysical tools.

Threaded fiberglass casing (6-inch to 8-inch diameter) will be installed with centralizers to the top of the aquifer. The entire annual space behind the casing will then be cemented. The adequacy of the cement job will be verified by a cement bond log and temperature log. Fiberglass casing is durable and resistant to corrosion. Such casing is
used extensively in deep well applications where corrosive water is present. 

During the historical review of the well, measurements of radioactivity in the ground water was noted. If the source of the radioactivity is ground-water seepage from radioactive geologic deposits noted on the gamma log of the well, the new casing and cement grout should eliminate the problem. If the radioactivity is radon gas from the aquifer, then venting the water at the wellhead with an air-release valve should mitigate the problem.

Following casing installation and cementing, the well would be color-video logged and tested to determine the aquifer hydraulic properties, yield, pressures (shut-in and operating), and water chemistry (including potable drinking water standards and radionuclides).

A wellhead works would be designed for the expected pressures and flows. The wellhead works should include an air-release valve, pressure gauge, sample port, non-intrusive flow meter, back-flow prevention valve, and other appurtenances deemed necessary by the design engineer. Flows, pressures, and water quality should be monitored on a regular basis. The air-release valve should be properly sized to evacuate anticipated accumulation of gas such as carbon dioxide and radon.

The Town should anticipate the need to monitor and maintain the wellhead works on a regular basis because of chemical deposition and corrosion. Periodic replacement of wellhead components and piping should be anticipated. Well maintenance may include the periodic use of an inflatable/recoverable packer and acid (hydrochloric or phosphoric) to remove accumulated deposits of calcium carbonate. At the completion of each well maintenance activity, the well should be video logged to determine the success of the maintenance work and to identify any areas of concern. Mechanical scrapers or drill bits should not be used for maintenance. With proper maintenance and reasonable care, the reconstructed well as a structure should last substantially longer than the original Frannie Well.

The estimated cost for this alternative is approximately $630,000. A detailed cost estimate follows. Under the assumption that this is a secondary water source, this project should be eligible for WWDC, RUS, EPA and or possibly SLIB funds for completion.

<table>
<thead>
<tr>
<th>Level III Cost Estimate</th>
<th>Unit</th>
<th>Quant</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 2 Rehabilitation of the well</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of Final Designs and Specifications</td>
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<td></td>
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<tr>
<td>Permitting and Mitigation</td>
<td>$ 2,000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal Fees</td>
<td>$ 500.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquisition of Access and Rights of Way</td>
<td>$ -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Project Components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site prep</td>
<td>$ 5,000.00</td>
<td>ls</td>
<td></td>
</tr>
<tr>
<td>Mob Wireline</td>
<td>$ 2,000.00</td>
<td>ls</td>
<td></td>
</tr>
<tr>
<td>Mob Washover</td>
<td>$ 3,000.00</td>
<td>ls</td>
<td></td>
</tr>
<tr>
<td>Wireline Rig w/Cutting Tool</td>
<td>$ 12,000.00</td>
<td>hr</td>
<td>40.00</td>
</tr>
<tr>
<td>Wireline Rig Pulling Casing</td>
<td>$ 28,500.00</td>
<td>hr</td>
<td>100.00</td>
</tr>
<tr>
<td>Washover Rig Standby</td>
<td>$ 40,000.00</td>
<td>hr</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Construct a Replacement Well (Alternative 3)

For this alternative, the Frannie Well would be plugged and abandoned in accordance with the State Engineer’s Office rules and regulations, and a nearby replacement well would be constructed under the existing water right. The state regulations require that the well be abandoned in a manner to prevent inter-aquifer communication following abandonment. The current condition of the well indicates substantial fluid flow behind the casing liner and well casing. Simply filling well with gravel and cement will not prevent inter-aquifer communication, and compliance with the state regulations will not be achieved. To ensure, proper plugging and abandonment, the casing liner, well casing, and cement would need to be removed from the well, as described above in Section 5.2.2.1. The aquifer section of the well bore would then be filled with washed gravel and the remaining well bore would be filled with cement grout.

The replacement well would be drilled and constructed in a manner that is similar to the well reconstruction described above in Section 5.2.2.2, except that reaming would not be done. The replacement well would be located within 500 feet of the original well. Distances varying from this number may alter the estimate by the cost of construction of the waterline. There is also risk that the replacement well may not yield as much water as the original Frannie Well or may require pumping. The estimated cost for this alternative is approximately $1,107,000. Abandonment costs are not eligible for WWDC funding ($260,000-$350,000 of the total). A detailed cost estimate follows. A replacement well may be eligible for WWDC, RUS, EPA and SLIB funding.
Wireline Rig w/ Cutting Tool  $12,000.00  hr  40.00  $300.00
Wireline Rig Pulling Casing  $28,500.00  hr  100.00  $285.00
Washover Rig Standby  $40,000.00  hr  100.00  $400.00
Washover Rig Establish Break Points  $24,000.00  hr  30.00  $800.00
Washover Rig Mill out Casing  $144,000.00  hr  180.00  $900.00
Cement  $10,125.00  cy  75.00  $135.00
Site prep  $5,000.00  ls
Cement  $21,000.00  cy  140.00  $150.00
Site prep  $5,000.00  ls
Gravel pack  $1,300.00  CY  20.00  $65.00

Dispose of materials  $15,000.00  ls

**New Well Costs**

Drilling Rig  $150,000.00  hr  300.00  $500.00
Site prep  $5,000.00  ls
Final Hook up  $8,000.00  ls
New Casing  $189,000.00  if  4,200.00  $45.00
Cement  $4,725.00  cy  35.00  $135.00
Gravel pack  $1,300.00  CY  20.00  $65.00
Logging  $9,000.00
New Line to System  $70,000.00  if  2,000.00  $35.00
Pump and Motor w/ Drop Pipe  $83,000.00
Water quality testing  $3,000.00  ls
Construction Cost Subtotal #1  $833,950.00
Engineering Costs = CCS#1 x 10%  $83,395.00
Subtotal #2  $917,345.00
Contingency = Subtotal #2 x 15%  $137,601.75
Construction Cost Total  $1,054,946.75
Project Cost Total  $1,106,946.75

**5.2.4 Plug and Abandon the Frannie Well and Water Right (Alternative 4)**

This alternative would plug and abandon the Frannie Well and forfeit the associated water right. The state regulations require that the well be abandoned in a manner to prevent inter-aquifer communication following abandonment. As in Alternative 3 above, the current condition of the well indicates substantial fluid flow behind the casing liner and well casing. Simply filling well with gravel and cement will not prevent inter-aquifer communication, and compliance with the state regulations will not be achieved. To ensure, proper plugging and abandonment, the casing liner, well casing, and cement would need to be removed from the well, as described above in Section 5.2.2.1. The aquifer section of the well bore would then be filled with washed gravel and the remaining well bore would be filled with cement grout.

The estimated well plugging and abandonment cost is $353,000, and would not be eligible for WWDC, RUS, EPA, or SLIB funding. This cost does not include the value of the lost water right and would provide no return on investment. A detailed cost estimate follows.
## Level III Cost Estimate

<table>
<thead>
<tr>
<th>Alternative 4 Plug and Abandon well</th>
<th>Unit</th>
<th>Quant</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Final Designs and Specifications</td>
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<td>5,000.00</td>
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<tr>
<td>Permitting and Mitigation</td>
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<tr>
<td>Legal Fees</td>
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<td>500.00</td>
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<tr>
<td>Acquisition of Access and Rights of Way</td>
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<tr>
<td>Cost of Project Components</td>
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</tr>
<tr>
<td>Mob Wireline</td>
<td>$</td>
<td>2,000.00</td>
<td>ls</td>
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<tr>
<td>Mob Washover</td>
<td>$</td>
<td>3,000.00</td>
<td>ls</td>
</tr>
<tr>
<td>Wireline Rig w/Cutting Tool</td>
<td>$</td>
<td>12,000.00</td>
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<tr>
<td>Wireline Rig Pulling Casing</td>
<td>$</td>
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<td>Washover Rig Standby</td>
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<tr>
<td>Washover Rig Establish Break Points</td>
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<tr>
<td>Washover Rig Mill out Casing</td>
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<tr>
<td>Cement</td>
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<td>Dispose of materials</td>
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<td>Engineering Costs = CCS#1 x 10%</td>
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<td>Subtotal #2</td>
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<td>Contingency = Subtotal #2 x 15%</td>
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<td>Construction Cost Total</td>
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<tr>
<td>Project Cost Total</td>
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<td></td>
<td>$381,687.00</td>
</tr>
</tbody>
</table>

### 5.2.5 Use An Alternate Existing Well (Alternative 5)

Under this alternative, the Frannie Well would be plugged and abandoned in accordance with State Engineer’s Office rules and regulations, and the associated water right would either be transferred to an existing hydrocarbon exploration well west of the town. If necessary, the Frannie water right would be abandoned a new water right would be established.

As in Alternative 3 above, the current condition of the well indicates substantial fluid flow behind the casing liner and well casing. Simply filling well with gravel and cement will not prevent inter-aquifer communication, and compliance with the state regulations will not be achieved. To ensure, proper plugging and abandonment, the casing liner, well casing, and cement would need to be removed from the well, as described above in Section 5.2.2.1. The aquifer section of the well bore would then be filled with washed gravel and the remaining well bore would be filled with cement grout.

For the purpose of this alternative, an assumption was made that the two Merit Wells (No. 122 and/or No. 136) would be available for use by the Town of Frannie. Well No. 122 is a Tenslep Formation well that would need to be deepened. However, it is closer to the Town than Well No. 136 (2,600 feet vs. 4,200 feet). Well No. 136 is a Madison
Limestone Formation well and would required no additional drilling. For this reason, Well #136 is more feasible and cost-effective than Well No. 122. The anticipated cost of deepening Well No. 122 exceeds the anticipated costs of additional rights of way and pipelines for Well No. 136. Geophysical logging, well development, testing, and water-quality work will be required before Well No. 136 could be used. Need and installation of a submersible pump and is also anticipated. The current condition of the well casing is not known. Use of Well No. 136 would be likely be a replication of the history of the Frannie Well. The estimated costs for this alternative total about $862,000. A detailed cost estimate follows. A plan of the pipeline routes is provided in the appendix. Abandonment costs ($260,000-$350,000 of the total), would not eligible for WWDC, RUS, EPA and SLIB funding. Such funding may available for conversion of Well No. 136 into a supply well for the Town.

<table>
<thead>
<tr>
<th>Level III Cost Estimate</th>
<th>Unit</th>
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<td>Acquisition of Access and Rights of Way</td>
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Cost of Project Components

### Abandon Costs

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<td>Mob Washover</td>
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### Enter new Well

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Conclusions and Recommendation

Alternative No. 2, Rehabilitate the Frannie Well, is the least-cost alternative (about $630,000) and should be pursued by the Town of Frannie because:

1. Based on available information from this investigation, the Frannie Well can be restored to a productive status for beneficial use. The rehabilitation work described herein can be performed with a reasonable level of confidence to achieve the desired objective. Under the assumption that the Frannie Well is a secondary water source, the restoration project should be eligible for WWDC, RUS, EPA and/or possibly SLIB funds for completion.

2. Alternative 1 merely delays taking action in favor of one of the other alternatives at potentially higher capital cost. The State Engineer may not allow any uncontrolled and non-metered flow from the well. All flows from the well should be put to beneficial use so as not to risk forfeiture of some or all of the water right.

3. Alternative No. 3, which is to plug and abandon the Frannie Well in accordance with the State Engineer’s Office rules and regulations, construct a nearby replacement well is about $477,000 more expensive than Alternative No. 2, and abandonment costs are not eligible for WWDC funding ($260,000-$350,000 of the total cost).

4. Alternative No. 4, which is to plug and abandon the Frannie Well in accordance with the State Engineer’s Office rules and regulations and forfeit the water right would cost about $260,000-$350,000. This cost would not be eligible for WWDC, RUS, EPA, or SLIB funding. Also, this cost does not include the value of the lost water right, and there would be no return on investment.

5. Alternative No. 5, which is to plug and abandon the Frannie Well in accordance with the State Engineer’s Office rules and regulations and transfer the water right to an existing hydrocarbon exploration well west of the town, the estimated total cost is about $862,000, or about $232,000 more than Alternative 2. Moreover, the need and installation of a submersible pump and is anticipated. The current condition of the well casing is also not known, and use of the exploration well would be likely be a replication of the history of the Frannie Well. Abandonment costs ($260,000-$350,000 of the total) would not eligible for WWDC, RUS, EPA and SLIB funding. Drilling or entering existing wells carry significant risks that cannot be evaluated until further investigation is performed. This increases the costs without a significant increase in potential asset.

The Town of Frannie should also investigate the feasibility of selling or leasing any excess water to generate an income stream from the well and recover both the Town and State investments in the rehabilitation project.
3d Caliper
Red is largest Diameter

Casing wall
Thickness
Red Thinnest

Optical Log (Digital Photo)
Punched hole in Casing

Red Line indicates the Reference line to High Side

Jaggedness of the reference line indicates turbulent flow

Puncture Hole

Exhibit 1 1457-1485
3d caliper
Red largest
Diameter
Red thinnest
Casing thickness

Small pinholes due most likely to corrosion
Bottom of Existing Casing
Perforations in Concrete Lining
Red Reference Line
(High Side)

Exhibit 4 end of Casing
Existing Ground Surface

12"-14" Bore hole

4360 Interface to Madison Limestone Aquifer

6-8" ID FRP w/ Steel Centralizers
(Fiberglass Reinforced Pipe)

Cement Grout

Permian to Cretaceous Deposits
Sandstone, Siltstone, and Shales
100-4360

Surficial Deposits
~ depth 40-100'

Pitless not shown

Madison Formation

Open Bore hole 7-3/8 to 9-3/4'

Break nts

Total Depth 4500'

Kirk #1 (Franz's) Well Rehabilitation
Well Design
Proposed
Kirk #1 rehabilitation
Level II
Alternative Sources of raw water, Indicating pipe alignments and lengths
Length to #122 3150 ft
Length to #124 4620 ft
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<th>COMPANY</th>
<th>Falcon Consulting</th>
<th>WELL</th>
<th>Kirk #1</th>
<th>FIELD</th>
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COMMENTS
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<tr>
<th>Depth (in)</th>
<th>Caliper Width (in)</th>
<th>ARM Caliper Loss</th>
<th>Resistance (ohm-m)</th>
<th>Guard Resistance</th>
<th>Count Rate (cps)</th>
<th>Density (g/cc)</th>
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<tr>
<td>3</td>
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<td>Single Arm (not calibrated)</td>
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<td>-300</td>
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<td>500</td>
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- **Natural Gamma**
  - Count Rate: 700 CPS
  - Density: 3 g/cc

- **Far Den**
  - Count Rate: 700 CPS
  - Density: 3 g/cc

- **Near Counts**
  - Count Rate: 700 CPS
  - Density: 3 g/cc
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<td>1000 g/cc</td>
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Graph and tables showing various measurements and data points.
End of Concrete lined bore hole.
Historical end of Casing

Concrete in Open Bore Hole

Open bore hole typ
Concrete showing up extensively

Bottom of open hole

Depth

Optical Image

10:000 0° 90° 180° 270° 0°

FALCON CONSULTING SERVICES LLC
PO BOX 3943
GILLETTE, WYOMING
907-767-0575
307-667-0572 fcs@icon.com
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Image: 0° 0° 180° 90° 270° 0°
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