

# Expanding the South Carolina Groundwater Monitoring Network



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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). Beginning in 2015, a cooperative agreement between SCDNR and the United States Geological Survey (USGS) facilitated the integration of 438 well sites routinely measured by SCDNR. A second cooperative agreement initiated in 2016 filled data gaps by digitizing lithology, well construction, and historical water level information at established NGWMN sites. Additionally, tidal corrections were calculated to improve the accuracy of water levels collected from wells close to tidal water bodies resulting in the addition of 18 Network wells and bringing the total to 456 well sites. In July 2017, SCDNR entered a third 24-month long cooperative agreement to expand the South Carolina Groundwater Monitoring Network. Twelve new wells were drilled in locations across the South Carolina Coastal Plain where information was lacking and for the purpose of understanding impacts of water use and climate change. The award ended on June 30, 2019; this report documents the activities undertaken by SCDNR during the award period.

## Background

The overall goal of the South Carolina Groundwater Monitoring Network is to increase the number of dedicated groundwater water-level wells open to the major aquifers in South Carolina that are required to generate accurate, statewide potentiometric maps of each aquifer and to evaluate changes in storage related to climate effects. Currently, there are 468 South Carolina wells in the NGWMN, which includes the 12 new wells drilled during this most recent award period (Figure 1). Locations of the newly drilled wells are shown as red (deep wells) and blue (shallow wells) triangles. The 468 wells included in the NGWMN are either part of South Carolina's baseline network of wells that are measured on a regular basis (approximately 6 times per year), or are part of a larger synoptic network of wells that are measured periodically for potentiometric mapping purposes (at least once every three years). Current and accurate information is known about wells belonging to these two networks, which made them good candidates for inclusion in the NGWMN. Water level measurements collected from these monitoring networks are obtained in accordance with SCDNR standard operating procedures and undergo quality assurance and control checks outlined in the NGWMN data management plan prior to being uploaded to the data portal.

Dedicated monitoring wells provide a reliable means of evaluating changes in storage or tracking problem areas (dewatering) since they are constructed to monitor specific depth intervals of an aquifer. South Carolina also seeks to develop a robust network of real-time drought-assessment network wells. Drought assessment wells are completed in the shallow (water-table) aquifer system and provide water level information to water managers and the State Drought Coordinator to assess conditions before and after droughts. Water-table data along with other hydrologic and meteorological data are used in the State to assess the severity of droughts.

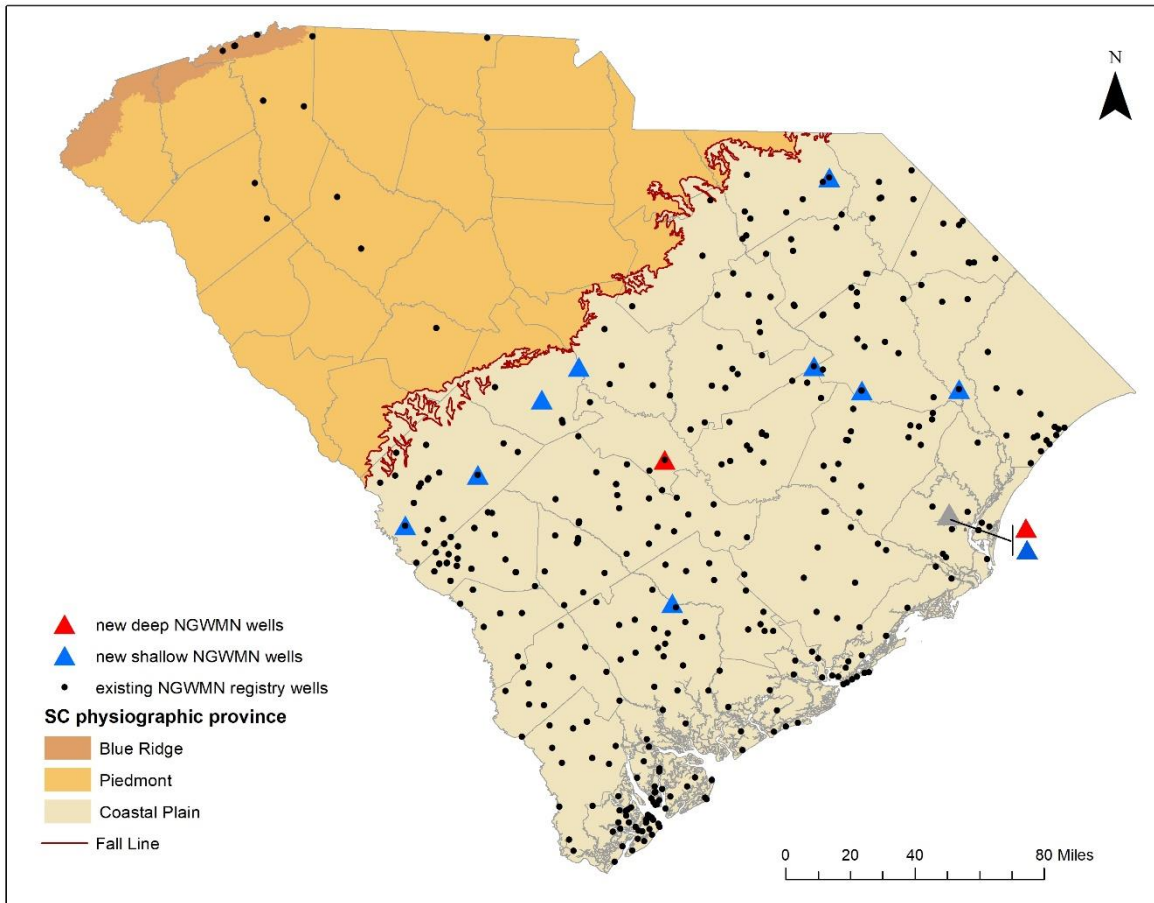


Figure 1. Map showing locations of National Ground-Water Monitoring Network registry wells; wells drilled during the award period are shown as red (deep wells) or blue (shallow wells) triangles.

SCDNR identified spatial data gaps in the SC Ground Water Monitoring Network in several locations across the Coastal Plain. Documented declines in water levels due to pumping at agricultural and/or municipal sites prompted the need for additional information about groundwater conditions in those areas of the Coastal Plain. There is also a need to increase the number of wells in the shallow aquifer system to monitor for changes in recharge as it pertains climate. To address these needs, twelve new wells were drilled in locations across the Coastal Plain where information was lacking (Table 1).

Table 1. New wells added to the National Groundwater Monitoring Network registry

| County Number<br>(SC Site No.) | Grid Number<br>(SC Site Name) | Latitude<br>(Decimal<br>Degrees) | Longitude<br>(Decimal<br>Degrees) | Datum | Well Depth<br>(feet) | Screened<br>interval<br>(feet) | Principal Aquifer system                     | Local Aquifer  |
|--------------------------------|-------------------------------|----------------------------------|-----------------------------------|-------|----------------------|--------------------------------|--|----------------|
| AIK-2741                       | 40W-q9                        | 33.353503                        | -81.808839                        | NAD83 | 80                   | 60–80                          | Surficial aquifer system                     | Shallow        |
| AIK-2742                       | 36U-o7                        | 33.542333                        | -81.485415                        | NAD83 | 50                   | 30–50                          | Surficial aquifer system                     | Shallow        |
| CAL-0215                       | 26T-x8                        | 33.598610                        | -80.647870                        | NAD83 | 699                  | 689–699                        | Southeastern Coastal<br>Plain aquifer system | McQueen Branch |
| COL-0803                       | 26AA-i6                       | 33.062181                        | -80.615000                        | NAD83 | 24                   | 14–24                          | Surficial aquifer system                     | Shallow        |
| CTF-0325                       | 17H-f2                        | 34.643140                        | -79.911640                        | NAD83 | 40                   | 20–40                          | Surficial aquifer system                     | Shallow        |
| FLO-0484                       | 16Q-t7                        | 33.855840                        | -79.766560                        | NAD83 | 40                   | 20–40                          | Surficial aquifer system                     | Shallow        |
| GEO-0390                       | 11W-h1                        | 33.394420                        | -79.378040                        | NAD83 | 640                  | 620–640                        | Southeastern Coastal<br>Plain aquifer system | Crouch Branch  |
| GEO-0391                       | 11W-h2                        | 33.394320                        | -79.378040                        | NAD83 | 40                   | 20–40                          | Surficial aquifer system                     | Shallow        |
| LEX-1702                       | 33R-b2                        | 33.822960                        | -81.198800                        | NAD83 | 56                   | 36–56                          | Surficial aquifer system                     | Shallow        |
| LEX-1703                       | 31P-s1                        | 33.942890                        | -81.032330                        | NAD83 | 32                   | 22–32                          | Surficial aquifer system                     | Shallow        |
| MRN-0178                       | 10Q-p3                        | 33.861560                        | -79.330480                        | NAD83 | 40                   | 20–40                          | Surficial aquifer system                     | Shallow        |
| SUM-0531                       | 18P-q3                        | 33.945610                        | -79.979706                        | NAD83 | 40                   | 20–40                          | Surficial aquifer system                     | Shallow        |

## Well Drilling Activities

### McQueen Branch monitoring well in Calhoun County

Increased groundwater use for crop irrigation in Calhoun County, South Carolina has raised concern among citizen groups that the increase may be affecting water levels in aquifers that are used for domestic supplies. Irrigation use increased from 1,559 MGY (million gallons per year) in 2001 to 3,426 MGY in 2012, and the number of registered irrigation wells increased from 25 to 73 during this same period. To address this concern, SCDNR, in collaboration with the USGS, drilled a core hole to 1,058 ft in the Town of Creston in south-central Calhoun County during the summer of 2013. Four aquifers were delineated at the site and are, in descending order: 1) the surficial aquifer (0 to 43 ft bls, below land surface); 2) Gordon aquifer (80 to 130 ft bls); 3) Crouch Branch aquifer (193 to 385 ft bls); and 4) McQueen Branch aquifer (660 to 850 ft bls). In 2014, three monitoring wells were completed at the site in the surficial, Gordon, and Crouch Branch aquifers and were equipped with automated water level recorders. These wells are included in the National Ground-Water Monitoring Network.

Most of the irrigation water being used in the county is being pumped from the Crouch Branch aquifer. An alternative source of groundwater is from the deeper, McQueen Branch aquifer. The McQueen Branch is a major aquifer in the State, consisting of unconsolidated sand of Late Cretaceous age. Transmissivity values up to 50,000 ft<sup>2</sup>/day have been obtained from the aquifer but are more commonly in the range of 10,000 to 20,000 ft<sup>2</sup>/day. Owing to a lack of funding, however, a monitoring well in the McQueen Branch aquifer was never constructed at the site. The purpose of this project, therefore, is to finish the well-cluster site by constructing a well in the McQueen Branch aquifer and equipping it with an automated water-level data recorder (ADR).

Drilling commenced on December 12, 2018 and was completed on January 4, 2019. An 8-inch borehole was drilled to 699 feet by AAA Well Drilling, Inc. of Lexington County, South Carolina, who was awarded the contract through a bidding process overseen by SCDNR's Procurement Office. Prior to installing the well casing and well screen, a suite of geophysical logs was obtained from the borehole using a Century logging unit operated by SCDNR. The suite included a gamma-ray log, 16- and 64-inch normal resistivity logs, a single-point resistance log, and a spontaneous-potential log. These logs are available upon request.

The well was constructed using 4-inch galvanized well casing that was installed from three feet above land surface to 689 ft bls. Attached to the bottom of the casing, from 689–699 ft, was a 10-ft section of 4-inch diameter stainless steel screen with a slot size of 0.010 inches. The bottom of the screen was capped with a stainless-steel plate welded onto the bottom of the screen. Casing centralizers were used about every 40 feet to keep the casing and screen centered in the borehole.

Following insertion and alignment of the casing and screen, a filter pack (sand #2) was placed around the well screen from 678–699 ft bls using a tremie-pipe method of emplacement. A 10-ft bentonite seal was then positioned from 668 ft to the top of the filter pack (678 ft) by washing bentonite pellets through a tremie line. Following emplacement of the filter pack and bentonite seal, the well was grouted with Portland Type I neat cement from the top of the bentonite plug to land surface using a tremie-pipe method. After the grout had time to set, the well was developed using compressed air until a clear, sand-free discharge was achieved. A 6-inch square, protective steel enclosure, constructed with a lockable

hinged cap, was inserted over the wellhead and cemented into place. A 3-ft by 3-ft concrete pad, approximately 4 inches thick, was poured around the well.

The new well was assigned SC county number CAL-0215 (Table 1). The initial water level in the well, measured on February 1, 2019, was 84.16 ft bls. Lithology information, well construction details, and water level at the completion of well development for this well was added to the NGMWN portal. The well was equipped with a Solinst Levellogger™ Edge Water Level Datalogger programmed to record water levels every hour, on the hour. The automatic data recorder is downloaded at the time of site visit, and manual tape-down measurements confirm the data recorder is functioning properly within an established error tolerance. Data are processed in accordance to SCDNR's standard operating procedures and reviewed for accuracy prior to being uploaded to the Oracle database and being made available on the SCDNR webpage and the NGMWN data portal.

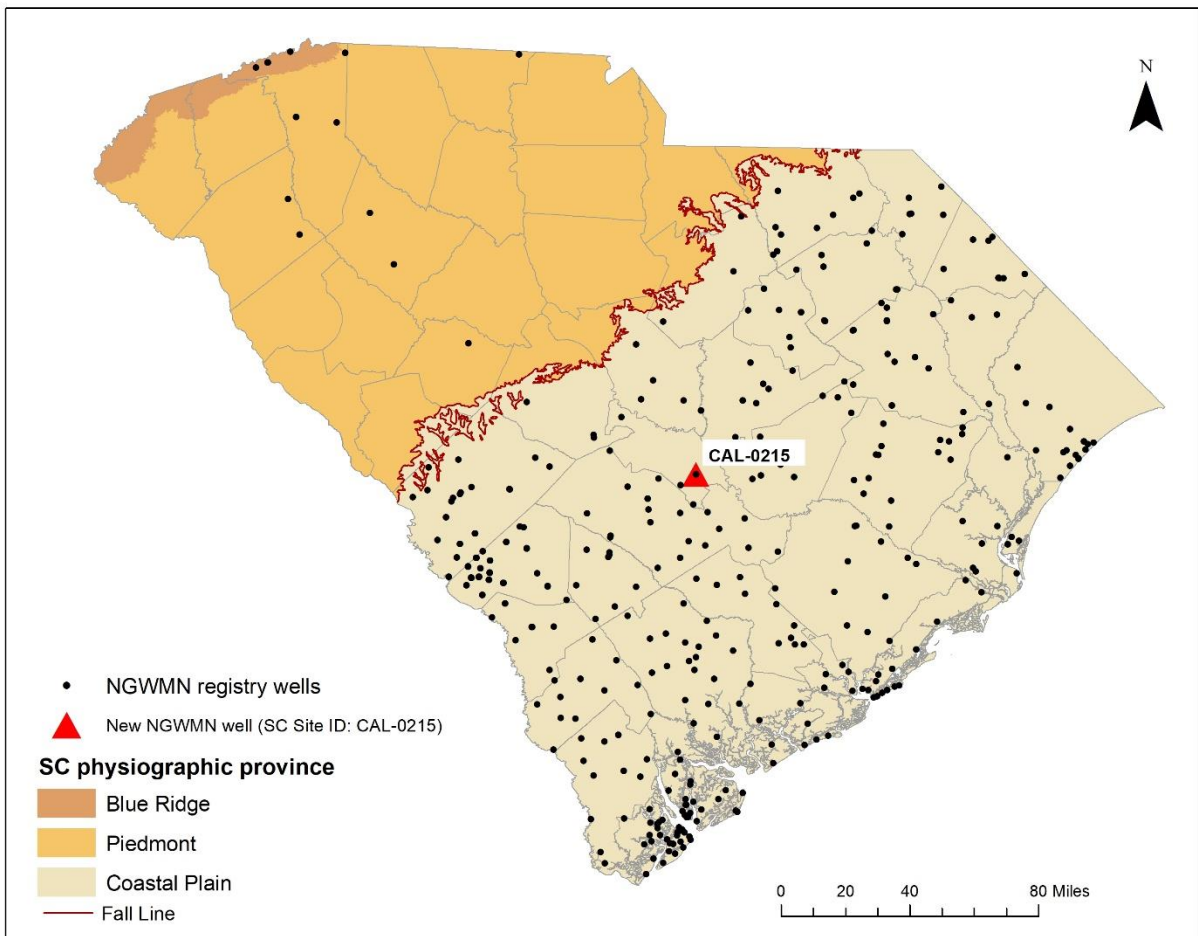


Figure 2. Location of new McQueen Branch aquifer well.

## Crouch Branch monitoring well in Georgetown County

A regional cone of depression has been identified in the Crouch Branch aquifer in Georgetown County (Figure 3). The Crouch Branch is a major aquifer in the State, occurring over most of the Coastal Plain. It consists of interbedded clay and unconsolidated sand of Late Cretaceous age. The aquifer is used as a municipal, agricultural, and industrial source of water across the State. The cone of depression in Georgetown County has been monitored primarily with data obtained every three years from non-dedicated monitoring wells in the area. Potentiometric surface maps indicate water levels near the cone of depression are declining at a rate of approximately 2 feet/year. As access to the non-dedicated monitoring wells can vary, the addition of a dedicated monitoring well allows for continuous monitoring to look at seasonal effects, changes in recharge, and/or changes in pumping rates. The purpose of this project was to construct a dedicated monitoring well in the Crouch Branch aquifer and to equip it with an automated water-level data recorder.

Drilling commenced on November 5, 2018 and was completed on November 30, 2018. An 8-inch borehole was drilled to 640 feet by AAA Well Drilling, Inc. of Lexington County, South Carolina, who was awarded the contract through a bidding process overseen by SCDNR's Procurement Office. Prior to installing the well casing and well screen, a suite of geophysical logs was obtained from the borehole using a Century logging unit operated by SCDNR. The suite included a gamma-ray log, 16- and 64-inch normal resistivity logs, a single-point resistance log, and a spontaneous-potential log. These logs are available upon request.

The well was constructed using 4-inch galvanized well casing that was installed from three feet above land surface to 640 ft bls. Attached to the bottom of the casing, from 630–640 ft, was a 10-ft section of 4-inch diameter stainless steel screen with a slot size of 0.010 inches. The bottom of the screen was capped with a stainless-steel plate welded onto the bottom of the screen. Casing centralizers were used about every 40 feet to keep the casing and screen centered in the borehole.

Following insertion and alignment of the casing and screen, a filter pack (sand #2) was placed around the well screen from 609–640 ft bls using a tremie-pipe method of emplacement. A 10-ft bentonite seal was then positioned from 597 ft to the top of the filter pack (609 ft) by washing bentonite pellets through a tremie line. Following emplacement of the filter pack and bentonite seal, the well was grouted with Portland Type I neat cement from the top of the bentonite plug to land surface using a tremie-pipe method. After the grout had time to set, the well was developed using compressed air until a clear, sand-free discharge was achieved. An 8-inch square, protective steel enclosure, constructed with a lockable hinged cap, was inserted over the wellhead and cemented into place. A 3-ft by 3-ft concrete pad, approximately 4 inches thick, was poured around the well.

The new well was assigned SC county number GEO-0390 (Table 1). The initial water level in the well, measured on January 17, 2019, was 176.91 ft bls. Lithology information, well construction details, and water level at the completion of well development for this well was added to the NGMWN portal. The well was equipped with a Solinst Levellogger™ Edge Water Level Datalogger programmed to record water levels every hour, on the hour. The automatic data recorder is downloaded at the time of site visit, and manual tape-down measurements confirm the data recorder is functioning properly within an established error tolerance. Data are processed in accordance to SCDNR's standard operating procedures and reviewed for accuracy prior to being uploaded to the Oracle database and being made available on the SCDNR webpage and the NGMWN data portal.



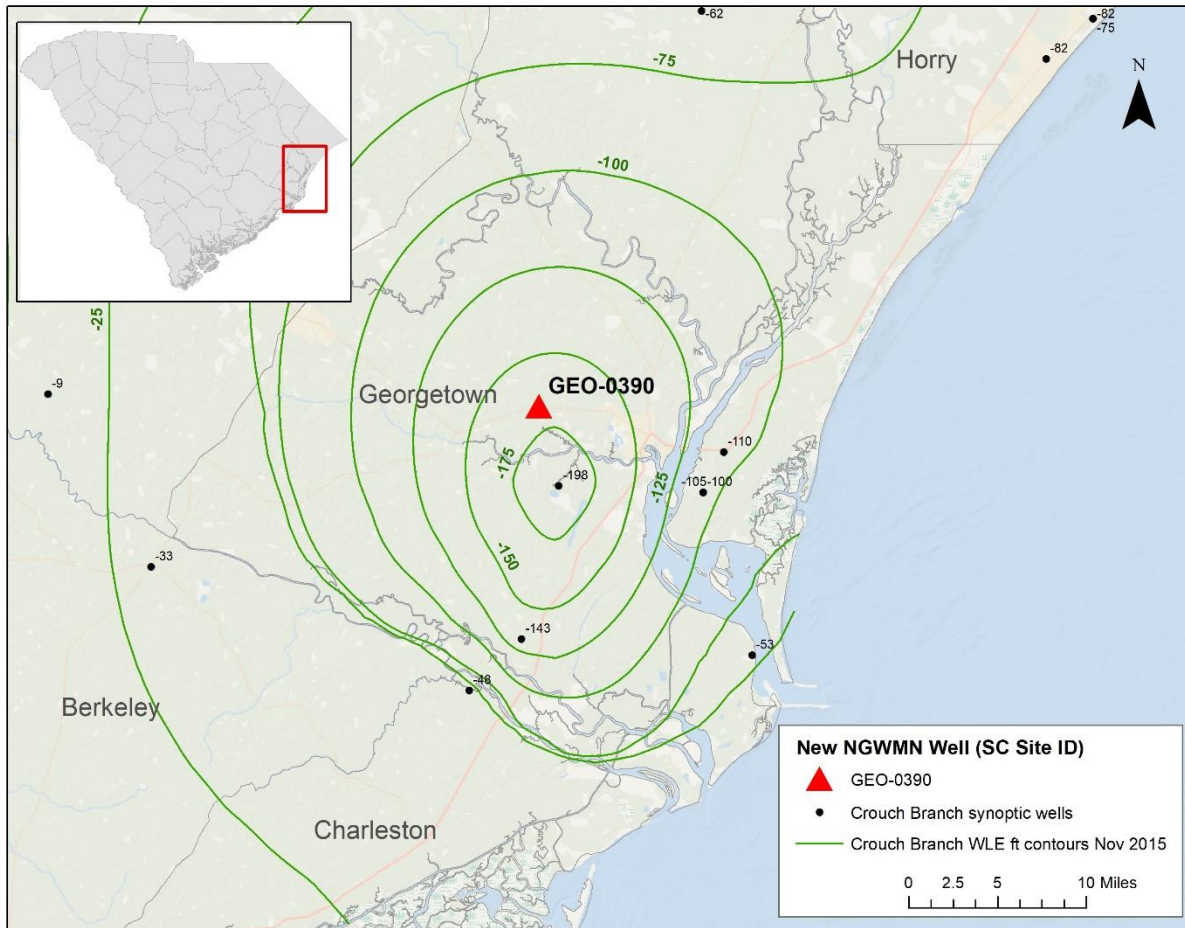


Figure 3. Potentiometric surface map from November 2016 water level data showing cone of depression in the Crouch Branch aquifer centered in Georgetown County. Location of new well shown with red triangle.

### Ten shallow monitoring wells in Coastal Plain Province of South Carolina

Increasing frequency of drought coupled with land use changes have the potential to impact the shallow aquifer system. The shallow aquifer system is important because it is a primary component of ecological flows. Additionally, the shallow aquifer system is the primary source of water for recharge of the deeper aquifer system. Prior to the construction of new wells during this award period, SCDNR only monitored nine wells in the shallow aquifer system.

A network of 10 shallow monitoring wells were drilled and instrumented to monitor the effects of climate variation and land use change on the surficial aquifer system. Data from these wells will be used by the South Carolina Drought Response Committee in their decision-making process, as well as monitoring of impacts due to land use changes. Development of urban areas along the coast and agricultural areas in the inner coastal plain have the potential to impact the flow systems in the shallow aquifer system. The increased monitoring would allow the changes to be documented.

Site selection was determined by three main factors: data gaps, access, and cost. Wells were placed where data gaps occurred in the network and at existing monitoring sites to allow for access granted by previously approved property use agreements and permits. Cost was another important factor. The first five wells were drilled in the eastern part of the state and travel was not originally factored into quotes for each well. Therefore, these wells were slightly more costly than anticipated and adjustments for the remaining five wells were made to cut back on costs. These adjustments included a decrease in well diameter from 4 inches to 2 inches (Table 2) and providing well construction materials where possible. Drill cuttings were collected and described, and a gamma-ray log was obtained from each well through the well casing. The gamma-ray logs are available upon request.

Table 2. Construction details for the shallow wells

| <b>SC Site Number</b> | <b>Well Depth (feet)</b> | <b>Screened interval (feet)</b> | <b>Casing Diameter (inches)</b> | <b>Bentonite Seal (feet)</b> | <b>Filter pack (feet)</b> | <b>Grout (feet)</b> | <b>Borehole diameter (inches)</b> |
|-----------------------|--------------------------|---------------------------------|---------------------------------|------------------------------|---------------------------|---------------------|-----------------------------------|
| <b>AIK-2741</b>       | 80                       | 60–80                           | 2                               | 50–55                        | 55–80                     | 0–50                | 6                                 |
| <b>AIK-2742</b>       | 50                       | 30–50                           | 2                               | 18–25                        | 25–50                     | 0–18                | 6                                 |
| <b>COL-0803</b>       | 24                       | 14–24                           | 2                               | 1–5                          | 5–24                      | 0–1                 | 6                                 |
| <b>CTF-0325</b>       | 40                       | 20–40                           | 4                               | 10–15                        | 15–40                     | 0–10                | 8                                 |
| <b>FLO-0484</b>       | 40                       | 20–40                           | 4                               | 10–15                        | 15–40                     | 0–10                | 8                                 |
| <b>GEO-0391</b>       | 40                       | 20–40                           | 4                               | 10–15                        | 15–40                     | 0–10                | 8                                 |
| <b>LEX-1702</b>       | 56                       | 36–56                           | 2                               | 26–31                        | 31–56                     | 0–10                | 6                                 |
| <b>LEX-1703</b>       | 32                       | 22–32                           | 2                               | 12–17                        | 17–32                     | 0–12                | 6                                 |
| <b>MRN-0178</b>       | 40                       | 20–40                           | 4                               | 10–15                        | 15–40                     | 0–10                | 8                                 |
| <b>SUM-0531</b>       | 40                       | 20–40                           | 4                               | 10–15                        | 15–40                     | 0–10                | 8                                 |

The new wells were assigned SC county and grid numbers (Table 1) and added to the NGWMN Registry. Lithology, well construction details, and water levels measured at the completion of well development were added to the NGMWN portal for each well. Each well was equipped with a Solinst Levellogger™ Edge Water Level Datalogger programmed to record water levels every hour, on the hour. Automatic water-level data recorders are downloaded at the time of site visit. Manual tape-down measurements confirm data recorders are functioning properly within an established error tolerance. The data are processed in accordance to SCDNR’s standard operating procedures and reviewed for accuracy prior to being uploaded to the Oracle database and made available on the SCDNR webpage and the NGWMN data portal.

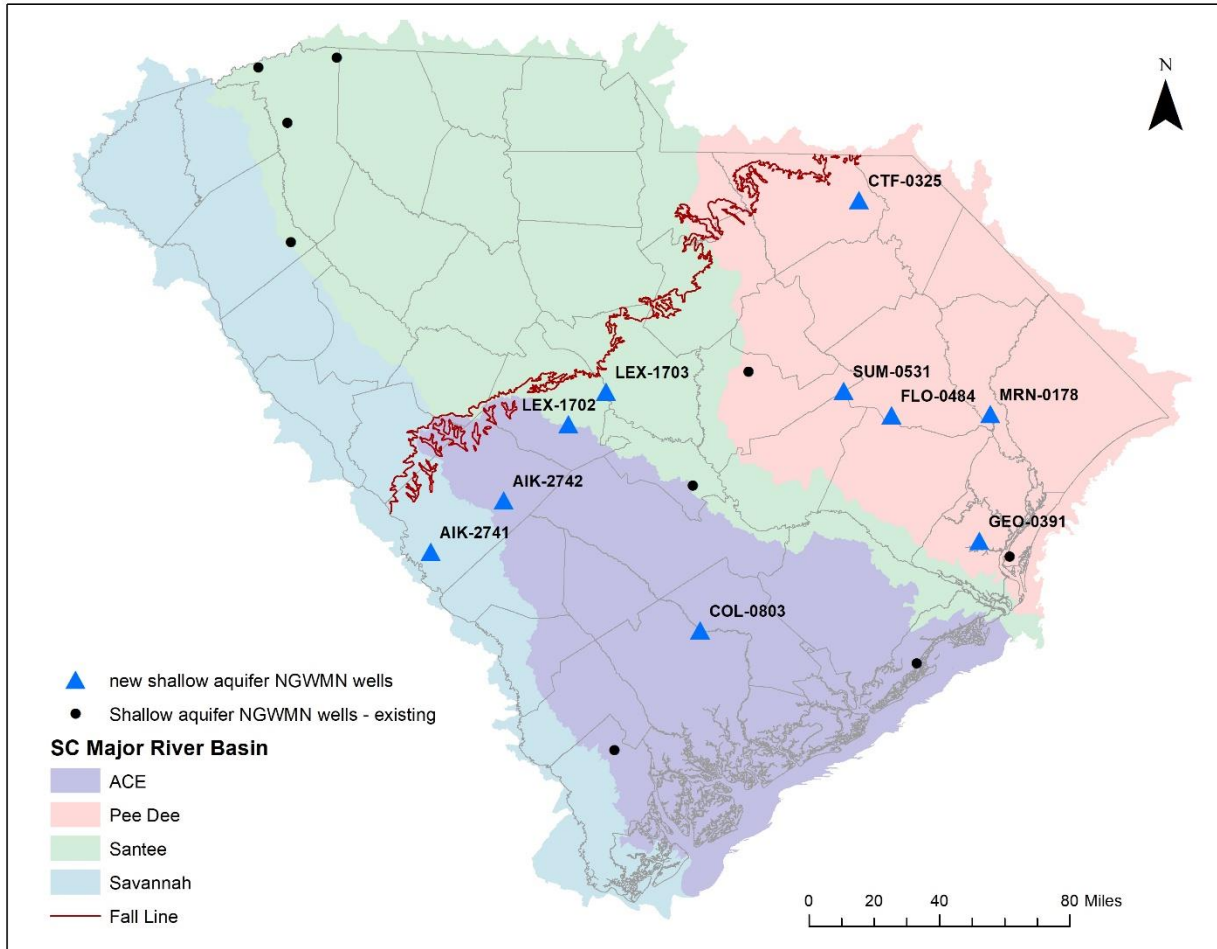


Figure 4. Locations of existing and new (blue triangles) shallow aquifer monitoring sites with major river basins of the state.

### Data Collection at NGWMN Sites

Routine groundwater monitoring of SC’s groundwater monitoring networks continued during the grant award period. Data were collected according to SCDNR guidelines and reviewed for quality assurance according to the established NGWMN data management plan for South Carolina. Data meeting criteria were loaded to the Oracle database for presentation through the NGWMN data portal. Static water level measurements from numerous wells belonging to SC’s synoptic well network were also collected during the award period. Those measurements underwent a quality assurance process and were uploaded to the NGWMN web tables for availability on the NGWMN web portal.

## References

- Czwartacki, B., Wachob, A., and Gellici, J.A., 2019, Potentiometric surface maps of the Upper and Middle Floridan and Gordon aquifers in South Carolina, November – December 2018: South Carolina Department of Natural Resources, Water Resources Report 61, 9 p.
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