

United States Department of the Interior

NATIONAL PARK SERVICE
Water Resources Division
1201 Oak Ridge Drive, Suite 250
Fort Collins, CO 80525



May 11, 2020

To: Mike Ryan, Chief of Facility Management, Point Reyes National Seashore (PORE)
David Demko, PE, Civil Engineer, PORE
Brannon Ketcham, Management Assistant, PORE

Through: John Wullschleger, Acting Chief – NPS Water Resources Division
Aquatic Systems Branch (ASB)

From: Steve Rice, PG, ASB Hydrogeologist 

Subject: Technical Assistance Report – Evaluation of the condition and performance of the Muddy Hollow well and recommendations on a potential well at the Limantour storage tank site (STAR requests 10892 and 13316)

Executive Summary

In 2019, the NPS Water Resources Division was requested to evaluate the potential for alternative groundwater supplies to replace the existing source of the Limantour water system at Muddy Hollow (STAR request #10861). Two areas were evaluated: Laguna Creek, which is an area below the existing 50,000-gallon storage tank, and a site near the existing hostel and environmental education center, where the bulk of the water demand is. The preferred option was to evaluate the Muddy Hollow well for condition and performance before determining if it could be retained (STAR# 10892). Later, a request was made to evaluate the potential for a new well site adjacent to the existing storage tank, which would allow for the Muddy Hollow well to be removed from a sensitive wetland area, and avoid significant lengths of buried water pipeline (STAR# 13316). Both requests are addressed in this report. Key findings include:

- The Muddy Hollow well was video surveyed and yield tested in January 2020. The well is in good physical condition with negligible sediment accumulation. The pump is appropriately set in the casing between the upper and lower screened intervals.
- The well was pumped at approximately 41 gallons per minute (full unrestrained flow) for a period of 4 hours. Water levels did not stabilize indicating the well was being over-pumped at this rate, however, standard operating flow rates of

approximately 25 gallons per minute through the treatment system are likely sustainable.

- Recovery time was significant; while 85% of drawdown was recovered during the same interval as pumping (4 hours), it took about 16.5 hours for the well to recover 95% of drawdown, which is a recommended level prior to additional pumping.
- Analysis of well performance indicates that aquifer transmissivity is low, likely due to the bulk of the well being completed in low permeability mudstone with water being derived from interbedded sandstone units over a long interval (no single zone is the major producer).
- For the purposes of removing the existing well from the Muddy Hollow wetland, which would significantly reduce the amount of water line replacement, a site adjacent to the existing 50,000-gallon storage tank was evaluated and found to be feasible with some caveats described below.
- Due to elevation differences between Muddy Hollow and the storage tank site on the ridge above it, and the estimated dip of the Purisima Formation (aquifer) it is anticipated that a test well at the tank site will need to be approximately 550 feet deep to target a similar zone as the 150-foot-deep Muddy Hollow well.
- Additionally, a variance to standard State requirements for yield testing and allowable production rate will have to be obtained, requiring a hydrogeological evaluation stamped by a California-certified Professional Geologist, or California Professional Engineer with 5-years' experience. The existing well will have to be retained as a monitor site for at least one year, after which it will need to be abandoned to State standards.

Muddy Hollow Well Evaluation

Evaluation of the Muddy Hollow well occurred during a site visit by the NPS Water Resources Division (WRD) January 7-9, 2020. The well was first surveyed with WRD's borehole video system. The goal was to determine the current condition of the well and confirm the completion details reported on the driller's log (Appendix A). A review of the borehole video with screen shots of pertinent features is contained in Appendix B.

The well sits at an elevation of approximately 57 feet above sea level, in a broad low-relief drainage and wetland named Muddy Hollow that ultimately discharges to Limantour Estero and Drakes Bay approximately 1.4 miles to the southwest (Figures 1 and 2). The borehole was constructed in 1997 to a depth of 156 feet (cased well ends at 150 feet). The well is completed in the Tertiary-aged Purisima Formation, which is known regionally to be a productive aquifer where sandstone units are encountered in the largely siltstone geology. While the well has been reliable since construction, there are multiple unknowns that needed to be quantified prior to committing to continue operation at this site and develop a new treatment system and transmission line rather than attempting to drill a new well elsewhere.

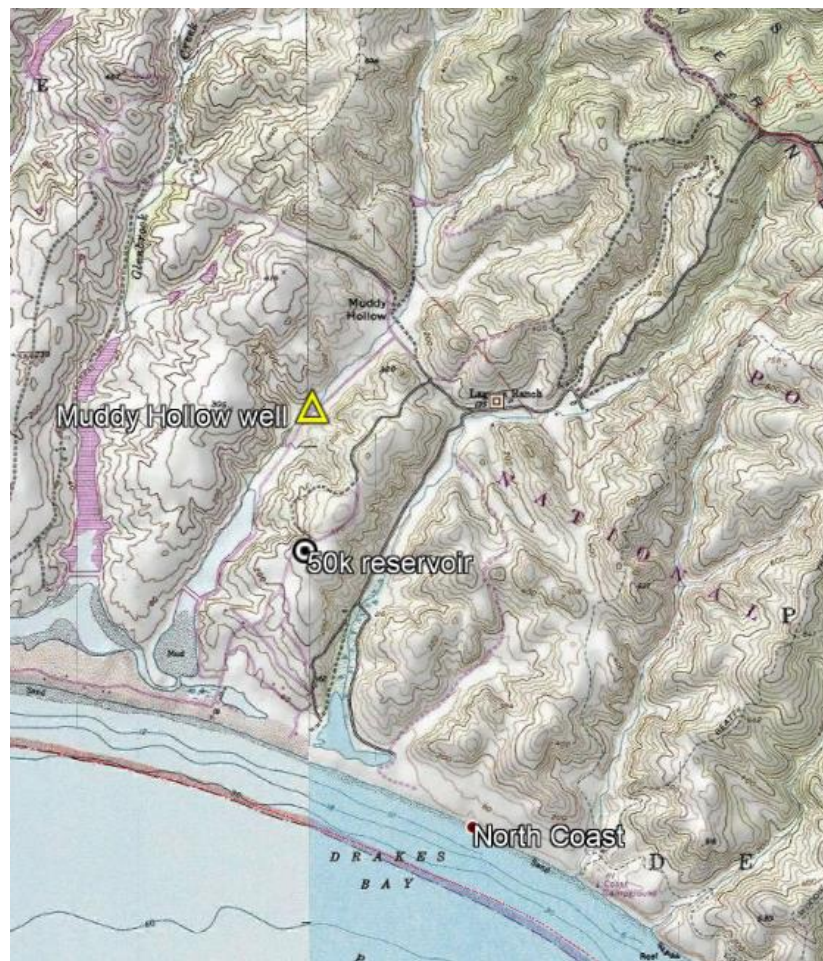


Figure 1. Location of the existing Muddy Hollow well related to the 50,000 gallon storage reservoir and main point of use (Laguna Ranch). Basemap from Google Earth.



Figure 2. View of the Muddy Hollow well site with access road, overhead power lines and treatment building. Muddy Hollow wetland is immediately behind the water treatment building. View to the southwest, photo date January 9, 2020.

Well video

The video survey confirmed a shallow depth to water (about 9 feet below ground) relative to the groundwater-producing zones which is consistent with confined conditions in the sandstone units of the Purisima Formation. The well casing and screen are 8-inch diameter PVC, and the pump is hung on 2-inch diameter PVC pipe. Water clarity was good, and there were no indications of damage or decay of the casing or well screen. Construction details including the depth and length of the two screened intervals (55-75 and 90-150 feet) were confirmed to be accurate. The production pump intake is at a depth of approximately 81.5 feet below ground and is appropriately set within a section of blank casing between the upper and lower screened intervals. The bottom of the well at 148 feet indicates that approximately 2 feet of sediment has accumulated since the well was constructed. The material is black and relatively coarse and is likely material high in iron and manganese that has precipitated from the water column, accumulated on the pump or casing walls and ultimately deposited on the bottom. This is a relatively small amount of material for a well that has been in operation for over 22 years. A depth-annotated summary of the video survey including still images is provided in Appendix B.

Drawdown and Recovery Test

A drawdown and recovery test was conducted on the Muddy Hollow well on January 9, 2020. The discharge line on the pump was disconnected prior to entering the treatment building (Figure 3). The treatment tanks (sand filtration) slow the rate of flow through the system, effectively reducing yield to approximately 25 gallons per minute (gpm). Well discharge was instead directed through an in-line digital flow meter then sent approximately 100 feet southwest and run through hay bales to reduce velocity and potential erosion (Figure 4). Water quality parameters including water temperature, pH, specific conductance, dissolved oxygen concentration and turbidity were logged at 1-minute intervals using an In-Situ AquaTroll 600 multiparameter sensor. Sediment concentration was measured using a 1-liter Imhoff cone.

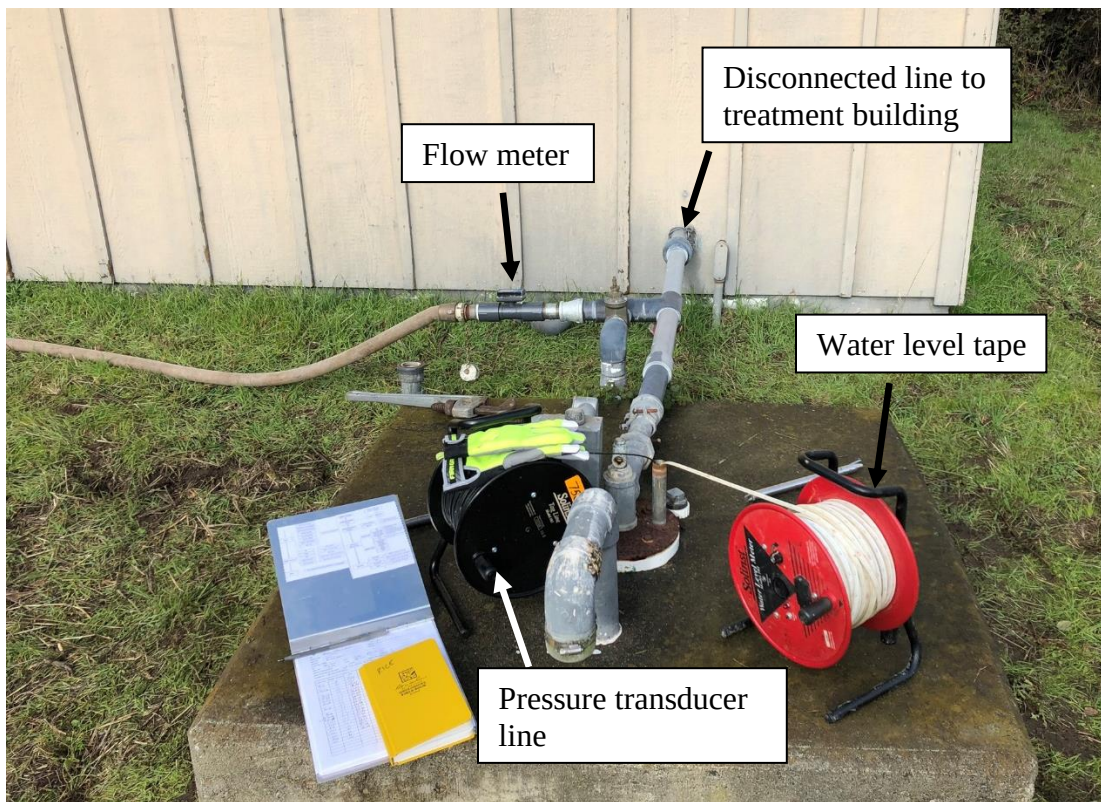


Figure 3. Discharge from the Muddy Hollow well bypassing the treatment building and discharging via a fire hose approximately 100 feet away. Black reel supports a pressure transducer, red wheel for manual depth to water measurements, digital flow meter to measure pumping rate. Photo date January 9, 2020.



Figure 4. Test discharge was slowed by hay bales to prevent erosion (in background). Water quality parameters were measured at this location. View to the southwest, photo date January 9, 2020.

Water levels were collected with both a manual water level indicator tape and a datalogging pressure transducer (InSitu LevelTroll 700) set to record at 1-minute intervals. A barometer at the wellhead (InSitu BaroTroll) was used to correct the well transducer data for atmospheric pressure influence. All water level measurements were made from the same reference point (top of access tube on well casing) and recorded to the hundredth of a foot. Manual measurement frequency for both the drawdown and recovery portions of the test followed the intervals shown in Table 1; pressure transducer measurements remained stable at 1-minute intervals. At 4 hours of pumping (240 minutes), the pump was shut off and recovery monitoring began.

Table 1. Summary of manual measurements of water level during the drawdown and recovery portions of the test.

Elapsed Time (minutes)	Measurement Frequency
0-1	15 seconds
1-5	30 seconds
5-30	5 minutes
30-60	15 minutes
60-240	30 minutes

Well Test Results

A total of 10,140 gallons were pumped over a period of 240 minutes (4 hours). This represents an average pumping rate of 42.25 gpm over the course of the test. Many instantaneous pumping rate readings were taken which varied between 41.3 and 42.8 gpm, indicating a stable rate throughout the test period. The range largely reflects a slow decreasing trend as water level decline resulted in reduced water pressure on the pump. Over the course of pumping, water levels were drawn down 34.1 feet from static conditions (Figure 5), representing approximately 75 percent of the available water column above the top of the upper screened interval, and well above the pump intake (Figure 6).

The total pumped volume is greater than that produced during a typical daily pump cycle: between 7,000-9,000 gallons based on operational sheets for the months January 2019-March 2020. Pumped volumes for these months averaged about 66,400 gallons per month, which is approximately 2,200 gallons per day. Current maximum demand periods for this well are unknown, but an engineering report on the system by the California Department of Health Services developed to approve the new well and treatment system estimated the maximum monthly demand to be 170,000 gallons in the month of July, with a maximum daily demand of 11,000 gallons (CA DHS, 1997).

As a comparison to the recent pumping test conditions, a test conducted after well completion in 1997 ran at 48 gpm for 33 hours with 46 feet of total drawdown. Considering the starting water level was reported at approximately 17.8 feet (unknown reference point), this would have lowered the water level to about 63.8 feet, nearly halfway down the upper screened interval. Furthermore, this test would have produced a total of about 95,000 gallons, nearly twice the available storage capacity of the existing system (50,000 gallons).

Maximum drawdown during the January 2020 test was 34.1 feet. Per the requirements of California source capacity testing (CA Code of Regulations Title 22 §64554), recovery after drawdown testing should indicate that within a period not exceeding the pumping time, the water level in the well should recover to within 2 feet or 95% (whichever is more stringent) of the drawdown measured during the test. Ninety-five percent of 34.1 feet is 32.4 feet, making the difference of 1.7 feet the more stringent metric to meet. The well was pumped for a period of 240 minutes; at a similar amount of recovery time (total time 480 minutes), water level drawdown had recovered 85 percent. The well did not recover to within 95% of the pre-pumping level until 994 minutes (16.6 hours) after the pump was shut off (Figure 7).

Two factors affected the well's ability to recover in an appropriate amount of time: pumping rate and test duration. First, the average pumping rate of 42.25 gpm resulted in a water level drawdown curve that never flattened during the 4-hour test, indicating that the well was being pumped at an unsustainable rate; this is acceptable for the purposes of testing but not for normal water supply operations. Fortunately, standard operation of the well routes pumped groundwater through a water treatment system consisting of filtration and treatment to reduce iron and manganese concentrations; this effectively reduces operational pumping rates to approximately 25 gpm (D. Demko, PORE, personal communication).

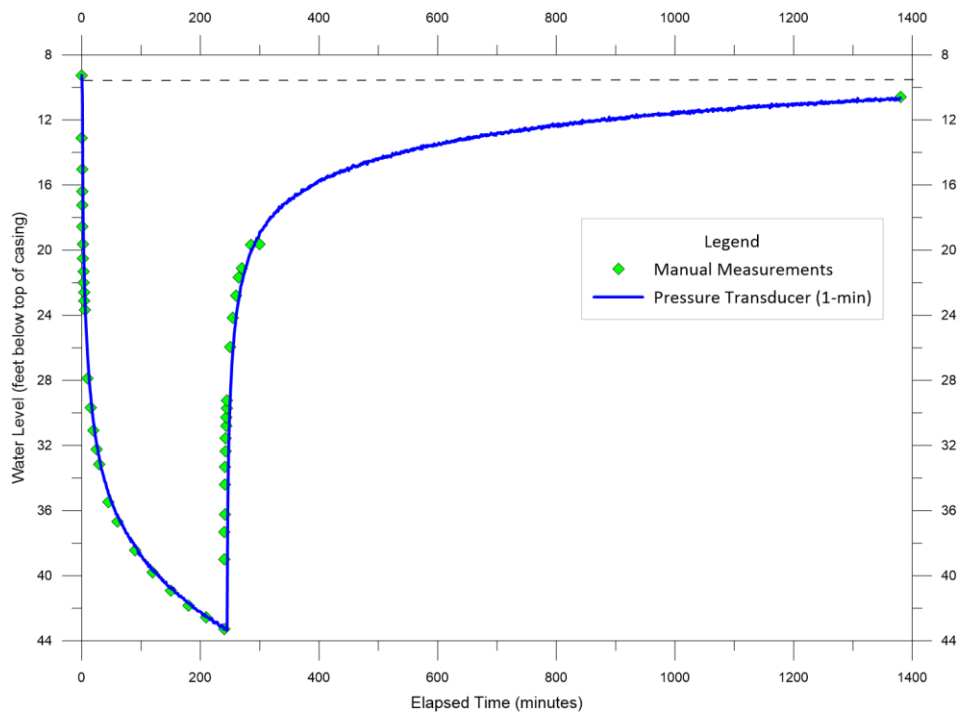


Figure 5. Manual measurements (green diamonds) and pressure transducer log (blue line) of drawdown and subsequent recovery of the Muddy Hollow well test on January 9, 2020. Dotted line represents static water level prior to the test.

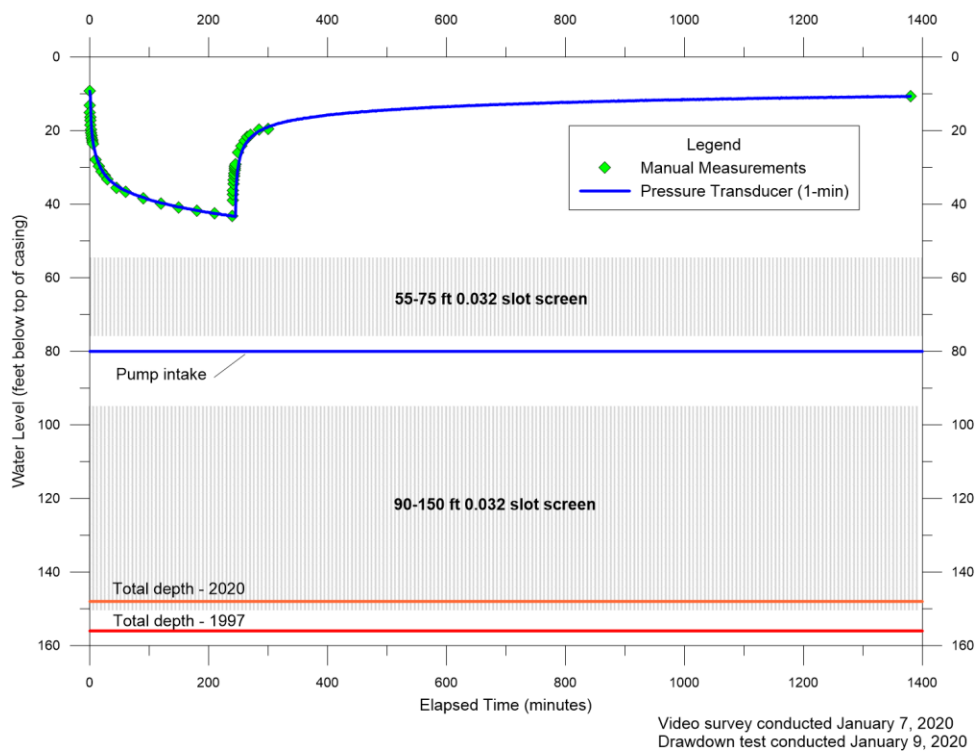


Figure 6. Manual measurements (green diamonds) and pressure transducer log (blue line) of drawdown and subsequent recovery of the Muddy Hollow well with pertinent well details determined during the well video survey.

If the pumping rate used during this test was reduced and similar to the normal operating rates, the drawdown curve would likely have flattened during the test period. Second, if the test was run longer at a stabilized drawdown, the recovery period would be extended which would enable the well to fully recover per State source capacity regulations. It is estimated that an 8- to 10-hour pumping interval at a lower rate would have resulted in adequate recovery during an interval of similar length, indicating operation to meet demands is currently sustainable.

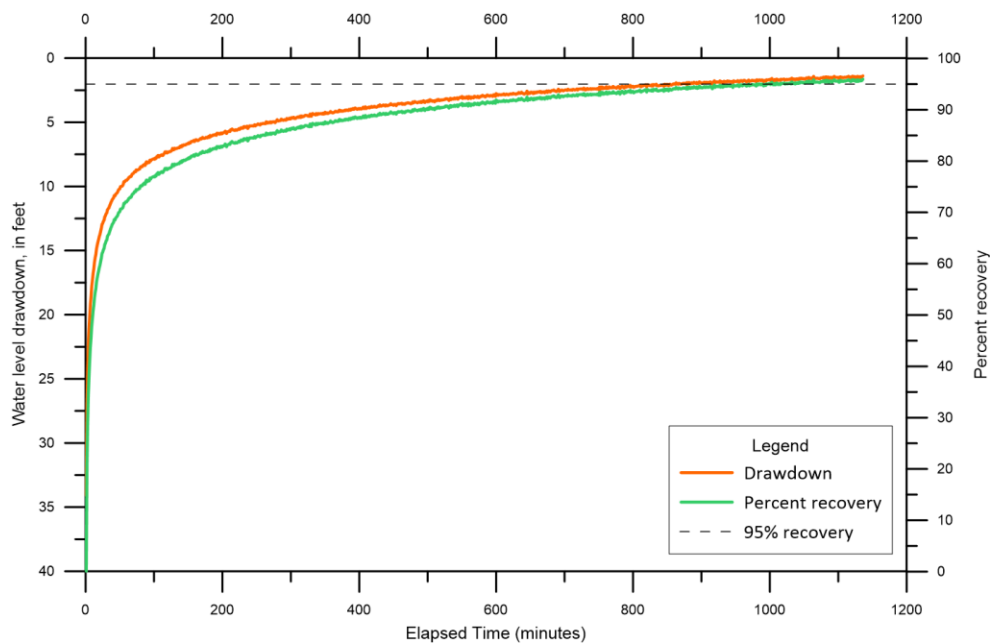


Figure 7. Water level recovery in feet (orange line) and in percent recovery from pre-test levels (green line) relative to the 95% recovery limit (dashed line).

Modeling of Test Results

Drawdown and recovery data were analyzed to estimate aquifer parameters. First, drawdown over the logarithm of time was plotted and aquifer transmissivity was calculated over log intervals (10-100 and 20-200 minutes) using the Cooper-Jacob (1946) straight-line method (Figure 8, upper). These calculations indicated a relatively low transmissivity of the aquifer supplying the well (121-126 ft²/day). Next, drawdown data were input into the aquifer analysis software Aqtesolv™ to estimate aquifer properties such as hydraulic conductivity and aquifer transmissivity. The data were modeled using the same straight-line approximation method, focusing on the pumping interval from 10-240 minutes to reduce the effects of early-time data which are influenced by the reduction of borehole storage. Results were similar (126.3 ft²/day) to the manually-calculated estimates of transmissivity, increasing confidence that the relatively low values are representative of the aquifer (Figure 8, lower).

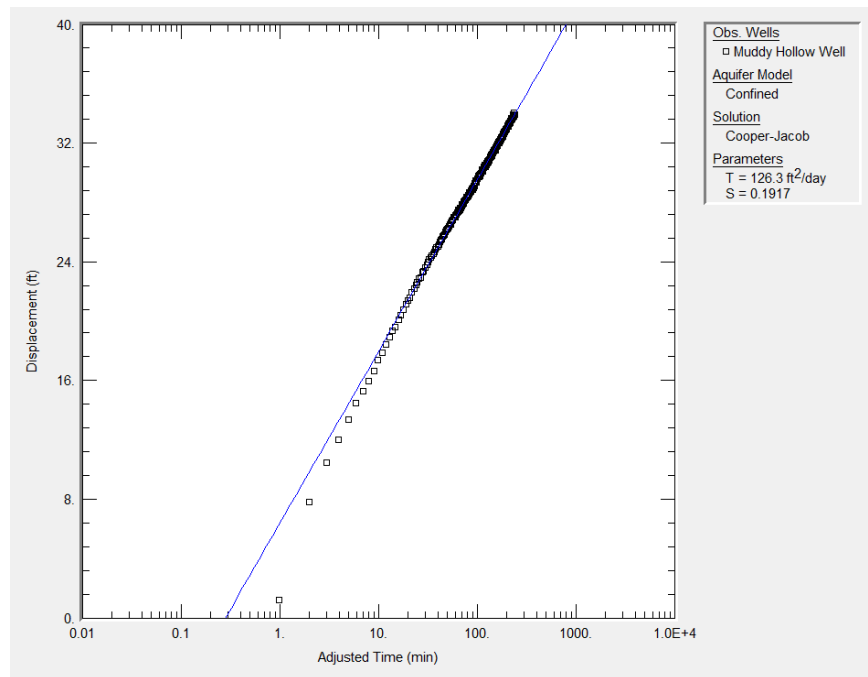
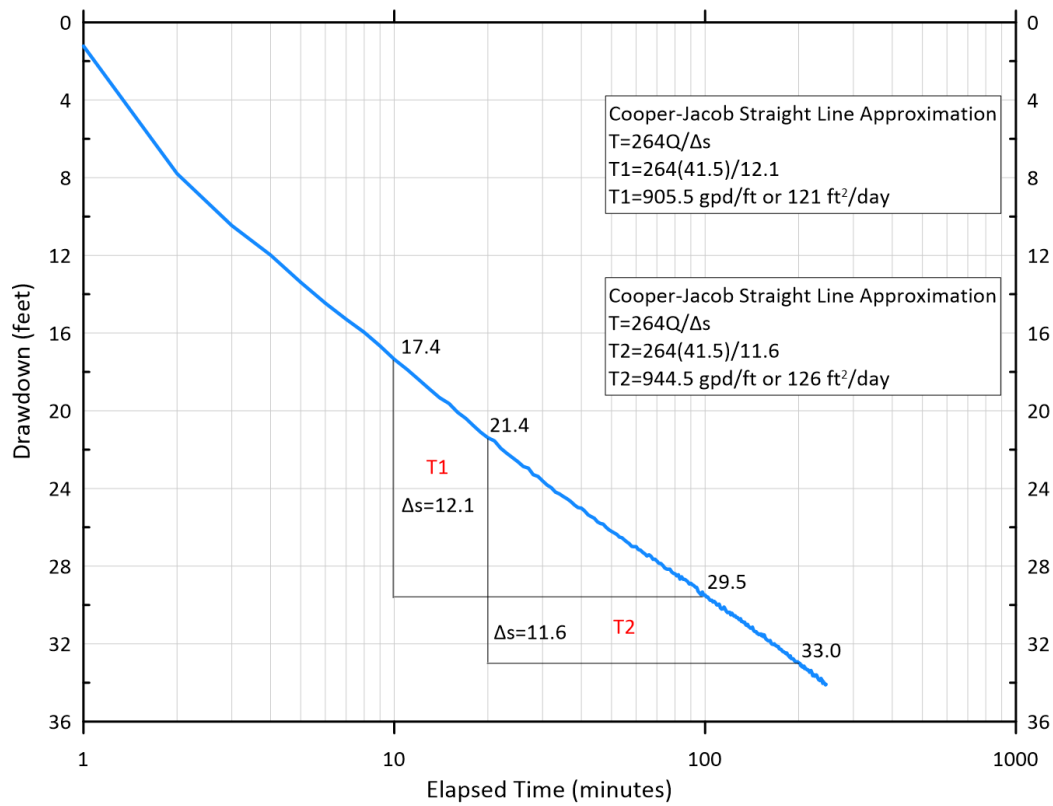


Figure 8. Manual estimations of aquifer transmissivity by the Cooper-Jacob (1946) straight-line method (above). Modeled estimation of aquifer transmissivity using drawdown data between 10-240 minutes to reduce effects of borehole storage associated with early time data (below).

Test data, both drawdown and recovery, were then evaluated with analytical solutions for confined aquifers, the Theis (1935) and Papadopoulos-Cooper (1967) methods. Both methods assume confined aquifer conditions and account for both drawdown and recovery data, while the Papadopoulos-Cooper solution also accounts for borehole storage. Results from the Theis solution estimated aquifer transmissivity at 185.6 ft²/day (Figure 9, upper). Considering the Theis solution assumes the well fully penetrates the aquifer (which is not the case at Muddy Hollow), the estimate of aquifer thickness of 125 feet is based on the actual saturated thickness penetrated by the completed well (140 feet). The results of the Papadopoulos-Cooper solution estimate a transmissivity of 124.6 ft²/day, agreeing closely with the two estimates of transmissivity via the Cooper-Jacob straight-line method (Figure 9, lower). Aquifer storage was estimated by both solutions, but these values are unreliable as observation well data are needed to appropriately calculate these values.

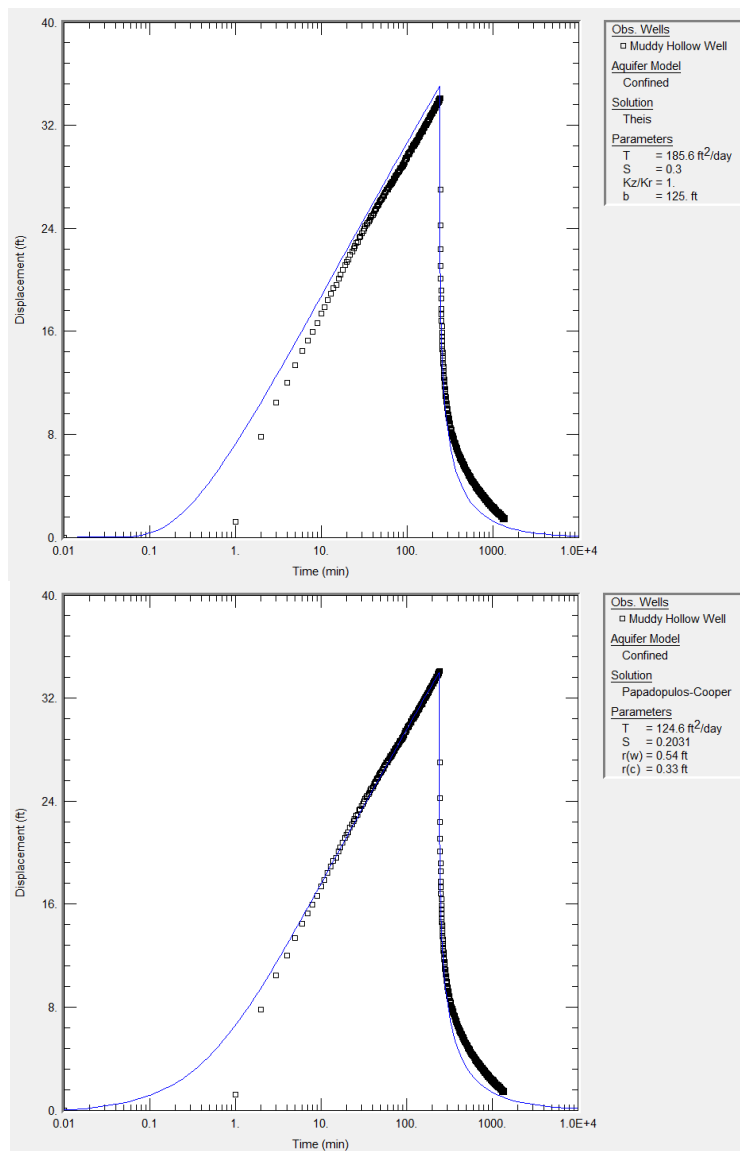


Figure 9. Model results of estimated aquifer parameters using the Theis (1935) solution (above) and Papadopoulos-Cooper (1967) solution (below) for confined aquifers, utilizing both drawdown and recovery data.

Water Quality Parameters

In addition to water level, water quality parameters were measured during the pumping component of the test. An In-Situ, Inc. AquaTroll 600 multiparameter sonde (S/N 469615) was programmed to collect data for water temperature, pH, specific conductivity, dissolved oxygen concentration, and turbidity at 1-minute intervals. Data are shown below in Figure 10.

Temperature, pH, and dissolved oxygen quickly stabilized and remained constant throughout the test; the jump in dissolved oxygen at 20 minutes may result from the transition of flushing out borehole storage to primarily pumping aquifer water. Specific conductivity and turbidity fluctuated but values were tightly constrained and indicative of stable conditions. Slight decreasing trends in the first 20-30 minutes may also be an indication of pumping out borehole storage. Anomalous spikes in specific conductivity may be attributed to sensor error. Water quality parameters do not show any specific concerns related to water treatment or the potential to degrade the well or pump over time.

An Imhoff cone was used to collect discharge water at 1-liter increments and determine how much sediment was being produced by the well and through the pump. No measurable sediment accumulation was observed, indicating the well is producing less than 10 parts per million (ppm) of sediment, the smallest amount that can be accurately measured by this method.

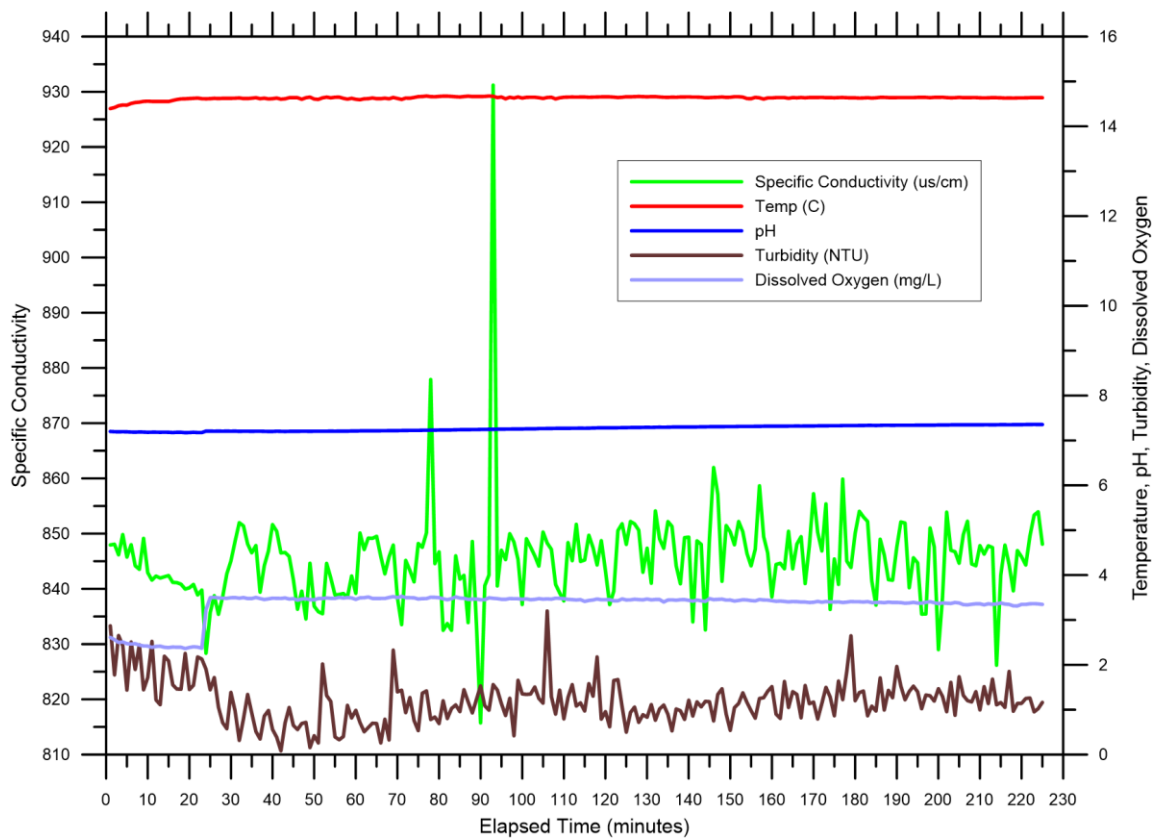


Figure 10. Summary of water quality parameters collected during the Muddy Hollow well test January 9, 2020.

Limantour Storage Tank Well Site Evaluation

Although the Muddy Hollow well appears to be functioning and is in good physical condition, there is an interest in developing a new well to replace it. A project is in place to upgrade the treatment system and realign the transmission pipeline from the well to the storage tank. This is a significant project in terms of scope, disturbance, and cost. However, there is also interest in removing this infrastructure from the Muddy Hollow wetland area.

One site of interest for a possible replacement well is on the ridge separating the Muddy Hollow and Laguna Creek drainages. This ridge has the paved road which connects the Laguna Ranch area to Limantour Beach and its developments. The current water storage infrastructure, a buried 50,000-gallon concrete tank, is located along this road. The site sits at an elevation of approximately 290 feet above sea level, which is about 230 feet higher than the current Muddy Hollow well located approximately 0.6 miles to the north (Figure 1).

The elevation of the storage tank site above the base level of the two drainages to the east and west indicates that reliable amounts of groundwater likely do not exist above a depth of at least 250 feet. To reach a similar depth as the Muddy Hollow well, a new well would need to be approximately 380 feet deep (230-foot elevation difference between well sites plus 150-foot well depth). However, to target the same saturated sandstone intervals intercepted by the Muddy Hollow well, assuming they are continuous over the relatively short distance between the two wells, the dip of the Purisima Formation also needs to be considered. The dip of the formation varies in the area, but an average value of 10 degrees to the southwest is considered reasonable. Considering this formation dip, a replacement well would likely require a borehole of approximately 550 feet deep to intercept the same horizons as the Muddy Hollow well.

Figure 11 shows two elevation profile lines from sea level to the Laguna Ranch area. The bold elevation profile line follows the lower elevation of Laguna Creek while the thin line follows the ridge being evaluated for a new well. Expected bedrock geology conditions are projected into the subsurface, and the relative depths of the Muddy Hollow well and a potential storage tank site well are plotted. Figure 12 shows the same area in plan view, with the location of the two profile lines, mapped geologic units (summarized in Table 2), and the existing and potential well sites.

While a new well at the storage tank site would require a significantly deeper borehole than the Muddy Hollow site, it does appear to be a feasible location to obtain groundwater from a hydrogeological perspective and may have additional benefits over the Muddy Hollow site. Besides being able to remove infrastructure from the Muddy Hollow wetland and restore this site, there may be a significant cost savings and operation and maintenance benefits associated with not having approximately 1.7 miles of new water transmission pipeline constructed to connect the Muddy Hollow well to the storage tank site. Additionally, if the treatment system requires major upgrades, it may be advantageous to develop a new treatment system for a new well rather than rehabilitating an existing system that is over 20 years old.

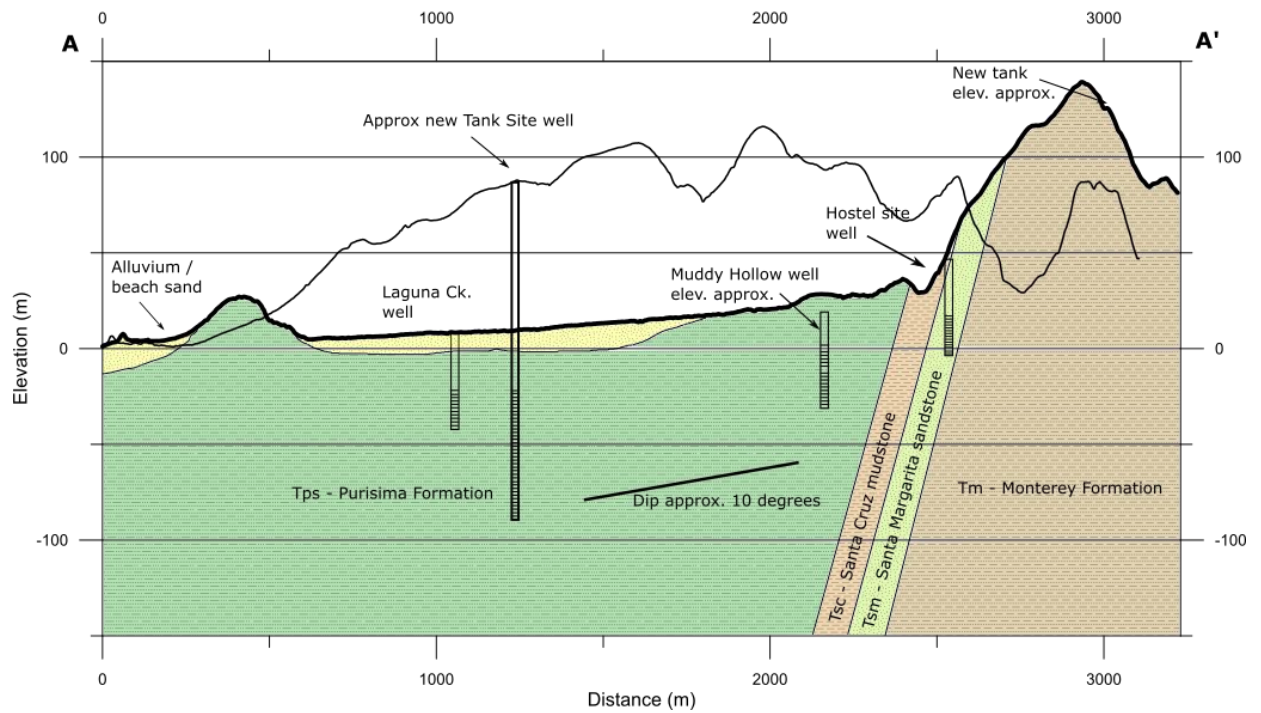


Figure 11. Conceptual cross-section lines following Laguna Creek from Drakes Bay northeast through the Laguna Ranch area (lower profile) and from Drakes Bay along the ridge separating Laguna Creek and Muddy Hollow (upper profile) showing the location of the storage tank and potential new well. Refer to Figure 12 for the location of the A-A' cross-section lines. Elevation profile extracted from 3-meter digital elevation model (DEM).

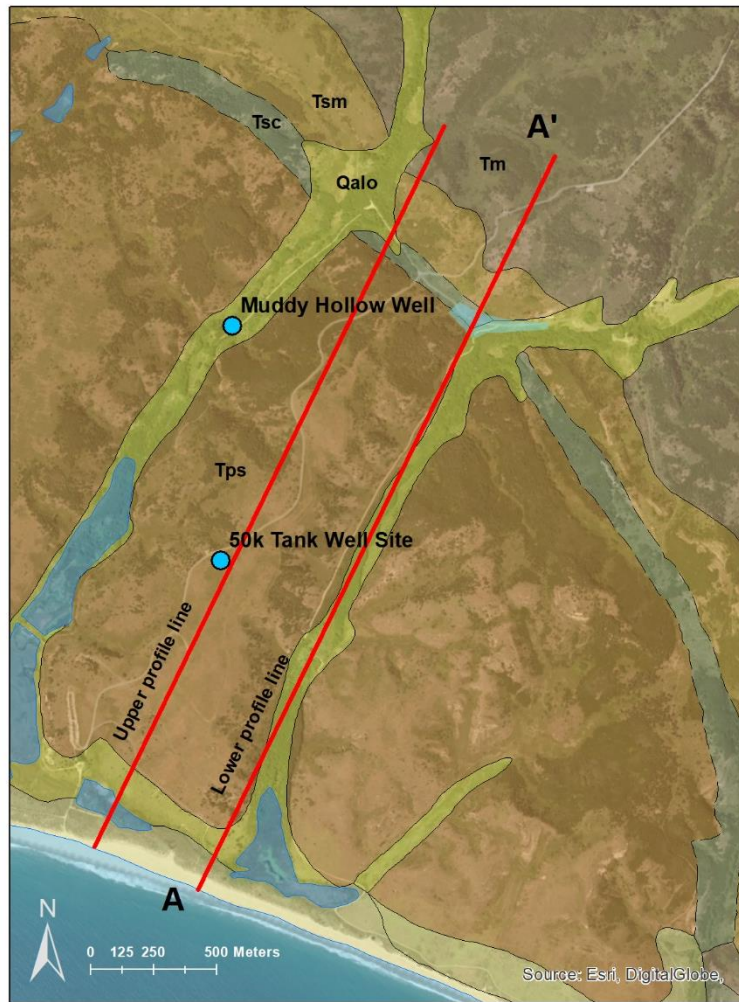


Figure 12. Location of the existing Muddy Hollow well and 50,000-gallon storage tank on mapped geologic units. Upper and lower profile lines from Figure 11 are approximated as red lines. Geologic unit descriptions are provided in Table 2.

Table 2. Summary of pertinent geologic units, from Clark and Brabb (1997)

Unit Symbol	Unit Name	Unit Description
Qbs	Beach Sand	Recent sand deposits along Drakes Bay
Qalo	Alluvium	Fluvial alluvium deposits along creeks and drainages
Tps	Purisima Formation	Thick-bedded olive-gray siltstone with sandstone interbeds. Muddy Hollow well and proposed Storage Tank site well completed here
Tsc	Santa Cruz Mudstone	Thin- to thick-bedded olive-gray to yellowish-brown siliceous mudstone
Tsm	Santa Margarita Sandstone	Massive, coarse- to fine-grained arkose sandstone, commonly greenish in color from glauconite content
Tm	Monterey Formation	Thin-bedded porcelanite, chert, and mudstone

Should a new well be investigated at the storage tank site, several minimum design, construction, and testing considerations should be incorporated into a scope of work. If the project moves forward, more detailed specifications can be developed in conjunction with PORE staff.

- A borehole should be drilled to a diameter that will accommodate an 8-inch diameter PVC well casing and screen with adequate spacing for filter pack and sanitary seal thicknesses. This would be approximately 12 inches at a minimum, but likely closer to 14-15 inches.
- Air rotary drilling techniques are preferred as they allow for more representative geologic samples to be collected, highlighting discrete and perhaps thin sandstone units that are water bearing zones. This technique also allows for periodic estimations of well yield by air-lift methods. However, if it is determined that an open borehole cannot be maintained, it may be necessary to complete the well using mud rotary. If this is the case, the driller should be required to have a contained mud circulation system to minimize surface disturbance.
- A new well will require a step-drawdown test to determine the ideal pump rate for a longer constant-rate test which will be used to determine a sustainable and State-permitted production rate. The step-drawdown test will occur over 3-4 steps of increasing pumping rates, moving to the next step once stable drawdown has been achieved. Total time for this test is estimated at 12 hours. The duration of the constant rate test will need to follow State requirements for determining source capacity in bedrock wells (Title 22, Section 64554(g)). These regulations stipulate that for fractured bedrock aquifers, production rates will only be granted for 25% of the test pumping rate for a 72-hour test and for 50% of the test pumping rate for a 10-day test. For this site, however, it may be possible to obtain a variance from these requirements (see below).
- This above stipulation can be modified through the development of a report to the State Water Board proposing a production capacity based on the results of other means of testing and an evaluation of the conditions and use of the supplying aquifer. Given the protections afforded by the location within PORE, it can be argued that the well is protected from sources of contamination, will not be impacting any other water developments, and is unlikely to be impacted by any other future development. These factors, and the relatively low demand of 20-30 gpm appear to make this site worthy of consideration by the Board for a waiver. It is suggested that the proposal to the Board be that the well is constant-rate tested for 24-48 hours and is granted the full amount of the test rate. The report to the Board needs to be prepared and stamped by a California registered geologist with three years groundwater experience or by a California registered engineer with five years groundwater experience, or a California certified hydrogeologist.

- It should also be proposed to the Board that the existing Muddy Hollow well be instrumented to monitor water levels for a period of at least one year to determine the influence of the new well. At the conclusion of the monitoring period, the Muddy Hollow well should be plugged and abandoned according to State standards.
- Results of water quality sampling will inform the type and level of treatment necessary to provide adequate potable water. The Muddy Hollow well currently treats for elevated iron and manganese; considering the proximity of the two sites and the same target formation, it is anticipated that these constituents will be elevated at a new tank site well. A broad suite of water quality analyses, meeting at least the minimum standards of California Code of Regulations Title 22, Chapter 15, should be collected near the end of the pumping period. Parameters with elevated concentrations should be re-analyzed at a few additional intervals in the months afterwards to confirm values and determine levels of fluctuation to best design adequate treatment.

For any questions or comments on this report, please contact Steve Rice at steven_rice@nps.gov or 970-267-7234.

CC:
NPS/WRD: Harvey

References

California Department of Health Services, 1997. Engineering report, in the matter of the permit application from Point Reyes National Seashore serving the Laguna Ranch facilities, Marin County, system number 211050; report prepared by Sherry L. King, October 16, 1997.

Clark, J. C. and E. E. Brabb. 1997. Geology of Point Reyes National Seashore and vicinity, California: a digital database (scale 1:48,000). Open-File Report 1997-456. US Geological Survey, Reston, Virginia.

Cooper, H.H. and C.E. Jacob, 1946. A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans., vol. 27, pp. 526-534.

Papadopoulos, I.S. and H.H. Cooper, 1967. Drawdown in a well of large diameter, Water Resources Research, vol. 3, no. 1, pp. 241-244.

Theis, C.V., 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophys. Union Trans., vol. 16, pp. 519-524.

APPENDIX A – Driller's log of existing Muddy Hollow well

DUPLICATE
Driller's Copy

Page 1 of 1

Owner's Well No. 509584

Date Work Began 5/6/97 Ended 5/12/97

Local Permit Agency MARIN COUNTY Environmental Health

Permit No. GWT - None Required Permit Date n/a

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

DWR USE ONLY - DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRBL/OWNER

WELL OWNER

Name POINT REYES NATIONAL SEASHORE

Mailing Address Muddy Hollow

City Point Reyes STATE CA ZIP

WELL LOCATION

Address Limontour Road (Muddy Hollow)

City Point Reyes

County MARIN

APN Book Page Parcel

Township Range Section

Latitude Longitude

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL HORIZONTAL ANGLE (SPROUT)

DEPTH TO FIRST WATER (FT) BELOW SURFACE

DEPTH FROM SURFACE FT. to FT.	DESCRIPTION <i>Describe material, grain size, color, etc.</i>
0 17	Brown sand, silts and gravel
17 33	Sands and clayey sand
33 57	Decomposed granite
57 67	HARD rock
67 94	Greenish brown hard shale and clayey sand
94 142	Gray clayey and sandy clay and gray sand
142 143	Hard sandstone
143 156	Gray sandy clay & greenish brown silty clay
156 TD	Hard sandstone

LOCATION SKETCH

WEST EAST

NORTH SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

 NEW WELL

 MODIFICATION/REPAIR

 Deepen

 Other (Specify)

 DESTROY (Describe Procedure and Materials Under "GEOLOGIC LOG")

PLANNED USE(S)

(✓)

 MONITORING

WATER SUPPLY

 Domestic

 Public

 Irrigation

 Industrial

 "TEST WELL"

 CATHODIC PROTECTION

 OTHER (Specify)

DRILLING METHOD MUD ROTARY FLUID Bentonite

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 17' 0" (FT) & DATE MEASURED 5/14 & 5/19/97

ESTIMATED YIELD 48 (GPM) & TEST TYPE PUMP TEST

TEST LENGTH 33 (Hrs.) TOTAL DRAWDOWN 46' (FT)

* May not be representative of a well's long-term yield.

TOTAL DEPTH OF BORING 156 (Feet)

TOTAL DEPTH OF COMPLETED WELL 150 (Feet)

DEPTH FROM SURFACE FT. to FT.	BORE-HOLE DIA. (Inches)	CASING(S)					INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)	ANNULAR MATERIAL			
		TYPE (✓)	MATERIAL / GRADE	CE-MENT (✓)	SE-MENT (✓)	FILL (✓)				FILTER PACK (TYPE/SIZE)			
0 156	13 3/4	X											
55 75		X	PVC/480	8"	CL200			.032					
90 150		X						.032					

ATTACHMENTS (✓)

 Geologic Log

 Well Construction Diagram

 Geophysical Log(s)

 Soil/Water Chemical Analysis

 Other

ATTACH ADDITIONAL INFORMATION IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME WEEKS DRILLING AND PUMP COMPANY by Ward Thompson

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS P.O. Box 176 City Sebastopol STATE CA ZIP 95473

Signed Ward Thompson DATE SIGNED 6/6/97 CAT LICENSE NUMBER 177681

WELL DRILLER/AUTHORIZED REPRESENTATIVE

DWR 186 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

APPENDIX B - Annotated video evaluation of Muddy Hollow well

The video evaluation was conducted by NPS-Water Resources Division (WRD) on January 7, 2020, before drawdown testing on January 9. The evaluation was conducted using NPS equipment including a color down-looking borehole camera. The following observations of notable features and intervals is supplemented by still images of the video file. The large video file is retained at both PORE and NPS-WRD for future reference.

0': Reference point. The depth encoder was reset to zero once the camera was pushed through the small-diameter port on the well cap. This location sits approximately 1 foot above ground surface, and thus depths shown on video still images are generally 1 foot greater than the corresponding depth on the well log.

8': Static depth to water. Well is under hydrostatic pressure, so water level stands at a higher level than the aquifer source.

30': Some minor mineral encrustation on the casing wall in this area. Also, drop pipe is resting against the side of the casing, indicating that the borehole is not plumb through this interval.

52': Mineral encrustation begins to disappear, perhaps due to a pH/redox condition at this depth or proximity to the upper screened section where water is more regularly agitated and circulated.

56': Start of upper screened interval (55 ft below ground). Perforations are in six concentric zones around the 8-inch casing. Well log states slots are 0.032 inches wide.

76': End of upper screened interval (75 feet below ground).

79': Casing centralizer on top of pump.

81.5': Pump intake. Intake and pump motor below are covered in black accumulated material. Pump motor may be inducing a magnetic field that is attracting micro-scale particles of iron and magnesium which are known to be in elevated concentrations in the groundwater.

91': Start of lower screened interval (90 ft below ground). Similar perforation orientation and diameter as upper section.

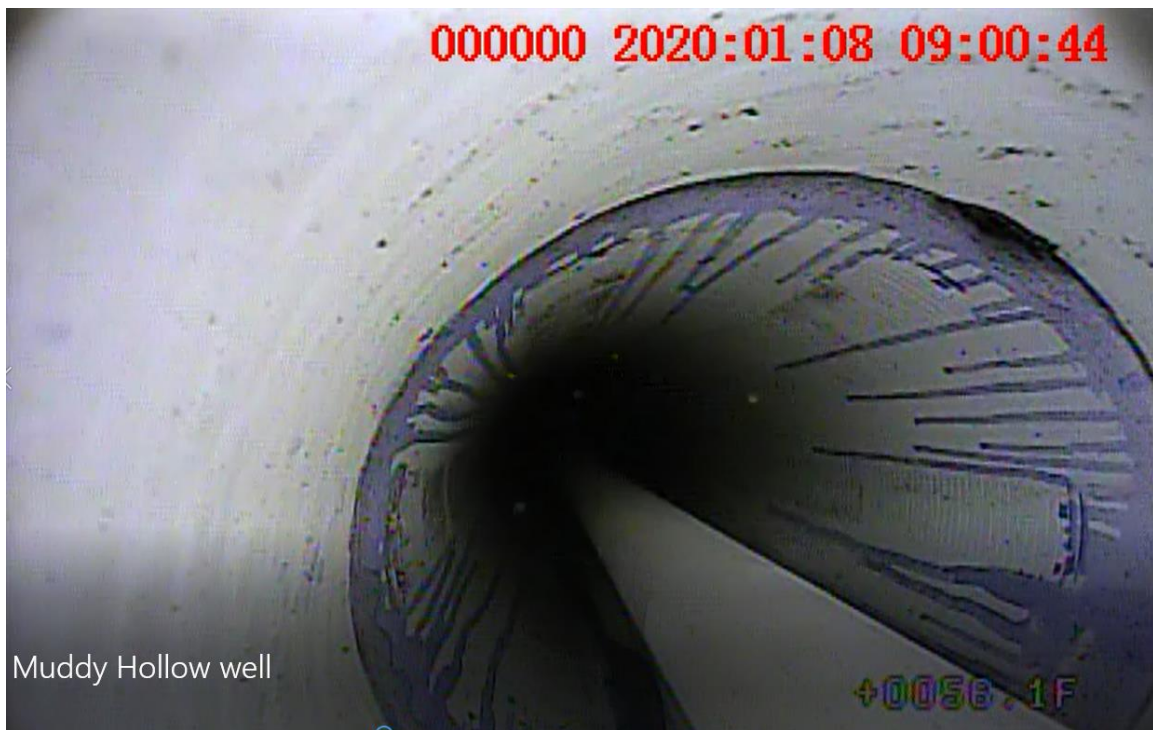
149': Total depth of well (148 ft below ground). This indicates that approximately 2 feet of material has accumulated in the well since construction in 1997.



Depth to water at approximately 8 ft. 2-inch PVC drop pipe is supporting production pump.



Minor mineral encrustation on well casing. Drop pipe rubbing along one side of the casing, indicating the borehole is not plumb through this section.



Start of upper screened interval. Evidence of PVC cement at casing joints is evident. Well casing walls no longer have mineral encrustation.



Casing centralizer on upper section of the production pump.



Top of pump immediately below casing centralizer, sitting in a section of blank casing between the upper and lower screened intervals.



Base of pump motor showing accumulation of black material, likely iron and manganese.



Accumulation of black sediment at the base of the well.