Prepared in cooperation with the U.S. Army Corps of Engineers

Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2018

Open-File Report 2020–1061

U.S. Department of the Interior
U.S. Geological Survey

Cover. Looking west along Broward River from U.S. Geological Survey (USGS) station 02246751, Broward River below Biscayne Boulevard near Jacksonville, Florida. Photograph by Jennifer Carson, USGS.

Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2018

By Patrick J. Ryan

Prepared in cooperation with the U.S. Army Corps of Engineers

Open-File Report 2020–1061

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment—visit https://www.usgs.gov or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit https://store.usgs.gov.

Suggested citation:
Ryan, P.J., 2020, Continuous stream discharge, salinity, and associated data collected in the Lower St. Johns River and its tributaries, Florida, 2018: U.S. Geological Survey Open-File Report 2020–1061, 34 p., https://doi.org/10.3133/ofr20201061.

ISSN 2331-1258 (online)

Acknowledgments

The author thanks the data collection personnel from the U.S. Geological Survey Caribbean-Florida Water Science Center in Orlando, Florida, for their help collecting and analyzing the streamflow and water-quality data.

Contents

Figures

Table

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F = (1.8 × °C) + 32.

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Abbreviations

JAXPORT	Jacksonville Port Authority
NOAA	National Oceanic and Atmospheric Administration
ppt	parts per thousand
PVC	polyvinyl chloride
SJRWMD	St. Johns River Water Management District
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2018

By Patrick J. Ryan

Abstract

The U.S. Army Corps of Engineers, Jacksonville District, plans to deepen the St. Johns River channel in Jacksonville, Florida, from 40 to 47 feet along 13 miles of the river channel, beginning at the mouth of the river at the Atlantic Ocean, in order to accommodate larger, fully loaded cargo vessels. The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, monitored stage, discharge, and (or) water temperature and salinity at 26 continuous data collection stations in the St. Johns River and its tributaries.

This is the third annual report by the U.S. Geological Survey on data collection for the Jacksonville Harbor deepening project and contains information pertinent to the data collection during the 2018 water year, from October 2017 to September 2018. Changes to the network on the main stem of the St. Johns River include the addition of (1) three new stations to monitor water temperature and salinity at Racy Point, Shands Bridge, and above Buckman Bridge; (2) stage data collection at both Buckman Bridge and Dames Point Bridge; and (3) three additional parameters, namely stage, velocity, and streamflow direction, to the St. Johns River at Jacksonville and Dames Point Bridge.

Discharge and salinity varied widely during the data collection period, which included residual effects from Hurricane Irma in September 2017 and above-average rainfall for all counties in the project area over the 4-month period from April to July. The annual mean discharge at Durbin Creek was greatest among the tributaries, followed by annual mean discharges at Ortega River, Trout River, Cedar River, Julington Creek, Clapboard Creek, Broward River, Pottsburg Creek, and Dunn Creek. The annual mean discharge for each of the main-stem sites was higher in the 2018 water year than that of the previous 2 years of this study. Among the tributary sites, annual mean salinity was highest at Clapboard Creek, the site closest to the Atlantic Ocean, and lowest at Durbin Creek and Ortega River, the sites farthest from the ocean. Annual mean salinity data from the main-stem sites on the St. Johns River indicate that salinity decreased with distance upstream from the ocean, which is expected. Relative to annual mean salinity calculated since the 2016 water year, annual mean salinity at all monitoring locations was lower for the 2018 water year, except for Durbin Creek, which was the same.

Introduction

The St. Johns River flows 310 miles (mi) northward through the eastern half of Florida, through Jacksonville and into the Atlantic Ocean (fig. 1). The river consists of lakes, marshes, and seagrass beds, as well as the main river channel (herein referred to as the "main stem") that, near its mouth, can accommodate cruise ships and cargo vessels with access to the Atlantic Ocean. Jacksonville Harbor is located along the first 20 river miles, beginning at the mouth of the St. Johns River where it empties into the Atlantic Ocean. Jacksonville Harbor currently can only accommodate small cargo vessels or large cargo vessels loaded below maximum capacity because of the authorized channel depth of 40 feet (ft). Dredging an additional 7 ft will allow the port to accommodate larger, fully loaded vessels. Beginning at the mouth, the U.S. Army Corps of Engineers (USACE) plans to deepen the first 13 river miles (USACE, 2014). Dredging construction began February 2018 (Jacksonville Port Authority [JAXPORT], 2018).

Salinity models indicate that the harbor deepening may alter salinity in part of the study area, potentially causing (1) salinity stress in some wetlands and submerged aquatic vegetation and (2) changes in some fish and macroinvertebrate distributions (USACE, 2014). Surface-water monitoring, required by permit, includes the collection of water temperature, salinity, and (or) stage, velocity, and streamflow data for at least 6 months prior to dredging, continuously throughout dredging, and for 10 years following dredging (Florida Department of Environmental Protection, 2016). The U.S. Geological Survey (USGS), in cooperation with the USACE, is responsible for monitoring all parameters at the gage locations listed in the permit that were not already being monitored by other entities as of January 2016, the beginning of the initial data collection period (Florida Department of Environmental Protection, 2016).

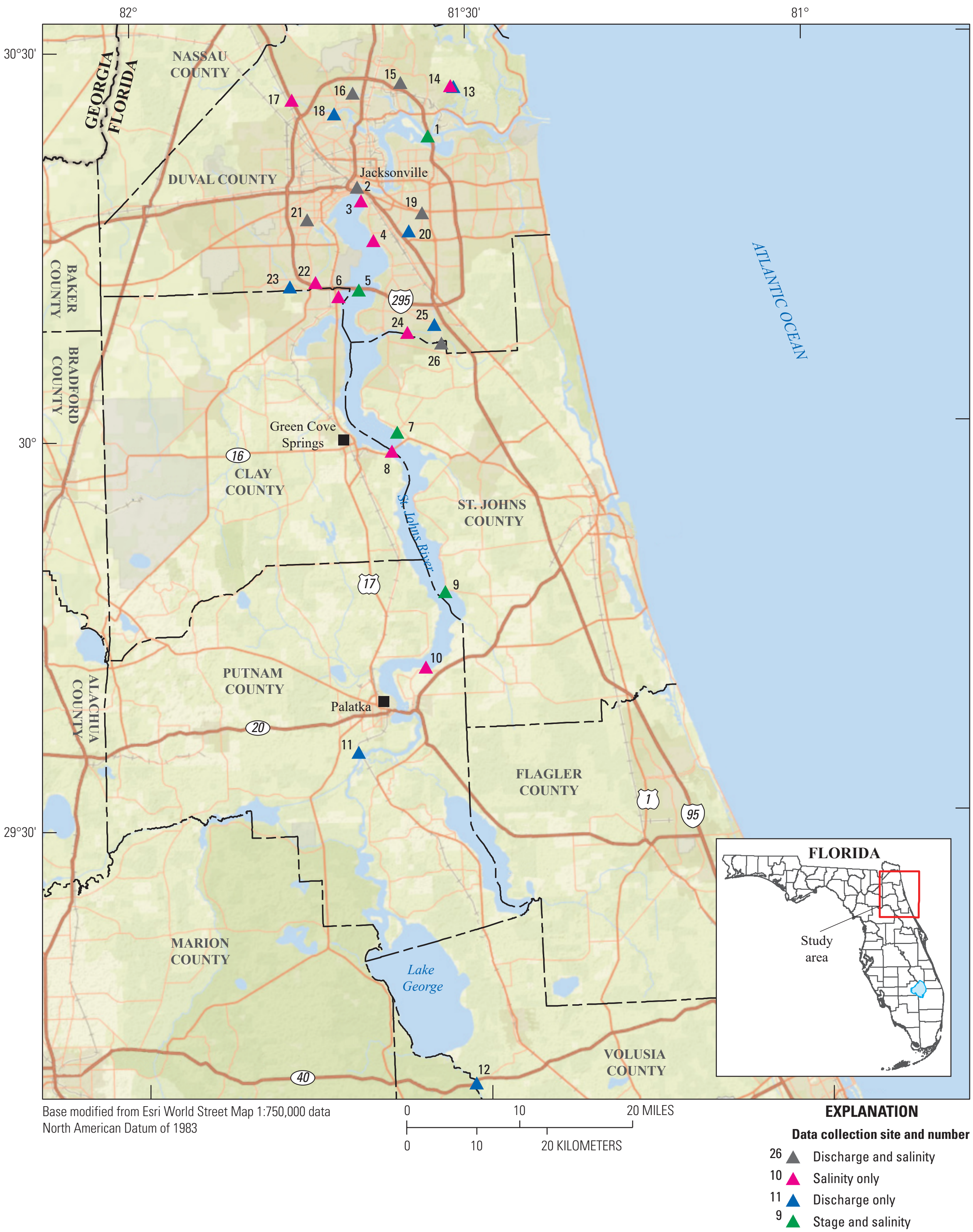

Figure 1. U.S. Geological Survey data collection sites on the St. Johns River and its tributaries. Map image is the intellectual property of Esri and is used herein under license. Copyright © 2019 Esri and its licensors. All rights reserved.

The streamflow and water-quality monitoring network was used to collect baseline data in the St. Johns River and its tributaries prior to dredging and can be used to discern changes, if any, during and after dredging.

This report provides an overview of the data collected from 26 surface-water discharge and (or) water-quality sites along the St. Johns River and its tributaries (1) under predredging conditions and (2) during the first year of dredging and third year of the study, specifically from October 2017 to September 2018 (figs. 1 and 2). The report documents the data collection sites, methods used to compute discharge and salinity, and parameters monitored at each site. The first 2 years of the study are described in Ryan (2018, 2019).

The data collected during this study are available from the USGS National Water Information System database (USGS, 2019).

Methods

The methods of data collection and processing, as well as the sites used for data collection, are described in the following sections. The descriptions of data collection sites are separated into those along the St. Johns River and those along its tributaries (table 1).

Methods of Data Collection and Processing

Stage data (gage height, in feet, referenced to the North American Vertical Datum of 1988) were collected at 15-minute intervals using various types of equipment, depending on location requirements, in accordance with USGS standards (Sauer and Turnipseed, 2010a). Discharge was routinely measured by using various types of equipment, depending on depth, velocity, and environmental conditions, in accordance with USGS standards (Sauer and Turnipseed, 2010b). Because of tidal and (or) wind effects, discharge, in cubic feet per second, was computed using the index-velocity method at most sites, in accordance with USGS techniques and methods (Levesque and Oberg, 2012). Discharge was computed using a stage-discharge relationship at a few sites where tidal influence was not substantial (Rantz and others, 1982). Where applicable, discharge data were filtered by using the Godin low-pass filter to remove principal tidal frequencies from unit values (Godin, 1972). By convention, the USGS designates ebb (seaward) flow as positive flow and flood (landward) flow as negative flow. The residuals are not total freshwater flows, but instead, a combination of seaward freshwater flows from the watershed and landward saltwater flows from the marine environment, along with storm surges from hurricanes or tropical storms.

Water temperature, in degrees Celsius, and specific conductance, in microsiemens per centimeter at 25 degrees Celsius, were measured at intervals of 1 hour or less in accordance with USGS techniques and methods (Wagner and others, 2006). Water-quality meters were installed in situ at sites in freshwater environments. A pump and intake system was installed at sites in harsh saltwater environments to reduce fouling. This setup consisted of a meter housed inside a polyvinyl chloride (PVC) chamber in a shelter. In this case, water was pumped into the chamber for 1–2 minutes before each measurement and drained from the chamber between measurements. The recording interval was reduced to one measurement per hour because of the power requirements for the pump setup. Because the chamber drains between measurements, water-quality parameters can be measured at multiple levels with one meter, if necessary. A rating table was used to convert specific conductance, in microsiemens per centimeter, to salinity, in parts per thousand (Wagner and others, 2006). Salinity was calculated for every site where water temperature and specific conductance were measured.

Missing discharge data can usually be attributed to equipment malfunction, either with the stage sensor or velocity meter (if the index-velocity method is used). For tidally filtered discharge calculation, the Godin low-pass filter requires 35 hours of continuous data before and after each data point (Godin, 1972). A data gap greater than 2 hours, therefore, results in a data gap of 3 days in the tidally filtered discharge record. For sites that include a pump setup, missing water-quality data are usually a consequence of power or pump failure, which prevents water from filling the chamber where the meter is housed. Biological fouling is a more common problem with meters installed in situ, where algal growth and crustaceans can affect the conductance measurement port or the temperature probe, both of which provide data used to calculate salinity. In either case, the affected values are not used, creating gaps in the final record.

Rainfall data for Duval, Clay, St. Johns, Putnam, and Volusia Counties in 2018 were obtained from the St. Johns River Water Management District (SJRWMD), which provides details about how average monthly rainfall data are compiled for counties in their district (SJRWMD, 2019). The period of record rainfall data to determine a long-term countywide average was compiled using National Oceanic and Atmospheric Administration (NOAA) rain gages in central and north Florida through 2009. Jacksonville Harbor and all monitoring sites included in this study are located within Duval County, except the St. Johns River sites at Astor in Volusia County, Dancy Point and Buffalo Bluff in Putnam County, Racy Point and Shands Bridge in St. Johns County, and above Buckman Bridge near the left bank in Clay County (fig. 1).

Quantile plots were created to show percentiles for annual discharge data collected at monitoring sites that have at least 10 years of record and a full contemporary year of data. The quantile plots group the annual peak discharges by water year. For this report, the 2018 water year includes data from October 1, 2017, to September 30, 2018. The resulting plots show how the 2018 water year discharge at a given station compares with that of previous water years. For discharges affected by tidal fluctuations, annual mean tidally filtered discharge was used to construct the plot.

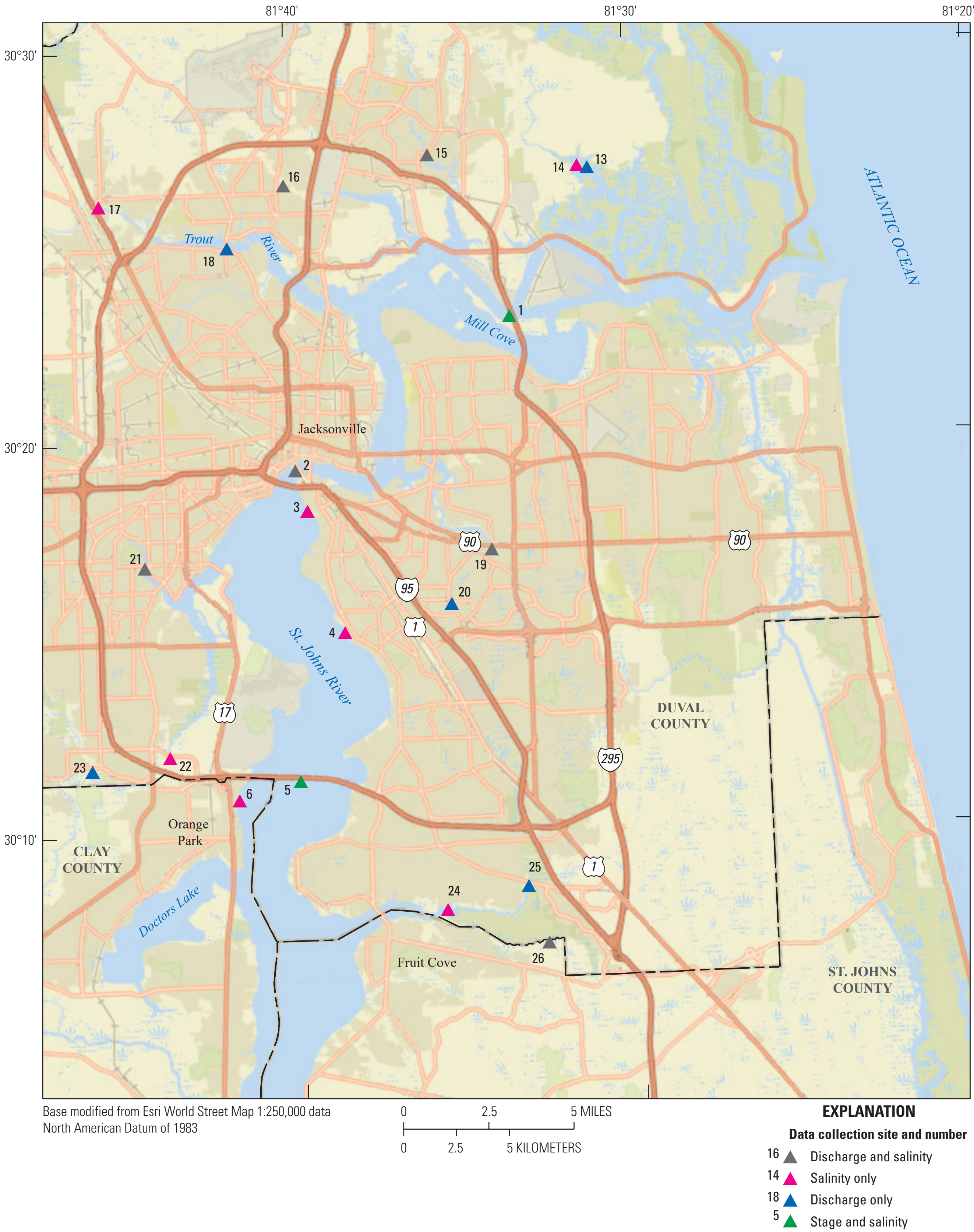

Figure 2. U.S. Geological Survey data collection sites in Clay, Duval, and St. Johns Counties, Florida. Map image is the intellectual property of Esri and is used herein under license. Copyright © 2019 Esri and its licensors. All rights reserved.

Table 1. U.S. Geological Survey data collection sites on the main stem of the St. Johns River and its tributaries and parameters published during the 2018 water year.

[USGS, U.S. Geological Survey; x parameter measured; --, parameter not measured; NA, not applicable]

Map number	USGS site number	USGS site name	Discharge	Gage height	Velocity	Temperature	Specific conductance	Salinity	River mile
		St. Johns River							
1	302309081333001	St Johns River Dames Point Bridge at Jacksonville, Fla.	--	x	x	x	x	x	10
2	02246500	St. Johns River at Jacksonville, Fla.	x	x	x	x	x	x	23
3	301817081393600	St. Johns River below Marco Lake at Jacksonville, Fla.	--	--	--	x	x	x	25
4	301510081383500	St. Johns River at Christopher Point near Jacksonville, Fla.	--	--	--	x	x	x	29
5	301124081395901	St. Johns River Buckman Bridge at Jacksonville, Fla.	--	x	--	x	x	x	34
6	301057081414800	St. Johns River above Buckman Bridge at Jacksonville, Fla.	--	--	--	x	x	x	35
7	02245340	St. Johns River below Shands Bridge near Green Cove Springs, Fla.	--	x	--	x	x	x	49
8	295856081372301	St. Johns River Shands Bridge near Green Cove Springs, Fla.	--	--	--	x	x	x	50
9	02245290	St. Johns River at Racy Point near Hastings, Fla.	--	x	--	x	x	x	64
10	294213081345300	St. Johns River at Dancy Point near Spuds, Fla.	--	--	--	x	x	x	71
11	02244040	St. Johns River at Buffalo Bluff near Satsuma, Fla.	x	x	--	--	--	--	90
12	02236125	St. Johns River at Astor, Fla.	x	x	--	--	--	--	127
		Tributaries							
13	02246825	Clapboard Creek near Jacksonville, Fla.	x	x	--	--	--	--	NA
14	302657081312400	Clapboard Creek above Buckhorn Bluff near Jacksonville, Fla.	--	--	--	x	x	x	NA
15	02246804	Dunn Creek at Dunn Creek Road near Eastport, Fla.	x	x	--	x	x	x	NA
16	02246751	Broward River below Biscayne Boulevard near Jacksonville, Fla.	x	x	--	x	x	x	NA

Table 1. U.S. Geological Survey data collection sites on the main stem of the St. Johns River and its tributaries and parameters published during the 2018 water year.—Continued

[USGS, U.S. Geological Survey; x parameter measured; --, parameter not measured; NA, not applicable]

Map number	USGS site number	USGS site name	Discharge	Gage height	Velocity	Temperature	Specific conductance	Salinity	River mile
		Tributaries—Continued							
17	302609081453300	Trout River below U.S. 1 at Dinsmore, Fla.	--	--	--	x	x	x	NA
18	02246621	Trout River near Jacksonville, Fla.	x	x	--	--	--	--	NA
19	02246518	Pottsburg Creek at U.S. 90 near South Jacksonville, Fla.	x	x	--	x	x	x	NA
20	02246515	Pottsburg Creek near South Jacksonville, Fla.	x	x	--	--	--	--	NA
21	02246459	Cedar River at San Juan Avenue at Jacksonville, Fla.	x	x	--	x	x	x	NA
22	301204081434900	Ortega River Salinity at Jacksonville, Fla.	--	--	--	x	x	x	NA
23	02246318	Ortega River at Kirwin Road near Jacksonville, Fla.	x	x	--	--	--	--	NA
24	300803081354500	Julington Creek at Hood Landing near Bayard, Fla.	--	--	--	x	x	x	NA
25	02246160	Julington Creek at Old St August Road near Bayard, Fla.	x	x	--	--	--	--	NA
26	022462002	Durbin Creek near Fruit Cove, Fla.	x	x	--	x	x	x	NA

Description of St. Johns River Main-Stem Sites

All sites on the main stem of the St. Johns River have substantive tidal influence, and therefore the calculated discharge is tidally filtered. Three new sites were added to the network on the St. Johns River to monitor water temperature and salinity above Buckman Bridge, at Shands Bridge, and at Racy Point, which also monitors stage. Other additions for this year of the study include the following: stage data collection at Buckman Bridge; velocity and streamflow direction at St. Johns River at Jacksonville; and stage, velocity, and streamflow direction at Dames Point.

The farthest upstream discharge monitoring site on the St. Johns River is in Astor, Fla., at the State Road 40 Bridge (table 1; river mile 127). Approximately 37 mi downstream, discharge is also calculated for the St. Johns River at Buffalo Bluff (river mile 90). Tidally filtered discharge values have been computed since 1994 at both Astor and Buffalo Bluff. The farthest upstream water-quality monitoring station along the St. Johns River is located at Dancy Point (river mile 71). Water temperature and specific conductance are measured at an approximate depth of 11.5 ft below the average high-tide level. Since May 2018, stage, water temperature, and specific conductance have been monitored farther downstream at the St. Johns River at Racy Point (river mile 64). The water-quality parameters are measured at an approximate depth of 2.5 ft below the average high-tide level. Water temperature and specific conductance are collected near the channel of the St. Johns River at Shands Bridge (river mile 50). This location was historically monitored from April 1995 to September 2001 at multiple depths and from April 2008 to September 2009 at the middle depth. The meter was reinstalled May 2018 at the middle-depth location of 10 ft below the average high-tide level. Just downstream near the right bank, stage, water temperature, and specific conductance are measured at an approximate depth of 8.5 ft below the average high-tide level at the St. Johns River below Shands Bridge (river mile 49).

A monitoring station located near the left bank of the St. Johns River just upstream from Buckman Bridge was installed January 2018. Water temperature and specific conductance are measured at an approximate depth of 4 ft below the average high-tide level at this station, St. Johns River above Buckman Bridge (river mile 35). A monitoring station at Buckman Bridge (river mile 34) near the main channel measures water temperature and specific conductance with separate pump setups and intakes at two different depths. One water-quality meter is used in the chamber and monitors both water properties at each depth. All water-quality parameters are monitored at approximate depths of 8 ft (top) and 16 ft (bottom) below the average high-tide level. Data collection for stage was added in October 2017. Water-quality monitoring stations at Christopher Point (river mile 29) and Marco Lake (river mile 25) measure water temperature and specific conductance at an approximate depth of 4 ft below the average high-tide level for each location. These sites are characterized by relatively shallow water having an average depth of less than 6 ft and represent river conditions in seagrass beds near the shore.

The St. Johns River at Jacksonville, Fla., data collection station, located near downtown Jacksonville at Acosta Bridge (river mile 23), is the farthest downstream gage that calculates discharge. Stage and discharge were previously monitored before the dredging study began, but water temperature and specific conductance data collection began in October 2015 at an approximate depth of 11 ft below the average high-tide level. The monitoring equipment was moved to the center of the channel in April 2018 because of fender construction, and the intake was installed at a new depth of 17 ft below the average high-tide level. Velocity and streamflow direction data collection were added in October 2017. Tidally filtered discharge values have been computed since 1996. A monitoring station at Dames Point Bridge in Jacksonville (river mile 10) measures stage, velocity, water temperature, and specific conductance; calculation of salinity began in October 2016. All water-quality data are collected at approximate depths of 15 ft (top) and 22 ft (bottom) below the average high-tide level by using one water-quality meter and pump setup with separate intakes, similar to those used at the station at Buckman Bridge. At Dames Point, the collection of stage data began in October 2017, and the collection of velocity and streamflow direction data began in May 2018.

Description of Tributary Sites

No changes to the tributary monitoring network occurred during this year of the study. A monitoring station on Julington Creek at Old St. Augustine Road calculates discharge 6.7 mi upstream from the confluence of Julington Creek and the St. Johns River (table 1). A nearby water-quality monitoring station measures water temperature and specific conductance at an approximate depth of 3.5 ft below the average high-tide level and is located approximately 3 mi downstream from Old St. Augustine Road on Julington Creek at Hood Landing.

Durbin Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity 3.5 mi upstream from the confluence with Julington Creek and 6.8 mi upstream from the confluence with the St. Johns River. The water-quality parameters are measured at an approximate depth of 3 ft below the average high-tide level. These locations are all tidally influenced, but large amounts of rainfall, resulting in increased discharge, can obscure the tidal signal.

Ortega River is monitored for stage and discharge at Argyle Forest Boulevard (Kirwin Road), 11 mi upstream from the confluence of the Ortega and St. Johns Rivers. Discharge has been computed intermittently at this location since 2002, and a stage-discharge rating was used for discharge computation during the study period, as no tidal influence is apparent in the stage data. A water-quality monitoring station that measures water temperature and specific conductance at an approximate depth of 6.5 ft below the average high-tide level is located at the bridge on Collins Road approximately 3 mi downstream from Kirwin Road at the Ortega River. Tidal influence is evident in the salinity data during times of low flow or increased stage in the St. Johns River.

The monitoring station on Cedar River measures stage, water temperature, and specific conductance at San Juan Avenue, 1.5 mi upstream from the confluence of the Cedar and St. Johns Rivers. The water-quality parameters are monitored at an approximate depth of 6 ft below the average high-tide level. Historical, tidally filtered discharge values have been computed intermittently since 2002. Wind, tide, and rainfall all substantively affect flow and salinity at Cedar River, and vertically stratified, bidirectional flow is commonly measured when strong winds occur opposite the direction of flow.

The station at Pottsburg Creek near South Jacksonville measures stage and is 7.3 mi upstream from the confluence of Pottsburg Creek and the St. Johns River. A stage-discharge rating was used for discharge computation during the study period. The data indicate tidal influence when stage is very low in the creek and elevated in the St. Johns River, but discharge measurements confirm the validity of the stage-discharge relationship. Pottsburg Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity at U.S. 90, 5.2 mi upstream from the confluence of Pottsburg Creek and the St. Johns River. The water-quality parameters are monitored at an approximate depth of 4 ft below the average high-tide level. This location has a more pronounced tidal signal than the upstream location on Pottsburg Creek, and discharge and salinity are affected primarily by rainfall and elevated stage in the river.

The monitoring station for Trout River calculates discharge at Lem Turner Road, 5 mi upstream from the confluence of the Trout and St. Johns Rivers. Water temperature and specific conductance are measured 9.3 mi upstream from the confluence at an approximate depth of 6 ft below the average high-tide level. Broward River is monitored for stage, discharge, water temperature, specific conductance, and salinity near Biscayne Boulevard, 6.3 mi upstream from its confluence with the St. Johns River. The water-quality parameters are monitored at an approximate depth of 4.5 ft below the average high-tide level. Discharge and salinity at these stations have a pronounced tidal signal, even when stage is elevated.

Dunn Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity at Dunn Creek Road, 5.3 mi upstream from the confluence of Dunn Creek and the St. Johns River. The monitoring station for Clapboard Creek calculates discharge near Sheffield Road, 4.5 mi upstream from the confluence of Clapboard Creek and the St. Johns River. Water temperature and specific conductance are measured at a location 0.5 mi upstream. The water-quality parameters are monitored at approximate depths of 5.5 and 6.5 ft below the average high-tide level. Discharge and salinity fluctuations at these stations are dependent on rainfall in the relatively small drainage area and on wind effects from the St. Johns River, owing to the proximity of the sites to the river and Atlantic Ocean.

Results

Because of the large project area and diversity of sites, discharge and salinity varied widely during the period. As expected, salinities were lowest at the tributary sites farthest from the ocean and highest during periods of low flow in the St. Johns River.

Rainfall

Duval County rainfall for the 2018 water year (October 2017–September 2018) was slightly above the long-term average and ranged from 4.0 inches (in.) below average in September to 3.8 in. above average in May (fig. 3). The total rainfall accumulation from October to March was 1.2 in. below average, and the total rainfall accumulation from April to July was 6.6 in. above average, the greatest of any consecutive 4-month period, based on monthly rainfall data from SJRWMD (2019). Yearly rainfall averaged 3.2 in. and 1.5 in. above average for Clay and St. Johns Counties, respectively, which was slightly higher than that of Duval County (SJRWMD, 2019). Rainfall for Clay County and St. Johns County ranged from 4.5 and 3.9 in. above average in May to 3.2 and 5.7 in. below average in September, respectively (figs. 4 and 5).

Compared to the total monthly average, the net positive rainfall total for the southern portion of the study area was higher than for the northern portion. Rainfall for Putnam and Volusia Counties were similar, totaling 8.1 and 6.9 in. above the average yearly total, respectively (SJRWMD, 2019). Rainfall for Putnam County ranged from 4.5 in. above average in April to 2.9 in. below average in September (fig. 6). Rainfall for Volusia County ranged from 6.7 in. above average in May to 3.9 in. below average in September (fig. 7). Like Duval County, the largest consecutive 4-month above-average rainfall for Putnam and Volusia Counties occurred during the months of April to July, totaling 11.6 in. and 12.1 in. above the cumulative average, respectively.

Daily discharge and salinity plots for the 2018 water year (October 2017–September 2018) are presented in the following sections where applicable. A year refers to a water year in these sections unless otherwise noted. Daily discharge is tidally filtered at sites where substantive tidal fluctuations occur. Salinity values are not filtered and include daily maximum, minimum, and mean values. Instantaneous values can be accessed via the USGS National Water Information System database (U.S. Geological Survey, 2019). Annual mean discharges are calculated only for sites having at least an entire year of discharge record. The annual mean is not calculated for partial years of record when stations were installed. Quantile plots are only made for sites having at least 10 years of annual streamflow record.

Main-Stem Sites

St. Johns River at Astor, Florida—Daily tidally filtered discharge at Astor ranged from −1,620 to 13,600 cubic feet per second (ft^3/s) during the 2018 water year, with an annual mean of 5,870 ft^3/s (fig. 8). A comparison of historical annual mean tidally filtered flows indicated that 2018 streamflow was the largest of the 24 complete years of record; the median tidally filtered annual mean flow for the period of record is 2,820 ft^3/s (fig. 9). This period was influenced by residual high flows from Hurricane Irma, which made landfall in September 2017, and by above-average rainfall in Volusia County from April to July (fig. 7), which caused two prolonged periods of streamflow greater than 10,000 ft^3/s (fig. 8).

St. Johns River at Buffalo Bluff Near Satsuma, Florida—Daily tidally filtered discharge at Buffalo Bluff ranged from −8,530 to 24,100 ft^3/s during the 2018 water year, with an annual mean of 9,390 ft^3/s (fig. 10). The highest discharges occurred in October because of residual flows from Hurricane Irma, with another period of elevated streamflow in July and August related to above-average rainfall in Putnam County from April to July (fig. 6). A comparison of historical annual mean tidally filtered flows indicated that 2018 streamflow was at the 94th percentile; the median tidally filtered flow for the period of record is 4,320 ft^3/s (fig. 11).

St. Johns River at Dancy Point near Spuds, Florida—Salinity on the St. Johns River at Dancy Point ranged from 0.2 to 0.4 parts per thousand (ppt) during the 2018 water year, with a median and mean of 0.3 ppt (fig. 12). The salinity data show the effects of increased freshwater flows related to summertime rainfall and residual flows from Hurricane Irma even at these low salinity values.

St. Johns River at Racy Point near Hastings, Florida—Salinity on the St. Johns River at Racy Point ranged from 0.2 to 0.4 ppt, with a median and mean of 0.3 ppt from May 2018 (when the monitoring station was installed) to September 2018 (fig. 13). Small fluctuations occurred because of tidal influence and summertime rainfall, as seen in the salinity values from late July to September.

St. Johns River Shands Bridge near Green Cove Springs, Florida—Salinity on the St. Johns River at Shands Bridge ranged from 0.2 to 0.4 ppt, with a median and mean of 0.3 ppt during the period from May 2018 (when the monitoring

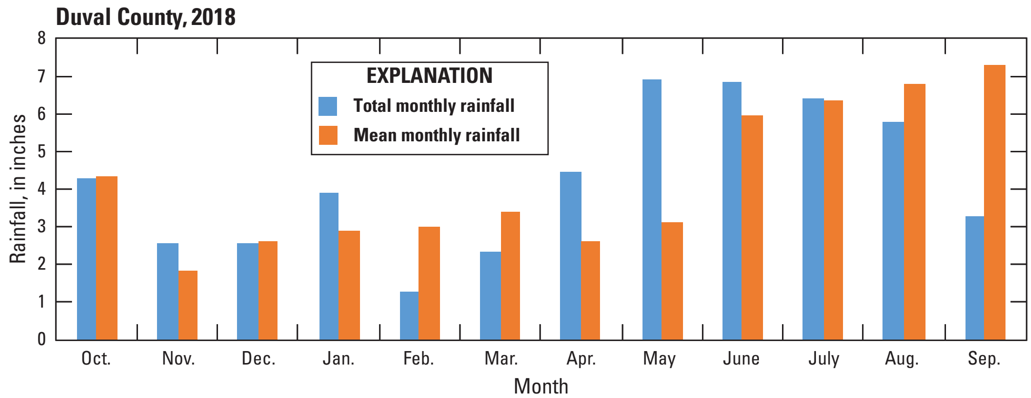

Figure 3. Graph of 2018 water year monthly rainfall and mean monthly rainfall for Duval County (St. Johns River Water Management District [SJRWMD], 2019).

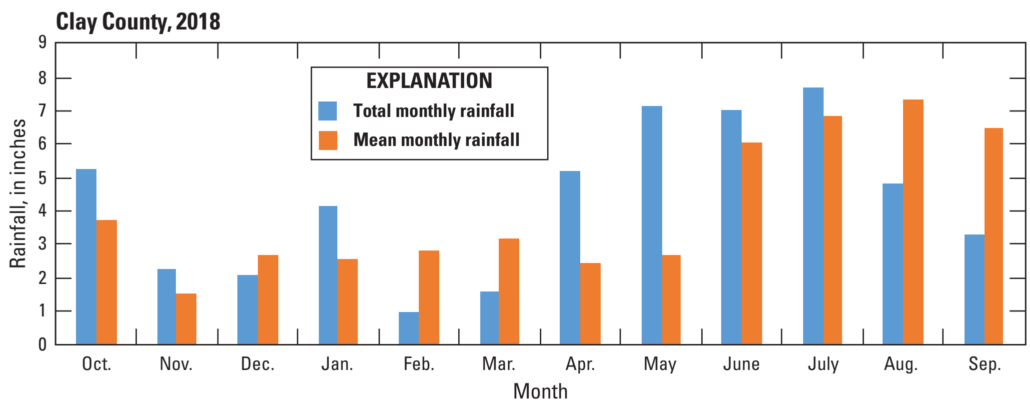

Figure 4. Graph of 2018 water year monthly rainfall and mean monthly rainfall for Clay County (St. Johns River Water Management District [SJRWMD], 2019).

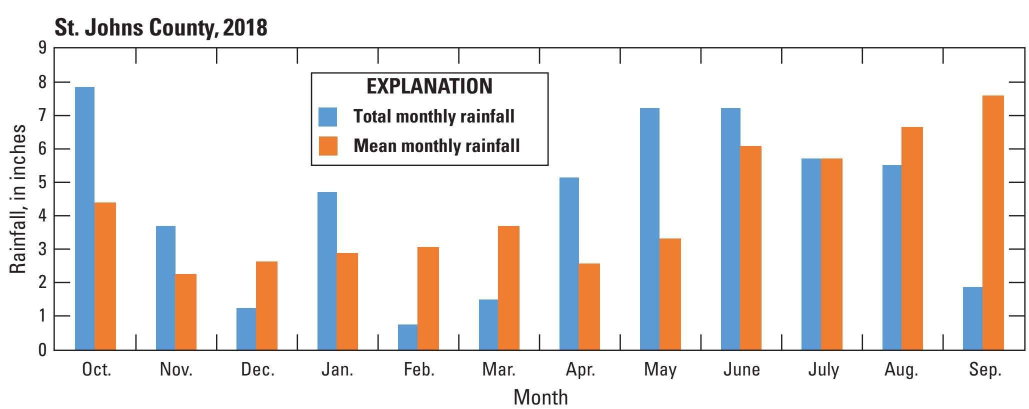

Figure 5. Graph of 2018 water year monthly rainfall and mean monthly rainfall for St. Johns County (St. Johns River Water Management District [SJRWMD], 2019).

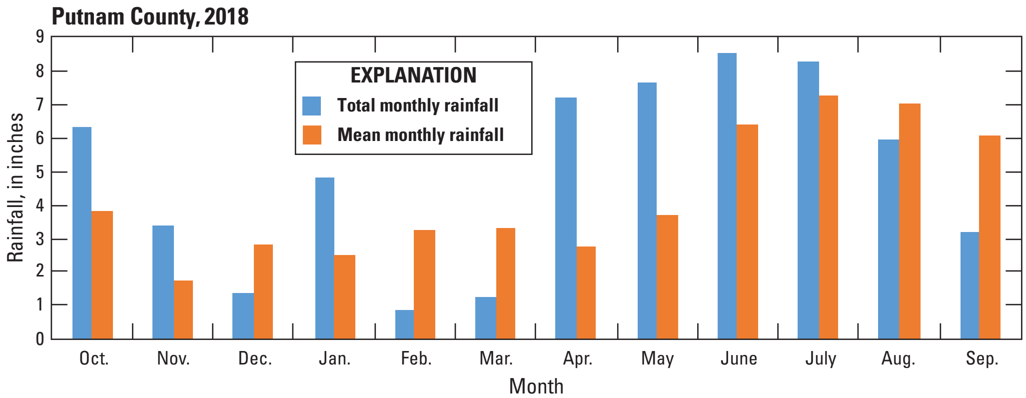

Figure 6. Graph of 2018 water year monthly rainfall and mean monthly rainfall for Putnam County (St. Johns River Water Management District [SJRWMD], 2019).

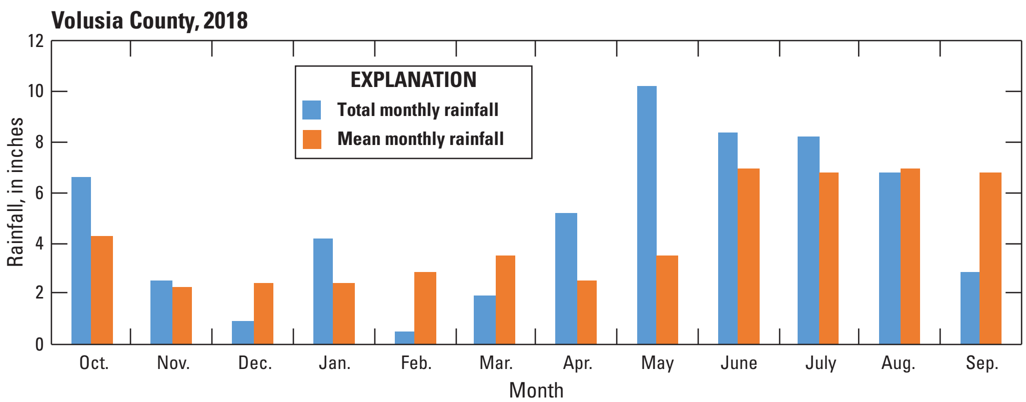

Figure 7. Graph of 2018 water year monthly rainfall and mean monthly rainfall for Volusia County (St. Johns River Water Management District [SJRWMD], 2019).

station was installed) to September 2018 (fig. 14). Fluctuations are similar to those at Racy Point and occur because of tidal influence and summertime rainfall, which can be seen in the salinity values from late July to September.

St. Johns River Below Shands Bridge near Green Cove Springs, Florida—Salinity on the St. Johns River below Shands Bridge ranged from 0.2 to 0.5 ppt during the 2018 water year, with a median and mean of 0.3 ppt (fig. 15). Data were not recorded for 28 days in August and 5 days in September because of equipment malfunction.

St. Johns River above Buckman Bridge at Jacksonville, Florida—Salinity on the St. Johns River above Buckman Bridge ranged from 0.2 to 6.4 ppt, with a median of 0.3 ppt and mean of 0.8 ppt during the period from January 2018 (when the monitoring station was installed) to September 2018 (fig. 16). The monitoring station was installed during a period of lower salinity with residual effects from Hurricane Irma. Salinity increased during March and April, and summertime rainfall lowered the salinity below 0.4 ppt from June to September.

St. Johns River Buckman Bridge at Jacksonville, Florida—Salinity on the St. Johns River at Buckman Bridge ranged from 0.2 to 9 ppt for the top location during the 2018 water year, with a median of 0.2 ppt and mean of 0.5 ppt, and from 0.2 to 15 ppt for the bottom location, with a median of 0.3 ppt and mean of 0.8 ppt (figs. 17 and 18). The monitoring station did not record water-quality parameters for 2 days in January (both locations), 27 days from March to April (top location only), and 10 days in August (bottom location only) because of equipment malfunction. Weekly salinity fluctuations are common and are caused by rainfall, tides, and wind.

St. Johns River at Christopher Point Near Jacksonville, Florida—Salinity at Christopher Point ranged from 0.5 to 15 ppt during the 2018 water year, with a median of 0.3 ppt and mean of 1.4 ppt (fig. 19). No data were logged from mid-October to mid-January because the dock was damaged by Hurricane Irma and subsequently reconstructed. Weekly salinity fluctuations are common and caused by rainfall, tides, and wind.

St. Johns River Below Marco Lake at Jacksonville, Florida—Salinity at Marco Lake ranged from 0.2 to 17 ppt during the 2018 water year, with a median of 0.3 ppt and mean of 0.9 ppt (fig. 20). No data were logged from mid-January to mid-May because the seawall was damaged by Hurricane Irma and subsequently reconstructed. Similar to those at Christopher Point, weekly salinity fluctuations are common and caused by rainfall, tides, and wind.

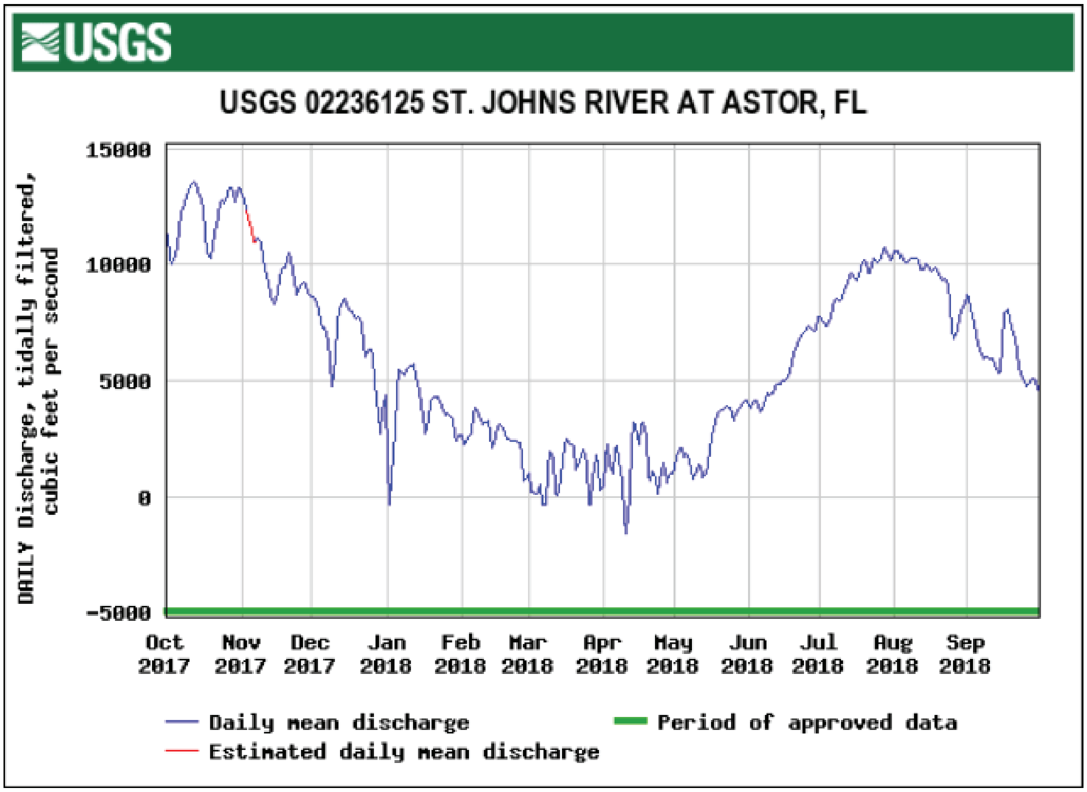

Figure 8. Daily mean tidally filtered discharge for St. Johns River at Astor, Florida.

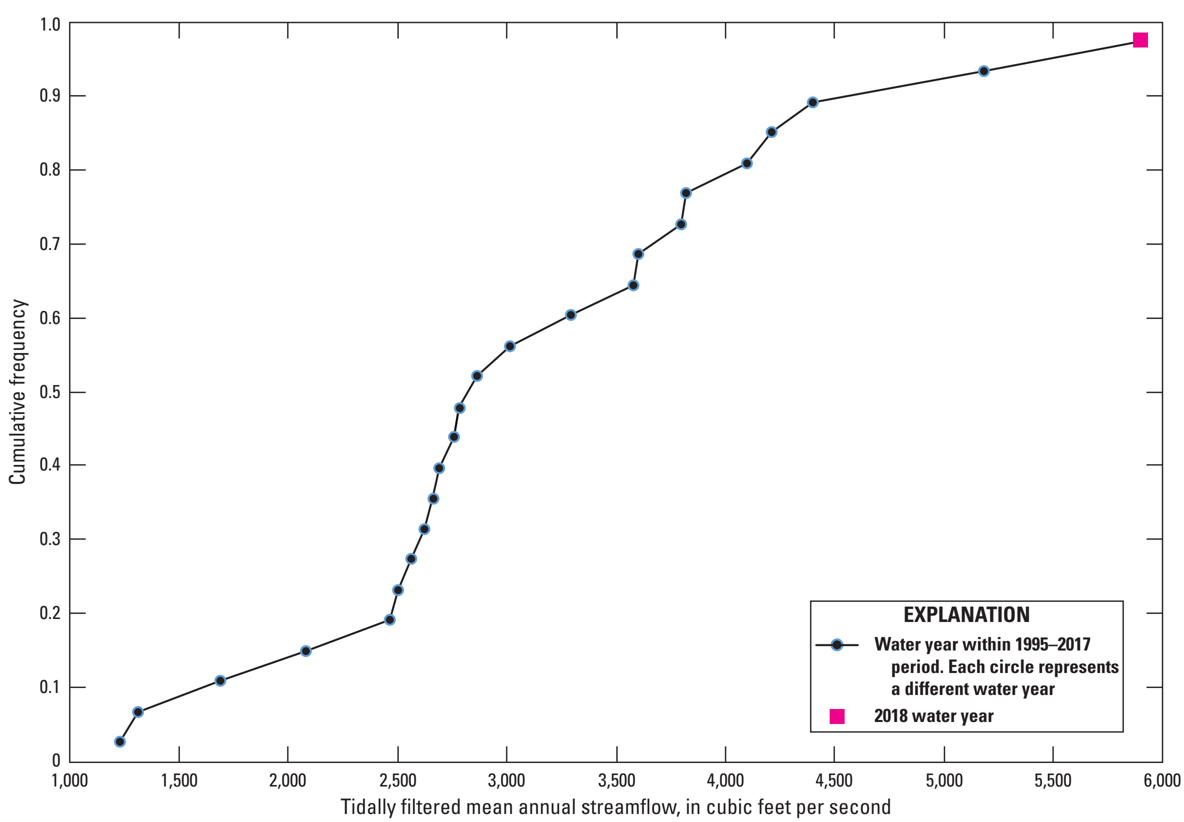

Figure 9. Annual mean tidally filtered streamflow data for St. Johns River at Astor, Florida.

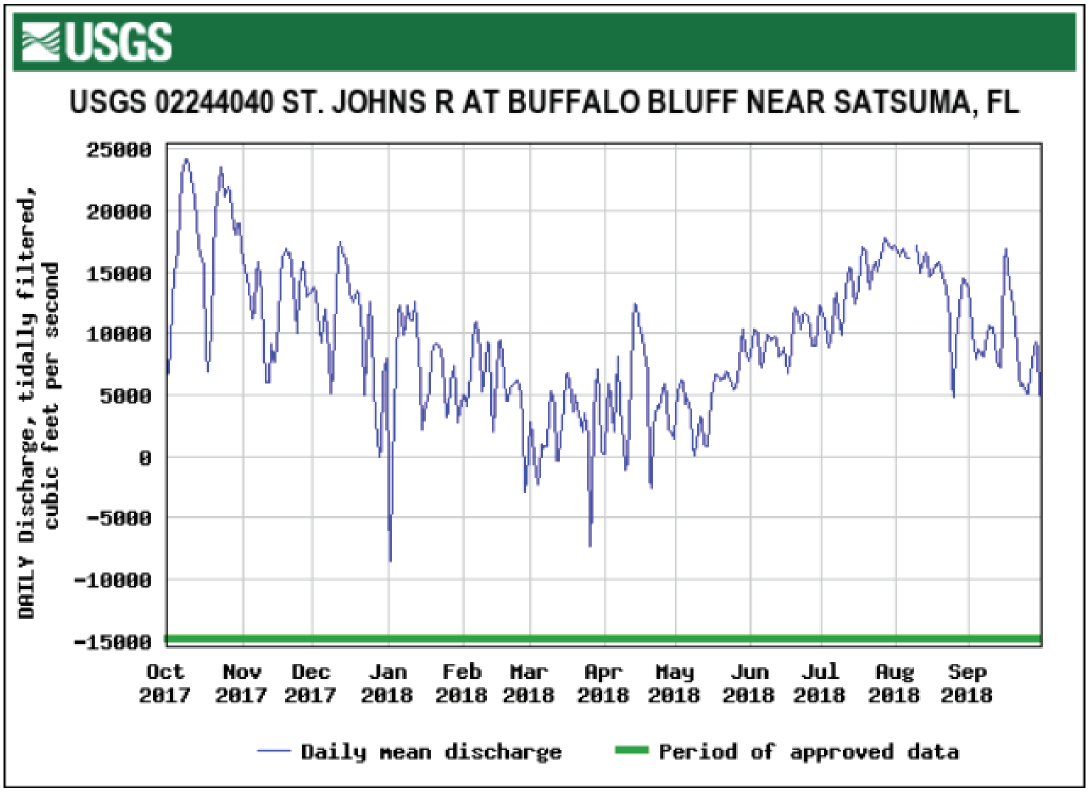

Figure 10. Daily mean tidally filtered discharge for St. Johns River at Buffalo Bluff near Satsuma, Florida.

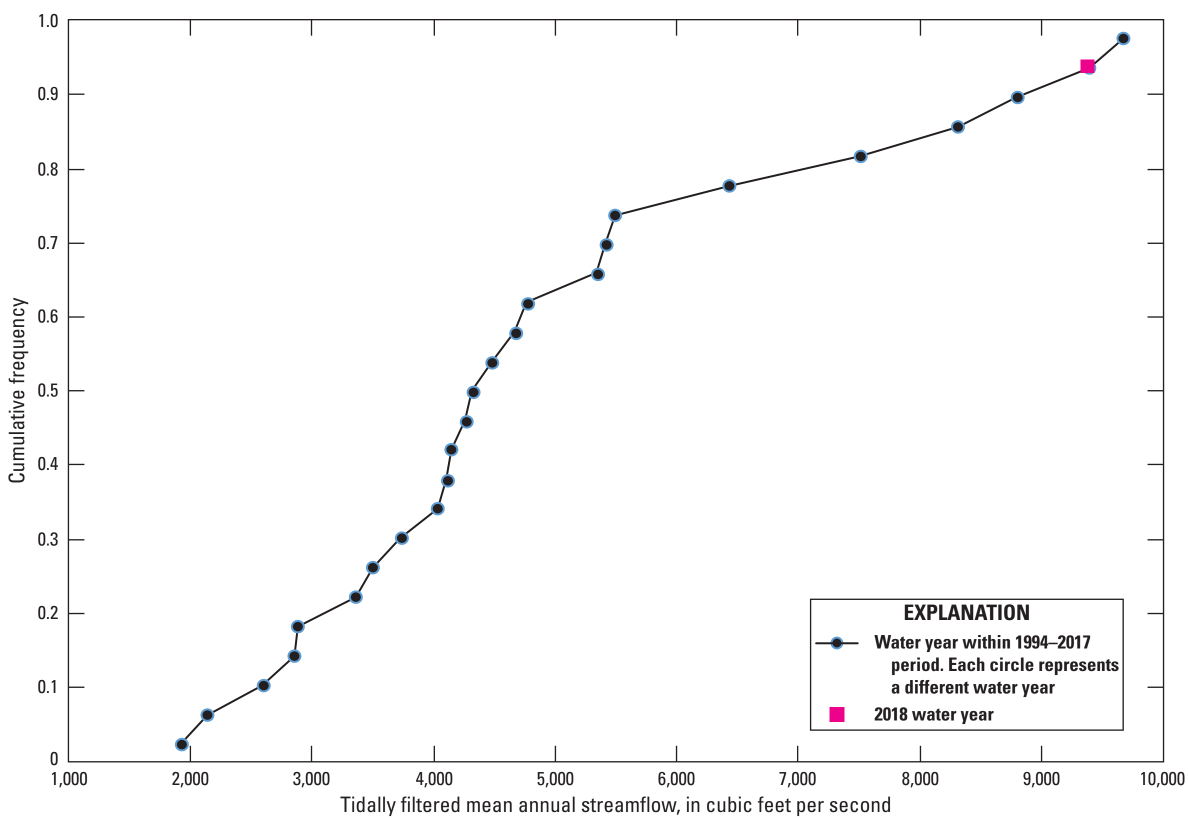

Figure 11. Annual mean tidally filtered streamflow data for St. Johns River at Buffalo Bluff near Satsuma, Florida.

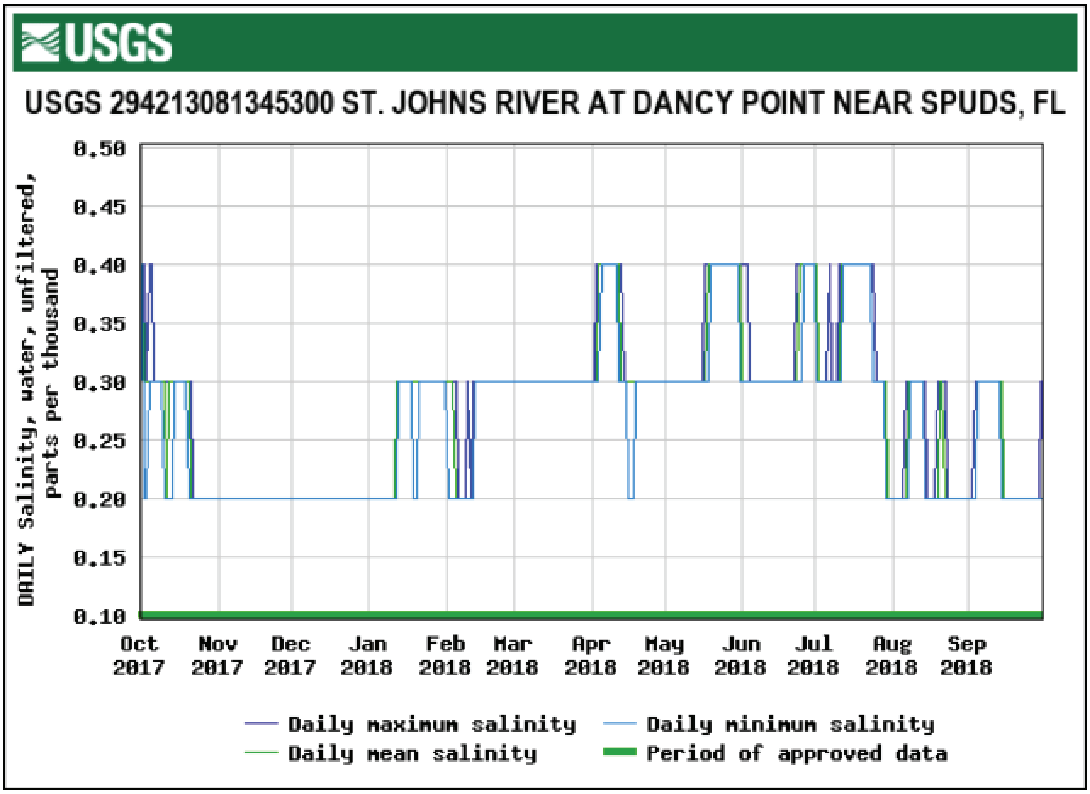

Figure 12. Daily maximum, minimum, and mean salinity for St. Johns River at Dancy Point near Spuds, Florida.

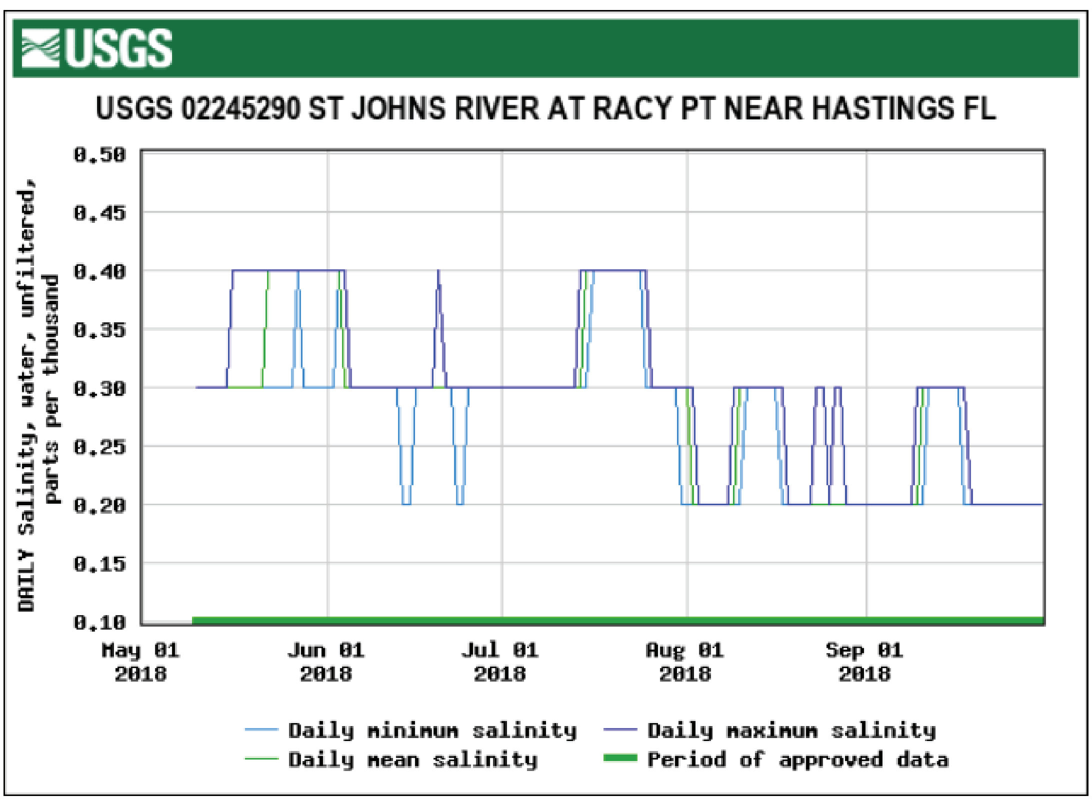

Figure 13. Daily maximum, minimum, and mean salinity for St. Johns River at Racy Point near Hastings, Florida.

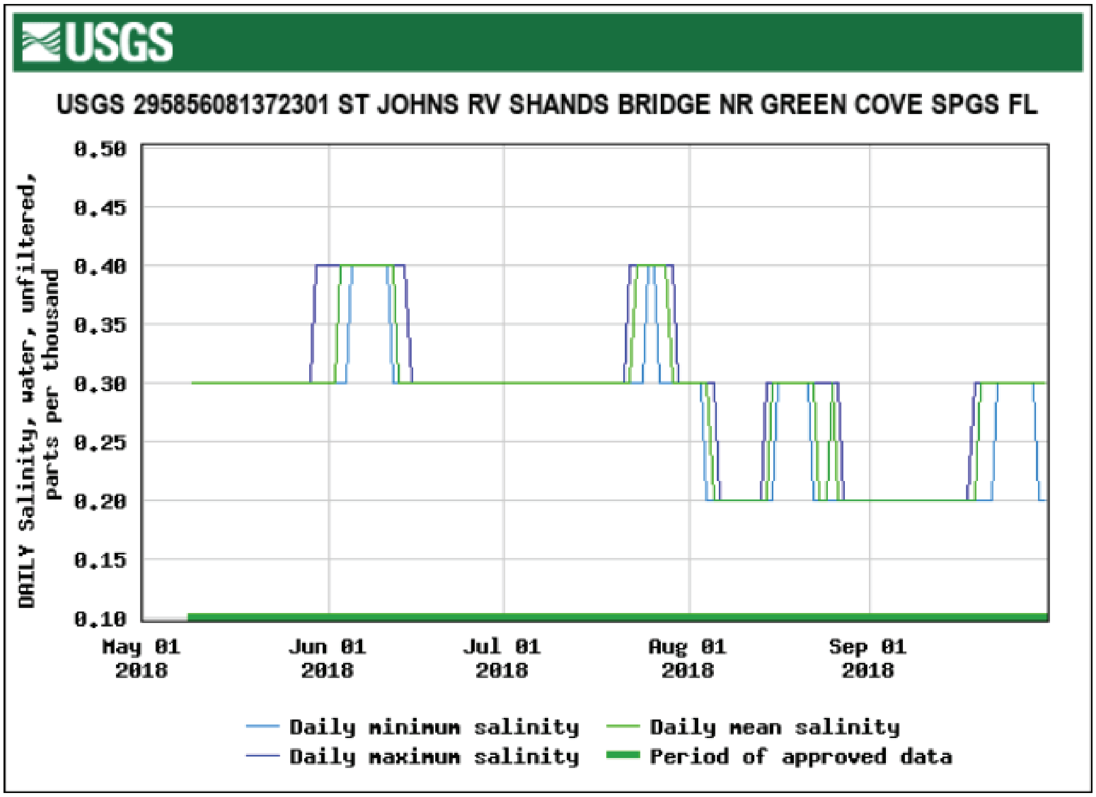

Figure 14. Daily maximum, minimum, and mean salinity for St. Johns River Shands Bridge near Green Cove Springs, Florida.

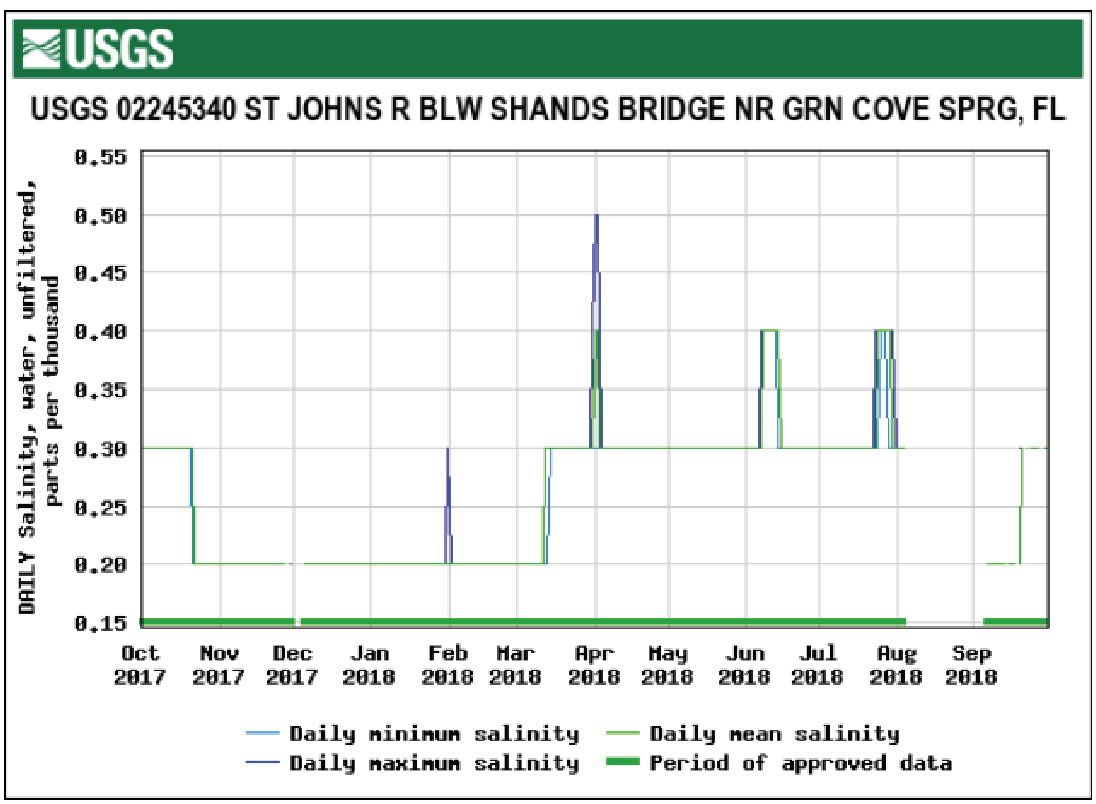

Figure 15. Daily maximum, minimum, and mean salinity for St. Johns River below Shands Bridge near Green Cove Springs, Florida.

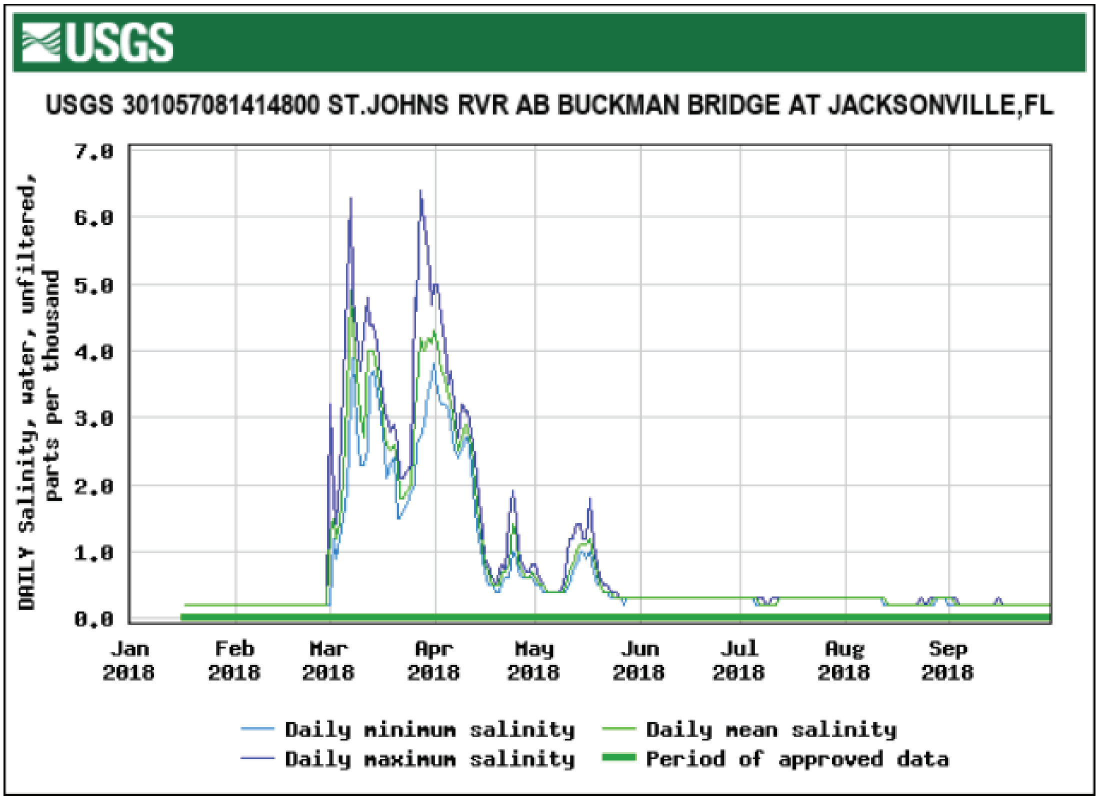

Figure 16. Daily maximum, minimum, and mean salinity for St. Johns River above Buckman Bridge at Jacksonville, Florida.

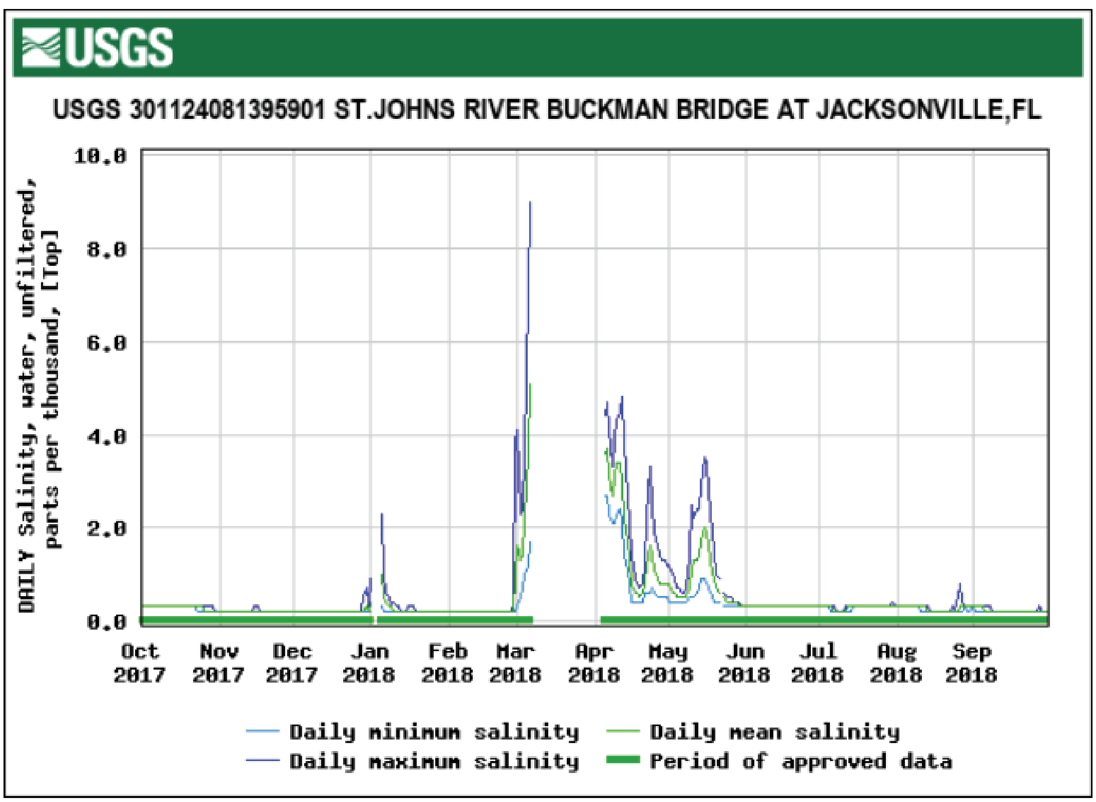

Figure 17. Daily maximum, minimum, and mean salinity for top location of St. Johns River Buckman Bridge at Jacksonville, Florida.

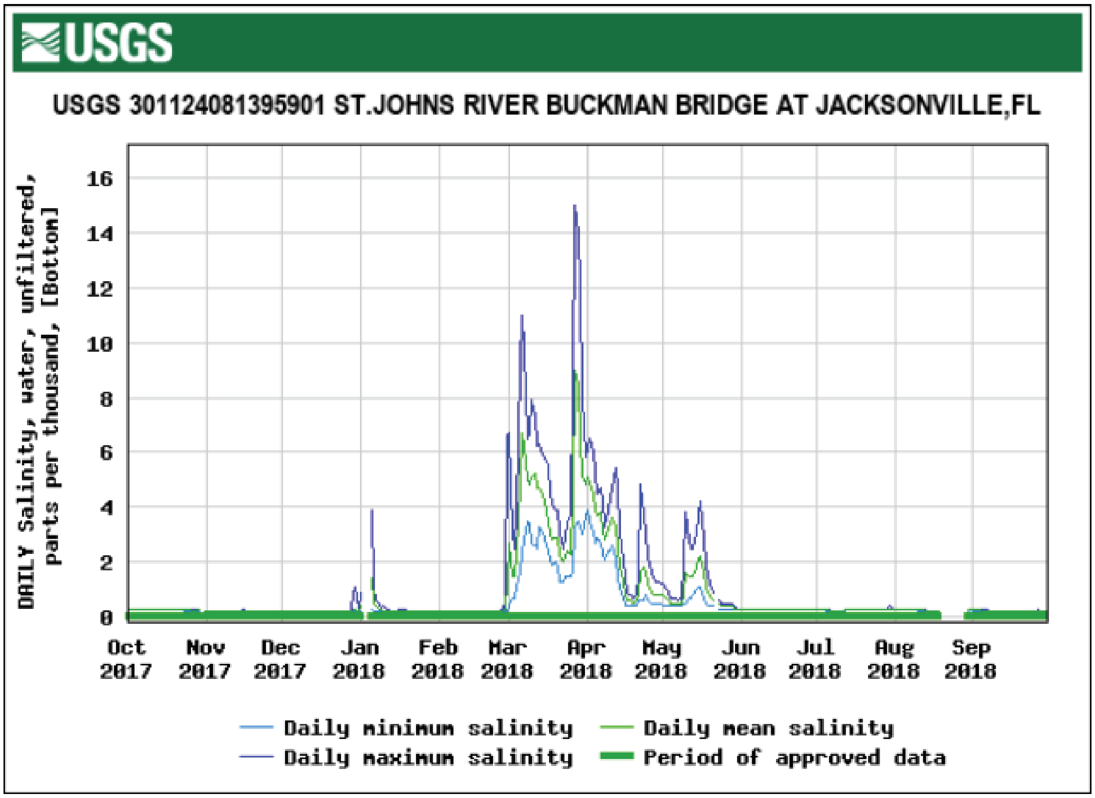

Figure 18. Daily maximum, minimum, and mean salinity for bottom location of St. Johns River Buckman Bridge at Jacksonville, Florida.

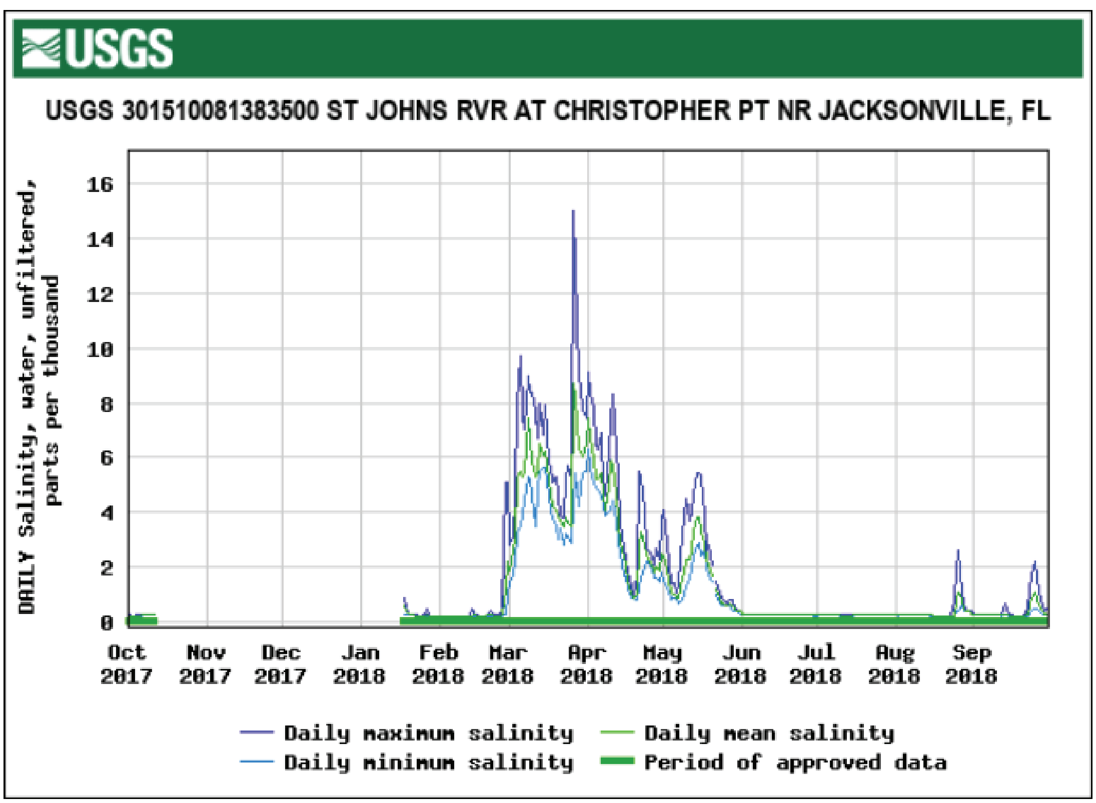

Figure 19. Daily maximum, minimum, and mean salinity for St. Johns River at Christopher Point near Jacksonville, Florida.

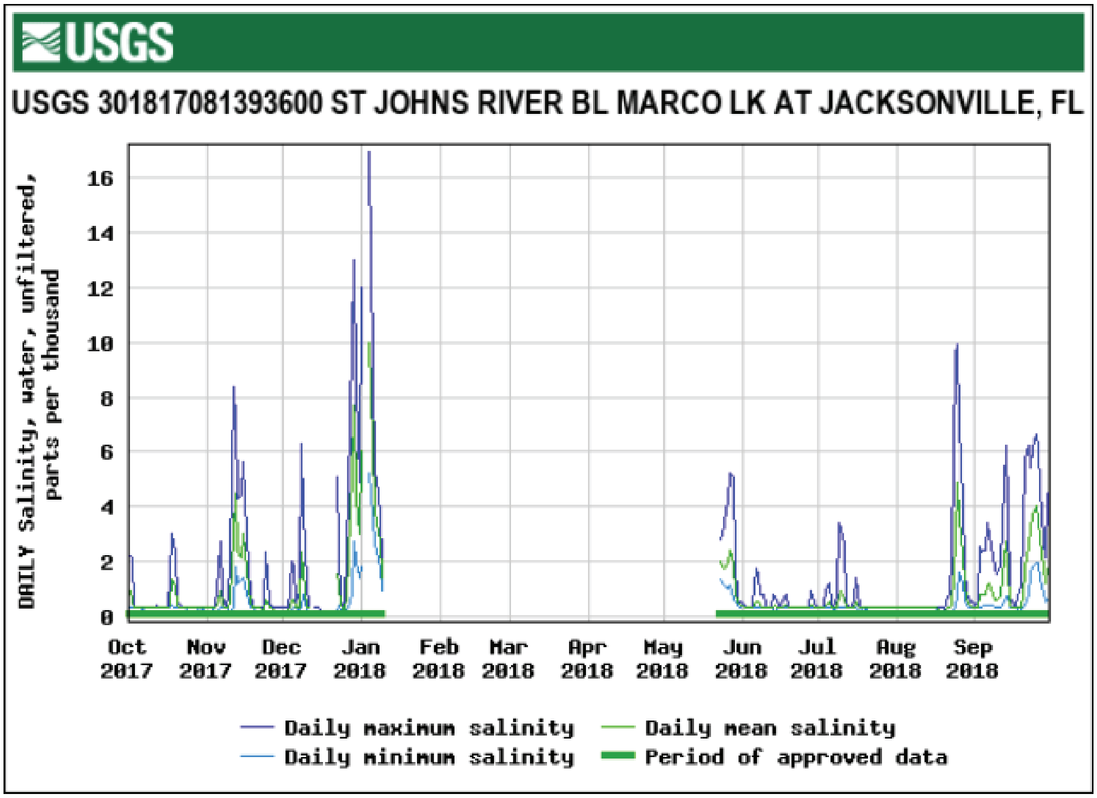

Figure 20. Daily maximum, minimum, and mean salinity for St. Johns River below Marco Lake at Jacksonville, Florida.

St. Johns River at Jacksonville, Florida—Daily tidally filtered discharge at the St. Johns River at Jacksonville ranged from −32,000 to 46,200 ft^3/s during the 2018 water year, with an annual mean of 9,510 ft^3/s (fig. 21). No discharge was computed for four short periods in December and January and 2 days in April because of equipment malfunction. Salinity ranged from 0.1 to 25 ppt over this same period, with a median of 1.6 ppt and mean of 3.7 ppt (fig. 22). Salinity was not computed for the entire month of November and for short periods in October, December, January, April, and July because of equipment malfunction. The minimum salinity for the 3-year period of record, 0.1 ppt, was recorded on December 21, 2017. Analysis of the daily tidally filtered discharge indicates an overall decreasing trend from October to March because of the residual flows from Hurricane Irma in September 2017 (fig. 21) and below-average rainfall accumulation during these months in Duval County (fig. 3). The discharge trend increased from June to August because of summertime rainfall. A comparison of historical annual mean tidally filtered flows indicated that the 2018 streamflow was at the 70th percentile; the median tidally filtered flow for the period of record is 5,780 ft^3/s (fig. 23). Annual mean tidally filtered streamflow record was used from 1997 onward because of data collection gaps in the historical data prior to 1997.

St. Johns River Dames Point Bridge at Jacksonville, Florida—Salinity on the St. Johns River at Dames Point Bridge ranged from 0.3 to 35 ppt for the top location during the 2018 water year, with a median and mean of 17 ppt, and from 0.3 to 34 ppt for the bottom location, with a median of 19 ppt and mean of 18 ppt (figs. 24 and 25). Salinity was not calculated at the bottom location for 7 days in February because of equipment malfunction. Salinity during the period was generally lower at the top location relative to the bottom and fluctuated weekly at both locations because of wind, tides, and upstream conditions. The lowest salinity for the 2-year period of record at both the top and bottom locations was 0.3 ppt, which occurred during multiple days in October 2017 as residual freshwater from Hurricane Irma exited the St. Johns River.

Tributary Sites

Julington Creek at Old St. Augustine Road Near Bayard, Florida—Daily tidally filtered discharge at Julington Creek ranged from −11.1 to 409 ft^3/s during the 2018 water year, with an annual mean flow of 45.5 ft^3/s (fig. 26). Multiple rises in discharge occurred during the period as a result of rainfall, but the tidally filtered flows remained below 150 ft^3/s for most of the period because of the rapid recessions.

Julington Creek at Hood Landing Near Bayard, Florida—Salinity at Julington Creek at Hood Landing ranged from 0.1 to 1.1 ppt during the 2018 water year, with a median of 0.1 ppt and mean of 0.2 ppt (fig. 27). Salinity increased above 0.5 ppt for portions of the period from March to April and decreased when flow increased through Julington Creek, which is most likely attributed to freshwater from rainfall.

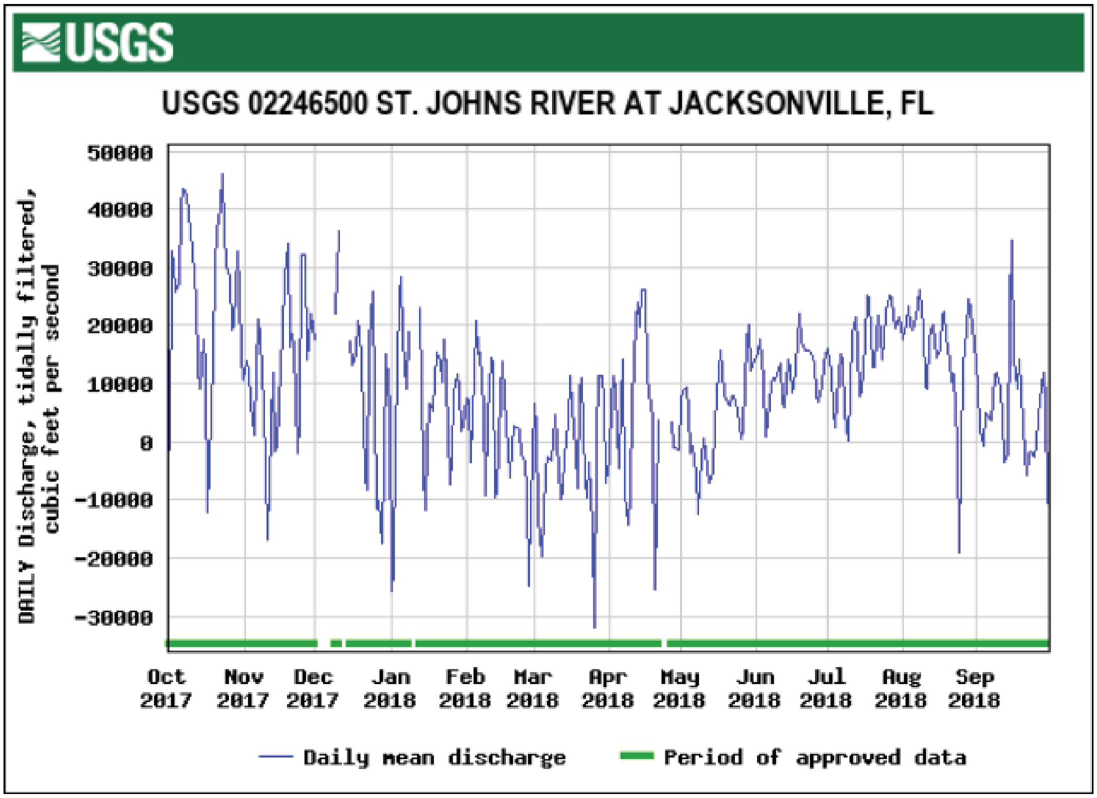

Figure 21. Daily mean tidally filtered discharge for St. Johns River at Jacksonville, Florida.

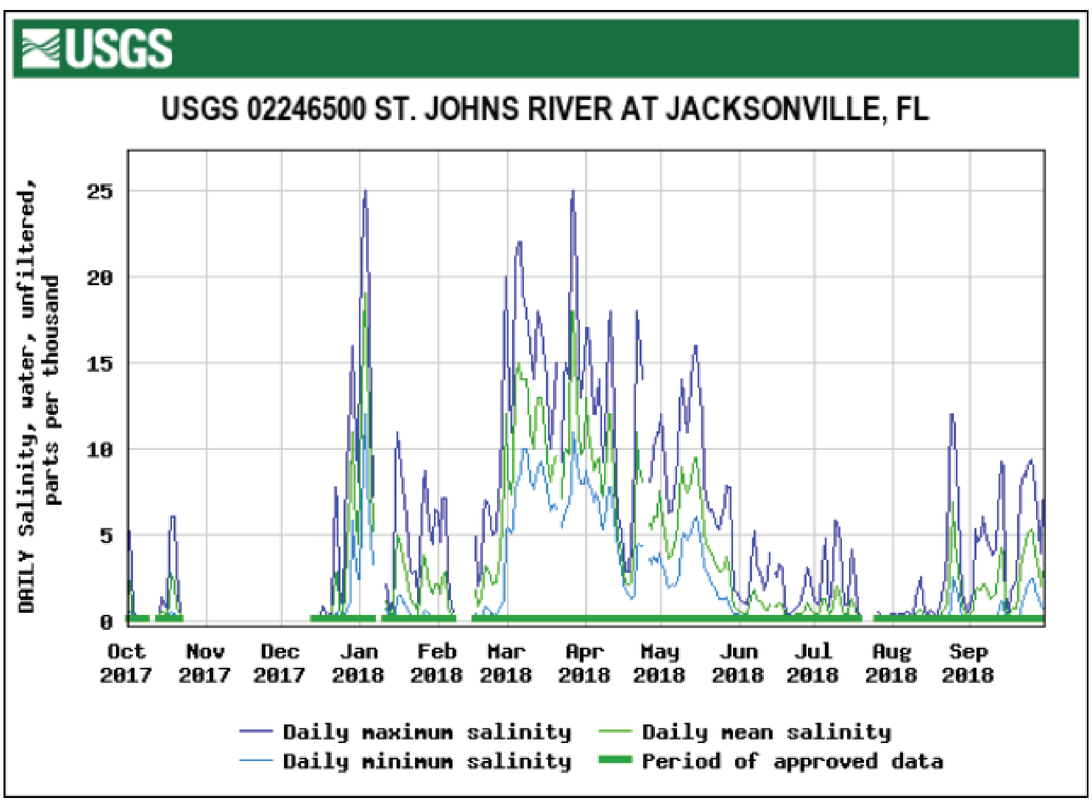

Figure 22. Daily maximum, minimum, and mean salinity for St. Johns River at Jacksonville, Florida.

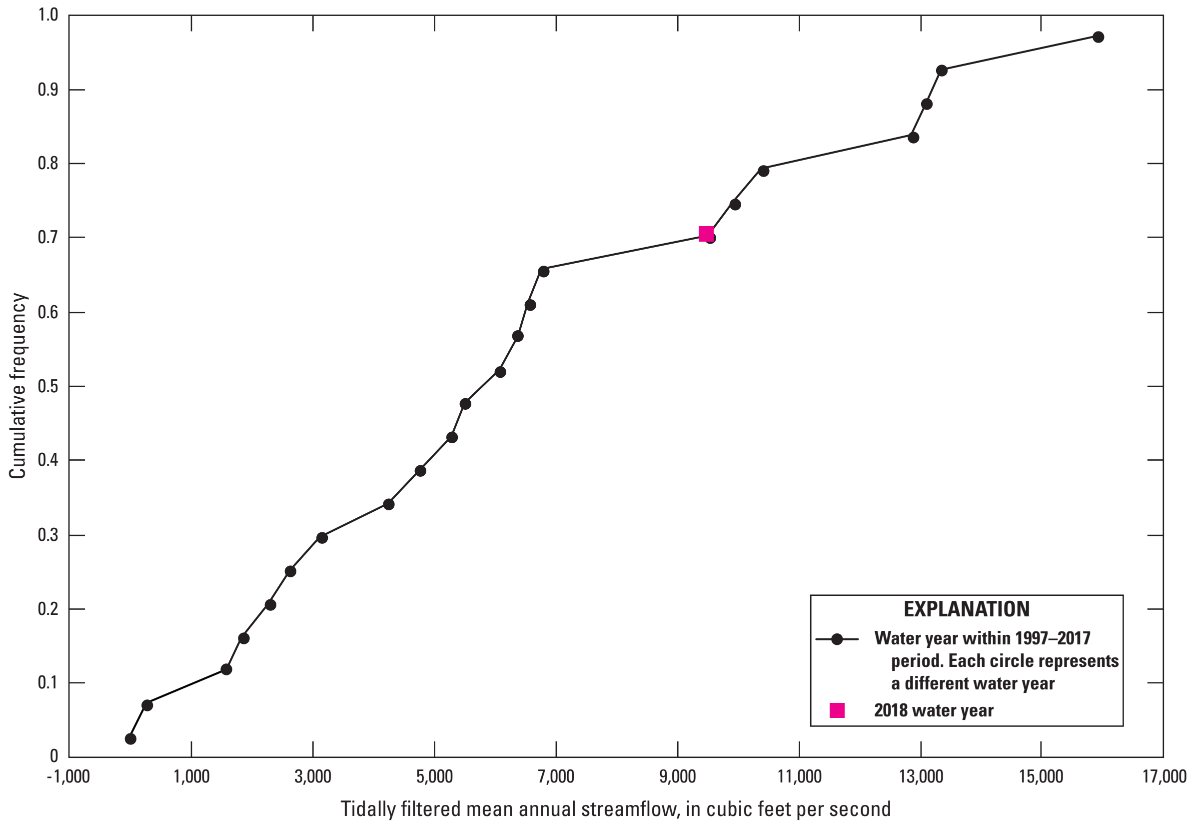

Figure 23. Annual mean tidally filtered streamflow data for St. Johns River at Jacksonville, Florida.

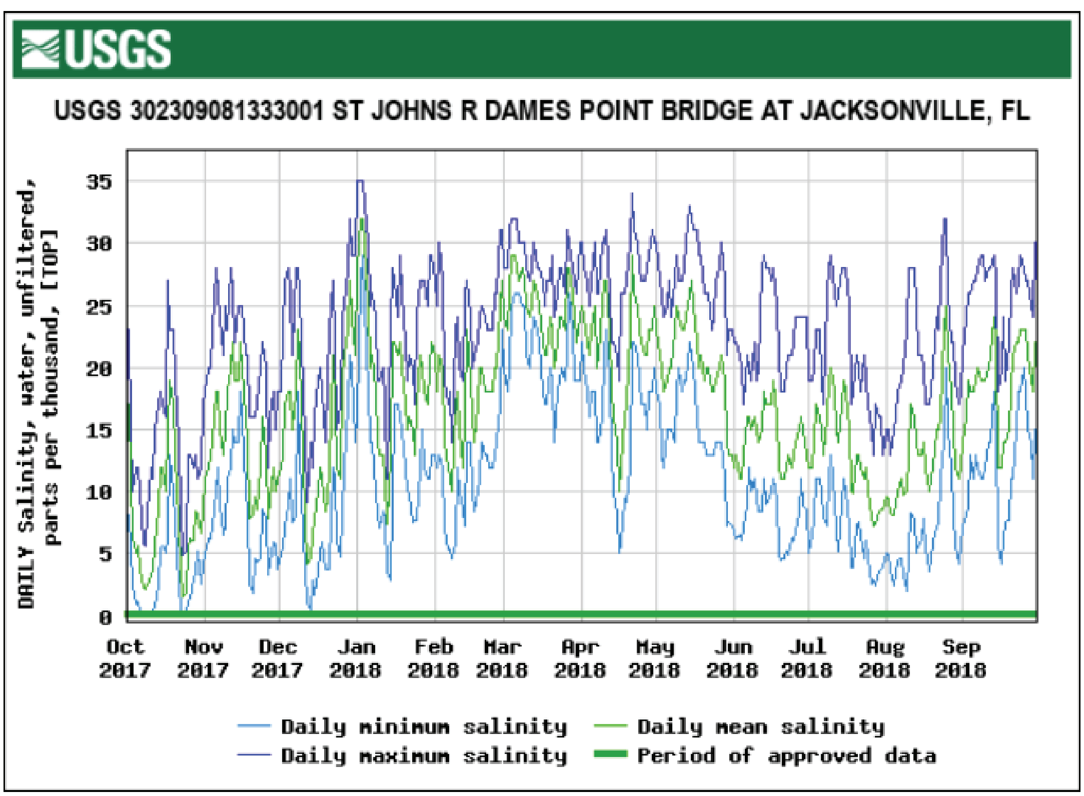

Figure 24. Daily maximum, minimum, and mean salinity for top location of St. Johns River Dames Point Bridge at Jacksonville, Florida.

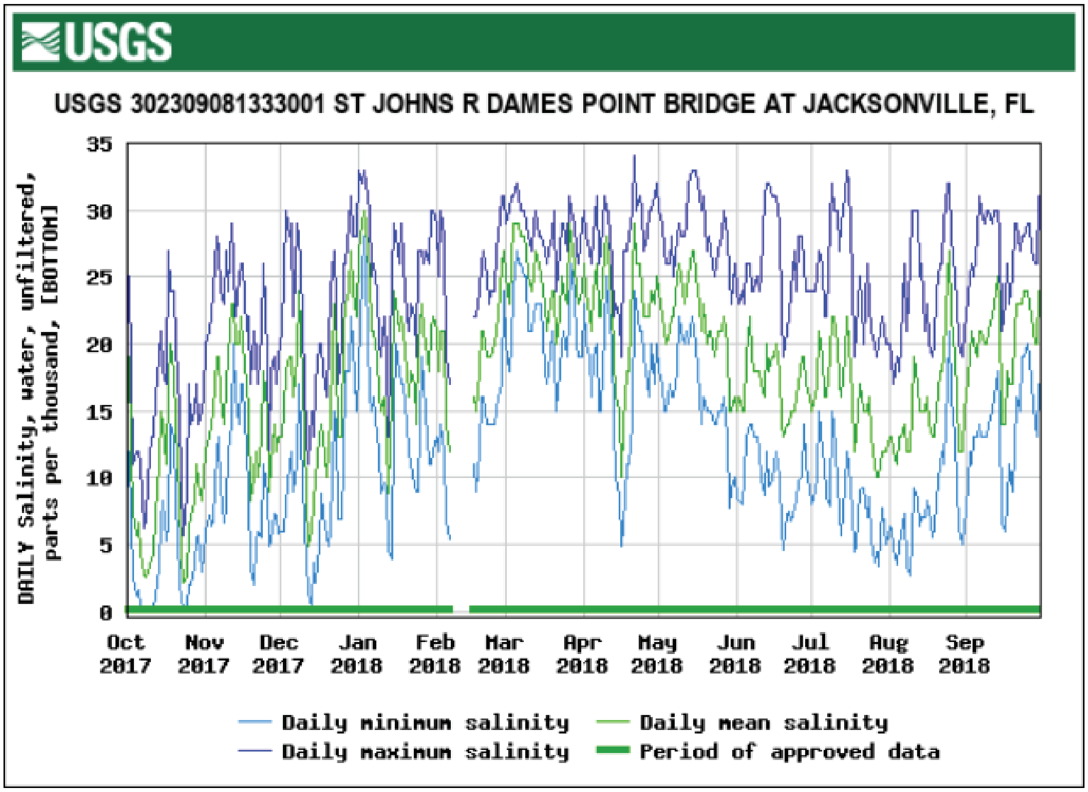

Figure 25. Daily maximum, minimum, and mean salinity for bottom location of St. Johns River Dames Point Bridge at Jacksonville, Florida.

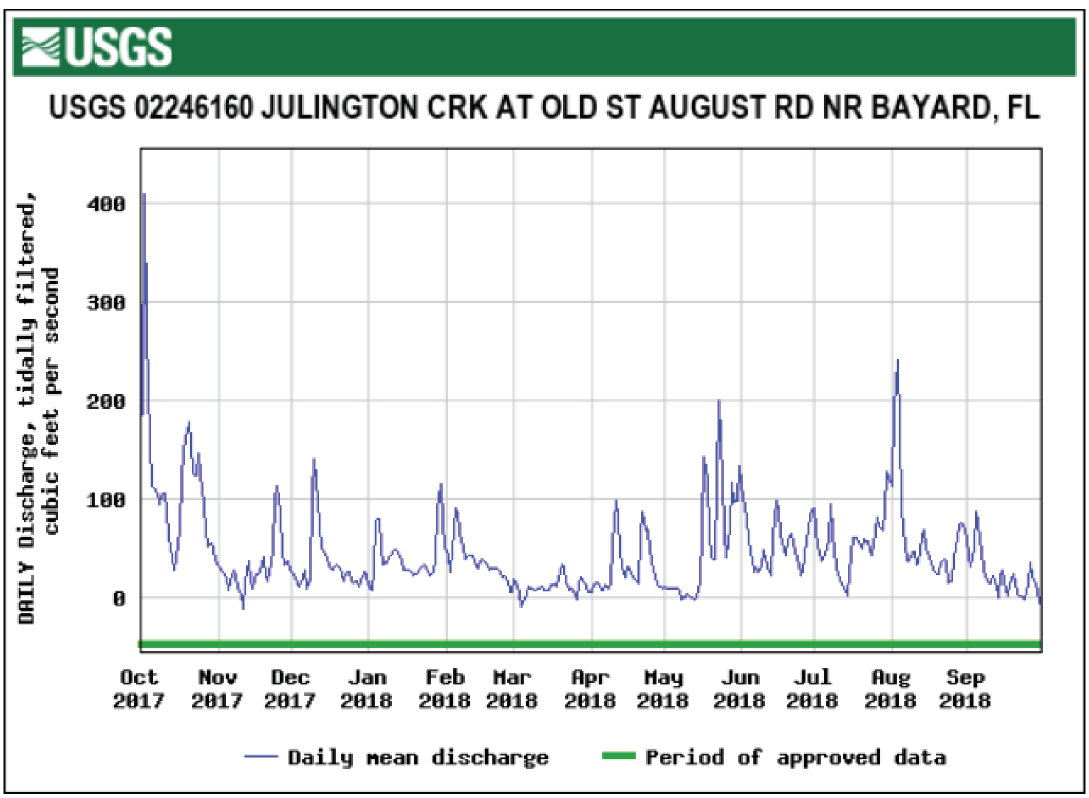

Figure 26. Daily mean tidally filtered discharge for Julington Creek at Old St. Augustine Road near Bayard, Florida.

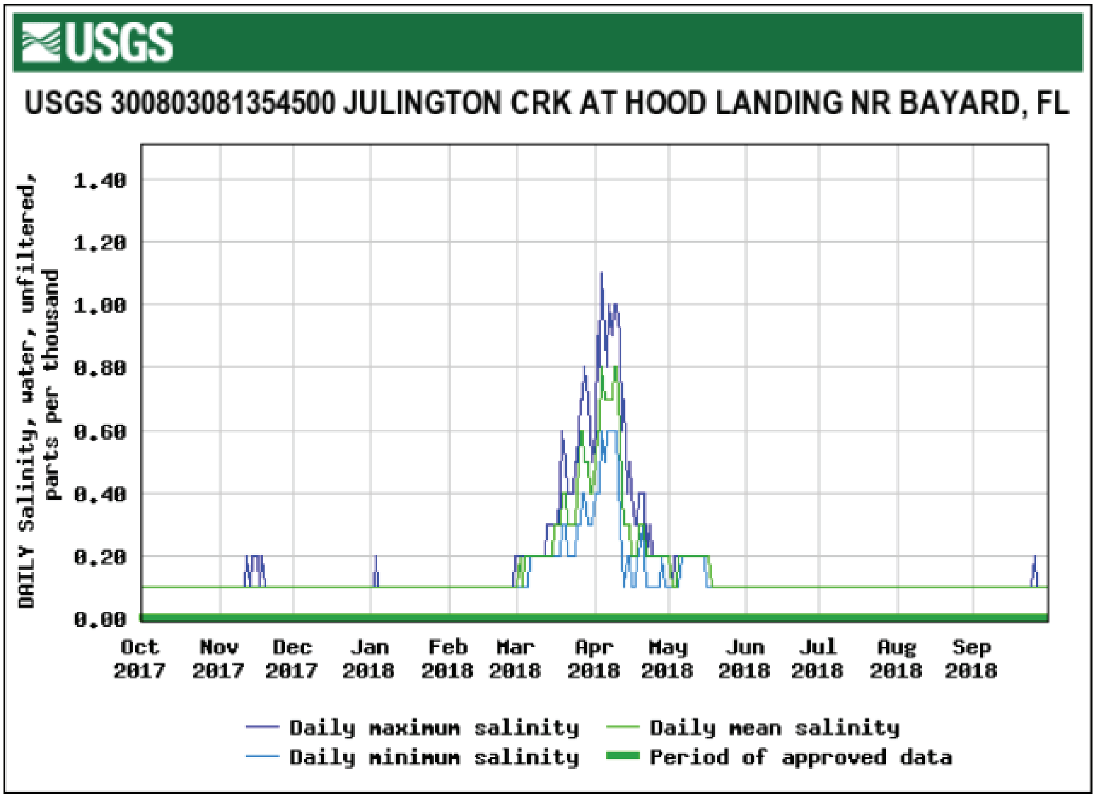

Figure 27. Daily maximum, minimum, and mean salinity for Julington Creek at Hood Landing near Bayard, Florida.

Durbin Creek Near Fruit Cove, Florida—Daily tidally filtered discharge at Durbin Creek ranged from 3.57 to 404 ft^3/s during the 2018 water year, with an annual mean of 93.5 ft^3/s (fig. 28). Discharge and salinity were not calculated for 4 days in July, and salinity was not calculated for 9 days in September because of equipment malfunction. Salinity was constant at 0.1 ppt over the entire period (fig. 29).

Ortega River at Kirwin Road Near Jacksonville, Florida—Daily discharge for Ortega River ranged from 9.78 to 764 ft^3/s during the 2018 water year, with an annual mean of 84.4 ft^3/s (fig. 30). Discharge exceeded 10 ft^3/s for the entire period with multiple peaks above 500 ft^3/s. The peak streamflow for the period of record ranked in the 50th percentile (fig. 31). The peak streamflow record does not include 2016, which has incomplete record because the monitoring station was installed that year.

Ortega River Salinity at Jacksonville, Florida—Salinity at Ortega River ranged from 0.0 to 5.1 ppt during the 2018 water year, with a median and mean of 0.1 ppt (fig. 32). The highest salinity values were calculated in March and April during periods of low discharge in Ortega River.

Cedar River at San Juan Avenue at Jacksonville, Florida—Daily tidally filtered discharge at Cedar River ranged from −3.82 to 250 ft^3/s during the 2018 water year, with an annual mean of 50.2 ft^3/s (fig. 33). Salinity ranged from 0.0 to 13 ppt, with a median of 0.1 ppt and mean of 0.9 ppt (fig. 34). Salinity peaked above 10 ppt two times during periods of low flow and rainfall in Duval County (fig. 3). Salinity was not calculated for 3 days in October and November because of equipment malfunction.

Pottsburg Creek Near South Jacksonville, Florida—Daily discharge for Pottsburg Creek at Bowden Road ranged from 3.62 to 350 ft^3/s during the 2018 water year, with an annual mean flow of 27.6 ft^3/s (fig. 35). Discharge remained below 300 ft^3/s except for one peak each in October and August.

Pottsburg Creek at U.S. 90 Near South Jacksonville, Florida—Daily tidally filtered discharge at Pottsburg Creek at U.S. 90 ranged from −15.3 to 353 ft^3/s during the 2018 water year, with an annual mean flow of 31.7 ft^3/s (fig. 36). Salinity ranged from 0.0 to 4.8 ppt, with a median of 0.2 ppt and mean of 0.3 ppt (fig. 37). Peak salinity exceeded 3 ppt during parts of March through May during periods of below-average rainfall in Duval County (fig. 3).

Trout River Near Jacksonville, Florida—Daily tidally filtered discharge at Trout River ranged from −290 to 660 ft^3/s during the 2018 water year, with an annual mean flow of 63.6 ft^3/s (fig. 38). Tidally filtered discharge exceeded 500 ft^3/s during periods in January and August. Discharge was not computed for 14 days in December because of equipment malfunction.

Trout River Below U.S. 1 at Dinsmore, Florida—Salinity at Trout River below U.S. 1 ranged from 0.0 to 8.3 ppt during the 2018 water year, with a median of 0.1 ppt and mean of 0.5 ppt (fig. 39). Daily maximum salinity values peaked above 5 ppt during most of March and portions of April and May.

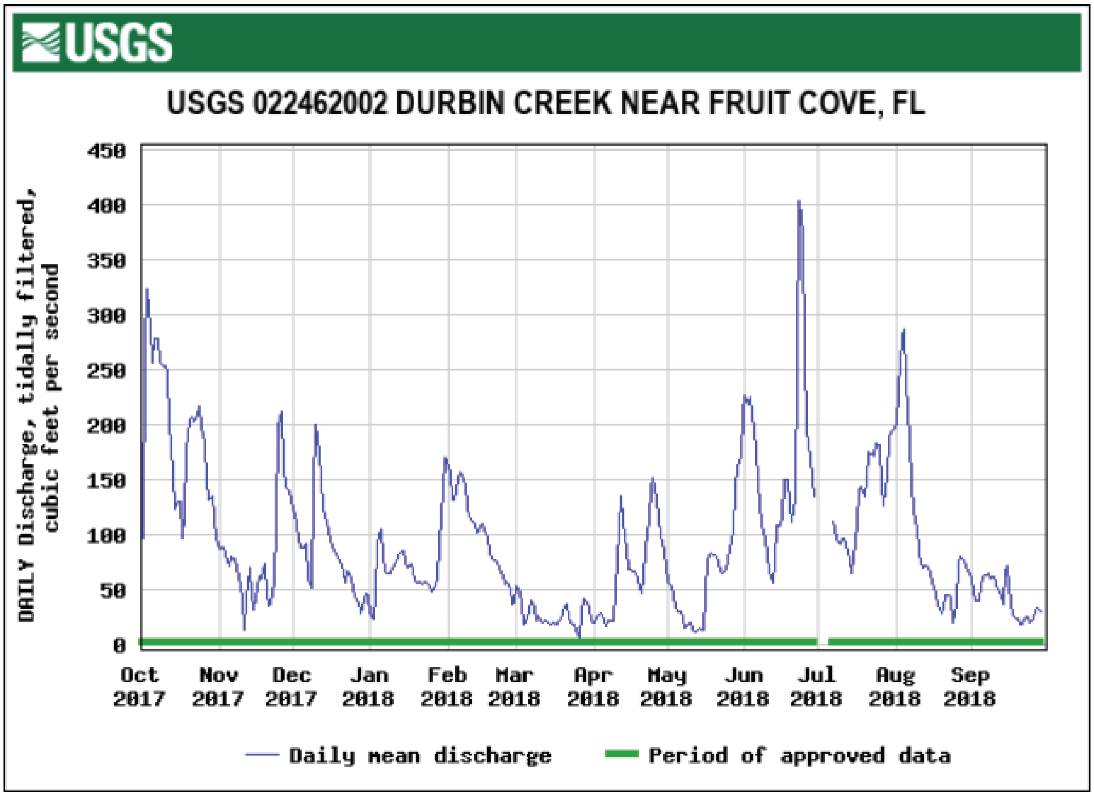

Figure 28. Daily mean tidally filtered discharge for Durbin Creek near Fruit Cove, Florida.

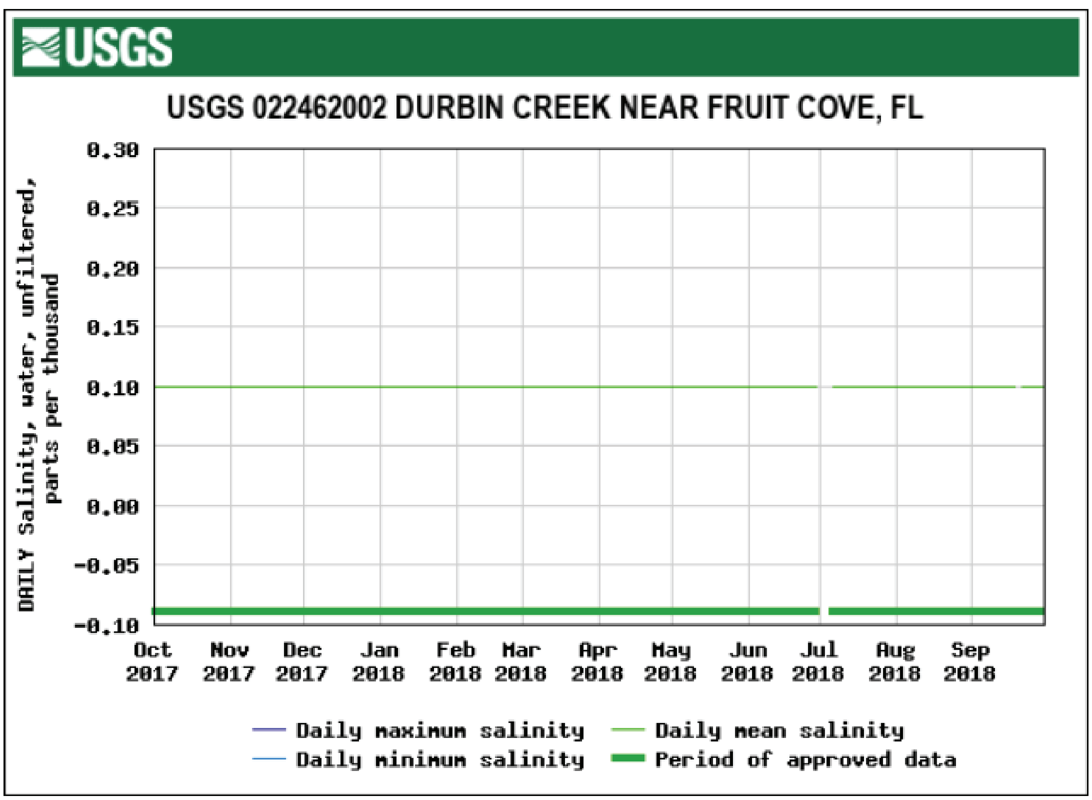

Figure 29. Daily maximum, minimum, and mean salinity for Durbin Creek near Fruit Cove, Florida.

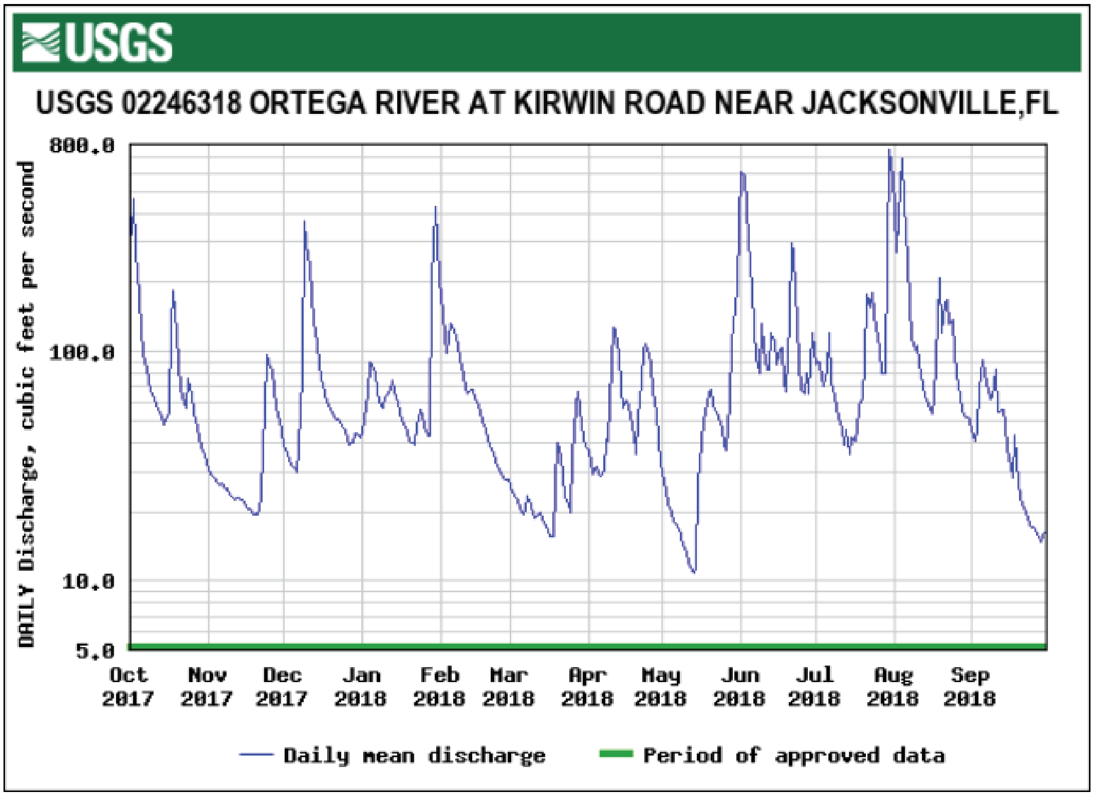

Figure 30. Daily mean discharge for Ortega River at Kirwin Road near Jacksonville, Florida.

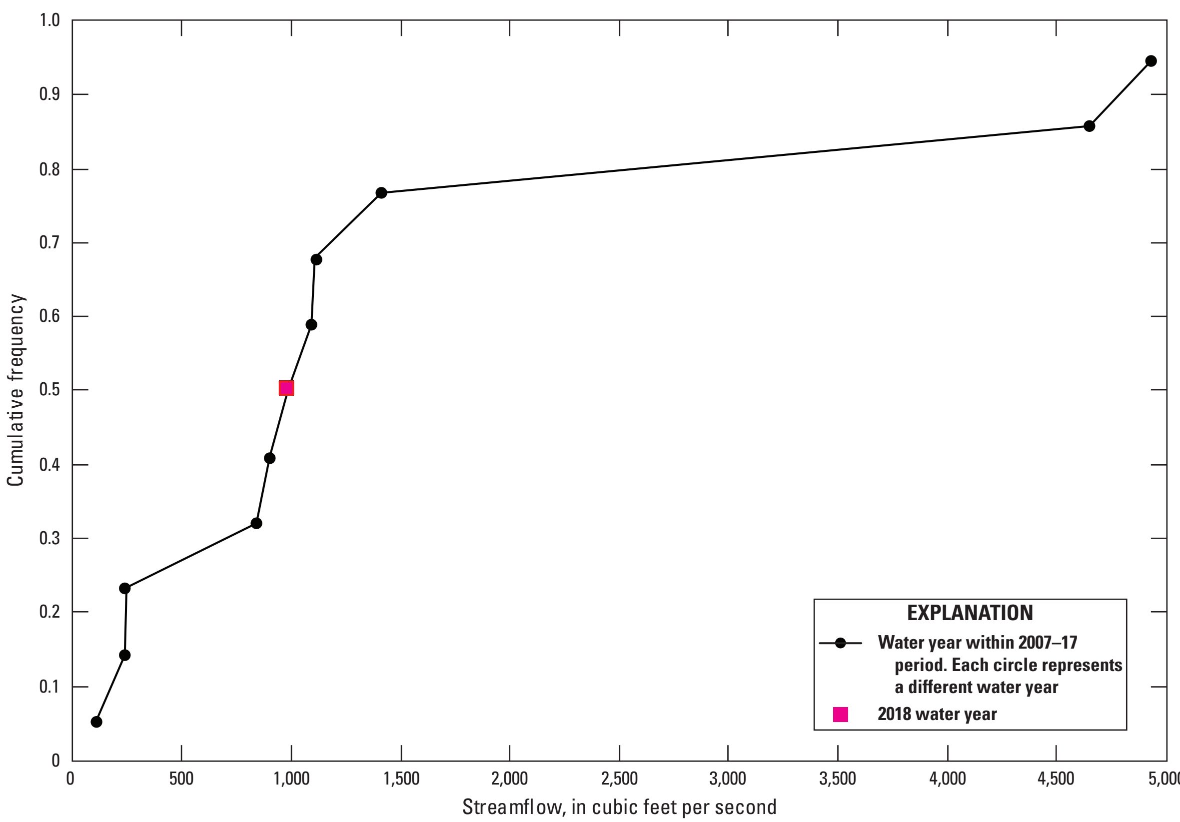

Figure 31. Peak streamflow at Ortega River at Kirwin Road near Jacksonville, Florida.

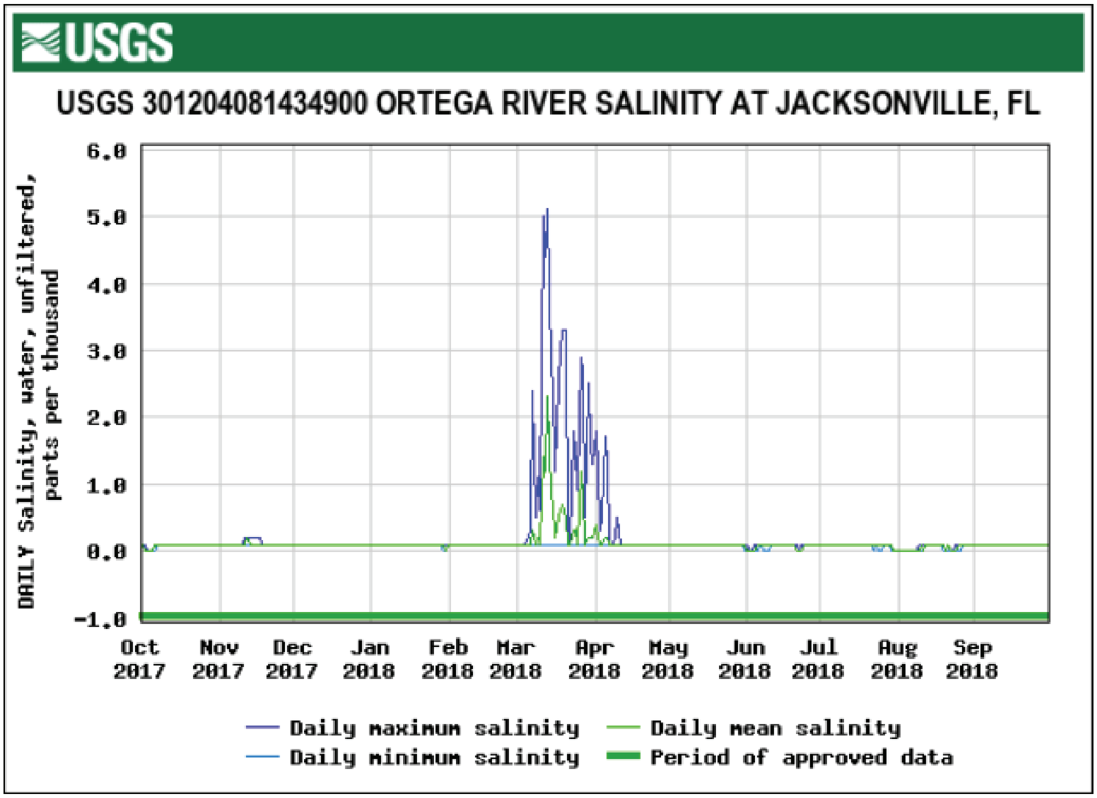

Figure 32. Daily maximum, minimum, and mean salinity for Ortega River at Jacksonville, Florida.

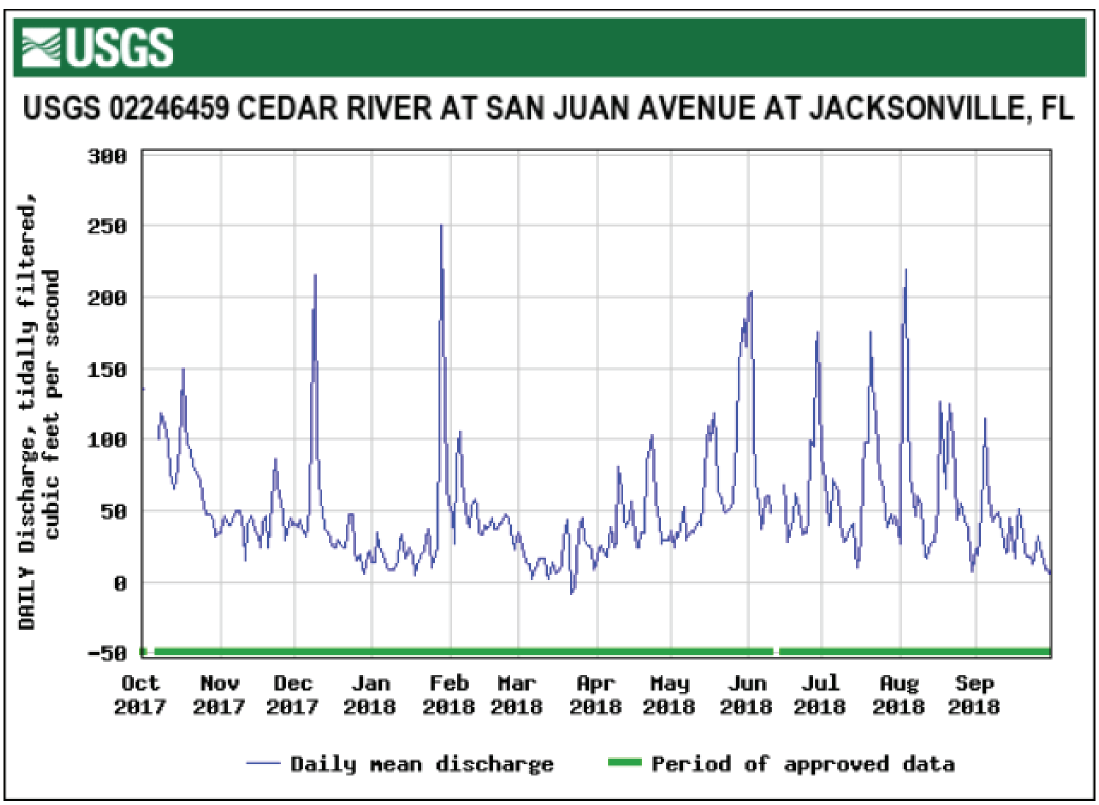

Figure 33. Daily mean tidally filtered discharge for Cedar River at San Juan Avenue at Jacksonville, Florida.

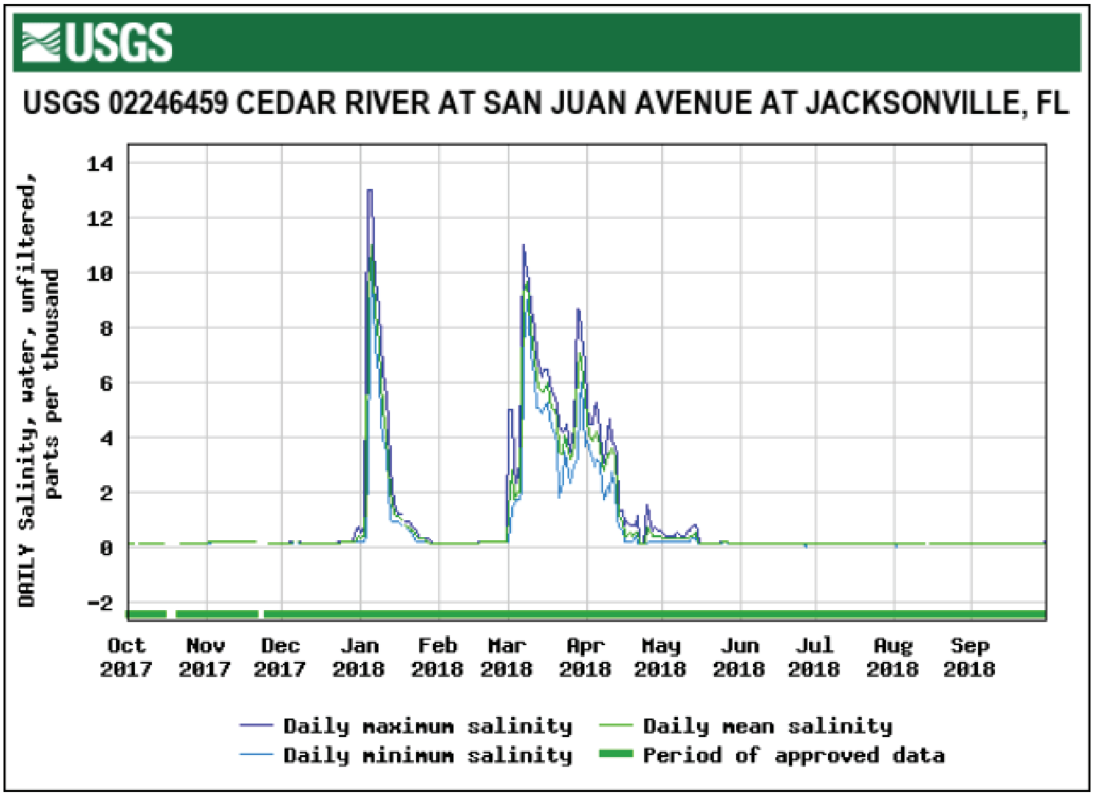

Figure 34. Daily maximum, minimum, and mean salinity for Cedar River at San Juan Avenue at Jacksonville, Florida.

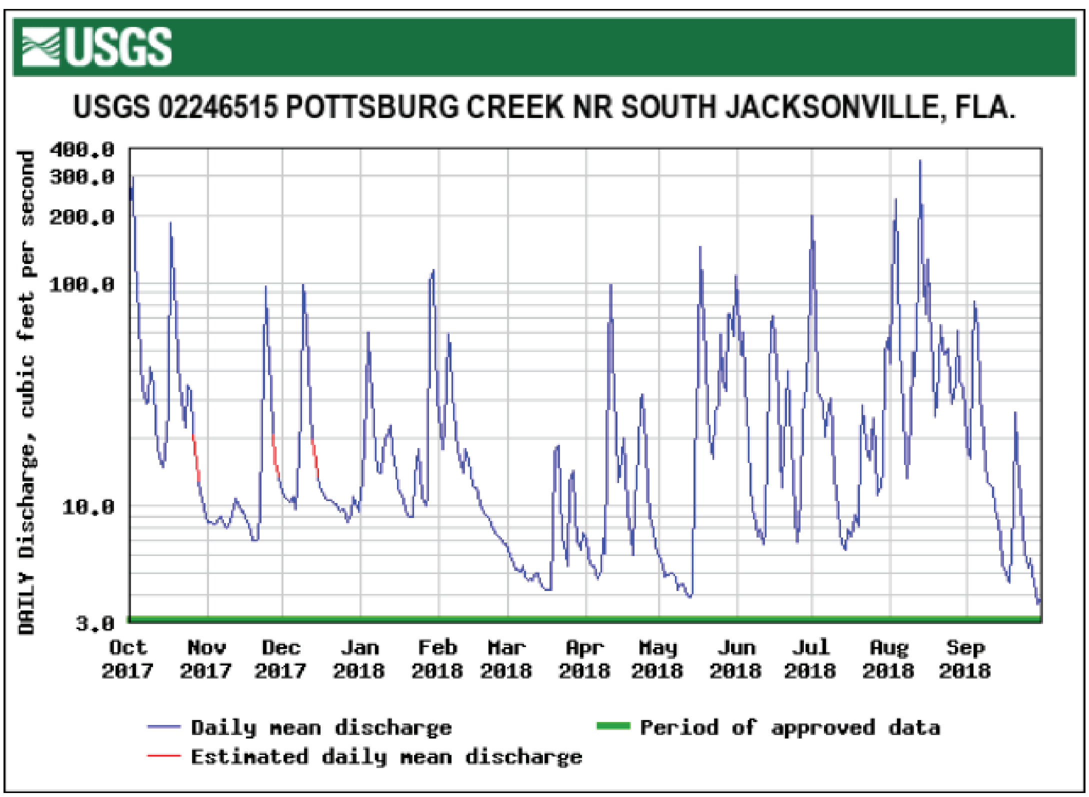

Figure 35. Daily mean discharge for Pottsburg Creek near South Jacksonville, Florida.

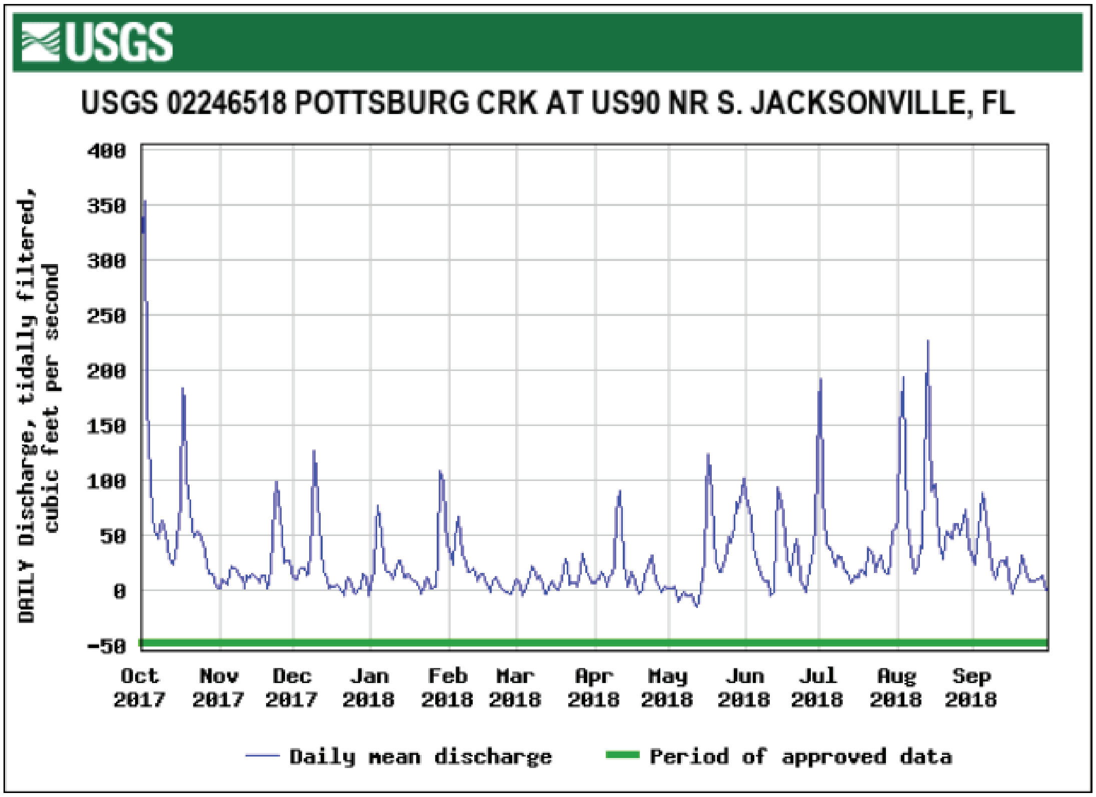

Figure 36. Daily mean tidally filtered discharge for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

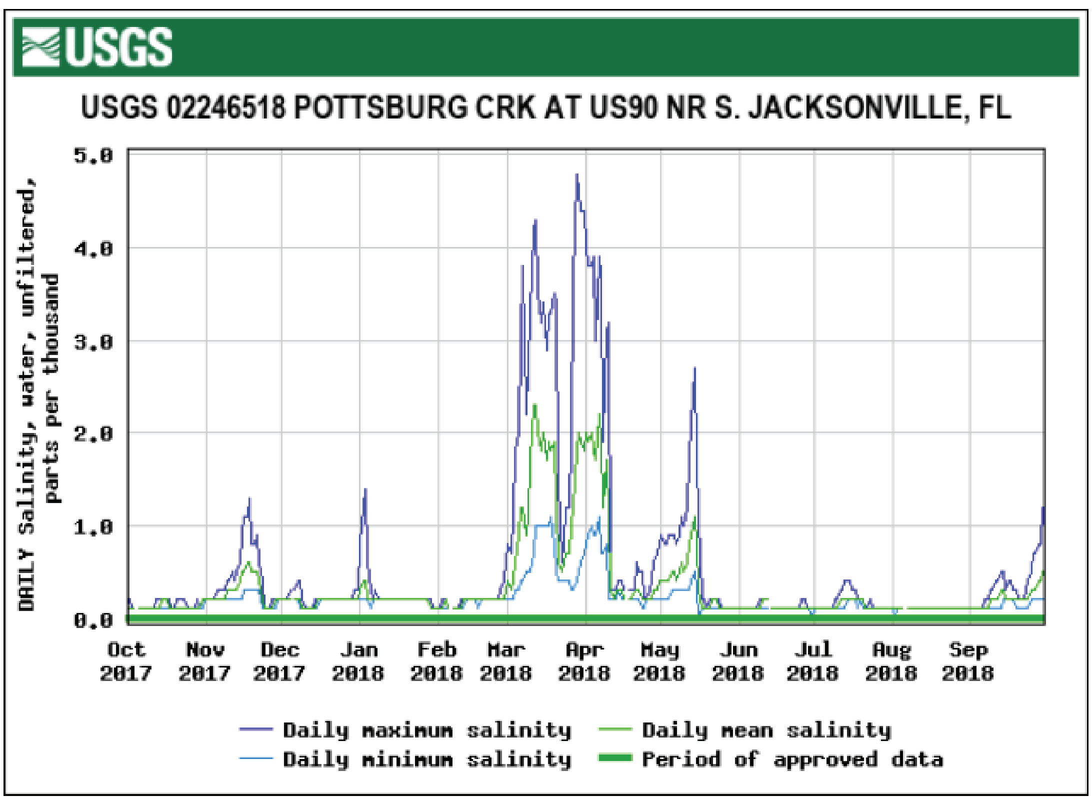

Figure 37. Daily maximum, minimum, and mean salinity for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

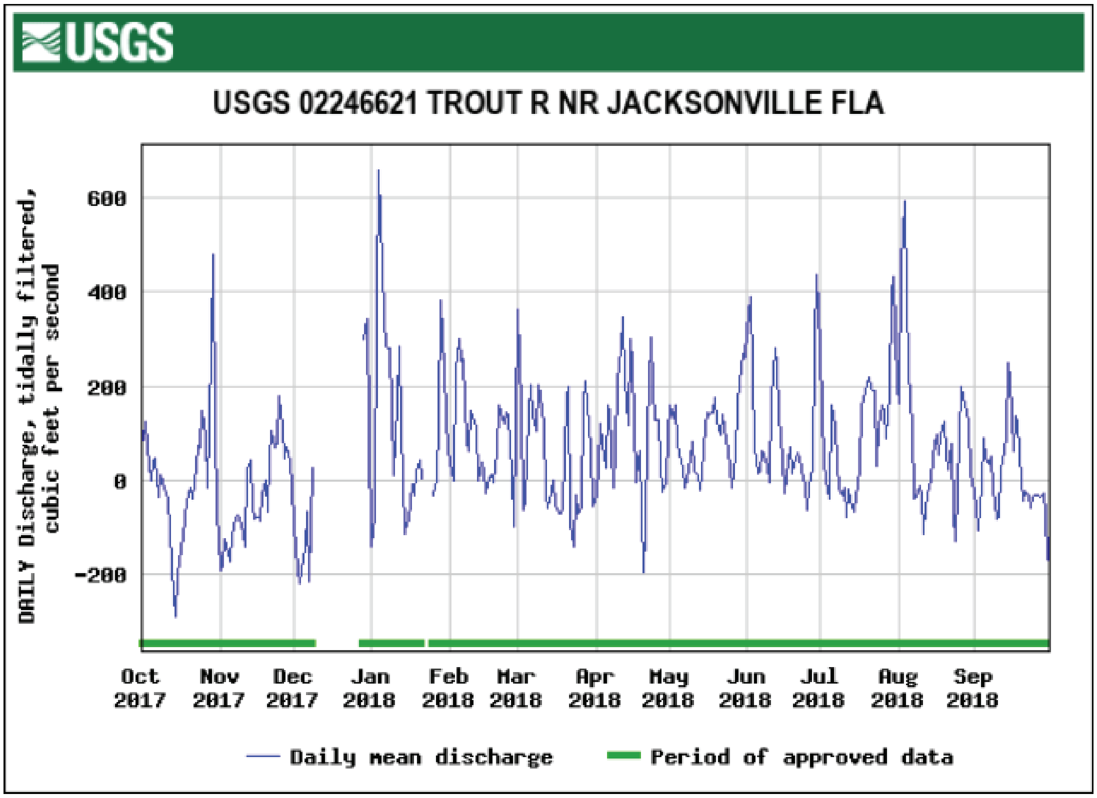

Figure 38. Daily mean tidally filtered discharge for Trout River near Jacksonville, Florida.

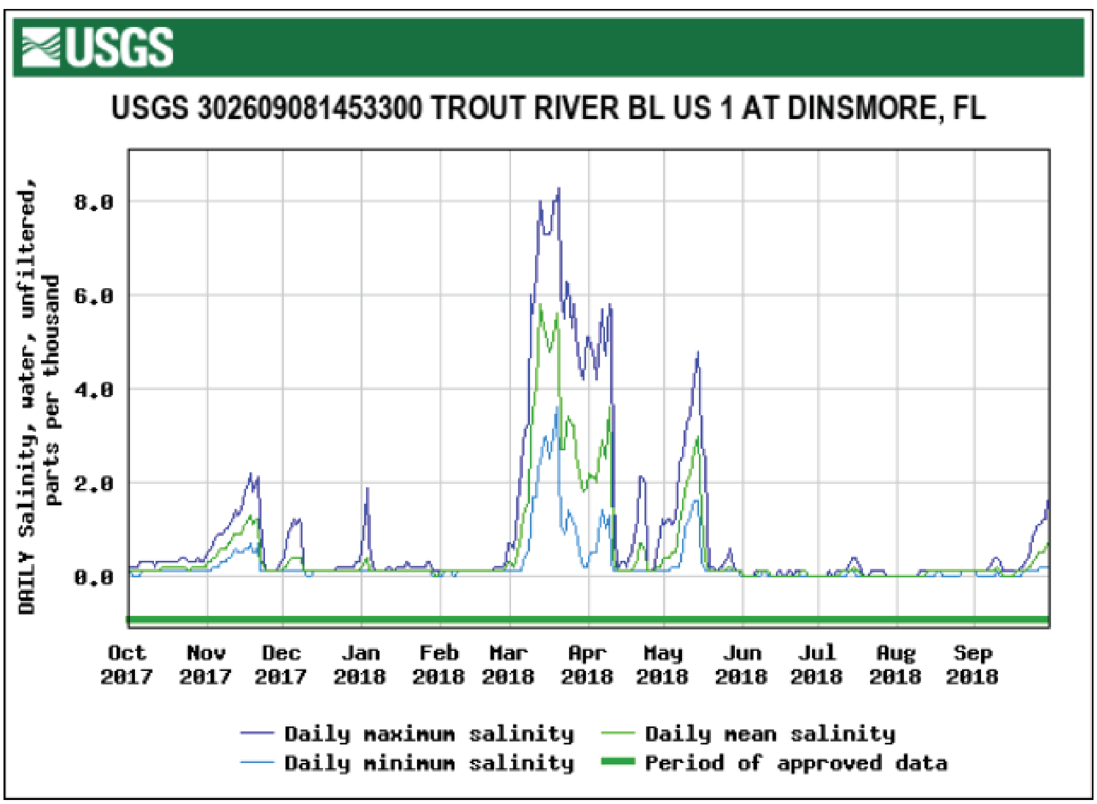

Figure 39. Daily maximum, minimum, and mean daily salinity for Trout River below U.S. 1 at Dinsmore, Florida.

Broward River Below Biscayne Blvd. Near Jacksonville, Florida—Daily tidally filtered discharge at Broward River ranged from −19.2 to 276 ft^3/s during the 2018 water year, with an annual mean flow of 32.9 ft^3/s (fig. 40). Salinity ranged from 0.0 to 6.5 ppt, with a median of 0.2 ppt and mean of 0.4 ppt (fig. 41). Discharge was relatively consistent during the period, with two peaks of daily tidally filtered discharge exceeding 200 ft^3/s (fig. 40). Salinity remained below 5 ppt from June through September because of summertime rainfall (fig. 3).

Dunn Creek at Dunn Creek Road Near Eastport, Florida—Daily tidally filtered discharge at Dunn Creek ranged from −6.89 to 114 ft^3/s during the 2018 water year, with an annual mean flow of 12.0 ft^3/s (fig. 42). Discharge was relatively consistent during the period, with only 2 days of daily tidally filtered discharge exceeding 100 ft^3/s. Daily value tidally filtered discharge data are missing for 8 days in October because of equipment malfunction. Salinity ranged from 0.0 to 9.7 ppt, with a median of 0.4 ppt and mean of 0.9 ppt over this period (fig. 43).

Clapboard Creek Near Jacksonville, Florida—Daily tidally filtered discharge at Clapboard Creek ranged from −107 to 260 ft^3/s during the 2018 water year, with an annual mean flow of 35.4 ft^3/s (fig. 44). Tidally filtered discharge remained below 200 ft^3/s for the entire period except for peaks in October, June, and September.

Clapboard Creek Above Buckhorn Bluff Near Jacksonville, Florida—Salinity at Clapboard Creek ranged from 0.4 to 29 ppt during the 2018 water year, with a median of 14 ppt and mean of 15 ppt (fig. 45). The lowest salinity occurred in early June, during the largest 4-month consecutive monthly rainfall total in Duval County (fig. 3). This low salinity value was also the lowest calculated for the 2-year period of record.

Discharge and Salinity Site Comparison

Analysis of the annual mean tidally filtered discharge for the 2018 water year along the main stem of the St. Johns River indicates that streamflow increased with distance downstream, as expected (fig. 46). Figure 46 also shows the 2018 water year had the highest annual mean discharge for each of the main-stem sites for the past 3 years. Of the tributaries, annual mean tidally filtered discharge was greatest at Durbin Creek, followed by Ortega River, Trout River, Cedar River, Julington Creek, Clapboard Creek, Broward River, Pottsburg Creek, and Dunn Creek, whose annual mean was lowest (fig. 47). Annual mean discharge at all tributary monitoring sites was lower for the 2018 water year than for the 2017 water year, except for Cedar River, which could be due to missing data resulting from Hurricane Irma in September 2017 (fig. 47). Relative to the 2017 water year, countywide annual rainfall for the 2018 water year was lower in Duval, Clay, St. Johns, and Putnam Counties and slightly higher in Volusia County (fig. 48).

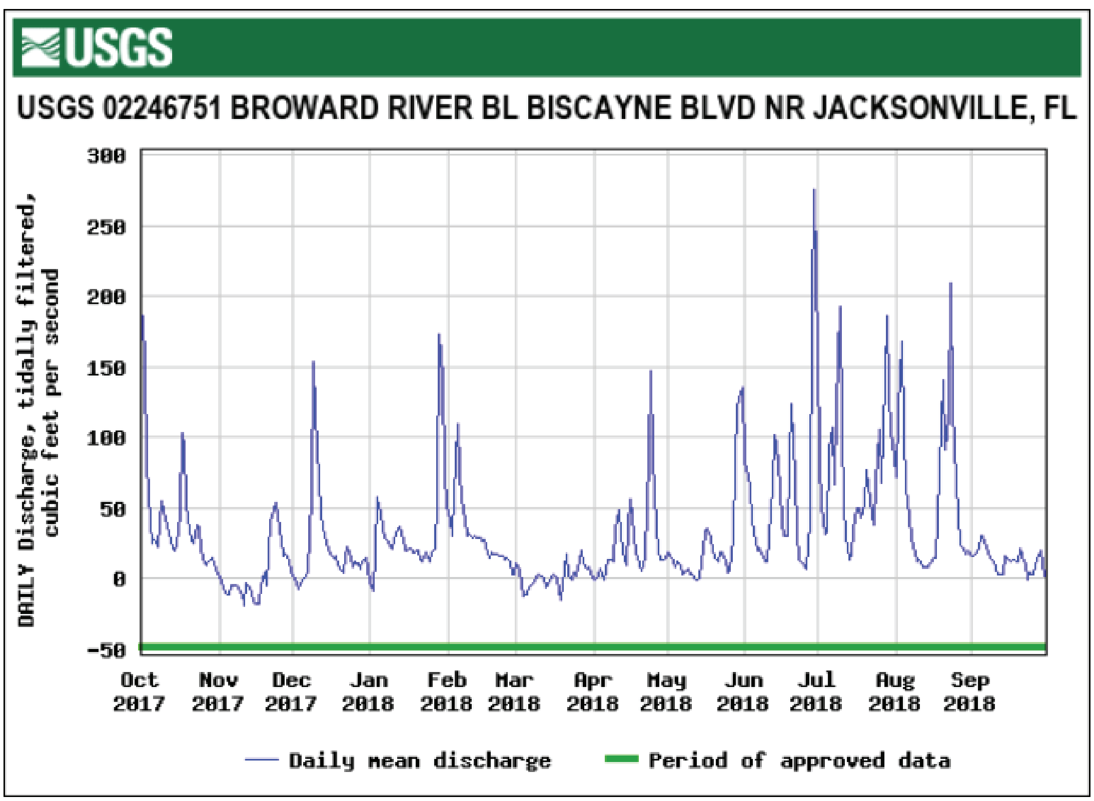

Figure 40. Daily mean tidally filtered discharge for Broward River below Biscayne Boulevard near Jacksonville, Florida.

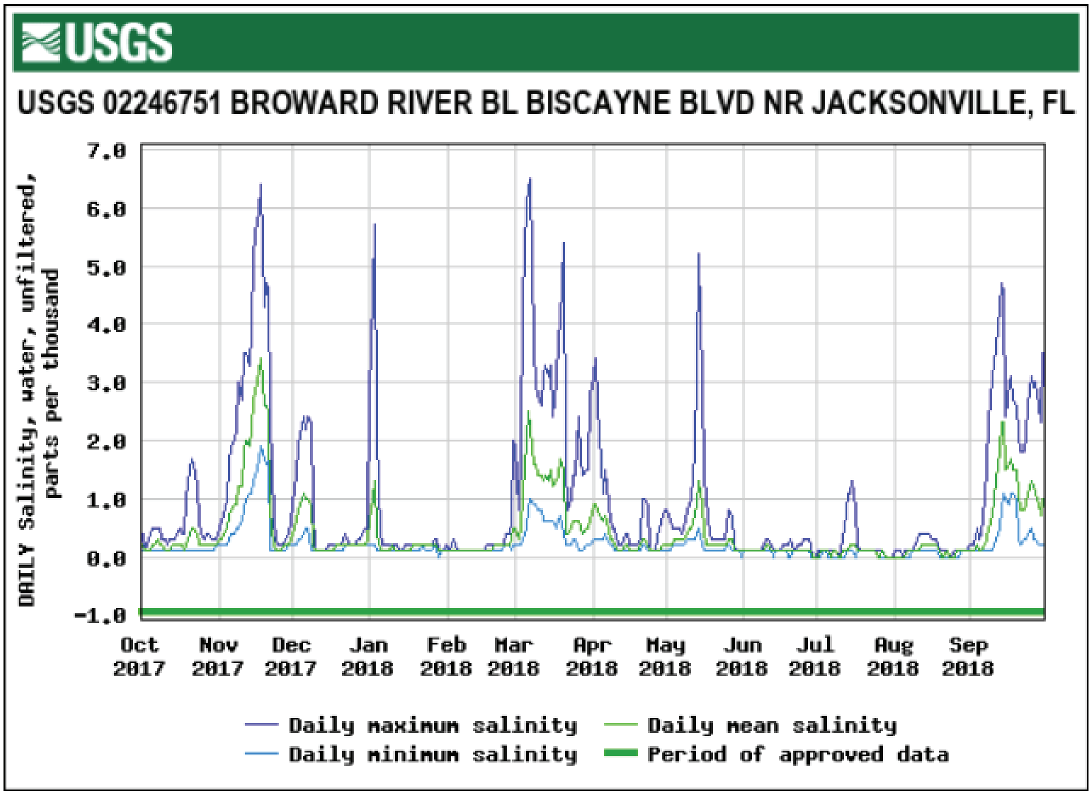

Figure 41. Daily maximum, minimum, and mean salinity for Broward River below Biscayne Boulevard near Jacksonville, Florida.

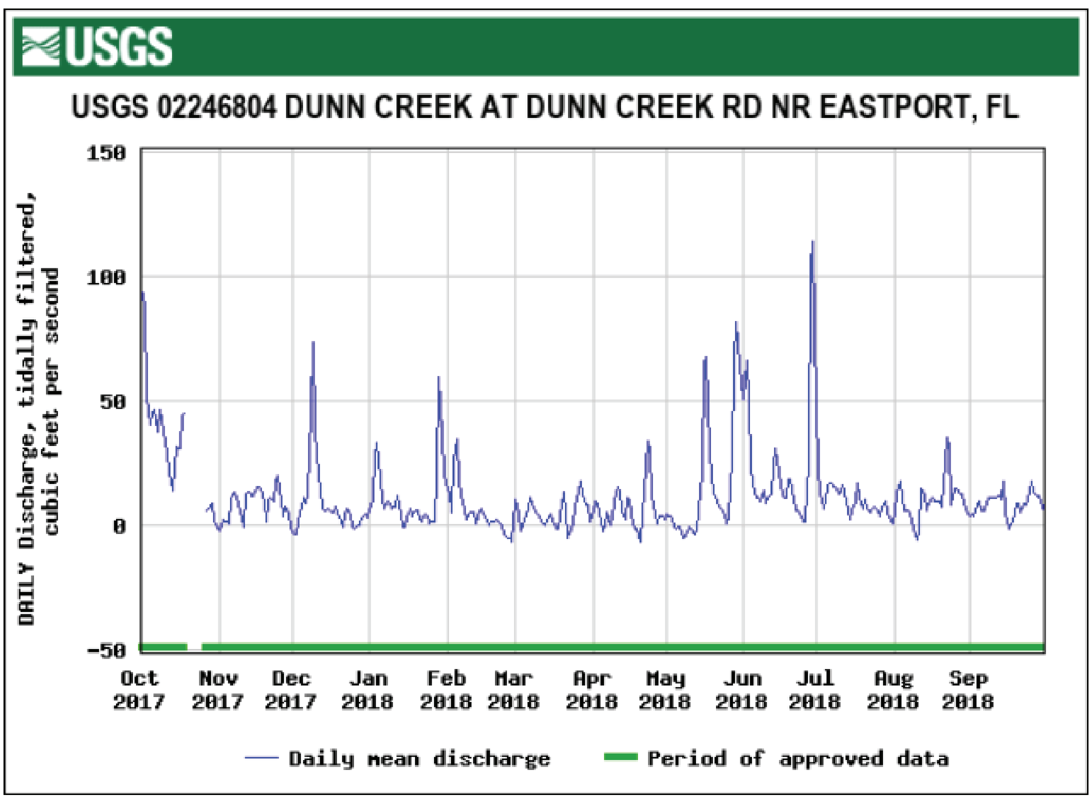

Figure 42. Daily mean tidally filtered discharge for Dunn Creek at Dunn Creek Road near Eastport, Florida.

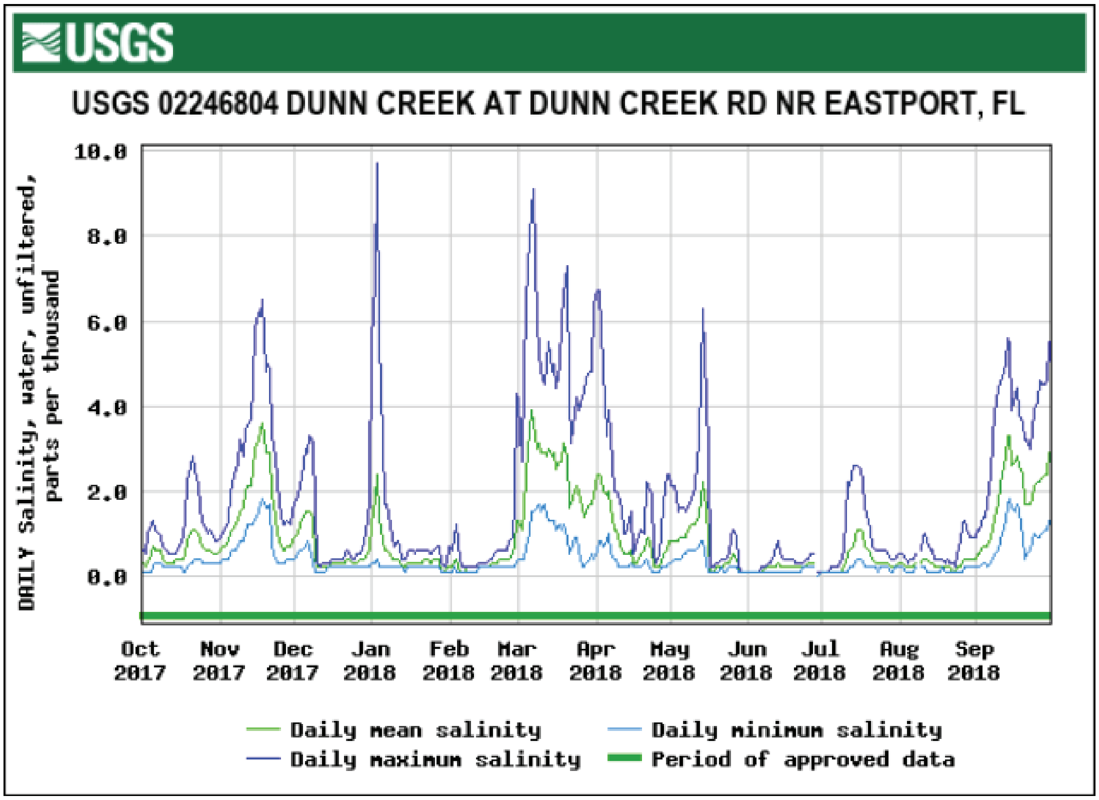

Figure 43. Daily maximum, minimum, and mean salinity for Dunn Creek at Dunn Creek Road near Eastport, Florida.

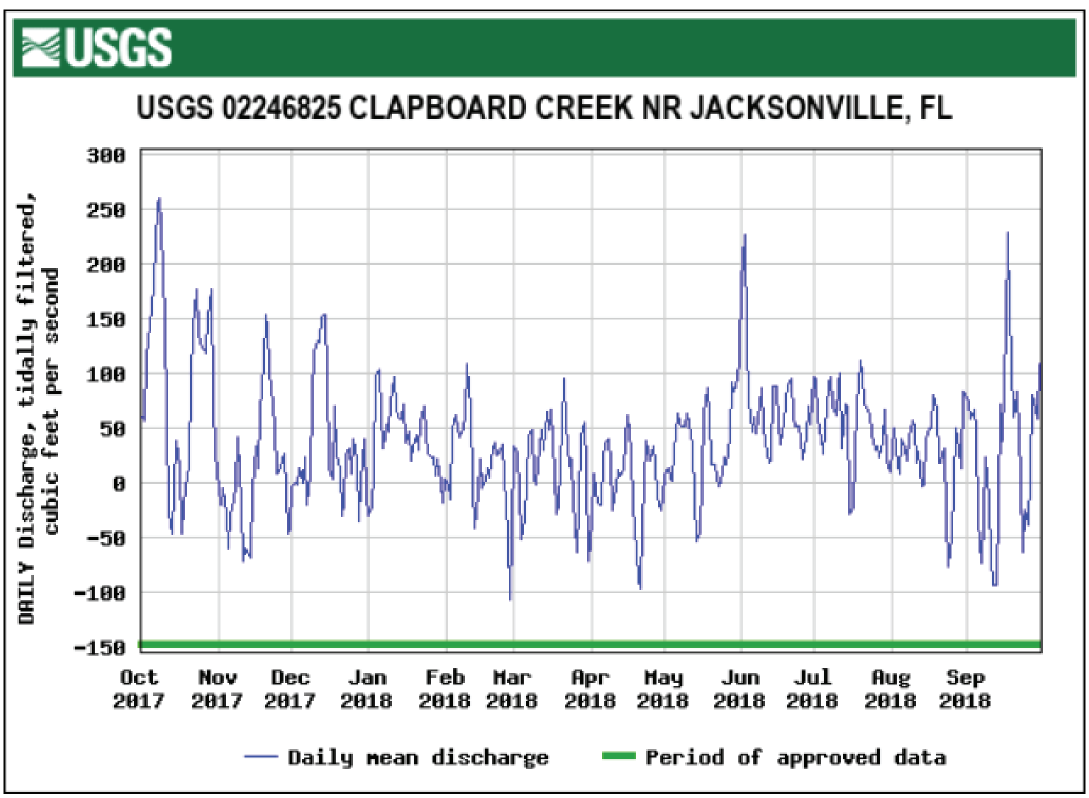

Figure 44. Daily mean tidally filtered discharge for Clapboard Creek near Jacksonville, Florida.

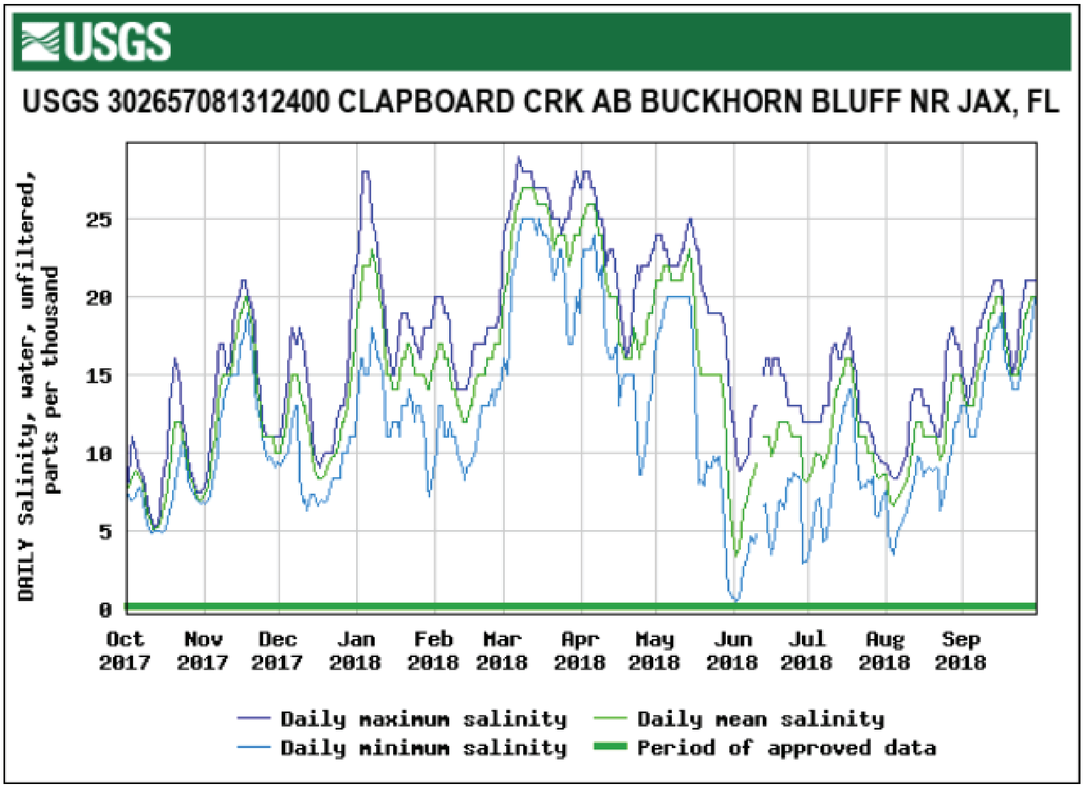

Figure 45. Daily maximum, minimum, and mean salinity for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida.

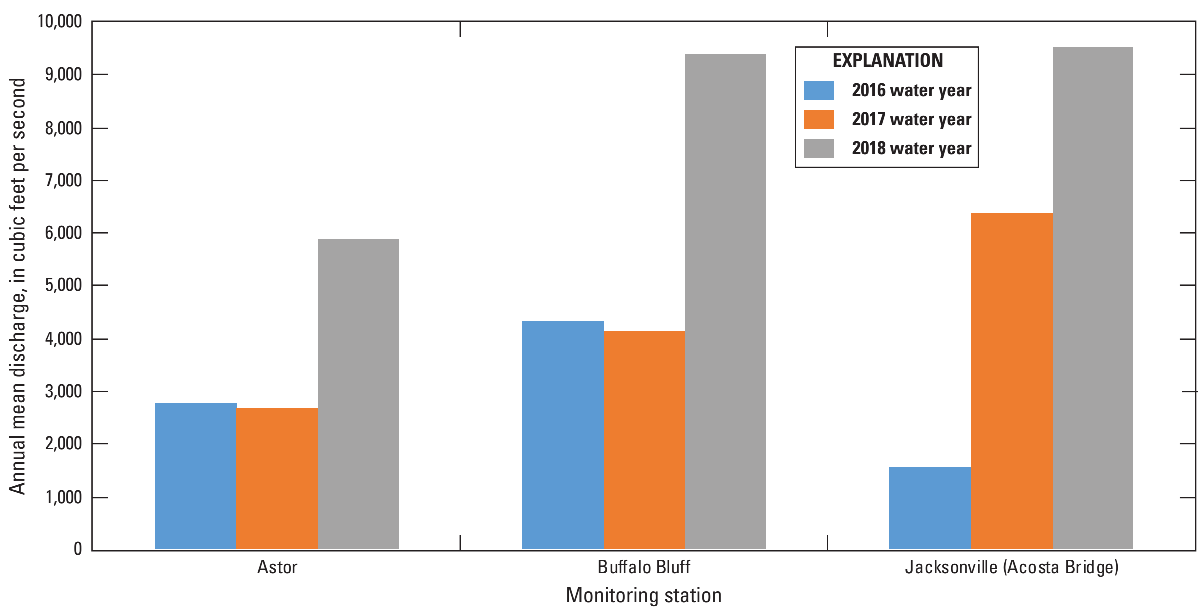

Figure 46. Annual mean discharge at St. Johns River main-stem monitoring sites.

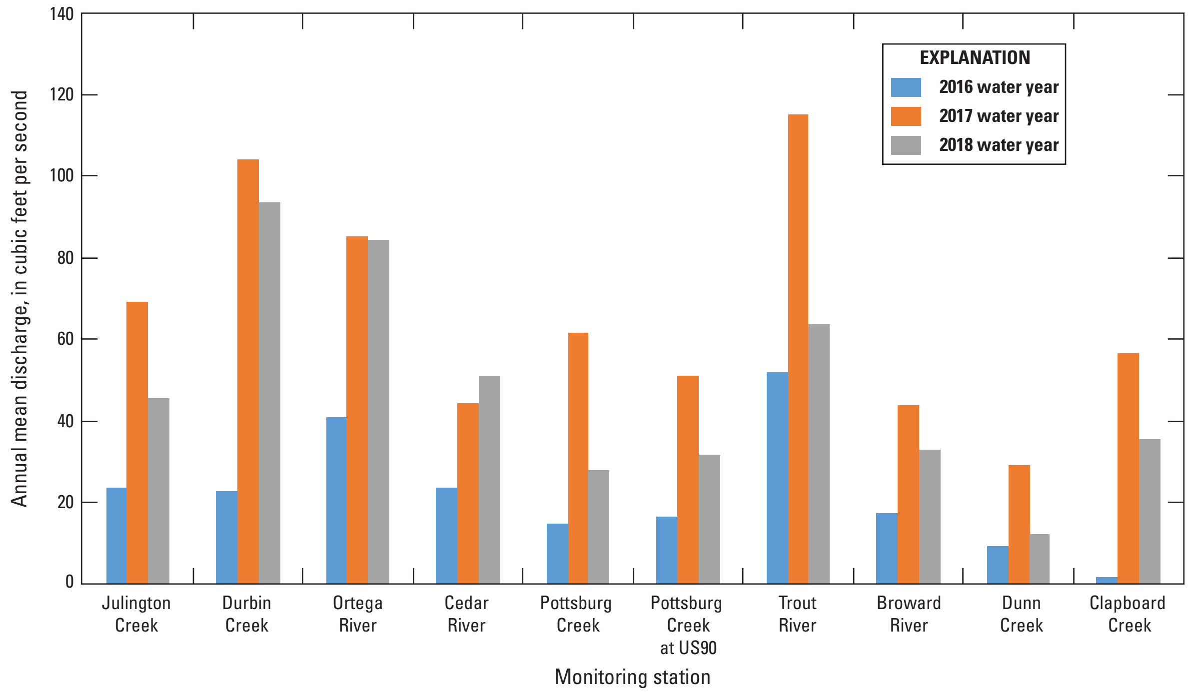

Figure 47. Annual mean discharge at St. Johns River tributary monitoring sites.

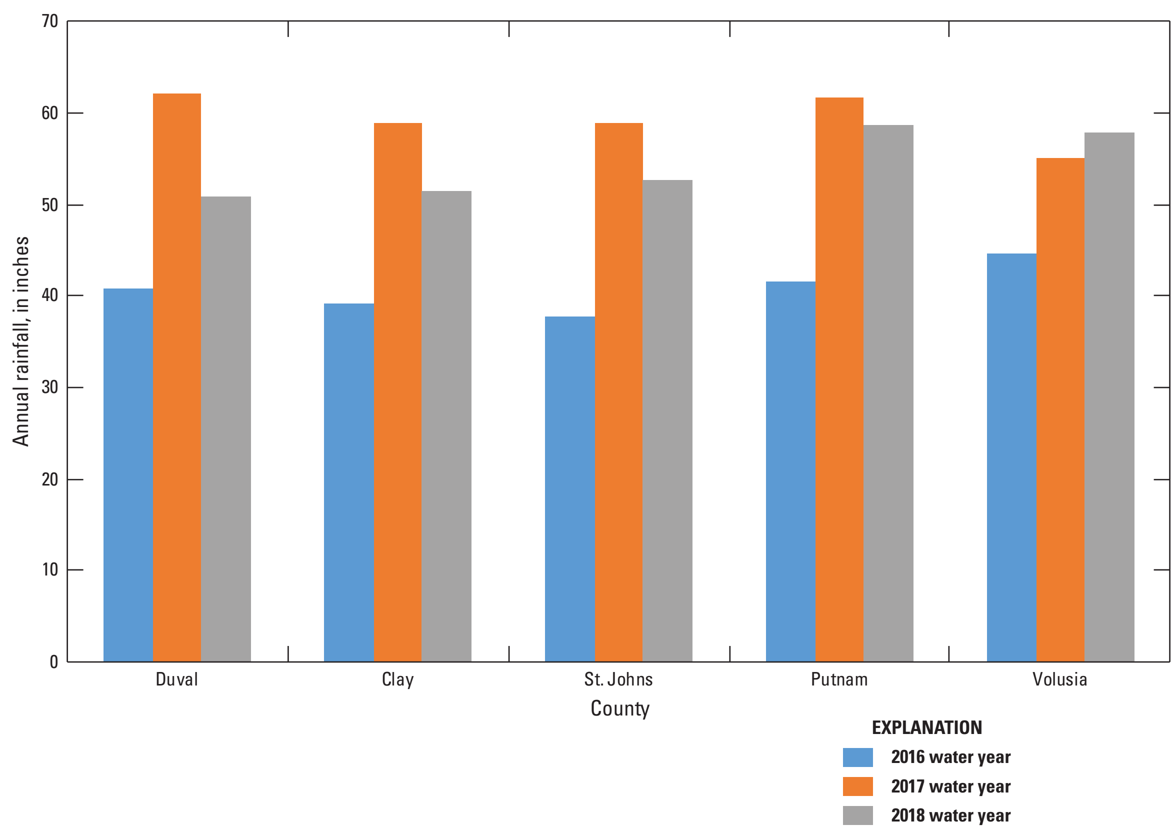

Figure 48. Annual rainfall for Duval, Clay, St. Johns, Putnam, and Volusia Counties.

Annual mean salinity for the main-stem sites generally decreased with distance upstream, which is expected (fig. 49). Annual means for some monitoring locations near the riverbank, such as Christopher Point and Marco Lake, differ from this trend. Salinities measured at both sites are more likely to be affected by wind and rainfall than those at other sites, resulting in different values than those obtained near the main channel. Clapboard Creek had the highest annual mean salinity of all tributaries because of its proximity to the Atlantic Ocean. Durbin Creek and Ortega River salinities were the lowest of all monitoring locations and were slightly lower than that of Julington Creek (fig. 50). A simple comparison of annual mean salinity among tributary sites and between the 2017 and 2018 water years indicates salinity was lower in 2018 at all locations except Durbin Creek, which remained the same (fig. 50). Salinity was also lower for the 2018 water year than for any previous water year for the relevant main-stem monitoring stations where salinity was calculated in previous years (fig. 49).

Summary

The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, collected data during the 2018 water year, from October 2017 to September 2018, at 26 sites on the St. Johns River and its tributaries. This period of data collection occurred prior to and during the commencement of dredging in February 2018 by the U.S. Army Corps of Engineers as part of its project to deepen the first 13 river miles of Jacksonville Harbor. Data collection began in the 2016 water year, and this is the third annual report of the study. Stage was measured at 17 sites, discharge was calculated at 13 sites, and water temperature and specific conductance data were collected at 19 sites; all parameters were measured at some sites. Salinity was calculated for each site where water temperature and specific conductance data were collected. Data were collected over a wide range of hydrologic conditions, including a period of above-average rainfall in Duval, Clay, St. Johns, Putnam, and Volusia Counties from April to July.

Annual mean discharge at Durbin Creek was greatest among the tributaries, followed by that of Ortega River, Trout River, Cedar River, Julington Creek, Clapboard Creek, Broward River, Pottsburg Creek, and Dunn Creek. The closest tributary site to the Atlantic Ocean, Clapboard Creek, had the highest annual mean salinity of the tributaries, and Durbin Creek and Ortega River had the lowest of all monitoring locations, being slightly lower than that of Julington Creek. Annual mean salinities for the main-stem sites indicate that salinity decreases with distance upstream from the ocean, which is expected. Annual mean salinity at all sites in the 2018 water year was lower than that of any previous water year except for Durbin Creek, which remained the same. Many factors—such as wind, rainfall, and hurricanes—influence flow and salinity within the project area.

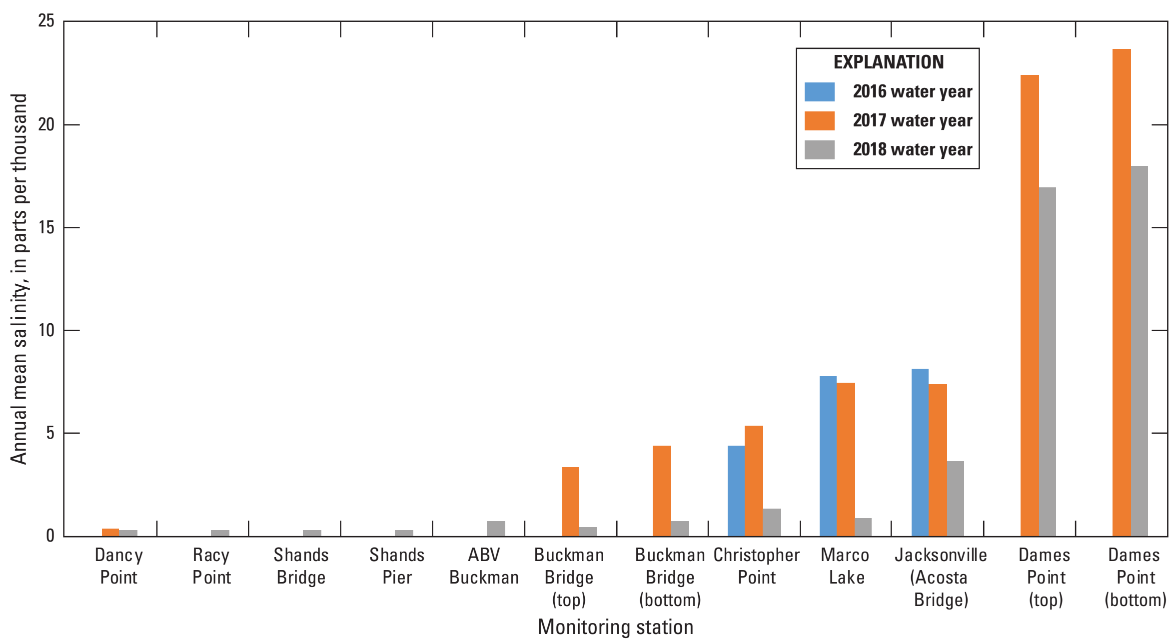

Figure 49. Annual mean salinity at St. Johns River main-stem monitoring sites.

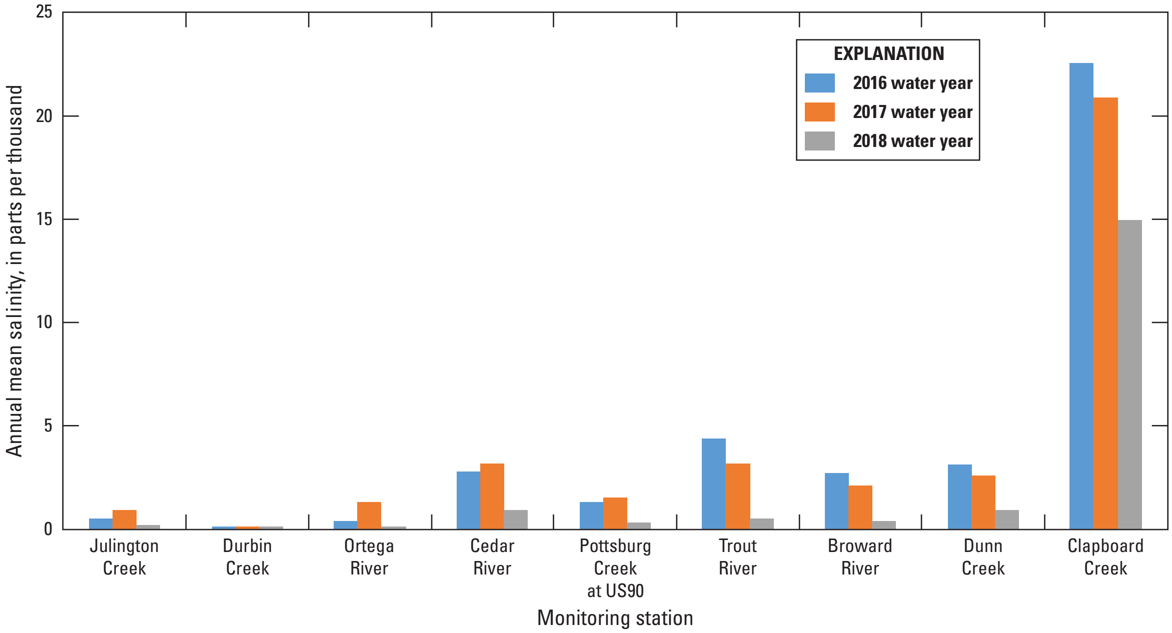

Figure 50. Annual mean salinity at St. Johns River tributary monitoring sites.

References Cited

Florida Department of Environmental Protection, 2016, Jacksonville Harbor Federal Channel Expansion Permit No. 0129277–017–BI, p. 22–23.

Godin, G., 1972, The analysis of tides: Toronto, University of Toronto Press, 264 p.

Jacksonville Port Authority [JAXPORT], 2018, Jacksonville harbor deepening fact sheet: 1 p., accessed March 21, 2019, at https://www.jaxport.com/sites/default/files/images/HarborDeepeningInfo_1.pdf

Levesque, V.A., and Oberg, K.A., 2012, Computing discharge using the index velocity method: U.S. Geological Survey Techniques and Methods, book 3, chap. A23, 148 p. [Also available at https://pubs.usgs.gov/tm/3a23/.]

Rantz, S.E., and others, 1982, Measurement and computation of streamflow, v. 1 and 2: U.S. Geological Survey Water-Supply Paper 2175, 631 p.

Ryan, P.J., 2018, Continuous stream discharge, salinity, and associated data collected in the lower St. Johns River and its tributaries, Florida, 2016: U.S. Geological Survey Open-File Report 2018–1108, 28 p., accessed September 18, 2019, at https://doi.org/10.3133/ofr20181108.

Ryan, P.J., 2019, Continuous stream discharge, salinity, and associated data collected in the lower St. Johns River and its tributaries, Florida, 2017: U.S. Geological Survey Open-File Report 2019–1078, 35 p., accessed September 18, 2019, at https://doi.org/10.3133/ofr20191078.

Sauer, V.B., and Turnipseed, D.P., 2010a, Stage measurement at gaging stations: U.S. Geological Survey Techniques and Methods, book 3, chap. A7, 45 p. [Also available at https://doi.org/10.3133/tm3A7.]

Sauer, V.B., and Turnipseed, D.P., 2010b, Discharge measurements at gaging stations: U.S. Geological Survey Techniques and Methods, book 3, chap. A8, 87 p. [Also available at https://doi.org/10.3133/tm3A8.]

St. Johns River Water Management District [SJRWMD], 2019, Rainfall summary—Hydrologic conditions report: 1 p., accessed March 21, 2019, at http://webapub.sjrwmd.com/agws10/hydroreport/

U.S. Army Corps of Engineers, [USACE], 2014, Jacksonville Harbor navigation study, Duval County, Florida: U.S. Army Corps of Engineers, Jacksonville District, Final integrated general reevaluation report II and supplemental environmental impact statement, 289 p. [Also available at http://cdm16021.contentdm.oclc.org/cdm/ref/collection/p16021coll7/id/2118.]

U.S. Geological Survey [USGS], 2019, USGS water data for the Nation: U.S. Geological Survey National Water Information System database, accessed August 2019 at https://doi.org/10.5066/F7P55KJN.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods, book 1, chap. D3, 51 p. [Also available at https://pubs.usgs.gov/tm/2006/tm1D3/pdf/TM1D3.pdf.]

For more information about this publication, contact

Director, Caribbean-Florida Water Science Center
U.S. Geological Survey
4446 Pet Lane, Suite 108
Lutz, FL 33559
(813) 498-5000

For additional information visit
https://www2.usgs.gov/water/caribbeanflorida/index.html

Publishing support provided by
Lafayette Publishing Service Center

Ryan—**Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries**—Open-File Report 2020–1061

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20201061