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Standard Operation Procedure 7: Hydrological Measurement for Manually-Measured Groundwater Wells

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Standard Operation Procedure 7: Hydrological Measurement for Manually-Measured Groundwater Wells

Frequency of Monitoring

Manually measured groundwater monitoring wells are deployed at all intensively-assessed wetlands with the exception of reference sites (see SOP 8). The well is generally situated near the sampling array centroid, but always within the intensive modules. The staff gauges at Virginia Kendall, Beaver Marsh, Pleasant Valley and Fawn Pond are not located within a vegetation survey plot.

The monitoring schedule is different for the manually measured wells and staff gauges at Wetlands of Management Concern (i.e., Pleasant Valley, Fawn Pond, Stumpy Basin, Virginia Kendall, Beaver Marsh, Rockside, Krejci, and Stanford) and Survey Sites (Table 7.1). Wetlands of Management Concern wells and staff gauges (n=33) are the focus of the “Wetland Monitors” volunteer group. Water depths at these wells are generally measured by the volunteers at least once a week, from March 15-October 15. Water depths at Survey Site wells (n=60) are only measured on certain years (see Table 15.1, SOP 15), that coincide with the Vascular Plant Monitoring (SOP 12). On the designated survey years, a seasonal employee is tasked with measuring water depths at all 60 wells at least 4-5 times from March 15-October 15. This is typically coupled with water chemistry measurements (SOP 11). Ecotones, which are installed at reference sites, are visited quarterly during the year to upload water level data.

Table 7.1. There are 3 different kinds of water level monitoring stations at Cuyahoga Valley National Park: groundwater wells, staff gauges, and ecotones. Altogether, 101 individual locations are surveyed.

Complex	Well #	Staff Gauge	Ecotone	Initial monitoring date
Pleasant Valley	5	1		September 12, 2008
Fawn Pond	5	1		July 3, 2009
Stumpy Basin	3			March 15, 2011
Virginia Kendall	4	1		July 6, 2009
Beaver Marsh	5	1		June 25, 2009
Rockside	1			April 2013
Krejci		2		March 2015
Stanford	4			March 2015
Survey Sites	60			May 2014
Reference Sites			8	November 2010
Total	87	6	8	Total: 101

Design and Construction of Manually-Measured Groundwater Wells

Groundwater monitoring wells are designed to measure the elevation of the surface of the water rather than a pressure head at a specified depth as a piezometer does. In general, the perforations in a monitoring well cover a much larger portion of the well screen than in a piezometer, so that the water moves freely along the pipe and can enter at any level, integrating all the water bearing strata in the soil (Sprecher 2000, 2008).

The manually-measured groundwater wells are made up of four basic components: well screen, adapter, riser pipe, and cap (Figure 7.1). Thinly cut perforations in the well screen allow water to pass into the well, but prevent coarse sediment from entering. A sand barrier filters fine clays and silt from passing into the well. The top threaded section, known as the riser pipe, allows the well screen to be attached to any length of PVC pipe to extend above ground. Riser pipes are cut at a height to provide an extra 50 cm above the maximum known water level for the wetland to prevent flooding into the well.

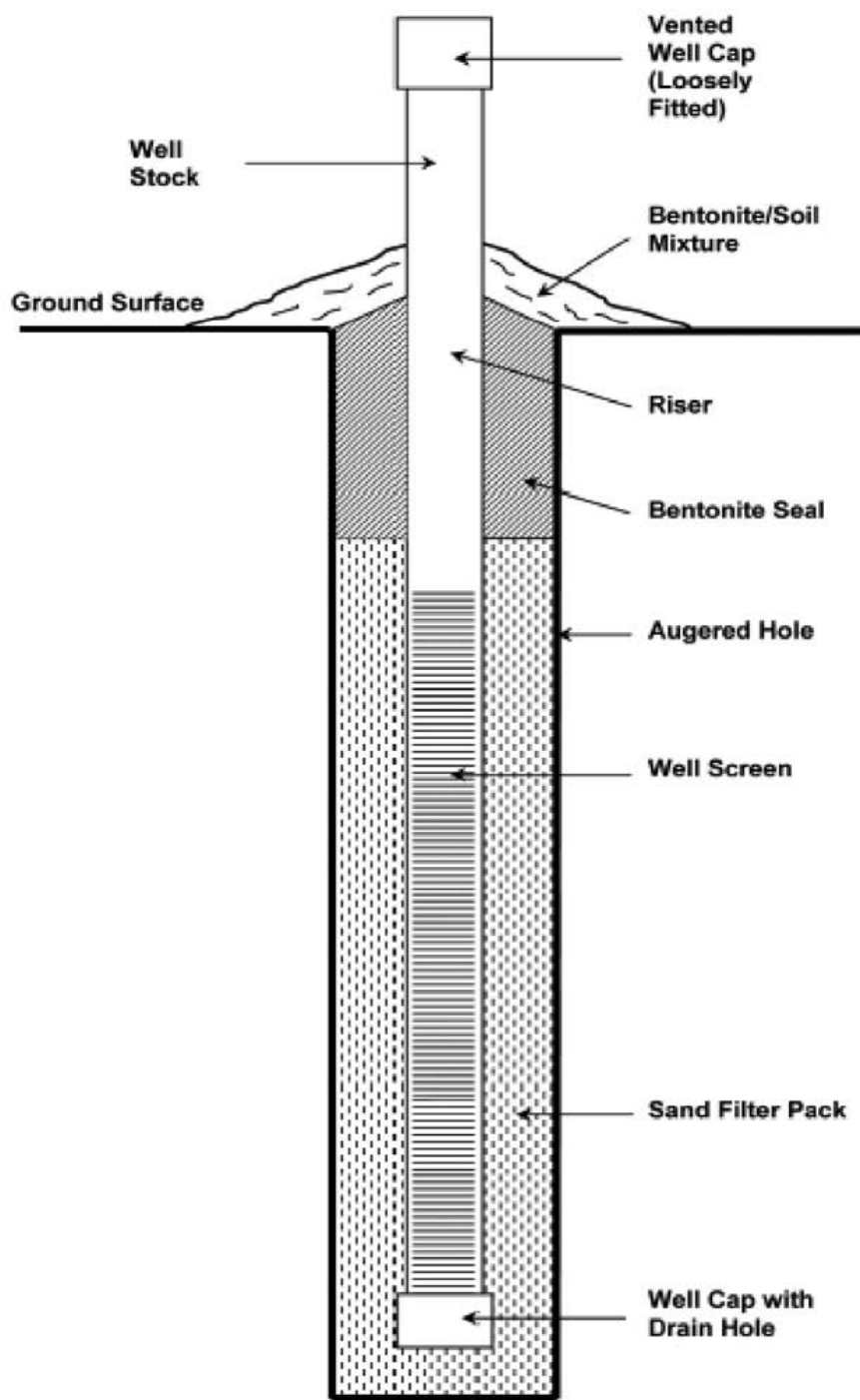


Figure 7.1. Construction design for a manually-measured groundwater well.

Well Materials

1. Well screen: 64.5cm (~25.4 in) long by 3.4 cm-inner diameter (~1.38 in) with 35 mm x 0.2 mm (~0.01 in) slots cut to the bottom of the screen
2. PVC pipe: 70 cm (~27.6 in) long x 4.2 cm-outer diameter (~1.65 in) schedule 40
3. Hacksaw
4. NPT female threaded to female unthreaded/socket weld adapter for schedule 40 pipe
5. 2 PVC caps: 4.2 cm-inner diameter schedule 40 (top and bottom of well)
6. PVC primer
7. PVC cement
8. Teflon tape
9. Matte brown and green spray paint
10. Drill bit: 2 mm
11. Drill
12. Identification tag and zip tie or wire for attachment
13. Silica sand (for 20-40 mesh)

Most of the listed materials can be purchased at a hardware or home improvement store. The well screen is a special order item. Currently, Johnson Well Equipment (1-850-453-3131) is the screen provider that we have identified.

Well Assembly

Wells are constructed at least 1-2 days before installation and stored in a warm, dry place to allow the cement and paint (if used) to fully cure. Drying times depend on temperature and humidity. Refer to PVC cement and spray paint instructions for additional guidance.

1. Cut 4.2 cm-outer diameter PVC pipe to 125 cm length.
2. Lightly sand bottom 5 cm of the outside of the riser section and the bottom of the well screen.
3. Wipe off the sanded sections with a rag.
4. Apply a thin coat of PVC primer to the recently sanded sections of the riser, inside of the socket weld (smooth end) of the adapter, and well screen.
5. Let primer dry according to directions.
6. Apply a thin coat of PVC cement to the primed portions of the riser, adapter, and well screen.
7. Immediately join riser and adapter, pressing ends together to insure a tight fit. Join well cap to well screen.
8. Allow cement to dry completely according to directions.
9. If threaded, apply teflon tape to threaded portion of well screen.
10. Screw the well screen onto the threaded portion of the adapter until hand tight.
11. Place cap on top of riser pipe.
12. As needed, spray paint the riser pipe and cap with the brown and green paint to camouflage to make the well less visible or with fluorescent paint to make more visible.
13. Drill three small holes (2 mm bit) at the side of the cap near the top to vent the well (Make sure the holes are not covered by the riser pipe when the cap is on).
14. Label with an NPS arrowhead decal and Well location ID (china marker).

Well Installation

1. Lay plastic tarp next to well location
2. Use a 3-in bucket auger to dig well hole. Auger soil from the top 16 inches, then push the top 6-8 inches out of the top of the auger.

3. Lay out the samples onto the tarp in sequence for a stratigraphic soil analysis (SOP 10).
4. Continue in 6-8 inch increments, until auger is at least 2 ft. below the water surface if possible. It can be difficult to dig much deeper than the water table because the saturated soil may slide out of the auger bucket, and the hole is susceptible to collapse.
5. If groundwater is present in the hole, use a well bailer to bail as much water out as possible. We use a 3" PVC pipe with a cap and a golf ball to bail water from our 3" auger holes (Figure 7.2).
6. Making sure pipe is vertical and centered in hole, backfill with silica sand for the entire length of the well screen. A layer of bentonite (several inches or to ground surface) should cover the sand, and excavated sand / soil can be used to backfill around the riser pipe (Figure 7.3).
7. Using hack saw, cut top of casing to desired height.
8. Using sharpie or china marker, write well number on outside of the well casing.
9. Complete soil stratigraphy analysis on soil sample (SOP 10) and document well deployment (Attachment 7.1)



Figure 7.2. The three essential components of our handmade well bailer include a 3" PVC pipe, a well cap with a hole, and a golf ball.



Figure 7.3. After the well is centered in hole, silica sand is sued to backfill the hole along the well screen. A layer of bentonite clay and soil backfill are the final layers.

Well Reinforcement

Vertical movement of groundwater wells is common, especially in areas with unconsolidated soils and active water tables. In extreme cases, we have observed wells moving up to 7 cm (Bingham, pers. obs.). To prevent movement, wells can be attached to angle iron that is driven into consolidated ground (Figure 7.4). We reinforce most wells that showed fluctuations over 3 cm, however, our measurement technique corrects for the vertical movement of the well (see *Measurement in Manually-Monitored Groundwater Wells* below).

Materials

1. Measuring tape
2. Gloves
3. Wire brush
4. 3-inch bucket auger
5. 1.25" x 1.25" x 0.25" angle iron (10ft long)
6. Post driver
7. Sledge hammer
8. Hacksaw
9. Hose clamp

10. Screwdriver or socket wrench
11. Sand
12. Bentonite clay

Well Removal (if needed)

1. Measure and record the current height from hard surface to the top of the well/calibration line.
2. Remove the existing well by twisting and pulling up. It helps if one person twists the well and another person pulls up on the well.
3. Clean the well using a wire brush using the nearest water source.
4. Clean sediments out of the well hole, using the 3 inch bucket auger.

Installation

1. Place the angle iron against the wall of the hole; make sure the angle is pointing North.
2. Wearing leather gloves, drive the angle iron into the ground using a post driver. A sledge hammer may be used once the angle iron is low enough to be hit safely. Drive the angle iron into the ground until it can no longer be moved by pulling up or pushing down on it with your hands. **Leave several inches exposed above ground to attach the well.** Remove excess angle iron with a hacksaw, if necessary.
3. Insert the well into the hole and attach it to the angle iron with a hose clamp, tighten with a screwdriver or socket wrench.
4. Backfill the hole using sand and bentonite clay (see *Well Installation*).
5. Measure and record the new height from ground, not including muck and unconsolidated sediments less than or equal to 30 cm in depth, to the top of the well/calibration line. If muck or unconsolidated sediments are greater than 30 cm, then the top of the muck surface is used as the starting point. Refer to values from previous sampling years to obtain comparable height values.

Well Maintenance

If sediments accumulate inside a well, a well bailer can be used to bail out the stagnant water and sediments. If sediments continue to accumulate within the well, well maintenance may be needed.

1. Measure the distance from the top of the well to the ground surface (at the North arrow).
2. Remove the well.
3. Clean the well screen with water and a wire brush.
4. Remove slumping sediment out of the auger hole.
5. Bail mucky water out of the auger hole before well reinstallation.
6. Position the well at approximately the same height as before.
7. Add a fresh sand / clay layer around the well.
8. Measure the distance from the top of the well to the ground surface.



Figure 7.4. Wells can be clamped to angle iron that is driven into consolidated ground, to prevent movement. All 40-inch Ecotone water level loggers are reinforced with angle iron. The dark blue line is the calibration point.

Design and Construction of Water Depth Instrumentation

We used a home-made “hydrolite” or “hydrobuzzer” device to measure water table depth in manually-measured groundwater wells (Figure 7.5). The original hydrolite design follows that of Bill Gawley of Acadia National Park. We modified the design to create the hydrobuzzer. Both instruments allow well measurements with centimeter-level accuracy.

Materials

1. 2 Silicone stopper (size 3: big end = 1”, small end = 5/8”)
2. 2 Nails or small diameter screws (1.25–1.5” long)
3. 24 gauge speaker wire (2 wire and 2-3 meters long)
4. Wire stripper
5. Electrical and duct tape
6. 3/4” PVC pipe (6” long)
7. Measuring tape (2-3 meters long, to thousands place)
8. Project enclosure box (3x2x1” or larger)
9. Drill

10. 1 9V battery
11. 1 9V battery snap connector
12. Adhesive back Velcro
13. 5mm LED assembly lamp
14. Drill bits – 7/64” (wire hole) and 5/16” (LED hole)
15. Piezo buzzer
16. Drill bits – 7/64” (wire/buzzer hole) and 11/64” (Velcro hole)

Assembly

1. Insert two nails or screws into the stopper to serve as the contacts of the ‘sensor’. Insert the nails / screws so that the heads are flush with the big end of the stopper. They should not touch at either end.
2. Strip the insulation surrounding the two copper wires to expose approximately ½ inch of wire at each end of the speaker wire.
3. Wrap the stripped wire around each nail and secure the wires to the nails with electrical tape (Figure 7.7).
4. Pull the wire through the PVC pipe and push the stopper into the pipe until the stopper is flush with the PVC pipe. For ease of disassembling, leave 3 inches of excess wire in the PVC, then push the second stopper into the opposite end of the pipe to seal the device from water infiltration.
5. Secure the measuring tape to the PVC using electrical or duct tape. Secure the speaker wire to the measuring tape every twelve inches with the tape.
6. Drill a hole on the smallest end of the project box (7/64” bit) as close to the bottom as possible, to insert the speaker wire.
7. **LED only:** Drill an additional hole, centered on the opposite small end of the project box (5/16” bit), to mount the LED light. Mount the LED light.
8. **Buzzer only:** Drill an additional hole, centered on the opposite small end of the project box (7/64” bit), for the buzzer. Drill a hole through both sides of adhesive back Velcro (11/64” bit) and attach the buzzer facing out the buzzer hole.
9. Connect the red wire from the LED/Buzzer to the red wire of the 9V battery snap connector and secure with electrical tape (Figure 7.8).
10. Insert the speaker wire through the designated hole near the bottom of the project box.
11. Connect one side of the stripped speaker wire to the black wire of the 9V battery snap connector and secure with electrical tape.
12. Connect the second side of the stripped speaker wire to the un-connected LED/buzzer wire and secure with electrical tape.
13. Attach the 9V battery to the bottom of the project box using adhesive Velcro.
14. Attach the lid to the project box.



Figure 7.5. The basic construction of a hydrolite or hydrobuzzer used to measure water table depth in manually-measured groundwater wells.



Figure 7.6. Speaker cord is attached to the nail "sensors" with electrical tape and protected inside a piece of PVC with rubber stoppers.



Figure 7.7. The LED light (or buzzer) is connected to the 9V snap connector and one section of the stripped speaker cord. The other section of stripped speaker cord attaches to the other 9V snap connector.

Measurement in Manually-Measured Groundwater Wells

To calculate groundwater depth, observers measure: 1) the height of the top of the well from the ground (outside of the well) and 2) the top of the well from water (inside the well). To reduce variability in readings due to equipment error, readings are always taken at the same point on the riser pipe, looking north.

Procedure for Water Depth Measurement

1. Find arrow on the well pointing north.
2. Hold the tape measure flat against the outside of the well with the hydrolight or hydrobuzzer sensors against the ground surface. The tape should be held as vertically level as possible. The top of the tape will be pulled tight enough to get the slack out. Measure to the very top of the well just above the north arrow to the nearest millimeter. Record the measurement in meters (Attachment 7.1).
3. Next, lower the hydrolight end of the tape down the well slowly. The sensor will transmit a signal to the LED (light up) or buzzer (sound) when the nails hit the water surface. Slightly pull back on the tape until the beeping stops or the light goes away. This represents the depth of water in the well. Record the measurement.

References

- Sprecher, S.W. 2000. Installing monitoring wells/piezometers in wetlands. WRAP Technical Notes Collection (ERDC TN-WRAP-00-02). U.S. Army Research and Development Center, Vicksburg MS. www.wes.army.mil/el/wrap
- Sprecher, S.W. 2008. Installing monitoring wells in soils (Version 1.0). National Soil Survey Center, Natural Resources Conservation Service, USDA, Lincoln, NE.

Attachment 7.1. Well Deployment Log and Soil Characterization Data form

Well Deployment Log
Cuyahoga Valley National Park

Wetland ID _____ Tract ID _____ Well # _____
 Mapped Soil _____ Monitoring Period _____
 Monitoring Depths _____
 Method to measure water levels _____ Frequency _____
 Height above surface _____
 Coordinate System: _____ N/S _____ E/W _____

Depths (cm)	Diagram	Backfill	Soil characteristics	Comments
0				
5				
10				
15				
20				
25				
30				
35				
40				
45				
50				
55				
60				
65				
70				
75				
80				
85				
90				
95				
100				
105				
110				
115				
120				
125				
130				
135				
140				
145				
150				

Bore hole diameter _____
 Well stock ID _____ OD _____
 Material of well stock _____
 Slot width _____
 Manufacturer _____

Maintenance History

Type	Date	Initials