Goliad County Recharge Evaluation

Summary of Field Data Collection for August 2020

Submitted by

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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. A third location was established at the Fuller property in January 2020 as reported by Rainwater and Coldren (2020). Aerial images (Google Earth) of the locations are shown in Figures 1, 2, and 3, respectively. Table 1 summarizes the details about the depths of the soil moisture sensor probes (P1-P5) at each of the datalogger sites (L1-L3, D1-D3, and F1-F3), as well as the coordinates of the datalogger sites and weather stations (WS). Local soil conditions were presented in the previous reports.

Data Collection

As reported by Rainwater and Coldren (2018b, 2019), data collection began in late June 2018 at the Landgrebe and Dohmann locations, and later at the Fuller location in January 2020. Table 2 provides the timing of the seven data collection visits since the previous data summary. The TTU team is grateful for the data downloads and maintenance performed by the District staff who provided the datafiles as email attachments or as datafile transfers. The most recent downloads were collected on 8/21/2020. 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. The data presented in this report were collected from 6/28/19 to 8/21/20. 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.

Most of the soil moisture sensors have performed well continuously, but there have been some instrument problems. P3 at site L1 does not provide readings due to cable damage by livestock and a subsequent failed repair attempt. P5 at site L3, the lowest probe, 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. The datalogger batteries failed at L2 on 12/9/2019 and were replaced on 1/14/2020. The weather station showed very little rain during those five weeks, and the soil moisture readings were relatively unchanged. Unfortunately, P2 at L2 did not show any more readings after that period, but P3 is at the same depth and continues to work. At Dohmann site D2, P5 provided reasonable readings until 10/2/2019 and then shut down. P2 at D2 failed on 2/4/2020, and P4 at D2 failed on 6/12/2020. These failures leave only P1 and P3 recording at D2. When the Fuller installation was completed on 1/10-12/2020, all 15 soil moisture sensors were providing reasonable readings. Unfortunately, P2 at F2 stopped working the next day and remains inactive. P5 at F2 missed some days in January due to a loose connection at the datalogger, but that sensor was reconnected and remains in service since 1/31/2020. As of the date of this report, 39 of the 45 installed soil moisture sensors were still working.

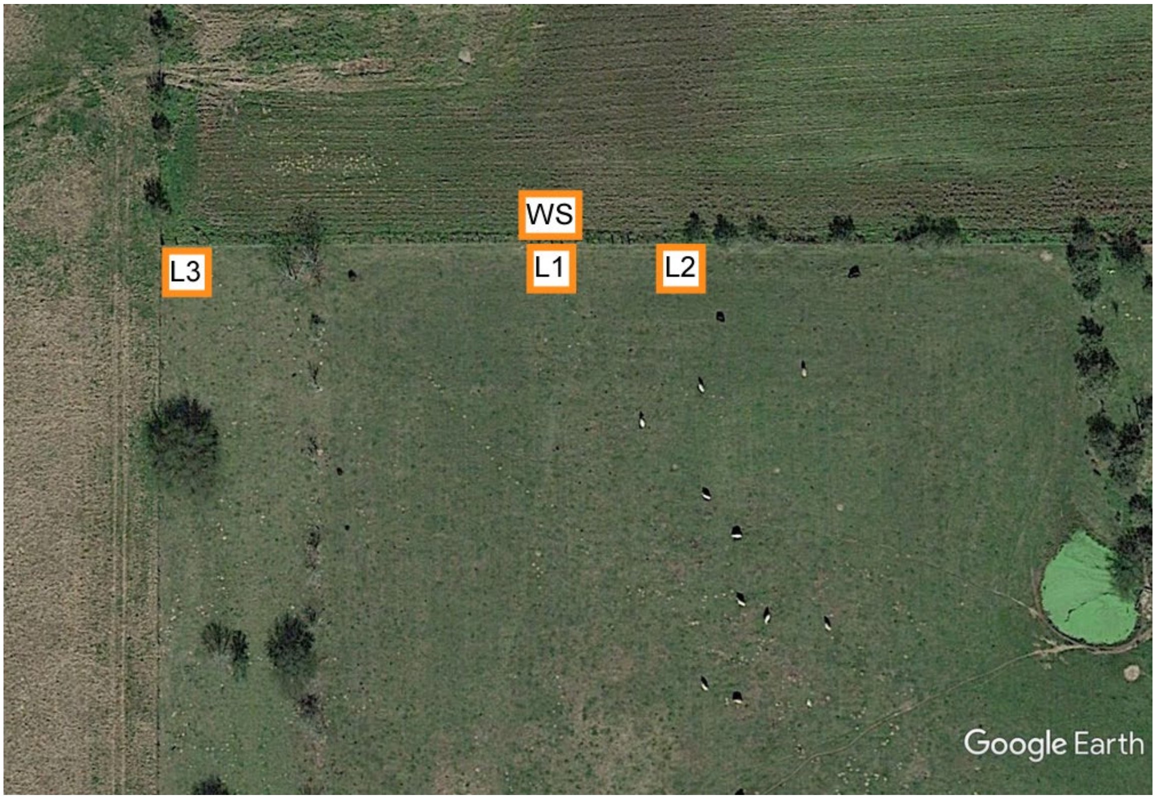

Figure 1. Approximate instrumentation sites at the Landgrebe cultivated location

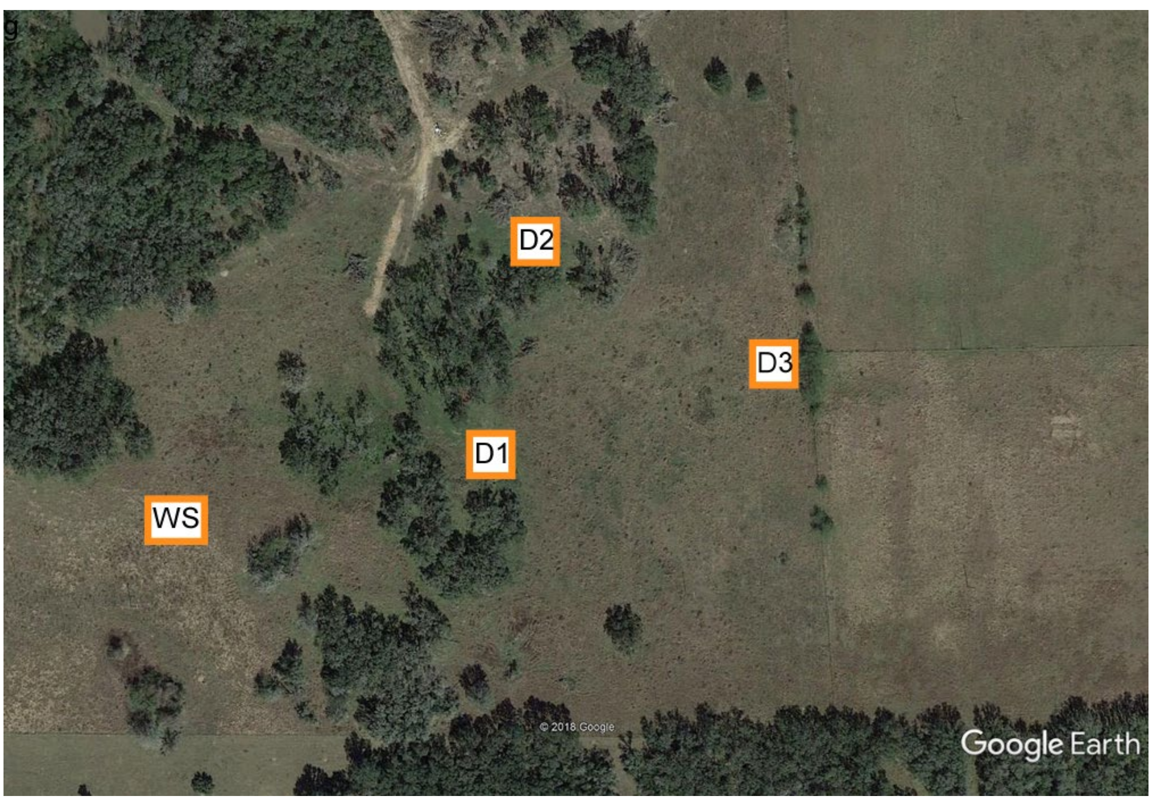

Figure 2. Approximate instrumentation sites at the Dohmann wooded location

Figure 3. Approximate instrumentation sites at the Fuller 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					
Ranch, Fuller	F1	28.6536039	-97.6195353	1.0	3.3	4.9	4.9	9.0
	F2	28.6537386	-97.6194403	1.0	lost	4.9	4.9	9.0
	F3	28.653917	-97.6194149	1.0	3.3	4.9	4.9	9.0
	WS	28.654	-97.619					

Table 2. Site Visit Dates

Date	Data Collectors
8/20/2019	GCGCD
10/2/2019	GCGCD
12/9/2019	GCGCD
1/30/2020	TTU (Fuller online)
3/24/2020	GCGCD
5/19/2020	TTU/GCGCD
8/21/2020	GCGCD

As noted in the previous reports, the WS at each site has instruments for rainfall (RF), wind speed, temperature, humidity, and solar radiation. The last four observations allow calculation of evapotranspiration for a reference grass (ET ref). The SpecWare Pro software presents the daily RF and ET ref values. During the past year, we had problems with the anemometers at both the Landgrebe and Dohmann properties. The anemometers were not rotating freely due to increased resistance on their shafts. The Landgrebe problem was noted first, so the TTU team replaced the Landgrebe anemometer on 5/19/20, but the Dohmann WS problem was first noted on that same date. The GCGCD staff attempted to repair the Dohmann anemometer by carefully cleaning the shaft, but the repair did not last long, so that anemometer will have to be replaced also. That repair should happen soon, and the GCGCD staff can take care of that task. The TTU team reviewed the wind speed data from all three WSs [1] to identify when the wind speeds diminished incorrectly and [2] to select replacement wind speed and ET ref data from one of the other sites. The Landgrebe data were replaced by the Dohmann site data from 12/1/2019 to 3/31/2020 and by the Fuller site data from 4/1/2020 to 5/19/2020. The Dohmann data were replaced by the Fuller site data from 4/14/2020 to 8/21/2020 for this report, and this adjustment must continue until the Dohmann anemometer is replaced. This replacement of missing data is the best we can do, but it should be noted that the ET ref values will likely be more similar, but not identical, from site to site, while the RF values will likely be more variable.

Results and Observations

With the start of data collection at the first two sites on 6/28/18, it was reasonable to see Year 1 of the dataset stretching from that date to 6/27/2019, Year 2 from 6/28/2019 to 6/27/2020, and Year 3 from 6/28/2020 to 6/27/2021. Data collection at the Fuller site began on 1/10/2020, starting almost six months into Year 2 and continuing into Year 3. Table 3 summarizes the twelve-month RF and ET ref values for the three sites and the three years. It is notable that the Year 1 RF totals of 48.92 in and 41.39 in at the Dohmann and Landgrebe sites, respectively, were well above the average annual RF of 36 to 37 in for Goliad. The Year 2 RF totals of 23.52 in and 27.77 in at the Dohmann and Landgrebe sites, respectively, were well below the Goliad annual average. The ET ref values for these two sites are a little higher for Year 2 than Year 1. The Fuller site RF and ET ref values in Year 2 were much smaller than the other two sites because of the shorter observation time. For the first two months of Year 3, the Landgrebe site received more rain than the other two sites, while the ET ref values were similar.

Table 3. Yearly Rainfall and ET ref

	6/28/18-6/27/19		6/28/19-6/27/20		6/28/20-8/21/2020	
Location	RF (in)	ET ref (in)	RF (in)	ET ref (in)	RF (in)	ET ref (in)
Dohmann	48.92	43.41	23.52	50.45	1.96	12.52
Landgrebe	41.39	45.52	27.77	49.13	3.59	11.01
Fuller	na	na	17.70	38.00	1.75	12.77

During Year 1, the rainfall events with 1.0 in or more were correlated with increases in soil moisture, but that year was much wetter than average at the two monitoring locations. Year 2 was much drier, and fewer days had 1.0 in or more of rain, as shown in Table 4. In addition, the largest daily RF amounts were much smaller than those seen in Year 1. The lower RF amounts led to drier soils, and much less response was noted in the soil moisture data. The RF, ET ref, and soil moisture data are presented for Years 2 and 3 for the Landgrebe and Dohmann locations in graphical form. As the observations began at the Fuller site in January 2020, the RF, ET ref, and soil moisture data are presented for the calendar year 2020.

Table 4. Dates with Daily Rainfall of 1.0 in or Greater in Year 2 and 3

	Rainfall (in)		
Date	Dohmann WS	Landgrebe WS	Fuller WS
10/16/2019	2.09	1.91	
10/29/2019	1.16		
10/30/2019	1.11		
1/22/2020	1.24	1.11	1.01
4/9/2020			1.23
5/12/2020		1.44	1.12
5/16/2020			1.17
5/24/2020		1.25	1.06
5/26/2020			1.17
6/26/2020			1.67

Figures 4 to 8 display the Year 2 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 4 is a bar chart that shows the daily values of RF and ET ref in in/d provided by the Landgrebe WS data. ET ref is calculated for a hypothetical reference grass as used in the Penman-Monteith approach, based on one of the most popular evapotranspiration formulas (Shuttleworth 1993). Figures 5 to 7 provide the variations in moisture content for the sensor probes at sites L1, L2, and L3, respectively. While the soil moisture data show decreased in the summer months, responses to the fall and spring rainfall events were noted in the upper sensors. The three lower sensors at all three sites changed little over the entire year, so it appeared that no water reached below the third depth of 4.9 ft.

Figure 8 shows the cumulative depths of rainfall and ET ref. Coupled with the large deficit between ET ref and RF, this dataset indicates that both evaporation from the soil and transpiration through the plants were drying the upper soils so that the water could not migrate below.

Figures 9 to 13 provide the Year 3 data for the Landgrebe location in the same progression. The two summer months were dry with only one daily RF value above 1.0 in followed by some smaller showers. The shallowest sensor showed drying between rains and increases following the events while the lower sensors showed declines or no change, indicating little to no further infiltration. Cumulative ET ref exceeded cumulative RF as expected.

Figures 14 to 18 summarize the Year 2 data for the Dohmann location. For the D2 and D3 sites, the shallower soil moisture sensors were most responsive to the rain events, while the two lower sensors showed little to no change. P4 at the D1 site sometimes responded to the rain events as much or more that the shallowest P1 during both years, so it may be possible that some short-circuiting may be occurring at that hole. Otherwise, the other lower sensors were stable or decreasing, again indicating little to no migration from above.

The Year 3 data for the Dohmann location is shown in Figures 19 to 23. With little rainfall, the soil moisture sensors at D1 and D3 changes little in the two summer months. The D2 site only has two remaining active sensors, and the shallower sensor showed temporary increases followed by drying, while the lower sensor was stable.

Figures 24 to 28 display the calendar year 2020 data for the Fuller location. As shown in Table 4 and Figure 24, the Fuller location received more RF than the other two locations. At the F1 site, the three upper soil moisture sensors responded to most of the larger events, but the two lower sensors showed little change. At the F2 site, only the shallowest sensor responded to the rain events, and the other three lower sensors were stable or declining. The F3 site sensors showed no responses to the rain events. As seen for the other sites, these data coupled with the large deficit between ET ref and RF indicated that no water was migrating through these sites during this dry year.

<u>Next Steps</u>

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. Also, during the May 2020 visit by the TTU team, Dr. Terry McLendon began 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. Those findings will be presented in the next fiscal year. 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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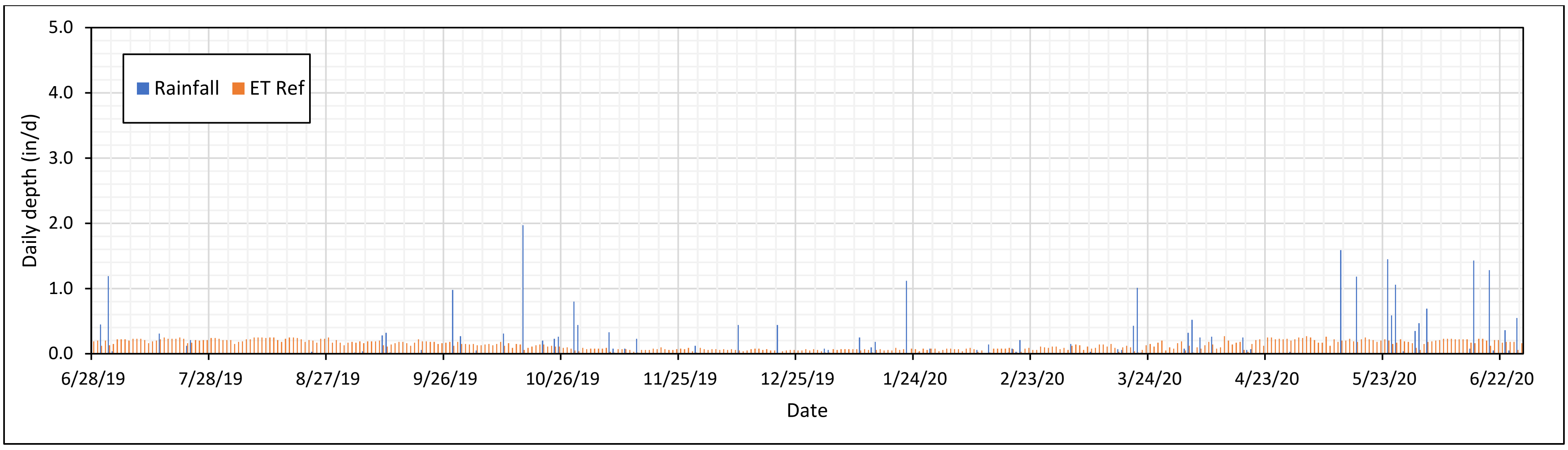

Figure 4. Landgrebe daily rainfall and ET ref June 28, 2019 to June 27, 2020

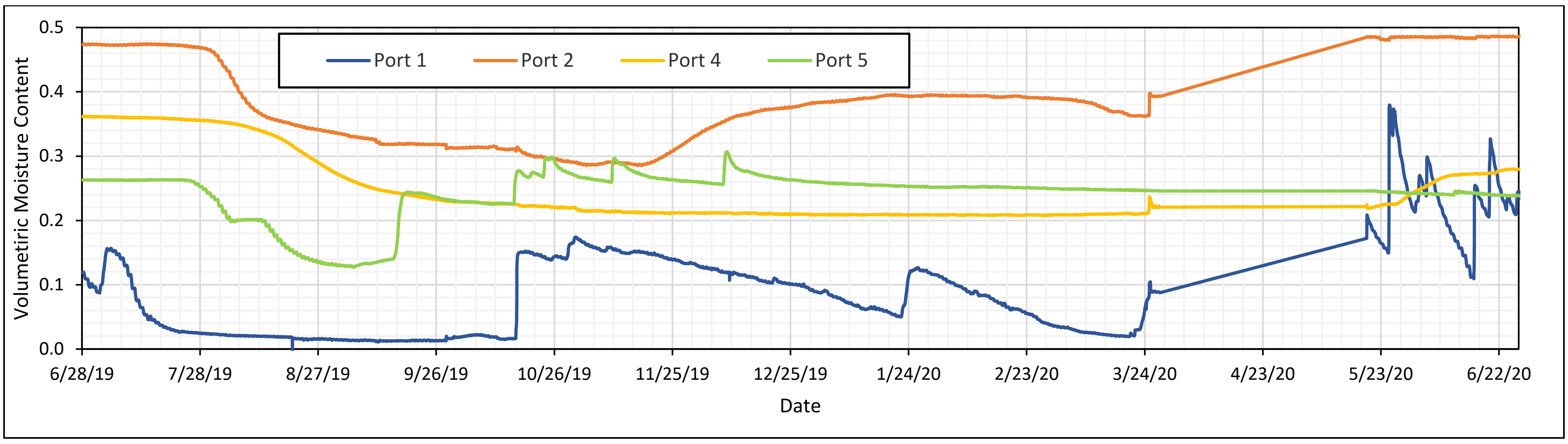

Figure 5. Landgrebe L1 soil moisture probes June 28, 2019 to June 27, 2020

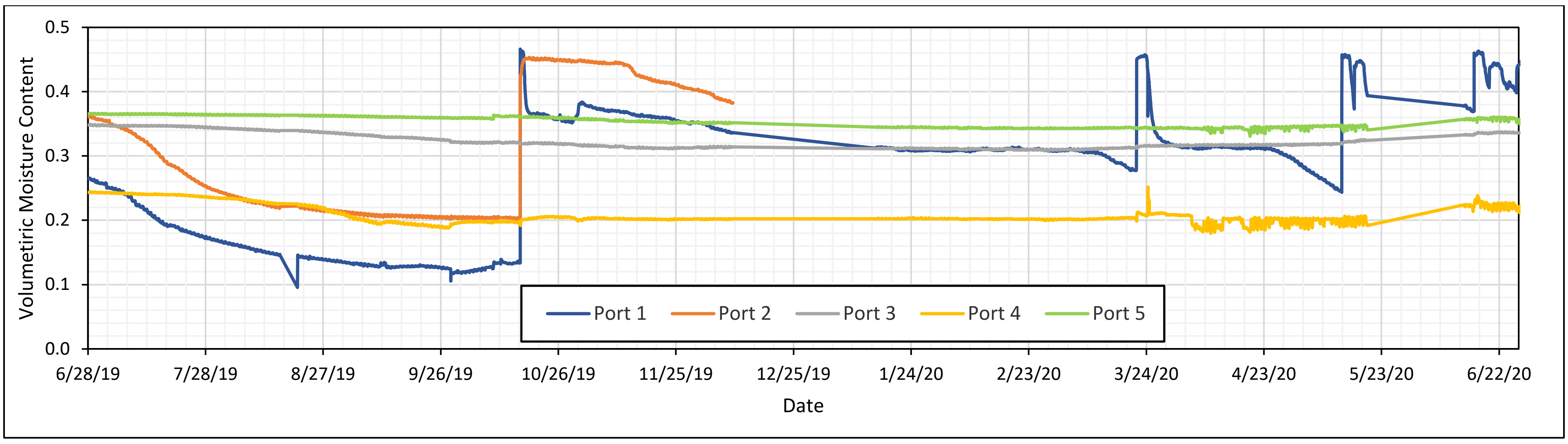

Figure 6. Landgrebe L2 soil moisture probes June 28, 2019 to June 27, 2020

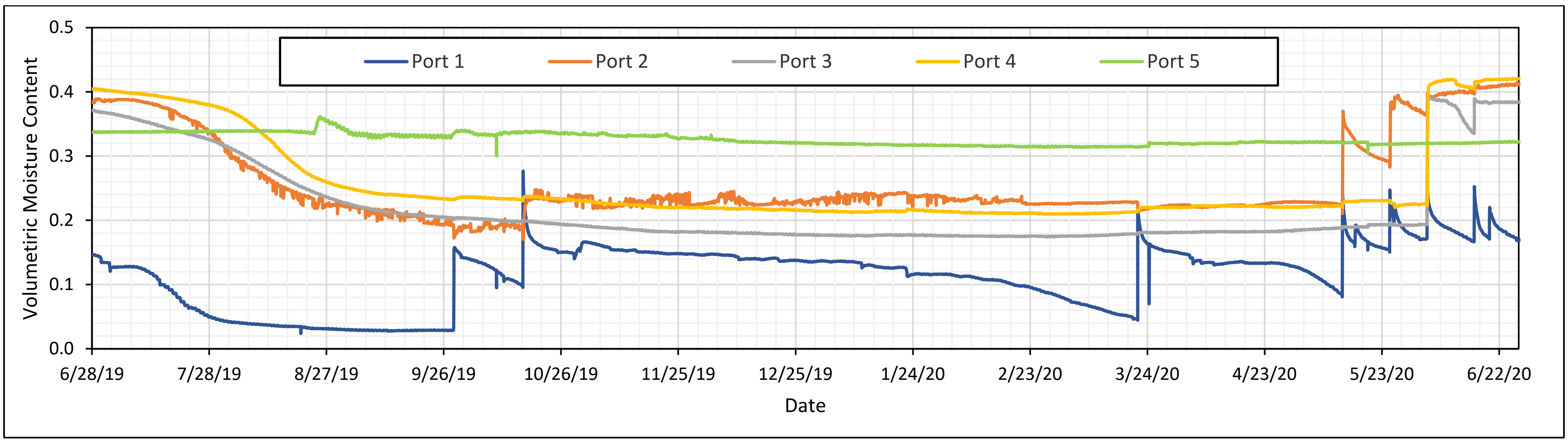

Figure 7. Landgrebe L3 soil moisture probes June 28, 2019 to June 27, 2020

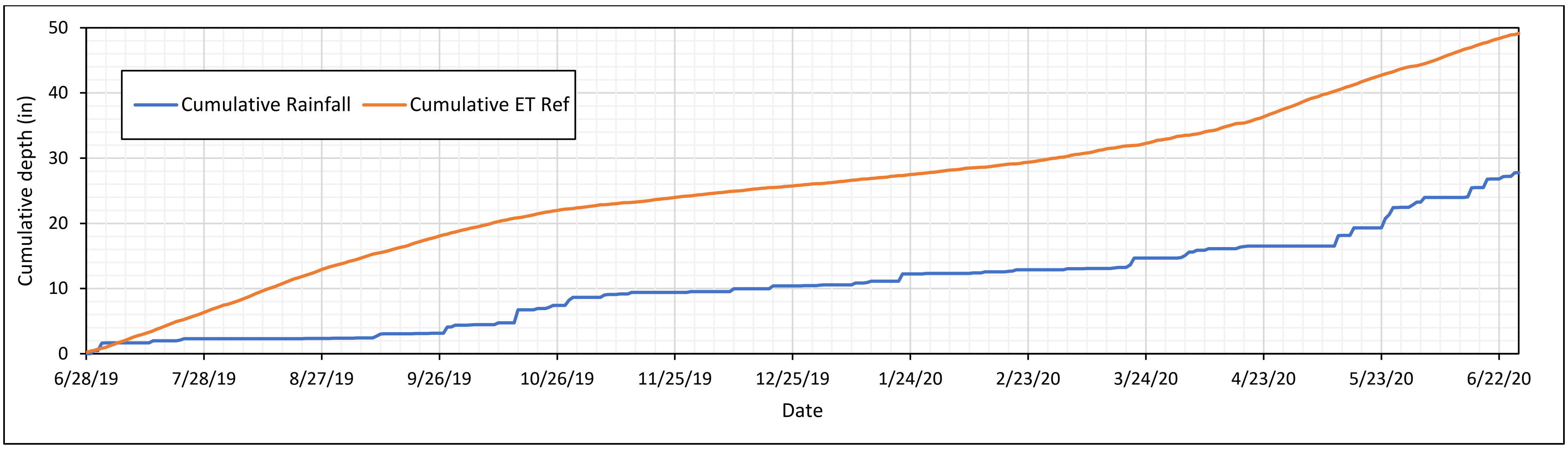

Figure 8. Landgrebe cumulative rainfall and ET ref June 28, 2019 to June 27, 2020

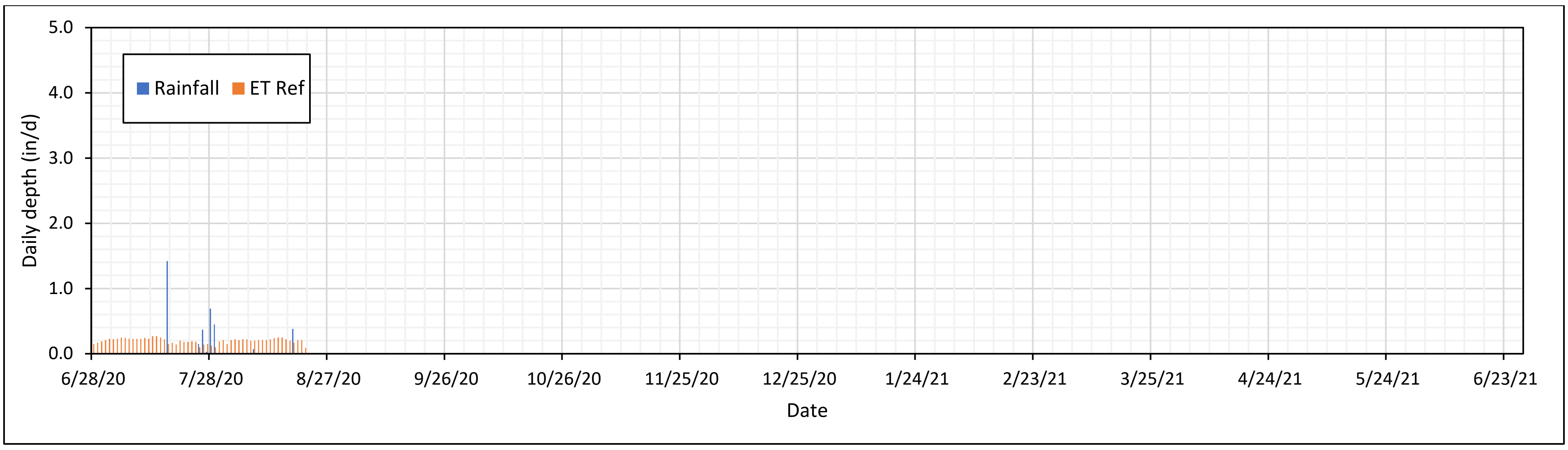

Figure 9. Landgrebe daily rainfall and ET ref June 28, 2020 to June 27, 2021

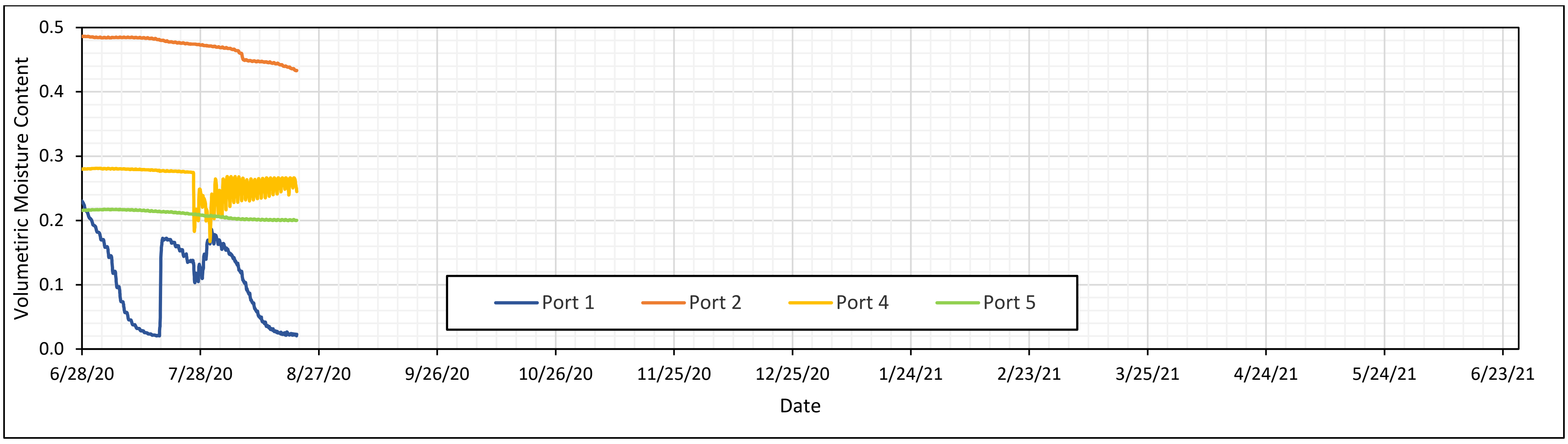

Figure 10. Landgrebe L1 soil moisture probes June 28, 2020 to June 27, 2021

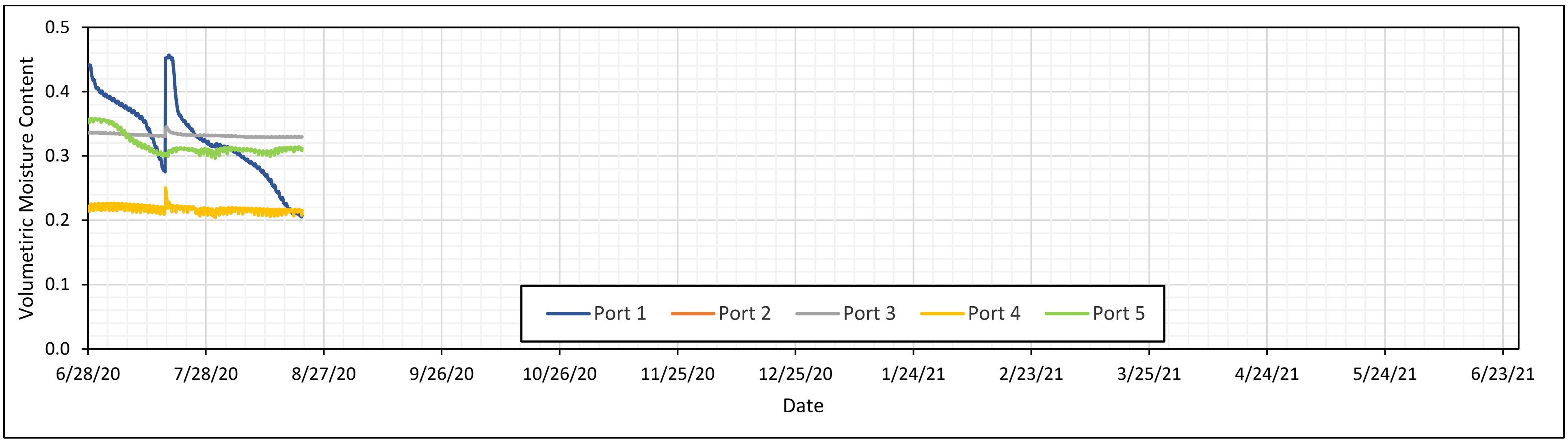

Figure 11. Landgrebe L2 soil moisture probes June 28, 2020 to June 27, 2021

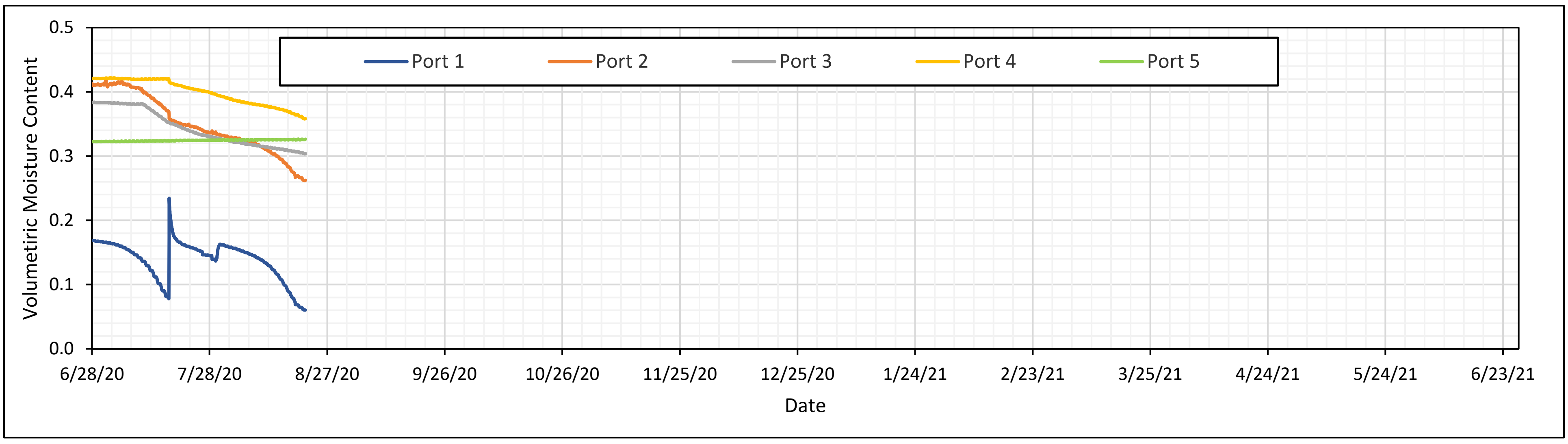

Figure 12. Landgrebe L3 soil moisture probes June 28, 2020 to June 27, 2021

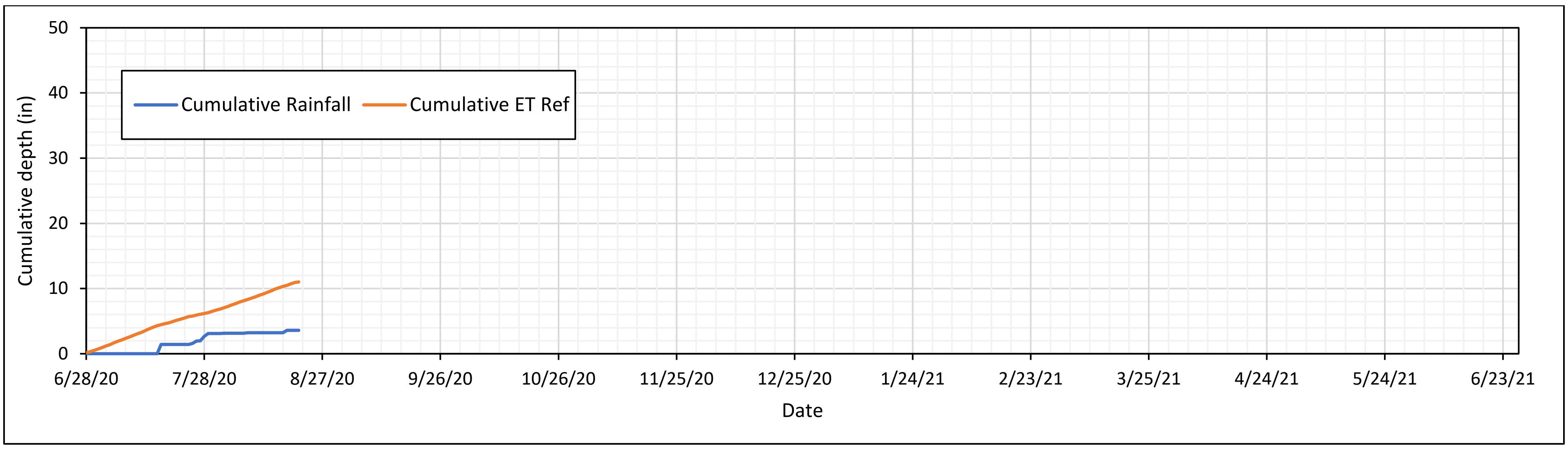

Figure 13. Landgrebe cumulative rainfall and ET ref June 28, 2020 to June 27, 2021

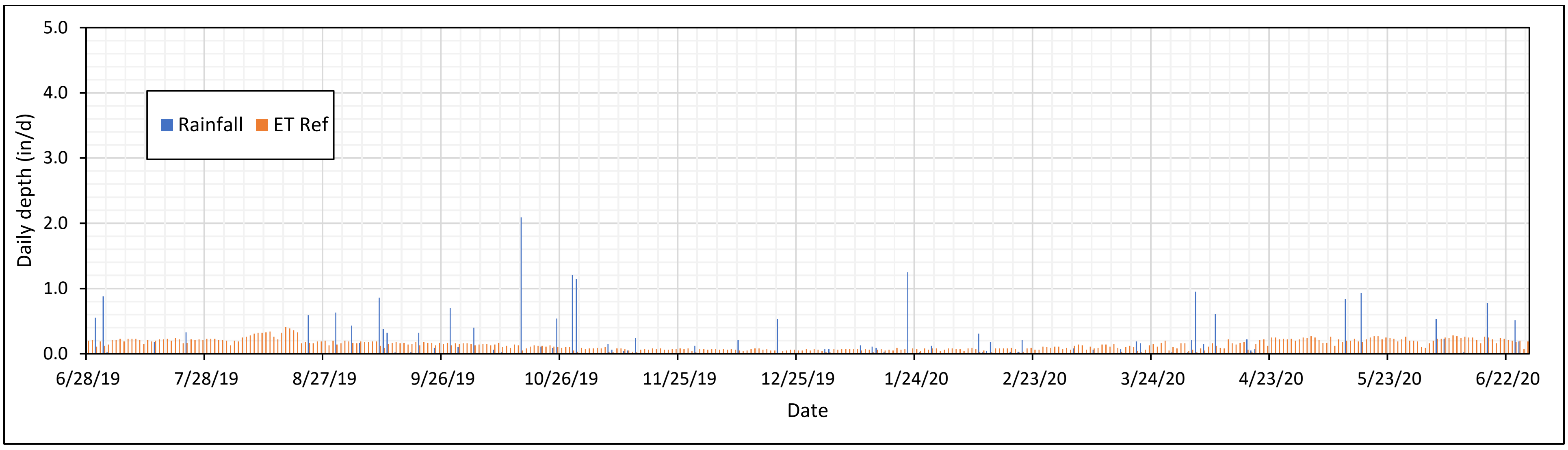

Figure 14. Dohmann daily rainfall and ET ref June 28, 2019 to June 27, 2020

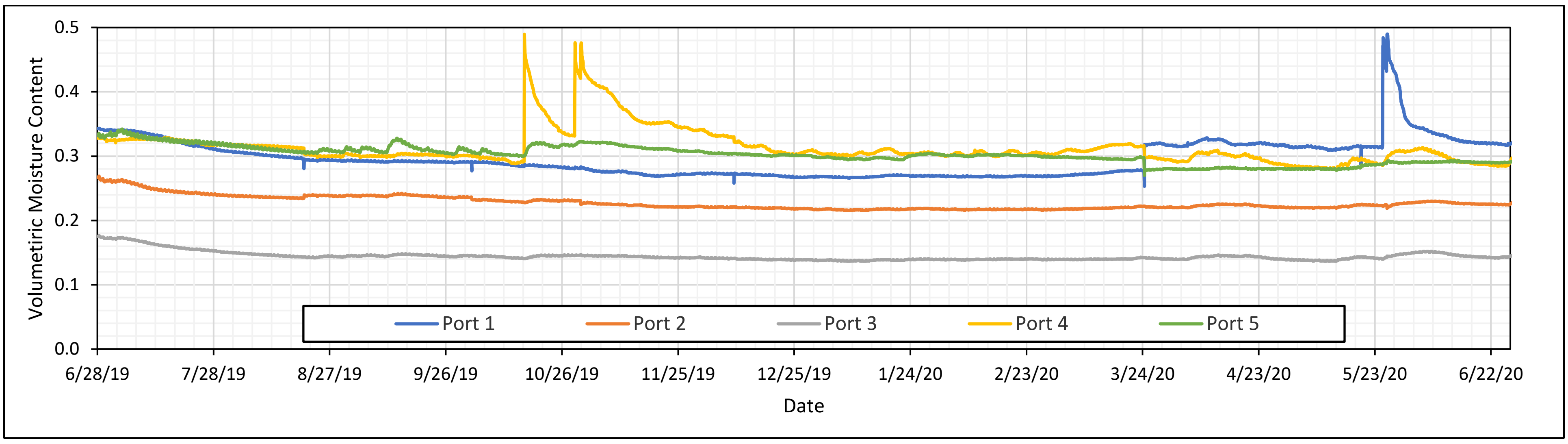

Figure 15. Dohmann D1 soil moisture probes June 28, 2019 to June 27, 2020

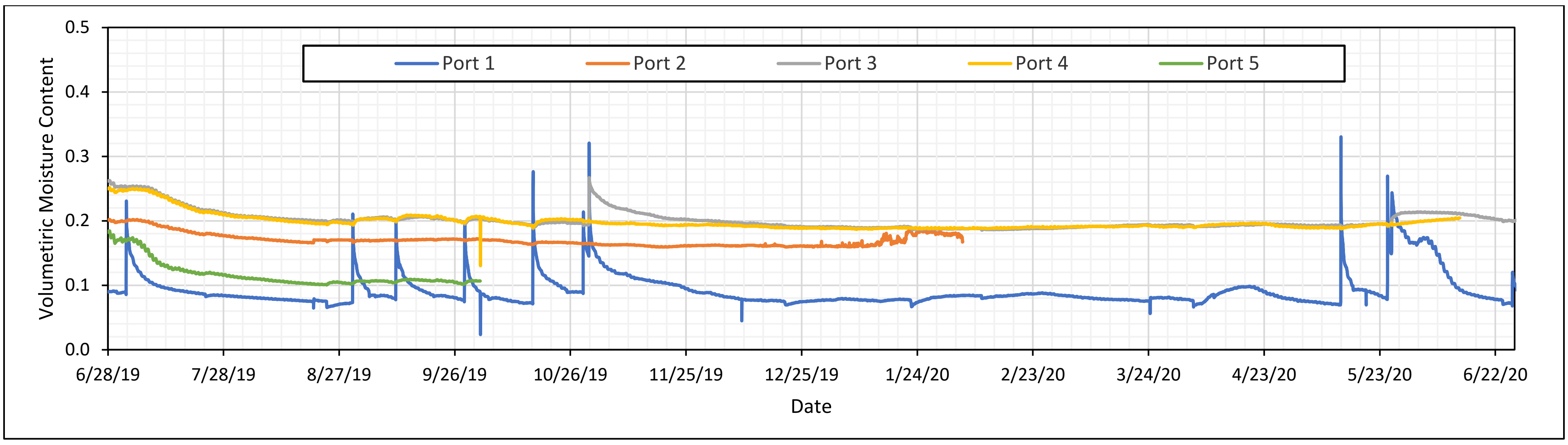

Figure 16. Dohmann D2 soil moisture probes June 28, 2019 to June 27, 2020

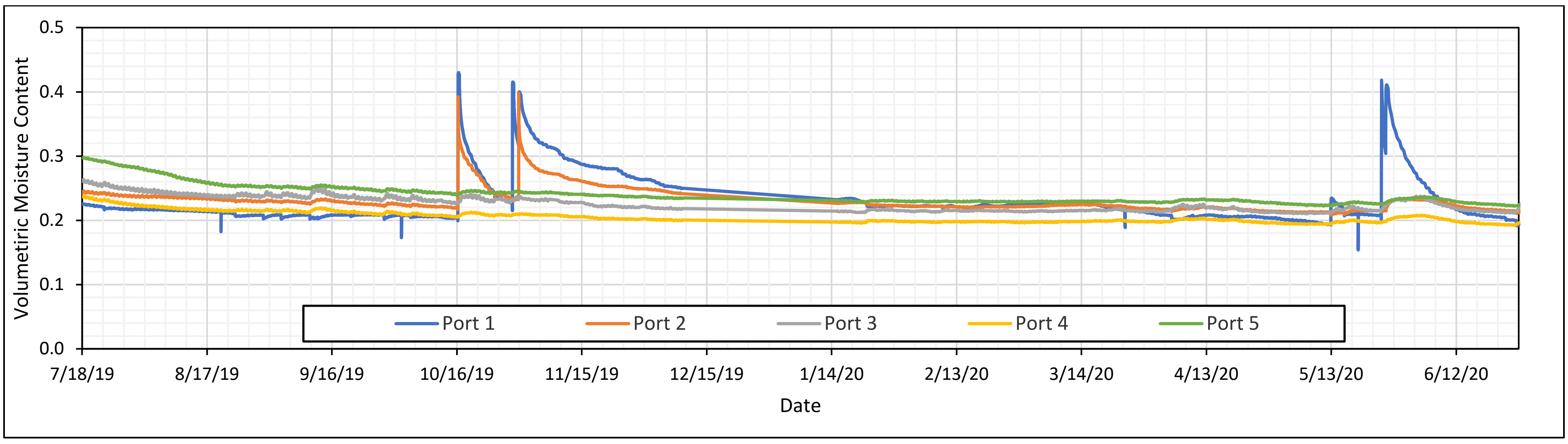

Figure 17. Dohmann D3 soil moisture probes June 28, 2019 to June 27, 2020

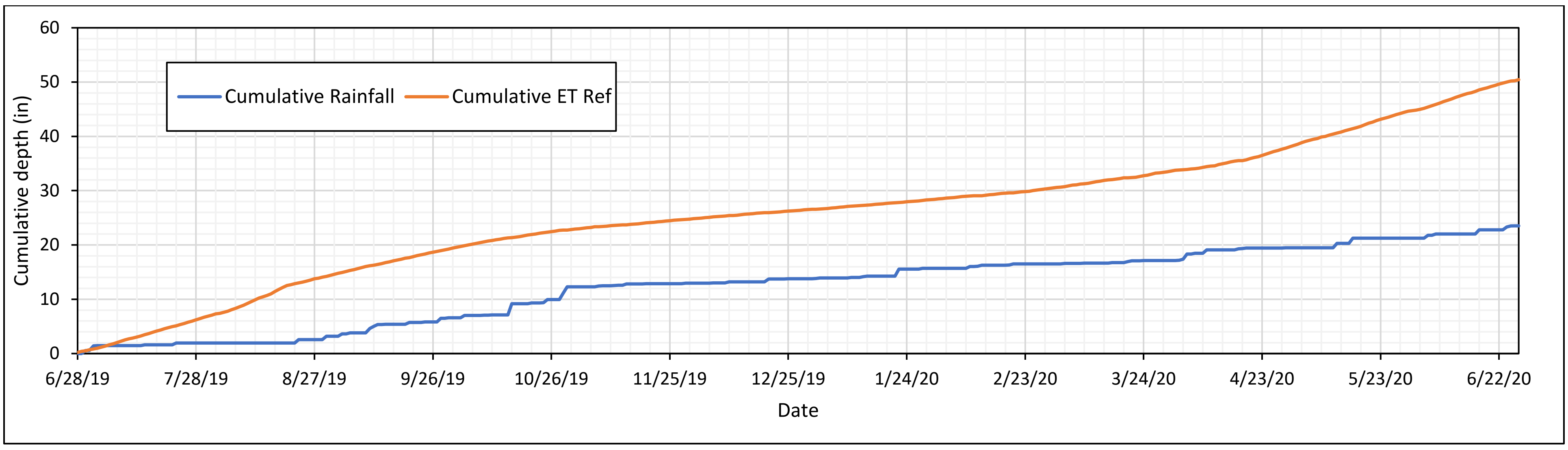

Figure 18. Dohmann cumulative rainfall and ET ref June 28, 2019 to June 27, 2020

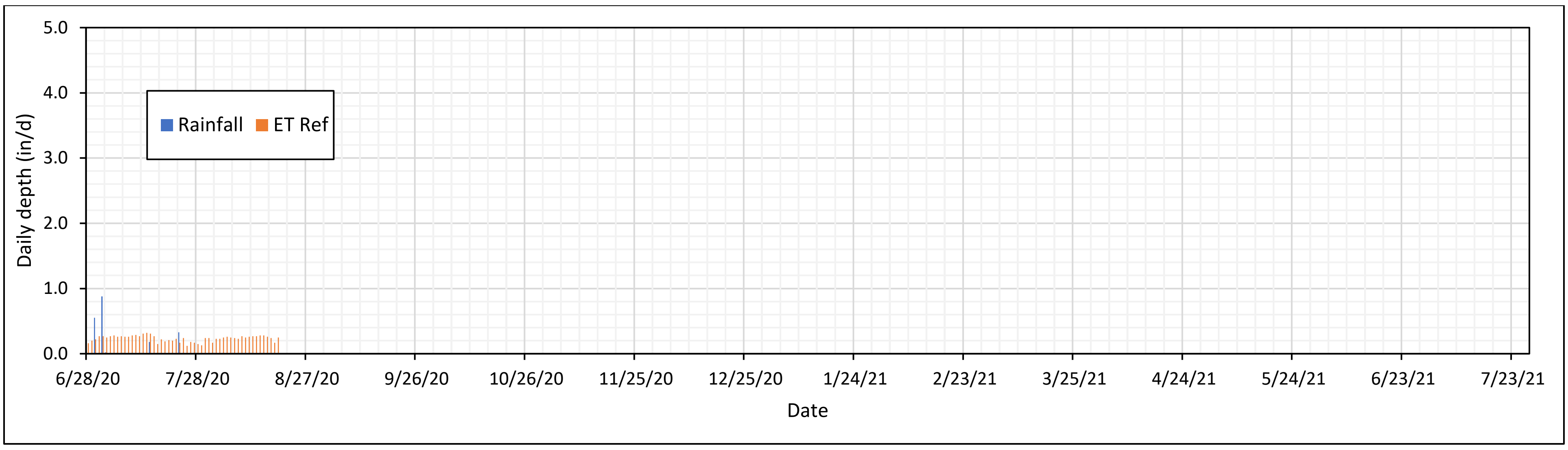

Figure 19. Dohmann daily rainfall and ET ref June 28, 2020 to June 27, 2021

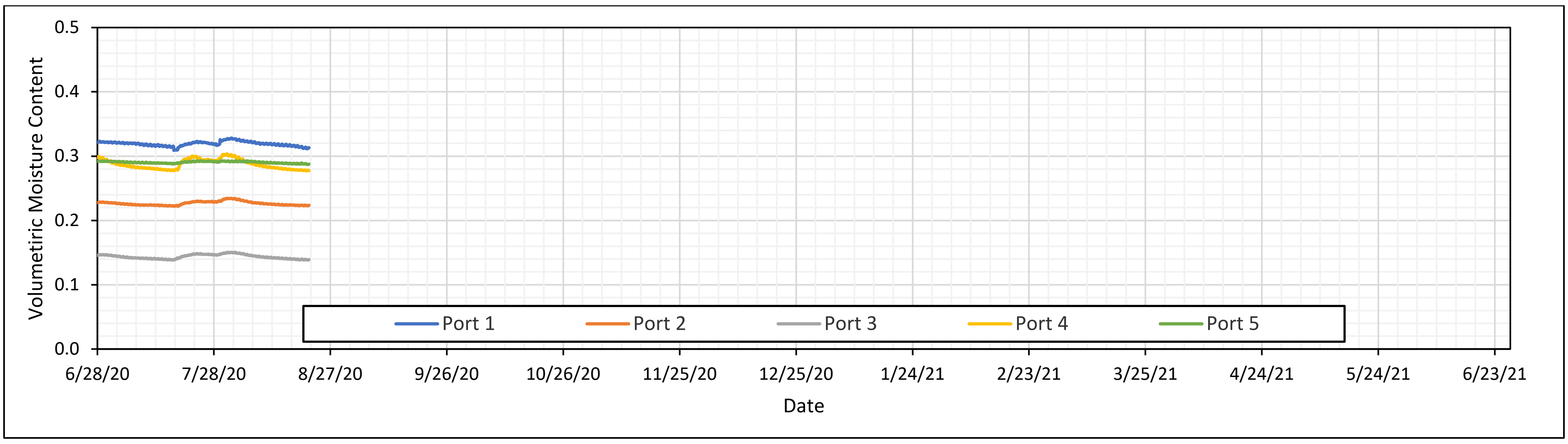

Figure 20. Dohmann D1 soil moisture probes June 28, 2020 to June 27, 2021

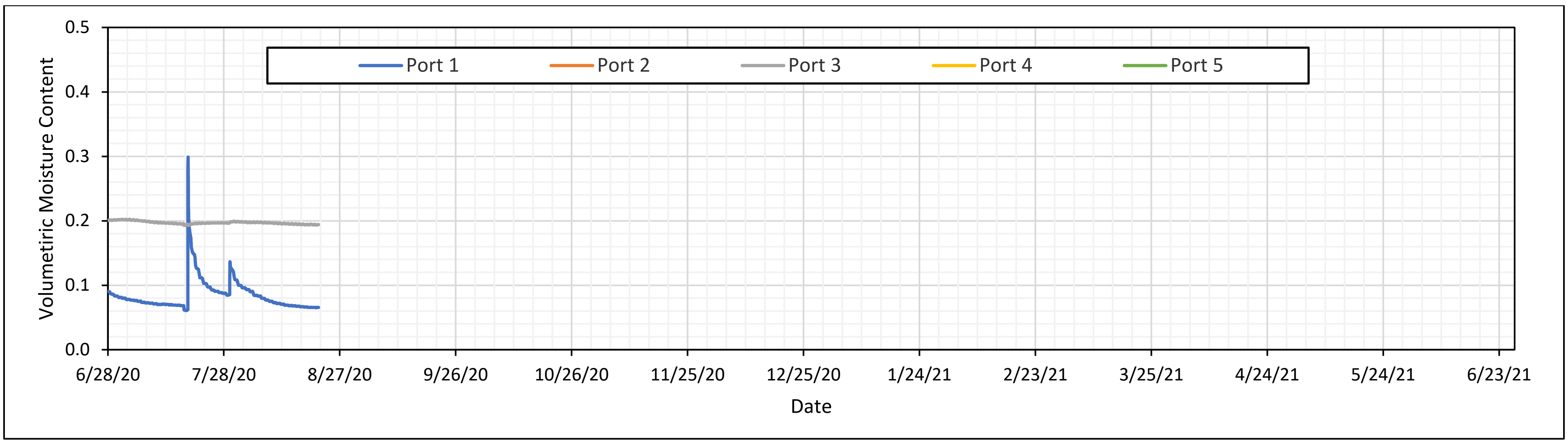

Figure 21. Dohmann D2 soil moisture probes June 28, 2020 to June 27, 2021

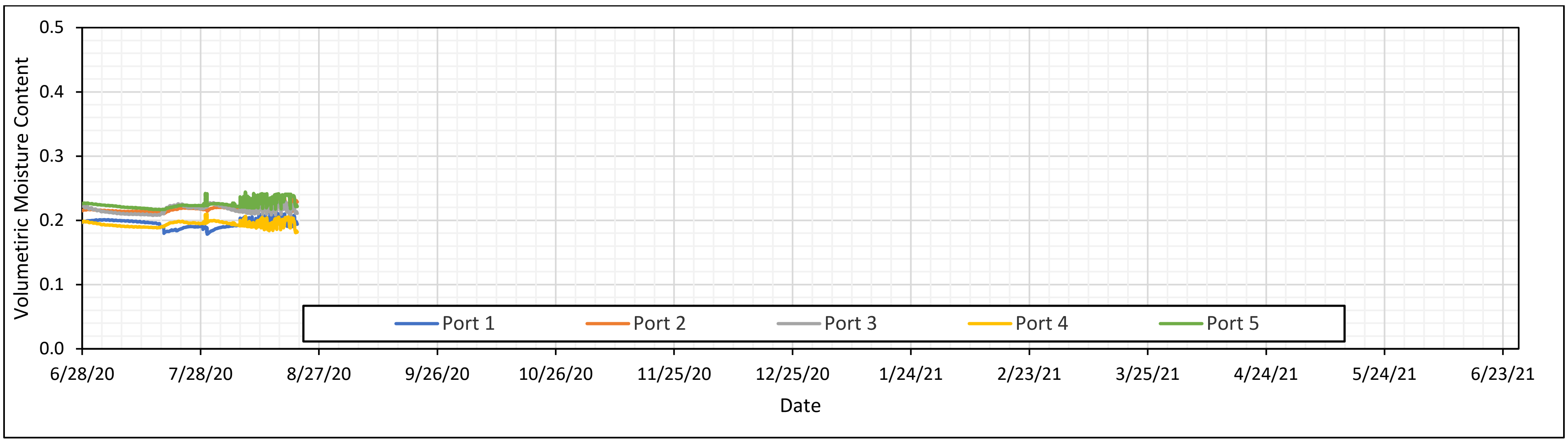

Figure 22. Dohmann D3 soil moisture probes June 28, 2020 to June 27, 2021

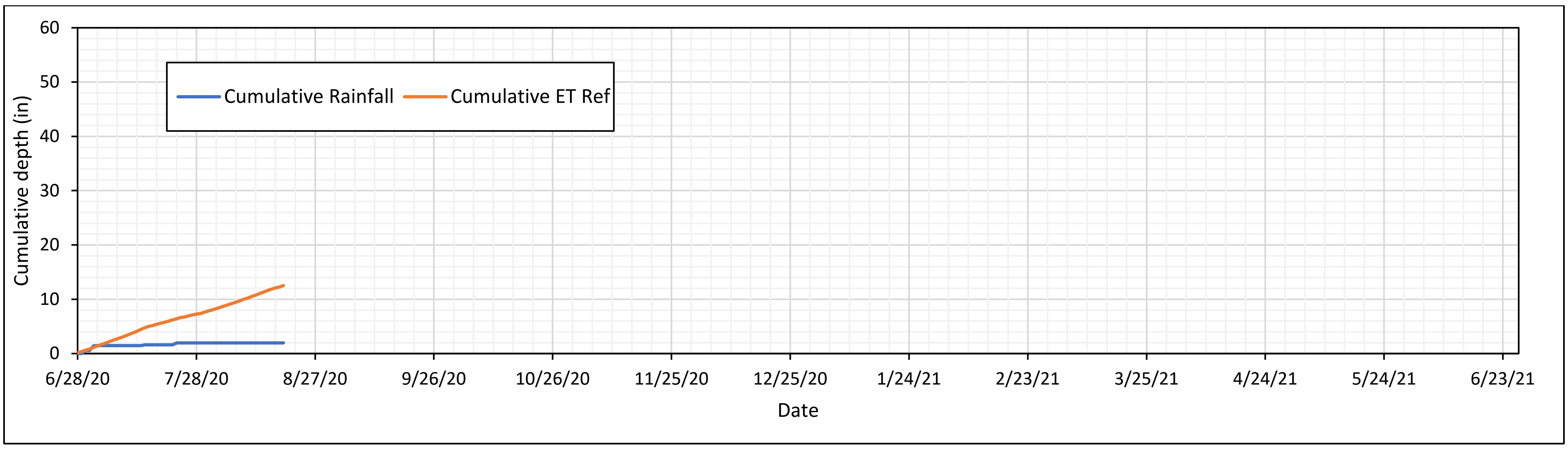

Figure 23. Dohmann cumulative rainfall and ET ref June 28, 2020 to June 27, 2021

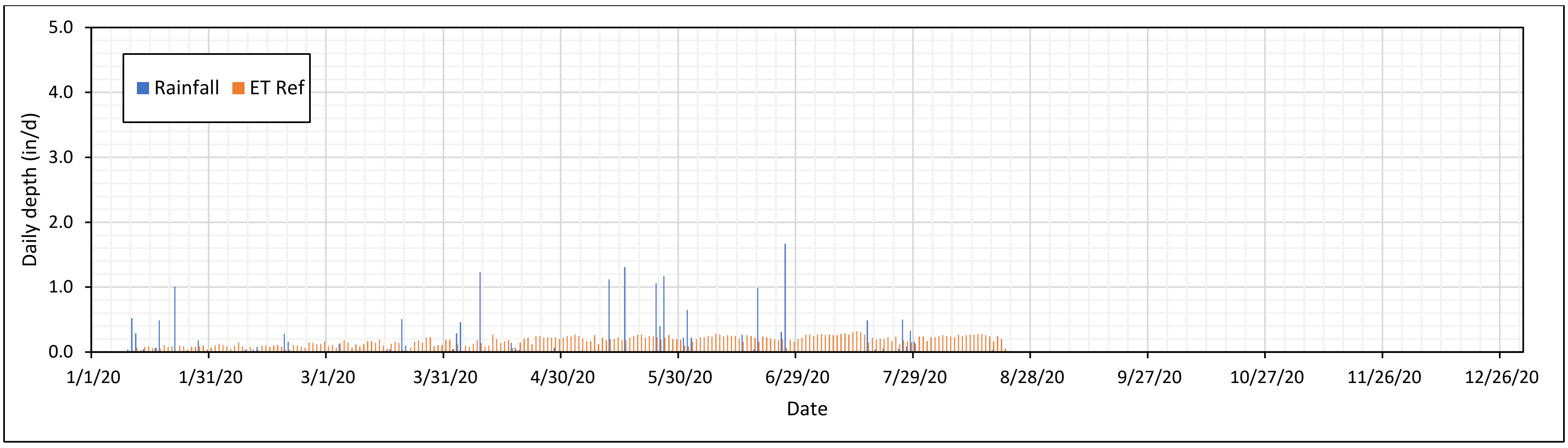

Figure 24. Fuller daily rainfall and ET ref January 1 to December 31, 2020

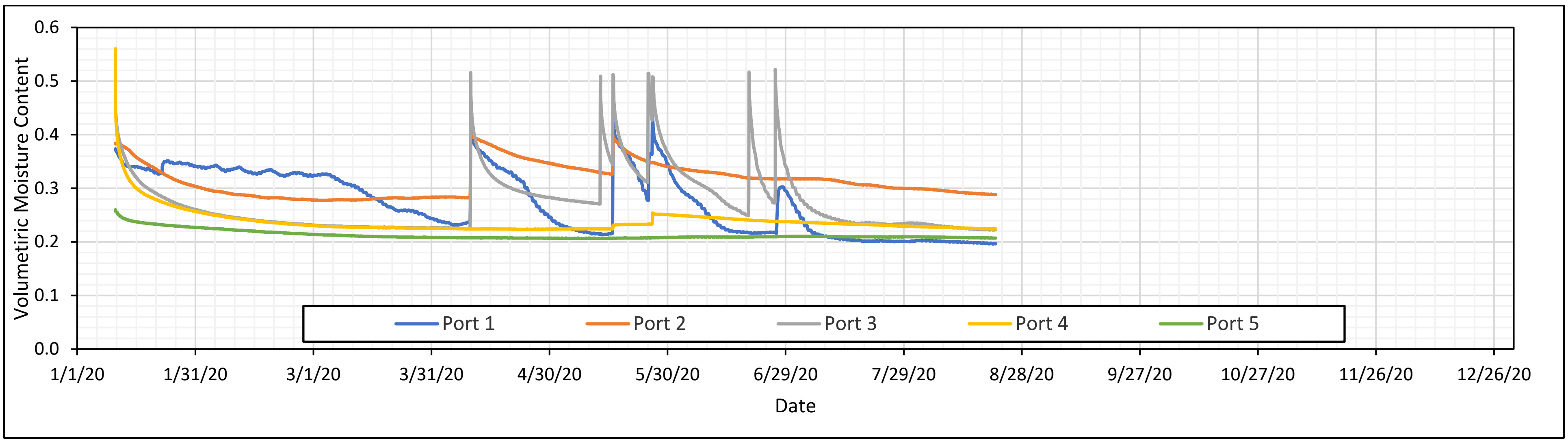

Figure 25. Fuller F1 soil moisture probes January 1 to December 31, 2020

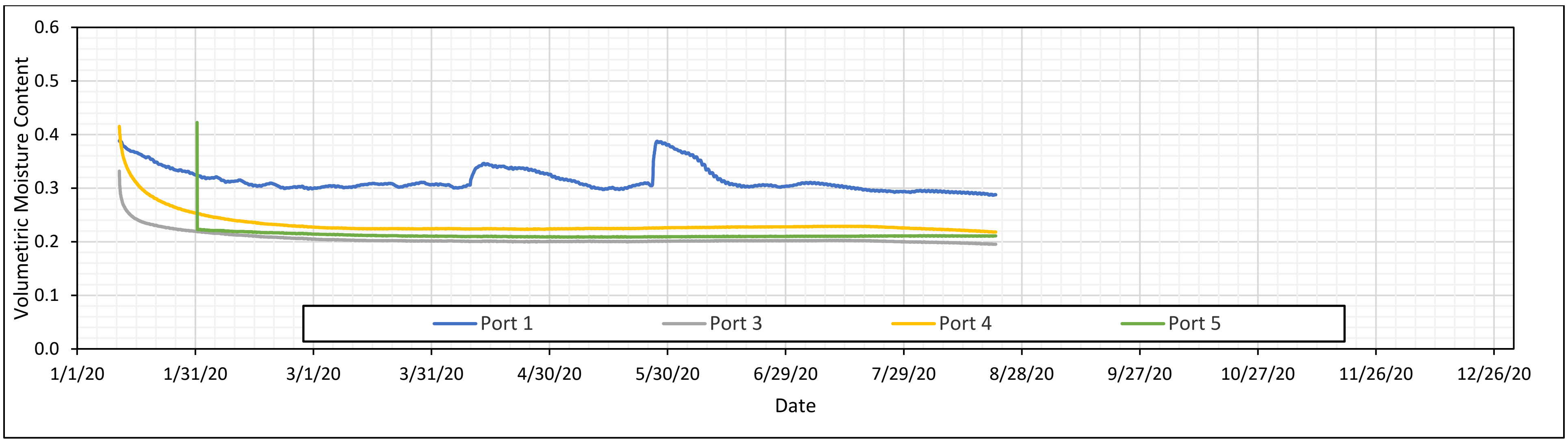

Figure 26. Fuller F2 soil moisture probes January 1 to December 31, 2020

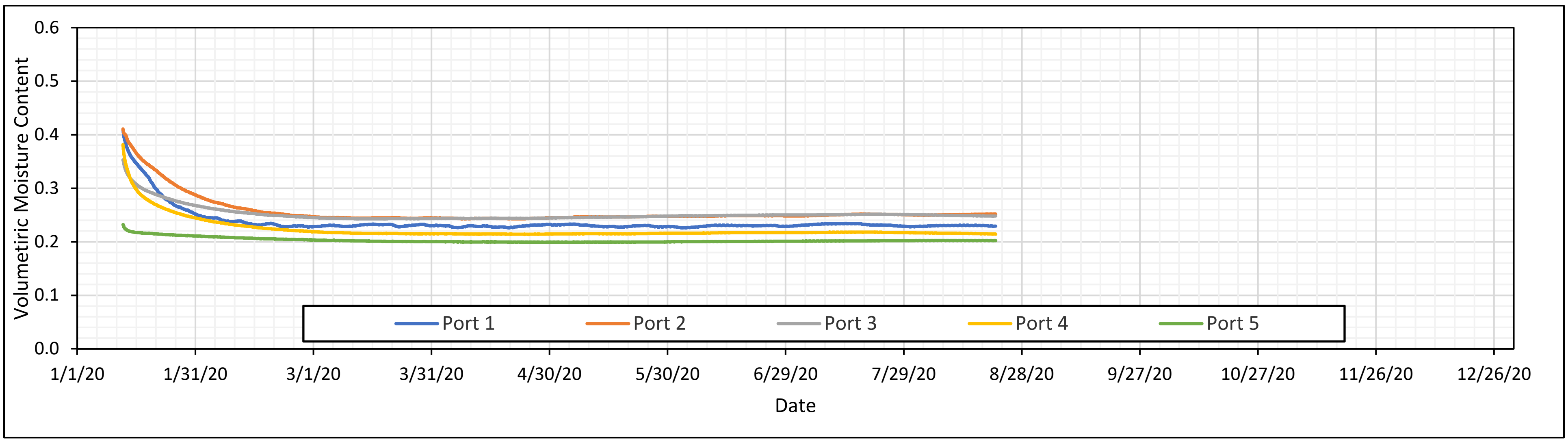

Figure 27. Fuller F3 soil moisture probes January 1 to December 31, 2020

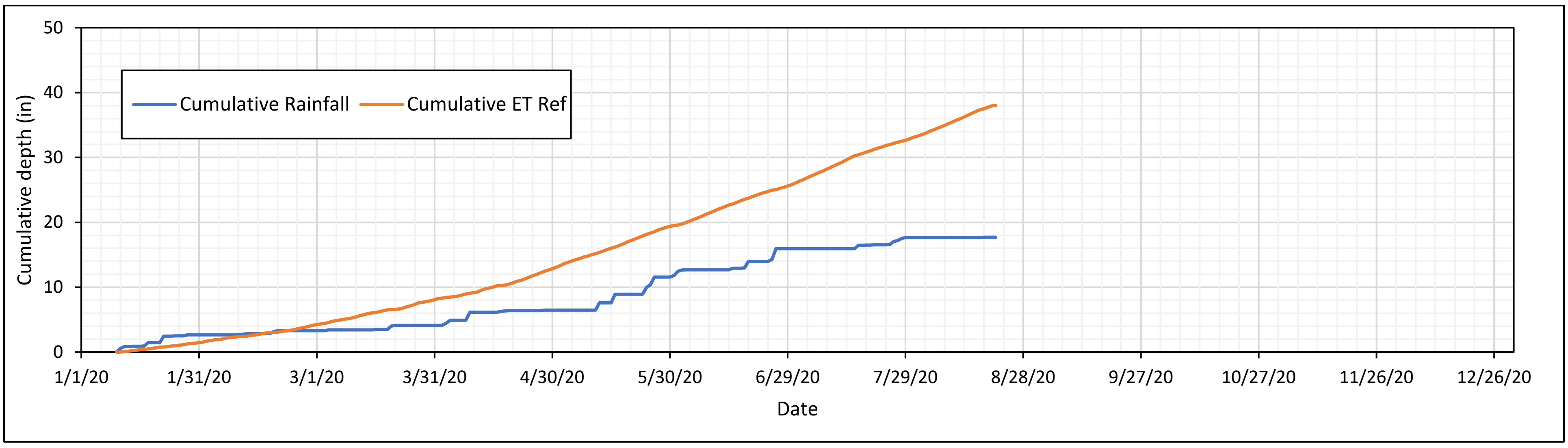

Figure 28. Fuller cumulative rainfall and ET ref January 1 to December 31, 2020