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Memorandum

To: Michelle Metteer

From: William Berg, P.G.
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Date: December 29, 2023

Subject: Minturn Wells 3 and 4 Testing Summary

BACKGROUND

This memorandum summarizes the Minturn Well Nos. 3 and 4 testing activities that were performed by Cascade Environmental (Cascade) from October 31, 2023 through November 16, 2023. The purpose of the Minturn Wells 3 and 4 testing program was to assess whether Minturn Well Nos. 3 and 4 could each reliably produce approximately 225 gallons per minute (gpm) and to gather some preliminary information regarding whether the wells would be classified as groundwater under the direct influence of surface water (GWUDI).

Both Minturn Well Nos. 3 and 4 have two screened intervals: one shallow and one deep. Due to the concern over the wells being classified as GWUDI, the upper screened interval in each well was to be sealed off during the aquifer testing so that only the lower screened interval was producing groundwater. This was achieved by using an inflatable packer to isolate the lower screened interval. The remainder of this memorandum describes the aquifer testing activities that took place during the testing program.

AQUIFER TESTING ACTIVITIES

Cascade mobilized from Arizona on October 30th and arrived onsite to Well No. 3 on the morning of October 31st. The rest of the 31st was spent on activities including site familiarization, coordination of well operations and well shutdowns with the Town of Minturn public works supervisor, recovering the pump column that fell of the pitless adapter in Well No. 3, and conditioning the well for the initial well video.

Well No. 3 Well Videos and Well Cleaning

The initial well video on Well No. 3 was performed on the morning of November 1. Due to conflicting well construction reports, well testing reports, and well diagrams, it was uncertain what the specifics regarding the well diameter and well construction were prior to the video. The initial well video showed that the casing size was approximately 7 inches in diameter from

the top to bottom of the well and that there was both an upper and lower screened interval. Had the upper well screen been approximately 5 inches in diameter, as indicated in the well construction and test report, the inflatable packer may not have fit in the well and the well testing would have been limited to a pump that could only produce approximately 100 gpm, regardless of aquifer ability. Construction details for Well No. 3 observed from the well videos are shown in Table 1.

The well video on November 1 showed the presence of both bacteria and mineral fouling on the well screens. Because of this, on November 1 through November 3, mechanical and chemical cleaning of the Well No. 3 screens was performed. This included using brushes of varying stiffness, an acidizing chemical treatment, and airlifting the water in the well to remove residue and chemicals from the cleaning process. Chemicals used to clean Well No. 3 were neutralized in a 500-gallon tank and released into small kettle depression approximately 60 feet east of and below the elevation of the well to avoid flow back toward the well. A second well video of Well No. 3 was performed on November 2, which showed that chemical cleaning and brushing removed some of the bacterial film on both screens, and it was Martin and Wood's opinion that more mechanical brushing was required to adequately clean out the lower screen. A third well video was taken on the morning of November 3, following the mechanical brushing, which showed additional improvement, but more brushing was considered necessary to remove material from corrosion near the joints between the top part of the lower screen, and the blank casing. Following the additional brushing, a final video on the afternoon of November 3 showed that the lower screen was cleaner, and the remaining oxidation at the joints between the casing and lower screen was considered by Cascade to not be removable and would not noticeably affect well performance.

Well No. 3 Specific Capacity Testing and Yield Results

On November 3, a specific capacity test was run for approximately two hours, where the goal was to maximize the pumping rate from the well utilizing its current pump with the discharge valve completely open, in order to estimate the maximum pumping rate from the well in its just-cleaned condition. A PVC sounding tube was installed to house the transducer for water level drawdown measurements during well testing. The static water level prior to the test was measured at 20.15 feet below ground surface (bgs), and the pump intake was set to a depth of around 77.9 feet bgs. The specific capacity test for Well No. 3 was initially run at a pumping rate of 80 gpm to measure the effect of cleaning on the screens, which indicated an improved specific capacity of 2.61 gpm/foot of drawdown from the original 2.17 gpm/foot of drawdown. The pumping rate was then increased to approximately 90 gpm, which is the maximum pumping rate that the pump and discharge valve would allow. The pumping rate needed to be maximized to stress the aquifer as much possible without reducing the water level below the level at which pump cavitation occurs (pump cavitation is when air enters the pump and is harmful to the pump). A maximum pumping water level of 61.71 feet bgs, which is the water level in the well during pumping, was obtained during the specific capacity test.

The specific capacity calculated at the maximum pumping rate of 89 gpm with a drawdown of 41.56 feet (61.71 feet bgs – 20.15 feet bgs = 41.56 feet bgs) was 2.14 gpm/foot of drawdown (89 gpm ÷ 41.56 feet of drawdown = 2.14 gpm/foot of drawdown). The decrease in specific capacity from pumping at 80 gpm to pumping at 89 gpm shows a decreasing ability

of the aquifer to keep up with increased pumping rates. Given the specific capacity, the pump intake depth, current static water level, and a maximum estimated pumping water level of approximately 68 feet bgs (cavitation will likely occur when the submergence depth of the pump is less than around 10 feet), an estimated maximum pumping rate of approximately 102 gpm was estimated for Well No. 3 (2.14 gpm/foot of drawdown × [pumping water level of 68 feet bgs – static water level of 20.15 feet bgs]) without damaging the pump components at the current static water level. Note that this test was performed without packing off the upper screen interval. A packer test was not performed on Well No. 3, as the estimated maximum pumping rate with both screens open is far less than the 225 gpm target for the well to deliver to the proposed water treatment plant.

Completion of Work at Well No. 3

Cascade disinfected and reinstalled the Town's existing pump for Well No. 3 by the end of the day on November 2. Cascade demobilized from Well No. 3 and mobilized to Well No. 4 on November 4.

Well No. 4 Initial Well Videos and Evaluation

The static water level at Well No. 4 was initially measured at a depth of 16.43 feet bgs. With some difficulty, Cascade was able to remove the pump assembly from the well and lower a bailer to remove sediment on November 4. Cascade was unable to get the bailer past the top of the lower screen, which is at a depth of approximately 67.7 feet bgs. The depth of the screened intervals and tagged bottom depth of Well No. 4 are shown in Table 1. The reasons for the difficulty in removing the pump and lowering the bailer to the bottom of Well No. 4 were made clear during an initial well video before conditioning the well. The initial well video showed warping in the lower screen at a depth of approximately 69.7 feet bgs that occluded nearly half of the 6-inch diameter. The video also showed the well contained sediment below a depth of approximately 78.2 feet bgs, along with a bend in the well casing above the lower well screen. The severity of the warping of the lower screen precluded mechanical brushing to clean the screen and would reduce the effectiveness of cleaning the lower screen with chemicals. Flocculant was added in attempts to obtain a clearer video of the well screens. A second well video was performed on November 5, which was still obscured by turbidity, despite the flocculants that were added the day prior. A static water level was measured at a depth of approximately 11.6 feet bgs from the video. The video also showed rubbing from the bailer cable on the well casing string below the upper screen at a depth of approximately 43 feet bgs. This indicates that the well is not plumb below the bottom of the upper screen at 38.4 feet bgs. An attempt was made to install a 1-inch PVC sounding tube with the original 3-inch PVC pump column pipe. The PVC sounding tube was intended to house the transducer for water level drawdown measurements during well testing. However, because of the deformed nature of the Well No.4 casing, the original pump and pump column were not able to be installed inside the casing together with the 1-inch PVC sounding tube. Cascade substituted the 3-inch PVC pipe with 2-inch steel pipe to carry out a specific capacity test for the well.

Well No. 4 Specific Capacity Testing

A specific capacity test was carried out at Well No. 4 on November 5 to see if it could yield close to 225 gpm. The intake of the pump was set to a depth of approximately 58 feet bgs. The pumping water level at Well No. 4 at approximately 89 gpm was approximately 16.7 feet bgs (19.48 feet below top of casing). Given a calculated drawdown of approximately 5.1 feet (16.7 feet bgs – 11.6 feet bgs = 5.1 feet of drawdown), the estimated specific capacity of Well No. 4 prior to cleaning was approximately 17.45 gpm/foot of drawdown (89 gpm ÷ 5.1 feet of drawdown = 17.45 gpm/foot of drawdown). Given the pump intake depth and specific capacity of Well No. 4 prior to cleaning, the well could potentially produce the 225 gpm needed for the water treatment plant.

Well No. 4 Well Cleaning and Additional Well Videos

Because of the favorable results of the initial testing, Cascade was instructed to attempt to airlift near the lower screened interval to clean out the sediment at the bottom of the well and to clean out the screens as much as possible with that same method. A well video was performed on November 6, which confirmed that the Well No. 4 lower screen was compromised (as seen on November 4) so that approximately 50% of the screen diameter was still open. The lower screen otherwise appeared to be intact and there was little evidence of screen clogging noted during the video. As described above, the well screen compromise prevented mechanical cleaning of the lower screen. The sediment in the bottom of the well appeared to be fine grained, with no evidence of filter pack sand. Because there was no evidence of filter pack sand in the well and the lower screen appeared to be intact, the well was airlifted and surged in an attempt to remove the fine grained sediment in the bottom of the well.

On November 7, a final well video of Well No. 4 was taken to see if airlift development of the screens achieved additional well cleaning. The lower screen in Well No. 4 appeared clearer, and about 5 feet of sediment was cleared from the bottom of the lower screen. There was no sign of further lower well screen compromise.

Well No. 4 Further Testing and Well Yield Results

Cascade received the packer to isolate the lower well screen from the upper well screen on November 7, and spent that day and part of November 8 setting up for further testing by running transducer cable through the packer. Martin & Wood obtained the transducer to measure water levels during testing and brought it to the site on November 8. Most of that day was spent setting up by threading the transducer cable through the packer port and splicing the cable together. Splicing was finished on November 9, and Cascade personnel left the site for a four-day break (following 10 days of work, as scheduled).

Cascade remobilized to the site on November 13. November 14 was spent testing and troubleshooting the packer assembly and installing the test pump. On November 15, additional packer assembly and transducer connection troubleshooting were performed before the testing could begin.

The bottom of the test pump was set to a depth of approximately 69 feet bgs and the pump intake was set at 66 feet bgs. The static water level could not be obtained as the packer

unfortunately prevented a depth to water measurement with a water level meter. The static water level was at 14.4 feet on November 14 and was used as the static water level on November 15 for Well No. 4 testing. At the beginning of testing of the lower screened interval in Well No. 4, the pumping rate was mistakenly set too high by Cascade, which resulted in a pumping rate of approximately 250 gpm and a drawdown of approximately 48 ft, which reduced the water level in the well to the pump intake quickly. The pump was shut down after a few minutes and the water level was left to recover.

Once the water level was 95% recovered after approximately 30 minutes, the test was restarted with a lower pumping rate of 150 gpm. Well No. 4 experienced 40 feet of drawdown immediately, resulting in a pumping water level (water level during pump testing) of approximately 54 feet. At this point it was clear that Well No. 4 was not going to be able to sustain a pumping yield much above 100 gpm from only the lower screened interval. The pumping water level at a pumping rate of approximately 100 gpm was found during testing to be approximately 57 feet bgs, which is approximately 9 feet above the pump intake. The water level was adjusted based on the drawdown observed at each pumping rate. Because the well could not sustain the original 150 gpm, the pumping rate was decrease to a point where the water level was constant at an acceptable level above the pump intake.

The Town's original pump was disinfected and reinstalled on November 16.

Conclusions and Recommendations

Well No. 3 appears to be capable of a maximum pumping yield of approximately 100 gpm with groundwater contributions from both screens. The drawdown in Well No. 3 during testing suggests that the well yield limitation for Well No. 3 is a combination of both geology and well diameter. The combination of geology and well diameter limit the rate of groundwater production from a well. The largest pump that can be installed can only produce about 100 gpm, due to well diameter limitations on what size pump can fit down the well. Because of both the well drawdown, which suggests aquifer conductivity limitations, and well casing size, Well No. 3 will be limited to approximately 100 gpm.

Well No. 4 may be capable of a maximum pumping yield of approximately 250 gpm with the groundwater contributions from both screens. However, this pumping rate was not tested due to GWUDI concerns. When the well is limited to only the lower screen, the estimated pumping yield was limited to approximately 100 gpm (during testing with the packer installed) because of the drawdown within the well approaching the pump intake. The packer limited water production to only the groundwater entering the well from the lower screen, which is the most likely non-GWUDI interval. The 100 gpm lower screen well yield limitation suggests that a significant portion of the Well No. 4 yield is from the upper screen. Because of concerns of surface water impacts from the upper screen, we conclude that Well No. 4's water production from the lower interval is limited to a well yield of approximately 100 gpm. Additionally, the lower screen in Well No. 4 is compromised and will have to be replaced at some point in the future due to well cleaning limitations.

If the Town continues to be interested in utilizing wells for its water supply. it is estimated that at least two new wells would be required to meet the demand of up to 450 gpm. We inquired with Cascade about the estimated cost for a new alluvial well in the area near the existing wells. The estimated well construction cost was approximately $75,000 to $85,000, depending on the well casing size. Pumping and power considerations would be separate, but at this cost, multiple additional wells may still be an attractive option to Minturn. Further testing is needed to evaluate the GWUDI status of the groundwater.

Table 1
Town of Minturn
Well No. 3 and Well No. 4 Construction Details

Well Construction	Well No. 3	Well No. 4
Inner Diameter, inches	7	6
Well Depth in feet below ground surface	87	78*
Casing material	Mild steel	Mild steel
Top of upper screen, in feet below ground surface	46	18
Bottom of upper screen, in feet below ground surface	51	38
Top of lower screen, in feet below ground surface	73	67[1]
Bottom of lower screen, in feet below ground surface	83	78
Screen material	Stainless steel wire wrap	Stainless steel wire wrap
Static water level, in feet below ground surface	20.15	11.40

Notes:

Screen and well depths rounded to the nearest interger.

*: Bottom not reached due to sediment intrusion at this depth. Well is likely deeper.

[1]: Screen is compromised approximaely 2 feet below this depth.