connected, with exchange that is spatially heterogeneous, episodically focused, and potentially enhanced by pumping-induced gradients in adjacent areas.

This investigation thus revisits a long-standing assumption in southeastern Georgia hydrogeology—that the Okefenokee is hydrologically isolated—and reframes it within the broader understanding of how confining layers behave in real landscapes: leaky, patchy, and dynamically coupled to the surface despite their apparent continuity.

2. Methods

2.1 Site description

The Okefenokee Swamp lies in the low-relief Atlantic Coastal Plain, straddling the Georgia–Florida state line (**Figure 1A**). Three flowpaths (Flowpaths 1-3) of the UFA in southeast Georgia have been identified based on predevelopment potentiometric surface (Plummer 1993). The locations of UFA wells along these flowpaths are shown in in Figure 1A, and their corresponding elevations above mean sea level (AMSL) are shown in **Figure 1B-D**. The swamp occupies a saucer-shaped topographic depression; swamp water surface elevations range from about 38 m AMSL at the northeastern rim to ~33–34 m AMSL at the southwestern outflow near Fargo, Georgia, USA (**Figure 1D**). The interior is characterized by peat accumulations (up to several meters thick) in broad prairies and cypress swamps, interspersed with slightly elevated sand "islands." The swamp's surface area expands and contracts seasonally, but generally covers ~1,500–1,800 km^2 of wetland. The climate is humid subtropical, with mean annual precipitation on the order of 1300 mm. Rainfall and runoff from a small upland catchment to the north provide nearly all water inputs, whereas losses occur via evapotranspiration and surface outflows. On a long-term basis, approximately 80 % of rainfall over the Okefenokee Swamp is lost to evapotranspiration, and the remaining 20 % exits as surface flow (Rykiel 1977), chiefly through the Suwannee River, which drains the western and northern parts of the basin, and the St. Marys River, which drains the southeast. Because this surface-water budget appeared to account for nearly all inflows, direct groundwater recharge from the swamp was long considered negligible (Georgia EPD, 2024). The prevailing interpretation held that the Miocene Hawthorn Formation formed an effective confining layer that isolated the swamp from the underlying Upper Floridan Aquifer.

Beneath the swamp's peat and sand deposits, the geologic framework consists of an unconfined surficial aquifer underlain by the Hawthorne Group, which in turn overlies the UFA (Thom 2015, Clarke *et al* 1990). The Hawthorne Group (Miocene age) is a sequence of clay and interbedded sand/carbonates that acts as a regional confining unit, limiting vertical flow. It is present throughout the Okefenokee Basin (Thom 2015)