




A Preliminary Assessment of the Groundwater Conditions

in Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg Counties, South Carolina

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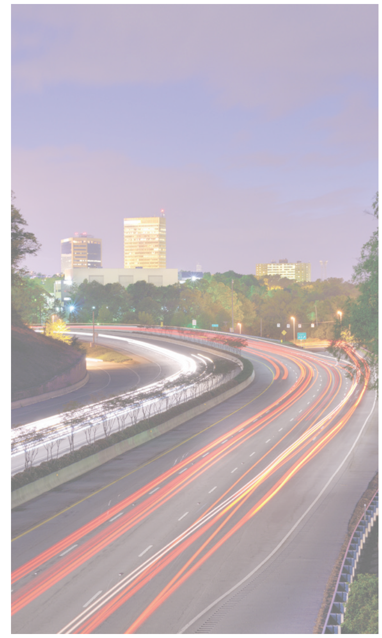
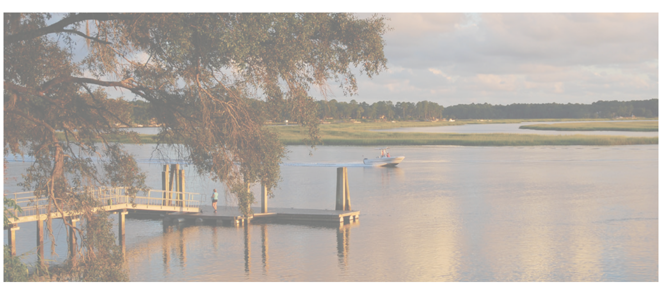
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
DNR

MAY 2017





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Executive Summary

The South Carolina Department of Health and Environmental Control (Department), in cooperation with the South Carolina Department of Natural Resources (SCDNR), has been evaluating groundwater conditions in the western Coastal Plain region of South Carolina in a series of investigations. SCDNR has previously recommended (SCDNR, 2004) the entire Coastal Plain province should be designated a Capacity Use Area in order to protect aquifer systems and ensure long-term sustainability of the groundwater resources. On July 19, 2016, Aiken County Council requested that portions of Aiken County be designated as a Capacity Use Area.

The Department has reviewed previously published reports on local groundwater conditions by the SCDNR and USGS in conjunction with reported groundwater withdrawal data for the counties of this region (Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg) to assess the current groundwater conditions in the area. This review indicates that water level declines in the aquifer systems of concern have been influenced by an increase in population, public water supply use and agricultural activities using groundwater and a series of long-standing droughts that have reduced recharge to the aquifer systems.

The preliminary data compiled in this report indicates that the entire Western Region (Figure 1 on page 3) meets the statutory requirements to be designated as a Capacity Use Area as shown in Figure 1 (the whole of Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg Counties) based on the following:

- The aquifers are interconnected beneath the counties in this region (Figure 3 on page 5).
- There is current documented increased demand and potential increases in future demand.
- Estimated declines in groundwater levels as follows:
    - Since 1998, in the Floridan/Gordon aquifers: Allendale and Barnwell Counties (8 feet).
    - Since 2001, in the Black Creek/Crouch Branch aquifer: Aiken County (< 5 feet), Allendale, Barnwell and Lexington Counties (5 feet), Bamberg County (10 feet), Calhoun and Orangeburg Counties (12 feet).
    - Since 2001, in the Middendorf/McQueen Branch aquifer: Aiken County (5 feet), Barnwell and Lexington Counties (10 feet), Allendale County (12 feet), Bamberg, Calhoun and Orangeburg Counties (15 feet).

Based on the preliminary data available to the Department, which have been summarized in this report, Aiken County along with Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg counties have developed and utilized groundwater to the degree that coordination and regulation of groundwater supplies may be needed pursuant to the Groundwater Use and Reporting Act, Section 49-5-60. As such, this preliminary data is provided to facilitate the gathering of public input and any additional data or information that will help inform the potential designation of these counties as the Western Capacity Use Area.

Introduction

The South Carolina Department of Health and Environmental Control (Department) received a formal request on July 19, 2016 from Aiken County Council to investigate and designate a Capacity Use Area within eastern Aiken County, South Carolina. Section 49-5-60 of the Groundwater Use and Reporting Act states in part that… *"In the state where excessive groundwater withdrawal present potential adverse effects to the natural resources or poses a threat to public health, safety, or economic welfare or where conditions pose a significant threat to the long-term integrity of a groundwater source… the board, after notice and public hearing…shall designate a capacity use area."* The notice and public hearing must be conducted such that local government authorities, groundwater withdrawers, or the general public may provide comments concerning the capacity use designation process. A Capacity Use Area must be designated by the board based on scientific studies and evaluation of groundwater resources and may or may not conform to political boundaries. Designation as a Capacity Use Area requires groundwater withdrawers within the Capacity Use Area to apply for and obtain a permit from the Department.

A groundwater user is defined as *"a person withdrawing groundwater in excess of three million gallons during any one month from a single well or from multiple wells under common ownership within a one-mile radius from any one existing or proposed well."* The permitting process is intended to allow the Department to coordinate and work with users of the groundwater resource to more effectively manage withdrawals to control and minimize adverse effects on the local aquifers. Withdrawals are permitted on reasonable use requirements as outlined in the regulation and demonstrated need(s) of a particular activity or industry. Mandatory reporting of groundwater use ensures permit compliance and allows the Department, local government agencies, and all interested stakeholders to determine historical use trends and establish criteria for future planning decisions.

Figure 1 (on the next page) shows the proposed Western Capacity Use Area which covers Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg Counties.

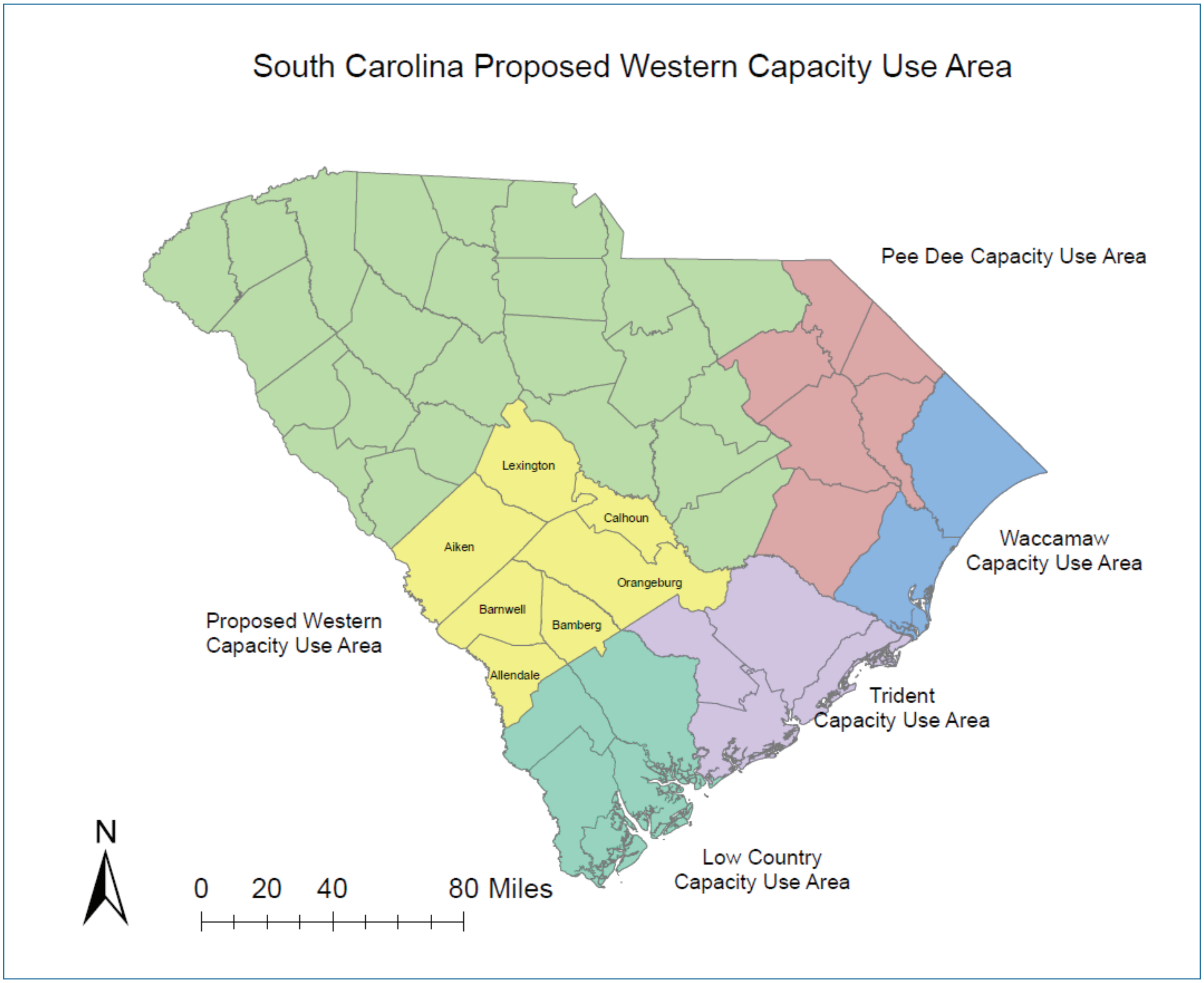

Figure 1: *Existing Capacity Use Areas and proposed Western Capacity Use Area.*

Western Region Climate

The general climate of South Carolina is influenced by a number of factors, including its location in the mid-latitudes and proximity to the Atlantic Ocean. The mid-latitude location provides for varying intensities of solar radiation during the year, resulting in four distinct seasons (summer, fall, winter, spring). The Western Region of the state is classified as humid subtropical. Average temperature in the region is 60-65 degrees Fahrenheit. According to the State Climatologist's office, the normal annual precipitation for the Western region of the Coastal Plain is between 45-50 inches. However, this area of the State has experienced periods of drought where significantly less precipitation has occurred, in particular, 2001, 2007 and more recently 2011. Figure 2 (on the next page) shows total yearly precipitation for this area of the State from 1980 to 2015.

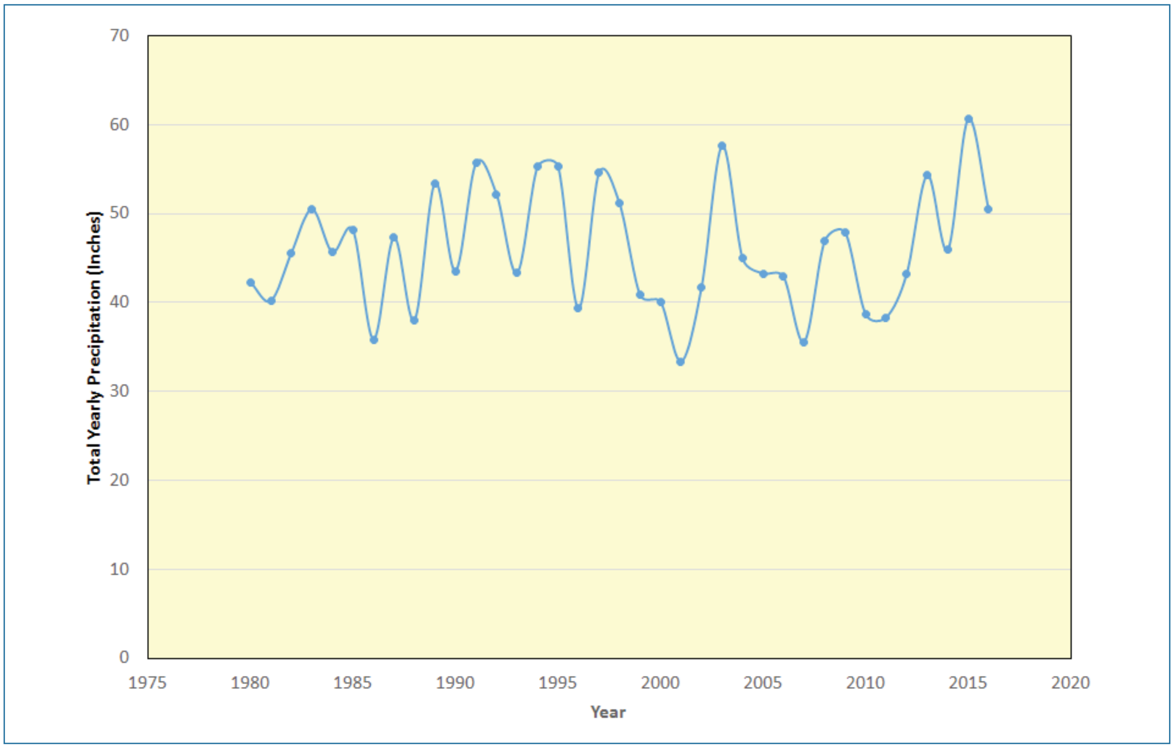

Figure 2: *Yearly precipitation totals for South Carolina Region 6, National Climate Data Center.*

Geohydrologic Framework

The geology and hydrogeology of the proposed Western Capacity Use Area of South Carolina is described in detail by United States Geological Survey (USGS) professional paper (pp) by Bruce Campbell et al. (2010), which incorporated 38 core holes and 68 water wells across the South Carolina Coastal Plain. In general terms, the aquifer systems range in age from Late Cretaceous to Tertiary (McQueen Branch, Crouch Branch, Gordon, Floridan, and Surficial) and overlay crystalline bedrock between Paleozoic and Triassic age. Overall, the lithologies of the aquifers are predominantly composed of sands and silts/muds, with some limestone. These are described as being formed in a transitional depositional environment, ranging from continental to marine (Campbell, et al., 2010). The units form a sedimentary wedge that thickens from a feather edge at the Fall Line to greater than 4000 feet down dip at the coastline **(Figure 3)**.

The identified confining units separating the aquifer systems are not as well defined in the proposed Capacity Use Area (i.e. little or no distinct separation between aquifer systems), while the McQueen Branch and Crouch Branch aquifers are reported to be the more productive units in this area (Campbell, et al., 2010). The recharge zone for these aquifers is at the Fall Line and the surficial aquifer discharges to surface water. Specific annual groundwater recharge rates have been calculated by USGS to be in the range of approximately 13 to 15 inches per year. In 2004, the Crouch Branch and McQueen Branch are reported to have had withdrawal rates of 1.27 and 5.41 million gallons per day (MGD), respectively, and surface discharge of the surficial aquifer at around 6.1 MGD (Campbell, et al., 2010).

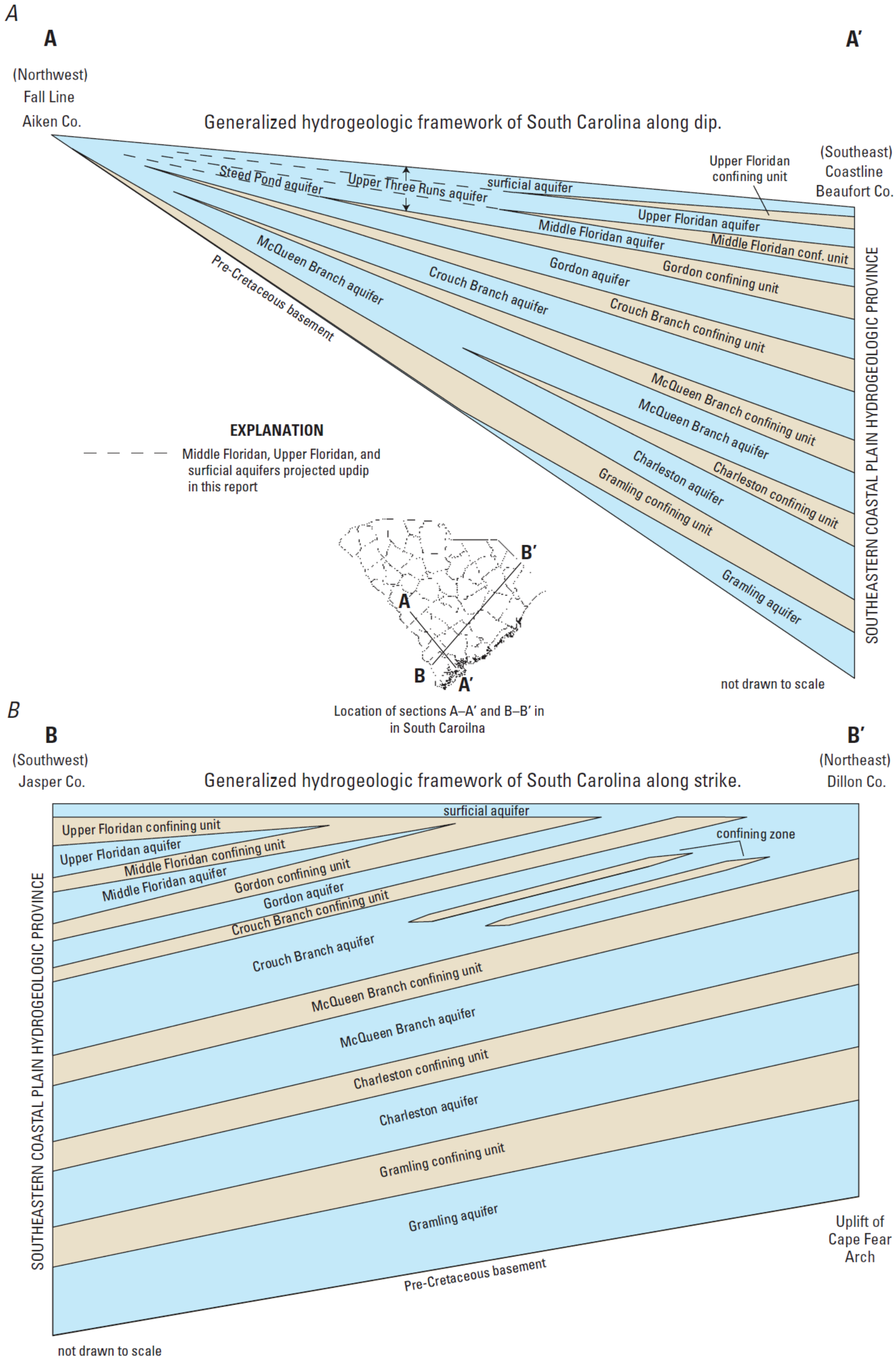

Figure 3: *Hydrogeologic framework of South Carolina (Campbell, et al., 2010).*

Historical Problems

Floridan and Gordon Aquifers

The shallower aquifer systems are hydrologically connected in the up-dip region of the proposed Capacity Use Area (see **Figure 3**), and therefore respond as unconfined aquifers in this region. Precipitation events generate the greater portion of recharge for the aquifer systems in the area, with the majority subsequently discharged through evapotranspiration and to the numerous creeks, streams, and rivers which dissect the geographical area. The groundwater flow paths in the shallow system are typically short, which in turn generate relatively high groundwater flow rates (Aucott W. R., 1988). Specific annual groundwater recharge rates have been calculated by USGS to be in the range of approximately 13 to 15 inches per year. Employing a porosity of 30 to 35 percent for the aquifers produces a water level rise (instantaneous) in the saturated thickness of the aquifer(s) of approximately 3.6 to 4.1 feet (Harrelson, Falls, & Prowell, 2002). The aquifers in the proposed Capacity Use Area respond more quickly to variations in recharge (precipitation and evapotranspiration rates) over time due to their relative shallow nature and relatively high transmissivities (Aucott W. R., 1988). Seasonal fluctuations in groundwater levels in the various aquifers are common due to increased use of groundwater for public consumption and irrigation during summer months. As use increases through spring into summer, groundwater levels decline. As use decreases in the fall and winter, the groundwater levels typically recover. An example of this response to seasonal fluctuations in groundwater demand is shown in Figure 8. While this well (AIK-0344) is screened in the Crouch Branch aquifer, this is a common response seen in the Coastal Plain aquifer systems to seasonal fluctuations in groundwater demand.

The South Carolina Department of Natural Resources (SCDNR) has collected long-term groundwater level from several locations in the Western region of the State. These include several monitoring wells in the Gordon aquifer, BRN-0352, ORG-0430, and ALL-0375. Water levels can be seen in Figures 4, 5, and 6, and all 3 of these wells indicate some degree of water level decline imprinted on seasonal variability. Previous work by SCDNR has shown water levels in the Gordon aquifer have declined in Allendale by approximately 8 feet and up to approximately 7 feet in Barnwell Counties since the mid-1990s (Harder, Gellici, & Wachob, 2012).

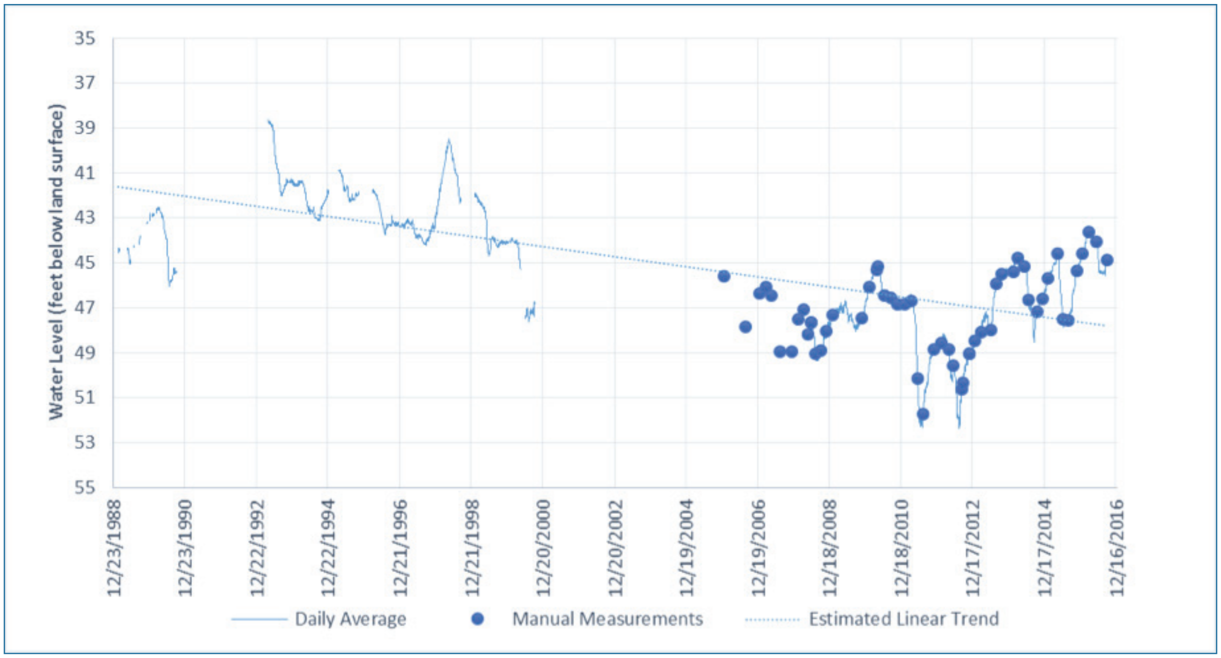

Figure 4: *Barnwell County, BRN-0352 Gordon aquifer average daily groundwater levels.*

ORG-0430 (**Figure 5**) water levels indicate temporal fluctuations which may be seasonally influenced, with measured levels from 81.53 to 97.7 feet below land surface. The probable seasonal fluctuation is observed as lows in the late summer early fall months (August-October) and its highest levels in the spring months (March-May).

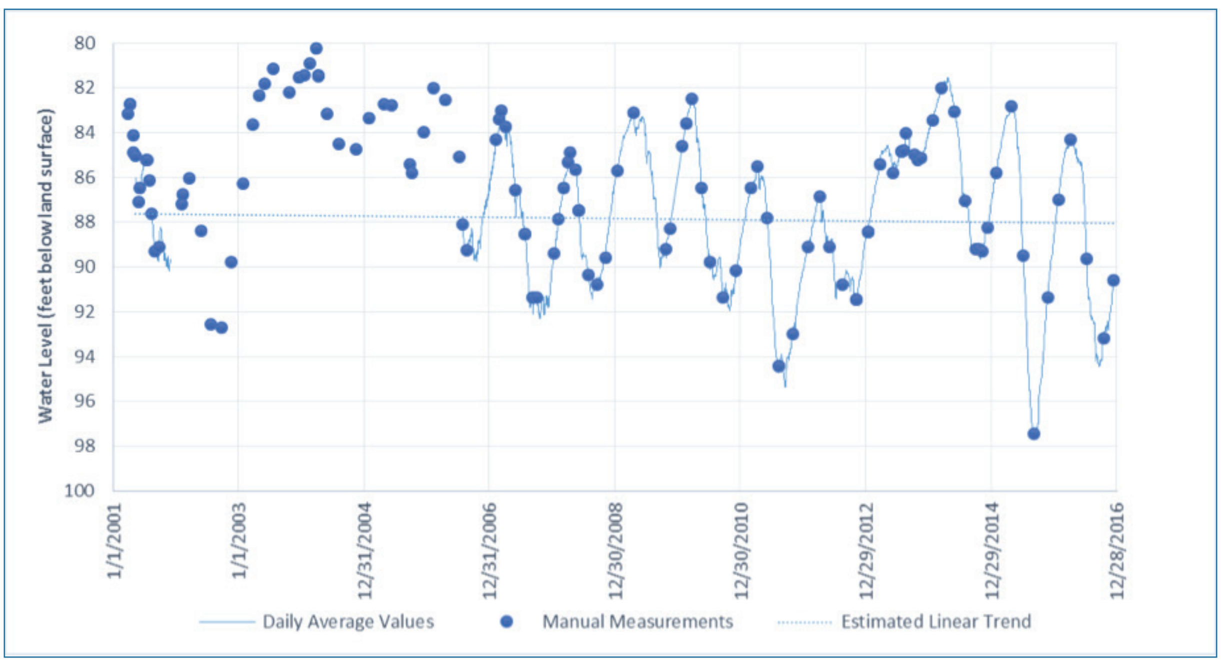

Figure 5: *Orangeburg County, ORG- 0430 Gordon aquifer average daily groundwater levels.*

ALL-0375 (**Figure 6**) water levels indicate a decline from June 1998 through October 2002, some recovery through May of 2004, and then another decline from December 2012 through present. The water levels range from 145.97 to 160.14 feet below land surface.

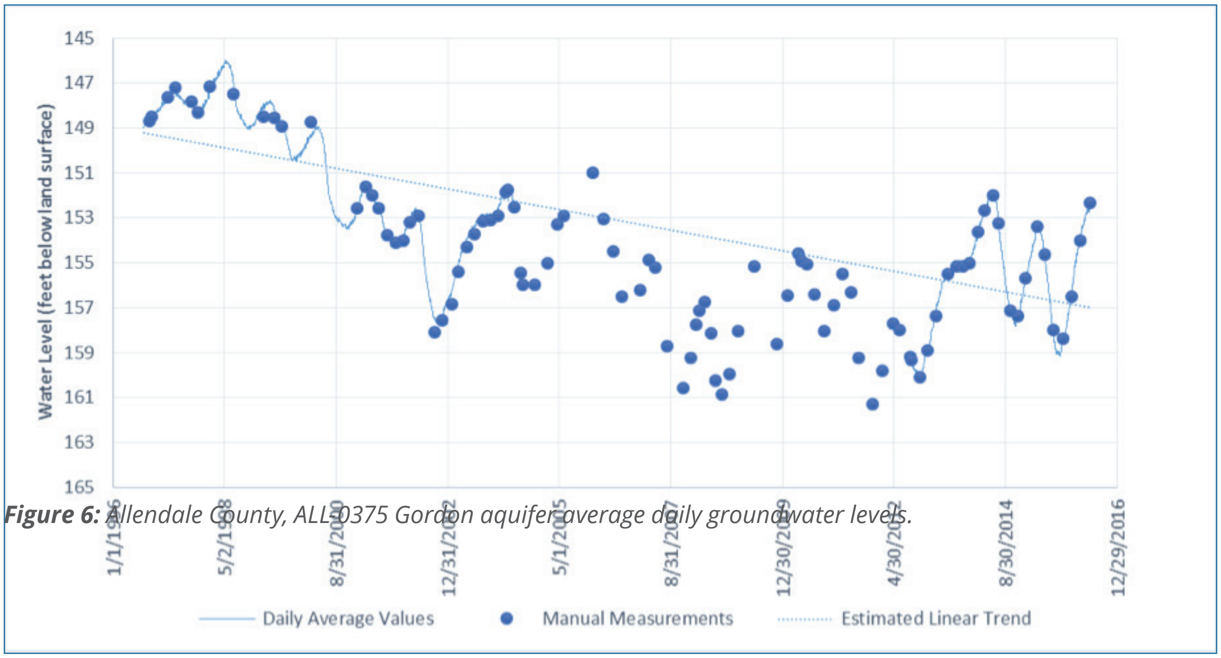

***Figure 6:** Allendale County, ALL-0375 Gordon aquifer average daily groundwater levels.*

Figure 7 shows the most recent potentiometric map produced by DNR of the water level elevations for the Floridan and Gordon aquifers. In general, in the counties of concern, there are no real cones of depression in groundwater elevations in these upper aquifers (Wachob, Hockensmith, Luciano, & Howard, 2014). This is likely due to little use as a resource, its access to recharge, and connectivity with surface water.

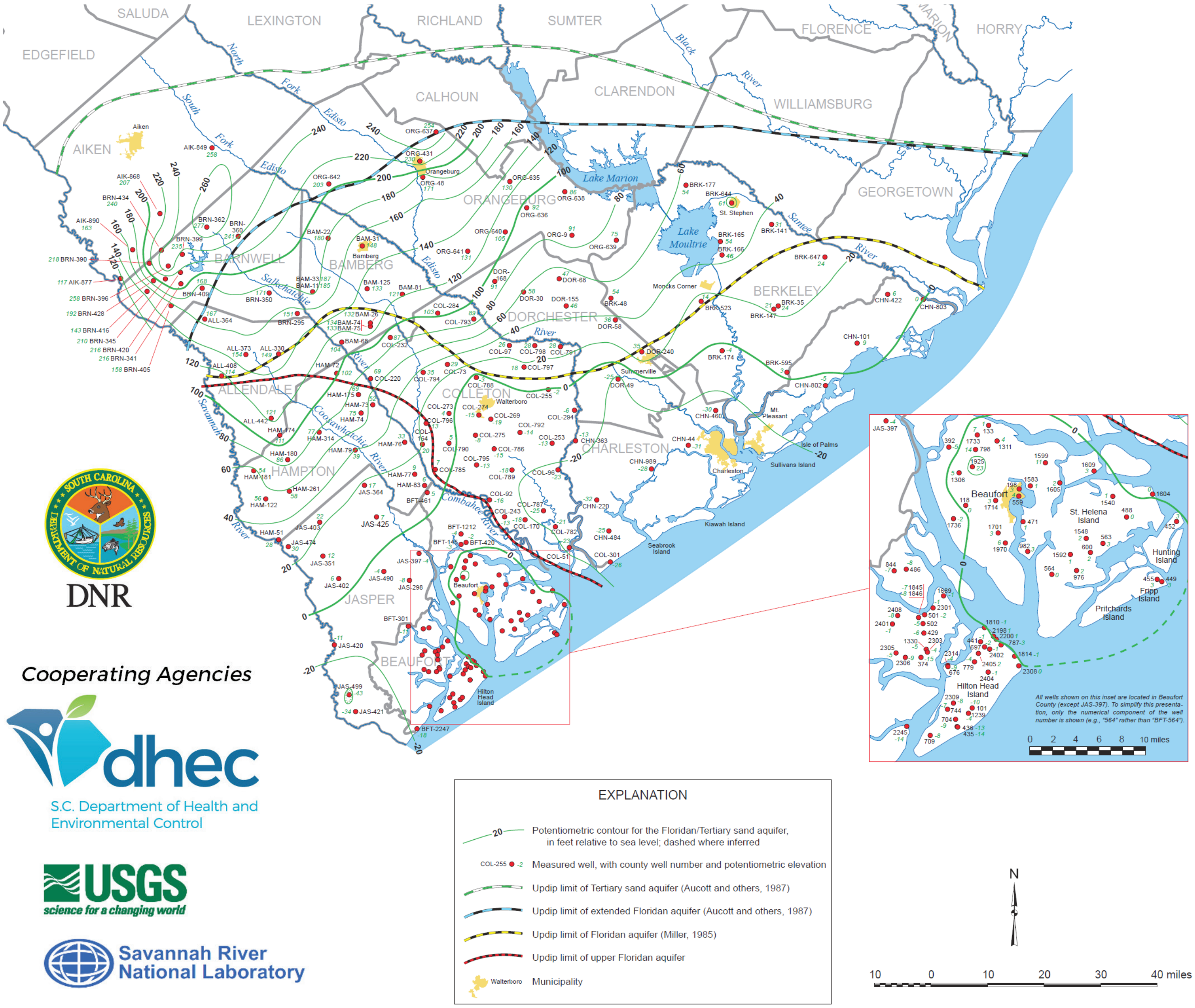

__Figure 7:__ Floridan/Gordon aquifer potentiometric map (Wachob, Hockensmith, Luciano, & Howard, 2014).

Crouch Branch Aquifer

The Crouch Branch aquifer, formerly Black Creek aquifer, is one of the most developed aquifers in the proposed Capacity Use Area (Campbell, et al., 2010). The Crouch Branch forms the uppermost regional Cretaceous aquifer (Aucott, Davis, & Speiran, 1987). It is characterized by fine-grained, sandy clay and calcareous clay beds in the eastern sections and is poorly sorted (Campbell, et al., 2010), but fairly uniform in permeability in the eastern region (Aucott, Davis, & Speiran, 1987). Lateral groundwater flow due to recharge is approximately 1.39 MGD (Campbell, et al., 2010). In 2004, withdrawals in the Aiken area from the Crouch Branch were approximately 1.27 MGD (Campbell, et al., 2010). Based on changes in groundwater elevations between the 2001 (Hockensmith, 2003a) and 2015 (Wachob and Czwartacki, 2016) potentiometric maps for the Black Creek/Crouch Branch Aquifer produced by SCDNR, the following declines in groundwater levels have been estimated: up to 5 feet in Aiken County, up to 5 feet in Allendale County, between 5 and 10 feet in Bamberg County, up to 5 feet in Barnwell County, up to 10 feet in Calhoun County, up to 5 feet in Lexington County and up to approximately 12 feet in Orangeburg County.

AIK-0344 (**Figure 8**) shows the seasonal fluctuations in groundwater levels in the Montmorenci area of Aiken County. While this is not long-term data, it does show the typical drop in groundwater levels during the summer months (a time of increased water use for drinking water, irrigation, etc.) and the recovery of groundwater levels towards the fall months as groundwater use declines.

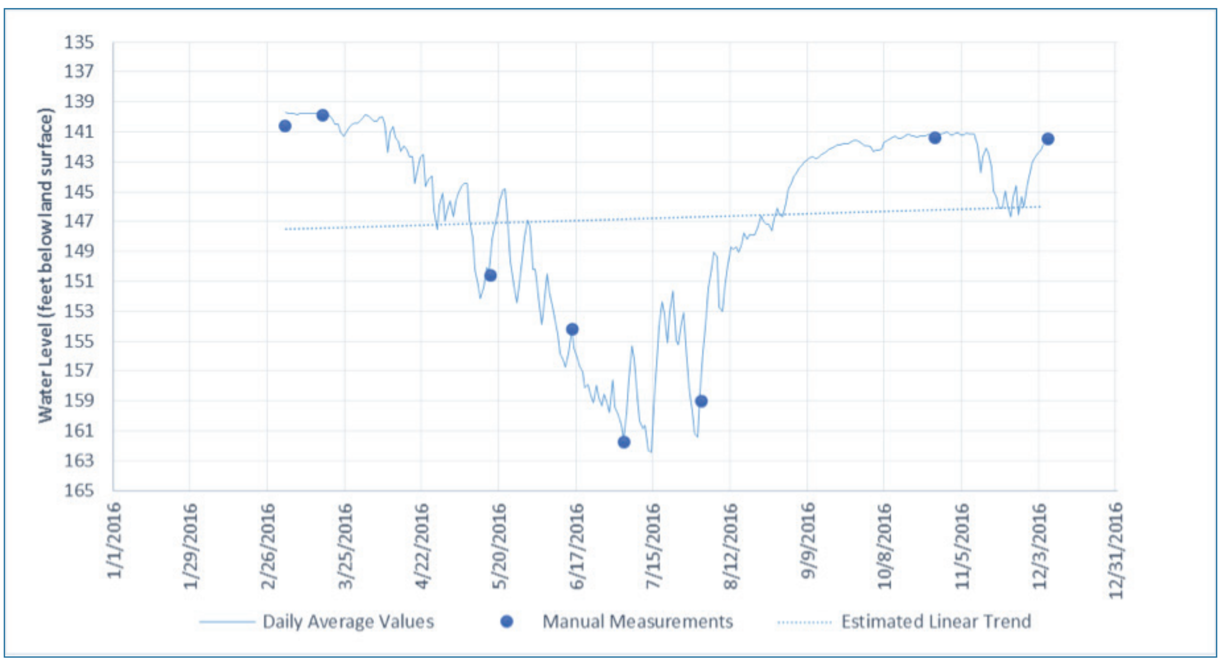

Figure 8: *Aiken County, AIK-0344 Crouch Branch aquifer average daily groundwater levels.*

AIK-0824 (**Figure 9**) water levels indicate moderate fluctuations from May 1993 through February 1999, whence it begins a steady decline. Note a data gap exists from September 2000 to October 2012, with overall groundwater decline of 5.32 feet (179.94 feet to 185.26 feet). Beginning September 2012 water levels appear to be relatively stable.

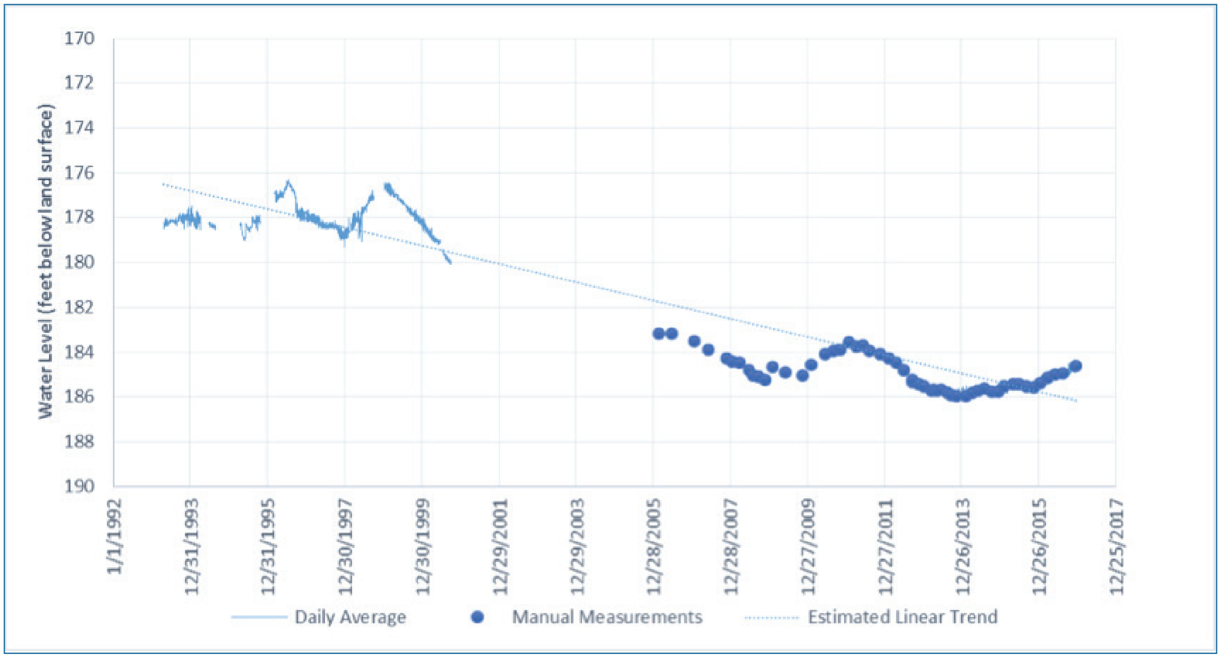

Figure 9: *Aiken County, AIK-0824 Crouch Branch aquifer average daily groundwater levels.*

AIK-0847 (**Figure 10**), as with AIK-0824, water levels indicate moderate fluctuations with an overall downward trend from May 1993 to September 2000 (23.31 feet to 26.91 feet). Note a data gap exists until January 2013, where the water level was 30.65 feet. The most recent data indicate greater annual variability, with a final measured depth of 28.86 feet in December 2015.

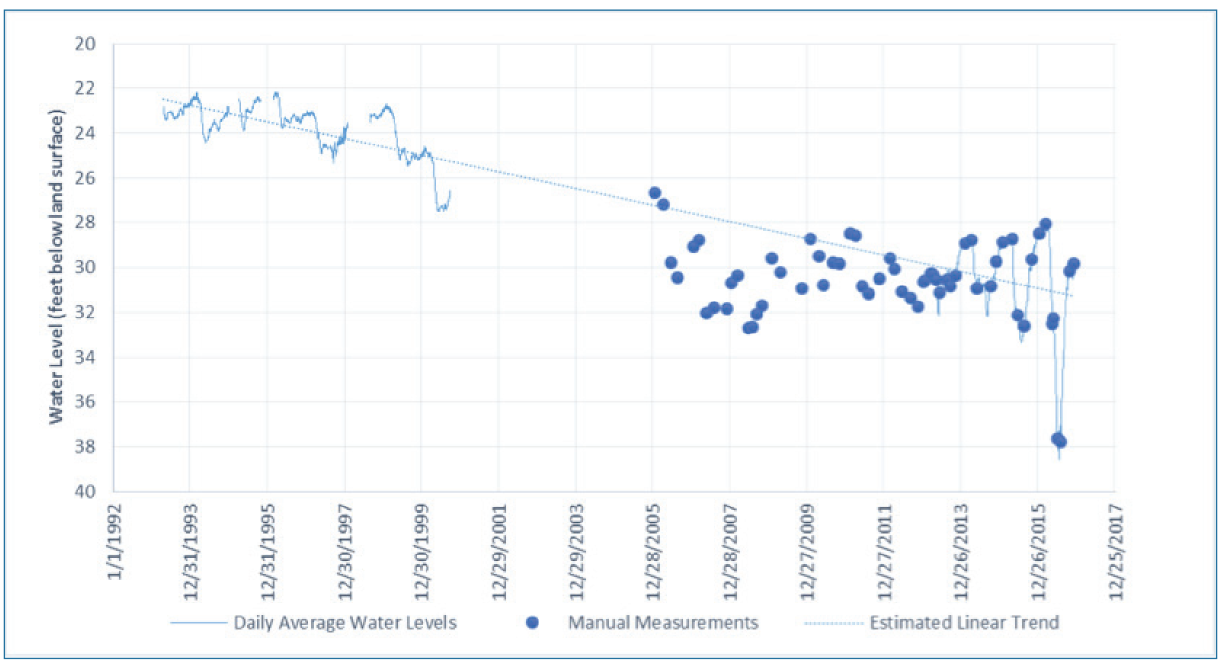

Figure 10: *Aiken County, AIK-0847 Crouch Branch aquifer average daily groundwater levels.*

AIK-2379 (**Figure 11**) measured water levels indicate a moderate decline through September 1997 with recovery reaching maximum in April 1998. Subsequently the measured water level has declined, with a minimum measured water level in August 2015 at 62.26 feet below land surface. This is a difference of approximately 4.4 feet from the minimum water level measured prior the noted data gap (57.91 in July 2001).

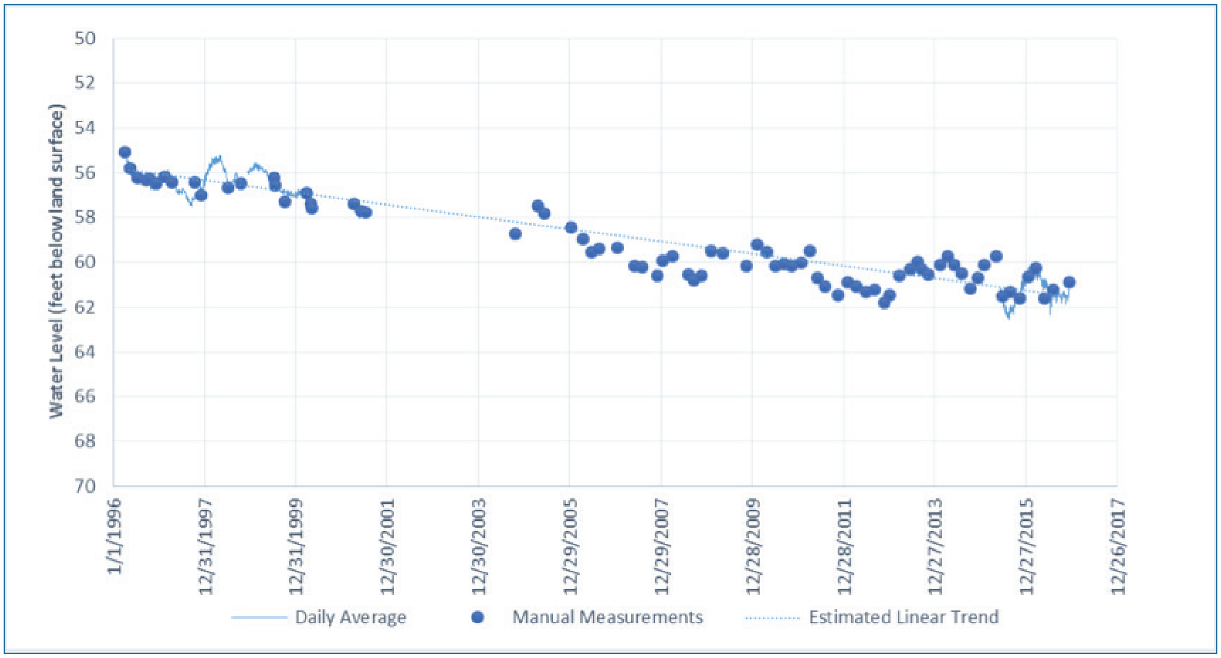

Figure 11: *Aiken County, AIK-2379 Crouch Branch aquifer average daily groundwater levels.*

ALL-0367 (**Figure 12**) has measured water levels which appear to mimic the response measured in ALL-0375. Data indicate a decline from April 1999 (82.69 feet) to May 2002 (91.21 feet). The overall trend stabilizes after 2002, but seasonal fluctuations are more exaggerated (up to 5.57 foot difference between April 2014 and October 2014).

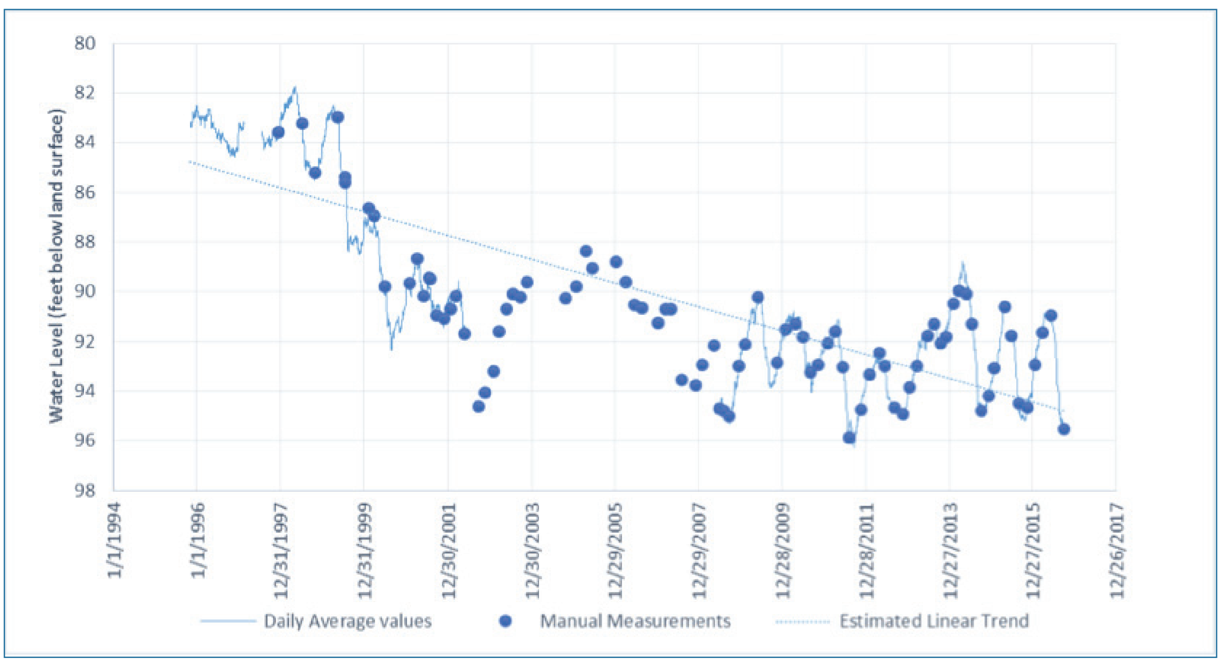

Figure 12: *Allendale County, ALL-0367 Crouch Branch aquifer average daily groundwater levels.*

ORG-0393 (**Figure 13**) measured water levels decline over time. Seasonal fluctuations become more magnified over time with a measured range of 5.2 feet in 2001 to a measured range of over 30 feet in 2015.

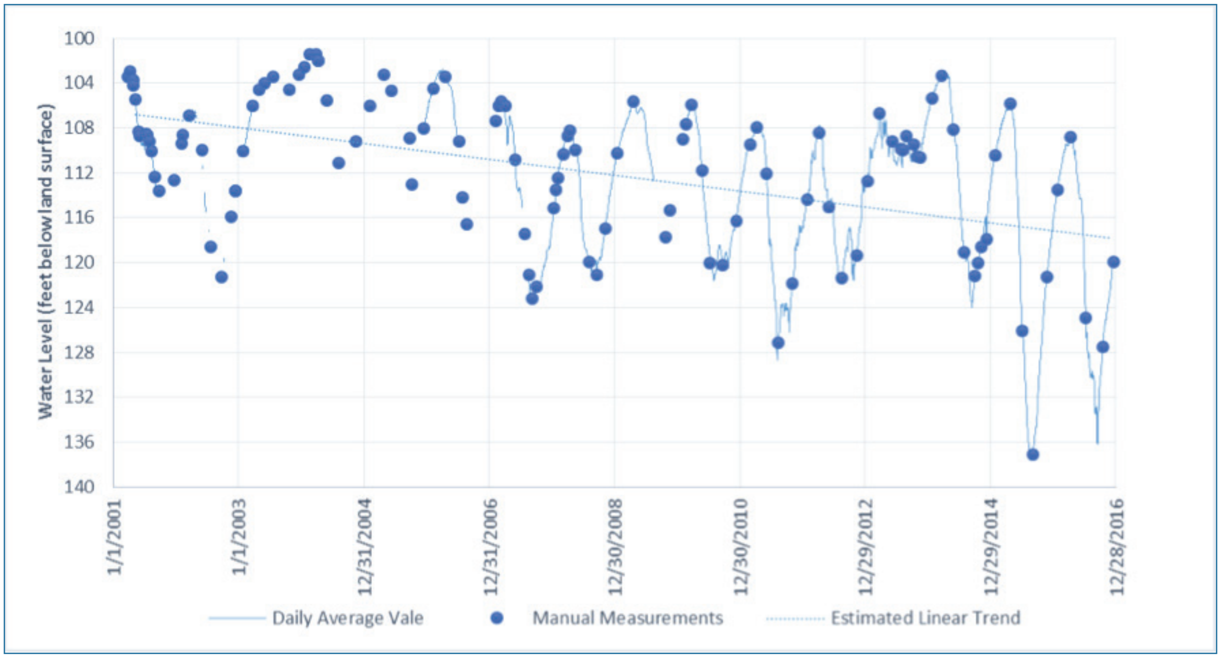

Figure 13: *Orangeburg County, ORG-0393 Crouch Branch aquifer average daily groundwater levels.*

Figure 14 shows the most recent potentiometric map produced by DNR, showing the groundwater elevations in late 2015 in DNR monitoring wells for the Crouch Branch aquifer (Wachob & Czwartacki, 2016). There is one major cone of depression (sustained declines in groundwater levels centered on areas of pumping) in Georgetown County but none identified in the Western Region of the state.

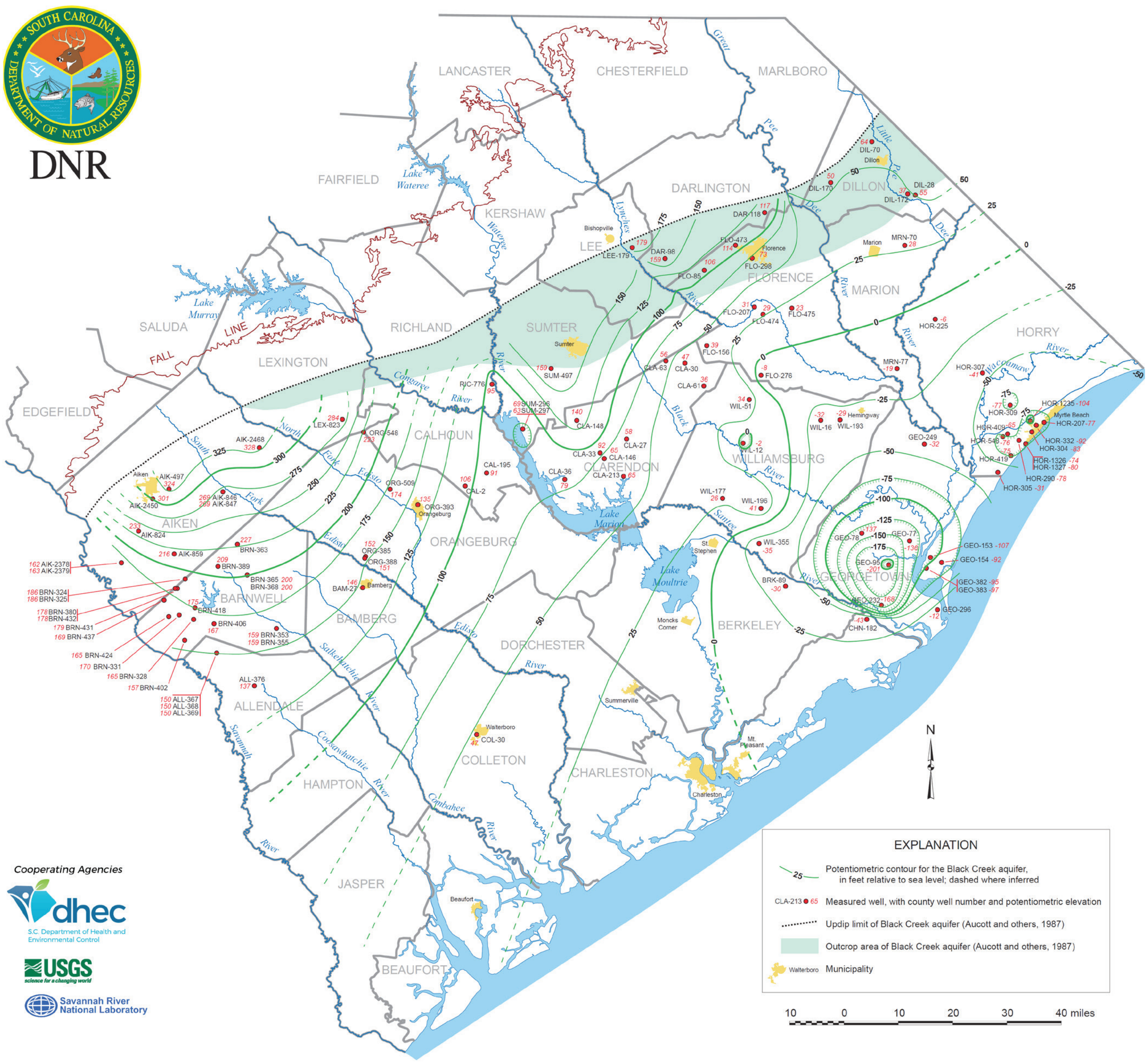

Figure 14: *Black Creek/Crouch Branch aquifer potentiometric map (Wachob & Czwartacki, 2016).*

McQueen Branch Aquifer

The McQueen Branch aquifer, formerly the Middendorf, along with the Crouch Branch aquifer, is the most developed aquifer in the Western Region of the state (Campbell, et al., 2010). It is characterized as unconsolidated, poorly sorted fine to coarse grained sand, and clayey sand, with some local gravel, which provides relatively constant hydraulic conductivity in the upper coastal plain area (Aucott W. R., 1988). In down-dip areas, it is confined from the top by the McQueen Branch confining unit, made up of clay beds (Campbell, et al., 2010). The confining unit is not as prevalent in the up-dip sections close to the fall line, causing the McQueen Branch and Crouch Branch aquifers to be combined in this region. Due to the coarse grained lithology, the McQueen Branch aquifer has produced wells with yields upwards of 1,500 gallons per minute, with reported withdrawals in the Aiken area of 5.41 MGD. Due to its productivity and relatively shallow nature, the McQueen Branch is an important water resource for this region, and is therefore important to preserve the integrity of the water resources within it. Based on changes in groundwater elevations between the 2001 (Hockensmith, 2003b) and 2014 (Wachob, 2015) potentiometric maps for the Middendorf/McQueen Branch aquifer produced by SCDNR, the following declines in groundwater levels have been estimated: up to 5 feet in Aiken County, up to 12 feet in Allendale County, up to 15 feet in Bamberg County, up to 10 feet in Barnwell County, up to 15 feet in Calhoun County, up to 10 feet in Lexington County and up to 15 feet in Orangeburg County.

AIK-0817 (**Figure 15**) measurements from May 1988 to April 1991 indicate a slight decline from 181.46 feet to 183.84 feet. In May 1993 water levels had recovered to original levels with subsequent measurements indicating slight temporal fluctuations and a steady measured decline until May 2000 (note data gap), whence water levels appear fairly constant, with temporal fluctuations measured.

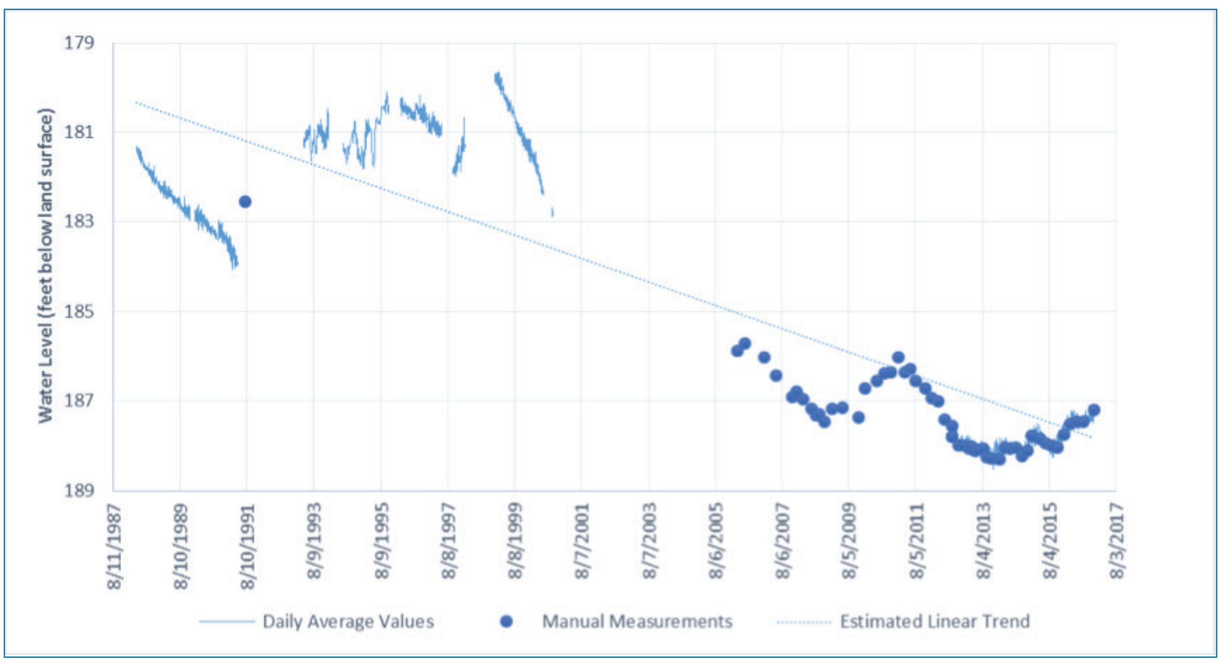

Figure 15: *Aiken County, AIK- 0817 McQueen Branch aquifer average daily groundwater levels.*

AIK-0826 (**Figure 16**) indicates an overall decline in measured water level from original data generated in October 1989 from 22.66 feet to 33.29 feet in July 2016.

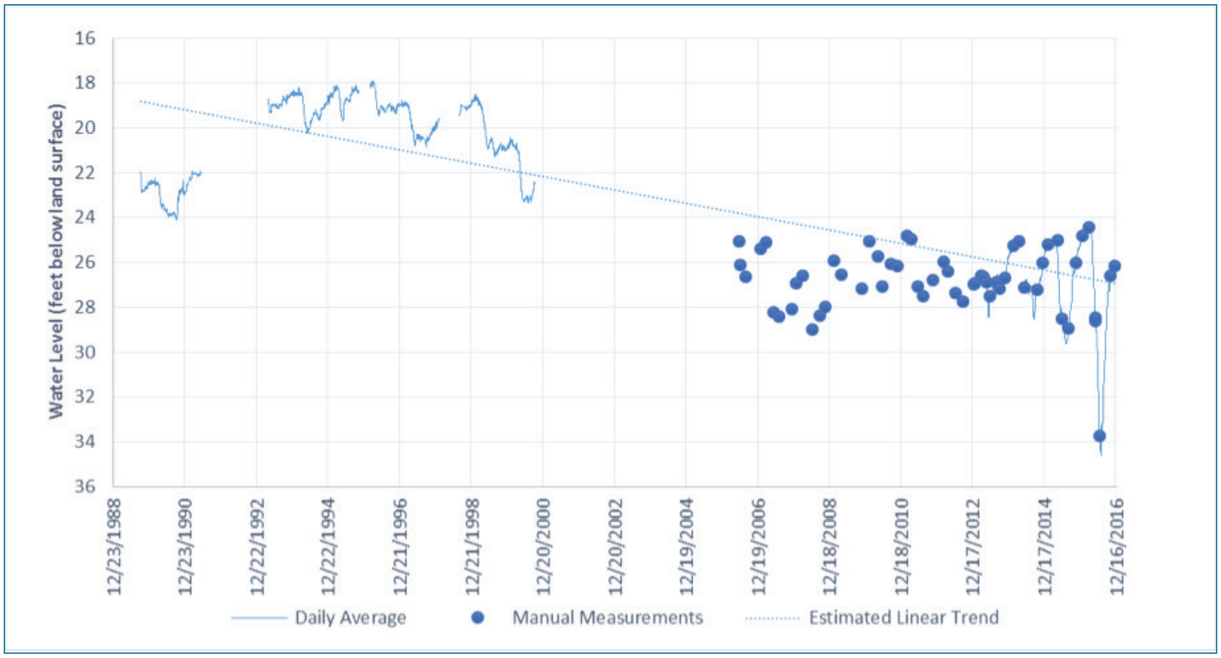

Figure 16: *Aiken County, AIK-0826 McQueen Branch aquifer average daily groundwater levels.*

LEX-0844 (**Figure 17**) indicates an overall decline in measured water level from original data generated in November 1999 from 69.12 feet to 75.61 feet in January 2003. Measured water levels appear relatively stable from January 2003 through April 2012, with a slight decline until August 2015. The most recent data indicates a gradual recovery in this well.

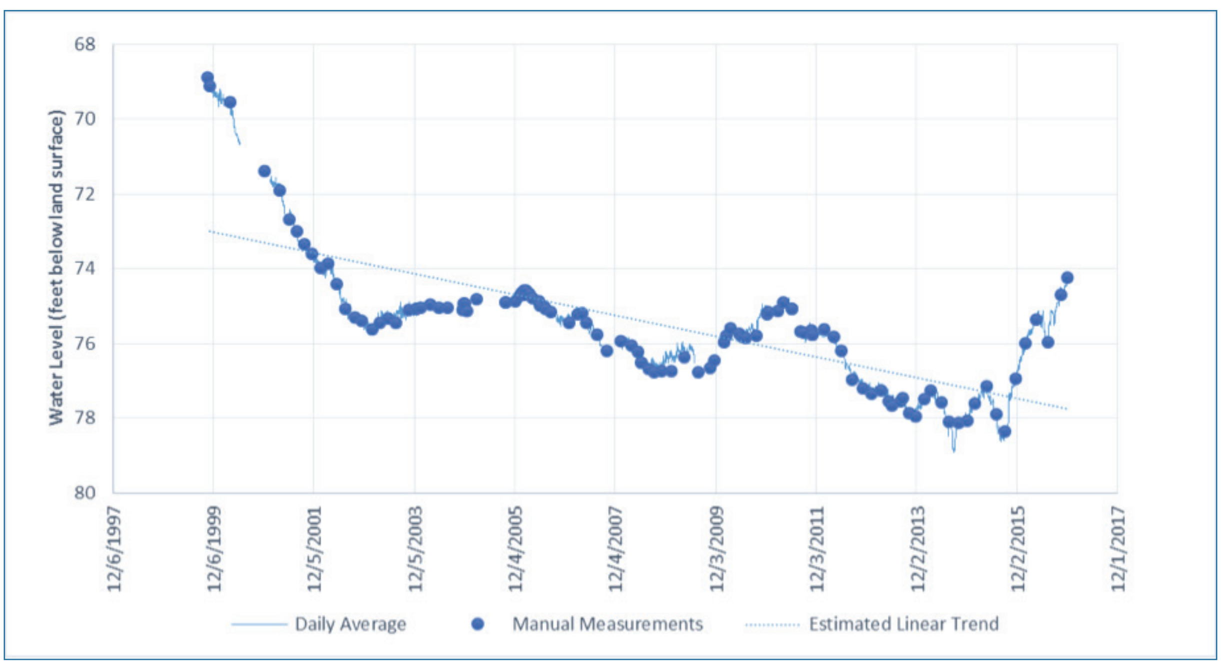

Figure 17: *Lexington County, LEX-0844 McQueen Branch aquifer average daily groundwater levels.*

Figure 18 shows a potentiometric map constructed by SCDNR in late 2014 for the McQueen Branch aquifer (Wachob, 2015) and is a representation of the regional groundwater elevations in the McQueen Branch aquifer. In the eastern part of the state and near the coast, cones of depression (sustained declines in groundwater levels centered around areas of pumping) have developed, but no major cones of depression have been identified in the Western Region of the state. However, across Aiken, Allendale, and Barnwell Counties, groundwater elevation declines have been noted between 3 and 10 feet since the mid-1990s, with little to no recovery after drought conditions in southern Lexington County (Harder, Gellici, & Wachob, 2012).

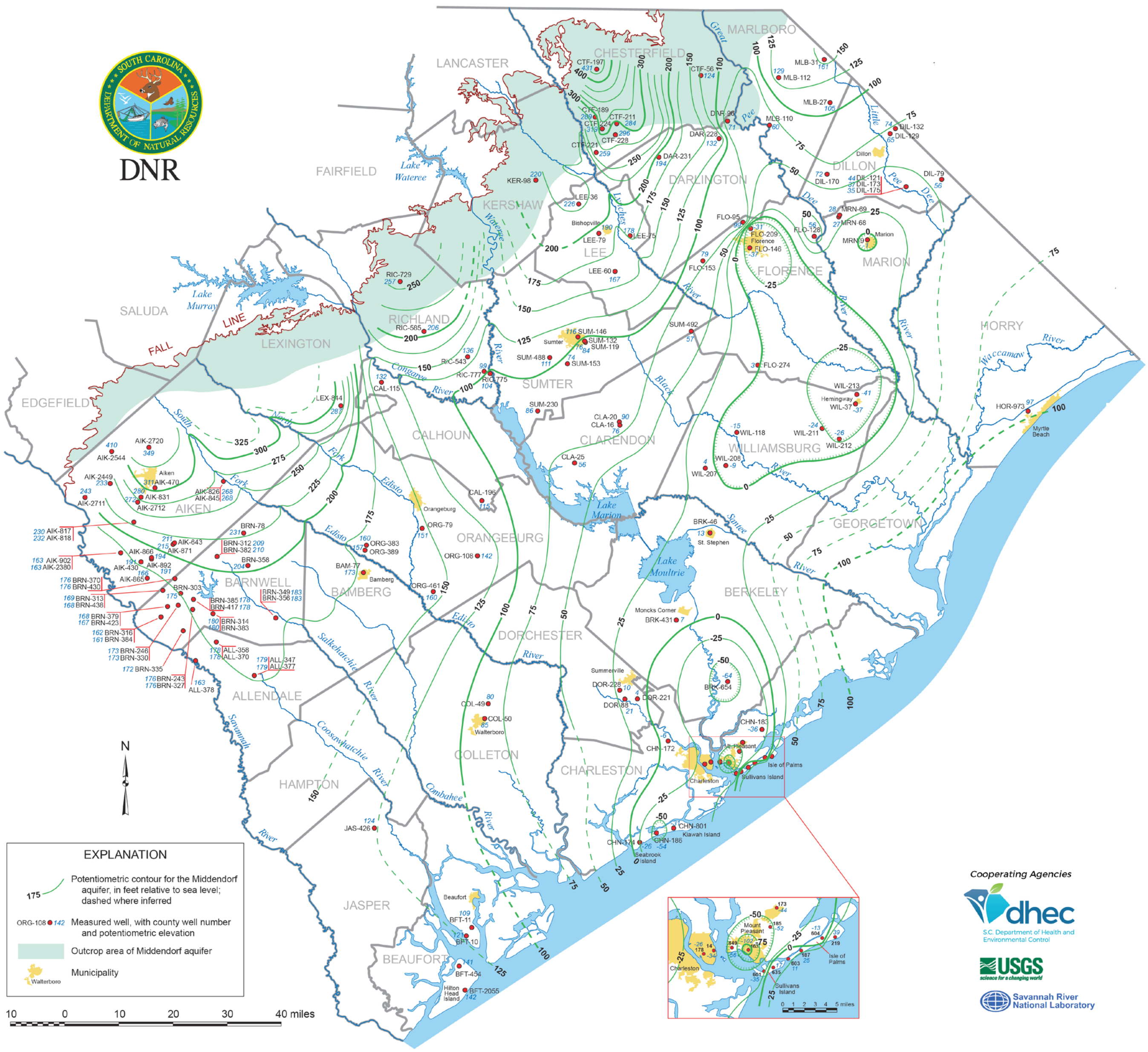

Figure 18: *Middendorf/McQueen Branch potentiometric map (Wachob, 2015).*

Population and Water Use Increases

Currently Aiken County utilizes groundwater wells as the main source for drinking water supplies, but due to increasing concerns over the viability of the aquifers over time, some utilities have begun developing surface water as a supplement to the groundwater source. The population of Aiken County in 2010 was 160,099 and is expected to increase to approximately 182,500 by 2030, a 14% increase. The reported groundwater use for public water supply increased from 947.14 million gallons a year (MGY) in 1983 to 5,177.56 MGY in 2015. Lexington County is projected to increase in population by 27% between 2010 and 2030 (262,391 to 333,200). The increasing demand on water utilities to serve the expanding population will create increasing pressure on the groundwater resource in some areas of the county. Measured groundwater levels in monitor wells maintained by SCDNR have typically declined in most of the aquifers that are developed in this region of the state. Reported groundwater use by county is shown in Figure 19.

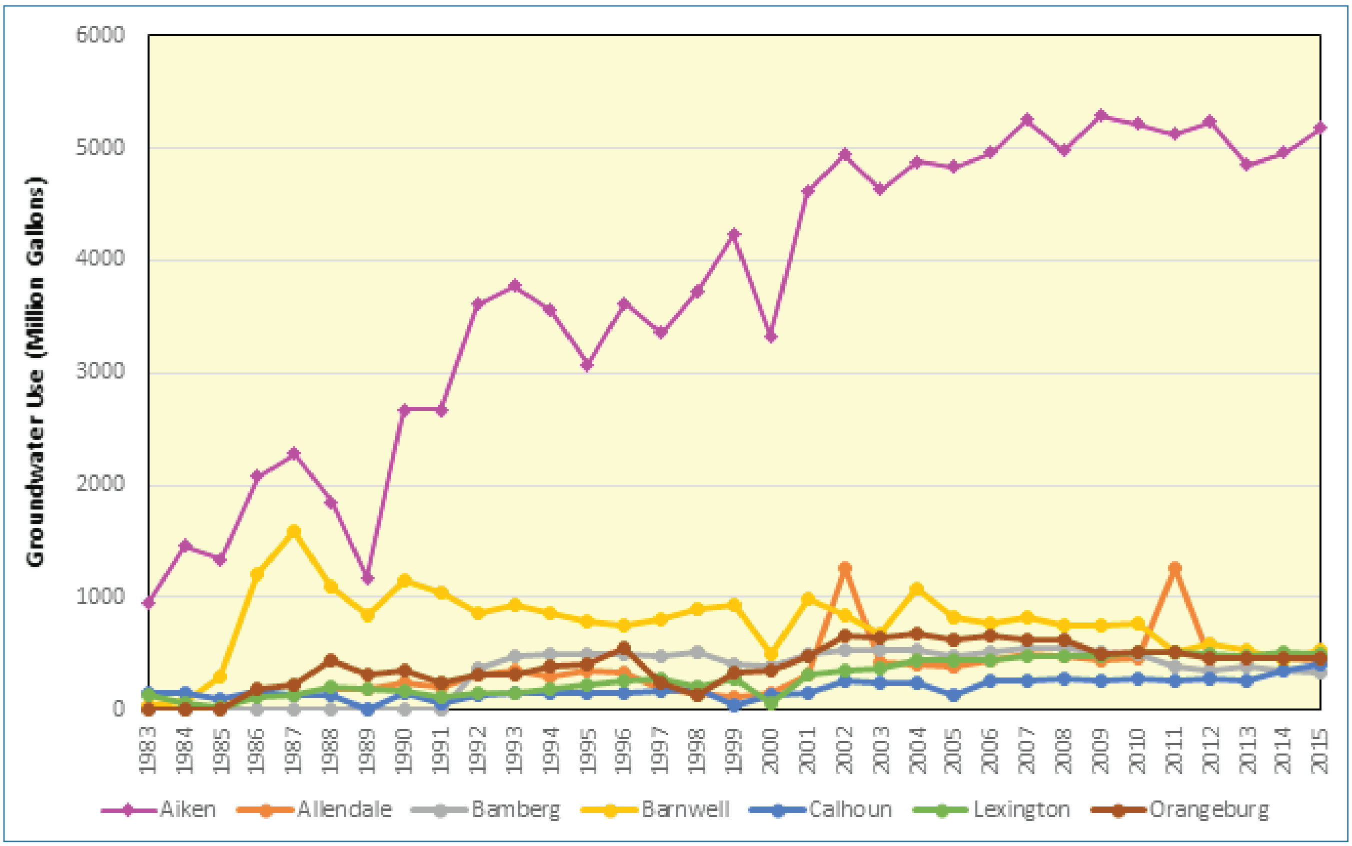

Figure 19: *Reported public water supply use (groundwater) in the designated Western Region counties.*

Although the population of Allendale, Bamberg, and Barnwell Counties are projected to decrease in the near future, it is anticipated that development of the aquifer systems will increase as agricultural use, as has been the case in Aiken, Calhoun, Lexington and Orangeburg Counties, which have seen upward trends in reported water use since 2009 (**Figures 20 and 21**).

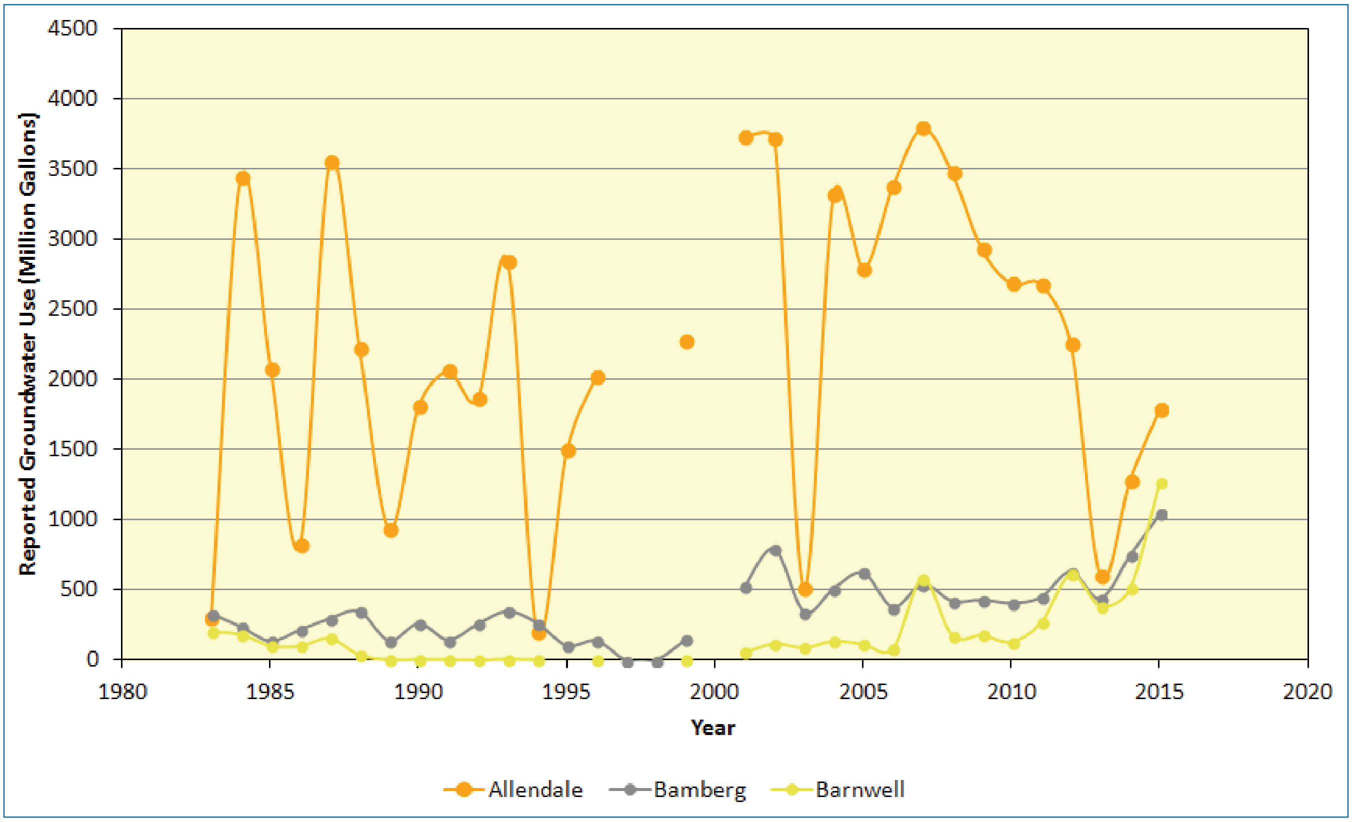

Figure 20: *Reported agricultural groundwater use in Allendale, Bamberg, and Barnwell Counties.*

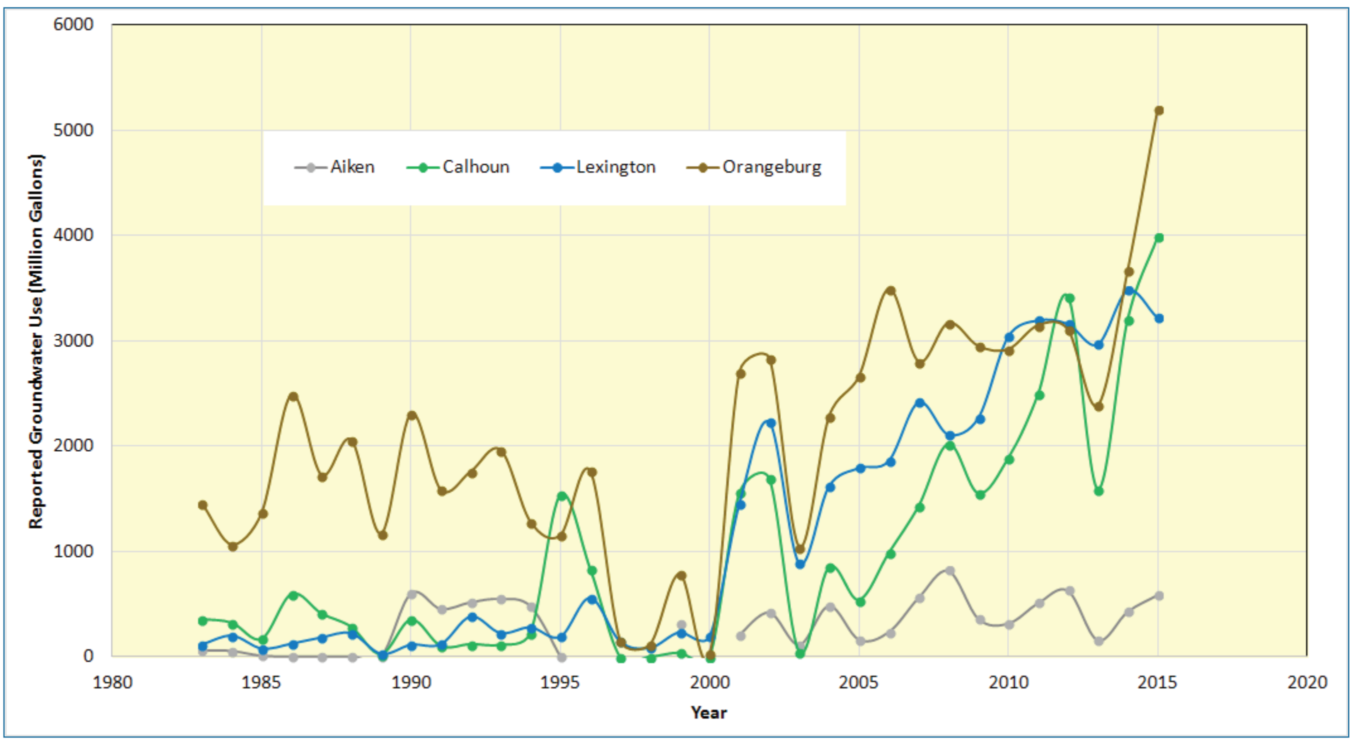

Figure 21: *Reported agricultural groundwater use in Aiken, Calhoun, and Orangeburg Counties.*

Conclusions and Recommendations

The aquifers in large portions of the Western Region of South Carolina are hydrologically interconnected, indicating groundwater users within the proposed Western Capacity Use Area are utilizing the same resource. Reported groundwater withdrawals in the region have steadily increased and groundwater level declines have been observed in monitoring wells across the counties of concern. Demands on the groundwater resource will continue to increase with a growing population. As the development of the groundwater resource continues, further water level declines will be expected and the potential for adverse impacts to current and future groundwater users will become more frequent and serious over time.

As the proposed counties share the same resource in conjunction with portions of the Low Country Capacity Use Area and the Trident Capacity Use Area, it is appropriate to incorporate the counties of Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg as the Western Capacity Use Area. If designated, the Western Capacity Use Area, in conjunction with the previously designated areas of the Low Country, Pee Dee, and Trident will place three quarters of the coastal plain counties under one reasonable and consistent regulatory program, thereby providing greater measures to prevent, mitigate, and abate potential unreasonable effects on the resource and those entities relying on that resource. Further, if designated, inclusion of the Western Capacity Use Area will, in part, address previous water management studies and reports produced by SCDNR requesting that the entire coastal plain become a Capacity Use Area (Badr, Wachob, and Gellici, 2004).

Based on the preliminary data available to the Department, which have been summarized in this report, Aiken County along with Allendale, Bamberg, Barnwell, Calhoun, Lexington, and Orangeburg counties have developed and utilized groundwater to the degree that coordination and regulation of groundwater supplies may be needed pursuant to the Groundwater Use and Reporting Act, Section 49-5-60. As such, this preliminary data is provided to facilitate the gathering of public input and any additional data or information that will help inform the potential designation of these counties as the Western Capacity Use Area.

Bibliography

Aucott, W. R. (1988). *The Predevelopment Ground-water Flow System and Hydrologic Characteristics of the Coastal Plain Aquifers of South Carolina.* U.S. Geological Survey.

Aucott, W. R., Davis, M. E., & Speiran, G. K. (1987). *Geohydrologic Framework of the Coastal Plain Aquifers of South Carolina.* Water-Resources Investigations Report, United State Geological Survey, Department of the Interior.

Badr, A. W., Wachob, A., & Gellici, J. A. (2004). *South Carolina Water Plan, Second Edition*. State of South Carolina, South Carolina Department of Natural Resources. Columbia, SC: Land, Water, and Conservation Division.

Campbell, B. G., Fine, J. M., Petkewich, M. D., Coes, A. L., Terziotti, S., Gellici, J. A., & Lautier, J. C. (2010). *Groundwater Availability in the Atlantic Coastal Plain of North and South Carolina.* U. S. Geological Survey.

Harder, S. V., Gellici, J. A., & Wachob, A. (2012). Water-Level Trends in Aquifers of South Carolina. *South Carolina Water Resources Conference. 1,* pp. 10-18. Journal of South Carolina Water Resources.

Harrelson, L. G., Falls, W. F., & Prowell, D. C. (2002). *Ground-Water Levels in the floridan-Midville Aquifer in the Breezy Hill Area, Aiken and Edgefield Counties, South Carolina, April 1999-November 2000.* Water-Resources Investigations Report, USGS, U.S Department of the Interior.

Hockensmith. Bremda L., (2001). *Potentiometric Map of Floridan Aquifer and Tertiary Sand Aquifer in South Carolina, 1998,* South Carolina Department of Natural Resources, Water Resources Report 23.

Hockensmith, Brenda L., (2003a). *Potentiometric Surface of the Black Creek Aquifer in South Carolina, November 2001,* South Carolina Department of Natrual Resources, Water Resources Report 29.

Hockensmith, Brenda L., (2003b). *Potentiometric Surface of the Middendorf Aquifer in South Carolina, November 2001,* South Carolina Department of Natrual Resources, Water Resources Report 28.

Hockensmith, Brenda L., (2009). *Potentiometric Surface of the Floridan Aquifer and Tertiary Sand Aquifer in South Carolina, November 2004,* South Carolina Department of Natural Resources, Water Resources Report 48.

National Climate Data Center. (n.d.). Retrieved from NOAA Satellite and Information Service: http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#

Palmer Drought Index Map. (n.d.). Retrieved from North American Drought Portal: www.drought.gov/nadm/content/palmer-drought-indices

Status of Population Projections Based on the 2010 Census Data. (2010). (U. S. Census Bureau) Retrieved from South Carolina Revenue and Fiscal Affairs Office: http://abstract.sc.gov/chapter14/pop5.html

Wachob, A. (2015). *Potentiometric Surface of the Middendorf Aquifer in South Carolina, November 2014*. South Carolina Department of Natural Resources, Water Resources Report 58.

Wachob, A., Hockensmith, B. L., Luciano, K., & Howard, C. S. (2014). *Potentiometric Surface of the Floridan and Tertiary Sand Aquifers in South Carolina, November 2013*., South Carolina Department of Natural Resources, Water Resources Report 56.

Wachob, A., & Czwartacki, B. (2016). *Potentiomeetric Surface of the Black Creek (crouch Branch) Aquifer in South Carolina, November 2015.,* South Carolina Department of Natural Resources, Water Resources Report 57.