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FLORIDA STATEWIDE AGRICULTURAL IRRIGATION DEMAND

Estimated Agricultural Water Demand: 2022 - 2050

THE BALMORAL GROUP
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AFSIRS	Agricultural Field Scale Irrigation Requirements Simulation
ALG	Agricultural Lands Geodatabase
AWS	Actual Water Savings
CDL	Cropland Data Layer
CFWI	Central Florida Water Initiative
CUP	Consumptive Use Permit
DPI	Division of Plant Industry
ET	Evapotranspiration
FAPRI	Food and Agricultural Policy Research Institute
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOR	Florida Department of Revenue
FLUCCS	Florida Land Use/Land Cover and Forms Classification System
FRIS	Farm and Ranch Irrigation Survey
GIS	Geographic Information System
GOES	Geostationary Operational Environmental Satellites
GPD	Gallons per Day
ILG	Irrigated Lands Geodatabase
INYR	Inches/Year
IWM	Irrigation and Water Management
LKB	Lower Kissimmee Basin
LWC	Lower West Coast
MGD	Millions of Gallons per Day
MIL	Mobile Irrigation Labs
NAIP	National Agricultural Imagery Program
NASS	National Agricultural Statistics Service
NRSP	North Ranch Sector Plan
NWFWMD	Northwest Florida Water Management District
SFWMD	South Florida Water Management Districts
SJRWMD	St. Johns River Water Management District
SRWMD	Suwannee River Water Management District
SWFWMD	Southwest Florida Water Management District
UEC	Upper East Coast
UKB	Upper Kissimmee Basin
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WMD	Water Management District
WUP	Water Use Permit

Executive Summary

The Florida Department of Agriculture and Consumer Services (FDACS) is charged with developing estimates of statewide agricultural water demand[1]. This process is described as the Florida Statewide Agricultural Irrigation Demand project, or FSAID. The current FSAID report covers the projection period through 2050 to align with regional water supply plan projection periods.

A crucial part of estimating statewide agricultural water needs is identifying the agricultural lands that are currently irrigated. **Table ES-1** summarizes irrigated lands as of crop year 2022 to correspond to the most recent year of available water use data from the Water Management Districts. **Figures 3 and 5** in the report provide graphics of County-level projected changes in acreage and water use. **Table ES-1** summarizes the updated agricultural and irrigated agricultural areas.

Table ES- 1. Florida Agricultural Acreage in Production, by District

WMD	Agricultural Lands 2022	Irrigated Crop Land 2022
	Acres	Acres
NWFWMD	712,961	53,344
SFWMD	2,950,658	1,042,680
SJRWMD	1,178,200	125,158
SRWMD	808,383	154,632
SWFWMD	1,830,659	324,013
Total	**7,480,860**	**1,699,826**

Through 2050, statewide total irrigated crop acreage is projected to decrease by about 56,000 acres (about a 3% drop in irrigated area). The projected decline in overall irrigated acreage is based on county-specific trends in irrigated area from 2015 to 2022, the most recent years of FSAID annual irrigated area refinements. The associated average-year water use is projected to decrease overall by about 3% or 59 MGD by 2050, with varying impacts on individual Water Management Districts (WMDs). South Florida Water Management District (SFWMD), St. Johns River Water Management District (SJRWMD) and Southwest Florida Water Management District (SWFWMD) are forecast to see declines in irrigated areas, while the northernmost districts are expected to see increases in the share of agricultural land that is irrigated.

The current total agricultural irrigation water use statewide is estimated at 1,811 MGD for an average year and 2,439 MGD for a 1-in-10 dry year. **Table ES-2** provides a breakdown by district of total crop irrigation use. **Table ES-3** provides estimated water use for livestock and aquaculture.

[1] Florida Statute 570.93. Department of Agriculture and Consumer Services; agricultural water conservation and agricultural water supply planning.

Table ES- 2. Estimated Irrigated Cropland Water Use

WMD	2022	2022	2022
	Acres	MGD	Inches/Year
NWFWMD	53,344	44	11.15
SFWMD	1,042,680	1,162	14.98
SJRWMD	125,158	142	15.28
SRWMD	154,632	155	13.45
SWFWMD	324,013	308	12.79
Total	**1,699,826**	**1,811**	**14.32**

Table ES- 3. Estimated Livestock/Aquaculture Water Use (2022)

WMD	Livestock water use (MGD)	Aquaculture water use (MGD)
NWFWMD	1.6	4.8
SFWMD	11.4	7.1
SJRWMD	3.9	1.7
SRWMD	9.1	0.4
SWFWMD	6.1	6.3
Total	**32.1**	**20.3**

Table ES-4 shows projected water use estimates by crop, while **Table ES-5** summarizes district level irrigated acreage projections from 2022 to 2050. By 2050, total average-year agricultural irrigation water demand is estimated at 1,752 MGD.

Table ES- 4. Irrigation Demand, MGD by Crop, 2022-2050

Statewide	2022	2025	2030	2035	2040	2045	2050	
Predominant Crop	Avg MGD	Avg MGD	Avg MGD	Avg MGD	Avg MGD	Avg MGD	Avg MGD	Dry MGD
Citrus	315	325	322	319	314	309	303	446
Field Crops	147	143	142	140	143	147	150	196
Fruit (Non-citrus)	80	79	77	74	74	73	72	92
Greenhouse/Nursery	138	135	130	130	129	129	129	144
Hay	114	113	114	116	115	114	113	160
Potatoes	33	33	33	33	32	32	32	47
Sod	51	51	51	50	50	49	49	60
Sugarcane	657	644	639	638	637	637	635	877
Vegetables (Fresh Market)	277	277	276	272	271	270	269	339
Total	**1,811**	**1,800**	**1,784**	**1,772**	**1,765**	**1,760**	**1,752**	**2,361**

Table ES- 5. Projected Irrigated Acreage by Water Management District, 2022-2045

WMD	2022	2025	2030	2035	2040	2045	2050	2022-2050	2022-2050
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Change	% Change
NWFWMD	53,344	54,049	55,137	56,211	57,289	58,359	59,444	6,101	11%
SFWMD	1,042,680	1,027,966	1,020,278	1,015,977	1,011,414	1,006,640	1,001,312	(41,368)	-4%
SJRWMD	125,158	124,708	122,976	121,060	118,483	116,383	113,884	(11,274)	-9%
SRWMD	154,632	157,449	162,070	166,618	171,020	175,717	180,317	25,685	17%
SWFWMD	324,013	320,241	313,431	306,999	300,501	294,528	288,694	(35,319)	-11%
Total	**1,699,826**	**1,684,413**	**1,673,893**	**1,666,864**	**1,658,706**	**1,651,626**	**1,643,651**	**(56,175)**	**-3%**

Historical records from USDA survey data indicate that Florida farmers have improved efficiency on average about 1% per year, overall. A long-term record of producer-reported acreage and water use was used to develop trends to project future irrigation conservation[2]. **Table ES-6** provides the future conservation results, which project irrigation efficiency improvements of about 6% of the total average year irrigation demand by 2050 (about 9% of total non-EAA irrigated demand). Detailed information on conservation methods and data sources are provided in **Appendix E**.

Table ES- 6. Estimated Efficiency Improvements by Water Management District, MGD

WMD	2025	2030	2035	2040	2045	2050
NWFWMD	1.1	2.5	3.0	3.4	3.7	4.0
SFWMD	16.9	32.8	40.2	45.0	48.9	52.0
SJRWMD	3.6	8.7	12.4	14.7	16.4	17.8
SRWMD	4.8	12.7	19.7	22.9	24.7	26.3
SWFWMD	3.4	7.6	9.6	11.0	12.1	13.1
Total	**29.9**	**64.3**	**84.9**	**96.9**	**105.9**	**113.2**
	**Amounts are cumulative over time; i.e. 29.9 mgd from 2025 is included in 64.3 mgd in 2030*					

Agriculture, especially citrus and sugarcane operations – the crops with the most significant areas and irrigation demand, has high fixed costs, which means that shocks to the system affect profits long before they affect acreage and water use. Some portion of producer response to systemic shocks are embedded in the underlying model that has been trained off many years of permit level water use from the Districts. The dataset incorporates housing boom and bust years, wild swings in energy prices, rapid spread of citrus greening, and numerous years of major natural disasters which have affected agriculture. The heavy investments in capital and labor arrangements inject an inherent lag to changes in agricultural practices, which is likely to be evident within water use as well.

The FSAID model incorporates both agronomic and economic factors that affect irrigation water demand. The model's ability to capture the variation in water use by profitability across crops and within crops over time provides an enhanced estimate of future irrigation demands. A number of factors present uncertainty in future projections for Florida agricultural irrigation demand. In **Appendix E**, the results of four agricultural water demand alternative scenarios are presented to show potential outcomes related

[2] USDA Farm and Ranch Irrigation Survey, Florida data

to western U.S. to eastern U.S. irrigated area shifts, possible trade improvements, potential citrus greening resolution, and increased conversion to non-agricultural land uses. These four scenarios had MGD changes (differences from the expected 59 MGD decrease in demand by 2050) ranging from -8 to 48 MGD.

The FSAID irrigation water demand projections estimate a roughly 56,000-acre decrease in statewide irrigated area through 2050, accompanied by a reduction of about 59 MGD in average-year water demand.

Introduction

The Florida Department of Agriculture and Consumer Services is charged with developing estimates of statewide agricultural water demand[3]. The process is described as the Florida Statewide Agricultural Irrigation Demand project, or FSAID; this report is the eighth annual update of FSAID water use estimates prepared by FDACS. The current and projected agricultural water use estimates are based on a model fitted to 2007 to 2022 metered or reported permit-level water use data from all Water Management Districts and have utilized updated spatial data to improve the representation of irrigated and non-irrigated agricultural lands.

The current baseline acreage and water use estimates are for the year 2022, which is the most recent year of available water use data provided by the Districts. This report includes estimates of irrigated agricultural areas and water demands for 2022 and projections for 2025 – 2050, in five-year increments. The estimates herein are provided to the Districts for their review and comment and ultimately for consideration in development of their respective water supply plans. This report describes the agricultural land acreage estimates and methodology, followed by the water use estimates and methodology. Following the water and land use estimates, frost-freeze protection estimates, irrigation conservation estimates, and livestock and aquaculture water demand estimates are provided.

This iteration of the FSAID agricultural water demand projections can be referenced as FSAID XI (FDACS 2024). Previous FSAID reports or datasets can be referenced similarly (i.e. FSAID III; FDACS 2016).

Methodology and Agricultural Land Acreage Estimates

Two spatial datasets of Florida's agricultural lands were created for the FSAID project. The Agricultural Lands Geodatabase (ALG) includes all agricultural land, while the Irrigated Lands Geodatabase (ILG) includes only irrigated agricultural land, as well as the estimated current and projected water use for each field.

[3] Florida Statute 570.93. Department of Agriculture and Consumer Services; agricultural water conservation and agricultural water supply planning.

A. ALG: Refinement of Agricultural Lands Geodatabase

The original FSAID ALG was developed in 2014 as part of the initial establishment of the FSAID program and underlying datasets. The following primary spatial data sources were used:

- Florida Statewide Land Use/Land Cover from the Water Management Districts,
- Consumptive Use Permit (CUP) polygons from the WMDs,
- Well locations,
- USDA's Cropland Data Layer (CDL) data,
- USDA's National Agricultural Imagery Program (NAIP)
- aerial imagery, and
- Irrigated Areas layers from SJRWMD and SWFWMD.

Substantial spatial data processing was completed to develop Florida's ALG and ILG to model current and projected agricultural water demands. The annual refinement to the ALG is based on stakeholder input, FDACS field staff reviews, FDACS BMP enrollment data, updated land use data prepared by Water Management Districts and the Florida Department of Environmental Protection (FDEP), the Florida Department of Revenue (FDOR) property appraisal data (parcel data), the CDL, and recent aerial imagery. Other updates included utilizing the most current field-verified data from USGS, and the most current available Statewide Land Use Land Cover data.

Cropland Data Layer Crop Classification

USDA's Cropland Data Layer (CDL) from 2022 was used to update crop types for ALG features in which the dominant CDL crop classification represented at least 40% of the area of an ALG field area (the threshold established based on detailed review of > 500 example fields). This CDL crop update occurred only for selected agronomic (field crops) and grazing land crop types. The goal of this process is to efficiently update crop types and to replace non-specific crop names like "FieldCrops" or "Cropland_Pastureland" with more accurate and descriptive crop types. The following dominant CDL crop types were utilized for updating ALG crop types to ensure that uncommon or unusual CDL crops are not incorrectly used for ALG crop classification: Corn, Cotton, Dry Beans, Grass_Pasture, Oats, Peanuts, Rye, or Soybeans. This process resulted in 5,289 features (about 223,000 acres) having a revised crop type using the 2022 CDL crops (most commonly updated to Peanuts, Cotton, or Corn).

B. ILG: Refinement of the Irrigated Lands Geodatabase

The Irrigated Lands Geodatabase (ILG) was updated to 2022 conditions based on manual review and evaluation using 2022/2023 aerial imagery, new or modified Water Use Permits (WUPs), 2022 Cropland Data Layer from USDA (CDL), FDACS field staff spatial data input, FDACS Division of Plant Industry (DPI) citrus layer, USGS field verification, and District-provided spatial data on irrigated area changes. All these datasets (list in **Table 1**) were used to target manual review of ILG features compared to aerial imagery and ancillary datasets. Updates were made to field geometry, crop type, irrigation system, and irrigation status (fallow or irrigated).

Table 1. FSAID data layers for spatial data refinements

DATA SOURCE	DESCRIPTION
Water Use Permits (WUP; recent new and revised were reviewed)	WUPs typically provide information on crop type and irrigation system; any new or modified WUPs from 2021 or more recent were manually reviewed.
FDACS OAWP field staff spatial data	Monthly (or bi-monthly) spatial data identifying ILG and ALG edits based on field visits or aerial reviews or producer input.
USDA Cropland Data Layer (CDL; 2022)	The CDL is a gridded dataset (30-meter resolution) that classifies crop type based on satellite data and ground-truth data from the Farm Service Agency (FSA) field reports at the Common Land Unit (CLU) scale. The dataset is updated annually based on satellite data collected from April to September.
U.S. Geological Survey irrigated areas field verification (USGS; 2021-2022)	U.S. Geological Survey (USGS) field verification in NWFWMD
FDACS Division of Plant Industry (DPI) active citrus layer; 2023	Statewide dataset of citrus areas, with attributes indicating survey date and classification that describes active production or abandonment
water use data; 2022 annual water use totals	Adjusted irrigated coverage based on District water use data for permits with 0 or low (< 3in/yr) water use.

Updates to the ILG were reviewed with personnel at each District. Draft ILG shapefiles were provided to each District during February of 2024, and meetings with the FSAID team staff in each District were conducted to collaborate on spatial data improvements. In some Districts, staff provided GIS data for recommended changes. In other Districts, comments were provided via email and were researched as part of continued ILG updates. In all cases, input was acknowledged and addressed.

Field verification was completed by USGS in 2023 and 2024 in parts of the SJRWMD. This entailed field surveys from publicly accessible roads to identify irrigation status, irrigation system, and crop type. The USGS spatial data were reviewed manually to edit the ILG where irrigated features in the ILG were missing or should be changed to not irrigated, where crop types were different, or where boundary adjustments were needed. FDACS' Division of Plant Industry (DPI) citrus dataset was used to review irrigated citrus features in the ILG. This was done by reviewing imagery at locations of irrigated citrus from the ILG that were inactive or missing in the DPI citrus layer. About 50,000 acres of citrus were converted to fallow citrus through those reviews. **Table 2** provides a summary of the total acreage in the current ILG and ALG. **Table 3** provides a breakdown by crop of acreage at the statewide level. **Appendix C** provides detailed tables by Water Management District and county, with estimates for split district counties available in **Table C- 28**.

Table 2. Summary of ALG and ILG for 2022 baseline

WMD	ALG fields	ALG area	ILG fields	ILG area
	Count	Acres	Count	Acres
NWFWMD	31,545	712,961	984	53,344
SFWMD	37,945	2,950,658	6,946	1,042,680
SJRWMD	34,398	1,178,200	4,335	125,158
SRWMD	28,239	808,383	2,375	154,632
SWFWMD	39,985	1,830,659	8,585	324,013
Total FSAID	**172,112**	**7,480,860**	**23,225**	**1,699,826**

Table 3. 2022 Florida Irrigated Cropland Acreage by Primary Crop

Primary Crop	2022 Acres	Share of total
Citrus	396,108	23%
Field Crops	175,948	10%
Fruit (Non-citrus)	38,490	2%
Greenhouse/Nursery	57,598	3%
Hay	152,742	9%
Potatoes	30,215	2%
Sod	54,336	3%
Sugarcane	583,962	34%
Vegetables (Fresh Market)	210,429	12%
Total	**1,699,826**	**100%**

C. Projections of Future Irrigated Areas

The following sections describe how changes in irrigated areas in Florida counties were estimated and spatially distributed.

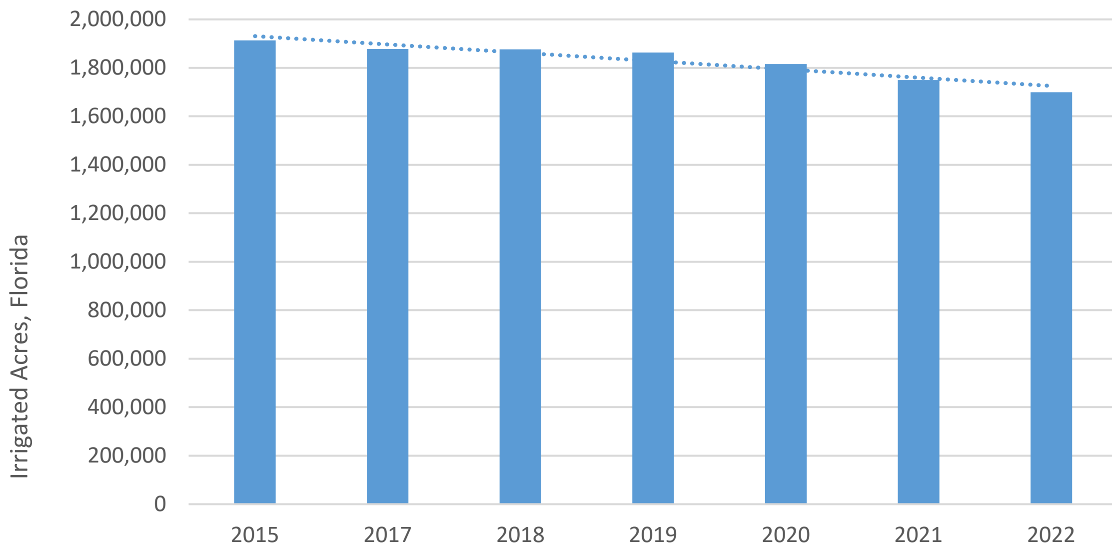
Trend Analysis from Historical FSAID Spatial Data

Long-term projections of irrigated agricultural lands were developed using historical, county totals of irrigated lands for each Florida county based on recent annual updates to the FSAID data. The ILG acreage from 2015 to 2022 for each County was used to develop trend analysis; **Appendix A** provides graphs of historical and projected irrigated acreage for each of Florida's 67 counties. This methodology is an improvement over the prior approach in FSAID in which long-term USDA Ag Census were used, as there was not a sufficiently long time series of accurate, ground-truthed and annually-updated irrigated areas. With the established history of the FSAID ILG's being annually updated, there is now a long enough recent historical time series to develop credible trends reflective of recent market and land use changes.

Regression procedures were used to forecast county-specific trends in irrigated area based on statistical fit. The functional form of each regression was selected based on best-fit criteria from logarithmic, linear, exponential, and power forms. The projected irrigated area changes were reviewed with FDACS and Water Management District personnel to evaluate the direction and amounts of irrigated acreage changes. In some counties, trend type was selected manually based on stakeholder input or reasonableness of the projected future acreage. Acreage projections were adjusted for Palm Beach County and Glades County to accommodate expected losses in irrigated area due to surface water projects. Osceola County irrigated acreage trends were adjusted to align with planned irrigated area increases of the North Ranch Sector Plan. Counties having total acreage change by 2050 of 500 acres or less (based on best-fit trend functions) were manually set to not change irrigated acreage over the projection period.

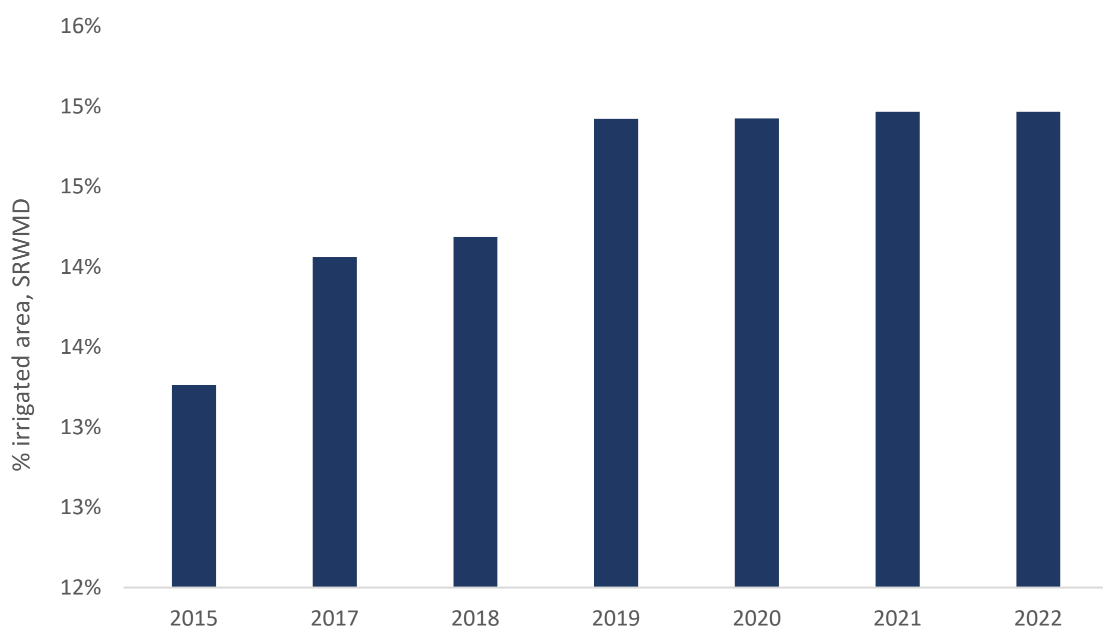
The annually updated, historical irrigated areas from FSAID are shown in **Figure 1**.

Figure 1. Statewide Irrigated Land, acres - Florida



To illustrate the increasing share of irrigation on agricultural lands in districts with recent irrigated area expansion (example: SRWMD) see **Figure 2**. Note the share of land irrigated increased from 13% to 15% from 2015 to 2022, during which over 32,000 irrigated acres were added in the district. It is also notable that irrigated acreage increases in SRWMD have moderated in the last four years. Only about 1,100 acres of irrigated area added in SRWMD from 2019 to 2022 (less than 300 acres/year). Trend projections based on these recent historical trends are also moderated as additional years of historical irrigated acreage are included in the time series used to train the county-specific trends for irrigated area.

Figure 2. SRWMD Trend in % irrigated land 2015 to 2022



Spatial Distribution of Projected Irrigated Area Changes

The county-level additions or declines in irrigated area were spatially distributed in the projections ILG using numerous decision rules for selecting ALG fields to become irrigated or ILG fields to become not irrigated. In counties with projected increases in irrigated acreage, R routines were used to select non-irrigated ALG fields to become irrigated until sufficient acreage is added in each 5-year projection period. The following conditions were used to constrain irrigated area additions, meaning if an ALG field was any of the following, it would not be a candidate for irrigation in a future period:

- Overlaps Florida Natural Areas Inventory (FNAI)
- NRCS Land Capability Classification > 5 (indicates lower quality soils)
- Overlaps a SFWMD planned surface water project.

Areas added to the ILG were prioritized based on having an active WUP and being near roads. Additionally, features within each group were also sorted by the development suitability index (least to most likely to develop based on the FL2070 development suitability index (FL2070, 2023). This means that the routine for ALG fields becoming irrigated, first looks at ALG fields overlapping an existing WUP for agricultural use, then looks at ALG fields with a distance to roadways less than half the county-average distance of ALG fields to roads, then looks at unpermitted ALG fields with above-average distance to roads, and each subset group is sorted lowest to highest by development suitability index (FL2070, 2023).

Similarly, in counties with project irrigated acreage declines, ILG features are identified first within urban boundaries (US Census), and fields are then sorted by development suitability index (FL2070, 2023) from least to greatest. This process looks first within urban boundaries (sorted lowest to highest by development suitability index), and then looks beyond urban boundaries in the County (also sorted by development suitability).

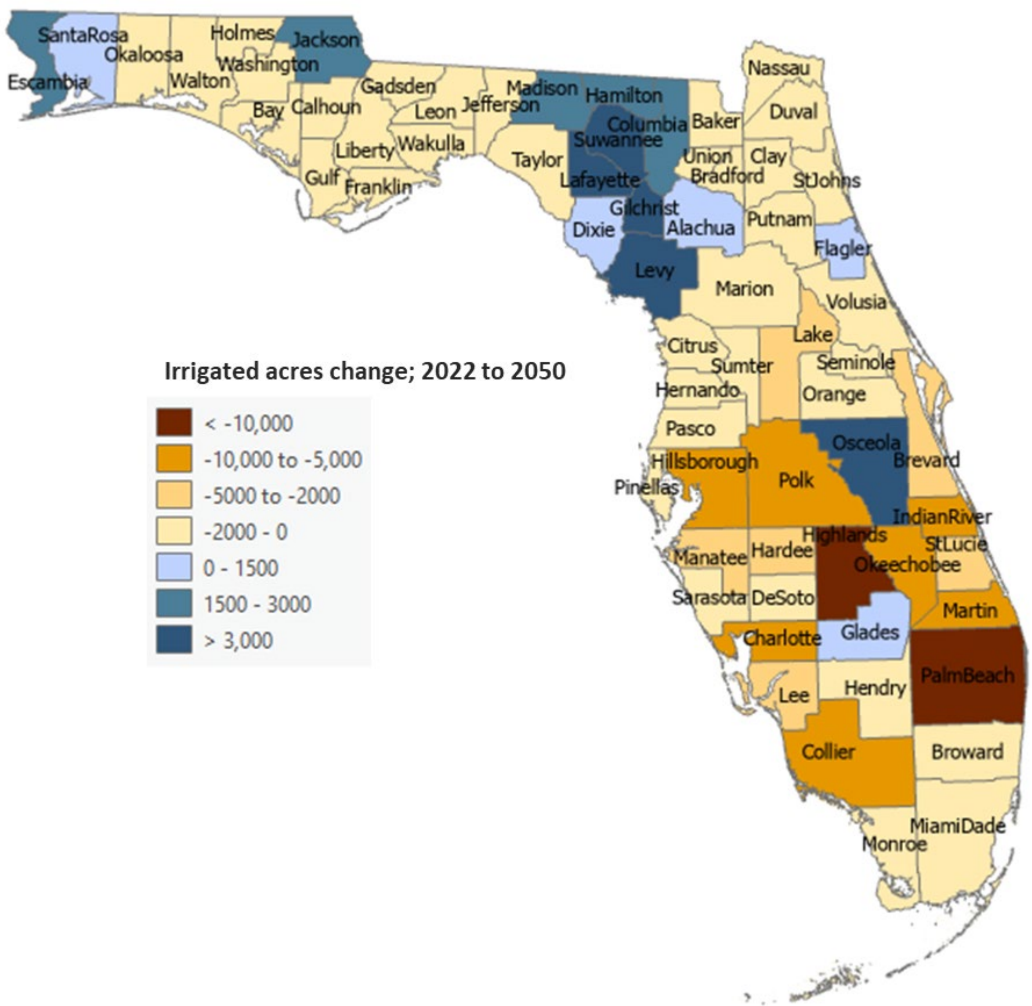
Acreage increases in Osceola County were adjusted manually to account for the additional irrigated acres specified in the North Ranch Sector Plan. For counties with a projected decrease in irrigated area, those decreases were required to occur in non-EAA regions, as the EAA is assumed to remain stable. However, a substantial exception to this occurs in Palm Beach County, with approximately 13k acres removed from the ILG in 2025 to accommodate the A-2 reservoir. That decline in Palm Beach County accounted for all the projected irrigated acreage decline in the County. In Glades County, projected declines in irrigated area were assumed negligible but were adjusted manually to add some irrigated areas to accommodate loss of irrigated areas (about 3,300 acres) due to a SFWMD surface water project (Lake Hicpochee Hydrologic Enhancement – FEB expansion planned for near-term 2025 impacts).

Projected agricultural acreage and irrigated acreage through 2050 by county are provided in **Table A-1** in the **Appendix A**. **Figure 3** illustrates the changes in irrigated areas from 2022 to 2050 by county; the majority of counties with large percent increases in irrigated area are in the northern portion of the state. Resulting acreage projections by District are provided in **Table 4.**

Table 4. Projected Irrigated Acreage by District

WMD	2022	2025	2030	2035	2040	2045	2050	2022-2050	2022-2050
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Change	% Change
NWFWMD	53,344	54,049	55,137	56,211	57,289	58,359	59,444	6,101	11%
SFWMD	1,042,680	1,027,966	1,020,278	1,015,977	1,011,414	1,006,640	1,001,312	(41,368)	-4%
SJRWMD	125,158	124,708	122,976	121,060	118,483	116,383	113,884	(11,274)	-9%
SRWMD	154,632	157,449	162,070	166,618	171,020	175,717	180,317	25,685	17%
SWFWMD	324,013	320,241	313,431	306,999	300,501	294,528	288,694	(35,319)	-11%
Total	**1,699,826**	**1,684,413**	**1,673,893**	**1,666,864**	**1,658,706**	**1,651,626**	**1,643,651**	**(56,175)**	**-3%**

Figure 3. County Level Projected Change in Irrigated Area: 2022 to 2050



D. Estimated Water Use

As required by Florida Statute, observations of irrigation water use were used as the basis for the FSAID estimates of spatially distributed statewide irrigation demand. Metered and reported water use data has been collected each year from the Water Management Districts. Historical metered/reported data extending from 2007 to 2022 were used to develop an analytical model to estimate irrigation water demand. The model specification is estimated using Ordinary Least Squares regression analysis to generate coefficients from the actual water use for each field-level variable. Variables include agronomic variables (crop choice, location, climate), engineering or physical factors (irrigation equipment, field size) and economic or behavioral factors (crop prices); the dependent variable is actual water use, derived from metered or reported water use data (hereafter, "metered data").

The model was initially developed based on published literature reflecting national trends in agricultural irrigation, and has been refined each year based on feedback from Districts, producers, and academics[4]. In the FSAID XI model, approximately 88,500 field-scale observations (from 2007-2022) are included in the dataset used to generate model coefficients. The R^2 or statistical "fit" of the model output to actual data is 0.77. **Appendix E** provides further detail on the model inputs, a detailed example of the model and discussion of specific elements of the model including price, costs and soils data.

i. Metered Data Records

The existing dataset of metered data records across Districts includes 16 years of permit-level water use from years 2007-2022. Input data was thoroughly evaluated for outliers, infeasible estimates based on irrigated area, and statistical heterogeneity. Multiple thresholds for inclusion in the dataset were tested including multiple standard deviations from the mean by crop by district; these included 10th and 90th percentile by crop by district and hard upper bounds (e.g.; 100 inches/year). Repeated statistical testing determined that the 25th and 90th percentile thresholds had values most representative of typical irrigation practice, and these thresholds were used to cull data for input to the water demand model.

Table 5 provides a summary by crop of metered data records, which includes field-level observations for each year from 2007-2022. Therefore, the total acreage of metered data in the input dataset greatly exceeds the current ILG, which represents only current, baseline irrigated area. **Appendix E** provides additional detail on screening of input data and distribution by District.

Table 5. Metered Data Records Summary by Crop

Primary Crop	Acres	Sample size, n
Citrus	3,446,746	33,308
Field Crops	587,622	6,894
Fruit (Non-citrus)	94,839	6,241
Greenhouse/Nursery	146,950	11,582
Hay	682,773	3,765
Potatoes	163,960	1,950
Sod	299,704	2,739
Sugarcane	1,066,223	3,873
Vegetables (Fresh Market)	1,221,200	18,169
Total	**7,710,017**	**88,521**

[4] See de Bodisco, C. (2007); Livanis, G., et al (2006); Moss, C. (1998); Schoengold, K., et al (2006); Chalfant, James A. (1984); Edwards, B. et al (1996).

Table 6 provides statewide average inches/year by crop as calculated by the Agricultural Field Scale Irrigation Requirements Simulation Model (AFSIRS) from the initial iteration of FSAID (FSAID I), metered or reported data for the previous FSAID X, and the current FSAID XI (metered) dataset.

Table 6. Statewide Average inches /year by Crop

Primary Crop	FSAID I AFSIRS results	FSAID X Metered or Reported Usage Input	FSAID XI Metered or Reported Usage Input
Citrus	14.4	11.6	11.5
Field Crops	10.2	10.6	10.9
Fruit (Non-citrus)	16.6	26.7	27.5
Greenhouse/Nursery	48.6	28.6	28.8
Hay	15.1	10.0	10.2
Potatoes	12.5	14.6	14.1
Sod	37.5	12.3	12.6
Sugarcane	24.6	16.8	17.3
Vegetables (Fresh Market)	11.9	17.4	17.5
Total	**19.5**	**13.6**	**13.7**

ii. Current Water Use Estimates

The resulting current water use estimates reflect a 2.8% decrease in overall irrigated acreage over the prior year (FSAID X) and a 2.2% decrease in overall water use as measured in Millions of Gallons per Day (MGD); see **Table 7** for the current FSAID XI values. Current baseline year 2022 irrigation water demand and the projected water demand for periods 2025-2050 were modeled using the average of rainfall and ET from 2005-2022.

Table 7. Estimated Statewide Water Use, 2022

Crop	Acres	MGD	in/yr
Citrus	396,108	315	10.7
Field Crops	175,948	147	11.2
Fruit (Non-citrus)	38,490	80	27.9
Greenhouse/Nursery	57,597	138	32.1
Hay	152,742	114	10.0
Potatoes	30,215	33	14.8
Sod	54,336	51	12.7
Sugarcane	583,962	657	15.1
Vegetables (Fresh Market)	210,429	277	17.7
Total	**1,699,826**	**1,811**	**14.3**

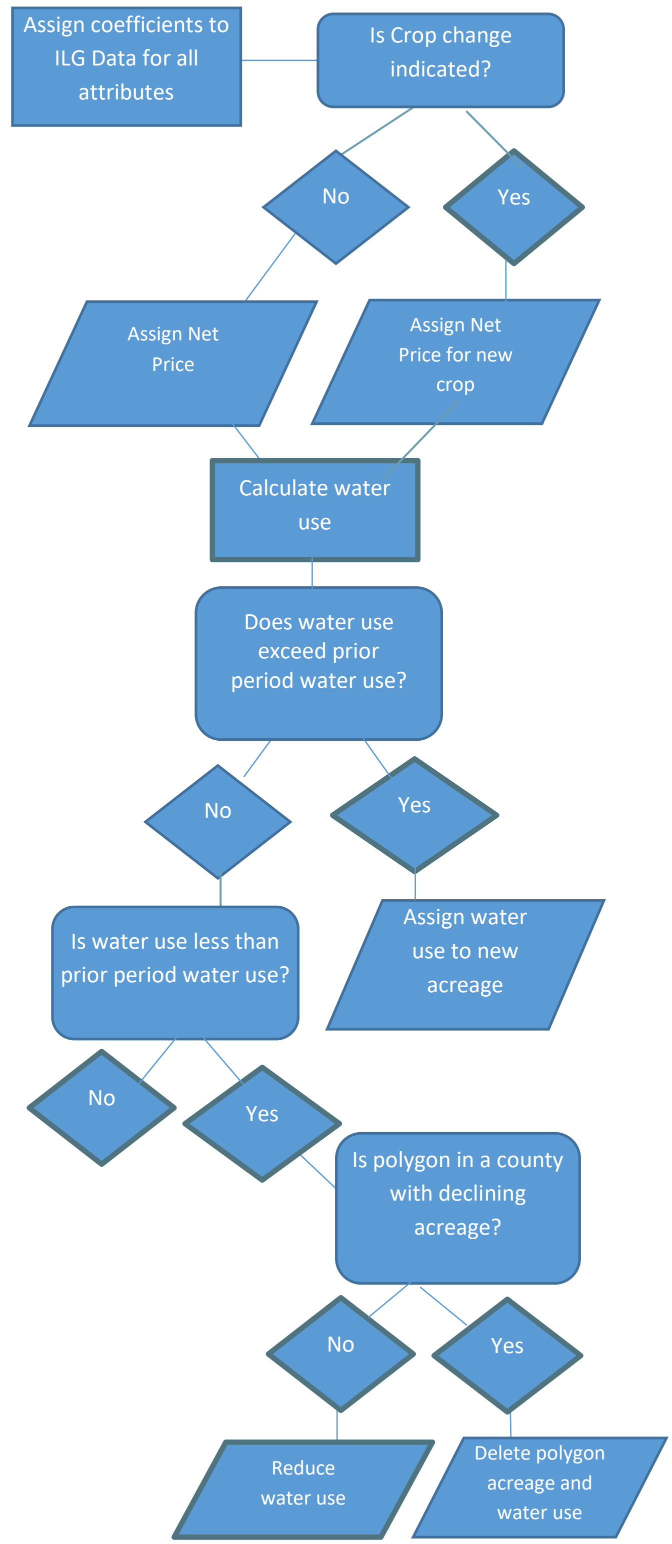
Source: SFWMD and TBG Work Product *Everglades Agricultural Area (EAA) area of 450,813 acres is held constant for sugarcane at 478 MGD.

E. Projected Water Use Methodology

Projected water use for the period from 2022-2050 is estimated by simulating future conditions using coefficients from the econometric model and substituting forecast future values for each variable. Since location and climate-related variables are either fixed or long-term averages, the simulation is driven mainly by price and cost forecasts and future land area.

i. Price Simulation

Figure 4. Spatial Distribution of Water Use Process



Future water use estimates were simulated by updating each explanatory variable in the model, and using the regression equation to estimate future water use. Each variable was estimated as follows:

1. Prices and costs were forecast for five-year periods from 2025 to 2050 using 10-year crop price forecasts from USDA, Food and Agricultural Policy Research Institute (FAPRI) extended using a crop specific growth trend.
2. The irrigated acreage changes were used to identify irrigated acreage for each five-year interval, as described in **Section C: Projections of Future Irrigated and Agricultural Land Area**. The net revenue variable was calculated by applying updated net revenue values to forecasted acreage.
3. ET and rainfall variables were updated by calculating mean historical values for an average year (2005-2022), assigned at the field level.
4. Estimated coefficients from the regression model were applied to forecast variables to simulate projected water use. The change in total water use was estimated at the field level, and applied to the acreage increase or decrease in each county.

ii. Spatial Distribution of Future Water Use

Spatial distribution of water use was applied according to the process outlined in **Figure 4**. Future water use changes that exceed water applied to current acreage were allocated across fields that were added to the ILG in future periods.

In some counties, agricultural acreage might not be sufficient to absorb the projected irrigated acreage after the constraints were applied, and if so, the acreage would be capped once the available land identified in the ALG was used. Conversely, if a county indicated fewer irrigated acres, the algorithm identified fields to remove from the ILG, with accordant water use. Crops were assigned based on the indicated crop mix from modeling results - i.e. the "excess" water from crops (crops that show higher water use for increased acreage). The predominant irrigation system used in the county for the crop was assigned. Rainfall and ET were assigned in the same manner as the rest of the ILG.

iii. Sensitivity Analysis

A number of model iterations were run to test the sensitivity of various parameters and alternative approaches to measuring variables. Sensitivity analyses were conducted to compare the impacts of truncating outliers through several approaches as detailed in **Appendix E**. A variety of scenarios affecting possible acreage and water demand results are also summarized in **Appendix E**.

Water Use Projection Results

F. Average Year Estimates

The resulting statewide water use estimates for each five-year period are provided in **Table 8** by crop, and **Table 9** by District. The total decrease in statewide irrigated area of 56,083 acres over the period through 2050 is accompanied by a net decrease in irrigation volume of 59 MGD for an average year. The effects are unevenly distributed by District, with a 16% increase in irrigation demand expected in SRWMD by 2050 and a 11% increase in irrigation demand in NWFWMD (although the latter comprises only about 5 MGD). Detailed breakdowns of county-level acreage by crop and District are included in **Appendix C**. **Figure 5** illustrates the percent change in irrigation water demand by county from 2022 to 2050.

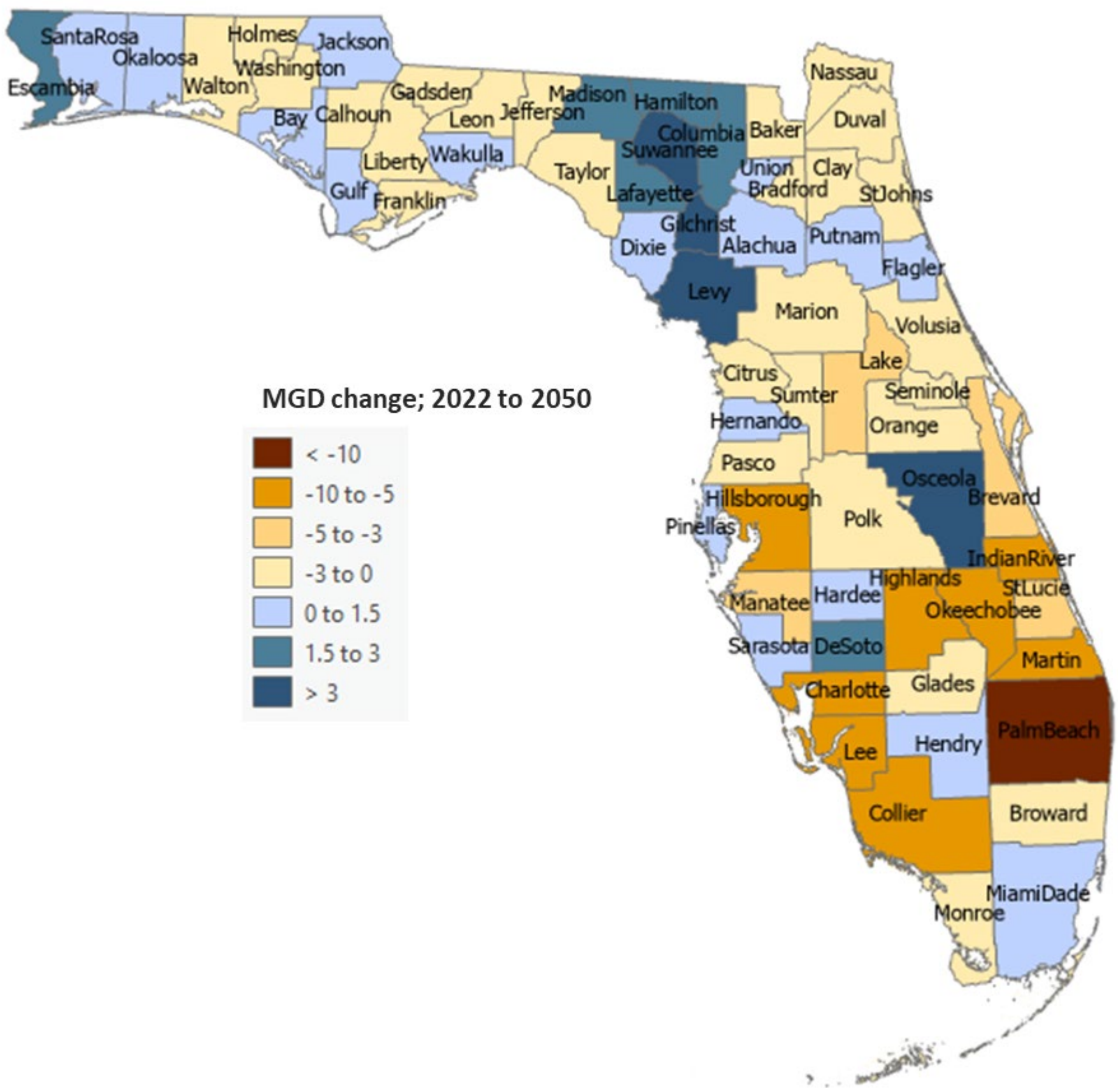
Table 8. Water Use Estimates by Crop Average Year

Statewide	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Predominant Crop	**Avg MGD**	**Avg MGD**	**Avg MGD**	**Avg MGD**	**Avg MGD**	**Avg MGD**	**Avg MGD**
Citrus	315	325	322	319	314	309	303
Field Crops	147	143	142	140	143	147	150
Fruit (Non-citrus)	80	79	77	74	74	73	72
Greenhouse/Nursery	138	135	130	130	129	129	129
Hay	114	113	114	116	115	114	113
Potatoes	33	33	33	33	32	32	32
Sod	51	51	51	50	50	49	49
Sugarcane	657	644	639	638	637	637	635
Vegetables (Fresh Market)	277	277	276	272	271	270	269
Total	**1,811**	**1,800**	**1,784**	**1,772**	**1,765**	**1,760**	**1,752**

Table 9. Water Use Estimates by District, Average Year

WMD	2022	2025	2030	2035	2040	2045	2050
	Avg MGD	Avg MGD	Avg MGD	Avg MGD	Avg MGD	Avg MGD	Avg MGD
NWFWMD	44	44	44	45	46	48	49
SFWMD	1,162	1,147	1,136	1,130	1,125	1,120	1,113
SJRWMD	142	142	139	136	133	130	128
SRWMD	155	154	158	161	167	173	178
SWFWMD	308	314	307	300	294	289	283
Total	**1,811**	**1,800**	**1,784**	**1,772**	**1,765**	**1,760**	**1,752**

Figure 5. County Level Projections of Change in Irrigation Demand: 2022 to 2050



G. Dry Year Estimates

Dry year estimates were calculated using crop and District-specific ratios of average irrigation water use to 1-in-10 use. The FSAID dry year estimates represent the irrigation demand that would be expected in 1 out of 10 years. Statewide, the overall average ratio is 1.34, but this varies widely by District. **Table E- 8** in **Appendix E** provides the ratios by crop and District and **Appendix E** also provides a more detailed description of how the average-to-dry ratios were developed. **Table 10** provides Dry Year Estimates by District, and **Table 11** shows Dry Year Estimates by Crop.

Table 10. Water Use Estimates by District, Dry Year (1-in-10)

WMD	2022	2025	2030	2035	2040	2045	2050
	Dry MGD	Dry MGD	Dry MGD	Dry MGD	Dry MGD	Dry MGD	Dry MGD
NWFWMD	61	61	62	63	65	67	69
SFWMD	1,552	1,532	1,518	1,510	1,504	1,498	1,489
SJRWMD	199	198	195	191	186	183	179
SRWMD	198	197	203	207	214	222	229
SWFWMD	428	437	428	418	410	403	395
Total	**2,439**	**2,425**	**2,405**	**2,389**	**2,380**	**2,372**	**2,361**

Table 11. Water Use Estimates by Crop, Dry Year (1-in-10)

	2022	2025	2030	2035	2040	2045	2050
Predominant Crop	Dry MGD	Dry MGD	Dry MGD	Dry MGD	Dry MGD	Dry MGD	Dry MGD
Citrus	464	480	475	470	463	455	446
Field Crops	193	187	186	183	187	192	196
Fruit (Non-citrus)	102	100	98	94	94	93	92
Greenhouse/Nursery	154	150	145	145	144	144	144
Hay	161	160	162	164	163	161	160
Potatoes	48	48	48	47	47	47	47
Sod	63	62	62	62	61	60	60
Sugarcane	906	889	882	881	879	878	877
Vegetables (Fresh Market)	348	349	348	342	342	341	339
Total	**2,439**	**2,425**	**2,405**	**2,389**	**2,380**	**2,372**	**2,361**

H. Frost and Freeze Protection Estimates

Irrigation for freeze protection is used on a variety of cold-sensitive crops in Florida. Freeze protection water volumes are a small percentage of the total statewide demand for normal irrigation (about 5%), but the withdrawals happen over a brief period, meaning that the impacts from these withdrawals can be significant. Frost protection water use in FSAID is limited to the major crops commonly requiring freeze protection: strawberries, blueberries, peaches, citrus, and ferns. Freeze-related irrigation events were estimated to occur on days with minimum temperature at or below freezing for fields in the ILG where crop type matched one of those listed above.

The USGS gridded Evapotranspiration (ET) data (from GOES platform) from 1996 to 2022 were used for estimating the average number of annual freeze events at ILG fields with a crop type that would be freeze protected. The dataset includes minimum temperature at 2km grid resolution, which was used to count the annual number of freeze events at the locations of ILG fields which would likely be freeze protected. The annual freeze events at ILG locations were then averaged at the county level for the 24-year period. The average number of freeze events for a county was combined with information on crop type and irrigation system to calculate annual average amounts of freeze protection water use. To calculate the amounts of freeze-protection water, the following irrigation intensities were used: 0.07 inches/hour for micro-spray irrigated citrus, 0.2 inches/hour for blueberries, strawberries, or peaches, and 0.3 inches/hour for ferns. A 14-hour freeze event duration was used. Frost/freeze water demand for future projections of the ILG varies from the current frost/freeze demands due to the additions or deletions of ILG polygons classified as Non-Citrus Fruit (which would include strawberry, blueberries, and peaches) and Citrus. It was assumed that all additional acres of Non-Citrus Fruit and Citrus in the ILG projection periods would be irrigated for freeze protection.

The average annual frost protection demand for the current ILG was about 62 MGD on an average annual daily flow (AADF) basis. This declined by about 12 MGD from the prior year FSAID estimates due to the substantial reductions in irrigated citrus in the base year ILG. Freeze protection irrigation demand decreased to about 58 MGD by 2050 due to declines in irrigated areas with crop types that would be freeze protected. **Table 12** summarizes freeze protection estimates by District.

Table 12. Estimated Freeze Protection Estimates by Year

WMD	2022	2025	2030	2035	2040	2045	2050
	MGD	MGD	MGD	MGD	MGD	MGD	MGD
NWFWMD	0.1	0.2	0.2	0.2	0.3	0.3	0.4
SFWMD	11.8	16.8	16.8	16.8	16.7	16.6	16.5
SJRWMD	10.2	5.1	4.9	4.7	4.6	4.5	4.2
SRWMD	1.2	1.3	1.3	1.4	1.6	1.7	1.8
SWFWMD	39.0	39.2	38.3	37.4	36.4	35.6	34.6
Total	**62.3**	**62.7**	**61.5**	**60.5**	**59.7**	**58.7**	**57.6**

In **Appendix D, Table D-1** provides a breakdown by Crop by District for freeze protection estimates, and **Table D-2** provides the county-level breakdown.

I. Conservation Estimates: Irrigation Efficiency Improvements

Under Florida Statute 570.93, "projected future water demands must incorporate appropriate potential water conservation factors". For purposes of incorporating potential water conservation factors, estimates of improvements in irrigation efficiency that can reasonably be expected over the planning period have been developed.

Two main datasets were explored for the purpose of estimating future irrigation efficiency improvements: Mobile Irrigation Labs (MIL) actual water savings (AWS) data and the USDA's Farm and Ranch Irrigation Surveys (FRIS), now known as the Irrigation and Water Management (IWM) Survey. The documented actual water savings through the MIL program are based largely on improvements in irrigation system distribution uniformity. The data available for MIL-based irrigation improvements from scheduling changes and sensor-based automation and other management improvements were determined to be of insufficient length to develop long-term future projections in conservation. However, this will change in coming years as the MIL database grows, and analysis is proceeding to test how MIL-based conservation estimates could work for FSAID long-term conservation estimates.

Data reflecting changes in farmers' use of irrigation water over the past 40 years is available from the USDA's IWM Survey. Using long-term trends avoids the uncertainty of estimating at the field level exactly what type of management change would be made and how many farms or fields would be expected to make that change. The IWM estimates show that over the entire time period for which data is available (1978-2018), the average farmer in Florida has decreased the amount of water used by 6,600 gallons/acre/year (which declines to 4,200 gallons/acre/year for the projection period of 2021-2045).

Some of the efficiency improvements will be due to irrigation system changes that have already been mostly implemented in many areas of the state (primarily a shift from gravity systems to drip and micro-spray systems); therefore, remaining improvements are likely to come from management changes through better scheduling and/or sensor-based automation. Evaluation of the IWM data for the period from 2003-2018 shows approximately 5,200 gallons/acre/year in improvement, which is likely more representative of future improvements to irrigation efficiency on newly irrigated land and for fields irrigated with drip or microsprinkler systems. This is reduced to 3,500 gallons/acre/year for the projection period of 2021-2045. Two exponential trends from the IWM dataset were used to estimate future irrigation efficiency improvement. The trend from 1978-2018 is used for currently irrigated fields that are not drip or microsprinkler irrigated, and the more conservative trend from 2003-2018 is used for newly irrigated fields or those irrigated with drip or microsprinkler. **Appendix E** provides more detail on the calculations used to derive the estimates and the supporting literature.

The resulting estimate of total irrigation efficiency improvements is about 113 MGD by 2050, or about 6% of total irrigation demand. **Table 13** provides a summary of estimated efficiency improvements by District.

Table 13. Estimated Efficiency Improvements by District

WMD	2025	2030	2035	2040	2045	2050
	MGD	MGD	MGD	MGD	MGD	MGD
NWFWMD	1.1	2.5	3.0	3.4	3.7	4.0
SFWMD	16.9	32.8	40.2	45.0	48.9	52.0
SJRWMD	3.6	8.7	12.4	14.7	16.4	17.8
SRWMD	4.8	12.7	19.7	22.9	24.7	26.3
SWFWMD	3.4	7.6	9.6	11.0	12.1	13.1
Total	**29.9**	**64.3**	**84.9**	**96.9**	**105.9**	**113.2**

Detailed efficiency improvements estimates are provided in **Appendix D** by Crop by District (**Tables D-3 through D-7)**, and by county (**Table D-8)**.

J. Livestock and Aquaculture Water Use

Livestock demands were determined using animal inventories from USDA Ag Census data and the typically utilized per animal daily water use. The most current Ag Census (2022) was used to define the numbers of cattle, cows, poultry, horses, and other livestock. Livestock inventories from the Ag Census have remained relatively stable in Florida for the last five censuses (2002, 2007, 2012, 2017, and 2022). The inclusion of updated Ag Census data for livestock inventories did not result in major changes in total livestock water demand estimates.

For purposes of estimating the future water use, stable livestock inventories and water use are assumed in the coming decades. Total statewide livestock demand for current conditions is estimated at 32.1 MGD. This is a decline of about 6 MGD from the previous year FSAID estimates, resulting from including more recent county-level livestock inventories from the 2022 Ag Census.

County-level water withdrawals for aquaculture were compiled using USGS 2015 water use data. Additionally, CUPs for several counties were found to have available metered data for aquaculture withdrawals, and these were used in conjunction with the USGS county-level aquaculture withdrawals to produce statewide aquaculture water demands. The maximum of county level sums of CUP-reported water use and USGS aquaculture water use was used. For counties with zero water use from the combination of USGS county-level aquaculture withdrawals and CUP data, aquaculture water demands may still occur if aquaculture features are present in the spatial dataset. The average statewide water demand per unit area for aquaculture features was used to estimate aquaculture water demand for features in counties with no other county total for aquaculture. Current aquaculture water use for 2022 is estimated to be 20.3 MGD. Future aquaculture demands are held constant for the planning period through 2050. Previous FSAID reports had projected increases in Miami-Dade to accommodate a large aquaculture operation there. These increases have already been observed in 2022 water use, so aquaculture demands are also held constant in Miami-Dade County through 2050.

Spatial distribution of county-level livestock and aquaculture water use at the sub-county level was achieved using ALG features with Crop2022 of Livestock or Aquaculture or Crop of ImprovedPastures. While there are several crop types in the ALG that might have grazing livestock present, only improved pastures are included in the livestock layer for the purposes of spatially distributing the county totals of livestock water use. This provides sufficient spatial disaggregation of water demands, while reducing the size and complexity of the livestock/aquaculture spatial dataset.

The statewide livestock inventory and water use is summarized in **Table 14**, and the total livestock and aquaculture water demands by District are presented in **Table 15**. A table of the county totals for livestock and aquaculture water demand are provided in **Appendix D**, **Table D-9**.

Table 14. Statewide Livestock and Aquaculture Totals for Current and Projected Periods

Animal group	Estimated Number of Animals	Water Use per Animal (gpd/head)	Total Demand (mgd)
Dairy Cows	71,827	150	10.77
Beef Cattle	1,567,071	12	18.80
Poultry, chickens	14,856,526	0.09	1.33
Equine	83,063	12	1.00
Goats	53,755	2	0.11
Hogs	12,739	2	0.03
Sheep	24,285	2	0.05
Aquaculture	NA	NA	20.3
Statewide Livestock and Aquaculture Total Demand			**52.4**

Table 15. Livestock and Aquaculture Total Water Use by District, MGD

WMD	Livestock Water Use (mgd)	Aquaculture Water Use (mgd)
NWFWMD	1.6	4.8
SFWMD	11.4	7.1
SJRWMD	3.9	1.7
SRWMD	9.1	0.4
SWFWMD	6.1	6.3
Total	**32.1**	**20.3**

FSAID Applications and Use

While FSAID was originally developed to support regional water supply planning by the Water Management Districts, it has evolved to support of variety of applications including: Best Management Practice (BMP) enrollment support (FDACS), estimating nutrient load impacts of cost-share projects (FDACS and DEP), hurricane loss impact estimates (University of Florida), studies of biofuels potential (Oak Ridge National Lab), Cropland Data Layer algorithm improvements (USDA), and the Florida Wildlife Corridor (analysis of potential payments for ecosystem services). The following table (**Table 16**) summarizes how the Water Management Districts utilize FSAID for regional water supply planning.

Table 16. FSAID applications in water supply planning

District	FSAID application
NWFWMD	Acreage and water demand projections used directly from FSAID
SFWMD	Acreage projections used with District-developed water demands from AFSIRS modeled on those acres with FSAID growth rates
SJRWMD	Acreage and water demand projections used directly from FSAID
SRWMD	Acreage and water demand projections used directly from FSAID
SWFWMD	Acreage projections used, with water use projections based on District historical water use and FSAID growth rates

FSAID Online Interface and Geodatabase

An online user interface has been developed to allow easier access to the agricultural acreage and water demand data. It is available at:

https://datavisual.balmoralgroup.us/FDACS-FSAID11

In addition to the web-based interface, the complete FSAID XI geodatabase has been made available. This contains shapefiles of water demand to facilitate further analysis and application of spatial water demand data. All appropriate metadata has been provided in the geodatabase. The FSAID XI geodatabase includes:

- The projections ILG: 2022 to 2050 irrigated acreage, crop type, average year and dry year water demand, conservation estimates, and freeze protection estimates (based on average 2005-2022 rainfall and ET)
- The 2022 ILG: includes only the base year 2022 irrigated areas and water demands (based on 2022 actual rainfall and ET)
- The ALG, which includes both irrigated and non-irrigated agricultural areas
- Livestock and Aquaculture: water demand estimates for all livestock and aquaculture
- Climate Factors: links the 2022 ILG with attributes for rainfall and ET (both for 2022 and 2005-2022 average), and soils (mukey and land capability classification)

Conclusions and Discussion

Summary

Overall agricultural water demand in Florida is anticipated to decrease by about 3% over the next 25 years based on declining total agricultural lands; irrigated lands also decrease moderately through 2050 (3% decrease in irrigated area from 2022 to 2050).

On a per acre basis, Florida farmers are projected to increase their irrigation efficiency by about 0.25% per year, well below the historical average from USDA Census data (about 1% annual efficiency improvement in recent two decades). Management practices can have an even greater influence than irrigation equipment, and the increased adoption of technology by Florida farmers continues to result in improvements in conservation of water. To the extent that more significant conservation quantities are desired, significant incentives are likely to be required to meaningfully shift this trajectory.

A number of factors will influence the agricultural irrigation patterns of Florida farmers over the next 25 years. Four alternative future scenarios were modeled to represent a range of uncertainties in Florida's agricultural water use. These scenarios include: 1) western U.S. to eastern U.S. agricultural migration, 2) trade adjustments that might improve prices for Florida berry and vegetable producers, 3) potential citrus greening solutions, and 4) increased land use change to non-agricultural uses. These are described in Appendix E. The potential changes in agricultural irrigation demands in Florida range from a 48 MGD increase to an 8 MGD decrease relative the FSAID 2050 projections.

The FSAID model incorporates historical behavior, through actual water use records, as well as behavior that is forward-looking (based on projections of prices and costs and trends developed on recent irrigated areas by County), through spatial allocation of future water demand. As urbanization encroaches on rural lands, and as western U.S. irrigation migrates toward Florida, lands that traditionally were not irrigated, or irrigated for small portions of the year, could increasingly be irrigated at a greater rate.

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