Goliad County Recharge Evaluation

Summary of Field Data Collection as of June 2019

Submitted by

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Submitted to

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Monitoring Sites

Rainwater and Coldren (2018a) previously reported the details of the instrumentation choices and site positions at the Landgrebe and Dohmann properties in Goliad County. Aerial images of the locations are shown in Figures 1 and 2. Table 1 summarizes the details about the depths of the soil moisture sensor probes (P1-P5) at each of the datalogger sites (L1-L3 and D1-D3), as well as the coordinates of the datalogger sites and weather stations (WS). According to the Soil Survey Staff (2018) as shown in the Web Soil Survey, the near-surface soil conditions are dominated by sandy loam and sandy clay loams. Grab samples were collected from the auger at sites D2, D3, L2, and L3 for characterization by moisture content, soil classification by visual observation, and color classification as shown in Table 2. These analyses were done by Dr. Leo Richarte, a post-doctoral research associate affiliated with our ecohydrological work. Outside and inside terminology for some color classifications refers to the clumps of soil that formed as the rotating auger moved through the soil. Some samples were omitted from the color classification. It is apparent in Table 2 for sites D2, D3, and L2 that caliche, a form of calcium carbonate, was found to intermingle with the other sediments below about 50 in from the land surface. The final depths of those holes were limited by auger refusal when solid caliche was encountered. At site L3, no caliche was encountered, and the hole depth was limited by the total length of auger flights available on site.

Data Collection Events

As reported by Rainwater and Coldren (2018b), data collection began on 6/28/18 at the L1, L3, D1, and D2 soil moisture sensor sites and both weather stations. Probe 3 at site L1 does not provide readings due to cable damage by livestock and a subsequent failed repair attempt. The other two of the soil moisture sensor sites, L2 and D3, were started on 8/23/2018, due to operator error on 6/28/18 (improper initiation of software data collection process). Since that time, the devices have operated continuously with the exception of P5 at site L3, the lowest probe, which provided no readings from 1/10/2018 to 4/19/2019, most likely due to a loose cable connection. Inspection of the L3 P5 recorded data showed the last reading was 0.338 m^3/m^3 on 1/10/19 and the first reading on 4/19/19 was 0.334 m^3/m^3. Corresponding readings for L3 P4, the probe directly above L3 P5, were 0.399 and 0.397 m^3/m^3, respectively, with little variation from that range for the period between 1/10/19 and 4/19/19. That set of observations indicated that L3 P5 did not likely experience any significant changes in moisture content during that time period.

Table 3 provides the timing of the nine data collection visits. The TTU team is grateful for the data downloads performed by the District staff who provided the datafiles as email attachments. The most recent downloads were collected on 6/13/19. All data files were converted to Excel spreadsheets for analyses and plotting. All Excel files are available upon request, as the tables are too large for inclusion in this report. With the observation period starting on 6/28/18 and ending on 6/13/19, a total of 350 days of data have been collected and analyzed. It should be noted that the soil moisture sensors provide data on 30- or 60-min intervals, while the WSs report to their dataloggers on 30-min intervals.

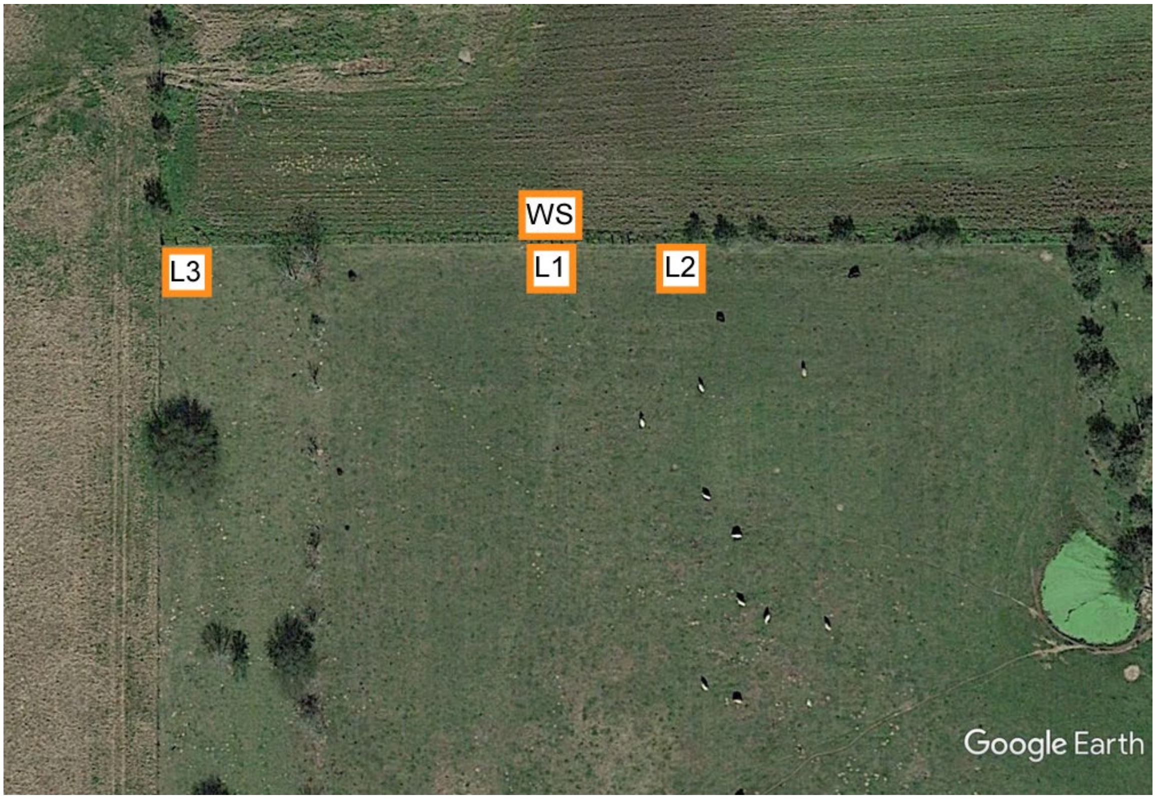

Figure 1. Approximate instrumentation sites at the Landgrebe cultivated location

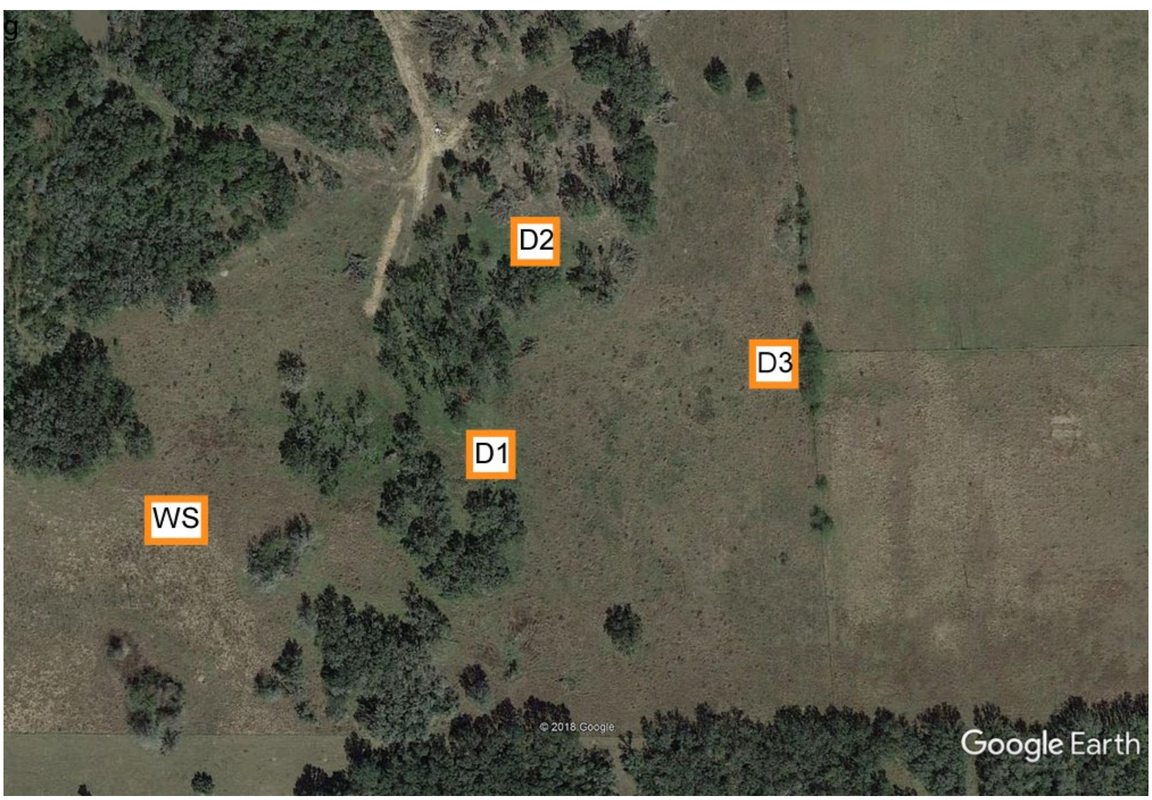

Figure 2. Approximate instrumentation sites at the Dohmann wooded location

Table 1. Installation Details

Land Use, Location	Site	Latitude (DD)	Longitude (DD)	Sensor Depths (ft)				
				P1	P2	P3	P4	P5
Cultivated, Landgrebe	L1	28.88164	-97.39657	1.0	3.3	4.9	4.9	5.9
	L2	28.88614	-97.39632	1.0	3.3	lost	4.9	5.9
	L3	28.88155	-97.39714	1.0	3.3	4.9	4.9	9.5
	WS	28.88164	-97.39657					
Ranch, Dohmann	D1	28.79439	-97.42340	1.0	3.3	4.9	4.9	8.2
	D2	28.79519	-97.42325	1.0	3.3	4.9	4.9	8.2
	D3	28.79480	-97.42204	1.0	3.3	4.9	4.9	8.2
	WS	28.79410	-97.42496					

Table 2. Characterization of Soil Grab Samples from Initial Drilling Events

Sample Site	Depth (in)	Moisture (%)	Classification (visual observation)	Color classification (wet color technique)
D2	20	10.73	Sandy clay loam	10 YR 3/2
D2	40	12.51	Clay loam	Outside 10 YR 2/1, inside 7.5 YR 4/6
D2	60	8.78	Clay loam, caliche	7.5 YR 4/6
D2	96	3.73	Clay loam, caliche	7.5 YR 7/2
D3	20	11.43	Clay loam	Outside 10 YR 2/1, inside 7.5 YR 4/4
D3	20	9.07	Clay loam	Outside 10 YR 2/1, inside 7.5 YR 4/4
D3	30	6.91	Caliche, gravel	7.5 YR 7/3
D3	47	7.15	Caliche, gravel	7.5 YR 7/3
D3	50	5.17	Caliche	
D3	70	5.26	Caliche	
L2	11	5.84	Sandy loam	10 YR 4/5
L2	25	10.28	Sandy clay loam	7.5 YR 4/6 to 5/6
L2	30	4.57	Caliche	7.5 YR 6/4
L2	37	10.69	Sandy clay	
L2	39	9.44	Clay	7.5 YR 5/6
L2	50	7.46	Caliche coated clay	7.5 YR 5/6
L2	60	3.77	Caliche coated clay	
L2	70	9.84	Caliche, clay	7.5 YR 5/6
L3	12	6.84	Sandy	10 YR 3/4
L3	34	11.03	Sandy loam	10 YR 3/4
L3	55	8.70	Clay loam	
L3	57	8.13	Sandy clay loam	
L3	114	11.15	Clay loam	7.5 YR 7/2

Table 3. Site Visit Dates

Date	Data Collectors
6/28/18	TTU
8/23/18	TTU
9/19/18	GCGCD
10/30/18	GCGCD
11/20/18	GCGCD
1/9/19	GCGCD
3/11/19	GCGCD
4/19/19	TTU
6/13/19	GCGCD

Figures 3 to 7 display the observations for the Landgrebe location, aligned vertically on a tabloid-sized page to allow visual comparison of the graphs while keeping the horizontal time axes aligned. Figure 3 is a bar chart that shows the daily values of rainfall and reference evapotranspiration (ET Ref) in in/d provided by the Landgrebe WS. ET Ref is calculated by the WS for a hypothetical reference grass as used in the Penman-Monteith approach, based on one of the most popular evapotranspiration formulas (Shuttleworth 1993). Figures 4 to 6 provide the variations in moisture content for the sensor probes at sites L1, L2, and L3, respectively. Figure 7 shows the cumulative depths of rainfall and ET Ref calculated since the readings began on 6/28/18. In similar fashion, Figures 8 to 12 show the observations for the Dohmann site. The bar chart in Figure 8 displays the daily rainfall and ET Ref values for the Dohmann WS in in/d, while Figure 12 shows cumulative values for rainfall and ET Ref depths for the observation period. Figures 9 to 11 show the moisture content values over time for the D1, D2, and D3 sites, respectively.

The daily rainfall data in Figure 3 indicated that most of the rainfall in the observation period occurred in 2018. While the total rainfall for the period was 39.98 in, ten events exceeded 1 in/d, with the six largest storms occurring in 2018. Table 4 lists the dates and rainfall depths for the Landgrebe WS for events with greater than 1 in/d. The timing of these rainfall events can be compared to responses in the soil moisture sensor values. For all three sites, P1 was most responsive, as was expected for the shallowest (1 ft) sensors. In the summer of 2018, before the 4.05-in event on 9/15/18, the moisture content was decreasing significantly at all three P1 sites, and most of the other sensors were experiencing some decreases. The large 9/15/18 event affected all of the moisture probes except for L3 P5, by far the deepest sensor. After the large event, L1 P1 and L3 P1 responded to all of the subsequent events listed in Table 4, as well as some of the smaller events. L2 P1 was much less responsive, decreasing slowly until the 4/7/19 event. Probes L2 P2 to L2 P5 were much less responsive after the 9/15/18 event and tended to decrease slowly after the large increase. It is too soon to tell whether the decreases in moisture content at the lower probes were due to extraction into the plants' root systems or downward movement, but future observations should boost confidence in data interpretation. The cumulative ET Ref value of 42.22 in was 2.24 in greater than the cumulative rainfall depth. It should be noted that this project does not quantify rainfall that is lost to surface runoff.

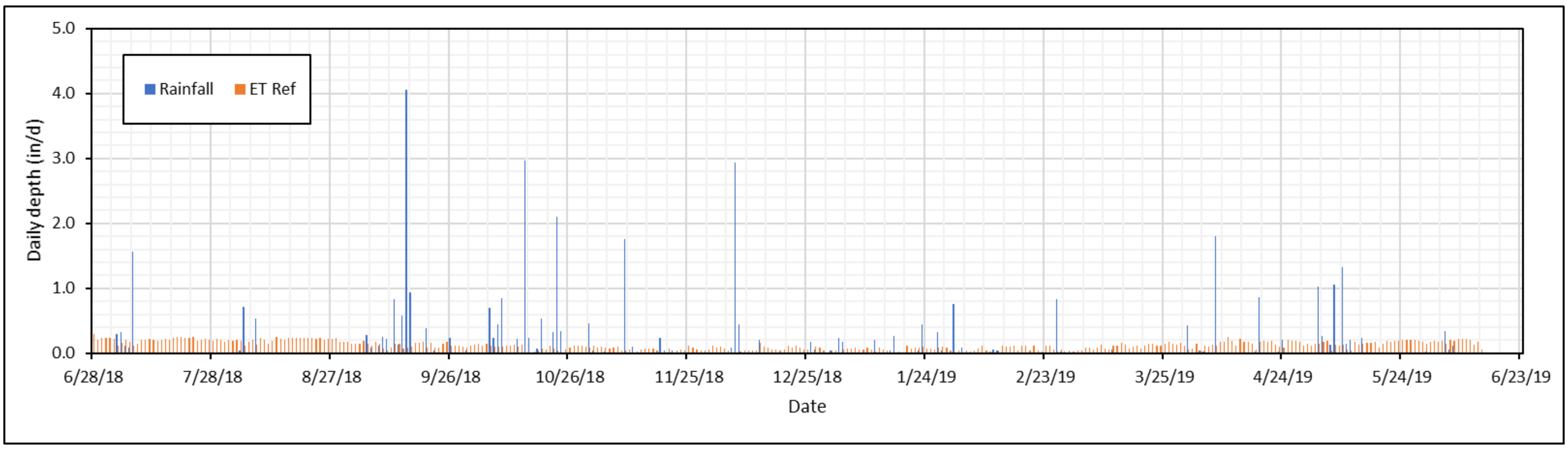

Figure 3. Landgrebe Weather Station Daily Rainfall and ET Ref, 6/28/2018 to 6/13/2019

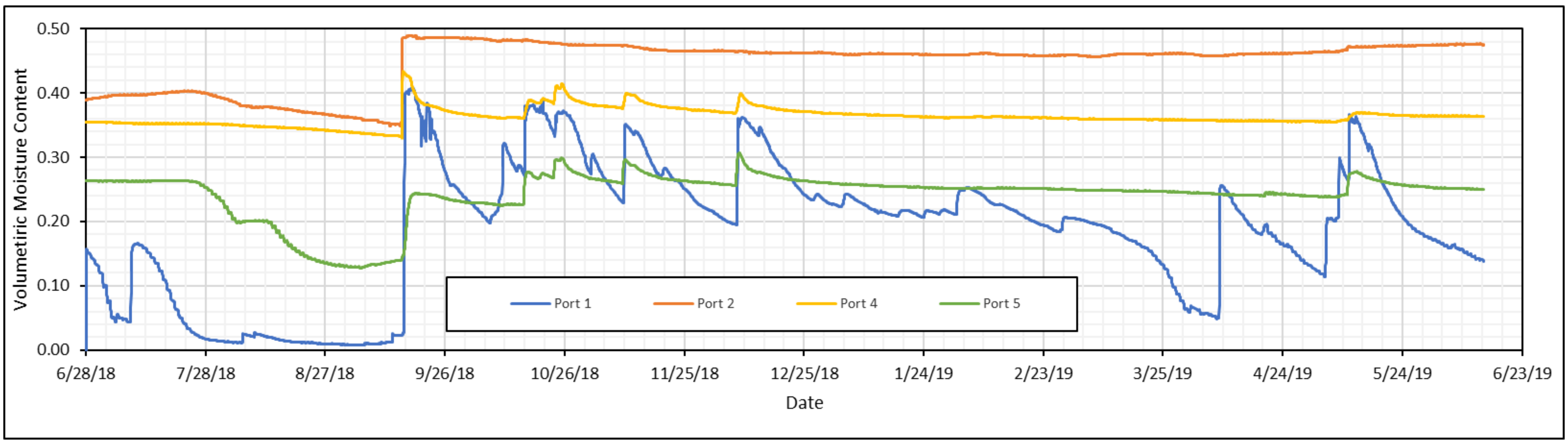

Figure 4. Landgrebe 1, 6/28/2018 to 6/13/2019

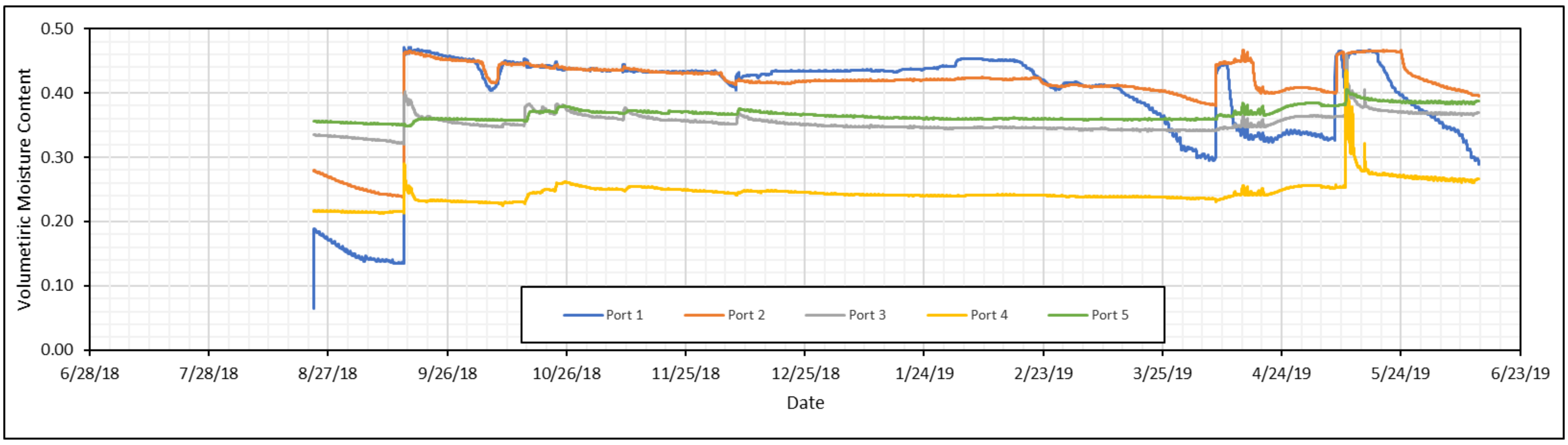

Figure 5. Landgrebe 2, 8/23/2018 to 6/13/2019

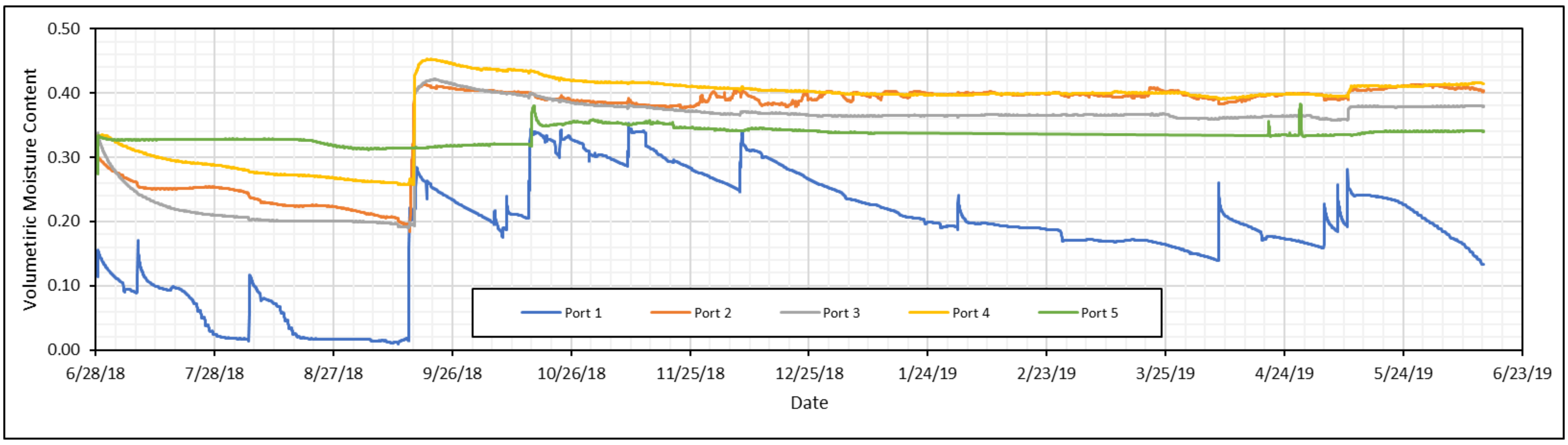

Figure 6. Landgrebe 3, 6/28/2018 to 6/13/2019

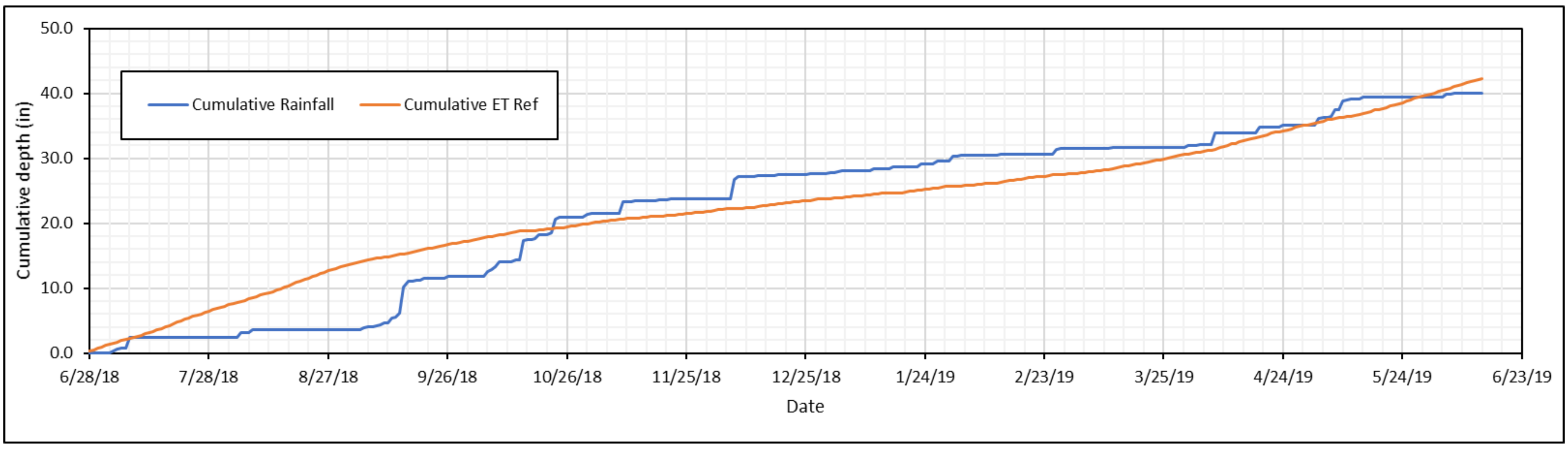

Figure 7. Landgrebe Weather Station Cumulative Rainfall and ET Ref, 6/28/2018 to 6/13/2019

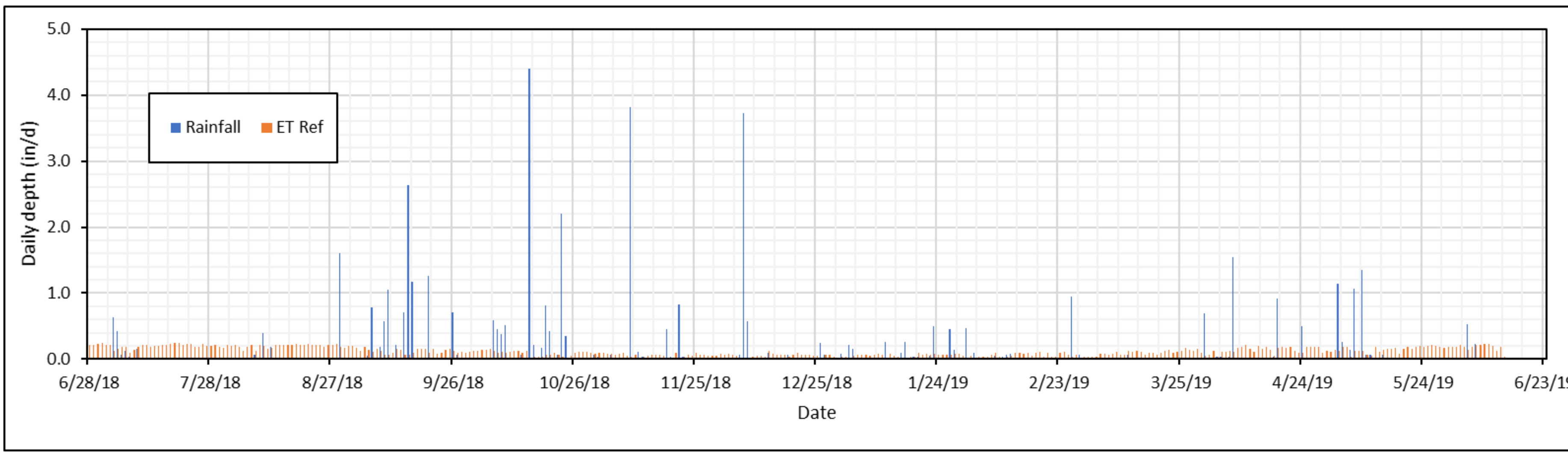

Figure 8. Dohmann Weather Station Daily Rainfall and ET Ref, 6/28/2018 to 6/13/2019

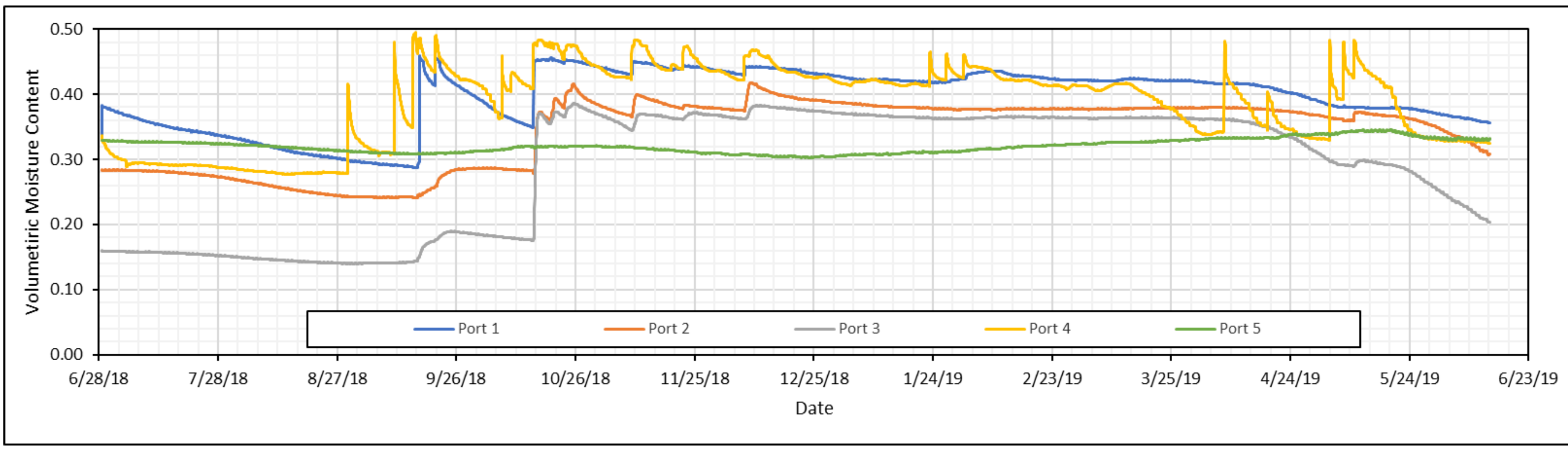

Figure 9. Dohmann 1, 6/28/2018 to 6/13/2019

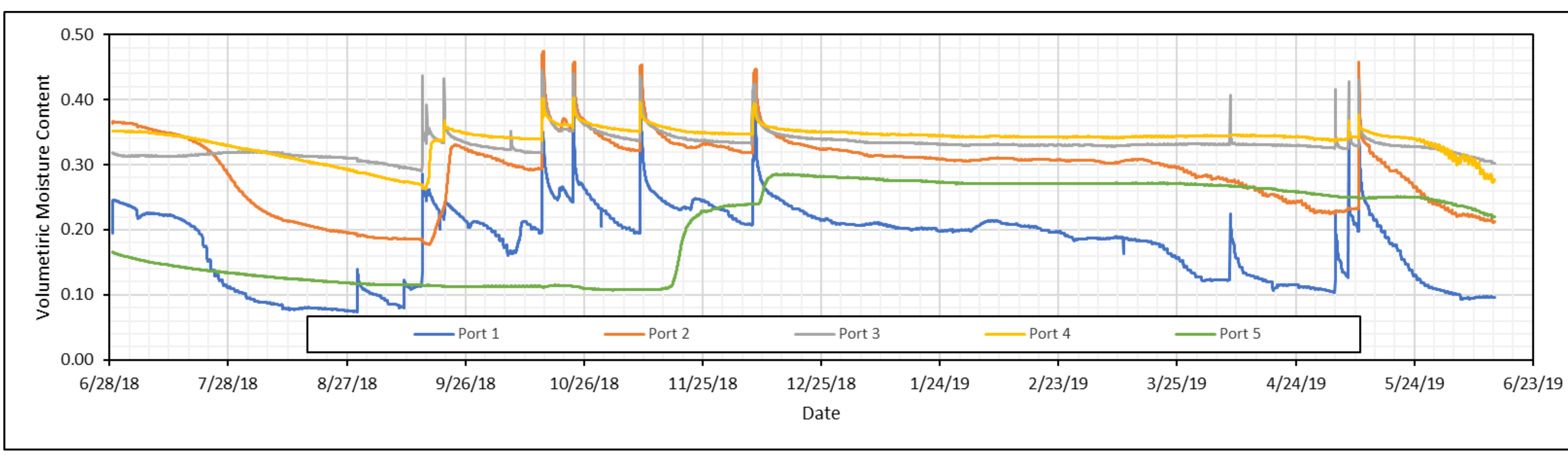

Figure 10. Dohmann 2, 6/28/2018 to 6/13/2019

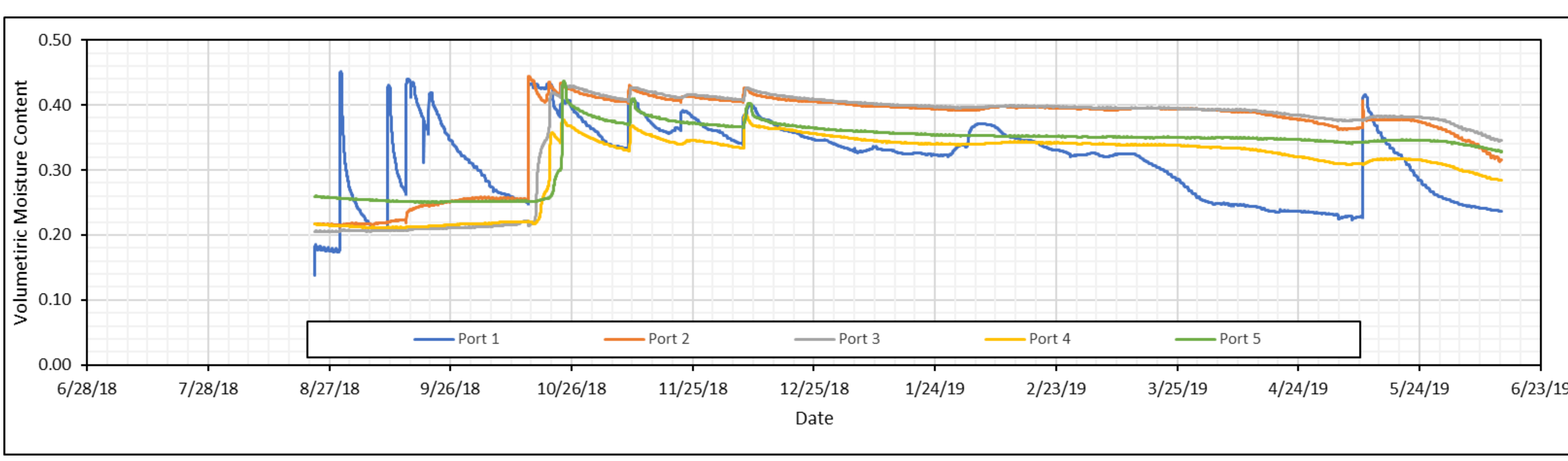

Figure 11. Dohmann 3, 8/23/2018 to 6/13/2019

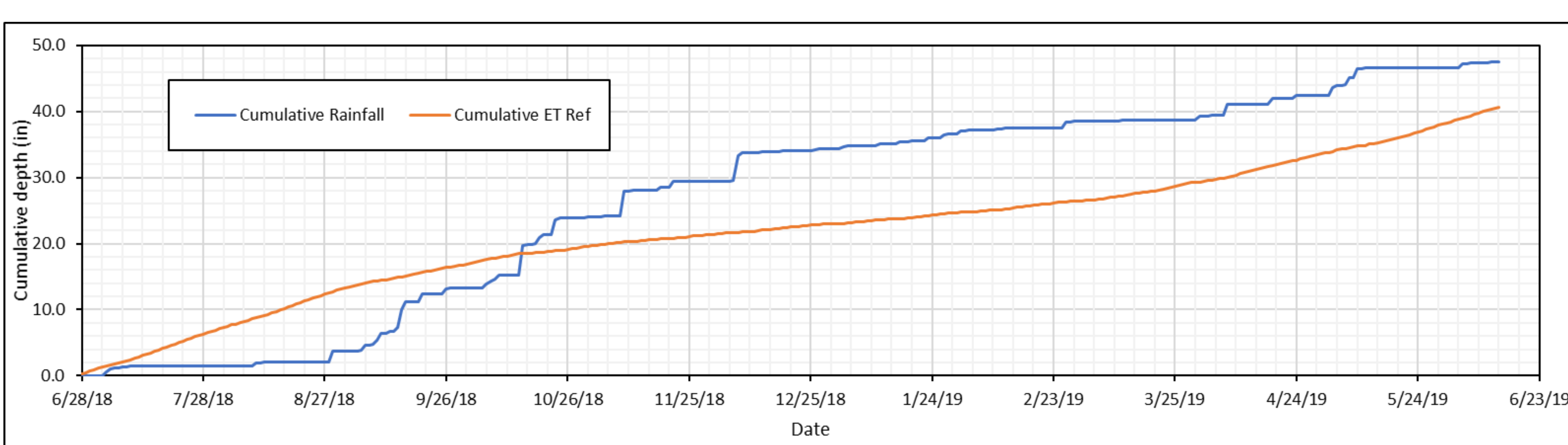

Figure 12. Dohmann Weather Station Cumulative Rainfall and ET Ref, 6/28/2018 to 6/13/2019

Table 4. Dates with Daily Rainfall of 1.0 in or Greater

Date	Rainfall (in)	
	Landgrebe WS	Dohmann WS
7/8/18	1.56	
8/29/18		1.61
9/15/18	4.05	2.63
10/15/18	2.97	4.40
10/23/18	2.10	2.20
11/9/18	1.76	3.81
12/7/18	2.94	3.73
4/7/19	1.80	1.55
5/3/19	1.03	1.14
5/7/19	1.06	1.07
5/9/19	1.33	1.35

Similar evaluation of Figure 8 for the Dohmann location indicated that most of the period's rainfall fell in 2018, and ten events with rainfall depths greater than 1 in were also noted, as shown in Table 4. The cumulative rainfall depth for the observation period was 47.43 in, over 18 percent more than the total at the Landgrebe WS. The D2 P1 and D3 P1 sensors were most responsive, while D1 P1 showed few event-related spikes after 10/15/18. P2, P3, and P4 appeared to be affected by most of the 2018 rainfall events with more than 1 in/d at all three sites, but with different magnitudes of moisture content change. D1 P5 showed little change in moisture content for the entire period. D2 P5 decreased slowly from the beginning of the observation period, then increased in November and December out of sync with the rainfall events, perhaps indicating some downward migration from above. D3 P5's moisture content increased first after the 10/15/18 4.4-in event, then showed small responses after the 11/9/18 3.81-in and 12/7/18 3.73-in events. As with the Landgrebe site, continued future observations are needed to better understand the competition between plant use and downward migration of water. The cumulative ET Ref value was 40.58 in for the Dohmann WS site.

Next Steps

The TTU team is hopeful to continue this monitoring and reporting work with the GCGCD staff into the future, with occasional site visits by the TTU for maintenance of the instrumentation. In the coming year, the TTU team hopes to characterize the vegetation types at both sites for assignment of appropriate ET crop coefficients to refine the estimates of soil water lost to ET at the sites. The TTU team is also available to discuss installation of one or more additional field observation locations, or other pertinent topics.

References

Shuttleworth, W., 1993. Chapter 4, Evaporation, in Handbook of Hydrology (D. Maidment ed.), McGraw-Hill, Inc., pp. 4.13-4.15.

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