Appendix C - Part 2
Injection Well Hindcasting
(Author: SRWMD, 2019)

Background

Public water utilities operate two wastewater treatment plants (WWTPs) in Gainesville, FL. The discharges from these WWTPs is later returned to the groundwater system. These facilities include the older Main Street facility and the newer Kanapaha facility, both of which are in the SJRWMD portion of the county. The treated wastewater discharged from the Main Street facility goes to Alachua Sink, while treated wastewater from the Kanapaha facility is injected into the aquifer through the Kanapaha well. The University of Florida also operates its own wastewater treatment plant and has two injection wells. Table 1 shows the reclaimed water flows that were estimated for injection wells in the NFSEG model. Figure 1 shows a map of the locations of injection wells.

Injection wells reclaimed water flows in NFSEG Domain	Q 2001 million gallons per day	Q 2009 million gallons per day	Q 2010 million gallons per day
Kanapaha	**7.83**	**7.46**	**6.94**
Alachua Sink	**7.04**	**6.37**	**5.76**
University of Florida	**1.53**	**1.51**	**1.48**

Table 1. Injection well reclaimed water flows as estimated in the NFSEG model

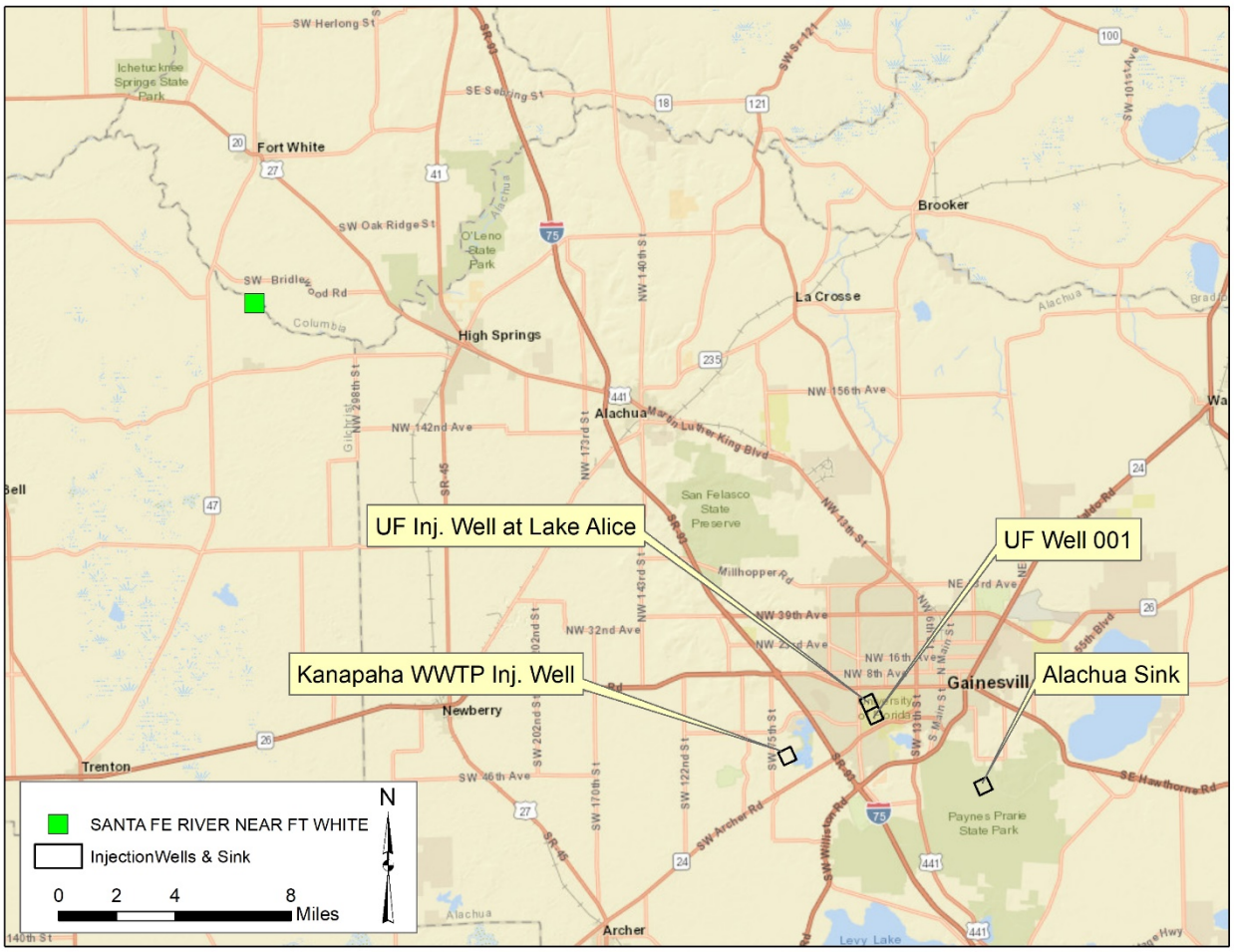

Figure 1. Map of injection wells located in the NFSEG

Murphree Well Field Withdrawal data

The Murphree well field is located in SJRWMD. Withdrawal data was obtained from SJRWMD and includes pumping estimates from 1986-2010. The Murphree withdrawal data was divided by Alachua County Public Supply data for corresponding years to get a ratio of withdrawal to public supply for each year. The ratios of reported years (1986-2010) were averaged together to get an average ratio of 0.901955. This ratio was used to hindcast and estimate Murphree withdrawal data going back to 1900 and for 2011-2015.

Kanapaha

The average estimated flow into the well at Kanapaha from January 1982 through February 1984 was 6.1 mgd (Phelps 1987). This value was used to estimate flow from 1978-1981. The Kanapaha wastewater treatment facility came online in 1977 but no month is stated, therefore it is assumed that it came online halfway through the year and half of the 6.1 mgd was assigned to 1977 (Gainesville Regional Utility Accessed 2019). Prior to 1977, the injection rate was set to zero because the wastewater treatment plant did not exist, therefore no water was being injected into the Floridan Aquifer.

Jones Edmunds has a time series of injection flows by month for Kanapaha from 1982 through 2012. Injection flows from each month were averaged to get an estimate for the flow in each given year. These numbers are also reported from Gainesville Regional Utilities Historical Wastewater Flow Rates.

Estimates for 2014-2015 were obtained from a SJRWMD file of wastewater treatment and reuse. This included data from 1995-2017.

From the reported data gathered, the average estimate of water injected for the Kanapaha well was 8.41794 MGD. Figure 2 shows the estimated flow of reclaimed water into the Kanapaha well.

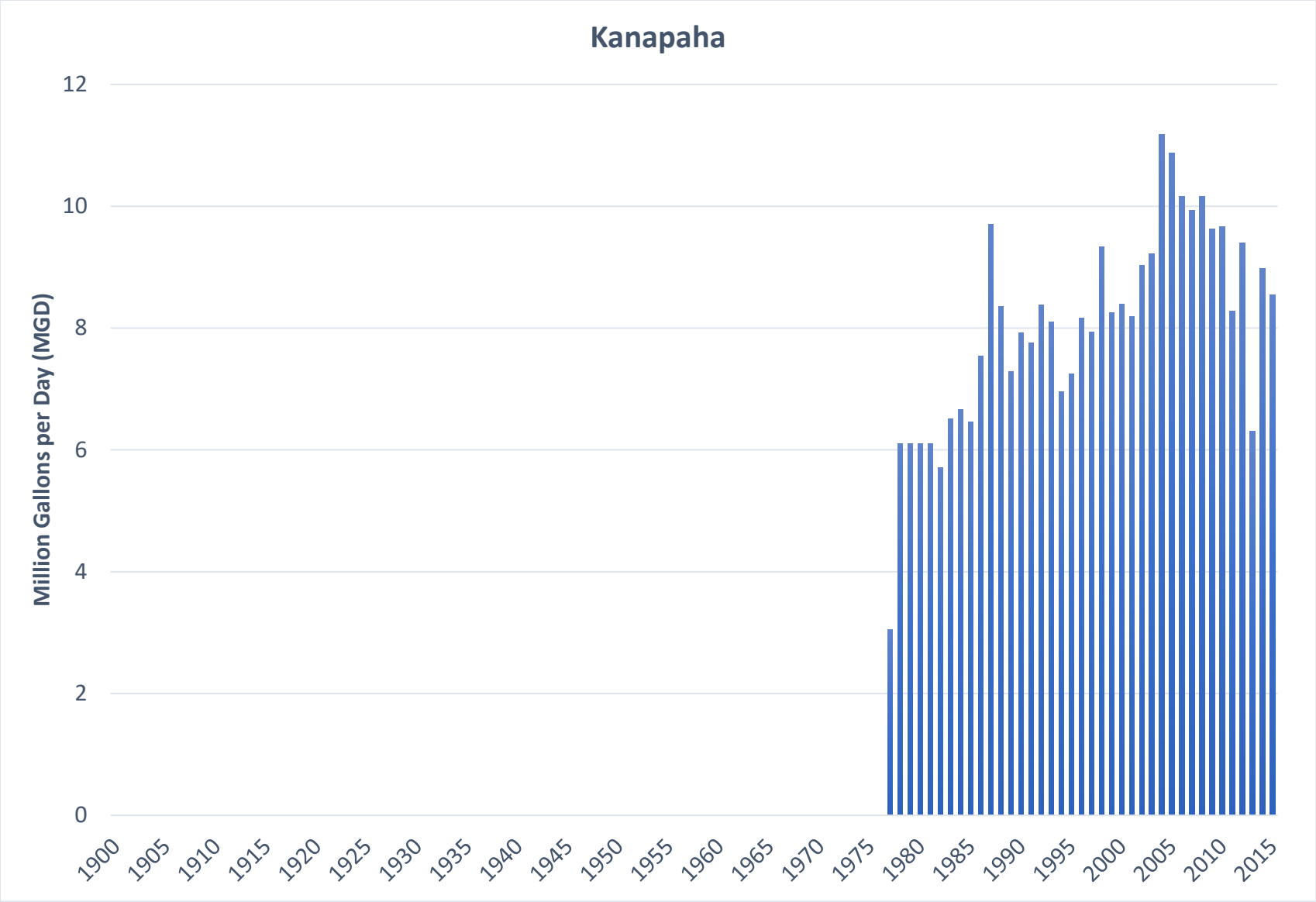

Figure 2. Estimated Kanapaha injection well flows

Alachua Sink

The main assumption regarding Alachua Sink is that all of the wastewater discharging from the Main Street WWTP is making its way to Alachua Sink. Another assumption made is that before the Kanapaha WWTP came online, the volume of treated wastewater being discharged to Alachua Sink included a proportional amount of the Kanapaha flow. The flow from the Main Street WWTP was hindcast back to 1930, when the plant came online (Gainesville Regional Utility Accessed 2019).

From 1982-2012, estimates were obtained from Gainesville Regional Utilities Historical Wastewater Flow Rates as well as the time series from Jones Edmunds. Estimates for 2014-2015 were obtained from SJRWMD file of wastewater treatment and reuse. This included data from 1995-2017. From the reported data gathered, the average of treated wastewater calculated for the Main Street WWTP was 5.8195 MGD.

For the years before the Kanapaha WWTP came online, the sum of the average injection of the treated Kanapaha wastewater ($\overline{Q}injection, Kanapaha$) and the Main Street treated wastewater (*Main Street*) was divided by the average withdrawal from the Murphree well field ($\overline{W}Murphree$) to find ratio *c1*. The value of *c1* is 0.59888.

$$c1 = \frac{\overline{Q}\text{injection, Kanapaha} + \text{Main Street}}{\overline{W}\text{Murphree}}$$

Then, the product of ratio *c1* and the average Murphree well field withdrawal ($\overline{W}Murphree$) was subtracted from the average of Alachua County Public Supply (Q_*Alachua*) to obtain an estimate of injection flow for each year of missing data (1900-1977) (*Pre-Kanapaha*).

$$\text{Pre Kanapaha} = (\text{Q\_}Alachua) - (c1 \times \overline{W}\text{Murphree})$$

After Kanapaha came online, the same methodology was applied to calculate ratio *c2*, however, the injection flow from Main Street ($\overline{Q}injection, Main\ Street$) was used, instead of adding in the Kanapaha flow. This value of *c2* is 0.24479.

$$c2 = \frac{\overline{Q}\text{injection, Main Street}}{\overline{W}\text{Murphree}}$$

Thus, the estimated injection (*Post-Kanapaha*) is the ratio *c2* multiplied by the average Murphree well field withdrawal. This was applied for years 1977-1981. The value in 1977 was divided by two, because of the assumption of the Kanapaha WWTP coming online halfway through the year. Injection estimates are available starting in 1982.

$$\text{Post Kanapaha} = c2 \times \overline{W}\text{Murphree}$$

Figure 3 shows the estimated flow into Alachua Sink.

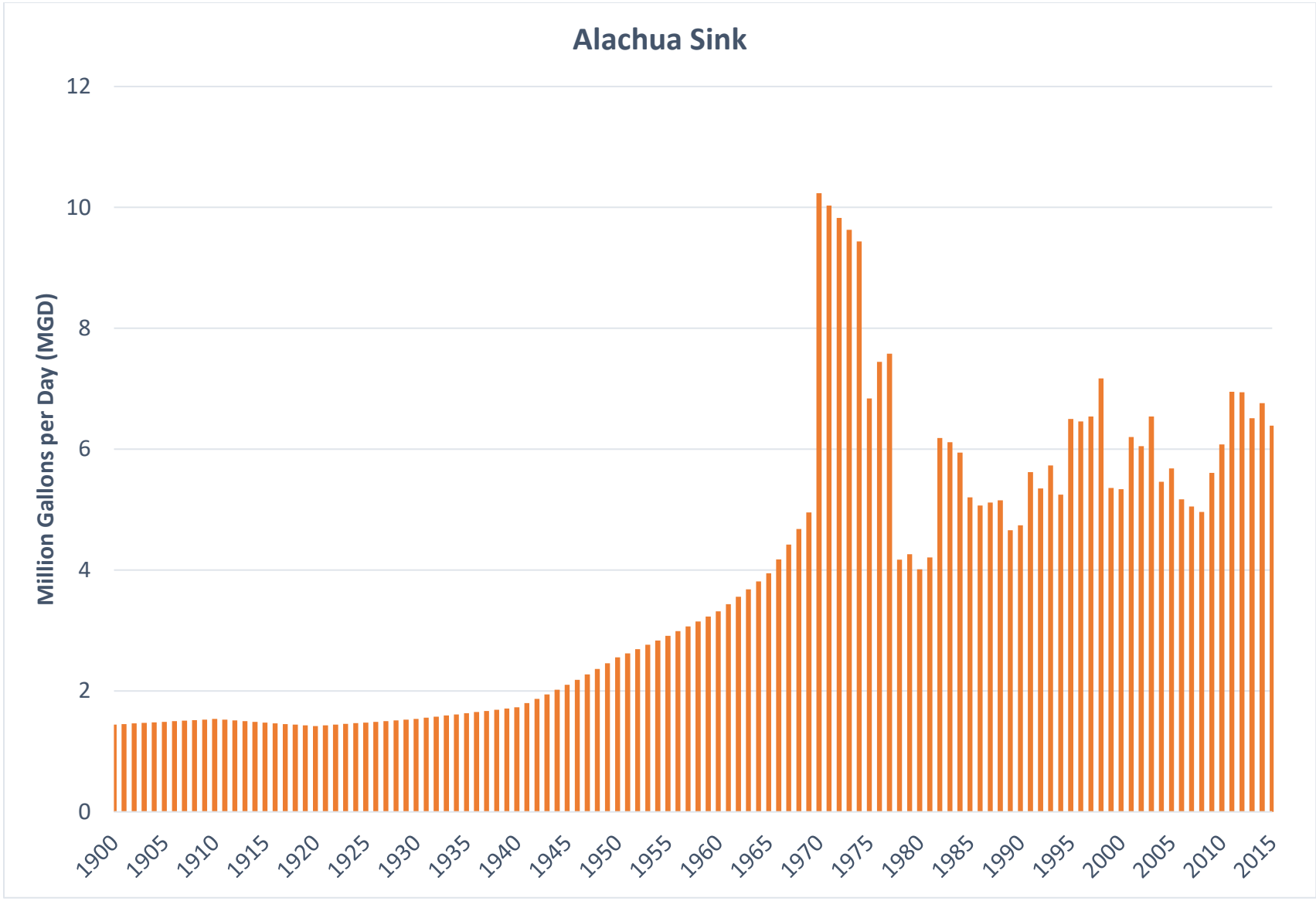

Figure 3. Estimated flows for Alachua Sink

University of Florida

The University of Florida wastewater treatment plant was constructed in 1926. In 1959, two injection wells were installed for lake level control. In 1994, the water reclamation plant (WRP) began operation and in 1995 the effluent from the plant was discharged directly to the R2 (Lake Alice - FLA011322_8285) injection well, leaving the other well, R1 (UF well number 001) to be used only for lake level control.

Starting in 1995, injection flow rates from the WRP and total flow rates were reported to FDEP. SJRWMD provided a spreadsheet with these numbers (file name "1995 - PRESENT WW TREATMENT AND REUSE MASTER FILE 051518"). The injection flow rates reported from 1995-2015 were assigned to only well R2 because the reclaimed water is injected directly into that well. Well R1 was set to zero for these years.

To estimate the flow through the wells prior to 1995, the average of the total flow reported from FDEP from 1995-2015 was calculated. This average of 1.890762 MGD was then divided by the average Murphree Well Field withdrawal for reported years (23.7734448 MGD) to get a ratio of 0.079532517. This ratio was then multiplied by the Murphree Well Field withdrawal data back to 1926 and divided equally amongst the R1 and R2 wells. Figure 4 shows the estimated flow into both University of Florida injection wells.

Figure 5 displays the time series for all injection wells where flows were estimated.

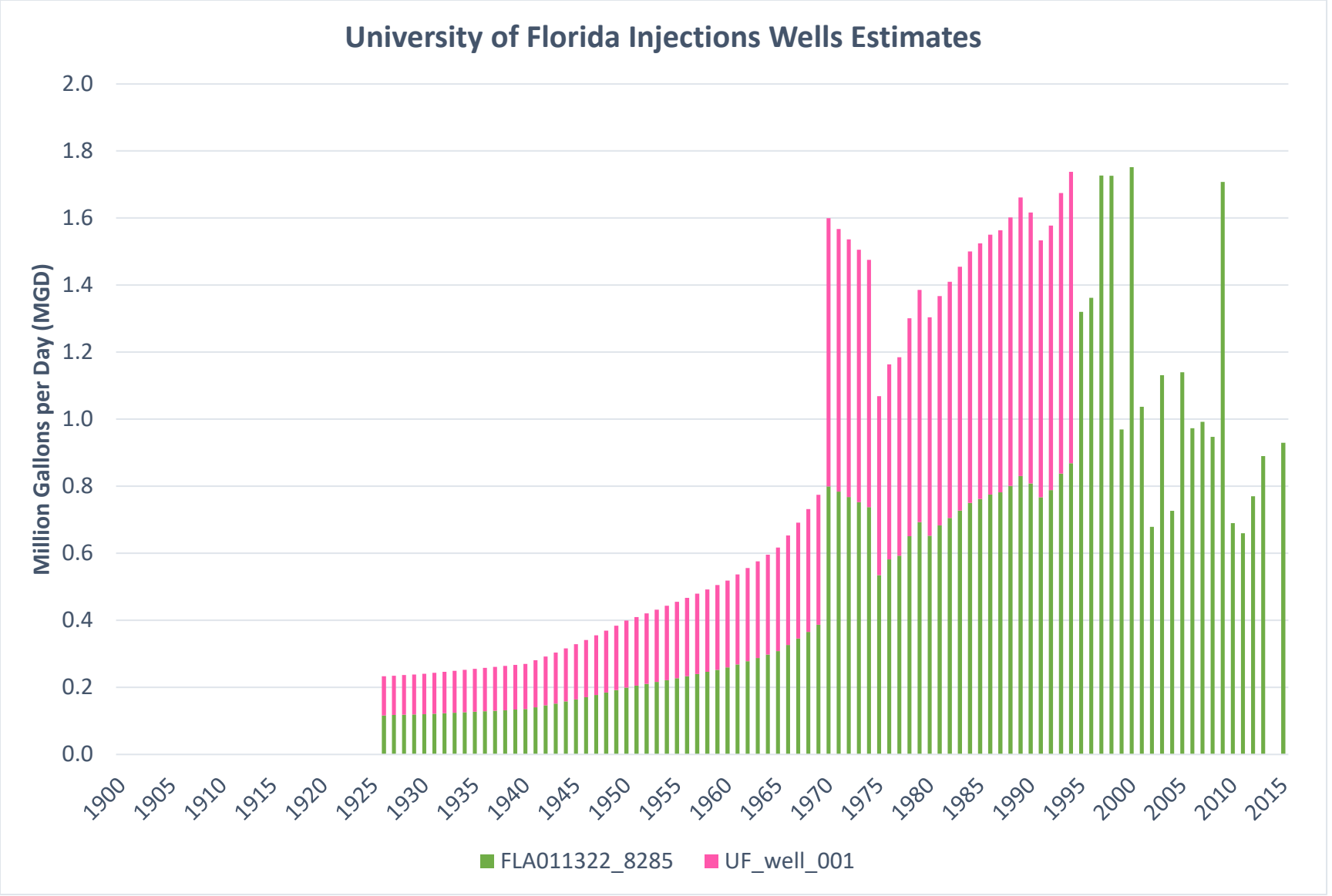

Figure 4. Estimated flows for University of Florida injection wells

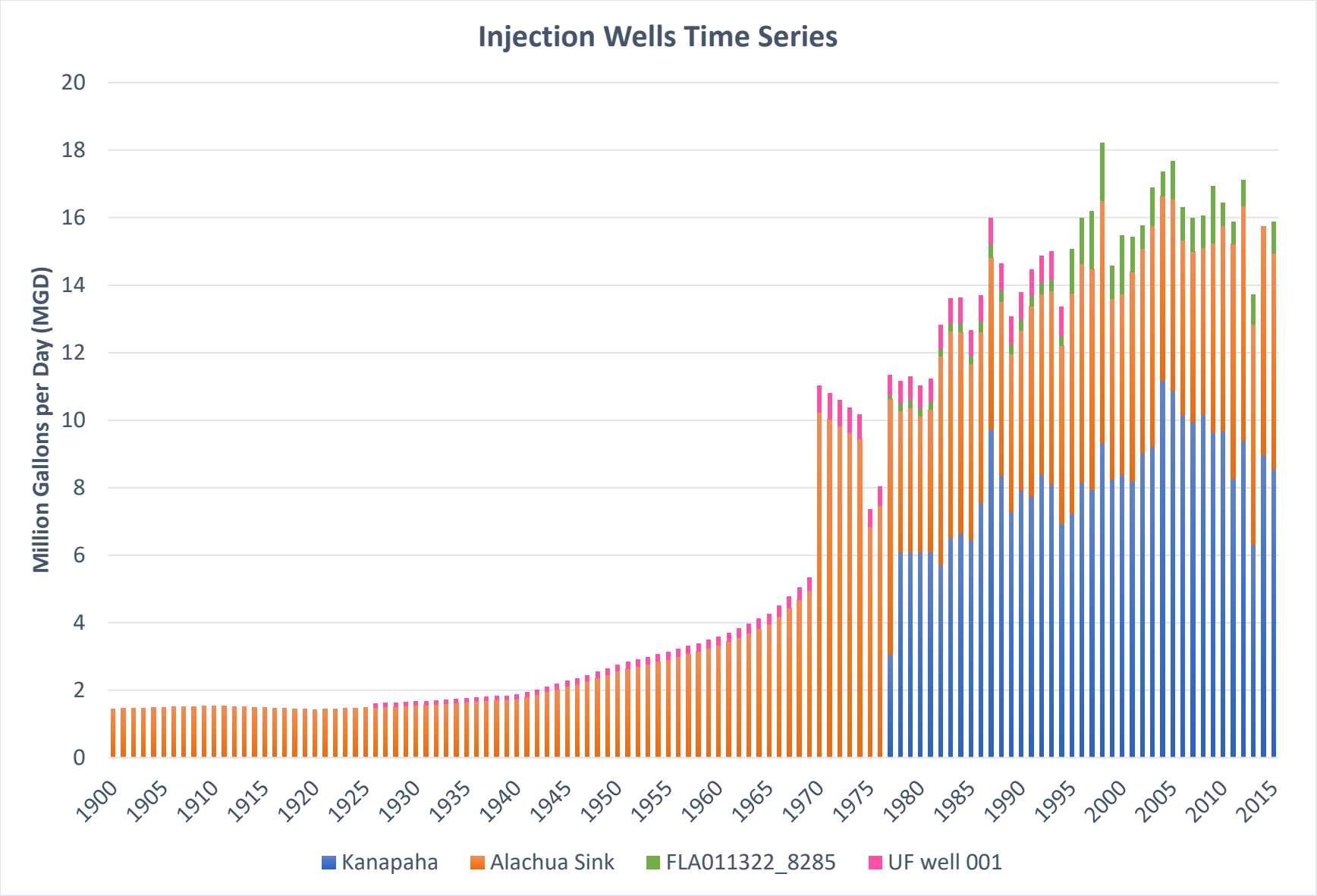

Figure 5. Estimated injection well flows time series for all wells

Moving Average

Lastly, a five-year moving average was calculated from the injection rates for each station. This moving average used the current year, and four years prior to calculate an average that was then applied for the given year. For example, the years used to calculate a five-year moving average for 2015 would include 2011, 2012, 2013, 2014, and 2015. Figure 6, Figure 7, and Figure 8 show the moving average estimates of injection for the Kanapaha well, Alachua Sink, and University of Florida wells. Figure 9 shows the moving average injection flows for all wells. The results of this injection well flow estimation process relative to the single-year estimates for the NFSEG are summarized in Table 2 (Durden, et al. 2019).

Year	Injection wells reclaimed water flows in NFSEG Domain (MGD)	Hindcasting Output (MGD)	Hindcasting Five-Year Moving Average Output (MGD)
2001	16.40	15.42	15.98
2009	15.34	16.94	16.60
2010	14.18	16.44	16.35

Table 2. Comparison between estimated injection well flows in the NFSEG model, hindcasting, and five-year moving average

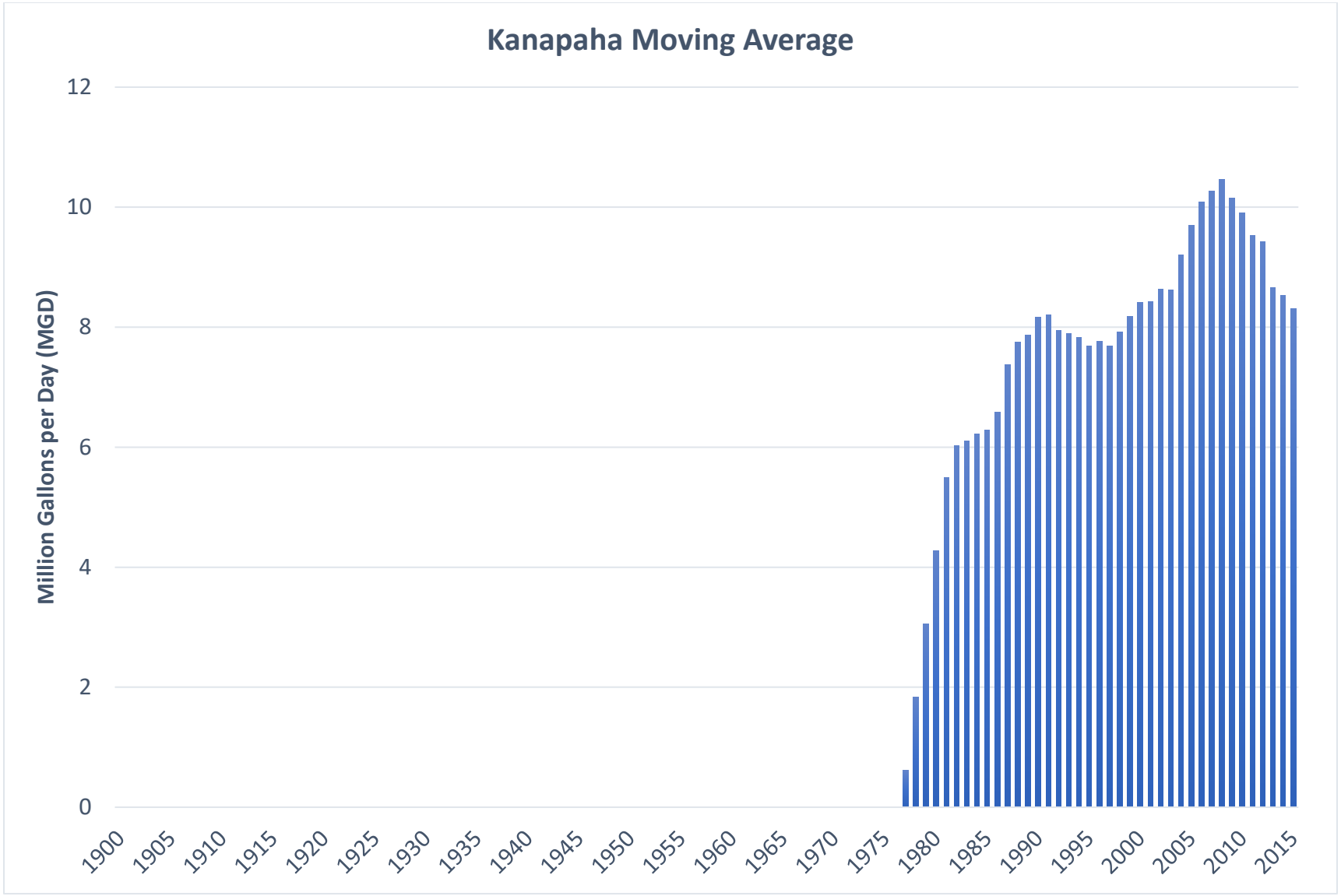

Figure 6. Moving average time series for Kanapaha injection well

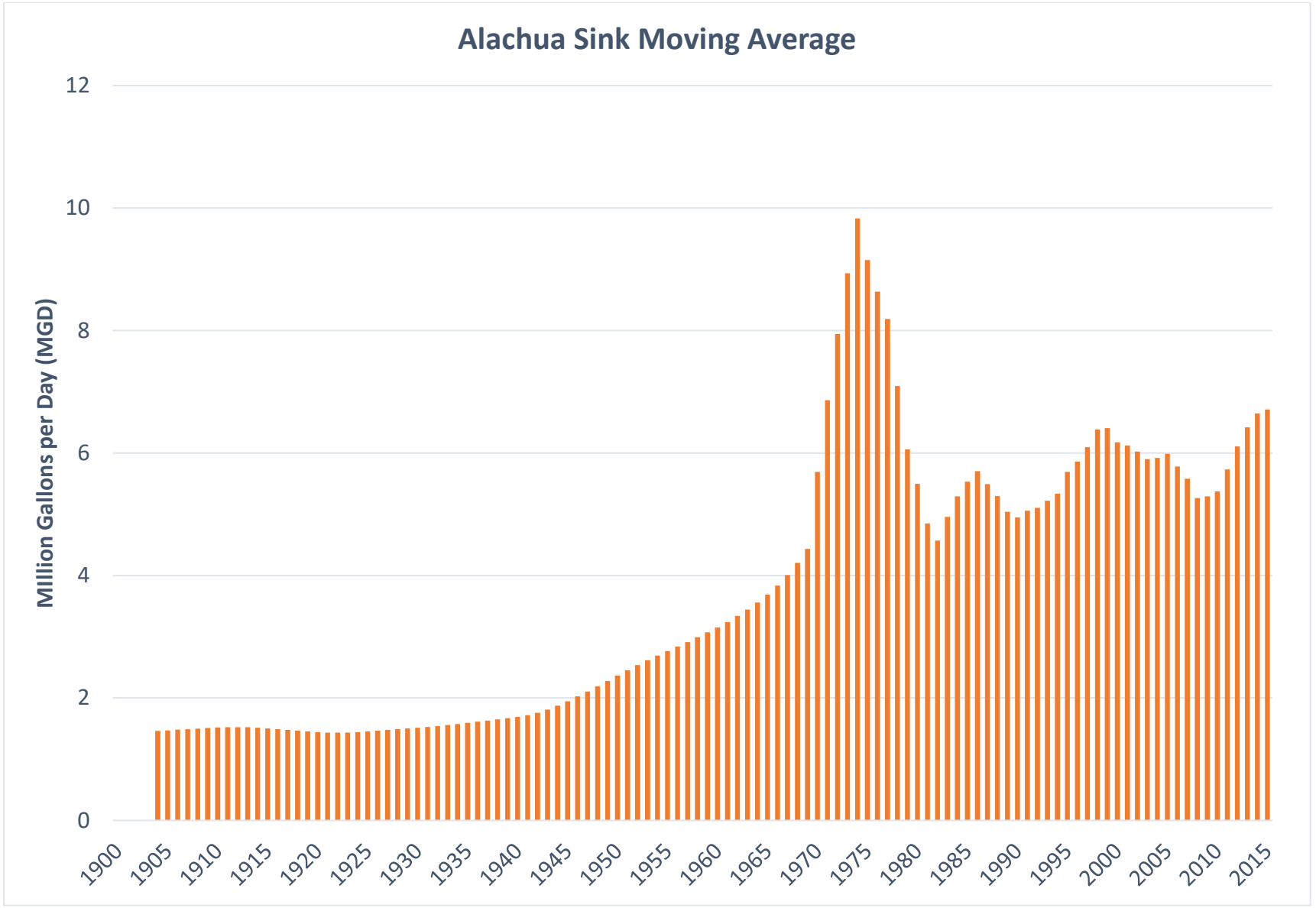

Figure 7. Moving average time series for Alachua Sink

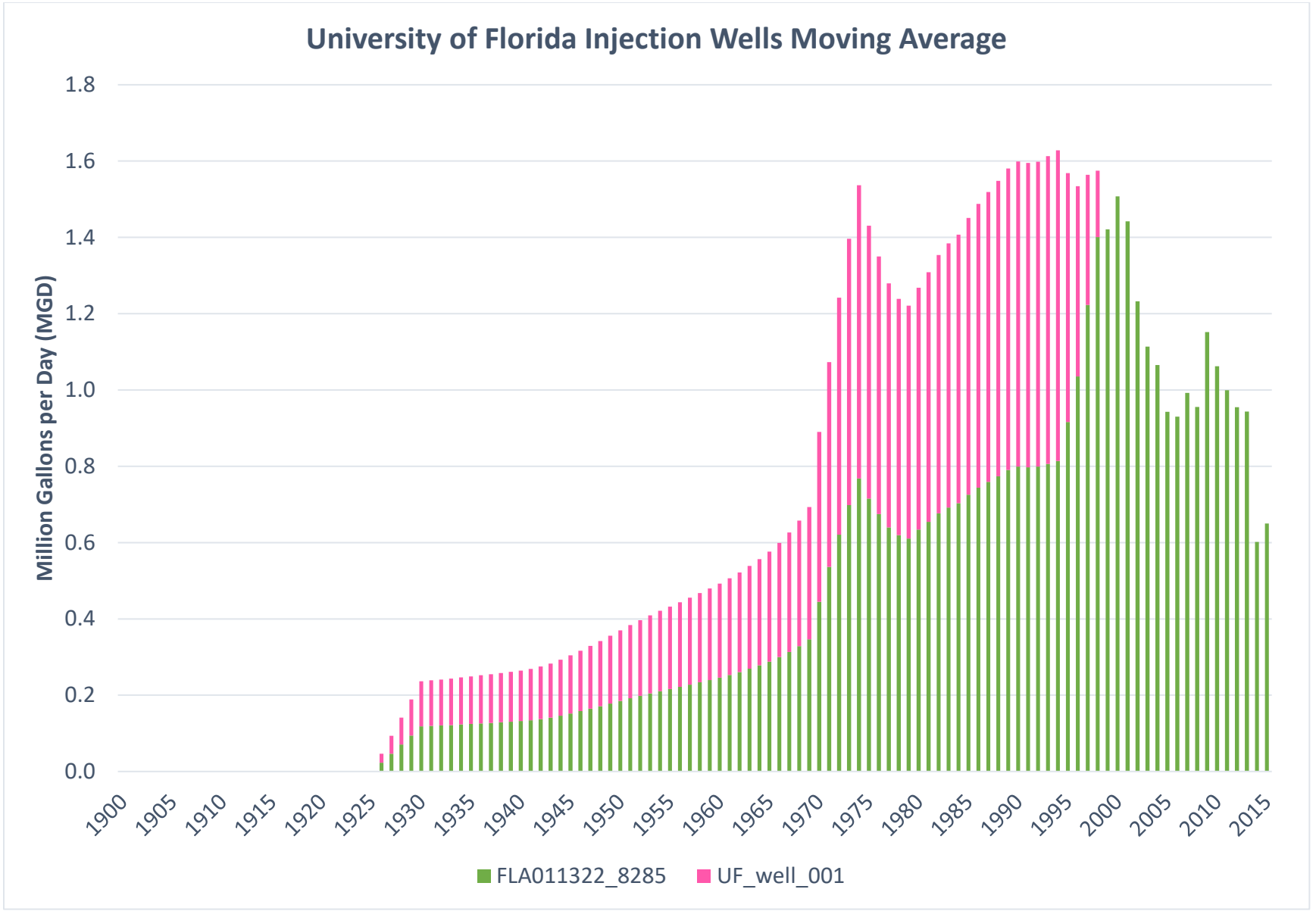

Figure 8. Moving average time series for University of Florida injection wells

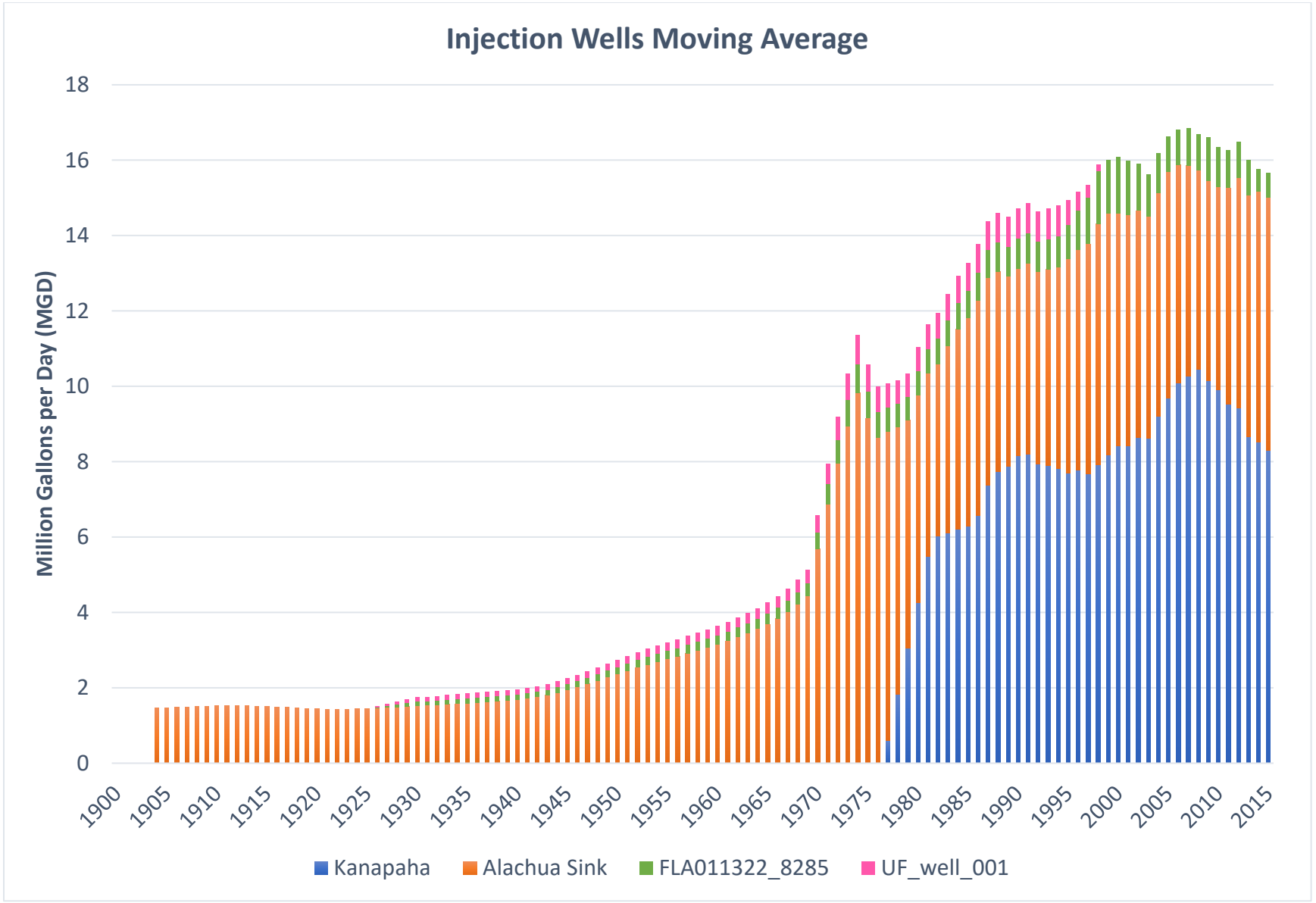

Figure 9. Moving average time series for all injection wells

References

Durden, D., F. Gordu, D. Hearn, T. Cera, T. Desmarais, L. Meridith, A. Angel, et al. 2019. "North Florida Southeast Georgia Groundwater Model (NFSEG v1.1). ." *St. Johns River Water Management District Technical Publication SJ2019-01.*

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Phelps, G.G. 1987. "Effects of Surface Runoff and Treated Wastewater Recharge on Quality of Water in the Floridan Aquifer system, Gainesville Area, Alachua County, Florida." *Water-Resources Investigations Report 87-4099.* https://doi.org/10.3133/wri874099.