QUEST FOR WATER IN COASTAL GEORGIA—ASSESSMENT OF ALTERNATIVE WATER SOURCES AT HUNTER ARMY AIRFIELD, CHATHAM COUNTY, GEORGIA

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Abstract. To meet growing demands for water in the coastal Georgia area, the U.S. Geological Survey, in cooperation with the U.S. Department of the Army, conducted detailed site investigations and modeling studies at Hunter Army Airfield to assess the water-bearing potential of ponds and wells completed in the Lower Floridan aquifer.

INTRODUCTION

Concern about saltwater intrusion at Hilton Head Island, South Carolina, has resulted in increased restrictions by the Georgia Environmental Protection Division (GaEPD) on permitted groundwater withdrawals from the Upper Floridan aquifer (UFA). To meet growing demands for water in the coastal Georgia area, GaEPD has encouraged use of alternative sources of water other than the UFA, including seepage ponds and wells completed in the surficial and Brunswick aquifer systems, and the Lower Floridan aquifer (LFA). During 2008–2010, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of the Army, Fort Stewart, conducted detailed site investigations and modeling studies at Fort Stewart and Hunter Army Airfield (HAAF) to assess the water-bearing potential of ponds and wells completed in the surficial aquifer system and wells completed in the LFA. These studies provide information to help manage and develop alternative water sources. This report summarizes results of water-availability evaluations conducted at HAAF.

Field investigations at HAAF include construction of a test well in the LFA and assessment of water availability at four pond sites. Test-well data include geophysical logs, core samples for hydraulic analysis, packer tests, water sampling and analysis, and aquifer testing. Pond data include bathymetry, pond volume and area, stage, discharge, and climatic data needed to develop a simplified hydrologic budget and estimate groundwater seepage. Groundwater modeling was used to evaluate the effects of LFA pumping on interaquifer leakage and groundwater levels in the UFA.

Description of Study Area

The U.S. Department of the Army, Fort Stewart and HAAF, are home to the 3rd Infantry Division (Fig. 1). The two sites are characterized by the flat topography and sandy topsoil that is typical of the Georgia coastal area. The study area has a humid subtropical climate with warm, humid summers and mild winters. The sites are underlain by Coastal Plain strata consisting of consolidated to unconsolidated layers of sand and clay and semi-consolidated to very dense layers of limestone and dolomite. These sediments constitute three major aquifer systems, in order of descending depth—the surficial, Brunswick, and Floridan (Fig. 2). The Floridan aquifer system consists of the UFA and LFA, and the UFA is the main source of groundwater supply in coastal Georgia.

Because of concern about saltwater intrusion, the GaEPD has implemented restrictions on groundwater withdrawal from the UFA and designated management zones in coastal Georgia. HAAF is located in the GaEPD "red zone" (Fig. 1), where withdrawal from the UFA is capped at 2004 rates, with the goal of reducing withdrawal by an additional 5 million gallons per day (Mgal/d) by 2008. Fort Stewart is located in the GaEPD "yellow zone," where total pumping from the UFA is limited to 5 Mgal/d above the 2004 rate.

ALTERNATIVE WATER SOURCES

To meet growing demands for water in coastal Georgia, the GaEPD has encouraged use of alternative sources of water to the UFA, including ponds and wells completed in the surficial and Brunswick aquifer systems, and in the LFA. Ponds and the LFA were evaluated as potential water-supply sources by the USGS at HAAF.

Ponds

In the coastal area, ponds are sometimes used as irrigation supply by golf courses, farms, or communities. During the dry season, when irrigation demand is highest, pond water levels are sustained primarily by groundwater seepage from the surficial aquifer system. The difference between seepage inflow to and outflow from a pond (net groundwater seepage or Gnet) was estimated at HAAF by using a water-budget approach based on data from onsite and nearby climatic and hydrologic stations. The availability of water from ponds during dry periods is controlled by Gnet, precipitation and evaporation, and the volume of water stored in the pond (Fig. 3).

Four ponds were evaluated as potential sources of water supply at HAAF—Oglethorpe Lake, Halstrum Pond, Wilson Gate Pond, and golf course pond (Clarke and Painter, 2010).

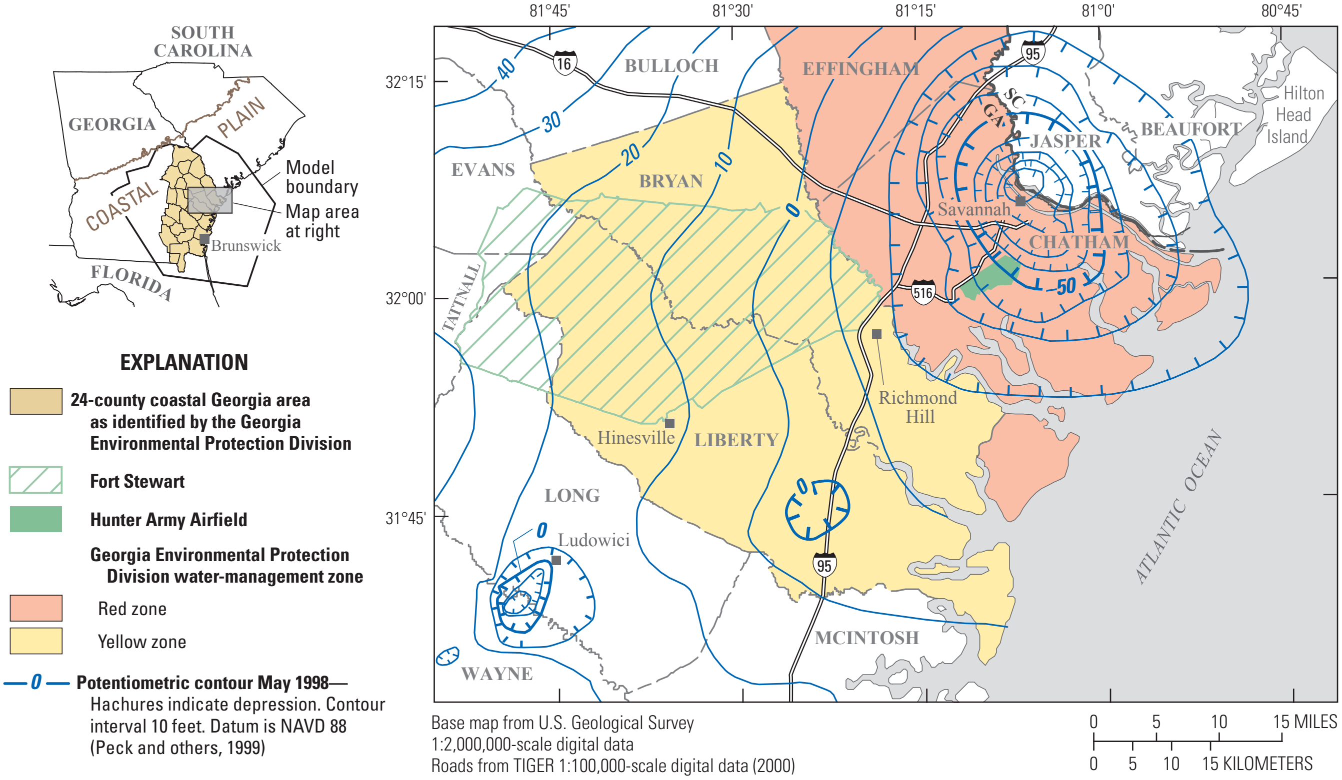

Figure 1. Location of Fort Stewart and Hunter Army Airfield, Georgia Environmental Protection Division water-management zones, and potentiometric surface of the Upper Floridan aquifer, 1998.

A water budget developed for November–December 2008 at the first three ponds (table 1) indicated maximum pond storage volumes ranging from 5.85 to 12.8 million gallons (Mgal) and cumulative Gnet ranging from –5.74 gallons per minute (gal/min), indicating a net loss in pond volume, to 19 gal/min, indicating a net gain in pond volume. A conservative estimate of the volume of water available for irrigation supply in the three ponds under typical summer conditions was provided by computing the rate of depletion of pond volume for an 8-hour pumping period at a rate of 500 gal/min, or 0.24 Mgal/d. The analysis assumed long-term average July precipitation and evaporation and the lowest estimated Gnet rate at each pond. At a withdrawal rate of 0.24 Mgal/d, available pond volume would be depleted in 24 days at Wilson Gate Pond, 31 days at Oglethorpe Lake, and 60 days at Halstrum Pond (table 1; Fig. 4). This conservative analysis assumes that daily evaporation and precipitation remain constant and that rates of Gnet remain constant as pond stage is lowered. The effects on fish populations of stage changes resulting from pond withdrawals would need to be considered when developing a water-withdrawal plan for each pond.

The water-supply potential at the golf course pond at HAAF was assessed by measuring flow downstream from the pond during February–July 2009 and examining historical stormflow measurements collected during 1979–87 (Clarke and Painter, 2010). Streamflow during both of these periods exceeded average daily (2005–2007) golf course water use (Fig. 5). Assuming an 8-hour daily irrigation period, the average discharge rate required to meet golf course water demand during the peak-demand months of March–May and July–October exceeds 200 gal/min (0.1 Mgal/d), with the greatest rate being 531 gal/min (0.25 Mgal/d) during July. During February–July 2009, daily average streamflow downstream from the golf course pond exceeded 238 gal/min (0.34 Mgal/d) 90 percent of the time, and 1,169 gal/min (1.68 Mgal/d) during the peak water-demand month of July. The golf course pond currently (September 2010) is being developed as a source of irrigation supply with a projected average withdrawal rate of 0.14 Mgal/d.

Lower Floridan Aquifer

To assess the hydrogeology and water quality of the Floridan aquifer system and the potential effects of LFA pumping on the UFA, a new LFA test well was constructed at HAAF during 2009. Field evaluation included aquifer-performance testing, packer tests, core hydraulic analysis, geophysical logging, flowmeter testing, water-quality sampling and analysis, and digital groundwater modeling (Clarke and others, 2010).

The LFA test well was pumped for 72 hours at a rate of 748 gal/min, with drawdown of 36 feet (ft), for a specific capacity of 20.8 (gal/min)/ft. Concentrations of dissolved constituents in water from the LFA were generally below drinking-water standards (U.S. Environmental Protection Agency, 2010). The deepest water sample (collected at a depth

Hydrogeologic unit[1] Savannah	Hydrogeologic unit[1] Brunswick	Aquifer system	Description
Water-table zone	Water-table zone	Surficial aquifer system	Consists of Miocene and younger interlayered sand, clay, and thin limestone beds. Includes a water-table zone and two confined zones. Provides water for irrigation supply throughout the coastal area.
Confining unit	Upper water-bearing zone	Surficial aquifer system	
Lower water-bearing zone	Lower water-bearing zone	Surficial aquifer system	
Confining unit	Upper Brunswick aquifer	Brunswick aquifer system	Upper and lower Brunswick aquifers consist of poorly sorted, fine to coarse, slightly phosphatic and dolomitic quartz sand and dense phosphatic limestone. Provides water for irrigation, public, and some small industry use, mostly in the Brunswick area.
Confining unit	Lower Brunswick aquifer	Brunswick aquifer system	
Upper Floridan confining unit	Upper Floridan confining unit		
Upper Floridan aquifer	Upper water-bearing zone	Floridan aquifer system	The Floridan aquifer system consists of carbonate rocks of varying permeability that have been subdivided into the Upper and Lower Floridan aquifers. The Upper Floridan aquifer is the principal source of water for all uses (excluding thermoelectric) in coastal Georgia. In the southern part of the coastal area, the Lower Floridan aquifer includes the saline Fernandina permeable zone, which is the source of saltwater intrusion at Brunswick. Saltwater intrusion into the Upper Floridan aquifer at Brunswick and at Hilton Head Island, South Carolina, has resulted in restrictions on water withdrawal in coastal Georgia.
Upper Floridan aquifer	Upper Floridan semi-confining unit	Floridan aquifer system	
Upper Floridan aquifer	Lower water-bearing zone	Floridan aquifer system	
Lower Floridan confining unit	Lower Floridan confining unit	Floridan aquifer system	
Lower Floridan aquifer	Confining unit	Floridan aquifer system	
Lower Floridan aquifer	Fernandina permeable zone	Floridan aquifer system	
Confining unit	Confining unit		Consists of low permeability marl that is not used for water supply.

[1]Modified from Randolph and others, 1991; Clarke and Krause, 2000.

Figure 2. Hydrogeologic units in coastal Georgia.

of 1,075 ft) had a chloride concentration of 480 milligrams per liter (mg/L), which exceeded the 250 mg/L secondary drinking-water standard. The sulfate concentration from this same sample was 240 mg/L, which was slightly below the 250-mg/L secondary drinking-water standard. Flowmeter testing results indicate that the deepest zone contributes only 2 percent of the total flow to the well and likely will not affect the quality of water in the completed well (Clarke and others, 2010).

At HAAF, results of a 72-hour aquifer test indicated that pumping a well completed in the LFA at a rate of 748 gal/min produced a drawdown response of 0.76 ft in a well completed in the UFA located 176 ft from the pumped well (Clarke and others, 2010). Steady-state model simulations indicate that pumping the LFA well produced a drawdown response in the overlying UFA greater than 1 ft over a 141-square-mile area and 2.03 ft at the pumped well. Simulated pumping resulted in a redistribution of flow among model layers, including increased downward and decreased upward leakage in all layers, and increased inflow and decreased outflow from lateral boundaries in the UFA and LFA. In the surficial aquifer, pumping the LFA resulted in increased inflow (recharge) from the general head boundary (0.36 Mgal/d). Fifty percent of the flow to the pumped LFA well was derived from increased leakage from the UFA, of which 65 percent occurred within 1 mile of the pumped well. The larger leakage near the well results from a larger head gradient between the pumped well and the overlying aquifer in areas close to the pumped well. The balance of flow to the LFA well was derived from decreased upward leakage to the UFA (48 percent) and from lateral boundaries (2 percent).

Because pumping from the LFA may increase the head gradient locally between the UFA and LFA, lower water levels in the UFA, and induce leakage (groundwater flow) from the UFA to the LFA, the GaEPD requires detailed assessments at new LFA wells. A guidance document issued in 2003 (Nolton Johnston, Georgia Environmental Protection Division, written commun., January 28, 2003) requires simulation of

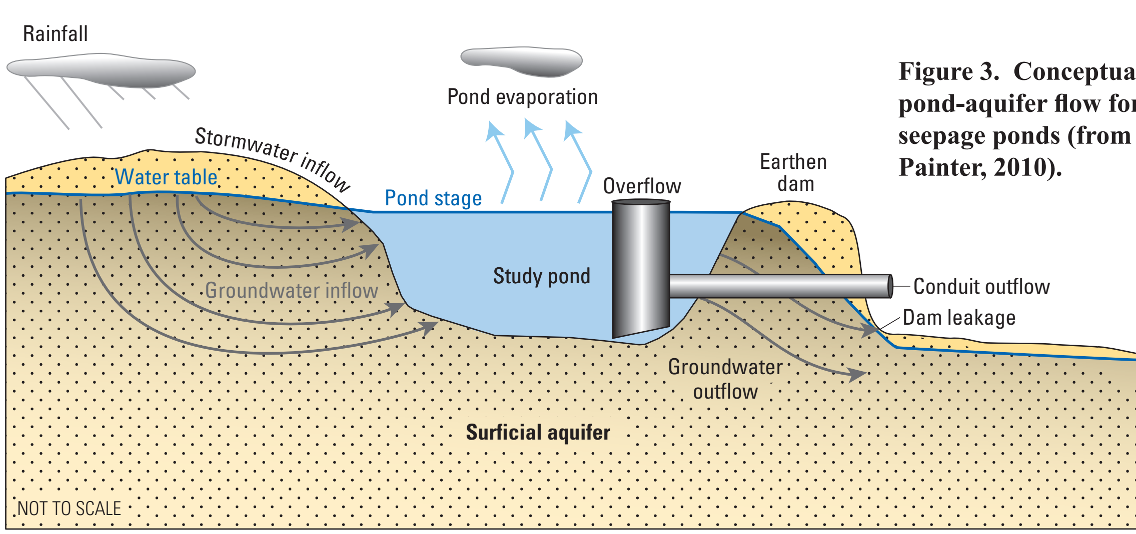

Figure 3. Conceptual model of pond-aquifer flow for coastal area seepage ponds (from Clarke and Painter, 2010).

Table 1. Summary of pond volume and net groundwater seepage and pond-volume depletion rates for Oglethorpe Lake and Halstrum and Wilson Gate Ponds, Hunter Army Airfield, Chatham County, Georgia.

[Modified from Clarke and Painter (2010); gal/min, gallons per minute]

Site	Year constructed	Acres	Maximum depth (feet)	Maximum volume (million gallons)	Average net groundwater seepage, November–December 2008 (gal/min)	Number of days for depletion of storage at 500 gal/min pumping rate[a]	Remarks
Oglethorpe Lake	1985	9.5	9	7.28	3	31	Pond dam leaking at rate of 280 gal/min in November 2008
Halstrum Pond	1968	4.6	17	12.8	19	60	
Wilson Gate Pond	1998	4.7	7	5.85	–5.74	24	

[a] Computed assuming long-term (1970–2000) average monthly precipitation (6.23 inches) and evaporation (8.49 inches), average net groundwater seepage during November–December 2008, and a pumping rate of 0.24 million gallons per day.

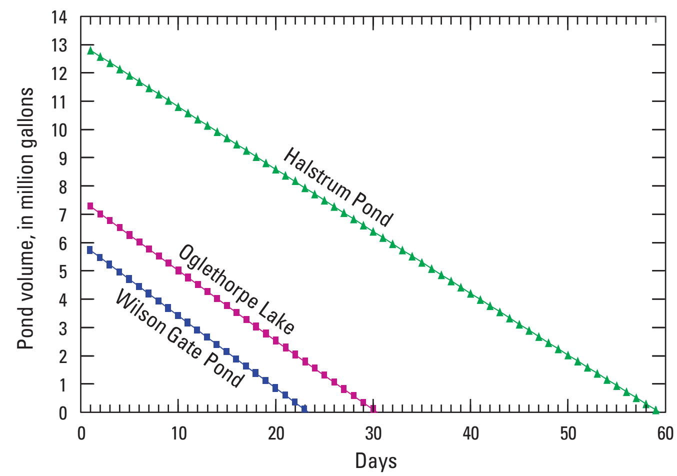

Figure 4. Hypothetical depletion rate of pond volumes as a result of 8-hour per day, 500-gallon per minute pumping rates (0.24 million gallons per day) based on long-term hydrologic conditions during July at Hunter Army Airfield, Georgia (modified from Clarke and Painter, 2010).

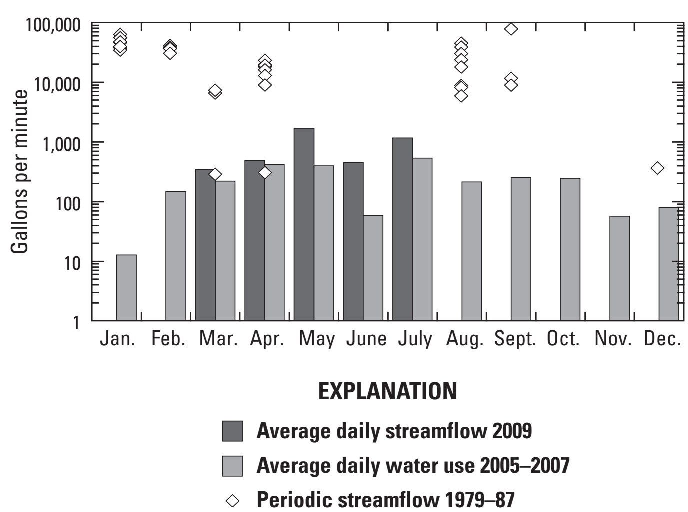

Figure 5. Average daily golf course water use, 2005–2007, periodic streamflow measurments during 1979–87, and average daily streamflow during March–July 2009 for golf course pond, Hunter Army Airfield, Chatham County, Georgia (from Clarke and Painter, 2010).

(1) aquifer leakage from the UFA to LFA resulting from pumping the new LFA well (leakage stipulation), and (2) the equivalent rate of UFA pumping that induces the identical maximum drawdown in the UFA that would be expected as a result of pumping the LFA (drawdown-offset stipulation). Results of this analysis can be used as a basis to reduce permitted pumping from the UFA in the same general area (within a 5-mile radius) by an amount equal to or greater than the determined leakage rate (Nolton Johnston, Georgia Environmental Protection Division, written commun., January 28, 2003). To address these stipulations, the USGS applied a revised regional groundwater-flow model to simulate long-term (steady-state) UFA leakage response to pumping from the LFA and to estimate the equivalent amount of pumping from the UFA that would produce similar drawdown (Clarke and others, 2010).

In the LFA pumping simulation, the UFA-to-LFA leakage rate increased by 361 gal/min (0.52 Mgal/d), and the simulated LFA-to-UFA leakage rate decreased by nearly the identical amount. In contrast, only 189 gal/min (0.27 Mgal/d) of pumping from the UFA was required to produce a drawdown equivalent to that from the LFA-pumping simulation. The discrepancy between these two rates arises because the cone of depression formed in response to pumping the UFA is steeper near the pumped well and covers a smaller area than the corresponding area simulated in response to pumping from the LFA (Clarke and others, 2010). Because the simulated leakage and drawdown offset rates cover a wide range, permitted pumping rates for the UFA and LFA will be dependent on which pumping reduction is deemed acceptable by the GaEPD. At this writing (September 2010), the GaEPD had not decided on permitted rates at HAAF.

POTENTIAL DEVELOPMENT OF ALTERNATIVE WATER SOURCES

Alternative water sources could provide some of the water supply at HAAF and alleviate stress on the UFA. Water supply at HAAF is from nine UFA wells with an average annual permit limit of 0.98 Mgal/d for all of the wells combined (Carol J. Couch, Georgia Environmental Protection Division, written commun., February 27, 2009). Additional water supply could be provided by a combination of pumping the LFA and the golf course pond (Fig. 6). Water from the other three ponds at HAAF (Table 1) are not being considered currently as water sources because of concerns about how changes in stage could affect pond oxygen levels and fish populations.

Streamflow monitoring indicates that the golf course pond at HAAF is sufficient for meeting current irrigation water demand throughout the year. The surficial aquifer system also may be a viable source for irrigation supply at HAAF, further reducing stress on the UFA. At this writing (September 2010), a surficial aquifer system test well is planned for installation and testing sometime during the fall of 2010.

Increases in total permitted withdrawals at HAAF will vary based on the amount of UFA pumping reduction stipulated by the GaEPD to mitigate leakage effects from LFA pumping. Pumping the LFA well at a rate of 1.08 Mgal/d would require reducing current UFA pumping by 0.52 Mgal/d (from 0.98 to 0.46 Mgal/d) to meet the leakage stipulation, whereas to meet the drawdown-offset stipulation would require a reduction of 0.27 Mgal/d (from 0.98 to 0.71 Mgal/d).

In summary, additional water supply at HAAF includes water provided by the golf course pond and a new LFA well, while accounting for reductions in UFA pumping mandated by the GaEPD (Fig. 6). Total water withdrawal at HAAF could increase from 0.98 Mgal/d (current UFA permit) to

- 1.68 Mgal/d if the golf course pond supplies 0.14 Mgal/d and the LFA well supplies 1.08 Mgal/d, while the UFA permit is reduced to 0.46 Mgal/d to account for offsetting total leakage response; or
- 1.93 Mgal/d if the golf course pond supplies 0.14 Mgal/d and the LFA well supplies 1.08 Mgal/d, while the UFA permit is reduced to 0.71 Mgal/d to account for offsetting maximum drawdown.

Additional supply is possible from wells completed in the surficial aquifer system and from other ponds located at HAAF.

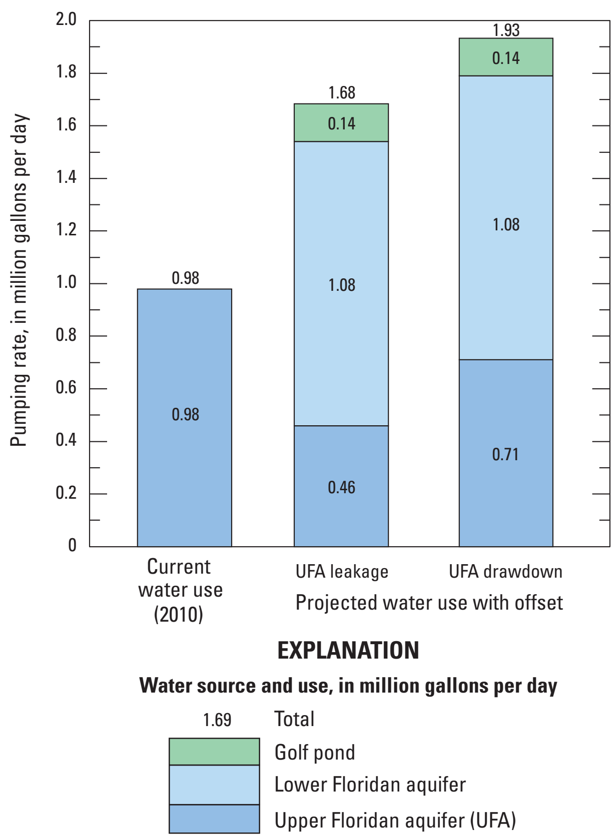

Figure 6. Current and projected average annual water use at Hunter Army Airfield, Chatham County, Georgia.

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