Well Maintenance and Support of Continuous Data at South Carolina NGWMN Sites

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Summary

The South Carolina Department of Natural Resources (SCDNR) serves as a data provider to the National Ground Water Monitoring Network (NGWMN). SCDNR has been providing groundwater level information since 2015. During the first year of award and participation, SCDNR added wells and set up web services to serve information through the NGWMN data portal. A second agreement during 2017-2018 filled data gaps in existing registry wells by digitizing historical paper records of lithology and historical water-level measurements. Tidal corrections for wells that exhibit tidal fluctuations were also calculated during that period. A third agreement during 2018-2019 expanded the South Carolina groundwater monitoring network by adding 12 wells across the South Carolina Coastal Plain. A fourth agreement was entered in 2019 to expand the network through drilling activities and to perform maintenance (well-head protection and well purging to evaluate connectivity) on existing NGWMN sites. That agreement was extended by one year due to interruptions caused by the COVID-19 pandemic. Finally, a fifth one-year agreement was entered during 2021-2022 to perform well maintenance (well purging to evaluate connectivity) and purchase equipment for monitoring wells. The contents of this report summarize those projects completed during the most recent award period.

Well Registry Maintenance

Updating and maintaining information served to the NGWMN portal is an ongoing task. Additional or missing water-level measurements have been added to the Oracle database at sites that were no longer meeting criteria or for those needing updates. Several wells have been turned off or removed from the Well Registry management interface. These wells include those not meeting monitoring criteria as Surveillance wells or they are underperforming Trend wells. Other wells have been destroyed, altered, or are now inaccessible. Updates to partial records or services showing up as blank in the NGWMN data portal are being corrected or removed. Water-level data are processed in accordance with SCDNR's standard operating procedures and reviewed for accuracy prior to being entered to the Oracle database. These data are available on the SCDNR Hydrology Section data viewer webpage and through the NGWMN data portal.

Project Summaries

Objective 4 - Project 1: Pump NGWMN wells to maintain connection to aquifer.

The purpose of this project was to pump wells to ensure they are connected to the aquifer and collecting accurate data. Seven wells were chosen and funded for this project (Fig 1). Several of the wells belong to SCDNR's Saltwater Intrusion Monitoring Network. This subnetwork of the larger South Carolina Groundwater Monitoring Network is comprised of wells sited close to the South Carolina coastline where changes in the freshwater-saltwater interface are documented or anticipated. Continuously logging temperature and conductivity probes are installed in these wells to track changes in specific conductance over time. Periodic

pumping of these and other wells that belong to the larger SC Network confirms that wells have a good connection to the aquifer and screens (or open hole intervals) are free from debris and/or sediment. Periodically purging wells of standing water is good practice for maintaining a reliable monitoring network.

There were two well location changes from the original funded project. Both changes were approved by the NGWMN Coordinator prior to work. The first change was due to the well (HOR-1327) being pumped and sampled for a different project before NGWMN funding was active. The second well (CHN-0101) was transferred to the USGS for continuous water-level monitoring. The replacement wells included a Gordon aquifer well (Site Name: CHN-0044/Site No.19DD-01) with a long period of record and a consistent downward trend. We could not find records that this well has been pumped in many years. The second Gordon aquifer well (Site Name: COL-0804/Site No. 25EE-y1) was a recent addition to the Network (drilled in 2020) that had never been pumped. We used this as an opportunity to assess well construction and determine if well screens were installed at the proper depth to measure changes in the aquifer.

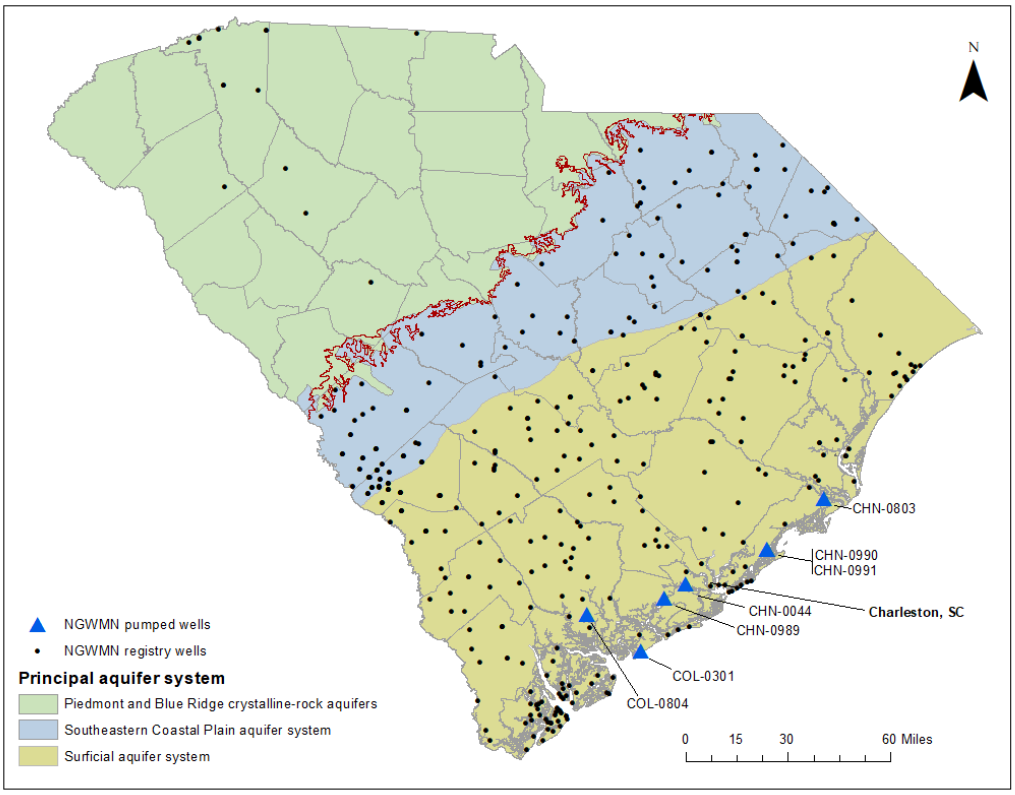


Figure 1. Locations of NGWMN registry wells by Site Name that were pumped under Objective 4.

Under the supervision of SCDNR staff, a drilling contractor provided and installed a temporary submersible pump to purge the wells shown in Fig 1. Wells were pumped for the length of time necessary to remove at least one well volume. A static water-level measurement was collected immediately before pumping and water level drawdown was monitored using an electric tape during pumping. A handheld multiprobe instrument was used to monitor

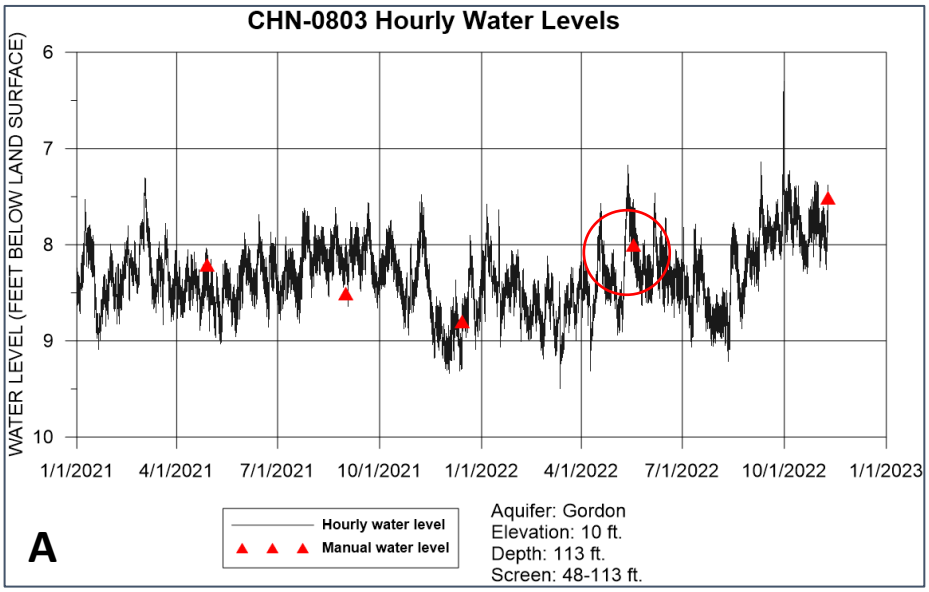
groundwater temperature and specific conductance. Pumping ended when field measurements of temperature and specific conductance stabilized for a period of more than 5 minutes. Field water quality information is not provided in this report but can be available upon request. Pumping information for each well was recorded during well purging and is shown in table 1.

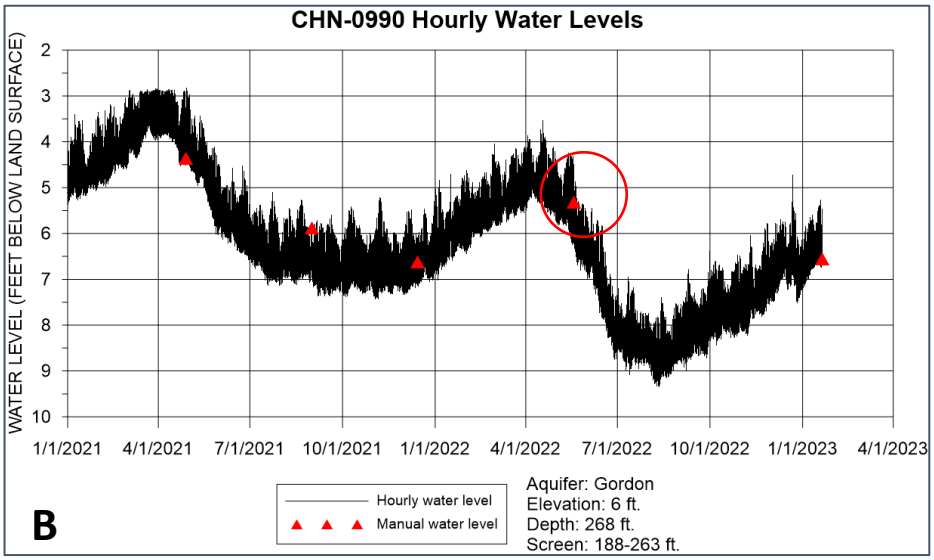
Table 1. Well construction, pumping details and drawdown for wells purged under Objective 4.

SCDNR Site Number	NGWMN Site Name	Well Depth (ft)	Casing Diameter (in)	Static Water Level (ft) at Start	Depth Pump Set (ft)	Pump Rate (gpm)	Drawdown (ft) at End	Pumping duration (h: mm)	Date Pumped
19DD-o1	**CHN-0044**	434	8	38.70	61	23.5	5.35	2:39	5/17/2022
11Z-b1	**CHN-0803**	113	5	10.25	40	26	8.32	0:17	5/18/2022
21EE-a2	**CHN-0989**	560	8	51.81	100	24	7.22	2:47	5/16/2022
14BB-p4	**CHN-0990**	268	4	8.35	40	18	6.30	0:36	5/18/2022
14BB-p5	**CHN-0991**	48	4	6.14	30	17	11.12	0:11	5/18/2022
22GG-w4	**COL-0301**	545	6	43.25	62	20.5	2.20	1:50	5/18/2022
25EE-y1	**COL-0804**	535	4	46.83	86	1.4	34.67	2:57	5/17/2022

The desired volume (based upon well construction and water column calculations) of water was removed for six of the seven wells. In those six wells, the average yield was 21.5 gallons per min (gpm) and the drawdown ranged from 2.20 – 11.12 feet (ft). COL-0804 yielded a maximum rate of 1.4 gpm with a 34.67-ft drawdown (Table 1). After purging the well for nearly three hours, we were unable to void an entire well volume. Due to the drawdown, the pump eventually lost suction and was removed. We were not able to lower the pump or attempt pumping again another day under the same contract. Although it was not directly recorded, water levels in most wells were observed to recover to near pre-pumping static water-levels quickly. COL-0804 recovered the slowest at a rate of approximately 1.2 foot per minute. At each site, dataloggers were re-deployed after the pump was removed from the well and programed to begin collecting water-levels during the same day.

Figure 3A-G show two-year period of record hourly hydrographs for the each of the wells pumped during this project. This period was selected to identify changes that may have occurred from pumping. Large changes in water level or a change in the general pattern could indicate aquifer connectivity problems. Hydrographs are grouped regionally in the following figure because the pattern and trends of water-level depends somewhat on location and depth. Wells north of Charleston, SC are shallow and poorly confined or unconfined with a hydraulic connection to a tidal water body. Wells located south of Charleston, SC are deep and well confined. In the following hydrographs manual tape-downs are shown as red triangles.





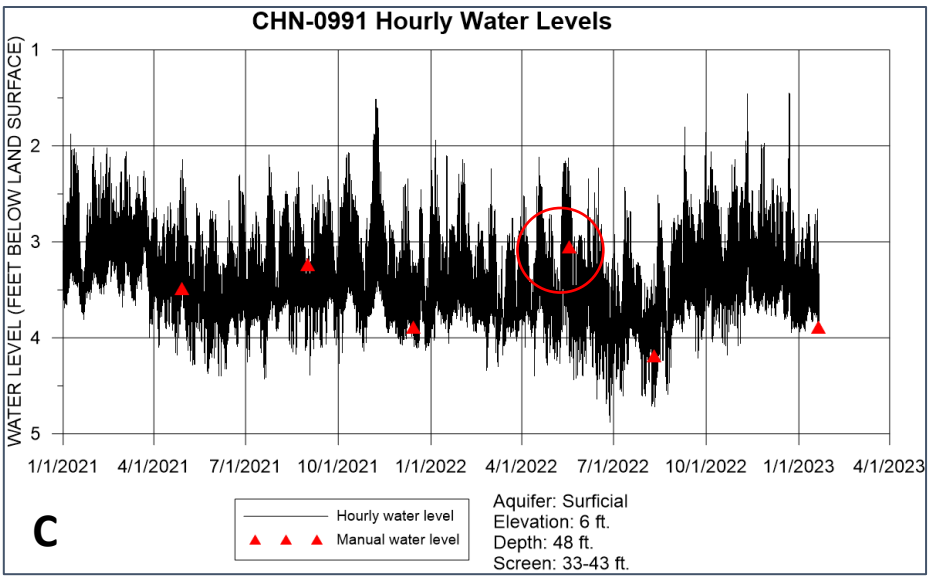
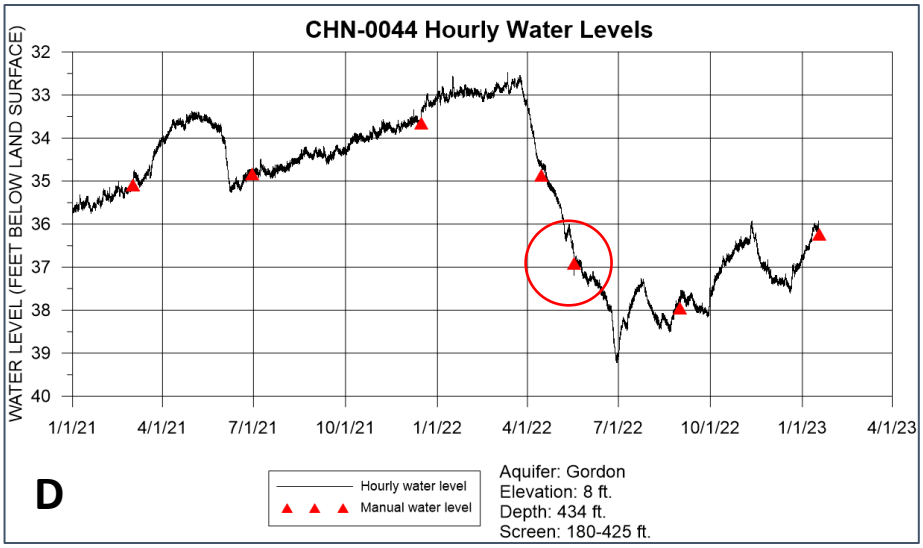
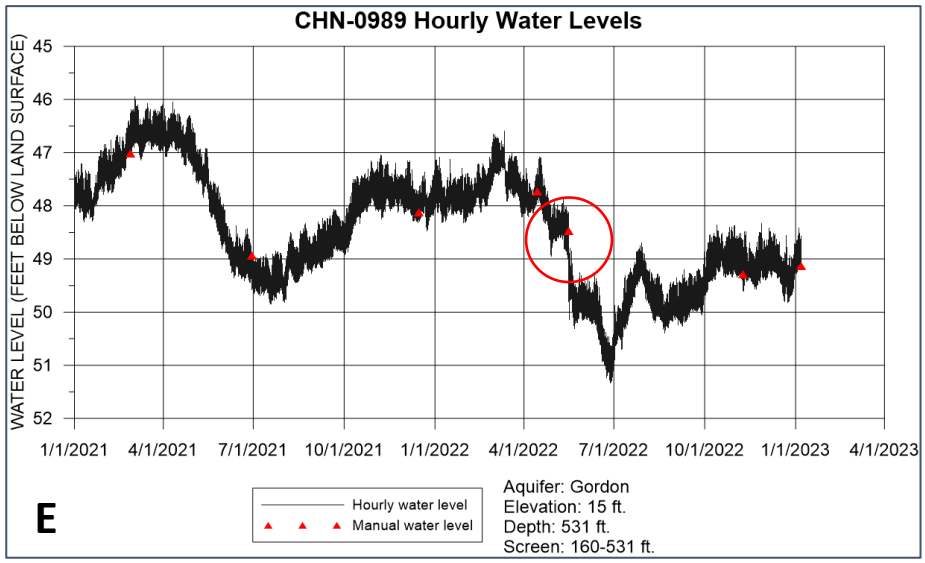


Figure 3A-C. Hourly hydrographs of wells pumped for Objective 4 located north of Charleston, SC (Fig. 1).





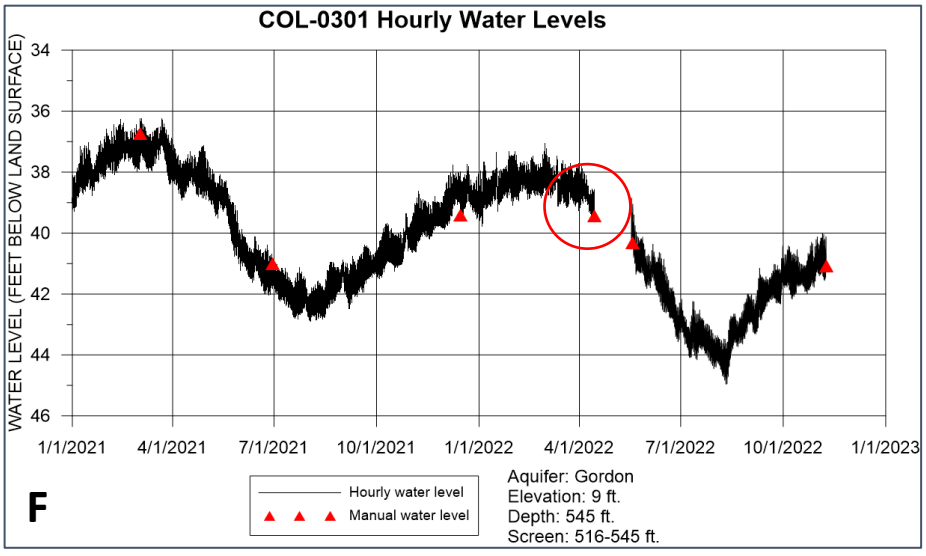


Figure 3D-F. Hourly hydrographs of wells pumped for Objective 4 located south of Charleston, SC (Fig. 1).

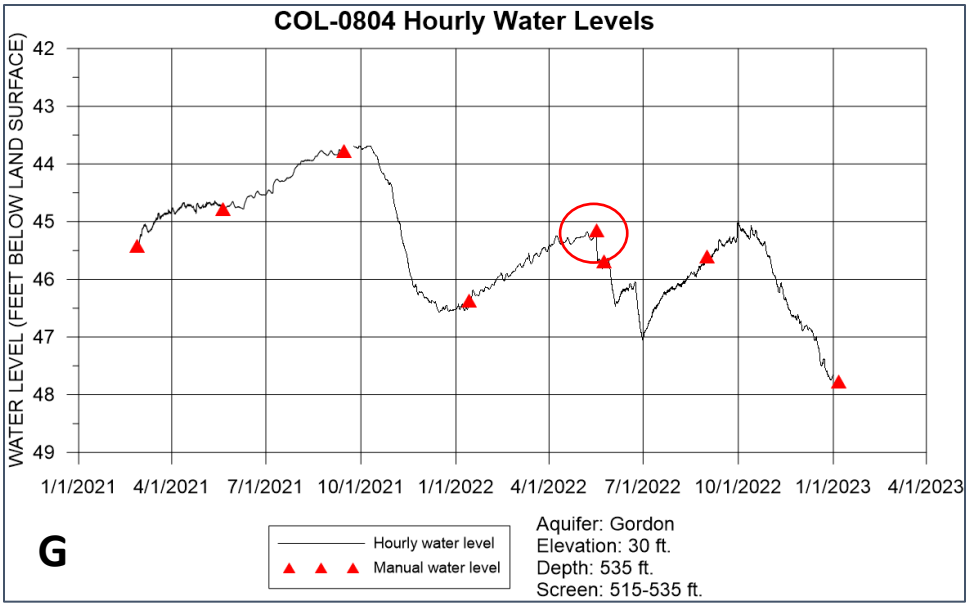


Figure 3G. Hourly hydrograph of wells COL-0804 pumped for Objective 4 (well located inland, south of Charleston, SC (Fig. 1).

A review of the hydrographs prior to and after pumping suggests that six of the wells are functioning as expected. They are free of sediment and are connected to the aquifer in which they are completed. Figure 3A-C show there is little to no change after pumping, so we feel confident that these wells are collecting reliable data. Fig 3D-F show declines in each well directly after pumping, but this time coincided with the typical decline in water-level due to increases in seasonal water use. A logger failure occurred at COL-0301 during re-deployment and data were not recoverable. Water-level trends in nearby wells, CHN-0044 and CHN-0989, suggest that the lost data would appear similar (Fig 3D-F). It is noted that in the short-term a comparison of COL-0301 to CHN-0044 and CHN-0989 is not straightforward due to differences in well construction. CHN-0044 and CHN-0989 are “screened” as open hole construction over several hundred feet and may be open to multiple permeable zones within the Gordon aquifer. Water-levels at these wells are more sensitive to fluctuations from pumping or climate than COL-0301 with a 30 ft screened interval deep in the Gordon aquifer. COL-0801 is constructed with a 20 ft screened interval deep in the Gordon aquifer (Fig 3G). We suspect that the well screens were not placed at the correct depth interval, or that the well was not properly developed. We plan to use a down-hole camera to inspect the well and will attempt to pump the well again with a submersible pump set deeper. Pumping in the area could also be affecting water-levels, for these reasons this well off in the data portal until a resolution can be identified.

Objective 6 - Project 2: Equipment Purchase for NGWMN Sites.

The purpose of this project was to purchase automatic data recorders to support continuous water-level data collection at NGWMN Trend sites. SCDNR's Groundwater Monitoring Network and associated NGWMN Trend water-level wells use water level dataloggers to record continuous water-level data at hourly intervals. As the loggers age sensor drift or other malfunctions are common. Sensors that are out of the specified tolerance range of 0.2 feet cannot be added to the database due to the high level of uncertainty. Automatic data loggers need to be periodically replaced to reduce the occurrence of data gaps.

SCDNR purchased and installed Solinst Levelogger® 5 Model 3001 loggers to replace ageing Solinst Levelogger® Edge Model 3001 Loggers for each of the 15 wells. Fig 4 shows the locations where replacements were made and Table 2 details well information for each replacement site.

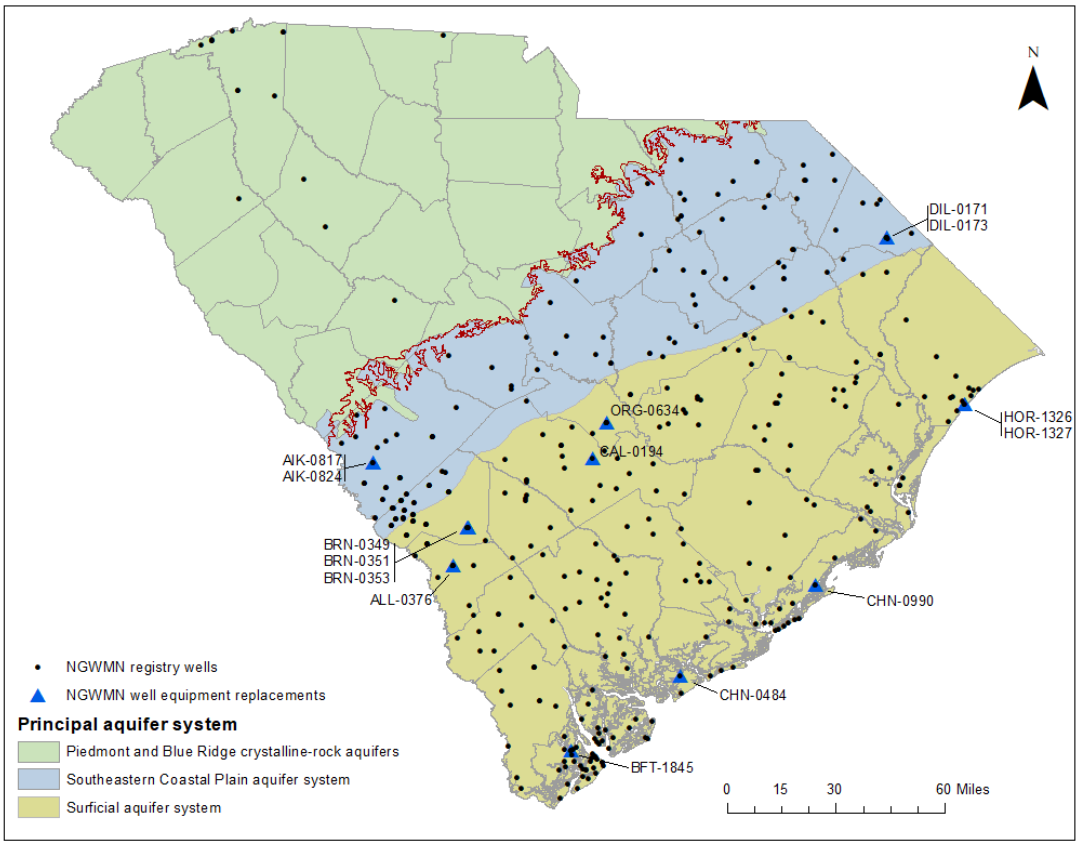


Figure 4. Map showing locations of NGWMN Trend wells were probe replacements were made under Objective 6.

Table 2. NGWMN Trend wells that received replacement loggers.

SCDNR Site Number	NGWMN Site Name	Well Depth (ft)	Monitoring Category	Monitoring Frequency	Principal Aquifer System	Equipment Purchased
40V-s2	**AIK-0817**	535	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
40V-s5	**AIK-0824**	365	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
35AA-q9	**ALL-0376**	994	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
28JJ-p5	**BFT-1845**	600	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
38Y-m42	**BRN-0349**	1045	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
34Y-x3	**BRN-0351**	95	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
34Y-x5	**BRN-0353**	588	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
26T-x6	**CAL-0194**	254	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
22GG-d1	**CHN-0484**	560	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
14BB-p4	**CHN-0990**	265	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
10L-c5	**DIL-0171**	555	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
10L-c4	**DIL-0173**	380	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
6T-a4	**HOR-1326**	600	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
6T-a5	**HOR-1327**	440	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001
27V-n2	**ORG-0634**	256	Trend	Continuous	Southeastern Coastal Plain	Solinst Levelogger® 5 Model 3001

SCDNR staff installed replacement Levelogger® 5 probes on Levelogger® 5 Direct Read Cables that were purchased with separate funding. Probes were installed according to established standard operating procedures set by the SCDNR Hydrology Section. Standard operating procedures dictate how to handle newly installed loggers to ensure the data is accurate and within the established tolerance range. SCDNR uses a summed cable length from a manually collected water-level and the barometrically compensated automatic data to track sensor performance, this process ensures that loggers are collecting data within the 0.2-foot tolerance. Staff make at least three site visits before adding new water-level data to the Oracle database. Multiple site visits result in an average cable length to be established while the sensor settles. This procedure has yielded reliable and accurate readings for continuously monitoring sites.