

Section 12

Sub-Regional Upper Floridan Aquifer Modeling for South-Central Georgia Sustainable Yield Assessment

12.1 Groundwater Modeling Approach for Sustainable Yield Assessment

Consistent with Section 11 of this report, two criteria were used to evaluate sustainable yield in the Upper Floridan Aquifer in the south-central Georgia area of the Coastal Plain. These criteria were groundwater level drawdown and reduction of groundwater contributions to stream baseflow. Reasonable metrics, which have been applied elsewhere for these two criteria, are no more than 30 feet of groundwater level drawdown in the targeted aquifer and no more than a 40 percent reduction of groundwater contributions to stream baseflow.

As discussed in Section 11.3, groundwater modeling simulations should be performed under a steady-state condition in order to evaluate whether the groundwater withdrawals from the aquifers are sustainable and to estimate the ultimate groundwater level drawdown and streamflow loss due to increased pumping once the aquifer has reached a new equilibrium. Therefore, a steady-state sub-regional Upper Floridan Aquifer model was developed based on the calibrated sub-regional transient Upper Floridan Aquifer model discussed in Section 8. For the south-central Georgia area, the steady-state model was used to: (1) estimate Upper Floridan Aquifer sustainable yields and (2) evaluate the potential effects on the groundwater and surface water systems (rivers and streams) due to increased pumping from the Upper Floridan Aquifer sustainable yields.

A series of groundwater flow modeling simulations was performed using the steady-state sub-regional Upper Floridan Aquifer model. These simulations were conducted to estimate the range of sustainable yields that could occur from existing and simulated new wells in the Upper Floridan Aquifer in south-central Georgia without creating unacceptable impacts to the environment. Simulated new wells were placed in model grid cells in the Upper Floridan Aquifer in south-central Georgia that did not already contain existing pumping wells (1,270 new wells). **Figure 12-1** shows the locations of the existing and simulated new wells in the Upper Floridan Aquifer in south-central Georgia. As shown on the figure, the spacing between the simulated new wells is approximately 10,000 feet.

For this analysis, simulation scenarios were performed with pumping from the Upper Floridan Aquifer in south-central Georgia increasing until either the groundwater level drawdown criteria of 30 feet was exceeded over a large area, or reduction of groundwater contributions to stream baseflow exceeded 40 percent. In these simulations, pumping from both underlying and overlying aquifers was maintained at the baseline pumping rates and pumping from the Upper Floridan Aquifer in the

eastern Coastal Plain area was simulated simultaneously due to potential groundwater level drawdown interference between the two areas.

These simulations are described below.

- **Simulation 1:** Pumping from the Upper Floridan Aquifer in south-central Georgia was uniformly increased in the existing wells and pumping from the Upper Floridan Aquifer in the eastern Coastal Plain was capped at baseline rates (lower end of sustainable yield range);
- **Simulation 2:** Pumping from the Upper Floridan Aquifer in south-central Georgia was non-uniformly increased in existing and simulated new wells in south-central Georgia and pumping was capped from existing wells at baseline rates in the eastern Coastal Plain (upper end of sustainable yield range).

12.2 Groundwater Modeling Results for Upper Floridan Aquifer Sustainable Yield Assessment in South-Central Georgia

The results of the groundwater modeling for the Upper Floridan Aquifer sustainable yield assessment are presented in **Table 12-1**. Rather than discuss the results of each simulation, the range of sustainable yields for the Upper Floridan Aquifer in south-central Georgia will be discussed in this section.

As shown in Table 12-1, the existing permitted pumping rate from the Upper Floridan Aquifer in south-central Georgia was approximately 329 mgd. Uniformly increased pumping from the existing wells in the Upper Floridan Aquifer in south-central

Georgia represents the low end of the range of sustainable yields, whereas non-uniform increased pumping from the existing and simulated new wells in the Upper Floridan Aquifer in south-central Georgia represents the high end of the range of sustainable yields.

As indicated in Table 12-1, if pumping is uniformly increased from existing wells in the *Upper Floridan Aquifer in south-central Georgia only*, the withdrawals can be increased by up to approximately 89 percent. This represents a reasonable lower bound estimate of sustainable yield, under which baseline pumping from the Upper Floridan Aquifer in south-central Georgia can be increased from 329 mgd to 622 mgd, resulted in an increased withdrawal of 293 mgd while pumping in the eastern Coastal Plain is held at current levels. Simulated hydraulic heads and drawdown with an increased withdrawal of 293 mgd are shown on **Figures 12-2 to 12-13**. This pumping scenario resulted in localized exceedance of the 30-foot groundwater level drawdown criterion and a corresponding reduction in groundwater contributions to stream baseflow of approximately 23 percent. This result suggested that pumping could be increased further if pumping is re-distributed before the baseflow reduction criterion is exceeded.

Table 12-1 Summary of Sustainable Yields in the Upper Floridan Aquifer in South-Central Georgia under Different Withdrawal Conditions for an Average Rainfall Year using the Steady-State Upper Floridan Aquifer Sub-Regional Groundwater Model

Pumping Conditions and Potential Impacts	Existing Pumping Conditions (Baseline)			Uniformly Increased Pumping from Existing Wells in UFA within South-Central Georgia and Baseline Pumping from UFA in Eastern Coastal Plain (Simulation 1)						Non-Uniformly Increased Pumping from Existing and Simulated New Wells in the UFA within South-Central Georgia and Baseline Pumping from UFA in Eastern Coastal Plain ¹ (Simulation 2)			
	South-Central Georgia	Eastern Coastal Plain	Total	South-Central Georgia	Eastern Coastal Plain	Total	Eastern Coastal Plain	Total	(% Increase) ⁴	South-Central Georgia	Eastern Coastal Plain	Total	(% Increase) ⁴
No. of Existing Pumping Wells	4,391	1,327	5,718	4,391			1,327	5,718	-	4,391	1,327	5,718	-
No. of Simulated New Pumping Wells	0	0	0	0			0	0	-	1,270	0	1,270	-
Upper Floridan Aquifer pumping (mgd)	329	146	475	622	764	868	146	768	-	836	146	982	-
Total pumping from all aquifers in the model domain (mgd)	1,019	836	1,855	1,312	1,454	1,558	836	2,148	-	1,526	836	2,362	-
Additional withdrawals from the Upper Floridan Aquifer (mgd)	0	0	0	293	435	393	0	293	89%	507	0	507	154%
Simulated groundwater level drawdown (ft) ²	-	-	-	30	30	30	-	-	-	30	-	-	-
Simulated river baseflow reduction (mgd) ³	-	-	-	23%	35%	31%	-	-	-	40%	-	-	-

¹ Pumping from existing wells is increased uniformly except for existing large users, which are capped at existing pumping rates.

² Simulated groundwater level drawdown was calculated by subtracting the groundwater elevations for each simulation from the corresponding values in the baseline condition.

³ The baseflow reduction was estimated for the streams and rivers in the outcrop areas from a model-wide water budget for each simulation.

⁴ % increase is the increase in additional withdrawals divided by the South-Central Georgia existing withdrawals from the Upper Floridan Aquifer.

If pumping is non-uniformly increased from existing and simulated new wells in the Upper Floridan Aquifer *in south-central Georgia only*, total pumping withdrawals could be increased further toward a possible upper bound for the range of sustainable yield. As indicated in Table 12-1, withdrawals can be increased by up to approximately 154 percent before pumping resulted in exceedance of the 30-foot groundwater level drawdown criterion and an exceedance of the baseflow reduction criterion of 40 percent. For this scenario, baseline pumping from the Upper Floridan Aquifer in south-central Georgia and eastern Coastal Plain areas can be increased from 475 mgd to 982 mgd, resulting in an increased withdrawal of approximately 507 mgd from the Upper Floridan Aquifer. Simulated hydraulic heads and drawdown with an increased withdrawal of 507 mgd are shown on **Figures 12-14 to 12-25**.

12.3 Potential Impacts on Groundwater Levels Due to Increased Groundwater Withdrawals in the Upper Floridan Aquifer in South-Central Georgia

Groundwater modeling results showing potential impacts due to increased groundwater withdrawals from the Upper Floridan Aquifer in south-central Georgia are presented in the form of groundwater level drawdown contours. The results of the sub-regional Upper Floridan Aquifer modeling are listed in Section 12.1. Groundwater elevation contours and groundwater level drawdown contours for the Upper Floridan Aquifer (Layer 2) through the Upper Atkinson Aquifer (Layer 7) are provided for the two simulations.

12.3.1 Baseline Condition

For comparison, the groundwater elevations in the Upper Floridan Aquifer (Layer 2) through the Upper Atkinson Aquifer (Layer 7) under existing baseline conditions are presented on **Figures 12-26 through 12-31**. As shown on Figure 12-26, the direction of regional groundwater flow in the Upper Floridan Aquifer north of south-central Georgia and the eastern Coastal Plain areas is primarily from northwest to southeast toward the Gulf Trough, whereas the direction of regional groundwater flow in the Upper Floridan Aquifer south of south-central Georgia is primarily from west to east toward the Atlantic Ocean. North of the Gulf Trough, there are potentiometric highs in the Upper Floridan Aquifer between the major rivers (Alapaha, Ocmulgee and Altamaha Rivers) with flow toward the rivers.

As indicated on Figures 12-27 through 12-31, the prevailing groundwater flow directions in the Claiborne-Gordon-Lower Floridan Aquifers and the Cretaceous Aquifer System within south-central Georgia and eastern Coastal Plain areas occur from northwest to southeast toward the Atlantic Ocean.

12.3.2 Potential Impacts with Lower End of the Range of Sustainable Yield

Figures 12-2 through 12-7 show the groundwater elevations for Layers 2 through 7 for simulated uniformly increased pumping from existing wells in the Upper Floridan Aquifer in south-central Georgia. As indicated on Figure 12-2, increasing pumping in south-central Georgia does not alter the regional groundwater flow directions in the Upper Floridan Aquifer from existing baseline conditions. The hydraulic gradients have become steeper around the major rivers and the Gulf Trough due to increased pumping from the existing wells (293 mgd).

The groundwater level drawdown for Layers 2 through 7 under uniformly increased pumping from existing wells in the Upper Floridan Aquifer in south-central Georgia are shown on Figures 12-8 through 12-13, respectively. As shown on Figure 12-8, drawdown in the potentiometric surface of the Upper Floridan Aquifer has increased in south-central Georgia, particularly in the vicinity of major rivers and near the Gulf Trough due to increased pumping from the existing wells in this area (approximately 293 mgd). As indicated on Figures 12-9 through 12-12, groundwater level drawdown due to increasing pumping in the south-central Georgia area extends from the Claiborne-Gordon Aquifers (Layer 3) to the Eutaw-Midville Aquifer (Layer 6) due to this simulated increased pumping. The magnitude of drawdown is reduced in each underlying aquifer. This drawdown indicates that recharge is being induced from underlying aquifers.

Some simulated drawdowns may have been locally greater than 30 feet in the vicinity of pumping wells, which did not exceed the sustainable yield criterion that drawdowns not exceed 30 feet between pumping wells. The criterion of no more than 40 percent of groundwater contributions to baseflow was not exceeded in the simulations of the lower end of the range of sustainable yield.

12.3.3 Potential Impacts with Upper End of the Range of Sustainable Yield

Figures 12-14 through 12-19 show the groundwater elevations in Layers 2 through 7 for non-uniformly increased pumping from the Upper Floridan Aquifer in the south-central Georgia and baseline pumping from the Upper Floridan Aquifer in the eastern Coastal Plain areas. As shown on Figures 12-14 and 12-15, simulated increased pumping in south-central Georgia does not alter the regional groundwater flow directions in the Upper Floridan Aquifer (Layer 2) or the Claiborne-Gordon Aquifers (Layer 3) from existing baseline conditions. The hydraulic gradients have become even steeper around the major rivers and the Gulf Trough due to simulated increased pumping from the existing wells (approximately 507 mgd).

The groundwater level drawdown for Layers 2 through 7 due to simulated non-uniformly increased pumping from the existing wells in the Upper Floridan Aquifer in south-central Georgia and the eastern Coastal Plain areas are shown on Figures 12-

20 through 12-25, respectively. As shown on Figure 12-20, drawdown in the potentiometric surface of the Upper Floridan Aquifer has increased further in the vicinity of major rivers and near the Gulf Trough due to simulated increased pumping from the existing wells (approximately 507 mgd). Groundwater level drawdown in the potentiometric surface of the Upper Floridan Aquifer (Layer 2) approaches 30 feet in areas north of the Gulf Trough and approximately 1 to 15 feet south of the Gulf Trough. As shown on Figure 12-21, drawdown approaches 30 feet in the Claiborne-Gordon Aquifer (Layer 3) near the Gulf Trough in Irwin and Ben Hill counties. As shown on Figures 12-22 through 12-25, drawdown due to simulated increasing pumping in the Upper Floridan Aquifer ranges from approximately 1 to 16 feet in the Clayton-Dublin Aquifers (Layer 4), 1 to 11 feet in the Upper Cretaceous Aquifer (Layer 5), and 1 to 2 feet in the Lower Cretaceous Aquifer (Layer 7).

Some simulated drawdowns may have been locally greater than 30 feet in the vicinity of pumping wells, which did not exceed the sustainable yield criterion that drawdowns not exceed 30 feet between pumping wells. The criterion of no more than 40 percent of groundwater contributions to baseflow was reached in the simulations of the upper end of the range of sustainable yield.

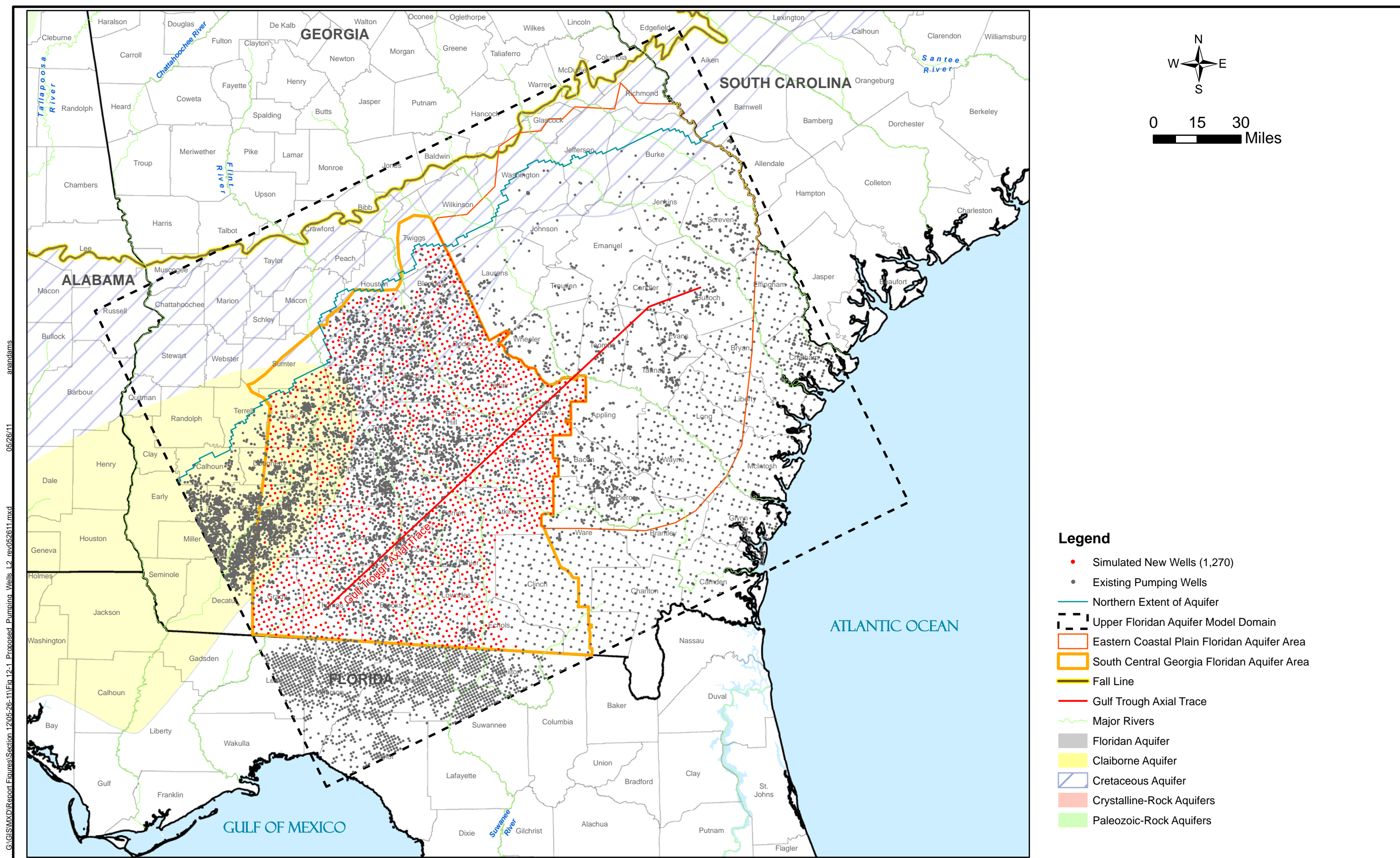
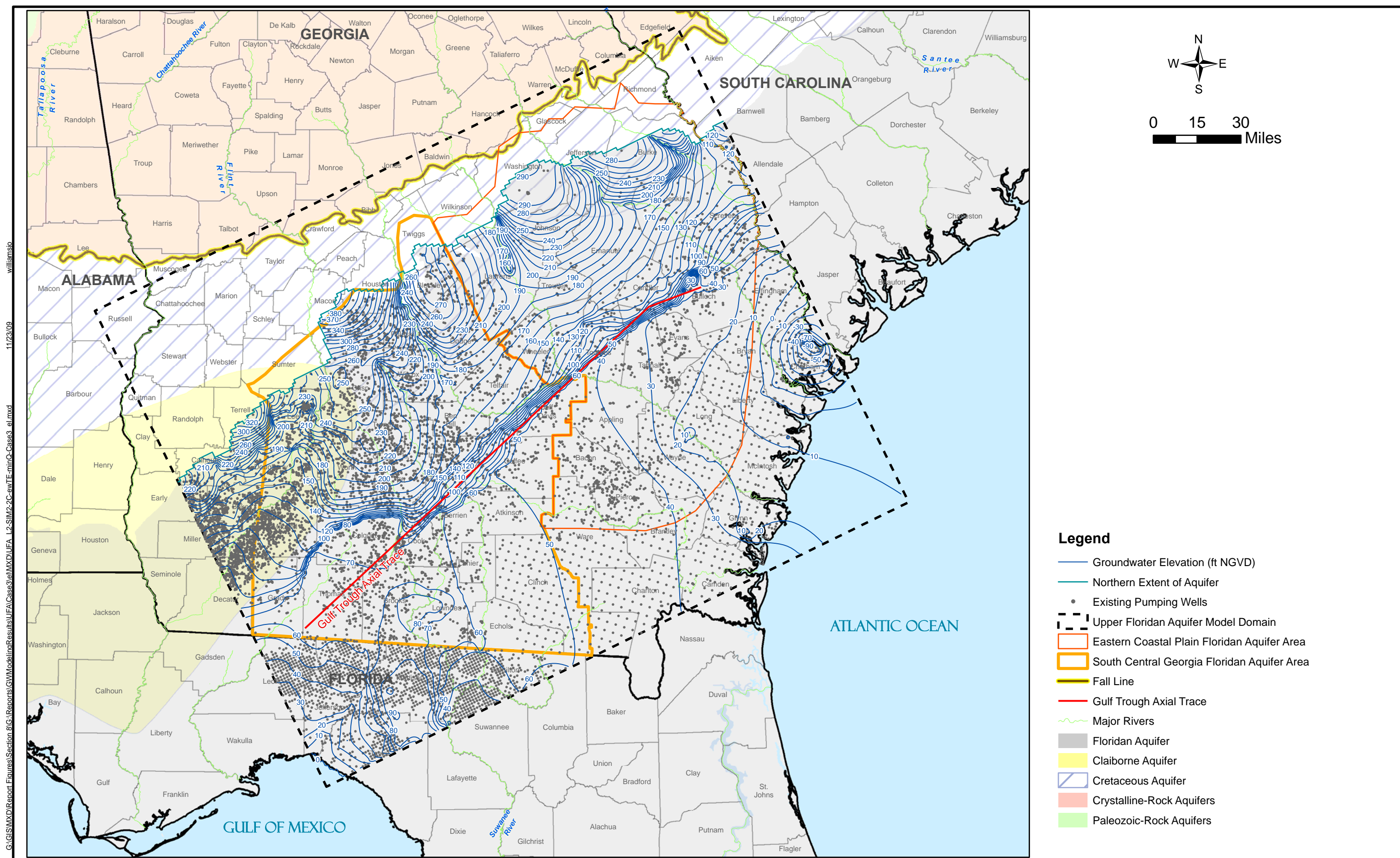


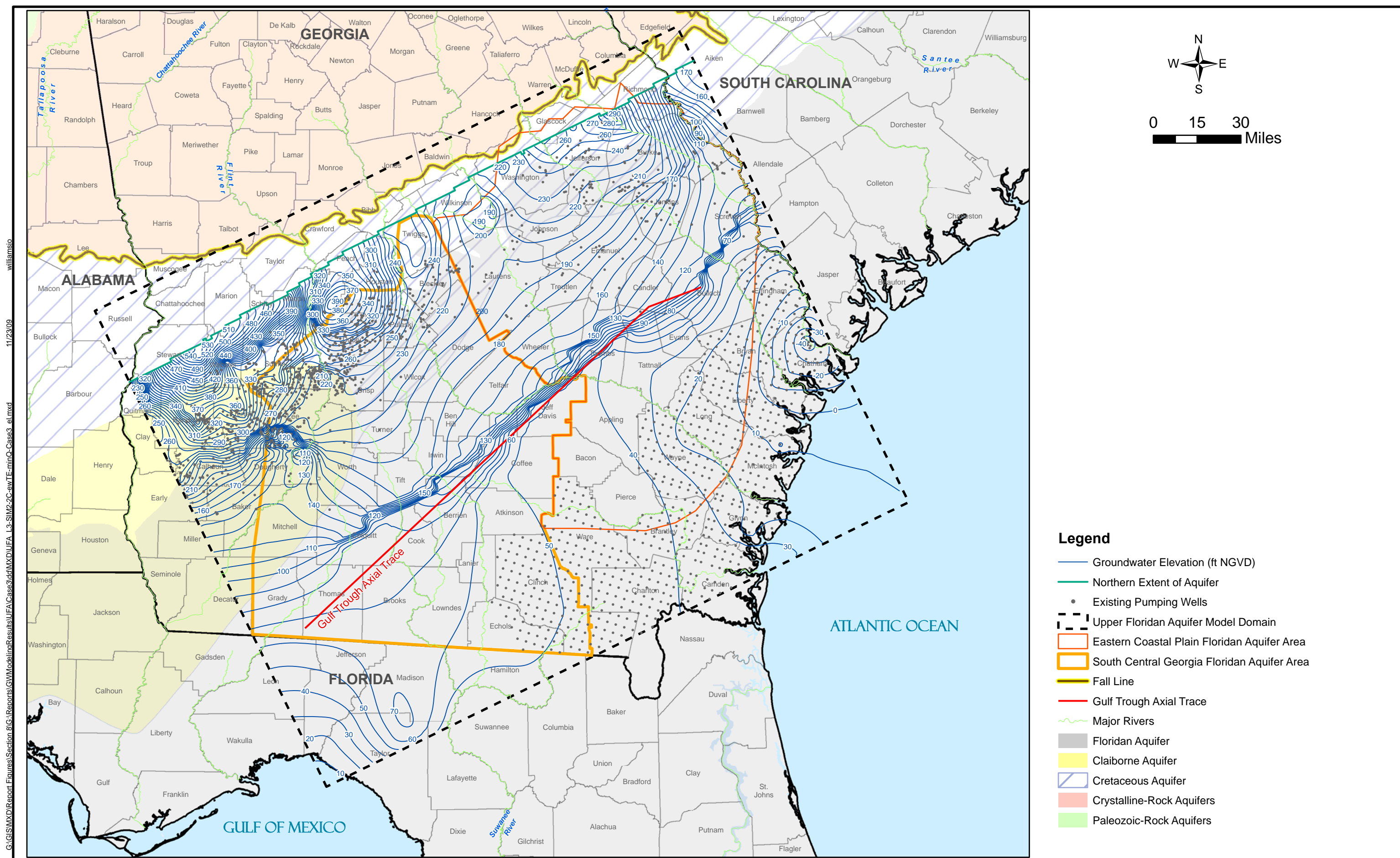
Figure 12-1
Locations of Existing and Simulated New Wells in Upper Floridan Aquifer (Layer 2)
Used in Sub-Regional Upper Floridan Aquifer Model



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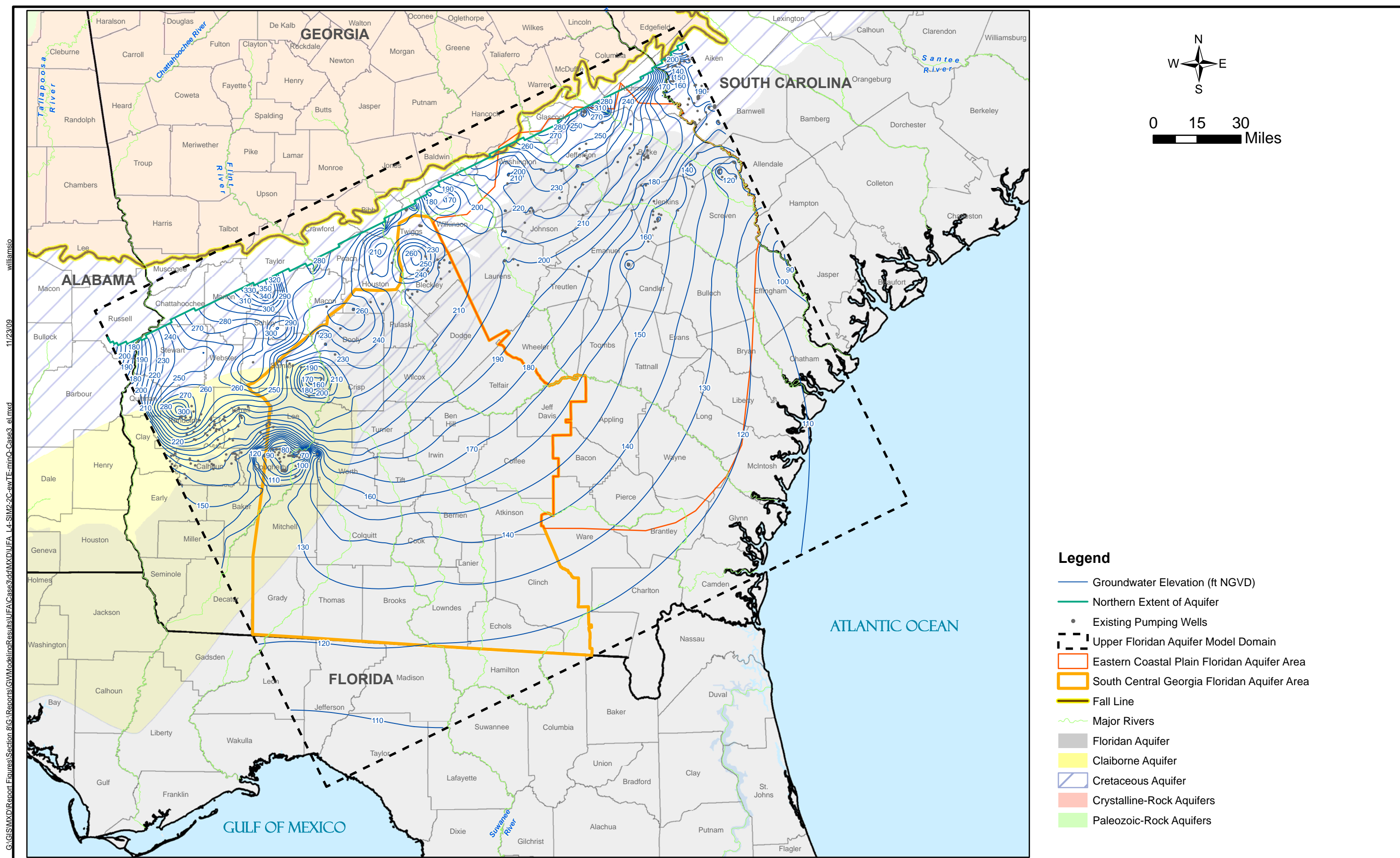
Figure 12-2
Simulated Groundwater Elevations in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

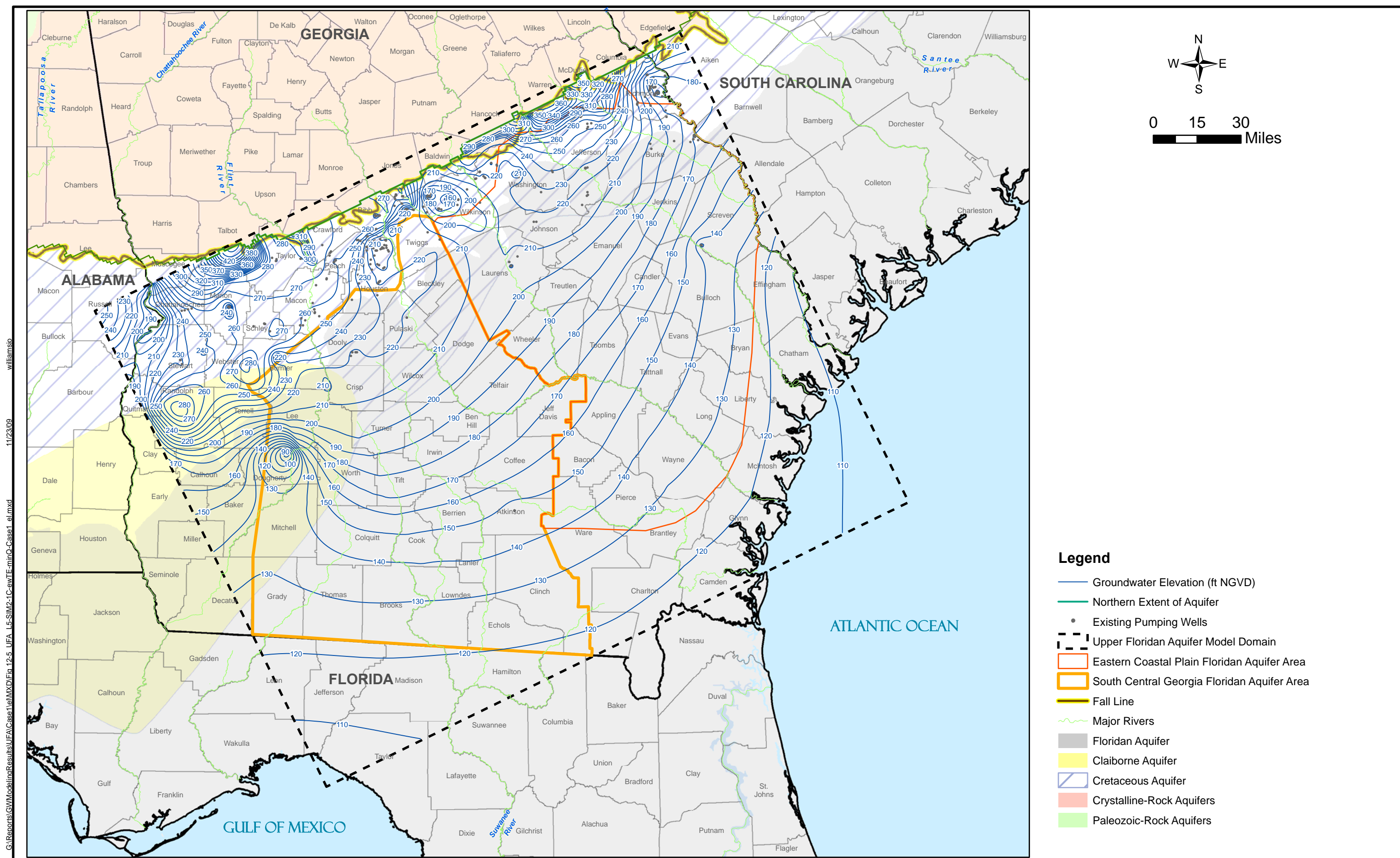


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Figure 12-3
Simulated Groundwater Elevation in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model





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Figure 12-5
Simulated Groundwater Elevation in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

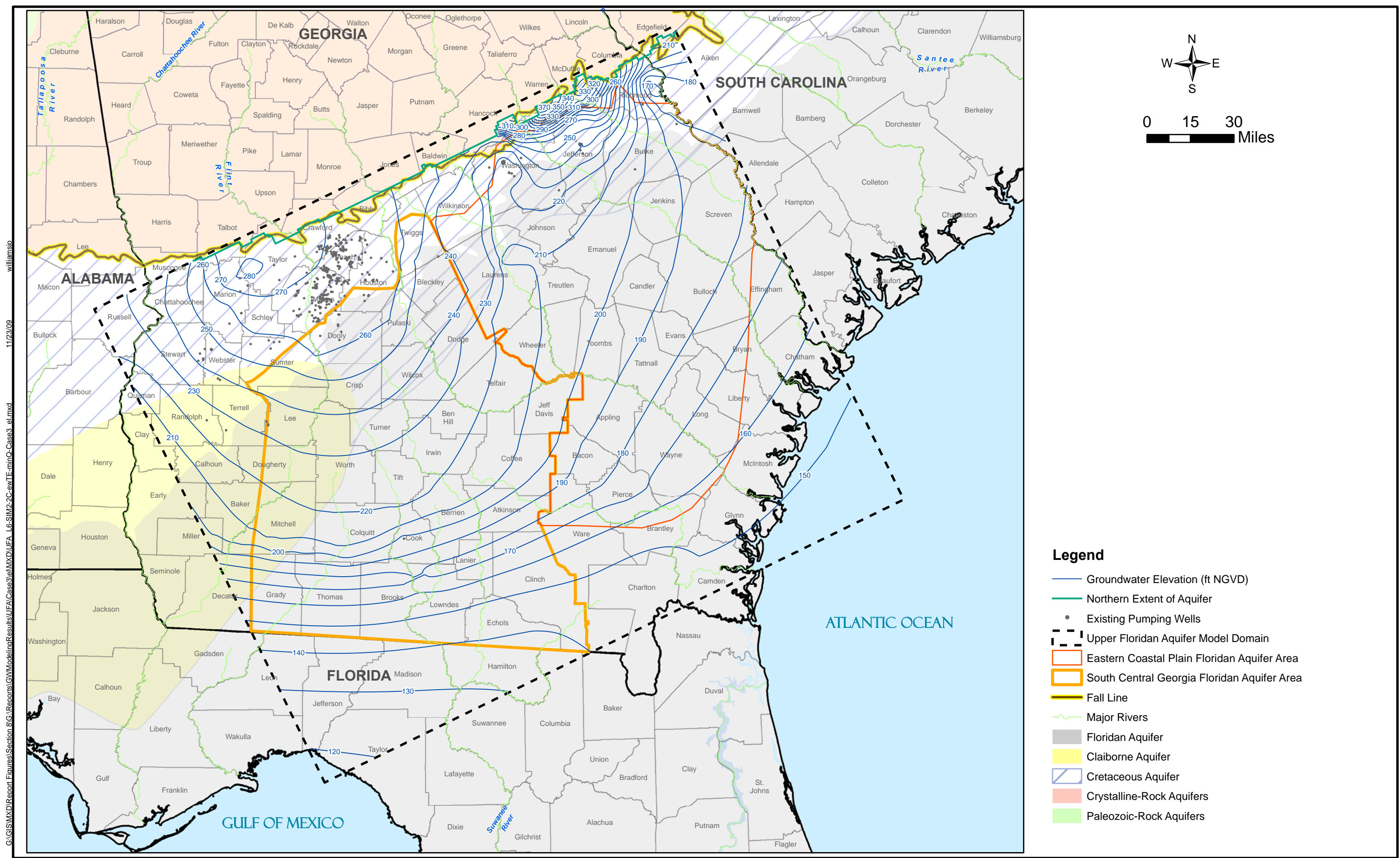
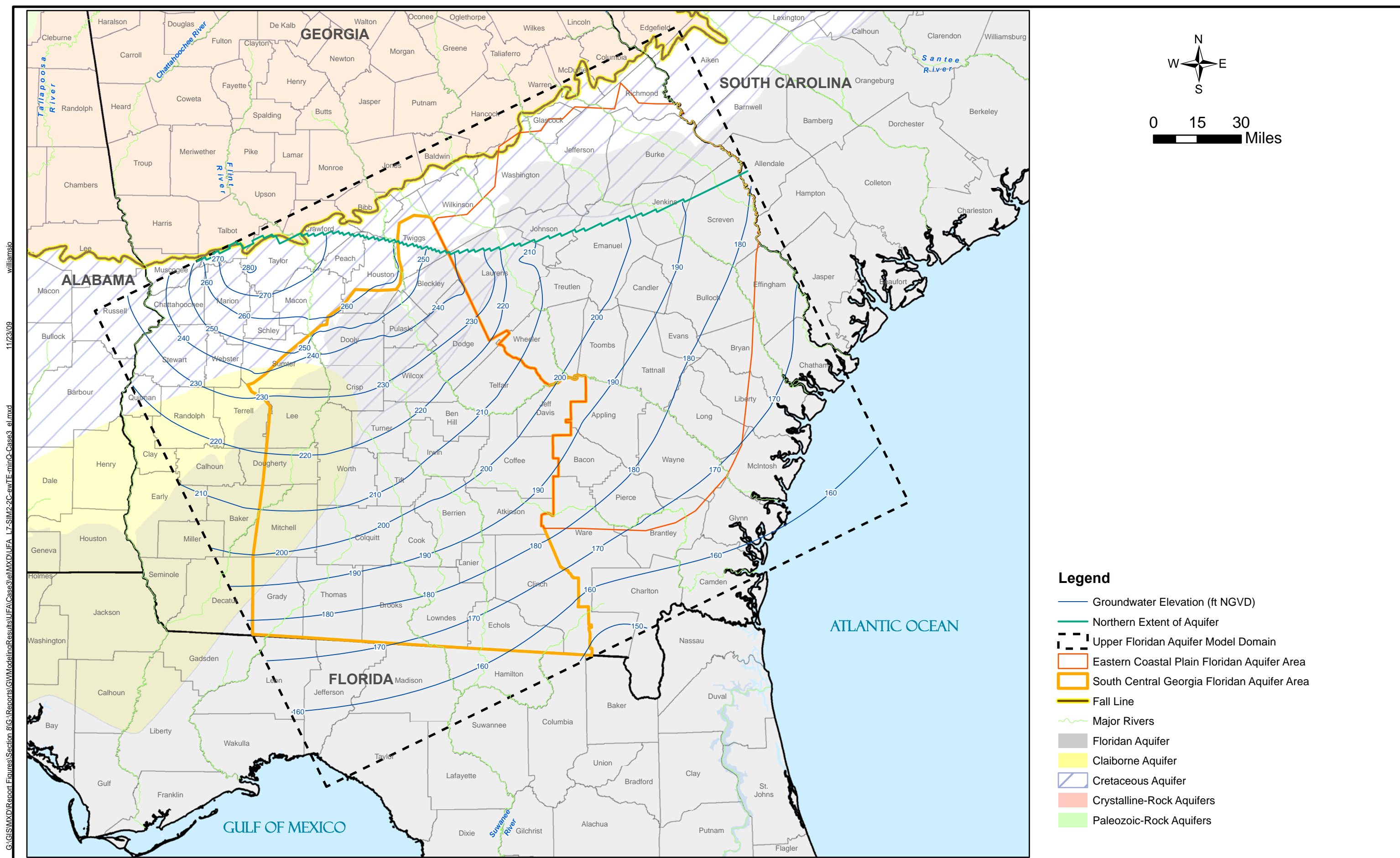
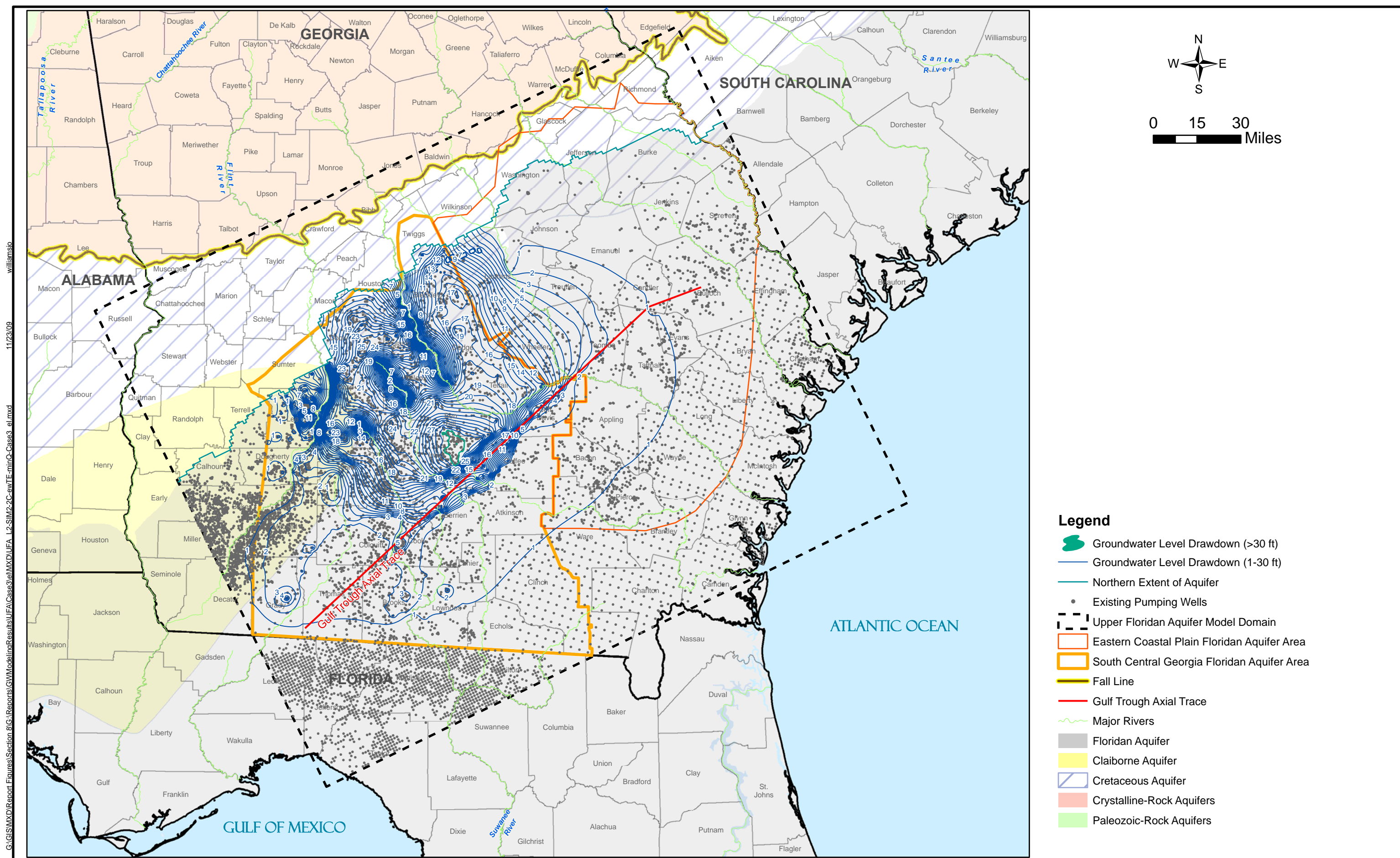


Figure 12-6
Simulated Groundwater Elevation in Eutaw-Midville Aquifer (Layer 6)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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Figure 12-8
Simulated Groundwater Level Drawdown in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

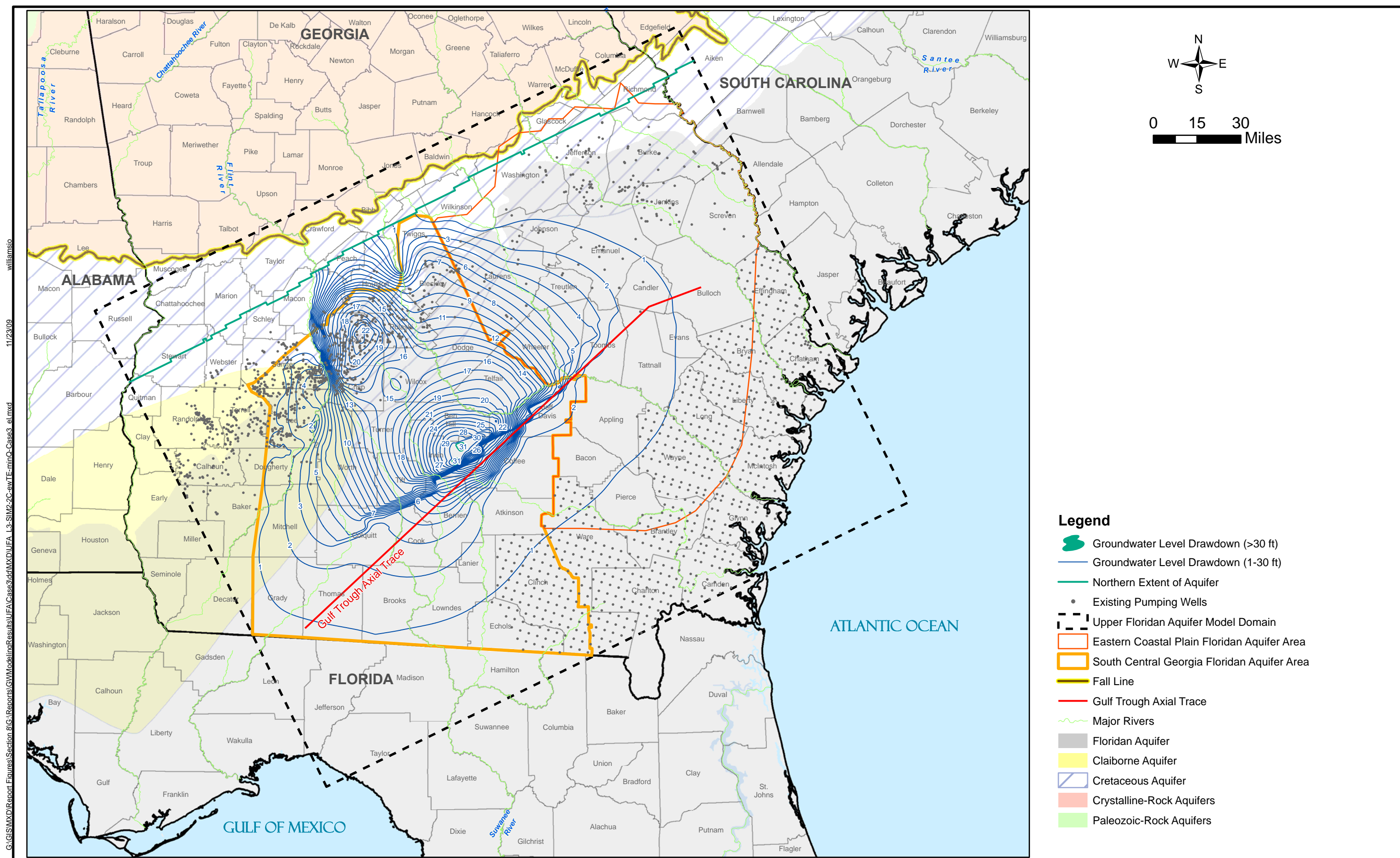
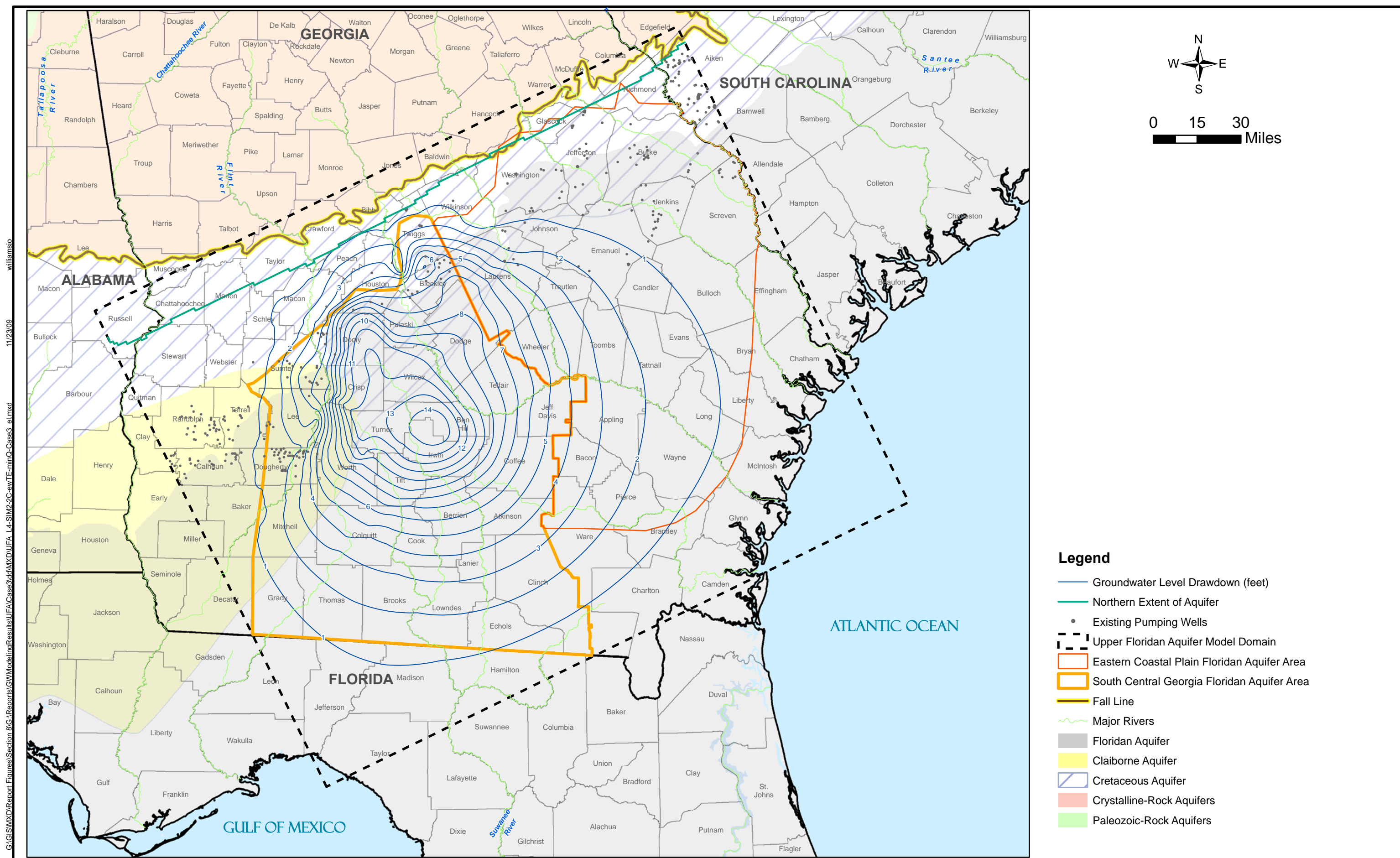
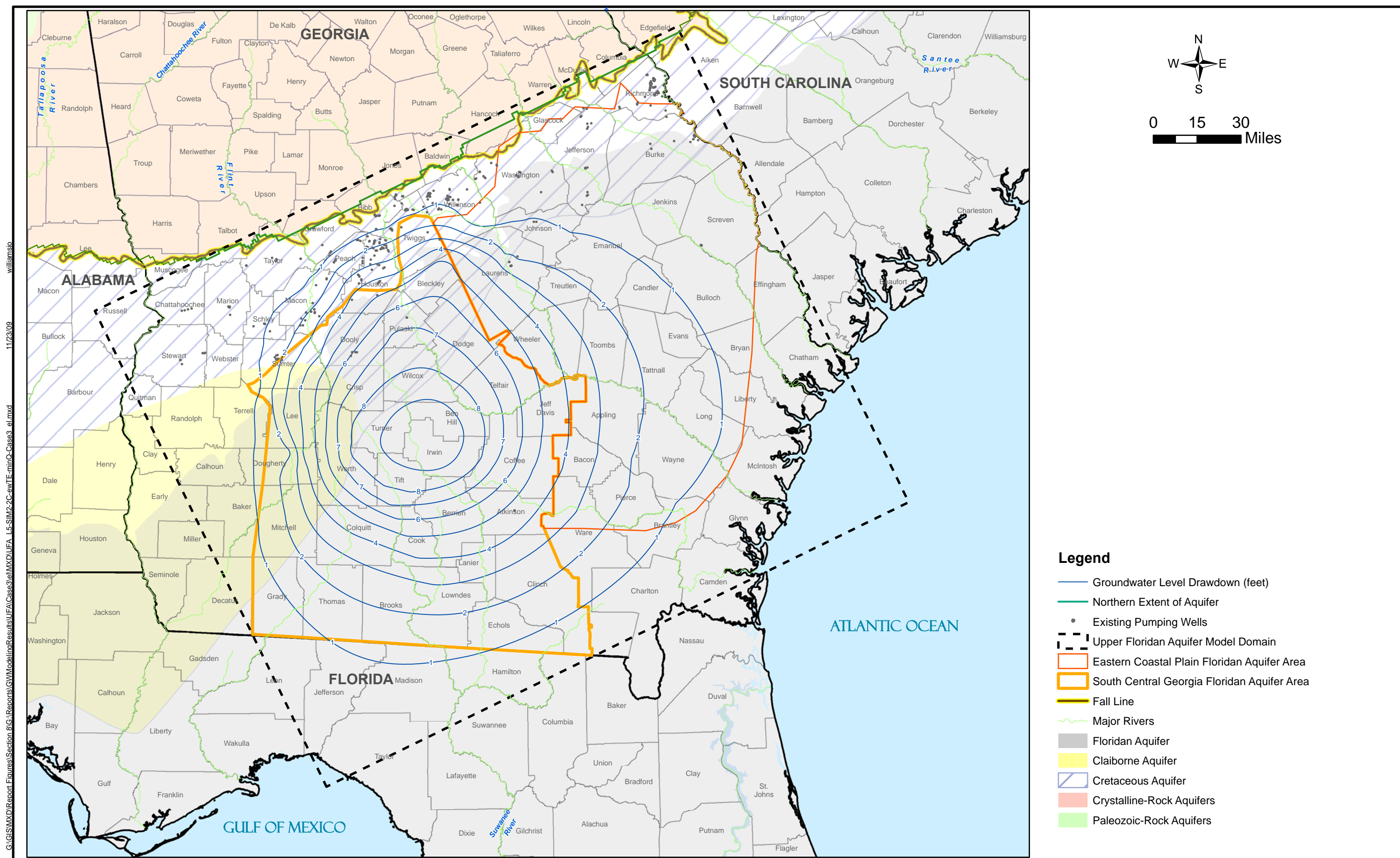


Figure 12-9
Simulated Groundwater Level Drawdown in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

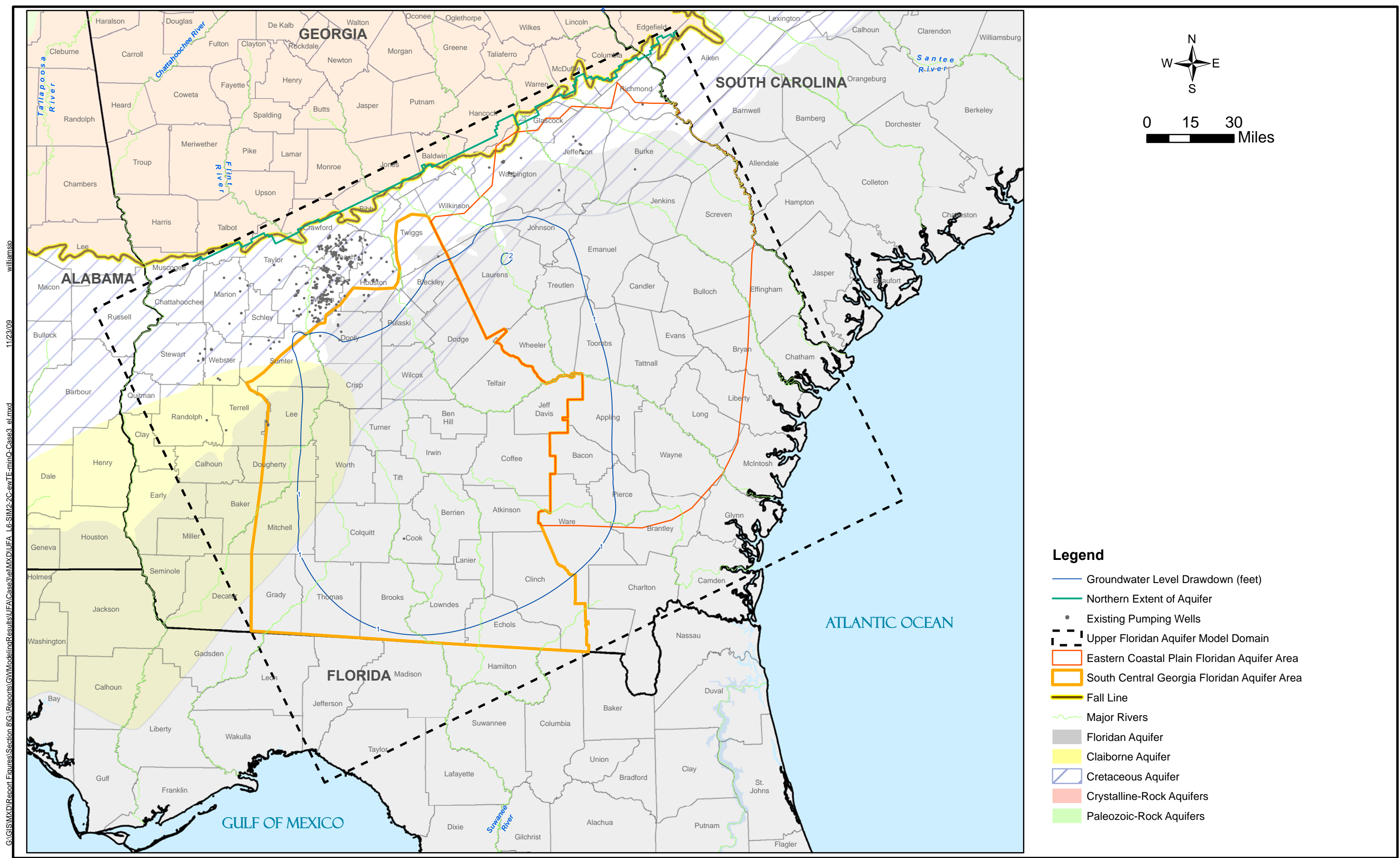


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Simulated Groundwater Level Drawdown in Clayton-Dublin Aquifers (Layer 4)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

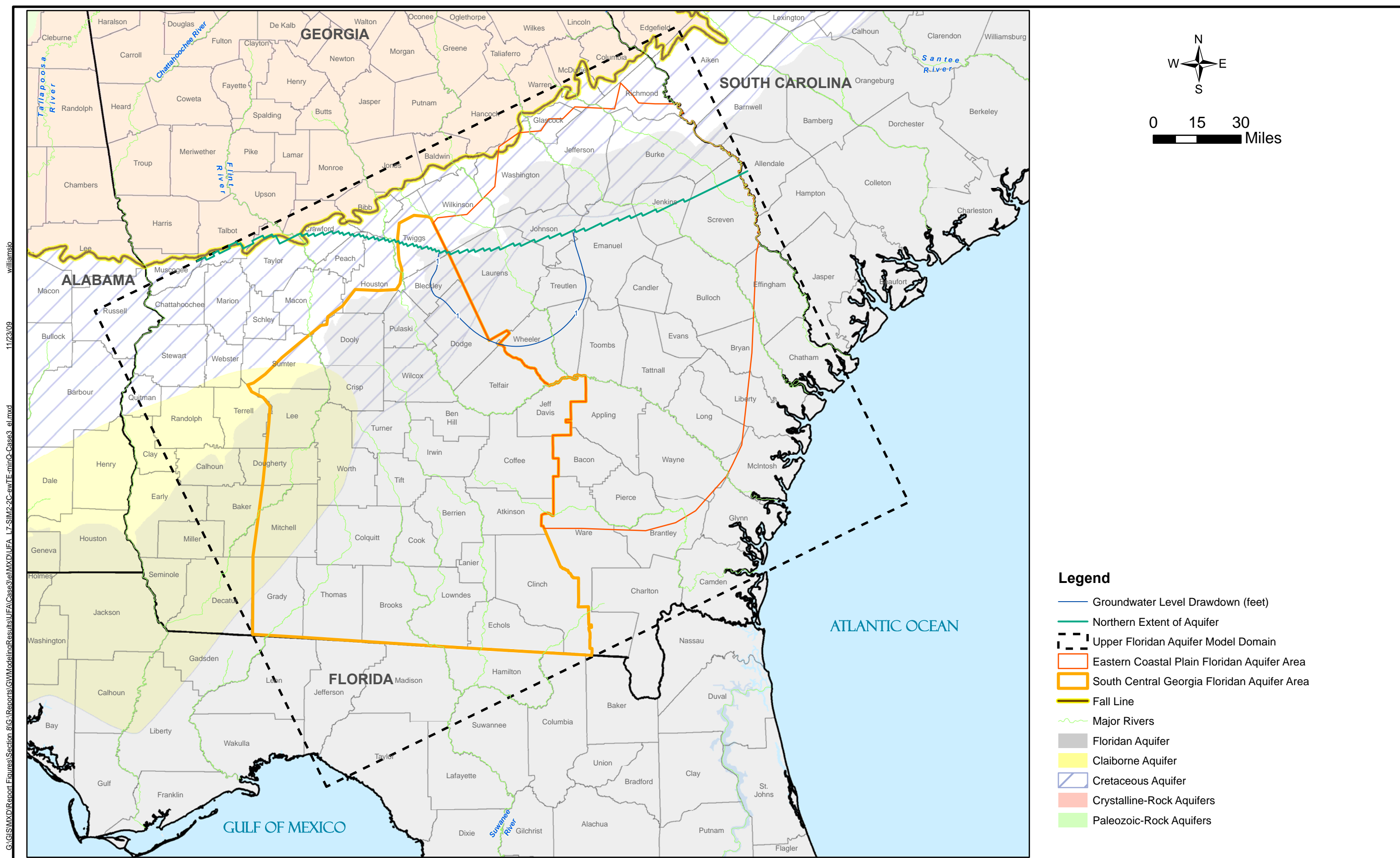


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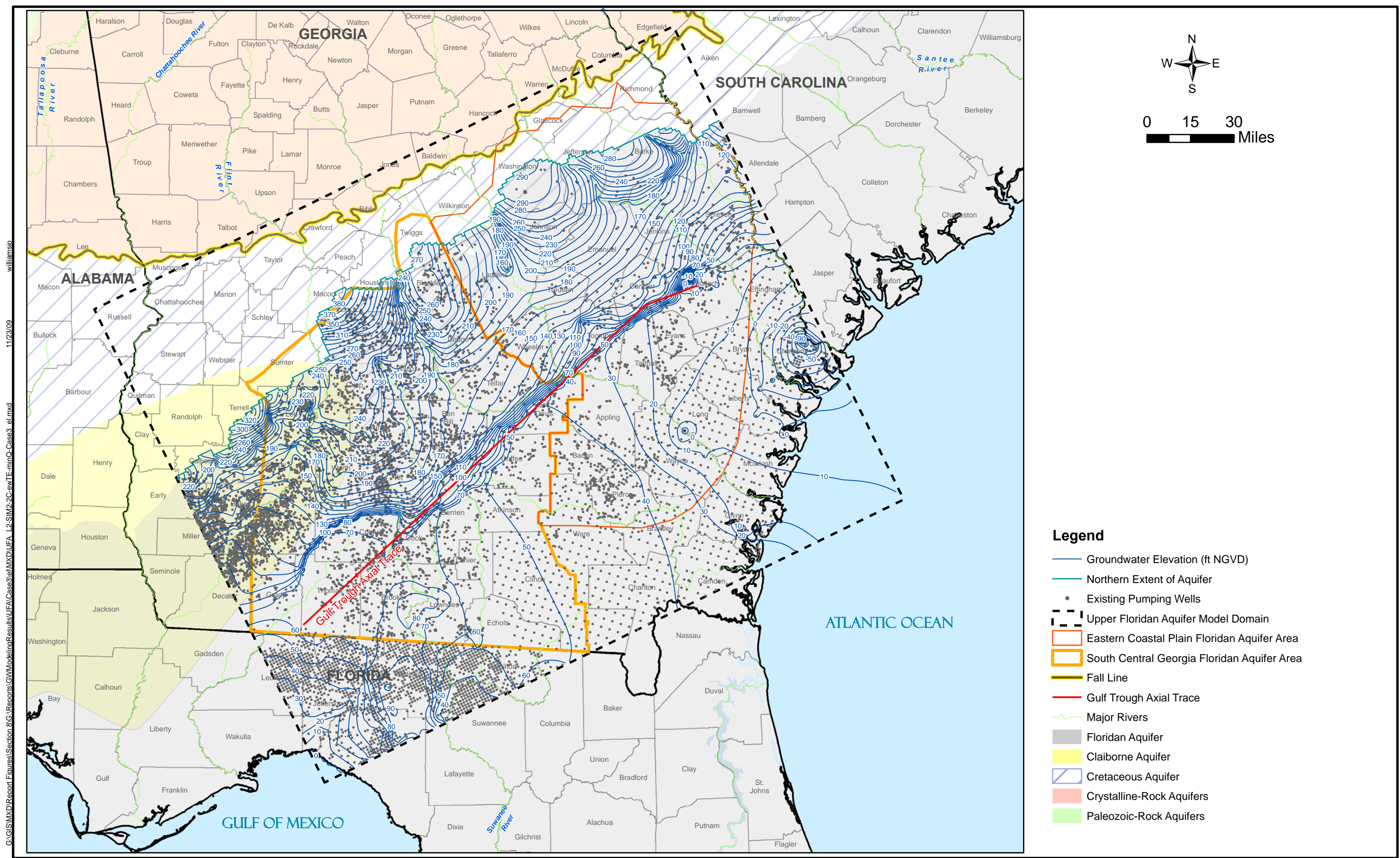
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CDM **Figure 12-12**
Simulated Groundwater Level Drawdown in Eutaw-Midville Aquifer (Layer 6)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



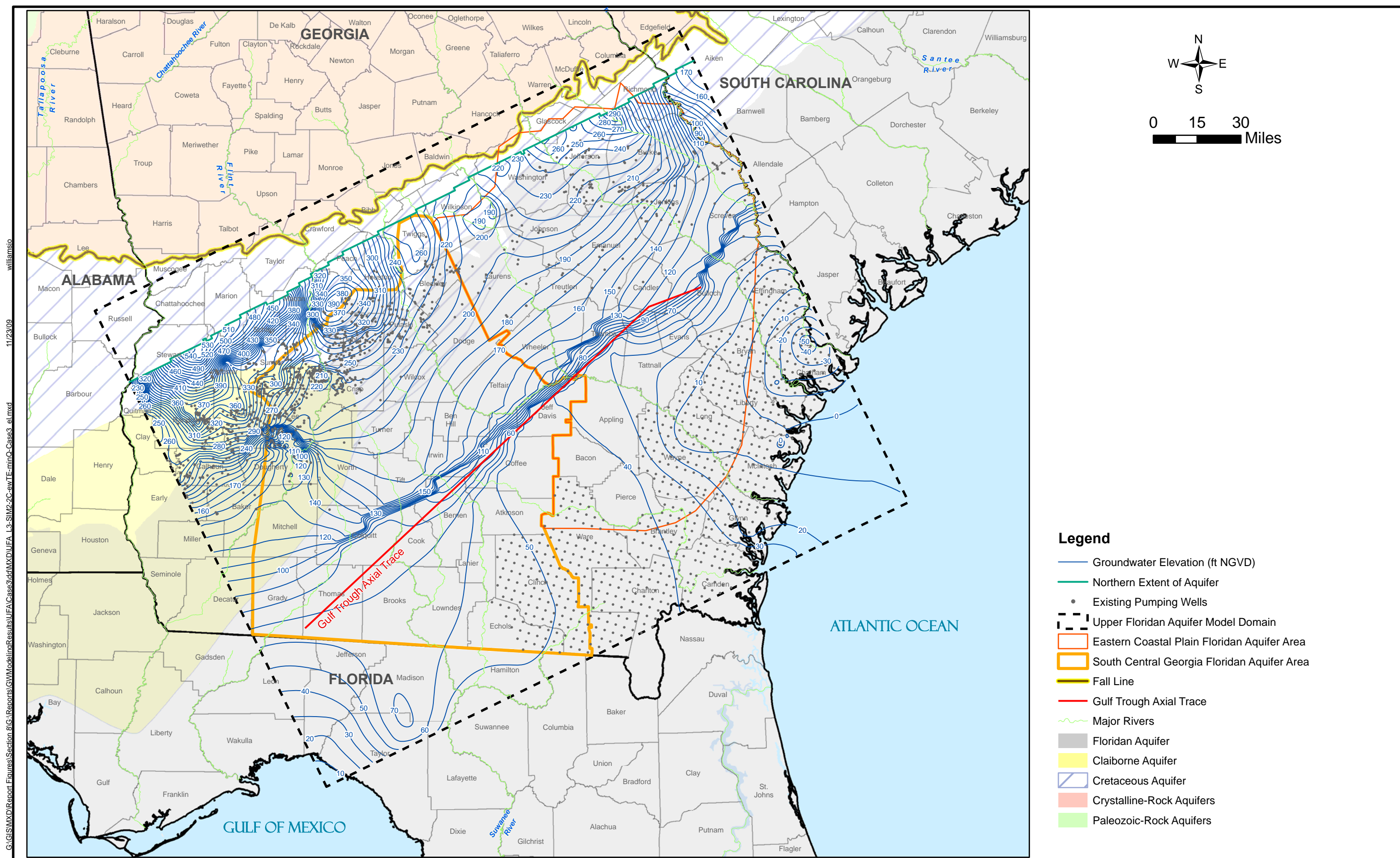
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CDM **Figure 12-13**
Simulated Groundwater Level Drawdown in Upper Atkinson-Upper Tuscaloosa Aquifers (Layer 7)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia ($\Delta Q = 293$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 12-14**
Simulated Groundwater Elevations in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 12-15**
Simulated Groundwater Elevation in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

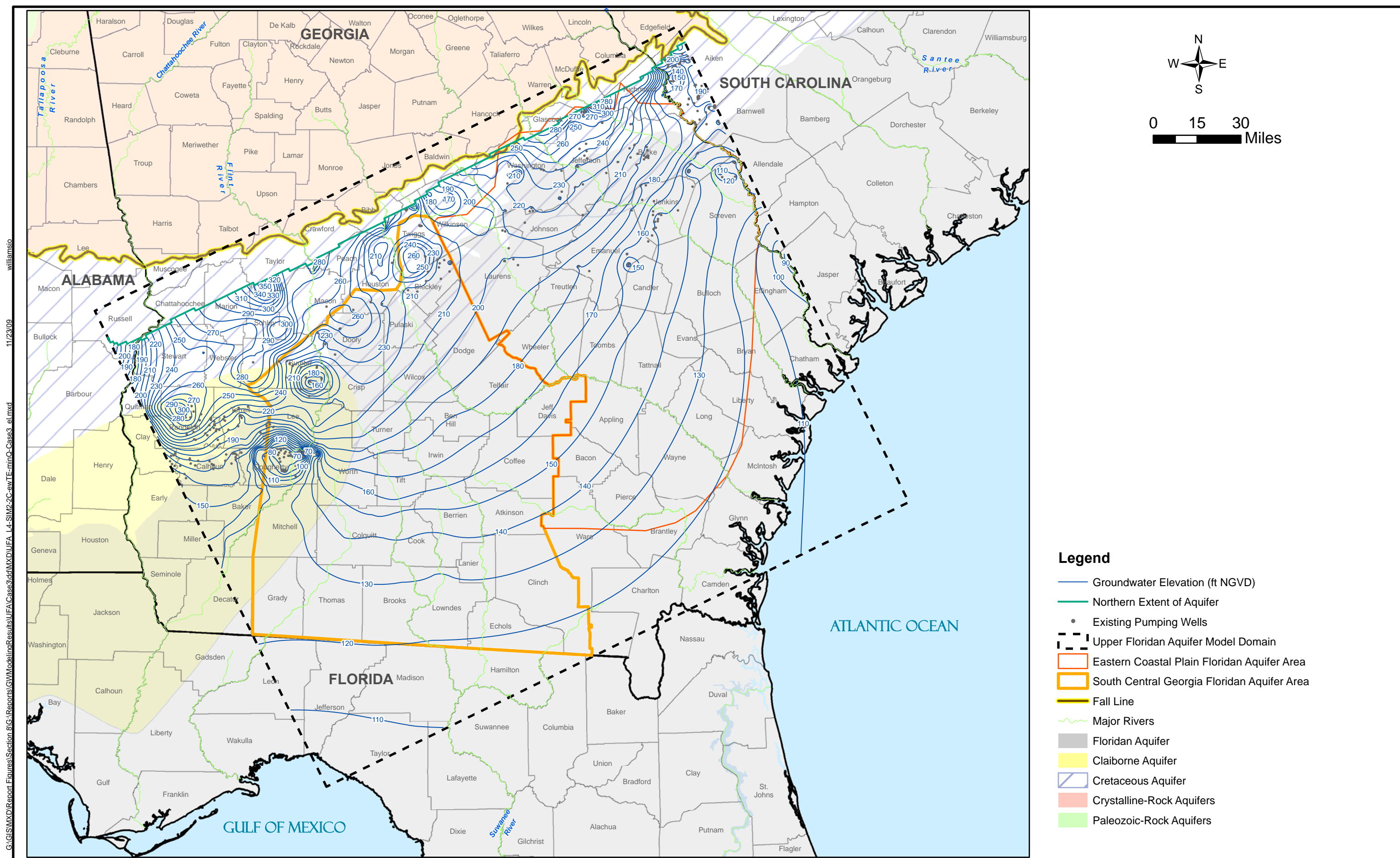
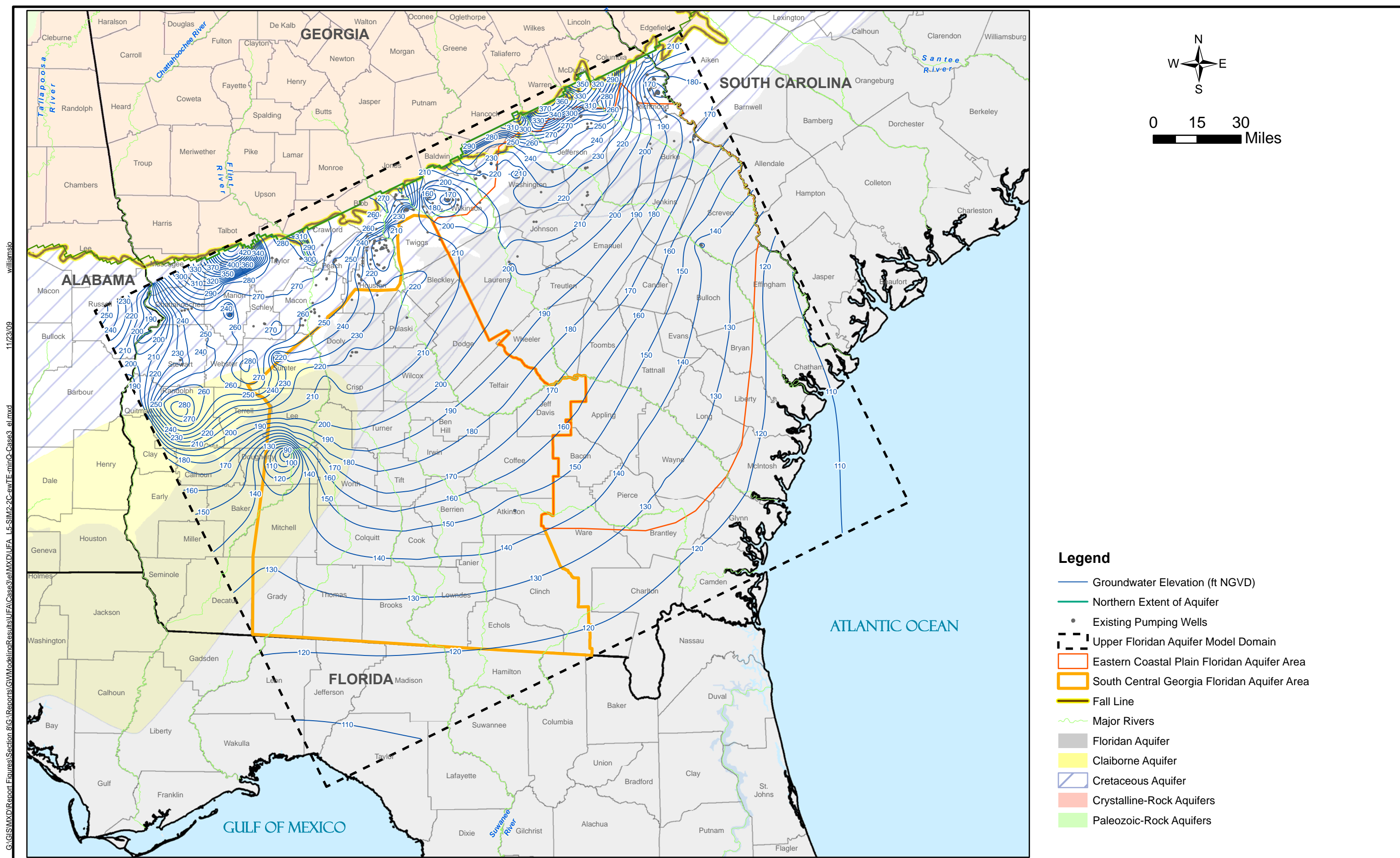
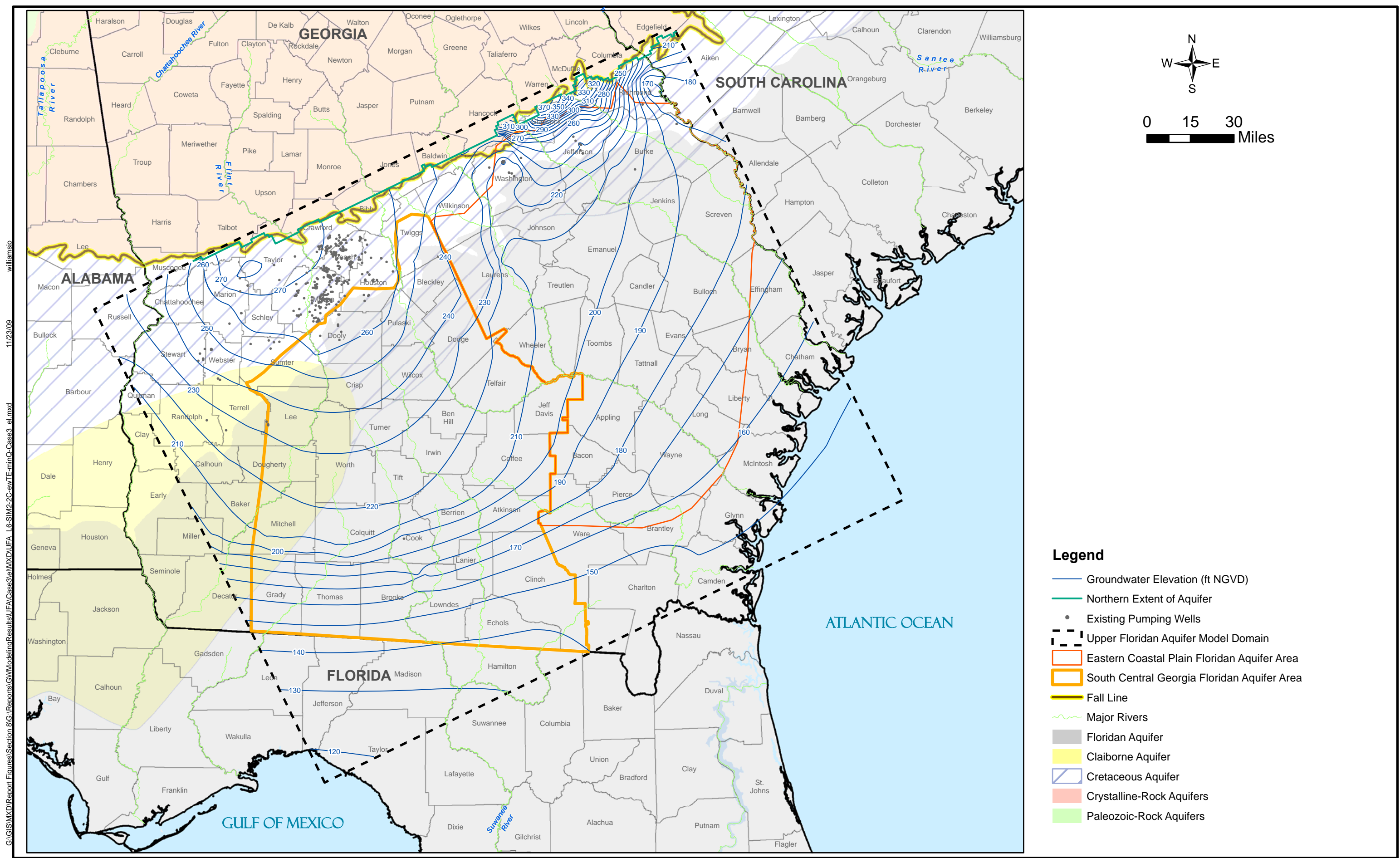


Figure 12-16
Simulated Groundwater Elevation in Clayton-Dublin Aquifers (Layer 4)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



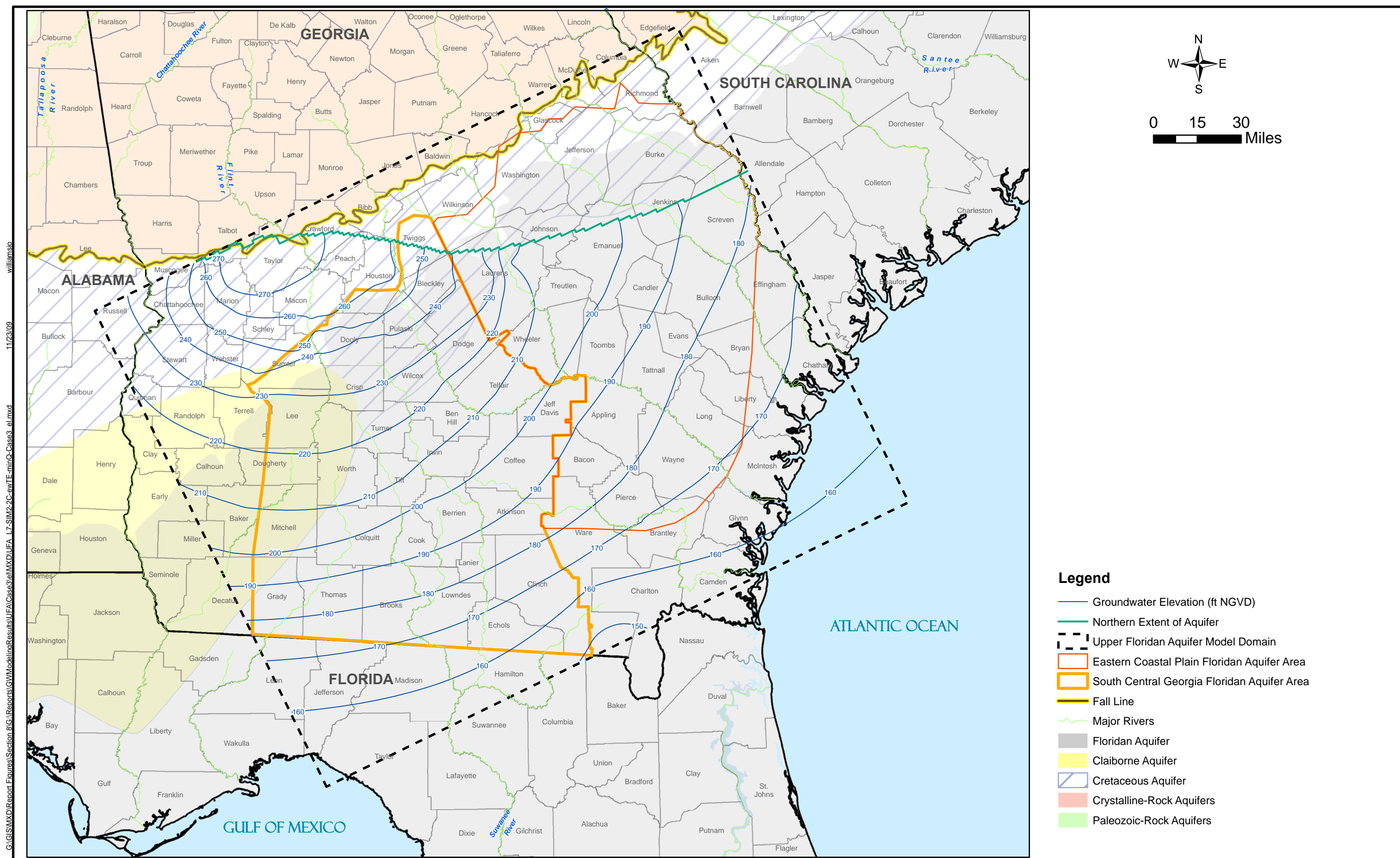
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CDM **Figure 12-17**
Simulated Groundwater Elevation in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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Figure 12-18
Simulated Groundwater Elevation in Eutaw-Midville Aquifer (Layer 6)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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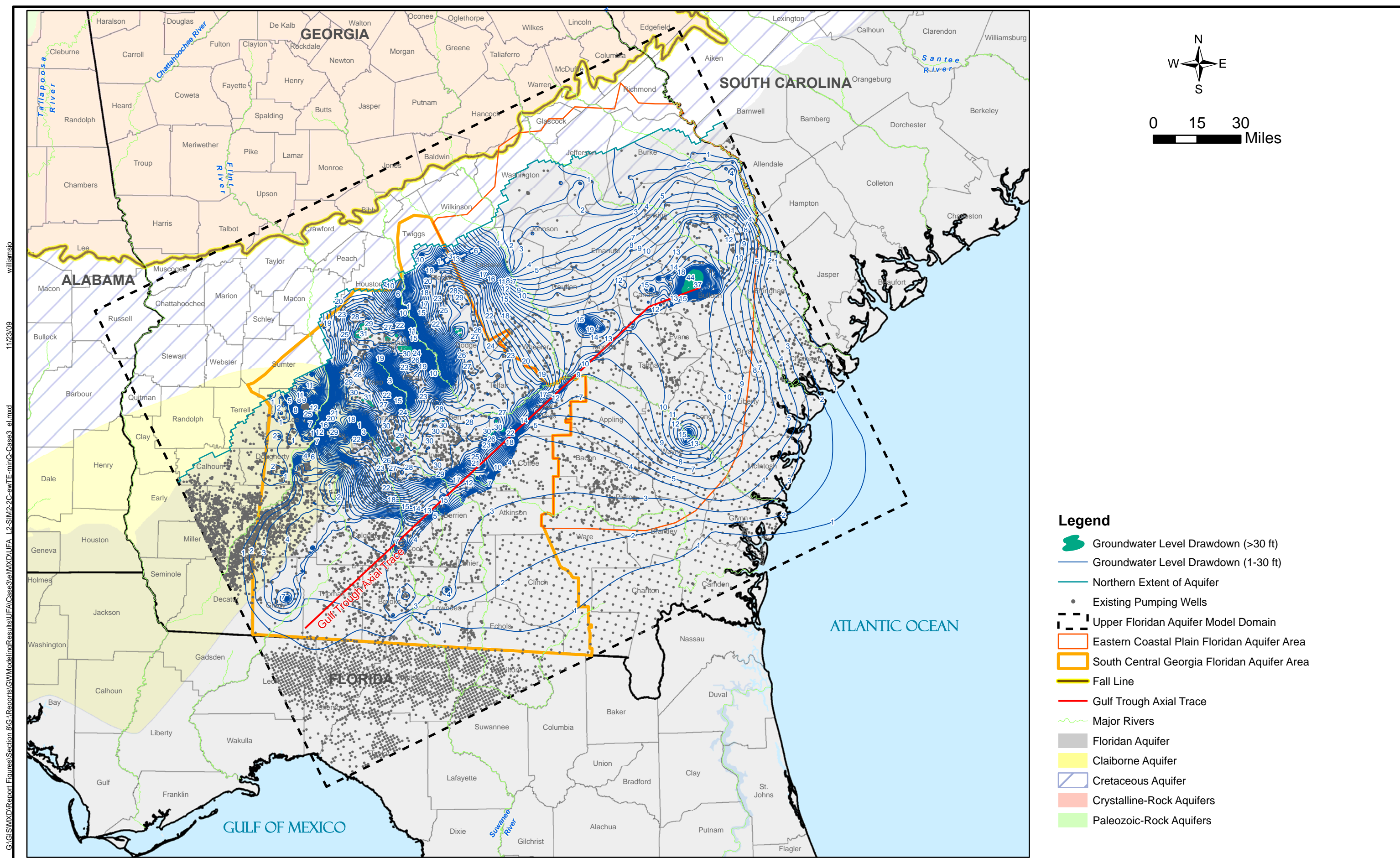
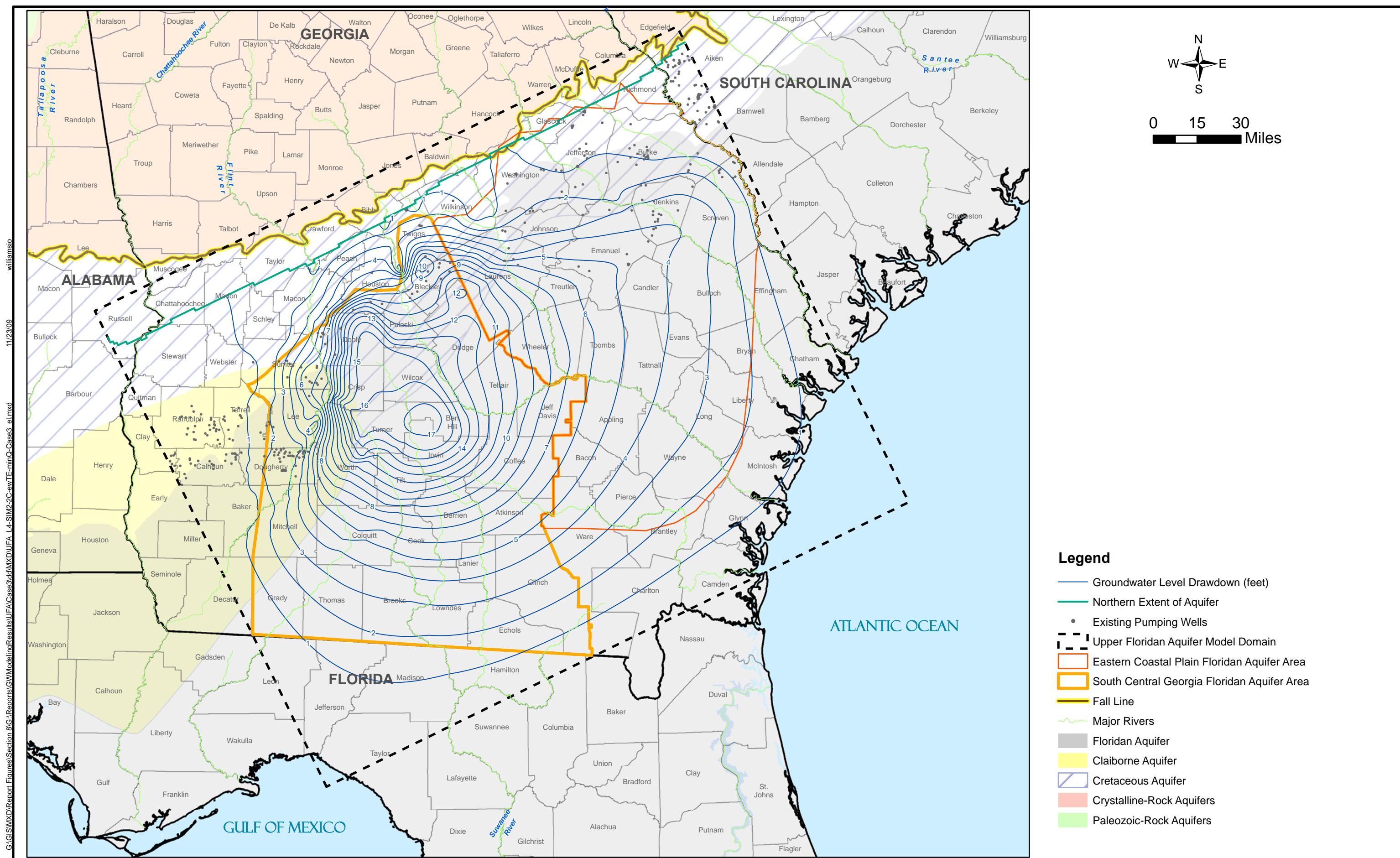
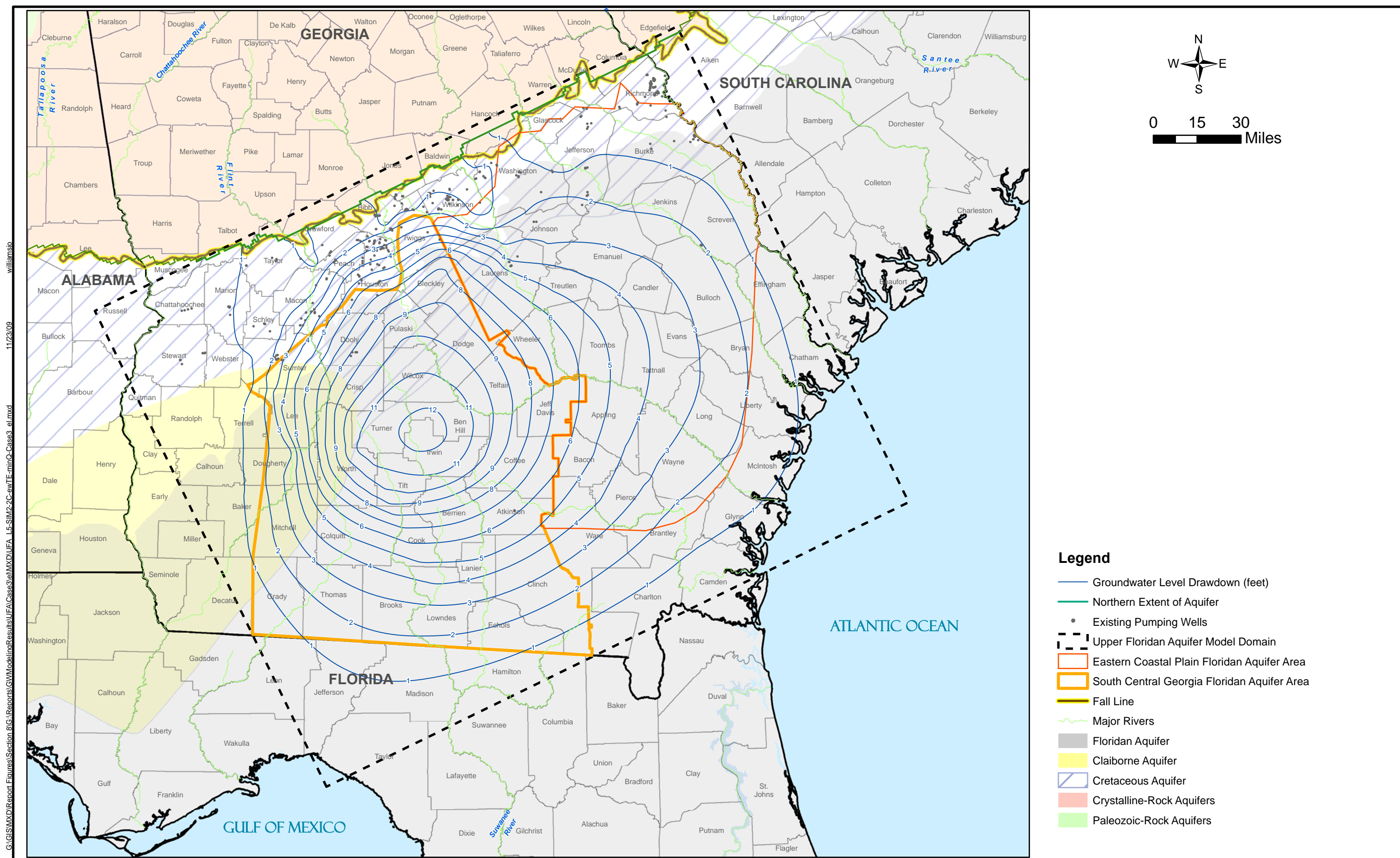


Figure 12-20
Simulated Groundwater Level Drawdown in Upper Floridan Aquifer (Layer 2)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



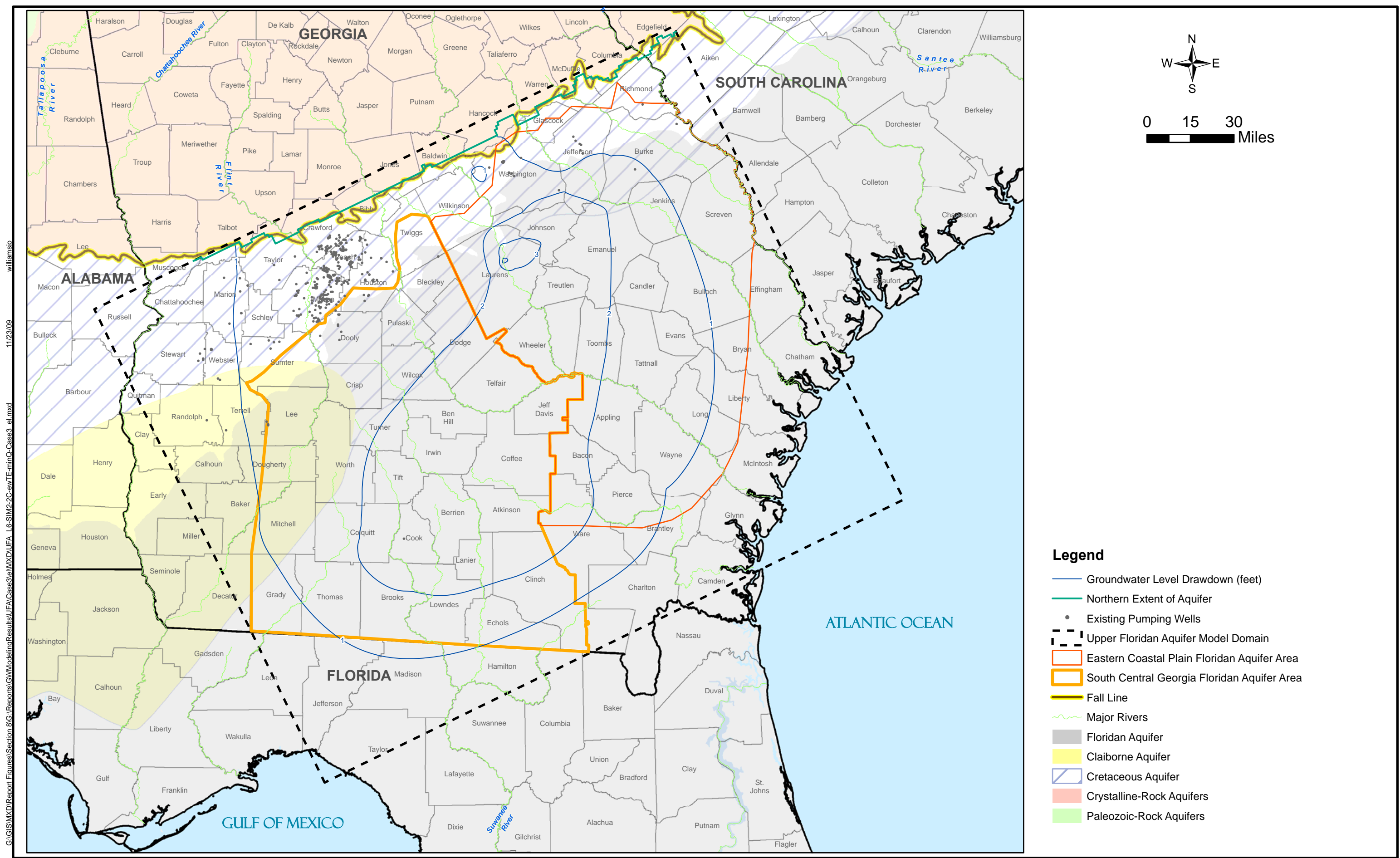
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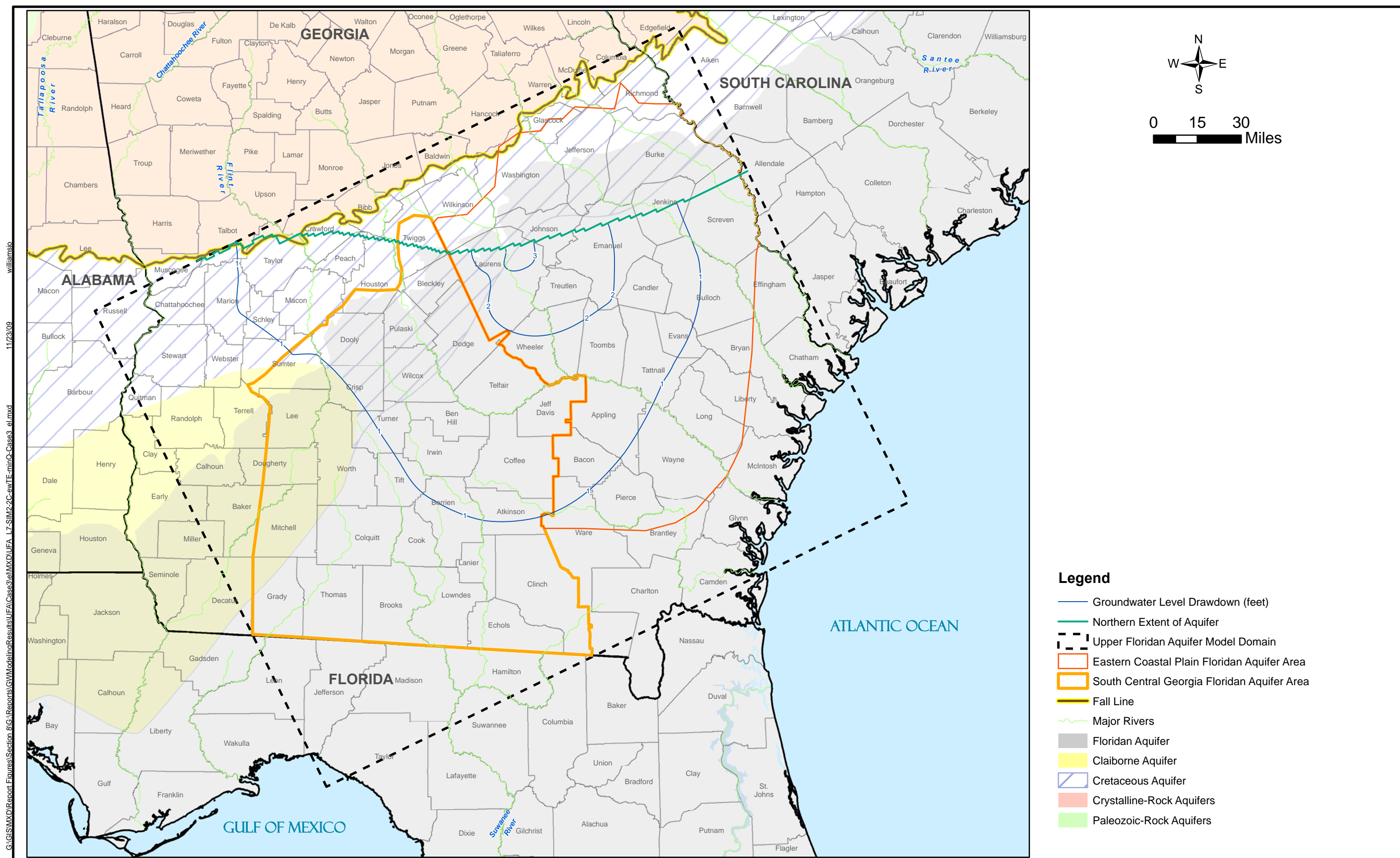
CDM **Figure 12-22**
Simulated Groundwater Level Drawdown in Clayton-Dublin Aquifers (Layer 4)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q= 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model



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Figure 12-23
Simulated Groundwater Level Drawdown in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q = 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model





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CDM **Figure 12-25**
Simulated Groundwater Level Drawdown in Upper Atkinson-Upper Tuscaloosa Aquifers (Layer 7)
Due to Increasing Existing Well Pumping in Upper Floridan Aquifer in South Central Georgia and Eastern Coastal Plain ($\Delta Q= 507$ mgd) Using Sub-Regional Upper Floridan Aquifer Model

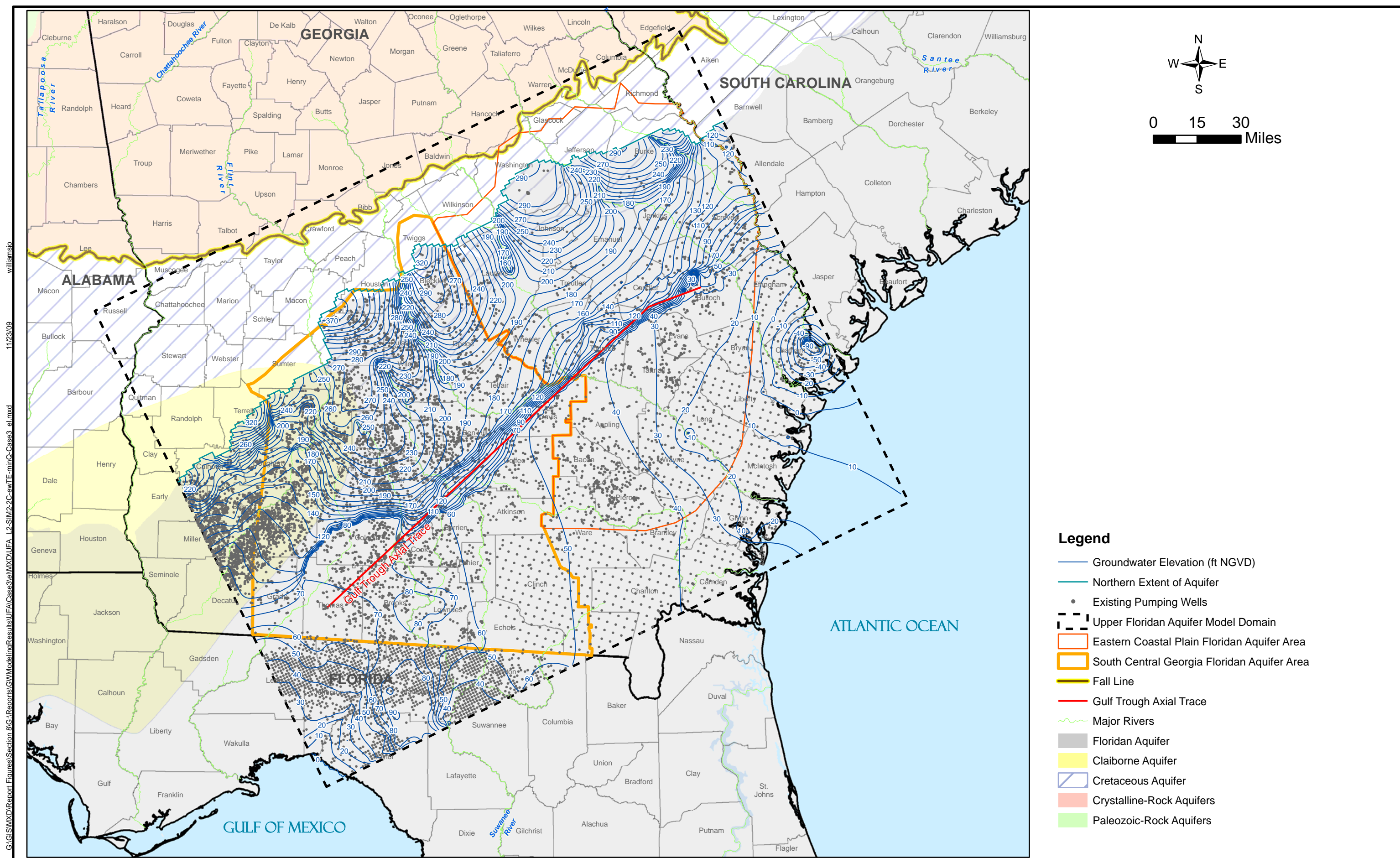
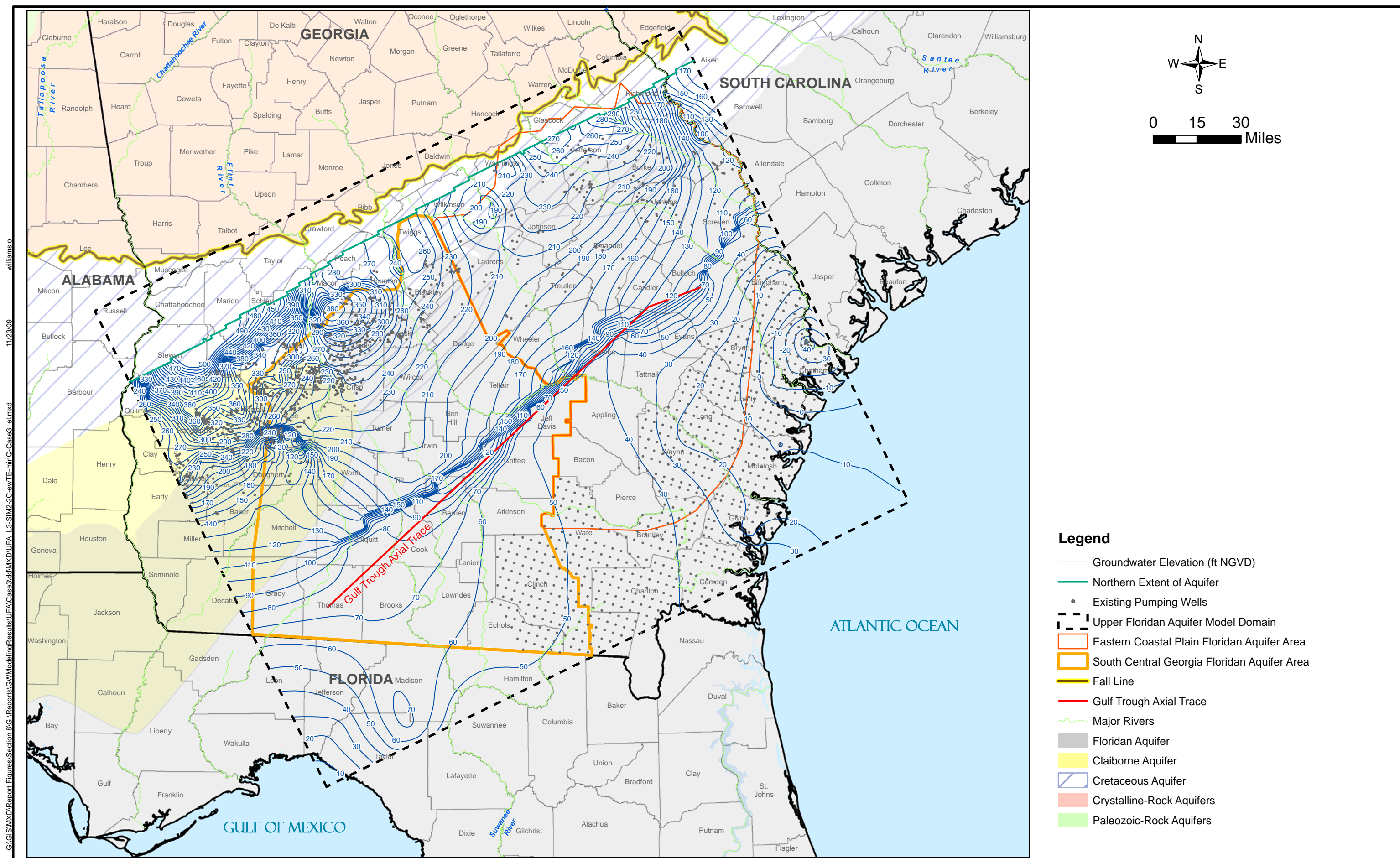
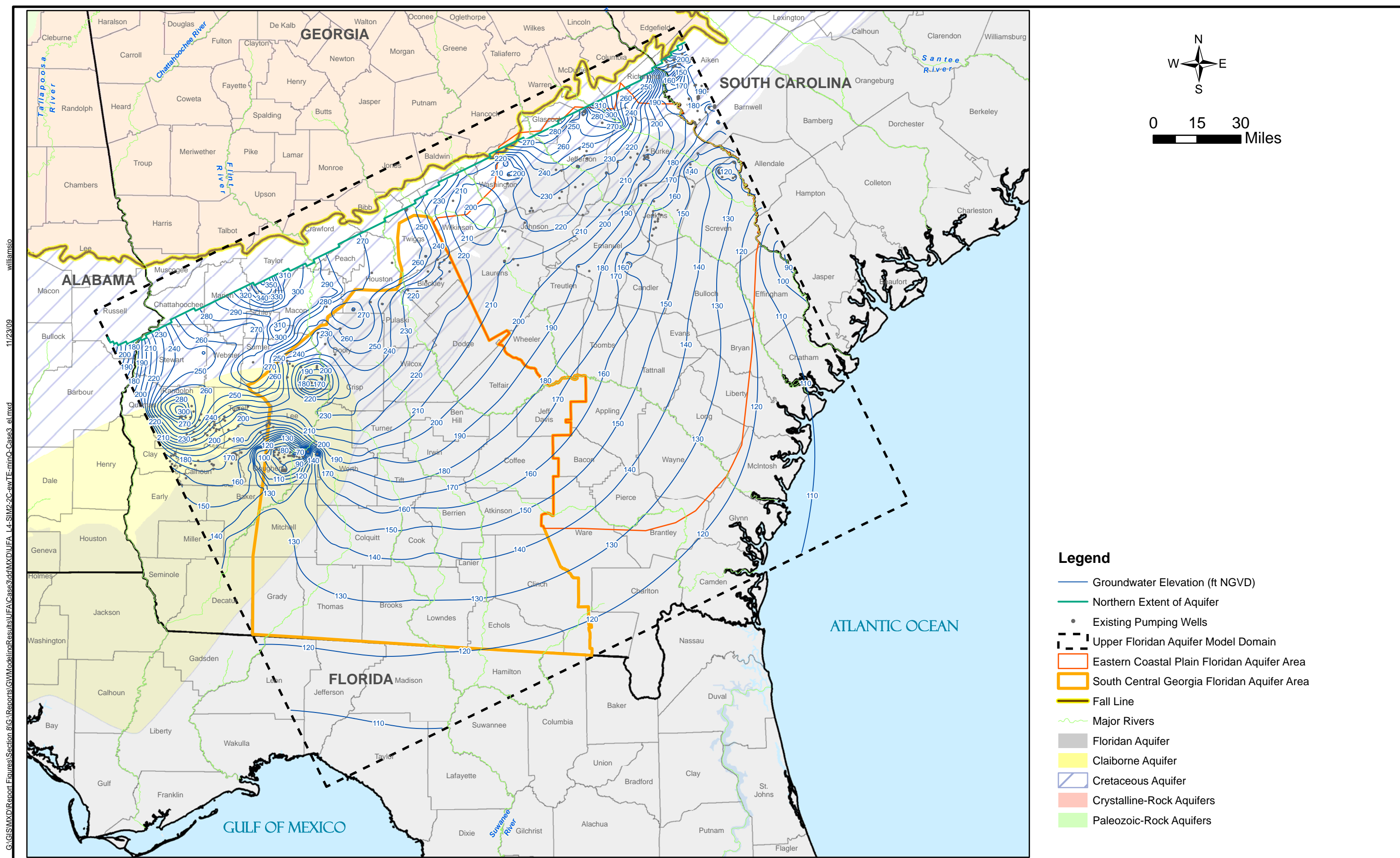


Figure 12-26
Simulated Groundwater Elevations in Upper Floridan Aquifer (Layer 2)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



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CDM **Figure 12-27**
Simulated Groundwater Elevation in Claiborne/Gordon/Lower Floridan Aquifers (Layer 3)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



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Figure 12-28
Simulated Groundwater Elevation in Clayton-Dublin Aquifers (Layer 4)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model

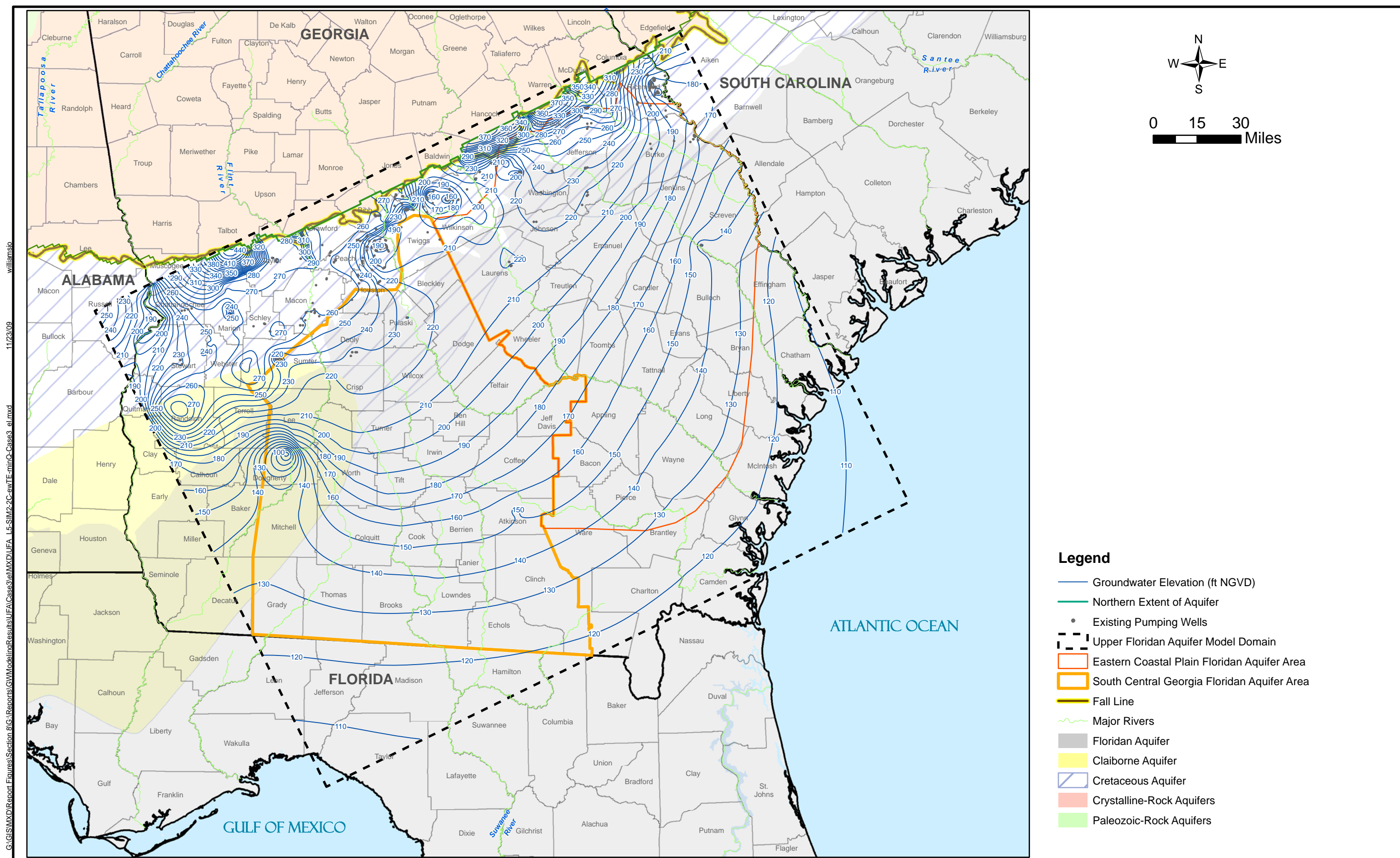
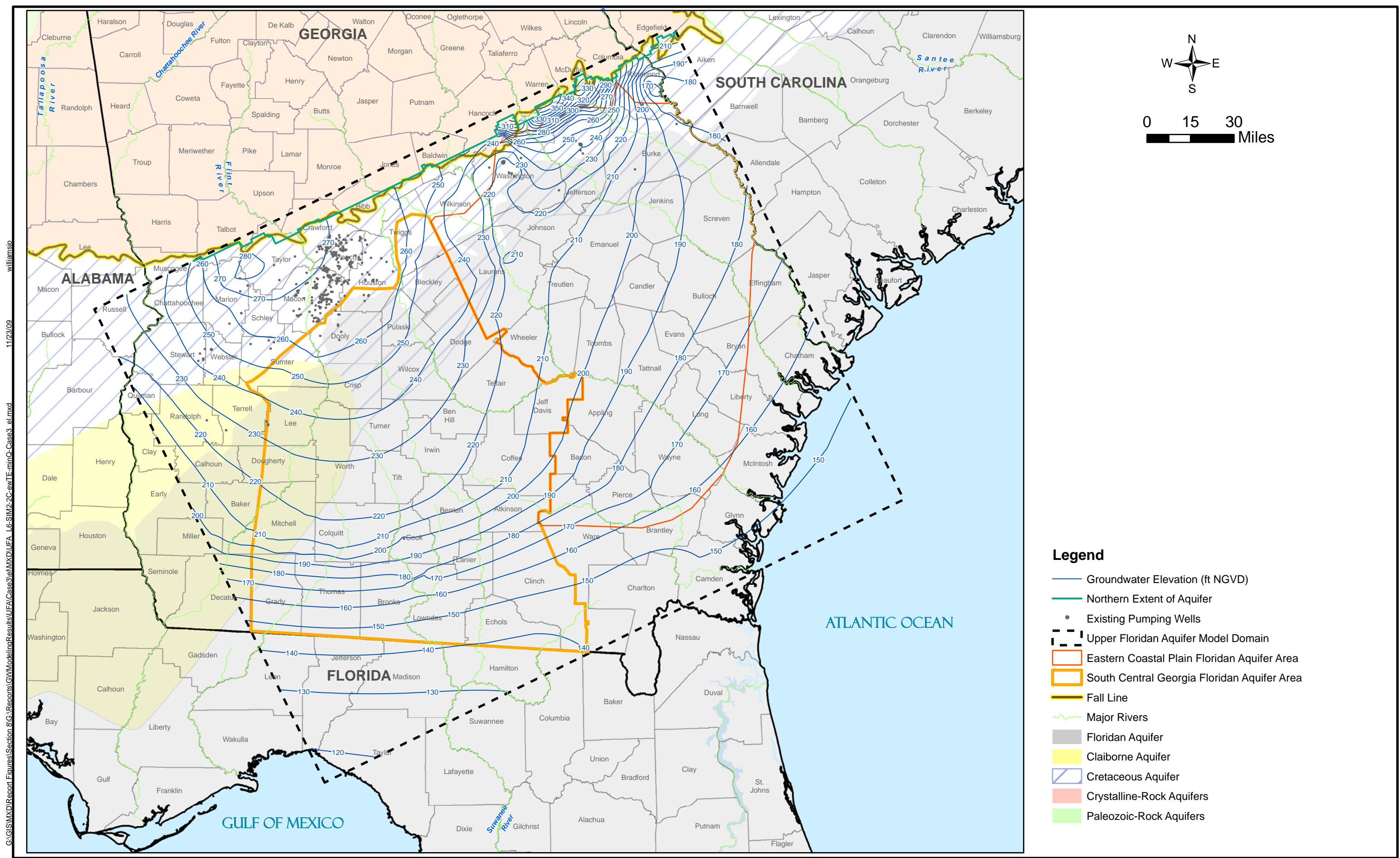
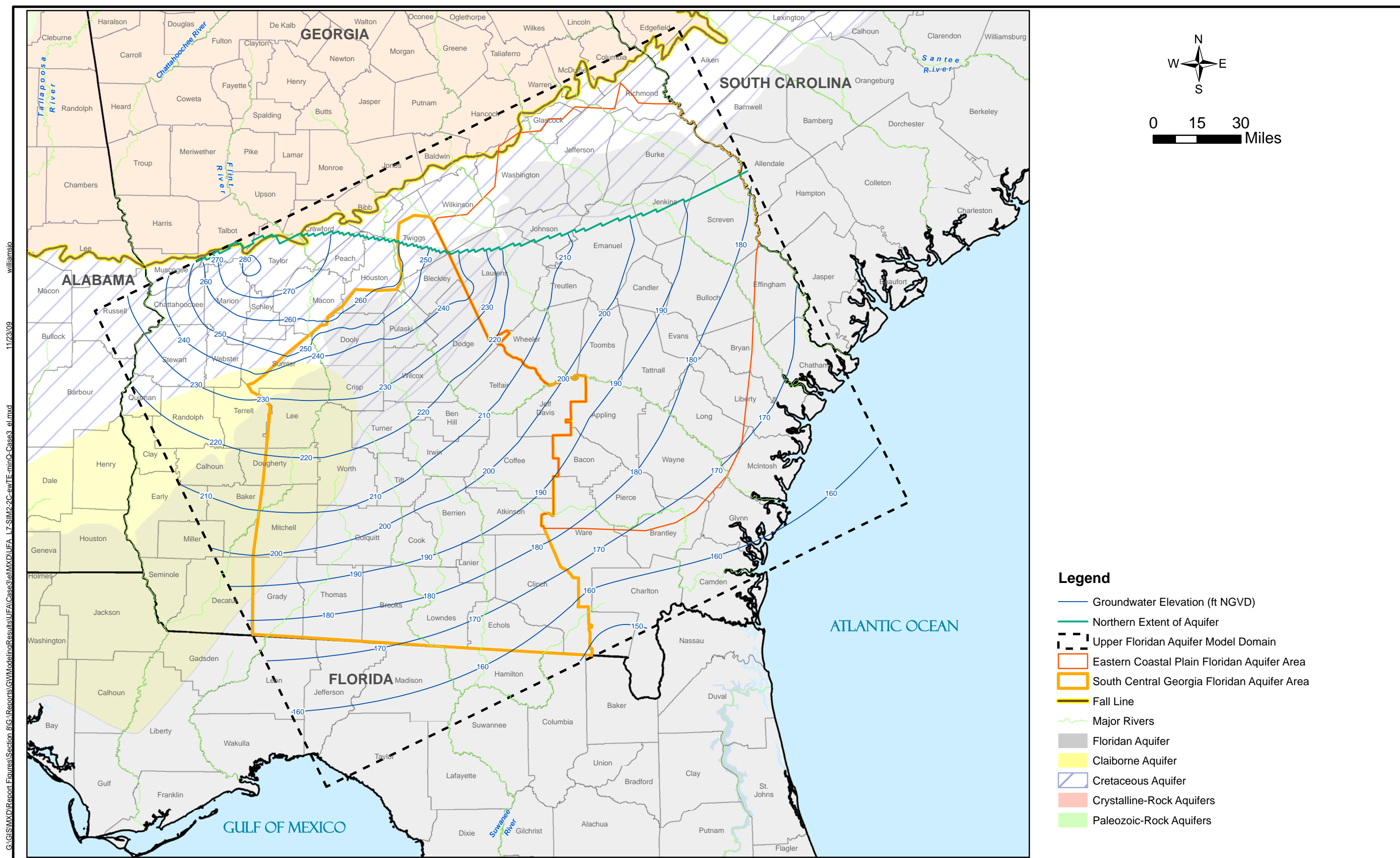


Figure 12-29
Simulated Groundwater Elevation in Providence Sand-Peedee-Dublin Aquifers (Layer 5)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



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Figure 12-30
Simulated Groundwater Elevation in Eutaw-Midville Aquifer (Layer 6)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model



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Figure 12-31
Simulated Groundwater Elevation in Upper Atkinson-Upper Tuscaloosa Aquifers (Layer 7)
At Current Pumping Conditions Using Sub-Regional Upper Floridan Aquifer Model