

Comments regarding the proposed well at Horseshoe Bend

Bighorn Canyon National Recreation Area

A new well is planned for construction for facilities at Horseshoe Bend at Bighorn Canyon NRA. Currently water is supplied from a spring about 1¾ miles to the NNW. Supplemental water is desired to fully meet the demand for usage in the area.

Selection of the target aquifer

Two test wells were constructed in the area in 1966. (These wells are different from the test borings discussed in the following section.) Both wells were completed in the Tensleep Sandstone and produced water that had high concentrations of sulfate (1000-1500 ppm). The water was unsuitable for human consumption without treatment. The test wells were plugged and abandoned. The Amsden Formation underlying the Tensleep Sandstone) might produce small amounts of poor-quality water and is therefore not considered as a potential target for well drilling.

The Madison Formation generally provides abundant supplies of good-quality groundwater to wells in the Bighorn Basin. There are no currently existing wells constructed into the Madison within several miles of the Horseshoe Bend area, so we can't be certain about the expected quantity or quality of water from the Madison at Horseshoe Bend. Several test borings were drilled in this area in 1966, but I was told that these test borings (discussed in the following section) no longer exist. So, although we have no site-specific data, the Madison seems to be the only viable target for construction of a well to supply large amounts of good-quality water.

Expected depth to the top of the Madison Formation

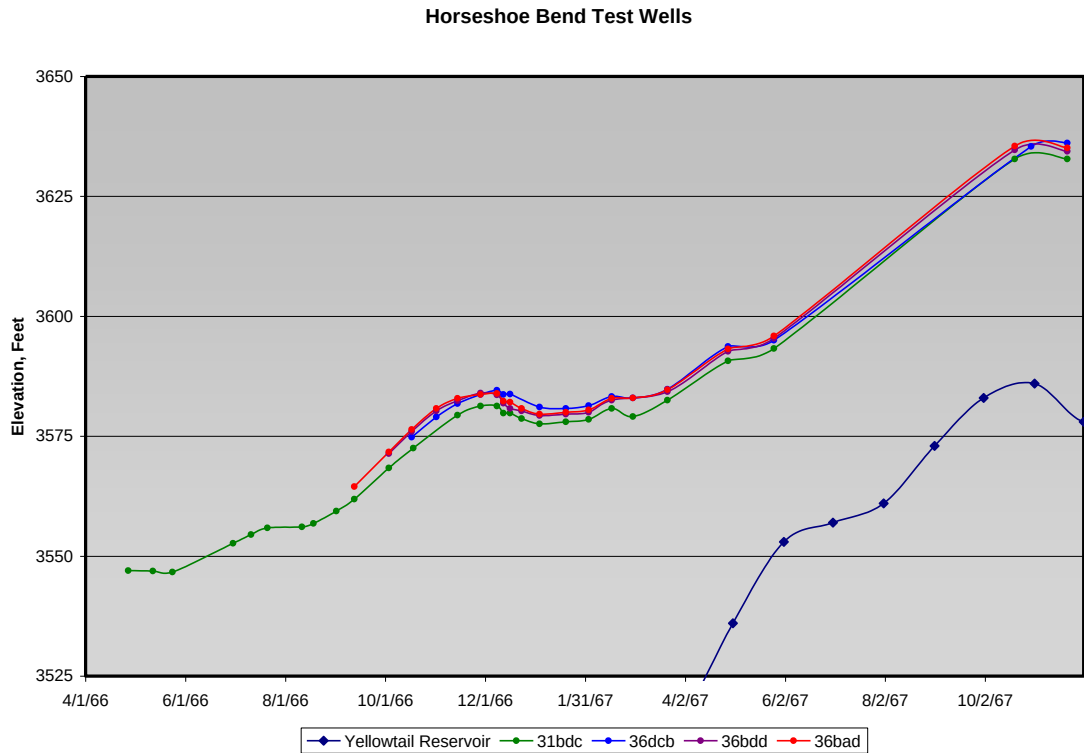
NPS drilled 5 test borings in the Horseshoe Bend area in 1966. Core samples were bored from the test holes for detailed geological analyses. These core samples provide a very detailed look at the stratigraphy of the area. Three of the test borings were made in vicinity of the campground, within about a half mile of the proposed site for the new well. One boring was made about a mile east of the proposed well site, near the river. The fifth boring was made about 2½ miles southeast of the proposed well site.

The geologist's logs for those test borings provide an elevation for the top of the Madison Formation in each of the borings. These data were used to estimate the slope (and direction of slope) of the top of the Madison Formation and project that slope to the proposed location of the new well. **The best estimate of the depth to the Madison Formation at the proposed well site is 425-450 feet below ground surface.**

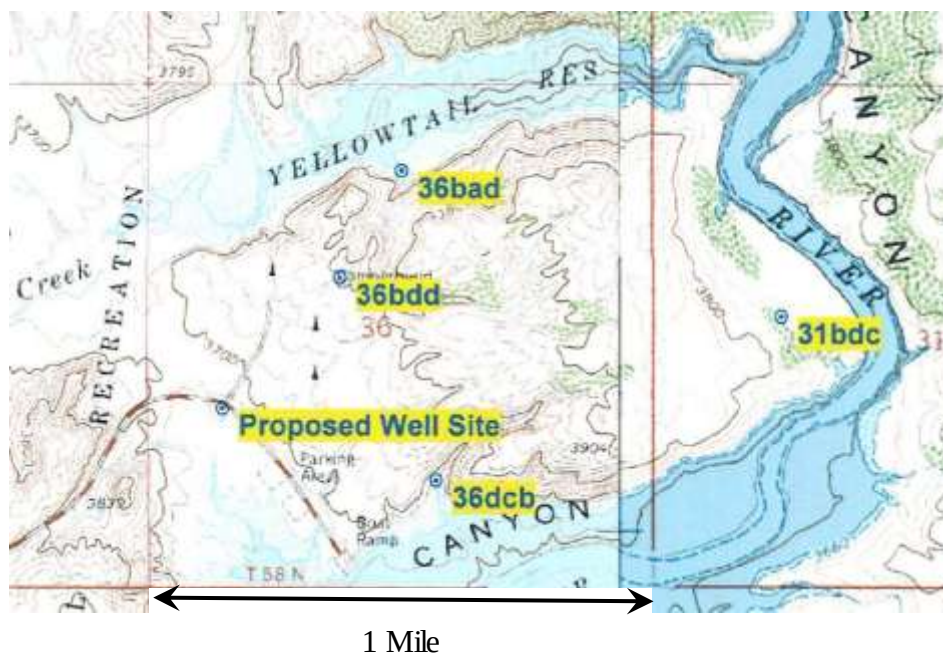
Expected water level in the proposed well

Water levels in the test holes at Horseshoe Bend were measured approximately monthly from the date that each well was completed in 1966 until late-November 1967. This coincided with the initial filling of the reservoir. Water levels in the test holes rose from about 3550 feet above mean sea level to about 3635 feet msl. I could not find any other

data, or more recent data, for water levels in wells completed in the Madison Formation in the vicinity of Horseshoe Bend.



If we assume these data are representative of current conditions, we would expect the water level in a well constructed into the Madison Formation to rise within the well casing to about 3630-3640 feet msl. Land surface at the proposed well site is about 3680 feet. **Therefore we should expect the water level in the well to be about 40-50 feet below ground surface.** The location of the test wells are shown on this map.



Well Construction

We should not specify a drilling method as that might severely limit the ability of the driller to complete the project. It might be necessary to construct mud pits and complete the drilling by mud rotary methods, or maybe the entire well can be drilled by air-rotary methods. I would expect that initially drilling would proceed by air rotary methods as this is much easier (and therefore more profitable) for the driller than mud rotary drilling. As drilling proceeds, we expect to encounter progressively more water as the well gets deeper. If too much water is encountered, it might not be possible to blow enough air into the well to continue removing the drill cuttings. Drillers refer to this as being “drowned”. If that occurs, they would need to mix and circulate drilling mud to reduce the flow of water into the well. Since we cannot predict whether air-rotary will remain a viable method for the entire drilling project, we need to leave the option open for mud-rotary drilling to ensure that the project can be completed.

Well construction should start by drilling an oversize hole to 38½ feet and cementing steel casing in place. This will provide a solid, stable working area at the top of the borehole and a solid anchor to cap the well in the unlikely event that the artesian pressure is large enough to result in a flowing well. A 17-inch hole should be drilled to 38½ feet and then cement 12-inch steel casing in place. The casing will extend 1½ feet above ground surface.

Well construction should then proceed by drilling a 11½-inch borehole through the Tensleep Sandstone and Amsden Formation and about 20-25 feet into the Madison Formation. I expect that the top of the Madison will be around 425-450 feet below ground surface, so this part of the drilling would run from about 40 to 450-475 feet below ground surface. Casing should be installed and cemented in place to prevent poor-quality groundwater from these formations from entering the well. PVC well casing is the preferred material as it will resist corrosion. Groundwater in the Tensleep and Amsden Formations are known to be corrosive. The recommended material for the wells casing is Certa-Lock PVC well casing, SDR-17 (other brands of PVC well casing are acceptable provided it is designated for use as well casing and has strength equal to, or exceeding, that of SDR-17). The 6-inch PVC SDR-17 Certa-Lock well casing has an inside diameter of 5.7-5.8 inches and an outside diameter of 6.625 inches and a collapse pressure of 224 psi. Casing centralizers should be used to keep the casing centered in the borehole and the annular space between the casing and the borehole should be filled with cement grout. It may be necessary to place the cement grout as two separate operations, filling approximately half the depth at a time to maintain a safety factor for the collapse pressure of the PVC casing.

After the cement grout has cured, drilling can proceed into the Madison using the largest bit that will fit inside the PVC casing, probably 5½”. Drilling should proceed should proceed into the Madison until the well produces at least 50 gpm. This might be a few tens of feet or a few hundred feet. We should probably plan on 200-300 feet, with an option to quit drilling anytime after 100 feet if an ample supply has been obtained.

Wells constructed into the Madison Formation in the Bighorn Basin are often completed as an "open borehole". No well casing is placed into the borehole adjacent to the Madison. The borehole is drilled through solid limestone rock formation which has enough structural strength to maintain an open borehole. The artesian pressure in the aquifer pushes water up the borehole into the section with the PVC casing. At this site, I expect the water level to rise to within about 40-50 feet below ground surface, about 400 feet above the top of the Madison Formation. The pump can be placed at some depth within the 6-inch PVC casing. That depth will need to be determined by pumping tests; estimates can be made during the development phase of the drilling operation by air-lift testing. Since the pump will not likely be placed at a depth that would place it in the Madison Formation (deeper than about 450 feet), it is not necessary to extend casing through the Madison.

If there is some need or reason to place casing (and well screen) to the entire depth of the well, it could also be PVC casing and slotted PVC screen. [e.g., Certa-Lock 5-inch PVC casing and slotted casing could be installed as a liner. The 5-inch PVC has an OD of 5.56" and would be a tight fit inside the 6-inch casing (ID= 5.7"). The 4½-inch casing and screen has an OD of 4.95" and would easily fit inside the 6-inch casing. The ID of the 4½-inch casing is 4.3" and would easily accommodate a 4-inch submersible pump.]

My recommendation is to skip the PVC liner and well screen. Leave the well as an open borehole completion in the Madison Formation. Place the pump within the section of 6-inch casing. The depth of the pump setting should be determined by testing during the development phase of the drilling. Use a separate line item in the bid schedule to accommodate the unknown depth of the pump setting. The pump could be placed as deep as approximately 450 feet below ground surface and still be within the cased section of the well.