



United States Department of the Interior

NATIONAL PARK SERVICE
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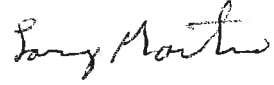
IN REPLY REFER TO:

November 9, 2007

L54(2380)
FOBO/General

Memorandum

To: Brian Carey, Superintendent, Fort Bowie National Historic Site

From: Larry Martin, Hydrogeologist, Water Operations Branch, WRD 

Subject: Water-Supply Well Issues at Fort Bowie

Summary: Alternatives for providing a safe, reliable water supply for facilities at Fort Bowie include continuing to use water from the well in the maintenance area, reconstruction of a pipeline and electrical service to the well in Siphon Canyon, and construction of a new well near the visitor center.

My recommendation is to continue to use the well in the maintenance yard and monitor its performance to determine when additional treatment will be necessary. We should first determine whether the steps that have been taken (adding in-line filters, reducing pumping rate, pumping at night, etc.) will allow continued use of the well for a long period before additional biofouling treatment is needed.

Discussion: The water-supply well in the maintenance yard at Fort Bowie continues to be plagued by biofouling problems, despite attempts to treat the well in December 2006. The primary problems are odor and color. The water frequently has a sulfurous smell, and the water is sometimes a reddish color. These problems are caused by the presence of bacteria that feed on the iron, manganese, and carbon in the groundwater. The well at Fort Bowie has the misfortune of penetrating rocks that contain abundant sources of iron, manganese, and carbon. Combining these food sources with regular introduction of oxygen during drawdown of the water level when the well is pumping creates ideal conditions for growth of the bacteria. The biofouling includes living and dead bacteria, their colony structures—sheaths, stalks, secretions, and other leavings. The result is an accumulation of biofilm material that partially plugs the openings in the aquifer and the well. Occasionally a piece of this material breaks loose and is sucked up the pump and into the water distribution system. Biofouling, and the bacteria associated with it, are not a human health threat.

The remainder of this report will briefly discuss water-supply options for facilities at Fort Bowie and provide gross cost estimates for each of the alternatives.

Figure 1 is a map from Google Earth with annotation to show approximate locations of geologic faults, springs, and wells in the vicinity of Fort Bowie National Historic Site.

Siphon Canyon Well -- The Siphon Canyon well was the water supply well for the park from about 1992 until 2002, when the well in the maintenance yard was brought on-line. The Siphon Canyon well is located on the south side of Siphon Canyon, about 3000 feet northwest of the maintenance yard at Fort Bowie. The well was constructed in 1966 but wasn't used until 1992, when the pipeline and electrical supply were constructed. The Siphon Canyon well is 102 feet deep and obtains water from fractured limestone. The well was test pumped in 1991 at about 120 gpm for 12 hours resulting in less than 2 feet of drawdown.

Use of water from the Siphon Canyon well was plagued by problems of maintaining electrical service for the pump and leaks in the pipeline. These problems resulted in construction of the well in the maintenance yard in August 2000. The pipeline and electrical service to the Siphon Canyon well have been removed.

Restoration of the Siphon Canyon well as the park's water supply has the highest probability of successfully providing potable water to park facilities without impacting flow from Mine Tunnel and Apache Springs. The well is a proven source of good-quality water. There is an abundant supply, and there is very little drawdown when the well is pumped. Use of the well would require construction of a pipeline to the well, approximately 3000 feet over steep, rough, rocky terrain. Burying the pipeline would be difficult, and therefore expensive. The original pipeline was elevated and insulated to surmount these problems. A solar panel might provide sufficient power to pump water from the well to a temporary storage tank in the maintenance yard, where a booster pump could be used to send it through the chlorinator and up to the main storage tank.

A solar panel and pumping system would cost around \$20-25,000. Cost estimates for a pipeline were made by comparison with a similar pipeline project at Rio Grande Village in Big Bend National Park in 2006 and adjusting the costs upward for inflation. I assumed a cost of \$20/ft for supplying materials and installation of 3000 feet of 1½" buried PVC pipe (\$60,000). I added a cost of \$70/yd³ for excavation in rock and assumed that the entire trench would be excavated in rock, 1 ft x 2 ft x 3000 ft = 6000 ft³, or 225 yd³ x \$70/yd³ is \$15,000. The total estimate for installation of a pipeline is \$75,000. Total cost estimate for a solar power supply system pump, and pipeline is \$100,000.

If reconstruction of a pipeline to the Siphon Canyon well becomes a seriously considered alternative, the well should be inspected with a borehole video camera and tested to insure that it is still in good shape and capable of producing large quantities of good quality water.

Construction of a new well -- Colleen Filippone and I investigated potential locations for a new well when we were at the park on Oct. 31. Potential well locations are limited by difficult access in rugged terrain and geologic conditions. A new well would need to be constructed in the limestone bedrock formations between thrust faults that trend southeast-northwest through the park. Bedrock to the northeast of the limestone outcrop is siltstone and is essentially impermeable. Bedrock to the southwest of the limestone outcrop is granite and is essentially impermeable. The limestone has been fractured by various geologic processes, resulting in formation of a very permeable aquifer. The Siphon Canyon well, Apache Spring, Mine Tunnel Springs, and Bear Spring all discharge water from the limestone aquifer.

Figure 2 shows two possible locations for a new well at Fort Bowie. These sites were selected using these criteria:

1. Locate the well in an area where it would penetrate the fractured limestone aquifer.
2. Locate the new well as far from the fault zone as possible to minimize the potential contact with metamorphosed limestone containing carbon and iron, i.e., attempt to avoid the geologic conditions encountered by the well at the maintenance yard.
3. Locate the well sites along existing roads, or at least in areas that would not require construction of a new road that would be a visual intrusion on the historic scenery of the effort.
4. Avoid locating the well within the perimeter of the ruins of the fort.
5. Maintain a setback distance from springs to limit impacts of groundwater pumping on spring flow.
6. Consider proximity to existing electrical service, routes for the water line to the storage tank, and the need for a chlorinator building.

The potential sites for a new well shown on figure 2 are examples for discussion purposes at this time. If it is decided to pursue construction of a new well, additional analysis and discussion should occur to identify the optimal location for a new well.

The cost for a new well was estimated at \$150/foot. A 200-foot deep well would cost around \$30,000 for construction. Additional cost would be incurred to install a pump and make all the necessary electrical and water line connections, easily another \$10,000 or more. The total cost would be largely dependent on the location of the well and the length pipeline, electrical supply, and trenching to bring the well on line.

There is no assurance that a new well would not develop biofouling problems. Our theory is that by moving the well location to the west, away from the fault zone, that we would not encounter the geologic strata that allow biofouling at the maintenance yard well. The potential locations for a new well shown on Figure 2 would place the well closer to Apache Springs and increase the potential for groundwater pumping to impact the flow from the spring.

Continued use of the Maintenance Yard Well -- The attempt to treat the biofouling problem in the well in December 2006 was only partially successful. It is believed that the main obstacle to cleaning the biofouling products from the well was the relatively small number of perforations in the well casing. The well remains in use and is the sole source of water for facilities at Fort Bowie. Several steps have been taken, or are planned, to reduce the effect of biofouling in the well on the water supply, including:

1. The configuration of the float valves in the water storage tank has been changed to reduce the frequency of pumping. The well now pumps water on an as-needed basis, operating approximately every other day when storage in the water tank has declined about 2000 gallons.
2. The pumping rate has been reduced to limit the amount of water-level drawdown and thus limit the introduction of oxygen into the well. Reducing the pumping rate also slows the velocity of water flowing into the well and may reduce the movement of biofouling products into the well.
3. In-line water filters are being installed at the two residences to remove solids from the water prior to entering the residences.
4. A timer has been installed to cause the well to pump only during nighttime hours, presumably when residents in park housing are not using water.
5. Continue to monitor water levels in the well to determine when it will be necessary to treat the biofouling again.
6. Conduct microparticulate testing to determine whether there is evidence of contamination from surface sources, e.g., giardia cysts and cryptosporidium. This testing should be performed during a wet period of the year, after there have been significant precipitation events.

The effects of biofouling have mostly been a problem at the two park residences. Because of the configuration of the water supply and distribution system, these residences sometimes receive water directly from the well, before it has gone to the main storage tank. When water is first pumped to the storage tank, any biofouling products settle to the bottom of the tank and odors dissipate before the water is drawn out of the storage tank.

If this well continues to be used as the water supply for the park, it will likely need to be treated again in the future to remove biofouling products. Treatment will be necessary either when water quality deteriorates, or when the perforations in the well casing becomes so plugged with biofouling products that the water level is drawn down to the pump intake when pumping occurs. The biofouling treatment will be much more effective if additional perforations are made in the well casing. This can be accomplished by using a perforator or mills knife, either of which are fairly common tools for well drillers. There should be a video log of the well before and after the perforating procedure. I would expect that adding additional perforations to the well would cost \$5-10,000 and would be a one-time cost. Chemical and physical treatment of the well to remove biofouling products will likely run \$15-20,000 and will be a recurring cost. It is impossible to predict how often this treatment will be necessary—perhaps annually or maybe several years between treatments. It's possible that the actions that have already been taken (installation, reducing the pumping rate, etc.) will allow the well to function adequately for several more years.

The current water level monitoring program will help identify when it will be necessary to treat the well again.

If there are any questions regarding this trip report, please call me at (970)-225-3515.

cc:

CHIR – Jose Rameriz, Elvin Cluff

CORO – Kym Hall

FOBO – Larry Ludwig, Phil Tapia, Erik Briske

1211 – Colleen Filippone, Janet Wise

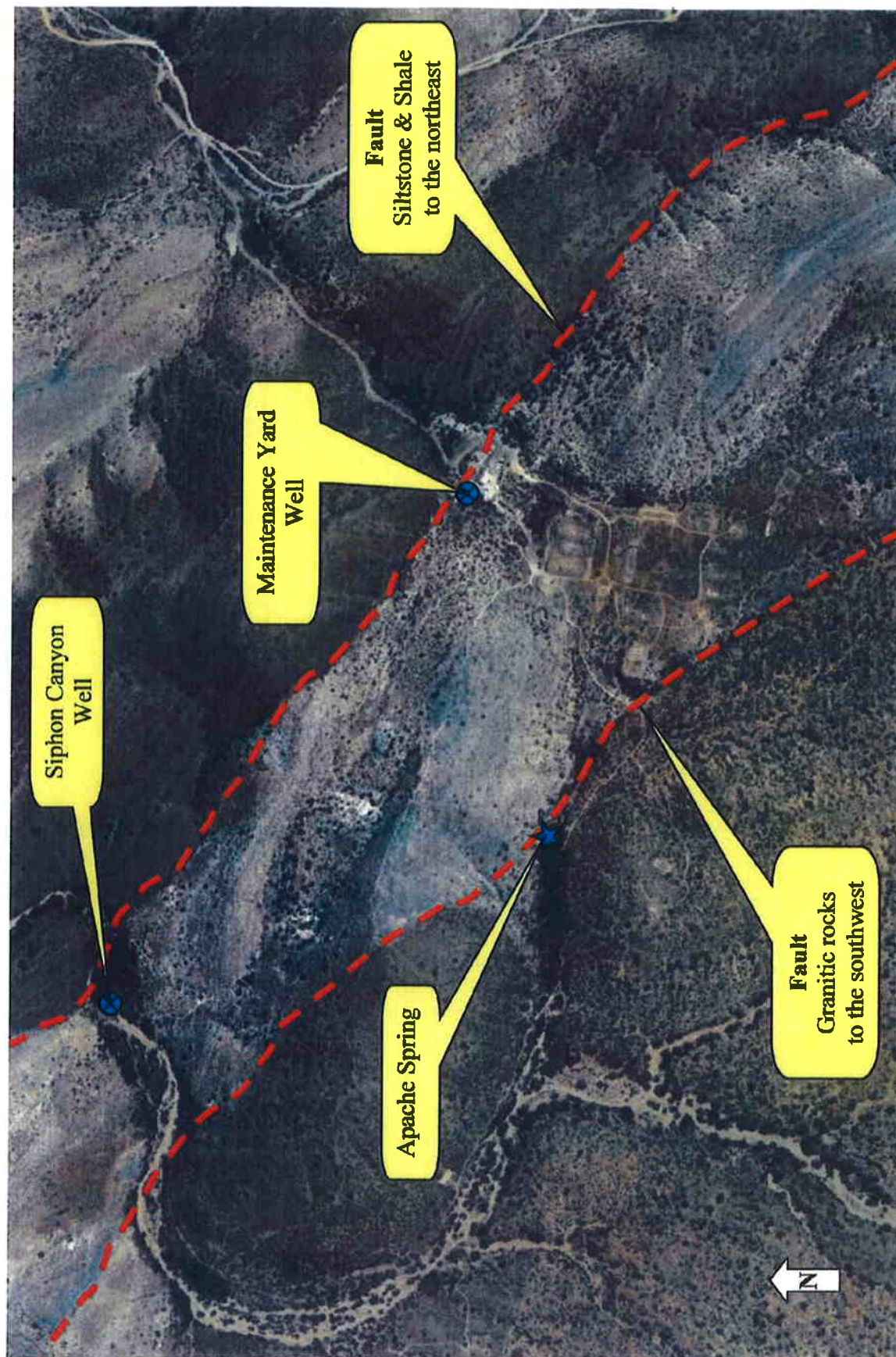


Figure 1. Location of wells, springs, and geologic features in the vicinity of Ft. Bowie. The permeable limestone bedrock formations occur as a NW-SE band between the fault zones.

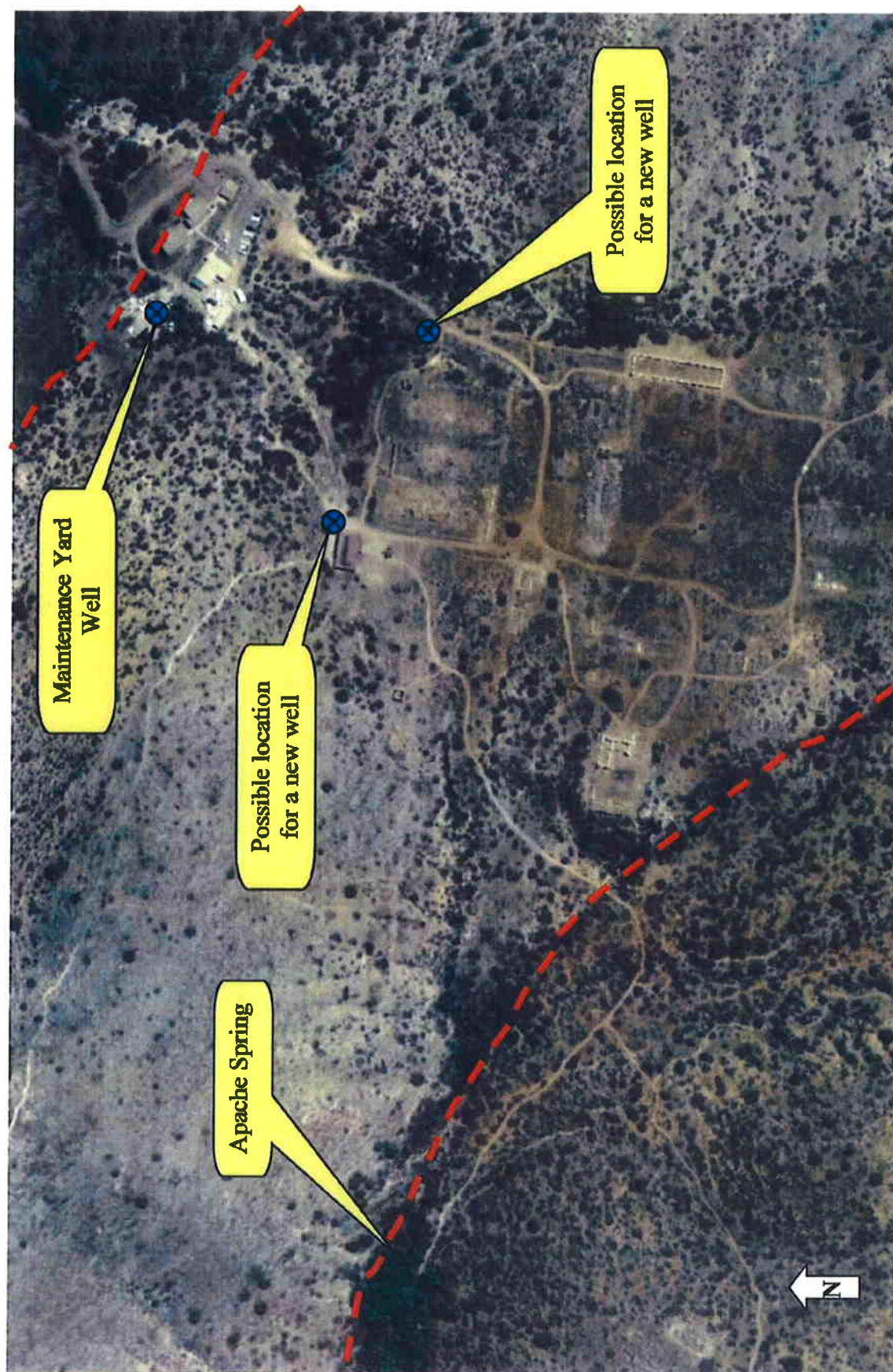


Figure 2. Potential locations for a new water supply well at Ft. Bowie.