Revisiting farm ponds for irrigation water supply in the Southeast US

Jim Hook, Professor, Soil and Water Resources

University of Georgia, PO Box 748, Tifton, GA 31793-0748. jimhook@uga.edu

Shane Conger, Research Professional in GIS

University of Georgia, PO Box 748, Tifton, GA 31793-0748. sconger@uga.edu

Kerry Harrison, PE, Extension Irrigation Engineer

University of Georgia, PO Box 748, Tifton, GA 31793-0748. kharriso@uga.edu

Abstract. *In humid regions, agricultural irrigation developed using stream and farm pond water sources. The same droughts that pushed farmers to irrigate often made these sources unreliable. Where deep groundwater aquifers existed, wells became the water supply of choice. In the SE Coastal Plain aquifers are showing signs of over-pumping, and high energy costs are causing a fresh look at farm ponds. We cataloged and characterized many of the 60,000 water bodies in the Coastal Plain of Georgia that could be used for irrigation. Proximity to cultivated fields, catchment area, potential pond storage, and proximity to other users were considered. Average pond sizes could not supply full-season irrigation for average pivot fields, although they could for small pivots and other systems. Many pond and catchment sites remain near irrigatable fields. With proper incentives, the irrigators could increase the capacity of surface water supplies for irrigation and decrease pressure on groundwater* aquifers.

Keywords. Southeast U.S., humid region, farm ponds, man-made, reservoirs, impoundments, sprinkler irrigation, surface water supply.

Introduction

As with most regions of the country, the Southeast U.S. has experienced the pinch between water supplies and water demands. Irrigation, mostly by overhead sprinkler systems, has relied upon self-supplied water sources, especially in the Coastal Plain where most row crop and vegetable production occurs. No federal or state programs have developed regional reservoirs or water distribution systems to support production agriculture, and none of the large federal reservoirs have been purposed for agricultural irrigation.

Initially farmers used surface water sources – streams and ponds - but as they became more dependent upon irrigated crop production, they came to rely upon groundwater supplies. While the major aquifers of the region, particularly the Floridan system, are extensive, there are areas with growing evidence that withdrawals may be exceeding long-term recharge. In the Coastal Plain, homeowners, municipalities, and most industries are completely dependent upon these same aquifers. Many are in close proximity to irrigated agriculture. Long term declines in water tables, or hydraulic heads in confined portions of the aquifers, threaten not only agriculture but also industries and other commercial and household uses.

Rainfall in this humid region can supply a portion of the water needed for irrigation, just as it supplies about half of the crops needs directly during the growing season. However, the water for that irrigation must to be captured and stored until irrigation is needed. Farmers have long recognized this. Many built or expanded impoundments on their properties to provide at least a portion of their irrigation water supply.

As the region comes to grips with growing populations, greater competition for existing water supplies, and more frequent shortages during drought, it has looked at all water supplies and demands more critically. As with other regions where agriculture faces competition for water, its water use is being questioned. To the extent that agriculture can secure water that is not in direct competition with that most other users and does not threaten environmental problems, it can secure its survival. With abundant rainfall, even in drought years, the Southeast farmers can probably accomplish this.

Our objective in this study was to determine to what extent could on-farm surface water storage meets irrigation needs in Georgia. Since all planning is local, we also sought to understand where current reliance on farm impoundments was greatest.

Background

Irrigated agriculture is a relatively new phenomena in the Southeast. A humid, temperate to subtropical region, it receives a plentiful supply of rainfall in most years. The rainfall, while never evenly distributed, occurs year-round. In most years, however, evapotranspiration from native vegetation and crops will exceed rainfall from May through October. Most of the river systems are short, extending from the Appalachian Mountains to the sea or Gulf just a few hundred miles away. This combination places a premium on stored water to see users through the summer months. In the past farmers accepted the summer shortfall and just lowered their production expectations. However, in the 1970’s farmers began installing irrigation as new pivots and other sprinkler equipment became practical for irregular shaped fields and rolling topography. Within a few years, higher production levels provided a competitive edge, and neither farmers nor their financial backers were willing to accept risk of drought induced crop failures any longer.

Water supplies for these sprinkler systems, which now cover almost 1.5 million acres in Georgia alone, include streams, farm ponds, and groundwater, all located on the irrigator's property. The dense, dendritic network of streams in Piedmont and Coastal Plain landscapes gave most farmers direct access to some flowing water, and withdrawals were secured by their riparian rights. Rights or not, streams of the region generally proved unreliable because of the summer rainfall-ET deficit. Much of the summer rainfall is intercepted by plants and dry soils before it can reach the streams, and many smaller streams go dry or have reduced flow when needs for irrigation are greatest. Farmers turned to their ponds that stored rainfall from the winter excess and from periodic summer runoff events. Many that were originally built for maintaining livestock became irrigation water supplies. As farmers turned to irrigation to maximize their production efficiency, even these ponds were seen as too risky and unreliable. If groundwater was an option, as it was throughout much of the Coastal Plain, it became the preferred water source. Not only was the source less dependent upon in-season rainfall, but also wells could be placed conveniently at the pivot point or other location that minimized pipe and pumping losses. Harrison documented the transition in water supplies in the triennial Georgia Irrigation Surveys (Harrison, $2005_{a,b}$). While the number of irrigation systems supplied from ponds and streams has remained constant at about 6,000 since the early 1970's, systems supplied from wells have increased from fewer than 1,000 in 1972, to 6,000 by 1986, and to more than 10,000 by 2000.

Georgia and US Geologic Survey (USGS) monitor depth of water table or hydraulic head in wells in the primary aquifers in Georgia. While these records show no long-term water table declines in the recharge areas of the principal – Floridan – aquifer, declines of up to 1 to 1.5 ft/y have been observed in confined areas of the Floridan aquifer. These declines are particularly steep in the central Coastal Plain area, and they have persisted for almost 25 years in some wells. During droughts of 1999 to 2002 and more recently 2007 to 2008, well failures have affected many who tapped this aquifer shallowly or who relied upon the shallower Miocene aquifer above it. These are areas with extensive agricultural irrigation. Declines are commonly seen during the pumping season. These partially rebound during Fall and Winter by hydraulic heads are not returning to previous Spring levels.

In the Suwannee and Ochlocknee Basins in the Central Coastal Plain and in selected watersheds within other river basins, withdrawals permitted by the Georgia's Environmental Protection Division (EPD) exceed normal summer and fall flows of their streams. Agricultural withdrawals in Georgia are permitted by pump capacity in gallons per minute with no limits on the daily or monthly pumping. For direct withdrawals from streams that have a 7Q10 value greater than 1 cfs, there are low stream flow levels that are supposed to protect stream base flow, but no surveillance is used to assure that pumps are turned off when these levels are reached. Normally, farmers stop pumping when flow is too low to keep their pumps primed. This occurs regularly, especially during the recent drought.

Because stream flow is unreliable, and because many withdrawals are made from the same stream by neighboring farmers, most have turned to on farm impoundments to catch and retain water. These farm ponds do provide water storage, but farmers do not always have impoundments with enough capacity to last through low rainfall periods between runoff-generating events. Thus many refill their ponds with wells.

As with other areas where agricultural irrigation is practiced, conflicts arise with others who depend upon the same shared sources of surface and groundwater, and ecosystems are challenged when natural flows and discharges from groundwater are altered. In the Georgia portion of the Coastal Plain, agriculture has fewer competitors than found in most irrigated areas. Most of the surface water withdrawn for irrigation is from stream and river systems that have few urban centers downstream. Those that are there rely upon groundwater. However, the regions abundant flora and fauna, well known for its bio-diversity, can be affected when streams dry earlier, reach lower summer levels, or remain low for extended periods because of withdrawals. Interstate challenges to surface water withdrawals are based in part upon impacts on threatened and endangered species. Groundwater withdrawals for irrigation can also compete directly with other users. Rural and urban homes, municipal suppliers of most community water systems, and commercial and industrial users are often close enough to be impacted by farm withdrawals.

Recognizing the value of rainfall and runoff as a source of water in the area, Georgia soil and water conservationists have identified farm ponds as a viable water storage method for agricultural irrigation. Using Farm Bill support, they have cost shared on new or enlarged pond construction when that pond will be used for existing irrigation. This includes systems irrigated by groundwater. With a view towards understanding the overall potential of farm ponds for irrigation supply and particularly identifying areas where ponds could be used more extensively in irrigation, we set out to inventory the existing impoundments and irrigation in the Georgia Coastal Plain

Approach

Most irrigation in Georgia and other Southeastern States occurs in Coastal Plain regions. We used US Geologic Survey maps of sub-basins (HUC8) that covered the Coastal Plain region of Georgia as study areas (USGS, 2005). In Georgia there are 32 sub-basins in the Coastal Plain. Ten of these receive part of the main stem flow from upstream areas that lie in the Piedmont areas of Georgia. These Piedmont streams – Savannah, Oconee, Okmulgee, Altamaha, Flint, and Chattahoochee – pass through the Coastal Plain relatively untapped by agriculture. Together, they account for fewer than 0.1% of all permitted surface water withdrawals in the Coastal Plain. Almost all of the surface water withdrawals for irrigation are from collected runoff and streams from rainfall that originates on the 32 Coastal Plain sub-basins themselves. We sought to identify water stored in impoundments in these areas.

No single comprehensive listing or map of all man-made impoundments exists for Georgia, but several efforts have identified the vast majority of water bodies including impoundments. Water bodies connected with flowing streams have been mapped with the Southeast NHD+ GIS data layer (USGS, 2006). The layer did not provide extensive enough mapping of ponds, but it did provide the most comprehensive mapping of streams in the region, allowing us to understand the extent to which these streams are impounded. The Georgia Department of Transportation undertook the mapping of the water bodies following passage of the Safe Dams Act in 1978. Highway structures including culverts, bridges, and paving are impacted by dam failures, and during storms impoundments may back up water onto rights-of-way. The DOT mapped water bodies of all types and sizes for each of the state's 159 counties (Georgia DOT, 1999).

Overlay of the NHD and DOT data sets showed that most impoundments of NHD were also mapped by DOT, but their area and shape often differed. In addition 2007 aerial imagery showed additional water bodies that were missed by both efforts. To get a better idea of the relationship of these data sets to visible imagery, and to understand where impoundments were in relation to streams and to each other, we created random transects. Each line was 10 to 25 miles in length with random orientation and starting point in the landscape. All water bodies that were visible on aerial imagery touched by or intersected by the lines were noted and visible boundaries for each drawn. Catchment areas were measured using topographic maps. Distance to nearby upstream and downstream impoundments and stream order and stream number (expressing the position of the impoundment relative to size of the stream) were noted. Sizes of remapped ponds were compared with DOT and NHD. Finally distance to nearby irrigated fields or potentially irrigated fields was measured.

Proximity of impoundments to irrigated fields required map coverage of known irrigation. During 2006-2008, the Georgia Soil and Water Conservation Commission (SWCC) mapped irrigated field areas as they installed flow meters as per 2003 legislation requiring that all permitted water withdrawals be metered. Field technicians used GPS to locate existing withdrawal points, pivot pads, and extent of irrigation hardware, as well as boundaries of irrigated areas for other fields. These were then mapped in GIS, although for pivots, irrigated area was only shown to the end tower for pivots and not the additional area reached by the end gun. We increased wetted areas by 5% to estimate this additional area in computing total irrigation areas from this data source. Georgia's Environmental Protection Division (EPD) also maintains a mapping of irrigation in the State. These were prepared in cooperation with farmers during the permit application and evaluation process or during county based permit days that attempted to bring early permit records up to date. Where subsequent field mapping of irrigated area by the SWCC confirmed these locations, their area values were substituted for EPD's. Finally, center pivots that were not mapped in either record set but were visible in 2007 aerial imagery were mapped by systematic scan of each county's image. Area and location of each field was accomplished in GIS.

Armed with the extensive mapping of ponds and irrigated fields we began a systematic analysis to estimate those ponds which could be used in irrigation and conservatively estimating storage capacities. All ponds of 30 acres or greater were individually inspected and ruled as available or not available for irrigation. Most were ponds owned or operated by electricity generators, municipalities, parks and recreation. Others were built as features in housing developments. Unless they had permitted withdrawals for irrigation (EPD permit records) or were located in areas adjacent to cropland, these were considered unavailable for irrigation. On the other end of the scale there were numerous impoundments created as landscape features, fire protection and livestock watering on individual rural properties. Although small ponds may be drained for irrigation in drought years, ponds under two acres do not provide enough storage for more than a single irrigation on an average irrigated field or perhaps two on a small fields. More commonly when these are used in irrigation, a well is used to refill the pond and hold water that will be pumped out at a rate greater than wells in the area could supply directly for irrigation. Ponds one acre or larger that were not otherwise designated for non-agricultural uses formed the base area for potential surface water storage in the Coastal Plain sub-basins.

Storage capacity was not recorded in either USGS or DOT records of water bodies. Topographic maps can provide estimates of depth of water at the impoundment dam. However, with 10 ft contours in many areas these would be very rough. Instead we used estimates of depth to area as provided by NRCS employees who design these ponds. From their estimates, we used a conservative storage of five feet as an average over all surface area of the pond. This may be too high for older ponds partially silted in from uphill and upstream soil erosion. It is too low for new ponds, especially those over 5 acres in area.

Results

Impoundments in Coastal Plain

Transects intersected 161 pond areas. Almost 65% of these had not been mapped by USGS in its National Hydrologic Data set; however almost all of them were included in Georgia DOT maps. Sizes of these impoundments varied from one to 220 ac, with an average of 11.7 ac. The distribution of pond sizes (Fig. 1) though shows that 75% have less than 9 ac surface area.

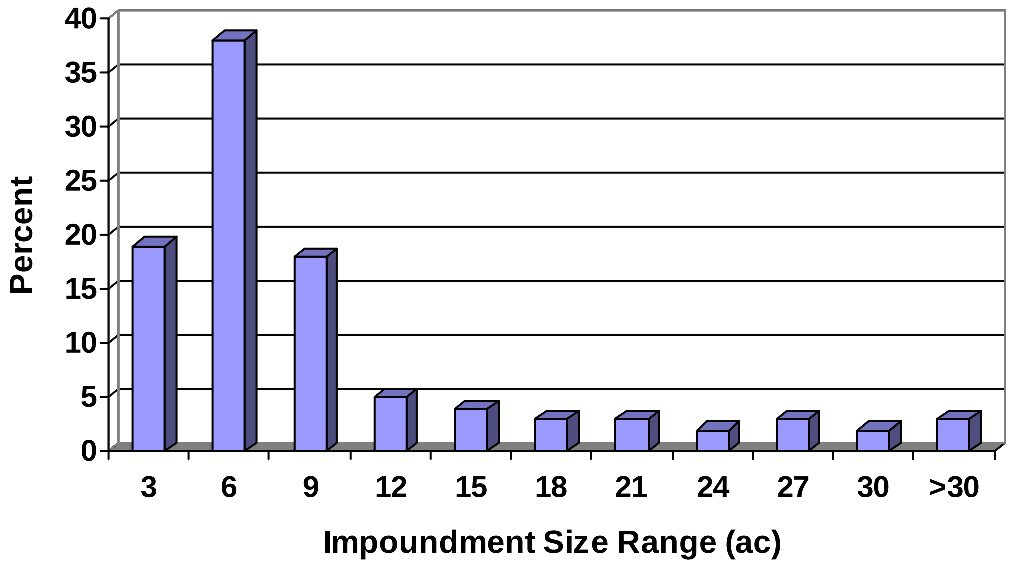

Figure 1. Distribution of pond sizes in the random sample of 161 impoundments intersected by random transects in the Georgia Coastal Plain.

We traced the source of water feeding the ponds. Catchment areas varied from 17 to more than 10,000 ac with average catchment of 900 ac. With less than 5% runoff from a catchment area following a 1 inch storm, the average catchment could provide 45 ac-ft, easily filling most small impoundments that have less than 9 ac surface area.

In the Coastal Plain, most impoundments are formed as a dam is placed across a water course. Of the 160 random ponds studied in detail, 84 or 52% were built across drainage ways that normally have no flow (off-stream). These ponds catch runoff during and immediately after a rainfall event, In a few cases interflow and even seepage from permanent water tables may support the pond. Ponds in these off-stream positions do not interfere with migration of fish or other stream life. These ponds in the Coastal Plain do typically include wetlands soil areas. New ponds require wetland mitigation if they are large, but the US Army Corps of Engineers has given blanket permission to NRCS to exempt small farm ponds for irrigation from wetland rules. While covering wetland areas near drainage ways is common, other parts of the impoundment lie outside of the wetland. This is because broad wetland areas are generally not suitably shaped for pond construction.

In addition to the 52% of ponds that were off-stream, another 36% were on first order streams. This section of the stream is the most upstream segment of flowing water in a stream system. In addition to runoff, first order streams typically are sustained by interflow and seepage from surrounding shallow water tables. They tend to dry up in drought years, but they can refill or maintain pond storage capacity between rainfall in other years. Generally speaking first order streams would have 7Q10 flows of less than 1 cfs, and EPD would not require low-flow shutoff for permitted withdrawals from these streams or ponds on them. Just 10% of ponds were on second order streams – below junction of first order streams – and only 2% of the ponds were on third order streams.

The topography of the area makes construction of large ponds impractical, however, many land-owners build one pond below another in a ‘string-of-pearls’ fashion. Of the transected ponds 46 or 28% of the ponds had at least one pond upstream. On average these were 0.59 mi upstream. There were 71 ponds, 44%, with a downstream pond located an average of 0.55 mi downstream. The close proximity provides options for management including draining an upstream pond to refill a downstream pond if pumping empties it during long rainless periods.

Analysis of ponds mapped by DOT in Georgia is startling. By their classification 81,000 water bodies have been built in the Coastal Plain. These include everything from the largest reservoirs to small dugout ponds located on individual properties. Some canals and industrial lagoons and waste storage ponds were also identified. We examined the classification of all industrial sites where they showed one or more ‘reservoirs” by their terminology using 2006 and 2007 aerial imagery. Often nearby “lake/ponds” had to be added to these sites as industrial . All lakes and ponds greater than 30 acres were also examined. Many of these are operated by others, and they often prohibit agricultural withdrawals. We classified these as power dams or regional reservoirs. A few were also mislabeled natural lakes or lagoons.

Of those impoundments remaining there were 80,000 classified as man-made structures. The distribution of sizes for these are shown in Fig. 2. We removed 35,234 ponds that were drawn with less than 1.0 ac surface area. Most of these would be considered landscape and livestock

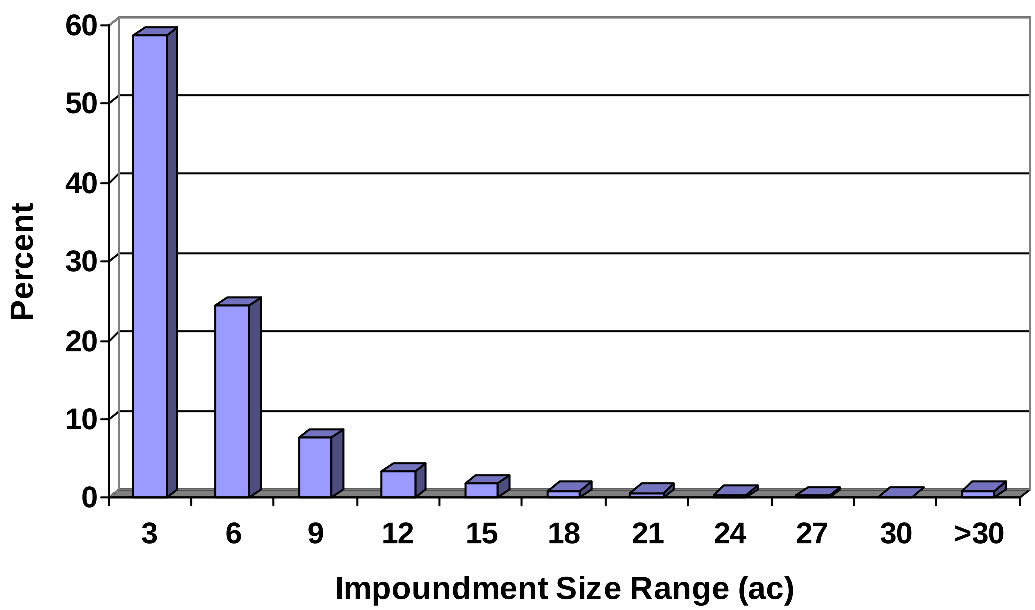

Figure 2. Distribution of pond sizes among the 44,700 ponds mapped by DOT that were greater than 1.0 acre in surface area.

ponds, although some much bigger than 1.0 ac could fit this category as well. The remaining 44,760 ponds included almost 58% that were less than 3 ac in size. Together ponds greater than 10 ac made up less than 10% of all the ponds in the Coastal Plain. Without reconstruction or enlargement, impoundments for irrigation are made up primarily from small ponds. However, the number and distribution of these ponds makes many accessible for irrigation.

Irrigation Proximity to Ponds

Irrigated areas mapped in Georgia show that there are 26,900 irrigated fields covering 1.344 million irrigated acres (Table 1). In the Georgia Department of Natural Resources designated Flint River Basin there are three sub-basins that have irrigated fields covering more than 20% of the basin's area. in the

Table 1. Irrigated field number and area by sub-basins (HUC8) in the Georgia Coastal Plain, computed ratios of irrigated area to sub-basin area, and number of potential farm ponds in the subbasin.

DNR River Basins	Sub-basin	Irrigated fields	Irrigated fields	Irrigated area/basin	Ponds
		no.	ac	%	no.
Altamaha	Altamha	515	16,850	1.88	1,657
Altamaha	Ohoopee	504	18,248	2.12	2,655
Chattahoochee	Middle Chattahoochee	178	5,851	0.32	812
Chattahoochee	Lower Chattahoochee	716	36,998	4.63	399
Flint	Middle Flint	2,226	132,449	13.27	1,534
Flint	Kinchafoonee-Muckalee	1,605	84,572	11.98	808
Flint	Lower Flint	2,231	174,472	21.35	1,284
Flint	Ichawaynochaway	2,187	118,569	16.75	979
Flint	Spring	2,388	146,944	29.06	739
Flint	Apalachicola	44	2,183	3.57	49
Ochlockonee	Apalachee Bay-St. Marks	8	230	0.15	100
Ochlockonee	Upper Ochlockonee	1,278	51,484	8.65	2,623
Ochlockonee	Lower Ochlockonee	264	13,094	5.11	398
Ocmulgee	Lower Ocmulgee	1,867	96,145	6.46	2,930
Ocmulgee	Little Ocmulgee	390	15,699	3.05	1,309
Oconee	Lower Oconee	376	14,027	0.91	2,997
Ogeechee	Upper Ogeechee	457	30,494	2.60	1,785
Ogeechee	Lower Ogeechee	448	25,521	3.18	1,695
Ogeechee	Canoochee	805	27,054	3.05	2,960
Ogeechee	Ogeechee Coastal	26	561	0.06	532
Satilla	Satilla	1,751	61,797	3.61	3,717
Satilla	Little Satilla	360	16,239	3.19	597
Satilla	Cumberland-St. Simons	15	367	0.07	316
Savannah	Middle Savannah	93	7,936	0.68	1,055
Savannah	Brier	192	14,667	2.70	948
Savannah	Lower Savannah	105	5,844	0.98	483
St. Mary	St. Marys	21	573	0.08	200
Suwannee	Aucilla	89	5,357	2.77	258
Suwannee	Upper Suwannee	44	1,012	0.08	308
Suwannee	Alapaha	2,356	89,669	8.14	3,352
Suwannee	Withlacoochee	1,121	51,916	6.26	2,560
Suwannee	Little	2,276	77,520	13.57	2,971

The comparison of pond numbers versus irrigated field numbers gives some impression of disparities that exist in some of the heavily irrigated sub-basins (Table 1). For example in the five sub-basins of the Flint basin that have large numbers of irrigated fields, each has fewer ponds than irrigation systems, often by half. In most of the other basins, ponds outnumber irrigated fields by more than 2:1. The Lower Flint River Basin which includes all or most of the sub-basins shown, is known as the Dougherty Plain. The region is unsuited to pond development. The terrain is nearly flat, and it has few streams. It has karst topographic features from the underlying thinly covered formations that make up the Floridan aquifer. In addition to unsuitable pond sites, shallow and productive wells can provide as much water as irrigators need.

In the Suwannee's Alapaha, Little, and Withlacoochee sub-basins, irrigation systems are also numerous. Here however, the Floridan is overlain by a thick clay and sand layer that serves as an aquiclude preventing recharge to the Floridan. The area can be tapped by wells in most areas, but bore holes are deeper and pumping rates lower than in the Dougherty Plain. The rolling topography known as Tifton uplands and underlying clay created a well-developed network of streams, and ideal pond sites are numerous. Farmers in this area build and depend upon surface water impoundments for part of their water supply. This is also the area where the greatest declines in groundwater head have been observed. Increasing dependence upon surface water here may help stabilize groundwater levels.

While sub-basin examination gives some idea of areas where both ponds and irrigated fields are numerous, it does not show whether they are close enough to irrigated fields to be put to that use. We looked at transect data to help clarify that. Ponds with pumps permitted or metered for irrigation withdrawals were obvious indicators of proximity. Approximately 25% of random ponds in our Coastal Plain transect survey had permitted or metered pumps in place. Additionally, aerial imagery showed that 66% of the random ponds had a farm field within 1300 feet of the edge of the pond. The quarter mile pumping distance is approximately the point at which pipe and installation begin to approach the cost of a well in the region. However, given low yield of some wells, farmers may chose to pump further from a reliable surface water source.

Irrigation Demands versus Supply in Impoundments

Irrigation amounts in the Georgia Coastal Plain were observed between 1999 and 2004 through the Ag Water Pumping study (Hook et al. 2005). For five years, almost 800 farms fields from randomly selected permitted withdrawals were metered. Monthly observations of crop type and irrigation were recorded by a team who drove throughout the region. Data was summarized by water source, sub-region, basin, county and irrigation type. Farmers who irrigated directly from wells applied more water than farmers who used surface water sources. Three of the observation years were during the prolonged 1998- to 2002 drought in the Southeast. Farmers had difficulties obtaining surface water from streams, and ponds did not refill before later season irrigations were needed. Most who used wells, including those who used wells to refill their ponds met reasonable needs for irrigation, as they judged adequate. Because we see these groundwater source irrigation as a truer measure of farmers intention to irrigate, we used the average application depths for them to estimate the irrigation water supply that would be needed if farmers relied upon water stored in the regions ponds. Those irrigation application depths are shown (Table 2) under each basin as a range. The lower number was application depths observed in the basin for 2004, an average year, while the higher value was average application depth for 2000, 2001and 2002, all drought years. The application depths vary by watershed in part because of differences in predominant crops, irrigation systems, soils, and production levels. For the comparison with pond capacity the upper or drought year value was used to compute irrigation amount in ac-ft/year (Table 2) from irrigated acres (Table 1).

Table 2. Irrigation requirements (demand) by sub-basin in drought years, total of pond surface area, estimated pond capacity as computed as 50 % of ponds available for irrigation and all ponds have 5 ft of water over their surface area. Percent of annual irrigation requirement that could be met by that estimated pond capacity for each sub-basin.

DNR Watershed	Sub-basin	Irrigation requirements	Pond area	Pond capacity	Annual Supply
		ac-ft	ac	ac-ft	%
Altamaha	Altamha	8,140	6,163	15400	100
5.2-5.8 in/yr	Ohoopee	8,820	10,031	25100	100
Chattahoochee	Middle Chattahoochee	4,920	4,099	10200	100
7.9-10.1 in/yr	Lower Chattahoochee	31,100	1,634	4090	45
Flint	Middle Flint	111,500	6,954	17400	16
7.9-10.1 in/yr	Kinchafoonee-Muckalee	71,200	4,726	11800	16
	Lower Flint	146,800	6,706	16800	17
	Ichawaynochaway	99,800	6,834	17100	17
	Spring	125,400	2,936	9840	8
	Apalachicola	1,840	144	360	20
Ochlockonee	Apalachee Bay-St. Marks	335	709	1770	100
7.8-17.5 in/yr	Upper Ochlockonee	75,100	10,687	26700	36
	Lower Ochlockonee	19,100	1,701	4250	22
Ocmulgee	Lower Ocmulgee	140,200	13,022	32600	23
7.3-10.9 in/yr	Little Ocmulgee	22,900	5,268	13200	58
Oconee 8.0-11.8 in/yr	Lower Oconee	13,790	14,567	36400	100
Ogeechee	Upper Ogeechee	31,000	8,914	22300	72
9.3-12.2 in/yr	Lower Ogeechee	25,900	7,698	19250	74
	Canoochee	27,500	12,794	32000	100
	Ogeechee Coastal	570	2,493	6230	100
Satilla	Satilla	36,600	13,181	33000	91
5.1-7.1 in/yr	Little Satilla	9,600	2,391	5980	62
	Cumberland-St. Simons	217	1,368	3420	100
Savannah	Middle Savannah	8,070	4,854	12140	100
9.3-12.2 in/yr	Brier	14,900	4,327	10820	73
	Lower Savannah	5,941	2,022	5060	85
St. Mary	St. Marys		837	2092	
Suwannee	Aucilla	3,040	1,348	3370	100
5.2-6.8 in/yr	Upper Suwannee	573	860	2150	100
	Alapaha	50,800	15,982	40000	78
	Withlacoochee	29,400	12,597	31500	100
	Little	43,900	11,867	29700	68

Pond area, the sum of all potential agricultural ponds within a basin was shown in Table 2. Since the transect study showed that already 25% of ponds are involved in irrigation and that 66% were close enough to fields to be used in irrigation, we examined the impact of doubling active irrigation from 25% to 50% of the farm ponds in each basin. Further we assumed that the average pond could yield 5 ft of water over the entire surface area of the ponds. While this could readily be obtained from larger and deeper ponds, some of the smaller ponds may require one refilling to provide that much water, a likely occurrence in most years including drought years in the Coastal Plain. Pond capacity thus was computed as surface area X 0.5 X 5 ft for each sub-basin.

In two thirds of the sub-basins, all of the regions irrigation could be supplied from ponds if 50% of them were used in irrigation as described. The greatest disparity between irrigation demand and pond capacity occurred in the Flint and Ochlockonee Basins. As mentioned earlier the Flint has a plentiful supply of groundwater and little opportunity for increased ponds, particularly in the Dougherty Plain area of the Flint. One fifth to one third of the demand could be met in the Lower and Upper Ochlockonee sub-basins. This is an area where pecan groves, sod farms, and ornamentals are produced and demand is higher her than in most basins. In most of the remaining sub-basins 50% or more of the annual demand could be met if pond withdrawals were increased. In many cases a single filling at the start of the growing season would suffice if seepage and evaporation did not reduce available water in storage.

With an average area for DOT-mapped ponds only 4.5 acres, average pond sizes could not supply full-season irrigation for average pivot fields of 100 acres as indicated in Georgia Irrigation Surveys (Harrison 2005a,b). However, with ponds doubled up and for smaller pivots and other fields, average and larger ponds could serve needs of most farmers of Georgia.

Conclusion

Ponds have been built in Georgia Coastal Plain for many reasons. The relationship of ponds to irrigated field numbers suggests that many were built in part to support irrigation. However, ready access to the Floridan aquifer in most areas of the Georgia Coastal Plain has led many to depend more heavily upon groundwater for irrigation supplies. Analysis of pond numbers, current use for irrigation, and proximity to irrigated fields suggests that in areas where groundwater supplies are overtaxed, farmers could turn to surface water as a reasonable alternative for areas outside of the Flint River basin. With proper incentives, the irrigators could increase the capacity of surface water supplies for irrigation and decrease pressure on groundwater aquifers.

Acknowledgements

We want to acknowledge the National Peanut Board's Southeastern Peanut Research Initiative and the Georgia Commodity Commission for Peanut whose 2003 funding permitted initiation of this study.

References

Georgia DOT. 1999. Georgia DLG-F Polygonal Hydrography. Georgia Department of Transportation. http://gis1.state.ga.us

Harrison, K. A. 2005a. Georgia Irrigation Survey - 2004. CES Misc. Pub. January 22, 2005.Athens, GA. (available http://www.nespal.org/sirp/agwateruse/facts/survey/)

Harrison, K. A. 2005b. Irrigation Survey for Georgia. p. In. K. J. Hatcher (ed.) Proceedings of the 2005 Georgia Water Resources Conference. Univ. of Georgia Institute of Ecology, Athens, Ga.

Hook, J.E., K.A. Harrison, G. Hoogenboom, and D.L. Thomas. 2005. Ag Water Pumping. Final Report of Statewide Irrigation Monitoring. Project Report 52. Ga. Geol. Survey, Envir. Protection Div., Atlanta, GA. 124p.(available http://www.nespal.org/sirp/awp/)

Hook, J.E., and E. R. Blood. 2001. Mapping agricultural withdrawal permits and irrigated area in the Lower Flint Basin. p.105-109. In. K. J. Hatcher (ed.) Proceedings of the 2001 Georgia Water Resources Conference. Univ. of Georgia Institute of Ecology, Athens, Ga.

Hook, J.E., K.A. Harrison, C. Lewis, D. Betts, and A. Alfonso. 2007. Agricultural Water Permitting: Turning regional plans into permitting decisions. DVD, 4 p. pdf.. *In* T.C. Rasmussen, G.D. Carroll, A. Georgakakos (eds.) Proceedings Georgia Water Resources Conference, March, 2007. Athens.

USGS. 2005. Georgia Land_Classification, coverages, huc8.
https://gis1.state.ga.us/index.asp?body=preview&dataId=2460

USGS. 2006. Region 03, Version 01_01, National Hydrography Dataset.
http://www.horizon-systems.com/nhdplus/HSC-wth03.php