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Why Does Florida's Aquifer Continue to Decline Despite Regulations Aimed at Preserving It: An Institutional Analysis and Way Forward

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ABSTRACT: Globally, aquifers underpin food security and domestic water supplies, yet many are severely threatened by over-extraction and pollution. In the southeastern United States, the Floridan Aquifer System is the primary source of water for drinking and other uses, especially in Florida. The system is distinctive because in Florida alone, it includes roughly 1100 artesian springs and extensive underwater caverns. Despite clear evidence that the aquifer and springs are seriously impaired, and despite legal and regulatory requirements for sustainable use, the state continues to issue consumptive-use permits and allow pollution to worsen. Why does this continue? After reviewing evidence of aquifer and spring deterioration, this paper analyses the legal and institutional framework governing Florida's water resources. It argues that Florida has adopted a centralized regulatory system dominated by large-scale water users, creating little incentive to prioritize conservation. The paper concludes with recommendations for reform, while recognizing the obstacles such reforms would face. Without radical governance reforms, Florida is likely to face an existential challenge as development priorities collide with the decline of the Floridan Aquifer System.

KEYWORDS: Aquifer, groundwater governance, springs, Floridan Aquifer System, nitrates, Florida, USA

INTRODUCTION

The United Nations reports that the world has gone from having a water crisis to 'Global Water Bankruptcy'. This means we have compromised the quantity and quality of water in our 'savings accounts', such as groundwater, so the damage is irreversible (Madani, 2026). Humans must radically change how they govern and use water. Groundwater overexploitation is threatening food security and domestic water supply. It is essentially a governance challenge because of the unique characteristics of large aquifers: they are common property resources that are invisible, have no clear boundaries, and are easily accessible. Further, many legal systems recognize a right to use any water found underneath one's land. Countries and communities have been attempting to find effective ways to govern this vital resource with, at best, mixed success.

In the United States, the Floridan Aquifer underlies the entire state of Florida as well as portions of Alabama, Georgia, and South Carolina; and it extends into the Gulf of Mexico and the Atlantic Ocean. The Aquifer averages 1000 feet (305 m)[1] thick, and freshwater can extend to a depth of 2000 feet below the land surface. It is thickest in the northern and central parts of Florida and rapidly thins toward the south and the coast. In northern and central Florida, it provides more than 90% of the water supply, including for ranching and agriculture. This area is also the location of a unique set of interconnected underground caverns and artesian springs that, historically, have been characterized by pure, clear water. Their

[1] Most data in Florida are in British units (inches, gallons, etc.). I have inserted metric equivalents in most cases.

temperature is about 72 degrees Fahrenheit (F; 22.2^0 Celsius) year-round. They support unique aquatic ecosystems and an important tourist industry.

But like other large aquifers, the Floridan Aquifer is threatened by over-pumping and deteriorating water quality. Some springs have stopped flowing; many are highly polluted. This is largely a result of the rapid development of the state, which supports a growing population, large-scale but perfectly legal pumping from the aquifer, and water pollution, especially nitrates from agricultural and landscape runoff. The state government recognized the need to reform water resources governance more than four decades ago. Legislation in 1972 switched water rights from a common law basis to state ownership of all water resources as a public resource held in trust for the benefit of its citizens. It established five water management districts (WMDs) based on the major river basins and promulgated numerous detailed regulations. State agencies are directed to protect fish, wildlife, and natural systems while also meeting growing municipal and agricultural demands (Stoa, 2014). But the legislation does not set priorities for balancing these interests.

There is widespread awareness of the problem, and the state invests in various programs to preserve the springs. Nevertheless, the deterioration of both the aquifer water level and water quality continues without abatement. Why is this? This paper argues that it is a result of serious flaws in the institutional arrangements that lead to perverse incentives. The focus is primarily on conditions in northern and central Florida, where most of the natural springs are located. The paper is based on an extensive review of literature, including grey literature available on the internet. It has also benefited from two detailed critical reviews by a knowledgeable specialist.

The next sections describe the Floridan Aquifer System and the institutional setup for governing water use in Florida. This is followed by an analysis of why the current governance system is failing. The conclusions and recommendations for reform follow.

THE FLORIDAN AQUIFER

The aquifer

This section briefly describes the Floridan aquifer and trends in its level and quality. Marella and Berndt (2005) and Scott et al. (2004) provide detailed descriptions of the aquifer's characteristics and geology.[2]

Aquifers are, essentially, underground, porous rocks that hold water and allow it to move through the holes within the rock. The Floridan Aquifer System covers approximately 259,000 km^2 and is composed of a thick sequence of carbonate rocks (limestone and dolomite); the thickness varies and is at its thickest in southern Florida. From top to bottom, the major hydrogeologic units of the Floridan aquifer are the Upper Floridan aquifer, middle confining and composite units, and the Lower Floridan aquifer. The middle confining unit restricts the movement of water between the Upper and Lower Floridan aquifers in some areas.

Throughout most of its extent, the Upper Floridan aquifer is overlain by sand, clay, and limestone. The clay and limestone generally comprise the intermediate aquifer system, i.e., confining units to the Upper Floridan aquifer, because they are less permeable than the Upper Floridan itself. Rainfall is the main source of recharge: of the average 130 cm of annual rainfall, an estimated 33 cm recharges the aquifer annually in the unconfined or semi-confined areas. However, rainfall varies considerably from year to year: several years of drought may be followed by several years of flooding; aquifer levels respond

[2] See also the USGS site (https://fl.water.usgs.gov/floridan/intro.html) and the St. Johns River Water Management District site (https://www.sjrwmd.com/water-supply/aquifer/#:~:text=The%20largest%20aquifer%20in%20the,America%20and%20the%20Atlantic%20Ocean) (accessed 30 July 2026)

directly to this variability (Meindl, 2024). Recharge is lowest in areas where the clay and limestone are thickest.

Natural discharge from the Upper Floridan aquifer occurs throughout Florida and southern Georgia, most commonly through springs. This characteristic makes the aquifer unique. A spring is formed when groundwater under pressure flows out through a natural opening in the ground. Ninety percent of the identified springs are in Florida.[3] The state's 'Springs Heartland', covering an estimated 5,664 square miles (260 km^2) in the Suwannee River Basin, accounts for over 300 major springs.[4] Cumulative discharge from Florida's springs has been estimated at nearly eight billion gallons per day (30.3 Mm^3/d) (Marela and Berndt, 2005). This water provides or augments streamflow throughout northern and central Florida as well as southern Georgia. There are also some springs discharging offshore into the Atlantic Ocean or the Gulf of Mexico.

Withdrawals from the Floridan Aquifer

Florida does not systematically monitor the quantity and quality of its water resources, including the aquifers and springs. There is no agreed baseline for comparison to establish trends, and no agreement on the causes of perceived declines in the water table or in spring water quality. Lake, river, and aquifer water levels are monitored by the water management districts.[5] However, when permits for large water withdrawals are issued, there is no monitoring of the actual water use (Meindl, 2024). Reliable recent data are difficult to find; a recent blog by the President of the Howard T. Odum Florida Springs Institute (Hereafter, the Florida Springs Institute) suggests there are no recent, reliable data that account for the millions of private wells used for domestic water and landscape irrigation.[6]

The current official data on Florida's water withdrawals dates from 2015 (Marella, 2020). These data are out of date, but there is no agreement on trends since that time: some studies suggest that the quantity pumped may have levelled off. Unfortunately, the two official data sources, from the United States Geological Survey (USGS), are not directly comparable, as the earlier study (Marella and Berndt, 2005) appears to count total water withdrawals as being from the aquifer. The most recent USGS study (Marella, 2020) distinguishes between withdrawals from ground and surface water; but this is an artificial construct given their high level of connectivity. These data are presented here in the absence of better data.

According to the earlier study by Marella and Berndt (2005), from 1950 to 2000, withdrawals of water from the Floridan aquifer system increased by more than 500% from 630 Mgal/d[7] (2.4 million m^3/d) in 1950 to 4020 Mgal/d (15.2 million m^3/d) in 2000. The increase is attributed to population growth, tourism, agricultural production, including livestock, and industrial uses, including mining and bottled water. Cumulatively, this led to extensive water-level drawdowns and saltwater intrusion in many coastal areas. For example, in northeastern Florida and eastern Georgia, aquifer levels declined since 1950 at an average rate of about one-third to one-half foot (10.2-15.2 cm) per year, while along coastal areas of the western panhandle of Florida, water levels declined about 100 feet (30.5 m) between 1950 and 2000. Spring water quality, polluted by agricultural and landscape chemical runoff, untreated stormwater runoff, and sewerage from septic tanks, also declined significantly over the same period (Marella and Berndt, 2005).

[3] New springs are identified every year.

[4] Robert Knight, https://www.theinvadingsea.com/2026/05/06/florida-springs-heartland-suwannee-river-most-endangered-groundwater-water-managment/ (accessed 3 August 2026)

[5] As an example, here is a link to the Suwannee River Water Management District data: www.mysuwanneeriver.com/507/Water-Data-Portal

[6] Robert Knight, https://www.theinvadingsea.com/2026/05/06/florida-springs-heartland-suwannee-river-most-endangered-groundwater-water-managment/ (accessed 3 August 2026)

[7] Mgal/d = million gallons per day.

Table 1 presents the estimated total withdrawals by category in 2015. By 2015, the total withdrawal of fresh water had increased to over 5,720 Mgal/d (21.7 million m^3/d) – a 42% increase in just 15 years. At that time, 92% of Florida's population obtained their domestic supply from groundwater. 'Agricultural self-supplied' was the second largest freshwater-use category in 2015, after public and private domestic use, accounting for 37% of the statewide total freshwater withdrawals. The irrigation data are unreliable, but according to Marella (2020), agricultural water use in 2015 was substantially lower than during most of the previous 30 years. This may be because of a decline in irrigated area due to rapid urban development (Williss et al., 2026).

Table 1. Total water withdrawals in Florida by category, 2015 (Mgal/d)

Category	Freshwater			Saline water			All water
	Ground	Surface	Total	Ground	Surface	Total	Total
Public supply	1,908.7	305.9	2,214.6	169.1[a]	1.1[a]	170.3[a]	2,384.9
Domestic self-supplied	176.9	0.0	176.9	0.0	0.0	0.0	176.9
Commercial-industrial-mining self-supplied	297.9	111.0	409.0	0.0	3.1	3.1	412.0
Agricultural self-supplied	1,010.7	1,078.1	2,088.8	0.0	0.0	0.0	2,088.8
Recreational-landscape irrigation [b]	181.9	215.6	397.5	0.0	0.0	0.0	397.5
Power generation	27.8	406.2	434.0	28.5	9,396.3	9,424.8	9,858.9
Totals	3,603.9	2,116.9	5,720.8	197.7	9,400.5	9,598.2	15,319.0

Source: Marella (2020: Table 1). All values are in Mgal/d. One Mgal/d equals 3785.4 m^3/d.

[a] Includes water withdrawn that is either treated through a desalination process or diluted with freshwater to meet drinking water standards. Before 2015, this water was classified as freshwater.

[b] Apparently includes landscape irrigation, and other domestic outdoor uses such as swimming pools.

Trends in water quantity and quality: The springs

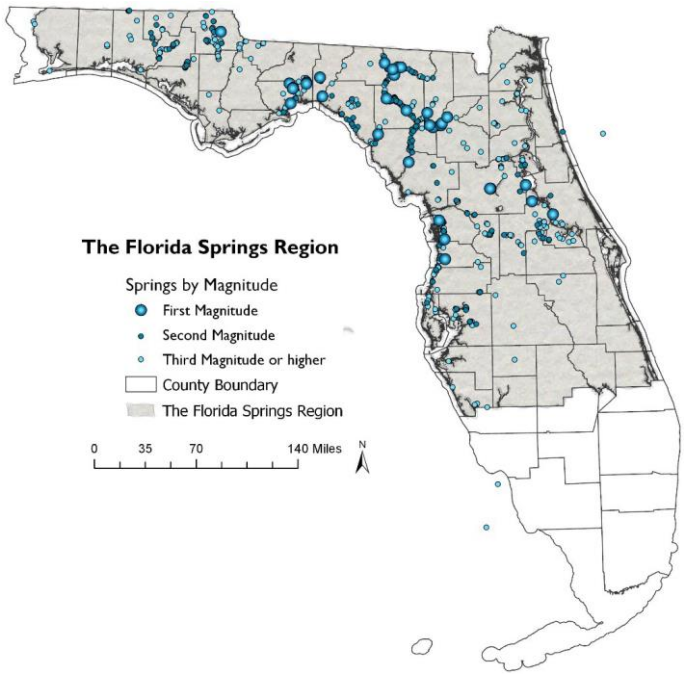
Groundwater supports a wide variety of natural and human-centred ecosystems. Such systems exhibit complex behaviours, such as feedback, nonlinear processes, multiple stable system states, and path dependency (Huggins et al., 2023). Therefore, changes in one parameter, for example, disruptions of natural flows or pollution, can have significant impacts throughout the system.

The Florida Springs Region (Figure 1), the focus of this paper, covers northern and central Florida, including four of the five Florida water management districts.[8] Springs occur in areas where karst features (sinkholes and caves) are common, the potentiometric surface of the Floridan Aquifer System is high, and surface elevations are low enough to allow groundwater to flow at the surface (Scott et al., 2004). Springs support unique aquatic ecosystems. They are monitored not only for their own value as resources, but

[8] Artesian springs are not currently found in the South Florida Water Management District. See Figure 1.

as a proxy for monitoring the Floridan Aquifer System. Most of Florida's springs have an average year-round water temperature of about 22.2^0 C. The water is clear and sparkling, 19 state parks are named after their springs. Millions of people visit them every year; indeed, the very heavy recreational use has become a serious threat to springs' ecosystems and water quality (Meindl, 2024).

Figure 1: The Florida Springs Region



Source: Florida Springs Institute map; data from Florida Department of Environmental Protection and Florida Geological Survey.

Many institutions have been studying and monitoring Florida's springs since the early twentieth century. In addition to the USGS (e.g. Konikow, 2013; Marella and Berndt, 2005) and the Florida Geological Survey (e.g. Scott et al., 2004), the Florida Springs Institute (2021a, b, 2022, 2024, 2025) has played an especially significant role. The findings have been consistently negative: not only are water withdrawals reducing spring flows and levels, but water quality is declining and becoming an increasingly serious risk to human and ecosystem health. The Florida Springs Council is a policy and advocacy organization that seeks to protect the springs, often using data from the Florida Springs Institute.[9]

Knight and Clark (2016) used discharge data from 393 artesian springs to estimate decadal discharge trends since the decade 1930-1939. They found that average spring flows declined by about 32% up to 2010. There is insufficient information concerning the safe yield of the Floridan Aquifer System, but their water balance methodology, unlike groundwater simulation models used by the state, suggests that too much water is being withdrawn. Based on biological research conducted in Florida springs, they estimate that these flow reductions are two to six times greater than the level of declines known to significantly harm aquatic resources.

In 2021, the Florida Springs Institute (2021a) implemented a 'Blue Water Audit' in the Florida Springs Region. The study synthesized data from multiple sources and focused on groundwater withdrawals and nitrogen loading, two significant anthropogenic impacts affecting the health of the aquifer and springs. The Audit developed detailed water quality and quantity footprints for the entire area. High and severe

[9] Indeed, there are overlapping members of their boards.

groundwater withdrawal footprints were found in areas with high population densities, large industrial uses such as phosphate mining, and thousands of properties with large agricultural water permits. Similarly, the nitrogen (nitrate) footprint results showed many areas with extremely high levels. Fertilizers made up the largest percentage of the total estimated load at 43%: an estimated 20.9 million pounds (9.5 million kg) of nitrogen are added to the aquifer each year in the Florida Springs Region (Florida Springs Institute, 2021a). There is also evidence that per- and polyfluoroalkyl substances (PFAS) are present in most springs, and in some, their levels are high enough to threaten human health (Holden et al., 2024).

During 2021-2022, the Florida Springs Institute monitored four major recreational springs, Lafayette Blue, Troy, Fanning, and Manatee, located in the middle and lower Suwannee River basin. Over the past 40 years, the Institute reports these springs have experienced accelerating reductions in average flows, increasing nitrate pollution, loss of native vegetation, proliferation of filamentous algae, and declining recreational use. These trends continue. All four require immediate interventions to reverse their decline (Florida Springs Institute, 2022).

Another 2023-2024 study of Silver Springs, an important recreational destination, documents significant declines in multiple water quality measures. Compared to historic data, Silver River's discharge has declined by 33% (~294 cubic feet per second [8.3 m^3/s]) from the historic average rate. In August 2026, its discharge had declined further, to less than half of its historic average.[10] The Total Maximum Daily Load (TDML) of nitrogen is 0.35 mg. Nitrate-nitrite levels in 2023 were more than three times the ecosystem impairment level; some major springs have levels 15 times the 'safe' level.[11] Nitrate levels have been rising since 1908 at a linear average of 0.0124 mg per litre per year (mg/L/y) (Florida Springs Institute, 2024).

A more recent study (Florida Springs Institute, 2025) examined the impact of dairy farming on the aquifer and springs in a portion of the Suwannee River, where there are over 85,000 dairy cows. These dairy farms produce an estimated nine million kg of nitrogen each year, of which an estimated 952,544 kg reaches the Floridan Aquifer System. Years of groundwater monitoring have shown that nitrate concentrations are well above the established safe level of 10 mg-N/L in drinking water supplies, leading to a higher-than-expected incidence of colorectal cancer in the region. Some biotic communities are also badly affected.

In 2025, it was reported that the USGS halted continuous nitrate monitoring in the main springs in the Suwannee River WMD. The district took over monitoring of one spring but did not have the resources to monitor the others. Twelve of the 13 springs' nitrate levels exceed the State's standard for a 'healthy spring'.[12]

In 2018 and again in 2025, the Florida Department of Environmental Protection (FDEP) implemented Basin Management Action Plans (BMAPs) for all major springs in this region, as required by law. The 2025 Suwannee River BMAP calls for reducing nitrogen loads by 85% from all sources. Although this is a legal mandate, there is no evidence that the WMD and FDEP have taken the steps needed to achieve this outcome. A lawsuit by the Florida Springs Council to force FDEP to implement restrictions on nitrate pollution in the Suwannee River Basin has been ongoing for several years. As this paper was being finalized, a settlement was reached obligating FDEP to adopt a new BMAP that includes specific load

[10] The latter figure is from the 23 August 2026 *Ocala Gazette*. The same source says that the aquifer in Marion County, where Silver Springs are located, has dropped "into the bottom 10th percentile", i.e. for 90% of the time over the past 30 years it has been above the current level. See: https://rb.gy/pjxavq (accessed 23 August 2026).

[11] These are 'Outstanding Florida Springs', a legal designation of 30 springs. I thank the reviewer of an early draft of this paper for this additional point.

[12] www.wuft.org/environment/2025-07-17/usgs-to-remove-some-water-quality-monitors-from-outstanding-florida-springs (accessed 29 July 2026)

reduction allocations for polluters and to measure progress. I discuss the provisions and limitations of this settlement below.[13]

A recent Florida Springs Institute study estimates that achieving the legally mandated BMAP levels in the Swannee River would require reducing the total dairy herd by some 72,000 cows (85%) and making major reductions in fertilizer use on farms. Further, dairies consume an estimated 48 million gallons per day (181,700 m^3/d) of potable groundwater; groundwater irrigation uses a lot more water. Spring and river flows in the basin are already below regulatory minimum levels due to groundwater pumping. Minimum flow and levels (MFL) in the Santa Fe and Ichetucknee Rivers, tributaries to the Suwannee, are below the MFL standard; their feeder springs are included in a regional groundwater flow recovery strategy (Florida Springs Institute, 2025).

The Florida Springs Institute (2021b) published a 'blueprint' for restoring the springs on the Santa Fe River (see also Knight and Meeks, 2022). It documented reductions in spring flows of about 200 Mg/d (757,082 m^3/d) resulting from increased population and agriculture; over the past 70 years, nitrogen concentrations in springs have increased by 1,000-80,000%. The current average nitrogen pollutant load in the river is about 1900 tons per year, with more than 95% coming from spring flows. Its conclusion confirms other studies: spring flow recovery will require drastic reductions in groundwater pumping and an 80% reduction in fertilizer and wastewater nitrogen. The Institute suggests that converting 55,000 ha of intensive agriculture to longleaf pine plantations would substantially contribute to achieving these reductions (Florida Springs Institute, 2021b).

The steady decline in spring and aquifer water levels, steady increase in nitrates over the past several decades, and increasing saltwater intrusion along the coast have all been extensively documented and publicized, often by the same state institutions charged with managing water resources sustainably. The Florida Springs Institute receives funding for some of its studies from state agencies. Although Meindl (2024) emphasizes that the science of attributing these trends remains controversial, no one denies there is a serious and growing problem whose solutions will require increasingly drastic and expensive measures with each passing year.

This raises a fundamental question, addressed in the next two sections: why, in the face of all this information, has Florida failed to take serious action to reverse the multiple threats to its water resources?

THE INSTITUTIONAL SETUP

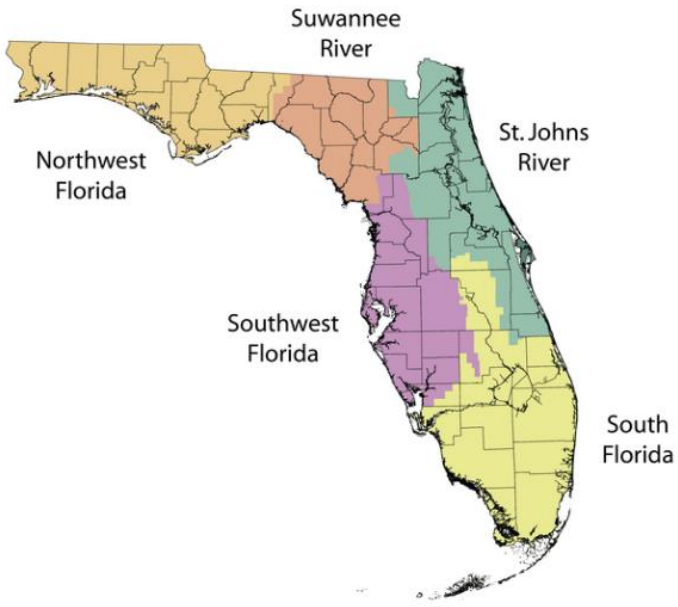
An overview of the legal and institutional setting

Before 1972, Florida's water law was based on common-law doctrine, where landowners owned the water on or under their land. The Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes), henceforth 'the Act', with various updates since then, now governs water management.[14] The state took control of all water resources and created five Water Management Districts (WMDs) with extensive powers to regulate water supply, drainage/flood protection, water quality, and natural resources protection. The WMD boundaries are based on the hydrology of five major water basins: the Northwest Florida WMD, St. Johns River WMD, Suwannee River WMD, South Florida WMD, and Southwest Florida WMD (Olexa et al., 2025a; Stoa, 2014; see Figure 2). The Floridan Aquifer System overlaps these boundaries, creating an inter-basin management challenge.

[13] See Meindl, 2024: chapter 4 for more information on legal battles.

[14] It is complemented by various other state laws, e.g. the Safe Drinking Water Act of 1977, and by federal laws and regulations. Especially significant, in principle, is the Florida Springs and Aquifer Protection Act - a 2016 act to protect a new class of waters: Outstanding Florida Springs.

Figure 2: Florida Water Management Districts



Source: FDEP https://floridadep.gov/owper/water-policy/content/water-management-districts (accessed 25 August 2026).

In 2016, the state legislature unanimously adopted the Florida Springs and Aquifer Protection Act (FSAPA). Because of opposition by many special interests and the FDEP itself, this Act was a substantially watered-down version of the original proposal (Meindl 2024). It had the following provisions:

1. Established 30 Outstanding Florida Springs (OFS)
2. Required FDEP to adopt Basin Management Action Plans (water quality restoration plans) for any OFS impaired by nitrogen pollution that would achieve water quality standards within 20 years
3. Required the delineation of 'Priority Focus Areas' for each OFS
4. Required FDEP to adopt recovery and prevention strategies to ensure that water levels and flows meet Minimum Flows and Levels (MFLs) within 20 years (Twenty-six of the 30 OFS are currently in violation of their MFLs [Palmer, 2026])
5. Prohibited certain land uses within OFS basins, and
6. Required the FDEP to "adopt uniform rules for issuing permits which prevent groundwater withdrawals that are harmful" to OFS and adopt a uniform definition of the term "harmful to the water resources".[15]

The final bill included numerous loopholes for polluters. Although undoubtedly a step in the right direction, many conservation groups, including the Florida Springs Council, opposed the final version of the bill because of concerns that the legislation would not achieve the lofty goals of restoring spring flow and water quality within 20 years. Clearly, the Council was correct.

In 2026, these requirements remain, at best, a work in progress – many of the provisions have not been implemented. A major weakness in the Act, FDEP's rules, and the handbooks used by WMDs is the failure to develop and apply a robust 'public interest' test for issuing water-use permits (Meyer and Sliger, ND). Further, FDEP has not adopted uniform rules for issuing permits to prevent harmful groundwater

[15] Quoted from www.floridaspringscouncil.org/single-post/a-decade-of-dep-s-dereliction-of-duty-to-protect-florida-s-springs (accessed 30 July 2026).

withdrawals and has not adopted an effective, uniform definition of the term 'harmful to the water resources'. Lawsuits brought by the Florida Springs Council and others to pressure FDEP to propose effective rules have, until very recently, failed (Palmer, 2026), even though this is contrary to the legislature's intent (Meyers and Sliger, ND). Stoa (2014) notes a significant weakness in WMDs: they are not legally empowered to consider environmental sustainability above other interests; in fact, quite the contrary. It is no surprise that many of Florida's aquatic ecosystems continue to decline.

Details of the official responsibilities of the WMDs are provided in Olexa et al. (2025b, 2025c). They are essentially responsible for short- and long-term water resources planning and for enforcing regulations on the use of water resources. They are mandated to develop a 20-year Regional Water Supply Plan that identifies future water supply needs and to update it every five years. They have specific responsibilities related to (1) water supplies, (2) water quality, (3) flood protection and floodplain management, and (4) natural systems. They may implement water supply systems or develop new infrastructure (Stoa, 2014), though this is not their primary focus. Rather, they provide data and technical advice and ultimately, through issuing consumptive water use permits, allow surface and groundwater withdrawals for 'beneficial' uses such as public water supply, agricultural and landscape irrigation, industrial use, mining, bottled water, and power generation. They are also mandated to monitor the quantity of water used and the quality of water resources, including in springs (Olexa et al., 2025c[16]).

An indicator of WMDs' broad power is their ability to levy *ad valorem* (property) taxes, in addition to those levied by counties and cities. As with other taxes, failure to pay can result in forfeiture of the property (Olexa et al., 2025a). Other income includes federal and state revenues, licenses, permit fees, grants, agricultural taxes, fund balances, and investment income (Stoa, 2014).

WMD administrative structure

WMDs are governed by a board of at least nine members appointed by the governor and confirmed by the state senate. Some are selected from statutorily designated areas within each district, and some are at-large members from within the district. They serve staggered four-year terms, are not paid, and can be reappointed. The board sets the policies and, subject to the governor's confirmation, hires an executive director to manage all WMD activities (Olexa et al., 2025a).

For example, the Board of the Suwannee River WMD has five members from designated sub-basins and four at-large positions, one of which is currently vacant. Of the eight current members, only one is a woman. Three members own companies involved in the tree business, a critical industry in the district; two are involved in other aspects of agriculture. Two others own other businesses (pawn broker, construction company), and one is a public official (city manager).[17] The current executive director has a background in agriculture and water management, having held senior state positions and having worked for a private firm. The governor appointed his predecessor to be the Secretary of the FDEP – the very agency in charge of monitoring the performance of WMDs.[18]

One more example: the Southwest Florida WMD has 13 board members. Six own and/or operate large farms, mostly cattle. One is a large real estate developer; others are attorneys, other business owners, or public servants (two).[19] Only three are women. Most of them have been appointed by a recent governor to other positions during their careers.

A review of the boards of other WMDs reveals the same pattern: boards are dominated by people with a strong interest in development or who are large commercial/agricultural water users. This pattern has persisted since the Republican Party gained control of the state government over 25 years ago. No

[16] Consult this source for details on WMDs' regulatory responsibilities.

[17] https://www.mysuwanneeriver.com/134/Current-Board-Members (accessed 26 July 2026).

[18] https://www.mysuwanneeriver.com/CivicAlerts.aspx?AID=607&ARC=1087 (accessed 26 July 2026).

[19] https://www.swfwmd.state.fl.us/about/aboinut-the-district/governing-board (accessed 26 July 2026).

one with scientific or environmental credentials has been selected as a WMD board member in recent years. Indeed, Meindl (2024) emphasizes the damage the last two Florida governors have done to efforts to conserve Florida's environment. Given their appointment by the governor, it is safe to assume that most board members are from the same political party and are loyal to the governor. They form a powerful network that makes all major water management decisions.

Basin Management Action Plans (BMAPs)

FDEP develops BMAPs, legally enforceable frameworks that contain comprehensive solutions, regional plans, and programs to achieve pollutant reduction targets. FDEP says they are developed with stakeholders, but consultation is very limited at best. BMAPs are intended to promote incremental load reductions through various projects and strategies and are said to be supported by simultaneous monitoring and studies.[20] As noted above, they have proven ineffective.

The Florida Springs Council and partners have pursued litigation to force FDEP to update and enforce BMAPs for over five years. On 1 September 2026, FDEP signed a settlement of these cases aimed at protecting seven outstanding springs on the Suwannee River, as well as Wekiwa River and Rock Springs, from further pollution. It focuses on reducing agricultural and landscape nitrates in the Suwannee basin, and sewage from septic tanks in the Wekiwa basin. It also improves the current BMAPs, provides for at least 16 new water quality monitoring stations, and requires FDEP to initiate compliance assistance and enforcement actions.[21] FDEP has agreed to update the BMAPs to require the additional reduction of hundreds of thousands of pounds of nitrogen pollution from row crops, dairies, and septic tanks by 2028, accelerating springs restoration.

But my reading of the settlement is that implementation depends on additional budget allocations from the legislature and cooperation of the Florida Department of Agriculture and Consumer Services (FDACS). Neither is a sure thing. Further, the overwhelming strength of the commercial agriculture and real estate development lobbies raises doubts as to how effective the state will be in the current and likely future political climate. The Florida Springs Council promises to monitor progress and is likely to be back in court within a few years.

The bottled water controversy

The pristine, crystal-clear water in the springs of the Floridan Aquifer System makes it an ideal source of bottled drinking water. The total amount extracted by water bottling companies is not tracked, but one estimate suggests that commercial companies statewide have permits to pump 1.1 to 1.5 billion gallons per year (4.2 to 5.7 Mm^3/y). Until recently, actual usage has historically been lower. BlueTriton, Zephyrhills, and Niagara are among the largest water bottling companies. In the larger scheme of things, the amount of groundwater extracted for bottling is not nearly as significant as for other uses. Nevertheless, it disproportionately affects spring flows because it takes water so close to the source (Bliss, 2023). Their visibility generates a lot of opposition from environmental groups and others.

For example, in 2019, the Seven Springs Company, then owned by Nestlé, requested to renew its five-year water-use permit to withdraw 1.15 Mgal/d (4353 m^3/d) from Ginnie Springs, a popular recreational spot. The company claimed it had not withdrawn its full quota previously, but planned to increase it.

[20] https://floridadep.gov/dear/water-quality-restoration/content/basin-management-action-plans-bmaps (accessed 26 July 2026).

[21] Details of the settlement and its significance can be found at the Florida Springs Council website (https://www.floridaspringscouncil.org/single-post/fsc-reaches-historic-settlement-to-protect-suwannee-wekiva-springs, accessed 13 September 2026); the settlement is available at the State of Florida Department of Administrative Hearings (https://www.doah.state.fl.us/DocDoc/2026/000111/26000111_237_09012026_134612727_e.pdf, accessed 13 September 2026).

There was strong opposition to granting this new permit from environmental groups, including the Florida Springs Institute, Florida Springs Council, and residents; some 19,000 petitions opposing the permit were submitted. Under its existing river MFL rule, and perhaps in response to the strong opposition, the Suwannee River WMD board initially rejected the application. The company appealed to the Florida Department of Administrative Hearings, where a judge ruled in favour of the company, claiming the benefits to the community outweighed the costs. This forced the Board to hire a firm to provide a revised rule as a basis for its final and unanimous board approval 'under protest' in 2021.[22]

During this process, the court also ruled that the Florida Springs Council had no standing in this battle. In 2023, a district Court of Appeals unanimously ruled that the Florida Springs Council does have a right to challenge the Seven Springs bottling permit, reversing a previous decision by the administrative judge. This did nothing to stop the permit from being issued, but it did confirm the Council's right to sue FDEP.

The law requires that pumping permits be issued only if there are clear and direct public benefits. The permit application fee was just US$115, but the Seven Springs Company pays 7% of Gilchrist County's tax income. This and job creation were offered as the benefits of issuing the permit. Indeed, the administrative judge accepted that the water use is 'in the public interest' simply because the permit holder provided assurances that it could process and sell the water: a private interest became a public interest.[23]

According to the Florida Political Review, three of the WMD board members voting in favour of issuing the permit are employed by Seven Springs[24]; one is a county commissioner. *The Review* points out that Board members have all been appointed by Republican governors, who have "a poor environmental record". The springs' flows have declined by 40% since 2001 because of increased pumping and lower rainfall. Flows in the Santa Fe River, a Suwannee River tributary, and its associated springs, have declined by half compared to historical average flows, well below the level needed to sustain its unique ecosystem.

More recently, Bloomberg reported that Nestlé had sold all its water bottling brands to a pair of private equity firms operating as BlueTriton Brands, Inc. (Bliss, 2023). This company owns a large percentage of the major bottling companies in the US. Seven Springs is now pumping water from Ginnie Springs and others at the highest permitted rate. As a private equity firm with a reputation for asset stripping, BlueTriton has been reducing costs by cutting staff and sidelining its environmental impact programs. The challenges facing Florida's springs from large, powerful water bottlers are not unique: other states such as California and Maine face similar challenges (Bliss, 2023). By law, a recovery plan is in place – yet the final decision was to grant this permit rather than obey the law.

ANALYSIS: WHY DOES THE AQUIFER CONTINUE TO DETERIORATE?

In January 2020, the President of the Florida Springs Institute wrote a remarkable open letter to FDEP's Office of Environmental Accountability and Transparency (Knight, 2020). The letter included 20 pages of graphs documenting the serious deterioration in the flows of two tributaries to the Suwannee River fed by numerous springs: Santa Fe and Ichetucknee. After reiterating the value of Florida's springs, the letter accuses FDEP and the water management district of being "complicit in the ongoing decline of Florida's once crystalline springs", and points out that even though Florida's springs have lost nearly a third of their historic average flows, the WMDs, with FDEP approval, continue to issue thousands of new well permits annually. The letter cites FDEP's own data to document the decline in river and spring flows and the

[22] Sources: https://floridaspringsinstitute.org/fla-gets-a-tiny-paycheck-as-nestle-taps-its-springs/, https://www.floridapoliticalreview.com/nestle-given-permit-to-access-ginnie-springs-aquifer/, and The Water Is Already Low At A Florida Freshwater Spring, But Nestlé Wants More : NPR (accessed 26 July 2026).

[23] Florida Springs Council https://www.floridaspringscouncil.org/single-post/the-nestle-case-december-7-update-on-our-seven-springs-legal-challenge (accessed 10 August 2026).

[24] I could not confirm this statement; their online bios do not show this, but the source is credible.

increasing pollution of the rivers; as flows decline and nitrate continues to be added, the river becomes more concentrated and toxic.

The letter recommended that no new well permits be issued and no expired permits be renewed on these rivers until a large volume of groundwater use is eliminated from existing permits. The letter also requests FDEP to "use its authority to expeditiously restore the Santa Fe and Ichetucknee Rivers and Springs". FDEP took no action. A check of the Suwannee River WMD website demonstrates that large numbers of permits continue to be routinely issued (or reissued) every month.[25] The data demonstrating the continuing deterioration of Florida's aquifers and springs are not in dispute. And the government, on paper, has the institutions, legal authority, and regulatory capacity to reverse these trends. Why does this not happen?

First, the last two governors have weakened the laws and rules aimed at conserving natural resources and have reduced investments in conservation. Second, the WMD governing boards are dominated by large-scale water users: large farms, tree plantations, industrial users, and real estate developers. They single-mindedly focus on growth and development and at best pay lip service to conservation. They are members of a network of politically connected powerful men (mostly) with close ties to the party in power. They can even get a rule changed if need be; consider the case where Seven Springs managed to have the criteria changed for assessing the trade-off between 'public interest' and achieving 'minimum flows and levels' to allow a water-use permit. Neither of the two WMD boards examined has grassroots community members, water resources experts such as ecologists or hydrologists, or representatives of research and outreach institutions like the Florida Springs Institute or the Florida Springs Council.

This is a product of an over-centralized, politicized administrative structure which can ignore local concerns. There were 19,000 negative public comments on the renewal of the Seven Springs permit, but the WMD argued they had no bearing on being "consistent with the public interest", and the administrative judge agreed (Palmer, 2026). In an article on Florida's environmental record, *Time* states that "[n]eglect, greed, and business interests are regularly privileged, and sometimes even celebrated, over the rights of communities", and notes that state laws have restricted local governments' capacity to regulate their environments. A recent law makes it nearly impossible for citizens to take legal action to oppose changes to comprehensive county plans, emboldening developers.[26]

There are no major public debates on these issues. Large commercial water users justify large-scale water use by arguing they create jobs, pay taxes, and generate wealth. Some deny the seriousness of aquifer degradation or blame it on climate change, thus absolving themselves of any responsibility.

Florida offers a classic case of elite capture: the legislature has weakened civil society's capacity to oppose development or misuse of natural resources. It has also severely limited local communities' power to impose strict environmental rules. Simultaneously, the political elite – agricultural, development, and industrial interests – have captured the regulatory framework contained in the Water Resources Law and FSAPA. Regulations are modified to suit their interests in the name of 'public interest'.

RECOMMENDATIONS

Civil society organizations like the Florida Springs Council face a dilemma: should they continue their efforts to bring about change by working within the current governance system? Or should they shift their focus to changing the governance system itself? This author does not wish to discourage the former:

[25] https://www.mysuwanneeriver.com/1617/Notice-of-Permit-Issuance (accessed 30 July 2026).

[26] https://time.com/6288683/florida-desantis-environment-climate-change/ (accessed 29 July 2026). *Time* cites another study showing 41% of legislators have ties to real estate development. See https://www.news-journalonline.com/story/news/state/2023/03/29/are-florida-lawmakers-real-estate-ties-a-conflict-of-interest/69946829007/?gnt-cfr=1&gca-cat=p&gca-uir=false&gca-epti=z116180e116180v000057&gca-ft=135&gca-ds=sophi (accessed 29 July 2026).

as the recent settlement demonstrates, it may be possible to begin reversing spring degradation by attempting to get the WMDs and FDEP to implement the intent of the laws. However, he remains sceptical that this strategy will achieve the transformation in water use required to conserve Florida's aquifers and unique springs. Therefore, the paper is not advocating abandonment of the current strategy; rather, both strategies should be pursued.

This paper does not attempt to provide a detailed roadmap for the way forward. The author does not have sufficient local social and political knowledge to do so, and he believes a new governance architecture should emerge from an inclusive bottom-up process. Therefore, this section outlines ideas drawn largely from international experience for consideration. Tinkering with the current governance system or waiting for a different party to take over state government will not solve the complex water issues Florida faces because the problems result directly from a flawed governance system. Clearly, designing and implementing major reforms will not be easy and will not happen quickly.

With this caveat, I recommend the following.

1. Accurate, timely data are a prerequisite for effective management

First, the lack of systematic, scientifically valid, real-time, long-term, reliable data on Florida's aquifers and springs is a major impediment to identifying agreed solutions. Therefore, FDEP should work with the WMDs to implement, in stages, a comprehensive system for monitoring trends in both water quantity and water quality, focusing on critical pollutants such as nitrates, salinity in coastal areas, and PFAS but expanding to others over time. The monitoring system should begin with a reasonable sample of wells in each WMD to begin identifying trends, but expand to mandatory monitoring of all wells, public and private, pumping more than 100,000 gallons per day (379 m^3/d). This should be expanded over time to include smaller wells. The quantity and quality of water pumped, in addition to water levels, should be monitored. The data should be included in a public web-based management information system.

This would enable understanding trends and obtaining data on the actual amounts and quality of water pumped. Low-cost piezometers and Conductivity-Temperature-Depth (CTD) divers equipped with sensors to continuously monitor groundwater levels and quality in geo-tagged wells that send readings to a website via satellite are available and in use in many countries: for example, Pakistan is implementing such a program country-wide (CGIAR Initiative on NEXUS Gains, 2025). As an interim measure, FDEP should explore the growing suite of state-of-the-art remote sensing techniques. These are useful for local- to global-scale groundwater monitoring and assessment, including proxies for groundwater extraction (Adams et al., 2022). They may prove less costly to implement and are likely to provide useful information to water managers.

Parallel to monitoring the aquifer, FDEP should work with the Florida Springs Institute and state universities to design and implement systematic, real-time monitoring of trends in springs' water outflow and its quality, as well as their ecosystems, beginning with the currently identified 30 Outstanding Florida Springs. This goes beyond the recent agreement to add 16 monitoring locations and would provide a scientific basis for designing interventions aimed at long-term spring conservation.

Effective management of any resource is impossible without accurate data. Implementing a comprehensive monitoring program will provide the foundation for identifying real problems, their causes, and possible solutions. Implementing this recommendation by itself would revolutionize water management.

2. Radical governance reform is a necessary condition for success

Ultimately, implementing well-designed policies is the most critical step needed to achieve sustainable, productive use of groundwater. Therefore, I recommend that advocates for change begin developing an alternative legal and institutional framework consistent with Florida's unique circumstances. Top-down state governance, Florida's current approach, rarely succeeds (Molle and Closas, 2019a). Globally, co-management by the state supporting strong community-based organizations has a better track record,

but only under the right conditions (Molle and Closas, 2019b). It is no panacea and is challenging to implement even with strong state support. Florida can draw on lessons from other places such as California (Langridge and Ansell, 2018), Nebraska, Australia, Spain, and New Zealand (Molle and Closas, 2019b; See Box 1). Local management supported and empowered by the state is often more effective, as in Nebraska, USA, through its Natural Resource Districts (Bleed and Babbit, 2015; Schoengold and Brozovic, 2018). In this and similar cases (e.g. Australia; see Shalsi et al., 2022), citizens control the local institutions, which receive strong government legal, policy, and technical support. However, in these cases, groundwater is used largely for one use, agriculture, rather than several large uses, as found in Florida.

Box 1: Nebraska's Natural Resource Districts

Irrigated agriculture in Nebraska, USA, is largely based on groundwater. In 1959, the state created local Natural Resource Districts (NRDs) authorized to implement corrective measures to ensure conservation of groundwater. These were strengthened in the 1960s and 1970s: legislation empowered the districts, enabling integrated management of resources. There are 23 NRDs, organized around river basin boundaries. Locally elected governing boards have taxing powers and the authority to regulate and manage a wide range of natural resources, including groundwater. Although they face intense local political pressure from water users, they have proven effective. The reasons for this effectiveness include: a consistent monitoring network, the separation between state bodies and NRDs, local enforcement of rules based on self-interest to comply, graduated sanctions, adequate funding mechanisms supported by the state, having ample taxing authority to pay for water conservation projects, and allowing anyone eligible for public office to serve (rather than just farmers)

Sources: Bleed and Babbitt (2015); Molle and Closas (2019b).

Lessons can be drawn from other experiences, but Florida cannot simply copy these models as its conditions are very different. A participatory process to develop a new governance model should also educate citizens, including local politicians, on the need for radical change and potential alternatives. This may help create pressure for reform. The Florida Springs Council currently focuses entirely on working within the system through legal action. Even if successful, which is in doubt, this will take decades to have a major impact. The Council has the capacity to spearhead this reform effort. Another possibility is for the Council to create a *Citizens' Commission on Florida's Water Future*. This could be based on a consortium of interested parties and be established as a non-profit legal entity. The purpose will be to lead a consultation process and consolidate the results into specific legislation.

Hydrologically based water management districts should remain as the critical institutions for implementation. However, state politicians' control must be eliminated. The WMD boards should be elected by citizens rather than chosen by the political elite. They should strive to include the full range of interests, including resource conservation, and not be dominated by large water users. WMD boards can be authorized to appoint representatives of critical interests as *ad hoc* members, as needed. Mechanisms are needed to achieve joint management of aquifers underlying multiple districts.

A new water resources act should prioritize conservation and sustainable resource use. Florida could consider granting aquifers, springs, and natural ecosystems high priority, perhaps through a mandated right to exist and flourish. The constitutions of Ecuador and South Africa protect natural resources, including water. Courts in several countries, e.g. New Zealand and even the USA, have granted rivers legal standing; and some communities in California, Washington, Michigan, and elsewhere have done the same for aquifers (Cuadrado-Quesadaet al., 2023).[27] Water resources are integrated – there are strong dependencies among rivers, springs, aquifers, and wetlands, for example. Their legal rights may need to

[27] See also https://www.greatlakesnow.org/2019/08/19/rights-of-nature/ (accessed 30 July 2026)

be circumscribed, but this would ensure that all water allocation decisions prioritize conserving the resource.

Florida should also consider creating a legal hierarchy of priority water uses, as other countries, such as South Africa, have done. Domestic supplies and personal use should be the highest priority, followed by resource conservation, i.e., ensuring that sufficient good-quality water remains in the aquifer to support humans and water-based ecosystems to flourish over the long term. Recreational use of springs also needs to be carefully preserved. This will leave a limited amount of water available for productive use.

In areas where the aquifer is being depleted, the WMDs must have the authority to set and enforce a limit on the amount of water pumped for all purposes. This limit must be based on a scientific assessment and be legally binding; it may vary from year to year based on the state of the aquifer. Such a limit may require drastic reductions in water consumption, especially for low-value uses such as irrigated field crops and landscape irrigation. The limit may need to be implemented gradually, but within a short period, to be specified clearly, many users will have to stop pumping. It must also be enforced, unlike the current situation.[28]

Market-based water allocation can help achieve conservation goals (Barbier, 2022). Water is a very valuable resource yet permits for its use currently cost almost nothing. More importantly, water management districts cannot charge water use fees, even for large commercial users. It is time to treat water as an economic as well as public good, as others have advocated in the past: at the least, large commercial operations should pay for the water they use.[29] Initially, charges may be assessed based on well capacity, but it is critical to measure actual water use. GPS-based meters installed by the WMD offer a solution. As the monitoring system is implemented, its record of actual water use can be the basis for the charge. Charges must be high enough to incentivize water conservation and to finance the WMDs. Modest charges initially, with the certainty that the price will increase, should encourage water conservation. This system can be complemented by encouraging seasonal water sales and trading among commercial users.

Another option is an auction system to allocate water use for a specified period. Auctions allow water users to buy and sell water rights, water allocations, or water permits. The WMDs could establish an auction system for portions of the water available for productive use and use the funds generated to cover their costs. Georgia has implemented irrigation *suspension* auctions, another interesting approach to water conservation. Several irrigation suspension auctions have been conducted in the Lower Flint River Basin to reduce water use in the region (Carrillo, 2026).

3. Technological innovations are critical

Finally, multiple technological innovations to use water more productively are available and can be expanded. In northern Florida, current livestock and irrigated crop farming systems will have to be drastically reformed or curtailed to reduce water consumption and non-point pollution of rivers and groundwater. Policy reform and market-based water pricing should be accompanied by support for research on, and adoption of, water-saving innovations to increase water productivity. Funds raised through water use fees can support this process (Barbier, 2022). Reusing recycled water and recharging groundwater can be expanded in some areas. Some water users' business models will need to change drastically to remain in business. Landscape irrigation is a low-value use and should be phased out by

[28] The Suwannee WMD has strict rules on the frequency and timing of landscape irrigation and fertilization, but based on the author's personal observation, these rules are not enforced.

[29] Florida Springs Institute https://floridaspringsinstitute.org/fla-gets-a-tiny-paycheck-as-nestle-taps-its-springs/ (accessed 15 August 2026). During consideration of the Aquifer and Springs Protection Act in 2015, an amendment mandating a new water-fee study was proposed, but was voted down in both houses of the FL legislature (Palmer, 2026).

adopting landscapes that do not require irrigation, as is done in other areas, and using processed grey water.

CONCLUSIONS

Florida's growth has historically been predicated on the assumption that water and other natural resources are unlimited. Water-use permits continue to be issued without serious regard to the sustainability of the resource. In some parts of Florida, new data centres are being proposed or built, extracting additional water. Permits continue to be issued for new communities' domestic water and landscape irrigation, water bottling, mining, and agriculture. Technical obstacles are overcome by rewriting the rules. The evidence is overwhelming that the amount and quality of water remaining in the Floridan Aquifer System and its springs are degrading rapidly. Florida has abundant water, but it is not unlimited and needs to be managed carefully. Without a major reversal in water policies, Florida will face an existential crisis, and the state is not equipped to manage it.[30]

The current laws are ineffective. For example, the FSAPA is supposed to protect springs. But in fact, it contains serious loopholes. The law requires farmers and other water users to obtain a water-consumption permit to pump groundwater, but the amount pumped is not monitored. The water levels in wells pumping over 100,000 gallons per day (379 m^3/d) with an eight-inch (20.3 cm) diameter pipe are monitored, but not the volume of water pumped. For smaller-diameter pumps, there is no provision for monitoring even though many pump large quantities (Meindl, 2024). The WMDs have aquifer-level databases on their websites, but they are used superficially. During droughts, WMDs announce limitations on the frequency of landscape irrigation. These are not effectively enforced and are not adequate to reverse groundwater mining.

The laws and regulations governing water resources management, and the institutions charged with their implementation, are dominated by developers and large-scale water users. Surprisingly, these parties do not seem to be driven by a long-term public interest motive: short-term profit rules.

This centralized political system is not designed to prioritize resource conservation and sustainable use of these resources. This is also why efforts to collect data, monitor trends, educate citizens, bring lawsuits, and advocate for change have fallen short. The Florida Springs Council, the Florida Springs Institute, and other similar organizations continue to work within a flawed political system, rather than focusing on achieving fundamental governance changes.

It is now or never

The Florida Springs Institute was established in 2010; the Springs Council was initiated in 2014 by uniting other existing organizations. Although they have contributed significantly to our knowledge of Florida's springs and raised public awareness, they have had, at best, limited success working within the current system to change policies and reverse the aquifer's decline. It is time to consider an alternative approach to complement their effort to work within the governance system. Achieving major policy and governance reforms will be extraordinarily difficult, given the entrenchment of the current network of larger-scale water users. But it is time to begin. Time is running out for Florida's water resources; the state should not wait until it, too, is facing water bankruptcy. The current legal and institutional system is not equipped to respond to the growing crisis and reverse the downward trends in water quality and quantity. Doing nothing should not be an option. The focus now should be on achieving radical political and legal reform, not continuing to tinker with a broken system.

[30] Climate change projections suggest the impacts of climate change on groundwater-dependent water suppliers will likely be modest in the foreseeable future, except for coastal impacts of rising seawater. Population growth is a far greater challenge (Maliva, 2025).

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AI USE DECLARATION

AI has not been used in the preparation of this paper except to calculate measurement equivalents.

REFERENCES

Adams, K.H.; Reager, J.T.; Rosen, P.; Wiese, D.N.; Farr, T.G.; Rao, S.; Haines, B.J.; Argus, D.F.; Liu, Z.; Smith, R.; Famiglietti, J.S. and Rodell, M. 2022. Remote sensing of groundwater: Current capabilities and future directions. *Water Resources Research* 58(10): e2022WR032219, https://doi.org/10.1029/2022WR032219

Barbier, E.B. 2022. The economics of managing water crises. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences* 380: 2238, https://www.jstor.org/stable/10.2307/27213317

Bleed, A. and Babbit, H. 2015. *Nebraska's natural resources districts: an assessment of a large-scale locally controlled water governance framework*, Policy Report 1, Robert B. Daugherty Water for Food Institute, University of Nebraska, https://digitalcommons.unl.edu/wffdocs/79/

Bliss, L. 2023. *The private equity firm tapping America's spring water*. Bloomberg, https://www.bloomberg.com/features/2023-california-spring-water-bluetriton/

Carrillo, R. 2026. *Georgia's agricultural water challenge: Lessons for the eastern U.S. and beyond*. The Daugherty Water for Food Institute at the University of Nebraska, https://waterforfood.nebraska.edu/news-and-events/news/2026/07/georgias-agricultural-water-challenge-lessons-for-the-eastern-u.s-and-beyond

CGIAR Initiative on NEXUS Gains. 2025. *Annual technical report on 2024*. Montpellier, France: CGIAR System Organization, https://hdl.handle.net/10568/174245

Cuadrado-Quesada, G.; Lictevout, E.; Schmeier, S. and Vargas, C.R. 2024. Revisiting groundwater law through the lenses of earth system law and rights of nature. *Wiley Interdisciplinary Reviews: Water* 11(2): e1684, https://doi.org/10.1002/wat2.1684

Florida Department of Environmental Protection and Florida Geological Survey. (n.d.). *The Florida Springs Region [Map]. Florida Springs Inventory*. Florida Department of Environmental Protection: Tallahassee, FL.

Florida Springs Institute (Howard T. Odum Florida Springs Institute). 2021a. *Blue water audit. Final project report*. Prepared for the Community Foundation of North Central Florida, 31 December 2021, https://floridaspringsinstitute.org/wp-content/uploads/2025/10/BWA-Final-Project-Report-final-123121.pdf

Florida Springs Institute. 2021b. *Blueprint for restoring springs of the Santa Fe River*. The Howard T. Odum Florida Springs Institute, https://floridaspringsinstitute.org/wp-content/uploads/2021/01/Santa-Fe-River-and-Springs-Restoration-Blueprint-01_27_21.pdf

Florida Springs Institute. 2022. *Health assessment of four outstanding Florida springs on the Suwanee River*. The Howard T. Odum Florida Springs Institute, https://floridaspringsinstitute.org/wp-content/uploads/2022/09/SUW-OFS-Final-Report_Revised.pdf

Florida Springs Institute. 2024. An ecological health assessment of Silver Springs, Florida. Final Report prepared for the Fish and Wildlife Foundation of Florida. The Howard T. Odum Florida Springs Institute, https://floridaspringsinstitute.org/wp-content/uploads/2023/04/Ecological-Heath-Assessment-of-Silver-Springs.pdf

Florida Springs Institute. 2025. Nitrate contamination and groundwater depletion by dairy farms located in North Florida's springs region. A Special Report by The Howard T. Odum Florida Springs Institute,

https://floridaspringsinstitute.org/wp-content/uploads/2026/02/Dairy-Farms.pdf

Holden, M.M.; Timshina, A.; Mehdi, Q.; Cromwell, L.A.; Osborne, T.; Aufmuth, J. and Bowden, J.A. 2024. Have per- and polyfluoroalkyl substances (PFAS) infiltrated Florida's freshwater springs? *Science of The Total Environment 952*: 175826, https://doi.org/10.1016/j.scitotenv.2024.175826

Huggins, X.; Gleeson, T.; Castilla-Rho, J.; Holley, C.; Re, V. and Famiglietti, J.S. 2023. Groundwater connections and sustainability in social-ecological systems. *Groundwater* 61(4): 463-478, https://doi.org/10.1111/gwat.13305

Knight, R.L. 2020. *Re-evaluation of minimum flows and levels for the Santa Fe and Ichetucknee Rivers and Springs*. Public letter to Kristine Papin Morris, Florida Department of Environmental Protection, Office of Environmental Accountability and Transparency, dated 24 January 2020, https://floridaspringsinstitute.org/wp-content/uploads/2022/02/FDEP-Public-Meeting-LSFR-and-IR-MFLs-FSI-comments-and-analysis-January-24-2020.pdf

Knight, R.L. and Clarke, R.A. 2016. Florida springs – A water-budget approach to estimating water availability. *Journal of Earth Science and Engineering* 6: 59-72, doi: 10.17265/2159-581X/2016.02.001

Knight, R.L. and Meeks, A. 2022. Assessing pollution and depletion of large artesian springs in Florida's rapidly developing water-rich landscape. In Currell, M.J. and Katz, B.G. (Eds). *Threats to springs in a changing world*, pp. 7-18. American Geophysical Union. Wiley and Sons: Hoboken, NJ, USA, https://doi.org/10.1002/9781119818625.ch2

Konikow, L.F. 2013. *Groundwater depletion in the United States (1900–2008)*. USGS. Scientific Investigations Report 2013-5079. U.S. Geological Survey: Reston, VA, USA, https://www.usgs.gov/publications/groundwater-depletion-united-states-1900-2008

Langridge, R. and Ansell, C. 2018. Comparative analysis of institutions to govern the groundwater commons in California. *Water Alternatives* 11(3): 481-510.

Madani K. 2026. *Global water bankruptcy: Living beyond our hydrological means in the post-crisis era*. United Nations University Institute for Water, Environment and Health (UNU-INWEH): Richmond Hill, Ontario, Canada. doi: 10.53328/INR26KAM001

Maliva, R.G. 2025. Climate change and Florida groundwater management – Actionable data and adaptations. *Water* 17: 1572, https://doi.org/10.3390/w17111572

Marella, R.L. and Berndt, M.P. 2005. Water withdrawals and trends from the Floridan aquifer system in the southeastern United States, 1950-2000: U.S. Geological Survey Circular 1278, https://doi.org/10.3133/cir1278

Marella, R.L. 2020. Water withdrawals, uses, and trends in Florida, 2015. U.S. Geological Survey Scientific Investigations Report 2019-5147 https://doi.org/10.3133/sir20195147

Meindl, C.F. 2024. *Florida springs: From geography to politics and restoration*. University Press of Florida: Gainesville, FL, USA.

Meindl, C.F. 2025. *Florida's 1,100 natural springs are under threat – a geographer explains how to restore them*. The Conversation, https://theconversation.com/floridas-1-100-natural-springs-are-under-threat-a-geographer-explains-how-to-restore-them-263704

Meyer, C. and Sliger. P. No date. *Florida's Water Resources Act: "Consistent with the public interest"*. Conservation Clinic, University of Florida Levin College of Law. Unpublished student paper, https://floridaspringsinstitute.org/wp-content/uploads/2021/02/Public-Interest-Paper-12.15.20-2.pdf

Molle, F. and Closas, A. 2019a. Why is state-centered groundwater governance largely ineffective? A review. *WIREs Water* 7: e1395, https://doi.org/10.1002/wat2.1395

Molle, F. and Closas, A. 2019b. Comanagement of groundwater: A review. *WIREs Water* 7: e1394, https://doi.org/10.1002/wat2.1394

Olexa, M.T.; Weng, W. and Olevnik, S.M. 2025a. *2025 Handbook of Florida water regulation: Florida Water Management Districts*. University of Florida: Institute of Food and Agricultural Sciences (IFAS), https://doi.org/10.32473/edis-fe594-2021

Olexa, M.T.; Weng, W. and Olevnik, S.M. 2025b. *2025 Handbook of Florida water regulation: Florida Department of Environmental Protection*. University of Florida: Institute of Food and Agricultural Sciences (IFAS), https://doi.org/10.32473/edis-fe593-2021

Olexa, M.T.; Weng, W. and Olevnik, S.M. 2025c. *2025 Handbook of Florida water regulation: Florida water resources policy*. University of Florida: Institute of Food and Agricultural Sciences (IFAS), https://doi.org/10.32473/edis-fe1043-2021

Palmer, R. 2026. Personal Communication.

Schoengold, K. and Brozovic, N. 2018. The future of groundwater management in the High Plains: Evolving institutions, aquifers and regulations. *Western Economic Forum* 16: 47-53. DOI: 10.22004/ag.econ.273678

Scott, T.M.; Means, G.H.; Meegan, R.P. Means, R.C. and others. 2004. *Springs of Florida*. Florida Geological Survey Bulletin 66. Florida Geological Survey: Tallahassee, FL, USA, https://ufdc.ufl.edu/UF00094032/00001/pdf/0

Shalsi, S.; Ordens, C.M.; Curtis, A. and Simmons, C.T. 2022. Coming together: Insights from an Australian example of collective action to co-manage groundwater. *Journal of Hydrology* 608: 127658, https://doi.org/10.1016/j.jhydrol.2022.127658

Stoa, R. 2014. Florida Water Management Districts and the Florida Water Resources Act: The challenges of basin-level management. *Kentucky Journal of Equine, Agriculture, and Natural Resources Law* L. 73, https://ecollections.law.fiu.edu/faculty_publications/188

Williss, R.; Carrillo, R.; Rimšaitė, R.; Melkani, A. and Brozović, N., 2026. *Agricultural water use trends in the U.S., 1997-2022*. Infographic. Daugherty Water for Food Global Institute, https://go.unl.edu/irrigation-trends